BRACHIOPOD GENERA AND SPECIES OF THE SUBORDER MARTINIIDINA FROM THE PERMIAN FAUNAS OF EAST AUSTRALIA AND NEW ZEALAND

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Earthwise 25

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Contents

LIST OF TAXA DISCUSSED IN THIS STUDY. New taxa in bold

PREFACE

This study continues the summary of the occurrences of brachiopods in Permian deposits of east Australia and New Zealand, focusing on members of Martiniidina.

REPOSITORIES

Fossils described throughout this report from Queensland are mostly housed in the Bulk Storage of the Queensland Museum, Hendra, Brisbane, and are registered individually by number with the prefix **UQF**. Fossils from other Queensland institutions involve **GSQ**, Geological Survey of Queensland and **QM**, Queensland Museum, both with F fossil registration numbers, and also stored at the Queensland Museum at Hendra, Brisbane. In New South Wales, repositories for fossils include **AMF** for Australian Museum, Sydney, **ANU,** Australia National University, Canberra, ACT; **CPC** – now **AGSO**, former Bureau of Mineral Resources – at Canberra ACT, including some fossils from Queensland; **MM** – Mining Museum, Sydney; **SUP,** Department of Geology, Sydney University; **UNEF**, Department of Geology, University of New England, Armidale, with material transferred to the Australian Museum. For Victoria, **NMVP**, Museum of Victoria, Melbourne. In Tasmania, **GST** refers to the Geological Survey of Tasmania. New Zealand repositories involve **OU**, Department of Geology, Otago University, Dunedin; and **BR**, for brachiopods kept at the Institute of Nuclear and Geological Sciences, Lower Hutt, New Zealand. From further afield, **B** and **BB** refer to collections at the Museum of Natural History **NH**(**BM**), London, and **SME** to the Sedgwick Museum, Cambridge.

ACKNOWLEDGEMENTS

Dr. Sangmin Lee has kindly provided references at my request.

SYSTEMATIC AND STRATIGRAPHIC SUMMARY

Phylum Brachiopoda Duméril, 1806

Class RHYNCHONELLATA Williams et al., 1996

Superorder Spiriferiformii Waagen, 1883

Order SPIRIFERIDA Waagen, 1883

Suborder MARTINIIDINA Waterhouse, 2010

[Martiniidina Waterhouse, 2010, pp. 13, 63].

Diagnosis: Dental plates, adminicula and tabellae varied in presence and development. Shells biconvex, smooth or coarsely plicate, some broadly costate, with varied micro-ornament of commarginal growth increments and/or radial capillae, spinules, pustules, grooves or pits.

Discussion: A feature of the suborder is the high degree of variation in internal plates, although the variation proceeded along a slender and acceptable range, consonant with external features of shape and micro-ornament, and no genus shows a spondylium, cruralium, or high ventral or dorsal medium septum. In many family groups the delthyrium is open. A connector plate is generally absent, certainly within the Australian and New Zealand groups summarized herein. A deltidium or deltidial plates are found in one major family. Martiniidiina is diverse, and is subdivided into two hyporders, which share of tabellae in at least some members. That is proferred as the most conservative of available choices in classification, yet marked a radical departure from the first and second series of *Revised Brachiopod Treatise*.

Hyporder MARTINIIDEI Waterhouse, 2010

[Nom. transl. hic ex Martiniiformii Waterhouse, 2010, pp. 13, 63].

Diagnosis: Genera smooth or plicate, seldom costate, micro-ornament varied, smooth, pitted, grooved, or minutely spinose. Interior with dental plates and adminicula present in several groups, but absent in a few. Dorsal valve with socket and crural plates, tabellae widely present, may be absent. Silurian (Wenlock) to Upper Permian (Changhsingian).

Discussion: To this hyporder (which is deemed to be equivalent to an infrasuborder and used for Class Bivalvia in Carter et al. 2009) are referred spiriferidan superfamilies and genera which

display adminicula, dental plates and crural plates with tabellae, together with genera deemed to have secondarily lost plates, as well as a major superfamily Martinioidea which lacks adminicula and tabellae. Overall shape is subrounded, plicae are more or less developed, and micro-ornament is varied, pitted, spinose, or grooved or smooth, with further variations, but without prominent commarginal lamellae, as pointed out by Carter & Gourvennec (2006, p. 1747), although exceptions such as *Carteriopsis* Waterhouse are known (Waterhouse 2016, p. 66).

A sister hyporder or infrasuborder Choristitidei (Choristitimorphii) Waterhouse (2016, p. 112) is also recognized. Genera in this hyporder are costate, with as a rule long adminicula and tabellae.

Superfamily **MARTINIOIDEA** Waagen, 1883

[Nom. correct. Carter, Johnson & Gourvennec *in* Carter et al. 1994, p. 338, pro Martiniacea Ivanova, 1972, p. 41, nom. promoveo ex Martiniinae Waagen, 1883, p. 542].

Diagnosis: Suboval biconvex shells, smooth, sulcate and/or plicate, micro-ornament may involve fine pits or spinules, may display commarginal growth increments or radial capillae. Dental plates may be reduced or absent, no adminicula; crural plates often reduced, never supported by tabellae (ie. so-called "dorsal adminicula"). Upper Devonian (Famennian) to Upper Permian (Changhsingian).

Discussion: Martinioidea embrace genera that lack adminicula and tabellae, and have moderate varying to virtually no dental plates. Martiniids make up a very minor part of an overall group in Australasia that is dominated by shells with short to long adminicula, plates which are entirely missing from martiniids. The martiniid group is really an outlier, but which justifiably takes naming rights over the entire plexus because of a long history of recognition as distinctive from *Spirifer*. Despite this long history, *Martinia* itself remains very poorly known as far as dental and crural plates are concerned, because of lack of attention to the type species, and even attributes of micro-ornament have been under contention – this being an all-too-familiar problem of spiriferiform genera based on type species preserved as a rule by exfoliated shells coming from the Early Carboniferous of Great Britain and monographed in the Nineteenth Century. Whilst some genera and species have been clarified through the studies of C. H. C. Brunton (1984) on

silicified material from Ireland and with his colleague D. J. C. Mundy in England, too many genera remain poorly known, including *Martinia,* and much more work is needed, along the lines followed by Legrand-Blain (1985) and Angiolini et al. (2011).

The family groups that seem to be most closely related to Martiniidae are Brachythyridae Fredericks and Perissothyrinae Carter, two associations which lack adminicula and tabellae, and may have reduced if any dental plates. They have stronger ribs, and the similarity may be due to convergence, but in the favoured interpretation, reflect a modest degree of divergence from allied sources. Several other groups included by Carter & Gourvennec (2006) in Martinioidea have been segregated as Ingelarelloidea and Gerkispiroidea, including Ingelarellidae Campbell, Notospiriferidae Archbold & Thomas, Gerkispiridae Carter, and Rorespiriferidae Waterhouse. Genera within these families and subfamilies have well-formed dental plates and adminicula in the ventral valve and crural plates supported by varyingly developed tabellae in the dorsal valve. By contrast, adminicula and tabellae are completely missing from Martinioidea. With such clear differences in morphology, it is relatively simple to allocate genera to superfamilies, without precluding genera that in their evolution came to lose plates.

Family **MARTINIIDAE** Waagen, 1883

[Nom. promoveo Ivanova 1959, p. 56 ex Martiniinae Waagen, 1883, p. 542].

Diagnosis: As for superfamily. Dental plates present or absent, lateral slopes may be weakly ribbed, smooth or plicate. Delthyrium may be closed or partly closed by deltidial plates, or rarely, subdelthyrial connector plate and/or pleromal ridges. Lower Carboniferous (Tournaisian) to Upper Permian (Changhsingian).

Subfamily **MARTINIINAE** Waagen, 1883

[Martiniinae Waagen, 1883, p. 542].

Diagnosis: Suboval biconvex shells with dental plates in most genera but no adminicula, crural plates small or large, no tabellae. Micro-ornament of pits or commarginal growth lines common. Mantle canal system linear, sublinear with branching or in a network. Carboniferous (Tournaisian) to Upper Permian (Changhsingian?).

Genera: *Martinia* M'Coy (syn. *Pseudomartinia* Leidholdt, *Paramartinia* Reed?), *Beschevella* Poletaev, *Chapursania* Angiolini, *Implexina* Poletaev, *Jilinmartinia* Li & Gu (syn. *Kalitvella* Lazarev & Poletaev), *Krabispirifer* Waterhouse, ?*Ladoplica* Xu & Grant, *Postamartinia* Wang & Yang, *Tiramnia* Grunt.

Discussion: Carter *in* Carter & Gourvennec (2006, p. 1748) diagnosed the subfamily as being without plates or septa in either valve. These statements are not correct. Many Martiniinae have dental plates, and most have crural plates, from which the crura arise: the crural plates are also called outer hinge plates in various studies.

Genus ***Martinia*** M'Coy, 1844

Although this genus has been long established, the nature of internal plates have yet to be resolved. It remains uncertain whether the type species has dental plates or not. There is also a question over radial canals, but it appears likely that the vascular canal system is linear. These matters are further discussed in Waterhouse (2016, pp. 89, 90).

Type species*: Spirifer glaber* J. Sowerby, 1820, p. 123 from the Lower Carboniferous (Visean) of the British Isles.

Discussion: The type species of *Martinia* M'Coy 1844, *Spirifer glaber* J. Sowerby, 1820, is a large transverse shell of Lower Carboniferous age in the British Isles with weakly defined dorsal fold for the length of the valve, and numerous subparallel radial mantle canals on the surface of the inner shell (George 1931, Muir-Wood 1951, Waterhouse 1981, pl. 30, fig. 3, 6, 7, pl. 31, fig. 1). Internal details have been poorly circumscribed for *Martinia*, and it is not certain whether dental plates and crural plates are present or absent. In the Davidson collection at the Museum of Natural History, London, specimen B 14531 from Derbyshire has thick stubby dental plates. But is it truely congeneric with *Martinia glaber*? And is the presence or absence of dental plates significand? *Paramartinia* Reed, 1949 was treated as junior synonym of *Martinia* by Carter (in Carter & Gourvennec 2006, p. 1748), but with incomplete comparison of internal features. *Paramartinia* was reported to lack dental plates by Reed (1949), but he was referring to adminicula rather than dental plates, which are not visible in the sole specimen described, and may be present, suspended above the floor of the valve, or may be absent.

Martinia*? *adentata Waterhouse, 1964

Fig. 1

1964 *Martinia*? *adentata* Waterhouse, p. 114, pl. 21, fig. 10-14, text-fig. 53A, B.
1968 *M. adentata* – Waterhouse, p. 53.
2001 *Spinomartinia*? *adentata* – Waterhouse, p. 89, pl. 5, fig. 26, 27, text-fig. 7a.

Diagnosis: Medium-sized non-sulcate shells of rounded outline, with well-defined sublinear pallial markings, thick umbonal callus, no teeth and highly reduced dental plates. Micro-ornament uncertain.

Holotype: BR 670 from conglomerates above the Brunel Formation, figured in Waterhouse (1964, pl. 21, fig. 10, 11, 13, 14, text-fig. 53A, B) and herein as Fig. 1A, C, OD.

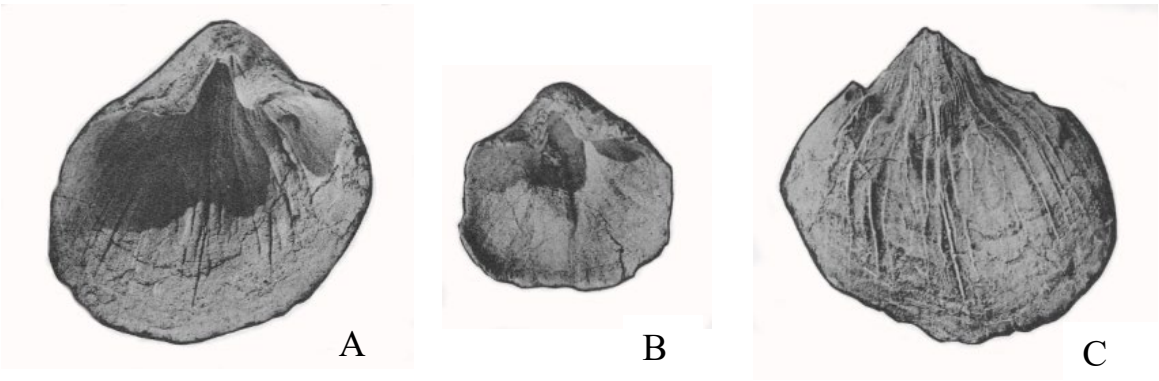


Fig. 1. *Martinia*? *adentata* Waterhouse. A, C, PVC cast and internal mould of BR 670, holotype, x1. B, PVC cast showing ventral interior, BR 675, x1. From conglomerates above Brunel Formation, below (or at base of) McLean Peaks Formation, Takitimu Group, New Zealand. (Waterhouse 1964).

Morphology: This species was named because of its stratigraphic importance, coming from a level with few other fossils, but needs to be better known, because the ventral micro-ornament is uncertain, and the dorsal valve not known. Although possibly belonging to the genus *Spinomartinia,* with support from the similarity in shape to *S. queenslandica* (see below) and the pallial lines, the generic position is not clear, exacerbated by uncertainty over the interior of the type species of *Martinia*. But from a stratigraphic point of view the species is distinctive.

Possibly allied material, though more likely to belong to a different taxon, was reported

from the Takitimu Group by Waterhouse (1968, p. 53), apart from that noted in the synonymy, and this shows surface pits and pustules.

Stratigraphy: The species is found in the McLean Peaks Formation as well as conglomerate assigned by **Campbell et al. (1990)** to the Brunel Formation. The enclosing sediment which contains *Martinia*? *adentata* differs substantially from Brunel lithologies, and possibly the conglomerate forms the base of the McLean Peaks Formation.

Martiniid sp. A

Fig. 2

1972 *Martinia* sp. A Armstrong, p. 37, pl. 4, fig. 4, 5, 9-11.
?1972 *Martinia* sp. cf. sp. A – Armstrong, p. 37, pl. 4, fig. 7, 8.

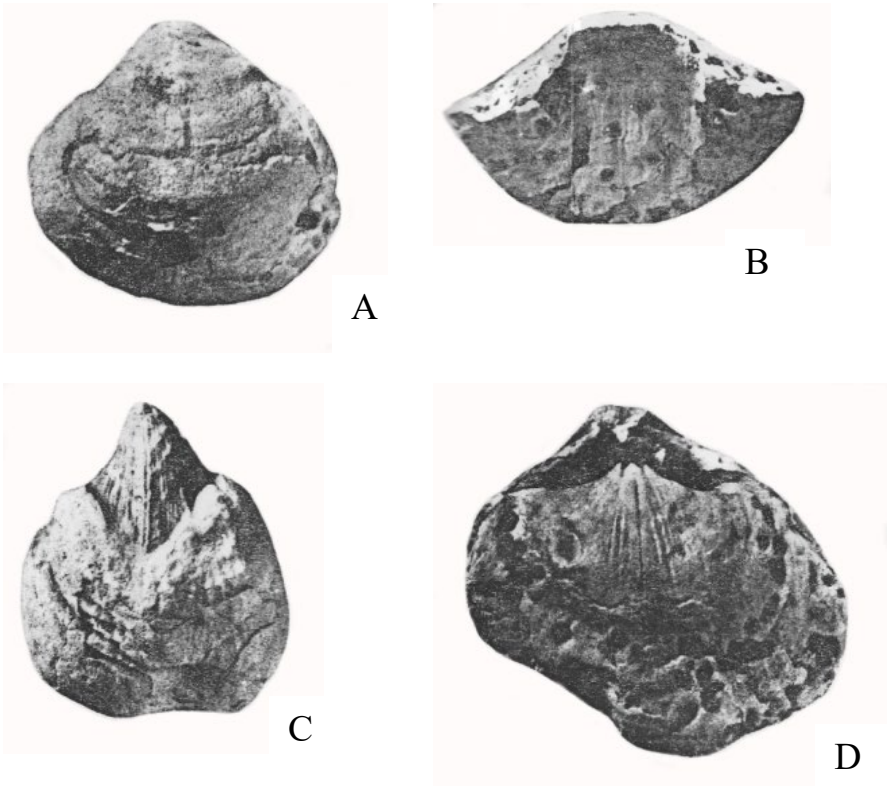


Fig. 2. Martiniid sp. A. A, ventral valve GSQF 11193. B, D, anterior and dorsal aspects of GSQF 11191. C, ventral internal mould GSQF 11192. Specimens x1 from Flat Top Formation, southeast Bowen Basin. (Armstrong 1972).

Armstrong (1972) recorded well-preserved martiniid specimens from the Flat Top Formation of the

southeast Bowen Basin. Only commarginal growth lamellae were observed by Armstrong, and he seemed uncertain if these were the sole component of the micro-ornament. He considered that specimens from the Condamine beds on the Queensland border could be allied or conspecific.

Martiniid sp. B

Fig. 3

1964 *Martinia* aff. *martinezi* [not (Cooper)] – Waterhouse, p. 119, pl. 22, fig. 1, 2, text-fig. 53C, D.
1976 *M*. aff. *martinezi* Waterhouse, p. 245, Fig. 6.3.

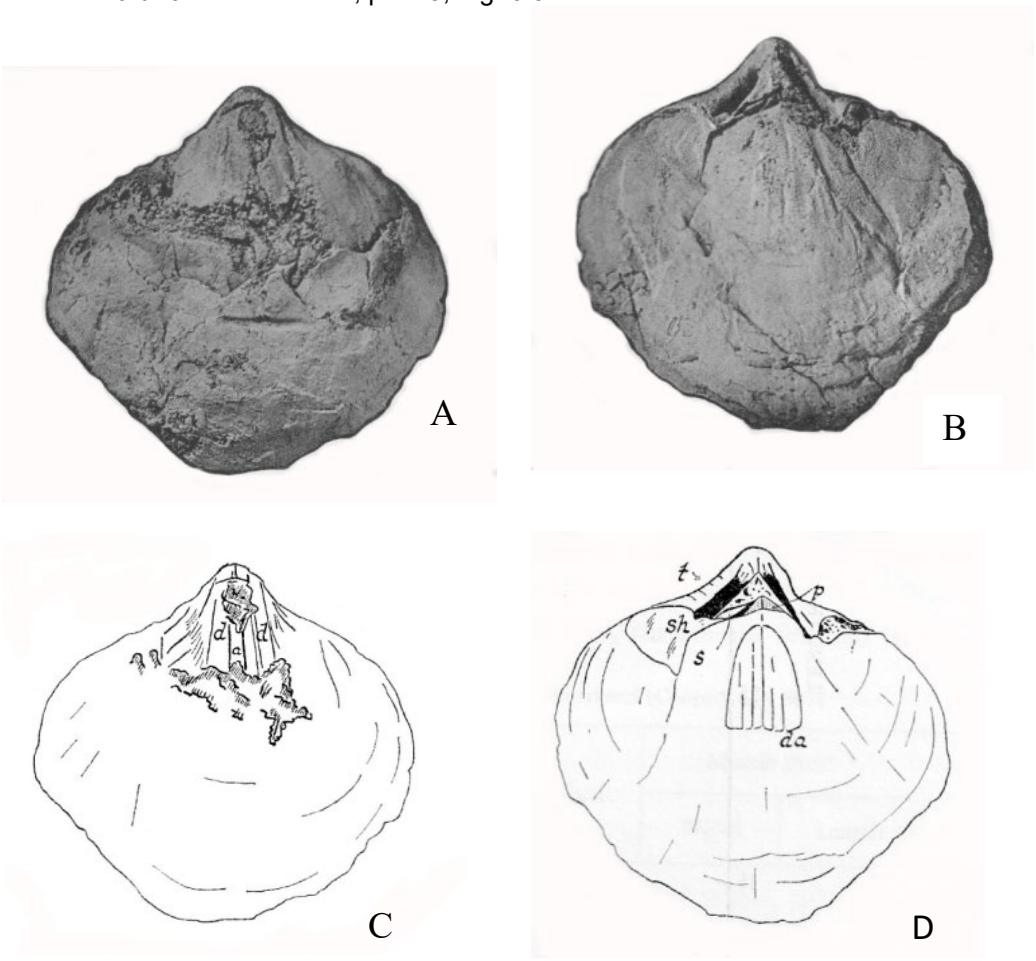


Fig. 3. Martiniid sp. B. Ventral and dorsal aspects of BR 669 with line drawings, x2, from Kildonan Member, New Zealand. d = diductor scar; da = dorsal adductor scar; p = cardinal process; s = dental socket; sh = shell adhering to mould; t = tooth. (Waterhouse 1964).

A small complete shell with rounded outline and weakly sinuate anterior margin has low commarginal growth ridges crossed by very fine radial striae, with shallow pits numbering some

two in 1mm, over both valves. Teeth are low and thin, supported by low dental plates. Further detail is provided in Waterhouse (1964), but only the one specimen is known. The New Zealand specimen is much less inflated than the Cooper material called *martinezi,* lacks plicae, and has a distinctive micro-ornament that cannot be securely matched with any established for other martiniiform genera, though it has to be said that the micro-ornament is poorly known for several genera, as summarized in the *Revised Brachiopod Treatise.*

Stratigraphy: The specimen comes from the Kildonan Member of the Bagrie Formation, New Zealand.

Martiniid sp. C

Fig. 4

1964 *Martinia* aff. *mongolica* [not Grabau?] – Waterhouse, p. 116, pl. 21, fig. 15, 16, pl. 22, fig. 3, text-fig. 53G, 54.

A single ventral valve comes from the Trig DD Formation in New Zealand, shaped as indicated in the synonymy, and moderately close to *Martinia*? *adentata* in shape, though teeth are strong and supported by low dental plates.

Fig. 4. Martiniid sp. C, PVC cast of ventral valve BR 666 x1 from Trig. DD Formation, New Zealand. (Waterhouse 1964).

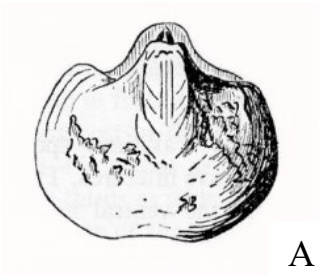
Martiniid sp. D

Fig. 5

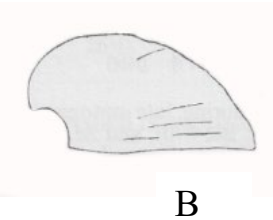
?1878 *Spirifer glaber* [not Sowerby] – Hector p. xii.
1964 *Martinia* sp. Waterhouse, p. 120, Text-fig. 53E, F.

Two ventral valves and a specimen with valves conjoined come from the Late Permian Pig Valley Limestone of east Nelson, New Zealand. They are characterized by well-rounded outline, prominent ventral umbo, shallow anterior sulcus and low dental plates. Micro-ornament not

known.



A



B

Fig. 5. Martiniid sp. D. A, internal mould and B, lateral profile of BR 665 x1.25. Pig Valley Limestone, New Zealand. (Waterhouse 1964).

Subfamily **SPINOMARTINIINAE** Waterhouse, 2016

[Spinomartiniinae Waterhouse, 2016, p. 96]

Diagnosis: Characterized by fine spines over both valves. Vascular imprints may be linear or reticulate, especially on ventral valve. Lower Permian (Sakmarian) to Late Permian (Changhsingian).

Name genus: *Spinomartinia spinosa* Waterhouse, 1968, p. 53 from Trig DD Formation (Changhsingian) of New Zealand, OD (Waterhouse 2002, p. 99).

Genera: *Duntonia* Waterhouse & Campbell, *Globosospiniger* Waterhouse, *Spinomartinia* Waterhouse.

Genus ***Spinomartinia*** Waterhouse, 1968

Diagnosis: Large transverse shells with well-spaced small spines over both valves. Small teeth, low dental plates.

Type species: *Spinomartinia spinosa* Waterhouse, 1968, p. 53 from Trig DD Formation, New Zealand, OD.

Spinomartinia queenslandica Waterhouse, 1987

Fig. 6

1970 *Martinia* sp. Armstrong, p. **202**, pl. 13, fig. 1-4, text-fig. 1.
1972 *Martinia* sp. Armstrong, p. 35, pl. 4, fig. 1-3, 12.
1987 *Spinomartinia queenslandica* Waterhouse, p. 40, pl. 11, fig. 10, 12-18, pl. 12, fig. 1.

Diagnosis: Subrounded shells with small umbonal callosity, usually non-sulcate, moderately simple vascular lines, less transverse than type species.

Holotype: UQF 70189 from upper Brae Formation, southeast Bowen Basin, figured in Waterhouse (1987, pl. 11, fig. 15, 16) and herein as Fig. 6A, B, OD.

Morphology: Micro-ornament has been figured by Armstrong (1972, pl. 4, fig. 12). This species is more elongate than *Spinomartinia spinosa*, to possibly suggest that some of the elongate Martiniid specimens of the preceeding pages could belong to *Spinomartinia*. But their micro-ornament needs to be well preserved to establish such a placement. Comparisons were offered with the type and other species by Waterhouse (1987, p. 41). Dental plates are moderately developed.

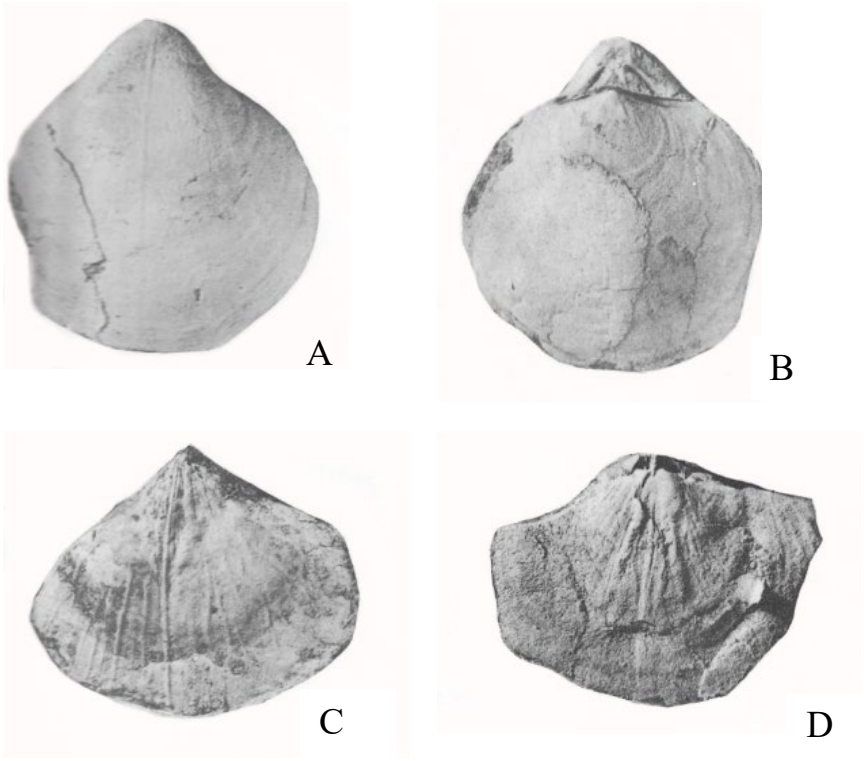


Fig. 6. *Spinomartinia queenslandica* Waterhouse. A, B, ventral and dorsal aspects of UQF 70189, holotype. C, ventral internal mould, UQF 70168. D, dorsal internal mould, UQF 70203. Specimens x2, from Brae Formation, Queensland. (Waterhouse 1987).

Stratigraphy: The species is found in the Brae Formation of the southeast Bowen Basin in

Queensland. These beds had been assigned to the Oxtrack Formation by Armstrong (1970a, 1972) and other geologists until the detailed field-work by Flood et al. (1981). However two specimens have been sourced from one genuine Oxtrack locality, and it has been suggested that these could have been derived from the Brae Formation (Waterhouse 1987, p. 41).

Spinomartinia spinosa Waterhouse, 1968

Fig. 7, 8

1968 *Spinomartinia spinosa* Waterhouse, 1968 p. 53, pl. 8, fig. 4, 5, 9-11, pl. 9, fig. 1-8, pl. 17, fig. 4.
1969 *Martinia* sp. Runnegar & Ferguson, p. 278, pl. 5, fig. 12, 13.
1972 *Martinia* sp. cf. sp. B Armstrong, pl. 4, fig. 6.
1978 *S. spinosa* – Waterhouse & Mutch, p. 522, text-fig. 16, 19-25.
1978 *S. spinosa* – Suggate et al., text-fig. 11.3, fig. 8-10.
1981 *S. spinosa* – Speden & Keyes, pl. 8, fig. 8-10.
1999 *S. spinosa* – Waterhouse, p. 6.
2001 *S. spinosa* – Waterhouse, p. 89, pl. 6, fig. 1-4, text-fig. 7b.
2015b *S. spinosa* – Waterhouse, p. 154.

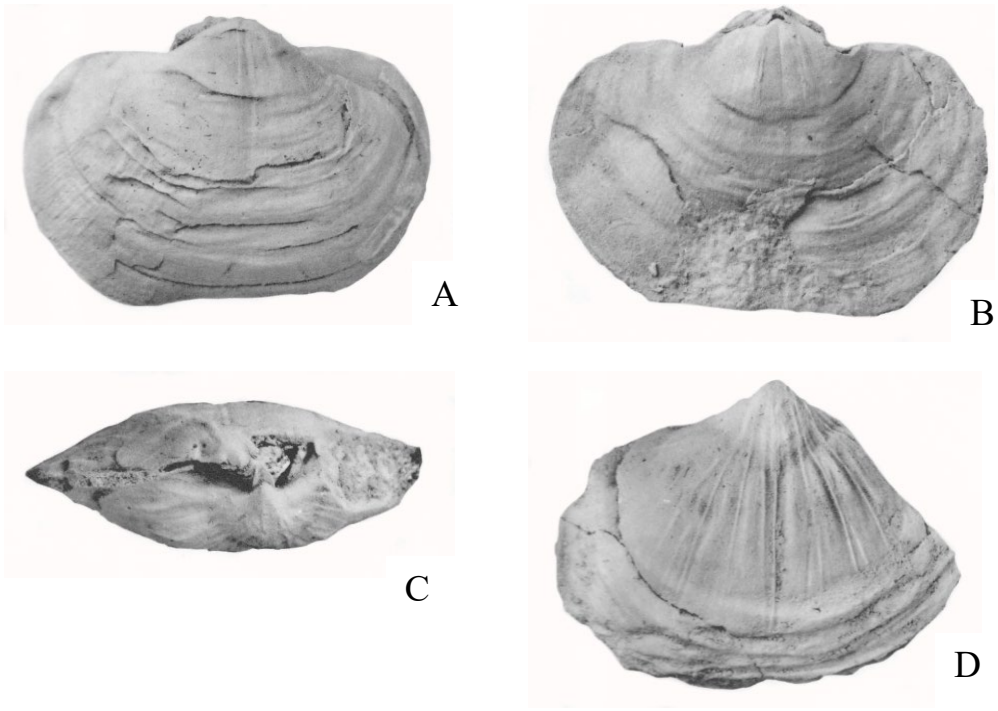


Fig. 7. *Spinomartinia spinosa* Waterhouse. A - C, ventral, dorsal and posterior views of holotype, OU 2413, x2. Dorsal valve on top in C. D, ventral valve showing vascular canals, BR 1187. Trig D (A-C) and Pine Bush Formations, New Zealand. (Waterhouse 1968).

Diagnosis: Large transverse shells with small spinules over both valves.

Holotype: OU 2413 figured from Trig DD Formation by Waterhouse (1968, pl. 8, fig. 10, pl. 9, fig. 2-4), Suggate et al. (1978) and Speden & Keyes (1981) and herein as Fig. 7A-C, 8, OD.

Morphology: Shells are broad and of moderate size. The specimen described as *Martinia* aff. *martinezi* [not Cooper] by Waterhouse (1964, 1976: see p. 11 herein) from the Kildonan Member has different micro-ornament of fine regularly arranged pits in quincunx, with lattice work of radial and commarginal ridges.

Stratigraphy: The species is found in the Kildonan Member of the Bagrie Formation and overlying Trig DD Formation, as well as in a Tertiary boulder deribed from Trg DD equivalents.

Fig. 8. *Spinomartinia spinosa* Waterhouse, panel showing micro-ornament of spines (as black dots) on dorsal external mould of holotype, OU 2413. Trig DD Formation. (Waterhouse 1968).

Genus ***Duntonia*** Waterhouse & Campbell, 2016

Diagnosis: Micro-ornament of fine pustules, finer and more numerous than those of *Spinomartinia*. Distinctive reticulate network of vascular impressions.

Type species: *Duntonia duntonensis* Waterhouse & Campbell, 2016 from Eglinton Subgroup, New Zealand, OD.

Duntonia duntonensis Waterhouse & Campbell *in* Waterhouse, 2016

Fig. 9

2016 *Duntonia duntonensis* Waterhouse & Campbell *in* Waterhouse, p. 99, Fig. 102.
2021 *D. duntonensis* – Waterhouse & Campbell, p. 28, Fig. 8.

Diagnosis: Variably transverse to elongate, distinctive network of vascular impressions, small socket plates, micro-ornament of fine pustules.

Holotype: BR 2447 from Eglinton Subgroup, New Zealand, figured by Waterhouse & Campbell *in* Waterhouse (2016, Fig. 102A-C; Waterhouse & Campbell, 2021, Fig. 8D-F) and herein as Fig. 9A-C, OD.

Morphology: As shown in Fig. 9B, the dorsal valve is much less inflated than the ventral valve.

Stratigraphy: The species comes from the Eglinton Subgroup, New Zealand, in the *Terrakea geniculata* Zone, equivalent to the *Magniplicatina undulata* Zone in Queensland.

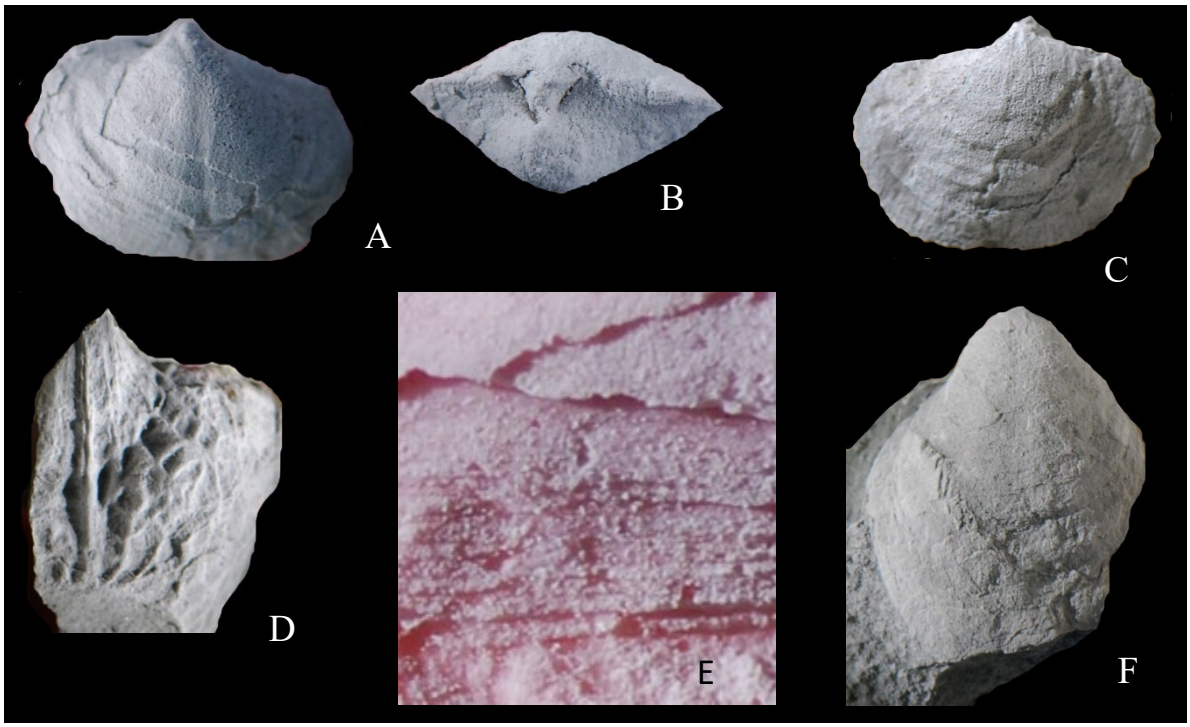


Fig. 9. *Duntonia duntonensis* Waterhouse & Campbell. A-C, ventral posterior and dorsal aspects of BR 2428, holotype, x4 approx. D, ventral internal mould BR 2447, showing mantle canals, x3. E, detail of micro-ornament on external cast BR 2446, x7. F, ventral valve 2442, x3. From Takitimu Group, New Zealand. (Waterhouse & Campbell 2021).

Family **BRACHYTHYRIDAE** Fredericks, 1924

[Nom. pref. hic pro Brachythyrididae Pitrat 1965, p. 706, transl. et correct. ex Brachithyrinae Fredericks, 1924, p. 316].

Diagnosis: Oval usually inflated and biconvex shells with moderately narrow hinge, ornamented by narrow plicae, radial capillae widespread, but absent from some genera, surface may be pustular. Delthyrium variably open or covered by subdelthyrial plate, deltidium or stegidial plates, no adminicula or tabellae. Upper Devonian (Famennian) to Upper Permian (Lopingian).

Discussion: Brachythyridoidea was recognized as a superfamily by Carter in Carter et al. (1994), and was placed quite separately from Martinioidea, but still within the massive suborder Spiriferidina. An assessment of the mantle canal system challenges such a position, because the pattern in type *Brachythyris* is very close to that of type *Martinia*, exhibiting long straight radiating canals in the ventral valve. A fuller account and discussion of affinities and source is provided in Waterhouse (2016, p. 99ff).

Taxonomy: In proposing Brachythyridoidea, Pitrat (1965) inserted the id, and that conforms with recommendations in ICZN 1999. Here, as allowed by the ICZN, it is preferred to delete the id as extraneous for the family ending, and superfamily ending. Surely rules for Latin grammar, invented in medieval to more recent times, should not be allowed to drastically mangle the brachiopod names when applied to higher categories of classification.

Subfamily **PUSTULOPLICINAE** Waterhouse, 2004, p. 234

[Pustuloplicinae Waterhouse 2004, p. 234].

Diagnosis: Plicate shells with micro-ornament of very small spinules. No adminicula or tabellae, low dental plates and crural plates. Upper Carboniferous (Gzhelian) to Upper Permian (Changhsingian).

Genera: *Pustuloplica* Waterhouse, ?*Capillispirifer* Zhang, *Zhejiangospirifer* Liang.

Discussion: If Brachythyridae is to include subfamilies that share most attributes and vary mainly in the strength and number of plicae, then Pustuloplinae may need to be upgraded to family status. *Pustuloplica* with its nodose micro-ornament is completely unlike that of the other genera referred to Brachythyridae, and furthermore it lacks deltidial and/or subdelthyrial plates, and has an umbonal callosity that passes forward into low pleromal ridges. So it resembles the delthyrial arrangement in some Spinomartiniinae, and is unique in terms of micro-ornament with its small

and numerous pustules over both valves.

Genus ***Pustuloplica*** Waterhouse, 1968

Diagnosis: Small strongly plicate shells with moderately short hinge, costae over sulcus and fold, micro-ornament of commarginal growth increments and radial threads bearing papillae. Delthyrium without deltidium or cover plate, bearing low umbonal or pleromal callist that divides in two towards the hinge, no subdelthrial connector plate.

Type species: *Pustuloplica baccata* Waterhouse, 1968 from Early Permian of New Zealand, OD.

Discussion: The genus in overall appearance is brachythyrid because of its plicae.

Pustuloplica ovulata n. sp.

Fig. 10, 11

2021 *Pustuloplica* sp. Waterhouse & Campbell, p. 35, Fig. 10A-C.

Derivation: ovulata - oval, subrounded (Lat.).

Diagnosis: Small moderately inflated shells with two strong sulcal ribs and low median rib. Pustules rounded rather than elongate.

Holotype: BR 2477 from Eglinton Subgroup of the Dunton Range, figured by Waterhouse & Campbell (2021, Fig. 10A-C) and herein as Fig. 10A, B, OD.

Fig. 10. *Pustuloplica ovulata* n. sp. A, B, external mould and latex cast of ventral valve, BR 2477. Fine pustules visible in Fig. 10B, x1.5. Eglinton Subgroup, Dunton Range, New Zealand. (Waterhouse & Campbell 2021).

Morphology: The ventral valve has six pairs of narrow round-crested high plicae, the innermost pair bordering a narrow sulcus, which bears three costae commencing up to 2mm in front of the beak. The hinge is narrow, cardinal extremities obtuse, and delthyrium narrow. Micro-ornament consists of fine commarginal growth increments, and shows numerous tiny pustules, and fine radial capillae, ten to twelve in 1mm. A ventral internal mould BR 2478 with attenuated umbo shows narrow and elongate adductor impressions, and there are no internal plates.

Stratigraphy: The species is found in the Eglinton Volcanics in the Dunton Range of New Zealand, in a zone equivalent to the *Magniplicatina undata* Zone in Queensland.

Fig. . 11. *Pustuloplica ovulata* n. sp., internal mould of posterior ventral valve BR 2478. Space bar 5mm long. Eglinton Subgroup. (Waterhouse & Campbell 2021).

Fig. . 11. *Pustuloplica ovulata* n. sp., internal mould of posterior ventral valve BR 2478. Space bar 5mm long. Eglinton Volcanics Subgroup. (Waterhouse & Campbell 2021).

Pustuloplica baccata Waterhouse, 1968

Fig. 12, 13

1968 *Pustuloplica baccata* Waterhouse, p. 47, pl. 7, fig. 4-7, 9, 10, pl. 16, fig. 9, text-fig. 9B.
2016 *P. baccata* – Waterhouse, p. 107, Fig. 109, 111.

Diagnosis: Weakly transverse swollen shells with ornament of four or five strong plicae pairs, three costae in the sulcus, fold bearing four costae, the inner pair arising close to umbo, the outer stronger pair commencing near mid-length. Fine elongate pustules, four in 1mm at 12mm from the umbo on holotype.

Holotype: BR 683 from Brunel Formation, New Zealand, figured in Waterhouse (1968, pl. 7. Fig. 6, 9, 10 and herein as Fig. 12A-C, OD.

Stratigraphy: This species is found in the *Notostrophia zealandicus* Zone of the Brunel Formation in the Takitimu Group of New Zealand.

Fig. 12.. *Pustuloplica baccata* Waterhouse. A-C, ventral, dorsal and posterior views (ventral valve on top) of internal mould BR 683, holotype, x2. From Brunel Formation New Zealand. (Waterhouse 1968).

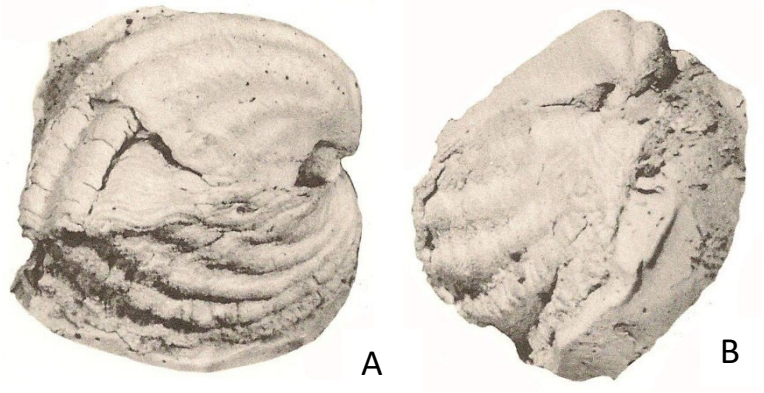


Fig. 13. *Pustuloplica baccata* Waterhouse, lateral and dorsal views of PVC cast, BR 680 x3. From Brunel Formation, New Zealand. (Waterhouse 1968).

Pustuloplica sp. A

Fig. 14

1968 *Pustuloplica* sp. Waterhouse, p. 49, pl. 8, fig. 2.

Two specimens are available from the middle Letham Formation, characterized by rounded outline and few plicae. Two costae lie in the anterior sulcus, and three plicae each side of the sulcus.

Fig. 14. *Pustuloplica* sp. A, BR 679 from middle Letham Formation, New Zealand, x2. (Waterhouse 1968).

Pustuloplica papillosa Waterhouse, 1987

Fig. 15

1987 *Pustuloplica papillosa* Waterhouse, p. 42, pl. 12, fig. 2-9, 30.
2016 *P. papillosa* – Waterhouse, p. 108, Fig. 110.

Diagnosis: Suboval shells with low plicae, no sulcal or fold costae, micro-ornament of low capillae, growth increments and very fine pustules.

Holotype: UQF 70215 from Brae Formation, southeast Bowen Basin, figured in Waterhouse (1987, pl. 12, fig. 2, 3) and Fig. 15A-C herein, OD.

Morphology: Material is well preserved as natural moulds.

Stratigraphy: The species is found only in the Brae Formation of Queensland.

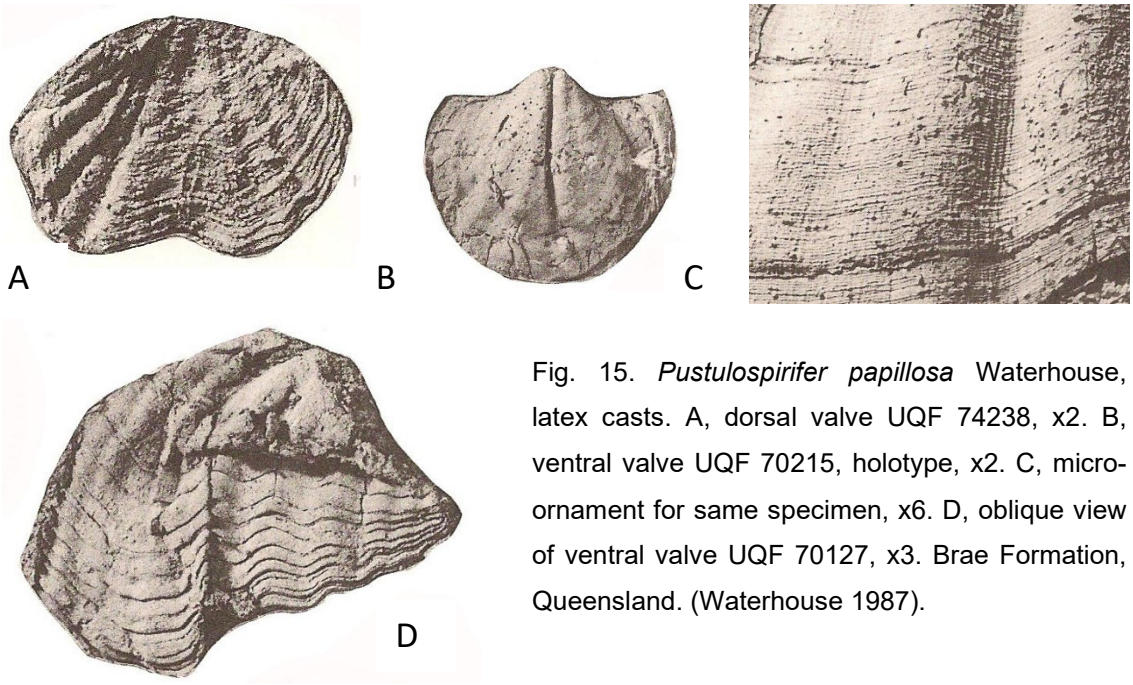


Fig. 15. *Pustulospirifer papillosa* Waterhouse, latex casts. A, dorsal valve UQF 74238, x2. B, ventral valve UQF 70215, holotype, x2. C, micro-ornament for same specimen, x6. D, oblique view of ventral valve UQF 70127, x3. Brae Formation, Queensland. (Waterhouse 1987).

Pustuloplica sp. B

Fig. 16

A specimen from the Ingelara Shale of the southwest Bowen Basin that was labelled *Cancellospirifer maxwelli* at the University of Queensland proved to be *Pustulospirifer* on sectioning, as demonstrated by the figure. The exterior of the shell was worn, but showed six pairs of plicae, unlike the material found in the Letham Formation of New Zealand or the Brae Formation of Queensland.

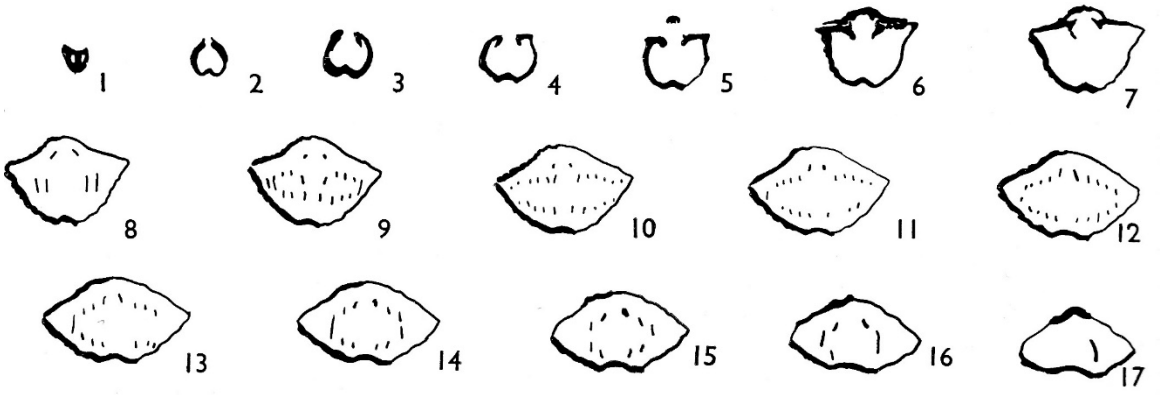


Fig. 15. *Pustuloplica* sp. B from lower Peawaddy Formation, southwest Bowen Basin, serial sections at intervals of 0.5mm, dorsal valve on top. Prepared from an unregistered University of Queensland specimen. (Waterhouse 1968).

Pustuloplica bicostata Waterhouse, 1968

Fig. 16

1968 *Pustuloplica bicostata* Waterhouse, p. 50, pl. 7, fig. 8, pl. 8, fig. 1, 3, 6-8.

Diagnosis: Sulcus has two strong costa and no median costa, pustules few and small.

Holotype: BR 701 from boulder derived from Nemo or Hilton Limestone of southern New Zealand. Figured in Waterhouse (1968, pl. 8, fig. 3, 6-8) and herein as Fig. 16C, D, OD.

Morphology: The species lacks the median costa of *Pustuloplica ovulata* and has a broad channelled fold, with other differences as outlined in Waterhouse (1968). But there are few speci-

imens, and these are not very well preserved.

Stratigraphy: The specimens come from a Tertiary boulder in the Takitimu Range, and contain the key fossil *Spinomartinia spinosa*, to indicate correlation with the nearby Nemo and Hilton limestones, and with the Trig D Formation further north.

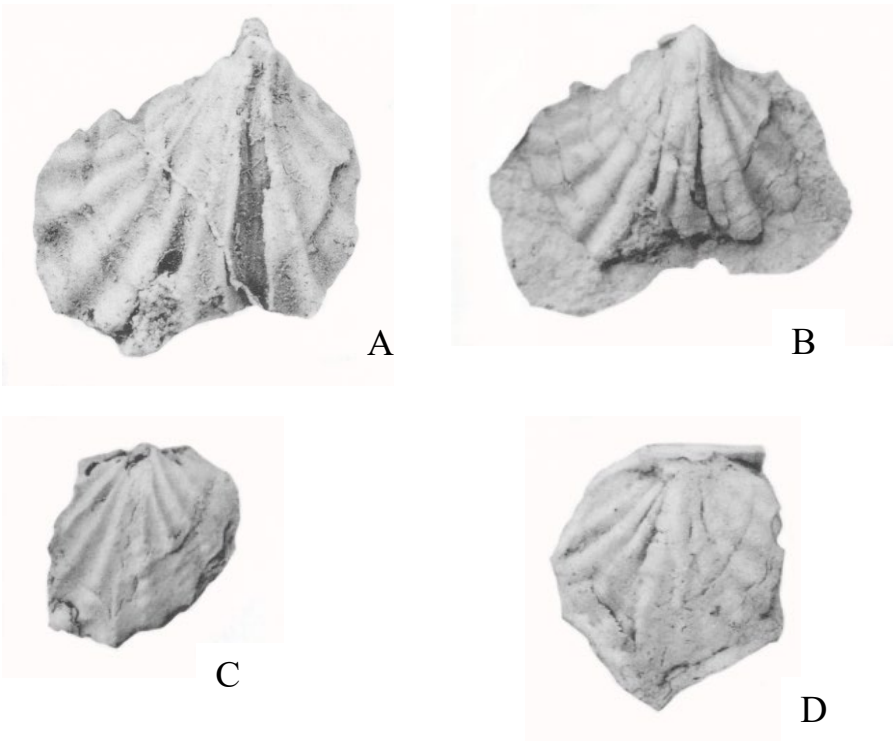


Fig. 16. *Pustuloplica bicostata* Waterhouse. A, ventral internal mould BR 702. B, latex cast of ventral valve BR 702. C, D, dorsal aspect of internal mould and latex cast of holotype, BR 701. Specimens x3, from Tertiary boulder derived from Nemo-Hilton limestones, Takitimu Range. (Waterhouse 1968).

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PERMIAN INGELARELLIDAE CAMPBELL (BRACHIOPODA) FROM EAST AUSTRALIA AND NEW ZEALAND

Abstract

A summary is presented for the known occurrences of ingelarellid genera and species throughout the Permian sediments of east Australia and New Zealand.

INTRODUCTION

Thanks to studies in Queensland by K. S. W. Campbell, beginning in 1959, followed by an extensive survey by McClung (1978) based on occurrences in New South Wales, Ingelarellidae have played a major role in the paleontological and correlation studies for the Permian of east Australia, and an initial and comprehensive proposal for subdivision of Permian faunas in east Australia was provided by Runnegar & McClung (1975) from analysis of the sequential occurrences of ingelarellid species. Their study was more accurate than some of the faunal divisions conjured by Briggs (1998) in relying on his interpretation of Productida, as well as the scheme proposed but never substantiated through systematic study by J. M. Dickins from various mainly bivalve-centred paleontological identifications, mostly unsustained by systematic description, in the geological reports by the Bureau of Mineral Resources, Geology & Geophysics on Queensland geology. Although incomplete with regards the younger Middle Permian and Late Permian, the Runnegar-McClung analysis remains of recognizable value. One of the advantages displayed by Ingelarellidae is that species were fewer, and arguably more widely dispersed than many species of Productida, and therefore more amenable to serving as principal indices for correlation, although different genera did occupy coeval sediments during some Middle Permian intervals. Ingelarellidae are more numerous than the closely costate spiriferids, but as a rule less common than members of Productida. For years after Campbell's initial study, all members in the group were referred to the one genus *Ingelarella,* but that is to deny the validity of *Ambikella* Sahni & Srivastava (1956) from the Himalayas of India. Within the array of species originally referred to *Ingelarella*, lineages may be perceived, involving the nature of the sulcus and fold, plication, overall shape, and form of the internal plates, and these lineages are provisionally

termed genera. Within such a framework, there stll remain ambiguities, as discussed in the text.

Family INGELARELLIDAE

Subfamily Ingelarellinae

Tribe Ingelarellini

Ingelarella – exterior with smooth or plicate shell, smooth or generally subplicate sulcus, surface grooves with wide interspaces, internal plates as in *Ambikella*, distinguished by channelled fold, and common presence of tigillum, which is a shell thickening of shell along the inner side of the sulcal crest in front of the adductor scars.

Ambikella – well-formed sulcus and fold, sulcal subplicae present or more commonly absent, no fold-channel, plicae present or absent, adminicula moderate to long, moderately closely spaced, tabellae moderate in length (0.3-0.25 of shell length), surface grooves with wide interspaces. No tigillum. Includes *ovata* Campbell and other Permian species, which in some specimens have surface grooves enclosed posteriorly by small C-shaped spinules, now assessed as an infrasubspecific variant.

Branxtonifera – subgenus with tabellae shorter than in *Ambikella*.

Fredericksia – small, biconvex with sulcus, fold poorly distinguished from lateral slopes except anteriorly, and low plicae. Internal plates well formed, but shorter than in many genera. Micro-ornament not certain.

Martiniopsis – shells without deep sulcus and high fold, no plicae. Surface grooves, interior with moderately long adminicula and tabellae, no tigillum.

Tigillumia – shells close to *Martiniopsis* and *Ambikella*, shallow narrow sulcus and round-crested fold, distinguished by long close-set subparallel adminicula and strong tigillum. Tabellae long.

Tweedaleia – adminicula and tabellae very low or not developed; sulcus and fold, no plicae.

Validifera – well-formed sulcus without subplicae, variable usually low plicae, round-crested fold. Characterized by well-spaced and divergent adminicula. Tabellae subparallel, moderately long.

Tribe Johndeariini

Johndearia – large usually non-plicate shells. May display short to strong subplicae in broad sulcus, fold round-crested or usually channelled, adminicula and tabellae of moderate length and widely spaced. No tigillum. Heavy posterior thickening in the ventral valve.

Oviformia – plicae strong to low, sulcus with anterior median swelling or fold, fold crest rounded or usually channelled, sulcate as a rule. Adminicula and tabellae moderately long. No tigillum.

Tumulosulcus – fold crest rounded as a rule, sulcus with median swelling. plicae weak or absent, very close to *Oviformia*.

Subfamily Geothomasiinae

Geothomasia – shells with well-formed sulcus and fold, smooth or plicate, subparallel closely spaced or moderately long and well-spaced adminicula and widely diverging short tabellae.

Danzania – plicate and close to *Tomiopsis*, without strong dorsal myophragm and dorsal adductor ridges. Short divergent tabellae.

Tomiopsis – low numerous plicae, subplicae within sulcus, channelled fold, moderately long adminicula, short widely diverging tabellae, myophragm, no tigillum as a rule. Deep and crowded long surface grooves and narrow interspaces.

Table 1. Genera of Ingelarellidae.

SYSTEMATIC STUDIES

Suborder **MARTINIIDINA** Waterhouse, 2010

Hyporder **MARTINIIDEI** Waterhouse, 2010

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Subfamily **INGELARELLINAE** Campbell, 1959

Tribe **INGELARELLINI** Cambell, 1959

Diagnosis: Medium to large shells, as a rule with sulcus and fold, may be smooth or plicate. Micro-ornament of fine short surface grooves, which rarely and not even in all specimens within a population may have tiny c-shaped species at posterior end, and there is so far no definite evidence that any one type of micro-ornament was restricted to one genus. As a rule, internal plates consist of dental plates and adminicula in ventral valve, and tabellae and socket plates in the dorsal valve, with tabellae as a rule placed next to the fold within the first pair of plical interspaces. In the Early Permian genus *Tweedaleia,* adminicula are so short that they are buried in posterior shell thickening, and tabellae are low and not always discernible. Early Carboniferous to Late Permian.

An overview of Ingelarellini in east Australia that shows the time ranges for species and illustrates the nature of genera is presented by Waterhouse & Shi (2010, Fig. 6, p. 24). Genera of Ingelarellidae are recorded in the Table on p. 30.

Genus ***Ingelarella*** Campbell, 1959

Diagnosis: Smooth to plicate shells, with two sulcal subplicae as a rule and median channel along fold.

Type species: *Ingelarella angulata* Campbell, 1959 from sandstone in the Ingelara Formation, southwest Bowen Basin, Queensland, OD.

Discussion: The median fold channel is of variable definition in some species (notably *Ingelarella plica* and *I. plana*), but Campbell (1960) stressed that the fold was channelled in these species.

Ingelarella intrudus Waterhouse, 2021b

Fig. 1, 2

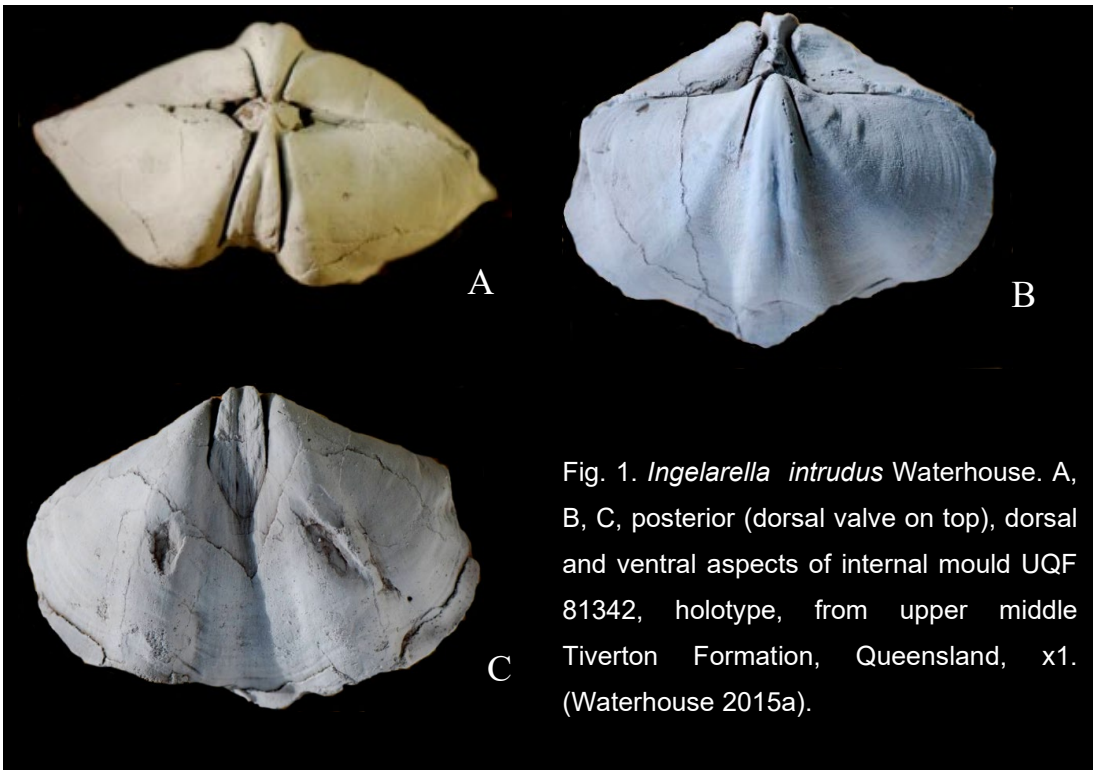


Fig. 1. *Ingelarella intrudus* Waterhouse. A, B, C, posterior (dorsal valve on top), dorsal and ventral aspects of internal mould UQF 81342, holotype, from upper middle Tiverton Formation, Queensland, x1. (Waterhouse 2015a).

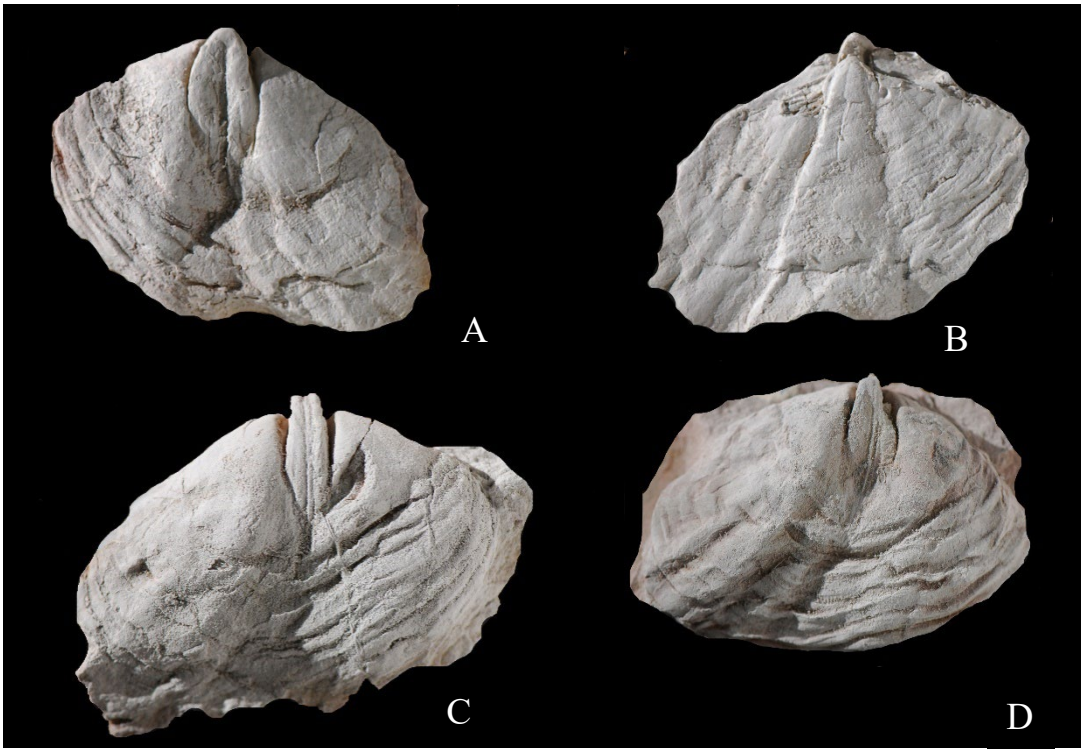


Fig. 2. *Ingelarella intrudus* Waterhouse. A, B, ventral and dorsal aspects of internal mould UQF 13511, x1. C, ventral internal mould UQF 13505, x1. D, ventral internal mould UQF 13509, x1. From Lakes Creek Formation, Queensland. (Waterhouse 2021b).

2011 *Ingelarella* sp. Waterhouse, Fig. 2J.
2015a *Ingelarella* sp. Waterhouse, p. 153, Fig. 102A-C.
2016 *Ingelarella* sp. Waterhouse, Fig. 68.
2021b *I. intrudus* Waterhouse, p. 122, Fig. 14, 15.

Diagnosis: Moderately large with sulcal subplicae and channelled fold as a rule, low, faint or no lateral plicae, adminicula moderately close-set and a quarter to a third of the length of the shell, tabellae weakly diverging, extending for a quarter to a third of the length of the valve.

Holotype: UQF 81342 from *Capillaria armstrongi* band in upper middle Tiverton Formation, figured by Waterhouse (2011, Fig. 2J; 2015a, Fig. 102A-C), and herein as Fig. 1A-C, OD.

Morphology: This appears to be the first species to consistently develop a channel along the crest of the dorsal fold.

Stratigraphy: The species is found in the top of the *Magniplicatina undulata* Zone and in the start of the overlying *Taeniothaerus subquadratus* Zone in the Tiverton Formation of the north Bowen Basin, and in the latter zone in the Lakes Creek Formation of the New England Orogen in Queensland.

Ingelarella sulcata Waterhouse, 1964

Fig. 3

1964 *Ingelarella sulcata* Waterhouse, p. 153, pl. 30, fig. 10, 12-14, pl. 31, fig. 1-3, text-fig. 74A-C.
1964 *I. ovata* [not Campbell] – Waterhouse, p. 152, pl. 30, fig. 6, 7, 9, 11, text-fig. 73.

Diagnosis: Shells close to those of *Ingelarella plana* and *plica*, ventral valve smooth, dorsal valve plicate, the fold bears a deeper channel compared with that of *Ingelarella plana*, and the tabellae are longer.

