THE PERMIAN FAUNAL SEQUENCE AT GYMPIE, SOUTH-EAST QUEENSLAND, AUSTRALIA

J. B. Waterhouse

25 Avon Street, Oamaru, New Zealand

With contribution by Paul E. Balfe, Brisbane

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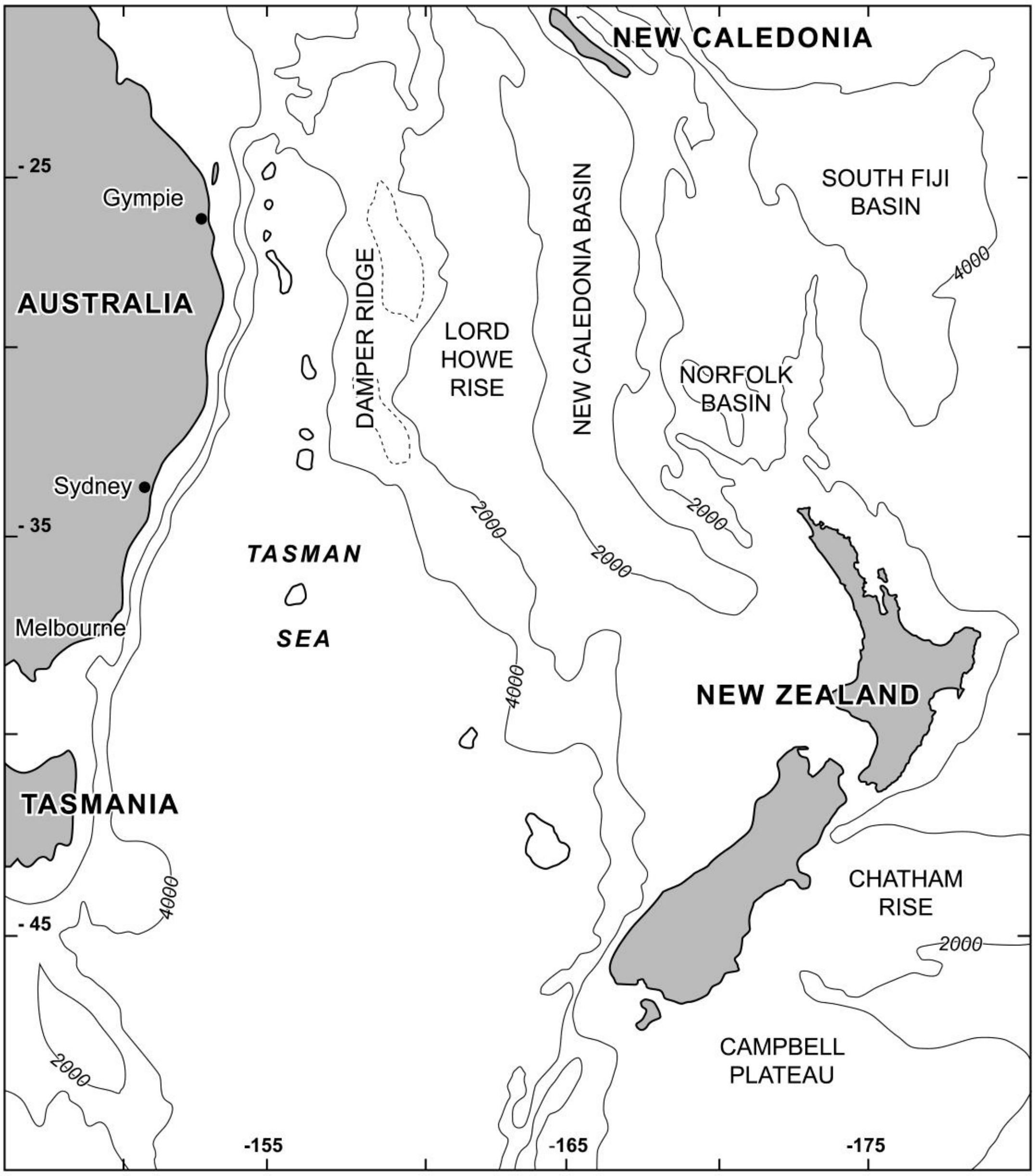

Fig. 1. Gympie, east Australia, and New Caledonia and New Zealand, with related Permian rocks and faunas.

This study describes and dates the Permian fossils found near Gympie in southeast Queensland. The older Permian faunas are moderately close to those of the remainder of east Australia, but the rocks and younger faunas are closer to those of New Caledonia and the Maitai and Brook Street rocks of New Zealand, and justify their recognition as belonging to a distinct Gympie block, once contiguous with parts of New Zealand and New Caledonia. The rocks were originally a segment of Durvillia, named for a volcanic arc, seaward trough and spreading ridge (see pp. 163-166).

Cover: *Geothomasia profunda* (Campbell) from Teebar Formation, near Gympie. See Fig. 52.

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LIST OF CONTENTS

TABLE 1. Correlations for Permian successions at Gympie and Gigoomgan with the east Australian macro-invertebrate faunal zones, after Waterhouse (2008b, 2015). Zones found at Gympie and Gigoomgan shown in bold. See p. 173.

Stage	East Australian zone	Gympie	Gigoomgan
Changhsingian	*Wairakiella rostrata*		
	Marginalosia planata		
	Spinomartinia spinosa	Tamaree Ftm South Curra Lmst	Gigoomgan Limestone
	Tigillumia parallela		Gundiah Bridge Formation
Wuchiapingian	*Martiniopsis woodi*		
Capitanian	*Pseudostrophalosia clarkei*		
Wordian	*Echinalosia ovalis*		
Roadian	*Pseudostrophalosia blakei*		
	Echinalosia maxwelli		
Kungurian	*Echinalosia discinia*		
	Wyndhamia typica		
	Glendella dickinsi		
	Attenuacurvus beds		
Artinskian	*Echinalosia conata*	275 Ma age Upper Nash clastics ?	
	Spinomartinia adentata		
	Ingelarella plica		
Sakmarian	***Taeniothaerus subquadratus***	Upper Rammutt Ftm ?	Teebar Formation
	Bookeria geniculata		
	Bookeria pollex		
Asselian	***Bandoproductus macrospina***	Monkland shales	Kolbar Formation
	Crassispinosella subcircularis	green fossiliferous sandstone	Kolbar Formation
	Strophalosiaria concentrica	Lower Rammutt Ftm	

INTRODUCTION

The Gympie Province of southeast Queensland in Australia is an amalgam of three distinct terranes according to Murray (1988) and Murray et al. (1989), and the eastern or so-called Gympie Block does not seem to fit with the other terranes to the west, let alone the rocks and faunas of the rest of east Australia, although Harrington (2008, p. xiii) suggested comparable rocks extended far to the north. The stratigraphy and faunas in the neighbourhood of Gympie township (Fig. 1) were summarized by Runnegar & Ferguson (1969), and their interpretation of the stratigraphy has largely stood the test of time. Rather less is known about related rocks a little to the north and west in an area summarized as Gigoomgan, studied by Brown (1964) and Cranfield (1989), and the geology of both areas has been overviewed by Jell & Cranfield (2013). The purpose of this monograph is to re-examine in detail the relative ages of Permian formations at Gympie and Gigoomgan, according to the International Standard Time scale. It is not surprising that there needs to be some adjustment to the initial proposals in Runnegar & Ferguson (1969), made more than forty years ago, largely before extensive studies of east Australian Permian faunas. In turn, the overview by Jell & Cranfield (2013) was handicapped by the lack of close systematic study of all but a few of the Gympie fossils, and indeed several such studies were apparently overlooked, involving the international Treatise on Invertebrate Paleontology, such as Brunton (2007, Brunton et al. (2000), Carter (2006a, b) and Carter & Gourvennec (2006), as well as more focused paleontological assessments (eg. Balfe & Waterhouse in Waterhouse 2004; Shi, Waterhouse & McCloughlin 2010 and Waterhouse 2004, 2008b, 2010b).

SUMMARY OF FINDINGS

GYMPIE SUCCESSION

Many maps have been provided on the geology of this area, including Ferguson (1948), Murray (1987), Waterhouse & Balfe (1987), Cranfield (1989, 1990, 1999), Cranfield & Scott (1993), Cranfield et al. (1997) and Jell & Cranfield (2013). An interesting summary of the goldfields is provided by Jack & Etheridge Jnr. (1892, pl. 48), here reproduced in part (Fig. 2), together with several sections (pl. 55-57), of which one is reproduced as Fig. 3. Runnegar & Ferguson (1969) presented an extensive map of the Gympie district andFig. 22, p. 75 also shows outcrop of South Curra Limestone near Gympie.

Highbury Volcanics

No fossil information is available. Jell & Cranfield (2013, p. 370) gave a possible age of early Asselian (ie. basal Permian), and possibly Late Carboniferous. But to judge from the position of the bulk of the Highbury Volcanic Group, and leaving aside the lava flows and intrusions in overlying sediment, the Highbury rocks seem likely to be entirely Carboniferous, if they lie, as is commonly assumed, stratigraphically below the Rammutt Formation.

Rammutt Formation

Green sandstone in the upper middle of the Rammutt Formation has yielded a fauna like that of the

Allandale Formation of New South Wales, and overlying Monkland shales contain a diverse *Bandoproductus* fauna, allied to faunas from the upper Burnett Formation of Queensland and lower Rutherford Formation of New South Wales. The two levels are judged to be Asselian in age, and equivalent to Asselian faunas of south and southeast Asia, older than the age allocated in Jell & Cranfield (2013) or Runnegar & Ferguson (1969).

TABLE 2. The match of the Permian faunal biozones of east Australasia (Waterhouse 2008b) with the stages proposed by Clarke & Farmer (1976) and "Faunas" of Dickins (1964, Dickins & Jensen 1964),somewhat adjusted, and the stages proposed for New Zealand Permian faunas by Waterhouse (1967a). The use of biozones is the most satisfactory of these options, with provisional correlation with international stages. The proposal from Clarke & Farmer (1976), shown in the left column as Australian stages, are a mix of series and stage rankings, and a new "Gympian Stage" is added, to cover the Upper Permian faunas at Gympie and Gigoomgan, only in an informal sense. The numbered "faunas" of Dickins also have value, but do include various biozones. On a crude basis, the bulk if not all the Highbury Volcanics at Gympie seems likely to be Carboniferous, possibly Hellyerian of Clarke & Farmer.Grey blocks without or with few diagnostic marine faunas.

Australian Stage	**Faunal biozone**	**Dickins (1964)**	**New Zealand stage Waterhouse (1967a)**
	Wairakiella rostrata		Makarewan
	Marginalosia planata		Waiitian
Gympian	*Spinomartinia spinosa*		Puruhauan
	Tigillumia parallela		
	Martiniopsis woodi		
Lymingtonian	*Pseudostrophalosia clarkei*	Fauna 1V	Flettian
	Echinalosia ovalis		
	Pseudostrophalosia blakei		
	Echinalosia maxwelli		Barrettian
	Echinalosia discinia		
	Wyndhamia typica	Fauna 111	
	Glendella dickinsi		
	Attenuocurvus beds		Mangapirian
	Echinalosia conata		
	Spinomartinia adentata		
	Ingelarella plica	Fauna 11	Telfordian
Bernacchian	*Taeniothaerus subquadratus*		
	Bookeria geniculata		
	Bookeria pollex		
Tamarian	*Bandoproductus macrospina*	Fauna 1	
	Crassispinosella subcircularis		
	Strophalosiaria concentrica		
Hellyerian			

South Curra Limestone

The entire South Curra Limestone was dated as Kungurian, or stated to be "mostly Kungurian," that is late Early Permian or Cisuralian, by Jell & Cranfield (2013). Such an age assignment is difficult to understand. The so-called "basal mollusc fauna" at the start of the South Curra Limestone was assigned an age of 275Ma (basal Kungurian) in Korsch et al. (2009), on the basis of radiometric determinations from sampling at the Eldorado Mine, some distance from the "basal mollusc fauna". The correlation between the sampled rock and the fossiliferous beds appears dubious, as analysed on pp. 119-121, and the faunas at all levels of the South Curra Limestone are much younger. The South Curra fossils differ substantially from Kungurian faunas known elsewhere in east Australia, as in the *Glendella dickinsi* Zone and *Wyndhamia typica* Zone of the Glendoo Sandstone Member and Freitag Formation of the Bowen Basin in Queensland, and lower Elderslie Formation of the Sydney Basin in New South Wales. Cranfield et al. (1997) expressed some reliance on unpublished foraminiferal determinations by V. Palmieri, but of course no late Permian standard for such foraminifera was available, rendering correlation extremely difficult. An overview of the Gympie succession was provided by Waterhouse (2002a, pp. 156-159), giving an interpretation close to that finalized in the present study. Close examination of a number of South Curra brachiopod species shows that many are younger than any other Permian marine species in east Australia, and are identical with Lopingian (latest Permian) faunas of New Zealand, which has links to Late Permian faunas of south Asia. On available evidence, the basal South Curra fauna is little older than the overlying faunas, with which it shares several species.

Tamaree Formation

The Tamaree Formation was dated as Wuchiapingian (early Late Permian) by Jell & Cranfield (2013), but it conformably overlies upper South Curra Limestone, and appears to be of the same age (mid-Changhsingian) as the topmost South Curra Limestone, even though the beds together with upper South Curra Limestone are moderately thick.

GIGOOMGAN SUCCESSION

Only generalized maps of the Gigoomgan Permian are available (Murray 1987; Cranfield 1999; Cranfield et al. 1997), with a more detailed presentation by Cranfield (1989), here reproduced as Fig. 22, p. 75. A thesis map by Brown (1964) has never been published, and Cranfield referred to another unpublished study by Rollason (1970) on the geology near Marodian. To judge from the fossil record, better understanding of the succession would be achieved by further and more detailed mapping.

Mant Basalt

The Mant Basalt roughly equates with the Highbury Volcanics, but has been much less studied. Its age remains uncertain. According to Cranfield (1989), some beds in the formation have yielded fossils that were assessed, provisionally at that time, as being essentially similar to those of the overlying Kolbar Formation (Brown 1964). The fossils were not specified, and have yet to be systematically described and analyzed.

Kolbar Formation

The Kolbar Formation was treated as equivalent to the Rammutt Formation in past studies. Some of the fossils indicate an upper Asselian age (*Protoanidanthus pokolbinensis, Attenuocurvus australis*), and two molluscs, *Pachymyonia morrisii and Keeneia* sp*.,* are likely to be slightly older, equivalent to the Allandale fauna of the north Sydney Basin.

Teebar Formation

The Teebar Formation was treated as correlative with the Tamaree Formation of Gympie by Jell & Cranfield (2013), and regarded as Wuchiapingian. It has no species or genus in common with the Tamaree Formation. It contains*Taeniothaerus homevalensis* Briggs and other species typical of the distinctive *Taeniothaerus subquadratus* Zone, of upper Sakmarian age, pointing to an age much greater than that of the Gigoomgan Limestone. That poses a question over the true relationship of the formation to the Gigoomgan beds, which are apparently younger, a more likely proposition than the possibilities that the fossils have been wrongly determined, or that the range of the species and genera concerned must be drastically extended.

Gundiah Bridge Greywacke

A unit of Brown (1964), although not discussed by Cranfield (1989), probably because it is not thick enough to have been shown in his map, has a distinctive lithology and its fauna is close to that of the lower South Curra Limestone at Gympie. It is of Changhsingian age.

Gigoomgan Limestone

A number of fossils are shared with the South Curra Limestone, and are Changhsingian rather than Kungurian in age.

PRESENT WORK

The present publication results from a survey of the Gympie fossils in the late 1980’s. Extensive notes were prepared, and photographs made with the help of John Coker of the University of Queensland. A thesis study by Paul Balfe has also been incorporated (see p. 74). The gap in time to the completion of the study has presented difficulties over questions of registration and locality detail, but the basic documentation is available at the Queensland Museum and Science Centre Annex at Hendra in Brisbane. A number of fossils collected by C. D. Brown from Gigoomgan have also been reviewed and illustrated.

The intricate classification for Bivalvia, foreshadowed by J. G. Carter et al. (2011), is partly reproduced in this study. Fuller accounts of taxonomy, definitions and delineations of family and ordinal group distinctions for brachiopods are provided in Waterhouse (2008a, 2013, 2015). The study in Waterhouse (2015) deals with the Tiverton faunas of the northern Bowen Basin in Queensland, and discusses many of the genera that are also found in the Gympie area, and also provides a biozonal framework for the Early Permian Cisuralian Series in east Australia (Waterhouse 2015, pp. 8-52). The volumes on Productida (Waterhouse 2013) and Spiriferida (Waterhouse in prep.) build on the studies in the international Treatise on Invertebrate Paleontology and outline the overall evolution of those major groups of Brachiopoda that dominate the macro-fauna of Gympie and Gigoomgan. OD refers to a type specimen by original designation, and SD refers to a subsequent designation. Throughout the present monograph, species are recorded from different faunal assemblages, and rather than repeat the full ordinal and family ranks, subsequent reference is made to the first use of the species in the monograph, together with order or suborder, family and genus.

REPOSITORIES

Material is housed principally at the Queensland Museum and Science Centre Annex at Hendra, Brisbane (prefix **QM**), and includes collections of the Geological Survey of Queensland (prefix **GSQ**), and the Department of Geology and Mineralogy, University of Queensland (**UQ**), registered as a rule with a serial number prefixed by F. Some present and all future F numbers will be treated as QM. Locality numbers are prefixed accordingly, usually where the fossil number lacks a prefix. A further collection lies at the National Museum of Victoria (**NMV-P**). **AM** refers to the Australian Museum, Sydney, **ANU** refers to collections kept at the Department of Geology, National University of Australia, Canberra, **TSM** refers to the Geological Survey of Tasmania, Hobart, and **UNE** to Department of Geology, University of Newcastle. Type material kept at the Institute for Geological and Nuclear Science, Lower Hutt, New Zealand (**GNS**) is registered serially by number with the prefix **BR** for brachiopods and **TM** for Mollusca, and **OU** refers to the Department of Geology, University of Otago, Dunedin. **NMH** refers to The Museum of Natural History, London, England, and **USNM** to the Smithsonian Institution, Washington D.C., United States.

ACKNOWLEDGEMENTS

I am grateful to Peter Jell, then Assistant Director and Andrew Rozevelds, now Director of Ecological History, Queensland Museum; and Rod Allen, George Fleming, Bob Day and and Susan M. Parfrey, then at the Geological Survey of Queensland, Brisbane, Queensland, for arranging the loan of specimens. Kristen Spring at the museum has helped considerably and significantly with registration of specimens and locality data. David Holloway, Melbourne, Victoria, facilitated the loan of material from the National Museum of Victoria. Various photographs are by John Coker under my supervision, and were developed and printed by C. Leigh, Audiovisual Section, University of Queensland. A number of the South Curra specimens were photographed by Paul Balfe with a few by JBW, and photographs for the Gigoomgan specimens were prepared by JBW. Steven Bagley, Department of Geology and Mineral Resources, University of Queensland, kindly determined a zeolitic mineral on a number of specimens as chamosite, and Prof. K. S. W. Campbell, Australian National University, has kindly re-examined type material of a brachiopod speciesto determine density of punctation.I am also grateful to Kristin Garbutt at the library of GNS, Lower Hutt, New Zealand, for assisting with some references.

2. EARLY PERMIAN BRACHIOPODA AND MOLLUSCA FROM THE MIDDLE RAMMUTT FORMATION, GYMPIE

SUMMARY

Brachiopods, bivalves and a gastropod are described from a green sandstone layer of the Rammutt Formation in the Gympie Group of southeast Queensland. One new genus *Gympietes aseptus* n. gen., n. sp. (Family Rugosochonetidae) is proposed, and a lectotype designated for *Betaneospirifer dubius* (Etheridge). The fauna is correlative, at least broadly, with the Allandale fauna of the north Sydney Basin.

INTRODUCTION

Permian fossils associated with the gold-bearing rocks of Gympie were first described by Etheridge Snr. (1872), and amplified by Etheridge Jnr. (in Jack & Etheridge Jnr. 1892) and Runnegar & Ferguson (1969). The oldest fossiliferous level (Fig. 2, 3) that has yielded substantial collections was recorded as a "greenish and highly fossiliferous sandstone, 33 ft thick", below fine sandstone and volcanic agglomerate and coarse pebbly conglomerate, which underlay the fossiliferous "Monkland or Phoenix Slates", that provided much of the Gympie gold, and counted as one of the four “slate”bands. Both units were referred to the Rammutt Formation by Runnegar & Ferguson (1969).

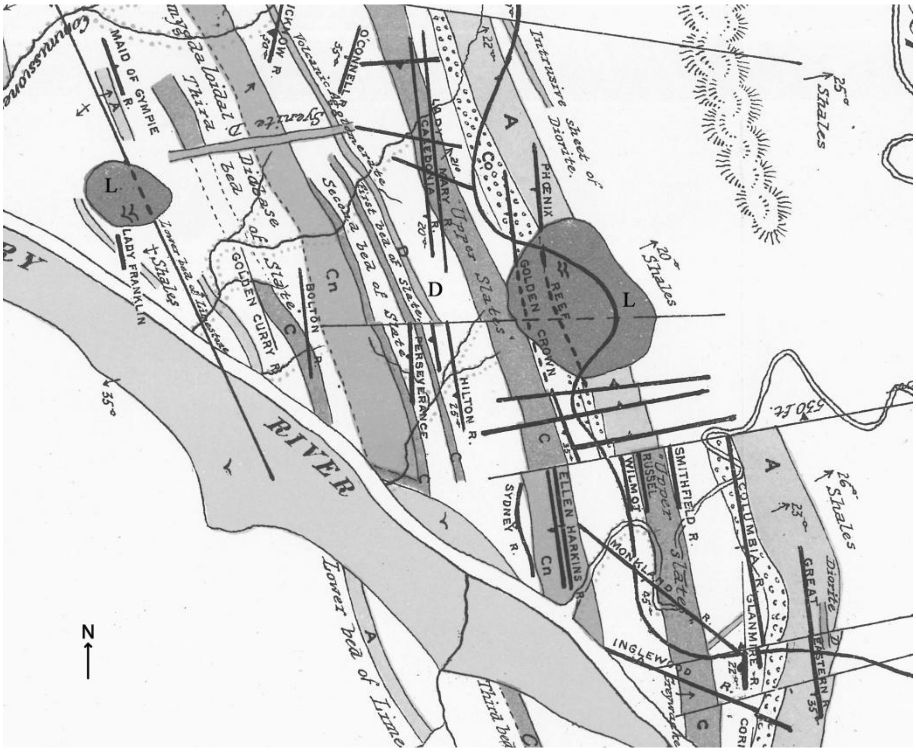


Fig. 2. Reproduction of a part of the geological map by W. H. Rands of the rocks at Gympie, shown as Fig. 48 in Jack & Etheridge Jnr. 1892, bordered to the southwest by the Mary River. The solid and sinuous black line to the right of centre shows the railway line. A, limestone (South Curra); C, the “four Black Slate bands of Gympie”; Co, conglomerate; **D (reinforced), greenish fossiliferous sandstone**; Cn, greenstone (Gn in caption); L (added), old alluvium.The unshaded white strips are shales and thin bedded sandstones.Distribution suggests an anticline, but is not confirmed. Scale 1km = 3cm.

Rands (1889, in Jack & Etheridge, Jnr., 1892, p. 75), and summarized in Denmead (1960), tabulated a section through Gympie, from near the railway station to near Channon Street bridge (Table 3). Gold has been extracted from the uppermost and fossiliferous shales, and some from the "first, second and third beds of slate", which lack fossils. The sequence has been illustrated in section by Jack & Etheridge (1892, pl. 55-58), as shown in Fig. 3, p. 10, though accord is not complete.

TABLE 3. Stratigraphic column through Rammutt Formation. Letters in bold added. The greenish sandstone provided fossils described herein.

		Feet	inches
w. **SOUTH CURRA LIMESTONE** Impure limestone (fossiliferous) (A in Fig. 2)		138	6
v. Coarse pebbly conglomerate with sandstone (very thick at [Railway – inserted] station)		360	0
RAMMUTT FORMATION			
u. Laminated sandstone	Phoenix	55	0
t. Shales (fossiliferous)	or	56	4
s. Coarse altered conglomerate	Monkland	10	0
r. Shales with beds of thin-bedded sandstone		50	0
q. Hard grey greywacke	Slates	20	0
p. Shales (fossiliferous)		66	
o. Coarse pebbly conglomerate		26	3
n. Laminated fine-grained sandstone		20	0
m. Angular grit (probably a volcanic agglomerate)		26	4
l. Greenish and highly fossiliferous sandstone (D in Fig. 2)		33	3
k. Greenish semi-crystalline greywacke		25	0
j. Shales, so-called 'First Bed of Slate'		15	2
i. Hard grey greywacke		19	8
h. Coarse altered conglomerate		20	0
g. Greenish semi-crystalline greywacke		16	6
f. Sandstone and coarse altered conglomerate		20	3
e. Shales, so-called 'Second Bed of Slate'		13	0
d. Hard altered crystalline greenstone - 'Gympie greenstone' (Cn in Fig. 2)		297	0
c. Green and purple altered chloritic rock; partly amygdaloidal volcanic rocks, partly volcanic ash, and partly stratified		315	0
b. So-called 'Third Bed of Slate' with a thickness of grey-green, fine-grained greywacke, and underneath altered chloritic rocks like those above		286	0
a. Limestone		20	0
		1909	0

This sequence may be compared with documentation of drill core logs near the Gympie Eldorado Gold Mine (Arnold 1996), as itemized by Sivell & Arnold (1999).

TABLE 4. Sequence through Permian, based on core logs.

SOUTH CURRA LIMESTONE		
Top break	5m	Main shear above Langton Dolerite
Langton dolerite	100m	Amygdaloidal olivine-bearing alkaline dolerite (sill)
Bottom break	10m	Main shear below Langton dolerite
RAMMUTT FORMATION		
Top conglomerate	20m	Clast supported unit at base of limestone
Upper Nash Clastics	20-70m	Volcanogenic conglomerate, arenite, siltstone, shale, variably carbonaceous, calcareous, pyritic (shallow marine)
Pengelly Siltstone	50m	Carbonaceous siltstone; micritic, pyritic (lagoonal)
Calton Clastics	10m	Andesitic-dacite conglomerate, arenite, siltstone, tuff
Calton Volcanics	110m	Plagioclase–phyric andesite, hematitic
Lower Nash Clastics	100m	Volcanogenic conglomerate, arenite, siltstone, derived from basalts, dacitic tuffs, hematitic (shallow marine to alluvial fan)
HIGHBURY VOLCANICS		

The units proposed but not formalized by Arnold appear to rank as members, and still require formal designation according to the International Stratigraphic Code. There seems to be little reason why the upper Nash clastics should not be distinguished formally by having its own particular and separate name, and the same applies to one or other of the Calton units proposed by Arnold and used by Korsch et al. (2009).

Arnold's stratigraphic column contains no information on the presence of fossils, but the green and fossiliferous sandstone of early workers might equate to part of the Calton Clastics or Lower Nash Clastics. More fossils come from higher in the Rammutt Formation, and these are clearly younger than those from the fossiliferous sandstone. The fossiliferous green sandstone was evidently derived from a volcanic source, described by Sivell & Waterhouse (1988) and Sivell et al. (1990) as an immature submarine tholeiitic intra-oceanic arc at the edge of Gondwana, and more detail has been elaborated on the volcanics by Sivell & McCullough (2001). The Rammutt faunas were listed by Runnegar & Ferguson (1969, p. 251) and assigned a lower Artinskian (Aktastinian) age – see Table 1, and correlated with so-called Fauna 11 in the Bowen Basin (Table 2), which was regarded as being represented in the Buffel, Tiverton, and Cattle Creek formations of the Bowen Basin. The account in Runnegar & Ferguson (1969, p. 251) implied that there was only one major fauna within the Rammutt Formation. However there are two major levels of fossils, with their distinct characteristics, which come from very different lithologies, and are separated by conglomerate, as pointed out by Waterhouse & Balfe (1987).

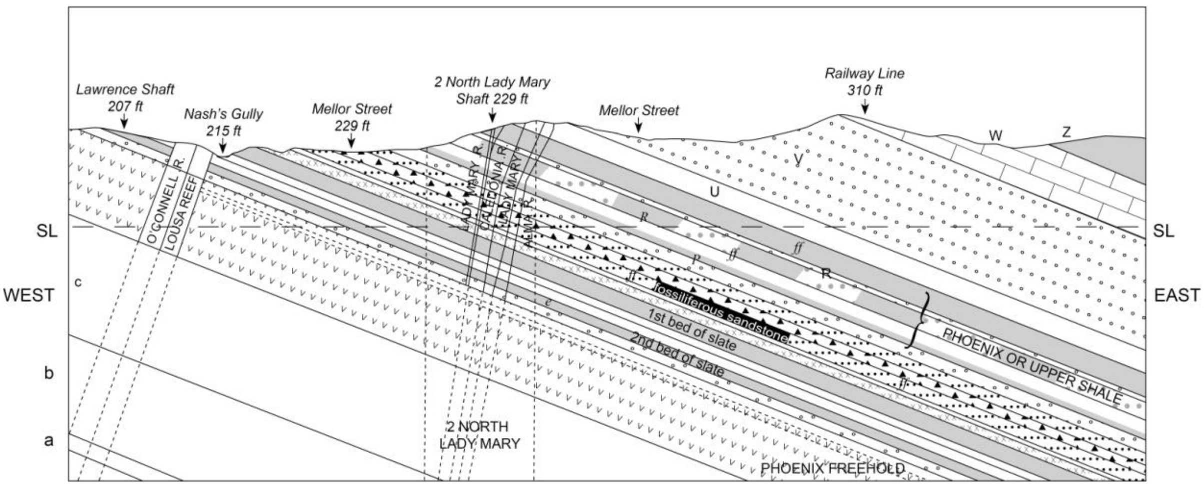


Fig. 3. Part of geological section through Gympie, compiled by W. H. Rands in Jack & Etheridge (1892, pl. 55), with some relettering. as follows: a, limestone; b, laminated greywacke and shales; "Third bed of Slate"; green and purple altered rocks; c, green and purple chloritic rock; P, shales; R, conglomerate; U, laminated sandstone; V, coarse conglomerate and beds of sandstone; W, (South Curra) limestone, overlain (to the right) by grey shales Z (Kin Kin). Fossiliferous sandstone as source of fossils highlit; ff – fossiliferous shales of Monkland Member.

The present study focuses attention on the older collections, from the sandstone. These are readily distinguished from the more muddy and fine and dark lithologies of the "Monkland beds" or "Phoenix Slates", later referred to either the Pengelly Siltstone or Upper Nash clastics in the higher

Rammutt Formation by Arnold (1996) as quoted in several articles. Several species have been named by Etheridge Snr. from this green sandstone as *Spirifera dubia*, *Spirifera bisulcata acuta*, *Edmondia concentrica, E. obovata*, *Aviculopecten? imbricatus* and *A. multiradiatus*. The *Edmondia* species have been revised by Dickins (1961a) and Runnegar (1967), *Aviculopecten imbricatus* and *A. multiradiatus* were synonymized with *Deltopecten limaeformis* (Morris) by Runnegar & Ferguson (1969, p. 251), and *Spirifer undifera undulata* Roemer of Etheridge has been redescribed and figured as *Ingelarella strzeleckii* (not de Koninck) by McClung (1978), a form later revised and emended to *Monklandia gympiensis* in Waterhouse (1998b). These species are further illustrated and examined in the present publication.

The purpose of this study is to revise most of the brachiopod and molluscan species from the green sandstone, clarify aspects of morphology and identification of the species named in early studies, and determine the age of the fauna. A number of genera and species represented only by small and few specimens are set aside. Material is not well preserved: mostly single valves are present as shells or natural moulds, and the matrix is so hard that breakage in extraction is almost inevitable. The fossils have also been deformed so that dimensions provided do not represent the exact original proportions. The shell material, especially in bivalves, has been partly replaced by a zeolite, identified as chamosite, which hinders the technique of leaching in dilute acid to facilitate the study of internal and external moulds.