Holotype: BR 658 figured by Waterhouse (1964, pl. 30, fig. 10, 13, 14, text-fig. 74A) and Fig. 3A, B herein, from Brunel Formation, New Zealand, OD.

Morphology: The ventral valve is smooth or shows very subdued plicae, and the dorsal valve is plicate as judged from the relatively few specimens that are available.

Stratigraphy: The species is only known from the Brunel Formation in the Takitimu Mountains of New Zealand.

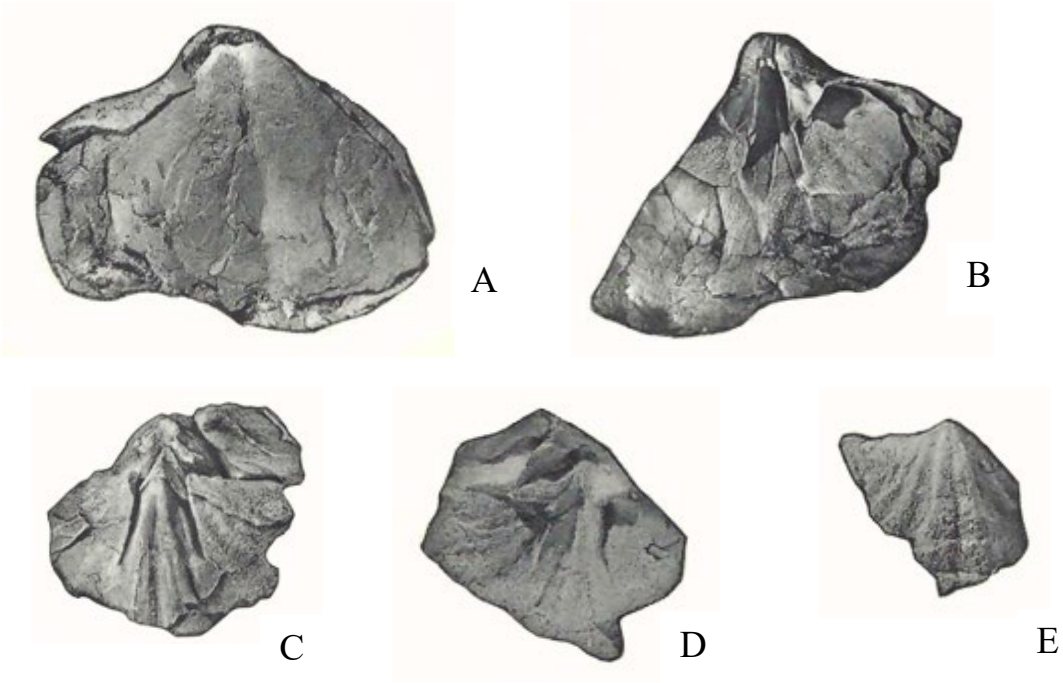


Fig. 3. *Ingelarella sulcata* Waterhouse. A, B, external and internal PVC cast of holotype, BR 658, x1. C, D, dorsal internal mould and cast, BR 660, x1. E, dorsal external cast BR 661, x1. Brunel Formation, New Zealand. (Waterhouse 1964).

Ingelarella plica Campbell, 1960

Fig. 4, 5

1960 *Ingelarella plica* Campbell, p. 1114, pl. 136, fig. 8-13.
1968 *Ambikella plica* – Waterhouse, p. 58, pl. 10, fig. 1-6, 8.
1983 *Tomiopsis plica* – Waterhouse, p. 160, pl. 2, fig. 10, pl. 3, fig. 1-4.
2008 *I. plica* – Waterhouse, p. 359, Fig. 6C.

Diagnosis: Small to moderate in size, both valves strongly plicate, adminicula strong, tabellae well-developed, of moderate length.

Holotype: UQF 25725 figured by Campbell (1960, pl. 136, fig. 12) from upper Cattle Creek Formation, southwest Bowen Basin, OD.

Morphology: Compared with *Ingelarella plana*, this species is typified by plicate shell. Despite the appearance of a round-crested fold for some dorsal valves, Campbell (1960, p. 1114) stated that the median fold carried " a well developed median depression".

Stratigraphy: The species was described from the upper Cattle Creek Formation in the southwest Bowen Basin, of Aktastinian (lower Artinskian) age, and also comes from the *Notostrophia zealandicus* and *N. homeri* Zones in the Brunel Formation of south New

Zealand.

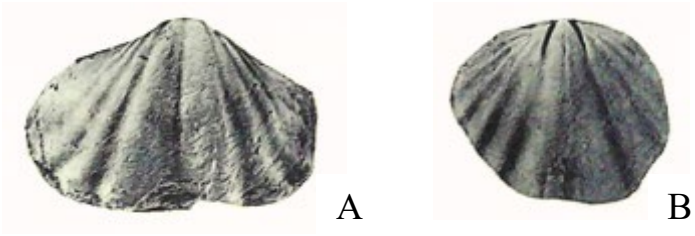


Fig. 4. *Ingelarella plica* Campbell. A, ventral exterior, UNEF 4747. B, small dorsal valve UQF 25726. Specimens x1 from Cattle Creek Shale, southwest Bowen Basin. (Campbell 1960).

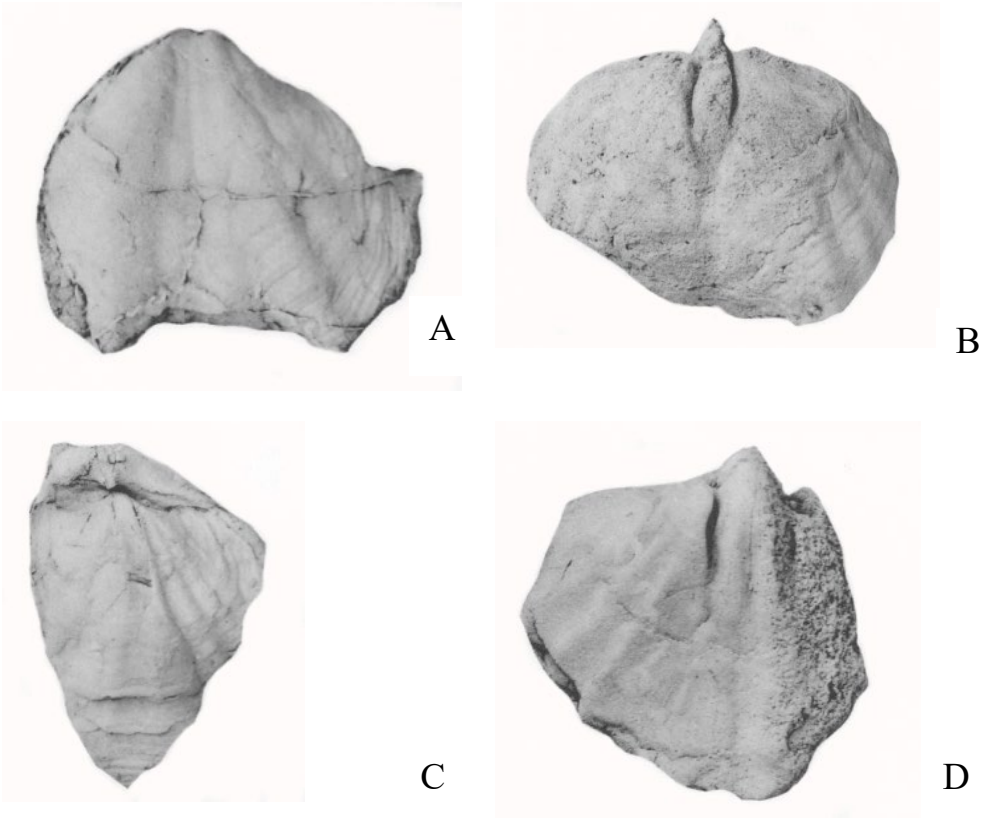


Fig. 5. *Ingelarella plica* Campbell. A, ventral exterior BR 632, PVC cast. B, ventral aspect of internal mould, BR 1338. C, dorsal aspect of latex cast, BR 1336. D, dorsal internal mould, BR 1337. A from *Notostrophia zealandicus* Zone, others from *N. homeri* Zone, Brunel Formation, New Zealand. Specimens x2. (Waterhouse 1968).

Ingelarella plana Campbell, 1960

Fig. 6

1960 *Ingelarella plana* Campbell, p. 112, pl. 136, fig. 1-7.
1978 *I. plana* – McClung, p. 38.

1983 *I. plana* – Waterhouse, p. 159, pl. 2, fig. 10, pl. 3, fig. 1-4.
1991 *I.* cf. *plana* – Begg & Ballard, p. 149, Fig. 8.

Diagnosis: Ventral valve sulcate, usually without plicae, dorsal fold with subrounded crest or more often shallow dorsal channel, valve may be weakly plicate. Adminicula short and well-spaced, tabellae well-spaced.

Holotype: UQF 15686 figured by Campbell (1960, pl. 136, fig. 6a-c) and herein as Fig. 6A, B from Cattle Creek Formation, southwest Bowen Basin, OD.

Morphology: Although the illustration (Fig. 4B, D) for *Ingelarella plana* indicates a fold with round crest, Campbell (1960) described a shallow depression in the dorsal fold. Otherwise the species would have to be classed as a member of *Ambikella* Sahni & Srivastava.

Stratigraphy: The species is found at the same level as *Ingelarella plica* Campbell, described below from the upper Cattle Creek Formation, and has been recorded from the upper Tiverton Formation in the north Bowen Basin, and in the Eglinton Subgroup of the Skippers Range in New Zealand.

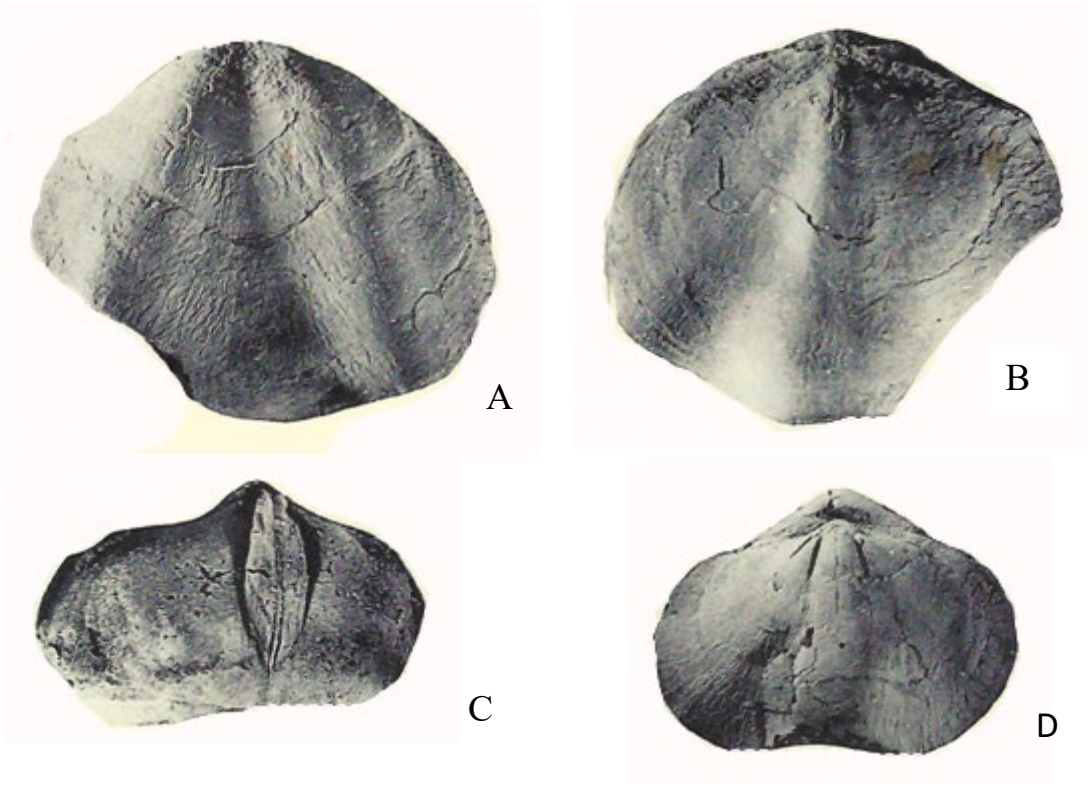


Fig. 4. *Ingelarella plana* Campbell. A, B, ventral and dorsal views of holotype, UQF 15686. C, ventral internal mould UQF 21971. D, dorsal view of internal mould, UNEF 4750. Specimens x1 from Cattle Creek Shale, southwest Bowen Basin. (Campbell 1960).

Ingelarella sp. A

Fig. 7, ?8F

aff. 1984 *Notospirifer* aff. *macropustulosus* [not Waterhouse] – H. J. Campbell et al. Fig. 6.6.
2020 Ingelarelloidea gen. & sp. indet. Shi et al., p. 416, Fig. 3D-G.

A somewhat elongate specimen was described in Shi et al. (2020, Fig. 3D-G) from the Pebbley Beach Formation in the south Sydney Basin. It is close to *Ingelarella subplicata* (see below) from the upper Letham Formation of New Zealand, but has a narrower and less upstanding dorsal fold. The narrow sulcus approaches that seen in a New Zealand specimen figured in Campbell et al. (1984) from Stephens Formation at Stephens Island (See Fig. 8F). The accompanying fauna approaches that of the upper Letham Formation in Southland, New Zealand (Waterhouse 2021).

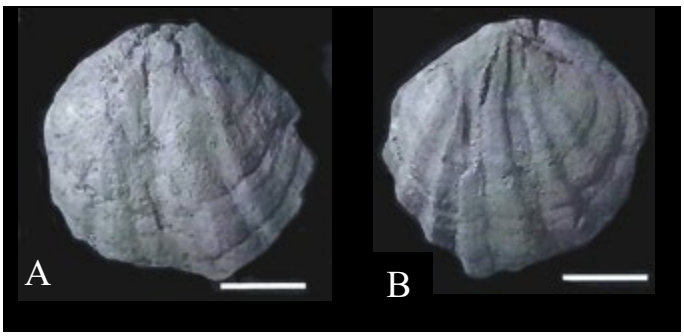


Fig. 7. *Ingelarella* sp. A. A, B, ventral and dorsal views of conjoined specimen AMF 146276 from Pebbley Beach Formation, south Sydney Basin, space bar 10m long. (Shi et al., 2020).

Ingelarella subplicata (Waterhouse, 1968)

Fig. 8A-E

1968 *Ambikella dissimilis subplicata* Waterhouse, p. 69, pl. 12, fig. 7, 9, 10, pl. 13, fig. 1, 2, 4, 7, text-fig. 2A.
cf. 1978 *Ingelarella* cf. *costata* [not Waterhouse] – McClung, p. 54, pl. 14, fig. 4-13.
1998 *I. subplicata* – Waterhouse, pp. 14-16.
2001 *I. subplicata* – Waterhouse, p. 101, pl. 7, fig. 12-17.
2016 *Tigillumia parallela* [not Waterhouse] – Waterhouse, Fig. 76A (part not B, C = *parallela*).
2023 *Ingelarella* sp. A – Lee in Lee et al., p. 16, Fig. 7A-N, 8, 9A-D.

Diagnosis: Medium-sized transverse shells with sulcus often bearing two subplicae, broad fold, as a rule with median channel, plicae number three to five subdued pairs. Adminicula subparallel and close-set, of moderate length, tabellae of moderate length and weakly

diverging, lying next to fold.

Holotype: BR 1537 figured in Waterhouse (1968, pl. 13, fig. 1, 2, 4) and Fig. 8A, B herein from upper Letham Formation, Wairaki Downs, New Zealand, OD.

Stratigraphy: The species is found chiefly in the *Echinalosia discinia* Zone in the upper Letham Formation of New Zealand. There is some approach shown by Sydney Basin specimens figured as *Ingelarella costata* [not Waterhouse] by McClung (1978, pl. 14, fig. 4-13) from the Fenestella Shale, with stronger plicae numbering two or three pairs, and deeper wider sulcus and higher fold, so that identity is close though not complete (Waterhouse 1998, p. 14). Lee in Lee et al (2023) has described similar material as *Ingelarella* sp. A from the Snapper Point Formation of the south Sydney Basin. Shells referred to *I. oviformis* (M'Coy) by McClung (1978, pl. 14, fig. 15, 16) are more strongly plicate than shells of the present species, and the posterior shell thickened. They come from the Belford Formation above the Fenestella Shale in the north Sydney Basin, as a probable descendent from *Ingelarella angulata* four pairs of plicae and wide fold channel and no visible sulcal subplicae. Adminicula and tabellae are comparable.

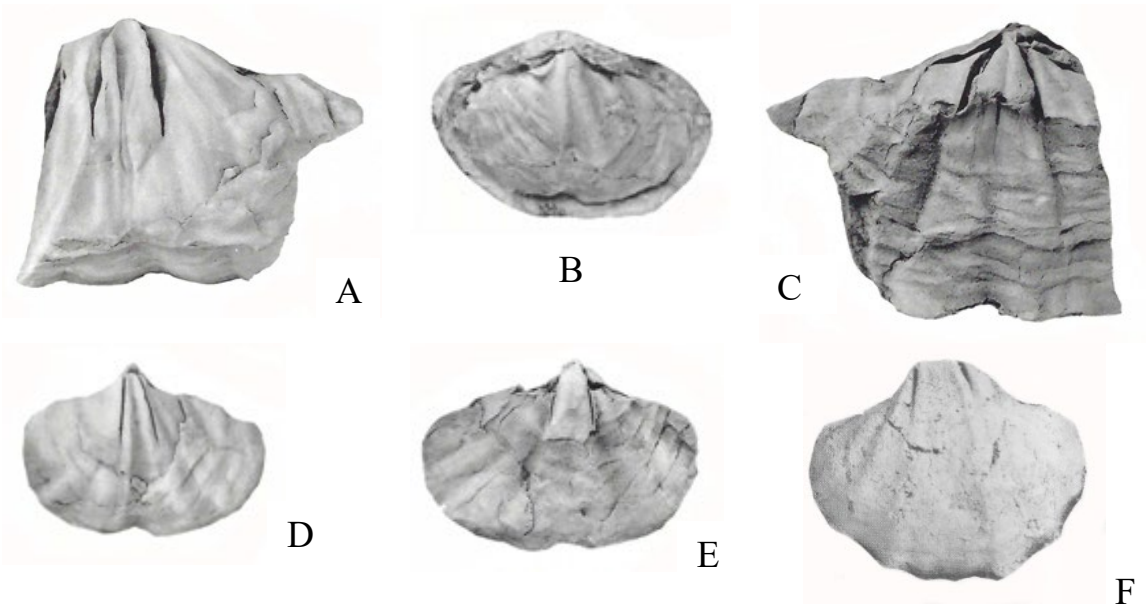


Fig. 8. *Ingelarella subplicata* (Waterhouse). A, B, ventral and dorsal aspects of internal mould, holotype BR 1357. C, E, ventral and dorsal aspects of internal mould BR 1352. D, external latex cast of same specimen. Specimens x1.5 from upper Letham Formation, Wairaki Downs, New Zealand. (Waterhouse 1968). F, possible *Ingelarella* sp A from Stephens Island boulder, BR 1636, x1.5. (Campbell et al. 1984).

are close. Unlike *oviformis*, the sulcus in the Belford specimen is not tumulate. The specimen shown by McClung (1978, pl. 14, fig. 14) as ?*Ingelarella oviformis* from the Fenestella Shale may prove to be an early example of a tumulate form.

Ingelarella angulata Campbell, 1959

Fig. 9

1930 ?*Martiniopsis subradiata* [not Morris] – Whitehouse, p. 157.
1953 "*Martiniopsis*" sp. a Campbell, p. 10, pl. 4, fig. 1-3, pl. 5, fig. 1-3.
1953 "*Martiniopsis*" sp. b Campbell, p. 10, pl. 4, fig. 4-9, pl. 5, fig. 4-6.
1959 *Ingelarella angulata* Campbell, p. 345, pl. 56, fig. 4a-c, pl. 57, fig. 1-5.
1960 *I. ingelarensis* Campbell, p. 115, pl. 135, fig. 1-3, pl. 138, fig. 4.
1961 *I. ingelarensis* – Campbell, p. 185.
1964 *I. angulata* – Hill & Woods, p. 18, pl. P9, fig. 13, 14.
1972 *I. angulata* – Hill et al., p. 18, pl. P9, fig. 13, 14.
1975 *Martiniopsis ingelarensis* – Runnegar & McClung, pl. 31.1, fig. 12, 13.
1978 *I. angulata* – McClung, p. 55, pl. 1, fig. 4, 6-9, 13-16, 18-23, 25, pl. 2, fig. 16, 17.
cf 1978 *I.* cf. *angulata* – McClung, p. 56, pl. 15, fig. 7-14.
1978 *I. ingelarensis* – McClung, p. 51, pl. 1, fig. 1-3, 5, 12, 17, 24, 26-28, ?10, pl. 2, fig. 16-17.
1983 *I. angulata* – McClung, p. 63, Fig. 7.1.
2006 *I. angulata* - Carter, p. 1758, Fig. 1157.3a-e.

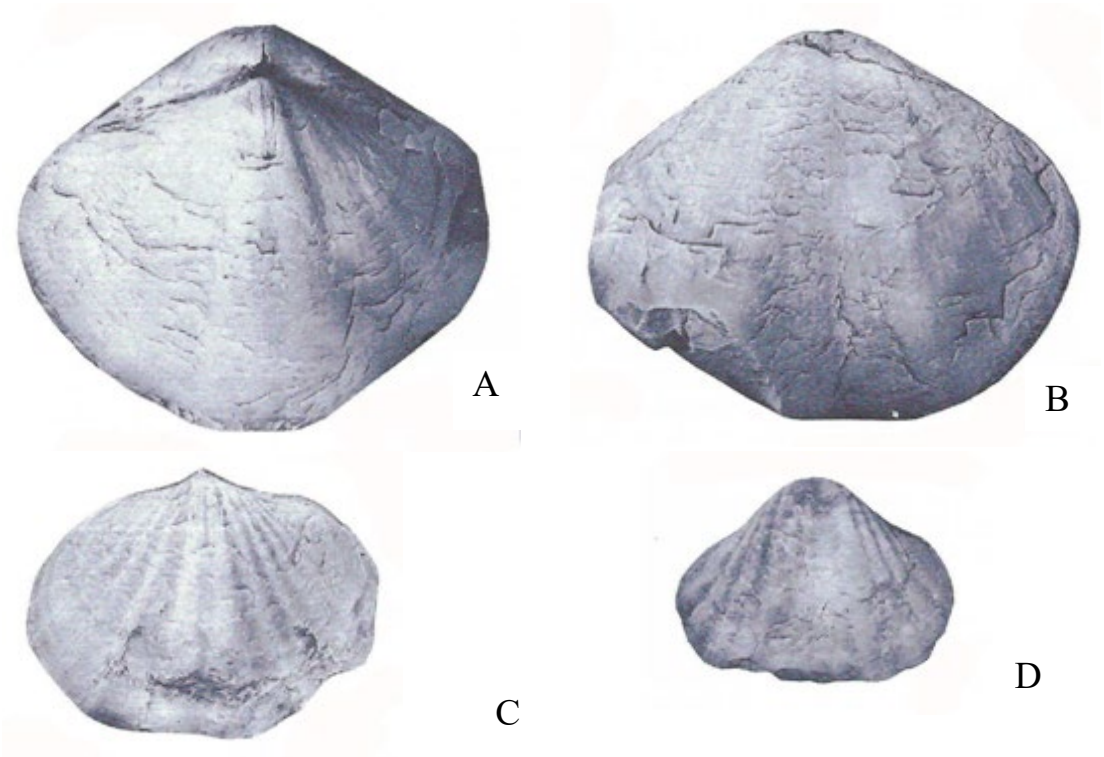


Fig. 9. *Ingelarella angulata* Campbell. A, B, dorsal and ventral aspects of specimen originally referred to *ingelarensis*, GSQ 12125. C, dorsal aspect of GSQ 12116. D, ventral valve GSQ 12127, both C and D originally assigned to *angulata*. Specimens from Ingelara Formation, reproduced at size shown in McClung (1978, p. 26), who stated "äll figures x17", which seems to indicate a decimal point has been lost.

Diagnosis: Transverse with well-defined sulcus, often with subplicae, fold moderately well defined, broadening anteriorly, channelled, adminicula subparallel, up to a third of the valve in length, tabellae diverge more widely each side of the fold, up to a third of the dorsal valve in length. Plicae either absent or faint, as in *ingelarensis*, and better defined in *angulate*, so that the species is bimorphous.

Holotype: For *angulata*, UQF 14295 figured by Campbell (1953, fig. 9, pl. 5, fig. 1-3; 1959, pl. 135, fig. 1a-c) from Dry Creek, Ingelara Station, southwest Bowen Basin, Queensland, OD. For *ingelarensis*, UQF 14170 figured by Campbell (1960, p. 1115, pl. 135, fig. 1a-c) from same locality.

Morphology: Many photographs provided by McClung (1978) strongly suggest that *ingelarensis* is a synonym of *angulata*, as concluded by McClung (1978, p. 27). These typify two distinct morphotypes within what appears to be a single bimorphous taxon. Often the *ingelarensis* specimens are larger than shells assigned to *angulata*.

Stratigraphy: McClung (1978, p. 56, pl. 15, fig. 7-14, 18-23, 25) compared material from the Muree Formation of the north Sydney Basin to Campbell's species, but allowed that the specimens were more elongate, and the plicae lower and adminicula slightly shorter, suggesting subsequent evolution from that species and implying that the two suites could be taxonomically separated. The sulcus is wider and the fold is slightly more raised and narrower. Perhap distinction at the level of subspecies would be preferable, but any distinction, though real, is subtle. He also figured as *oviformis* two strongly plicate specimens from the Fenestella Shale with wide fold channel and non-tumulate sulcus that somewhat resemble *angulata* (UNEF 12207, 14359), as discussed on p. 38..

Armstrong (1970a, pl. 15, fig. 9) illustrated from a dorsal aspect a complete specimen that he claimed belonged to *Ingelarella angulata* from the Fenestella beds of the Sydney Basin. The specimen has short tabellae and a narrow round-crested fold, and some five or six pairs of strong plicae. It does not look close to *angulata*. McClung (1978) did not refer to the form in his synonymy for *angulata*, but offered no alternative identification.

Ingelarella globosa Campbell, 1961

Fig. 10

1961 *Ingelarella globosa* Campbell, p. 184, pl. 26, fig. 1-3, text-fig. 12.
1988 *Tomiopsis globosa* – Parfrey, p. 18, pl. 4, fig. 12, 13, 16, 22.

Diagnosis: Shells close to *Ingelarella angulata* in detail, but more inflated, strong plicae and sulcal subplicae, deep furrow along the fold.

Holotype: UQF 21943, figured by Campbell (1961, pl. 26, fig. 2a-c) and Fig. 10C herein from Orange Creek (= Barfield) Formation, southeast Bowen Basin, Queensland, OD.

Stratigraphy: This taxon is limited to what Campbell (1961) termed the Orange Creek Formation, which is discussed in Derrington et al. (1959) and Derrington & Morgan (1960, p. 205) and appears to be a duplicate name for the Barfield Formation.

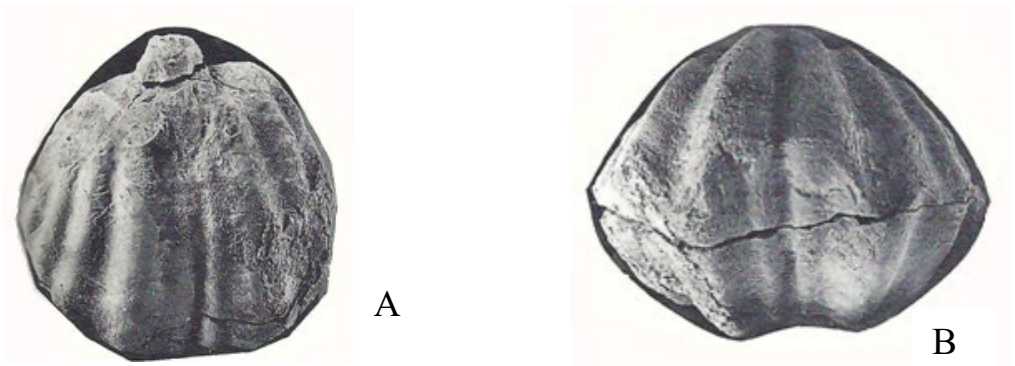


Fig. 10. *Ingelarella globosa* Campbell. A, B, ventral and anterior aspects of internal mould with valves conjoined, UQF 21928, x0.8, x1. C, dorsal valve of holotype, UQF 21943, x1 from Barfield Formation (Campbell 1961).

Ingelarella canalis Waterhouse, 2022a

Fig. 11

1983 *Ingelarella* cf. *mantuanensis* [not Campbell] – McClung, p. 64, Fig. 8.1-8 (part, not Fig. 7.2 = *I. mantuanensis*).
1987 *Tomiopsis ingelarensis* [not Campbell] – Waterhouse, p. 31, pl. 8, fig. 14, 16, 18; pl. 9, fig. 1-3.
1988 *T. angulata* [not Campbell] – Parfrey, p. 17, pl. 4, fig. 9, 10, 14, 15, 17, 20.
1988 *T. ingelarensis* [not Campbell] – Parfrey, p. 18, pl. 4, fig. 18, 19, 21, 23.
2022a *Ingelarella canalis* Waterhouse, p. 39, Fig. 3, 4.

Diagnosis: Of medium size, ventral plicae low and may be absent, dorsal valve weakly plicate, ventral sulcus characterized as a rule by persistent median groove, dorsal fold

rounded in profile posteriorly, with broad anterior median depression as a rule. Adminicula apparently variable in length, placed close to each other or well-spaced, tabellae well-developed as a rule, long in shells at late maturity.

Holotype: UQF 15683 figured by Waterhouse (1987, pl. 8, fig. 14, 16) from Barfield Formation, southeast Bowen Basin, OD.

Morphology: *Ingelarella canalis* is close to *Ingelarella ingelarensis* Campbell (now = *angulata*), and distinguished by the development of a distinct median groove along the centre of the ventral sulcus. Nor is the groove is developed in shells assigned to *I. angulata*.

Stratigraphy: This species is found in the Barfield Formation of the southeast Bowen Basin and Catherine Sandstone of the southwest Bowen Basin.

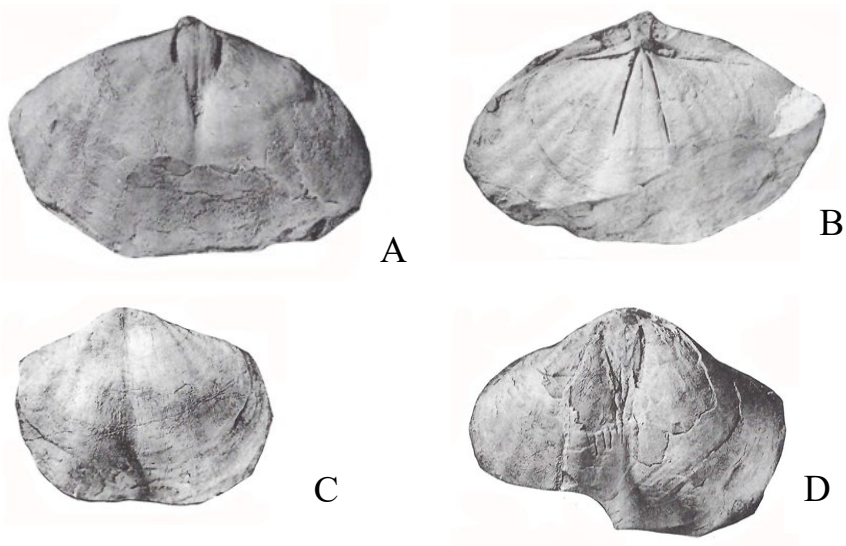


Fig. 11. *Ingelarella canalis* Waterhouse. A, B, ventral and dorsal aspects of specimen with valves conjoined, UQF 74220. C, ventral valve UQF 15667. D, ventral aspect UQF 70002. Specimens x0.5 from Barfield Formation, southeast Bowen Basin. (Waterhouse 1987).

Ingelarella dissimilis Waterhouse, 1964

Fig. 12

1964 *Ingelarella dissimilis* Waterhouse, p. 162, pl. 32, fig. 4-8, 10, 11.
1987 *I. dissimilis* – Waterhouse, p. 36, pl. 10, fig. 5-9, 11-13, pl. 11, fig. 1.
1998 *Tomiopsis* (*Johndearia*) *dissimilis* – Waterhouse, p. 19.
2002 *I. dissimilis* – Waterhouse, Tables 10, 11, p. 51.

Diagnosis: Medium-large transverse shells with typically broad sulcus, fold broad anteriorly,

bearing wide shallow channel, plicae regularly present in two to four pairs, stronger on dorsal valve. Adminicula and tabellae well developed, moderately spaced.

Holotype: BR 836 figured by Waterhouse (1964, pl. 32, fig. 4, 5, 7, 8) and Fig. 12A-C herein from middle Mangarewa Formation, below *Maxwellosia ovalis* Superzone and above Letham Burn Member and the following *Pseudostrophalosia blakei* Zone at the base of the Mangarewa Formation.

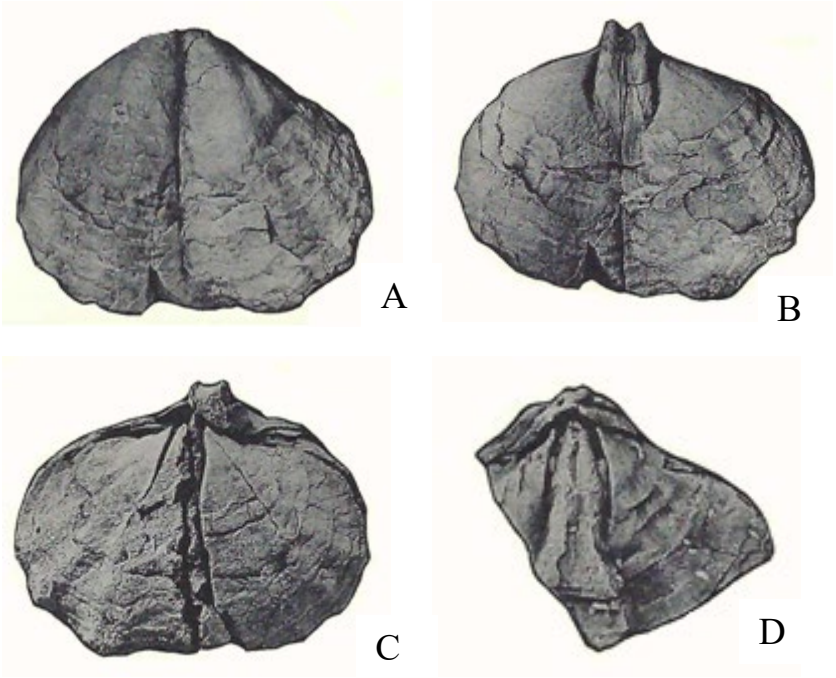


Fig. 12. *Ingelarella dissimilis* Waterhouse. A, ventral exterior. B, C, ventral and dorsal aspects of internal mould after leaching in dilute HCl of BR 836, holotype, x1. D, dorsal aspect of internal mould BR 835, x1.5. Specimens from lower middle Mangarewa Formation, New Zealand. (Waterhouse 1964).

Morphology: This species would appear to be a close ally of *Ingelarella mantuanensis* Campbell as summarized below, distinguished by the more regular development of plicae, and the consistently broad anterior fold and other features. Its acme occurred at Mangarewa level 3 in New Zealand and the apparently correlative basal Flat Top Formation in the southeast Bowen Basin of Queensland, but appears to have persisted beyond its acme in a minor role. *I. singletonensis* McClung from the Mulbring Formation in the north Sydney Basin would appear to be a derivative, but has narrower usually more distinct fold and sulcus.

Stratigraphy: This species was originally described from the lower Mangarewa Formation above the *Pseudostrophalosia blakei* fauna, and it is also common in correlative beds of the basal Flat Top Formation with *Acanthalosia blakei*. The species persisted into younger beds in Queensland.

Ingelarella mantuanensis Campbell, 1960

Fig. 13, 14

1960 *Ingelarella mantuanensis* Campbell, p. 1118, pl. 137, fig. 1-3, pl. 138, fig. 1-3.
1961 *I. mantuanensis* – Campbell, p. 185, pl. 24, fig. 1, 2.
1964 *I. mantuanensis* – Waterhouse, p. 158, pl. 31, fig. 7, 8, pl. 35, fig. 5.
1964 *I. mantuanensis* – Hill & Woods, p. 16, pl. P8, fig. 9-11.
1968 *Ambikella mantuanensis* – Waterhouse, p. 63, pl. 11, fig. 1-8, pl. 12, fig. 1, pl. 17, fig. 5, pl. 18, fig. 3.
1972 *I. mantuanensis* – Hill, Playford & Woods, p. 16, pl. P8, fig. 9-11.
1975 *Martiniopsis mantuanensis* – Runnegar & McClung, pl. 31, fig. 1, 14-16.
1978 *Ambikella mantuanensis* – Suggate et al., Fig. 4.6, fig. 2, 4, 5.
1978 *I. mantuanensis* – McClung, p. 53, pl. 2, fig. 18, 19, pl. 13, fig. 11, 12.
1983 *I. mantuanensis* – Waterhouse & Jell, p. 245, pl. 2, fig. 8.
?1983 *I.* cf. *mantuanensis* – McClung, p. 64, Fig. 7.2 (part, not Fig. 8 = *I. canalis*).
1987 *I. mantuanensis* – Waterhouse, p. 34, pl. 9, fig. 11, 13, pl. 10, fig. 1-4.
2002 *I. mantuanensis* – Waterhouse, Table 11, p. 51, Table 12, p. 52, Table 18, p. 57.

Diagnosis: Large usually transverse shells, normally with plicae, rarely may be smooth, sulcus often subplicate, fold as a rule with median channel, adminicula moderately long and weakly divergent, tabellae also well developed and diverge, lying each side of the fold.

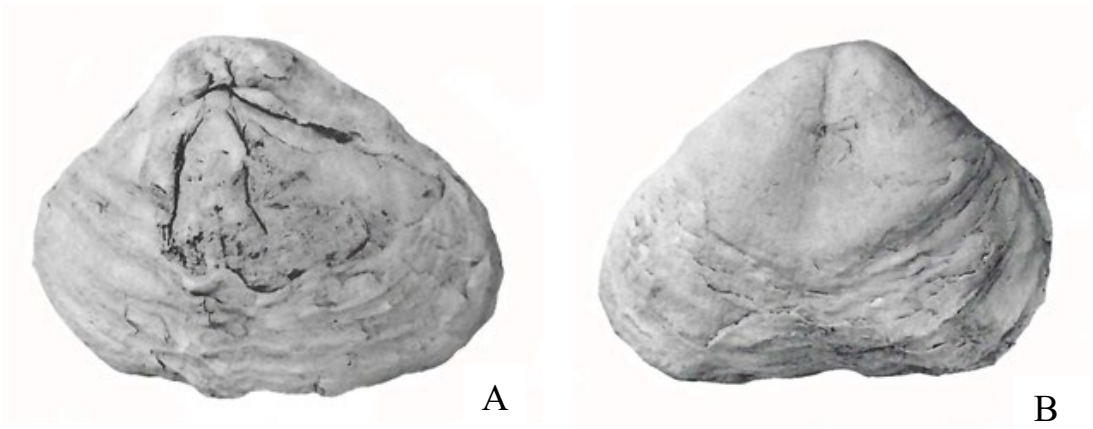


Fig. 13. *Ingelarella mantuanensis* Campbell. A, B, dorsal and ventral aspects of BR 923 x0.8 from Mangarewa Formation, New Zealand. (Waterhouse 1968).

Holotype: UQF 15659 figured by Campbell (1960, pl. 138, fig. 1a-c) and Fig. 13A, B herein from Mantuan Formation of southwest Bowen Basin, OD.

Morphology: The species is represented by a range of material, and specimens vary in the strength of plication, as shown in the original figures provided by Campbell (1960). The length of the adminicula and tabellae imply that the species could be treated as an ally of *Tigillumia* Waterhouse, but most specimens differ from that genus in their plication and length and spacing of the adminicula and tabellae, leaving a question over the identity of some specimens presently assigned to *mantuanensis*.

Stratigraphy: The species is found primarily in the Mantuan Member of the Peawaddy Formation, Scottville Member and Flat Top Formation of the southwest, north and southeast Bowen Basin respectively, with the Muree Formation of the north Sydney Basin. It has been reported from the Nowra Sandstone and Berry Formation of the south Sydney Basin by McClung (1978, p. 54) as well as upper middle Mangarewa Formation of New Zealand (Waterhouse 1964, 1968). The species has been listed from Tasmania by Clarke & Banks (1975), with no supporting figures or description, and the species was not described by Clarke (1987) in his study of Malbina Formation species.

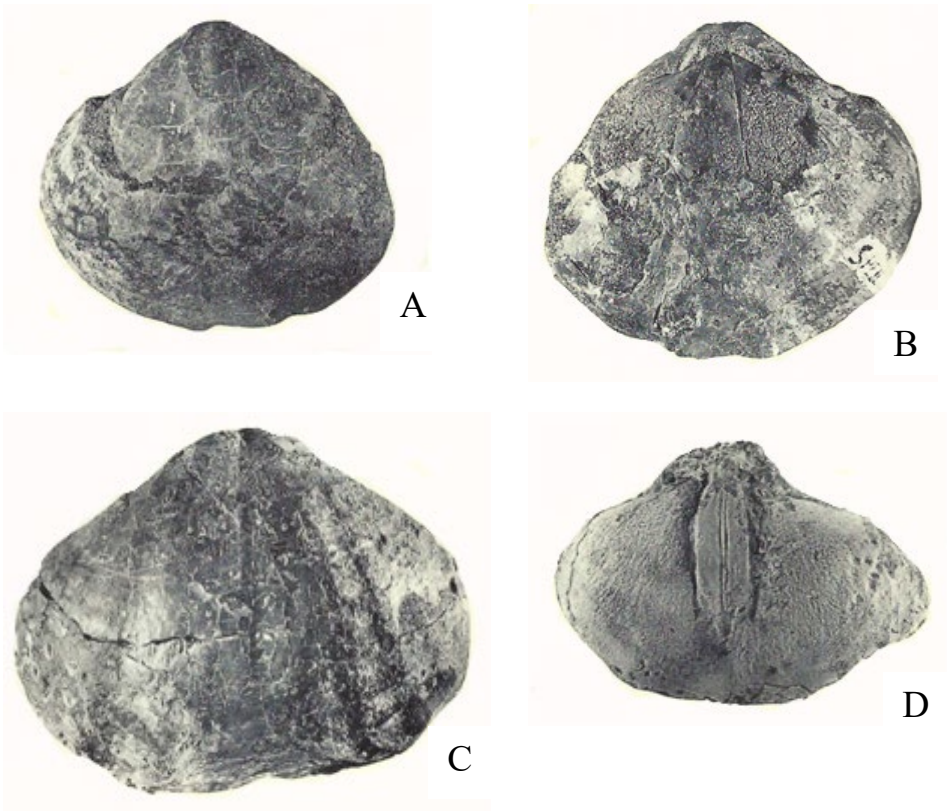


Fig. 14. *Ingelarella mantuanensis* Campbell. A, B, ventral and dorsal aspects of holotype, UQF 15659. C, ventral valve UQF 15661. D, ventral interior, UQF 25683. Specimens x0.66, from Mantuan Member, southwest Bowen Basin. (Campbell 1960).

Ingelarella singletonensis McClung, 1978

Fig. 15

1978 *Ingelarella singletonensis* McClung, p. 54, pl. 2, fig. 12, 13, pl. 13, fig. 13, 14, pl. 14, fig. 1-3.

Diagnosis: Close to *Ingelarella dissimilis* in most details, but the fold is less sulcate in some but not all specimens. The plicae are more variably developed, ranging from none to two or three pairs, and ventral adminicula lie slightly further apart. There is also a strong approach to *I. mantuanensis*, but *singletonensis* has shorter more widely spaced adminicula.

Holotype: UNEF 14132 figured by McClung (1978, pl. 14, fig. 1, 2) and Fig. 15C, D herein from Mulbring Formation, north Sydney Basin.

Morphology: There are similarities to both *Ingelarella dissimilis*, and to some specimens assigned to *mantuanensis*.

Stratigraphy: This species is limited to the Mulbring Formation in the north Sydney Basin.

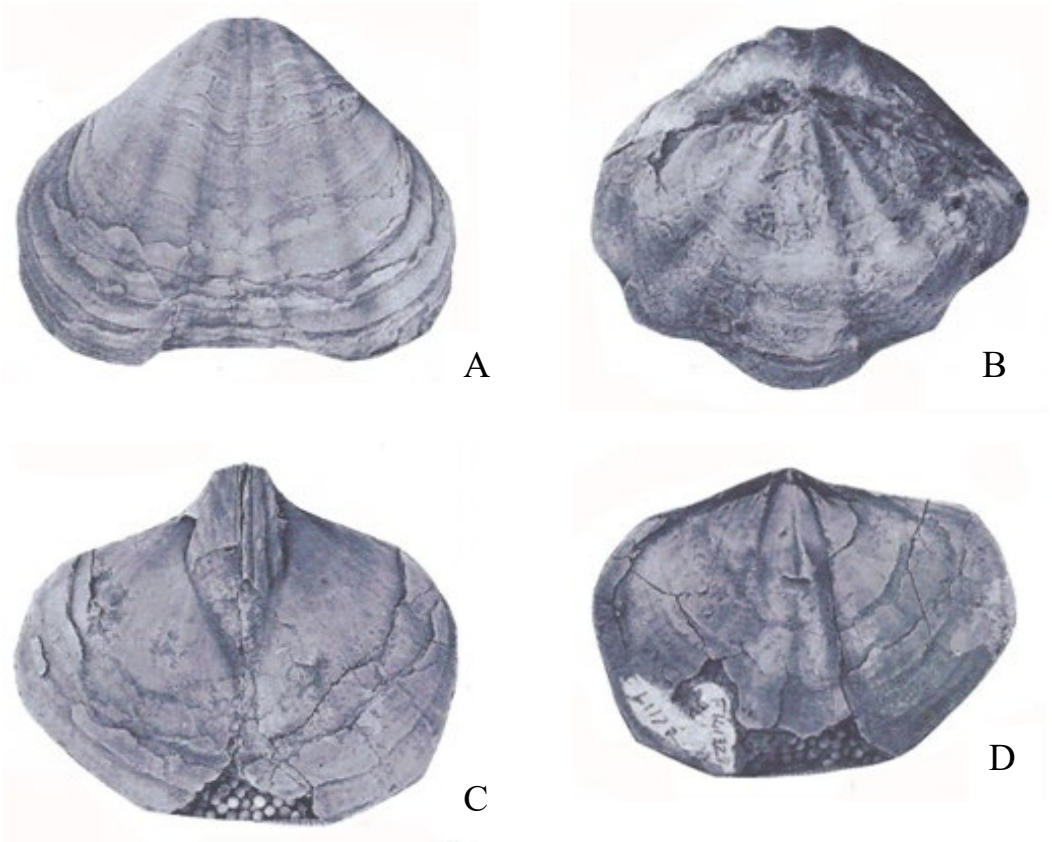


Fig. 15. *Ingelarella singletonensis* McClung. A, ventral valve UNEF 14013. B, dorsal aspect of conjoined specimen, UNEF 14012. C, D. dorsal and ventral aspects of internal mould UNEF 14132, holotype. Specimens x0.7, from Mulbring Formation, north Sydney Basin. (McClung 1978).

Ingelarella havilensis Campbell, 1960

Fig. 16, ?17

1955 *Martiniopsis* sp. Isbell, p. 12.
1960 *Ingelarella havilensis* Campbell, p. 1120, pl. 139, fig. 3-6.
1965 *I. ingelarensis* [not Campbell] – Waterhouse & Vella, p. 68, pl. 4, fig. 1, 4?, 5, 6 (part, fig. 2, 3, possibly *Geothomasia delicatula* - see p. 123].
1965 *I. mantuanensis* [not Campbell] – Waterhouse & Vella, p. 69, pl. 5, fig. 1.
1965 *I. dissimilis* [not Waterhouse] – Waterhouse & Vella, p. 69, pl. 5, fig. 2.
1982 *Tomiopsis ingelarensis* [not Campbell] – Waterhouse, p. 56, pl. 23e, j.
1983 *I. havilensis* – Dickins, Fig. 3A-E, F?.
1989 *Martiniopsis havilensis* – Dickins, p. 77, pl. 4, fig. 15-17? (**or *costata***?), pl. 5, fig. 1-5, 13?, 14 (part, not pl. 4, fig. 8-14 = *I. costata*, not pl. 5, fig. 6-11 = plicate transverse shells from Exmoor Ftm, possibly worn *havilensis* or *costata*).
1998 *Tomiopsis* (*Ingelarella*) *havilensis* – Waterhouse, p. 16.
2002 *I. havilensis* – Waterhouse, p. 45, Table 18, p. 57.
2022e *I. havilensis* – Waterhouse, p. 307, Fig. 5A, B.

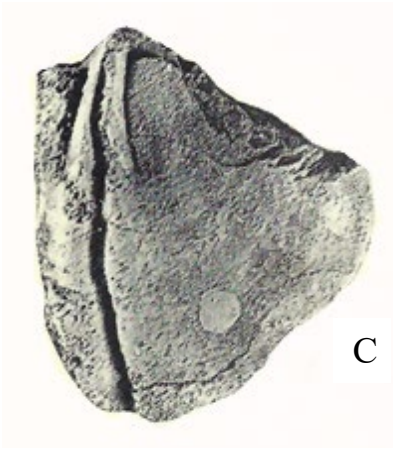


Fig. 16. *Ingelarella havilensis* Campbell. A, ventral valve holotype, UQF 15797. B, incomplete internal mould of ventral valve UQF 15738. C, dorsal internal mould UQF 15800. Specimens x1, from Havilah fauna of Dear (1972), north Bowen Basin. (Campbell 1960).

Diagnosis: Large transverse shells that are smooth or usually bear subdued plicae, and characterized by deep median groove in the ventral sulcus, and commonly a narrow dorsal groove in the crest of the fold. Internal plates somewhat variable in length and spacing, but typically of moderate length in mature specimens.

Holotype: UQF 15797 figured by Campbell (1960, pl. 139, fig. 3) and Fig. 16A herein from upper Blenheim Formation, north Bowen Basin, Queensland, OD.

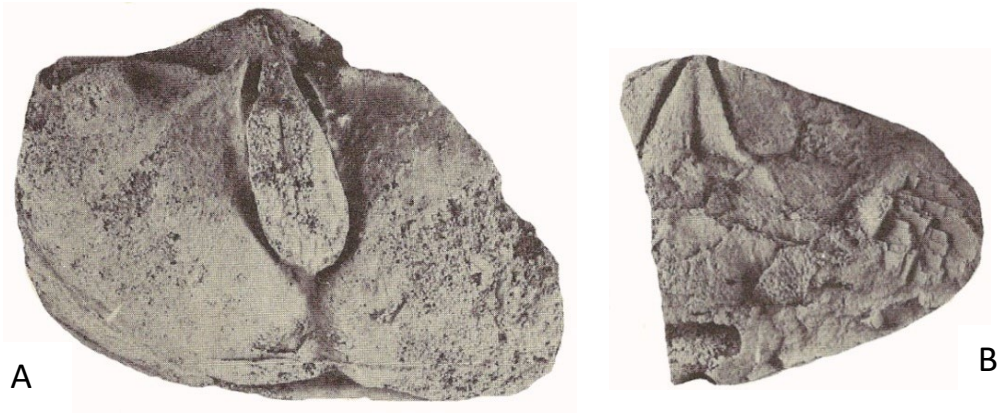


Fig. 17. *Ingelarella* cf. *havilensis* Campbell?. A, ventral internal mould UQ F 47260, x1. B, internal mould of dorsal valve UQF 54143, x1. The identification requires consolidation, given the lack of any known dorsal valve. From South Curra Limestone, Gympie. (Runnegar & Ferguson (1969).

Stratigraphy: This species occurs high in the marine Permian of the Bowen Basin, widely as discussed in Waterhouse (2022d, p. 30), and in the *Ingelarella costata* Zone at the top of the Mangarewa Formation in New Zealand (see Waterhouse 1998; 2022d). Runnegar (1968) recognized the likelihood that the species was found in the topmost marine Permian of Queensland (except for Gympie, which he had misinterpreted), though that view was discountenanced by McMinn (1985), for he regarded the Mantuan Member with "*Echinalosia*" *ovalis* as having the youngest marine Permian in east Australia, a widespread view unsupported by either geological mapping or paleontology.

The species has been reported from Late Permian sediments near Gympie in southeast Queensland by Runnegar & Ferguson (1969, p. 254, pl. 4, fig. 6-8) and Waterhouse (2015b, p. 114, Fig. 40A, B), as illustrated in Fig. 17, but no dorsal valves were figured, suggesting that the reports should be regarded as unconfirmed.

Ingelarella costata Waterhouse, 1964

Fig. 18, 19

1964 *Ingelarella costata* Waterhouse, p. 159, pl. 31, fig. 6, 9-15, pl. 32, fig. 1-3, pl. 35, fig. 2, 3; Text-fig. 75, 76.
1968 *Ambikella costata* – Waterhouse, p. 67, pl. 12, fig. 2-5, 11.
1968 *A. costata soror* Waterhouse, p. 68, pl. 12, fig. 6, 8.
1982 *Tomiopsis costata* – Waterhouse, p. 57, pl. 14F.
1989 *Martiniopsis havilensis* [not Campbell] – Dickins, p. 77, pl. 4, fig. 8-14 (part, not fig. 15, 16, 17? as worn specimen of *havilensis* or *costata*; not pl. 5, fig. 1-5, 13?, 14 = *havilensis*, pl. 5, fig. 6-11 = sp. indet., possibly worn *havilensis* or *costata*).
1998 *Tomiopsis* (*Ingelarella*) *costata* – Waterhouse, p. 17.
2001 *I. costata* – Waterhouse, p. 102, pl. 7, fig. 20.
2002 *I. costata* – Waterhouse, Table 11, p. 51, Tables 17, 18, pp. 56, 57.
2022d *I. costata* – Waterhouse, p. 278, fig. 6.

Diagnosis: Strongly plicate, low sulcal subplicae and median rib anteriorly, dorsal fold channel, adminicula moderately long and well-spaced.

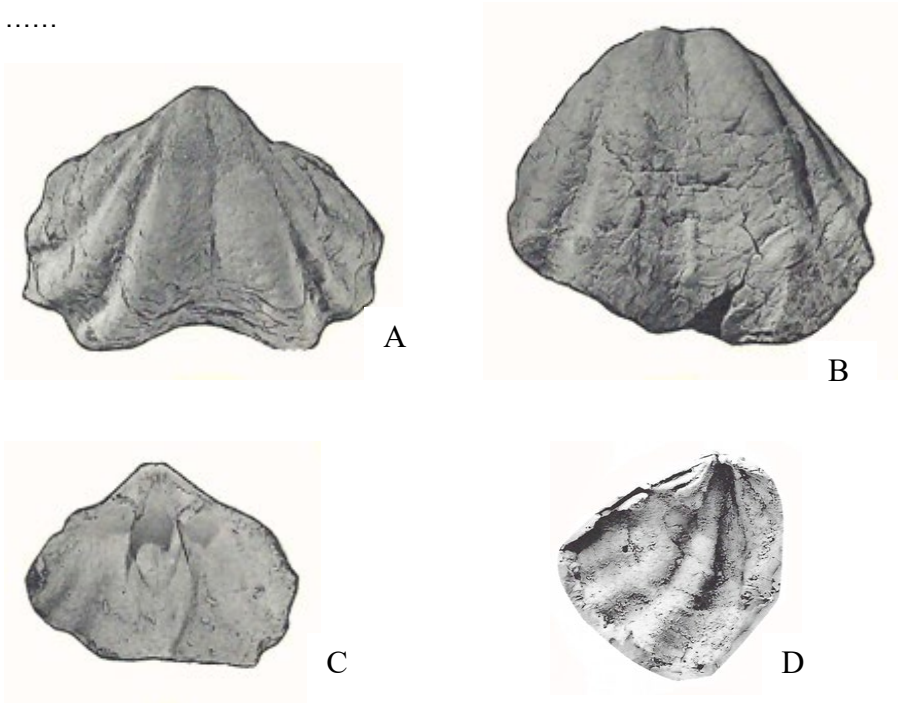


Fig. 18. *Ingelarella costata* Waterhouse. A, B, posterior and anterior views of ventral valve holotype, BR 603, x1. C, PVC cast of ventral interior, BR 620, x1. D, latex cast of dorsal interior, BR 1459, x2. From topmost Mangarewa Formation, New Zealand. (Waterhouse 1964, 1982).

Holotype: BR 613 from uppermost Mangarewa Formation, New Zealand, figured by Waterhouse (1964, pl. 31, fig. 6, 11, 13, 15; pl. 35, fig. 2, 3) and herein as Fig. 18A, B, OD.

Morphology: Only large specimens in late maturity show the median sulcal costa. That offers a marked contrast with the deep sulcal groove characteristic of *Ingelarella havilensis.*

Stratigraphy: The species is found in the highest marine sediments of the north and western

Bowen Basin of Queensland, and in the topmost Mangarewa Formation of Wairaki Downs, New Zealand, where, in contrast to east Australia, the marine succession continues for four additional marine zones as well as additional barren marine beds, counter to the interpretation resulting from various misidentifications of fossil species by some Australian paleontologists.

Fig. 19. *Ingelarella costata* Waterhouse, ventral aspect of internal mould BR 1411, x2. Paratype of *Ambikella costata soror* Waterhouse, 1968, now regarded as juvenile specimen of *costata*. Uppermost Mangarewa Formation, New Zealand.

Ingelarella fergusoni Waterhouse, 2015b

Fig. 20, 21

1964 *Ingelarella ingelarensis* [not Campbell] – Hill & Woods, p. 18, pl. P9, fig. 3, 4.
1969 *Ambikella ingelarensis* [not Campbell] – Runnegar & Ferguson, p. 278, pl. 4, fig. 3-5.
1972 *I. ingelarensis* [not Campbell] – Hill et al., p. 18, pl. P9, fig. 3, 4**.**
2015b *I. fergusoni* Waterhouse, pp. 113, 152, Fig. 37C, 39, 72, 73.

Fig. 20. *Ingelarella fergusoni* Waterhouse, holotype UQF 44264, x1. South Curra Limestone, southeast Queensland. (Runnegar & Ferguson 1969).

Diagnosis: Medium in size, shallow sulcus with two subplicae or smooth, fold with steep sides and shallow median channel, flanks smooth or with three plicae pairs. Adminicula moderately long and closely spaced and becoming subparallel anteriorly, tabellae long and divergent.

Holotype: UQF 44264 figured by Runnegar & Ferguson (1969, pl. 4, fig. 5), Waterhouse (2015b, Fig. 39), and Fig. 20 herein, from upper South Curra Limestone, Gympie, OD.

Stratigraphy: The species is found in the upper South Curra Limestone and Gigoomgan Limestone near Gympie, southeast Queensland.

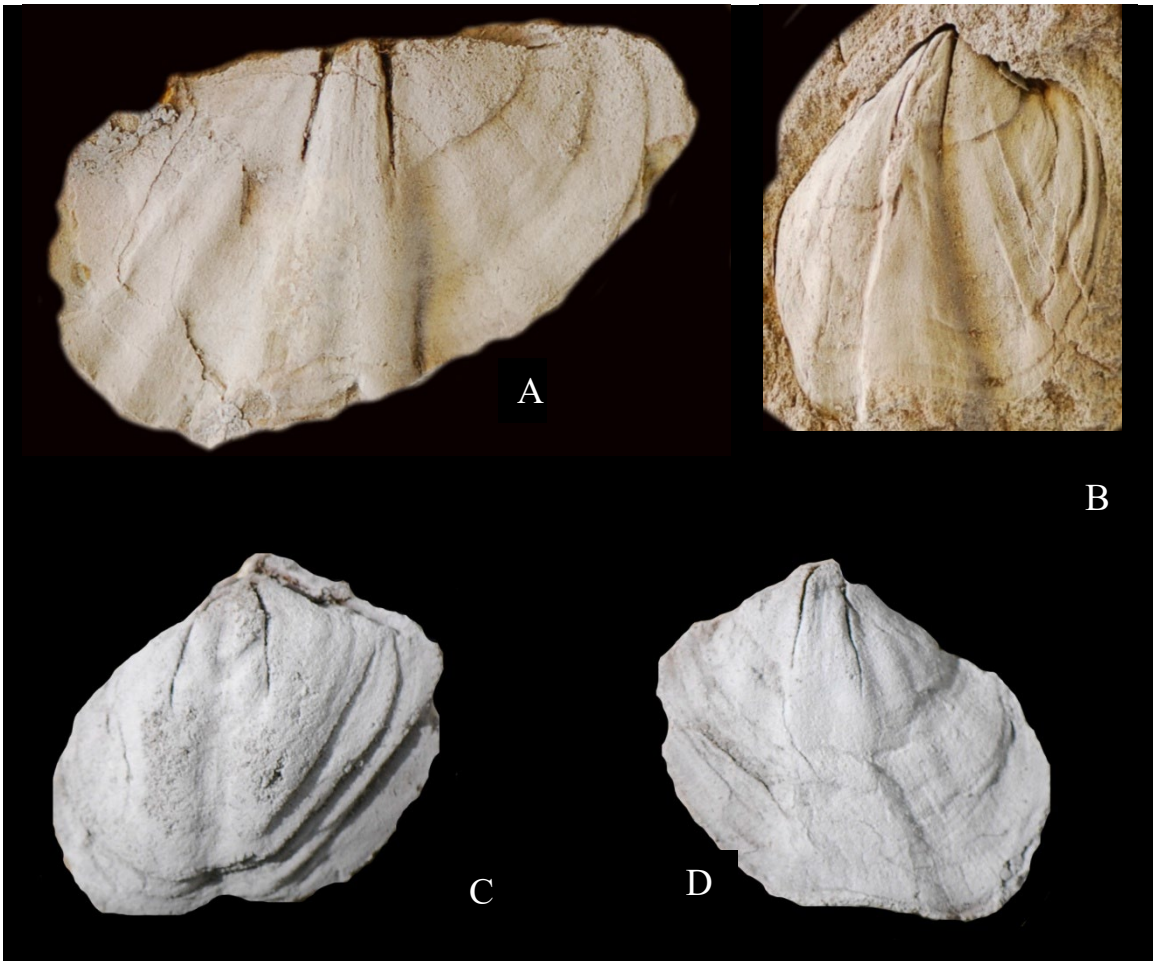


Fig. 21. *Ingelarella fergusoni* Waterhouse. A, dorsal aspect of internal mould UQF 46686, x2. B, UQF 46685, internal mould of dorsal valve, x1, possibly stretched longitudinally. C, D, ventral and dorsal aspects of UQF 46687, x2. From South Curra Limestone, Gympie. (Waterhouse 2015b).

Ingelarella sp. B

Fig. 22

1880 *Spirifer glaber* [not G. B. Sowerby] – Hector p. 28 (part).
1917 *Martinia* (*Martiniopsis*?) *subradiata* [not Sowerby] – Trechmann, p. 59 (part, not pl. 5, fig. 3 = *Johndearia antesulcata*).
1964 *Ingelarella* n. sp. B Waterhouse, p. 169, pl. 33, fig. 3.

Morphology: Ventral valve with faint signs of plicae on internal mould, flanks of sulcus said to be more gently rounded than in *Ingelarella* sp. C. Rounded sulcal flanks conform with the sketch in Fig. 22B, but the sketch must be inaccurate, given what can be seen on the

photograph. Adminicula long and parallel.

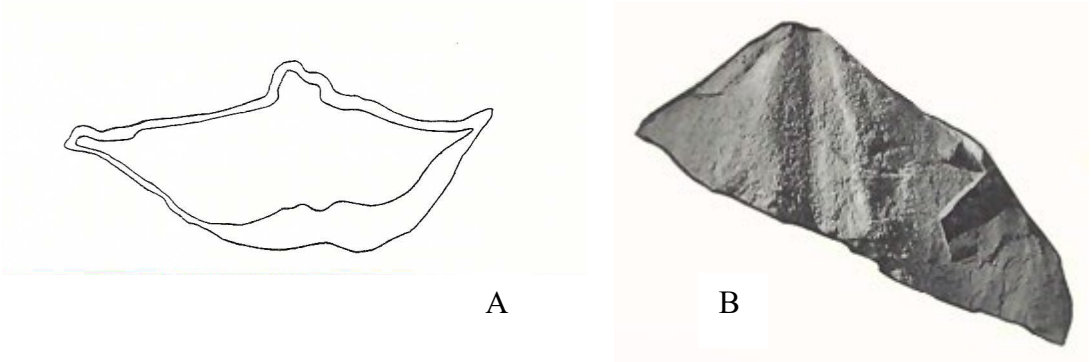
Stratigraphy: The specimen comes from the Pig Valley Limestone of east Nelson, New Zealand, of Late Permian age.

Fig. 22. *Ingelarella* sp. B, ventral internal mould, BR 912 x1. From Pig Valley Limestone, Nelson, New Zealand. (Waterhouse 1964).

Ingelarella sp. C

Fig. 23

v1880 *Spirifer glaber* [not G. B. Sowerby] – Hector, p. 28 (part).
1917 *Martinia* (*Martiniopsis*?) *subradiata* [not Sowerby, or Morris] – Trechmann, p. 59 (part, not pl. 5, fig. 3 = *Johndearia antesulcata* - see p. 92 herein).
1964 *Ingelarella* sp. C Waterhouse, p. 169, pl. 33, fig. 4, text-fig. 77.



A B

Fig. 23. *Ingelarella* sp. C. A, cross-section, BR 846, x1. The photograph shows that the sides of the sulcus are more sharply defined than indicated in the sketch. B, ventral view of same specimen, x1. Pig Valley Limestone, Nelson, New Zealand. (Waterhouse 1964).

This form is based on a single specimen with well-defined ventral sulcus and dorsal channel. It comes from the Pig Valley Limestone of late Permian age, in the *Marginalosia planata* Zone of east Nelson, New Zealand.

Genus ***Ambikella*** Sahni & Srivastava, 1956

Diagnosis: Inflated moderately large shells with deep ventral sulcus, often with subplicae, and moderately high dorsal fold bearing rounded and non-channelled crest as a rule, adminicula moderately long and divergent, tabellae short to well-formed, lying along innermost pair of interplicae next to the fold.

Type species: *Ambikella fructiformis* Sahni & Srivastava, 1956 from Lower Permian of Sikkim, India. The reference to Carboniferous in the *Revised Brachiopod Treatise* by Carter (2006, p. 1758) is erroneous, as shown by Tricholan Singh (1979, p. 183).

Discussion: As interpreted by Sahni & Srivastava (1956), *Ambikella* was typified by having a dorsal sulcus, but examination of the types at the Geological Survey of India at Calcutta (Kolkata) showed that material had been deformed, with the so-called ventral valve showing dorsal socket plates (Waterhouse 1965; Singh 1979). Though aspects were challenged by Archbold in Archbold & Singh 1993, his reassessments have proved inaccurate, and he failed to examine the types at Kolkata. The genus is represented in east Australia, especially in the Early Permian (Waterhouse 2015a).