SYSTEMATIC DESCRIPTIONS

Many of the fossils were collected in the nineteenth century, including the Richard Daintree Collection and material obtained from the Gympie goldfield by Aplin (1868): Daintree had been appointed chief geologist for northern Queensland in 1868, and Aplin for southern Queensland. Etheridge Snr. (1872, p. 326) recorded that “the ship (“Queen of the Thames”) which conveyed both Mr Daintree and his large collection of minerals and fossils from Melbourne, was wrecked off the east coast of Africa, near the village of Bredarsdorp; and as may be supposed, neither minerals nor fossils were much improved by their long submergence prior to recovery. The labour and anxiety of many years’ research to establish the age and nature of the stratified rocks of Queensland was then nearly lost; and but for the fortunate position of the ship near the shore, fresh collections must have been made to elucidate the physical character and structure of the colony.”

The Daintree collection that in part is re-examined in this study was described in 1872 by Etheridge Snr. and a number of specimens refigured and discussed by Etheridge Jnr. (1892). Etheridge Jnr. & Dun (1906, p. 3) thought that the collection had been lost, but that is not so, although the whereabouts of some of the material described by Etheridge remains unresolved (A. Rozevelds, pers. comm.). There has been no complete systematic study of the fossils since the work by Etheridge Jnr. to the present time.

D’Oyly H. Aplin worked extensively around the Gympie district during the mining for gold, and gained many fossils from underground mines no longer accessible. Further fossil collections were contributed by R. L. Jack (see Jack & Etheridge Jnr. 1892, p. 74) and Rands (1889), and an extensive summary is provided in Jack & Etheridge Jnr. (1892, pp. 74-84). It is these accounts which indicate two distinct fossil levels in what is now called the Rammutt Formation, the first one in fossiliferous green sandstone, followed by a second in fossiliferous shales, the difference being reflected not only by the lithology, but by the nature of the fossils, and their relative age. It should be appreciated that it is now not possible to recollect, and even the mullock heaps, left scattered around Gympie, and rich in spoil from the mines, and with many fossils from "fossiliferous shales", have been destroyed or lost, although collectable into the 1980's.

Collections made for the Queensland Museum, Geological Survey of Queensland and Department of Geology & Mineralogy, University of Queensland are now all stored at the Queensland Museum and Science Centre Annex at Hendra in Brisbane. What is most useful throughout this study is the segregation of faunas from the greenish fossiliferous sandstone and from the shales. The locality detail, often cursory for early collections, and obscured by time and present inaccessibility, has to be regarded as of less importance.

Phylum Brachiopoda Duméril, 1806

Class Strophomenata Williams et al., 1996

Superorder STROPHOMENIFORMII Opik, 1934

Order TRIPLESIIDA Moore, 1952

Suborder ORTHOTETIDINA Cooper & Grant, 1974

Superfamily **ORTHOTETOIDEA** Waagen, 1884

Family **STREPTORHYNCHIDAE** Stehli, 1954

Streptorhynchid gen. and sp. indet.

Fig. 4A

Description: A posterior fragment of an internal mould of a dorsal valve QM F 17748 from Lady Mary Reef is over 30 mm across, and gently convex, measuring 4.5mm in height. It shows sturdy diverging crural plates, well defined dental sockets, and narrow high median septum. Muscle scars are subtriangular and lightly impressed. Faint signs of costae are present on the interior, about ten in 5mm anteriorly.

No ventral valve is available.

Discussion: Streptorhynchids are not common in early Permian faunas of eastern Australia, but Nillsen (1982) discovered fragments in the lower Wasp Head Formation of the south Sydney Basin, and they are reported as characterizing what is now called the *Strophalosiaria concentrica* Zone (see Table 1, p. 2) in the Late Palaeozoic sequences of Tasmania (Waterhouse 2008b, 2013), whereas they are rare to absent from the overlying *Crassispinosella subcircularis* Zone (M. J. Clarke, pers. comm.). The present specimen is too incomplete to be adequately compared with *Grumantia costellata* Clarke (1992a, p. 14, Fig. 4A-K) from the *Strophalosiaria concentrica* Zone of Tasmania, and also reported from the lower fossiliferous beds at Wasp Head in southern New South Wales.

Superorder PRODUCTIFORMII Waagen, 1883

Order CHONETIDA Muir-Wood, 1962

Superfamily **CHONETOIDEA** Bronn, 1862

Family **RUGOSOCHONETIDAE** Muir-Wood, 1962

Subfamily **SVALBARDIINAE** Archbold, 1981

Genus ***Gympietes*** n. gen.

Derivation: The name is taken from the township Gympie, with the suffix -etes commonly applied to chonetid genera.

Type species: *Gympietes aseptus* n. sp. from Rammutt Formation (Asselian), Gympie, southeast Queensland, here designated.

Diagnosis: Smooth shells with obtuse cardinal extremities, cardinal row of spines, no body spines, ventral valve little inflated, dorsal valve almost flat. Ventral interior with short median septum and pair of low median vascular trunks as a rule, may be absent; dorsal valve with cardinal process, curved socket ridges, brachial shields, slightly impressed adductor scars, rarely with median septum even in large shells, no clearly defined anderidia or lateral septa.

Discussion: The genus is known from the middle Rammutt Formation in the Gympie Basin, of Early Permian age, and there is a possible occurrence in the overlying *Bandoproductus* fauna in the upper Rammutt Formation, although this specimen is poorly preserved and generically insecure, possibly even belonging to *Capillonia*, a genus also found in the South Curra limestone at Gympie and in the early and middle Permian of the Bowen Basin. *Gympietes* is like *Svalbardia* Barkhatova, 1970, type species *Chonetes capitolinus* Toula from Spitsbergen, in its smooth exterior and flat dorsal valve but has a short ventral septum and no dorsal septa, except rarely for a very short posterior median ridge in some specimens. No body spines appear to be developed. The smooth genus *Komiella* Barkhatova, 1970, type species *Chonetes omolonensis* Licharew from northeast Russia, as discussed by Archbold (1981), has well developed dorsal medium and lateral septa. The chonetid *Sandrella* Waterhouse, 1986c, type species *S. platina* Waterhouse from the Wuchiapingian lower Testha Sandstone Member of the Gungri Formation, Zanskar Himalaya, is similar externally in its gently convex ventral valve, obtuse cardinal extremities, and flat dorsal valve, but this form lacks hinge spines and has five septa in the dorsal valve.

From Lower Carboniferous (Visean) faunas of New South Wales, *Leiochonetes* Roberts, 1976, type species *L. salisburyensis* Roberts, with its semicircular outline and pointed cardinal extremities is moderately close to the new genus in its lack of sulcus and fold and presence of short ventral median septum. There is a short dorsal septum, short anderidia, and no vascular ridges. Amongst Svalbardiinae, this genus is the only one with comparably reduced internal septation, but nonetheless shape and septation differ.

Neochonetes (*Zechiella*) Archbold (1999), type species *Chonetes davidsoni* von Schauroth from the Wuchiapingian of northern Europe, has somewhat reduced internal septation, but is more elongate and has the fine and distinct ribbing indicative of Subfamily Rugosochonetinae (Muir-Wood 1962, pl. 5, fig. 28, 29). Internal detail for *Zechiella* is provided in illustrations by Trechmann (1945, pl. 15, fig. 1-5b) and Malzahn (1957, pl. 10, fig. 5-6, pl. 11, fig. 3).

Gympietes aseptus n. sp.

Fig. 4B-O

1987 Chonetid Waterhouse & Balfe, p. 30, pl. 1, fig. 1, 2.

Holotype: GSQ F 13182, from GSQ L 191, Rammutt Formation (Asselian), Gympie, figured in Fig. 4K, here designated.

Diagnosis: Transverse shells with rounded cardinal extremities, generally with median flattening or shallow sulcus over little inflated ventral valve.

Dimensions in mm for ventral valves of *Gympietes aseptus*:

Locality	Width	Length	Height
GSQ L 212	14.5	11	1.9
GSQ L 212	19	13.2.	4
GSQ L 209	24	13.2.	4
GSQ L 191	19	11.8	?2.2
GSQ L 179	19.5	14.2	5
GSQ L 182	24	13.5	3.8
GSQ L 182	18	14.8	2
GSQ L 182	21.5	12.8	2.1

Description: Shells transverse to almost subquadrate in outline, little inflated, cardinal extremities obtuse throughout ontogeny, ventral valve gently inflated, maximum width just behind or in front of mid-length; median shell gently arched or flattened, or rarely sulcate with angle of about 25^{o}, but variable. Dorsal valve very weakly concave, almost flat over disc, and slightly upturned anterior margin, indicating a short trail. Ventral cardinal interarea lies in plane of commissure, with horizontal growth lines and broad delthyrium with angle of 120^{o}, interarea ventrally inclined from hinge in smaller shells. Dorsal interarea low, steep, with broad notothyrium. Cardinal spines emerge from ventral hinge in prominent row, number 12-15 each side, turn abruptly within interarea. External surface of both valves smooth apart from low growth lamellae; no body spines are visible.

Ventral teeth large and lie along hinge; median septum usually short, thick and high, extending for only a sixth of length of shell between hinge and anterior margin, but reaching mid-length in about 10% of sample and in one specimen beyond; similar number of shells have no median septum. Low small round adductors and large suboval diductor scars. Fine pustules prominent around margin of shell, and thin flange may develop around rim.

Dorsal cardinal process narrow, supported by low socket ridges extending laterally in front of narrow dental sockets, not reaching lateral margin of shell. Adductor scars faintly impressed as a rule, subrounded; raised in only one specimen. No dorsal median septum or lateral septa developed, except for low anterior septum in two out of twenty specimens. Brachial shields represented as broad mounds, but brachial ridges not preserved; anterior shell marked by irregular mounds and pits, which

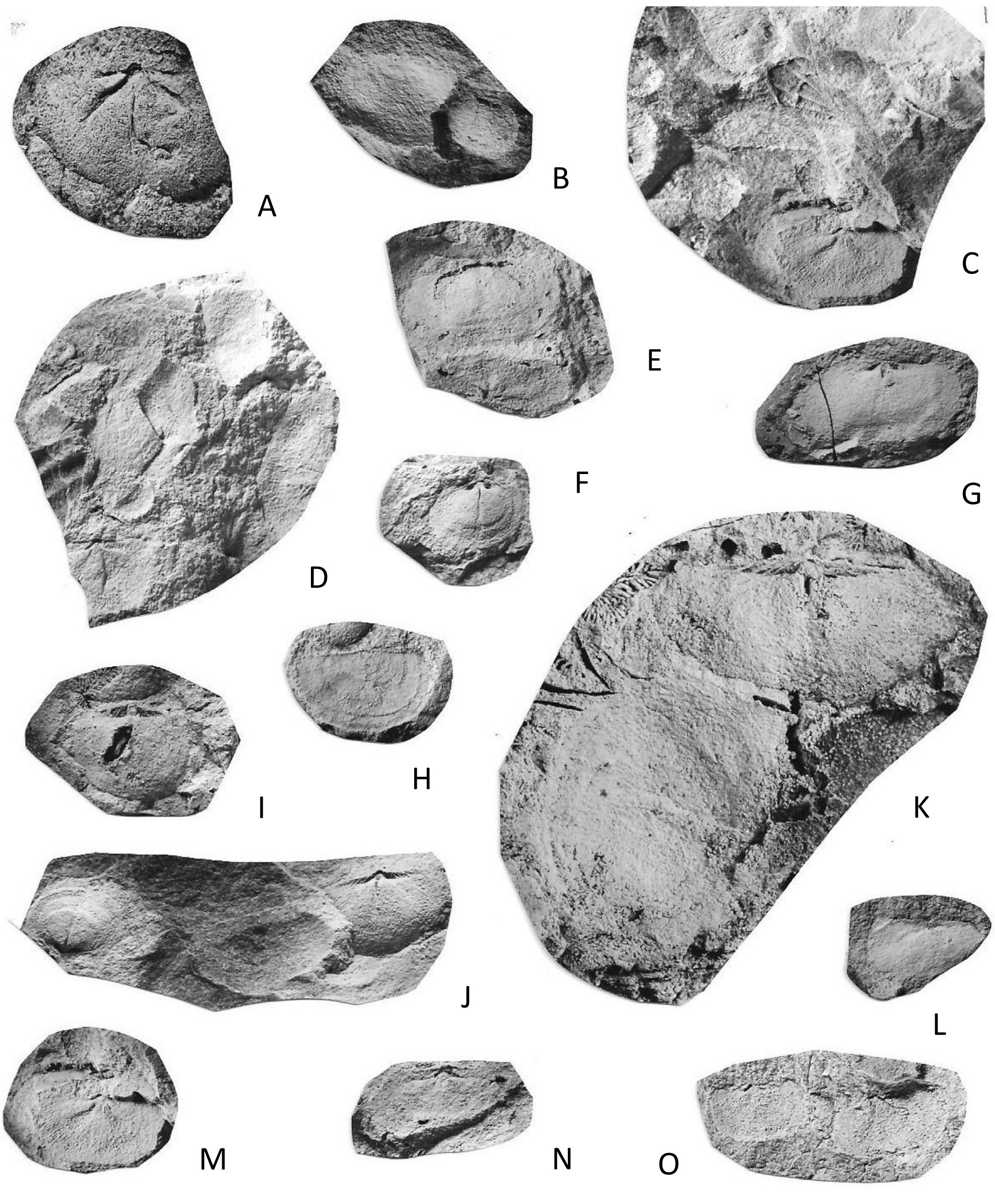


Fig. 4. A, Streptorhynchid, dorsal internal mould QM F 17748 from Lady Mary Reef, x1. B – O, *Gympietes aseptus* n. gen., n. sp. B, ventral exterior (to left), GSQ F 13180 from GSQ L 212. C, dorsal internal mould, GSQ F 13137 from GSQ L 212, with other fragments. D, dorsal internal mould GSQ F 13147, lower left, with other fragments, from GSQ L 212. E, specimen with valves conjoined, ventral valve partly lost to reveal underlying dorsal exterior, GSQ F 13189 from GSQ L 182. F, ventral internal mould GSQ F 13136 from GSQ L 209. G, small ventral internal mould GSQ F 13139 from GSQ L 212. H, dorsal valve external mould GSQ F 13179 from GSQ L 191. I, damaged ventral internal mould GSQ F 13138 from GSQ L 182. J, ventral internal mould, GSQ F 13141 at right, GSQ F 13142 at left, from GSQ L 212. K, ventral internal mould, holotype GSQ F 13182, above ventral external mould, from GSQ L 191, x2. L, dorsal external mould GSQ F 13140 from GSQ L 182. M, dorsal internal mould, QM F 14505 from GSQ L 212. N, dorsal internal mould GSQ F 13183 from uncertain locality. O, dorsal internal mould, GSQ F 13143. All specimens x 1, except K.

are elongate in some specimens, round in most.

Resemblances: This species was collected during early days of gold-mining. It possibly was identified as *Chonetes cracowensis* Etheridge Snr., 1872, in Jack & Etheridge Jnr. (1892, p. 262), but the identification is not certain, because a chonetid is also common in younger beds at Gympie. *Chonetes cracowensis*, now referred to *Svalbardia* Barkhatova by Waterhouse (1986a, pl. 2, fig. 25-32), comes from the Sakmarian Fairyland Formation of the Cracow district in the southeast Bowen Basin of Queensland. It is a smooth shell with cardinal spines and flat dorsal valve*,* and obtuse cardinal extremities, very like the present material in general appearance. But *Svalbardia cracowensis* may be distinguished by its slightly greater inflation, and lack of median sulcus from the ventral valve, and presence of prominent taleolae, possibly pointing to body spines, which are not clearly developed on the new species. Internally *cracowensis* has a prominent long median ventral septum, low or no double median vascular trunks, and prominent dorsal median septum and anderidia, with other internal differences. Other species of *Svalbardia*, including Arctic species (Barkhatova, 1970) and others from Western Australia recorded by Archbold (1981), similarly differ in their internal septa and may have prominent body spines.

The species *Tivertonia yarrolensis* (Maxwell, 1964), initially described from the Yarrol Formation of the Yarrol Basin, is more inflated, with abruptly obtuse cardinal extremities, and possibly no body spines – at least none were reported by Archbold (1983a, 1986). Within the ventral valve the median septum is comparatively short, vascular trunks moderately prominent, and dorsal septum long, with anderidia. The dorsal valve is concave, and dorsal septa are well developed. Specimens from the Tiverton Formation in the northern part of the Bowen Basin have been referred to the same species by various authors, but the specimens belong to a different genus, *Svalbardia* Barkhatova, and are assigned now to a different species, *Svalbardia armstrongi* Waterhouse (2015).

Shells now identified as *Capillonia brevisulcus* (Waterhouse) from the overlying South Curra Limestone at Gympie are smaller than the Rammutt species, and have a more swollen often non-sulcate ventral valve, with more concave dorsal valve, and no body spines. The double vascular trunks are prominent, and dorsal septa are well developed. Cardinal extremities are abruptly obtuse or slightly acute as a rule.

Class Rhynchonellata Williams et al., 1996

Superorder SPIRIFERIFORMII Waagen, 1884

Order SPIRIFERIDA Waagen, 1884

Suborder MARTINIIDINA Waterhouse, 2010a

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Martiniopsis*** Waagen, 1883

Type species: *Martiniopsis inflata* Waagen, 1883, p. 524 from Chhidru Formation (Wuchiapingian) of Salt Range, Pakistan, OD.

Diagnosis: Distinguished by absence or faint development of sulcus and fold, no plicae. Adminicula, tabellae and micro-ornament of fine short grooves in quincunx as in family.

***Martiniopsis*? sp.**

A fragment of a dorsal valve QM F 17747 (found with *Monklandia* QM F 2087) is less than 34mm wide and has a wide well formed interarea, no fold or sulcus at least over the posterior half of the shell, and no plicae. Micro-ornament is not clear. A double-ridged laminated ctenophoridium lies under the notothyrium. Low socket and crural plates converge at about 120^{o}, resting on tabellae that diverge to the floor of the valve at an angle close to 70^{o} and diverge forward at 25^{o}. Muscle field lightly impressed, with low median ridge. Shell thin.

The generic determination is far from certain, because only the posterior part of a valve is preserved, with no anterior and no ventral valve. There is no clearly defined fold developed, as far as can be seen, unlike the arrangement in *Ambikella* Sahni & Srivastava, *Ingelarella* Campbell, or *Geothomasia* Waterhouse, to mention three of the more common genera in the Lower Permian of east Australia, and tabellae are moderately developed, unlike the arrangement in the dorsal valve of *Tweedaleia* Waterhouse, but nonetheless the material does not suffice to definitely circumscribe the genus. *Martiniopsis* other than at Gympie is not known in the Permian of east Australia, but is found in the Late Permian of New Zealand

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

Type species: *Ambikella fructiformis* Sahni & Srivastava, 1956, p. 207 from Early Permian (?Sakmarian) of Sikkhim, Himalaya, OD.

Diagnosis: Shells with broad sulcus and fold, sulcus rarely subplicate, fold without median channel, lateral shell with or without lateral plicae, adminicula and tabellae moderately to well developed, surface ornament of elongate grooves more or less in quincunx. See Waterhouse (2015, p. 153ff).

Ambikella sp.

Two small ventral valves from Lady Mary Reef, QM F 14411 and QM F 17745, have a median sulcus, no lateral plicae, and adminicula extending for about a third of the length of the valve, diverging forward from the hinge, and subparallel in front. The specimens are too incomplete to be identified with confidence. The lack of plicae and the long subparallel adminicula suggest an approach to *Ambikella elongata* (McClung & Armstrong, 1975) from the Beckers Formation of Cranky Corner Basin, and other correlative levels in New South Wales, and to the somewhat similar species *A. bundellaensis* n. sp. (see p. 168) from the basal Permian of Tasmania.

The lack of dorsal valves hinders full identification, because the nature of the tabellae is of critical importance for species delination (see p. 168 and Waterhouse 2015), and these are not available for examination.

Family **NOTOSPIRIFERIDAE** Archbold & Thomas, 1986

Subfamily **NOTOSPIRIFERINAE** Archbold & Thomas, 1986

Genus ***Notospirifer*** Harrington, 1955

Type species: *Spirifer darwini* Morris, 1845, p. 279 from Muree Formation (Wordian), New South Wales, OD.

Diagnosis: Fold of moderate height, sulcus with two subplicae as a rule, plicae well developed, micro-ornament of deep exopunctae called globons, in front of low stubby spines. Adminicula short, tabellae short if present, often absent.

Notospirifer? sp.

Fig. 5H

A small ventral valve GSQ F 13163 from GSQ L 201 with three pairs of plicae may belong to *Notospirifer* or allied genus. It has a well defined sulcus, apparently without ribs or subplicae, three pairs of moderately well defined and narrow plicae, and short adminicula.

Subfamily **GLENDONIINAE** Clarke, 1987

Genus ***Monklandia*** Waterhouse, 1998b

Type species: *Monklandia gympiensis* Waterhouse, 1998b, p. 37 from Rammutt Formation (Asselian), Gympie, Queensland, OD.

Diagnosis: Strongly plicate shells with broad sulcus bearing subplicae and broad-crested fold with median groove as a rule, surface ornament of fine grooves passing forward from c-spines; shell thin, with thin exolayer. Adminicula moderately long, tabellae well developed.

Discussion: This genus is allied to genera within the Notospiriferidae, for which a few genera have been recognized in eastern Australia, and found to extend into New Zealand. *Notospirifer* itself is distinguished by the surface pits in a primary layer of shell, and blunt surface spines. Tabellae are short or not developed (Clarke 1987). *Glendonia* McClung & Armstrong, 1978 has pronounced spines lying behind surface grooves, more as in the present genus, and the primary shell layer is thin. It is characterized by the narrow fold along the ventral sulcus. *Farmerella* Clarke (1992b) is externally similar, but has very short surface grooves in front of small c-shaped spines, leading to deep pores called mesopunctae, and a median sulcal ridge. *Birchella* Clarke, 1987 has surface shell structure and ornament as in *Glendonia*, but lacks the sulcal costa, and has considerable secondary thickening in the ventral valve. None of these genera has the long tabellae of the present form, nor the wide sulcus with subplicae and wide fold, or narrow comparatively numerous plicae.

Monklandia gympiensis Waterhouse, 1998b

Fig. 5A - G

1872 *Spirifera undifera* var. *undulata* [not Roemer] – Etheridge Snr., p. 330, pl. 16, fig. 3-5 (not pl. 15, fig. 4 = *Neilotreta*).

1877 ?*Spirifer strzeleckii* [not de Koninck] – de Koninck, p. 235 (not pl. 13, fig. 1, 1a, pl. 14, fig. 1, 1a = *strzeleckii*). Also 1898, p. 183.

1892 *Spirifera strzeleckii* – Etheridge Jnr. p. 234, pl. 10, fig. 5-6 (part, not fig. 7 = *Neilotreta*).

?1969a *Ambikella konincki* [not Etheridge] – Runnegar, p. 294, pl. 2, fig. 1 (part, not fig. 2-4, ?5 = *Geothomasia simplicitas*).

1978 *Ingelarella strzelecki* – McClung, p. 43, pl. 3, fig. 20-26.

1987 *'Notospirifer' strzeleckii* – Waterhouse & Balfe, p. 30, pl. 1, fig. 6, 7.

1998b *Monklandia gympiensis* n. gen., n. sp. Waterhouse, p. 37.

2006a *M. gympiensis* – Carter, p. 2779, Fig. 1860.4a, b.

Holotype: QM F 946, figured by Etheridge Snr. (1872, pl. 16, fig. 3), Etheridge Jnr. (1892, pl. 10, fig. 6) and McClung (1878, pl. 3, fig. 24), from Rammutt Formation (Asselian), Gympie, OD.

Diagnosis: Transverse shells with five or usually six pairs of narrow plicae, wide ventral sulcus with two subplicae, wide flat-topped dorsal fold with median groove. Micro-ornament dense, of small c-shaped spines behind short surface grooves.

Description: This species has been described by Waterhouse (1998b). The type specimen comes from Lady Mary Reef at Gympie. The shell is distinctive and transverse with strong but narrow plicae in five or mostly six pairs, broad very shallow flat-floored sulcus with two sulcal subplicae, and wide flat-topped fold, usually with a median sulcus, although a dorsal valve GSQ F 1568 that was figured by Etheridge Jnr. (1892, pl. 10, fig. 5) has a flat-crested fold, without channel.

Adminicula extend for about one fifth of the length of the valve, and tabellae for one fourth. The critical feature not observed by earlier authors lies in the micro-ornament. This consists of very fine shallow grooves, up to five in 1mm overlapping to number ten per mm, each arising in front of a very fine c-shaped spine, and up to 0.7mm long. The grooves taper anteriorly, and may radiate laterally forward from the centre of the interspaces.

Resemblances: Specimens identified as *Ingelarella branxtonensis* by McClung (1978) from the Farley and Rutherford Formations of the Hunter Valley, New South Wales, also approach *gympiensis*. Type *branxtonensis* has short and widely diverging tabellae and the shell is more inflated than that of *Monklandia*. Briggs (1998, p. 33) pointed out that the Rutherford specimen of McClung (1978, pl. 4, fig. 6-8) showed considerable approach to what is now called *gympiensis*, although it may be noted that the fold in fig. 7 lacks a sulcus. Indeed, an upper Rutherford specimen of McClung (1978, pl. 4, fig. 9, 10) is much closer, with sulcal subplicae and dorsal fold sulcus. But this and other specimens have fewer plicae than in the Monkland types, and belong to a separate species of *Monklandia*, named *mcclungi* herein (see p. 171). A dorsal valve figured by McClung (1978, pl. 3, fig. 3) as *Ingelarella konincki* (Etheridge) from the Cranky Corner Formation of the Cranky Corner Basin, New

South Wales, has subparallel tabellae and sulcus in the dorsal fold, much as in *gympiensis,* but shows only three pair of plicae – the number may be incomplete, but the specimen appears to be closer to *Monklandia mcclungi.*

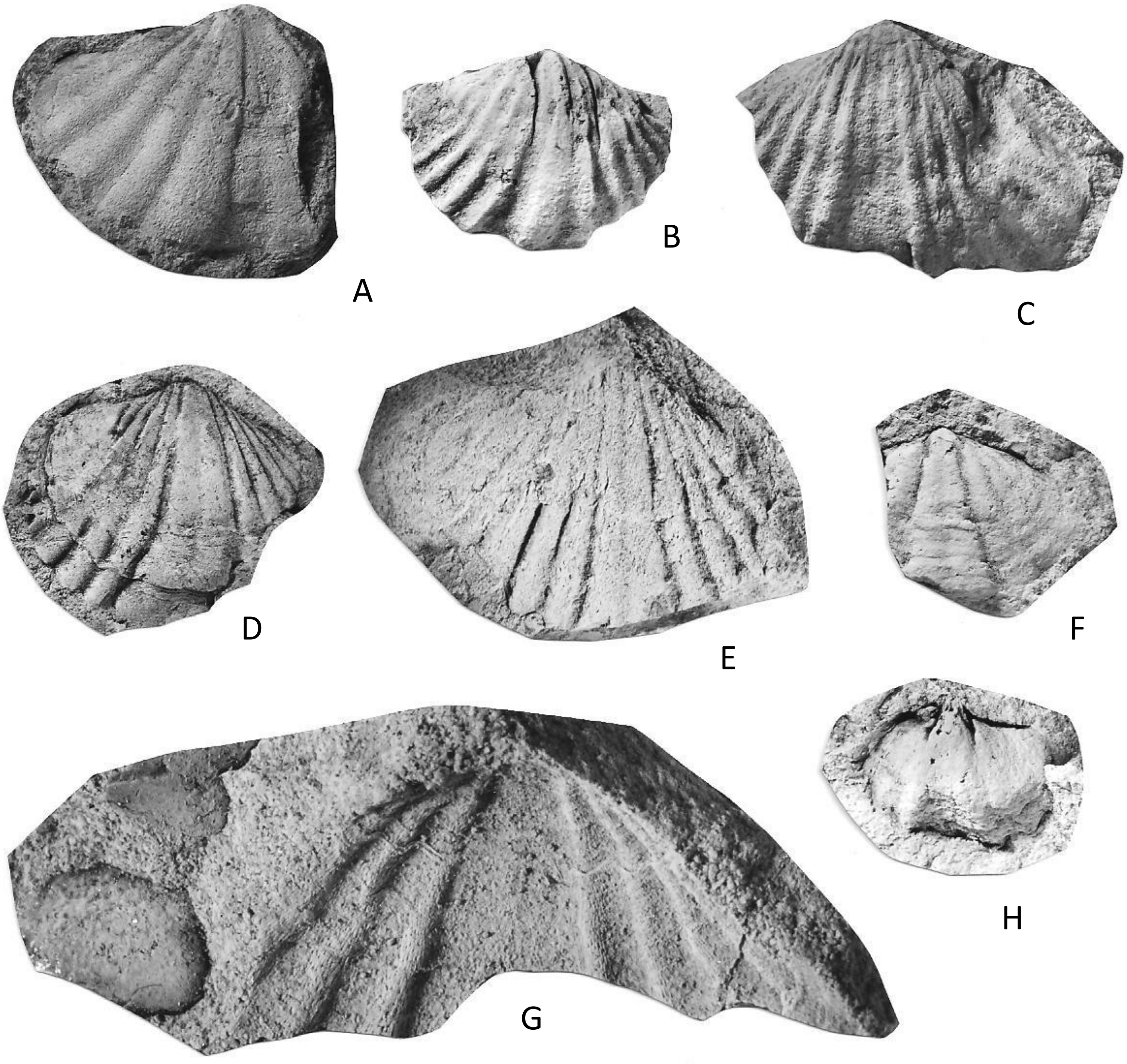


Fig. 5. A-G, *Monklandia gympiensis* Waterhouse. A, ventral valve GSQ F13184 from GSQ L 201. B, dorsal internal mould GSQ F 13157 from GSQ L 201. C, ventral valve ?UQ F 45461 from UQ L 2768. D, latex cast of dorsal valve GSQ F 12518 from GSQ L 201. E, dorsal valve GSQ F 21578 from GSQ L 182. F, latex cast of dorsal valve GSQ F 13157 from GSQ L 201. (See Fig. 5B). G, extemal mould of ventral valve GSQ F 13159 from GSQ L 191, x2. Specimens x1, except G. H, *Notospirifer*? sp. GSQ F 13163 from GSQ L 201, x2.

The species named *Martiniopsis konincki* Etheridge Jnr. (1892) from the Allandale Formation of north Sydney Basin as revised by McClung (1978) and Waterhouse in Waterhouse et al. (1983) is similar to *Monklandia gympiensis* in that plicae are narrow, though only three to four pairs in number, and the sulcus is moderately broad with two subplicae, and the dorsal fold wide. The species *konincki* is more inflated than *Monklandia gympiensis*, with narrower less flattened sulcus, weaker subplicae, fewer plicae, and narrower higher dorsal fold, generally with feebly sulcate crest (eg. McClung 1978, pl. 3, fig. 4, 5). Waterhouse recorded surface grooves, but could not observe if spines were present, so that this remains to be clarified, with implications for its taxonomic position.

One specimen figured by Runnegar (1969a, pl. 20, fig. 1) conforms with *gympiensis* in the strong definition of the sulcus with two prominent subplicae, but seems to have only four pair of plicae, closer to *konincki,* to suggest a degree of overlap between the two species, although the smooth unusually non plicate outer shell is more extensive than usual. However the dorsal valve is not known, hindering full identification. It comes from the Allandale Formation of the Hunter Valley.

The figure of Etheridge Snr. (1872, pl. 15, fig. 4), repeated by Etheridge Jnr. (1892, pl. 10, fig. 7), has a costa along each of four plicae, unlike the ornament in *Monklandia*, and suggestive of a trigonotretid, such as *Neilotreta*. But Etheridge Snr. referred the specimen to *Spirifera undifera undulata*, like other specimens now regarded as *Monklandia*, and Etheridge Jnr. included the specimen in *strzelecki,* like the specimens now treated as *Monklandia*. (See p. 72).

Discussion: McClung (1978, p. 43) cited a Gympie specimen figured by Etheridge Snr. (1872) as lectotype of *Spirifer strzeleckii* de Koninck (1877). This is improper. Although de Koninck (1877) had referred Etheridge's specimens to *strzeleckii,* he had based the description and definition of his species *strzeleckii* on completely different specimens, obtained from early Middle Permian beds of the Hunter Valley, New South Wales, rather than Early Permian of Gympie. Thus even though de Koninck's specimens were later lost by fire, the Etheridge specimens cannot be considered available as replacement types: they in fact differ substantially from de Koninck's species. Campbell (1960, p. 1111) came to the same conclusion. He stated "I am convinced that they are definitely not conspecific with either of the types [of *strzeleckii* – inserted] figured by de Koninck, and since they do not appear to have been used in drawing up the original description, they do not qualify as syntypes." It is therefore concluded that McClung's redefinition of *strzeleckii* is unacceptable, so that the Gympie specimens cannot be ascribed to *strzeleckii* de Koninck. The correct procedure is to refer the Gympie specimens to a different form, and this was done in Waterhouse (1998b), in proposing the specific name *gympiensis*.

Of the two specimens figured by de Koninck (1877), that of de Koninck (1877, pl. 13, fig. 1, 1a) is identical with *Ingelarella etheridgei* McClung (1978). The other (pl. 14, fig. 1, 1a) has a grooved fold, and is somewhat like a very transverse version of *oviformis* M'Coy. No particular match has been found. Waterhouse (1998b, p. 39) designated the specimen figured by de Koninck (1877, pl. 13, fig. 1, 1a) as lectotype of the species *strzeleckii* de Koninck, and, in view of its destruction by fire, proposed as neotype the specimen figured by McClung (1978, pl. 9, fig. 3, 6), UNE 14263, kept at the University of New England, and since transferred to the Australian Museum, Sydney. This replaces the name *etheridgei* McClung with *strzeleckii* de Koninck, and should enable ready recognition of de Koninck's species. It is a transverse notospiriferiform shell with narrow fold bearing well formed although restricted channel in the neotype, and associated dorsal valves have short widely diverging tabellae.

Superfamily **SPIRIFEROIDEA** King, 1846

Family **NEOSPIRIFERIDAE** Waterhouse, 1968a

Subfamily **NEOSPIRIFERINAE** Waterhouse, 1968a

Genus ***Betaneospirifer*** Gatinaud, 1949

Type species: *Spirifera moosakhailensis* Davidson, 1862, p. 28 from Wargal Formation (Capitanian or Wuchiapingian), Salt Range, Pakistan, OD.

Diagnosis: Large as a rule, with wide hinge and extended interareas, delthyrial cover plate, five pair of plicae as a rule with one pair entering sulcus, fine costae and moderate commarginal laminae.

Betaneospirifer dubius (Etheridge, Snr., 1872)

Fig. 6A - F

1872 *Spirifera dubia* Etheridge Snr., p. 330, pl. 16, fig. 6.
1892 *S. dubia* – Jack & Etheridge Jnr., p. 231, pl. 10, fig. 14.
1948 *Neospirifer dubius* – Branson, 1948, p. 426.
1969 *Trigonotreta? dubia* – Runnegar & Ferguson, p. 251.
?1969a *Neospirifer* sp. nov. Runnegar, p. 293, pl. 20, fig. ?16, 17 (part, not fig. 8, 19 = aff. *tasmaniensis*).
1987 *N. dubius* – Waterhouse & Balfe, 1987, p. 30, pl. 1, fig. 5.
2008b *N. dubius* – Waterhouse, Fig. 3B, C.

Neotype: Specimen GSQ F 13152 from L 1440, Rammutt Formation (Asselian), Gympie, here nominated to replace the original type figured specimen, which is now lost. Figured by Waterhouse & Balfe (1987, pl. 1, fig. 5) and herein as Fig. 6A.

Diagnosis: Shell small as preserved, distinguished by shallow broad ventral sulcus, and low dorsal fold. Well defined plicae, with low moderately numerous branching costae, crossed by prominent growth lamellae, cardinal extremities angular.

Dimensions in mm for *Betaneospirifer dubius*:

Specimen	Width	Length	Height
ventral valve, neotype	35	29	6
dorsal valve QM F 14408	29	18	3.5

Description: Shells small, transverse, ventral umbo incurved over hinge, moderately prominent, with angle of 95-100^o, maximum width at hinge with acute cardinal extremities and angle measuring close to 50^o, ventral interarea moderately high, inclined ventrally from commissure, dorsal interarea not exposed. Delthyrial cover plate small, marked by growth-lines passing forward into pleromal ridges below inner dental plates. Ventral sulcus shallow, well defined, posteriorly widens at 18-20^o, within broad plicae, and anteriorly embraces innermost pair of plicae by widening at 35-40^o; dorsal fold with angle of 20^o, low although well defined with rounded cross-profile, elevated above lateral shell. Ventral plicae number seven to nine pair, three inner pair well defined, lateral plicae narrow, all persisting to anterior margin; dorsal plicae number seven to eight pair, of which four inner pair are well defined, and lateral plicae fine. Costae fine to coarse, with rounded crests, number seven anteriorly in ventral sulcus, two prominent; primary costa usually high or prominent over posterior 15-20mm, then bifurcates; innermost plication with five costae. Lateral plicae have one or two, rarely three costae which arise mostly by bifurcation, some by intercalation. Dorsal fold with four costae, lateral plicae with only two, costae increasing by bifurcation some 20mm in front of umbo, lateral plicae simple and without costae. Commarginal lamellae moderately prominent over both valves; growth laminae number five or six in 1mm anteriorly, radial capillae not visible.

Dental plates of ventral valve high, subvertical to subhorizontal, concave upwards, supported by short widely spaced adminicula, with strongly developed pleromal ridges along inner side of dental plates at junction. Umbonal callosity low, broad. Muscle field lozenge-shaped, extending into umbonal cavity, adductor ridges well defined, broad, with bordering ridges extending for the posterior half the length of field, and divided posteriorly by well developed myophragm in best preserved interior. Adductor ridges fuse in front to form one broad poorly delimited ridge, bear faint irregular longitudinal striae. Diductor scars broad, with well defined sublongitudinal grooves and two anterior growth undulations. Faint pallial pits, and posterior shell thickened to 2mm. Dorsal interior not known.

Resemblances: It seems likely that these specimens are not fully mature. The lack of a prominent umbonal callosity from the ventral valve, and development of a thick delthyrial plate marked by growth lines show that the form belongs to Neospiriferidae, and the species is referred to *Betaneospirifer*, because it has a wide hinge and the innermost plication, often narrow, lies within the sulcus.

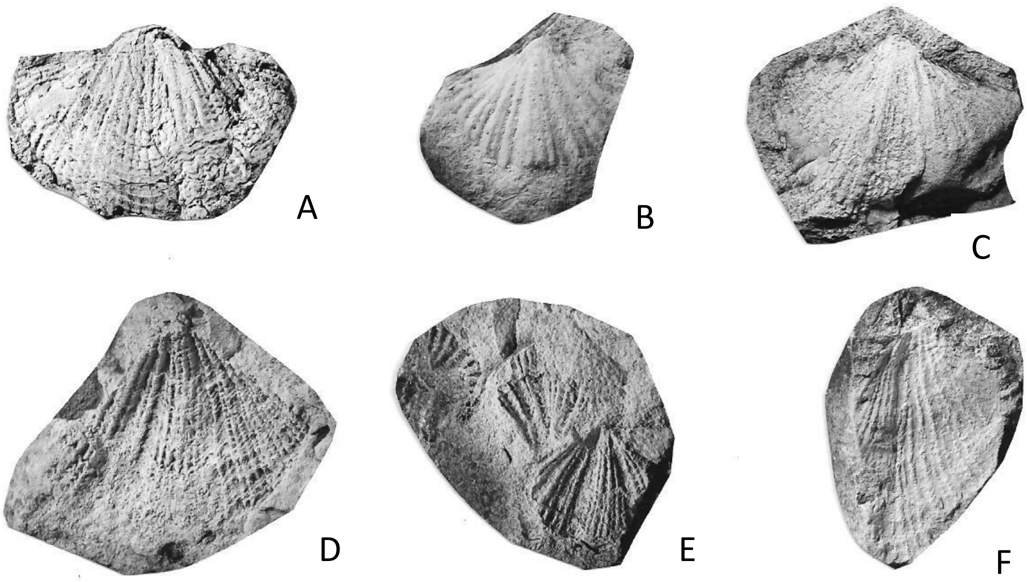


Fig. 6. *Betaneospirifer dubius* (Etheridge). A, neotype ventral valve GSQ F 13152 from GSQ L 1440. B, small dorsal valve QM F 14408. C, small ventral valve GSQ F 13153 from GSQ L 182. D, ventral extemal mould QM F 14405. E, small external moulds of ventral valves, GSQ F 13154 and 13155. F, extemal mould of dorsal valve GSQ F 13144. Locality numbers for E and F not known. Specimens x1.

Material recorded as *Neospirifer* sp. nov. by Runnegar (1969a, pl. 20, fig. 17) from the lower sandy unit (Wasp Head Formation) of the Conjola Group, south Sydney Basin, is somewhat worn, but shows wide cardinal extremities and the innermost plicae pair on the ventral valve appears to lie within the sulcus. There are up to seven or eight pairs of plicae in one of the specimens, and costae are comparatively fine and subequal, not differentiated as in *Trigonotreta* or *Grantonia*. Another specimen figured by Runnegar (1969a, pl. 20, fig. 16) has only three pair of plicae, and reduced inner sulcal pair. But the nature of the delthyrium is not known, leaving uncertainty.

Most Neospiriferidae in east Australia belong to *Simplicisulcus,* distinguished by lacking plication in the sulcus. *S. concentricus* (Waterhouse, 1987a) from the Brae Formation of the southeast Bowen Basin is similar in general ornament and ventral umbonal interior, but it has rounded cardinal extremities and finer dorsal costae. The type species of *Simplicisulcus, Neospirifer arthurtonensis* Waterhouse, 1968a from New Zealand is close in size and overall shape, with similar prominent and broad ventral umbo, and strong commarginal laminae. In this species, the plicae are more robust over the ventral valve and fewer in number, and costae are stronger, compared with *dubius.*

The species *dubia* was allocated to *Trigonotreta* Koenig by Runnegar & Ferguson (1969). The type species of this genus, *Trigonotreta stokesii* Koenig, 1825, as revised by Clarke (1979), is of moderate size at maturity with rounded cardinal extremities and strong plicae, and generally few costae, and large umbonal callosity that is missing from the Gympie species. The Gympie material does not show the same suboval outline and highly inflated shell as this form, and has more angular cardinal extremities, slightly wider and shallower ventral sulcus and lower dorsal fold. The ventral umbo in *dubius* appears to be more prominent and less incurved. Dorsal plicae are comparable in strength and number near the hinge, and commarginal lamellae are well developed in both *dubius* and *stokesii*. Internally, the ventral valve of *dubius* has a modestly developed delthyrial plate rather than umbonal callosity, and shorter muscle field. Type *T. stokesii* is well known in early Permian faunas of Tasmania, including the Swifts Jetty Sandstone and Glencoe Group (Clarke, 1979).

Grantonia australis (Bion, 1928) is based on a Tiverton species from the north Bowen Basin in Queensland (see Waterhouse 1987a, p. 17 and Waterhouse 2015, p. 193), and appears to be limited to the Bowen Basin, although perhaps the taxon *hobartensis* Brown, 1953 from the *Taeniothaerus subquadratus* Zone of Tasmania is no more than a variant. Although Armstrong (1968b) synonymized *stokesii, dubia* and *hobartensis,* the taxa *australis* and *hobartensis* both have a broader muscle field, and wider ventral sulcus and higher dorsal fold than *dubius. Trigonotreta cracovensis* (Wass, 1966) from the Fairyland Formation of the southeast Bowen Basin has an elongate shape as a rule, alate cardinal extremities, lower commarginal ornament and less elongate ventral muscle field, with other differences (Waterhouse 1987a, p. 17; Waterhouse 2015, p. 192).

Spirifera undifera var. *undulata* [not Roemer] of Etheridge Snr. (1872, p. 331, pl. 15, fig. 4) is an internal mould of a ventral valve, which appears to have a costa on the flanks of some plicae. This specimen could prove to be a worn specimen of *dubius*, but given the sparsity of the subsidiary ribs is more likely to be a specimen of *Neilotreta* (see p. 72).

Discussion: No indication was provided in early studies of the likely source of the type specimen of *dubius*, but similar shells of the same size are more common in the middle Rammutt volcanogenic green sandstone than in the Monkland beds or younger levels. Runnegar & Ferguson (1969) listed the species from the Rammutt Formation, without providing further indication of likely stratigraphic level. Fredericks (1931, pl. 3, figs. 3B-41) identified a specimen from northeast Siberia with Etheridge's form, as *Cyrtospirifer dubius*, but his specimens show little similarity.

Order SPIRIFERINIDINA Ivanova, 1972

Suborder SYRINGOTHYRIDINA Grunt, 2006

Superfamily **SYRINGOTHYROIDEA** Fredericks, 1926

Family **SYRINGOTHYRIDAE** Fredericks, 1926

Subfamily **PERMASYRINXINAE** Waterhouse, 1986b

Genus ***Permasyrinx*** Waterhouse, 1986b

Type species: *Subansiria procera* Armstrong, 1970a, p. 149 from Fairyland Formation (Sakmarian), southeast Bowen Basin, Queensland, OD.

Diagnosis: Large transverse shells with high ventral interarea, sulcus well defined, smooth, fold high and smooth, plicae numerous, micro-ornament of shallow linear grooves extending in front of tiny spinules, shell densely punctate. Dental plates high, adminicula high and short, joined at junction by connector plate; without syrinx but with syrellum or calcite rod posteriorly, muscle field short, myosepta may be developed along the posterior adductor scars. Dorsal ctenophoridium, short subhorizontal socket plates, crural plates, low median ridge.

Permasyrinx allandalensis (Armstrong, 1970a)

Fig. 7E

1969 *Pseudosyrinx* sp. nov. Runnegar, p. 292, pl. 20, fig. 13, 14.

1970a *Pseudosyrinx allandalensis* Armstrong, p. 140, pl. 1, fig. 1-3, 5, 6 (part, not fig. 4, 7 = aff. *archboldi* Waterhouse).

1970a *Subansiria procera* [not Armstrong] – Armstrong, pl. 2, fig. 17 (part, not fig. 12-16 = *procera*, not fig. 18 = *Cyrtella papula* n. sp.).

Holotype: ANU F 17766 from Allandale Formation (Asselian), Sydney Basin, figured by Armstrong (1970, pl. 1, fig. 1, 2), OD.

Diagnosis: Fold low with rounded crest, up to 12 pair of round-crested plicae.

Description: An incomplete dorsal valve GSQ F 13148 from unknown locality has broadly rounded low median fold and more than eight pair of low plicae, the full number not known. Cardinal extremities obtuse, crest of fold rounded, and crests of plicae also broadly rounded.

Resemblances: Although the specimen is incomplete it agrees as far as preserved with *Permasyrinx allandalensis* (Armstrong), initially described from the Allandale Formation of the Hunter Valley, New South Wales, and also present in the upper Wasp Head beds of southern New South Wales and the Lizzie Creek Volcanic Group of the Bowen Basin in Queensland. Armstrong reported that a few specimens of *allandalensis* had a shallow dorsal groove (through wear?), and indeed the present decorticated dorsal valve has a faint median groove. He also stated that punctae occurred at a density of 600-800 per square centimetre, compared with an estimated 1200-2000 punctae in *acuta*. None of the specimens that Armstrong examined at the University of Queensland show punctae, so this count cannot be checked. Prof. K. S. W. Campbell, Australian National University, has kindly re-examined type material of *allandalensis* that is kept at the Department of Geology, Australian National University. He reported that ventral valve ANU F 17766 has 12-18 punctae per square mm depending on where the count is made, and pointed out that this indicates a density at twice the figure indicated by Armstrong. The density is thus much the same as in the present specimen.

Permasyrinx*? *acuta (Etheridge Snr., 1872)

Fig. 7A – C

1872 *Spirifera bisulcata* Sowerby var. *acuta* Etheridge Snr., p. 329, pl. 16, fig. 1.
1892 *Spirifera trigonalis* Martin var. *acuta* – Jack & Etheridge Jnr., p. 230, pl. 10, fig. 12.
1987 *Permasyrinx acuta* (Etheridge) – Waterhouse & Balfe, p. 30, pl. 1, fig. 3.

Holotype: Sole specimen QM F 5639, by monotypy, from QM L 784, Alma Reef, Rammutt Formation (Asselian), Gympie. See Etheridge Snr. (1872), refigured by Etheridge Jnr. (1892) and Waterhouse & Balfe (1987), and herein as Fig. 7A.

Diagnosis: Subelongate shells with only moderately inflated ventral valve and well rounded comparatively low dorsal fold, up to twelve pairs of plicae on ventral valve. The nature of the anterior dorsal fold and presence of syrellum are uncertain.

Description: Ventral valve QM F 14404 transverse, with only moderately high interarea, smooth sulcus, and some twelve pairs of plicae. Delthyrium closed by concave plate with swelling below umbo. Dorsal fold moderately high, with apparently rounded crest; higher in holotype than other shells, well defined in some specimens, or gradually sloping into lateral shell. Ten pairs of plicae in holotype, and one or two more pair to each side, only nine pairs in small specimen, and ten pairs on larger specimen, twelve pairs in best preserved external mould, curving out in small shell, straight in others. Dorsal interarea low, almost in plane of shell, with horizontal striae and very broad low notothyrium. Micro-ornament of slender surface grooves, each passing forward from a minute spinule, commarginal growth lines, two per mm. Shell coarsely punctate, punctae numbering four to five in 1mm, and up to 13-20 in one square mm, radiating forward and inward over plicae.

Ventral valve with short high narrowly diverging adminicula, supporting widely diverging dental plates (QM F 14404). Adminicula joined by connector plate with commarginal growth lines. Adductor impressions form double groove anteriorly in front of low narrow median ridge; diductor scars lightly marked by longitudinal ridges and grooves. Dorsal socket plates low, enclosing curved narrow dental sockets; ctenophoridium with some 25 irregular vertical laminae; well developed median septum commences at base of process and extends over posterior fourth of shell length.

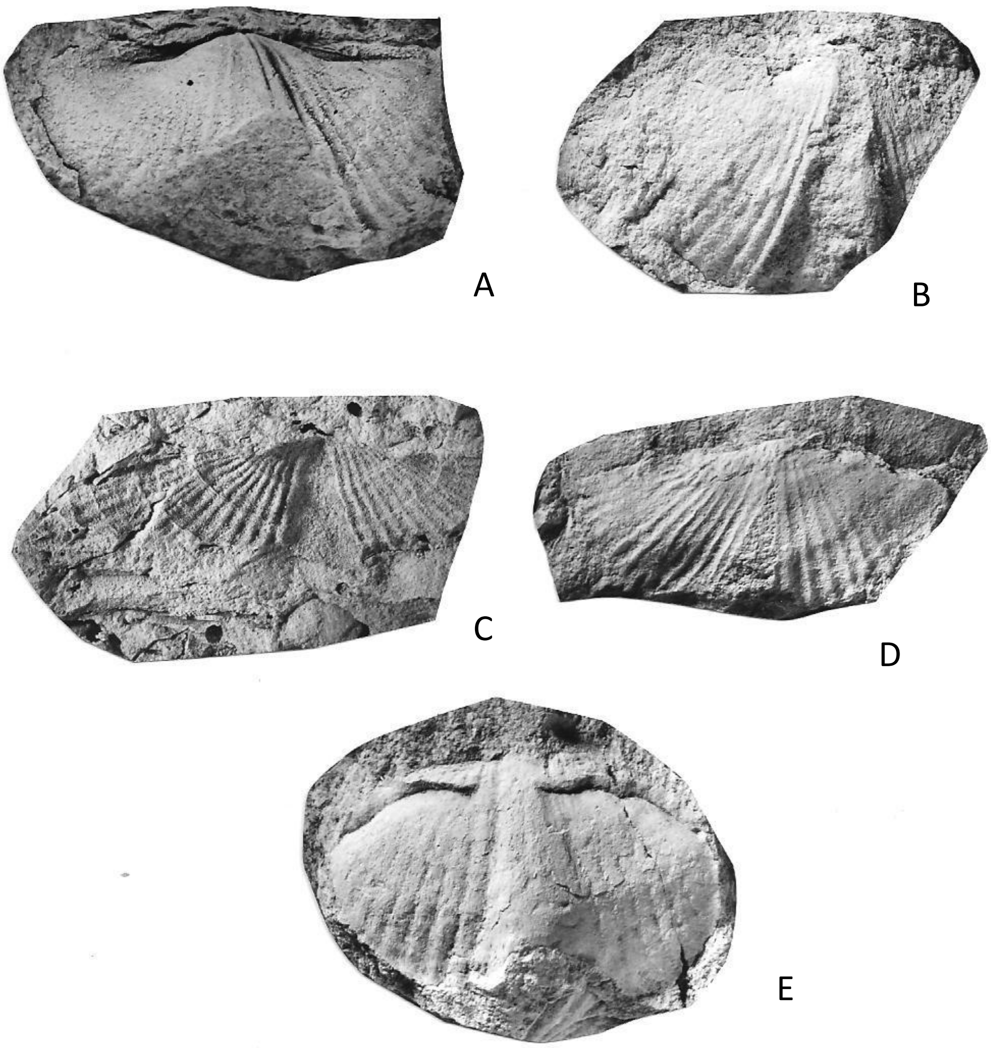


Fig. 7. A – C, *Permasyrinx*? *acuta* (Etheridge). A, holotype, dorsal internal mould QM F 5639 from QM L 784. B, ventral valve GSQ F 13178 from GSQ L 1443. C, dorsal external mould GSQ F 13149 from GSQ L 182. D, *Sulcicosta* sp. damaged dorsal valve GSQ F 13150 from GSQ L 182. E, *Permasyrinx allandalensis* (Armstrong), dorsal valve GSQ F 13148. Specimens x1.

Resemblances: *Permasyrinx allandalensis* (Armstrong, 1970a) from the Allandale Formation and Wasp Head Formation of the Sydney Basin and at Gympie is close in shape, and has up to 11 or 12 pairs of plicae, close to the range in present material, a comparatively little inflated ventral valve, with interarea of comparable height and round-crested dorsal fold. The edges of the ventral sulcus are more sharply defined in *acuta*. Although certainty is lacking, because of the sparse material available for *acuta*, the two do appear to be close, but the less crisply defined sulcus and fold of *allandalensis* offer distinctions from *acuta*.

Shells described as *Subansiria granulata* by Armstrong (1970a) from the Tiverton Formation of the north Bowen Basin in Queensland have a somewhat similar shape and number of plicae, and the fold lacks a median groove as in *Permasyrinx*. The ventral valve of type and topotype material of *granulata* is more inflated, and the dorsal fold higher than in *acuta,* and in one specimen, the plicae split anteriorly into low costae, recalling the genus *Cundaria* Archbold, 1996 from Western Australia, which is transverse with syrellum.

Permasyrinx archboldi Waterhouse, 2015 from the Tiverton Formation of the north Bowen Basin is close in shape with posteriorly pointed ventral umbo and a number of narrow plicae, and has a calcite rod or syrellum and myosepta as in *Permasyrinx* and *Syrella* Archbold, 1996, and in what appears to be a very close ally, *Primorewia* Licharew & Kotlyar (1978, pl. 11, fig. 3, 4a) from Kungurian-Roadian faunas of northeast Russia. The plicae are more numerous in the present form. A channel at the crest of the dorsal fold typifies *Syrella*, but is not visible in type *acuta*, though the possibility remains that this is because the anterior fold is damaged. But any assignment of *acuta* to *Permasyrinx* or *Syrella* can only be provisional, because uncertainty over fold and syrellum.

Discussion: The holotype of *acuta*, one of the specimens initially named by Etheridge Snr. (1872) that is still preserved, is an incomplete specimen exposed on a weathered sample of rock, that presumably came from surface outcrop. Only a few additional specimens have been found. The name was overlooked in a paleontological study of the Gympie faunas by Runnegar & Ferguson (1969) and in a description of allied genera and species by Armstrong (1970a) from east Australia.

Genus ***Sulcicosta*** Waterhouse, 1983

Type species: *Pseudosyrinx plicata* Armstrong, 1970a, p. 142 from the Capertree Group of western Sydney Basin, New South Wales, OD.

Diagnosis: Medium in size, transverse to subelongate, fold and sulcus bear several costae.

Sulcicosta sp.

Fig. 7D

1987 *Sulcicosta* sp. Waterhouse & Balfe, p. 30, pl. 1, fig. 4.

Description: A single poorly preserved dorsal valve QSQ F 13150 from GSQ L 182 is available, measuring about 46 mm in width, 22mm long and 5mm high, with some ten pairs of fine plicae, and a low fold apparently carrying some five or six costae. Micro-ornament and interior are not shown, and the shell is slightly deformed and damaged over the fold, but traces of the costae remain to indicate that the shell belongs to *Sulcicosta*.

Resemblances: *Sulcicosta* is a distinctive genus. The type species *Sulcicosta plicata* (Armstrong) is more elongate and has a higher dorsal fold though it has a similar number of plicae. *Sulcicosta costata* Waterhouse, 1987a from the Dresden Formation (Sakmarian) of the southeast Bowen Basin has eight or nine pairs of plicae.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Megaorder MYALINATA H. Paul, 1936

Order MYALINIDA H. Paul, 1936

Superfamily **INOCERAMOIDEA** Giebel, 1852

Family **ATOMODESMIDAE** Waterhouse, 1976b

Genus ***Trabeculatia*** Waterhouse, 1979

Type species: *Atomodesma trabeculum* Waterhouse, 1963b, p. 712 from Little Ben Sandstone (Changhsingian), Nelson, New Zealand, OD.

Diagnosis: Hinge long, extended posterior wing, heavy thickening below slender ligament.

Trabeculatia sp.

Fig. 10A

Fragments show the prismatic structure typical of this family, with well defined growth layers. A left valve GSQ F 13162 from GSQ L 201 has a broad umbo, angle close to 90^{o}, and well defined posterior wing. The shape is like that of *Trabeculatia* Waterhouse, but the hinge and anterior are obscure. Previously, the oldest known species of this genus was thought to be *Trabeculatia marwicki* (Waterhouse, 1958) from south Otago, New Zealand, a species also found with a small fauna at Gyzeh near Lumsden in the Upukerora Breccia of Landis (1974), which is slightly younger than the *Echinalosia conata* Zone, of late Artinskian age (Waterhouse 2008b), and equivalent to the early Kungurian *Attenuocurvus* beds at Wairaki Downs in New Zealand.

Megaorder OSTREATA Férussac, 1822

Superorder OSTREIFORMII Férussac, 1822

Order PECTINIDA Gray, 1854

Suborder ANOMIIDINA Gray, 1854

Hyporder AVICULOPECTINOIDEI Starobogatov, 1992

Superfamily **AVICULOPECTINOIDEA** Meek & Hayden, 1865

Family **DELTOPECTINIDAE** Dickins, 1957

Subfamily **SQUAMULIFERIPECTINAE** Waterhouse, 2008a

Genus ***Squamuliferipecten*** Waterhouse, 1986b

Type species: *Aviculopecten extensus* Fletcher, 1929, p. 6 from Wandrawandrian Formation (Kungurian) of south Sydney Basin, OD. This appears to be a subjective junior synonym of *Aviculopecten media* Laseron, 1910.

Diagnosis: Large shells, biconvex with right valve less inflated than left, well developed right anterior auricle with byssal notch, small posterior wings. Ornament of interlocking or opposed subangular to rounded plicae on both valves, with a varying number of secondary ribs or costae, crossed by well formed close-set growth lamellae. Ligament platyvincular, may bear pseudotrabeculae.

Squamuliferipecten squamuliferus (Morris, 1845)

Fig. 8A - C

1845 *Pecten squamuliferus* Morris, p. 278, pl. 14, fig. 1.

1872 *Aviculopecten multiradiatus* Etheridge Snr., p. 327, pl. 13, fig. 1.

1906 *A. squamuliferus* – Etheridge Jnr. & Dun, p. 8, pl. 1, fig. 4, pl. 8, fig. 4 (part, not pl. 2, fig. 4, 5 = n. sp. or var.).

1906 *A. profundus* [not de Koninck] – Etheridge Jnr. & Dun, p. 9, pl. 11, fig. 4, 5.

1929 ?*A. squamuliferus* – Fletcher, p. 4.

1959 *A. squamuliferus* – Sahni & Dutt, p. 658, pl. 24, fig. 1, 2.

1964 *Deltopecten limaeformis* [not Morris] – Hill & Woods, pl. P11, fig. 11, 12.

1969 *D. limaeformis* – Runnegar & Ferguson, p. 251.

1972 *D. limaeformis* – Hill, Playford & Woods, pl. P11, fig. 11, 12.

1982b ?*Corrugopecten squamuliferus* – Waterhouse, pl. 24e.

1987b *D. limaeformis* – Waterhouse, p. 153, pl. 6, fig. 1 (part, not pl. 5, fig. 12 = *latispatia* Waterhouse).

1987b *D. illawarrensis* [not Morris] – Waterhouse, p. 154, pl. 6, fig. 6 (part, not fig. 9 = *mitchelli*).

1987b *Squamuliferipecten squamuliferus* – Waterhouse, p. 157, pl. 7, fig. 1, pl. 8, fig. 10.

1987b *Squamuliferipecten* sp. Waterhouse, p. 155, pl. 6, fig. 2, 4.

1987 *D. limaeformis* – Waterhouse & Balfe, p. 30, pl. 1, fig. 10, 11.

2008a *S. squamuliferus* – Waterhouse, p. 88, text-fig. 42.

2015 *S. squamuliferus* – Waterhouse, p. 251, Fig. 198C, 199B, 202A, D.

Lectotype: NHM PL 3685 from Mount Wellington, Tasmania, probably Cascades Group, figured by Morris (1845, pl. 4, fig. 1) and Waterhouse (1982b, pl. 24, fig. e), SD Waterhouse (1982b, caption pl. 24e). The probable locality exposes undifferentiated Cascades Group, which crops out on Huon Road (M. R. Banks, pers. comm. to B. Runnegar). Holotype for *multiradiatus* QM F 1208 from the Rammutt Formation, Lady Mary Reef, Gympie, southeast Queensland, figured by Etheridge Snr. (1872) and Waterhouse & Balfe (1987, pl. 1, fig. 10), and Fig. 8A herein, by monotypy.

Diagnosis: Large shells, right valve a little less inflated than left valve, right anterior auricle very large, ornament of 37-50 round-crested plicae and secondary costae which are moderately numerous, commarginal lamellae prominent.