The type species, apart from being deformed, has a round-crested fold. That appears to distinguish the genus from *Ingelarella*, which was named later than *Ambikella.* But although Sakmarian species in east Australia consistently show a round-crested fold, some of the earlier taxa vary somewhat in that regard, so that the understanding of the genus depends on what is the predominant distinction between the two genera. Here species are assigned to *Ambikella* because most, though not all specimens, have a round-crested fold.

Ambikella bundellaensis Waterhouse, 2015b

Fig. 24, 25

1990 *Tomiopsis elongata* [not McClung & Armstrong] – Clarke, p. 64, Fig. 10A-G, ?H-L.
1990 *T. konincki* [not Etheridge] – Clarke, p. 64, Fig. 11A-H, ?I. ?J.
1992 *T. elongata* [not McClung & Armstrong] – Clarke, p. 22, Fig. 10A-G, ?H-L.
1992 *T. konincki* [not Etheridge] – Clarke, p. 22, Fig. 11A-H, ?I, ?J.
2015b *Ambikella bundellaensis* Waterhouse, p. 168.

Diagnosis: Narrow elongate shells with tabellae well-spaced and not as long as those of *elongata*.

Holotype: GST 14151 from basal Bundella Formation, Tasmania, figured by Clarke (1990,

Fig. 10A, B); Clarke (1992, Fig. 10A, B) and Fig. 24B herein, OD.

Morphology: This species is distinguished from *Ambikella elongata* by its less transverse shape, involving narrower deeper sulcus, broader slightly lower fold and lower plicae. Compared with *elongata*, the adminicula and tabellae are shorter and often placed further apart. The adminicula of *bundellaensis* are short to moderately long and subparallel anteriorly – indeed they may appear to converge anteriorly to a slight degree. Some of the Tasmanian specimens (eg. Clarke 1990, text-fig. 10A, C, I) suggest the presence of a low and narrow tigillum, though first-hand inspection is required. The specimens figured by Clarke (1992, Fig. 10B, D, F) have tabellae extending for about a fifth to a third of the length of the valve, and they diverge widely immediately in front of the hinge, unlike those of restricted and type *elongata*, in which the tabellae diverge at a gentle angle and extend further forward.

Disconcertingly, a few specimens of *bundellaensis*, including the holotype, have a channelled fold, unlike the majority. Slightly younger species are more consistent in their morphology, with round-crested folds in all specimens. Clarke (1990, 1992) claimed that two species were present in what is now regarded as *bundellaensis*, but his so-called *elongata* are very close to his so-called *konincki.* Three figures show that the tabellae for *elongata* (Clarke 1990, 1992, Fig. 10A, D, G) are slightly longer than in those assigned to *konincki* (Fig. 11F, G, H), but they still lie in the innermost pair of interplicae, and all could be part of one variable suite, very close in shape and plication.

Whether the specimens included by Clarke (1990, 1992, Fig. 10H-L) from the Inglis Formation in *elongata* are the same is difficult to determine, given the few specimens figured, with no information on micro-ornament. They apparently lack sulcal subplicae, like some Bundella specimens, and adminicula are long and close-set in Clarke (1990, 1992, Fig. 10 H and K, closer to those of *elongata*. For so-called *konincki* from the Swifts Jetty Sandstone, high in the Massey Creek Group of Tasmania and younger than the Bundella Formation (Clarke 1990, Fig. 11 I , J), adminicula and tabellae are moderately long and well spaced, not exactly the same as in specimens from the older rocks, but the plates are not as long as those of *elongata* and the tabellae are longer and do not diverge widely as in *konincki*. The specimens figured from the slightly younger Swifts Jetty Sandstone (Clarke 1990, Fig. 11. I, J) are very close, but need first examination and clarification of the exterior to achieve full

comparison. One specimen from the Swifts Jetty Sandstone in Clarke (1990, 1992, Fig. 11.I, J) has sulcal subplicae, and the fold appears to be rounded. The tabellae are longer than in *konincki* and do not diverge, unlike those of *konincki* and are moderately close to those of *bundellaensis* from the lower Bundella beds. On the whole, it appears that the specimens in Clarke (1990, 1992, Fig. 10, 11) belong to *Ambikella* rather than *Tomiopsis* or *Geothomasia*, with most if not all referable to *A. bundellaensis*.

Stratigraphy: The species marks the earliest known occurrence of *Ambikella* in the Permian of east Australia. It comes from the Bundella Formation of Tasmania, whereas elongate comes from the Beckers Formation at Cranky Corner, New South Wales.

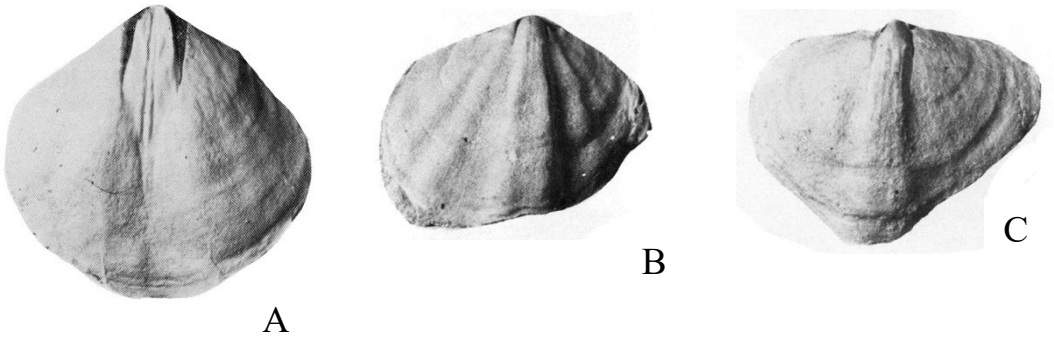


Fig. 24. *Ambikella bundellaensis* Waterhouse. A, ventral internal mould, GST 14150. B, dorsal internal mould GST 14163, holotype. C, dorsal internal mould GST 14164. Specimens x1, from Bundella Formation, Tasmania. Described as *konincki* by Clarke (1990).

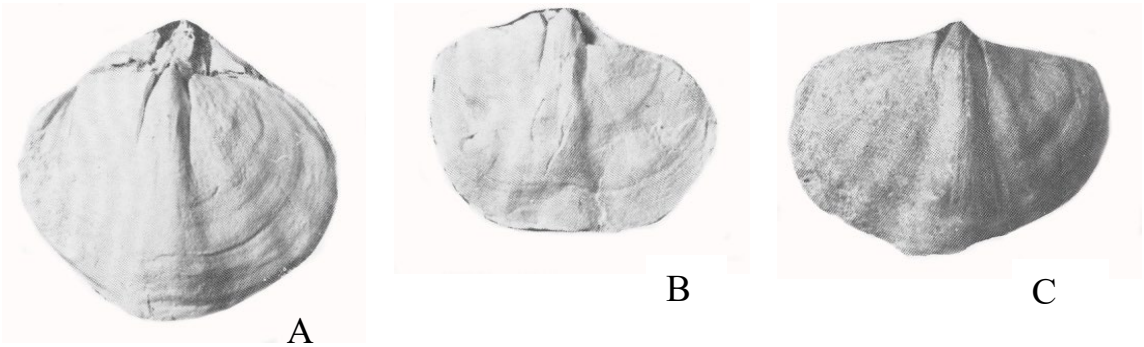


Fig. 25. *Ambikella bundellaensis* Waterhouse, dorsal aspects of internal moulds. A, internal mould, GST 14151. B, dorsal internal mould GST 14153. C, dorsal internal mould GST 14165. Specimens x1, from Bundella Formation, Tasmania, described as *elongata* by Clarke. C, dorsal internal mould GST 14165 described as *konincki* from Swifts Jetty Sandstone. (Clarke 1990).

Specimens from the slightly younger Inglis Formation in the Hellyer Gorge region of Tasmania appear to be close (Clarke 1990, Fig. 10H-L). In addition, the specimens from much the same beds, within the limits of the information supplied by Clarke, are close to the specimens he ascribed to *elongata*, but this time they were separated as *Tomiopsis koninckі*. They are less plicate than the specimens figured by Koninck and the tabellae of the dorsal valve cling to the flanks of the fold, in his Fig. 11F, H, J., unlike those of *koninckі.* They diverge weakly along the first pair of interspaces in Fig. 11B, and are short. It is the shortness of the tabellae in some specimens that distinguishes them, but there is overlap between the two suites assigned by Clarke to *koninckі* and *elongata*, and pending further examination and analysis, they are referred to the one taxon, whilst allowance should be made for the lack of detail presented by Clarke (1990, 1992) and the fact that he figured only internal moulds**.**

Ambikella elongata (McClung & Armstrong, 1975)

Fig. 26, 27

1975 *Martiniopsis elongata* McClung & Armstrong, p. 231, fig. 1a-j.
1975 *M. elongata* – Runnegar & McClung, pl. 31.1, Fig. 1, 2.
1978 *Ingelarella elongata* – McClung, p. 46, pl. 2, fig. 1-2; pl. 3, fig. 7-11.
1998 *Tomiopsis elongatum* – Briggs, p. 31, Fig. 18B, C.
2003 *T. elongata* – Archbold, p. 162, Fig. 3.1-23.
2004 *T. elongata* – Archbold et al., Fig. 2A-F.
aff. 2015b *Ambikella* aff. *elongata* – Waterhouse, p. 57, Fig. 18.

Diagnosis: Small, transverse with high round-crested fold and deep sulcus, no plicae as a rule, adminicula of moderate length, subparallel, tabellae long to medium in length, subparallel, heavy secondary posterior thickening.

Holotype: UNEF 13017, figured by McClung & Armstrong (1975, fig. 1), McClung (1978, pl. 3, fig. 7, 8) and Fig. 26A herein from the Beckers Formation, Cranky Corner, New South Wales, OD.

Morphology: This species is highly distinctive, judged from the material described by McClung & Armstrong (1978). Clarke (1990, 1992) reported *Tomiopsis elongata* from the Bundella Formation from Tasmania, but the specimens are judged to belong to *Ambikella bundellaensis*, and have shorter adminicula and tabellae than in *elongata*. None of the Cisterna-Shi (2014) specimens from the upper Wasp Head Formation can be securely identified with *elongata*, with two showing or suggesting a tumulate sulcus as in *Tumulosulcus*

piersoni and most having short widely spaced adminicula and short often widely diverging tabellae, as in *Geothomasia simplicata.*

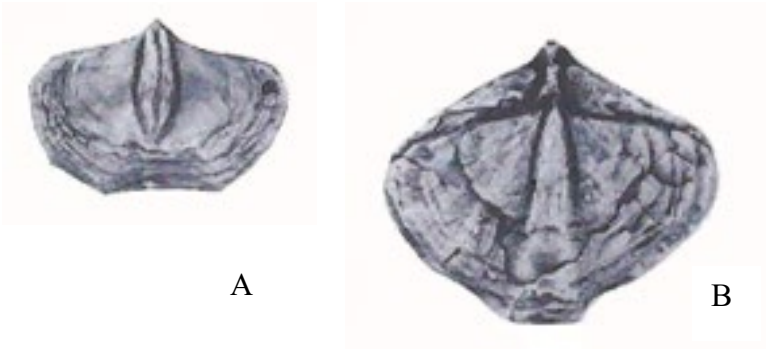


Fig. 26. *Ambikella elongata* (McClung & Armstrong). A, ventral aspect, UNEF 13017 holotype. B, dorsal aspect of specimen with valves conjoined, UNEF 13014. Specimens x 1.5 from Beckers Formation, Cranky Corner Basin, New South Wales. (McClung 1978).

Stratigraphy: According to Briggs (1998, p. 31), the species *elongata* ranges as high as "Faunizone 3" on Maria Island at the top of the *Strophalosia* (now *Crassispinosella*) *subcircularis* Zone, and his figured specimens are elongate with weakly defined sulcus, long extended ventral umbones, and narrowly diverging posterior walls. There is no information in Briggs (1998) on the dorsal valve or internal plates, which renders any identification open to caution. Archbold (2003, p. 162) rejected Briggs' interpretation. Nonetheless, there is a degree of variation in suites of ingelarellid species that underlines the need for careful evaluation. Available data does not fully agree with Briggs (1998, Fig. 14), who claimed that

Fig. 27. *Ambikella elongata* (McClung & Armstrong). A, B, ventral valve exterior and internal mould CPC 35326. C, internal mould CPC 35325. Arrow points to anterior end of tabellum. Specimens x1 from Beckers Formation, Cranky Corner, New South Wales. (Archbold et al. 2004).

the Cranky Corner Sandstone was equivalent to Allandale Formation and contained *Tomiopsis konincki* in place of *elongata*. Archbold (2003, Fig. 3) did not confirm the occurrence of *konincki* in the Cranky Corner Basin, but figured only material from the upper Beckers Formation, so that further checks are needed. **Could be mcclungi?**

The broken specimens described from the *Bandoproductus macrospina* Zone of the upper Rammutt Formation at Gympie as *Ambikella* aff. *elongata* by Waterhouse (2015b, p. 57, Fig. 18) are close and include long and closely spaced adminicula and tabellae. but differ from *bundellaensis* and *elongata* in having a neatly constrained sulcus. More material is needed for adequate comparison.

Ambikella regina (Waterhouse, 1987)

Fig. 28 - 30, aff. 31

1978 *Ingelarella* cf. *branxtonensis* [not Etheridge Jnr] – McClung, pl. 4, fig. 12.
1983 *Tomiopsis elongata* [not McClung & Armstrong] – Waterhouse et al., pl. 3, fig. 8 - 10, 13 (part, not fig. 5 = *Validifera prima*).
1987 *Tomiopsis regina* Waterhouse, p. 28, pl. 7, fig. 3-6, 8-10.
1990 *T. branxtonensis* [not Etheridge] – Clarke, p. 70 (part).
1992 *T. branxtonensis* [not Etheridge] – Clarke, p. 410 (part).
1998 *T. regina* – Briggs, p. 35.
cf. 2015a *Ambikella* cf. *elongata* – Waterhouse, p. 154, Fig. 103.
2015a *A. regina* – Waterhouse, p. 156, Fig. 104-106A.

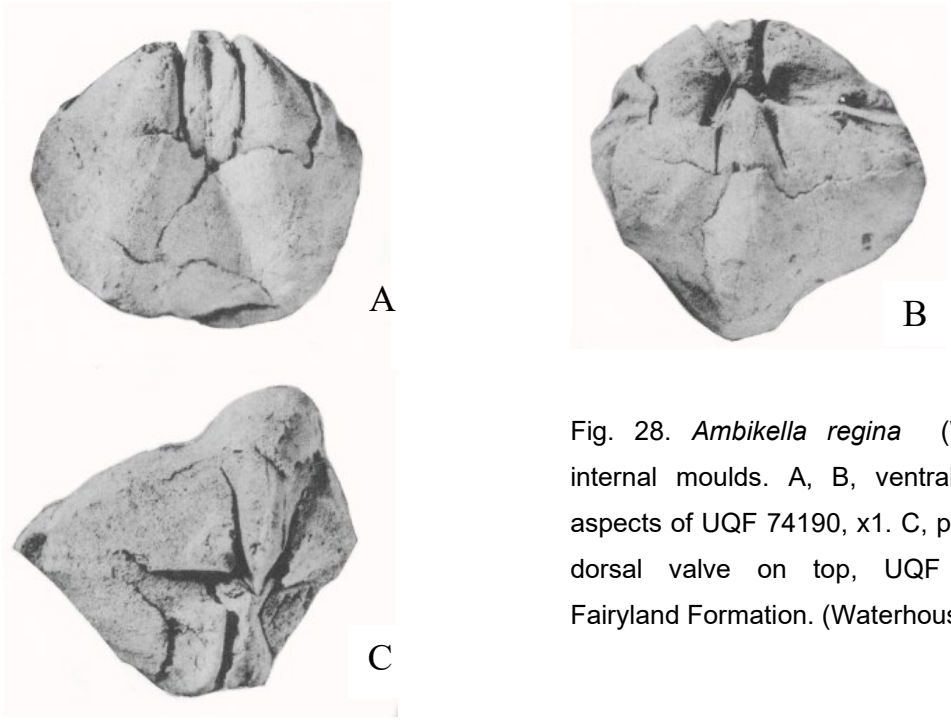


Fig. 28. *Ambikella regina* (Waterhouse), internal moulds. A, B, ventral and dorsal aspects of UQF 74190, x1. C, posterior view, dorsal valve on top, UQF 74191, x1. Fairyland Formation. (Waterhouse 1987).

Diagnosis: Medium-sized shells with well-formed sulcus that becomes broad anteriorly,

lacking subplicae, low well-formed fold with rounded crest and no suggestion of a channel, plicae low with innermost pair emphasized or the only pair developed, most shells without plicae, little shell thickening. Adminicula moderately long, subparallel or weakly divergent, close-set. Tabellae diverge then lie parallel, of moderate length. Surface grooves dense.

Holotype: UQF 21499 from Fairyland Formation, southeast Bowen Basin, figured by Waterhouse (1987, pl. 7, fig. 3, 4), OD.

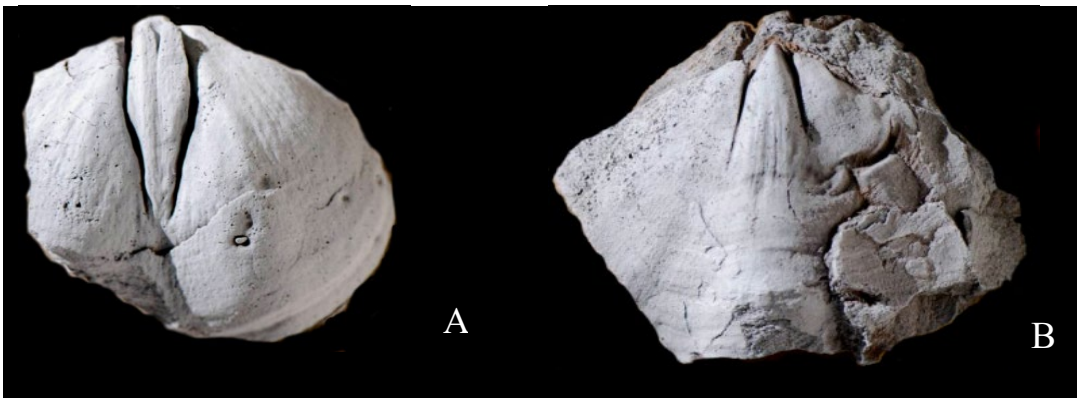


Fig. 29. *Ambikella regina* (Waterhouse). A, ventral internal mould UQF 81619, x1. B, dorsal view of internal mould of both valves, UQF 81611, x1.3. Lower Tiverton Formation. (Waterhouse 2015a).

Morphology: Compared with *Ambikella elongata*, the shells are larger with adminicula slightly more widely spaced, and well-formed tabellae diverging forward strongly near the umbo, and anteriorly diverging much less. The specimens that had been figured as *elongata* by Waterhouse, Briggs & Parfrey (1983) and compared with *elongata* by Waterhouse (2015a, p. 153), were reidentified with *regina* by Briggs (1998). I agree with Briggs, and the identification points to correlation between the lower Tiverton Formation and the Fairyland Formation of the southeast Bowen Basin.

Fig. 30. *Ambikell*a aff. *regina* Waterhouse, dorsal internal mould UNEF 4011 x from Rutherford Formation, north Sydney Basin. (McClung 1978).

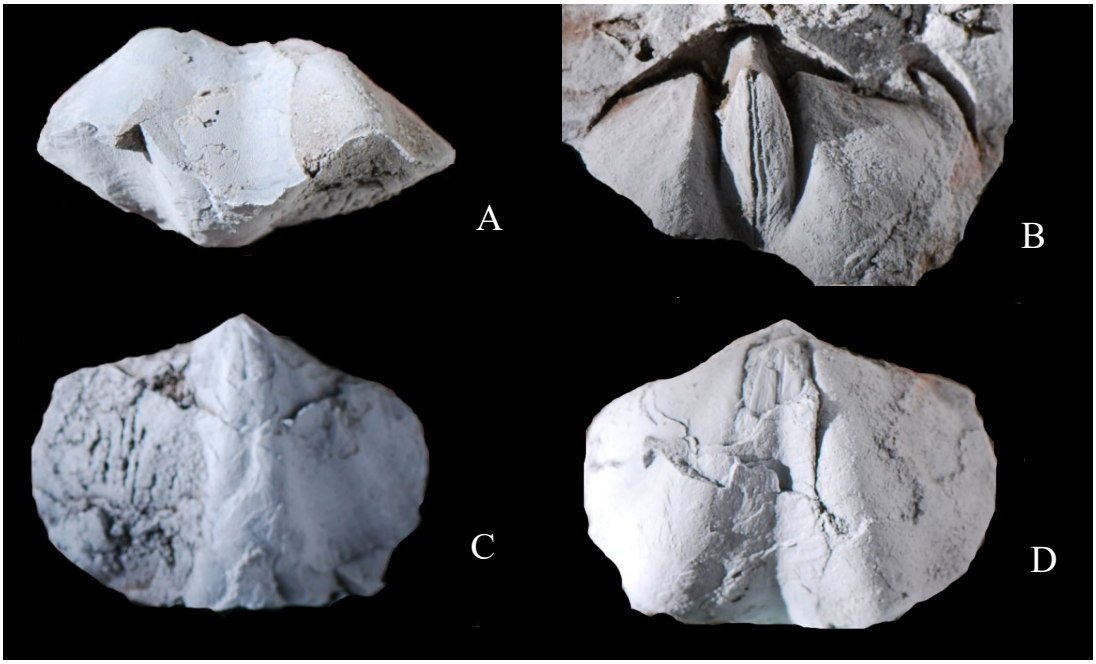


Fig. 31. *Ambikella regina* Waterhouse. A, C, D, anterior, dorsal, and ventral aspects of partly shelly specimen, showing vestiges of spire on left in C, UQF 81683, x2. Ventral valve on top in A. B, ventral internal mould UQF 81680, x1.5. From lower Tiverton Formation, north Bowen Basin (Waterhouse 2015a).

Stratigraphy: The species is known from the Fairyland Formation of the southeast Bowen Basin, the lower Tiverton Formation in the north Bowen Basin of Queensland, and possibly the Rutherford Formation of the north Sydney Basin in New South Wales.

Ambikella ovata (Campbell, 1961)

Fig. 32, 33

1961 *Ingelarella ovata* Campbell, p. 177, pl. 24, fig. 3-9.
1964 *I. ovata* – Maxwell, p. 47, pl. 9, fig. 29, 30.
1964 *I. ovata* – Hill & Woods, pl. P9, fig. 10-12.
1968 *Ingelarella branxtonensis* [not Campbell] – Runnegar, pl. 1, fig. 6-11 (part, not fig. 12 = *branxtonensis*).
1970b *I. ovata* – Armstrong, p. 204, pl. 14, fig. 4 (part, not fig. 5, 6 = *Ambikella profunda*).
1972 *I. ovata* – Hill, Playford & Woods, pl. P9, fig. 10-12.
1975 *Martiniopsis ovata* – Runnegar & McClung, pl. 31.1, fig. 6, 8, 9, 24 (part, not fig. 7 = *Ambikella symmetrica*).
1978 *I. ovata* – McClung, p. 46, pl. 2, fig. 7; pl. 4, fig. 14, 15, 18, 19; pl. 5, fig. 1 (part, not pl. 2, fig. 8; pl. 4, fig. 16, 17, 20 = *A. symmetrica*).
1983 *Ambikella ovata* – Waterhouse, Campbell & Williams, p. 303, text-fig. 3, 4.
1983 *Ambikella* sp. Waterhouse, Campbell & Williams, p. 303, text-fig. 5.
1986 *Homevalaria ovata* – Waterhouse, p. 110.
1987 *Tomiopsis ovata* – Waterhouse, p. 29, pl. 7, fig. 7, 15, 18, 20-21, 22; pl. 8, fig. 1, 2, 3-6?

2006 *H. ovata* – Carter & Gouvennec, p. 1763, Fig. 1160.2a-e.
2015a *Ambikella ovata* – Waterhouse, p. 152, Fig. 106B, 107-110.
2015b *A. ovata* – Waterhouse, p. 133, Fig. 51.
2016 *A. ovata* – Waterhouse, Fig. 69.

Diagnosis: Weakly transverse and inflated large shells with broad ventral sulcus bearing faint signs of two subplicae in some specimens, fold crest broad and rounded, lateral shell generally smooth or may be weakly plicate, adminicula long and subparallel, tabellae of moderate length and low angle of divergence.

Fig. 32. *Ambikella ovata* (Campbell) dorsal aspect of internal mould UQF 81323, x1.5. (Waterhouse 2015a).

Holotype: UNEF 3182 from “zone 13” of Tiverton Formation, Homevale, figured by Campbell (1961, pl. 24, fig. 4a-c), Hill & Woods (1964, pl. P9, fig. 10, 11), Hill et al. (1972), and Carter & Gouvennec (2006, Fig. 1160.2a-c), OD.

Fig. 33. *Ambikella ovata* (Campbell). A, ventral internal mould UQF 81312, at full maturity, x0.7. B, ventral internal mould UQF 81316 , x0.8. Tiverton Formation. (Waterhouse 2015a).

Morphology: The sulcus is wider and deeper than in *regina*. Scattered individuals from the

type area in the Tiverton Formation developed small c-shape spines or spinelets at the posterior end of the surface grooves, but many other specimens show no such spines (Waterhouse 2015a, p. 161), to confirm the view of Clarke (1992) that the spines were a morphological variation and of no classificatory significance, counter to the view of Waterhouse (1986, p. 110), which was wrong, though accepted by Carter & Gouvennec (2006, p. 1763, Fig. 1160.2a-c).

Stratigraphy: The species is found in the middle Tiverton Formation, Lizzie Creek Volcanics, the Elvinia Formation of the southeast Bowen Basin and the Yarrol Basin in Queensland, upper Farley Formation in the north Sydney Basin of New South Wales and Eglinton Volcanics of New Zealand. Clarke & Banks (1975) reported but did not describe or figure the species from Tasmania.

Ambikella furca Waterhouse, 1967

Fig. 34, 35

?1880 *Spirifer glaber* [not Sowerby] – Hector, p. 28 (part).
?1917 *Martinia* (*Martiniopsis*) *radiata* [not Sowerby or Morris] – Trechmann, p. 59 (part, not pl. 5, fig. 3 = *Johndearia antesulcata*).
1967 *Ambikella furca* Waterhouse, p. 96, Fig. 5F, 34-37, 39.
1978 *A. furca* – Suggate et al., Fig. 4.7, fig. 11, 13, 14.
1978 *Ingelarella mantuanensis* [not Campbell] – McClung, p. 53.

Diagnosis: Medium size, transverse and more inflated than preceeding species, sulcus commences as narrow groove, widens to bear two subplicae, fold with rounded crest, ventral plicae in two to four pairs, lower than in older species, better defined on dorsal valve. Adminicula long and subparallel, tabellae very long.

Holotype: BR 1194 figured by Waterhouse (1967, Fig. 34, 35, 37) and Fig. 34A, B, D herein from lower Pig Valley Limestone, Nelson, New Zealand, OD.

Morphology: The fold, it must be emphasized, is round-crested, to distinguished the species from *Ingelarella mantuanensis.* McClung (1978, p. 54) identified the New Zealand specimens with *mantuanensis* but was well astray, specifically and generically. Like certain other Australian paleontologists, McClung was determined to force New Zealand Permian stratigraphy and paleontological aspects despite differences in morphology and stratigraphic succession into the same mould that he had ascribed to east Australia and their fossils.

Stratigraphy: This species is relatively common in the Pig Valley Limestone, classed in the

Marginalosia planata Zone of late Changhsingian age, second to youngest of all the marine macro-faunal zones to be found in New Zealand, and absent from east Australia.

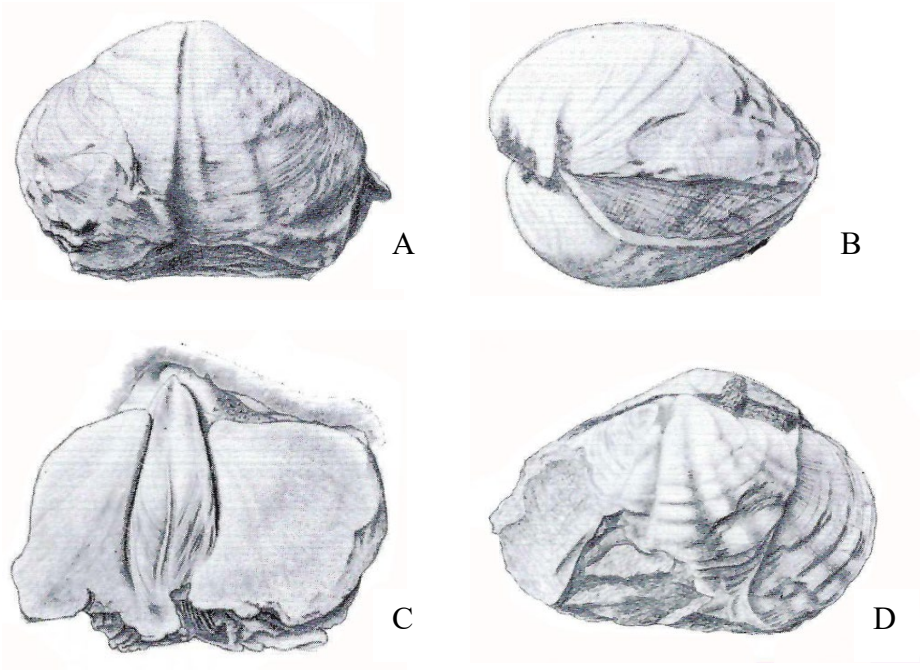


Fig. 34. *Ambikella furca* Waterhouse. A, B, D, ventral, lateral and dorsal aspects of holotype, BR 1194. C, ventral aspect of internal mould, BR 1191. Specimens x1 from Pig Valley Limestone, Nelson, New Zealand.

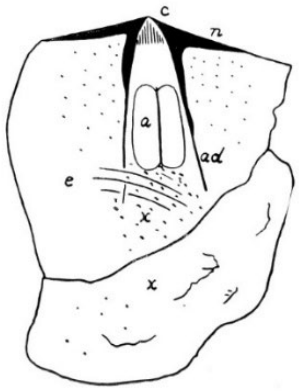


Fig. 35. *Ambikella furca* Waterhouse, broken internal mould of dorsal valve BR 1277, x1.5. a, adductor scar; ad, long tabellae; c, myophore area of cardinal process; e, traces of spiralia; n, interarea; x, matrix covering anterior shell. From Pig Valley Limestone, New Zealand. (Waterhouse 1967).

Ventral valves from the Pig Valley Limestone including a strongly plicate shell were assigned to *Ambikella* in Waterhouse (1967, Fig. 41, 42) but show no dorsal valve, so the generic position is in question.

Ambikella (***Branxtonifera***) new subgenus

Derivation: From Branxton, place-name in New South Wales.

Diagnosis: Shells close to *Ambikella*, distinguished by the tabellae which are short and diverge forward, though still largely within the first pair of interplicae next to the dorsal fold.

Name species: *Martiniopsis subradiata* var. *branxtonensis* Etheridge, 1919 from the FarleyFormation of the SydneyBasin in New Soiuth Wales.

Discussion: The species *branxtonensis* together with *symmetrica* Campbell and *profunda* Campbell form a subset in which tabellae are shorter than in other species assigned to *Ambikella*. The tabellae diverge widely, but as a rule remain within the first pair of interspaces next to the fold. Aspects of the tabellae suggest a possible relationship with *Geothomasia* (see p. 113ff), and such an identification was adopted by Waterhouse (2015a), and Campbell's species *symmetrica* and *profunda* were similarly treated. Now I prefer a generic shift, and distinguish the subset of species, involving *branxtonensis, symmetrica* and *profunda* as a subgenus characterized by their very short tabellae which diverge widely from inception, but which lie largely within the first pair of interplicae from the fold.

Ambikella (***Branxtonifera***) ***branxtonensis*** (Etheridge, 1919)

Fig. 36, 37

1919 *Martiniopsis subradiata* var. *branxtonensis* Etheridge, p. 185, pl. 28, fig. 5-6; pl. 29, fig. 1, 2.
1964 *Ingelarella branxtonensi*s – Waterhouse, p. 165.
1968 *I. branxtonensis* – Runnegar, pl. 1, fig. 12 (part, fig. 6-11 = *ovata*?).
1975 *M. branxtonensis* – Runnegar & McClung, pl. 31.1. fig. 4, 5.
1978 *Ingelarella branxtonensis* – McClung, p. 45, pl. 2, fig. 5, 6; pl. 3, fig. 12-19; pl. 4, fig. 1-5, 11 (part, not pl. 4, fig. 6-10, 12 = *Monklandia mcclungi*).
aff. 1990 *Tomiopsis* cf. *branxtonensis* – Clarke, p. 66, Fig. 11A-J.
aff. 1992 *T*. cf. *branxtonensis* – Clarke, p. 410, Fig. 11A-J.
2015a *Geothomasia branxtonensis* – Waterhouse, p. 165, Fig. 111-114.
2016 *G. branxtonensis* – Waterhouse, Fig. 78.

Diagnosis: Transverse shells with well-formed sulcus and round-crested fold, plicae in three or four pairs, of moderate strength. Adminicula of shortto medium length, tabellae short and diverging.

Lectotype: AMF 22 figured by Etheridge (1919, pl. 29, fig. 1), Runnegar (1968, pl. 1, fig. 9), McClung (1978, pl. 3, fig. 16, 17) and Fig. 37B herein from Farley Formation, SD Waterhouse (1964, p. 165).

Stratigraphy: This species was described initially from the Farley Formation of the Sydney

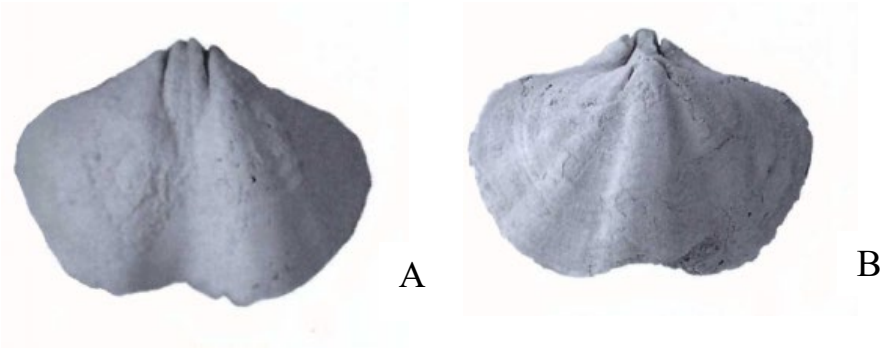


Fig. 36. *Ambikella branxtonensis* (Etheridge). A, B, ventral and dorsal aspects of UQF 81318 from UQL 4506, x1. From lower middle Tiverton Formation, Queensland. (Waterhouse 2015a).

Basin, and figured from the middle Tiverton Formation of the Bowen Basin in Queensland, the latter like the type material in shape, but larger with slightly shorter internal plates relative to the size of the shells. Clarke (1990, p. 68, Fig. 12A-K; 1992) recorded specimens that are close, although somewhat older, from the Swifts Jetty Sandstone in the uppermost Bundella Formation of Tasmania.

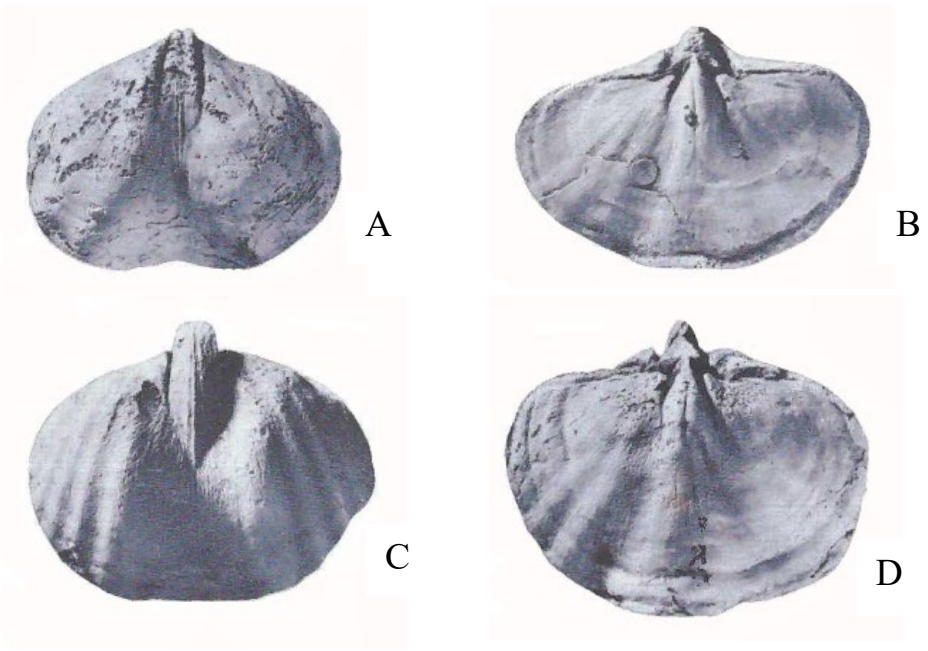


Fig. 37. *Ambikella branxtonensis* (Etheridge Jnr), internal moulds. A, ventral view, AMF 33. B, dorsal view AMF 22, lectotype. C, ventral view UQF 29397. D, dorsal view AMF 53787. Specimens x1 from Farley Fomation, north Sydney Basin. (McClung 1978).

Taxonomy: Clarke (1992) referred specimens assigned wrongly to *elongata* by Waterhouse, Briggs & Parfrey (1983) from the lower Tiverton Formation of Queensland to *branxtonensis*, as endorsed by Cisterna & Shi (2014), but these particular specimens have longer tabellae and are reassigned to *Ambikella regina* Waterhouse, as proposed by Briggs (1998), apart from one specimen discriminated as *Validifera prima* Waterhouse, 2015a.

Ambikella (***Branxtonifera***) ***symmetrica*** (Campbell, 1961)

Fig. 38, 39

1961 *Ingelarella symmetrica* Campbell, p. 179, pl. 23, fig. 1-6.
1970b *I. ovata* [not Campbell] – Armstrong, pl. 14, fig. 14, fig. 4 (part, not fig. 5, 6 = ?*profunda*). See Waterhouse (2015a, p. 134).
1974 *Martiniopsis ovata* – McCarthy et al., Fig. 4D.
1975 *M. ovata* [not Campbell] – Runnegar & McClung, pl. 31.7 (part, not fig. 6, 8, 9, 24 = *ovata*).
1978 *Ingelarella ovata* – McClung, p. 47, pl. 2, fig. 8; pl. 4, fig. 16, 17, 20 (part, not pl. 2, fig. 7; pl. 4, fig. 14, 15, 18, 19; pl. 5, fig. 1 = *ovata*).
2015a *Geothomasia symmetrica* – Waterhouse, p. 166, Fig. 115-121.
2016 *G. symmetrica* – Waterhouse, Fig. 79.

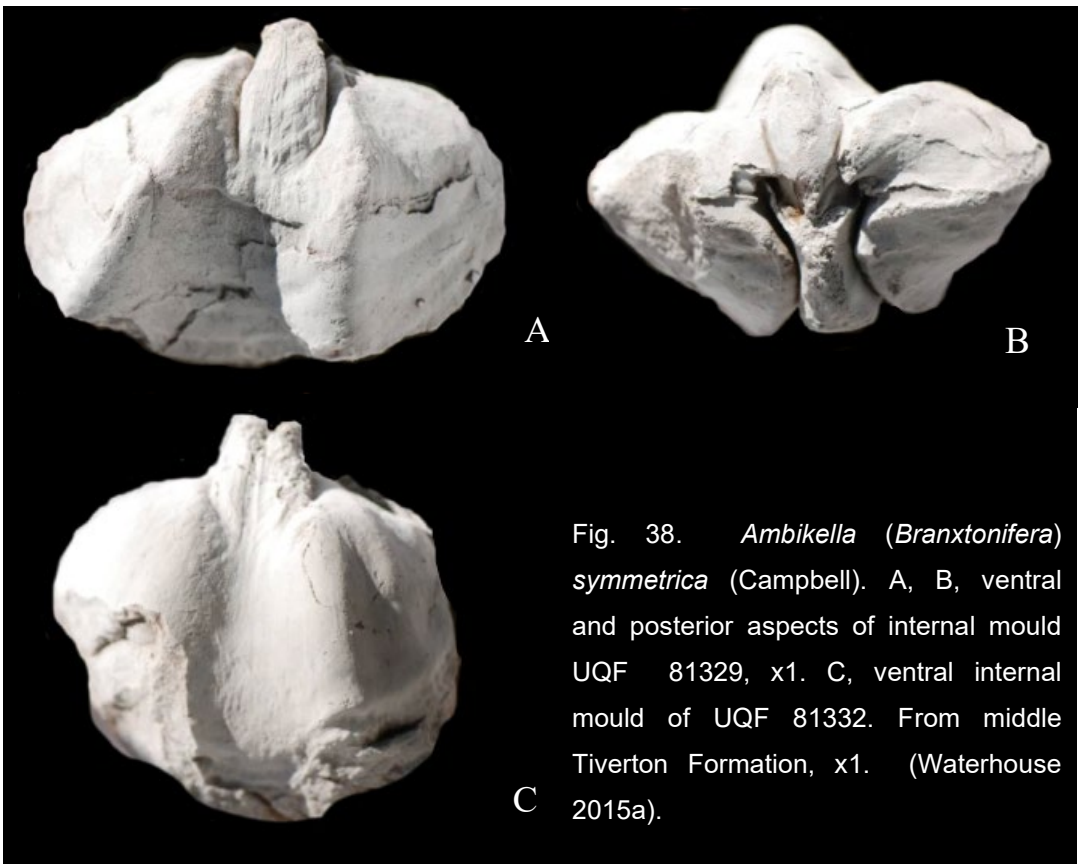


Fig. 38. *Ambikella* (*Branxtonifera*) *symmetrica* (Campbell). A, B, ventral and posterior aspects of internal mould UQF 81329, x1. C, ventral internal mould of UQF 81332. From middle Tiverton Formation, x1. (Waterhouse 2015a).

Diagnosis: Shells with prominent pair of plicae on the dorsal valve near the fold as a rule,

borders of sulcus may also be elevated. Adminicula moderately well-spaced and short, tabellae short and divergent.

Holotype: UNEF 5851 from middle Tiverton Formation at Homevale, north Bowen Basin, figured by Campbell (1961, pl. 23, fig. 1), OD.

Stratigraphy: The species has been described from the middle Tiverton Formation as well as the Farley Formation by McClung (1978) and the Emu Creek beds north of Drake, northern New South Wales, by McCarthy et al. (1974)

Fig. 39. *Ambikella* (*Branxtonifera*) *symmetrica* (Campbell), ventral internal mould UQF 81328 from middle Tiverton Formation, x1. (Waterhouse 2015a).

.***Ambikella*** (***Branxtonifera***) ***profunda*** (Campbell, 1961)

Fig. 40

1892 *Martiniopsis darwinii* [not Morris] – Etheridge, p. 240, pl. 39, fig. 5-7 (part, not pl. 9, fig. 13, 14 = aff. *Notospirifer* indet, perhaps *extensus*).
1961 *Ingelarella profunda* Campbell, p. 174, pl. 24, fig. 10-14?; pl. 28, fig. 9-13.
1964 *I. profunda* – Hill & Woods, pl. P9, fig. 15-16.
1964 *I. profunda* – Maxwell, p. 47, pl. 9, fig. 26-28.
1970a *I. profunda* – Armstrong, p. 204, pl. 13, fig. 8-10.
?1970a *I. ovata* [not Campbell] – Armstrong, p. 204, pl. 14, fig. 5, 6 (part, not fig. 4 = *symmetrica*?). See Waterhouse 2015a, p. 135.
1970b *I. profunda* – Armstrong, p. 294, Text-fig. 1E, I.
1972 *I. profunda* – Hill, Playford & Woods, pl. P9, fig. 15-16.
1975 *M. profunda* – Runnegar & McClung, pl. 13.1, fig. 17-18.
1978 *I. profunda* – McClung, p. 46, pl. 2, fig. 9; pl. 4, fig. 13?
2015a *Geothomasia profunda* – Waterhouse, p. 172, Fig. 122, 123, 138G.
2015b *G. profunda* – Waterhouse, p. 135, Fig. 52.
2016 *G. profunda* – Waterhouse, Fig. 72B, p. 75 (fide Armstrong 1970b).

Diagnosis: Shells with moderately well-developed sulcus and fold and usually three pairs of comparatively strong plicae.

Holotype: UQF 21922 (Campbell (1961, pl. 28, fig. 11), from upper middle Tiverton Formation,

OD.

Morphology: Although the tabellae may be short as in *Geothomasia*, they extend along the first pair of interspaces from the fold, as in *Ambikella*, rather than cut across the first pair of plicae from the fold as in *Geothomasia*. As discussed further on p. 126, this taxon is close in many respects to a variety of *subradiata* which Etheridge (1892) named *morrisi*, and as the type specimen is still extant, at the Natural History Museum in London, there may have to be adjustment to the name of the species, if it can be confirmed that its tabellae are short as in *profunda*..

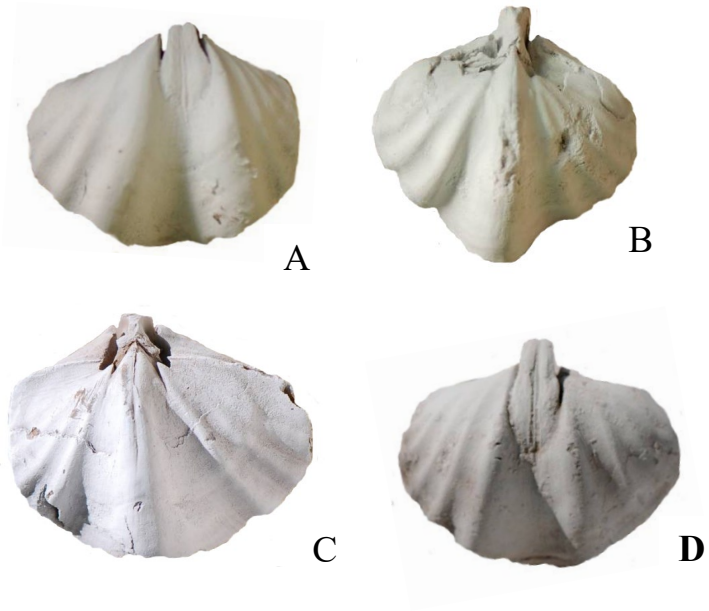


Fig. 40. *Ambikella* (*Branxtonifera*) *profunda* (Campbell). A, C, ventral and dorsal aspects of internal mould with valves conjoined, UQF 81334, x1. B, D, dorsal and ventral aspects of UQF 81335, x1. Tiverton Formation. (Waterhouse 2015a).

Stratigraphy: The species is found in the Tiverton Formation of the north Bowen Basin, the Yarrol Basin of Queensland, and the Teebar Formation near Gympie, southeast Queensland.

Genus ***Martiniopsis*** Waagen, 1883

Diagnosis: Shell distinguished by lack of sulcus, fold and plicae. Surface ornament and internal plates as in other ingelarellids.

Type species: *Martiniopsis inflata* Waagen, 1883 from lower Chhidru Formation of Salt

Range, Pakistan, OD.

Discussion: Ida Brown (1953) made an important contribution in her study of *Martiniopsis*, relevant not only to that genus but other members within the family, and indeed to Spiriferida as a whole, in recognizing that dental plates of the ventral valve were supported by separate plates, that she called adminicula. Previously the ventral plates were regarded as one set, not two. Her analysis of internal plates is relevant within the Superorder Martiniidina, but has been widely ignored especially by students of Middle Paleozoic brachiopods, including writers of the *Revised Brachiopod Treatise*. The view that dental supports were formed by a single pair of plates rather than two sets for Middle Paleozoic brachiopods is yet to be established.

McClung (1978, p. 40) correctly distinguished *Martiniopsis* by its lack or virtual absence of a sulcus and fold, and smooth flanks. But he added the criterion of allegedly unthickened shell – which is here discounted, because it depends of maturity of the shell and the nature of its environment.

Kotlyar & Popeko (1967), followed by Carter et al. (1994), referred the genus to a separate family Martiniopsidae, but this fortunately was abandoned by Carter (2006) in the *Revised Brachiopod Treatise*.

Martiniopsis? sp.

2015b *Martiniopsis*? sp. Waterhouse, p. 17.

The fragment of the posterior part of dorsal valve QMF 17747 shows well-formed interarea and lacks a fold, sulcus or plicae and shows well formed tabellae. It comes from the lower Rammutt Formation at Gympie, southeast Queensland.

Martiniopsis woodi Waterhouse, 1964

Fig. 41, 42

1964 *Martiniopsis woodi* Waterhouse, p. 148, pl. 30, fig. 3-5; pl. 37, fig. 2, 3, Fig. 71, 72A, B.
1968 *M. woodi* (?) – Waterhouse, p. 57 (part, not shells from GS locality 5868 = *Spinomartinia,* remainder = *woodi*).
1976 *M. woodi* - Waterhouse, p. 246, Fig. 6,1, 2; Fig. 7.1, 5.
aff. 1992 Martenacea (sic) fam. & gen. indet. H. J. Campbell, p. 56, text-fig. 2A, text-fig. 2B, C of less usual shape, but likely conspecific.
1998 *Martiniopsis* cf. *woodi* – Waterhouse, p. 24ff.
2001 *M.* cf. *woodi* – Waterhouse, p. 98.
2002 *M. woodi* – Waterhouse, pp. 98, 153.
2010 *M. woodi* – Shi et al., Fig. 7C.
2016 *M. woodi* – Waterhouse, p. 75, Fig. 71A, B, Fig. 72A.

Diagnosis: Large thick-shelled slightly transverse shells with extended ventral umbo, adminicula and tabellae long.

Holotype: BR 575 figured by Waterhouse (1964, pl. 30, fig. 3) and Fig. 42A herein from Earnvale Member of Bagrie Formation, Arthurton Group, north Otago, New Zealand, OD.

Morphology: The tabellae extend along the first pair of interspaces from the fold, as in *Ambikella*, rather than cut across the first pair of plicae from the fold as in *Geothomasia*.

Stratigraphy: This species is found in the Earnvale Member of the Bagrie Formation, and is associated with another spiriferid, *Simplicisulcus,* which like *woodi* is close to material from the upper Wargal and the lower Chhidru Formation of the Salt Range, Pakistan. Upper Wuchiapingian conodonts are also present in the Salt Range fauna, suggesting that the Earnvale fauna may also be of late Wuchiapingian age. This is further supported by the

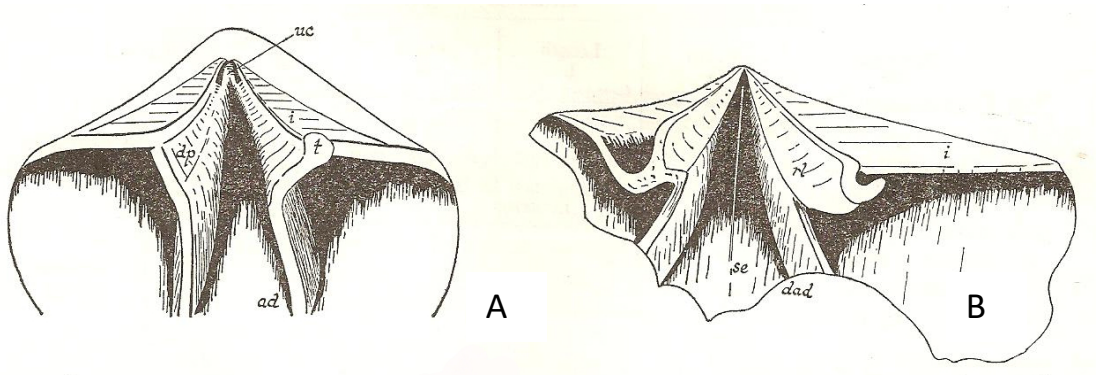


Fig. 41. *Martiniopsis woodi* Waterhouse. Interior of ventral and dorsal valves, x0.8. ad – adminicula; dad – tabellae; dp – dental plate; i – interarea; rl – crural plate; se – dorsal septum; t – tooth; uc – umbonal callosity. From Earnvale Member, Bagrie Formation, New Zealand. (Waterhouse 1964).

discovery of shells close to *Martiniopsis woodi* in North Auckland by J. M. Marwick and C. T. Trechmann, in a carbonate overlying rocks with late Guadalupian fusulines involving *Lepidolina* or close ally (see Waterhouse 2002, p. 152; 2022d, p. 241). The brachiopod specimens were figured by H. J. Campbell (1992) and the shape varies, the ventral posterior lateral slopes being very long and diverging less than in some but not all (H. J. Campbell 1992, Fig. 2A) and another suggesting a rather globose anterior (Campbell 1992, Fig. 2B). H. J. Campbell (1992, p. 56) dismissed the specimens as non-descript. He proposed that

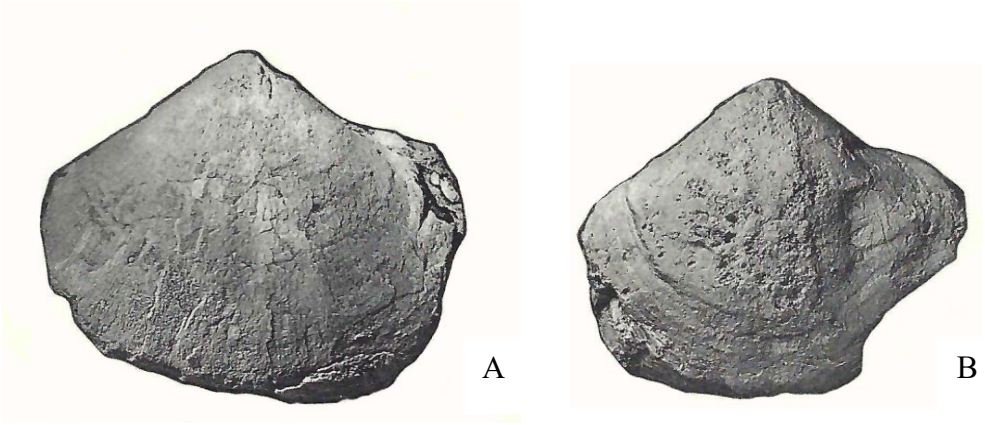


Fig. 42. *Martiniopsis woodi* Waterhouse. A, holotype BR 575. B, ventral valve BR 578. Specimens x1 from Earnvale Member, north Otago, New Zealand. (Waterhouse 1964).

the specimens came from the "Wether Hill" (= Nemo) Limestone of Southland. There are no specimens of *Martiniopsis* to be found in this limestone, judged from research and careful collecting by A. R. Mutch and the writer, and H. J. Campbell has never reported specimens from those beds. Moreover this particular limestone lacks volcanic fragments and does not show the water-worn surface displayed by the North Auckland specimens. His proposal must be rejected, together with his claim which stated that the fossils did not come from North Auckland, mainly it would appear, because he could not find any specimens in North Auckland.

Martiniopsis patella Waterhouse, 1967

Fig. 43, 44

1967 *Martiniopsis patella* Waterhouse, p. 93, text-fig. 8, 29-31, 33.
2001 *M. patella* – Waterhouse, p. 98, pl. 7, fig. 4, 5.

Diagnosis: Large transverse shells with short lateral margins, posterior ventral valve smooth or weakly channelled, broad weakly sulcate anterior margin, adminicula and tabellae short and diverging.

Holotype: BR 827, figured in Waterhouse (1967, text-fig. 8, 30) and Fig. 43A herein from Wairaki Breccia, Wairaki Downs, New Zealand, OD.

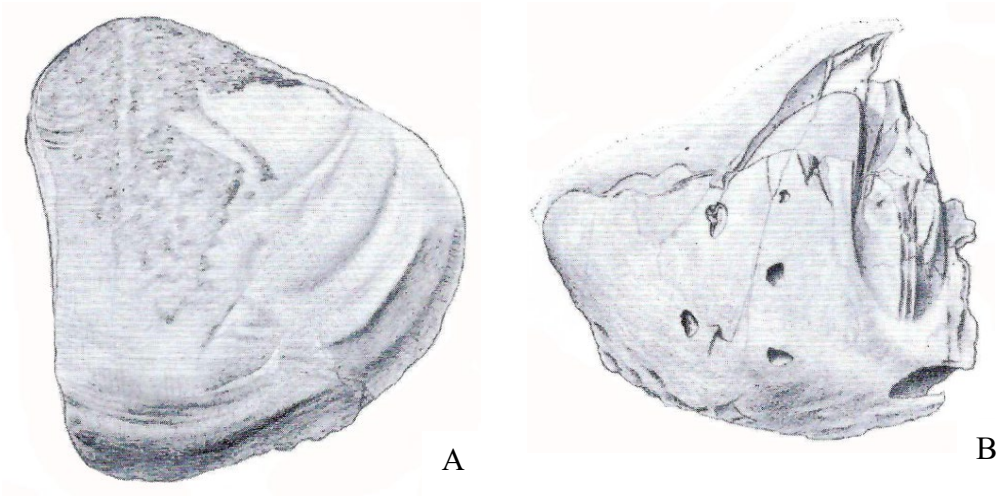


Fig. 43. *Martiniopsis patella* Waterhouse. A, partly decorticated ventral valve holotype, BR 827. B, ventral internal mould BR 829. Specimens x1 from Wairaki Breccia, Southland, New Zealand. (Waterhouse 1967).

Stratigraphy: This species comes from the youngest marine Permian fauna known in New Zealand, placed in the *Wairakella rostrata* Zone, regarded as being of very late Permian (late Changhsingian) age.

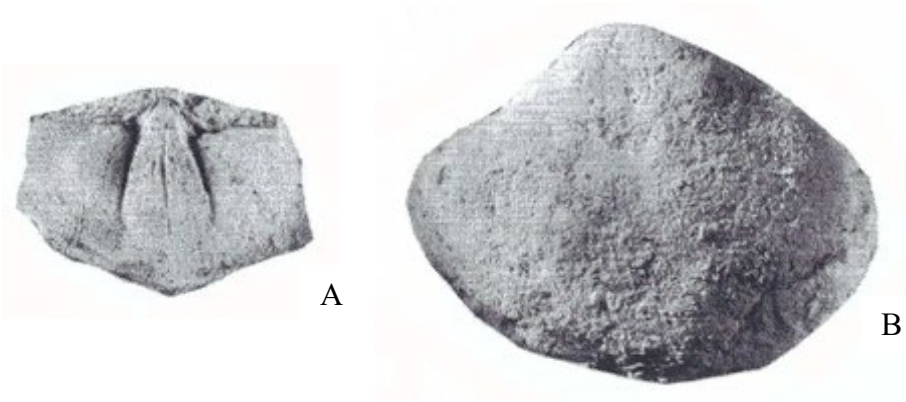


Fig. 44. *Martiniopsis patella* Waterhouse. A, dorsal internal mould, BR 2393. B, ventral valve OU 18288. Specimens x1 from Wairaki Breccia, Southland, New Zealand. (Waterhouse 1967)

Genus ***Tigillumia*** Waterhouse, 1998

Diagnosis: Shells of moderate size, subequilateral, may be smooth or with low plicae, fold and sulcus variably defined. Characterized by long closely spaced adminicula and tigillum, as well as tabellae.

Type species: *Martiniopsis biparallela* Waterhouse, 1987 from Brae Formation, southeast Bowen Basin, Queensland, OD.

Tigillumia adminiculata (Waterhouse, 1982)

Fig. 45

1964 *Martiniopsis* n. sp. Waterhouse, p. 147, pl. 30, fig. 1, 2, text-fig. 70.
1982 *M. adminiculata* – Waterhouse, p. 56.

Diagnosis: Subglobular broadly but almost imperceptibly sinuate shells with rounded outline, long closely spaced adminicula and tigillum, tabellae of moderate length and well-spaced, divergent.

Holotype: BR 603 from Brunel Formation, Takitimu Mountains, figured by Waterhouse (1964, pl. 30, fig. 1, 2, text-fig. 70) and Fig. 45A, B herein, OD.

Stratigraphy: The species is limited to the Brunel Formation in the *Notostrophia zealandicus* Zone, a little older than the *N. homeri* Zone in the overlying Brunel Formation which is equivalent to the *Echinalosia preovalis - Ingelarella plana* Zone of Aktastinian age in the upper Cattle Creek, Roses Pride and other levels in the Bowen Basin. There is as yet no known marine equivalent in east Australia for the *Notostrophia zealandicus* Zone.

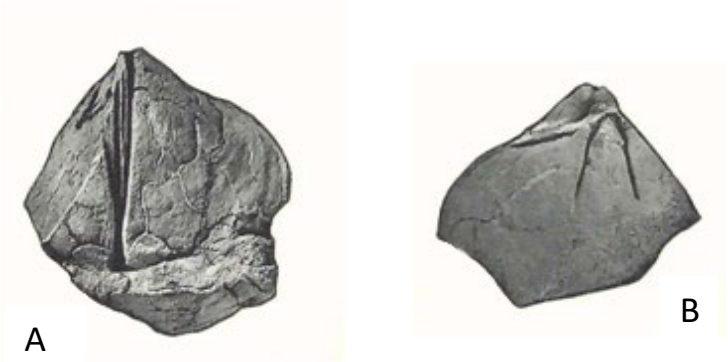


Fig. 45. *Tigillumia adminiculata* (Waterhouse). A, B, ventral and dorsal aspects of holotype, BR 603 from Brunel Formation, New Zealand, x1. (Waterhouse 1964).

Tigillumia biparallela (Waterhouse, 1987)

Fig. 46, cf. 47

cf. 1983 *Ingelarella mantuanensis* [not Campbell] – McClung, p. 64, Fig. 7.3, 4 (part, not Fig. 8.1-8 = *I. canalis*).

1987 *Martiniopsis biparallela* Waterhouse, p. 25, pl. 6, fig. 8-11, 13-15.
1998 *Tigillumia biparallela* Waterhouse, p. 26.
2007 *T. biparallela* - Carter in Gourvennec & Carter, p. 2779, Fig. 1858.3a,b.

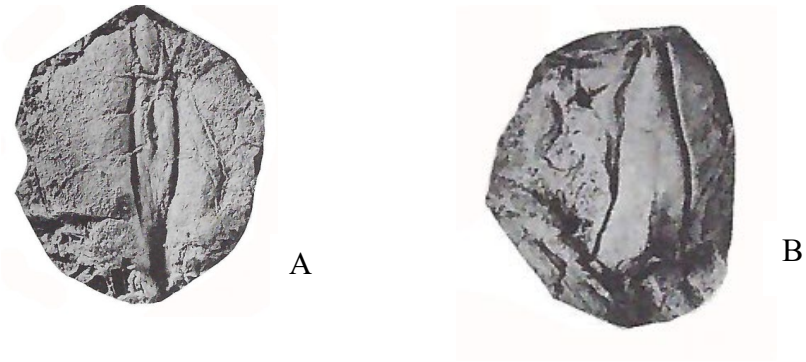


Fig. 46. *Tigillumia biparallela* Waterhouse. A, ventral internal mould UQF 70310. B, dorsal internal mould UQF 70138. Specimens x1.5 from Brae Formation, southeast Bowen Basin. (Waterhouse 1987**).**

Diagnosis: Largely non-plicate shells with only a very shallow if any ventral sulcus, long and closely spaced adminicula and unusually long tabellae, tigillum or rod of thickening in front of ventral muscle field well developed.

Holotype: UQF 70134 figured in Waterhouse (1987, pl. 6, fig. 9) from Brae Formation, southeast Bowen Basin, Queensland, OD.

Morphology: This species differs from *Tigillumia adminiculata* through its slightly higher dorsal fold and longer and more closely spaced tabellae. There is considerable similarity to fragments figured as *Ingelarella mantuanensis* [not Campbell] by McClung (1983, Fig. 7.3, 4) from level E of the Eddystone 1 core, as Fig. 47.

Stratigraphy: The species is found in the Brae Formation, of Kungurian age, and appears to be represented at level E in the Eddystone GSQ core in the southwest Bowen Basin.

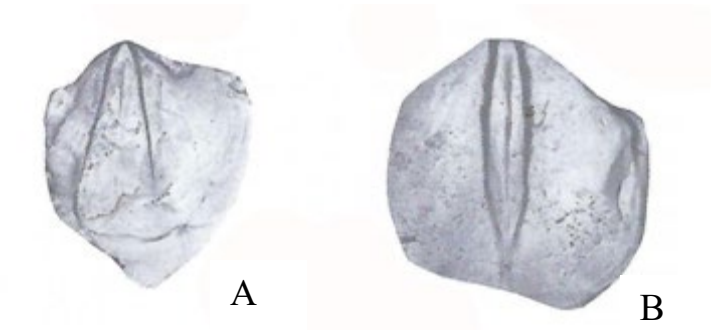


Fig. 47. *Tigillumia* sp. indet. A, dorsal internal mould GSQF 12506. B, internal mould GSQF 12508. Specimens x1 from interval E, Eddystone 1, Queensland. (McClung 1983).

Tigillumia confusa (Waterhouse, 1968)

Fig. 48B, 49, 50, aff. 48A, C

1968 *Ambikella confusa* Waterhouse, p. 60, pl. 10, fig. 9-12; pl. 15, fig. 3; pl. 18, fig. 1, text-fig. 7B. (part, pl. 10, fig. 7, pl. 14, fig. 9, pl. 15, fig. 7 = aff. *confusa*).
1987 *Tomiopsis ingelarensis confusus* – Waterhouse, p. 32, pl. 9, fig. 4-7, 9, 12.
2002 *Ingelarella ingelarensis confusus* Waterhouse, Table 8, p. 48.

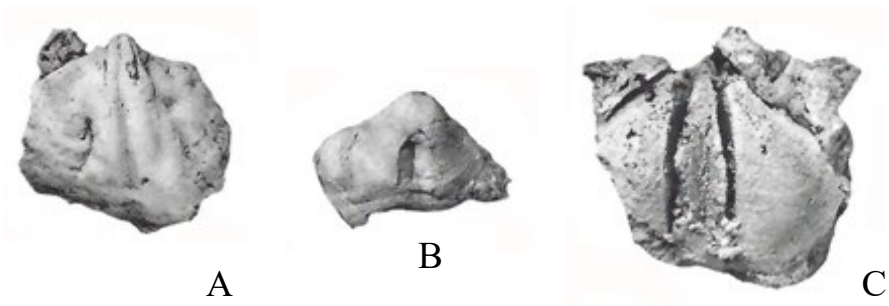


Fig. 48. *Tigillumia* aff. *confusa* (Waterhouse). A, internal mould of ventral valve BR 978. C, internal mould of ventral valve, BR 1327. Specimens x2 from middle Letham Formation, New Zealand. B, *T. confusa* (Waterhouse), PVC external cast of umbonal portion of holotype, BR 593 x 2 from Letham Burn Member, New Zealand. (Waterhouse 1968).