Discussion: The sole specimen figured and described as *Aviculopecten multiradiatus* Etheridge Snr. (1872) is a little inflated shell with some 50 narrow ribs and well developed growth lamellae. Several other specimens are also little inflated with some 40-45 ribs. The species is probably identical with *Squamuliferipecten squamuliferus* (Morris) from Tasmania, even though the difference in age between types of the two species, Sakmarian for *squamuliferus,* Asselian for *multiradiatus*, might

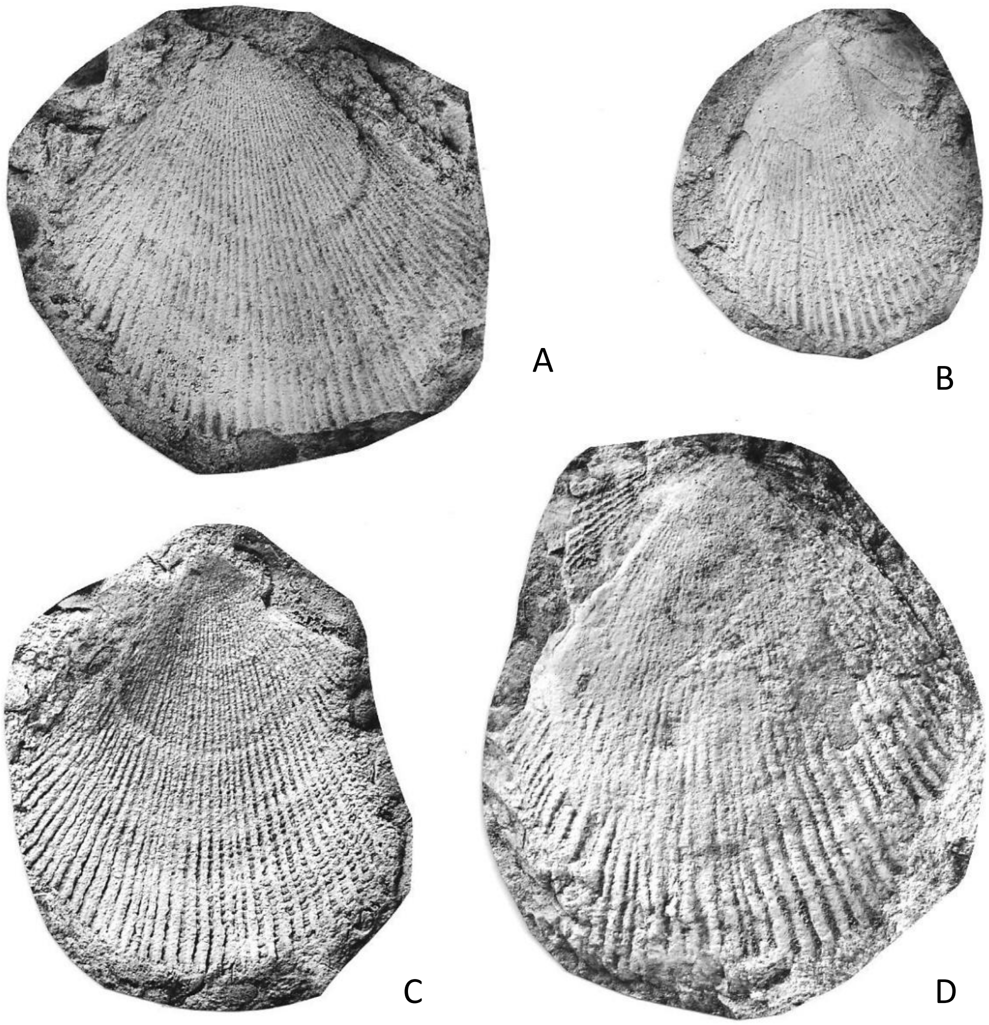


Fig. 8. *Squamuliferipecten squamuliferus* (Morris). A, left valve QM F 1208, holotype of *multiradiatus* Etheridge. and C, believed to be the external mould, next to streptorhynchid of Fig. 3A. B, right valve GSQ F 14391 from GSQ L 201, D, left valve GSQ F 13162 from GSQ L 1445, from overlying "Monkland beds". Specimens x1.

encourage validity to be ascribed to both taxa. Etheridge Snr. (1872) also identified *Aviculopecten limaeformis* from Gympie, but the specimen cannot be found, and the figure (Etheridge Snr., 1872, pl. 14, fig. 1) suggests few strong and some fine (25-30) plicae, approaching the ornament of *mitchelli* Etheridge & Dun.

Dimensions in mm of *Squamuliferipecten squamuliferus*:

	Length	Height	Width
left valve, *multiradiatus* type, QM F 1208	?67	60	8.5
right valve QM F 14391	36	46	4

Subfamily **UNDOPECTININAE** Waterhouse, 2008a

Genus ***Undopecten*** Waterhouse, 1982b

Type species: *Pecten fittoni* Morris, 1845, p. 277 from Mt Wellington (Middle Permian), Tasmania, OD.

Diagnosis: Both valves plicate and costate, well formed resilifer.

Discussion: Both valves are plicate and convex, with resilifer, somewhat as in *Aviculopecten* M'Coy, and the resilifer is visible in the type specimen of *fittoni* NHM PL 3687 at the Natural History Museum, London, England. *Undopecten* is distinguished from *Aviculopecten*, *Deltopecten* and other plicate genera by the development of costation as well as plication over both valves. *Turbopecten* Astafieva, *Acanthopecten*? sp. of Amler (1992, pl. 2, fig. 6) and *Undorugosa* Waterhouse are related, as reviewed in Waterhouse (2008a, p. 74ff).

Undopecten imbricatus (Etheridge Snr., 1872)

Fig. 9

1872 *Aviculopecten? imbricatus* Etheridge Snr., p. 327, pl. 14, fig. 2.

Holotype: Sole specimen figured by Etheridge Snr. (1872, pl. 14, fig. 2), by monotypy, from Rammutt Formation (Asselian), Gympie.

Diagnosis: Shells distinguished from *Undopecten fittoni* (Morris) by having finer costae.

Description: *Aviculopecten*? *imbricatus* Etheridge Snr. (1872, p. 327, pl. 14, fig. 2) from the Gympie district, the figured specimen now lost, has only 22 strong plicae bearing faint longitudinal "markings" which "run down the ribs" (ie. plicae), and imbricate growth laminae.

Fig. 9. *Undopecten imbricatus* (Etheridge Snr.), left valve as figured by Etheridge Snr. 1872, x1.1.

Discussion: Aspects of the shell named *Aviculopecten imbricatus* from the Rammutt Formation by Etheridge Snr. (1872, p. 327) suggest *Undopecten*. This is a plicate left valve, with imbricate growth laminae, and Etheridge referred to faint longitudinal markings that “run down each of the ribs” (ie. plicae). Species of *Undopecten* in east Australia have been discussed and figured by Waterhouse (1982b, pl. 19c, e). In addition to the type species *fittoni* Morris which is of Middle Permian age, specimens of the genus are found in earlier faunas, such as the Allandale Formation of mid-Asselian age in the Sydney Basin, and left valves from the Ravensfield Member of the Farley Formation (Sakmarian) in the Sydney Basin were figured by Waterhouse (1982b, pl. 19c). The costae represented by these “longitudinal markings” are possibly finer than those of *fittoni,* indicating a separate species, most likely from the middle Rammutt Formation. Unfortunately Etheridge’s species could not be found amongst the museum collections, and no further material has been found, so that it is not possible to name a neotype or consolidate the nature of the taxon.

Etheriplica Waterhouse (2008a, p. 139) from the Middle Permian of eastern Australia is rather similar in general appearance, with the ornament of the left valve dominated by fine ribs, and plicae restricted to the lower half to two thirds of the left valve, the plicae arising in the interspaces between the primary costae. The type species, *E. plicata* (Waterhouse) in Waterhouse & Jell (1983) from the Bowen Basin, appears to be close to *Aviculopecten depressus* Fletcher from the Sydney Basin. The right valve is not plicate.

Genus ***Corrugopecten*** Waterhouse, 1982b

Corrugopecten sp.

Fig. 10B

A small fragment, QM F 14506 from GSQ L 1443 has diversified ribbing like that seen on left valves of *Corrugopecten*.

Hyporder MONOTOIDEI Waterhouse, 2001

Superfamily **EURYDESMOIDEA** Reed, 1932

Family **EURYDESMIDAE** Reed, 1932

Genus ***Eurydesma*** Morris, 1845

Type species: *Eurydesma cordatum* Morris, 1845, p. 276 from Allandale Formation (Asselian), north Sydney Basin, New South Wales, OD (Dickins 1961b, p. 143).

Diagnosis: Large equivalve or subequivalve shells with anteriorly placed umbones, byssal notch below small right anterior ear-ledge, right anterior ear-ledge may jut into left valve hinge, left valve anterior ear-ledge may lie parallel to hinge or jut across commissure, ligament opisthodetic, right valve may have broad shallow socket, or one or two low dental bosses, left valve may have one large or rarely two dental bosses and intervening socket, posterior adductor muscle scar large, subcentrally placed, pallial line continuous ventrally, pitted dorsally, possibly closed beneath umbo.

Discussion: *Eurydesma* is one of the most characteristic of Permian genera to be found in Gondwana. The numerous species found in east Australia are reviewed in Waterhouse (2015, pp. 281-292, Fig. 237), and have been shown to be comparatively restricted in time range, and so reasonably diagnostic of particular biozones, with the youngest species, *alisulcatum* Waterhouse, found in

Kungurian deposits of the south Sydney Basin.

Eurydesma sp.

Fig. 10D - F

1987 *Eurydesma* sp. Waterhouse & Balfe, p. 30, pl. 1, fig. 8.

Description: Shell small, squashed, umbo placed well forward, anterior shell high and concave, posterior wing small. Ligament channelform.

Dimensions in mm of *Eurydesma* sp. :

Locality	Length	Height	Width	Hinge length	Umbo from anterior
GSQ F 13167	19	20	7	?12	4.5
QM F 14407	33	35	8	?17	9.5

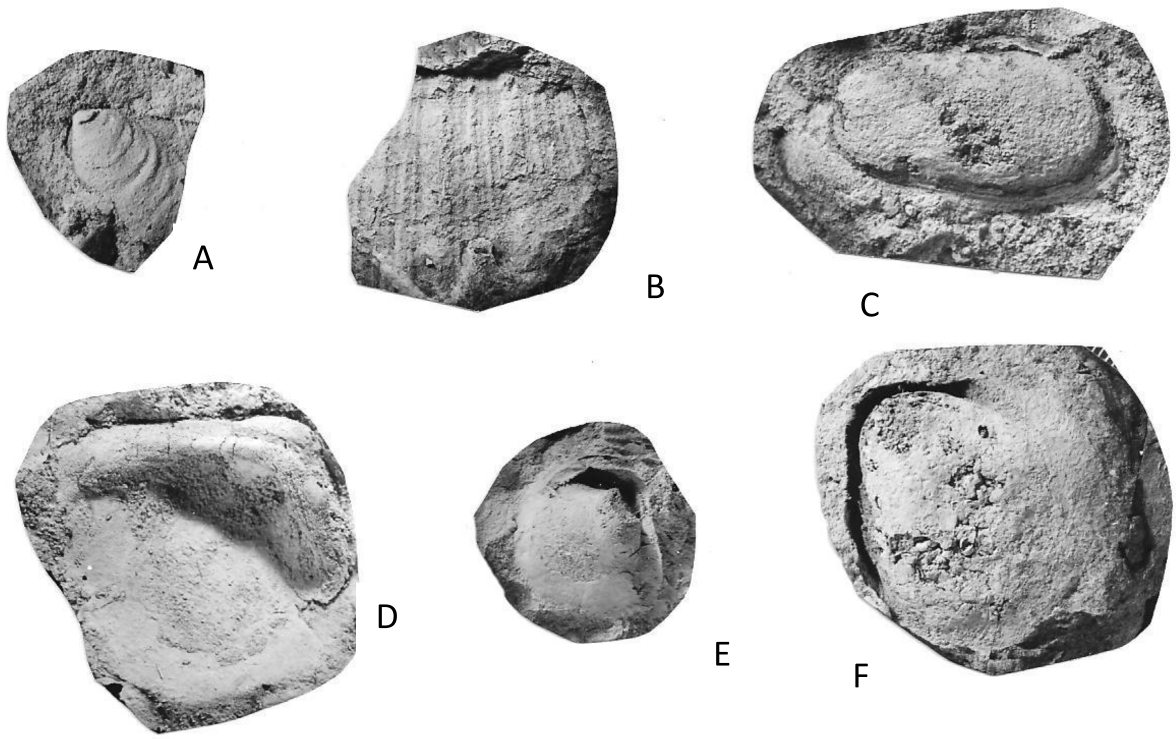


Fig. 10. A, *Trabeculatia* sp. left valve GSQ F 13145 from GSQ L 201. B, *Corrugopecten* sp., fragment of left valve QM F 14506 from GSQ L 1443. C, *Stutchburia simplex* (Dana), left valve QM F 14411. D – F, *Eurydesma* sp. D, F, latex cast and internal mould of QM F 14407. E, right valve internal mould GSQ F 13167 from GSQ L 191. All specimens x1.

Resemblances: These are small and slightly deformed specimens that come close to *Eurydesma cordatum* Morris from the Allandale Formation of north Sydney Basin, and widely reported from elsewhere, as summarized by Waterhouse (1987b), with further overview by Waterhouse (2015). It is difficult to specifically identify single small valves of *Eurydesma*, but certainly the present specimens belong within the *E. cordatum* superspecies, which includes such species as *E. glaebula* Waterhouse,

2015. They differ strongly from the plexus of species that includes *E. ovale* Etheridge Jnr. & Dun, 1910 with high suboval shape, and *E. protrudus* Waterhouse with *E. alisulcatum* Waterhouse, which are little inflated shells with long anterior margin, and in some species, well developed posterior wing, as summarized in Waterhouse (2015). But the small size of present specimens must imply that they were only in an early growth-stage. The mature *E. cordatum* usually develops a distinct lateral sulcus, and this is not visible on present material, quite likely because the present specimens are all immature, and so too small to show the sulcus that develops during maturity. A somewhat similar species *E. glaebula* that lacks the sulcus even into maturity is found in the lower Tiverton Formation of the northern Bowen Basin in Queensland (Waterhouse 2015, p. 283), and identity with this form cannot be ruled out in view of the small size of the Rammutt specimens.

Superorder CARDIIFORMII Férussac, 1822

Order CARDIIDA Férussac, 1822

Superfamily **KALENTEROIDEA** Marwick, 1953

Family **KALENTERIDAE** Marwick, 1953

Genus ***Stutchburia*** Etheridge Jnr., 1900

Type species: *Orthonota*? *costata* Morris, 1845, p. 274 from Broughton Formation (Wordian), south Sydney Basin, New South Wales, OD.

Diagnosis: Elongate equivalve or subequivalve shells, umbones small and anteriorly placed, lunule and deep escutcheon present, commarginal ornament traversed by costae radiating from umbo in some species. Cardinals 2 and 3b obsolescent, P1 and P111 also obsolete and P11 well defined. Anterior adductor scar large, adjoining low myophore buttress posteriorly, posterior adductor scar large, less impressed.

Stutchburia simplex (Dana, 1847)

Fig. 10C

1847 *Modiolopsis simplex* Dana, p. 159.
1849 *Cypricardia simplex* – Dana, p. 703, pl. 9, fig. 2.
1900 *Stutchburia simplex* – Etheridge Jnr., p. 182.
1988 *S. simplex* – Waterhouse, p. 177, pl. 5, fig. 2.

Holotype: USNM 3632, sole specimen described and figured by Dana (1849), by monotypy, from Allandale Formation (Asselian) at Hunter Valley, north Sydney Basin, New South Wales.

Diagnosis: Small elongate shells without costation.

Description: A left valve QM F 14411 is 38 mm long, 21 mm high and about 5 mm thick, with umbo placed well forward, and no sign of radial ribs. There are subdued growth lirae which are not laminate, and no sign of muscle scars.

Resemblances: This specimen looks very close to the specimen figured by Dana (1849).

Megaorder SOLENATA Dall, 1889

Order HIATELLIDA J. Carter in Carter et al. 2011

Superfamily **EDMONDIOIDEA** King, 1850

Family **PACHYDOMIDAE** Fischer, 1886

Subfamily **PACHYDOMINAE** Fischer, 1886

Genus ***Pyramus*** Dana, 1847

Type species: *Pyramus myiformis* Dana, 1847, p. 157 from Gerringong Volcanics (Wordian), south Sydney Basin, New South Wales, SD Newell (1956, p. 7).

Diagnosis: Distinguished chiefly by its elongate outline, low to moderate inflation and pedal musculature, involving small scars attached to anterior adductor, large discrete anterior retractor, possible umbonal retractor below umbo, and small posterior retractor attached to posterior adductor.

Discussion: As shown by Waterhouse (1965a) and confirmed by Runnegar (1967), the pedal musculature differs somewhat from that of *Megadesmus* Sowerby, 1838.

Pyramus laevis (Sowerby, 1838)

Fig. 11A - G

1838 *Megadesmus laevis* Sowerby, p. 15, pl. 3, fig. 1.

1838 *M. cuneatus* Sowerby, p. 15, pl. 3, fig. 3.

1838 *M. antiquatus* Sowerby, p. 15, pl. 3, fig. 2.

1845 *?Pachydomus globosus* [not Sowerby] – Morris, pl. 10, fig. 3, 4.

1847 *P. ellipticus* Dana, p. 157.

1847 *P. cuneatus* – Dana, p. 160.

1847 *P. antiquatus* – Dana, p. 160.

1849 *Astartila cyprina* [not Dana] – Dana, p. 689 (part).

1849 *P. cuneatus* – Dana, p. 693, pl. 5, fig. 1a-b.

1849 *P. antiquatus* – Dana, p. 693, pl. 5, fig. 2.

1849 *Maeonia elliptica* Dana, p. 697, pl. 6, fig. 5a-c (part, not fig. 6, 6a = *myiformis*).

1877 *P. laevis* – de Koninck, p. 214, pl. 20, fig. 1.

1898 *P. laevis* – de Koninck, p. 200, pl. 20, fig. 1.

1907 *Notomya* (*Megadesmus*) *cuneata* – David, pl. 34, fig. 2.

1956 *Pachydomus cuneatus* – Newell, Fig. 2A, B.

1958 *Pachydomus cuneatus* – Müller, p. 523, fig. 639.

1966 *Pyramus laevis* – Runnegar, p. 375, fig. 1.

1967 *Pyramus laevis* – Runnegar, p. 34, pl. 1, fig. 1-12, pl. 2, fig. 1-10, text fig. 4.

1967 *Pyramus concentricus*? [not Etheridge] – Runnegar, pl. 3, fig. 8-11, 13.

1968 *Pyramus laevis* – Runnegar, pl. 19, fig. 2-8, pl. 20, fig. 1, 7-9, 13.

1969a *Pyramus laevis* – Runnegar, p. 284, pl. 18, fig. 1-6.

1969a *Pyramus laevis* – Waterhouse, p. 48, pl. 9, fig. 3, text fig. 23.

1969a *Notomya cuneata* – Waterhouse, p. 51, pl. 8, fig. 5, pl. 10, fig. 2, 4, text fig. 26, 27.

1974 *Pyramus laevis* – Runnegar, pl. 1, fig. 11, 12.

1987 *Pyramus antiquatus* – Waterhouse & Balfe, pl. 1, fig. 12.

1988 *Pyramus laevis* – Waterhouse, pp. 48, 187, pl. 9, fig. 6, pl. 13, fig. 4, pl. 14, fig. 2, 3, pl. 15, fig. 2, 5, 7, 8.

Holotype: (by monotypy), NHM L 61050, figured by Sowerby (1838, pl. 3, fig. 1) and refigured by Runnegar (1967, pl. 1, fig. 1) from Allandale Formation, Harper's Hill, north Sydney Basin. Further types are cited by Runnegar (1967, p. 34).

Diagnosis: Subrounded shells with broad umbo placed behind anterior third of shell length, shell thin, exterior surface marked by low growth lines and rugae. A second subset has thick shell and high growth rugae (*antiquatus*).

Dimensions in mm of *Pyramus laevis*:

Locality	Length	Height	Width	Umbo from anterior
laevis				
QM F 14413	55	41	10	19
antiquatus morphotype				
GSQ L 206	58	45	31	21
GSQ F 13164	35	26	16	12

Discussion: Several specimens belong to this species and show the typical outline and low ornament. A shallow sulcus extends ventrally near mid-length. The species has been discussed by Runnegar (1967) and Waterhouse (1988). Runnegar (1967) synonymized *Pyramus laevis* (Sowerby) with *antiquatus, cuneatus* and *ellipticus*, and the forms are all somewhat similar in shape, although not fully identical, and come from the same Allandale beds at Harper's Hill, Hunter Valley, New South Wales. The synonymy was followed by Waterhouse (1988), but he showed that statistically two groups could be distinguished on dimensions, and the more inflated less high shells were further characterized by thick shell and ragged strong ornament (*antiquatus*), in contrast to the more slender shells with thin shell and fine commarginal growth rugae (*laevis*). The same two groups are found at Gympie, but all specimens are little inflated. The statistical analysis in Waterhouse (1988) is based on very few specimens, and further study is required to establish whether one or two species are present, but it does appear that two morphotypes could prove to be separable, based on differences in inflation and the thickness and surface of the shell.

A suite of shells ascribed by Runnegar (1967 pl. 3, fig. 8-11, 13) to *Pyramus concentricus*? (Etheridge Snr., 1872) is shaped very like *P. antiquatus*, rather than the elongate outline with anteriorly placed broad umbones seen in *concentricus*. They come from the Lizzie Creek Volcanic Group of the Bowen Basin, and early Permian faunas of the south Sydney Basin. The specimen of Runnegar (1967, pl. 3, fig. 7) from the "*Eurydesma*" beds near Warwick, south Queensland, might also be related.

The identification of a shell fragment with *Pyramus laevis* by Archbold (2003, Fig. 5.12) from the Cranky Corner Sandstone of the Cranky Corner Basin in New South Wales cannot be verified from the figure provided, and no description was provided.

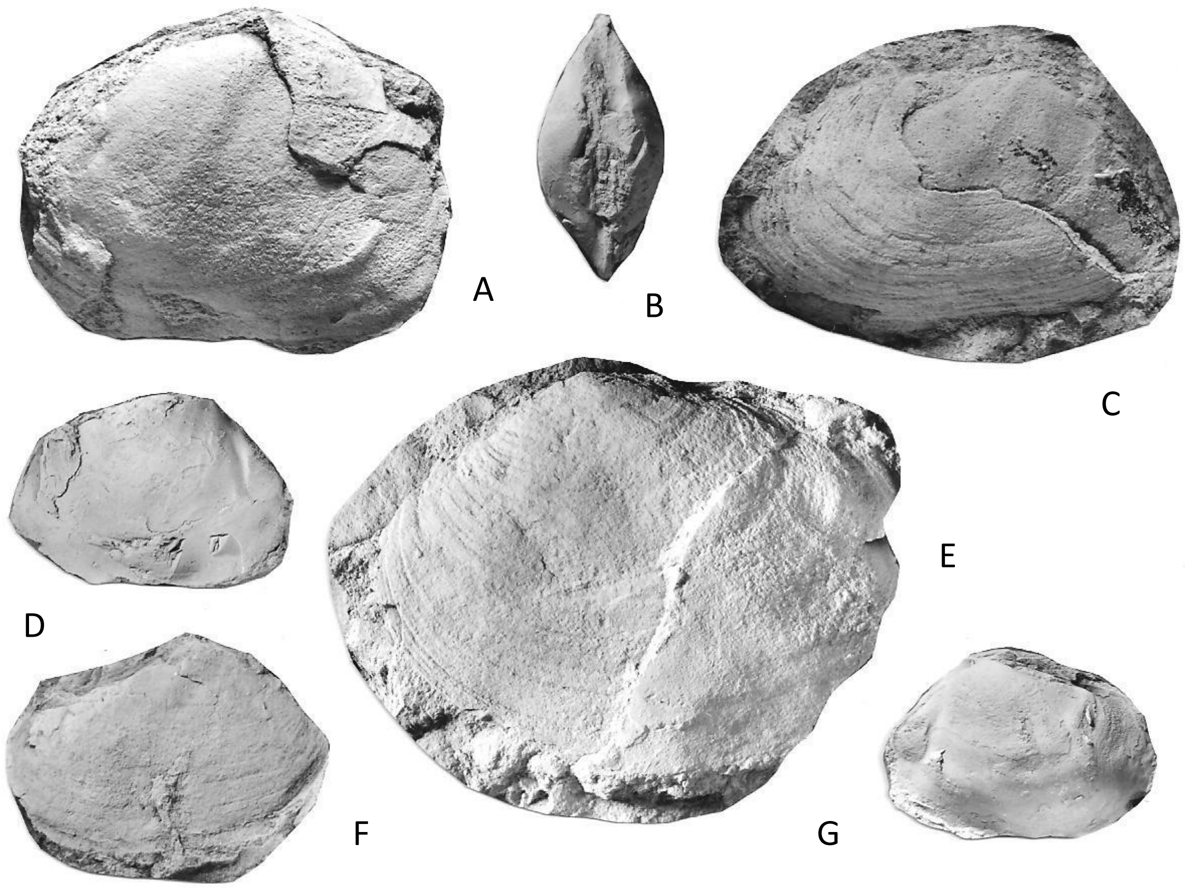


Fig. 11. *Pyramus laevis* (Sowerby). A, right valve QM F 14412 from Lady Mary Reef. B, D, G, decorticated mould, dorsal (anterior above), right lateral and left lateral aspects of GSQ F 13164 from GSQ L 206. C, right valve QM F 14398. E, left valve GSQ F 13165, locality uncertain. F, right valve side of GSQ F 13166 from GSQ L 191. Specimens x1.

Pyramus concentricus (Etheridge Snr., 1872)

Fig. 12A – F

1872 *Edmondia concentrica* Etheridge Snr., p. 328, pl. 13, fig. 2.

1872 *E. obovata* Etheridge Snr., p. 328, pl. 13, fig. 3.

1892 *Sanguinolites concentricus* – Jack & Etheridge Jnr., p. 281, pl. 43, fig. 7.

1961a *Pyramus concentricus* – Dickins, p. 128, pl. 16, fig. 1, 2.

1964 *P. concentricus* – Hill & Woods, pl. 10, fig. 12.

1967 *P. concentricus* – Runnegar, p. 40, pl. 3, fig. 2-6.

1972 *P. concentricus* – Hill, Playford & Woods, pl. 10, fig. 12.

1987 *P. concentricus* – Waterhouse & Balfe, p. 30, pl. 1, fig. 9.

Neotype: GSQ F 9285, from fossiliferous green sandstone of Gympie, figured by Etheridge Jnr., (1892, pl. 43, fig. 7), designated by Runnegar (1967, p. 41). The original figured specimens of *concentrica* and *obovata* have been lost (Runnegar 1967, p. 41). According to Parfrey (1996, p. 204), the neotype GSQ F 9285 was cited by Runnegar for a left valve figured in Etheridge Jnr. 1892, pl. 43, fig. 7, and described as a cast (ie. external mould). A left valve was wrongly cited as the same neotype by Runnegar as figured by Dickins (1961a, pl. 16, fig. 1), Hill & Woods (1964, pl. 10, fig. 12) and Hill et al. (1972, pl. 10, fig. 12). This latter specimen according to Parfrey is GSQ F 1557. Curiously it shows the same anterior breakage and general shape as the Etheridge specimen, and is a solitary valve. Locality data in Runnegar (1967) was also corrected by Parfrey (1996, p. 204).

Diagnosis: Elongate little inflated shells with anteriorly placed umbo and low ornament.

Dimensions in mm of *Pyramus concentricus*:

Specimen/locality	Length	Height	Width	Umbo from anterior
GSQ F 14	34	19	5	10.5
GSQ F 13172	65	36	12	15

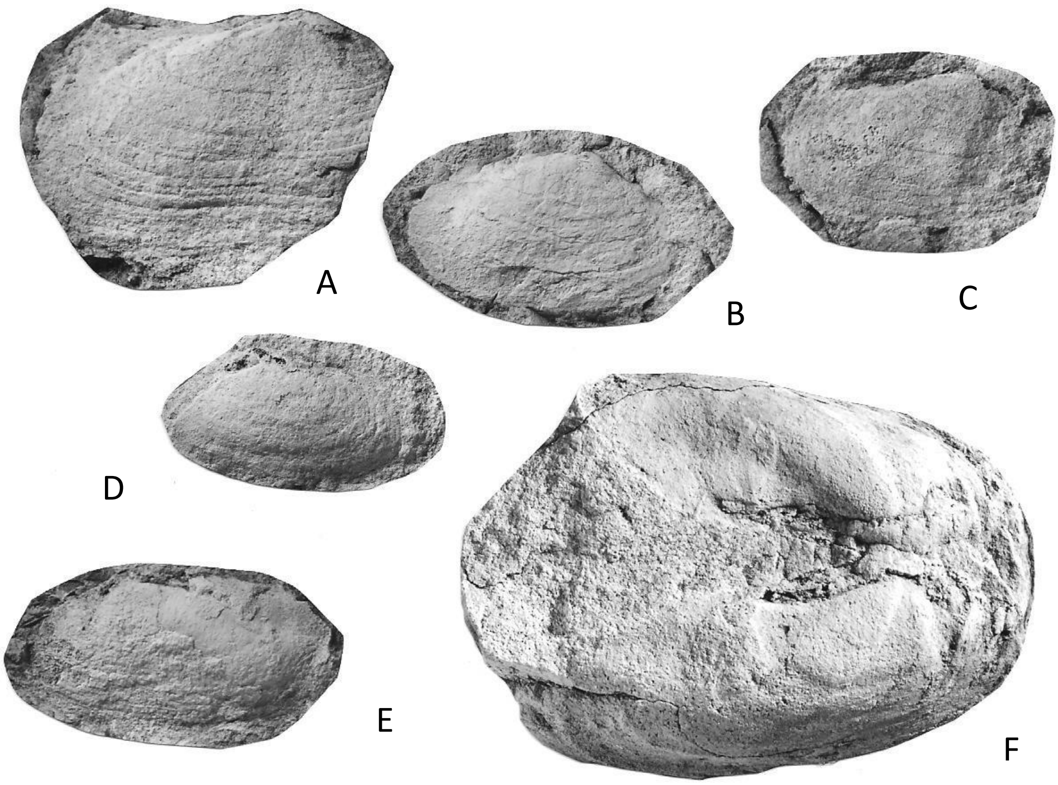


Fig. 12. *Pyramus concentricus* (Etheridge). A, right valve GSQ F 13170 from GSQ L 188. B, right valve GSQ F 13173 from GSQ L 188. C, right valve GSQ F 13166 from GSQ L 191. D, left valve GSQ F 13171 from GSQ L 188. E, left valve GSQ F 13174 from GSQ L 188. (See Runnegar 1967, pl. 3, fig. 5 for somewhat similar specimen registered as GSQ F 9287). F, dorsal aspect of both valves, anterior to right, GSQ F 14 from GSQ L 188. Specimens x1.

Discussion: A number of specimens from GSQ L 188 belong to this species, with thin shell, broad sulcus below the umbo in most shells, low growth ornament, and broad low umbones. The species has been redescribed by Dickins (1961a) and Runnegar (1967). Shells appear to vary in height and position of umbo but few are complete enough to be measured adequately. The species looks as though it were ancestral to *Pyramus myiformis* Dana, 1847. Runnegar (1967) described *Pyramus concentricus*? from various early Permian faunas in the Sydney Basin, New England, and Bowen Basin, but none of the specimens are close, being much higher shells with narrower umbones and concave dorsal posterior margin, as in the *P. antiquatus-laevis* suite.

One of the present specimens from GSQ L 188, with valves splayed open (Fig. 12F), is very like the type of *Edmondia obovata* Etheridge in outline, with anteriorly placed umbones and elongate posterior, but is a little more inflated than usual and has a well defined lateral sulcus. It looks a little like *Australomya hillae* Runnegar, 1969a from the lower Conjola Formation (now Wasp Head Formation) of south Sydney Basin, a more slender and elongate shell tending to have a somewhat concave dorsal posterior margin, but has a more anteriorly placed umbo, less rounded anterior shell and better defined lateral sulcus.

Class Gastropoda Cuvier, 1797

Order PATELLIDA Rafinesque, 1911

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **SINUOPEIDAE** Wenz, 1938

Subfamily **TURBONELLINAE** Knight, 1956

Genus ***Paraplatyschisma*** Waterhouse, 1983

Type species: *Planikeeneia branxtonensis* Fletcher, 1958 from Elderslie Formation (Wordian), north Sydney Basin, OD.

Diagnosis: Shells with inflated rounded whorls, notch in aperture well below mid-height, spire moderately large, ornament of radial growth lines and faint spiral ribs. Base closed by plug as a rule, but spire may be more openly coiled.

Paraplatyschisma sp.

Fig. 13A - C

Diagnosis: Moderately large shells with prominent spire, weak growth lines, wrinkles and fine spiral threads.