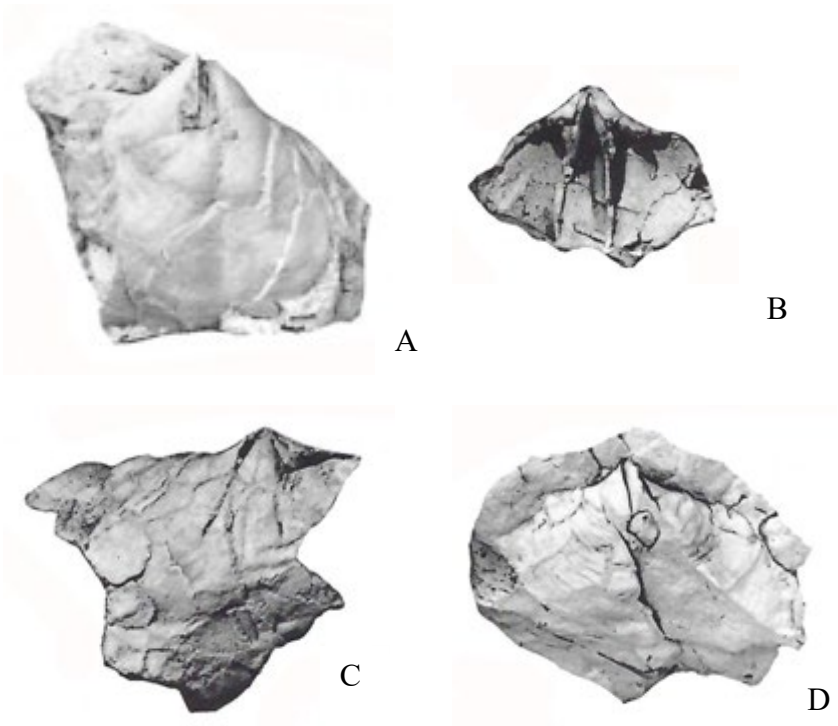


Fig. 49. *Tigillumia confusa* (Waterhouse). A, ventral valve BR 592. B, PVC cast of ventral valve, holotype BR 593. C, internal mould of dorsal valve, BR 594. D, internal mould of dorsal valve BR 838. Specimens x2, from Letham Burn Member, New Zealand. (Waterhouse 1968).

Diagnosis: Small to medium-sized shells, distinguished by the broad ill-defined ventral sulcus bearing median depression variably defined as a groove or channel, very low broad dorsal fold, no plicae as a rule. Adminicula moderately long, subparallel, tabellae of moderate length and divergent but closely spaced.

Holotype: BR 593 figured by Waterhouse (1968, pl. 10, fig. 10, pl. 15, fig. 3) and herein as Fig. 48B, 49B from Letham Burn Member, basal Mangarewa Formation, New Zealand, OD.

Morphology: The medianly grooved ventral sulcus, close-set moderately long adminicula and long diverging tabellae are features which distinguish distinguish this species. Specimens from the Oxtrack Formation of the southeast Bowen Formation are larger with signs of very low plicae, and have broad less well defined ventral sulcus, and longer adminicula, though they are close in many respects.

Specimens from the middle Letham Formation that were initially assigned to *confusa* in Waterhouse (1964) are distinguished by the narrow well-formed channel along the length of the ventral valve, as shown in Fig. 48A.

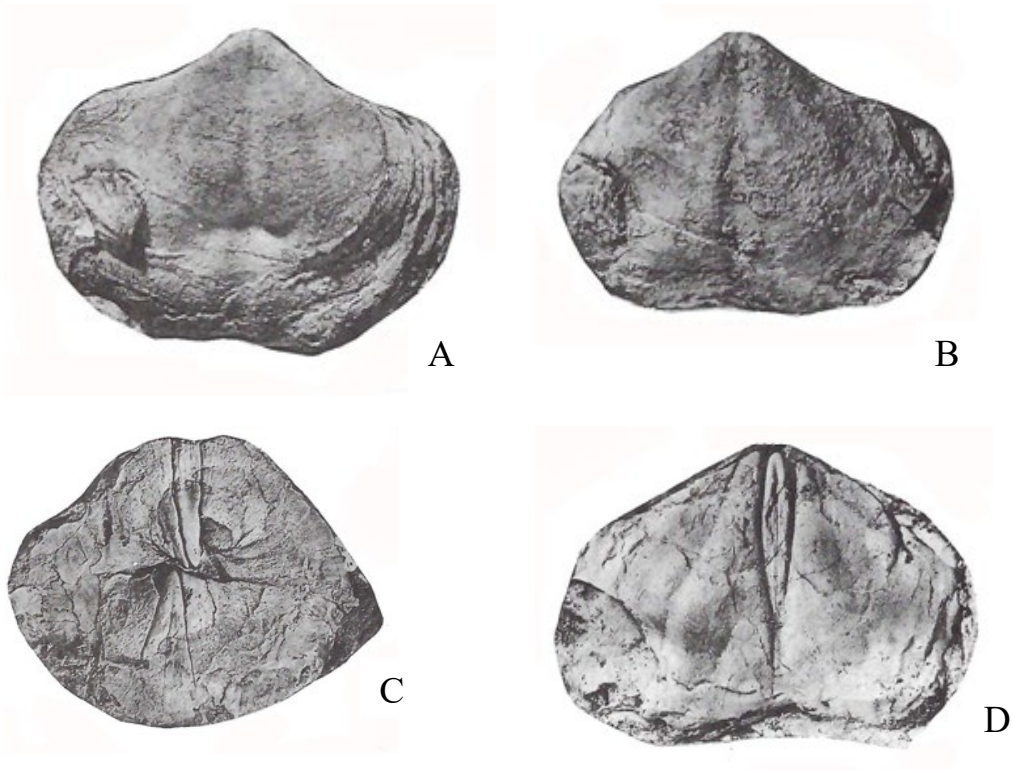


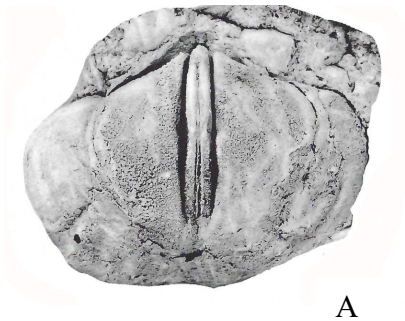
Fig. 50. *Tigillumia confusa* (Waterhouse). A, latex cast of ventral valve, UQF 70745, x1, holotype. B. ventral valve UQF 70651, x1. C, internal mould of specimen UQF 70635 showing splayed dorsal valve and ventral valve, x1.5. D, ventral internal mould UQF 70635 x0.8. Oxtrack Formation. (Waterhouse 1987).

Stratigraphy: The type specimens are found in the *Echinalosia maxwelli* Zone in New Zealand. Older specimens from the middle Letham Formation in the *Wyndhamia typica* Zone (see Fig. 48A, C) initially included in the species were later mistakenly referred to what is now treated as *Tumulosulcus undulosa* in Waterhouse (1998, p. 13), but they are here regarded as aff. *confusa*, distinguished by their better formed median ventral channel and lack of sulcal swelling. Specimens closely allied to type *confusa* are found in the Oxtrack Formation of the southeast Bowen Basin in Queensland.

Tigillumia parallela (Waterhouse, 1964)

Fig. 51

1964 *Ingelarella parallela* Waterhouse, p. 166, pl. 32, fig. 9, 13, 15; pl. 35, fig. 7; pl. 36, fig. 1.
1968 *Ambikella parallela* – Waterhouse, p. 71, pl. 13, fig. 3, 5, 6; pl. 14, fig. 7 (part, not fig. 8 = *calamata*).
1969 *A. mantuanensis* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 9-12.
1978 *A. mantuanensis* – McClung, p. 53.
1998 *Tigillumia parallela* – Waterhouse, p. 28.
2010 *Ambikella parallela* – Shi et al., Fig. 8C.
2015b *T. parallela* – Waterhouse, pp. 98, 143, Fig. 31E-G, 51.
2016 *T. parallela* – Waterhouse, p. 75, Fig. 70B (part, not 70A = *Ingelarella subplicata*).



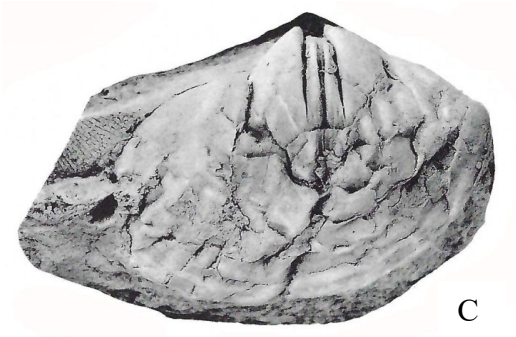


Fig. 51. *Tigillumia parallel*a (Waterhouse). A, internal mould of ventral valve BR 1215, x1. B, dorsal aspect of deformed internal mould BR 1213, x2. C, ventral internal mould BR 1209, x1.5. From Kildonan Member, Arthurton Group, north Otago. (Waterhouse 1968)

Diagnosis: Moderately large and transverse, distinguished by transverse shape and presence

of low plicae in a number of specimens. Long closely spaced adminicula and long tabellae, ventral adductors narrow and sited on the crest of a narrow ridge.

Holotype: BR 633 figured by Waterhouse (1964, pl. 32, fig. 9) from Kildonan Member, Bagrie Formation, Arthurton Group, north Otago, New Zealand, OD.

Morphology: This is a distinctive species well represented by numerous specimens.

Stratigraphy: The species is found in the Kildonan Member of the Bagrie Formation in north Otago, New Zealand, and in the South Curra Limestone of southeast Queensland.

Supposed *Tigillumia* appears to be productiform

Fig. 52

1999 *Tigillumia mintyi* Waterhouse, p. 22, fig. 1a-d.
2001 *T. mintyi* – Waterhouse, p. 99, pl. 7, fig. 6 (part, not fig. 7-11 = *T. calamata*).

A specimen from Wairaki Downs of New Zealand that was named *Tigillumia mintyi* appears to be productiform, given the presence of somewhat regularly disposed swellings over the entire shell, The genus is uncertain. The holotype, OU 18289 figured by Waterhouse (1999, text-fig. 1a) and Waterhouse (2001, pl. 6, fig. 6) comes from the Hilton Limestone, *Spinomartinia spinosa* Zone, Wairaki Downs, New Zealand, OD. The species is now regarded as suspect, perhaps a productidan, possibly *Echinalosia denmeadi* (2015b, pp. 84, 140), from the Gympie region of Queensland, though with deeper sulcus.

Fig. 52. "*Tigillumia*" *mintyi* Waterhouse, ventral valve OU 18269 x2, holotype. (Waterhouse 2001).

Tigillumia calamata n. sp.

Fig. 53, 54

1968 *Ambikella parallela* [not Waterhouse] – Waterhouse, p. 73, pl. 14, fig. 8 (part, not pl. 13, fig. 3, 5, 6, pl. 14, fig. 7 = *parallela*).
1969 *A. mantuanensis* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 10 (part, not fig. 9, 11, 12 = *planeria* n. sp.).

2001 *T. mintyi* [not Waterhouse] – Waterhouse, p. 99, pl. 7, fig. 7-11 part, not fig. 6 = productidan).

Derivation: calamatas – misfortune (Lat.).

Diagnosis: Small transverse shells with moderately prominent beaks, shell smooth or with shallow anterior sulcus which may be groove-like. Adminicula close-set and moderately spaced for the genus.

Holotype: BR 18298 figured by Waterhouse (2001, pl. 7, fig. 7) and herein as Fig. 53B, from Hilton Limestone, *Spinomartinia spinosa* Zone, New Zealand, here designated.

Stratigraphy: This species is found in the Hilton Limestone of Changhsingian age, and in a boulder found in the Takitimu Range that has a similar fauna and presumably was derived from a similar source. Near Gympie in southeast Queensland, one of the specimens assigned to *Ambikella mantuanensis* by Runnegar & Ferguson (1969) has closely spaced but comparably short adminicula as in the present species (Fig. 53D).

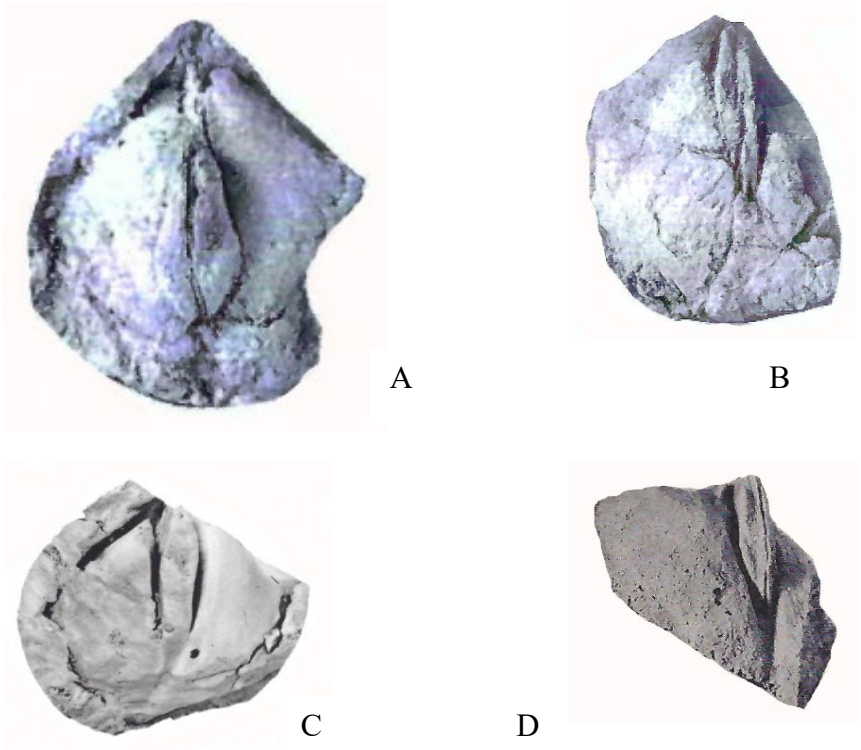


Fig. 53. *Tigillumia calamata* n. sp. A, ventral internal mould OU 18294, x1.5. B, ventral internal mould OU 18298 x2, holotype. Hilton Limestone, Wairaki Downs. C, ventral internal mould, OU 2473 x1 from Tertiary boulder, Southland. (Waterhouse 1968). D, ventral internal mould UQF 45584 x 1 from South Curra Limestone, Gympie (Runnegar & Ferguson 1969).

Fig. 54. *Tigillumia calamata* n. sp., dorsal internal mould OU 18297, x2, corrected from published caption. From Tertiary boulder derived from *Spinomartinia spinosa* Zone, Southland. (Waterhouse 1968).

Tigillumia planeria n. sp.

Fig. 55

1969 *Ambikella mantuanensis* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 9, 11, 12.
1987 *Tomiopsis* n. sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 16, 17.
2015b *T. mintyi* [not Waterhouse] – Waterhouse, p. 114, Fig. 41A-C.

Derivation: planus – level, plane, (Lat.)

Diagnosis: Small transverse shells, shell smooth or with shallow anterior sulcus which may be groove-like. Adminicula and tabellae longer and more close-set than in other species.

Holotype: UQF 47262 figured by Waterhouse (2015b, Fig. 41C) and Fig. 54B herein, from South Curra Limestone, Queensland, here designated.

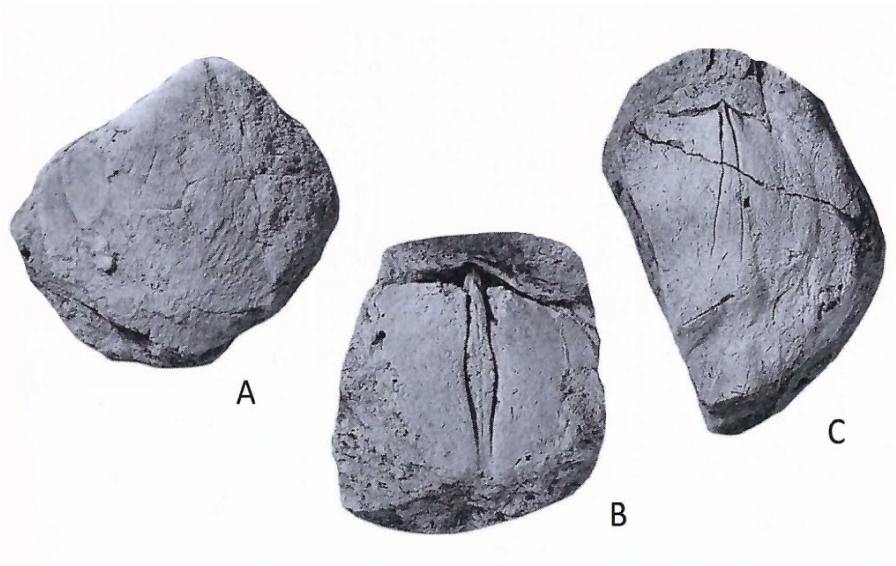


Fig. 55. *Tigillumia planeria* n. sp. A, ventral exterior UQF 47263. B, ventral internal mould UQF 47262, holotype. C, dorsal internal mould UQF 47264. Specimens x0.75, from South Curra Limestone, Gympie. (Runnegar & Ferguson 1969).

Morphology: This species is close in appearance to *Tigillumia biparallela* from the Brae Formation of the southeast Bowen Basin, but has more secondary thickening around the umbonal region of the ventral valve, more prominent ventral umbo, and greater inflation. The adminicula are longer and more closely set and converge anteriorly.

Stratigraphy: The species is limited to to the upper South Curra Limestone of Gympie, and is of the same age as *Tigillumia calamata* (formerly *mintyi*), but has internal plates that are longer and closer to each other, in a less inflated shell.

Genus ***Tweedaleia*** Waterhouse, 2010

Type species: *Tweedaleia tweedalei* Waterhouse, 2010, p. 71 from middle Tiverton Formation, Queensland, OD.

Diagnosis: Distinguished by reduced adminicula and low or even apparent lack of tabellae from dorsal interior. Fold with rounded crest, plicae low or absent.

Discussion: *Tweedaleia* is an outstanding genus amongst Ingelarellidae, because adminicula and tabellae are reduced or lacking. In other respects, to judge from shape, micro-ornament and ventral interior, the genus has evolved from east Australian species allocated to *Ambikella*, and it is likely but not yet proven that the adminicula were very short and have been buried in secondary thickening. The tabellae are apparently absent from a number of specimens, but in some specimens are represented by a very low ridge, as suggested in Fig. 56E. The large size and lack of plicae help indicate that the genus is not notospiriferid.

Tweedaleia tweedalei Waterhouse, 2010

Fig. 56, 57

2010 *Tweedaleia tweedalei* Waterhouse, p. 71, Fig. 31, 32, corrected from Waterhouse 2015a, p. 178.
2015a *T. tweedalei* Waterhouse, p. 178, Fig. 130A, 131C, D, F.
2016 *T. tweedalei* – Waterhouse, p. 78, Fig. 80.

Diagnosis: Specimens with short adminicula buried in secondary shell and reduced tabellae, unusually high fold. Sulcus very shallow or absent over the umbo.

Holotype: Specimen UQF 81340 from Tiverton Formation, figured in Waterhouse (2010, Fig. 31C, D, F, 32A; 2015a, Fig. 130A, 131C, D, F), as well as Fig. 56A, B, C and Fig. 57A herein, OD.

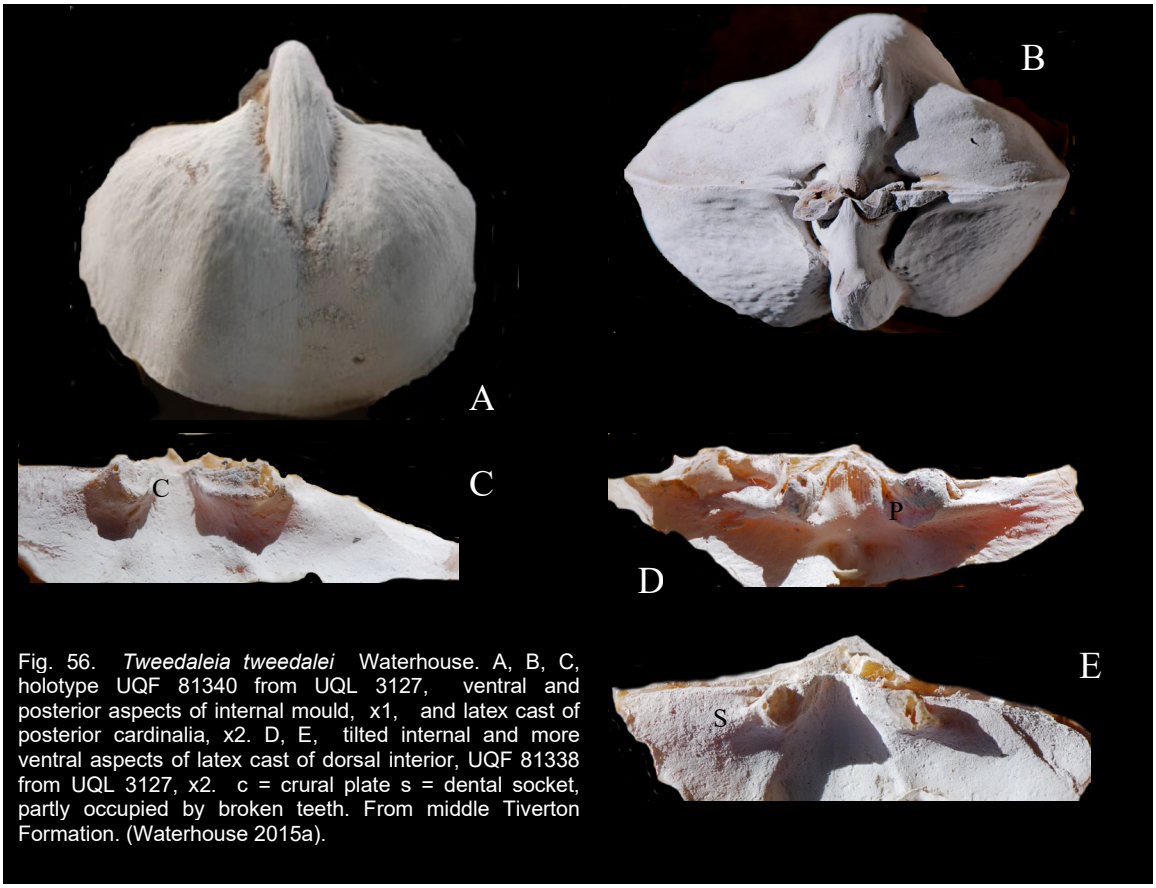


Fig. 56. *Tweedaleia tweedalei* Waterhouse. A, B, C, holotype UQF 81340 from UQL 3127, ventral and posterior aspects of internal mould, x1, and latex cast of posterior cardinalia, x2. D, E, tilted internal and more ventral aspects of latex cast of dorsal interior, UQF 81338 from UQL 3127, x2. c = crural plate s = dental socket, partly occupied by broken teeth. From middle Tiverton Formation. (Waterhouse 2015a).

Morphology: The substantially reduced adminicula and tabellae marks a most distinctive genus. The shell thus has come to mimic *Martinia* and allies, but there remain vestiges of the tabellae, and the micro-ornament is like that of Ingelarellidae: indeed the form could be treated as a subgenus of *Ambikella*.

Stratigraphy: The species is found only in the middle Tiverton Formation.

Fig. 57. *Tweedaleia tweedalei* Waterhouse. A, dorsal aspect of holotype UQF 81340, x1. B, dorsal valve UQF 81341, x1. From middle Tiverton Formation. (Waterhouse 2015a).

Genus ***Validifera*** Waterhouse, 2015a

Diagnosis: Plicate shells with adminicula that are placed well apart and diverge widely. Tabellae moderately developed, subparallel.

Type species*: Ingelarella valida* Campbell, 1961, p. 177 from Tiverton Formation, OD.

Discussion: The well-spaced adminicula and consequently broad ventral adductor scars are unusual amongst Ingelarellidae. The genus is yet another form to be regarded as an offshoot from *Ambikella*, and arguably should be regarded as a subgenus of that genus. Material has been described from Permian faunas in Queensland and New South Wales, and the type species reported from Tasmania by Clarke & Farmer (1976), though the latter report is yet to be substantiated through description and illustration.

Validifera prima Waterhouse, 2015a

Fig. 58

1983 *Tomiopsis elongata* [not McClung & Armstrong] – Waterhouse, Briggs & Parfrey, p. 134, pl. 3, fig. 5 (part, not fig. 8, 9, 10, 13 = *regina*).
1992 *T. branxtonensis* [not Etheridge] - Clarke, p. 23 (part, also *Ambikella regina*).
2015a *Validifera prima* Waterhouse, p. 176, Fig. 128, 129.

Diagnosis: Small, transverse with high rounded fold and deep sulcus, three to five pair of plicae, adminicula of moderate length, somewhat divergent and well-spaced, tabellae of medium length to long, subparallel, heavy secondary thickening of posterior shell.

Holotype: UQF 81309 from lower Tiverton Formation (Waterhouse 2015a, Fig. 128), and herein as Fig. 57A-C, OD.

Morphology: Clarke (1992) supported by Cisterna & Shi (2014, p. 540) maintained that Tiverton specimens misidentified by Waterhouse in Waterhouse, Briggs & Parfrey (1983) as "*Tomiopsis elongata*" not McClung & Armstrong belonged to the species *branxtonensis*, as indeed was accepted in Waterhouse (2015a). But one of those specimens in Waterhouse, Briggs & Parfrey (1983, pl. 3, fig. 5) has widely spaced ventral adminicula and much longer tabellae, and is included in the present species. The other specimens are placed in *Ambikella regina* rather than Etheridge's species. Compared with *Validifera valida*, the inner ventral plicae are less prominent and adminicula less divergent and adductor scars smaller.

Stratigraphy: The species is found in the lower Tiverton Formation of the northern Bowen Basin.

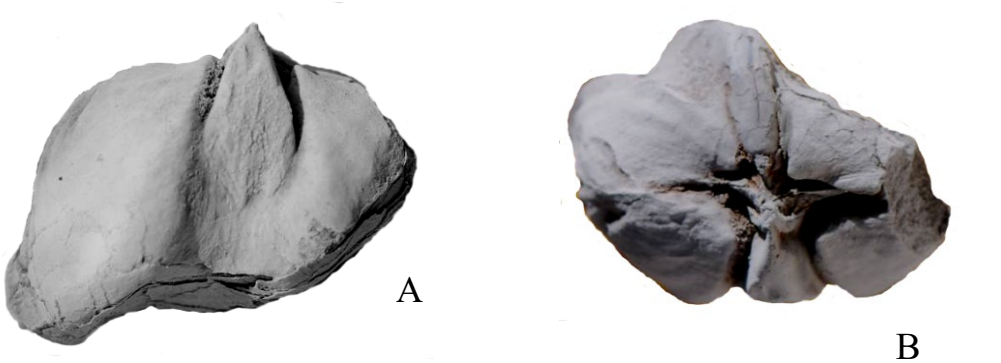
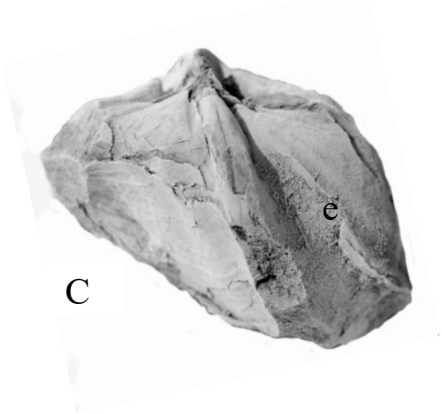


Fig. 58. *Validifera prima* Waterhouse. A, B, C, holotype, ventral, posterior, and dorsal views of internal mould UQF 81309, x1, dorsal valve on top. Lower Tiverton Formation. (Waterhouse 2015a).



Validifera valida (Campbell, 1961)

Fig. 59, 60

1961 *Ingelarella profunda valida* Campbell, p. 177, pl. 28, fig. 14, 15.
1987 *Tomiopsis profunda valida* – Waterhouse, p. 30, pl. 8, fig. 10, 11.
2015a *Validifera valida* – Waterhouse, p. 174, Fig. 124-127.

Diagnosis: Large shells with well spaced adminicula, sulcus and low lateral plicae, especially in the dorsal valve, long tabellae, widely spaced adminicula.

Fig. 59. *Validifera valida* (Campbell), dorsal aspect of internal mould UQF 81444 from the Tiverton Formation, x2. (Waterhouse 2015a)

Holotype: UQF 21918 from middle Tiverton Formation (Campbell (1961, pl. 28, fig. 14), OD.

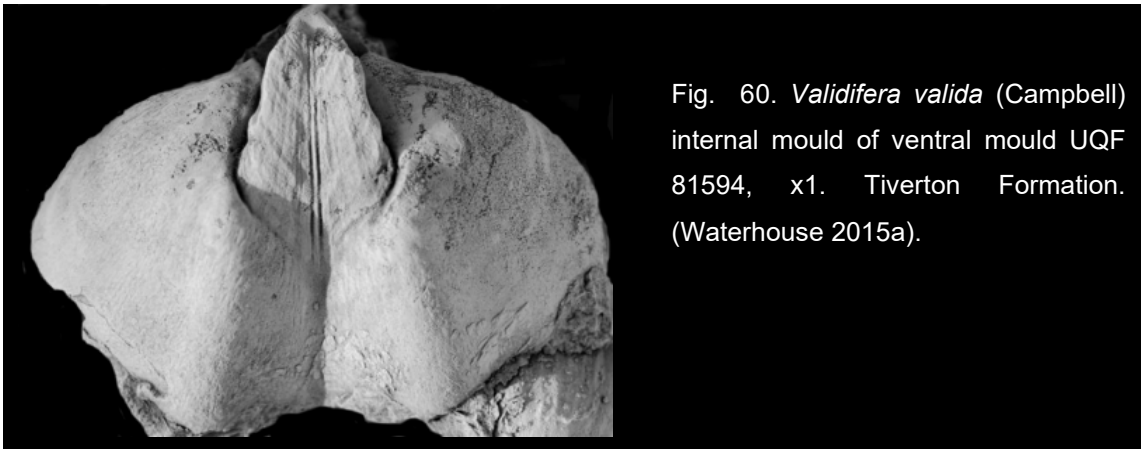


Fig. 60. *Validifera valida* (Campbell) internal mould of ventral mould UQF 81594, x1. Tiverton Formation. (Waterhouse 2015a).

Morphology: The species is large with deep and wide sulcus and few or no lateral plicae on the ventral valve.

Stratigraphy: The species occurs in the *Capillonia armstrongi* band and *Taeniothaerus subquadratus* Zone of the upper middle Tiverton Formation.

Validifera? sp.

2015b *Validifera*? sp. Waterhouse, p. 143, Fig. 60A.

A poorly preserved ventral valve from the Gundiah Bridge Greywacke of C. D. Brown (1964) in the Gigoomgan area near Gympie of southeast Queensland possibly belongs to *Validifera.* This unit is of Changhsingian age.

Tribe **JOHNDEARIINI** Waterhouse, 2016

[Johndearini Waterhouse 2016, p. 76].

Diagnosis: Large subquadrate or rounded shells with minor or no plication, heavy posterior thickening, sulcus commences well in front of the umbonal tip and may be tumulate in some genera, adminicula and tabellae well-spaced and of short to moderate length. Permian, limited to east Australia and New Zealand.

Genera: *Johndearia* Waterhouse, *Oviformia* Waterhouse and *Tumulosulcus* Waterhouse.

Genus ***Johndearia*** Waterhouse, 1998

Diagnosis: Medium to large in size, transverse, with wide hinge and heavy posterior thickening, especially for ventral valve. Plicae low or absent, sulcus may be poorly defined,

subplicae rarely present, no median swelling, fold subdued with crest rounded as a rule, channelled to varying degree. Internal plates short and well-spaced.

Type species: *Ingelarella isbelli* Campbell, 1961 from the lower Blenheim Formation of north Bowen Basin, OD.

Discussion: *Johndearia* Waterhouse (1998, p. 19) is represented by a few species in east Australia and later spread to New Zealand. Although it possibly evolved from *Validifera*, as suggested by some specimens of *Validifera* which have a sulcus commencing some distance in front of the umbonal tip (see Waterhouse 1987, pl. 8, fig. 11), most species have a channelled fold, suggesting descent form *Ingelarella*.

Johndearia brevis (McClung & Armstrong, 1975)

Fig. 61, cf. 62 - 64

cf. 1901 *Spirifer* (*Martinia*) *subradiatus* Morris – Frech, pl. 57c.
cf. 1964 *Ingelarella* sp. A Waterhouse, p. 157, pl. 31, fig. 4, 5.
1968 *Ambikella* cf. *ingelarensis* [not Campbell] – Waterhouse, p. 60, text-fig. 6B.
1975 *Martiniopsis brevis* McClung & Armstrong, p. 232, fig. 2.
1975 *M. brevis* – Runnegar & McClung, p. 432, 433, Fig. 31.1, fig. 26, 27.
1978 *Ingelarella brevis* – McClung, p. 46, pl. 2, fig. 20, 21, pl. 5, fig. 2-9, pl. 6, fig. 1-12, pl. 7, fig. 1-13.
cf. 1981 *Martiniopsis* (*Ambikella*) *ingelarensis* [not Campbell] – Dickins, p. 31, pl. 4, fig. 20-24, pl. 5, fig. 2-12, 14- 17 (part, not pl. 5, fig. 1, 13 = *Tumulosulcus cessnockensis*).
cf. 1998 *Tomiopsis* (*Johndearia*) sp. aff. *brevis*? – Waterhouse, p. 19.
2002 *Johndearia brevis* – Waterhouse, p. 34.
2023 *J. brevis* – Lee in Lee et al., p. 18, Fig. 6, 6N, 8, 9E, H?, 10 (part, not Fig. 11A-N = *Tumulosulcus undulosa*).

Diagnosis: Transverse shells with wide hinge, sulcus shallow and fold low, rounded or rarely with shallow median channel, adminicula short and well-spaced, tabellae usually short, diverge widely, becoming weakly divergent or subparallel anteriorly.

Holotype: UNEF 142112 figured by McClung (1978, pl. 5, fig. 5) and herein as Fig. 61B, from Elderslie Formation, north Sydney Basin, OD.

Morphology: McClung (1978) figured an array of specimens, showing the species variation.

Stratigraphy: The species is reported extensively from the Elderslie Formation of the north Sydney Basin and Snapper Point Formation of the south Sydney Basin, with one specimen (McClung 1978, pl. 6, fig. 11) figured from the Fenestella Shale in the south Sydney Basin.

Material described by Dickins (1981) and partly refigured herein as Fig. 63 and 64 may prove to belong to *Johndearia brevis*, being similar in shape and close in internal plates. Admittedly the smaller dorsal valves as shown in Fig. 79, p. 106 herein are not matched

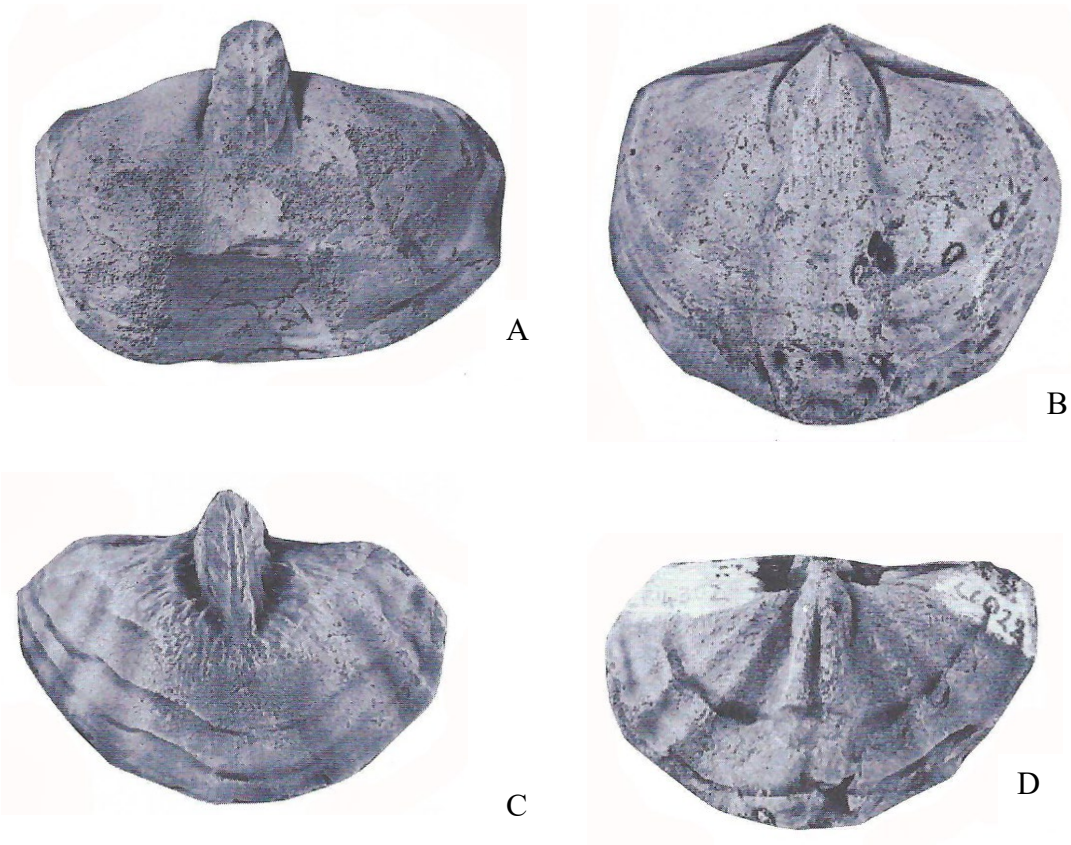


Fig. 61. *Johndearia brevis* (McClung & Armstrong). A, ventral internal mould, UNEF 12216. B, dorsal internal mould UNEF 14212, holotype. C, ventral internal mould UNEF 14265. D, dorsal internal mould UNEF 14302. Specimens x1 from Elderslie Formation, north Sydney Basin. (McClung 1978).

by the large range of shells figured as *brevis* by McClung (1978), because these have an upstanding conspicuous but narrow fold and closely-spaced tabellae, much as in *Tumulosulcus cessnockensis* (McClung, 1978) as outlined shortly. It seems that two species were represented in the suite figured by Dickins (1981). If they were conspecific, then it appears that the tabellae have moved further apart with growth, which does not seem to be normal for the development of brachiopod species. The suite was described from Warwick near the Queensland border with New South Wales, in an area with diverse faunas and in need of detailed mapping and competent paleontological study.

A specimen (Fig. 62) from the middle Letham Formation, in the *Wyndhamia typica* Zone at Wairaki Downs, New Zealand, might prove to be related (Waterhouse 1998). It differs from many of the Australian specimens, but does have plicae and tabellae close to the dorsal

fold as in some of the specimens figured from the Elderslie Formation by McClung (1978, pl. 6, fig. 3, pl. 7, fig. 5, 11).

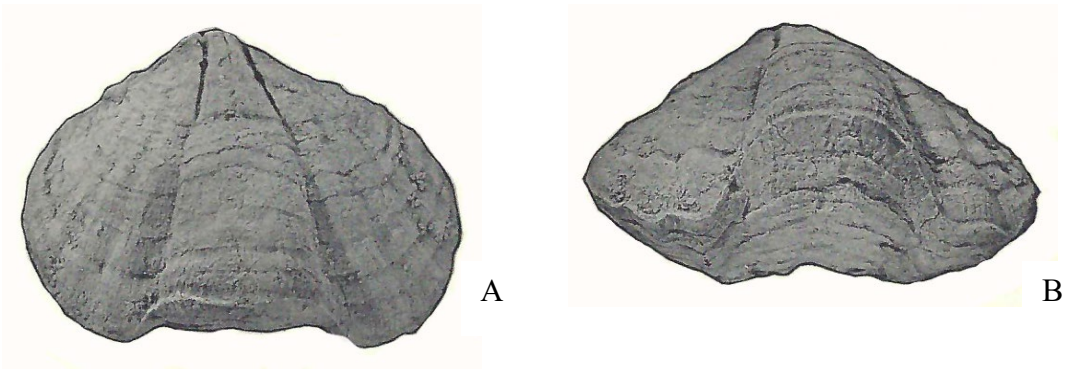


Fig. 62. *Johndearia* cf. *brevis* (McClung & Armstrong), dorsal and anterior aspects of internal mould BR 830, x1, from mid-Letham Formation, Wairaki Downs, New Zealand. (Waterhouse 1964).

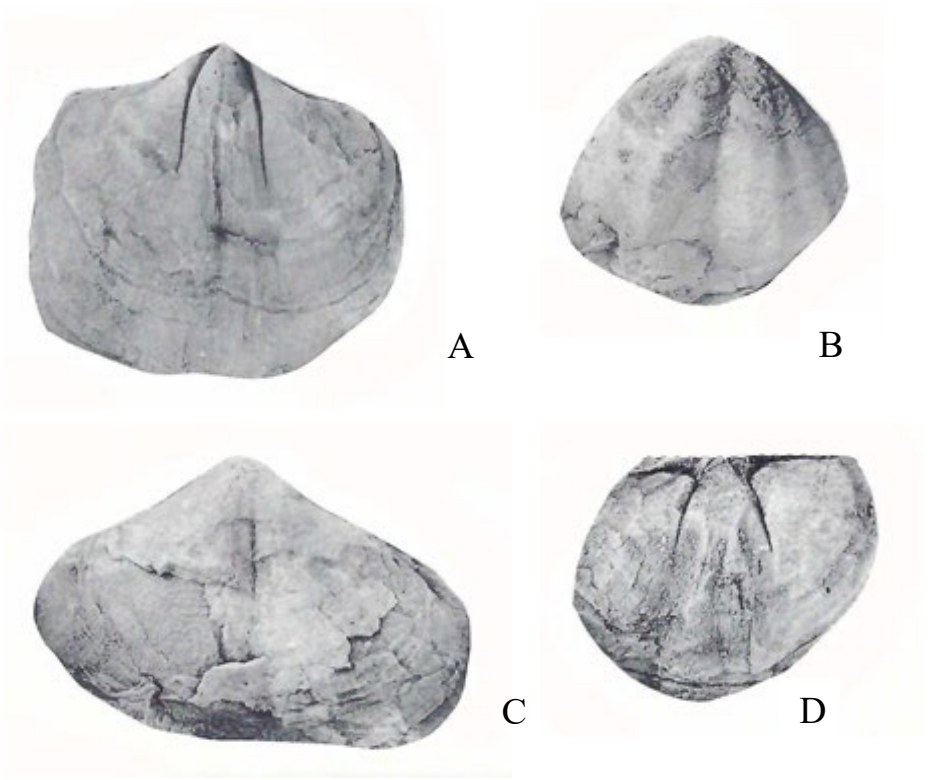


Fig. 63. *Johndearia* cf. *brevis* (McClung & Armstrong), A, dorsal internal mould CPC 20188. B, ventral valve CPC 20184. C, ventral valve CPC 20185. D, dorsal valve CPC 20186. Specimens x1, from Warwick. (Dickins 1981).

Specimens that are possibly comparable to *brevis*, sulcate without subplicae or median groove, and with no plicae over the lateral shell, come from the middle Letham Formation in New Zealand. They have short well-spaced adminicula, and apart from one incomplete example (Waterhouse 1968, text-fig. 6B), have not been figured. In addition, there is some approach to material figured by Frech (1901, pl. 57c) from grey limestone in Tasmania, kept at the Hamburg Museum, and called *Spirifer* (*Martinia*) *subradiatus* Morris. The specimens figured in Frech (1901) are transverse with broad sulcus, and faint or no plicae.

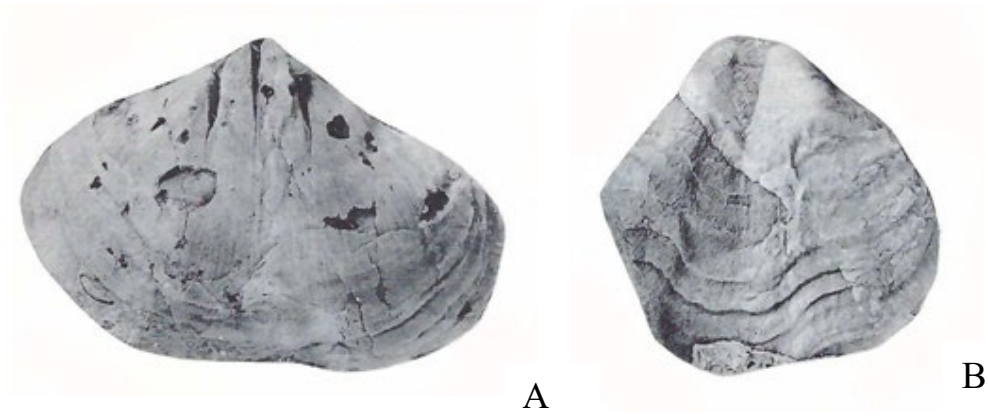


Fig. 64. *Johndearia* cf. *brevis* (McClung & Armstrong). A, internal mould CPC 20181. B, ventral valve CPC 2082. Specimens x1.8 from Warwick. (Dickins 1981).

Johndearia isbelli (Campbell, 1961)

Fig. 65

cf. 1845 *Spirifer subradiatus* Sowerby? – Morris, p. 281, pl. 16, fig. 3.
1961 *Ingelarella isbelli* Campbell, p. 181, pl. 25, fig. 1-5.
1964 *I. isbelli* – Hill & Woods, pl. P9, fig. 5, 6.
1972 *I. isbelli* – Hill et al., pl. P9, fig. 5, 6.
1975 *Martiniopsis isbelli* – Runnegar & McClung, pl. 31.fig. 30, 31.
1978 *I. isbelli* – McClung, p. 52, pl. 2, fig. 26, 27, pl. 5, fig. 10?, pl. 12, fig. 1-6, fig. 7? (part, pl. 5, fig. 10 = *I. singletonensis*?).
1983 *M. isbelli* – Waterhouse & Jell, p. 245, pl. 2, fig. 11, 15.
1987 *Tomiopsis isbelli* – Clarke, p. 275, Fig. 10A-E, 11A-D (part, not Fig. 12A-C = *J. magna*).
1998 *Tomiopsis* (*Johndearia*) *isbelli* – Waterhouse, p. 18.
2007 *Johndearia isbelli* – Carter in Gourvennec & Carter, p. 2778, Fig. 1859.1a,b.
2016 *J. isbelli* – Waterhouse, Fig. 76, p. 77.

Diagnosis: Large subelongate shells distinguished by size and roundly subquadrate shape, with weakly defined medianly v-shaped and wide ill-defined sulcus, fold low with weak median channel in some shells. Heavy posterior thickening. Adminicula short and well spaced, tabellae long and subparallel anteriorly.

Holotype: UQF 25040 figured by Campbell (1961, pl. 25, fig. 2a-c) and Fig. 65B, D herein, from lower Blenheim Formation, north Bowen Basin, OD.

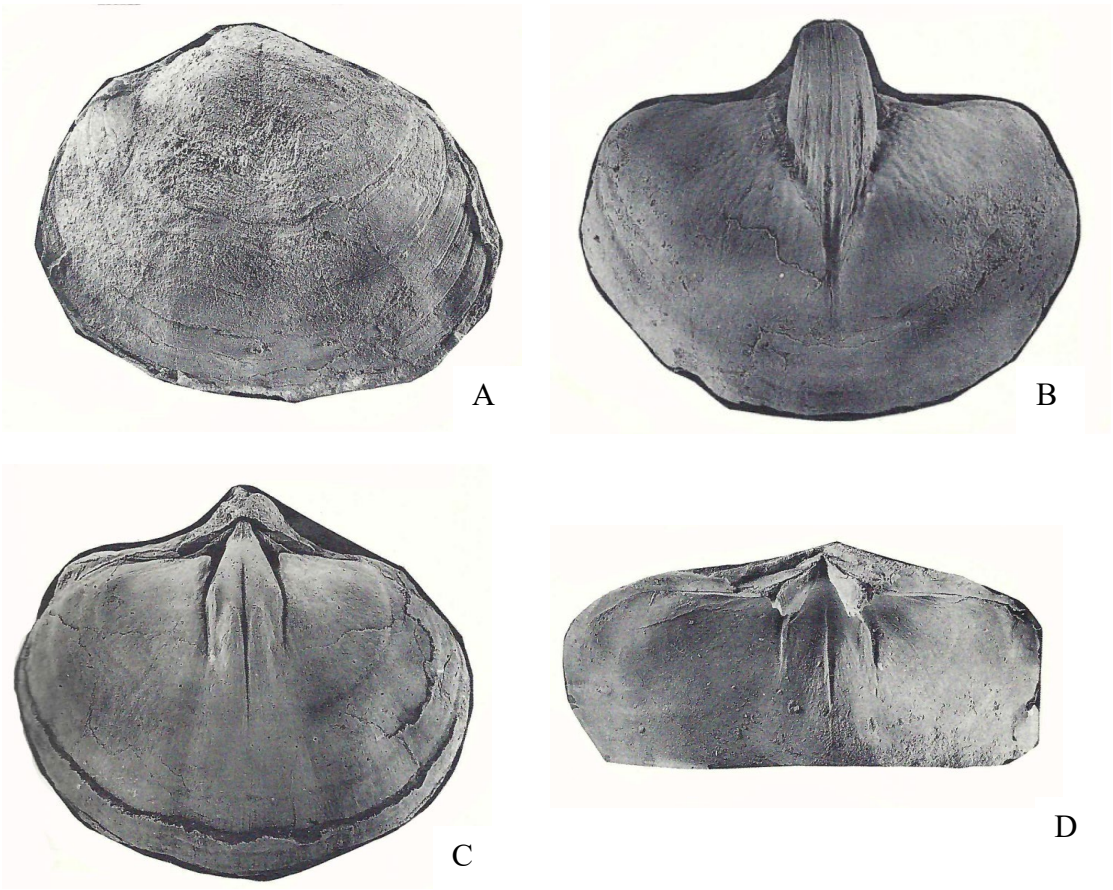


Fig. 65. *Johndearia isbelli* (Campbell). A, latex cast of ventral valve UQF 25126. B, ventral aspect of holotype, UQF 25040, holotype. C, dorsal view of internal mould, UQF 25039. D, latex cast of dorsal interior of holotype. See Fig 65A. Specimens x0.75, from Moonlight Formation, north Bowen Basin. (Campbell 1961).

Morphology: McClung (1978, pl. 5, fig. 10) figured a specimen from the Gerringong Volcanics (pl. 5, fig. 10) that is too incomplete to provide assurance of its specific or generic identity, and only a small part of a Fenestella Shale specimen was figured (pl. 12, fig. 7). Shells from Tasmania show weak channelling in the dorsal fold (Clarke 1987), and the fold is better defined than in the types. Most have a subplicate ventral sulcus, approaching the Bickham and Muree specimens figured from the Sydney Basin by McClung (1978, pl. 12, fig. 1-6).

Some New South Wales specimens were said to be weakly plicate, though none

were illustrated. Although the presence of a shallow channel in the dorsal fold provides a possible distinction from type *isbelli*, Waterhouse & Jell (1983) figured similar specimens from the Moonlight Sandstone of the north Bowen Basin.

Stratigraphy: McClung (1978) stated that *isbelli* was common in the Belford and Muree Formations of the north Sydney Basin, the Bickham and Porcupine Formations of the north-west Sydney Basin, and Nowra and Berry Formations as well as Gerringong Volcanics of the south Sydney Basin, though the figured specimen (McClung 1978, pl. 5, fig. 10) looks more like *Ingelarella singletonensis*. Clarke & Banks (1975) reported the species from the *isbelli* and *ovalis* zones of Tasmania, and many specimens were figured by Clarke (1987). These specimens are somewhat younger than those found in the north Bowen Basin. There is a degree of similarity in Fig. 65C to the figure presented by Morris (1845, pl. 16, fig. 3) from Tasmania, which Morris identified as *Spirifer subradiatus* Sowerby, a species for which none of the original specimens are preserved, nor the source well located. (See Fig. 94, p. 124).

Johndearia pelicanensis (Campbell, 1960)

Fig. 66

1960 *Ingelarella pelicanensis* Campbell, p. 1119, pl. 135, fig. 4, 5, pl. 140, fig. 5.
1964 *I. pelicanensis* – Hill & Woods, pl. P9, fig. 1, 2.
1972 *I. pelicanensis* – Hill et al., pl. P9, fig. 1, 2.
1998 *Tomiopsis* (*Johndearia*) *pelicanensis* – Waterhouse, p. 21.

Diagnosis: Transverse with wide hinge, subdued umbones, very shallow and anterior sulcus, low or imperceptible fold, no plicae. Adminicula and tabellae short and widely spaced, posterior shell heavily thickened.

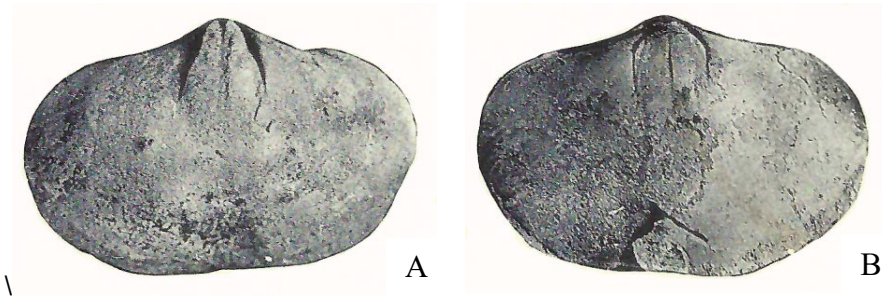


Fig. 66. *Johndearia pelicanensis* (Campbell), ventral and dorsal views of internal mould, UQF 2075, from Pelican Creek fauna, north Bowen Basin, Queensland, x1. (Campbell 1960).

Holotype: GSQ 2078 figured by Campbell (1960, pl. 140, fig. 5a-c) from the Pelican Creek fauna of Dear (1972).

Morphology: Little is known of the variation displayed by this species.

Stratigraphy: The species is limited to the north Bowen Basin, in the Pelican Creek fauna of Dear (1972), classed as coming within the top of the *Echinalosia* (*Unicusia*) *minima* Zone (see Waterhouse 2022c).

Johndearia isbelliformis (Waterhouse, 1978)

Fig. 67

1978 *Tomiopsis isbelliformis* Waterhouse *in* Waterhouse & Mutch, p. 522, text-fig. 12-15, 17, 18.
1998 *T*. (*Johndearia*) *isbelliformis* – Waterhouse, p. 22.
2001 *Johndearia isbelliformis* – Waterhouse, p. 102, pl. 8, fig. 3.
2015b *J. isbelliformis* – Waterhouse, pp. 142, 152, Fig. 60B, 74.

Diagnosis: Transverse shells with wide shallow sulcus, very low dorsal fold with faint median channel in at least some specimens, plicae rarely present. Adminicula short and well-spaced, tabellae also well-spaced and short.

Holotype: BR 2231 figured by Waterhouse (1978, text-fig. 14) and herein as Fig. 67A from the Nemo Limestone at Wether Hill Station, New Zealand, OD.

Morphology: This species is reminiscent of *Johndearia pelicanensis*, but is more elongate, with better defined sulcus and fold.

These Nemo specimens may have been confused with *Martiniopsis* by H. J. Campbell (1992), but the specimens differ substantially from *Martiniopsis woodi*, in the presence of a sulcus and low fold, and in the short well-spaced adminicula. Campbell claimed that were the specimens truely sourced from North Auckland then they should be accompanied by fusulines. His understanding of North Auckland stratigraohy was confused: the fusulines come from the Orua Limestone below the Wherowhero Limestone with *Martiniopsis*. (See Waterhouse 2002, p. 150ff).

Stratigraphy: The species is found in the Nemo and Hilton limestones at Wether Hill and nearby at Wairaki Downs in New Zealand, and is present in the South Curra Limestone at Gympie and Gundiah Bridge greywacke of C. D. Brown (1964) in the Gigoomgan area near Gympie in southeast Queensland.

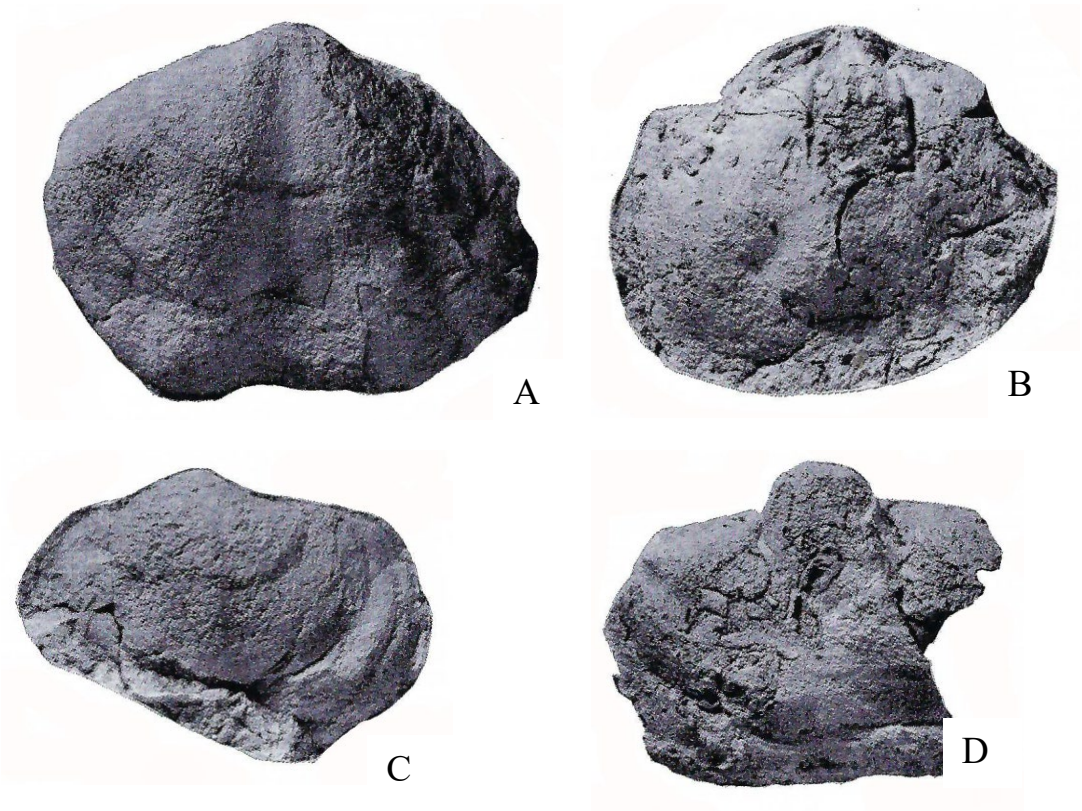


Fig. 67. *Johndearia isbelliformis* Waterhouse. A, ventral valve holotype, BR 2231. B, internal mould of dorsal valve, BR 2232. C, mature dorsal valve BR 2233. D, internal ventral mould BR 2234. Specimens x1 from Nemo Formation, Southland, New Zealand. (Waterhouse & Mutch 1978).

Johndearia antesulcata (Waterhouse, 1967)

Fig. 68

1880 *Spirifer glaber* [not Sowerby] – Hector, p. 28 (part).
1917 *Martinia* (*Martiniopsis*) *subradiata* [not Sowerby] – Trechmann, p. 59, pl. 5, fig. 3.
1964 *Ingelarella* sp. B Waterhouse, p. 168, pl. 33, fig. 3.
1967 *I. antesulcata* Waterhouse, p. 98, Fig. 38, 40.

Diagnosis: Medium in size, ventral valve smooth or weakly plicate in three to four pairs, dorsal plicae better developed, sulcus ill-defined and commences some distance in front of the umbo, fold low with broad median channel. Adminicula moderately long and diverge weakly forward, well-spaced weakly divergent tabellae.

Holotype: BR 653 figured by Waterhouse (1967, Fig. 38) and Fig. 68A herein, from Pig Valley Limestone, Nelson, New Zealand, OD.

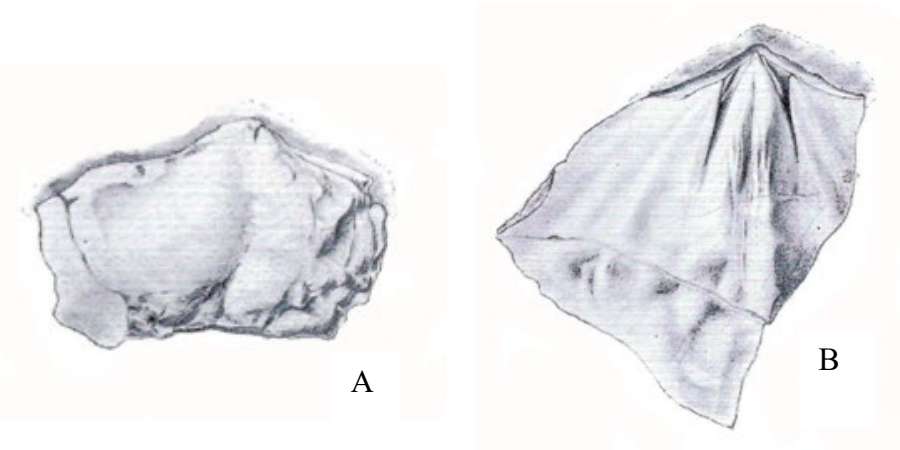


Fig. 68. *Johndearia antesulcata* (Waterhouse). A, crushed ventral valve holotype BR 653. B, dorsal internal mould BR 1282. Specimens x1 from Pig Valley Limestone, Nelson. (Waterhouse 1967).

Morphology: Not many specimens are available for this species. The sulcus commences in front of the umbo and is weakly defined.

Stratigraphy: The species is limited to the Pig Valley Limestone in the Goat Hill Group (see Waterhouse 2021a, Table 2, p. 98). This is placed in the *Marginalosia planata* Zone of Late Changhsingian age.

Genus ***Oviformia*** Waterhouse, 2015b

Diagnosis: Plicate shells, ventral sulcus with anterior swelling, dorsal fold with channel in most specimens, adminicula and tabellae short to moderate in length and spacing.

Type species: *Spirifera* (*Brachythyris*) *oviformis* M'Coy, 1847, p. 234 from the Muree Formation of the north Sydney Basin, New South Wales, OD**.**

Oviformia sweeti Waterhouse, 2015b

Fig. 69

1987 ?*Notospirifer* sp. Waterhouse & Balfe, p. 30, pl. 1, fig. 13.
2015b *Oviformia sweeti* Waterhouse, p. 70, Fig. 19C, 21C-L.

Diagnosis: Shells with three pairs of ventral plicae and exceptionally broad sulcus bearing two subplicae posteriorly as a rule, replaced by anterior median swelling; dorsal valve with two pairs of plicae and high fold divided by channel. Adminicula short and placed moderately far apart; tabellae short, subparallel, placed each side of fold.

Holotype: NMVP 134555 from Rammutt Formation (Asselian), figured in Waterhouse (2015b, Fig. 21C, J) and herein as Fig. 69A, OD.

Morphology: These specimens have an outstandingly well-defined ventral sulcus that contains a swelling of varying width and height, and the dorsal fold has a broad median channel.

Stratigraphy: This species is found only in the upper Rammutt Formation of Gympie, in southeast Queensland. It is of upper Asselian age, with *Bandoproductus* Jin & Sun, 1981.

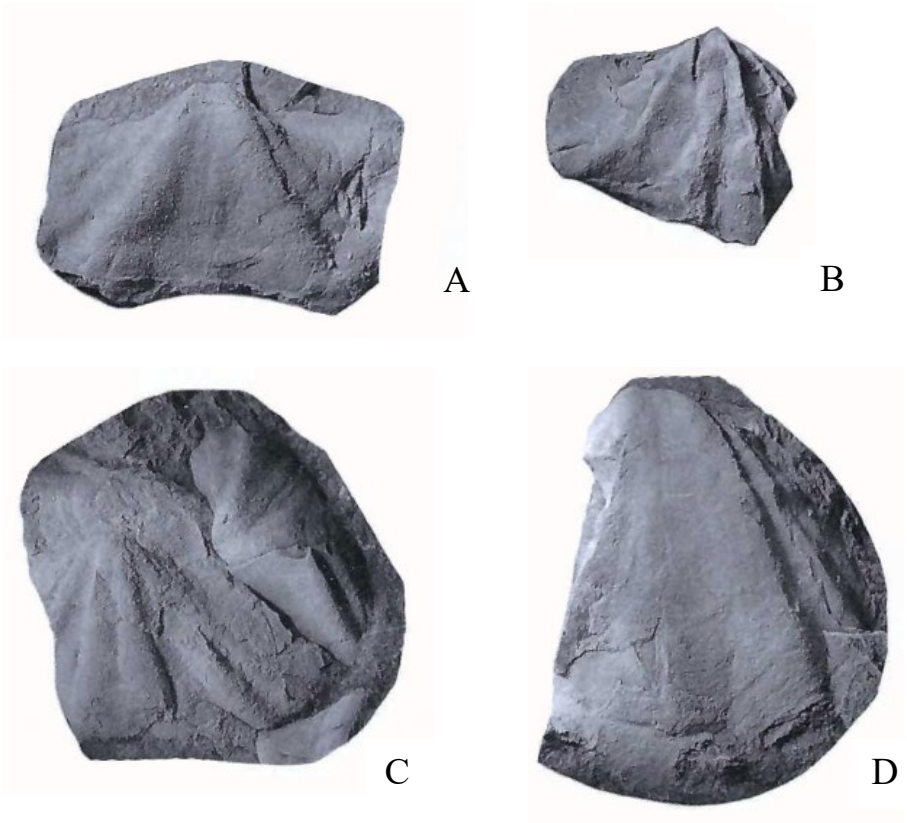


Fig. 69. *Oviformia sweeti* Waterhouse. A, ventral valve NMVP 134555, holotype. B, dorsal internal mould NMVP 134554. C, dorsal valve (lower left) NMVP 134556 and ventral valves NMVP 134557 and 134558. D, ventral valve NMVP 134564. Specimens x1 from upper Rammutt Formation, Gympie. (Waterhouse 2015b).

Oviformia belfordensis (McClung, 1978)

Fig. 70

1978 *Ingelarella belfordensis* McClung, p. 51, pl. 11, fig. 6-13.
?1978 *I. ingelarensis* [not Campbell] - McClung, p. 51 pl.n 11, fig. 4 (part, not other specimens).

Diagnosis: Large with shallow broad sulcus and low fold which is channelled as a rule, flanks smooth or with two to four pairs of plicae, well-developed on a number of dorsal valves. Typified by relatively short and well-spaced adminicula, tabellae moderately thick and extending for a fifth to a quarter of the length of the valve. Substantial secondary thickening is developed along the hinge.

Holotype: UNEF 14463 figured by McClung (1978, pl. 11, fig. 12, 13) and herein as Fig. 70D, from Belford Formation, Sydney Basin, OD.