Description and Resemblances: A few specimens are available, mostly squashed, broken and decorticated. The best preserved is deformed, but with other fragments shows the subglobose whorls typical of the genus, anomphalous base, and radial spiral ribs, seven in 5mm over the base, though these are not visible in the illustrations. The spire is high, but not as high with such swollen whorls as seen in the closely related species *Paraplatyschisma etheridgei* Waterhouse, 1987b from the Fairyland, Elvinia and Rose's Pride Formations in the southeast Bowen Basin. *Paraplatyschisma rotunda* (Etheridge Snr., 1872, pl. 18, fig. 3) comes from the same beds at Cracow, and was also figured by Etheridge Jnr. (1892, p. 286, pl. 15, fig. 6) and Waterhouse (1987b, p. 177, pl. 11, fig. 9-11, 15, 16) and includes *Keeneia afflicta* Wass (1967, p. 70, fig. 2), also figured by Hill & Woods (1964, pl. 12, fig. 14) and Hill, Playford & Woods (1972, pl. 12, fig. 14). The selenizone is placed in comparable position, but its whorls are slightly less extended and more globose, arguably though doubtfully due to compression of the Gympie specimens. *Keeneia twelvetreesi* Dun, 1913 from the *Strophalosiaria concentrica* Faunizone 1 in the Tasmanites shale of Tasmania (Calver et al. 1984) is somewhat similar in appearance, but is described as deeply umbilicate, and the whorls expand less rapidly. No umbilicus is present in the material from Gympie.

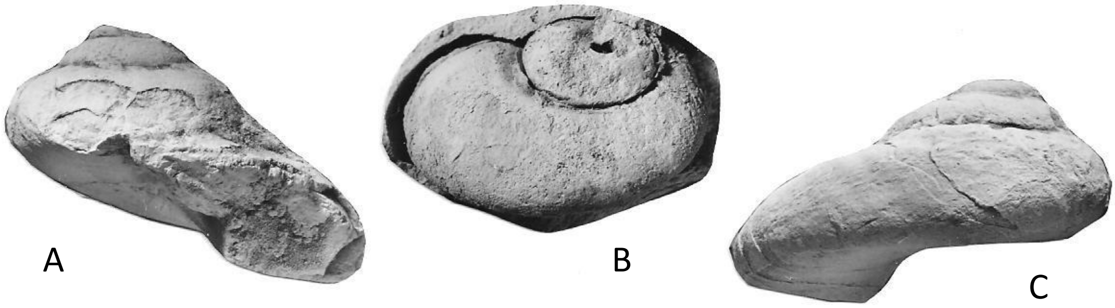


Fig. 13. *Paraplatyschisma* sp. A, C, apertural and abapertural aspects of GSQ F 13177 from GSQ L 1446. B, oblique lateral view of QM F 14507 from GSQ L 182. Specimens x1.

CORRELATION

Several of the species from the Rammutt "fossiliferous green sandstone" indicate correlation with the Allandale Formation of the north Sydney Basin, and the upper Wasp Head Formation of the south Sydney Basin. A specimen is close to *Pseudosyrinx allandalensis* Armstrong from these formations and also reported from the Lower Bowen Volcanics (= Lizzie Creek Volcanic Group) of the north Bowen Basin. *Betaneospirifer dubius* (Etheridge) is possibly represented in the Wasp Head Formation of the south Sydney Basin. Amongst the bivalves, *Pyramus laevis* (Sowerby) is characteristic of the Allandale Formation, and *laevis* was also reported from the lower Conjola Formation, now Wasp Head Formation, of the south Sydney Basin. *Eurydesma* is probably juvenile *E. cordatum* Morris, which is especially typical of the Allandale and correlative beds (Waterhouse 2015) and *Stutchburia simplex* (Dana) has been reported only from the Allandale fauna. *Squamuliferipecten squamuliferus* (Morris) is also found at this level, but ranges into younger Permian beds. *Paraplatyschisma* is close to but not fully identical with *P. rotunda* (Etheridge), which ranges from the Fairyland Formation into the Elvinia Formation, of Sakmarian age, and Rose’s Pride Formation, of lower Artinskian age. Some of these species are also reported in early Permian faunas of Tasmania by Clarke & Banks (1975, p. 456), with systematic descriptions provided by Clarke (1990, 1992a).

The early Permian *Strophalosiaria concentrica* fauna is slightly older than the faunas of the Allandale Formation. This fauna was stated to be typified by streptorhynchids which were missing from the overlying *Crassispinosella subcircularis* fauna. The presence of a fragment of streptorhynchid in the Rammutt collection thus might suggest a possible correlation. The present fauna differs substantially from that of the upper Rammutt beds, which are dominated by productids and fenestellid bryozoa, and have no specimens of *Monklandia*, and virtually no bivalves.

The age of the Allandale and Wasp Head Formations of the Sydney Basin and allied faunas of Tasmania has been considered to be Asselian (Table 1) by Waterhouse (1976a, 2008b), based primarily on overall relationships with faunas and sequential changes in the Permian of south Asia, and is further discussed in Waterhouse (2015, pp. 18 - 47).

TABLE 5. Faunal list for GSQ brachiopods and bivalves from the "fossiliferous green sandstone" in the lower Rammutt Formation, with numbers of specimens from fossil localities. First figure - ventral or left valve, second figure - dorsal or right valves, third figure - conjoined valves; f = fragment. A dorsal valve of *Permasyrinx allandalensis* comes from an uncertain locality, formerly F 17, and the gastropod *Paraplatyschisma* is represented by eleven specimens from L 182, two specimens from L 191, seven specimens from L 201 and single specimens from L 188, L 204 and L 1446, all GSQ localities.

	L179	L182	L188	L191	L201	L204	L205	L206	L209	L212	L1440	L1443
Gympietes aseptus	1,3, 0	72,8,0		4,2,0	4,1,0				4,2,0	13,11,0	1,1,0	
Monklandia gympiensis		3,5,0	1,1,0	2,0,0	13,19,0					3,1,1	1,0,0	1,2,0
Notospirifer sp.					1,0,0							
Betaneospirifer dubius		3,0,0		1,0,0	0,1,0						1,0,0	
Permasyrinx ? acuta										0,1,0		1,0,0
Sulcicosta sp.		0,1,0										
Trabeculatia sp.					1,0,0							
Squamuliferipecten squamuliferus		1,0,0	2f		1,0,0			0,0,1				
Corrugopecten sp.												1,0,0
Eurydesma sp.				0,1,0								
Pyramus laevis		0,2,0	2,0,0	5,6,0	3,5,0	2,0,0	1,1,0	0,0,1	0,0,2	?1,0,0		
P. concentricus	1,1,0		8,7,2	4,4,0	4,4,1		6,5,0					

TABLE 6. Locality details for specimens from Gympie made for Geological Survey of Queensland, as recorded in GSQ files.

Register No.	**Details as recorded**.
L 179	From S Homeward Bound and Hibernia in 175' crosscut; 130' W from shaft, Gympie area 50 links S of Gympie Homeward Bound No. 3 shaft, Gympie area.
L 182	50 links S of Gympie Homeward Bound No. 3 shaft.
L 188	Commissioner Gully at Louisa Street.
L 191	From Columbia Extended.
L 201	Boddington's Paddock, Horseshoe Bend.
L 204	From Mullock Tip, No.3, North Columbia.
L 205	From 1 North Brickfield mullock tip.
L 206	From 1 North New Zealand.
L 209	Fossils from 1 N Phoenix.
L 212	From 2 N Columbia Smithfield.

L 1440 7 & 8 S Lady Mary.

L 1443 New Zealand PC.

L 1446 4 N Phoenix.

TABLE 7. Queensland Museum fossils. At the initial time of study in the 1980's, a QM F number was assigned to one specimen that was associated with a number of other unregistered specimens from the same unnumbered locality, often on the same block. Most are labelled only as coming from Gympie: additional information is shown where available. Subsequently several have been allocated fresh QM F numbers. *Undopecten imbricatus* may have come from one of these localities. This table shows associations within F numbers of 1980's.

QM F number Specimens

1208a,b Streptorhynchid dorsal valve, *Betaneospirifer dubius* ventral valve, *Permasyrinx allandalensis*, *Squamuliferipecten multiradiatus* Etheridge Snr. (= *squamuliferus*) left valve and holotype, left valve, *Paraplatyschisma* sp. one specimen, ?*Peruvispira* single specimen. Lady Mary Reef.

2086 *Monklandia gympiensis* ventral and dorsal valve, *Pyramus laevis* left valve.

2087 *Martiniopsis* sp. ventral valve, *Monklandia gympiensis* ventral valve.

3272 *Monklandia gympiensis* dorsal valve (Etheridge Snr., 1872, pl. 16, fig. 4).

3273 *Monklandia gympiensis* two dorsal valves.

5639 *Permasyrinx*? *acuta* holotype.

14386 *Betaneospirifer dubius* ventral valve, *Pyramus laevis* left valve.

14387 *Monklandia gympiensis* fragments.

14391 *Monklandia gympiensis* dorsal valve, *Squamuliferipecten squamuliferus* rlght valve and fragment.

14392 *Pyramus concentricus* left valve.

14394 *Betaneospirifer dubius* fragment.

14398 *Monklandia gympiensis* seven ventral valves, *Pyramus laevis* eight+ valves.

14402 *Betaneospirifer dubius* ventral valve.

14404 *Permasyrinx? acuta.*

14405 *Betaneospirifer dubius.*

14407 *Permasyrinx? acuta* ventral valve, *Eurydesma* left valve. CaIedonian Hill.

14408 *Betaneospirifer dubius* dorsal valve.

14409 *Monklandia gympiensis.*

14411 *Betaneospirifer dubius* ventral valve, *Ambikella* sp. two ventral valves (including newly allocated QM F 17745), *Stutchburia simplex* left valve, *Pyramus laevis* two right and two left valves. Lady Mary Reef.

14412 *Pyramus laevis* right and left valve. Lady Mary Reef.

14413 *Pyramus laevis* right and left valve. Lady Mary Reef.

3. BRACHIOPODA AND BIVALVE FROM THE UPPER RAMMUTT FORMATION

SUMMARY

Brachiopods and a bivalve are described from the Monkland shales (= Pengelly Member?) of the upper Rammutt Formation, which had yielded most of the gold recovered from the Gympie area by 1990. New taxa are *Magniplicatina dunstani* n. sp. and *Hoskingia glabra* n. sp. The fauna contains *Protoanidanthus pokolbinensis*, *Bandoproductus macrospina* and *B. walkomi* found in the Sydney Basin and Yarrol Basin of New South Wales and Queensland, and is considered to be correlative with the upper Burnett Formation of the Yarrol Basin and lower Rutherford Formation of the Sydney Basin. These levels are late Asselian in age, older than the so-called Fauna 11 levels of the Farley Formation and Tiverton Formation. Some of the genera in the member are unusual for faunas of east Australia, and point to conditions warmer than usual.

INTRODUCTION

The Monkland beds were named by Rands (1889, see Jack & Etheridge Jnr. 1892) for the upper gold-bearing shales in the Permian succession at Gympie, southeast Queensland, just below the thick carbonates now called the South Curra Limestone (see Waterhouse & Balfe 1987). They were also called the Phoenix beds. The name Monkland is applied to a road and an old mine at Gympie. According to Rands (1889) and Dunstan (1911), two bands of fossiliferous shale are present, over a thickness estimated to be 202ft. The section of rocks and fossils as envisaged by early workers is presented on p. 9. A different sequence, with different names, is presented on the same page (p. 9) from Arnold (1996), based on cores near the Eldorado Gold Mine near Gympie. Carbonaceous siltstone was named by Arnold as the Pengelly Siltstone, less than 50m thick, which is close in thickness to that of the Monkland or Phoenix beds. But no fossils were documented in Arnold's summary, and carbonaceous shale and siltstone are also found in the overlying upper Nash clastics. The Arnold names remain in limbo, pending clarification over boundary limits, fossil content, and delineation of lateral variation, and await application of the rules of stratigraphic nomenclature. Insofar as the units named upper Nash, Pengelly and lower Nash are contained within the Rammutt Formation, they must be considered to be members, and it appears preferable to modify the upper and lower titles with a distinct name for lower Nash, assuming a simple sequence. Up till now, no clear justification appears to have been published for disposing of the name Monkland, and given the apparent confusion between "upper Nash" and Pengelly, as elaborated on p. 120, the new and informal proposals have not exactly proved themselves as unambiguous and useful. So in the meantime, the names are used informally, and the earlier names are more readily applied to fossils and their distribution. It has long been the custom to defend and adjust earlier proposed units, and extend courtesy to early authors, provided the names can be applied with some tightening of definitions. In this case, Monkland has been used in the literature from the nineteenth century through to 1987, and has the advantage for the present study of being more securely related to the occurrence of fossils. But validation or firm rejection awaits proper and formal application according to the rules of stratigraphic nomenclature.

Fossils were described from the Monkland shales principally by Etheridge Snr. (1872) with species now ascribed to forms of *Protoanidanthus, Magniplicatina* and *Bandoproductus*. Etheridge thought that the beds were Devonian, even though species included one assigned to *Productus cora* d'Orbigny, a well known species of early Permian age (or arguably in those days, late Carboniferous). Some of his specimens are intact at the Queensland Museum and Geological Survey of Queensland, but labels are damaged, and in part indecipherable. Jack & Etheridge Jnr. (1892) repeated Etheridge's identifications, but dated the fossils as Permo-Carboniferous. Runnegar & Ferguson (1969, p. 251) stated that the Phoenix or Monkland slate applied to the first thick shale below the South Curra Limestone, but Rands (1889) did incorporate two shale bands. They classed the fauna as part of the Rammutt Formation, and treated it as Early Permian, or what Dickins (1964) had called "Fauna 11" (see Table 2, p. 4), which is found widely in east Australia (Dickins & Malone 1973), and is represented in the Fairyland, Elvinia, Cattle Creek and Tiverton faunas of the Bowen Basin and Yarrol Formation of the Yarrol Basin to the north and west of Gympie. It is further established that the fauna is not completely like that of other Early Permian faunas of east Australia, several brachiopod genera being restricted to this Gympie fauna. The presence of *Protoanidanthus pokolbinensis* and *Bandoproductus* suggests a likely tie with the *Bandoproductus macrospina* Zone (Waterhouse 2008b), found in the Yarrol Basin and Sydney Basin below typical "Fauna 11".

Most of the collections were made by D'Oyly Aplin, Government Geologist of southern Queensland in the 1860's (Woods 1964) during the days of active mining, and came from subsurface outcrop, collected as small slabs which are densely covered with shells. The matrix is dark grey, and generally consists of fine sandstone, silty-muddy sandstone, or sandy siltstone, with green medium-fine sandstone much less common. One intriguing aspect is the occurrence of large isolated boulders in the "Upper or thick Bed of Shale" (Rands in Jack & Etheridge Jnr. 1892, p. 77), including boulders of fine siliceous greywacke, coarse greywacke, and granite, as if dropped by ice. Yet the fauna from the shale points to conditions warmer than usual, so possibly the boulders were emplaced through submarine sliding, reworked from till, or lahar deposits, in either case the source unknown, but likely to have been from the volcanic arc.

The subsurface shells are generally deformed, with shell replaced partly by the zeolite chamosite and in some cases, pyrite. For most fossils, locality detail is sparse. Specimens collected for the University of Queensland came from the Dawn Pocket of the Mary River and are in silty fine sandstone, and preserved as naturally weathered casts, not very deformed.

SYSTEMATIC DESCRIPTIONS

Phylum Brachiopoda Duméril, 1806

Order CHONETIDA Muir-Wood, 1955

Family **RUGOSOCHONETIDAE** Muir-Wood, 1962

?**Gympietes** sp.

Fig. 17A

See p. 13 for typology, synonymy and diagnosis.

Description: The interior of a transverse ventral valve QM F 14428 is available, with shell penetrated by pyrite. The exterior is possibly smooth and not costate, judged from an anterior fragment of the exterior surface, without conspicuous body spines. A very shallow anterior sulcus is developed. The ventral median septum is well developed posteriorly, and extends as a fine almost imperceptible ridge a little beyond mid-length. Dorsal valve with maximum width at mid-length, gently concave, with median anterior flattening, and smooth non-costate shell.

Discussion: *Gympietes* n. gen., n. sp. from underlying beds in the Rammutt Formation at Gympie has only a shallow or no sulcus, a smooth exterior, and short median septum. Present material is too sparse and poorly preserved to allow secure determination. The sulcus on *Tivertonia yarrolensis* (Maxwell, 1964) from the Yarrol Basin of Queensland is broader than on this specimen, and *Svalbardia armstrongi* Waterhouse (2014), which is found abundantly towards the top of the *Bookeria geniculata* Zone in the Tiverton Formation of the northern Bowen Basin in Queensland, has virtually no sulcus, and longer, stronger ventral septum. *S. saeptata* Waterhouse (2015, p. 68) from the Farley Formation of the Sydney Basin in New South Wales is distinguished by its exceptionally long dorsal septum, long ventral septum and presence of sulcus in many specimens.

Suborder STROPHALOSIIDINA Waterhouse, 1975

Superfamily **STROPHALOSIACEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Dasyalosiid gen. & sp. indet.

Fig. 17B

Description: Shell of moderate size, subquadrate in shape, hinge just over half the width of shell, cardinal extremities angular-obtuse at 110-120^{o}, maximum width in front of mid-length. Large cicatrix on ventral umbo; ventral interarea low, 1-2.5mm high, dorsal interarea very low. Ventral valve gently convex overall, with no well defined sulcus, dorsal valve gently concave, possibly a little thickened, without dorsal fold, short subgeniculate trail and no ventral geniculation. Ventral valve bears relatively large erect spines up to 1.1mm in diameter; spines 2-3mm apart along rows, 1.5-2mm apart between rows over mid-valve. Poor preservation obscures further detail. Dorsal spines poorly exposed, fine and erect, three in 2mm in parts, but full distribution obscure. Their presence shows that the material is dasyalosiid. Low commarginal wrinkles also cover ventral valve, 1-2mm apart, and growth steps are present on the dorsal valve.

Dorsal median septum long; dorsal adductor scars small and rounded. Other detail not exposed.

Resemblances: The overall shape, short hinge, gently concave dorsal valve and strong ventral spines are features shared with *Pseudostrophalosia jukesi* (Etheridge, 1880), assigned to a genus proposed by Clarke (1970). The species was originally described from the Berriedale Limestone of Tasmania, and has been revised by Maxwell (1954a). Various features cannot be adequately compared, and it appears that the ventral spines are more erect than in *jukesi*, in which spines are sturdy but generally flattened against the shell, and the dorsal valve is apparently less thickened than in *jukesi*.

Briggs (1998, p. 76) recorded *Echinalosia warwicki* (Maxwell) at GSQ L 184, located at a mullock heap from Smithfield Phoenix Golden Mile, Gympie, but it has not been possible to check this occurrence for the present study.

Suborder LINOPRODUCTIDINA Waterhouse, 2013

Superfamily **PAUCISPINIFEROIDEA** Muir-Wood & Cooper, 1960

Family **ANIDANTHIDAE** Waterhouse, 1968b

Subfamily **ANIDANTHINAE** Waterhouse, 1968b

Genus ***Protoanidanthus*** Waterhouse, 1986a

Type species: *Protoanidanthus compactus* Waterhouse, 1986a, p. 60 from Dresden Formation (Sakmarian), southeast Bowen Basin, Queensland, OD.

Diagnosis: Small shells with reduced dorsal ears lacking alar extensions, and comparable ventral ears; ornament much as in *Anidanthus*.

Protoanidanthus pokolbinensis Briggs, 1998

Fig. 14A, B

1872 *Strophomena rhomboidalis* var. *analoga* [not Phillips] – Etheridge Snr., p. 331, pl. 15, fig. 5 (part, not pl. 15, fig. 3, pl. 16, fig. 7 = *Magniplicatina dunstani*; pl. 18, fig. 1 = indet.).

1892 *Strophomena rhomboidalis* var. *analoga* – Etheridge Jnr., p. 245 (part, not pl. 12, fig. 9 = *dunstani;* not fig. 8, pl. 40, fig. 6 indet.).

1998 *Protoanidanthus pokolbinensis* Briggs, p. 199, Fig. 95E-O.

Holotype: UQ F 75348 from Silver Spur beds (Asselian) of Texas area, Queensland, figured by Briggs (1998, Fig. 95J, K), OD.

Diagnosis: Ribs moderately fine and ventral spines not conspicuous.

Description: Shells with well formed moderately large but not huge ventral ears, dorsal ears large with alate extremities, but not extended forward or laterally; swollen ventral valve may have posterior sulcus and anterior fold, coarse costellae, numbering 14-16 in 10mm, crossed by low rugae over trail. Dorsal valve coarsely costate, crossed by moderately low commarginal rugae and laminae. Spine detail not clear, some spines appear to be present near start of trail, no dorsal spines.

Briggs (1998) recorded the species, together with *Bandoproductus*, from the Rutherford Formation of New South Wales, and specimens are also found in the Kolbar Formation (see p. 126).

Resemblances: *Anidanthus springsurensis* Booker, 1932 from the Cattle Creek and Rose's Pride Formations of the western Bowen Basin has finer radial ornament, ribs numbering from 17-25 in 10mm, and is readily distinguished by its larger dorsal ears and wedge-like dorsal valve (Waterhouse 2013, pp. 327-329). Well preserved specimens figured as *Anidanthus springsurensis* (not Booker)

A

B

Fig. 14. A, rock slab from UQ L 2773 with dorsal valve of *Protoanidanthus pokolbinensis* Briggs (UQ F 46607) and *Magniplicatina dunstani* n. sp. (UQ F 46606) including a ventral valve external mould with row of prominent hinge spines. B, slab from UQ L 2773 with the same species, UQ F 45609. Specimens x2.

from Prospectus Creek, south Bowen Basin, by Parfrey (1986, Fig. 2.2a-d) belong to *Protoanidanthus*. The Prospectus Creek specimens have finer ribs and narrower but longer ventral ears than in *pokolbinensis.*

Gympie specimens have coarse costellae, ranging from 14-16 in 10 mm, moderately large ventral and dorsal ears, and dorsal ornament of prominent transverse ridges. The size of the ears and the strength of costae and moderate development of dorsal laminae and rugae are features that most strongly resemble aspects of *Protoanidanthus polkobinensis* Briggs (1998) from the *Bandoproductus*

Zone of the Silver Spur beds in the Texas area of south Queensland, and in this species spines are less conspicuous than in *P. compactus* Waterhouse, and dorsal commarginal rugae are stronger. The costae not as fine as those of *P. gosforthensis* Briggs, which has 26 to 30 ribs in 10mm, and less alate cardinal extremities.

Discussion: A specimen from the Lady Mary Reef figured by Etheridge Snr. (1872, pl. 15, fig. 5) was identified as *Anidanthus* by Hill (1950 p. 12), and ascribed by Runnegar & Ferguson (1969 p. 251) to *A*. *springsurensis* Booker.

Superfamily **PROBOSCIDELLOIDEA** Muir-Wood & Cooper, 1960

Family **PAUCISPINAURIIDAE** Waterhouse, 1986b

Subfamily **MAGNIPLICATIINAE** Waterhouse, 2001

Tribe **MAGNIPLICATIINI** Waterhouse, 2001

Subtribe **MAGNIPLICATIINAI** Waterhouse, 2001

Genus ***Magniplicatina*** Waterhouse, 1983

Type species: *Cancrinella magniplica* Campbell, 1953, p. 7 from Ingelara Shale (Roadian), southwest Bowen Basin, OD.

Diagnosis: Closely costate shells with ventral spines in one, two or three rows close to hinge, arranged in quincunx over venter with posteriorly prolonged bases, may be erect over trail, dorsal valve without spines, both valves covered by persistent usually strong rugae. Muscle scars faint, dendritic from early ontogeny, cardinal process trifid.

Magniplicatina dunstani n. sp.

Fig. 14A, B, Fig. 15A, B

1872 *Strophomena rhomboidalis* var. *analoga* [not Phillips] – Etheridge Snr., p. 331, pl. 15, fig. 3, pl. 16, fig. 7 (part, not pl. 15, fig. 5 = *Protoanidanthus pokolbinensis,* not pl. 18, fig. 1 = indet.).

1892 *S. rhomboidalis* var. *analoga* Etheridge Jnr., p. 245, pl. 12, fig. 9 (part, not fig. 8, pl. 40, fig. 6 = indet.)

Derivation: Named for B. Dunstan.

Holotype: QM F 14433, upper Rammutt Formation (Asselian), Gympie, figured herein as Fig. 15A, here designated.

Diagnosis: Small little inflated shells, with small ears and close-set fine wrinkles and fine capillae, ventral spines emerging from short and slender bases over body of shell.

Description: Specimens numerous and somewhat deformed, a ventral valve measuring 22mm wide, 19mm long and nearly 3mm high. Ventral valve gently convex with no sulcus or median flattening, ventral umbo broad with angle of 110-120^{o} and extended little beyond hinge, ventral umbonal slopes low, gently convex, cardinal extremities subangularly obtuse at 110^{o}, but acute with angle of 50-60° in some specimens, ears gently convex, maximum width of shell placed near mid-length. Dorsal valve gently concave with concave ears, short semi-geniculate trail. In ventral valve trail curves evenly on from the visceral disc, but may be crushed and appear geniculate. Both valves covered by fine even capillae, numbering 22-28 in 10 mm anteriorly; increase on ventral valve by intercalation, crossed by 19-20 fine wrinkles on both valves, with rounded crests and evenly concave interspaces, covering entire dorsal valve and most of ventral valve, but absent from anterior ventral valve and trail. Fine growth lines also present, numbering four to six per mm anteriorly. Ventral spines fine, cover entire valve, erect in two irregular rows over posterior ears; some erect over visceral disc and trail, most body spines emerge from slender slightly raised spine bases extended posteriorly for some 2-3mm. Dorsal valve bearing large pits along hinge, and lacking spines. Visceral disc less than 1mm thick in mature specimens, possibly a little compressed.

Ventral muscle scars scars slightly raised, subrounded in outline. Dorsal median septum extends to just past mid-length, narrow anteriorly. Muscle scars slightly raised, subrounded in outline.

Resemblances: This species is distinguished from *Bandoproductus*, which is common in the same beds, by its smaller size, closely spaced commarginal wrinkles, slender elongate ventral spine bases and often finer ribs. Several species of *Magniplicatina* from Permian faunas in east Australia and New Zealand are close in overall size, shape and ornament, but are distinguished by having much stronger and fewer commarginal wrinkles. *M. undulata* Waterhouse (1986a, p. 45, pl. 9, fig. 17-20) from the Elvinia Formation of the southeast Bowen Basin is moderately close in shape, and has comparable fine ribs, at 21-26 in 10mm**,** but spine bases are more prominent, and ears acute and projecting, often with a slightly wider hinge, and wrinkles are a little stronger.

Discussion: This is a common species in the Monkland beds. Two capillate productids of comparable size were figured by Etheridge Snr. (1872). One, as pl. 15, fig. 3, called *Strophomena rhomboidalis* var. *analoga* Phillips by Etheridge, is transverse with low close-set wrinkles, and apparently belongs to *Magniplicatina*. The other specimen (pl. 16, fig. 7), called *Strophomena rhomboidalis* var. in the plate caption, and *analoga* in the text (p. 331), from Gympie goldfield, has fine numerous wrinkles and fine costellae, with small protruding ears. The wrinkles curve hingewards over the median shell, but perhaps this was due to deformation. The specimen is now lost and its identity uncertain, but probably belonged to *dunstani*. The specimen was also figured under the same name in Jack & Etheridge Jnr. (1892, p. 245, pl. 12, fig. 9), the figure strongly suggesting that the hingewards inflection of commarginal rugae was a deformation during life.

Family **AURICULISPINIDAE** Waterhouse, 1986a

Subfamily **LYONIINAE** Waterhouse, 2001

Genus ***Bandoproductus*** Jin & Sun, 1981

Type species: *Bandoproductus hemiglobica* Jin & Sun, 1981, p. 138 from Bando Group (Asselian), Tibet, OD.

Diagnosis: Medium size, wide hinge, row of stout spines along hinge, spines numerous over venter with prolonged and swollen bases entering costae. Ventral adductor scars subrectangular.

Bandoproductus macrospina Waterhouse, 1986a

Fig. 15C-E, Fig. 16

?1892 *Productus* sp. ind. (a) Etheridge Jnr., p. 255, pl. 13, fig. 6.

1964 *Linoproductus* cf. *lyoni* (not Prendergast) – Maxwell, p. 43, pl. 7, fig. 28-31.

1976 *Linoproductus* cf. *lyoni* – Roberts et al. fig. 6.

1986a *Cancrinelloides* (*Bandoproductus*) *macrospina* Waterhouse, p. 57, pl. 13, fig. 13, 14, 17, 18 (part, not fig. 15, 16 = *walkomi*).

1987 *Cancrinelloides* or related genus Waterhouse & Balfe, pl. 1, fig. 13-15.

1998 *Bandoproductus macrospina* – Briggs, p. 155, Fig. 78A-D.

2008b *B. macrospina* – Waterhouse, p. 353, Fig. 3D.

Holotype: UQ F 43142 from Burnett Formation (Asselian), Yarrol Basin, Queensland, figured by Maxwell (1964, pl. 7, fig. 29) and Waterhouse (1986a, pl. 13, fig. 17).

Diagnosis: Large highly convexo-concave shells distinguished by moderately coarse costellae (ca. 11-16 in 10mm anteriorly), spines in row along hinge with a few additional spines, narrow spine bases in ventral valve, both valves bearing well defined commarginal wrinkles.

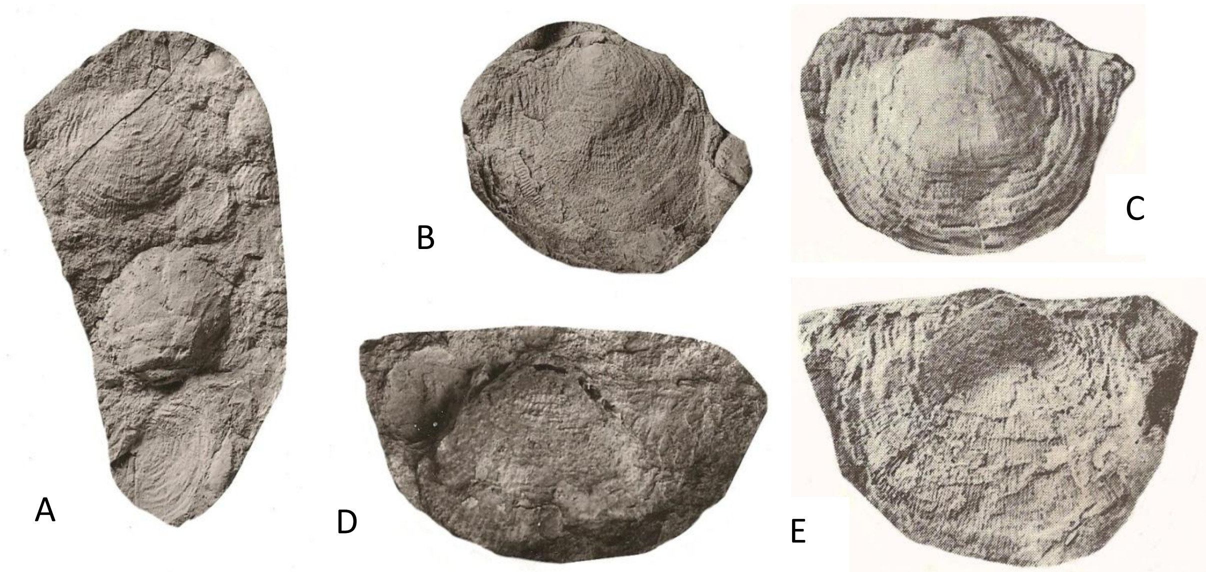


Fig. 15. A, B, *Magniplicatina dunstani* n. sp. A, slab with ventral valve QM F 14433, holotype, another ventral valve (upside down) QM F 17155 and dorsal internal mould QM F 17756. Specimens x1. B, dorsal external mould, QM F 17761, x2. C-E, *Bandoproductus macrospina* Waterhouse. C, ventral internal mould, x1. D, part of ventral valve over dorsal valve QM F 17751, x2. E, ventral external mould, x1. D, E, from Waterhouse & Balfe (1987, pl. 1, fig. 13,15).