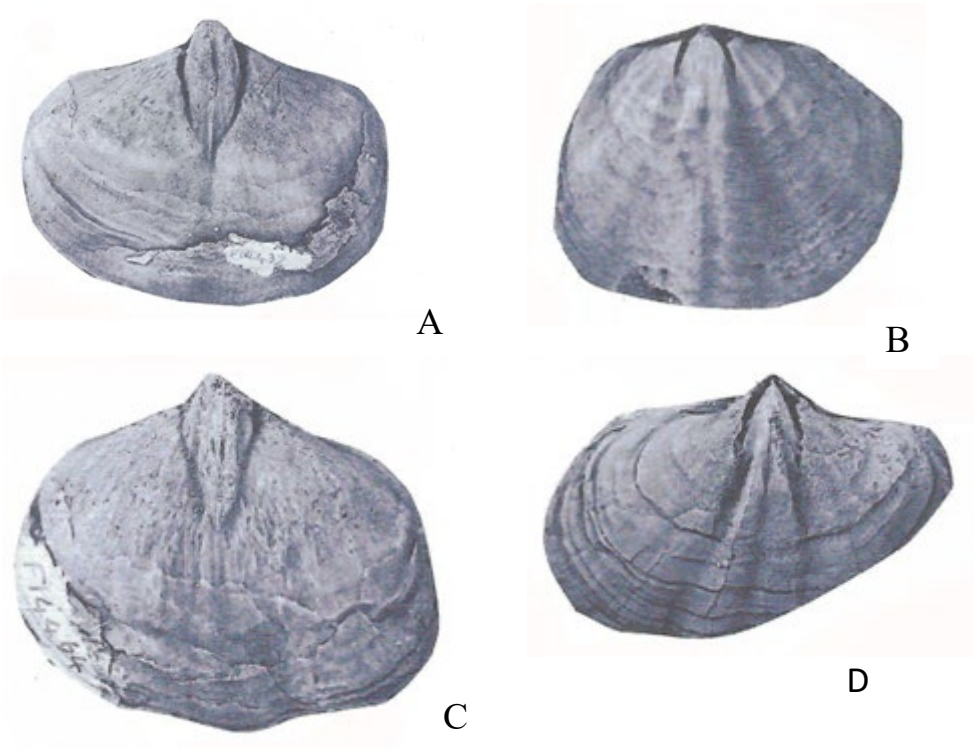


Fig. 70. *Oviformia belfordensis* (McClung). A, ventral internal mould UNEF 14437 x0.5. B, UNEF 14430, dorsal internal mould, x1. C, UNEF 14464 ventral internal mould showing sulcal swelling, x1. D, dorsal internal mould UNEF 14463 x1, holotype. Specimens from Belford Formation, Sydney Basin. (McClung 1978).

Morphology: The morphology is somewhat variable, and McClung figured only non-plicate ventral valves and mostly plicate dorsal valves, all with well-defined channel along the dorsal fold. McClung noted an approach to *Ingelarella dissimilis* Waterhouse, but the adminicula are substantially shorter and the sulcus wider in *belfordensis*. An anterior swelling which may bear two subplicae is developed in the sulcus in a number of specimens assigned to *belfordensis.* The species is not easy to place, because plicae are low and the sulcus only

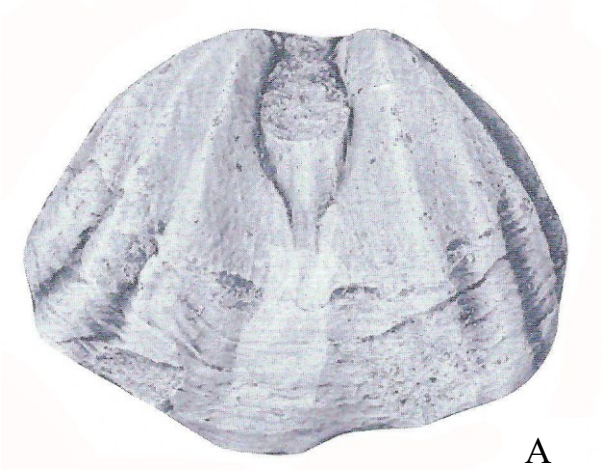
shows signs of two subplicae but a definite median sulcal swelling occurs in some specimens, and the fold shows a definite median channel. Internal plates are moderately short, and are well-spaced.

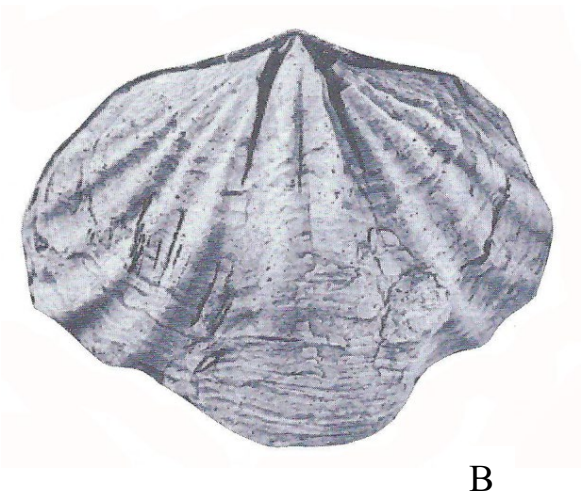
Stratigraphy: The species is limited to the Belford Formation of the north Sydney Basin.

Oviformia oviformis (M'Coy, 1847)

Fig. 71, 72

1847 *Spirifera* (*Brachythyris*) *oviformis* M'Coy, 1847, p. 234, pl. 13, fig. 5, 6.
1877 ?*Spirifer oviformis* – Koninck, pl. 11, fig. 6.
1907 *?Martiniopsis oviformis* – David, pl. 38, fig. 5.
1960 *Ingelarella oviformis* – Campbell, p. 1115, pl. 139, fig. 2a-c.
1978 *I. oviformis* – McClung, p. 42, pl. 14, fig. 14?; pl. 15, fig. 1-6 (part, not pl. 14, fig. 15, 16 = *Ingelarella* aff. *angulata*?). **check 14/14**
1987 *Tomiopsis oviformis* – Clarke, p. 275, Fig. 13.
2015b *Oviformia oviformis* – Waterhouse, p. 68.
2016 *O. oviformis* – Waterhouse, Fig. 75, p. 76.





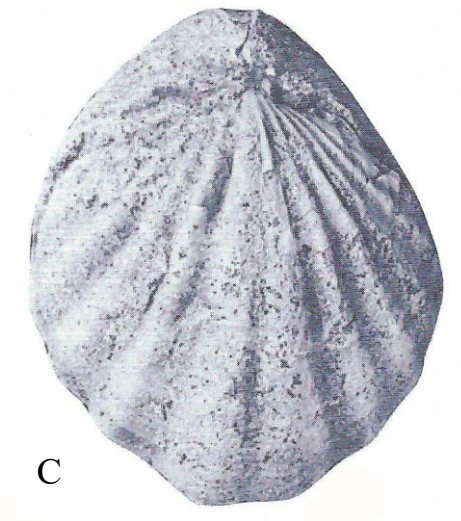


Fig. 71. *Oviformia oviformis* (M'Coy). A, B, ventral and dorsal aspects of internal mould of specimen with valves conjoined, MMF 2063. C, dorsal aspect of conjoined specimen MMF 2055. Specimens from Muree Formation, x1. (McClung 1978).

Diagnosis: Medium size, subequilateral to weakly elongate shells with tumulate anterior sulcus and well-defined dorsal channel, three to five pairs of prominent plicae as a rule, adminicula of moderate length, tabellae well developed as a rule, though short in the type specimen.Lectotype: SME 10649 as figured by M'Coy (1847, pl. 13, fig. 6), Campbell (1960, pl. 139, fig. 2a-c) and Fig. 72 herein, from Muree Formation or equivalents at Barraba, Hunter Valley, New South Wales, SD Campbell (1960, p. 1115).

Stratigraphy: The species is found in the Muree Formation and Belford Formation. McClung (1978, p. 43) also reported the species from the Fenestella Shale of the south Sydney Basin, but the two specimens figured by McClung (1978, pl. 14, fig. 15, 16) from the Belford Formation of the south Sydney Basin are less elongate, and have four rather than thre pairs of plicae and a less clearly swollen sulcus. Possibly they belong to *Ingelarella,* approaching *angulata* Campbell, whereas the Belford specimen of McClung (1978, pl. 14, fig. 14) looks like an early ally or precursor for *Oviformia oviformis*.

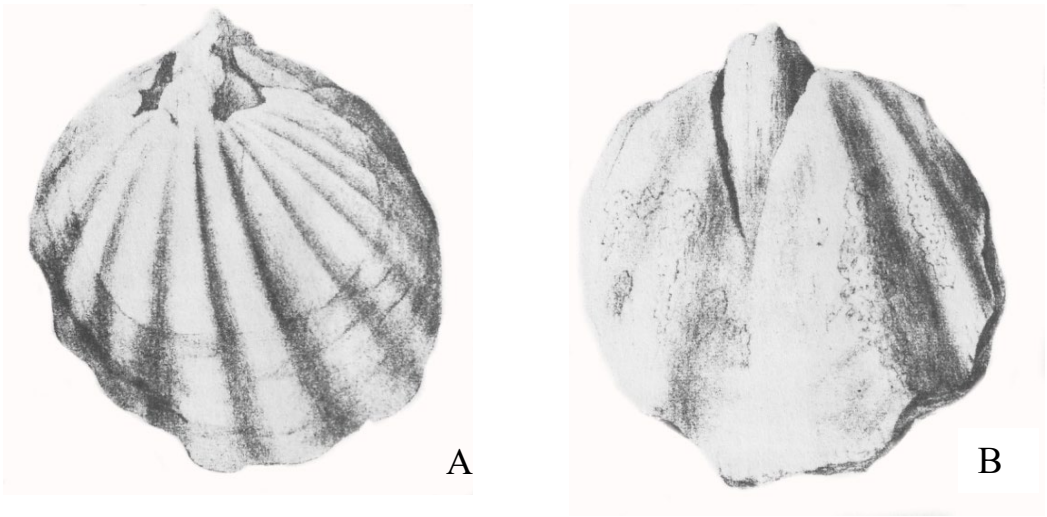


Fig. 72. *Oviformia oviformis* (M'Coy). A, B. dorsal and ventral aspects of lectotype SME 10649, x1. Muree Sandstone. (M'Coy 1847).

Oviformia alteplica (Waterhouse, 2015b**)**

Fig. 73

1964 *Ingelarella ingelarensis* [not Campbell] – Hill & Woods, pl. P9, fig. 4 (part, not fig. 3 = *fergusoni*).
1969 *Ambikella profunda* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 1, 2.

1972 *I. ingelarensis* [not Campbell] – Hill et al., pl. P9, fig. 4 (part, not fig. 3 = *fergusoni*).
2015b *Ingelarella alteplica* Waterhouse, pp. 94, 142, Fig. 30A-M, 59.
2015b *Tigllumia parallela* [not Waterhouse] – Waterhouse, p. 98, Fig. 31E-G.

Diagnosis: Medium size and distinctive in shape, sulcation and plication, with well-defined sulcus and narrow deeply channelled fold, three or four pairs of high plicae as a rule, adminicula long and closely spaced, tabellae long and variably spaced.

Holotype: UQF 26954 figured by Waterhouse (2015b, Fig. 30C) and Fig. 73A herein, from lower South Curra Limestone, OD.

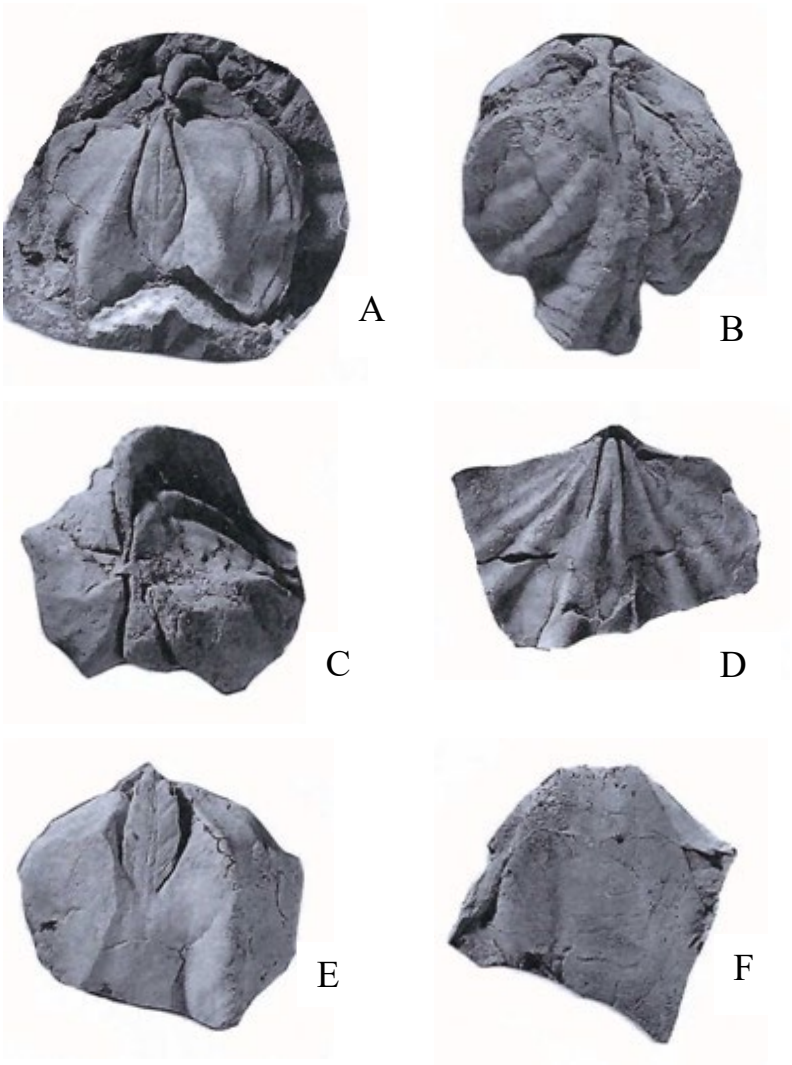


Fig. 73. *Oviformia alteplica* (Waterhouse). A, ventral aspect of internal mould with both valves conjoined, UQF 76954, holotype. B, C, dorsal view of specimen with valves conjoined, UQF 45474. D, dorsal internal mould UQF 69182. E, ventral internal mould UQF 45479. F, latex cast of ventral valve, showing slight anterior swelling in the sulcus. Specimens x1 from South Curra Limestone, Gympie, Queensland. (Waterhouse 2015b).

adminlcula like those of *Tigillumia*.

Morphology: This is an unusual species, given its closely spaced and long internal plates, reminiscent of and apparently evolved from *Oviformia oviformis*, but meriting further analysis. Arguably the species should be classed as a distinct genus, together with *Oviformia excelsus* as described below. Unlike *Tigillumia*, the plicae are strong in *alteplica*, and the sulcus and fold commence at the umbo, and adminicula are spaced well apart. Questions arise about the source – could the species have arisen from from *Tigillumia* through an independent swelling of the ventral sulcus, and retention of the long *Tigillumia*-like tabellae in the dorsal valve, as shown in Fig. 73D? This seems to me an reasonable option, but seems less likely than evolution from *Oviformia*. But *excelsus*, described below, differs even more, with Stratigraphy: This species is represented in the lower and upper South Curra Limestone and in the Gundiah Bridge Greywacke of Brown (1964),at Gigoomgan near Gympie, southeast Queensland.

Oviformia excelsus (Waterhouse, 1968)

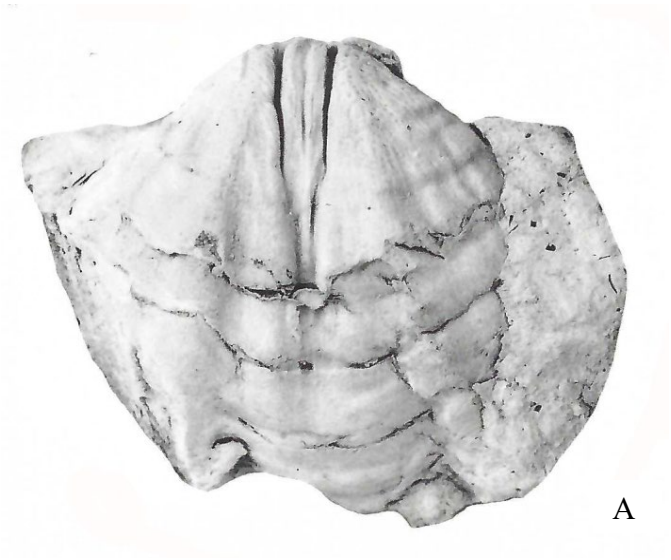
Fig. 74

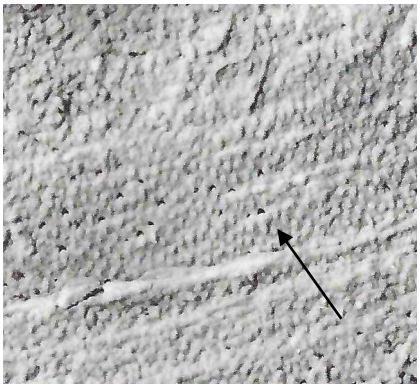
1968 *Notospirifer excelcus* Waterhouse, p. 80, pl. 15, fig. 1, 2, 6.
1978 *Ingelarella excelsus* – McClung, p. 41.

Diagnosis: Ventral valve slightly longer than high, with swollen anterior sulcus and four to five pairs of low plicae. Adminicula moderately long, closely spaced subparallel and anteriorly convergent. Sulcal swelling with two subplicae. Scattered minute c-shaped spinules and dense pits.

Holotype: BR 1383 as figured in the synonymy and Fig. 74 herein, from Kildonan Member of the Bagrie Formation, north Otago, New Zealand, OD.

Morphology. This form is based on rare specimens so its variation is not known. Waterhouse (1968) assigned the species to *Notospirifer* Harrington, 1955 because of the presence of small spines, but McClung (1978) rightly pointed out that such spines appear on species of *Ingelarella*, and appear to be present in various members of Ingelarellidae. The nature of the adminicula strongly suggest either derivation from *Tigillumia*, or convergence with members of that genus from oviformiin stock. The presence of tiny and crowded pits over the shell surface rather than elongate short grooves implies possibly a distinct genus, but material is sparse.





B

Fig. 74. *Oviformia excelsus* (Waterhouse), BR 1383, holotype ventral valve A, internal and C posterior aspects. B, detail of micro-ornament, with arrow indicating fine c-shaped spines. Kildonan Member, Bagrie Formation, New Zealand. (Waterhouse 1968).

Stratigraphy: The species is found only in the Kildonan Member of New Zealand. There are differences from the allied species *Oviformia alteplica* of the Gympie area in Queensland, and no individual of *alteplica* is like *excelsus*.

Genus ***Tumulosulcus*** Waterhouse, 2015b

Diagnosis: Medium to large shells, characterized by median swelling in the anterior sulcus, and round-crested fold often without a channel, apart from exceptions in large populations. Lateral shell often smooth, dorsal valve may show low plicae. Adminicula of moderate length, tabellae well-developed, moderately spaced, subparallel anteriorly as a rule.

Type species: *Ingelarella magna* Campbell, 1960, p. 1117 from upper Moonlight Sandstone, north Bowen Basin, Queensland, OD.

Discussion: This genus is represented by several species in the Middle Permian of Queensland and New South Wales, whilst noting the need for caution about the distinctions

between this genus and *Oviformia*, which has page priority. Care is taken to illustrate some of the comparatively exceptional individuals that strongly point to shells intermediate between the type species of *Oviformia* and *Tumulosulcus*, which support a merging between the two genera, or strongly suggest that *Tumulosulcus* is no more than a subgenus, to be distinguished through the more quadrate and less transverse outline. On the other hand, the commonly rounded rather than channelled fold opens the possibility that members of the genus evolved from *Ambikella* rather than *Ingelarella*

Tumulosulcus piersoni (Cisterna & Shi, 2014)

Fig. 75 - 77

2014 *Tomiopsis koninckí* [not McClung & Shi] – Cisterna & Shi, p. 538, Fig. 6.2?, 4, 5?, 7?, 8?, 9, 10, not Fig. 6.1? = *Geothomasia koninckí,* not Fig. 6. 2, 5, 6, 11 = *Geothomasia simplicata*).
2014 *T. piersoni* Cisterna & Shi, p. 540, Fig. 7.1?, 2, 10?, 11, 15?, 17-20, 22, 23?, 24? (part, possibly not Fig. 7.3?, 4, 5?, 6, 7, 8, 9, 12, 13?, 14 though require inspection, several possibly belonging to Geothomasia . Possibly Fig. 7.21, 22 could be *Ambikella.* Fig. 7.23, 24 possibly *simplicata* but show no dorsal valve).
cf. 2014 *Tomiopsis* sp. aff. *koninckí* [not Etheridge] – Cisterna & Shi, p. 538, Fig. 6.28, 29, (part, ? not fig. 12-27, 30, mostly if not all *Geothomasia simplicitas.* See p. 119. .
2014 *Tomiopsis*? sp. Cisterna & Shi, p. 540, Fig. 7.29.

Diagnosis: Weakly transverse with two to four pairs of plicae of varying generally low strength, fold with rounded crest as a rule, sulcus moderately prominent with very weak or no subplicae. Tabellae short, placed each side of the fold.

Holotype: NMVP 30931 figured by Cisterna & Shi (2014, Fig. 7.19, 20) and Fig. 75C, D herein from upper Wasp Head Formation, south Sydney Basin, OD.

Morphology: Cisterna & Shi (2014) stated that the Runnegar (1969) material figured from Wasp Head beds had come from the same level, and that his pl. 20, fig. 2 showed similar subdued plicae as in *piersoni* (though the plicae in Runnegar 1969, pl. 20, fig. 4 from the same locality are stronger). These specimens certainly appear to belong to *Geothomasia*, not *Tumulosulcus*. But the holotype *piersoni* (Cisterna & Shi, 2014, Fig. 7. 19, 20) shows a tumulate sulcus as in *Oviformia* and *Tumulosulcus*, with one growth lamination arching forward, and the dorsal valve appears to show traces of tabellae that lie close to the dorsal fold. Similar tabellae are clearly indicated in Fig. 7.18, 22. The specimen depicted as *Tomiopsis*? sp. in Cisterna & Shi (2014, Fig. 7.29) has a definite and well-formed median swelling for most of the length of the sulcus (See Fig. 76). Many of the dorsal valves have

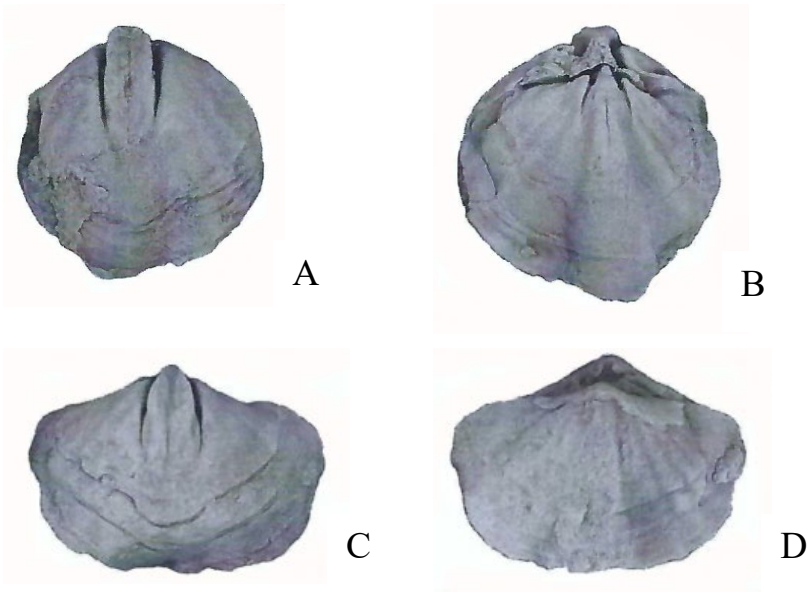


Fig. 75. *Tumulosulcus piersoni* (Cisterna & Shi). A, B, ventral and dorsal aspects of conjoined specimen NMVP 309897, x1.2. Described as *Tomiopsis koninckí* by Cisterna & Shi (2014, Fig. 6.27, 28). From lower or middle Wasp Head Formation. C, D, ventral and dorsal aspects of conjoined specimen NMVP 309931, x1.2, holotype from upper Wasp Head beds, south Sydney Basin. Note the course of the strong lamination within the sulcus. (Cisterna & Shi 2014).

short widely diverging tabellae in contrast to other specimens with tabellae close to the flanks of the fold, so there would appear to be a mixture of at least two species, so that a number of their specimens need to be more closely inspected and the present proferred synonymy is only provisional. The sulcus of several specimens bears two subplicae, and for other specimens, bears indications of a median swelling (Cisterna & Shi 2014, Fig. 7.?15, 24) and possibly but less clearly for other specimens such as Fig. 7.11. Pending necessary closer inspection, the assemblage appears to be divided into at least two taxa, a species *piersoni,* belonging to *Tumulosulcus*, and a second assemblage belonging to *Geothomasia*, which would possibly include the specimens identified by Cisterna & Shi (2014) with *Tomiopsis* aff. *koninckí.* These specimens appear to be allied to *Geothomasia simplicitas* (see below), with slight morphological differences involving a narrower sulcus and lower plicae.

The holotype as refigured in Fig. 74C, D shows a possibly tumulate sulcus, although the figure and the lack of detail in the Cisterna-Shi account does not allow the possibility to

Fig. 76. *Tumulosulcus piersoni* (Cisterna & Shi) internal mould of ventral valve NMVP 309941, x1.5, from upper Wasp Head Formation, south Sydney Basin. (Cisterna & Shi 2014).

be ruled out that the appearance is due simply to a forward rather than outward extension of the shell. However other specimens as in Fig. 75 and 76 herein are undoubtedly tumulate, making it likely that the holotype is also tumulate. There must be a further reservation, over the possibility that specimens of *Ambikella* are also present, as for instance in Cisterna & Shi (2014, Fig. 6. 21, 22). But this will require further examination of the material and perhaps further collecting, and any attempt at present to distinguish *Ambikella* would be speculative and perhaps unneccessarily add to the complexity.

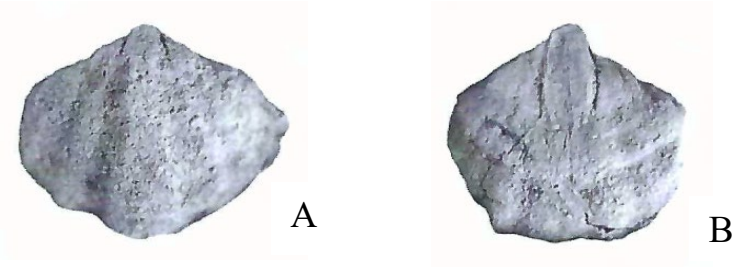


Fig. 77. *Tumulosulcus piersoni* (Cisterna & Shi). A, dorsal valve, UQF 73041, x2.5. B, ventral valve UQF 73032 x2.5. Upper Wasp Head Formation. (Figured as *Tomiopsis koninckii* by Cisterna & Shi 2014).

Stratigraphy: This species comes from the uppermost Wasp Head Formation, and apparently from older beds in the same formation (see Fig. 75A, B).

Tumulosulcus cessnockensis (McClung, 1978)

Fig. 78, cf. Fig. 79A, B

1978 *Ingelarensis cessnockensis* McClung, p. 49, pl. 2, fig. 10, 11; pl. 10, fig. 4-15, 18, 19.

1978 *Ingelarella* sp. nov. McClung, p. 50, pl. 8, fig. 4-6.
1978 *I. ingelarensis* [not Campbell] – McClung, p. 51, pl. 10, fig. 16; 17, pl. 11, fig. 1-5.
?1981 *Martiniopsis* (*Ambikella) ingelarensis* [not Campbell] – Dickins, p. 31, pl. 5, fig. 1, 13, 14 (part, not pl. 4, fig. 20-24; pl. 5, fig. 2-12, 15-17 = ?*Johndearia brevis*). **See p. 84.**

Diagnosis: Medium size, shell tends to be more transverse than *undulosa*, few subdued if any plicae, fold well-defined as a rule, round-crested, sulcus may be bordered by a pair of lateral plicae. Adminicula of moderate length and spacing, tabellae well-developed, weakly curved or straight throughout length and weakly divergent.

Holotype: UNEF 12504 figured by McClung (1978, pl. 10, fig. 7, 8) and Fig. 78A, B herein from lower to middle Elderslie Formation, north Sydney Basin, OD.

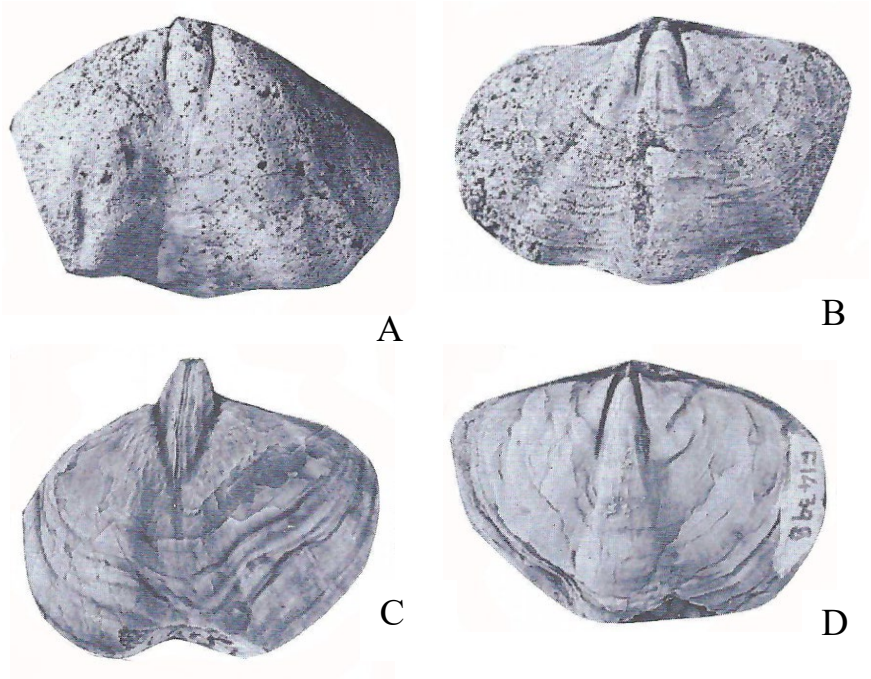


Fig. 78. *Tumulosulcus cessnockensis* (McClung). A, B, UNEF 12504, holotype, ventral and dorsal aspects of internal mould with valves conjoined, x1, from Elderslie Formation. C, D, internal mould of specimen with valves conjoined UNEF 14398 x1 identified with *Ingelarella ingelarensis* [not Campbell] by McClung (1978). From Fenestella Shale, north Sydney Basin. Growth laminae show that the anterior sulcus is swollen. (McClung 1978).

Morphology: This species is close to *Tumulosulcus undulosa* (see below) but is more transverse and the adminicula are slightly closer to each other and the tabellae are straight in outline, diverging weakly forward, whereas the tabellae in *undulosa* may change course and

anteriorly become parallel, according to McClung (1978) for possible specimens from the Elderslie Formation. Also one out of three specimens figured in McClung (1978) has a channelled fold. The specimen of Fig. 78D somewhat approaches dorsal valves from Warwick as figured by Dickins (1981, pl. 5, fig. 1, 13, 14), and possibly the particular Warwick specimens belong to *Oviformia cessnockensis*. The specimens described by McClung (1978, pl. 10, fig. 16, 17; pl. 11, fig. 1-5) as *Ingelarella ingelarensis* [not Campbell] are small transverse shells, sulcus with weak subplicae in one of two specimens, and indication of anterior swelling, as well as upstanding dorsal fold, with rounded crest as a rule. Adminicula are short and moderately spaced, and the tabellae are well-formed, placed each side of the fold. The fold and sulcus even on small specimens differ in profile from those features on *ingelarensis*. Most of McClung's figured specimens show a rounded non-channelled crest for the dorsal fold, but one Belford specimen (McClung 1978, pl. 11, fig. 4) has a grooved fold, two sulcal subplicae and subdued swelling in the anterior ventral sulcus, as well as lateral plicae, here deemed likely to belong to *Oviformia belfordensis* found in the Belford Formation.
Stratigraphy: This species occurs in silty sandstones of the north Sydney Basin in the Elderslie Formation, often correlated with (now *Johndearia*) *brevis*, and in the Fenestella Shale. It was reported from the lower and possibly middle Wandrawandian Siltstone of the south Sydney Basin, and McClung (1978, p. 50) noted that the species may range upwards into the lower *undulosa* zone in the south Sydney Basin. **Needs check**

Fig. 79. *Tumulosulcus cessnockensis* (McClung). A, dorsal valve with well-defined fold, CPC 20190. B, dorsal valve, CPC 20189. Specimens x1, from Warwick. (Dickins 1981).

The direction and placement of internal plates of specimens from the Freitag Formation in the southwest Bowen Basin are on the whole closer to those of *cessnockensis*

rather than *undulosa*, especially Waterhouse (2001, pl. 7, fig. 21) and including the McLoughlin(1988) figured specimen, and one of the three dorsal valves from the Freitag Formation has a channelled fold. But *cessnockensis* is more transverse in outline and tends to be feebly plicate. There is some disparity in ranges assessed for *undulosa* and *cessnockensis.* The species *undulosa* in the Sydney Basin is younger than c*essnockensis*, which is found chiefly in the slightly older Elderslie beds with *brevis*. It is possible that *cessnockensis* which is found only in the Sydney Basin was contemporary with *undulosa* in Queensland, which comes from Gebbie beds in the north Bowen Basin. And it may be noted that some specimens assigned by McClung (1978, pl. 10, fig. 6, 18, 19) to *cessnockensis* approach *undulosa* in morphology.

Lee in Lee et al. (2023, p. 21) noted that Waterhouse (2001, p. 100) had suggested that *cessnockensis* McClung seemed likely to be a synonym of *brevis*. He ignored or overlooked the Waterhouse (2015b) elaboration of morphologies and evolutionary streams which recognized of *Oviformia* and *Tumulosulcus*, and distinguished the taxon *cessnockensis* from the species called *brevis*.

Tumulosulcus undulosa (Campbell, 1961)

Fig. 80 - 82

1845 *Spirifera subradiata* [not Sowerby?] – Morris p. 281, pl. 16, fig. 2 (part, see p. 124 herein).
1924 *Martiniopsis subradiata* [not Sowerby] – Richards & Bryan, p. 102, pl. 19, fig. 4.
1961 *Ingelarella undulosa* Campbell, p. 180, pl. 26, fig. 4-9.
1975 *M. undulosa* – Runnegar & McClung, pl. 31.1, fig. 28-29.
1978 *I. undulosa* – McClung, p. 47, ? pl. 8, fig. 1-3, 7.
1978 *Ingelarella* sp. nov. McClung, p. 50, pl. 8, fig. 4-6.
1988 *I. undulosa* – McLoughlin, pl. 1, fig. 1.
1998 *Tomiopsis* (*Ingelarella*) *undulosa* – Waterhouse, p. 12.
2001 *I. undulosa* – Waterhouse, p. 100, pl. 7, fig. 18, 19, 21; pl. 8, fig. 1, 2.
2008 *Johndearia undulosa* – Waterhouse, p. 71, p. 365.
2023 *J. brevis* [not McClung & Armstrong] – Lee in Lee et al., p. 18, Fig. 9E-H?. Fig. 11A-E, G, I, J?, K, Fig. 11F, H, G, L-N ventral valve uncertain (part, not Fig. 10 = *Johndearia brevis*).
2023 *Notospirifer* cf. *triplicata* [not Waterhouse] – Lee in Lee et al., Fig. 12T (part, not Fig. 8, 9I-K, 11O-V, 12A-S = *gentilis.*

Diagnosis: Large subequilateral shells with few if any faintly developed plicae, broad sulcus, fold with rounded crest in the type specimens.

Morphology: Many of the specimens from the Snapper Point Formation that were assigned to *Johndearia brevis* (McClung & Armstrong) by Lee in Lee et al. (2023, Fig. 11) have a swollen anterior ventral sulcus, as in *Tumulosulcus*, and the specimens overall come close to

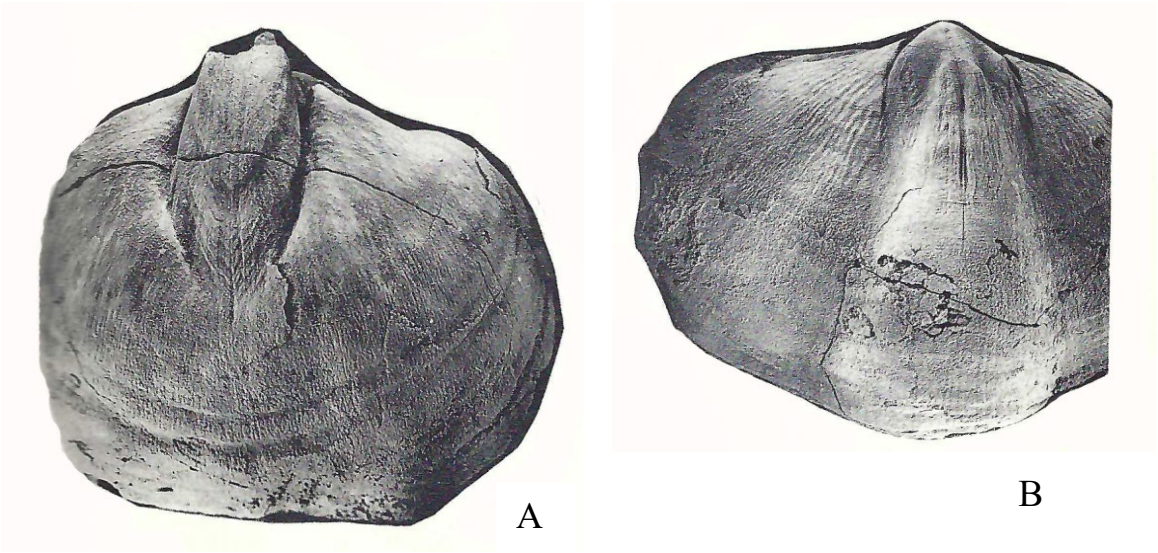


Fig. 80. *Tumulosulcus undulosa* (Campbell). A, internal mould of ventral valve UNEF 5841, x1. B, internal mould of dorsal valve, UNEF 5838, x0.9. From the Gebbie Sandstone, north Bowen Basin. (Campbell 1961).

Tumulosulcus undulosa (Campbell) from the north Bowen Basin. They cannot be deemed to belong to *brevis*, which consistently lacks a sulcal swelling. It is assumed that micro-ornament figured in Lee et al. (2023, Fig. 9E-H) belongs to this species, because the figures were prepared from AGSO material which also featured in the figures of *Tumulosulcus*. Lee in Lee et al. (2023, p. 18) failed to describe the nature of the sulcus in the Snapper Point material. He recorded “no sulcal plication except sulcus-bounding plicae”. The statement is incorrect, because a plication is present in the sulcus of the AGSO material, and underlines how difficult it is to deal with the complexity and variation displayed by brachio-pods in general and ingelarellids in particular. Some of his specimens figured as *brevis* display a simple sulcus (eg. Lee in Lee et al. 2023, Fig. 10A, F, L). Some display two subplicae within the sulcus (Fig. 10N). Both of these morphologies are regarded as true *brevis*. Other specimens as shown in Fig. 81 display a median anterior swelling in the sulcus and a weak anterior channel in the dorsal fold of Lee et al. 2023, Fig. 15H. These is now placed in *Tumulosulcus undulosa*.

Stratigraphy: The north Bowen Basin specimens of *undulosa* came from the Gebbie Formation according to McClung (1978), but the source remains to be pinpointed. In the Sydney Basin, McClung (1978) recorded the species from the finer and siltier sandstones of

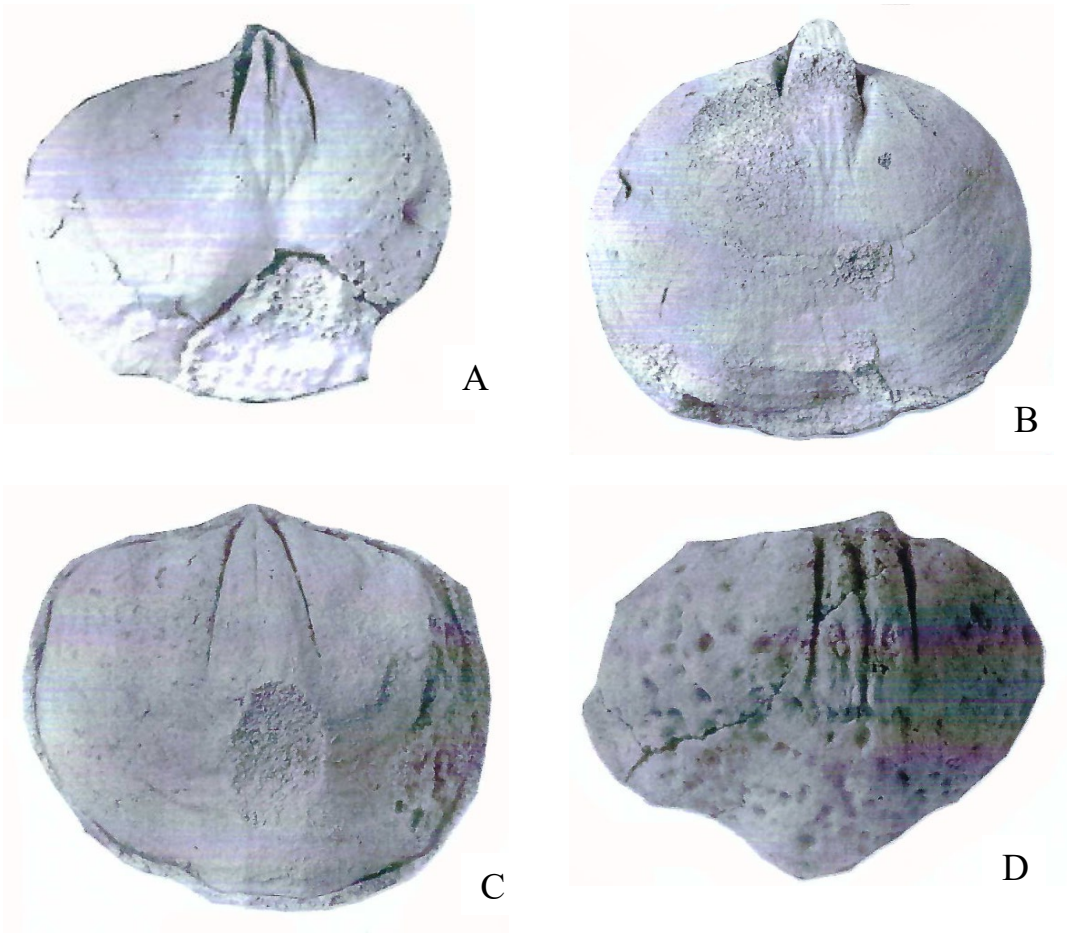


Fig. 81. *Tumulosulcus undulosa* (Campbell). A, ventral internal mould UQF 65491, x1.5. B, ventral internal mould UQF 65478, x0.75. C, dorsal internal mould UQF 65489, x1. D, dorsal internal mould UQF 65479, x1. From Freitag Formation, southwest Bowen Basin. (Waterhouse 2001).

the Elderslie Formation, and lower and middle Wandrawandian Formation, considering that the species ranged from the *brevis* Zone and possibly into the *undulosa* Zone. Specimens from the Freitag Formation and upper part of the underlying Aldebaran Formation in the southwest Bowen Basin belong to *Tumulosulcus undulosa* (McLoughlin 1988, Waterhouse 2001), though the Freitag Formation was assigned a much younger age by Briggs (1998) on the basis of shells, which he misidentified as *Pseudostrophalosia clarkei*. No ingelarellids like *undulosa* are found with *Ps. clarkei*: this ingelarellid species is found much lower in the stratigraphic column (Waterhouse 2022c). The species is present in the south Sydney Basin in the Snapper Point Formationais shown by specimens recorded by Lee in Lee et al. (2023).

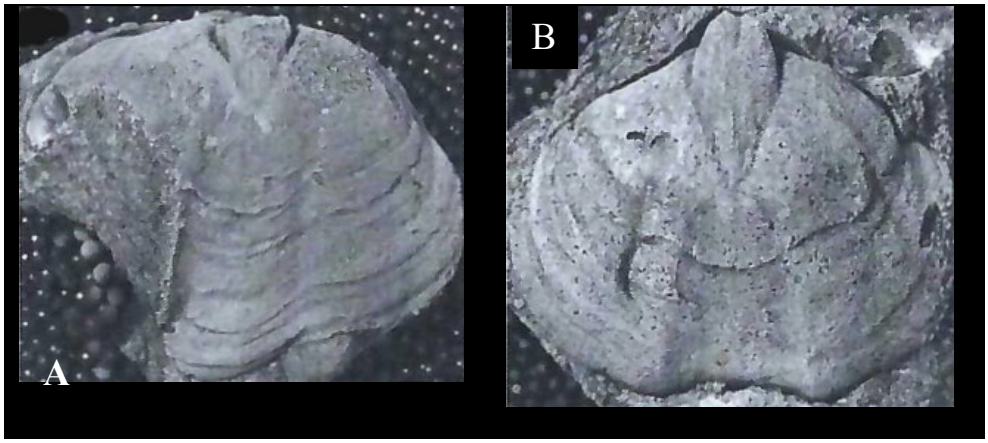


Fig. 82. *Tumulosulcus undulosa* (Campbell). A, internal mould of ventral valve CPC 44468. B, ventral internal mould CPC 44469. Specimens close to x1.5, from Snapper Point Formation, south Sydney Basin, previously misidentified as *Johndearia brevis*. (Lee et al. 2023**).**

Tumulosulcus magna (Campbell, 1960)

Fig. 83, 84

1960 *Ingelarella magna* Campbell, p. 116, pl. 140, fig. 1-4.
1978 *I. magna* – McClung, p. 47, pl. 8, fig. 8.
1983 *Tomiopsis magna* – Waterhouse & Jell, p. 245, pl. 2, fig. 6, 7, 13.
?1987 *T. isbelli* [not Campbell] – Clarke, p. 275, Fig. 12A-C (part, not Fig. 10, 11 = *isbelli*].
1987 *T. magna* – Waterhouse, p. 35, pl. 11, fig. 2.

Diagnosis: Large subequilateral shells with weak plicae and shallow channel on dorsal fold, adminicula well-spaced and barely a third of the length of the valve.

Holotype: GSQF 2051 figured by Campbell (1960, fig. 1) and Fig. 83A herein from Moonlight Sandstone or basal Blenheim Formation, north Bowen Basin, Queensland. To judge from the footages provided by Campbell (1960), and the revised assessment of the formation boundary, encouraged by faunal content, the Moonlight level is most likely.

Morphology: North Bowen Basin shells from the upper Moonlight Sandstone figured by Waterhouse & Jell (1983) have weak plicae and shallow dorsal channel, reminiscent of the fold in the dorsal valve ascribed to *magna* by Campbell, and shaped like both *magna* and *isbelli.* Amongst shells from Tasmania figured by Clarke (1987), those from Friendly Bay have a strong anteriorly channelled fold, whereas the shells from the younger Abels Bay Formation have a higher simple non-channelled dorsal fold, and are referred to a separate taxon, *Tumulosulcus abelensis* (see p. 113). The Flat Top specimen figured from the southeast

Bowen Basin in Waterhouse (1987, pl. 11, fig. 2) also has a weak fold channel.

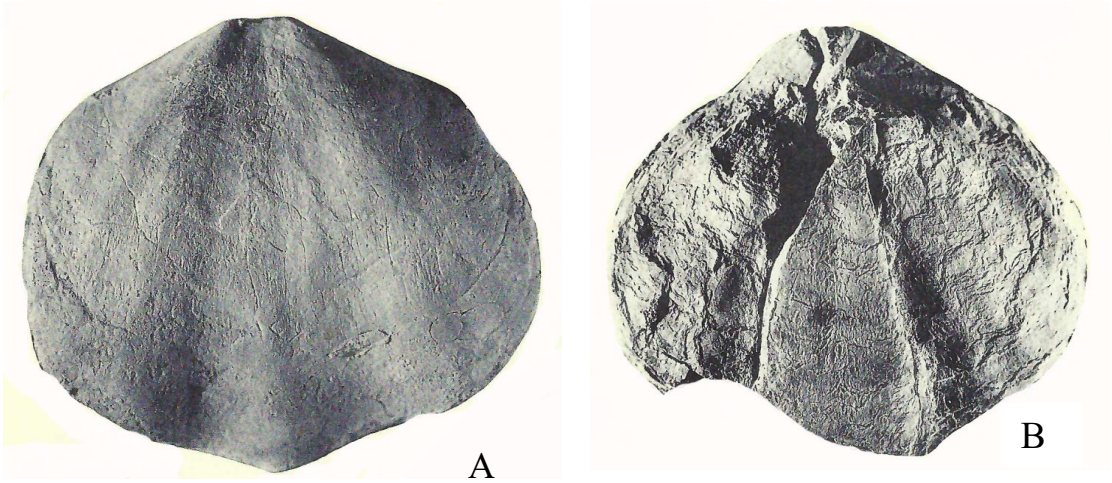


Fig. 83. *Tumulosulcus magna* (Campbell). A, ventral valve GSQ 2051, holotype. B, dorsal aspect GSQF 2322. Specimens x0.75 approx., probably from Moonlight Sandstone, north Bowen Basin, Queensland. (Campbell 1960).

Stratigraphy: As pointed out by McClung (1978), shells like *Tumulosulcus magna* come from disparate stratigraphic levels. *Ingelarella magna* of McClung (1978 p. 47, pl. 8, fig. 8) comes from the Elderslie Formation, and might prove to belong to *Tumulosulcus undulosa*, but does seem to agree in shape with *magna*. So do weakly plicate specimens figured from the upper Moonlight Sandstone by Waterhouse & Jell (1983). McClung's *Ingelarella* sp. A of his pl. 8, fig. 4-6 from the Elderslie Formation show some similarities, with non-channelled dorsal fold, but the ventral valve lacks a tumulus and the specimens possibly belong to *Johndearia brevis.* McClung (1978) reported the species *undulosa* from as low as the upper Snapper Point Formation, and stated that the species ranged through the middle Wandrawandian Formation of the south Sydney Basin, in the *brevis* and *undulosa* zones, a (McClung 1978, p. 48), whereas, he stated, it was restricted to the *isbelli* zone in Queensland. McClung (1978) thought the specimens might be of polyphyletic origin, which would imply complex interrelationships still to be unravelled: perhaps those with dorsal channel stemmed from Ingelarella stock and those with rounded fold came from *Ambikella* stock. The Flat Top specimen figured by Waterhouse (1987) in Queensland is certainly close,

though with a very prominent and cleft median sulcal swelling and reduced adminicula. Coming from what McClung called the *ovalis* Zone, it is found apparently in the same zone in Tasmania, where the species was considered to range upwards from the *Echinalosia preovalis - Ingelarella plana* Zone, though evidence for such a range is yet to be provided. The Malbina E specimens could belong to magna, but no dorsal valves were figured, so they could prove to be *abelensis.*

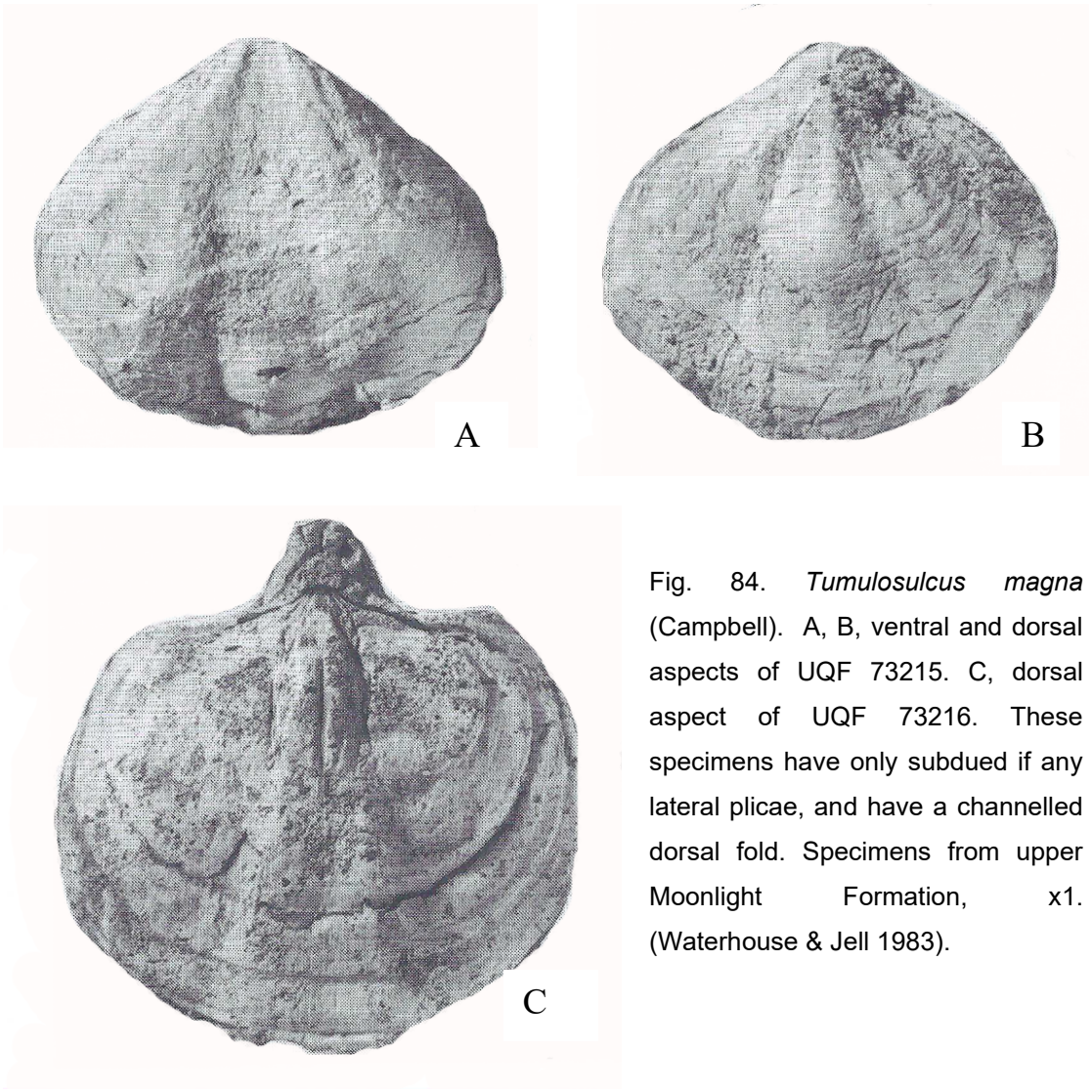


Fig. 84. *Tumulosulcus magna* (Campbell). A, B, ventral and dorsal aspects of UQF 73215. C, dorsal aspect of UQF 73216. These specimens have only subdued if any lateral plicae, and have a channelled dorsal fold. Specimens from upper Moonlight Formation, x1. (Waterhouse & Jell 1983).

Tumulosulcus warneri (McClung, 1978)

Fig. 85

1978 *Ingelarella warneri* McClung, p. 52, pl. 13, fig. 1-10.
2015b *Tumulosulcus warneri* – Waterhouse, p. 170, Fig. 80A, B.

Diagnosis: Weakly transverse, with broad concave sulcus, swollen anteriorly, fold rounded in section, plicae few and subdued. Adminicula and tabellae comparatively short, heavy posterior thickening.

Fig. 85. *Tumulosulcus warneri* (McClung). A, dorsal aspect of internal mould UNEF 12507 x1 from Porcupine Formation. B, ventral aspect of internal mould, UNEF 12348 x1 from Bickham Formation, New South Wales. (McClung 1978).

Holotype: UNE 12343 figured by McClung (1978, pl. 13, fig. 2, 5) from Porcupine Formation, west north Sydney Basin, OD.

Stratigraphy: The species is limited to the Bickham and Porcupine Formations in the Murrurundi-Gunnedah area of northern New South Wales. McClung (1978) reported a specimen from the Snapper Point Formation at Tallong, south Sydney Basin. He emphasized the distinctive fold but made no note of the approach to c*essnockensis*, and the two suites could benefit from closer inspection to consolidate evidence for separation.

Tumulosulcus abelensis n. sp.

Fig. 86

1987 *T. magna* – Clarke, p. 273, Fig. 9A-G.

Derivation: Named from Abels Bay, Tasmania.

Diagnosis: Close to *undulosa* in shape, distinguished by lack of channel from fold.

Holotype: GST 36320 from Friendly Beaches, figured by Clarke (1987, Fig. 9C) and herein as Fig. 86A, here designated.

Morphology: Specimens from Tasmania as figured by Clarke (1987) have a longer stronger

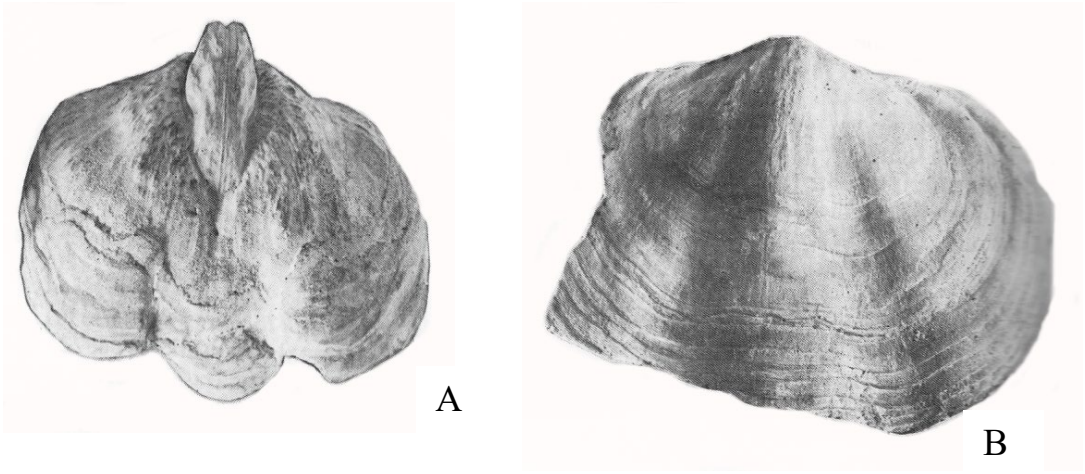


Fig. 86. *Tumulosulcus abelensis* n. sp. A, ventral internal mould GST 36320. B, latex cast of dorsal valve GST14042B, holotype. From Friendly Beaches and Abels Bay, Tasmania. (Clarke 1987).

sulcal swelling and are distinguishable as a separate contemporaneous and slightly younger taxon. Clarke characterized his *magna* specimens through their rounded dorsal fold, yet the fold of type *magna* has a shallow channel along the crest. Amongst shells from Tasmania figured by Clarke (1987), those from Friendly Bay and Abels Bay Formation have a high simple non-channelled dorsal fold. Figures in Clarke (1987) show well the internal plates and the micro-ornament.

Stratigraphy: The species appears to be slightly younger than Malbina E, and may be upper Capitanian in age.

Tumulosulcus mckellari n. sp.

Fig. 87

1964 *Ingelarella pelicanensis* [not Campbell] – Waterhouse, p. 165, pl. 32, fig. 12, 14, 16, pl. 33, fig. 2.
2002 *J. pelicanensis* [not Campbell] – Waterhouse, Table 18, p. 57.

Derivation: Named for Ian McKellar.

Diagnosis: Sulcus with narrow median swelling. Hinge wide and with heavy posterior thickening.

Holotype: BR 649 from upper Mangarewa Formation, figured in Waterhouse (1964, pl. 32, fig. 12, 14, 16, pl. 33, fig. 2) and herein as Fig. 87A-D), here designated..

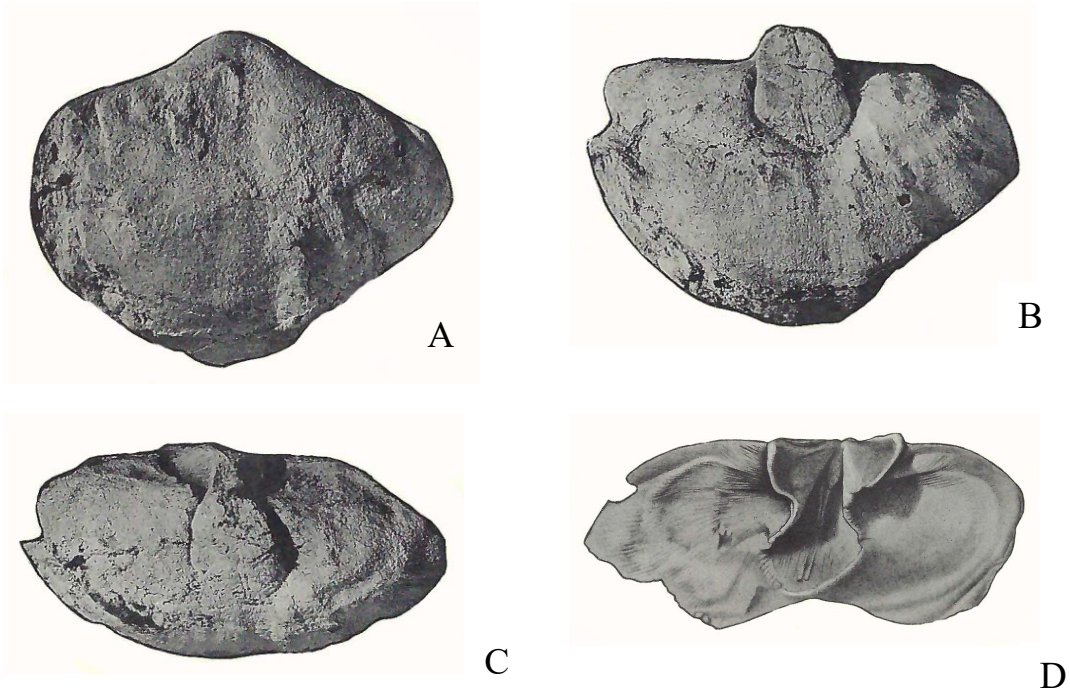


Fig. 87. *Tumulosulcus mckellari* n. sp. A-C, ventral valve exterior, ventral posterior and ventral aspects of the same specimen after leaching to show the internal mould, BR 649. D, latex cast of same specimen. Specimen x1 from uppermost Mangarewa Formation, New Zealand. Originally assigned to *Ingelarella pelicanensis*. (Waterhouse 1964).

Morphology: It is considered that this form should be named, in spite of its rarity (so far), and inadequate knowledge of its full morphology. The species signals the first entry into New Zealand of the Australia genus *Tumulosulcus*.

Stratigraphy: Shells come from the uppermost Mangarewa Formation at Wairaki Downs, and were originally regarded as aff. *pelicanensis* but is now shown to be a different genus

Subfamily **GEOTHOMASIINAE** Waterhouse, 2016

[Geothomasiinae Waterhouse, 2016, p. 78].

Diagnosis: Tabellae short and widely divergent.

Genera: *Geothomasia* Waterhouse, *Danzania* Pavlova, *Tomiopsis* Benediktova. Lower Carboniferous (Visean) to Late Permian (Wuchiapingian).

Discussion: *Tomiopsis* Benediktova, 1956 is the earliest known ingelarellid. It developed during Early Carboniferous or Mississippian time in Russia, and persisted it would appear into

Pennsylvanian time. *Tomiopsis* had been widely reported for Australian faunas in earlier and now outdated studies, but in spite of various articles of mostly twentieth century vintage, and even one by Cisterna & Shi as late as 2014 that disregarded the Treatment in the Revised Brachiopod Treatise of 2007, the genus *Tomiopsis* is not found in the Permian of east Australia, because overall shape and micro-ornament differentiates between species that belong to either *Tomiopsis* or *Geothomasia*. But the two genera do share similar tabellae. *Geothomasia* developed throughout Australia during Permian times, as an exceptional genus, derived from but not identical with *Tomiopsis*.

Genus ***Geothomasia*** Waterhouse, 1998

Diagnosis: Shells with well-formed sulcus, fold without channel as a rule, lateral shell smooth or displaying few plicae that may be strong, fine surface grooves. Adminicula of moderate length and moderately separated, tabellae short and widely divergent.

Type species: *Tomiopsis teicherti* Archbold & Thomas, 1986, p. 593 from the Wandagee Formation (Baigendzinian) of Carnarvon Basin, Western Australia, OD.

Discussion: *Geothomasia* was proposed initially as a subgenus of *Tomiopsis* Benediktova, 1956 for a group of species rather similar to each other, and known from Permian deposits of late Cisuralian to Lopingian age in Western Australia. *Geothomasia* includes the west Australian species *teicherti, hardmani, balgoensis, globosus* and *pauciplicatus*, all named as species of *Tomiopsis* by Archbold & Thomas (1986), and of Baigendzinian (late middle Early Permian) to Wuchiapingian (Late Permian) age. A geographically distinct group with similar short widely diverging tabellae is developed in east Australia, especially in Early Permian faunas (Waterhouse 2015a). In Western Australia, the adminicula of *Geothomasia* are well spaced and tend to be short and widely divergent, and the secondary thickening much less compared with east Australian material. Sulcal subplicae appear in a number of specimens in various species of *Geothomasia*, and the flanks of the fold are steep and well-defined. A late Permian ally is present in the Himalaya, initially called *Tomiopsis himalayicum* Waterhouse, 1978, p. 58, named for a species described by Diener (1903, pl. 9, fig. 2-4). Older species in Western Australia ascribed to *Tomiopsis* by Archbold & Thomas (1986), including *woodwardi* and *notoplicatus* and perhaps *rarus*, have longer less divergent tabellae,

and belong to *Ambikella* Sahni & Srivastava, 1956. *Geothomasia* appeared in Asselian (early Cisuralian) times, as summarized in Waterhouse (2022d, p. 164), and became rare after Aktastinian (mid-Cisuralian) times in east Australia. Species found in the Early Permian of east Australia include *Martiniopsis konincki* Etheridge, 1892 whereas another early Permian species *Martiniopsis elongata* McClung & Armstrong, 1975 belongs to *Ambikella*. Somewhat similar forms are found in mid-Carboniferous faunas of northern Russia, described by several authors, and varying a little in the nature of the fold, so that it would appear that distribution involved migration from Carboniferous stock from Russia into the Early Permian of east Australia, and then into Western Australia in later Cisuralian time.

Geothomasia konincki (Etheridge, 1892)

Fig. 87, 88

1877 *Spirifer darwini* [not Morris] – Koninck, p. 242, pl. 10, fig. 11, 11a (part, not pl. 10, fig. 11b; pl. 11, fig. 10; pl. 16, fig. 1 fide McClung 1978, p. 44).
1892 *Martiniopsis subradiata* var. *konincki* Etheridge, p. 239.
1969 *Ambikella konincki* – Runnegar, p. 294, pl. 20, fig. 1, 5 (part, not fig. 2-4 = *simplicitas*).
1983 *Tomiopsis konincki* – Waterhouse *in* Waterhouse, Briggs & Parfrey, p. 135, pl. 3, fig. 11, 12, 14, 15.

2014 *T. konincki*– Cisterna & Shi, p. 538, Fig. 6.1? (part, not Fig. 6.2?, 4, 5?, 7?, 8?, 9, 10 = *piersoni*), not Fig. 6. 2, 5, 6, 11 = *Geothomasia simplicata*).

Diagnosis: Medium-sized to large shells characterized by sulcal subplicae and shallow groove along the fold in a few specimens, plicae as a rule distinct in three or rarely four pairs. Widely divergent short tabellae.

Neotype: UQF 73296 figured by Waterhouse, Briggs & Parfrey (1983, pl. 3, fig. 14) from Allandale Formation, north Sydney Basin, and Fig. 87A herein, OD. The original material as figured by Koninck (1877, pl. 10, fig. 10, 11a) from the Allandale Formation was destroyed by fire (Runnegar 1969, p. 294). It seems difficult if not impossible to match the exact locality from which the Koninck specimen came, but the neotype provides a good approximation to his figure in shape. Clarke (1990, 1992) asserted that the neotype was a member of *Notospirifer*, but notospiriferids differ in the style of plication and sulcus and fold, and the neotype was selected from a range of specimens kept at the Australian Museum and University of Queensland, and close to the original material named *konincki* by Etheridge (1892) for material figured by Koninck (1877).

Morphology: Some difficulty arises in interpreting this species. The prime factor for

recognition depends on the presence of distinct close-set plicae and short widely divergent tabellae, rounded or weakly channelled fold, and sulcal subplicae moderately developed in the lectotype, though other material from the same stratigraphic level may have stronger subplicae. Various figures from the older Permian in the Sydney Basin need to be confirmed through first-hand examination of the specimens concerned, because, as a remote possibility, some individuals belong to *Geothomasia konincki*, and others possibly to *Monklandia*, first described from Gympie in Queensland. *Monklandia* shares sulcal subplicae with *G. konincki* and has a more channelled fold, and usually if not always stronger and more numerous plicae. Different micro-ornament with small c-shaped spines and grooves is developed in at least some Gympie specimens of *Monklandia*. Its tabellae are of medium length, and appear to vary in position, lying close to the flanks of the fold as a rule, but also in some specimens commencing in the second not first pair of interspaces from the fold, whereas the tabellae in *konincki* were described as short and widely diverging from the mid-

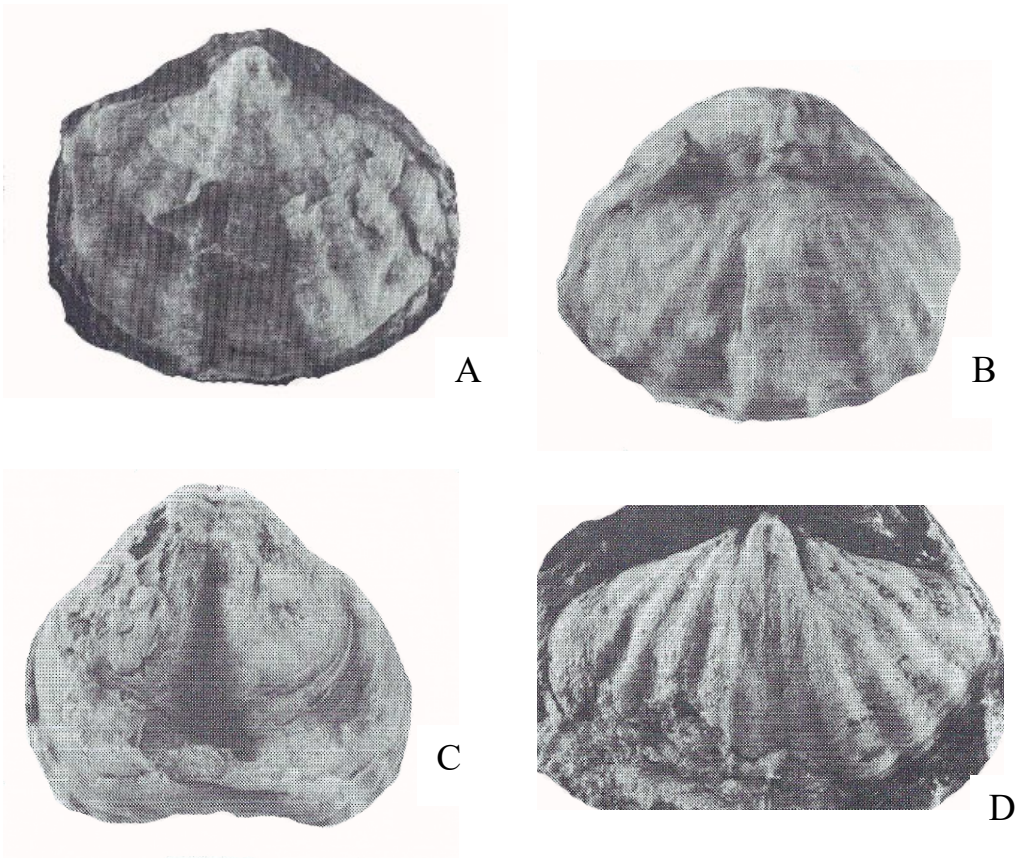


Fig. 87. *Geothomasia konincki* (Etheridge), A, ventral valve neotype, UQF 73296. B, C, dorsal and ventral aspects of conjoined specimen, UQF 73297. D, internal mould of ventral valve UQF 73311. Specimens x1, from Allandale Formation, north Sydney Basin. (Waterhouse, Briggs & Parfrey 1983).

line of the fold in Waterhouse, Briggs & Parfrey (1983), pointing to *Geothomasia.* A specimen from the Lochinvar Formation figured by McClung (1978, pl. 3, fig. 5) as *koninckі* has tabellae along the first pair of interspaces, and a weak mid-fold groove, suggesting possible *Monklandia*.

Clarke (1990, 1992) ignored the specific attributes of the species *koninckі*, offering no detailed comparison with Koninck's original figure or the neotype. His so-called *koninckі* has tabellae very different from those of Etheridge's taxon (See p. 53 herein).

Some of the specimens figured as *Tomiopsis koninckі* (Etheridge) by Cisterna & Shi (2014, Fig. 6) may well prove to be a distinct species of *Geothomasia*, with comparatively long adminicula, including Fig. 6. 1, especially long and closely spaced in Fig. 6.9, and signs that the sulcus contain two subplicae, whereas the specimen in Cisterna & Shi (2014, Fig. 6. 8 has short widely spaced adminicula. The sulcus in this specimen is of indeterminate nature, and it could have been tumulate, or subplicate. The dorsal valves mostly have short widely splayed tabellae, except for fig. 6.10, which has longer tabellae, subparallel and lying each side of the dorsal fold, reminiscent of the arrangement in *Tumulosulcus piersoni*, though such identification needs to be more firmly established. These differences were not mentioned by Cisterna & Shi, and either not noticed, or regarded as insignificant. Whatever, at best they were treated as natural variations, just as ingelarellid species were treated as natural variants within a few taxa before the studies initiated by K. S. W. Campbell. But the species based on specimens carefully segregated by Campbell are much less variable than those recognized for "*Tomiopsis*" *koninckі* by Cisterna & Shi (2014).

Cisterna & Shi (2014) in their synonymy of *koninckі* omitted reference to the original type specimen and to its replacement neotype. They seemed to treat Clarke as the prime and and irrefutable authority, who also ignored the Koninck material named *koninckі* by Etheridge (1892). Type *koninckі* from the Allandale Formation of New South Wales has a narrow ventral sulcus with strong subplicae, and lower and broad fold with rounded to very weakly channelled crest, as shown by Koninck (1877, p. 242, pl. 10, fig. 11, 11a), the original type, and neotype in Waterhouse, Briggs & Parfrey (1983, pl. 3, fig. 14) and further Allandale material in McClung (1978, pl. 3, fig. 4, 6). Some specimens figured as *koninckі* by Cisterna & Shi (2014, Fig. 6.3, 4, 9, and probably Fig. 6.7, 10) belong to *Oviformia piersoni* given the

tumulate sulcus and tabellae close to the fold. Others as figured by Cisterna & Shi (2014, Fig. 6.5, 6, 11) appear to be variants of *Geothomasia simplicitas*, given the broad fold and low plicae, and short widely diverging tabellae. *G. simplicatas* has fine surface grooves normal for *Geothomasia* (Nillsen 1982), whereas the micro-ornament of *konincki* is yet to be consolidated.

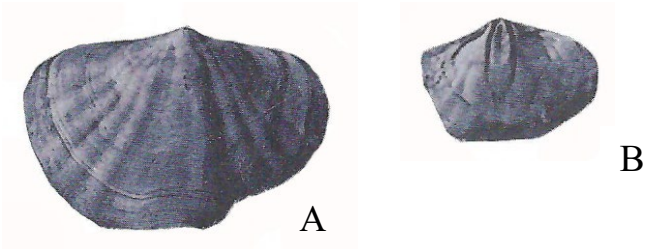


Fig. 88. Possible *Geothomasia konincki* (Etheridge), A, dorsal valve UNEF 12230 from Allandale Formation. B, ventral internal mould UNEF 12227 from Allandale Formation. Specimens x1 from New South Wales. (McClung 1978). These were also referred to *konincki* by McClung.

Cisterna & Shi (2014) reported the species *konincki* from the lower and middle Wasp Head Formation of the south Sydney Basin. They made no attempt to adjust the generic position to conform with – or question, or refute if they thought it necessary – the classification in the *Revised Brachiopod Treatise* (Gourvennec & Carter 2007, pp. 2778, 2779), even though they claimed to accept the recognition of the taxa in question. It would appear that their approach was to regard some of the variations involving shape, degree of plication, nature of the sulcus, disposition of internal plates as not worthy of attention. Fig. 6.10, in Cisterna & Shi (2014), stated to be a ventral valve, is surely a dorsal valve with moderately long and subparallel tabellae, not short and widely diverging as in *Geothomasia* or in the species *konincki.* The fold is well-rounded in section, with broad crest. Two ventral valves have sulcal subplicae, whereas another (Fig. 6.4) shows a slight sulcal swelling. Figures are not easy to interpret, given the variation in size, and in the differing directions of rather feeble lighting, and no information is provided for each specimen as to the stratigraphic position, so it is desirable to re-examine the specimens to determine their generic position and specific allegiance, a matter which will hopefully stimulate further enquiry. Several of their

specimens indicate sulcal subplicae, but the crest of the fold appears to be high and rounded in cross-section, signifying *simplicitas* rather than *konincki*.

Stratigraphy: The species is typical of the Allandale Formation. Examples have been reported from the Cranky Corner Formation of New South Wales (McClung 1978). Clarke (1990, 1992) described supposed *konincki* from Tasmania, especially the Bundella Formation but these belong to *Ambikella,* as judged by the nature of the dorsal fold and the tabellae.

Geothomasia simplicitas Waterhouse, 2015b

Fig. 89 - 91

?1969 *Ambikella konincki* Runnegar, p. 294, pl. 20, fig. 2, 3, 5 1, 4 (part not fig. 1 = *konincki,* 4?, 5 = indet., possibly *simplicitas*).
1975 *Martiniopsis konincki* [not Etheridge] – Runnegar & McClung, pl. 31,1, fig. 3.
1978 *Ingelarella konincki* – McClung, p. 44, pl. 2, fig. 3, 4, pl. 3, fig. 1, 2 (part, not pl. 3, fig. 3 = *Monklandia mcclungi* from Cranky Corner Sandstone, pl. 3, fig. 4 = *konincki* (?part, not 5? = *Monklandia* cf. *mcclungi* from Lochinvar Formation), not pl. 3, fig. 6 = *Ambikella elongata?* from Allandale Ftm.
2014 *T. konincki* [not Etheridge] – Cisterna & Shi, p. 538, Fig. 6.2?, 3?, 5, 6, 11 (part, not Fig. 6.1 = konincki, not Fig. 6.3?, 6.4, 6.9, 6.10 = Tumulosulcus piersoni,
2014 *Tomiopsis* sp. aff. *konincki* [not Etheridge] – Cisterna & Shi, p. 538, mostly *simplicatas* - eg. Fig. 6. 12-27, 30 (part, not Fig. 6. 28, 29 = *Tumulosulcus piersoni*).
2014 *T. piersoni* Cisterna & Shi, p. 540, Fig. 7.3, 4, 5?, 6, 7, 8, 12?, 14, 24, 25, 27, 28 (part, not Fig. 7.1?, 2, 10?, 11, 15?, 17, 18, 19, 20, 23? = *Oviformia piersoni*, These and other specimens require closer examination). May include a species of *Ambikella.*(Fig. 7. 21, 22).
2015b *Geothomasia simplicitas* Waterhouse, p. 169, Fig. 79A, B.

Diagnosis: Small and as a rule elongate with four pair of weak plicae as a rule, round-crested fold, distinguished by broad shallow sulcus with often poorly defined subplicae, and without a median swelling, adminicula short to moderately long, tabellae short and widely diverging across second pair of interspaces from fold as a rule.

Holotype: UNEF 12243 from Wasp Head Formation (Asselian), figured by McClung (1978, pl. 2, fig. 3, 4, pl. 3, fig. 1, 2), Waterhouse (2015b, Fig. 79) and Fig. 89A, B herein, OD.

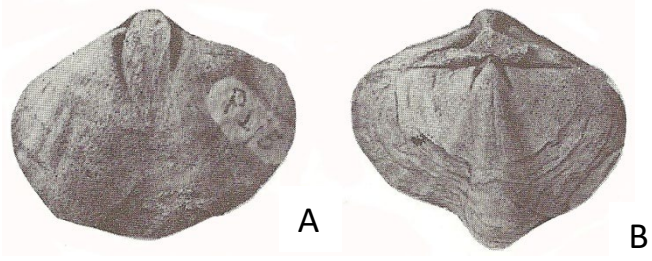


Fig. 89. *Geothomasia simplicatas* Waterhouse. A, B, holotype UNEF 12243, internal aspects of ventral and dorsal valve, x1, from Wasp Head Formation. (McClung 1978).

Morphology: This species is based on shells that are distinguished from *Geothomasia konincki* (Etheridge**)** by having a broader non-tumulate sulcus and weaker plicae. *G. simplicatas* has fine surface grooves normal for *Geothomasia* (Nillsen 1982). There is no median channel along the dorsal fold. Material figured by Runnegar (1969) from the upper Wasp Head beds of the south Sydney Basin includes likely *simplicatas* as well as specimens of more debatable allegiance, with plicae stronger than in the types. Specimens were recorded from unspecified parts of the Wasp Head Formation of the south Sydney Basin by McClung (1978, pl. 2, fig. 3, 4, pl. 3, fig. 1, 2), adding Lochinvar and Cranky Corner material which is not conspecific as the material has tabellae next to the dorsal fold to indicate *Ambikella*. The material is discriminated from *Monklandia gympiensis* by the short widely diverging tabellae, and by the rounded dorsal fold, and fainter subplicae, if any, in the ventral sulcus, and more subdued plicae.

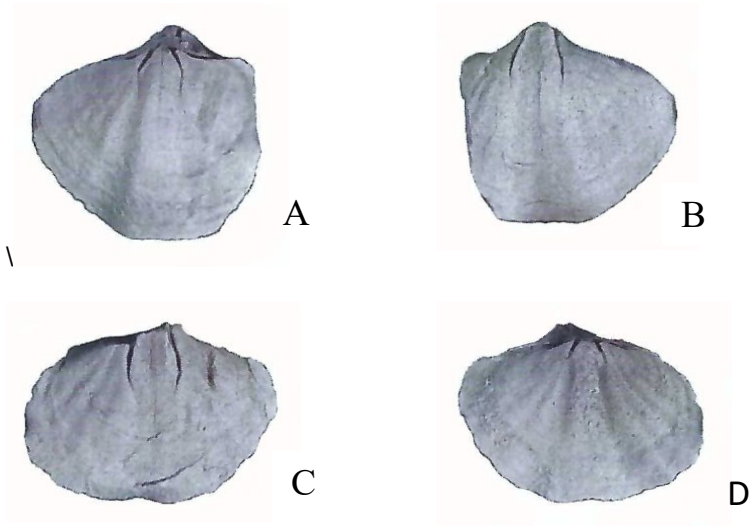


Fig. 90. *Geothomasia simplicitas* Waterhouse. A, B, dorsal and ventral aspects of conjoined specimen, NMVP 309928, x1.2. C, D, ventral and dorsal aspects of conjoined specimen NMVP 309929, x1. From upper Wasp Head Formation, south Sydney Basin. (Cisterna & Shi 2014).

A number of specimens are weakly transverse with two to four pairs of plicae of varying generally low strength, fold with broadly rounded crest as a rule, broader than in *simplicitas*, sulcus moderately prominent with very weak or no subplicae, narrower than in

simplicitas. A prime factor for recognition depends on the rounded nature of the fold, and the common but not universal lack of sulcal subplicae.

Cisterna & Shi (2014, Fig. 6.12-30) described a suite of specimens from the uppermost Wasp Head Formation as *Tomiopsis* sp. aff. *koninckí,* considered to be differentiated from *koninckí* by their larger size, less developed plicae and more prominent sulcus and fold. **Tabellae were said to be shorter than in *koninckí***. The adminicula were described as being shorter than in *koninckí*, though this is contradicted by some of their figures (eg. 2014, Fig. 6.13, 27). No description or figures were offered for the exterior, though external moulds are abundant in the upper Wasp Head Formation, and the authors clearly believed internal moulds sufficed. Most of the dorsal valves appear to belong to *Geothomasia*, and most of the ventral valves appear to have two subplicae in the sulcus, though that needs to be checked. But some, including one conjoined specimen NMVP 309897 as figured in Cisterna & Shi (2014, Fig. 6.29) is clearly *Tumulosulcus,* related to *piersoni* (Cisterna & Shi). Specimens figured only so far as the ventral valve is concerned are more difficult to identify in the absence of the dorsal valve, although shells with tumulate sulcus can obviously be ruled out.

Various figures from the older Permian in the Sydney Basin need to be confirmed through first-hand examination of the specimens concerned, because some individuals may prove to belong to *Geothomasia koninckí*, and others possibly to *Monklandia*. *Monklandia* shares sulcal subplicae and channelled fold with some *G. koninckí*, but usually if not always has stronger and more numerous plicae, wider dorsal fold channel and different micro-ornament with small c-shaped spines and grooves on at least some specimens. Its tabellae are not as divergent as in *koninckí.*

Specimens from the Bundella Formation of Tasmania that were described and figured by Clarke (1990, 1992) are similar in their rounded fold and plain sulcus for most specimens, although Fig. 11G (in both articles) has a fold channel and subplicae lie in the sulcus in Fig. 11D (in both articles). They fall close in some morphological aspects to *simplicitas,* although the tabellae are much less divergent than in *Geothomasia,* except for one specimen with only short tabellae. They are regarded therefore as belonging to *Ambikella*, close to *A. bundellaensis.* A specimen in Clarke (1990, 1992, Fig. 11.I, J) has

sulcal subplicae, and the fold appears to be rounded, though this is not entirely clear. The specimen comes from the Swifts Jetty Sandstone high in the Massey Creek Group of Tasmania.

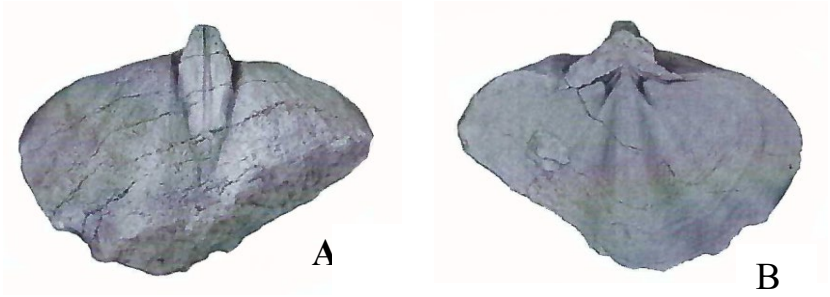


Fig. 91. *Geothomasia simplicitas* Waterhouse. A, B, ventral and dorsal aspects of conjoined specimen, NMVP 309933, x1. Upper Wasp Head Formation. (Cisterna & Shi 2014).

Stratigraphy: This species comes from the uppermost Wasp Head Formation. Cisterna & Shi (2014) stated that the Runnegar material figured from Wasp Head beds came from the same level, and that his pl. 20, fig. 2 showed similar subdued plicae. (The plicae in another Runnegar specimen from the same locality are a little stronger, in pl. 20, fig. 4). These specimens certainly appear to belong to *Geothomasia.* Similar tabellae are clearly indicated in Cisterna & Shi (2014, Fig.7.18, 22).

Geothomasia delicatula Waterhouse, 2022d

Fig. 92

?1965 *Ingelarella ingelarensis* [not Campbell?] – Waterhouse & Vella, p. 68, pl. 4, fig. 2, 3 (part, not fig. 1, 4-6 = *I. havilensis*).
2022c *Geothomasia delicatula* Waterhouse, p. 165, Fig. 30, 31, 32A

Diagnosis: Small shells with low lateral plicae and sulcal subplicae, fold with broad crest, in some shells weakly channelled anteriorly. Adminicula moderate in length, curved in outline, tabellae short, divergent. Dense micro-ornament of crowded elongate grooves.

Holotype: UQF 82689, figured by Waterhouse (2022d, Fig. 30C) and Fig. 91B herein, lower *Echinalosia* (*Unicusia*) *minima* Zone, upper Blenheim Formation, north Bowen Basin, OD.

Morphology: The species is distinguished by its low plicae, well-defined sulcal subplicae, and

Impersistent if any fold channel. Tabellae commence in the first pair of interspaces from the fold and diverge forwards, crossing the first pair of plicae from the fold.

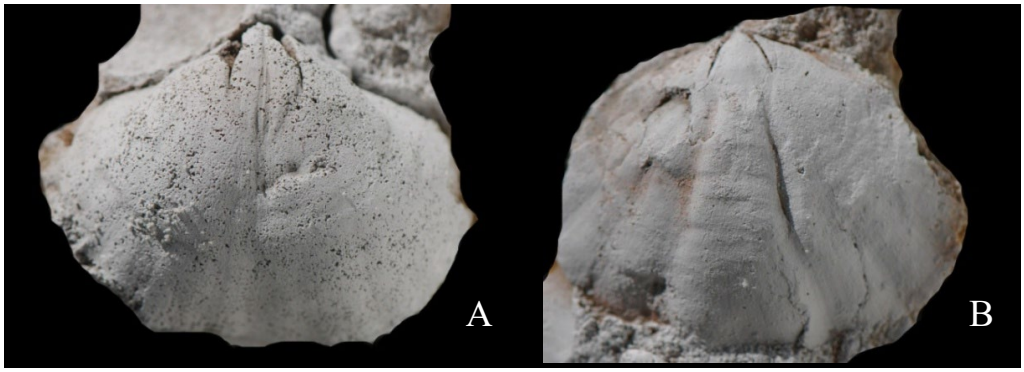


Fig. 91. *Geothomasia delicatula* Waterhouse. A, ventral internal mould UQF 59565**,** x1.5. B, dorsal internal mould UQF 82689, x2, holotype. Specimens from Blenheim Formation just above Scottville Member, north Bowen Basin. (Waterhouse 2022c).

Nelson material from the Flowers Formation that is provisionally refrred todelicatula has had no dorsal valves described. But the ventral valve differs from havilensis in lacking any sulcal groove, and the accompanying fauna is closely allied to that of the havilensis fauna in the upper Blenheim Formation in the *Echinalosia* (*Unicusia*) *minima* Zone.

Stratigraphy: The species occurs in the *Echinalosia* (*Unicusia*) *minima* Zone towards the top of the Middle Permian marine faunas in the north Bowen Basin of Queensland.

NAMES OF INGELARELLID SPECIES, SOME OF WHICH ARE NO LONGER IN USE

In the early days of geological and palaeontological exploration, several species were named, but are now treated through the assessments by Campbell (1960) and McClung (1978) as of uncertain stratigraphic source, with original specimens as a rule no longer intact. Only some were ever figured: and some could not be matched with now available material.

Ingelarellid *subradiata* (G. B. Sowerby, 1844)

Fig. 92 - 97

1844 *Spirifer subradiata* G. B. Sowerby, p. 159.
1845 *S. subradiata* – Morris, p. 281, pl. 15, fig. 5, 5a, pl. 16, fig. 1-4.
1892 *Martiniopsis subradiata* – Etheridge Jnr, p. 238, pl. 11, fig. 14.
1978 *Ingelarella subradiata* – McClung, p. 42.

The stratigraphic source of Sowerby's material is not known, and no material of the original collection at the Museum of Natural History is preserved, so that the species is indeterminate. By contrast, some of the Morris specimens kept at the Museum of Natural History are well illustrated and are extant, surely raising the possibility that comparable material will yet be found, and properly assessed. Given that the original *radiata* material is now not extant, and the source uncertain, the Morris specimens remain available for assessment. McClung (1978, p. 42) suggested that one specimen of Morris (1845, pl. 16, fig. 3) and refigured herein as Fig. 92B belongs to *isbelli,* now treated as a member of genus *Johndearia*, and suggested that another (Morris 1845, pl. 16, fig. 2) belongs to *Ingelarella plana* (Fig. 93). This is discounted, because the sulcus is tumulate, and the specimen comes close to *Tumulosulcus undulosa* (Campbell). Another of the specimens figured by Morris (1845) as *subradiata* was named *morrisi* by Etheridge (1892) and this appears to be a viable species (Fig. 94-96), very close to if not senior synonym for *profunda* Campbell. The situation will become clearer when and if more material can be described and figured from Tasmania, to be compared with the *profunda* specimens widely described from Queensland, and allow confirmation of the nature of the dorsal tabellae, which are short in *profunda*.

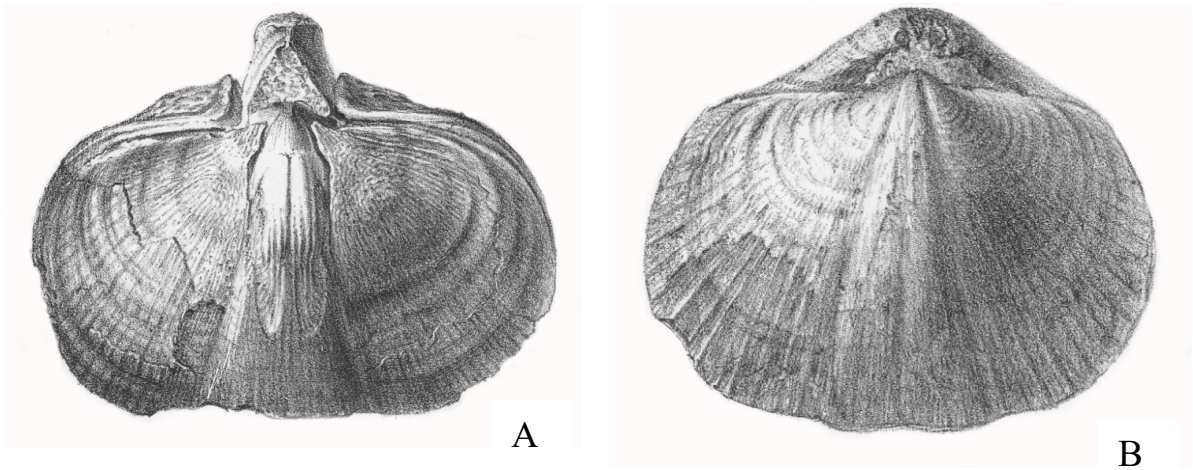


Fig. 92. A, *Spirifer subradiatus* G. B. Sowerby of Morris (1845, pl. 16, fig. 3) from Illawarra, possibly close to *Johndearia brevis* (McClung & Armstrong, 1978). B, *S. radiatus* G. B. Sowerby of Morris (1845, pl. 16, fig. 1) from Tasmania, possibly belonging to *Tumulosulcus isbelli* (Campbell, 1961). Specimens x1, kept at Natural History Museum.

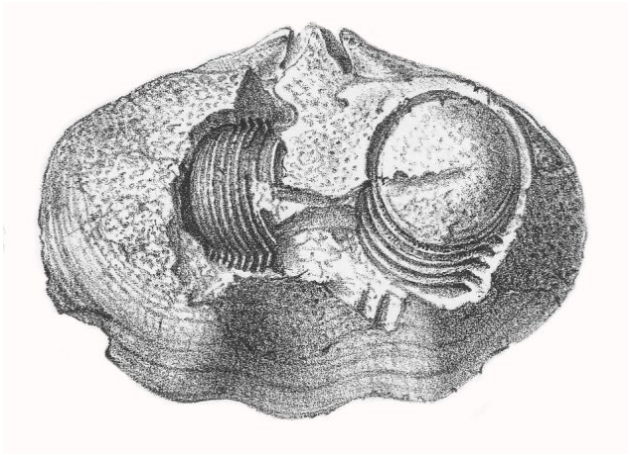


Fig. 93. A, *Spirifer subradiatus* G. B. Sowerby of Morris (1845, pl. 16, fig. 2) from Tasmania, possibly *Tumulosulcus undulosa* (Campbell, 1961). Specimen x1, kept at Natural History Museum.

Fig. 94. A, *Spirifer subradiatus* G. B. Sowerby of Morris (1845, pl. 16, fig. 2) from Tasmania, showing the dorsal side of Fig. 93, as a plaster cast prepared by the Natural History Museum of London. Possibly *Tumulosulcus undulosa* (Campbell, 1961). (New).

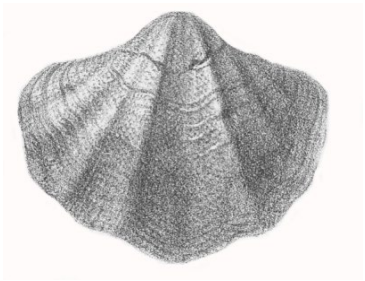


Fig. 95. Specimen figured as *Martiniopsis*? *subradiata* by Morris (1845, pl. 15, fig. 5a), possibly a specimen of Notospiriferidae or more doubtfully close to *Ambikella profunda*, with ribs too narrow-crested. Locality uncertain. (Morris 1845).

The specimen figured by Morris (1845, pl. 15, fig. 5a) is of uncertain allegiance, and shows some similarities to Notospiriferidae (Fig. 97).

Ambikella hombrianus (d'Orbigny, 1846)

1846 *Spirifer hombrianus* d'Orbigny, pl. 6, fig. 15-18.
1960 *Ingelarella hombrianus* – Campbell, p. 1111.
1978 *Ingelarella hombrianus* – McClung, p. 42.

The fold is rounded in cross-section of the specimen from somewhere in the Hunter Valley, suggesting *Ambikella*. According to Campbell and McClung, no comparable specimens have since been found, so that the name should be allowed to lapse.

Ingelarella elegantula (Johnston, 1888)

1888 *Inoceramus elegantula* Johnston, pl. 15, fig. 13, 13a.
1978 *Ingelarella elegantula* – McClung, p. 43.

The specimen comes from Tasmania, and McClung stated that the locality will be difficult to identify, and that the name should be allowed to lapse.

Ambikella morrisi (Etheridge, 1892)

Fig. 96 - 98

1845 *Spirifer subradiatus* [not Sowerby] – Morris, pl. 15, fig. 5 (part, not fig. 5a = n. det., pl. 16, fig. 4 possibly = *isbelli*.)
1892 ?*Martiniopsis subradiatus* var. *morrisi* var. nov. Etheridge Jnr, p. 240, pl. 11, fig. 12, 13.
1978 *Ingelarella morrisi* – McClung, p. 44.

The Morris specimen on which Etheridge (1892) based his taxon is extant at the Museum of Natural History in London. Etheridge (1892, p. 240) included *Spirifera glabra* Koninck (1877, pl. 1, fig. 1, 1a, pl. 11, fig. 8. Not pl. 12, fig. 1b, c in synonymy, and regarded the Morris specimen Morris specimen as being close to *Spirifera hombrianus* d'Orbigny (1846, pl. 6, fig. 12-18). Two figures were provided by Etheridge (1892) of a specimen regarded by Etheridge (1892) as not

Fig. 96. *Ambikella* (*Branxtonifera*) *morrisi* (Etheridge), Natural History Museum nominated as the type of *Martiniopsis*? *subradiata* var. *morrisii* by Etheridge (1892, p. 240). Possibly from "Illawarra, Glendon", but location needs clarification. The specimen somewhat approaches *Ambikella profunda* (Campbell). The subplication along the left side of the fold is scarcely visible in the plaster duplicate.

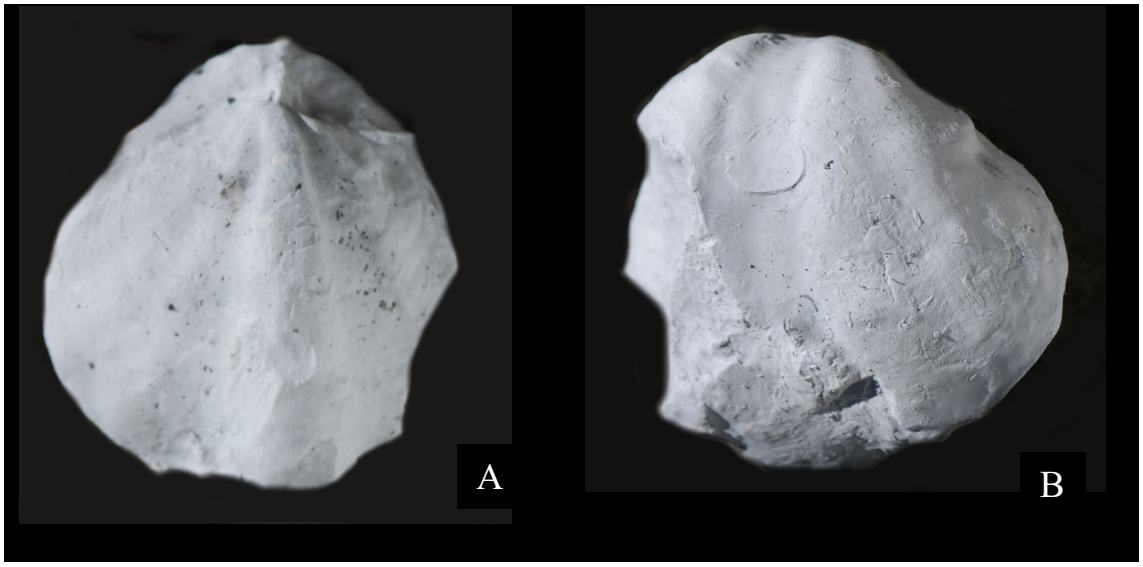


Fig. 97. *Ambikella* (*Branxtonifera*) *morrisi* (Etheridge). Dorsal and ventral aspects of a plaster cast provided by the Natural History Museum, London. The specimen was nominated as type of *Spirifer morrisi* Etheridge, 1892, x1. (New).

completely typical (see Fig. 98), but the specimen is not that different from the Morris specimen, and McClung included the specimen shown in Morris (1845, pl. 15, fig. 5a) in this form. He allowed that Etheridge regarded his own material as exceptional, and therefore unsuitable to be considered as possible lectotype. But it is here considered that McClung was correct, and that the Tasmanian specimen may be considered as likely to be conspecific. There are differences, notably in the strength of the plicae, but overall there is considerable similarity, and perhaps the differences were induced by geographic factors. One difficulty is that faunas from Tasmania

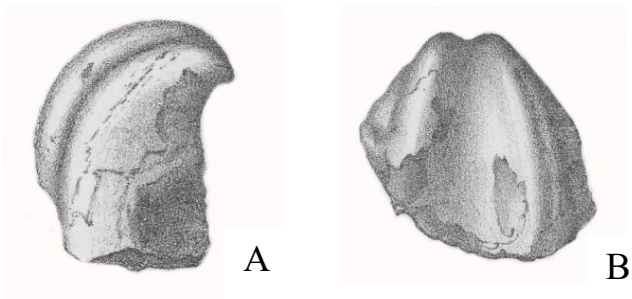


Fig. 98. *Ingelarella morrisi* (Etheridge). A, B, lateral and ventral aspects of ventral valve x1 from Burnett district, Queensland. (Etheridge 1892).

likely to be correlative with the Etheridge specimen have yet to be described and figured.

McClung (1978) considered that the Morris specimen belonged to *Ingelarella ovata* Campbell, which seems unconvincing, because of the presence of low plicae over both valves, and therefore comes much closer to *I. profunda* Campbell, 1961 and *I. symmetrica* Campbell, 1961, both well-known from the Tiverton Formation of the north Bowen Basin. Given that the holotype as nominated by Etheridge is still extant at the Museum of Natural History in London, this may have to assume seniority over the name *profunda.* `

Ingelarellid *transversa* (Etheridge Jnr, 1892

1877 *Spirifer glaber* [not Dana] – Koninck, p. 227, pl. 12, fig. 1b.
1892 *Martiniopsis subradiata transversa* Etheridge Jnr, p. 239.
1960 Name to lapse – Campbell, p. 112.
1978 Name to lapse – McClung, p. 45.

Campbell (1960) and McClung (1978) reported that the Koninck specimen had been destroyed by fire and that the locality had never been given.

Martiniopsis deltoidea Andrews, 1908

1908 *Martiniopsis deltoidea* Andrews, p. 5.
1924 *Martiniopsis deltoides* (sic) – Richards & Bryan, Table 8.
1936 *Martiniopsis deltoidea* – Voisey, 164.
1978 *Ingelarella deltoidea* – McClung, p. 45.

As noted by McClung (1978), this name is a nomen nudum, with the species never described or figured.

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_____ 2021c: Macro-faunal biozones and correlation for the Early Permian (Asselian – Kungurian) marine beds of east Australia and New Zealand. Earthwise 19: 181-267.

_____ 2022a: Some brachiopods and molluscs from the Catherine Sandstone, southwest Bowen Basin, Queensland. Earthwise 20: 35-57.

_____ 2022b: Brachiopods and molluscs from the Scottville Member, *Pseudostrophalosia clarkei*

Zone, north Bowen Basin, Queensland. Earthwise 20: 97-123.

_____ 2022c: Brachiopods and molluscs from the *Echinalosia (Unicusia*) *minima* Zone, upper Blenheim Formation, north Bowen Basin, Queensland. Earthwise 20:125-266.

_____ 2022d*:* Macro-invertebrate fossils of the *Ingelarella costata* Zone in the upper Blenheim Formation and correlates of the Bowen Basin, Queensland. Earthwise 20: 267-300.

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Family **NOTOSPIRIFERIDAE** Archbold & Thomas, 1986

Diagnosis: Small to medium-sized plicate shells with diverse micro-ornament, involving varying development of small spines or protuberances and shallow grooves. Swollen hollows called globons present in the main and middle layer of shell of one subfamily. Tabellae as a rule very short or not developed, if present as a rule commence in first or even second pair of interspaces from fold, unlike Ingelarellidae in which tabellae lie clkose to the fold throughout their length; tabellae may extend forwards across first pair of plicae. Micro-ornamanet of small spines, as a rule "barchan spines", so-called because they approach in miniature the shape of barchan dunes in deserts, with lateral wings that curve forwards each side of the main dune with its concave face. The flanks of each barchan spine may be and generally is prolonged by a narrow low ridge, well shown by Clarke (1992a) as reproduced herein as Fig. 53, p. 182. The front of the spine is succeeded by a groove, which in one subfamily Notospiriferinae leads to a pit or globon plunging into the middle layer of the shell.

Discussion: This family is distinguished from Ingelarellidae by its more complex surface structure and micro-ornament, and by the usual lack or poor development of tabellae, although crural plates are fully developed. Shells are invariably plicate, whereas Ingelarellidae includes species that are smooth or simply sulcate. The family flourished in east Australia and New Zealand, and appears to have been limited otherwise to comparatively few species over Gondwana, with no certain occurrences in the northern hemisphere. The family is herein divided into several genera and subgenera, but various aspects of shell structure and micro-ornament especially remain to be resolved, and the reliability of subplicae and fold channel remain to be firmly established.

Several authors have contributed to the family: H. J. Harrington in his recognition of *Notospirifer* and N. W. Archbold & G. Thomas for delineating the family-group: K.S.W. Campbell for describing several species, G. McClung, J. D. Armstrong and M. J. Clarke for recognizing allied genera, with J. D. Armstrong also focusing on details of micro-ornament. Clarke (1987) recognized a distinct subfamily Glendoniinae.

Subfamily **NOTOSPIRIFERINAE** Archbold & Thomas, 1986

Diagnosis: Subsurface ornament of globons, which are small globose to elongate hollows that expand into the thick median layer of shell below the surface of the shell from the anterior

end of short surface grooves.

In general, the shell surface of Notospiriferinae is made up of pits surrounded by a network of shell ridges and barchan spines. In a number of species generally assigned to *Notospirifer*, the ridges are thicker and the micro-ornament less crisply defined. In some species, the presence of spines is not established. Nor for most species assigned to *Notospirifer* is the depth of the globons precisely known, with most authors failing to provide thin sections that could have elucidated this aspect of the morphology. Instead various authors have relied on external moulds, which do not clearly indicate the relative depth and size of the globon, leaving it unclear if globons always penetrate the thick median layer of shell, rather than just the exolayer.

Several other morphotypes in the past have been referred to *Ingelarella*, but appear to belong to Notospiriferinae, from aspects of shape and micro-ornament. So-called *Ingelarella strzeleckii* (not de Koninck) of McClung (1978) differs substantially from *Notospirifer* in having wide subplicate sulcus and channelled broad fold, with a number of narrow plicae, surface ornament allied to that of *Notospirifer* and comparatively short tabellae, so that the species, now named *gympiensis*, is referred to a separate genus *Monklandia* Waterhouse, 1998. Another supposed *Ingelarella* named *I. denmeadi* Campbell, 1961 has a high wide simple fold and sulcus and many fine plicae, and a somewhat similar species *Notospirifer undulatus* Parfrey, 1986 has notospiriferid micro-ornament. The species are referred to *Tabellina* Waterhouse, which appears to be senior synonym of *Kelsovia* Clarke, 1990.

Genus ***Notospirifer*** Harrington, 1955

Diagnosis: Plicate shells bearing two prominent subplicae within sulcus as a rule, low dorsal fold normally channelled, micro-ornament of globons, ridges, grooves and spines. Short adminicula and reduced or no tabellae.

Type species: *Spirifer darwini* Morris, 1845, p. 279 from Elderslie Formation, north Sydney Basin, New South Wales, OD.

Discussion: The amount of variation displayed in micro-ornament by *Notospirifer*-like shells was not fully realized for many years, having been hampered by poor preservation of micro-ornament for the type material of Harrington's genus. The micro-ornament of *Notospirifer* has

been figured to show a closely spaced array of globons (Armstrong 1968, pl. 2, fig. 9), but was reported by Armstrong (1970b) as consisting of small blunt spines and shallow grooves, although this is not shown, or at least clearly shown, in his figure. Clarke (1992a, p. 73), apparently quoting Armstrong (1970b), stated that *Notospirifer* had small upright microspines behind short grooves leading anteriorly into deep globose and elongated pits. But it is not certain that spines lie behind the grooves, because Campbell (1960, 1961) recorded only "deep closely packed subcircular or slightly elongate pits" and made no reference to spines of any sort. Thus, regrettably, the exact nature of the micro-ornament in the type species remains to be verified. External features involving the shape, number and nature of plicae, and nature of sulcus and fold also help provide key attributes. There may be a degree of variation, but the type and other species are little to moderately inflated with low plicae and shallow sulcus bearing as a rule two subplicae, and fold as a rule bearing a median channel. Such specimens are referred herein to *Notospirifer,* subgenus *Notospirifer.* Subgeneric variations are recognized for species close to *Notospirifer* (*Notospirifer*), distinguished by a high dorsal fold (*Papulinella*), and another form in which sulcal subplicae are not developed (*Mesopunctia*). The value of these distinctions remain to be assessed, and will discussed further in the final study of this series on the Permian brachiopods of east Australia and New Zealand.

Subgenus ***Notospirifer*** Harrington, 1955

Diagnosis: Sulcus with two subplicae, fold with channel as a rule. Believed to have small barchan spines with ridge leading to spine, and two ridges, one each side, leading forward from each side of barchan spine. A groove lies in front, leading to a small deep pit or globon.

Type species: *Notospirifer darwini* (Morris, 1845) from Muree Sandstone of north Sydney Basin, OD.

Notospirifer (***Notospirifer***) ***triplicata*** Waterhouse, 2015a

Fig. 1 - 4

1983 *Tomiopsis konincki* [not Etheridge] – Waterhouse et al., p. 135, pl. 3, fig. 15 (part, not fig. 11, 12, 14 = *konincki*).
2015a *Notospirifer triplicata* Waterhouse, p. 181, Fig. 132-136.

Diagnosis: Medium-sized moderately inflated shells with three to five pair of low ventral

plicae, usually three or four pairs of dorsal plicae, sulcus generally with two low subplicae, rarely may be smooth, fold smoothly rounded or with median groove, micro-ornament of shallow dense globons and small barchan spines.

Holotype: Specimen UQF 81343 from lower Tiverton Formation, figured in Waterhouse (2015a, Fig. 133, 134A, 135) and herein as Fig. 2A, OD.

Morphology: Shells of moderate size, transverse, hinge about two thirds of shell width, ventral valve well inflated at maturity, interarea high and gently concave, dorsal interarea very low, cardinal extremities obtuse. Sulcus commences at umbo and widens at an angle close to 25°, with anterior tongue, usually bears two very low subplicae, dorsal fold low with steep low walls, and broad crest, smooth, or with very shallow median groove. Three or often four pairs of plicae on each valve with signs of fifth pair in some specimens. Micro-ornament of small barchan spines each with slightly elongate swollen pit in front, crowded, about four in 1mm across the shell, and two per mm longitudinally. Some growth lamellae well developed.

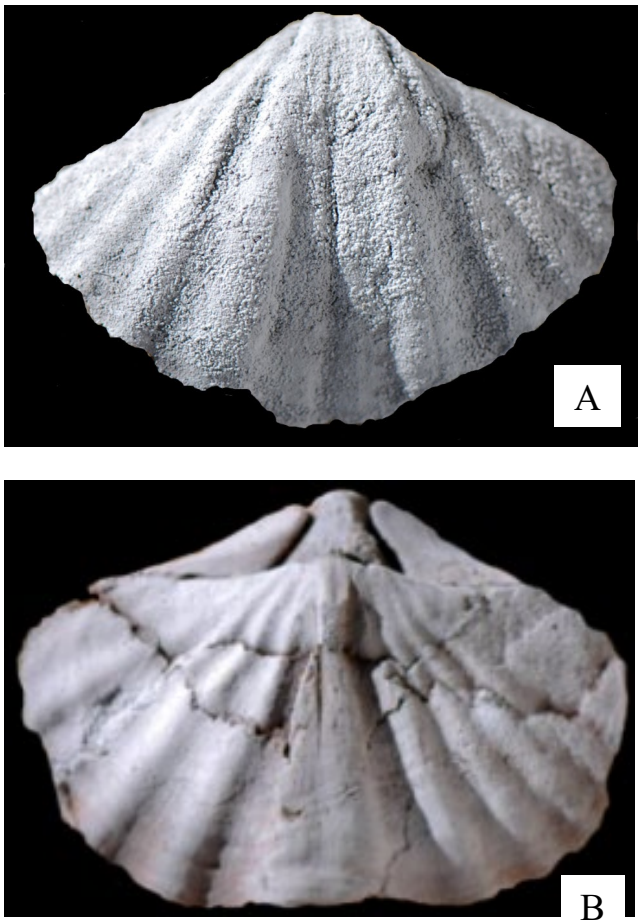


Fig. 1. *Notospiirfer* (*Notospirifer*) *triplicata* Waterhouse. A, B, ventral and dorsal aspects of internal mould UQF 81853, x4. B, dorsal aspect of holotype, UQF 81343. Lower Tiverton Formation. (Waterhouse 2015a)

Dorsal valve with very short tabellae extending along second pair of interspaces from fold, cardinal process not visible, median septum extending almost two thirds length of valve, dorsal adductors not clearly impressed.

This species is referred to *Notospirifer* because of its low inflation, shallow sulcus and low fold. Some specimens agree with the type of the genus in the presence of sulcal subplicae and median groove in the fold. The micro-ornament shows, rarely, small barchan spines, the paucity perhaps reflecting presvation.

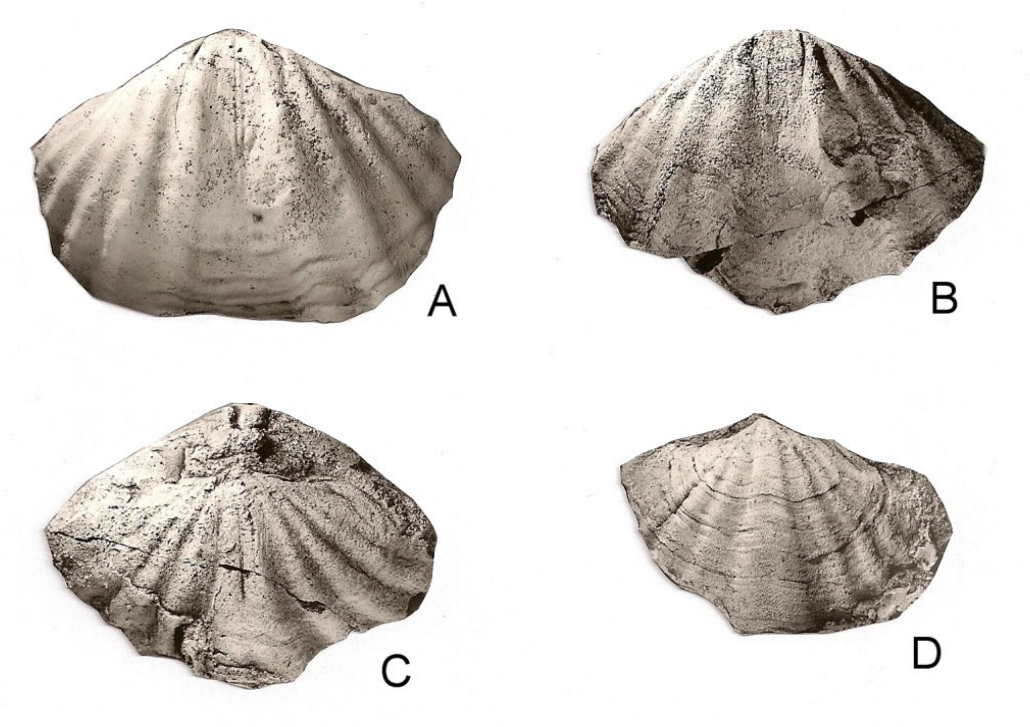


Fig. 2. *Notospirifer* (*Notospirifer*) *triplicata* Waterhouse. A, ventral aspect of specimen with valves conjoined, holotype UQF 81343. B, C, ventral and dorsal aspects of internal mould with valves conjoined, UQF 81344. D, latex cast of dorsal valve UQF 81345. Specimens x1, from lower Tiverton Formation, north Bowen Basin. (Waterhouse 2015a).

Rather similar specimens were described by Lee in Lee et al. (2023) from the Snapper Point Formation of the south Sydney Basin, showing mostly three pairs of plicae and less swollen ventral valve, so that they appear to be closer to *Notospirifer gentilis* Waterhouse *in* Waterhouse & Jell (1983, pl. 3, fig. 1-5) from the Glendoo Sandstone Member above the Tiverton Formation in the north Bowen Basin. *N. gentilis* has three pairs of plicae, two

Fig. 3. *Notospirifer* (*Notospirifer*) *triplicata* Water-house, posterior view (dorsal valve on top) of holotype UQF 81343, x2. Lower Tiverton Formation, (Waterhouse 2015a).

Fig. 4. *Notospirifer* (*Notospirifer*) *triplicata* Waterhouse, detail of latex cast of ventral valve UQF 81348, x7 approx., showing surface ornament of small dense spines. Lower Tiverton Formation. (Waterhouse 2015a).

sulcal subplicae and comparatively narrow low round-crested fold, broadening anteriorly. The adminicula are shorter and more widely diverging and the tabellae are slightly longer than in the present species. Some specimens showing a mid-sulcal anterior swelling, as in Lee et al. (2023, Fig. 12T), and a mid-sulcal groove, as in Fig. 12F, T, like that of Waterhouse & Jell (1983, pl. 3, fig. 5), but not in all specimens and such features are observable in some specimens of *triplicata*.

Notospirifer extensus Campbell (1961, pl. 28, fig. 1-4) from the Stanleigh Shale, southwest Bowen Basin, has sulcal subplicae in a comparatively wide sulcus, flattened crest to dorsal fold, and as a rule two or three pair of ventral plicae, and is close in shape to the new form. It is distinguished by its widely divergent short adminicula.

Stratigraphy: The species was described from the lower Tiverton Formation.

Notospirifer (***Notospirifer***) ***extensus extensus*** Campbell, 1961

Fig. 5 - 7

1961 *Notospirifer extensus* Campbell, p. 187, pl. 28, fig. 1-4.
1970b *N. extensus* – Armstrong, p. 289, Fig. 1C, 2A-C, 3D-H, 4.
?2021 *Notospirifer* sp. Waterhouse & Campbell, p. 33, Fig. 10D.

Diagnosis: Medium to large size for the subfamily, three to four pairs of plicae, short widely divergent adminicula, no tabellae. Sulcal subplicae on holotype, fold crest with slight flattening.

Holotype: UQF 21959 figured by Campbell (1961, pl. 28, fig. 1a - d) and Fig. 5A, 6A-C herein from purported Stanleigh Shale, southwest Bowen Basin.

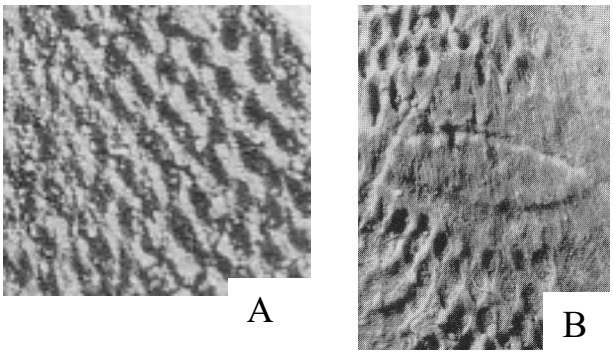


Fig. 5. *Notospirifer* (*Notospirifer*) *extensus extensus* Campbell. A, detail of micro-ornament on UQF 21959, holotype, x30. Stanleigh Shale. (Campbell 1961). B, micro-ornament on UQF 45142 from Tiverton Formation, x10. (Armstrong 1970b).

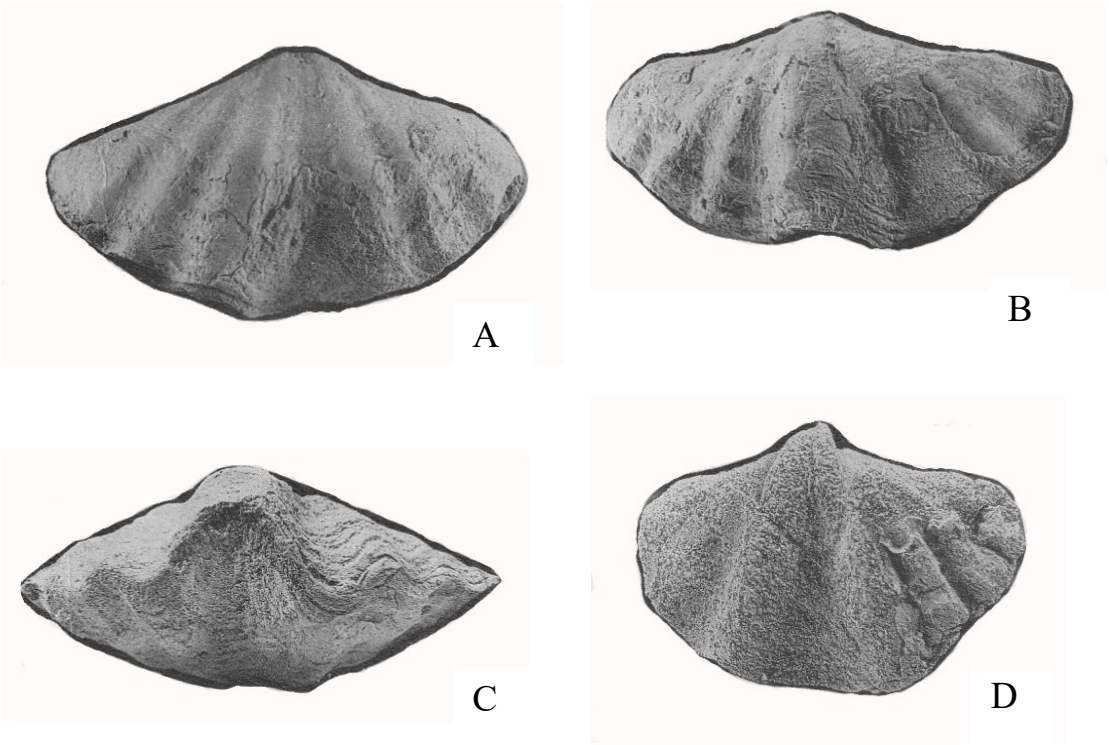


Fig. 6. *Notospirifer* (*Notospirifer*) *extensus extensus* Campbell. A, B, C, ventral, dorsal and anterior aspects of UQF 21959 holotype. D, ventral internal mould UQF 21951, x1. Stanleigh Shale. (Campbell 1961).

Morphology: Campbell (1961) and Armstrong (1970b) have presented rather similar illustrations of the micro-ornament, though interpretation is not easy, as to whether the features are pits as seems probable, or ridges, in which case the figures have been back-lit. Nor is it clear if the figures show the actual exterior of the shell, or a mould. The pits were described by Campbell as having a diameter of 0.2mm, and there appear to be some five or six pits per mm. The fold may be rounded, or flattened.

Fig. 7. ? *Notospirifer* (*Notospirifer*) *extensus extensus* Campbell, external cast of ventral valve BR 2497, x5. Eglinton Subgroup. (Waterhouse & Campbell 2021).

Stratigraphy: Although Ken Phillips in Hill & Denmead (1960, pp. 189-191) considered that the

Stanleigh Formation to be older than the Dilly Shale, Campbell (1961, p. 188) reported that the *Notospirifer* was found with *Ingelarella ingelarensis* and "*Strophalosia* cf. *typica*" which correct would point to a younger age. But these identifications have not been verified.

Notospirifer (***Notospirifer***) ***extensus tweedalei*** Campbell, 1961

Fig. 8

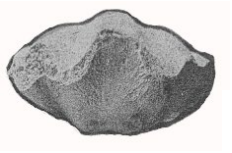
1961 *Notospirifer extensus tweedalei* Campbell, p. 187, pl. 28, fig. 5-8.

Diagnosis: Small shells with two, three or rarely four pairs of ventral plicae, two or three dorsal pairs, faint sulcal subplicae, close to *Notospirifer* (*Notospirifer*) *extensus*, but with slightly more elongate surface pits.

Holotype: UQF 24061 from Oaky Creek, figured by Campbell (1961, pl. 28, fig. 5a, b) and herein as Fig. 8A.

Stratigraphy: the subspecies is limited to the type locality at Oaky Creek.

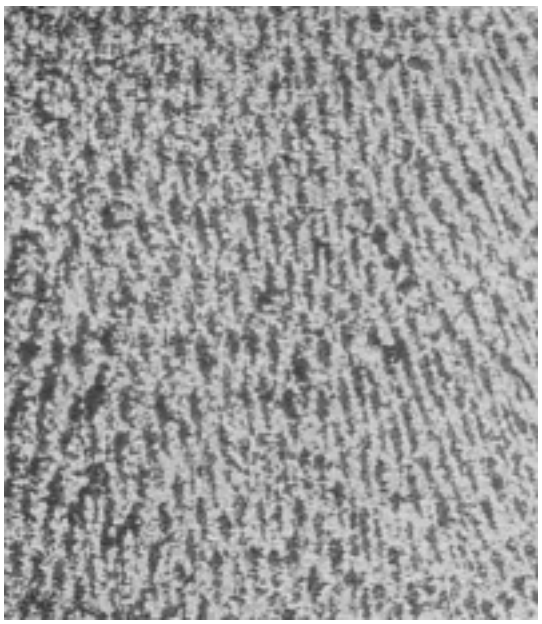
A



B

C

.



D

Fig. 8. *Notospirifer extensus tweedalei* Campbell. A, ventral view of UQF 24061, holotype. B, C, anterior and dorsal aspects of UQF 24062. D, latex cast showing micro-ornament, UNE 6016a, shown at twice the size presented in the original (with no size given). Oaky Creek. (Campbell 1961).

Notospirifer (***Notospirifer***) ***gentilis*** Waterhouse *in* Waterhouse & Jell, 1983

Fig. 9 - 11

1983 *Notospirifer gentilis* Waterhouse *in* Waterhouse & Jell, p. 245, pl. 3, fig. 1-5.
2020 *N. gentilis* – Shi et al., p. 476, Fig. 4C, D, 5, 6.
cf. 2023 *N*. cf. *triplicata* {not Waterhouse] – Lee *in* Lee et al., p. 23, Fig. 8, 91-K, 11O-V, 12A-S (part, not Fig. 12T = *Tumulosulcus undulosa*].

Diagnosis: Small little inflated shells with three or four pairs as a rule of low plicae, fold round-crested, sulcal subplicae in few specimens, surface ornament of elongate pits with small posterior spines, no tabellae in types.

Holotype: UQF 63926 from Glendoo Sandstone Member, north Bowen Basin, figured in Waterhouse & Jell (1983, pl. 3, fig. 5) and herein as Fig. 9A, OD.

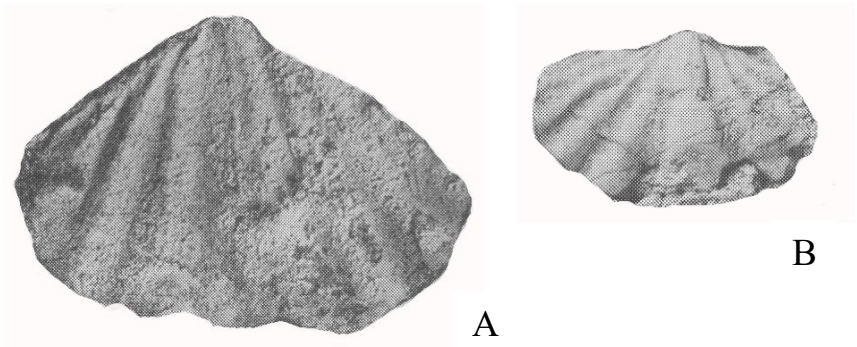


Fig. 9. *Notospirifer* (*Notospirifer*) *gentilis* Waterhouse. A, ventral valve, UQF 63926, holotype, x2. B, dorsal valve UQF 73222, x2. From Glendoo Sandstone Member, Queensland. (Waterhouse & Jell 1983).

Morphology: No spines were reported for the Glendoo types, but Shi et al. (2020, Fig. 4C, D) figured elongate spines and grooves. These number eight to ten per mm.

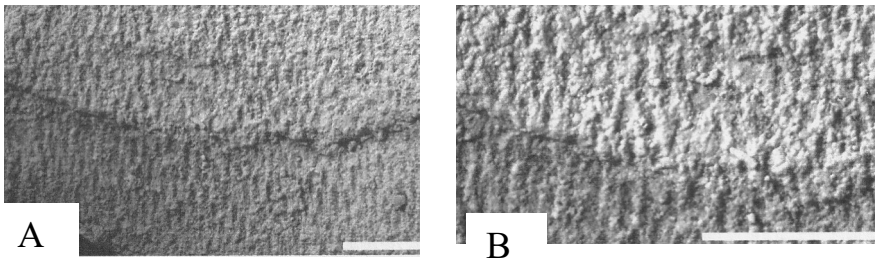


Fig. 10. *Notospirifer gentilis* Waterhouse, detail of micro-ornament, showing fine elongate spines, AMF 146268. Pebbley Beach Formation. Scale bar = 1mm. (Shi et al. 2020).

Stratigraphy: The species has been described from the Glendoo Sandstone Member of the

north Bowen Basin, and the Pebbley Beach Formation of the south Sydney Basin. These specimens are also very close to the specimens recorded from the overlying Snapper Point beds as *N. triplicata* by Lee in Lee et al. (2023), and appear to have a similar ventral valve that is less inflated than in *triplicata*, and generally has three or four pairs of plicae, compared with three to five pairs on *triplicata.* The dorsal fold channel may be better developed in *gentilis* than in *triplicata.*

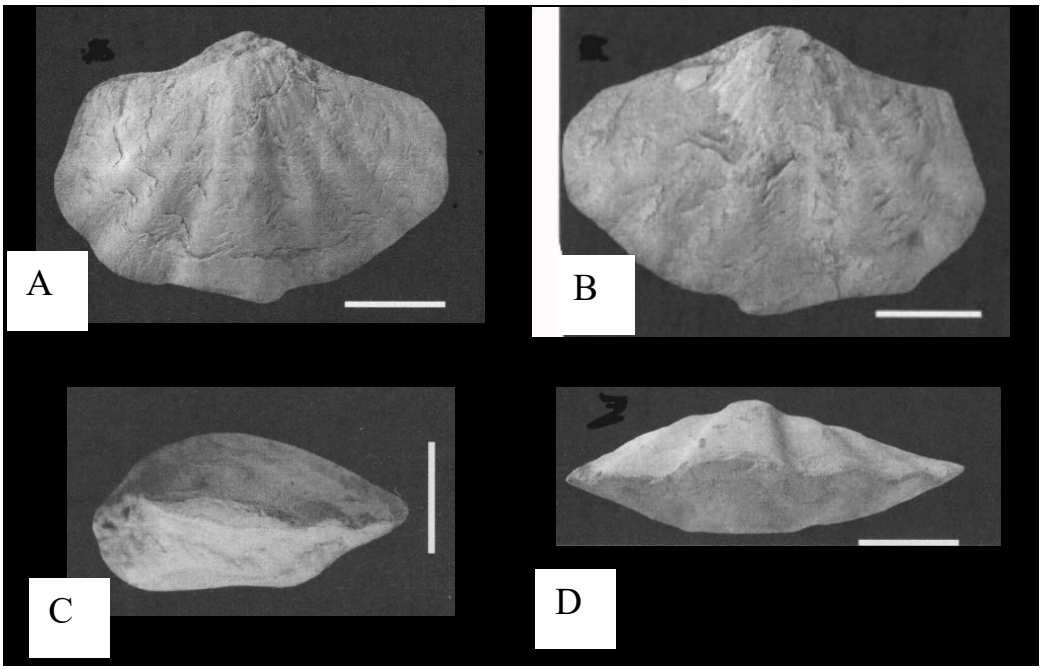


Fig. 11. *Notospirifer* (*Notospirifer*) *gentilis* Waterhouse. A-D, dorsal, ventral, anterior (dorsal valve on top) and lateral (dorsal valve on top) aspects of AMF 146244, scale = 10mm. From Pebbley Beach Sandstone. (Shi et al. 2020).

Notospirifer (***Notospirifer***) ***darwini*** (Morris, 1845)

Fig. 12, 13?, 14

1845 *Spirifer darwini* Morris, p. 279.
?1849 *S. darwini* – Dana, pl. 1, fig. 7a (part, not Fig. 7b).
1955 *Notospirifer darwini* – Harrington, p. 115, pl. 23, fig. 7, 11, 12, 14.
1959 *N. darwini* – Campbell, p. 342, pl. 56, fig. 1.
1967 *N. darwini* – Waterhouse, p. 274, pl. 13, fig. 1-3, ?fig. 4-7, 12.
?1968 *N. darwini* – Armstrong, p. 199, pl. 2, fig. 1-3, 9.
?1968 *Notospirifer* sp. cf. *darwini* – Armstrong, pl. 2, fig. 4, 8, 9.

Diagnosis: Medium-small transverse shell with three pairs of plicae in each valve, traces of a fourth pair, innermost ventral pair comparatively wide, plicae broad with well-rounded crests,

sulcus with two subplicae, fold with median channel. Micro-ornament needs clarification, pits lie densely over the surface, uncertain if spines are present. Adminicula short and well-spaced, no tabellae in some shells; in other possible specimens, tabellae commence in the interspace between the first and second pair of plicae.