Description: Shell highly concavo-convex, transverse, large ventral valve QM F 3425 measuring 56mm wide, 42mm long and 13.5mm high. Ventral umbo broad with angle of 100-110°, little extended beyond the hinge, gently incurved. Umbonal walls steeply convex, not high, maximum width at hinge, ears moderately large, gently convex, with rounded or subacute extremities. Visceral disc suboval, less curved over median shell, but without flattening or sulcus, trail short and subgeniculate. Ventral valve often swollen as in type material, yet visceral disc thin. Dorsal valve moderately concave with flattened ears and subgeniculate trail, no median fold or sulcus. Both valves ornamented by costellae, 16-18 in 10mm at 10 mm from ventral umbo, and 11-13 in 10 mm anteriorly and over much of the shell, increasing by intercalation, with broadly convex crests and narrow V-shaped interspaces. Both valves also covered by fine wrinkles, highest postero-laterally, and faint on ears. They number just over 30 on large specimens, and are not completely regular in course, and may fade laterally. Fine growth-lines also developed, two to four per mm. Single row of hinge spines well developed, spines erect and 1.5mm in diameter, rarely a few additional spines present. Fine spines scattered over the remainder of the valve, emerging from crest of costellae, some erect, especially laterally, others emerging from gradually widening spine-bases, 3-5mm long, diameter up to 0.8mm, usually 0.6mm. No dorsal spines.

Ventral interior poorly exposed, revealing lightly impressed subrectangular elongate adductor platform and lightly impressed diductors. Low rounded ridge extended along posterior wall, set forward of the hinge-line. Dorsal cardinal process not exposed, supported in front by broad low ridge passing forward into narrow median septum, divided by median groove, only one third of valve in length. Adductor scars very faint, and full outline not clear; brachial ridges low and short.

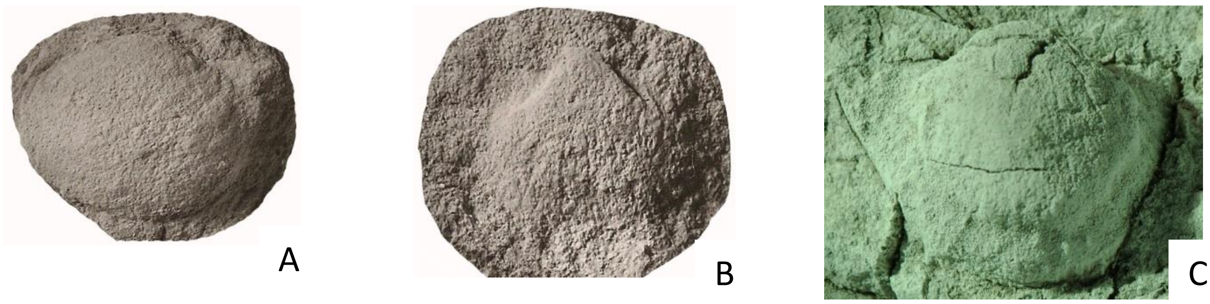


Fig. 16. *Bandoproductus macrospina* Waterhouse. A, ventral valve GSQ F 13187 from GSQ L 1445, x1. B, ventral valve GSQ F 13186, x2. C, UQ F 61932 from upper Burnett Formation, Yarrol Basin**,** x1.

Resemblances: Type *Bandoproductus macrospina* (Waterhouse, 1986a) has strong spines along the hinge, somewhat uneven costellae, moderately prominent body spines more numerous than in present material, subdued commarginal wrinkles and arched disc. The species comes from the upper Burnett Formation of the Yarrol Basin (Maxwell, 1964) and is likely to be of late Asselian age, as discussed by Waterhouse (2015, pp. 19, 39, 40). The ventral valve figured by Etheridge Jnr. (1892, pl. 13, fig. 6) from the Burnett district of central Queensland appears to be conspecific.

Bandoproductus walkomi Briggs, 1998

1872 *Productus cora* [not d'Orbigny] – Etheridge Snr., p. 328, pl. 15, fig. 1, 2.

1892 *P. cora* – Etheridge Jnr., p. 248, pl. 12, fig. 14 (part, not pl. 13, fig. 1, pl. 38, fig. 11 = *Costatumulus tumida*).

1986a *Cancrinelloides* (*Bandoproductus*) *macrospina* [not Waterhouse] – Waterhouse, p. 57, pl. 13, fig. 15, 16 [fide Briggs 1998] (part, not pl. 13, fig. 13, 14, 17, 18 = *macrospina*).

1998 *Bandoproductus walkomi* Briggs, p. 153, Fig. 77A-J.

Holotype: UQ F 75301 from lower Rutherford Formation (Sakmarian), figured in Briggs (1998, Fig. 77C, D), OD.

Diagnosis: Close to *Bandoproductus macrospina*, distinguished by fine ribbing, and variable presence of low commarginal rugae.

Description: Ventral valves display a row of hinge spines and moderately numerous spines over the venter, with slightly swollen and prolonged spine bases. The ribs are fine, numbering some 25 in 10mm. Briggs (1998, p. 155) compared a specimen from GSQ L 1331 to *walkomi*.

Resemblances: The species *walkomi* is very close to *macrospina* and is distinguished by its finer costation. Arguably some doubt attaches to the specific significance of the difference, because Briggs (1998) recognized co-occurrences of *walkomi* with *macrospina* amongst the type collections described by Waterhouse (1986a), and at Gympie both morphotypes are to be found. But there appear to be no intermediate forms, and two distinct populations. At least some Gympie specimens are less rugose than the types.

This appears to be one of the most common species represented in the Monkland or Phoenix beds of Gympie. In many respects the two species *macrospina* and *walkomi* are close, and although they are not discriminated in Table 9 and 10, it is agreed with Briggs (1998) that they should be separated, at least provisionally. Briggs (1998, p. 153) included in his synonymy reference to *Cancrinella levis* (Maxwell, 1964, p. 8, fig. 8e), and this seems to refer to a record, not an illustration, in the right hand column of the chart.

Discussion: Most specimens are squashed and deformed, but a very few specimens are relatively intact, some from the mines, and some from surface outcrop. Specimens figured as *Productus cora* (not d'Orbigny) by Etheridge Snr. (1872, p. 328, pl. 15, fig. 1, 2) and repeated by Etheridge Jnr. (1892, p. 248 (part), pl. 12, fig. 14) have comparably fine ribbing, but are larger and less rugose than other specimens of *walkomi*. The specimen ascribed to *Productus cora* by Etheridge Snr. (1872, pI. 15, fig. 2) seems to be possibly sulcate, and to have a possible row of hinge spines. The sulcus lies at an angle to the hinge, and so could have developed by deformation. It is believed that this specimen is preserved as QM F 14415, which is an inner dorsal valve with part of the ventral valve and traces along the inner dorsal hinge of the ventral spines. Part of a torn label carries the letters Prod, and another label reads Pl. 3, fig. 2 (the same as the third plate of Etheridge's article). The specimen figured by Etheridge Snr. (1872, pl. 15, fig. 1) is possibly represented on a slab, if it is assumed that the figure is somewhat idealised, with a fragment on the left now lost (or originally restored in the figure, left of the figured crack). The specimen is labelled, in part illegibly, with Fig. 1 clearly visible, and is entitled: Devonian N Caledonian Reef, Gympie, Queensland, *Productus cora* (QM F 14414). Some doubt is attached to the identity of dorsal valves figured by Etheridge Snr. (1872). One ascribed to *Strophomena rhomboidalis* var. by Etheridge Snr. (1872, pl. 16, fig. 7) has inflected growth lines, suggestive of a median fold. This possibly, but not certainly, could be due to deformation, as discussed on p. 50 for *Magniplicatina***.** Other authors (eg. Hill 1950, Runnegar & Ferguson 1969) treated this specimen as *Cancrinella farleyensis* (Etheridge Jnr. & Dun, 1909). Etheridge Jnr. (1892, pl. 13, fig. 1, pl. 38, fig. 11) figured dorsal valves from Stanwell and Mt Britton Goldfield in the Bowen Basin that look close to *Bandoproductus,* but they are deemed to belong to *Costatumulus tumida* (Waterhouse).

Order RHYNCHONELLIDA Kuhn, 1949
Suborder STENOSCISMATIDINA Waterhouse, 1981
Superfamily **STENOSCISMATOIDEA** Oehlert, 1887
Family **STENOSCISMATIDAE** Oehlert, 1887
Stenoscismatid gen. and sp. indet.
Fig. 17D

The posterior fragment of a small ventral valve QM F 17760 about 12mm wide shows a ventral spondylium, and lacks ribs or well developed sulcus. Not even the family can be determined with accuracy. It might belong to *Coledium* Grant, known in the Elvinia Formation of southeast Bowen Basin (Waterhouse 1986a), and equally rare in the Tiverton Formation of the northern Bowen Basin (Waterhouse 2015, p. 145). Otherwise there are no members of the suborder to be found in the east Australia Permian, except for rare specimens from the nearby Gigoomgan Limestone (p. 151).

Superorder SPIRIFERIFORMII Waagen, 1884
Order SPIRIFERIDA Waagen, 1884
Suborder MARTINIIDINA Waterhouse, 2010b
Superfamily **AMBOCOELIOIDEA** George, 1931
Family **AMBOCOELIIDAE** George, 1931
Subfamily **ATTENUOCURVINAE** Waterhouse, 2010b
Genus ***Attenuocurvus*** Waterhouse, 2010b

Type species: *Attenuatella attenuata* Waterhouse, 1964, p. 108 from Tertiary boulders derived from Upper Permian (Changhsingian), Takitimu Mountains, New Zealand, OD.

Diagnosis: Small, slightly to moderately elongate, ventral valve moderately inflated with weakly to moderately incurved ventral umbo and high interarea divided by partly covered delthyrium, shallow sulcus. Dorsal valve gently concave as a rule, may be gently convex posteriorly. Both valves ornamented by dense array of small erect spines of uniform diameter. High ventral adductor platform with anterior ridge or tigillum extending to anterior third of shell; socket plates, crural plates sessile or supported by very low tabellae. Spiralia truncated to part of a coil.

Discussion: The related Australian genus *Biconvexiella* Waterhouse, 1983 from the upper middle Tiverton Formation of the Bowen Basin has more convex dorsal valve, less arched ventral valve and spines in a range of diameters, interspersed with rare large spines at least three times greater in diameter than finer spines, in that regard resembling *Attenuatella* Stehli, 1954. Its spire is truncated as in *Attenuocurvus* and probably *Attenuatella*.

?Attenuocurvus australis **(**Armstrong & Brown, 1968)

Fig. 17G

1968 *Attenuatella australis* Armstrong & Brown, p. 60, pl. 8, fig. 1-16, text-fig. 1.

2010a *Attenuocurvus australis* – Waterhouse, p. 67, Fig. 30.

Holotype: UQ F 52677 figured by Armstrong & Brown (1968, pl. 1, fig. 9) from Kolbar Formation (Asselian), southeast Queensland, OD.

Diagnosis: Small with attenuated and incurved ventral valve, traversed by narrow distinct sulcus, high ventral interarea and delthyrium open below a small posterior plate, dorsal valve weakly convex next to hinge but concave overall, both valves ornamented with fine pustules. The affinities cannot be fully assessed from just one deformed specimen, but it occurs at a level correlated with the occurrence of the species *Attenuocurvus australis* in the Kolbar Formation, some 600ft below the base of the Gigoomgan Limestone, as discussed on p. 127.

Superfamily **MARTINIOIDEA** Waagen, 1883

Family **MARTINIIDAE** Waagen, 1883

Martiniid gen. & sp. indet.

Fig. 17F, H

Diagnosis: Moderately large oval shells, median groove commencing at posterior ventral umbo, well formed sulcus limited to anterior, anterior dorsal valve slightly swollen medianly. Dental plates well formed, pallial markings subdued.

Dimensions in mm for martiniid sp.:

Specimen	Width	Length	Length dorsal	Height	Hinge width
GSQ F 11350	51	55	51	21	36

Description: Shell subrounded, slightly elongate to weakly transverse, ventral umbo broad and low, angle of 100^o, bearing slender shallow median groove posteriorly, passing into sulcus about mid-length, which widens rapidly with broad floor extending into short anterior tongue. Ventral interarea poorly defined, moderately high with broad delthyrium. Dorsal valve little inflated, thickness close to that of ventral valve, with moderately high well formed interarea, divided by broad notothyrium with angle of 110^o, bearing faint horizontal markings. Shell evenly and gently convex medianly over posterior shell, raised broadly in front. Surface ornament obscure, with scattered pits or tiny flattened pustules that might be reflecting a secondary affect due to wear, no definite spines.

Teeth supported by well-formed dental plates, converging at about 100^o but squashed, no adminicula. Adductor field depressed, marked longitudinally by four or five grooves; diductor scars each wider than adductors, and lightly scored by longitudinal ridges and grooves. Pallial lines faint, not strongly anastomosing. Teeth supported in dorsal valve by low socket plates and subhorizontal crural plates, each side of well-formed laminated ctenophoridium. Low median ridge lies in front, over posterior fourth of shell length. Dorsal adductors lightly impressed, subrectangular, marked by somewhat irregular ridges and grooves, diverging slightly forwards. Spire not shown, and floor of valve comparatively smooth.

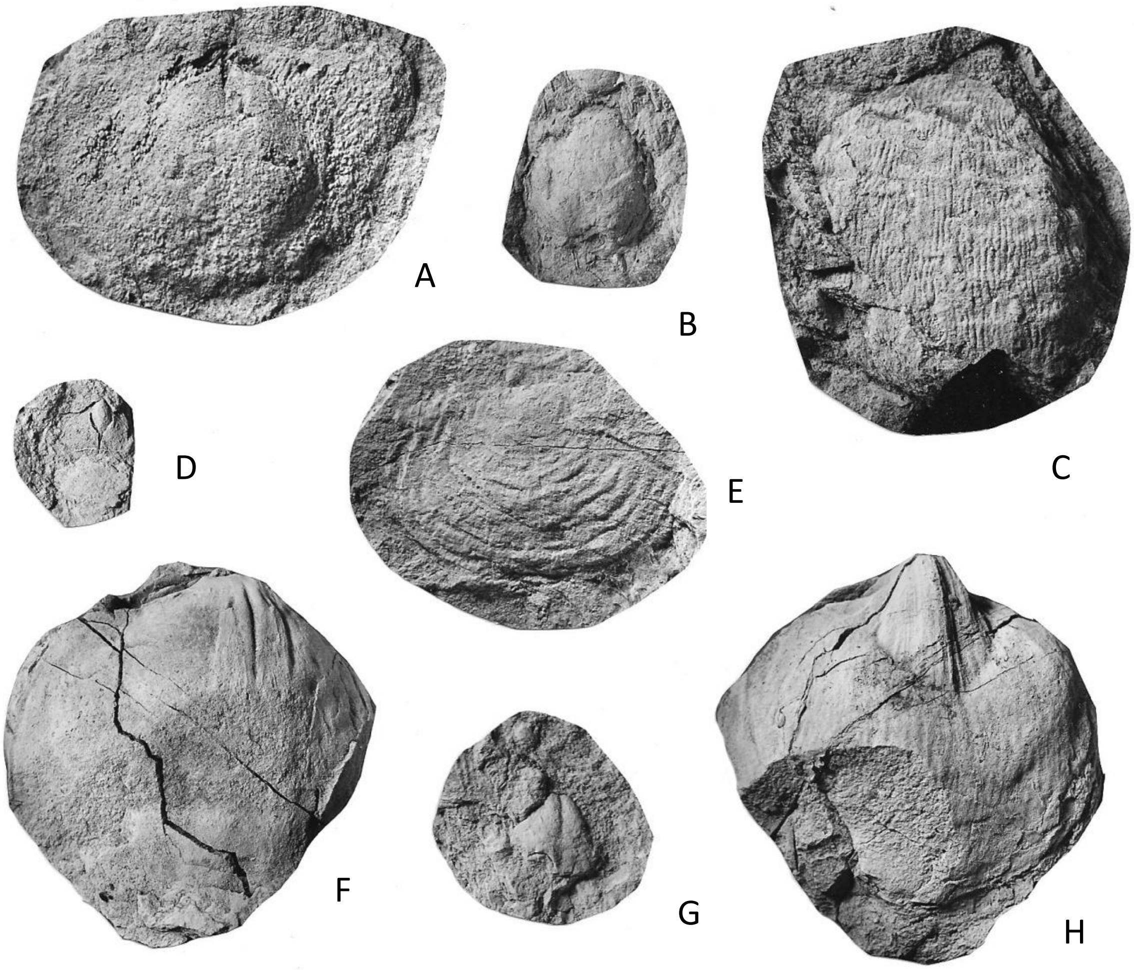


Fig. 17. A, chonetid, possibly *Gympietes aseptus* n. gen., n. sp., QM F 14397, x2. B, dasyalosiid ventral valve, QM F 17752, x1. C, E, *Magniplicatina dunstani* n. sp. C, GSQ F 13158 ventral valve, x2. E, dorsal valve QM F 17758, x2. D, stenoscismatid ventral valve internal mould, QM F 17760, x2. F, H, martiniid, ventral and dorsal aspects of internal mould GSQ F 11350 from GSQ L 216, x1. The dorsal adductors have weak rims, but they are not septa. G, *Attenuocurvus australis* (Armstrong & Brown), ventral valve QM F 14430, x2.

Discussion: *Spinomartinia queenslandica* Waterhouse (1987a, pl. 11, fig. 10, 12-18, pl. 12, fig. 1) from the Brae Formation (Roadian, Middle Permian) of the southeast Bowen Basin in Queensland has a more rounded outline, with prominent median ventral groove internally, and a low sulcate dorsal fold anteriorly. *S. spinosa* Waterhouse from the overlying South Curra and Gigoomgan limestones at Gympie is more inflated. The posterior position of the ventral muscle field in the Rammutt material is like that of *Spinomartinia* and so suggests a possible alliance, at least to subfamily level. There is no certainty over the presence of the small spines that help characterize species classed as members of *Spinomartinia*, so that generic affinities remain obscure, but a little further preparation may clarify the position of this material.

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

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

See p. 17 for typology and diagnosis.

Ambikella aff. ***elongata*** (McClung & Armstrong, 1975)

Fig. 18A – D

aff. 1975 *Martiniopsis elongata* McClung & Armstrong, p. 231, Fig. 1.

aff. 1978 *Ingelarella elongata* – McClung, p. 46, pl. 2, fig. 1, 2, pl. 3, fig. 7-11.

aff. 2003 *Tomiopsis elongata* – Archbold, p. 162, Fig. 3.1-23.

cf. 2015 *Ambikella* cf. *elongata* – Waterhouse, p. 153, Fig. 103.

Holotype: UNE F 13017, figured by McClung & Armstrong (1975, fig. 1) and McClung (1978, pl. 3, fig. 7, 8) from Beckers Formation (Asselian), Cranky Corner Basin, New South Wales. Since transferred to the Australian Museum, Sydney.

Diagnosis: Small, transverse with rounded fold and deep sulcus, no plicae as a rule, adminicula of moderate length, subparallel, tabellae long to medium in length, subparallel.

Description: Shell median small in size, transverse, ventral umbo broad with umbonal angle of 110-120°, not strongly incurved, nor extended far beyond hinge, cardinal extremities well rounded, maximum shell width near mid-length, hinge about two thirds of shell width. Ventral cardinal area concave, interrupted by broad open delthyrium with angle close to 45°. Dorsal interarea lower, notothyrial angle 80-85°. The ventral and dorsal valves are of approximately equal height. Ventral sulcus commences at umbo, shallow throughout length, with angle of 30°. Dorsal fold very low posteriorly, displaying a broad and well rounded crest, with no or very faint median flattening or sulcus; no sulcal subplicae visible, lateral plicae subdued on some specimens, absent from others. Micro-ornament of fine grooves in quincunx 0.2-0.3mm long and numbering seven to eight per mm, measured across the shell.

Teeth supported by scapular-shaped dental plates, which are concave upwards and converge on subvertical adminicula that diverge forward at a low angle, extending over posterior third of shell length. Adductors narrow, sited on ridge bearing small ridges and median groove. Diductors broad, not heavily marked. Floor of valve bearing small pits and pustules, shell thickened posteriorly on inner side of adminicula. One specimen shows small pleromal ridges passing forward from umbo near junction of dental and adminicular plates.

Ctenophoridium laminated, with socket and crural plates each side, tabellae well developed, lying each side of fold, subvertical, extending just over one third of valve in length. Short median ridge over posterior fourth of shell length; muscle scars not impressed, lightly scored by grooves and ridges. Shell thin, with tiny pits and pustules over dorsal floor.

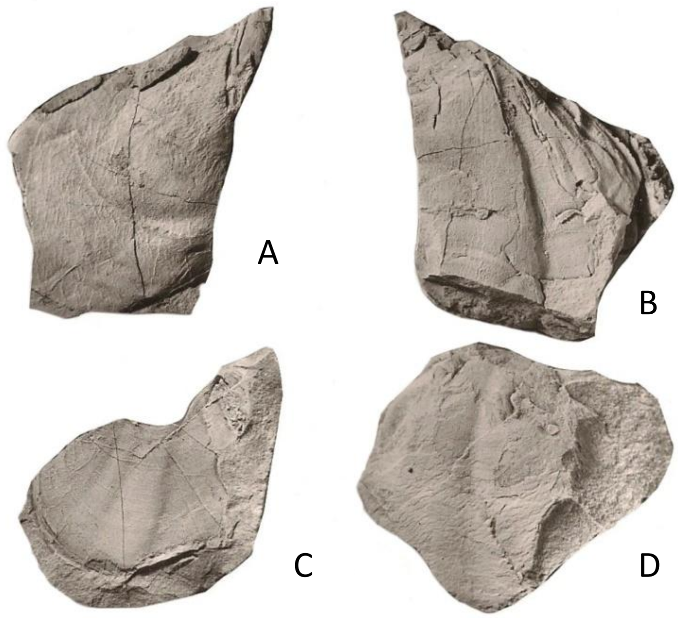


Fig. 18. *Ambikella* aff. *elongata* (McClung & Armstrong). A – C, ventral and dorsal aspects and ventral external mould of GSQ F 13160 from GSQ L 216. D, ventral valve GSQ F 13161 from GSQ L 216. Specimens x1.

Resemblances: This species is typified by its well developed internal plates, and shallow sulcus and low fold, with subdued or no plicae. *Tomiopsis postglabra* Waterhouse, 1987a from the Dresden Formation of southeast Bowen Basin is moderately close in external appearance, but the tabellae especially and to less extent the adminicula are short internally, suggesting the genus *Geothomasia* Waterhouse. *Ambikella elongata* (McClung & Armstrong, 1975, Fig. 1; McClung 1978, pl. 2, fig. 1, 2; pl. 3, fig. 7-11; Archbold 2003, Fig. 3:1-23) from the Early Permian Beckers and Tamby Creek Formations of the Cranky Corner Basin in New England is moderately close, with slightly longer tabellae and narrower dorsal fold in specimens figured by McClung (1978) and broader fold and shorter tabellae in specimens figured by Archbold (2003). Allied material, closer to that figured by McClung (1978), is found at the base of the Tiverton Formation in the north Bowen Basin (Waterhouse 2015), below the *Bookeria pollex* Zone.

The Tasmanian suite of *Ambikella* from the basal Bundella Formation and Inglis Formation figured as *elongata* by Clarke (1990, p. 64, Fig. 10A-L; 1992a, p. 22, Fig. 10A-L) is similar to *elongata* in many respects, with shells laterally smooth or weakly plicate and suggestions of two low subplicae in the sulcus and round-crested dorsal fold. The outline of the Tasmanian specimens is distinctly less transverse than type *elongata*, with posterior walls diverging less, and the sulcus is often narrower. The adminicula are short to moderately long and subparallel anteriorly – indeed they may appear to converge anteriorly to a slight degree and tabellae diverge posteriorly at a much wider angle than they do in type *elongata* as described by McClung & Armstrong (1975) and Archbold (2003) from the Cranky Corner Basin of New South Wales. These and other differences displayed by the Tasmanian material suggest a different species, discussed further on p. 168. How it compares with unfigured Lochinvar material reported by McClung (1978) is not known.

Two specimens allocated to *elongata* from the Spirifer Zone of Maria Island, Tasmania, by Briggs (1998, Fig. 18B, C) cannot be specifically identified in the absence of the dorsal valve.

Suborder SPIRIFERIDINA King, 1846

Superfamily **TRIGONOTRETOIDEA** Schuchert, 1893

Discussion: Shells are plicate and costate as a rule, with cancellate micro-ornament of fine radial and commarginal lirae. Dental plates supported by adminicula, median septum rarely present, crural plates developed, and no tabellae.

Discussion: Members of this superfamily arose from from Pinguispiriferinae, and were paucicostate early in their growth history, but gradually developed costae, to converge with Spiriferoidea.

Family **TRIGONOTRETIDAE** Schuchert, 1893

Subfamily **TRIGONOTRETINAE** Schuchert, 1893

Genus ***Grantonia*** Brown, 1953

Type species: *Grantonia hobartensis* Brown, 1953, p. 61 from Berriedale Limestone (upper Sakmarian), Tasmania, OD.

Diagnosis: Transverse shells with strong persistent plicae, as a rule numbering three to five pair, with minor additional plicae, costae variable in development, primary costae generally predominant, open delthyrium and large umbonal callosity.

Discussion: Type *Grantonia* is distinguished from type *Trigonotreta* by having fewer plicae, wider hinge, and better developed costae posteriorly, and numerous costae anteriorly, contrary to Armstrong (1968b) and Carter (2006a). The fold and sulcus of *Trigonotreta* contain only one to three costae, compared with ten to twelve costae in *Grantonia* (Waterhouse 2014, p. 191). The present specimens appear to be the oldest known form of *Grantonia*, and the plicae approach those of *Trigonotreta* in number and costae develop further from the umbones than in younger *Grantonia*. On the other hand costae become numerous, notably over the sulcus and fold. The present specimens differ from other Early Permian species of both genera in lacking prominent primary costae.

Grantonia murrayi n. sp.

Fig. 19

Derivation: Named for C. S. Murray.

Holotype: QM F 17762, upper Rammutt Formation (Asselian), Gympie, Fig. 19E, here designated.

Diagnosis: Moderately large shells, transverse into early maturity, with well defined sulcus and fold, at least five and usually seven pairs of persistent plicae, costae in some specimens broad, arise over plicae by splitting, primaries not very high even posteriorly, usually three to five ribs on plicae, growth lamellae well developed. Ventral muscle field relatively narrow.

Dimensions in mm for *Grantonia murrayi* n. sp.

Specimen	Width	Length	Height	valve
QM F 14410	45	33	10	ventral
QM F 14399	46	27	5	dorsal
GSQ F 13168	90	58	28	ventral

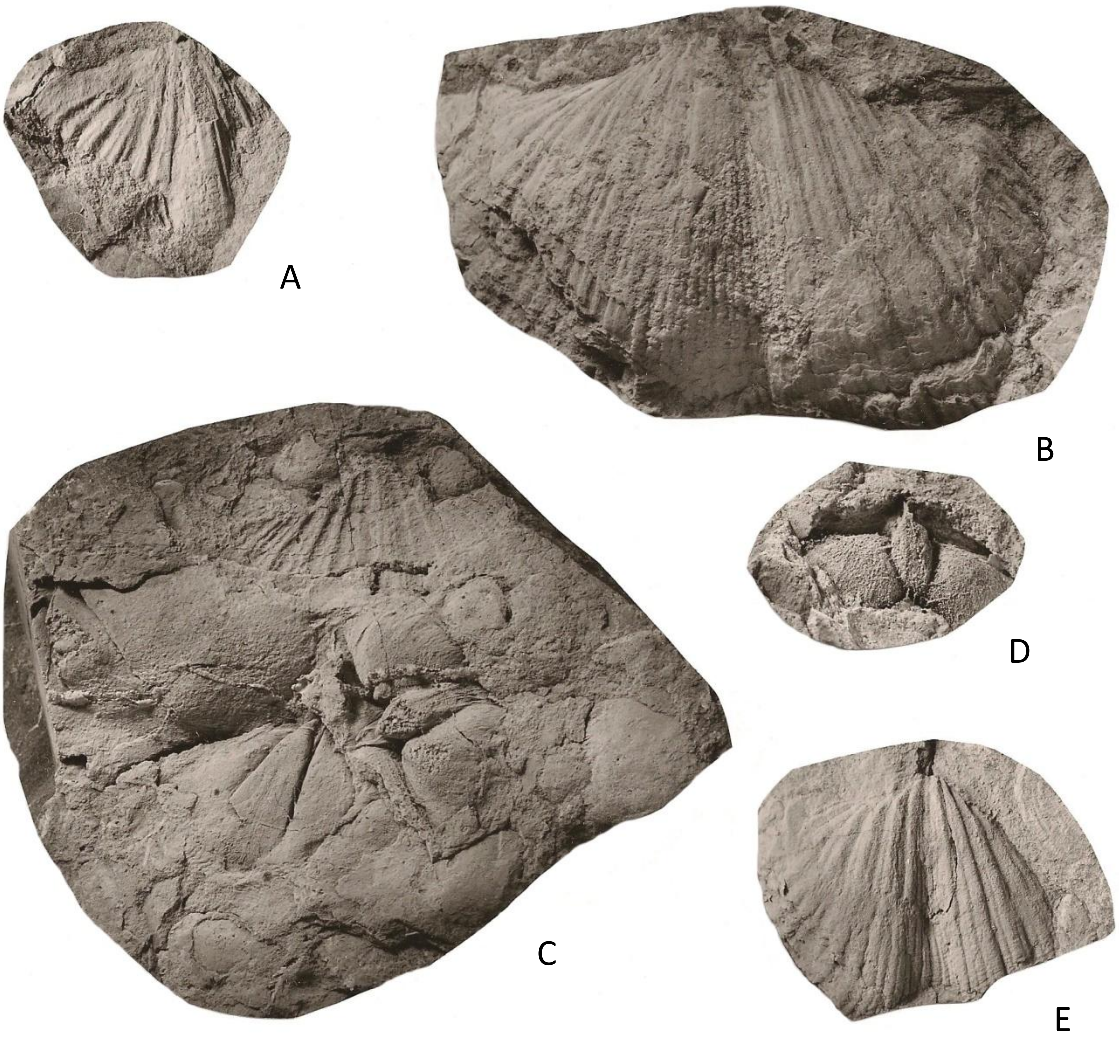


Fig. 19. *Grantonia murrayi* n. sp. A, dorsal valve QM F 14399. B, large ventral valve, GSQ F 13168 from GSQ L 6886. C, block with part of external mould GSQ F 13175, above two dorsal internal moulds GSQ F 13182 and 13185 of *Oviformia sweeti* n. gen., n. sp. (see p. 70) from GSQ L 1441. D, internal mould of ventral valve GSQ F 13198 from uncertain locality. E, latex cast of ventral valve QM F 17762, holotype, showing broad low costae. Specimens x1.

Description: Several specimens immature, transverse, ventral umbo moderately prominent, angle close to 90°, maximum width at hinge, or just in front, cardinal extremities abruptly obtuse; cardinal interarea high, concave, interrupted by narrow open delthyrium with angle of 45^{o} in small specimen.

Ventral sulcus commences at umbo, widens at angle of 30^o between crests, and at angle of 17-18^o along trough-like median strip; dorsal fold widens at angle of 23°, crest broadening anteriorly, rounded, not very high. Some five pairs of plicae developed on each valve with further slender plicae or costae laterally; inner pair incorporated in sulcus after 10mm. Costae broad, not extremely high, somewhat irregular in development, commencing within 12-15mm from ventral umbo and 6mm from dorsal umbo, increasing to three or four over plicae anteriorly on small shells, crossed by well developed growth laminae; 10-14 costae within sulcus. Large specimen from GSQ L 6886 from different lithology of breccia in calcitic matrix measures some 90mm in width, with well formed ventral sulcus, and plicae in seven pairs bearing up five sturdy but not very high costae.

Ventral interior with scapular-shaped dental plates converging at 95^o, well developed umbonal callosity, and short subvertical adminicula, bowed in outline. Muscle field not wide, with broad adductors and narrow diductors. Dorsal valve has laminated ctenophoridium and median septum, adductors subrectangular, lightly impressed.