Lectotype: BB 6243 from Muree Sandstone at Glendon, north Sydney Basin, figured by Harrington (1955, pl. 23, fig. 7, 11, 12, 14); Campbell (1959, pl. 56, fig. 1) and.Waterhouse (1967, pl. 13, fig. 1-3), and Fig 13A-C herein, SD Campbell (1959, p. 343).

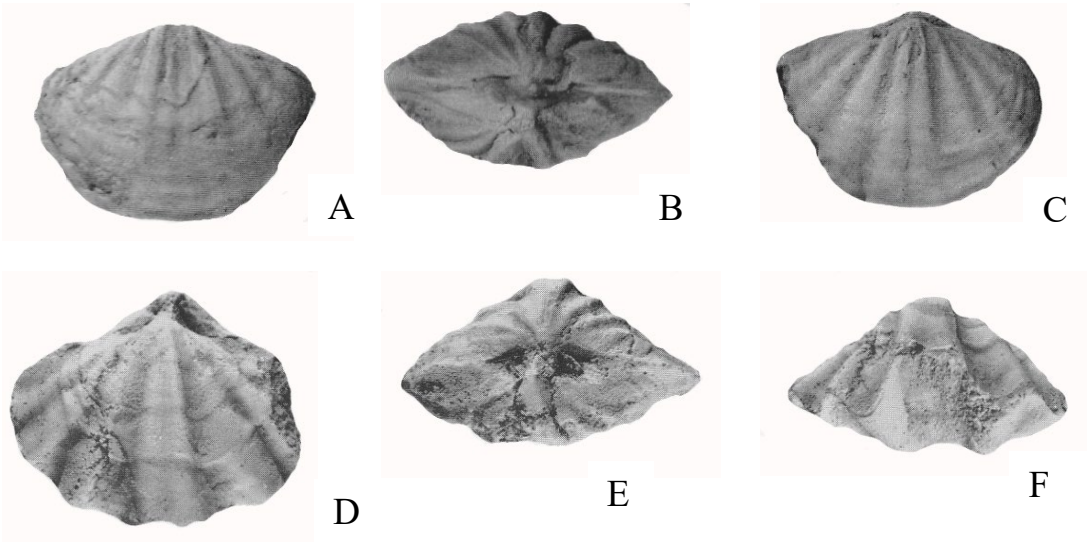


Fig. 12. *Notospirifer* (*Notospirifer*) *darwini* (Morris). A-C, ventral, posterior (dorsal valve on top) and dorsal aspects of holotype, BB 6243, x1. D-F, dorsal, posterior (dorsal valve on top) and anterior aspects (dorsal valve on top) of ANU 14610, a possible topotype of *darwini*, with identity challenged by Armstrong (1968). This specimen was claimed by Armstrong to have too high a fold and deep a sulcus to be conspecific, but it shows the fold channel and sulcal subplicae of *darwini*, suggesting that the high fold and deep sulcus anteriorly were features variable within the species, or developed with increased maturity. Muree Sandstone. (Waterhouse 1967).

Morphology: The nature of the shell has uncertaint aspects. Waterhouse (1967) endeavoured to clarify the species from Muree material, possibly topotypic in coming from Glendon, New South Wales, declaring that four plicae pairs were present, though only three pairs appear to be present on the lectotype, and drawing attention to the two sulcal subplicae and dorsal fold

channel. He regarded two Australian National University specimens as critical. The more complete specimen ANU 14610 has four ventral plicae pairs, and is more inflated and less transverse than the lectotype, but shares comparable sulcal subplicae and dorsal fold channel, and short tabellae are clearly present, arising over the first pair of plicae from the fold. The external mould of this specimen shows a dense array of tiny barchan spines, the largest 0.2mm across, arising at the edge of growth-laminae as a rule, and behind short radial grooves.

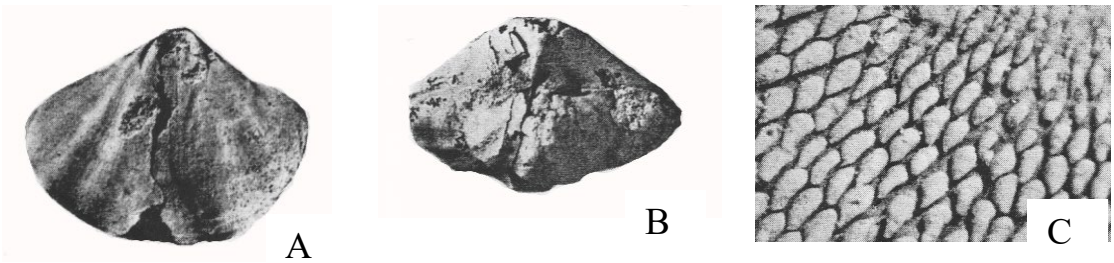


Fig. 13. ?*Notospirifer* (*Notospirifer*) *darwini* (Morris). A-C, ventral valve, x1, posterior view, x1 (dorsal valve on top), and micro-ornament x10 of UQF 56154, described as external surface of the shell, but in fact produced by weathering of the shell surface to represent the surface of the mould. Spines, grooves and ridges have been removed or are masked.. The arguably not exactly well-preserved specimen of A and B appears to lack the sulcal subplicae and fold channel seen in type *darwini*. Muree Sandstone. Adminicula lie in the first pair of interspaces or ointersplicae from the sulcus, but the position of tabellae is obscured by damage. (Armstrong 1968).

Armstrong (1968) agreed that the species had three or four pairs of gentle plications, two sulcal subplicae and a fold channel, and that tabellae were either short or absent. He described the micro-ornament as comprising closely spaced radially oriented grooves separated by ridges with a small spine at the posterior end of each groove, and rightly corrected Waterhouse to state that each groove lead anteriorly, rather than posteriorly, into a "thin cyclindrical pit." He relied partly on specimen UQF 56154 (Fig. 13 herein) from the Muree Sandstone (Armstrong 1968, pl. 2, fig. 1-3, 9) which in the figures does not show clearly any sulcal subplicae or fold channel, though subplicae in general were reported by Armstrong. The micro-ornament was considered to consist of closely spaced short radial grooves separated by ridges, with a low knob-like protuberance at the posterior end of each

groove, and the anterior end of each groove led to a pit. The pits, here called globons, number some three per mm, according to his figure. He stated that the micro-ornament on the Waterhouse specimen ascribed to *darwini* (Waterhouse 1967, pl. 13, fig. 4-7) was quite different, though just in what respects was not explained. Waterhouse's photograph implies an ornament solely of little spinules (see Fig. 14), which perhaps led Clarke (1987, p. 282) to proclaim that the specimen belonged to *Glendonia*. He emphasized that globons had to be visible to signify *Notospirifer*, and that their absence indicated *Glendonia*. But globons are mainly visible after the shell surface has been eroded, and this has not occurred with the ANU material, because the surface spines are still clearly visible. The Armstrong text emphasized the presence of grooves, and the presence of barchan spines: it did not indicate the presence or absence of globons, which lie below the surface of the shell.

Stratigraphy: The type material comes from the Muree Sandstone of the north Sydney Basin.

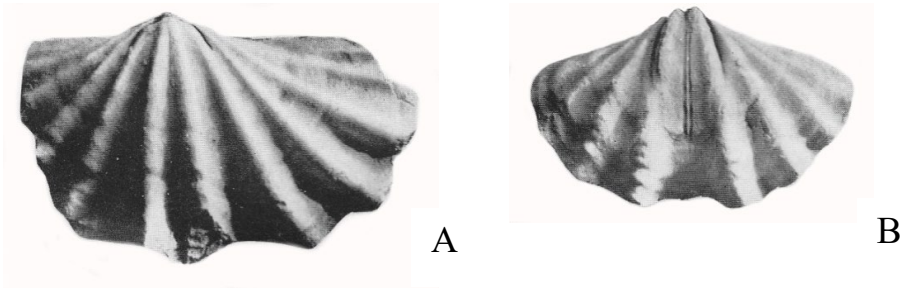
Fig. 14. *Notospirifer* (*Notospirifer*) *darwini* (Morris) or ally. A, external ornament on ANU 14610, x5, possibly topotype. Spines are definitely present. Grooves and ridges not shown, but were described in the text. The specimen was identified as Glendonia by Clarke (1990, p. 282) but shows no median rib. Muree Formation. (Waterhouse 1967).

Notospirifer (***Notospirifer***?) sp.

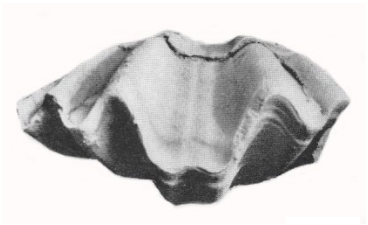
Fig. 15

1969 *Notospirifer* cf. *minutus* [not Campbell) – Wass & Gould, p. 221, pl. 15, fig. 1-5.

Internal moulds described from South Marulan of New South Wales differ from the species *minutus* Campbell in having more plicae and having subplicae and deep fold channel. The specimens approach *Notospirifer* (*Notospirifer*), and may represent a separate species. No repository was provided in the article, but it is presumed that the repository is Sydney University.



A B



C

Fig. 15. *Notospirifer* (*Notospirifer*?) sp. A, dorsal internal mould SUP 25572. B, ventral internal mould, SUP 25552. C, anterior aspect, internal mould SUP 25551. Specimens x2, from South Marulan. (Wass & Gould, 1969).

Subgenus ***Mesopunctia*** Waterhouse, 1998

Diagnosis: Small transverse shells with few rounded plicae and smooth sulcus that lacks subplicae, fold round-crested without channel, micro-ornament of small blunt crescentic spines, weakly prolonged posteriorly, behind short elongate surface grooves. Shell mesopunctate, with globons occupying the thick median layer of shell of both valves. Ventral interior as for family. Tabellae in dorsal valve short, in first pair of interspaces from the fold, frequently not developed.

Notospirifer (***Mesopunctia***) ***paraextensus*** Waterhouse (1987)

Fig. 16, 17

1987 *Notospirifer paraextensus* Waterhouse, p. 38, pl. 9, fig. 2, pl. 10, fig. 15, pl. 11, fig. 4.

Diagnosis: Transverse shells with four or rarely five pairs of plicae, subparallel adminicula, no tabellae. No sulcal subplicae or median ridge, no fold channel. Dense spines.

Holotype: UQF 27529 from Fairyland Formation, southeast Bowen Basin, figured by Waterhouse (1987, pl. 9, fig. 2, pl. 10, fig. 15, pl. 11, fig. 4) and Fig. 16A-C herein, OD.

Morphology: This species is close to *Notospirifer* (*Notospirifer*) *extensus extensus* Campbell, 1961 from the Stanleigh Shale in the southwest Bowen Basin, and similarly lacks tabellae.

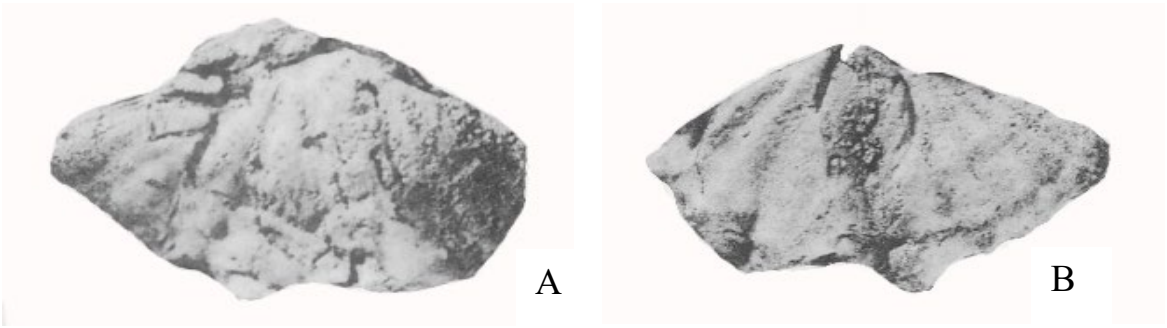


Fig. 16. *Notospirifer* (*Notospirifer*) *paraextensus* Waterhouse. A, B, UQF 27529, holotype, ventral and dorsal aspects of internal mould, x4. Fairyland Formation. (Waterhouse 1987).

But unlike that species, it lacks sulcal subplicae and has more pairs of plicae as a rule, and less widely diverging adminicula. Globons number two to three per mm.

Stratigraphy: The species is limited as far as known to the Fairyland Formation of Queensland.

Fig. 17. *Notospirifer* (*Notospirifer*) *paraextensus* Waterhouse, UQF 27529, holotype, outer surface of ventral valve with dorsal valve attached, x6, showing globons in the worn surface to the left and spines to the right. Fairyland Formation. (Waterhouse 1987).

Notospirifer (***Mesopunctia***) ***macropustulosus*** Waterhouse, 1968

Fig. 18 - 21

1964 *Notospirifer microstriatus* [not Waterhouse] – Waterhouse, p. 70, pl. 33, fig. 5-7, 9-12; pl. 37, fig. 4-6; text-fig. 78, 79A, C, D, E (part, not pl. 33, fig. 1, 8, 13; pl. 34, fig. 1, 2; pl. 36, fig. 2, text-fig. 79B = *Wairakispirifer microstriatus*).
1968 *N. macropustulosus* Waterhouse, p. 76, pl. 14, fig. 2, 3; pl. 18, fig. 2, 4, text-fig. 6E.
1983 *N. macropustulosus* – Waterhouse & Jell, p. 246, pl. 3, fig. 6.
1987 *N. macropustulosus* – Waterhouse, p. 39, pl. 8, fig. 9, 13, 15, 17; pl. 9, fig. 10; pl. 11, fig. 9, 11.
1992b *Notospirifer macropustulosus* - Clarke, p. 76.
1998 *Mesopunctia macropustulosus* – Waterhouse, p. 41.
2007 *M. macropustulosus* – Gourvennec & Carter, p. 2779, Fig. 1860.3a, b.

Diagnosis: Plicae number three pairs or more rarely four pairs and up to five pairs, fold moderately high, round-crested, sulcus concave without median ridge or subplicae. Adminicula extend each side of fold within first pair of interspaces; tabellae absent as a rule, if present very short and variably placed in first or second pair of interspaces, or cross the first pair of plicae.

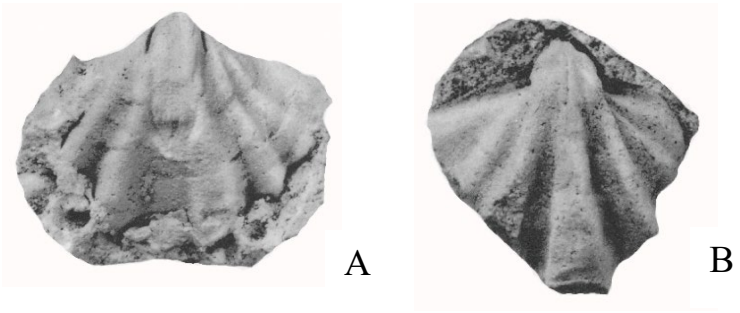


Fig. 18. *Notospirifer* (*Mesopunctia*) *macropustulosus* (Waterhouse). A, ventral internal BR 708, holotype, x3. B, dorsal internal mould, BR 726 x3. From upper Mangarewa Formation, New Zealand. (Waterhouse 1968).

Holotype: BR 708 from upper Mangarewa Formation, figured in Waterhouse (1968, pl. 14, fig.. 2, text-fig. 6E) and Fig. 18A herein, OD.

Morphology: Judged from data in Waterhouse (1968), the grooves and globons vary in density according to maturity of the shell, ranging from ten in 1mm through six in 1mm to as few as four in 1mm anteriorly in a mature shell.

Stratigraphy: The species has been described from the *Maxwellosia ovalis* Superzone and *Ingelarella costata* Zone in the middle and upper Mangarewa Formation at Wairaki Downs, New Zealand, and from the lower Blenheim Formation and Flat Top Formation of the Bowen Basin in Queensland.

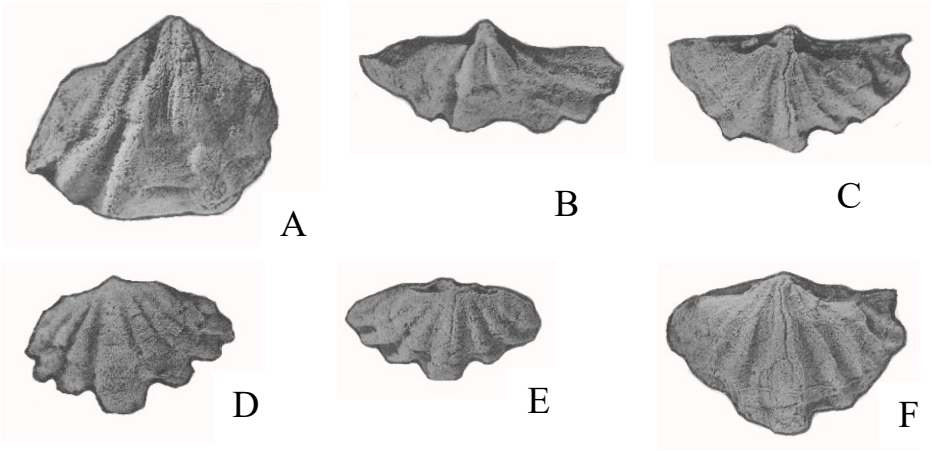


Fig. 19. *Notospirifer* (*Mesopunctia*) *macropustulosus* (Waterhouse). A, ventral internal BR 715, x2. B, ventral internal BR 730, x2. C, F, dorsal internal mould, BR 735, x2. D, PVC cast of dorsal valve, BR 723, x2. E, natural internal dorsal mould of same specimen. From upper Mangarewa Formation, New Zealand. (Waterhouse 1964).

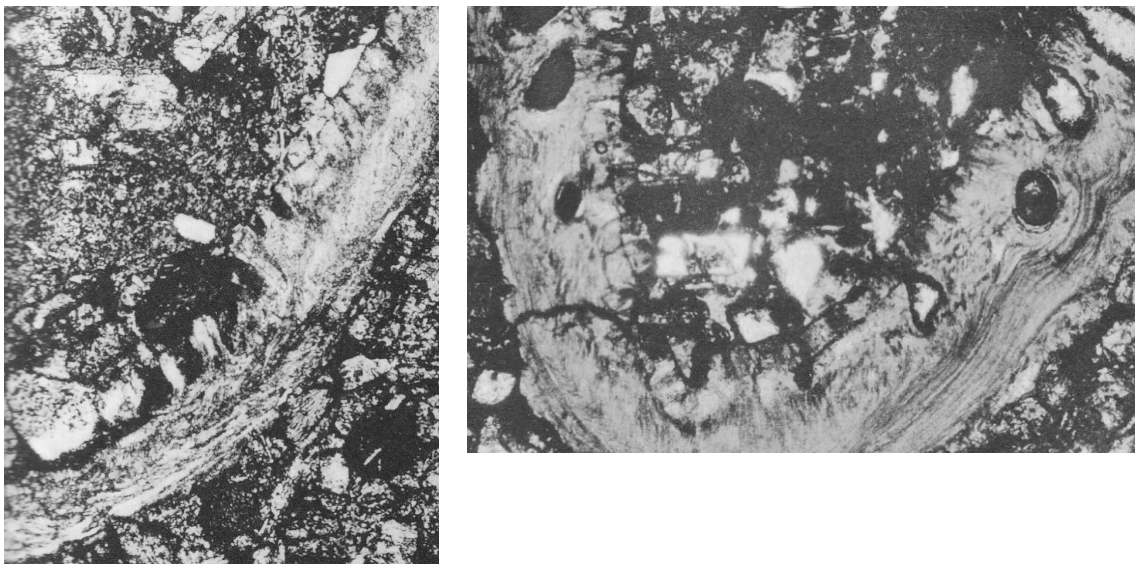


Fig. 20. *Notospirifer* (*Mesopunctia*) *microspinosus* (Waterhouse). A, B, transverse thin section of BR 1430, x60. Exterior on top, lateral edge to right. The punctae penetrate the outer and thin primary layer and occasionally enter the main layer, but not the thick inner layer. Upper Mangarewa Formation. (Waterhouse 1964, 1968). The lack of similar sections other than in Armstrong (1970b) compromises our understanding for many Notospiriferidae.

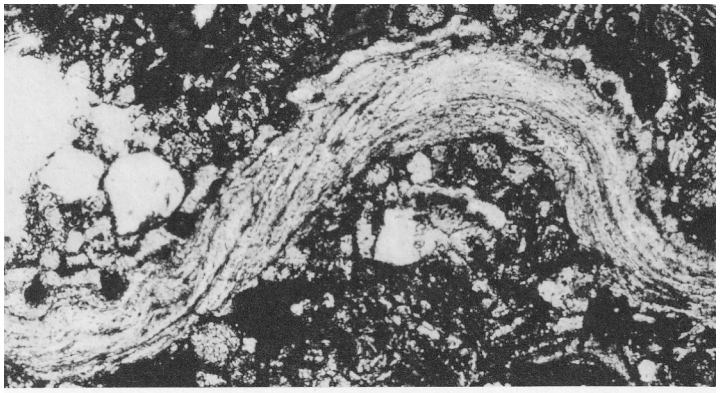


Fig. 21. *Notospirifer* (*Mesopunctia*) *macrospinosus* (Waterhouse), transverse section, x65, with inner laminated inner layer. Upper Mangarewa Formation. (Waterhouse 1968).

Notospirifer (***Mesopunctia***?) ***spinosa*** Waterhouse & Vella, 1965

Fig. 22

1965 *Notospirifer spinosa* Waterhouse & Vella, p. 70, pl. 4, fig. 7-13.
1978 *N. spinosa* – Suggate et al., Fig. 4.7, 15, 16.

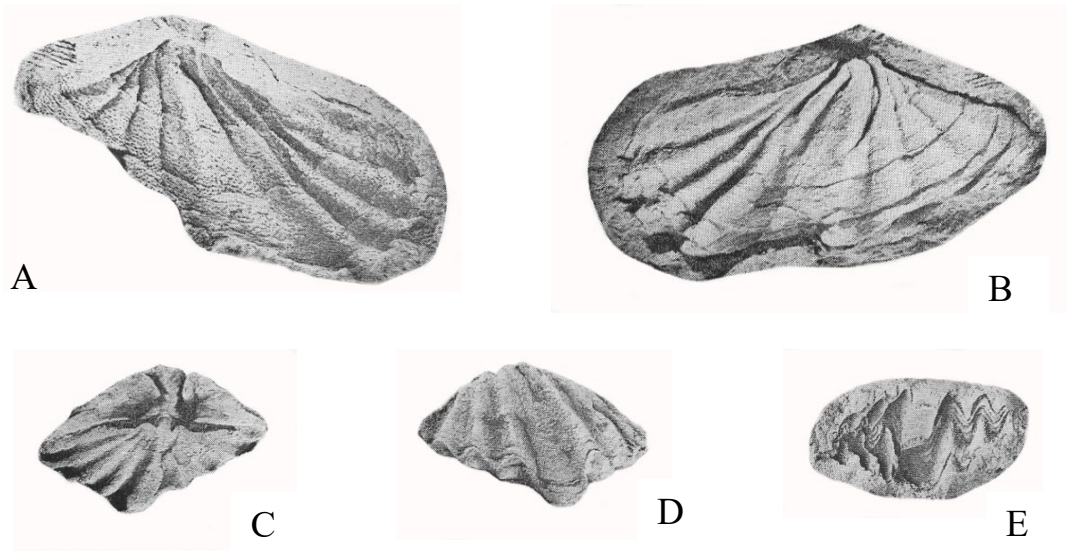


Fig. 22. *Notospirifer* (*Mesopunctia*?) *spinosa* Waterhouse & Vella. A, B, ventral external and internal mould. C-E, dorsal and ventral aspects of internal mould and E, external mould, holotype. Specimens x1.5 from Flowers Formation, west Nelson, New Zealand. (Waterhouse & Vella 1965).

Diagnosis: Small transverse shells with low umbones and three to six plicae pairs, sulcus

lacking subplicae but with faint hint of median swelling anteriorly, fold crest rounded, but again with hint of anterior median channel.

Holotype: Specimens were not registered and were kept at the time of the publication at Victoria University Department of Geology. From Flowers Formation, figured by Waterhouse & Vella (1965, pl. 4, fig. 7, 9-11), Suggate et al. 1978, Fih. 4, 7, 15, 16) and herein as Fig. 22C-E, OD.

Morphology: The implications of the faint sulcal swelling and fold depression remain to clarified – do they imply relationship to *Glendonia* McClung & Armstrong, 1978, or independent duplication? The material needs to be re-examined to clarify the generic position. There is in Waterhouse & Vella (1965, pl. 4, fig. 11, as reproduced herein in Fig. 22E) the suggestion of possible cylindrical sedimentary fillings of punctae., and the density of the spines is greater than is normal for *Glendonia* and allied taxa. Possible globons or sdedimentary fillings of former puncate may also be suggested in Fig. 22C, D.

Stratigraphy: The species is found in the Flowers Formation of west Nelson, and appears to belong to the *Echinalosia* (*Unicusia*) *minima* Zone, well represented in the north Bowen Basin. However more needs to be learned about this species and its generic affinities.

Notospirifer (***Mesopunctia***) ***minutus*** Campbell, 1960

Fig. 23 - 26

1955 *Martiniopsis*? sp. Isbell, p. 13.
1960 *Notospirifer minutus* Campbell, p. 1121, pl. 139, fig. 6-8.
1970b *N. minutus* – Armstrong, p. 291, Fig. 1D.
?1987 *N. minutus* – Clarke, p. 279, Fig. 14A-C.
2022 *N. minutus* – Waterhouse, p. 170, Fig. 33.

Diagnosis: Shells small, with three to five pairs of plicae. Sulcus broad. Fold moderately high with flat or weakly channelled crest. Adminicula lie along first pair of interspaces from sulcus.

Fig. 23. *Notospirifer* (*Mesopunctia*) *minutus* Campbell, ventral valve UQF 82695, x2.5. Blenheim Formation. (Waterhouse 2022).

Fig. 24. *Notospirifer* (*Mesopunctia*) *minutus* Campbell. A-C, ventral, posterior and anterior aspects of holotype, UQF 15829, x1. From upper Blenheim Formation, *Echinalosia* (*Unicusia*) *minima* Zone, north Bowen Basin. (Campbell 1960).

Holotype: UQF 15823 from Rosella Creek, north Bowen Basin, figured by Campbell (1960, pl. 139, fig. 6a-c) and Fig. 24A-C herein, OD.

Morphology: Clarke (1987) reported the species from Malbina Member E of Tasmania and showed well-preserved micro-ornament with closely placed globons (Fig, 26), numbering three to four in 1mm.

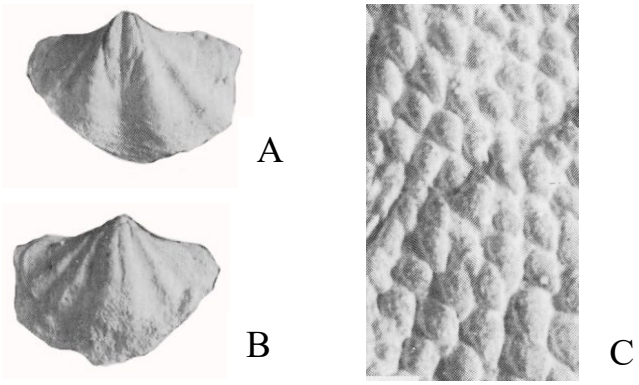


Fig. 25. ?*Notospirifer* (*Mesopunctia*) *minutus* Campbell, A, B, ventral and dorsal views of internal mould GST 14049A. C, micro-ornament on same specimen, showing globons much less elongate than those depicted by Armstrong. Malbina Member E, Tasmania. (Clarke 1987). No figures of the true external ornament were provided, and the globons differ markedly from those of type *minutus*.

Stratigraphy: *Notospirifer minutus* Campbell was originally described from the *Isbellina pelicanensis* band in the Pelican Creek fauna of Dear (1972) , and the species was further

recorded from the same area by Waterhouse (2022). There have been reports of the species in older faunas, but they appear to have been identified mainly by their small size, leaving it difficult to determine if the identity is based on specimens not at full maturity. Clarke (1987) recorded similar looking specimens from the slightly older Malbina Member E from Tasmania, with globons much more symmetrical in shape than the elongate globons demonstrated by Armstrong to typify type *exigua* (cs. Fig. 25C with Fig. 26), and the crest of the Tasmanian fold is less flattened.

Well-preserved internal moulds from South Marulan, south New South Wales that were identified with *minutus* by Wass & Gould (1969) are not close, showing a deep fold channel and stronger plicae.

Fig. 26. *Notospirifer* (*Mesopunctia*) *minutus* Campbell, detail of elongate globon infillings over anterior shell, x10, UQF 15823. Note the difference from the slightly older Tasmanian material in Fig. 25. From *Isbellina pelicanensis* band. (Armstrong 1970b).

Subgenus ***Papulinella*** Waterhouse, 1998

Diagnosis: Shells large for the family. Plicae high with narrow crests and broad interspaces, sulcus may lack subplicae, fold high with median channel as a rule, micro-ornament varied, often with short posterior protuberances or blunt or crescentic barchan spinules passing anteriorly into ridge each side of globon.

Type species: *Notospirifer hillae* Campbell, 1961, p. 185 from Tiverton Formation of Bowen Basin, Queensland, OD.

Discussion: This subgenus is distinguished by the high dorsal fold and strong plicae from *Notospirifer* (*Notospirifer*) Harrington, 1955. The plicae are high and have narrow rounded crests,

narrower and less rounded than in *Notospirifer*. Small spines are definitely present, as shown in figures of the micro-ornament provided for *hillae* by Armstrong (1970b, Fig. 1B, G, H).. Given the uncertainty over whether *Notospirifer* really lacks spines, *Papulinella* could be provisionally treated as a subgenus of *Notospirifer*, distinguished by the large size, strong plicae, high dorsal fold, lack of subplicae from the sulcus in some material, and possibly, but only possibly, by the presence of barchan spines. In *Papulinell*a, tabellae are generally lacking but rare specimens suggest short tabellae entering the first pair of interspaces from the fold, and in other specimens the second pair of interspaces next to the sulcus and fold. *Notospirifer* (*Notospirifer*) has no tabellae or tiny tabellae entering the innermost pair of interspaces and adminicula cut across the second lateral pair of interspaces to lie in the first pair of interspaces, so that there is little difference in tabellae between the two, and indeed the tabellae where present are so short that relating them to interspaces is difficult.

Notospirifer (***Papulinella***) ***hillae hillae (***Campbell, 1961)

Fig. 27 - 31

1961 *Notospirifer hillae* Campbell, p. 185, pl. 25, fig. 6, pl. 27, fig. 1-6, 11.
1964 *N. hillae* – Hill & Woods, pl. P9, fig. 7-9.
aff. 1968 *Notospirifer* sp. aff. *hillae* - Waterhouse, p. 74.
1970a *N. hillae* – Armstrong, p. 204, pl. 14, fig. 7, 8.
1970b *N. hillae* – Armstrong, p. 288, Fig. 1B, G, H.
1972 *N. hillae* – Hill, Playford & Woods, pl. P9, fig. 7-9.
1998 *Papulinella hillae* – Waterhouse, p. 34.
2007 *P. hillae* – Carter *in* Gourvennec & Carter, p. 2779, Fig. 1860.1a-c.
2015a *P. hillae* - Waterhouse, p. 184, Fig. 137, 138A-F, 139.

Diagnosis: Comparatively large shells with three to six pairs of strong plicae, sulcus rarely with faint subplicae, fold channelled as a rule, short well-spaced adminicula, no tabellae as a rule.

Holotype: UNEF 3007 from Tiverton Formation, Bowen Basin, figured by Campbell (1961, pl. 27, fig. 3), OD.

Morphology: Specimens variable, display a channel as a rule along the dorsal fold, but the sulcus lacks subplicae as a rule. Adminicula are short and usually well-spaced, lying in the first or second

Fig. 27. *Notospirifer* (*Papulinella*) *hillae* (Campbell), dorsal internal mould of small specimen UQF 81347, x4. Tiverton Formation. (Waterhouse 2015a).

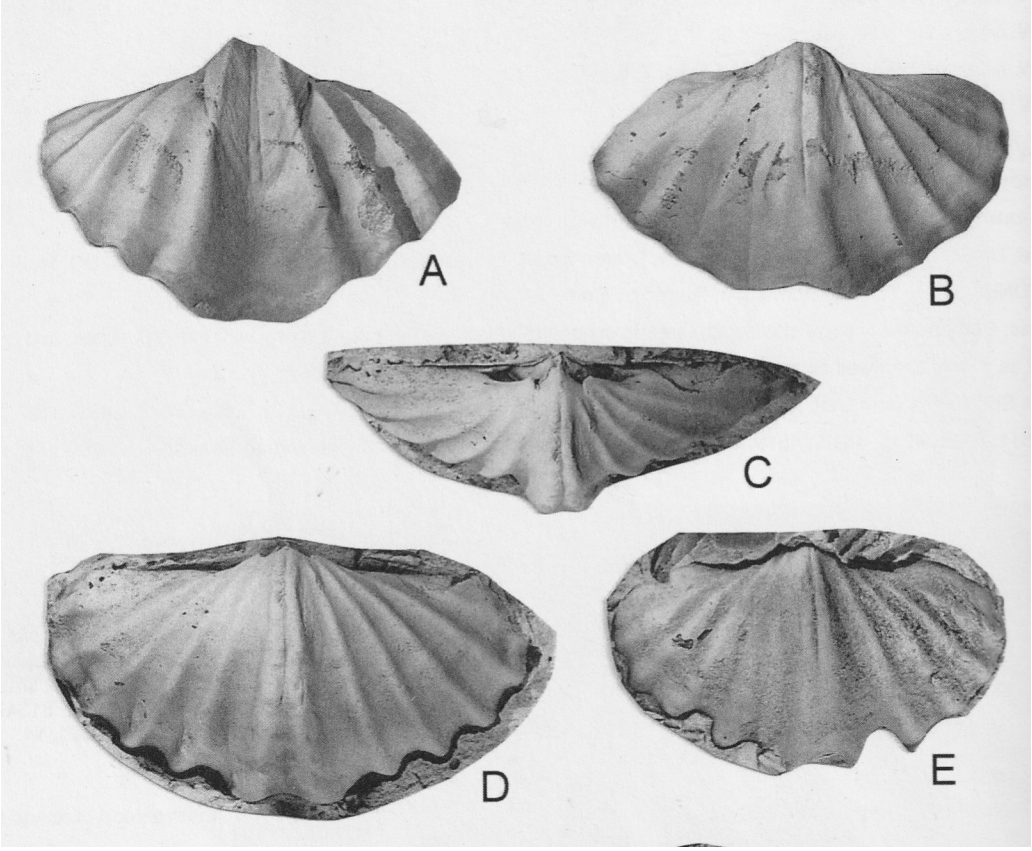


Fig. 28. A-F. *Notospirifer* (*Papulinella*) *hillae* (Campbell). A, B, ventral and dorsal aspects of internal mould with valves conjoined, UQF 81349, x1. C, D, posterior and dorsal aspects of internal dorsal mould UQF 81350, x1. Tiverton Formation. (Waterhouse 2015a).

Fig. 29. *Notospirifer* (*Papulinella*) *hillae* (Campbell), a fragment of the true exterior of ventral valve UQF 81854, x6. Note that globons are not obvious. Tiverton Formation. (Waterhouse 2015a).

Fig. 30. *Notospirifer* (*Papulinella*) *hillae* (Campbell), external mould of worn dorsal valve UQF 81811, x9. Tiverton Formation. (Waterhouse 2015a).

pair of interspaces from the sulcus (first pair in the holotype), or starting over the innermost pair of plicae. Tabellae are absent from most specimens, but a few specimens have very short tabellae lying in either the first or mostly second pair of interspaces from the fold. A number of specimens have a channelled fold. The micro-ornament consists of close-set globons, for which figures were provided by Campbell (1961, pl. 27, fig. 2a) and Armstrong (1970b, Fig. 1B, G. H). The globons are round to slightly elongate and vary in shape over different parts of the shell. Some lie in front of a stubby posterior elevation, prolonged as a ridge like a barchan horn each side of the globon. In front the globon is bordered by the posterior terminus of the groove. In other specimens, or over parts of the surface, the globons lie in quincunx, with each lateral ridge passing forward into the spine behind a globon: in other parts, the posterior ridge is not elevated, and the surface ornament looks like a meshwork of ridges with hollows in between. Spines lie each at the anterior end of a short ridge, and short ridges also extend forward from the forward projecting horn each side of the spine, whilst a short groove extends forward from the anterior middle face of the spine. Globons tend to be elongate. There are some four or five pits in 1mm, judged from Campbell's data, compared with two to four spines in 1mm figured by Armstrong (**1970b**).

Armstrong (1970b) offered excellent figures of micro-ornament from one specimen, that shows the ridge which extends forward from each wing of the barchan spine into the next spine in quincunx (Fig. 33), but this pattern is not visible in all specimens.

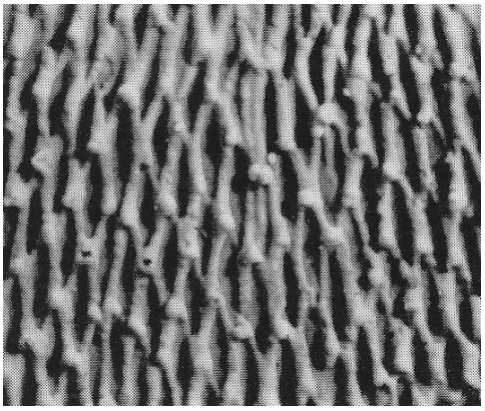


Fig. 31. *Notospirifer* (*Papulinella*) *hillae* (Campbell), micro-ornament of UQF 56047 x 15. This is the true external surface of the shell, showing little of the globons that lie largely below the surface. Tiverton Formation. (Armstrong 1970).

Stratigraphy: The species is found in the *Magniplicatina undulata* and *Taeniothaerus subquadratus* Zones of the Tiverton Formation at Homevale, north Bowen Basin. Specimens of *Papulinella hillae* (Campbell) have been reported from the Roses Pride Formation and lower Elvinia Formation of the southeast Bowen Basin by Waterhouse (1987, p. 39, pl. 10, fig. 10?, 14). The Roses Pride specimens have four pair of plicae, approaching those from the upper middle Tiverton Formation at Homevale. The sulcus of specimens from the Elvinia Formation was recorded as grooved, which is not the case for most Tiverton specimens. *Notospirifer* sp. aff. *hillae* Campbell described by Waterhouse (1968, p. 74) from the *Notostrophia zealandicus* Zone in the Brunel Formation of southern New Zealand, slightly older than the Roses Pride beds of Queensland, has micro-ornament of spines and anterior grooves, each of which passes forward into a pit or globon.

Compared with *Notospirifer triplicata* Waterhouse which has three or four pair of plicae, the *hillae* specimens are larger, with higher and narrowly crested fold, channelled in some specimens, not in others, higher plicae, more abruptly rounded cardinal extremities, and adminicula spaced further apart.

Notospirifer (***Papulinella***) ***hillae plicata*** Campbell, 1961

Fig. 32

1961 *Notospirifer hillae plicata* Campbell, p. 187, pl. 27, fig. 7-10.

Diagnosis: Most ventral valves have five to six pairs of plicae and dorsal valves have five pairs with signs of a sixth on some specimens. *Notospirifer* (*Papulinella*) *hillae* has wider and fewer plicae, usually four pairs.

Holotype: UNEF 3043 from Campbell's zone 9 of Tiverton Formation, figured by Campbell (1961, pl. 27, fig. 10a-c) and herein as Fig. 32A, B, OD.

Morphology: Campbell (1961, p. 189) stated that pits were finer and more numerous than in *hillae*, even though the *plicata* specimens are smaller. He discriminated this subspecies *plicata* for shells from his so-called zones 4 -10 of the Tiverton Formation for shells which tended to be more plicate, as compared with *hillae hillae*,found in his overlying "zones 11 – 13". Campbell

(1961, table 3) was able to show a distinct decrease by one pair of plicae in specimens from above his “zone 10” and a increase in number of specimens with four pair of plicae and diminution of specimens having six pairs of plicae. His holotype for *plicata* has no sulcal subplicae, a dorsal channel along the fold, adminicula possibly in the second lateral pair of interspaces, and no tabellae. The specimen has five pair of plicae. The holotype of *hillae hillae* has no sulcal subplicae, adminicula in the second interspace, and again, five pair of plicae, the fifth pair inconspicuous. The dorsal valve is not preserved.

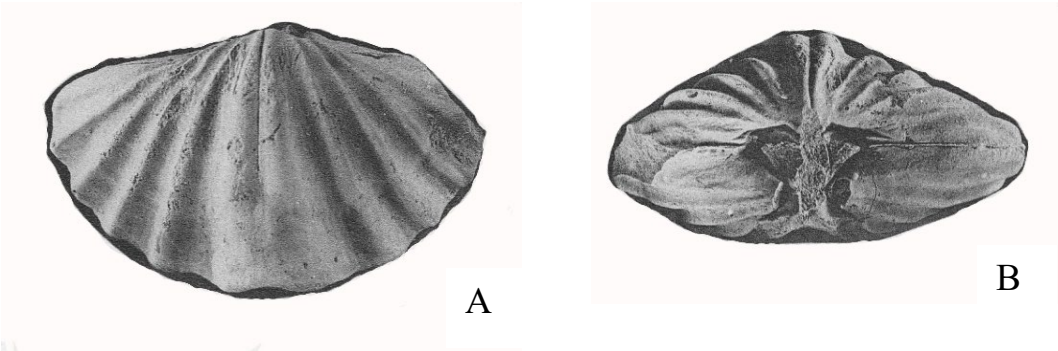


Fig. 32. *Notospirifer* (*Papulinella*) *hillae plicata* Campbell. Dorsal and anterior aspects of internal moud UNEF 3043 holotype, x1. Tiverton Formation. (Campbell 1961).

Stratigraphy: The subspecies occurs in Campbell's zones 4 to 10 of the Tiverton Formation near Homevale Station, north Bowen Basin.

Notospirifer (***Papulinella***) ***hillae wilsoni*** Waterhouse, 2015a

Fig. 33

2015a *Papulinella wilsoni* Waterhouse, p. 189, Fig. 140.

Diagnosis: Medium to large for genus, with three or less commonly four pairs of narrow high plicae and wide interspaces, dorsal fold high.

Holotype: UQF 81355 from middle Tiverton Formation, figured as Waterhouse (2015a, Fig. 141B) and herein as Fig. 33B, OD.

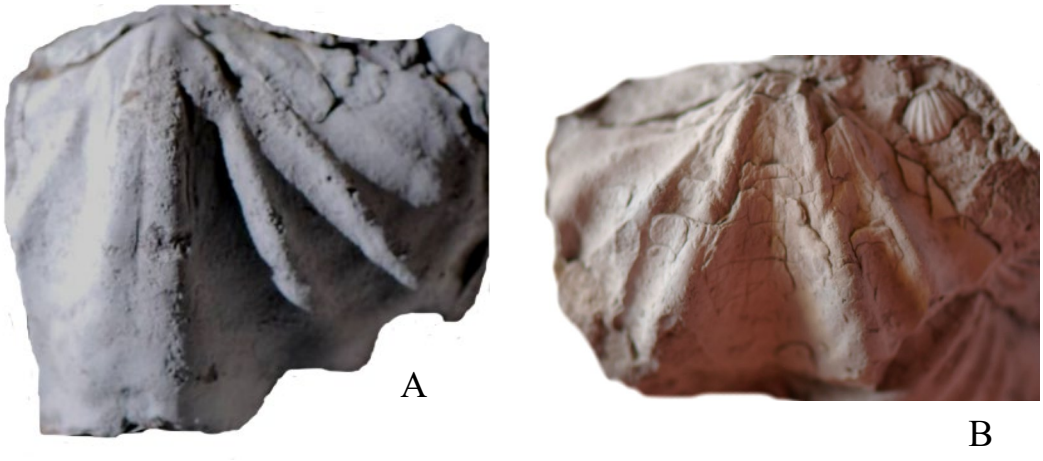


Fig. 33. *Notospirifer* (*Papulinella hillae wilsoni* Waterhouse. A, dorsal internal mould UQF 81354, x2. B, holotype, partly decorticated ventral valve UQF 81355 , x1. Middle Tiverton Formation. (Waterhouse 2015a).

Morphology:. The shells are large and transverse, with umbo incurved, having an angle of 110^{o}, hinge wide, cardinal extremities obtuse, ventral interarea moderately high, concave and bearing open delthyrium with angle of 80^{o}, dorsal interarea low. The ventral sulcus is broad and bordered by plicae diverging forward at 40^{o}, without subplicae, rib or groove, dorsal fold upstanding and medianly flattened or usually channelled. Ventral plicae lie in three pair, with fourth subdued outer pair on some specimens, dorsal plicae similar, crests on both valves narrow, interspaces broad. Micro-ornament of globons surrounded by ridges, close-set, in quincunx, blunt short barchan spinules developed at anterior end of fine short ridges and extended a little anteriorly from the barchan-like spine. There are irregular and few commarginal laminae.

The specimens are distinguished by having only three pairs – or rarely four pairs – of plicae, and the plicae are high and narrow and the interspaces very wide. They differ strongly from *Notospirifer triplicata*, with three pair to five pairs of plicae, and much lower fold.

Stratigraphy: Specimens are scattered throughout the middle Tiverton Formation, in both the

shells from UQL 1622 (band 5 = Campbell's zone 5), UQL 2619 (band 12), UQL3127 (general), UQL 4517 and UQL 4521, from both the *Magniplicatina undulata* Zone and principally in the *Taeniothaerus subquadratus* Zone of the Tiverton Formation. Details of the UQL fossil localities are provided in Waterhouse (2015a, pp. 349, 350).

Genus ***Farmerella*** Clarke, 1992b

Diagnosis: Small to medium-size shells with well-formed but for the family narrow sulcus and fold, sulcus may have narrow median rib, plicae in five or six pairs, angular crests, micro-ornament of small spines behind short grooves leading to deep, elongate globons, tabellae absent, or very short.

Type species: *Farmerella exoporosa* Clarke, 1992b from Deep Bay Formation of Tasmania, OD.

Farmerella exoporosa Clarke, 1992b

Fig. 34

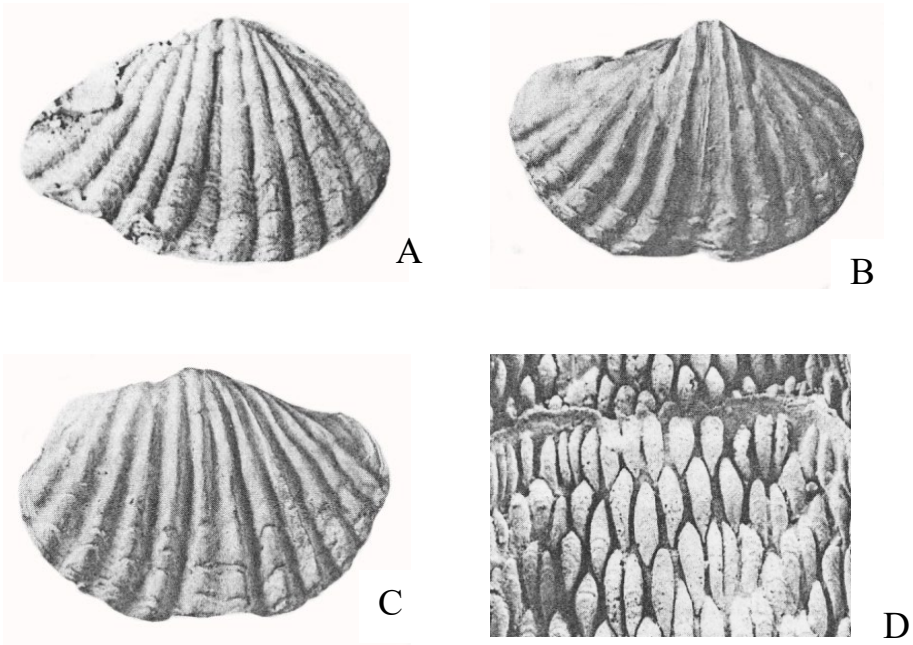


Fig. 34. *Farmerella exoporosa* Clarke. A, latex cast of ventral exterior, GST 15501, x1. B, C, ventral and dorsal aspects of internal mould, GST 15504, x1. D, worn external mould of dorsal valve GST 15506, x20. Deep Bay Formation, Tasmania. (Clarke 1992b).

1985 *Notospirifer* sp. nov. Clarke in Farmer, p. 35.
1991 Gen. nov. B Clarke, p. 64, Fig. 5.
1992b *Farmerella exoporosa* Clarke, p. 4, pl. 1A-J.
2006 *F. exoporosa* – Carter, p. 1762, Fig. 1159.2a-c.

Diagnosis: Closely plicate shells with median sulcal ridge, clearly developed fold channel, adminicula may commence in second pair of interspaces from the sulcus and extend forward into the first pair of interspaces from the fold.

Holotype: GST 15500 A, B figured by Clarke (1992b, pl. 1, fig. F, G) from Deep Bay Formation, Tasmania, OD.

Morphology: Clarke (1992b) stated that the median costae along the ventral sulcus is not present in all specimens. He placed the genus within Notospiriferinae (Clarke 1992, p. 73). Globons are well- developed, slightly elongate but swollen, and number six to seven in 1mm.

Stratigraphy: The species is found in the Deep Bay Formation, which belongs to the *Johndearia brevis* Zone, of likely Kungurian age.

Farmerella sp.

Fig. 35

2015b ?*Farmerella* sp. Waterhouse, p. 99, Fig. 31H-J.

Fig. 35. *Farmerella* sp. A, ventral internal mould UQF 69256. B, latex cast of ventral valve, unregistered. C, ventral internal mould UQF 69255. Specimens x1 from lower South Curra Limestone, Gympie. (Waterhouse 2015b).

A few ventral valves from the lower South Curra Limestone of the Gympie district in southeast Queensland appear to belong to this genus. They have five pairs of plicae, and a median costa

extends along the sulcus. Adminicula are short, and the muscle platform small. Growth laminae are relatively strong.

Genus ***Monklandia*** Waterhouse, 1998

Diagnosis: Shell multiplicate, tabellae which are longer than in many Notospiriferinae often start outside of, ie. lateral to first and innermost pair of interplicae and then cross the first pair of plicae to lie along innermost pair of interspaces**.** Plicae variable in strength and number. Adminicula may lie or start in the first pair of interspaces from the sulcus, rather than within the sulcus.

Type species: *Monklandia gympiensis* Waterhouse, 1998 from Rammutt Formation, Gympie, east Queensland.

Discusssion: *Monklandia* Waterhouse was named for a species originally referred in Australia to *Spirifera undifera* var. *undulata* [not Roemer] by Etheridge Snr (1872, p. 330, pl. 16, fig. 3-5) and later described as ?*Spirifera strzeleckii* [not Koninck] by Koninck (1877, p. 235 [not pl. 13, fig. 1, 1a, pl. 14, fig. 1, 1a = *strzeleckii*]. The Koninck specimens described and figured as *strzeleckii* came from the early Middle Permian of New South Wales and were later destroyed by fire. McClung (1978, p. 43) sought to replace the destroyed specimens with material described by Etheridge Snr (1872) from Gympie, Queensland, and called the specimens *Ingelarella strzeleckii*, but his procedure was improper because he did not apply Koninck's name to material from the same source as Koninck's *strzeleckii*, and the Gympie specimens are clearly not conspecific (though they could well be congeneric) with the much younger New South Wales specimens and should receive a separate name. Campbell (1960, p. 1111) had come to the same conclusion "Ï am convinced that they are definitely not conspecific with either of the types [of *strzeleckii*] figured by de Koninck." So Waterhouse (2015b) renamed the Gympie specimens *gympiensis*, and cited and figured Gympie material, with discussion and comparison with other material. From the nature of the micro-ornament with its surface ornament consisting of fine grooves passing forward from c-shaped spinules, Waterhouse concluded that the genus was notospiriferid, not ingelarellid. But this is contentious, given the development of small c-shape spines in various

ingelarelids, and unlike notospiriferids, the tabellae appear to be unusually long in some specimens (eg. McClung 1978, pl. 3, fig. 22, 24, 26; Waterhouse 2015b, Fig. 5B), though shorter in Waterhouse (2015b, Fig. 5D, F).Significantly, tabellae may lie outside the innermost pair of interplicae, which is more often seen in Notospiriferidae than in Ingelarellidae. Adminicula and tabellae are relatively short in a species recognized as *Monklandia mcclungi* by Waterhouse (2015b, p. 171) in the Rutherford Formation of the Hunter Valley in the north Sydney Basin, distinguished by having only four pairs of plicae and smaller size. Earlier the specimens had been assigned to *Ingelarella* rather than *Notospirifer* by McClung (1978), and Briggs (1998) referred the Gympie "*strezeleckii*" to *Tomiopsis*. McClung (1978) had also assigned the species he called *etheridgei* and *davidi* to *Ingelarella*. Yet in their plication and arrangement of internal plates, they approach aspects of the type species of *Monklandia*, and are close to Koninck's species *strzeleckii.*

The types of genus *Monklandia* differ critically from *Ingelarella* and other genera assigned to Ingelarellinae through the position of the adminicula, which lie or at least start in the first pair of interplicae from the sulcus, whereas in *Ingelarella* and allies, the adminicula lie within the sulcus. And the tabellae in many specimens commence within the interspaces between the first and second pair of plicae from the fold, though not in all specimens, whereas in *Ingelarella* and allies, the tabellae lie next to the fold. There remains the need to record and describe in detail the nature of the micro-ornament, especially for the type species, so that there is at present a degree of provisionality about *Monklandia*'s generic allegiances.

Monklandia gympiensis Waterhouse, 1998

Fig. 36, 37

1872 *Spirifera undifera* var. *undulata* [not Roemer] – Etheridge Snr, p. 330, pl. 16, fig. 3-5 (part, not pl. 15, fig. 4 = *Neilotreta*).
?1877 *S. strzeleckii* [not Koninck] – Koninck, p. 235 (not pl. 13, fig. 1, 1a; pl. 14, fig. 1, 1a = Strzelecki & indet.].
1892 *Spirifera strzeleckii* – Etheridge Jnr, p. 234, pl. 10, fig. 5-6 (part, not fig. 7 = neospiriferid (*dubia*?)?).
1978 *Ingelarella strzeleckii* – McClung, p. 43, pl. 3, fig. 20-26.
1987 *'Notospirifer' strzeleckii* – Waterhouse & Balfe, p. 30, pl. 1, fig. 6, 7.
1998 *Monklandia gympiensis* n. gen., n. sp. Waterhouse, p. 37.
2001 *M. gympiensis* – Waterhouse, p. 18, Fig. 5A-G.

2006 *M. gympiensis* – Carter, p. 2779, Fig. 1860.4a, b.
2015b *M. gympiensis* – Waterhouse, p. 18, Fig. 5A-G.

Diagnosis: Plicae strong in both valves, sulcus with subplicae, fold broad with well-defined median channel. Adminicula of moderate length, placed along first interspace between first and second pair of plicae from the sulcus, tabellae well developed and up to a quarter of the length of the valve, lying either next to the fold or usually within the interspace between the first and seond pair of plicae from the fold.

Holotype: QMF 946, figured by Etheridge Snr (1872, pl. 16, fig. 3), Etheridge Jnr (1892, pl. 10, fig. 6) and McClung (1978, pl. 3, fig. 24) and Fig. 37B herein, from Rammutt Formation, Gympie, southeast Queensland, OD.

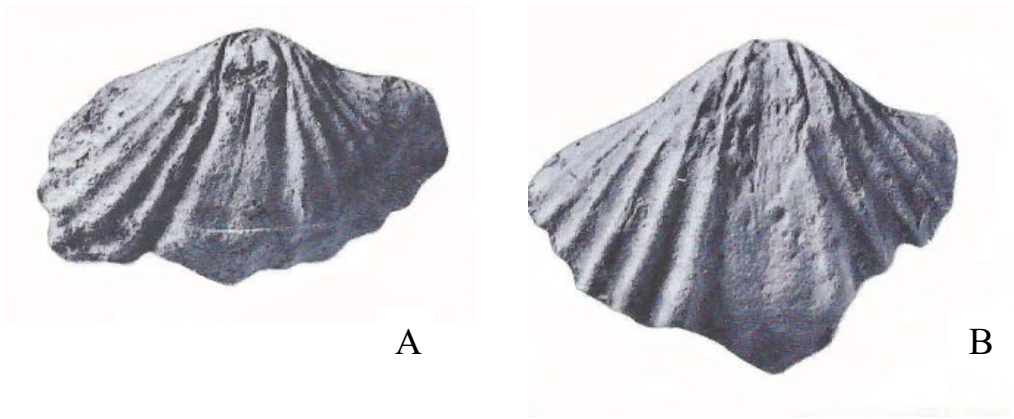


Fig. 36. *Monklandia gympiensis* Waterhouse. A, dorsal aspect, GSQF 11373. B, ventral internal mould, QMF 5774. From Rammutt Formation, Gympie. (McClung 1978).

Morphology: The type specimen comes from the Lady Mary Reef at Gympie, southeast Queensland. The specimens usually display six pairs of plicae, but some have fewer plicae. The shell surface is covered by a dense micro-ornament of small c-shaped spines behind short surface grooves. Adminicula lie in the first pair of interspaces from the sulcus and tabellae lie in the second pair of interspaces from the fold.

Stratigraphy: The species is possibly limited to the Gympie area, though specimens from the Sydney Basin could be allied.

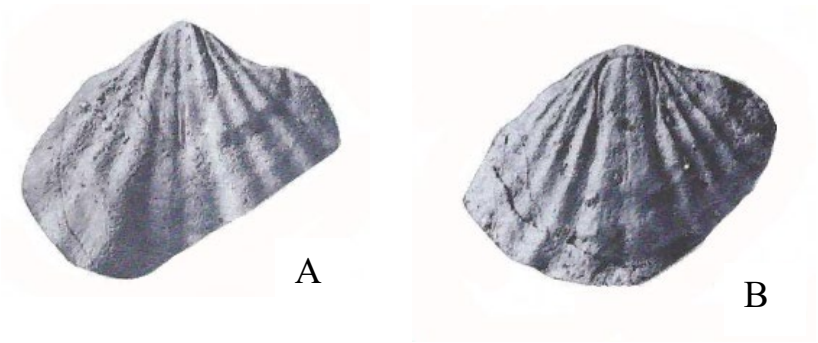


Fig. 37. *Monklandia gympiensis* Waterhouse. A, ventral aspect GSQF 11376. B, dorsal internal mould, GSQF 946, holotype. Specimens showing plicae with subrounded cross-profiles. From Rammutt Formation, Gympie. (McClung 1978).

Monklandia mcclungi Waterhouse, 2015b

Fig. 38, aff. 39, 40

1978 *Ingelarella koninckí* [not Etheridge Jnr] – McClung, p. 44, pl. 3, fig. 5, aff. pl. 3, fig. 3 (part, not pl. 2, fig. 3, 4, pl. 3, fig. 1, 2 = *Geothomasia simplicatas*, not pl. 3, fig. 4 = fig. 5 = *Monklandia* sp. 6 = *Ambikella elongata*?).
1978 *I. branxtonensis* [not Etheridge Jnr] – McClung, p. 45, pl. 4, fig. 6-10 (part, not pl. 2, fig. 5, 6; pl. 3, fig. 12-19; pl. 4, fig. 1-5, 11 = *Ambikella branxtonensis* Etheridge).
1998 *I. strzeleckii* [not Koninck] – Briggs, p. 33.
2015b *Monklandia mcclungi* Waterhouse, p. 171, Fig. 81.

Diagnosis: Small transverse shells with usually four pair of plicae, sulcus on dorsal fold may be weakly developed, adminicula may commence in first or even second pair of interspaces from sulcus, tabellae as a rule lie within innermost pair of interspaces from fold.

Holotype: UNEF 12244 from upper Rutherford Formation, north Sydney Basin, figured by McClung (1978, pl. 4, fig. 9, 10) and Fig. 38A, B herein, OD.

Morphology: Some members of this species were identified by McClung (1978) with *Ingelarella branxtonensis* (Etheridge), but the Etheridge species is larger and slightly less plicate. The tabellae for *branxtonensis* diverge widely immediately in front of the dorsal umbo, though staying within the first pair of interspaces next to the fold, whereas in *mcclungi* the tabellae in some specimens start in the second pair of interspaces from the fold, and come to lie close to the flanks of the fold.

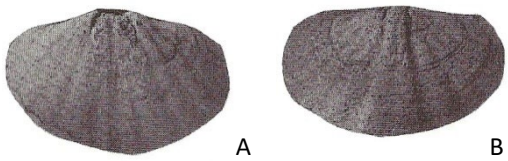


Fig. 38. *Monklandia mcclungi* Waterhouse, ventral and dorsal aspects of holotype, internal mould, formerly registered as UNEF 12244, now at Australian Museum. From upper Rutherford Formation, Hunter Valley. See McClung (1978, pl. 4, fig. 9, 10).

The species is readily distinguished from *Ambikella elongata*, through having more widely spaced and shorter internal plates. Some specimens figured are less amenable to classification. The specimen of McClung (1978, pl. 3, fig. 3) from the Cranky Corner Sandstone, New South Wales (see Fig. 39) has a distinct fold channel and well-defined plicae, with tabellae close to the fold. It is distinguished by its prominent dorsal channel in the fold, and so of uncertain affinities, although that might prove to be a variable feature. One of the tabellae clearly lies next to the fold, as in Ingelarellinae, and the other cuts from the second interspace from the fold. .The specimen of McClung (1978, pl. 3, fig. 4) from the Allandale Formation could be *konincki*, as in McClung, 1978, given that only a very shallow fold channel is present, but the tabellae need to be seen. McClung (1978, pl. 3, fig. 5) shows a small specimen identified as *I. konincki* from the Lochinvar Formation with several plicae pairs, faint fold channel, possibly due to wear above the internal septum, and tabellae lie close to the fold, largely suggestive of *Ambikella*, though a faint fold channel indicates possible *Monklandia*. The specimen is smaller than *gympiensis* and older than other known *mcclungi*. The specimen of McClung (1978, pl. 3, fig. 6) from Allandale would seem to fit with *elongata*, but needs to be checked at first hand. The ventral interspaces from the fold, and come to lie close to the flanks of the fold.

Fig. 39. *Monklandia* aff. *mcclungi* Waterhouse, dorsal valve MMF 17601 from Cranky Corner Sandstone. (McClung 1978).

Discussion: Briggs (1998) pointed out that the specimen figured by McClung (1978, pl. 4, fig. 6-8) as *branxtonensis* was closer to the Rammutt Formation shells called *strzeleckii* (not Koninck) by McClung. The specimen of McClung (1978, pl. 4, fig. 9, 10) is even closer, though not so noted by Briggs. To Briggs, this meant that the Rammutt Formation was to be correlated with the upper Rutherford Formation of the north Sydney Basin. *Bandoproductus walkomi* Briggs comes from the lower Rutherford Formation, and from the Monkland or Pengelly beds at Gympie, above so-

Fig. 40. *Monklandia mcclungi* Waterhouse. Ventral, dorsal and anterior aspects (dorsal valve on top) of UNE 12492, from upper Rutherford Formation, north Sydney Basin. (McClung 1978).

called *strzeleckii* (now *Monklandia gympiensis*) at Gympie and below *M. mcclungi* in New South Wales. Were the fossils consistent in distribution, so-called *strzelecki* should be found below *walkomi,* not above. The upper Rutherford specimens are distinctly smaller than type *gympiensis*, and tend to have three or four rather than five pairs of prominent plicae.

Monklandia*? *etheridgei (McClung, 1978)

Fig. 41, 42

1877 *Spirifer strzeleckii* [not Koninck] – Koninck, pl. 13, fig. 1, 1a (part, not pl. 14, fig. 1, 1a).
what = Also David 1898, p. 183 fide McClung 1978.
1978 *Ingelarella etheridgei* McClung, p. 48, pl. 2, fig. 22, 23; pl. 9, fig. 1-14; pl. 10, fig. 1-3.
1978 *Ingelarella davidi* McClung, p. 49, pl. 9, fig. 15-24.

Diagnosis: Widely transverse, deep sulcus with well-formed sulcus bearing two subplicae on some internal moulds, well-formed fold with faint median channel, usually five pairs of plicae. Adminicula short and well-spaced, tabellae short and placed within second interspace from fold.

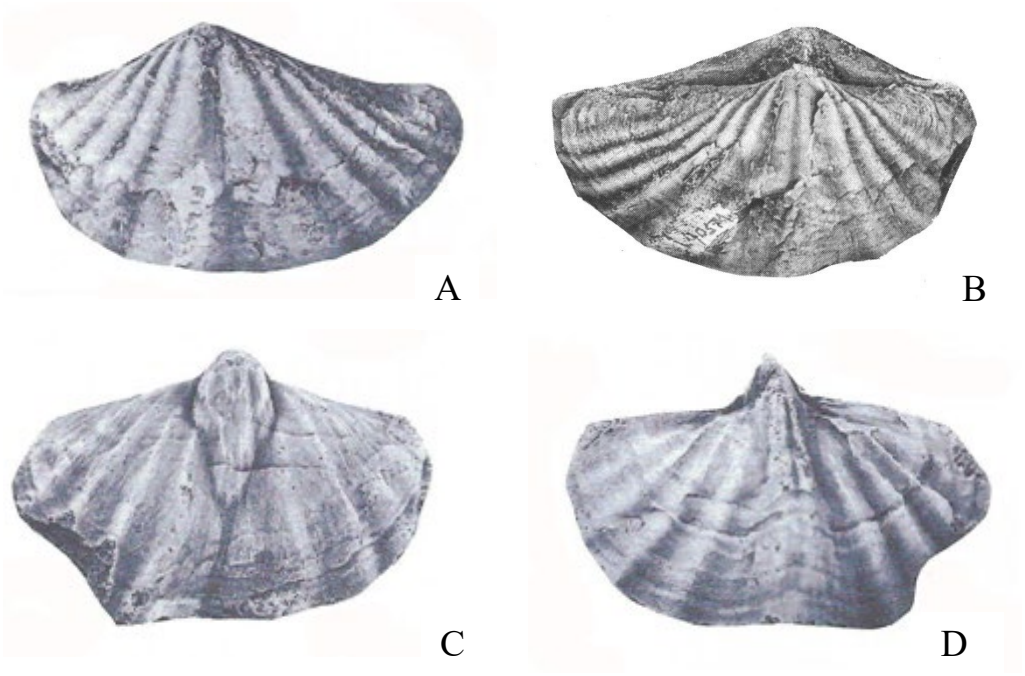


Fig. 41. *Monklandia*? *etheridgei* (McClung). A, B, UNEF 14263, ventral and dorsal views of holotype. C, D, UNEF 14277, ventral and dorsal aspects of internal mould. Specimens x1 from Elderslie Formation, north Sydney Basin. Note the apparent presence of pits indicating punctae in Fig. 41A, B. (McClung 1978).

Holotype: UNEF 14263 figured by McClung (1978, pl. 9, fig. 3, 6) and Fig. 41A, B herein from Elderslie Formation, north Sydney Basin. For *davidi*, UNEF 14312 figured by McClung (1978, pl. 9, fig. 18, 19) from Elderslie Formation, OD.

Morphology: Variation is considerable in the Elderslie suite figured by McClung (1978). The morphologies of *etheridgei* and *davidi* appear to be identical, the differences lying solely in size, apparently reflecting the different (unspecified) substrates for each group, according to McClung (1978, p. 49). Globons or possible spines are suggested in several of McClung's figures. (See Fig. 44B, C herein).

McClung (1978, p. 48) considered that one of Koninck's specimens figured as *strzeleckii* (pl. 13, fig. 1, 1a) from the Elderslie beds with well-developed plicae and round-crested fold belonged to *etheridgei*. The other specimen of Koninck (1877, pl. 14, fig. 1, 1a) is distorted and

has a grooved fold, and could not be identified by McClung. That strongly suggests that *strzeleckii* Koninck has priority and requires citation of a neotype. Surely that would be preferable to abandoning Koninck's species, which has enjoyed long priority and therefore seniority. Therefore the taxon *etheridgei* may well prove to be a junior synonym of *strzelecki* Koninck.

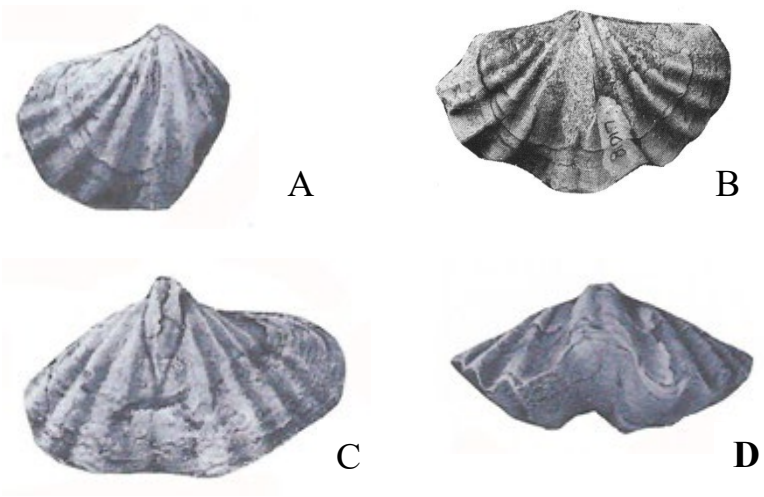


Fig. 42. *Monklandia davidi* (McClung) = *etheridgei* (McClung). A, dorsal internal mould UNEF 14311. B, C, D, dorsal, ventral and anterior aspects of internal mould, UNEF 12805. Specimens x 1, from Elderslie Formation. Tentatively regarded as equivalent to *etheridgei*. (McClung 1978).

Stratigraphy: McClung (1978, p. 48) reported unfigured specimens of the species from the lower Wandrawandian Sandstone, and did not provide any detail of the relationship to *Wyndhamia typica* within the Elderslie Formation, so that facet still awaits clarification. He considered that *Martiniopsis strzeleckii* Koninck of Clarke & Banks (1975, p. 462) belonged to *etheridgei.* This form was listed in their faunizone 8, just above *Aperispirifer lethamensis* Waterhouse and *Anguliplica phalaena* (Dana) with various other listed species in need of proper documentation, but chiefly suggestive of Kungurian to Roadian faunas. The very high correlation potential value of a number of Tasmanian faunas remains to be realized through further systematic description and illustration.

McClung (1978) noted that the species *etheridgei* also occurred in the same zone as

what is now called *Johndearia brevis* Zone in the lower Wandrawandian Siltstone in the south Sydney Basin.

Subfamily **GLENDONIINAE** Clarke, 1992b

Diagnosis: Distinguished by micro-ornament of low ramped spines behind long shallow grooves, tabellae short or absent. Globons and any form of punctation said to be absent.

Discussion: This group is close to Notospiriferinae, but surface grooves are shallower and longer than the globons characteristic of Notospiriferinae, and Clarke in proposing the subfamily implied that deep pits were absent, and did not record any form of punctation. This subfamily was characterized by its “micro-ornament of quincunxially arranged shallow elongate grooves terminated anteriorly by low elongate spinules and shallow elongate pits” according to Carter et al. (1994, p. 341) and Carter & Gourvennec (2006, p. 1762). Those authors distinguished the subfamily from Notospiriferinae by the position of the spines, placed behind the grooves in Notospiriferinae, and in front of the grooves in Glendoniinae. But the grooves in *Glendonia* do lie in front of the spines, not behind (cf. McClung & Armstrong 1978, pl. 1, fig. 21-23; Clarke 1987, p. 70). Often the ridges that extend forward from each wing of the barchan spine in Notospiriferinae do not appear to be developed in members of Glendoniinae. The need remains for further clarification. The claim that punctae are definitely absent raises the question of whether the group should be so closely allied to Notospiriferinae, or whether they should be recognized as a discrete family. In turn, that may imply superfamily status for notospiriferids and glendoniids.

Genus ***Glendonia*** McClung & Armstrong, 1978

Diagnosis: Genus characterized by strong median subplication along sulcus, and channelled dorsal fold. Strong lateral plicae. Micro-spines suberect, with anterior groove. Tabellae may be comparatively well-developed.

Type species: *Glendonia ulladullensis* McClung & Armstrong, 1978, p. 3 from Wandrawandian Siltstone, south Sydney Basin, OD.

Glendonia ulladullensis McClung & Armstrong, 1978

Fig. 43 - 45

1877 ?*Spirifer duodecimcostata* [not M'Coy] – Koninck, pl. 12, fig. 4a.
1888 ?*Spirifer oviformis* [not M'Coy] – Johnston, pl. 11, fig. 2.
1978 *Glendonia ulladullensis* McClung & Armstrong, p. 3, pl. 1, fig. 1-13, 21, 22; pl. 2, fig. 1-4, ?5, 6.
2006 *G. ulladullensis* – Carter, p. 1762, Fig. 1160a-d.
2016 *G. ulladullensis* – Waterhouse, Fig. 91.
2023 *G. ulladullensis* – Lee in Lee at al., p. 24, Fig. 6P, 12U-X.

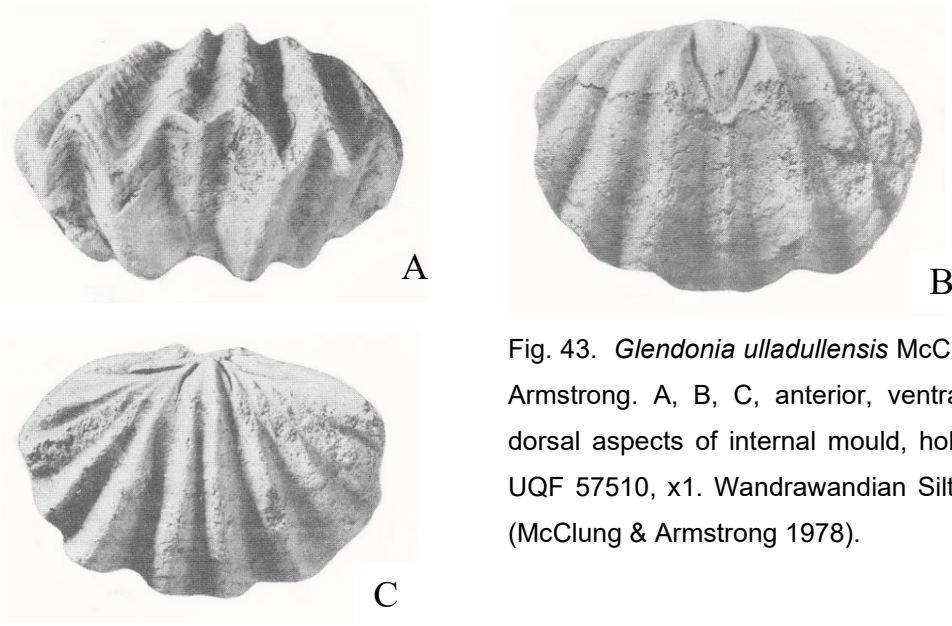


Fig. 43. *Glendonia ulladullensis* McClung & Armstrong. A, B, C, anterior, ventral and dorsal aspects of internal mould, holotype, UQF 57510, x1. Wandrawandian Siltstone. (McClung & Armstrong 1978).

Diagnosis: Subequidimensional to moderately transverse and inflated, three or four strong plicae pairs, sulcus with high median plication, fold with well-defined median channel, moderately long tabellae, which are usually strong and divergent and may curve inwardly anteriorly. Some three or four spines per mm; often no ridge extending forward from side of each spine, though there are exceptions.

Holotype: UQF 57510 from Wandrawandian Formation (north North Head), figured by McClung & Armstrong (1978, pl. 1, fig. 1-3) and Fig. 43A-C herein, OD.

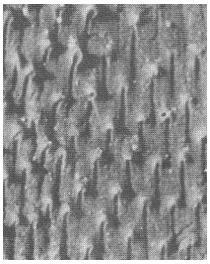


Fig. 44. *Glendonia ulladullensis* McClung & Armstrong, latex cast showing micro-ornament of UQF 57513, x15. Wandrawandian Siltstone. (McClung & Armstrong 1978).

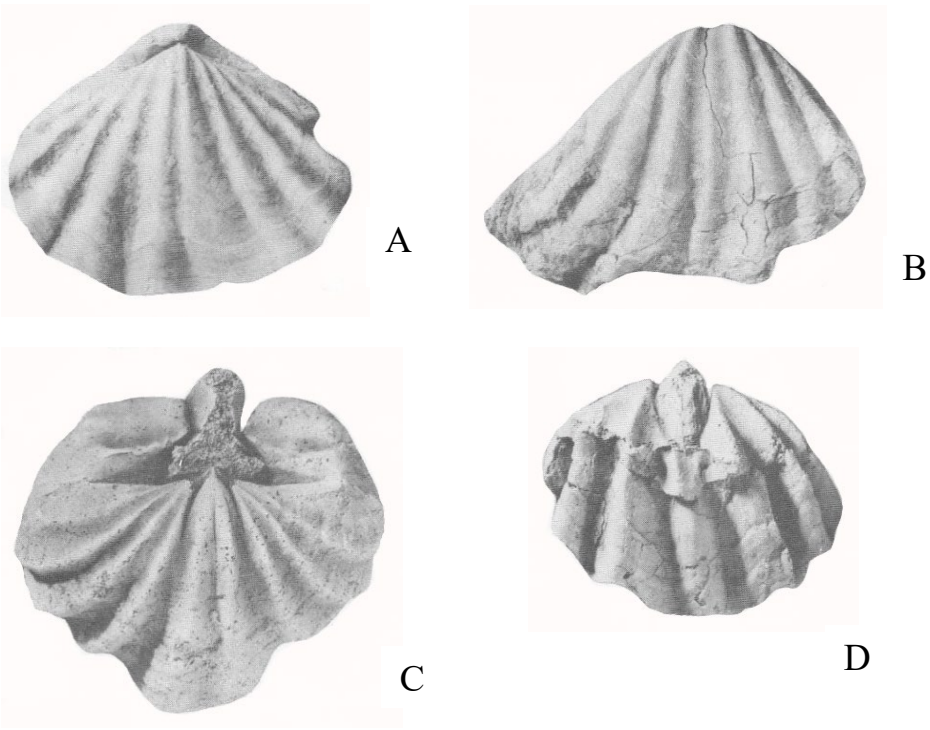


Fig. 45. *Glendonia ulladullensis* McClung & Armstrong. A, dorsal aspect, AMF 21796. B, ventral aspect, UQF 57514. C, dorsal aspect, internal mould, AMF 21783. D. ventral aspect, UQF 57511. Wandrawandian Siltstone, x1. (McClung & Armstrong 1978).

Morphology: A number of specimens were figured by McClung & Armstrong (1978).

Stratigraphy: The species is most common in the lower and middle Wandrawandian beds of the south Sydney Basin, and is reported as being moderately common in the Belford Formation of the north Sydney Basin, and present in the Moonlight Sandstone of the north Bowen Basin.

Glendonia duodecimcostata (M'Coy 1847)

Fig. 46 - 48

1847 *Spirifer* (*Brachythyris*) *duodecimcostata* M'Coy, p. 234, pl. 17, fig. 2, 3.
1967 *Notospirifer* sp. Waterhouse, p. 276, pl. 13, fig. 8-11, 12.
1968 *N. duodecimcostatus* – Armstrong, pl. 1, fig. 1-20, pl. 2, fig. 10-13.
1969 "*Spirifer" duodecimcostatus* – Armstrong, p. 201, pl. 1, fig. 1-20, pl. 2, fig. 10-13.
1978 *Glendonia duodecimcostata* – McClung & Armstrong, p. 3, pl. 2, fig. 9-20.
1987 *G. duodecimcostata* – Clarke, 279, Fig. 15A-J.
1998 *Monklandia glendonensis* Waterhouse, p. 39.

Diagnosis: Small transverse shells with three to six pairs of strong plicae, narrow median sulcal fold, short highly divergent tabellae lying on first lateral pair of plicae or in outer adjoining interspace. Spines suberect, appear to be entire without barchan wings.

Lectotype: SME 10644 from Muree Sandstone, figured by M'Coy (1847, pl. 17, fig. 5), Campbell (1960, pl. 139, fig. 2a-c) and Fig. 47 herein, SD Waterhouse (1967, p. 278**).**

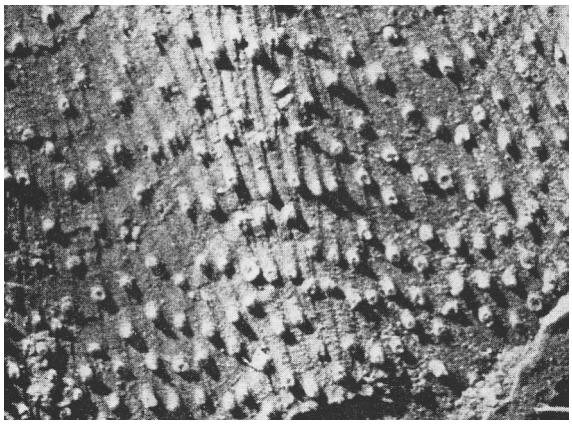


Fig. 46. *Glendonia duodecimcostatus* (M'Coy), micro-ornament of UQF 56167 x17, from Muree Sandstone. (Armstrong 1968).

Morphology: Compared with *ulladullensis*, this species is small and more transverse, with more plicae pairs as a rule, and shorter more divergent tabellae. *Glendonia exigua* has weaker plicae. Armstrong (1968) included with a query specimens described by Dana (1849, pl. 2, fig. 1a, b) and Koninck (1877, pl. 12, fig. 4 (part, not pl. 12, fig. 4a), but these references were deleted in the definitive study by McClung & Armstrong (1978).

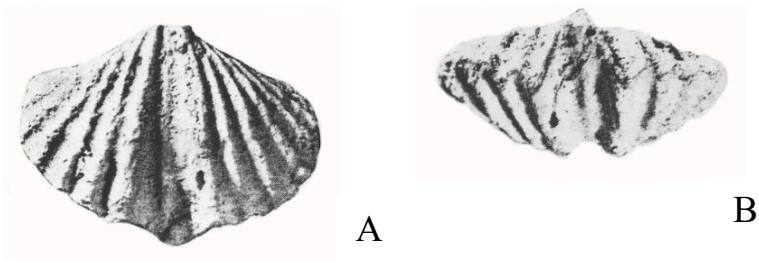


Fig. 47. *Glendonia duodecimcostata* (M'Coy). A, B, dorsal and ventral aspects of internal E 10644 holotype, x From Muree Sandstone. (Armstrong 1968).

Stratigraphy: The species is found in the Muree Sandstone, and has been reported widely from the Bowen and Sydney Basins and Tasmania, said to range from the *brevis* to *ovalis* Zone, with Armstrong (1968) recording a number of stations.

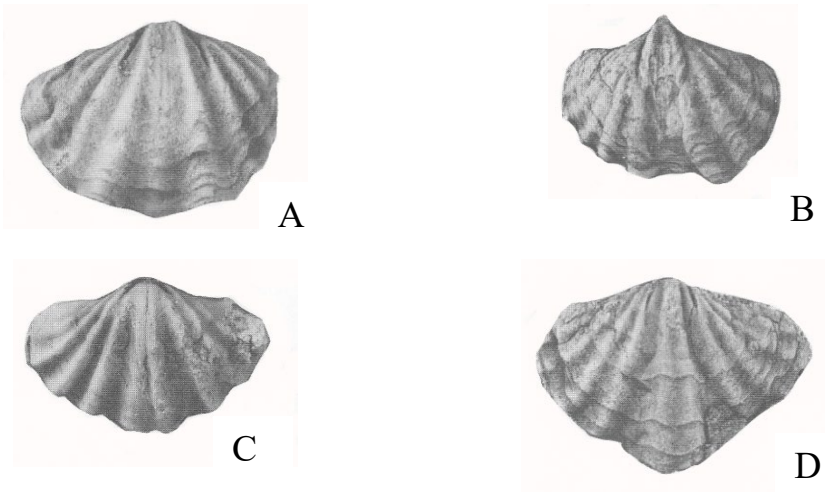


Fig. 48. *Glendonia duodecimcostata* (M'Coy). A, GSQF 11040, ventral internal mould. B, UNEF 14250 ventral internal mould. C, dorsal internal mould GSQF 10554. D, dorsal internal mould UNEF 14248. A, C, upper Gebbie (or basal Blenheim) Formation, B, D, Branxton Subgroup. (McClung & Armstrong 1978).

Monklandia glendonensis Waterhouse, 1998, p. 39 was proposed for the material illustrated by Armstrong (1968, p. 200, pl. 2, fig. 5-7, 14, 15), but the proposed holotype is clearly *Glendonia* as pointed by Clarke (1992b, p. 76) and the species should be abandoned, as the material is likely to belong to *Glendonia duodecimcostata* (M'Coy). However the specimen figured in Waterhouse (1967a, pl. 13, fig. 4-7, 12) and placed in *Glendonia* by Clarke (1992b, p. 76) lacks the sulcal mid-rib of *Glendonia* and may well belong to *Notospirifer* (*Notospirifer*) *darwini.*

Glendonia exigua McClung & Armstrong, 1978

Fig. 49, 50

1978 *Glendonia exigua* McClung & Armstrong, p. 4, pl. 1, fig. 14-20, 23.
1983 *Notospirifer* (*Glendonia*) *exigua* – Waterhouse & Jell, p. 246, pl. 2, fig. 9.
2022 *G. exigua* – Waterhouse, pp. 82, 172, Fig. 13, 34.

Diagnosis: Small, strongly biconvex, with three or four plicae pairs, short tabellae.

Holotype: UQF 57522, figured by McClung & Armstrong (1978, pl. 1, fig. 16-18) and herein as Fig. 50A, B, C from upper Blenheim Formation, north Bowen Basin, OD.

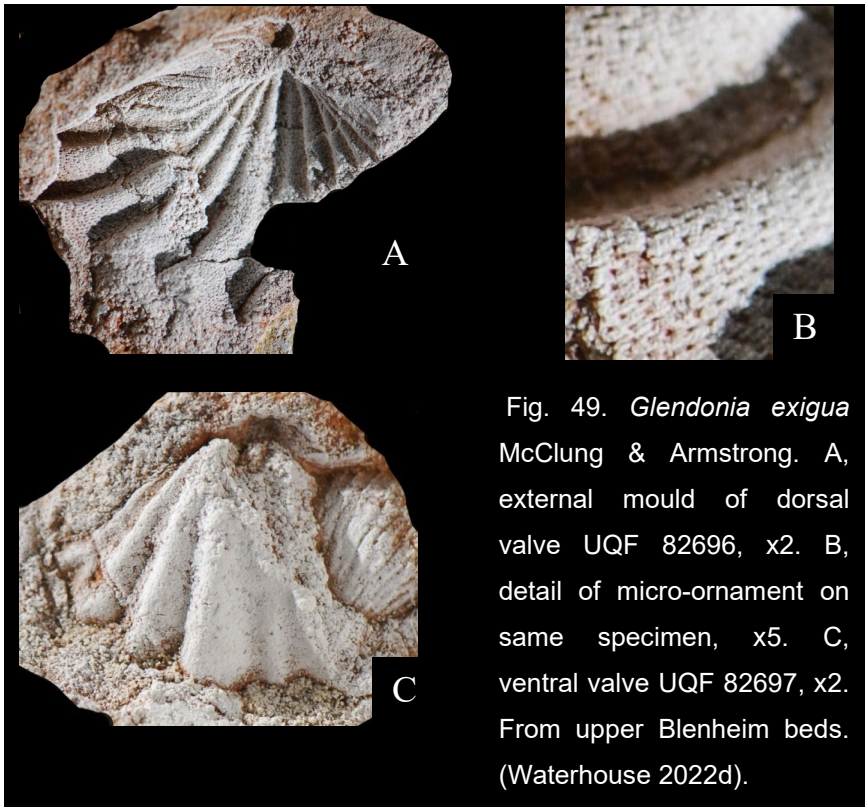


Fig. 49. *Glendonia exigua* McClung & Armstrong. A, external mould of dorsal valve UQF 82696, x2. B, detail of micro-ornament on same specimen, x5. C, ventral valve UQF 82697, x2. From upper Blenheim beds. (Waterhouse 2022d).

Morphology: Many specimens were figured by Armstrong (1968) and McClung & Armstrong (1978). There are three or less often four spines per mm.

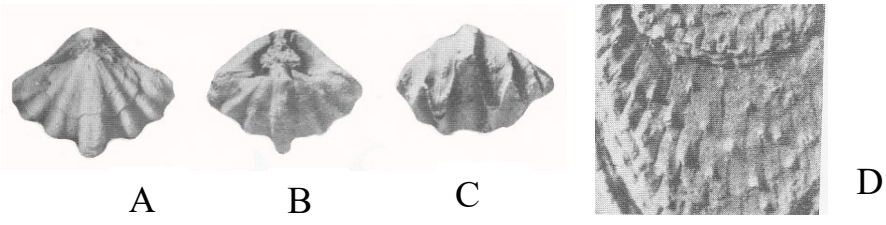


Fig. 50. *Glendonia exigua* McClung & Armstrong. A-C, views of holotype UQF 57519 x1. D, micro-ornament on UQF 57522, x15. Upper Blenheim Formation, north Bowen Basin, Queensland. (McClung & Armstrong 1978).

Stratigraphy: McClung & Armstrong (1978, p. 3) and Armstrong (1968) reported that the species ranged from the *brevis* to *ovalis* zones, a matter to be checked.

Genus ***Birchsella*** Clarke, 1987

Diagnosis: Small transverse subequally biconvex shells with three to six angular plicae pairs, ventral muscle field very broad, no tabellae, posterior thickening considerable in ventral valve. Micro-ornament of well-developed short spines, reportably with surface groove leading forwards.

Type species: *Birchsella spinosa* Clarke, 1987 from Abels Bay Formation, Tasmania, OD.

Discussion: *Birchsella* differs from *Glendonia* in the presence of massive posterior-lateral thickening of the ventral valve and details of muscle field. Tabellae are feebly if at all developed. According to Clarke (1987, p. 283), the micro-ornament of *Birchsella* is almost identical with that of *Glendonia*. Clarke provided illustrations of many specimens, which do not appear to fully substantiate details of his description. No figure clearly shows a mid-sulcal rib, which might be because of his preference for figuring internal moulds. Nor do the good figures of micro-ornament confirm that a groove extends forward from each spinule. The figures indicate six to eight spines in 1mm,. Such spines are much more numerous at the top of his Fig. 16M.

Birchsella spinosa Clarke, 1987

Fig. 51

1973 Spiriferid gen. nov. Clarke, pp. 50, 59.
1987 *Birchsella spinosa* Clarke, p. 283, Fig. 16A-S, 17A-O.
2006 *B. spinosa* - Carter, p. 1763, Fig. 1161.2a-d,

Diagnosis: As for genus.

Holotype: GST 14054A, B from Abels Bay Formation, Tasmania, figured by Clarke (1987, Fig. 16L, M) and Fig. 51C, D herein, OD.

Stratigraphy: The species is found only in the Abels Bay Formation at the top of the marine succession in Tasmania. Carter (2006) stated the age was Lopingian, which may be too young, unless the Abels Bay formation proves to be of early Wuchiapingian age. But an upper Capitanian age appears more likely.

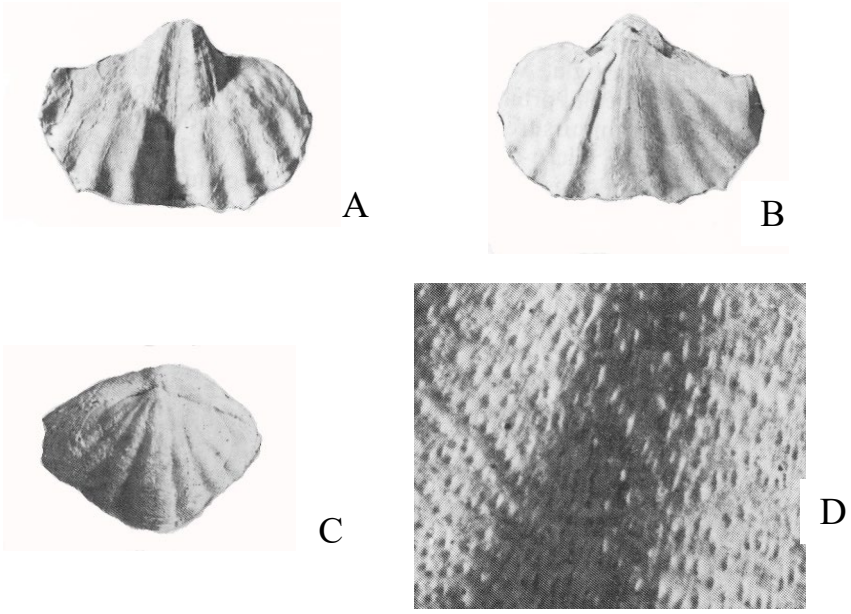


Fig. 51. *Birchsella spinosa* Clarke. A, B, ventral and dorsal aspects of internal mould, GST 14055, x1. C, latex cast of exterior for dorsal valve and ventral umbo, holotype GST 14054, x1. D, micro-ornament on same specimen x10. Abels Bay Formation, Tasmania. (Clarke 1987).

Genus ***Tabellina*** Waterhouse, 1986

Diagnosis: Shells may be large for family with strong high and broad dorsal fold bearing rounded crest, well-defined to deep ventral sulcus, which may bear two subplicae, lateral plicae well defined, may be numerous, micro-ornament of low ramped spines behind elongate not very deep grooves. Adminicula moderately developed, tabellae short or absent, long low dorsal septum.

Type species: *Ingelarella denmeadi* Campbell, 1961, p. 171 from Fairyland Formation, southeast Bowen Basin, Queensland, OD.

Discussion: *Kelsovia* Clarke, 1990, p. 70, type species *K. superba* Clarke, 1990 from the early Permian of Tasmania is a subjective synonym, agreeing in ornament and internal plates, as discussed by Waterhouse (1998). Whilst Clarke (1990, p. 70) noted that the morphology of *Kelsovia* was close to that of *Notospirifer* and *Glendonia*, he placed the genus is Ingelarellidae. **Check et** Clarke (1990, 1992a) and Carter (2006) placed *Tabellina* in Family Ingelarellidae, but the genus belongs with *Kelsovia* in the notospiriferid subfamily

Glendoniinae. *Kelsovia* is similar in micro-ornament and internal plates to *Glendonia*, as realized by Clarke (1990).

Tabellina superba (Clarke, 1990)

Fig. 52, 53

1990 *Kelsovia superba* Clarke, p. 70, Fig. 13A-N.
1992a *K. superba* - Clarke, p. 23, Fig. 13A-N.
1998 *Tabellina superba* - Waterhouse, p. 36.
2006 *K. superba* - Carter, p. 1763, Fig. 1161.1a-e.
2016 *T. superba* - Waterhouse, p. 189.

Diagnosis: Small medium in size, with three or four pairs of plicae as a rule, rarely five pairs on dorsal valve, fold round-crested or with shallow median groove, sulcus concave or with suggestions of two very low plicae or median ridge. Micro-ornament of barchan spines each with anterior long shallow groove, low ridge leading forward from each flank of the spine seldom in evidence. Adminicula short, subparallel, tabellae short, commence outside first pair of interspaces and curve back to lie in first pair of interspaces.

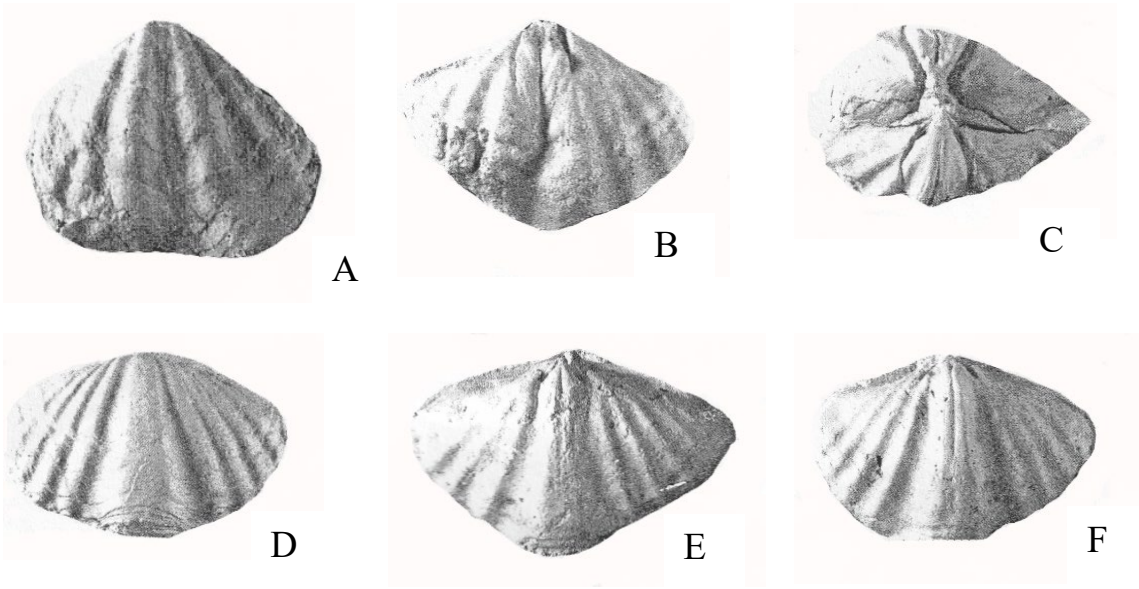


Fig. 52. *Tabellina superba* (Clarke). A, ventral valve GST 14173. B, ventral internal mould, GST 361085. C, posterior view of internal mould GST 14172, ventral valve on top. D, F, dorsal valve exterior GST 361234 and internal mould GST 361168, holotype. E, dorsal internal mould GST 361238. Specimens assumed to be x1 (although not stated in Clarke's publication), Swifts Jetty Sandstone, Tasmania. (Clarke 1990).

Holotype: GST 361234 and 361168 (counterparts of external and internal dorsal moulds) from Swifts Jetty Sandstone, Tasmania, figured by Clarke (1990, 1992a, Fig. 13H, I, K, N) and herein as Fig. 52D, F, OD.

Morphology: A range of specimens was figured by Clarke (1990, 1992), with excellent figures of the micro-ornament. The variation in shape, plication and especially nature of the dorsal fold suggests a degree of instability which diminished in younger species. Judged from figures only three spines lie along one commarginal row in 1mm.

Stratigraphy: The species comes from the "Spirifer" Zone in Tasmania at Fossil Cliffs, Maria Island, of Early Permian (Asselian) age.

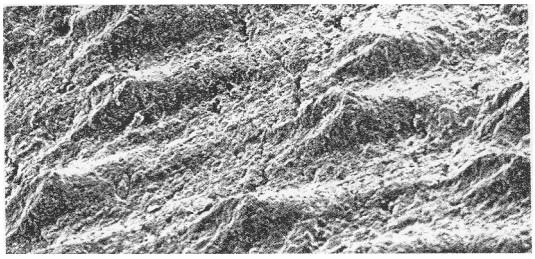


Fig. 53 *Tabellina superba* (Clarke), micro-ornament on holotype GST 361234, dorsal valve, anterior aperture to left, x35. Swifts Jetty Sandstone, Tasmania. Note the absence of any pit at the anterior end of each groove. (Clarke 1990).

Tabellina denmeadi (Campbell, 1961)

Fig. 54

1961 *Ingelarella denmeadi* Campbell, p. 171, pl. 23, fig. 7-13.
1964 *I. denmeadi* – Hill & Woods, pl. P 8, fig. 12, 13.
1972 *I. denmeadi* – Hill et al., pl. P8, fig. 12, 13.
1986 *Tabellina denmeadi* – Waterhouse, p. 4.
1987 *Tabellina denmeadi* – Waterhouse, p. 26, pl. 6, fig. 12, 16, 17; pl. 7, fig. 1, 2.
2006 *T. denmeadi* – Carter, p. 1762, Fig. 1158.2a-c.

Diagnosis: Large shells with five to seven pairs of plicae.

Holotype: UQF 30238 figured by Campbell (1961, pl. 23, fig. 9) from Fairyland Formation, southeast Bowen Basin, OD.

Morphology: This species would have to be regarded as exceptional amongst Ingelarellidae in the high number of plicae and the shortness of the tabellae, but is more normal for Notospiriferidae. Campbell (1961) noted that the grooves were 0.3-0.5mm long. Carter (2006) regarded the species and genus as a member of Ingelarellidae, but the tabellae are more like those of Notospiriferidae.

Stratigraphy: The species is limited to the Fairyland Formation.

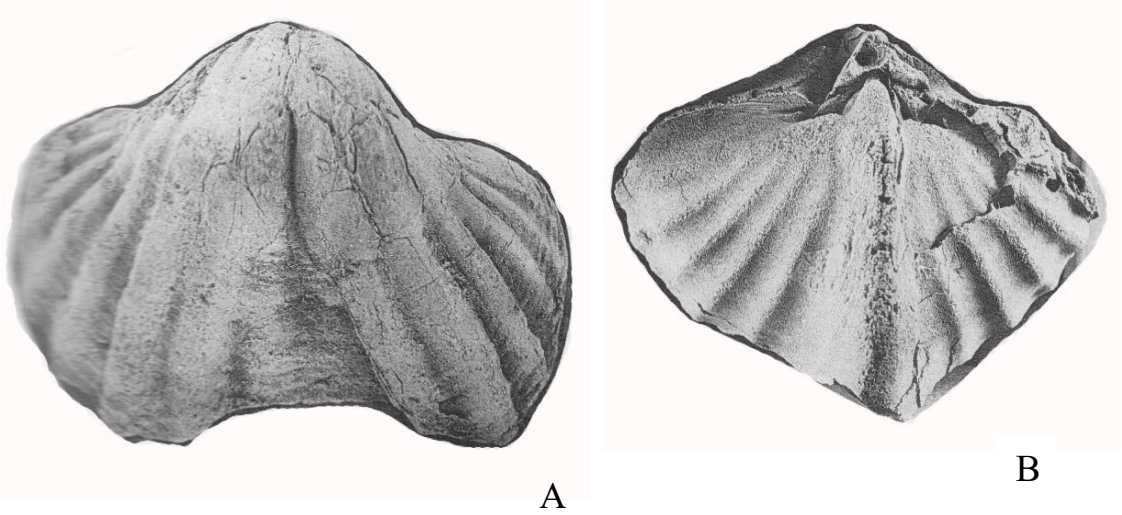
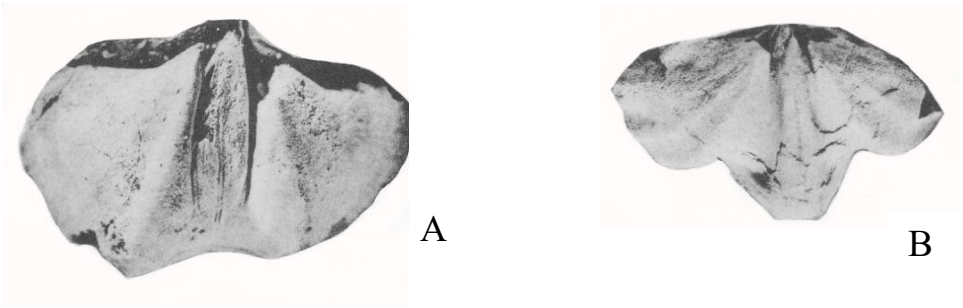


Fig. 54. *Tabellina denmeadi* (Campbell). A, ventral valve UQF 27448 x1. B, dorsal internal mould, UQF 12595, x1. Fairyland Formation. (Campbell 1961).

Tabellina cracowensis Waterhouse, 1987

Fig. 55

1987 *Tabellina cracowensis* Waterhouse, p. 26, pl. 7, fig. 11-14.



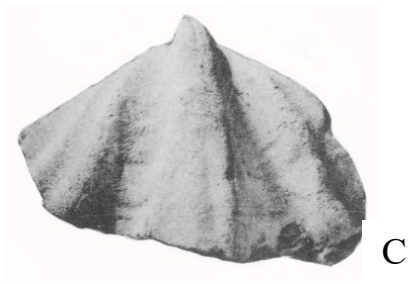


Fig. 55. *Tabellina cracowensis* Waterhouse. A, ventral internal mould UQF 12616. B, C, posterior and anterior aspects of dorsal internal mould, UQF 74193, holotype. Specimens x1 from Fairyland Formation, southeast Bowen Basin. (Waterhouse 1987).

Diagnosis: Deep ventral sulcus and high wide dorsal fold, two to three pairs of plicae over lateral shell. Adminicula long, tabellae very short, divergent.

Holotype: UQF 74193 from Fairyland Formation, figured in Waterhouse (1987, pl. 7, fig. 12, 14) and herein as Fig. 55B, C, OD.

Stratigraphy: The species is limited to the Fairyland Formation of the southeast Bowen Basin, but its prominent dorsal fold appears also in a younger and different taxon.

Tabellina armstrongi Waterhouse, 1998

Fig. 56, cf. 57

1978 *Notospirifer*? n. sp. McClung & Armstrong, p. 4, pl. 2, fig. 21-25.
1982 *Notospirifer* sp. A Waterhouse, p. 57, pl. 15i.
1990 *Kelsovia* sp. Clarke, p. 72.
1998 *Tabellina armstrongi* Waterhouse, p. 36.

Diagnosis: Well-developed ventral sulcus, three pairs of plicae, with signs of a fourth pair on some specimens. Dorsal fold comparatively high with well-rounded crest.

Holotype: GSQF 12287 from Cattle Creek Shale, figured by McClung & Armstrong (1978, pl. 2, fig. 24, 25) and Fig. 56A herein, OD.

Morphology: This species is characterized by its few plicae pairs, very high fold and very short tabellae, and micro-ornament of prominent elongate grooves in front of barchan spines. Rarely a ridge extends in front of the barchan horns. The species is close to *Tabellina cracowensis*, but is smaller with stronger lateral plicae in both valves.

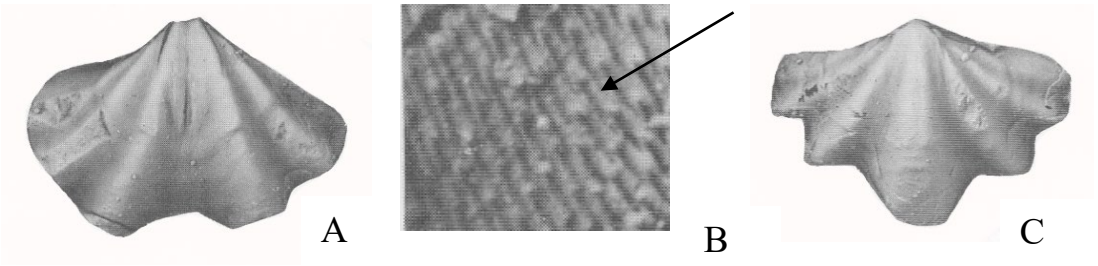


Fig. 56. *Tabellina armstrongi* Waterhouse. A, ventral internal mould GSQF 12287, holotype, x2. B, detail of micro-ornament for same specimen, x30. An arrow points to a rare ridge extending in front of the barchan horn and this leads forward into another spine. C, dorsal internal mould GSQF 12234, x2. Cattle Creek Formation. (McClung & Armstrong 1978).

Stratigraphy. Type material comes from the Cattle Creek Formation in the southwest Bowen Basin, and rare specimens from the Brunel Formation of New Zealand appear to be conspecific. The spines have inconspicuous or no ridges leading forward from each side.

The incomplete internal mould of a ventral valve BR 1454, figured as *Notospirifer* sp. B by Waterhouse (1982, p. 57, pl. 14b) shows some similarities, in having a high round-crested fold and only two pairs of plicae. The specimen is too incomplete to be sure of affinities, but may reasonably be regarded as *Tabellina* cf. *armstrongi.*

Fig. 57. *Tabellina* cf. *armstrongi* Waterhouse. A, ventral internal mould BR 1450 x2, from upper Brunel Formation, New Zealand. (Waterhouse 1982).

Tabellina aff. ***armstrongi*** Waterhouse, 1998

Fig. 58

2015a *Tabellina. armstrongi* – Waterhouse, p. 190, Fig. 141D, 142.

Discussion: Waterhouse (2015a, pp. 190, 191) referred rare specimens to *Tabellina armstrongi* from the upper middle Tiverton Formation of the north Bowen Basin in the *Taeniothaerus subquadratus* Zone to *Tabellina armstrongi*. These are much larger than the type specimens but show comparable plicae and fold, and barchan spines behind slender grooves. They agree with this species in having a round-crested prominent fold, two pairs of dorsal plicae with signs of a third, and very short widely diverging tabellae, though these lie within the innermost pair of plical interspaces, whereas those in type *armstrongi* lie under the first pair of plicae or outside. Three spines lie along 1mm. The shells are three times the size of type *armstrongi*, which would appear to be well beyond permissible limits imposed by environmental parameters for recognizing the specimens as belonging to the same species. The specimens appear likely to have descended from *Tabellina cracowensis*, with strengthening of the lateral dorsal plicae.

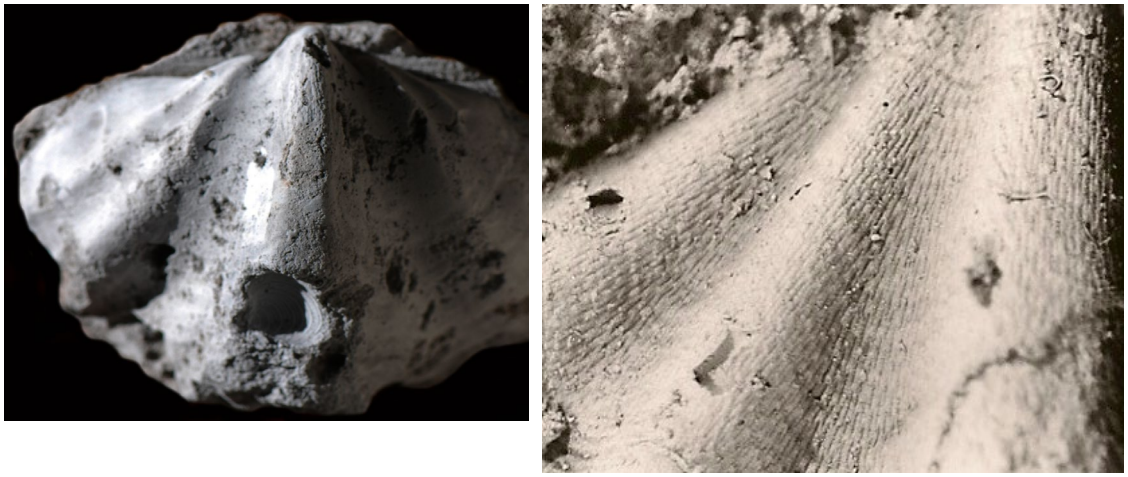


Fig. 58. *Tabellina* aff. *armstrongi* Waterhouse, internal mould of dorsal valve UQF 81842, x1. B, latex cast of ventral valve UQF 81356, x4. Upper middle Tiverton Formation. (Waterhouse 2015a).

Tabellina undulata (Parfrey, 1986)

Fig. 59

1986 *Notospirifer undulatus* Parfrey, p. 62, Fig. 2.5, 3.1.
2015a *Tabellina undulata* – Waterhouse, p. 189, Fig. 141A-C.

Diagnosis: Large with several pairs of plicae, two sulcal subplicae, medianly flattened dorsal fold, reduced tabellae.

Holotype: GSQF 12936 from Camboon Andesite, figured by Parfrey (1986, Fig. 3.1b), OD.

Morphology: *Tabellina undulata* (Parfrey, 1986) from Camboon Andesite near Biloela, southeast Bowen Basin shows a broad fold with rounded crest and five to six pair of strong lateral plicae, and the internal mould figured by Parfrey (1986, Fig. 2.5d) shows sulcal subplicae. Micro-ornament consists of closely spaced shallow linear pits **widening posteriorly** and possible crescentic – ie. barchan – spines. The species is close to *T. denmeadi* (Campbell, 1961) from the Fairyland Formation near Cracow, southeast Bowen Basin, in the number of plicae, but the fold is slightly lower, and the adminicula slightly more divergent and shorter. Only one of various figured specimens of *denmeadi* has sulcal subplicae (Campbell 1961, pl. 23, fig. 12), whereas subplicae are variably developed in two of the three ventral valves figured by Parfrey (1986). The adminicula are subparallel but short, the dorsal septum is long, and surface grooves long and shallow.

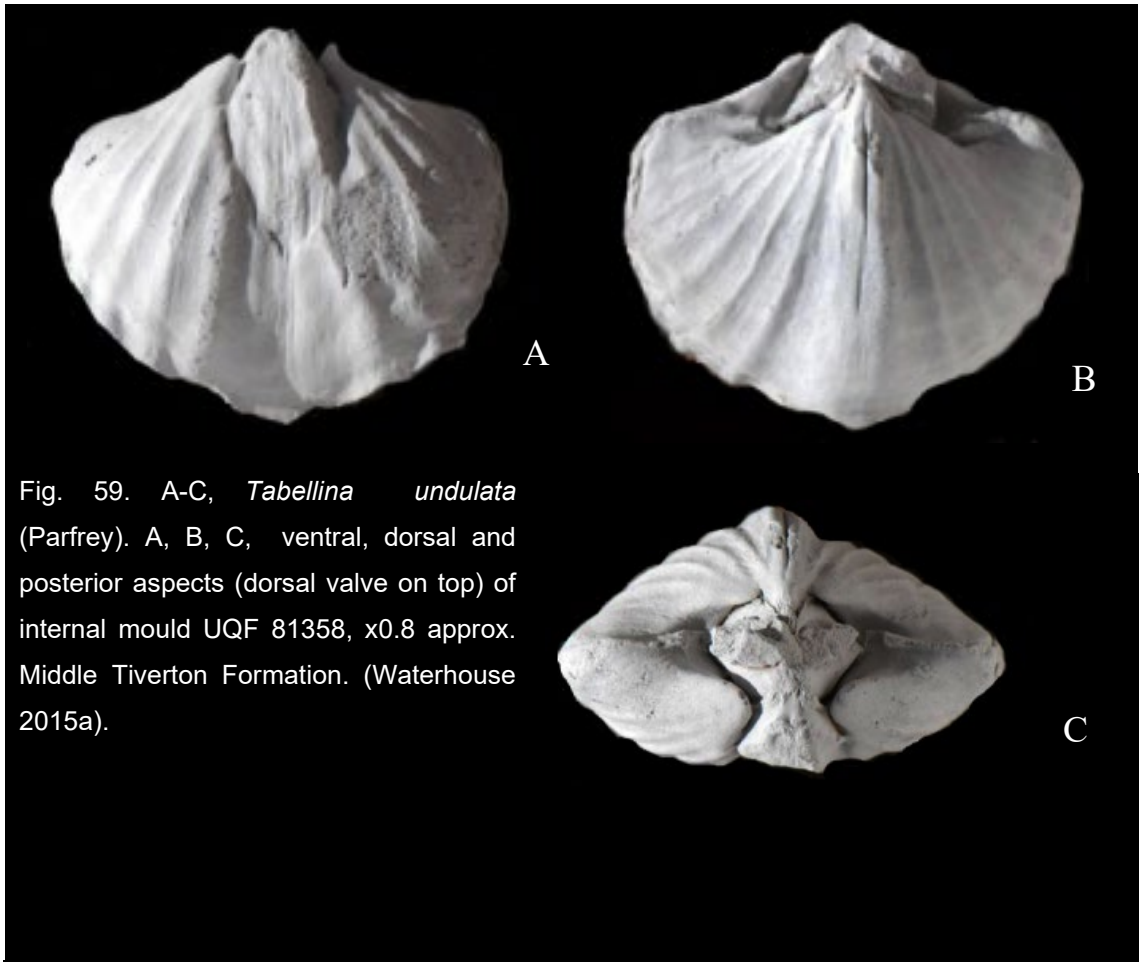


Fig. 59. A-C, *Tabellina undulata* (Parfrey). A, B, C, ventral, dorsal and posterior aspects (dorsal valve on top) of internal mould UQF 81358, x0.8 approx. Middle Tiverton Formation. (Waterhouse 2015a).

Parfrey (1986) was assured that her species *undulatus* differed from *Ingelarella denmeadi* (Campbell. She wrote that the latter is a large strongly biconvex species with five to seven pair of plicae, short tabellae and a very high rounded fold. "It cannot be mistaken for the present species", ie. *undulata*. Yet there are strong external similarities in size, shape, plication and fold. There are differences in the length of the adminicula and tabellae, but whether these reflect specific differences or variation appears to be contentious, and her species may need to be synonymized with Campbell's taxon. Waterhouse (2015a) judged that material from the lower Tiverton Formation in the north Bowen Basin had a fold comparable to that of *undulata*, whereas *denmeadi* showed a higher fold. That is true of the specimens figured by Campbell (1961, pl. 23, fig. 9b and 10), to justify distinction, and the anterior fold of undulatus is possibly broader, but full assessment awaits extensive survey of material.

Stratigraphy: The species is found in the Camboon Andesite of the southeast Bowen Basin and in the middle Tiverton Formation of the north Bowen Basin.

Tabellina laseroni Waterhouse *in* Shi et al., 2020

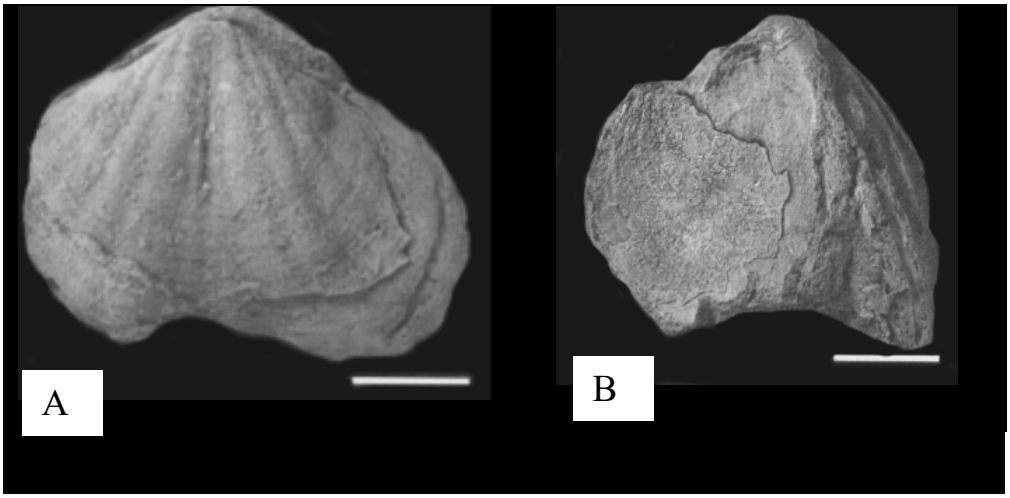
Fig. 60, 61

2020 *Tabellina laseroni* Waterhouse in Shi et al., p. 421, Fig. 4A, B, 7.

Diagnosis: Transverse with low distinct plicae in three of four pairs, fold with rounded crest. Adminicula short and well-spaced, tabellae of moderate length, well-spaced. Micro-ornament of low recumbent spinules, opening anteriorly.

Holotype: AMF 146235 figured by Shi et al. (2020, Fig. 7C, D) from Pebbley Beach Formation, and Fig. 60B, C herein, OD.

Morphology: The tabellae are short in the holotype (see Shi et al., 2020, Fig. 7D), and the micro-ornament was regarded in Shi et al. (2020, p. 421) as being like that figured for *Kelsovia* by Clarke (1992a, Fig. 13K).



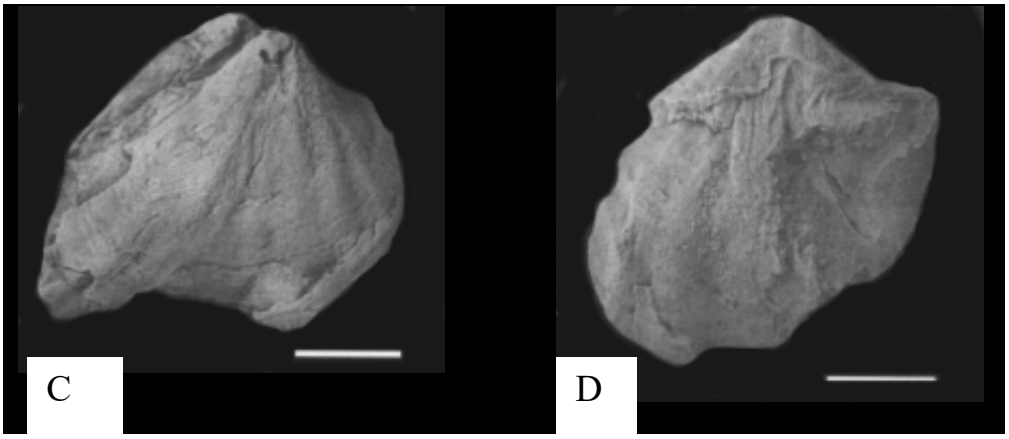


Fig. 60. *Tabellina laseroni* Waterhouse. A, ventral aspect of AMF 146234. B, C, dorsal and ventral aspects of AMF 146735 holotype. D, ventral valve AMF 146236. Specimens from Pebbley Beach Formation, scale = 10mm. (Shi et al. 2020).

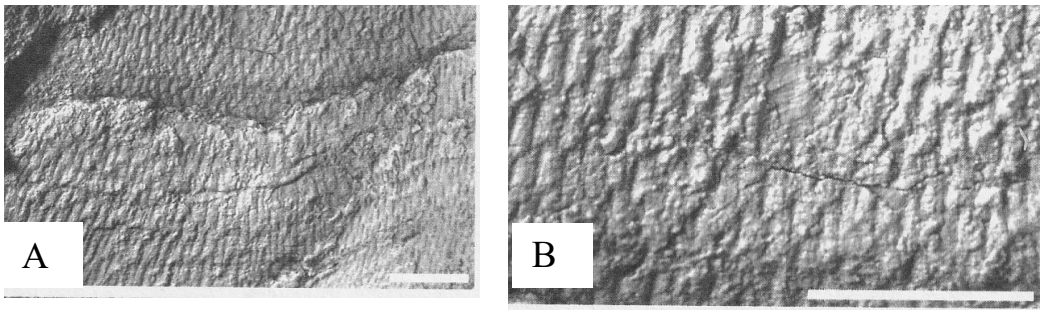


Fig. 61. *Tabellina laseroni* Waterhouse. A, B, micro-ornament on holotype AMF 146235 from Pebbley Beach Formation. Spines have a groove in front and for a few, a ridge extends anteriorly from the spine horn. Scale bar = 1mm. (Shi et al. 2020).

Stratigraphy: *Tabellina laseroni* is found in the Pebbley Beach Formation of the south Sydney Basin.

CLASSIFICATION UNCERTAIN, WITH SPECIES IN NEED OF FURTHER STUDY

Two species in particular are deemed to be in need of further study, because they either show features not apparent in species assigned to Notospiriferinae and Glendoniinae, or, as in one case, have features that are in dispute. Both species appear to display the presence of fine cylindrical pores, not swollen as in Notospiriferinae, that penetrate the outer shell in the laminae which especially anteriorly project from the main body of the shell, in both valves.

Genus ***Wairakispirifer*** Waterhouse, 1998

Diagnosis: Medium-small little inflated shells with well-formed ventral sulcus, lacking subplicae or median rib, low relatively wide dorsal fold with rounded crest, plicae well formed, rounded, micro-ornament of fine ribs, possibly short but of uncertain length, separated by grooves, no obvious spines. Punctae slender and cylindrical, deep. Adminicula distinct, little posterior thickening. No tabellae.

Type species: *Notospirifer microstriatus* Waterhouse, 1964 from Letham Burn Formation of New Zealand, OD.

Discussion: No thin sections are available to show the nature of the punctae, which are described in the text, and illustrated in Waterhouse (1964, pl. 36, fig. 2). The figure shows crowded punctae preserved as sediment-filled casts, present in the laminae that project from the body of the shell and through the anterior shell at the margin, and they are dense. No pores are visible over the outer surface of the shell, to suggest that the exolayer is not pierced by punctae. However uncertainties remain, and require clarification. The micro-ornament is dominated by fine grooves and ridges, which is also a feature of *Glendonia* and *Tabellina*, but these are not known to lead to punctae - though no thin sections have been prepared. The ribs are of uncertain length - they cross the anterior laminae as shown in the figure (see Fig. 62C), but how long they are over the main body of the shell needs to clarified.

Wairakispirifer microstriatus (Waterhouse, 1964)

Fig. 62

1964 *Notospirifer microstriatus* Waterhouse, p. 170, pl. 33, fig. 1, 8, 13; pl. 34, fig. 1, 2, text-fig. 79B (part, not pl. 33, fig. 5-7, 9-12; pl. 37, fig. 4, 6, text-fig. 78, 79A, C-E = *Notospirifer* (*Mesopunctia) macropustulosus*).
1987 *N. microstriatus* – Waterhouse, p. 39, pl. 11, fig. 3.
1998 *Wairakispirifer microstriatus* – Waterhouse, p. 40.
2007 *W. microstriatus* – Gouvennec & Carter, p. 2779, Fig. 1860.2a-b.

Diagnosis: As for genus. Three pairs of plicae. Spines either very rare or absent.

Holotype: BR 707 from Letham Burn Member, Wairaki Downs, figured in Waterhouse (1964, pl. 33, fig. 1, 8, 13) and herein as Fig. 62A, D, OD.

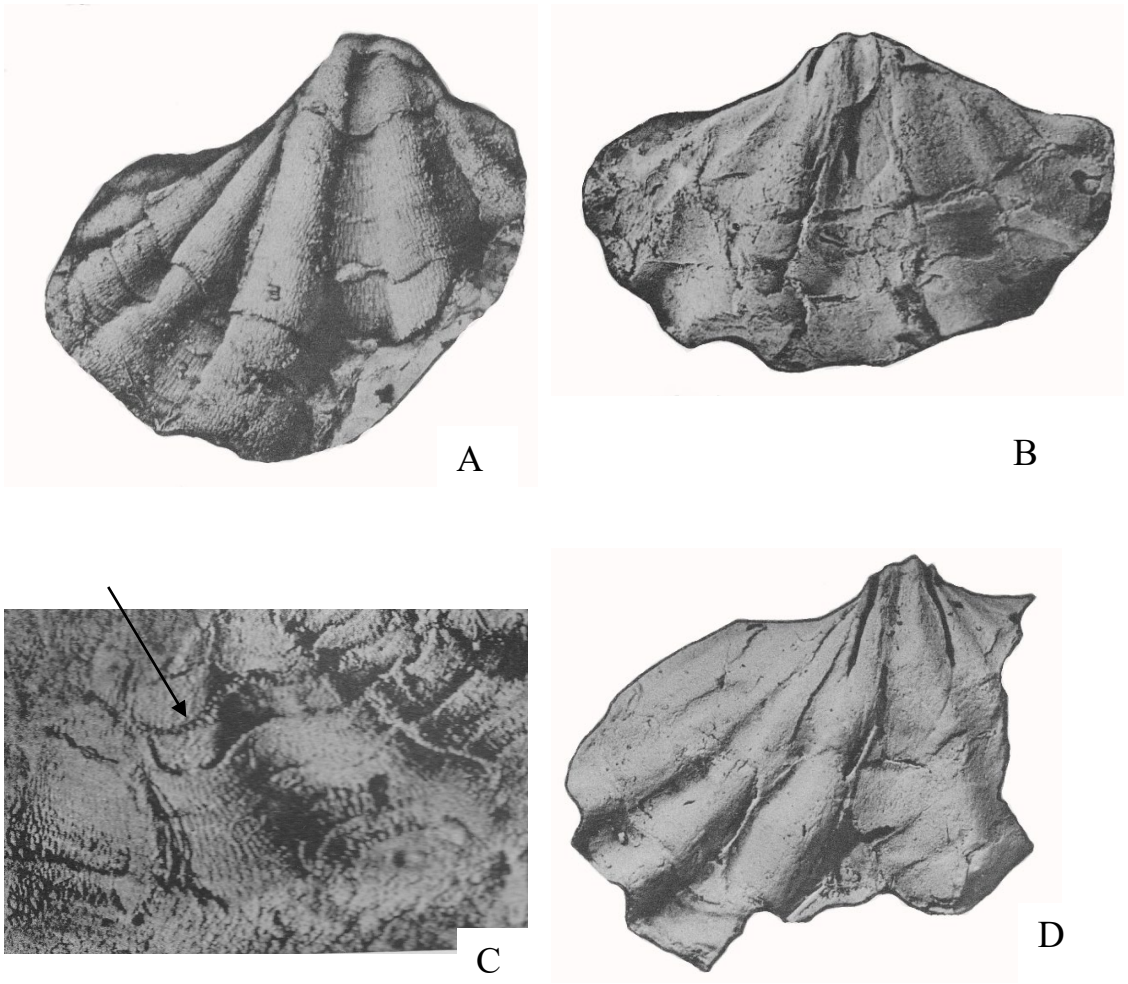


Fig. 62. *Wairakispirifer microstriatus* Waterhouse. A, PVC external cast of BR 707, holotype. B, ventral internal mould, BR 705, x4. C, micro-ornament of anterior ventral valve BR 942, x5. Arrows point to pores that penetrate the projecting and commarginal laminae, and globons are visible to the left. D, leached ventral internal mould BR 707, x4. Letham Burn Member, Wairaki Downs, New Zealand. (Waterhouse 1964).

Morphology: These specimens are well preserved and moderately numerous, but through a regrettable oversight, no topotype dorsal valves were figured, although they are available. A question centres on the presence or absence of spinules. It seems doubtful that any are present, but this needs to be checked. Probably the capillae and grooves are short (Waterhouse 1982, p. 39), , but this needs to be checked.

Stratigraphy: The species is reliably found in the Letham Burn Member of New Zealand, and described from the Oxtrack Formation in the southeast Bowen Basin. The figure provided of a ventral valve from the lower Letham beds in Waterhouse (1968, p. 78, text-fig. 6A) indicates a more inflated shell, and the micro-ornament shows external pits and rather short grooves,

suggestive of *Notospirifer*.

"***Notospirifer***" ***microspinosus*** Waterhouse, 1968

Fig. 63, 64

1968 *Notospirifer microspinosus* Waterhouse, p. 78, pl. 14, fig. 4-6, 10.
1976 *N. microspinosus* – Waterhouse, p. 248, Fig. 7.6.
1992b *Glendonia microspinosus* – Clarke, p. 76.
1998 *Mesopunctia microspinosus* – Waterhouse, p. 43.

Diagnosis: Small, subelongate, two to three pairs of ventral plicae and two pairs of dorsal plicae, no sulcal subplicae or median rib, no dorsal channel. Short adminicula, minute tabellae. Dense array of small spines each with very fine anterior short groove. Punctae preserved as sediment-filled casts that deeply penetrate anterior lamellae, numbering some six in 1mm and pits visible over shell surface in published figure (see Fig. 64 herein).

Fig. 63. "*Notospirifer*" *microspinosus* Waterhouse. A, dorsal internal mould BR 1251, x3. B, C, ventral and dorsal aspects of internal mould, BR 1250, holotype, x3. Kildonan Member, New Zealand. (Waterhouse 1968).

Holotype: BR 1250 from Kildonan Member, Bagrie Formation, New Zealand, figured in Waterhouse (1968, pl. 14, fig. 5, 6, 10 and herein as Fig. 63B, C, OD.

Stratigraphy: The species comes from the Kildonan Member of the Bagrie Formation in New Zealand.

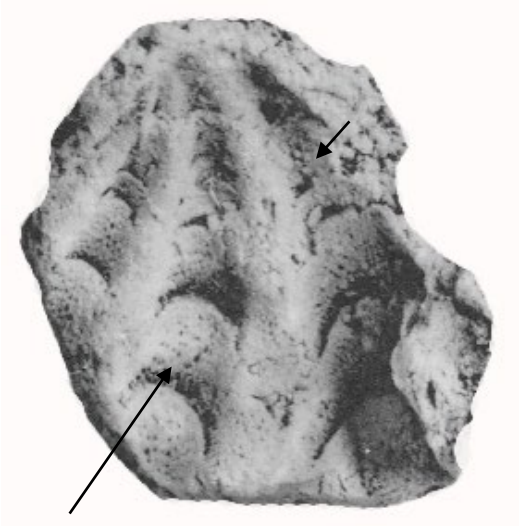


Fig. 64. "*Notospirifer*" *microspinosus* Waterhouse, dorsal external mould, BR 1250, holotype, x6, showing spinules as dark hollows that penetrate the laminae protruding from the shell at intervals, as pointed to by the long arrow. The short arrow on the right points to the shaded circles indicating surface pits. Kildonan Member, New Zealand. (Waterhouse 1968).

Generic position: Clarke (1992b) declared that this species belonged to *Glendonia* Clarke, but a significant illustration of the holotype in Waterhouse (1968, pl. 14, fig. 10) was ignored or misunderstood by Clarke in declaring that the species belonged to *Glendonia.* The figure, reproduced as Fig. 64, shows prominent pits that penetrate the outer laminae, and form round - not elongate - pits over the surface of the shell. Such pits were nowhere reported for *Glendonia* by Clarke 1987, 1992b) or by McClung & Armstrong (1978) in erecting the genus *Glendonia*. Another guide to the generic placement is offered by the nature of the sulcus. It lacks the strong median rib typical of *Glendonia*. Clarke (1992b, p. 76) undertook to publish further on the identity *of microstriatus* with H. J. Campbell, but he did not keep that undertaking, (which may or not have been his fault), and no such article has ever appeared.

Notospiriferid gen. & spp. indet.

1964 *Notospirifer microstriatus* [not Waterhouse?] – Waterhouse, p. 170.
1967b *Notospirifer* n. sp. Waterhouse, p. 101.

Notospiriferids are found in the Pig Valley limestone of the upper Maitai Group in the *Marginalosia planata* Zone of east Nelson, and a fragmentary dorsal valve is known from the Wairaki Breccia at Wairaki Downs in Southland. These specimens are yet to be reassessed.

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SIMPLIFIED INDEX FOR GENERA AND SPECIES DISCUSSED IN THIS STUDY.

New taxa in bold