Resemblances: These specimens are distinguished from various species of *Trigonotreta* Koenig, 1825 and *Grantonia* Brown, 1953 in being more transverse at early growth stages, and in having lower primary and secondary costae, which are comparatively broad before splitting, at least in some specimens. The ventral muscle field is relatively narrow, like that of *Trigonotreta stokesii* Koenig, 1825 (see Clarke 1979), rather than the broad ventral muscle field which helps characterize *Grantonia cracovensis* Wass, 1966 or *G. australis* (Bion, 1928). The plicae of the large specimen in Fig. 19B are as numerous as in *Betaneospirifer dubius* from the middle Rammutt Formation, but are wider with gentler flanks.

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **DIELASMIDAE** Schuchert, 1913

Subfamily **DIELASMINAE** Schuchert, 1913

Tribe **HOSKINGIINI** Waterhouse, 2010b

Genus ***Hoskingia*** Campbell, 1965

Type species: *Dielasma trigonopsis* Hosking, 1933, p. 44 from Madeline Formation (Artinskian), Western Australia, OD.

Diagnosis: Comparatively large, dental plates and pedicle collar present, inner hinge plates sessile or almost so.

Discussion: *Hoskingia* has been reinterpreted by Waterhouse (2010b, p. 80) and shown to be close to Dielasmidae in the development of the septalium and dental plates, whereas Campbell (1965) and Jin et al. (2006, p. 2040) regarded the form as close to *Beecheria* Hall & Clarke, 1893. The dorsal septa in *Beecheria* form a double tented structure, completely unlike the arrangement in *Hoskingia,* underlining the difference in family relationships.

Hoskingia glabra n. sp.

Fig. 20

Derivation: glaber – smooth, Lat.

Holotype: QM F 57786 from GSQ L 1441, upper Rammutt Formation (Asselian), figured as Fig. 20A, C, here designated.

Diagnosis: Large shells with small pedicle collar, moderately coarse punctae and smooth shell without strong plicae or deep ventral sulcus, no conspicuous radial ornament.

Dimensions in mm for *Hoskingia glabra*:

GSQ F	Width	Length	Length	Height ventral	Height dorsal
57786	34	56	50	18	
57787	47	47	44		10 crushed

Description: Shell moderately large, elongate, ventral umbo prominent with small pedicle collar and posterior walls diverging at nearly 50°, persisting beyond mid-length, ventral valve medianly less convex, but without sulcus, bearing slender median groove over at least middle third of length; dorsal valve a little less inflated, posterior walls diverging at 70°, shell raised medianly over mid-length, slightly flatter at anterior margin. Punctae number 13-18 per mm. Both valves unevenly ornamented by commarginal wrinkles, numbering three in 5mm, more closely spaced in dorsal valve. Faint longitudinal lineations suggested in Fig. 20A, C might be a metamorphic effect.

Dental plates slender and close to lateral walls. Muscle scars not clearly impressed. Dorsal sockets long and shallow, cardinal process masked, median ridge extends forward beyond posterior third of shell length, inner hinge plates close to floor of valve, extending for less than a quarter of dorsal valve length as far as can be seen, bearing low crural bases which lie a little closer to the mid-line than to the lateral edges.

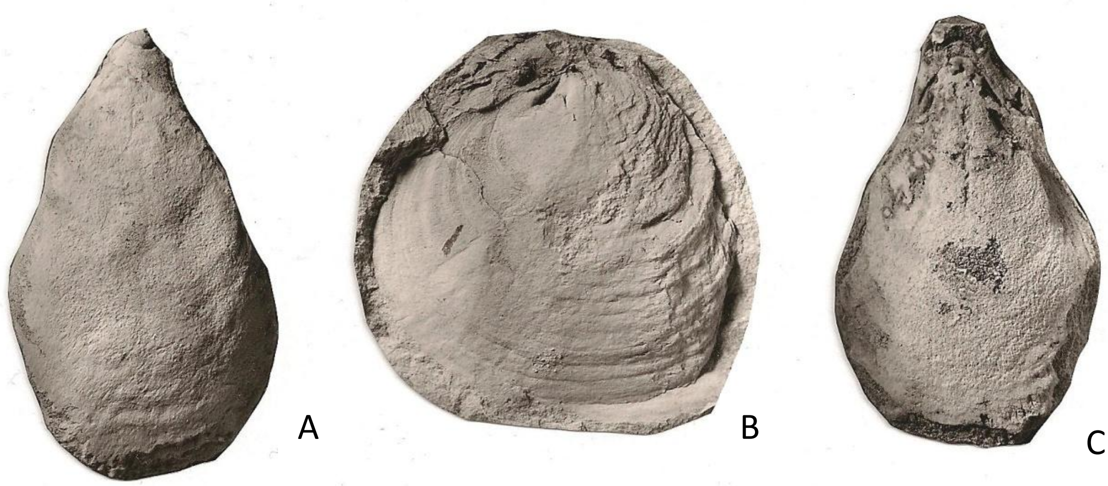


Fig. 20. *Hoskingia glabra* n. sp. A, C, ventral and dorsal aspects of holotype, QM F 57786 from GSQ L 1441, x1. B, dorsal view of QM F 57787 from GSQ L 1445, x1.

Resemblances: This species is distinguished by its lack of ventral sulcus or strong radial ornament, and comes closest to *Hoskingia kennediensis* Campbell (1965, p. 65, pl. 12, fig. 1-3, text-fig. 26) from the Bulgadoo Formation (Kungurian) in the north end of the Kennedy Range in Western Australia. The crural bases are based further apart in *kennediensis*, and the hinge is comparatively broader.

Phylym Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Order PECTINIDA Gray, 1854

Family **DELTOPECTINIDAE** Dickins, 1957

Genus ***Squamuliferipecten*** Waterhouse, 1986b

Squamuliferipecten squamuliferus (Morris, 1845)

Fig. 8D

See p. 30 for typology and diagnosis.

Description: A left valve GSQ 13162 from L 1445 shows the ribs typical of the species.

CORRELATION

The stratigraphic position of the Monkland beds points to a likely Early Permian age, younger than the fossiliferous sandstones of the middle Rammutt Formation, though in the same formation, and older than the South Curra Limestone. The most significant taxon for age determination is *Bandoproductus,* a genus also found in the upper Burnett Formation of the Yarrol Basin (*macrospina, walkomi*), and the lower Rutherford Formation of the north Sydney Basin (*walkomi*). This genus is represented in various faunas of south Asia that are dated by various authors as upper Asselian, examples including Karakorum Range of Pakistan (Angiolini 1995, Angiolini et al. 2005) and western Yunnan (Shen et al. 2000). In Western Australia, an allied genus *Lyonia* is found chiefly in the upper Lyons Group in the Carnarvon Basin, and also the overlying *Neilotreta occidentalis* Zone of the lower Callytharra Formation. In Tibet, *Bandoproductus* has been reported from the Pondu (or Pondo) Group just above diamictites (Jin & Sun 1981), dated as late Asselian and comparable to the occurrence of *Bandoproductus* in the upper diamictites (Asselian) of the Phuket Group in south Thailand (Waterhouse 1982c). *Protoanidanthus pokolbinensis* Briggs is found with *Bandoproductus walkomi* in the Silver Spur beds of south Queensland. The occurrences are in faunas older than those typical of so-called Fauna 11, now the *Bookeria pollex, B. geniculata* and *Taeniothaerus subquadratus* Zones, as represented in the Fairyland and Elvinia Formations of the southeast Bowen Basin, the Tiverton Formation of the north Bowen Basin, the Yarrol Formation of the Yarrol Basin, and Farley Formation of the Sydney Basin (Waterhouse 2015). The fauna has little in common with the Allandale fauna of the Sydney Basin, and at Gympie lies above an Allandale-type fauna, that may be equivalent to or slightly older than Allandale. *Attenuocurvus* is likely to be the same as *A. australis* from the Kolbar

Formation of Gigoomgan. *Ambikella* is moderately close to *A. elongata* (Armstrong & McClung) from the Cranky Corner sequence in New South Wales. So far this Rammutt fauna provides the best known representation of the *Bandoproductus macrospina* Zone in east Australia.

TABLE 8. Description of GSQ localities for Geological Survey of Queensland collections from the Monkland beds at Gympie.

L 216 From Great Northern Extended Mullock Tip.

L 1435 1 North Smithfield.

L 1441 1 S New Zealand.

L 1445 3 N Phoenix.

L 1447 5 N Phoenix.

TABLE 9. Geological Survey of Queensland material. First figure - ventral valve; second figure - dorsal valve, third figure - conjoined valves. For bivalve, first figure indicates left valve.

Species	L 216	L 1435	L 1441	L 1445	L 1447
Magniplicatina dunstani		1,0,0			
Bandoproductus spp.			0,0,1	11,6,0	5,0,0
Martiniid sp.	4,0,1				
Ambikella aff. *elongata*	1,0,1				
Hoskingia glabra			0,0,1	0,0,1	
Squamuliferipecten squamuliferus				1,0,0	

TABLE 10. UQ L 2773, collected from Dawn Pocket, Mary River, Gympie.

	Ventral valve	Dorsal valve	Both valves
Bandoproductus spp.	18	6	1
Protoanidanthus pokolbinensis	13	8	5
Grantonia sp.	0	1	0

TABLE 11. Queensland Museum collections of Permian brachiopods from Monkland shales of upper Rammutt Formation. A QM F number had been assigned by the 1980's to one specimen that is associated with a number of other unregistered specimens from the same unnumbered locality, often on the same block, and often recorded only as coming from Gympie. This QM F number here serves as a guide. It is not a locality number, but the table shows the all-important association of specimens and species. First figure - ventral valve; second figure - dorsal valves, third figure - conjoined valves. A ventral valve of a stenoscismatid comes from an uncertain locality.

	2089	3425	3431	4332	3434	14397	14399	14400
? Gympietes sp.						1,0,0		
Dasyalosiid sp.							1,0,0	
Protoanidanthus pokolbinensis	0,0,1		9,0,1	3,2,0	3,2,0		0,0,4	2,1,0
Magniplicatina dunstani						4,0,0	1,1,6	
Bandoproductus spp.	8,1,1	2,0,0	5,0,0			1,0,0	1,0,0	
Grantonia murrayi						0,1,1	0,1,0	3,0,0

Table 11 continued.

	14414	14415	14428	14429	14430	14431	14433	21895
? *Gympietes* sp.			1,1,0					
Dasyalosiid sp.		8,2,0	3,2,0		27,2,1		1,1,0	
Protoanidanthus pokolbinensis	8,0,0	25,5,6	14,9,1		4,4,18	2,2,0	0,1,0	20,0,20
Magniplicatina dunstani		22,5,1	5,0,0		2,1,2	9,0,3	6,1,0	10,0,0
Bandoproductus spp.	4,1,1	26,6,1	12,2,0	2,0,0	4,0,0	4,0,0	1,0,0	5,0,0
Attenuocurvus australis					1,0,0			
Grantonia murrayi	2,0,0				2,1,0			

4. AN EARLY PERMIAN BRACHIOPOD FAUNULE FROM THE UPPER RAMMUTT FORMATION

SUMMARY

Brachiopods are described from the Sweet Collection in the National Museum of Victoria at Melbourne, collected from Gympie and believed to have come from the gold-bearing Monkland beds towards the top of the Early Permian Rammutt Formation. The age is likely to be late Asselian in international terms, close to that of the upper Lyons Group of Western Australia, and the upper Burnett Formation of the Yarrol Basin, Queensland. Species include *Protoanidanthus pokolbinensis* Briggs and *Magniplicatina dunstani*, shared with other Monkland beds, the new taxon *Oviformia sweeti* n. gen., n. sp. and a possible occurrence of *Neilotreta*, a trigonotretid otherwise found in the Cranky Corner Basin, New South Wales, and Lower Permian of Western Australia.

INTRODUCTION

Some fossils from the Gympie district of southeast Queensland collected during the exploration and development of gold-mining (Denmead, 1987) were sent to the Museum of Victoria, Melbourne. One of these Melbourne collections is not matched by any I have seen in Queensland. It consists of some 70 specimens, mostly brachiopods, originally part of the Sweet collection. George Sweet had collected extensively from south Queensland, including Gympie, and his material was at least in part examined in Jack & Etheridge Jnr. (1892, p. 748). However no specific mention of this particular collection can be traced, and the only locality information provided is the name Gympie. From comparison of lithology and examination of the fossils, it is believed that the collection probably came from the fossil-bearing Monkland beds (alternatively called Pengelly Siltstone or upper Nash beds – see p. 9) near the top of the Rammutt Formation in the Gympie Group (Waterhouse & Balfe 1987). Monkland faunas are well represented at the Queensland Museum and Science Centre Annex at Hendra, Brisbane, which now also houses collections made by the Geological Survey of Queensland and the University of Queensland, but none contain any trace of a spiriferiform brachiopod otherwise not known in east Australia, allied to *Neilotreta,* and only two examples are known elsewhere, this time in the upper Rammutt Formation, of an unusual ingelarellid species found in the Sweet collection. A third species is the brachiopod *Protoanidanthus*, and another is *Magniplicatina dunstani* n. sp., both found in other stations at Gympie and Gigoomgan. This study describes some of the brachiopods from the collection.

The rock is distinctive. It is unweathered, implying that it was collected subsurface, probably from a gold mine, and is a steel-grey fine slightly muddy sandstone, with darker, siltier layers 1-2mm thick, and some thin layers of coarser green sandstone. Shells are comparatively numerous, generally matrix separated, mostly as single valves, and now altered, with the calcite enriched by the zeolite chamosite. In addition small 0.5-1.0mm cubes of pyrite are scattered widely through the matrix, and concentrated in the shell material. These features are characteristic of the Monkland beds to-

-wards the top of the Early Permian Rammutt Formation in the lower Gympie Group at Gympie, where two shale bands contain numerous fossils, mostly in shale and fine sandstone like that of the present collection**.**

The specimens were originally complete, mostly separate, valves, but have been broken during extraction from a tough matrix. The shell is altered, as described previously, which hinders satisfactory leaching in acid, and many shells have been stretched or crushed under tectonic deformation.

The material is housed at the Museum of Victoria (Natural History), and significant specimens are serially registered by number, with the prefix **NMV P.**

SYSTEMATIC PALAEONTOLOGY

Phylum Brachiopoda Duméril, 1806

Order PRODUCTIDA Waagen, 1883

Family **ANIDANTHIDAE** Waterhouse, 1968b

Genus ***Protoanidanthus*** Waterhouse, 1986a

Protoanidanthus pokolbinensis Briggs, 1998

Fig. 21A

See p. 47 for typology, synonymy and diagnosis.

Description: Seven ventral valves, three dorsal valves, and other fragments are present. A well preserved small ventral valve measures 13.5mm wide, 12mm long and 3.2mm high and shells are up to 30mm in width and 18mm long, and 7mm high. A dorsal valve measures 25mm wide, 13.5mm long and 2.6mm high. Shell subrounded, ventral umbo not extended far beyond hinge, umbonal walls gently convex, low, diverging at maximum width of shell near mid-length. Ventral ears moderately large, well defined, extend well forward with gently convex surface and obtuse cardinal extremities. Visceral disc evenly arched, without sulcus but slightly less curved medianly. Ornament of even ribs, about 16 in 10mm, range 14 to 17 in 10mm anteriorly, without visibly prolonged spine bases. Spines few and fine over body of shell and aligned along hinge, though not well preserved. Growth wrinkles very subdued, and growth lines not clear. The shell seems to be less than 0.5mm thick, except posteriorly, where it is nearly 1mm thick over the ventral muscle field. Dorsal valve gently concave, with large ears extending well forward, but not extended laterally much if at all beyond maximum width of shell, which is placed towards posterior third of shell length. Dorsal disc ornamented by fine radial ribs spaced much as in ventral valve, without spines. Growth steps of irregular spacing and not lamellate, ears comparatively smooth.

Ventral muscle field not strongly thickened, suboval smooth adductor impressions, raised above shell floor, anteriorly placed oval diductor impressions. Posterior hinge slightly thickened. Dorsal interior with short median septum, between two widely diverging smooth and slightly raised adductor scars and start of brachial ridges: further detail not visible.

Discussion: In ornament and nature of ears, the specimens are closest to the species *Protoanidanthus pokolbinensis* Briggs, a species proving to be widespread in the early Permian of eastern Australia during late Asselian time. The species is characterized by the size of its ventral and dorsal ears, and moderately strong costae, and comparatively few spines over the ventral disc. The species is found in the Monkland beds (p. 47) and the Kolbar beds of Gigoomgan (see p. 126), as well as in the Silver Spur beds of the Texas area, Pokolbin district, in south Queensland, and reported by Briggs (1998, p. 201) at a number of localities in the Rutherford Formation of the Lochinvar Anticline at Singleton in the Hunter Valley. *P. compactus* Waterhouse, 1986a from the Fairyland and Dresden Formations of the southeast Bowen Basin is more spinose. *Protoanidanthus zavodowskii* (Abramov & Grigorieva, 1983) from the Late Carboniferous Abagin and Akachin beds of Verchoyan in northeast Russia is only moderately close, having smaller ears, slightly stronger ribs, and more vaulted visceral disc.

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Genus ***Magniplicatina*** Waterhouse, 1983

?***Magniplicatina dunstani*** n. sp.

See p. 49 for typology and diagnosis.

Description: Two obscure specimens may belong to this genus. The better preserved specimen is about 32 mm wide, and has a gently convex ventral valve with fine capillae, numbering 24 in 10mm anteriorly, on a short geniculate trail. The worn disc shows traces of elongate spine bases and low commarginal wrinkles, and bases of several erect spines are present on the ears.

Discussion: In size and overall appearance, these specimens appear to be conspecific with *Magniplicatina dunstani* n. sp. which is well represented in the Monkland beds, and the specimens display the same characteristics.

Order SPIRIFERIDA Waagen, 1884

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Oviformia*** n. gen.

Derivation: Named from species name, oviformia.

Type species: *Spirifera* (*Brachythyris*) *oviformis* M'Coy, 1847, p. 234 from the Muree Formation (Wordian) at Barraba, near Cessnock, Hunter Valley, New South Wales, here designated.

Diagnosis: Plicate shells, ventral sulcus characteristic with anterior median fold, dorsal fold with channel, micro-ornament of short grooves in quincunx. Adminicula and tabellae short to moderate in length and spacing.

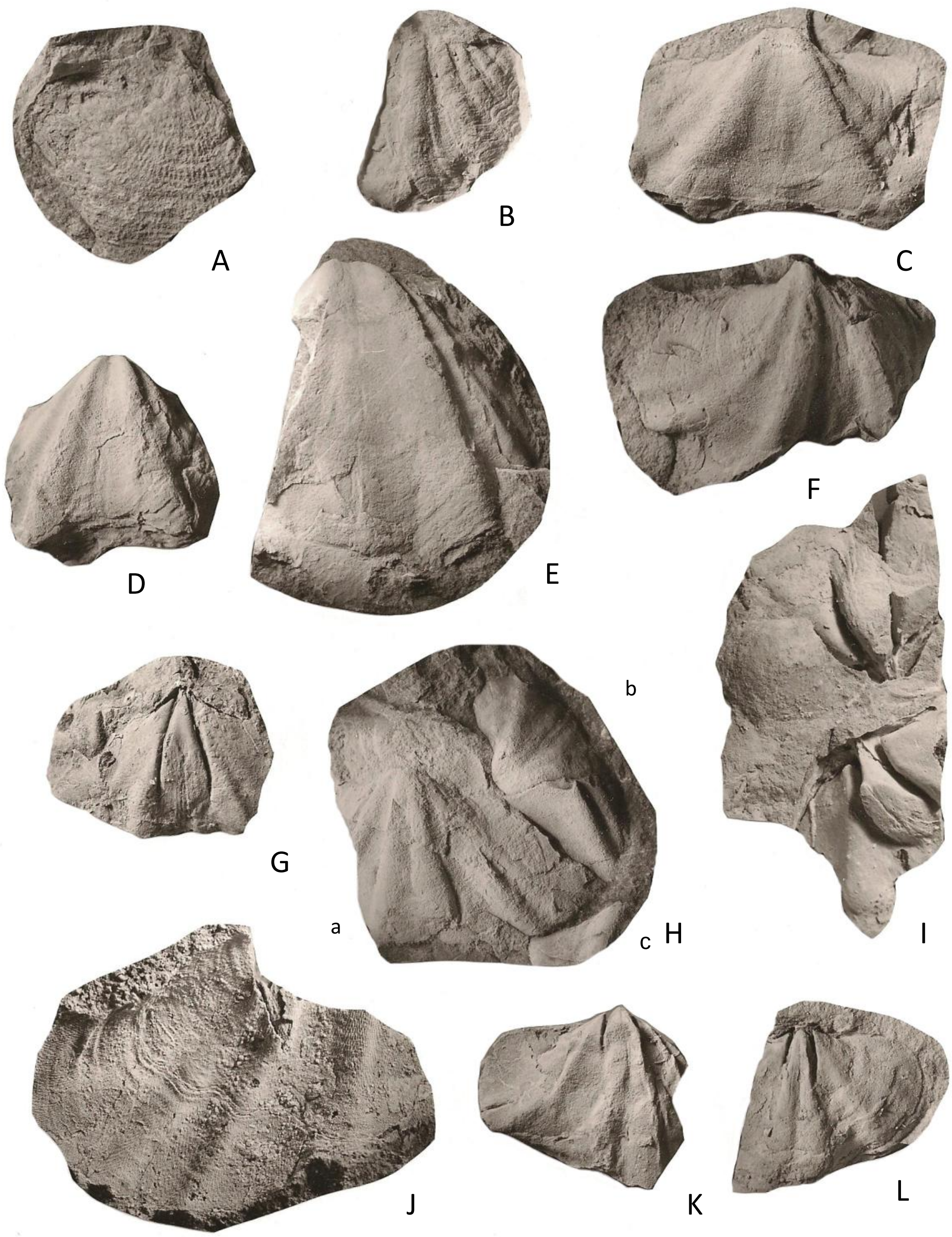


Fig. 21. A, *Protoanidanthus pokolbinensis* Briggs, NMV P134550, dorsal valve external mould, x2. B, *Neilotreta* sp., broken dorsal valve NMV P134551. C – L, *Oviformia sweeti* n. gen., n. sp. C, holotype ventral valve NMV P134555. See also 21J. D, ventral valve NMV P134562. E, ventral valve NMV P134564. F, ventral valve NMV P134563. G, ventral valve NMV P134552. H, dorsal valve (a) and ventral valves (b, c) NMV P134556 – 134558. I, ventral valve internal moulds NMV P134560 and 134561. J, external mould of holotype NMV P134555, x2. K, dorsal internal mould NMV P134554. L, dorsal internal mould NMV P134553. Specimens x1, except Fig. 21A, J.

Discussion: This genus is very close to *Ingelarella*, but unlike that genus, has a fold in the ventral sulcus. The oldest known species, *Oviformia sweeti* n. sp. from Gympie, is older than known *Ingelarella*, which first appeared in east Australia in the Tiverton Formation of the north Bowen Basin (Waterhouse 2015, p. 152), and became common as *Ingelarella plica* Campbell in the uppermost Tiverton Formation, of Aktastinian (Artinskian) age.

Oviformia is based on *Spirifera* (*Brachythyris*) *oviformis* M'Coy (1847, pl. 13, fig. 5, 6) from the Muree Formation and Fenestella Shales of the Sydney Basin in New South Wales, and also reported from the Belford Formation of the Sydney Basin, as summarized by McClung (1978, p. 42, pl. 14, fig. 14-16, pl. 15, fig. 1-6).

Oviformia sweeti n sp.

Fig. 19C, Fig. 21C - L

1987 ?*Notospirifer* sp. Waterhouse & Balfe, p. 30, pl. 1, fig. 13.

Derivation: Named for George Sweet, who presented the material to the Museum of Victoria, Melbourne.

Holotype: NMV P134555 from Rammutt Formation (Asselian), Fig. 21C, J, here designated.

Diagnosis: Shells with three pairs of ventral plicae and 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.

Description: Few specimens are complete, but size can be estimated from half specimens. Some 30 ventral valves were measured, and range in mm as follows: width, 21-58; length, 20-49; length of dorsal valve, 15-43; height of both valves, 12-25; height of ventral valve, 8.5-23; height of dorsal valve 4.5-12, the considerable variation reflecting the degree of distortion and differing states of maturity. Shells transverse to elongate, ventral umbo moderately prominent and incurved over hinge, umbonal angle measuring 90°, posterior walls moderately high, concave in outline, curving out to well rounded cardinal extremities, maximum width of shell near mid-length. Dorsal valve less inflated, with inconspicuous umbo. Interareas poorly defined, delthyrium open and narrow with angle of 40°. Ventral sulcus commences at umbo, and widens steadily forward at angle of 55°, with broadly concave floor, bearing two low subplicae in over half the specimens for posterior quarter to third of shell length in mature specimens, replaced anteriorly by broad median swelling over anterior half to third of shell length, and the fold may increase or diminish in definition to anterior margin. Dorsal fold narrow and well defined, bearing narrow to broad median sulcus. Ventral plicae number three pairs, moderately high and distinct, curving outwards, the innermost pair bordering the sulcus, the outer pair low. Dorsal plicae number only two pairs. Micro-ornament of fine short surface grooves, largely in quincunx, about

0.2mm long. Many shells are decorticated and show grooves over 0.7mm long, believed to be due to fibres within the shell. Growth stops of variable spacing present, with very fine growth increments, 10-15 per mm.

Teeth of moderate size and supported by scapular-shaped dental plates, which converge inwards at 90-100^o, and are underpinned by short adminicula, that extend forward for less than a third of the shell length, and diverge to the floor of the valve at 50-60^o. Pleromal thickening low or absent, no large umbonal callosity. Adductor ridges low, may be bordered and divided by slender ridge, diductor scars each wider than adductor platform, lightly marked by low more or less longitudinal irregular ridges and grooves. Floor to each side bearing low pustules; posterior shell up to 4mm thick.

Dorsal interior has small ctenophoridium, socket plates and low crural plates supported by short subvertical tabellae which extend along the flanks of the fold for only a fifth of the length of the valve, longer in a few instances. Adductor scars are not impressed, and the myophragm commonly found in Ingelarelloidea is not developed in some shells and very low in others. Shell very thin, less than 0.5mm thick posteriorly in mature specimens.

Resemblances: Two internal moulds from the Monkland beds are kept at the Queensland Museum and Science Centre Annex and can be identified through their similarity to internal moulds of the present collection (Fig. 19C). The species is unusual, distinguished from most other species of Ingelarellidae by the well developed anterior fold in the ventral sulcus, and well developed median channel passing along the crest of the dorsal fold. In other aspects of morphology, the species comes close to *Ingelarella*, in both internal plates and channeled fold. In these respects the new form compares with another unusual species called *Spirifera* (*Brachythyris*) *oviformis* M'Coy (1847) from the Middle Permian Muree Formation at Barraba, near Cessnock, Hunter Valley, and also reported from the Belford Formation and Fenestella Shales of the Sydney Basin in New South Wales by McClung (1978). Present specimens are as a rule more transverse, allowing for the tectonically induced distortion, and the sulcus is wider, and there are three pair of plicae in the ventral valve, two pair on the dorsal valve, whereas the number of plicae varies from three to five pair in *oviformis.* Internally, the plates, especially tabellae, are shorter in the new form.

The specimen in McClung, 1978, pl. 14, fig. 14 is probably allied to *oviformis,* counter to the claim by Waterhouse (2001, p. 101) that it apparently belonged to *Ingelarella subplicata* Waterhouse, 1964.

Suborder SPIRIFERIDINA Waagen, 1884

Superfamily **TRIGONOTRETOIDEA** Schuchert, 1913

Family **TRIGONOTRETIDAE** Schuchert, 1893

Subfamily **TRIGONOTRETINAE** Schuchert, 1893

Genus ***Neilotreta*** Waterhouse, 2008b

Type species: *Trigonotreta narsahensis occidentalis* Thomas, 1971, p. 108 from upper Lyons Group (Asselian) of Western Australia, OD.

Diagnosis: Four or five pair of simple plicae on each valve, costae limited chiefly to sulcus and fold and occasional plicae split into two. Other detail, including capillate micro-ornament and interior of short high adminicula and absence of tabellae as in *Trigonotreta*.

Discussion: This genus is like immature *Trigonotreta* in so far as costae are largely absent, and as well the plicae are fewer. The genus is represented in the Beckers and Cranky Corner Formations from the Cranky Corner Basin, New South Wales, and is otherwise not known in east Australia, but is found in the early Permian of Western Australia and in India.

Neilotreta sp. indet.

Fig. 21B

1872 *Spirifera undifera* var. *undulata* [not Roemer] – Etheridge Snr., p. 330, pl. 15, fig. 4 [part, not pl. 16, fig. 3-5 = *Monklandia gympiensis*).

1892 *Spirifera strzeleckii* [not de Koninck] – Etheridge Jnr., p. 234, pl. 10, fig. 7 (part, not pl. 10, fig. 5, 6 = *M. gympiensis*).

Description: A fragment of a ventral valve external mould NMV P134551 is over 27mm long, and shows five plicae one side of the sulcus, with broad rounded crests and narrow interspaces. One fine rib arises anteriorly on the outer side of the inner plicae pair, and other single ribs appear anteriorly also along the inner side of some lateral plicae. Fine growth steps and lines are present, 1.2mm apart, with finer lines numbering three per mm. Micro-ornament is poorly preserved, and of uncertain nature, but show traces of fine longitudinal capillae, six per mm, as well as an overall grainy surface presumably due to the matrix.

An internal mould of a ventral valve as shown in the synonymy appears to have been lost. It came from the Lady Mary Reef, possibly in the upper Rammutt Formation, unlike other specimens regarded as conspecific by Etheridge Snr. (1872) and Etheridge Jnr. (1892), which are from the green fossiliferous sandstone. The figure shows single low costae lying parallel to some plicae.

CORRELATION

Specimens assigned to *Magniplicatina* appear to be conspecific with the species *dunstani* found in the Monkland or Pengelly beds of the upper Rammutt Formation at Gympie, and *Protoanidanthus* belongs to *pokolbinensis* Briggs from the Monkland beds at Gympie. The other Monkland faunas have numerous *Bandoproductus*, and are likely to be correlative with *Bandoproductus* and allied faunas found elsewhere in Australia, including those from the upper

Burnett Formation of the Yarrol Basin (Waterhouse 1986a) and upper Lyons Group of the Carnarvon Basin, Westem Australia (Archbold 1983b, Waterhouse 2008b). The faunas are judged to be late Asselian in terms of the world standard stratotypes, as discussed by Waterhouse (2015).

The presence of *Neilotreta* suggests possible correlation with the Cranky Corner Sandstone or Beckers Formation of Cranky Corner, New South Wales, and this appears to be reinforced by the closeness of Monkland *Ambikella* (p. 57) to *A. elongata* (McClung & Armstrong), in the restricted sense, and not including close but slightly different specimens assigned to the species from Tasmania. In turn that suggests that the Cranky Corner and perhaps Beckers Formations fall within the *Bandoproductus* Zone, even though that genus is not found in them. Both *Lyonia*, allied to *Bandoproductus*, and *Neilotreta* are found in the *Neilotreta occidentalis* Zone of Archbold (1993) of Western Australia. The palynomorph zone APP 21, based on *Pseudoreticulatispora pseudoreticulata*, is found in the lower Cranky Corner Sandstone and upper part of the Beckers Formation, and zone APP 22, based on *Microbaculispora trisina,* is found in the upper Cranky Corner Sandstone (Balme & Foster 2003, pp. 130, 131).

TABLE 12. Brachiopod species from the Sweet collection, showing number of specimens.

Species	Ventral valve	Dorsal valve	Both valves conjoined
Protoanidanthus pokolbinensis		7	2
?*Magniplicatina dunstani*	2		
Oviformia sweeti	44	9	1
Neilotreta sp.	1		

Rare fragments of other taxa are present, including *Glendonia* or *Farmerella*, a spiriferid (s. l.) , fenestellid and ?*Bransonia* (Rostroconchia).

5. BRACHIOPODA AND MOLLUSCA FROM THE SOUTH CURRA LIMESTONE

J. B. Waterhouse & Paul E. Balfe

SUMMARY

Brachiopoda and Mollusca from the South Curra Limestone are revised and redescribed, and the following new species proposed: *Echinalosia denmeadi*, *Anidanthia aplini*, *Magniplicatina cranfieldi*, *Ingelarella alteplica, I. fergusoni*, *Cyrtella papula* and *Fletcherithyris runnegari*. The faunas appear to be substantially younger than previously believed, and are amongst the youngest known of marine faunas in Australia, but not latest Changhsingian.

INTRODUCTION

This study was commenced as an Honours Project in the Department of Geology and Mineralogy, University of Queensland, by Paul Balfe (Balfe 1976), under the supervision of J. B. Waterhouse. Material was collected in the lower South Curra Limestone of the Gympie Basin, at UQ L 2703, UQ L 3925 and UQ L 3926 (Fig. 22), on the property of H. Rammutt, which lies north of Rammutt Road, approximately 1.5km northeast of Chatsworth, near Gympie in southeast Queensland. Later we added substantially to these collections, and we have also examined material at the university, examined by Bruce Runnegar. All illustrated material is from UQ L collections, now housed in the Queensland Museum and Science Centre Annex at Hendra, Brisbane, and the prefix UQ L is abbreviated to L.

The nomenclature presently used for the stratigraphic sequence exposed in the Permian-Triassic Gympie Province was largely proposed by Runnegar & Ferguson (1969), building on work by Rands (1889) and Dunstan (1911), and subsequently emended by Murphy et. al. (1976), as endorsed by Murray (1987). South Curra and younger fossils received little explicit attention in Etheridge Snr. (1872) or Jack & Etheridge Jnr. (1892), but Runnegar & Ferguson (1969) focused on these faunas, with some systematic descriptions, many figures, faunal lists, and discussion of correlation. Waterhouse & Balfe (1987) reassessed the faunas, providing several illustrations, and Waterhouse & Sivell (1987a, b) evaluated faunal relationships with the New England Orogen and New Zealand.

STRATIGRAPHY OF THE SOUTH CURRA LIMESTONE

The South Curra Limestone is a bioclastic calcarenite, varying from about 50m to 110m in thickness, and coarsely bedded in layers up to 1m thick. Runnegar & Ferguson (1969) distinguished three invertebrate faunas in the South Curra Limestone. In the basal metre or so of the formation, a molluscan fauna, dominated by what was then thought to be *Megadesmus nobilissimus* de Koninck, 1877, was named the “basal mollusc fauna”. Immediately above this horizon is calcareous siltstone 7-10m thick, with a brachiopod-dominated fauna called the “lower brachiopod fauna”. These two faunas were interpreted as being of Artinskian age, equivalent to

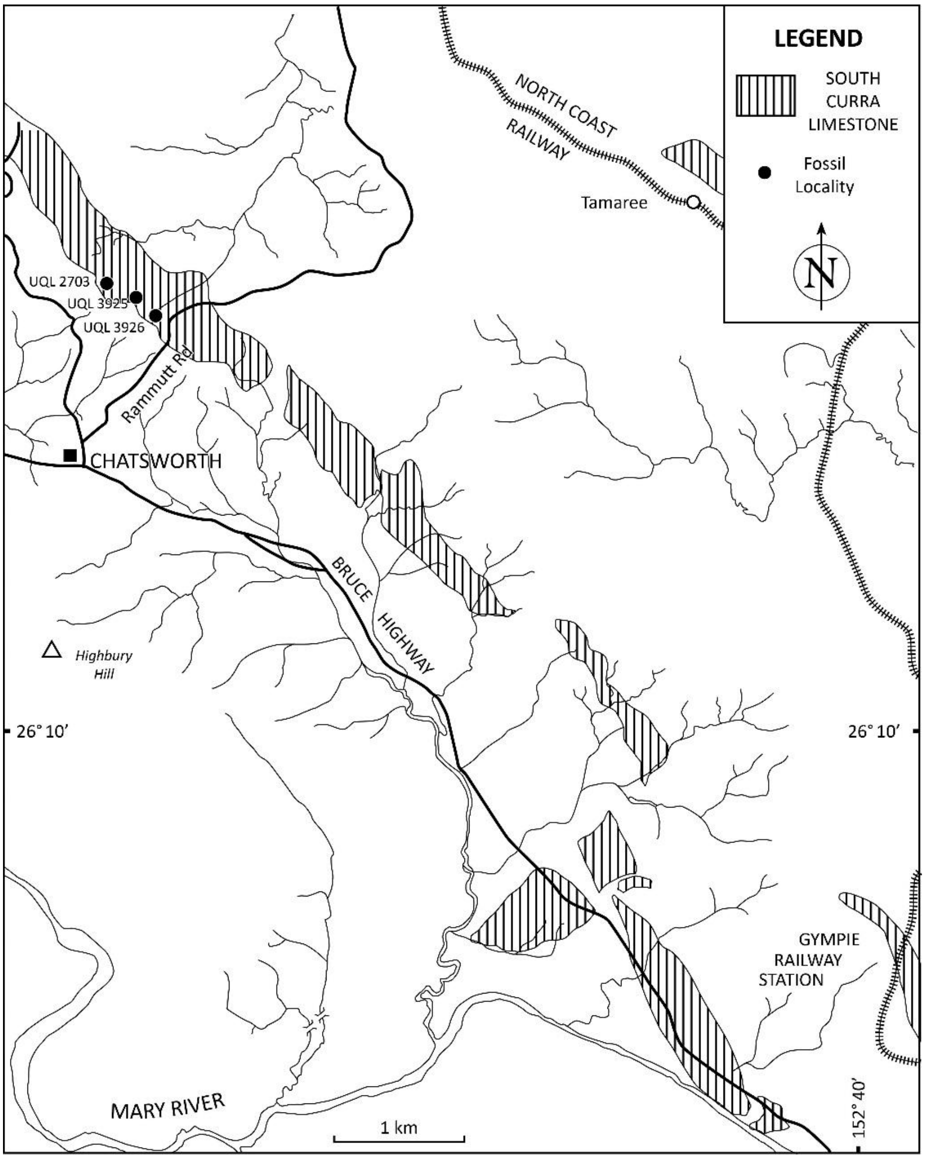


Fig. 22. Outcrop of South Curra Limestone at Gympie, from Balfe (1976). Localities collected by the authors are shown near the top of the figure.

the faunas of the Tiverton Formation at Homevale, in the Bowen Basin and Fauna 11 of Dickins & Malone, 1973 (see Table 2, p. 4). The uppermost fauna in the limestone, occurring in the top 10-18m of the formation, has a distinctive fauna called the "upper brachiopod fauna" and was matched by Runnegar & Ferguson (1969) with the Kazanian Flat Top fauna in the southeastern Bowen Basin. If the basal limestone faunas are Artinskian, and if the upper limestone faunas are Kazanian, there must be a substantial faunal gap in the limestone, equivalent to the upper Artinskian, Kungurian and Ufimian Stages. Fauna 111 of Dickins & Malone (1973) would appear to be completely absent, even though the South Curra Limestone is apparently homogeneous and not very thick. There are minor disconformities, related to minor pauses, surges and discontinuities in sedimentation, but these are not restricted to any one horizon, and appear to be homologous with the minor disconformities widely found in shallow water limestones. Overall, the limestone and its nature and variability appear to be consistent with geologically continuous sedimentation, interrupted by relatively brief pauses, at various horizons. This would suggest that the faunas might have been wrongly assessed, or that species typical of Fauna 11 were somehow replaced by species of Fauna 1V, without intervention of Fauna 111. Balfe (1976) re-examined the brachiopods from the lower South Curra Limestone, and concluded that the brachiopods were much younger than allowed by Runnegar & Ferguson (1969), as suggested by Waterhouse & Balfe (1987). As foreshadowed in Waterhouse (2002a, pp. 156-159) and Shi et al. (2010), the South Curra faunas appear to all of Changhsingian, or very late Permian in age, with no major break within the limestone, but with minor disconformities, and possibly a degree of faunal mixing thanks to reworking.

SYSTEMATIC DESCRIPTIONS

(a) Basal mollusc fauna

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Order PECTINIDA Gray, 1854

Suborder ANOMIIDINA Gray, 1854

Hyporder AVICULOPECTINOIDEI Starobogatov, 1992

Superfamily **HETEROPECTINOIDEA** Beurlen, 1954

Family **HETEROPECTINIDAE** Beurlen, 1954

Subfamily **ETHERIPECTININAE** Waterhouse, 1982b

Genus ***Etheripecten*** Waterhouse, 1963c

Type species: *Etheripecten striatura* Waterhouse, 1963c, p. 195 from Kildonan Member (Changhsing -ian), Bagrie Formation, New Zealand.

Diagnosis: Left valve bears costae in several orders as a rule, arising by intercalation, primary costae generally remaining prominent. Right valve costae simpler and more uniform, increase by intercalation. Growth lines arch dorsally in interspaces. Shell aragonitic or calcitic (see Waterhouse 2015, p. 269).

Etheripecten striatura Waterhouse, 1963c

Fig. 23

1956 *Aviculopecten* n. sp. cf. *hiemalis* [not Salter] – Marwick in Wood, p. 47, fig. 23b, c.

1963c *Etheripecten striatura* Waterhouse, p. 195, Fig. 1-5.

1969 *E. striatura* – Newell, p. 337, fig. C62.1a, b.

1969 *Aviculopecten* sp. Runnegar & Ferguson, p. 263, pl. 1, fig. 10 (part, not fig. 11).

1978 *E. striatura* – Suggate et al. Fig. 4.7. fig. 5, 7.

1982b *E. striatura* – Waterhouse, p. 23, pl. 9a, b, f, g.

2008a *E. striatura* – Waterhouse, p. 136, Fig. 75A-C.

Holotype: TM 3630 figured by Waterhouse (1963b, fig. 1) from Kildonan Member (Changhsingian), Bagrie Formation, New Zealand, OD.

Diagnosis: Small shells with long right anterior auricle, left valve primary ribs seven to nine in number, with fine threads or riblets along crest, and three further orders, commarginal laminae well developed.

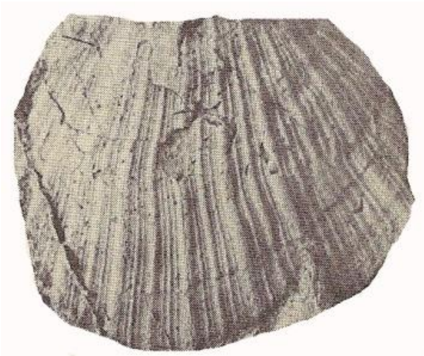


Fig. 23. *Etheripecten striatura* Waterhouse, latex cast of left valve fragment UQ F 45408 from UQ L 2703a, x1, as figured by Runnegar & Ferguson (1969, pl. 1, fig. 10).

Description: The left valve figured by Runnegar & Ferguson (1969) has seven or eight primary costae, bearing fine threads or riblets along the crest, and three further orders of ribbing. The Ulladulla specimen from the south Sydney Basin that was compared with the Gympie specimen by Runnegar & Ferguson (1969, pl. 1, fig. 11) has some eleven primary costae, so that although close in many respects, appears to belong to a different species.

Megaorder SOLENATA Dall, 1889

Order HIATELLIDA Carter in J. G. Carter et al., 2011

Superfamily **EDMONDIOIDEA** King, 1850

Family **PACHYDOMIDAE** Fischer, 1887

Subfamily **PACHYDOMINAE** Fischer, 1887

Genus ***Megadesmus*** Sowerby, 1838

Type species: *Megadesmus globosus* Sowerby, 1838 from Allandale Formation (Asselian), Sydney Basin, New South Wales, SD Woodward (1856, p. 302).

Diagnosis: Large shells with low to moderately high and enrolled anteriorly placed umbones, shell thin to thick, right tooth variable, may become obsolete, posterior gape slight, anterior adductor scar not connected to anterior retractor scar by isthmus.

Discussion: The genus *Cleobis* Dana, 1847, type species *Cleobis grandis* Dana, 1847, p. 154 from “Illawarra”, Broughton Formation (Wordian), south Sydney Basin, New South Wales, SD Newell 1956, p. 10, is synonymized with *Megadesmus*, following Runnegar (1967) and Waterhouse (1969a, Waterhouse & Jell 1983). Although there are differences between the two type species, notably in the comparatively thin shell, lack of coarse rugged growth-lines and usually weaker dentition found in *Cleobis grandis* as compared with *Megadesmus globosus*, the overall shape is very close. In the two thin-shelled species *Protraxia nobilissimus* and *P. gryphoides*, the anterior adductor is joined posteriorly to the anterior retractor scar by an isthmus, whereas in type *Megadesmus* and in *grandis*, the isthmus is absent (Runnegar 1965, Fig. 1f; Waterhouse 1969a, pp. 41, 53, text-fig. 7; Waterhouse 2015, p. 308). In that respect, *Protraxia* is like members of Vacunellidae and Myoniidae, which share the isthmus that extends posteriorly from the upper anterior adductor scar, whereas the isthmus is missing from *Megadesmus, Pyramus* and *Astartila*.

Megadesmus ponderosus Waterhouse, 2010b

Fig. 24, 25

1965 *Megadesmus* (*Megadesmus*) *nobilissimus* [not de Koninck] – Runnegar, p. 237, pl. 13, fig. 11, 15, pl. 14, fig. 3, 4, 6, 8-12, 15, text-fig. 2 (part, not pl. 13, fig. 14, 16-18, pl. 14, fig. 1, 2, 5, 7, 13 = *Protraxia nobilissimus*).

1967 *M. nobilissimus* – Runnegar, p. 101, pl. 20, fig. 2, 6, text-fig. 3G.

1969a *M. nobilissimus* – Waterhouse, p. 43, pl. 10, fig. 3, pl. 22, fig. 3, pl. 23, fig. 1-3, text-fig. 18 (part, not pl. 6, fig. 2, 5, 6, pl. 7, fig. 1, 3 (not 2 as in caption), text-fig. 7A, 8A, 17, 19A = *P. nobilissimus*).

1969 *M. nobilissimus* – Runnegar & Ferguson, pl. 1, fig. 1-3.

1987 *Megadesmus* n. sp. Waterhouse & Balfe, p, 32, pl. 2, fig. 1, 2.

2010b *Megadesmus ponderosus* Waterhouse, p. 108, Fig. 48, 49.

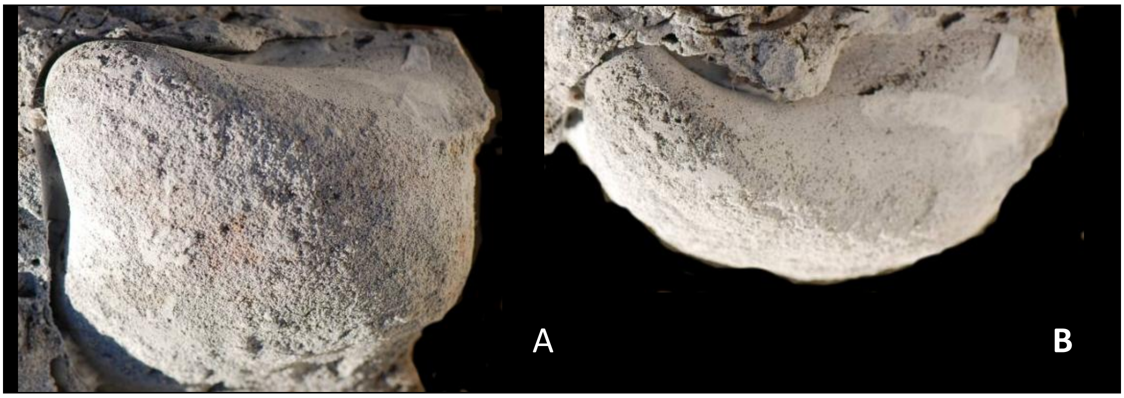


Fig. 24. *Megadesmus ponderosus* Waterhouse, lateral and dorsal aspects of leached left valve UQF 61883 from UQL 2703a, x1.

Holotype: UQ F 46635 from UQL 2703a, basal South Curra Limestone (Changhsingian), Gympie, southeast Queensland, as figured herein in Fig. 25A, and also in Runnegar (1965, pl. 14, fig. 3, 4, 9; 1967, pl. 20, fig. 2, 6), Runnegar & Ferguson (1969, pl. 1, fig. 1-3) and Waterhouse (2010b, Fig. 49A), OD.

Diagnosis: Well to moderately inflated shells with umbones anteriorly placed and swollen, massive tooth in right valve, shell thick.

Resemblances: Compared to *Protraxia nobilissimus* (de Koninck) from the Farley Formation and especially Ravensfield Sandstone Member of the north Sydney Basin, New South Wales, this species is more swollen and less oval in outline. The umbo is anteriorly placed and more swollen, and the anterior dorsal margin steeper and less concave in outline. The shell is thick in the Gympie material, whereas it is thin in the Farley specimens. The internal right tooth as figured by Runnegar (1965, pl. 14, fig. 6, 8) is much larger than found in *nobilissimus*. Another Farley species, *P. gryphoides* (de Koninck) has larger more swollen and more incurved umbones and greater inflation, shorter hinge and thin shell (Waterhouse 2015).

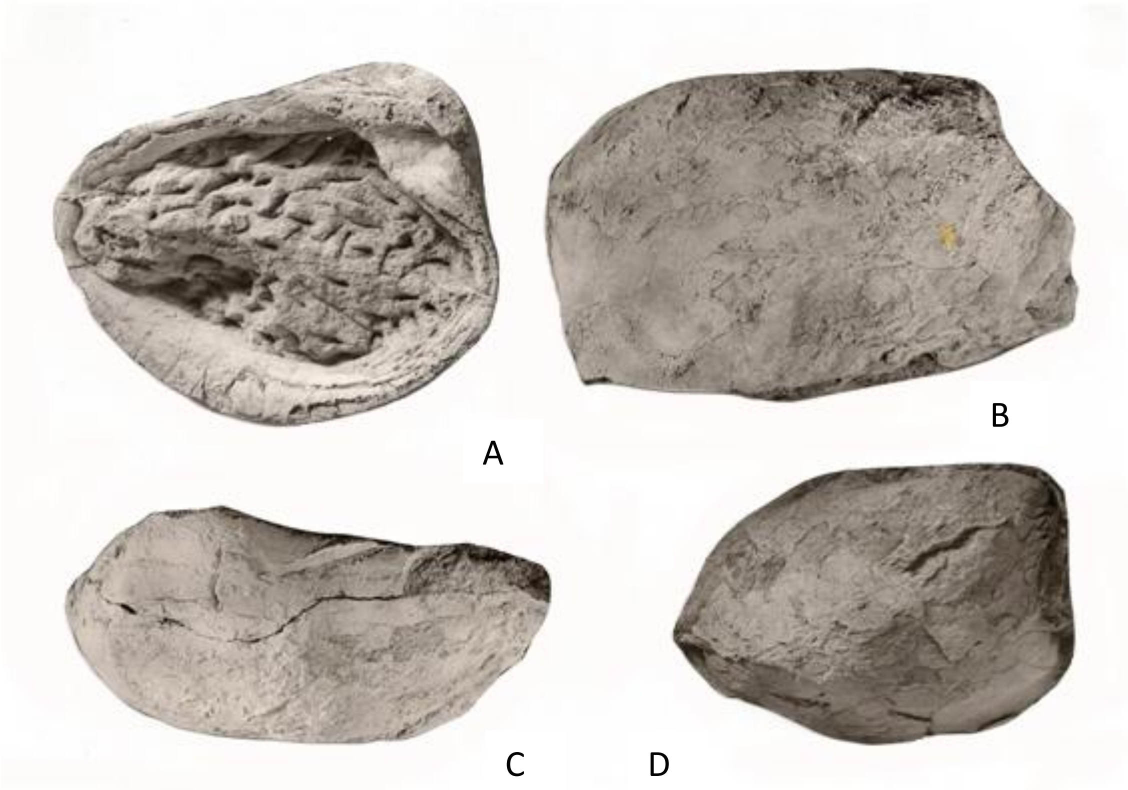


Fig. 25. *Megadesmus ponderosus* Waterhouse. A, interior of left valve holotype UQ F 46635. B, C, lateral and dorsal aspects of left valve UQ F 76949. D, right valve UQ F 45394. Specimens from UQ L 2703a, x1.

Amongst Australian species, the Gympie specimens come close to *Megadesmus grandis* (Dana) – see Waterhouse & Jell (1983) for summary – but the tooth in this species is small and the shell thin, and the umbones slightly more prominent and may be less anteriorly placed. A related species *deflatus* in Waterhouse & Jell (1983), from the Glendoo Sandstone Member of the Gebbie Formation in the north Bowen Basin, has a small right valve tooth, and pedal isthmus as in *Protraxia.*

Megadesmus trigonalis (Johnston, 1887, 1888), refigured by Waterhouse (1969a, pl. 7, fig. 2, 4, pl. 8, fig. 1), is only moderately close in outline, with greater inflation, and less concave dorsal anterior margin. It comes from the Brumby Marl of the Golden Valley Group in Tasmania, and seems to be allied to *M. globosus* Sowerby. Sowerby's species, based on material from the Allandale Formation of the Sydney Basin, is similarly swollen with extended ventral anterior, thick shell and blunt tooth. *Cleobis robusta* Laseron, 1910 from Burrier, south Sydney Basin, differs in shape from the present form, with slightly more posteriorly placed umbo and more oval outline, and is essentially close to *M. grandis* (Dana), as proposed by Runnegar (1965).

Astartila blatchfordi Hosking (1931, pl. 7, fig. 4a, b, 5; 1933, pl. 6, fig. 3), also figured by Dickins (1956, pl. 2, fig. 10-12) and Dickins & Skwarko (1993, pl. 48, fig. 23), looks moderately like the Gympie specimens but is less elongate with higher more prominent umbones. It comes from the Wandagee and Coyrie Formations of Baigendzinian age in the Carnarvon Basin, Western Australia. Various other species from the Permian of Western Australia that were ascribed to *Astartila* Dana and *Astartila*? by Dickins (1956, 1957, 1963) also belong to *Protraxia* or *Megadesmus*, as pointed out by Waterhouse (1969a; 2015, p. 310).

Family **EDMONDIIDAE** King, 1850

Subfamily **MYONIINAE** Waterhouse, 1969a, 1987b

Genus ***Pachymyonia*** Dun, 1932

Type species: *Maeonia morrisii* Etheridge, 1919, p. 186 from Allandale Formation (Asselian), north Sydney Basin, New South Wales, OD.

Diagnosis: Moderately large shells with very strong posterior umbonal ridge.

Discussion: The authorship of Myoniinae is discussed in Waterhouse (2015, p. 317). Skarlato & Starobogatov (1979) proposed the unit as a family, but failed to meet requirements of the Zoological Commission (ICZN 1999) to provide any discrimination from Edmondiidae and other groups.

Pachymyonia sp.

Fig. 25

1969 *Myonia morrisi* [not Etheridge] – Runnegar & Ferguson, pl. 1, fig. 4.

Discussion: A fragmentary right valve UQ F 45391 from UQ L 2703a at Gympie was identified by Runnegar & Ferguson (1969) with *Myonia* (now *Pachymyonia*) *morrisii* from the Early Permian faunas at Lochinvar, Sydney Basin. This species is represented in the Kolbar Formation near Gympie, as illustrated in Fig. 47, and has a broad umbonal ridge and high carina. The angle and especially nature of the posterior umbonal ridge and relationship to the posterior face, and lack of deep narrow lateral sulcus in the South Curra specimen suggest a closer approach to *Pachymyonia triangulata* Waterhouse (1969a, pl. 17, fig. 2, 5, pl. 18, fig. 1, 4-7; text fig. 7B, 12). This species has an abruptly angular but not raised carina steeply inclined from the hinge at 45-50°, and broad shallow lateral sulcus as a rule. *P. triangulata* was initially recorded from the *Echinalosia ovalis* and *Terrakea brachythaera* Zones in the middle Productus Creek Group of New Zealand, and has been found in the Blenheim Formation of the north Bowen Basin by Waterhouse & Jell (1983, p. 252, pl. 5, fig. 9) and in the Flat Top Formation of the south Bowen Basin by Waterhouse (1987b, p. 30, pl. 11, fig. 7), of Wordian age. The present fragment differs from New Zealand type *P. triangulata* in that the shell may be slightly more elongate with no lateral sulcus and the posterior ridge is more concave in outline.

In these respects the fragment comes closer to the specimen figured as *P. triangulata* by Waterhouse & Jell (1983) from the upper Moonlight Sandstone Member of the northern Bowen

Basin. Only a broad shallow sulcus is developed on the lateral flanks, and the posterior ridge is not strongly raised. The Moonlight specimen comes from the upper Moonlight Sandstone in the *Pseudostrophalosia blakei* Zone (see Waterhouse 2008b), judged to be of Roadian or Wordian age.

Fig. 25. *Pachymyonia* sp., incomplete right valve, UQ F 45394a, from L 2703a, x1.

(b) Lower brachiopod fauna, South Curra Limestone

Phylum Brachiopoda Duméril, 1797

Superorder PRODUCTIFORMII Waagen, 1883

Order CHONETIDA Muir-Wood, 1955

Superfamily **CHONETOIDEA** Bronn, 1862

Family **RUGOSOCHONETIDAE** Muir-Wood, 1962

Subfamily **SVALBARDIINAE** Archbold, 1982

Genus ***Capillonia*** Waterhouse, 1973a

Type species*:* *Lissochonetes brevisulcus* Waterhouse, 1964 from Trig DD Formation (Changhsingian), New Zealand, OD.

Diagnosis: Transverse, often weakly sulcate convexo-concave chonetids, with cardinal spines, no body spines, pseudodeltidium and chilidial plates present. Ventral valve smooth, dorsal valve may be finely capillate. Ventral septum high and short, dorsal median septum moderately long, lateral ridges along the hinge, weakly developed anderidia.

Capillonia brevisulcus (Waterhouse, 1964)

1925 *Chonetes* cf. *vishnu* [not Salter] – Marwick, p. 362, text-fig. 2, 3.

1964 *Lissochonetes brevisulcus* Waterhouse, p. 21, pl. 1, fig. 7-11, pl. 2, fig. 1-8, pl. 3, fig. 1, 2, pl. 31, fig. 3, 4, text-fig. 2A, 3-5.

1969 *Lissochonetes* cf. *yarrolensis* [not Maxwell] – Runnegar & Ferguson, pl. 2, fig. 24-25.

1969 *Lissochonetes* sp. Runnegar & Ferguson, pl. 5, fig. 8.

1973a *Capillonia brevisulcus* – Waterhouse, p. 37.

1978 *C. brevisulcus* – Waterhouse & Mutch, p. 517, text-fig. 3-6.

1978 *C. brevisulcus* – Suggate et al. text-fig. 4.7, fig. 6, 10.

1981 *C. brevisulcus* – Speden, pl. 7, fig. 6, 10.

1982a *C. brevisulcus* – Waterhouse, p. 29, pl. 6c.

1987 *Capillonia*? *semicircularis* [not Campbell] – Waterhouse & Balfe, p. 32, pl. 2, fig. 3.

2000 *C. brevisulcus* – Racheboeuf, p. 415, Fig. 271.2a-c.

2001 *C. brevisulcus* – Waterhouse, p. 15, pl. 1, fig. 2-9.

Holotype: BR 917 from Trig DD Formation (Changhsingian), Arthurton Group, New Zealand, figured in Waterhouse (1964, pl. 2, fig. 4, pl. 3, fig. 2, 3), Suggate et al. 1978), Speden (1981) and Racheboeuf (2000, Fig. 271a), OD.

Diagnosis: Medium-sized chonetids; outline semicircular to transversely subrectangular, cardinal extremities subrectangular to weakly alate. Venter somewhat flattened, ventral sulcus and dorsal fold usually weakly developed, may be absent. Ventral septum strong and high posteriorly, vascular trunks well developed, dorsal septum absent from smaller shells.

Description: Outline approximately semicircular, maximum width usually at hinge, cardinal margins subrectangular or slightly alate. Sulcus faintly developed or absent, fold absent or anteriorly placed. Ventral valve of low to moderate convexity, greatest curvature in umbonal region; dorsal valve concave. Ventral umbo small, ears small, flattened or weakly concave on dorsal valve. Ventral area apsacline, up to 2mm high; dorsal area low, inclined postero-ventrally at 30^{o} from plane of commissure; both areas taper evenly to the cardinal extremities. Notothyrium partly closed by chilidial plates; cardinal process with deeply grooved median lobe visible externally in central part of notothyrium, between chilidial plates. Weathering of surfaces produces fine lines of papillae on both valves, numbering 15 rows in 10mm near the anterior margin. Eight to ten cardinal spines lie along the hinge, with bases inclined towards umbo internally, inclined away from umbo externally. Shell surface poorly preserved, hindering complete description.

Ventral median septum distinct, one-quarter to two-fifths of valve length, high posteriorly; ventral adductors tear-shaped, short, weakly differentiated. Diductors large, weakly impressed, weakly striated. Vascular trunks divided by a low rounded groove along central anterior portion of disc, well developed in larger individuals. Hinge teeth long, curving postero-laterally. Submarginal ridge extends from base of socket ridge around anterior edge of disc.

Dimensions in mm of *Capillonia brevisulcus*: Average L/W = 0.59

Specimen	Length	Width	L/H
UQ F 69213	7.1	13	0.54
UQ F 69243	7.1	13	0.54
UQ F 69244	?9	20	0.45
UQ F 69245	9	17	0.53
UQ F 69246	10	?18	?0.56
UQ F 69247	13	20	0.65
UQ F 69248	10	14	0.71
UQ F 69249	12	18	0 67
UQ F 69249	12	18	0.67
UQ F 45443	13	21	0.62

Cardinal process with trilobed posterior face, lateral lobes partly obscured by chilidial plates, median lobe deeply divided. Adductors smooth, elongate, slightly divergent anteriorly, no differentiation observed, anderidia developed, median septum absent in shell 15mm wide (UQ F 69243), well developed in larger specimen (eg. UQ F 45451). Brachial ridges weakly impressed: socket ridges strong, curving posteriorly, extend into lateral septa lying subparallel to hinge.

Further material is recorded from the upper South Curra Limestone and the Gigoomgan Formation (pp. 108, 148, Fig. 66).

Resemblances: These specimens were previously ascribed to *Lissochonetes yarrolensis* Maxwell, 1964 which is now classed as *Tivertonia* Archbold, 1986. Compared with *yarrolensis*, Gympie material shows a distinctly lower ventral valve profile and usually wider hinge, and ventral valves of *yarrolensis* have a slightly longer and stronger median septum. The dorsal median septum is absent from immature Gympie specimens, with only a smooth, flattened median area in smaller specimens, whereas type and topotype material of *T. yarrolensis* shows a low median septum. Specimens of *Capillonia semicircularis* (Campbell, 1953, p. 6, pl. 1, fig 10-13) from the Ingelara Shale, Catherine Sandstone and lower Peawaddy Formation (Parfrey 1988, p. 32, Table 10) in the southwest Bowen Basin in Queensland usually lack a dorsal median septum according to Campbell (1953), although Dear (1971) has observed a very weak incipient septum or a smooth medial flattening. Specimens from the Flat Top Formation of the Bowen Basin have a median septum in immature and mature shells (Waterhouse 1986a). Shells figured from the Barfield Formation and Flat Top Formation of the southeast Bowen Basin by Parfrey (1988, pl. 2, fig. 11-13) and Waterhouse (1986a, pl. 2, fig. 32-35, pl. 3, fig. 1-4) are close in internal detail, but are more elongate. The shape of the South Curra specimens is much closer to that of *Capillonia brevisulcus* (Waterhouse, 1964) from the *Spinomartinia spinosa* Zone and less commonly in the *Tigillumia parallela* Zone, of the Arthurton Group and Glendale Formation of New Zealand (Waterhouse 2001, 2002a, p. 65).

Taxonomy: Hill, Playford & Woods (1972, pl. P4, fig. 4) figured a specimen which they call *Lissochonetes australis*, attributing the species to Maxwell, 1954b. The name *australis* was used by Maxwell, but was never published.

Order PRODUCTIDA Waagen, 1883

Suborder STROPHALOSIIDINA Waterhouse, 1975

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Genus ***Echinalosia*** Waterhouse, 1967a

Type species: *Strophalosia maxwelli* Waterhouse, 1964, p. 32 from Letham Burn Formation (Roadian), New Zealand, OD.

Diagnosis: Spines of two series interspersed over ventral valve, simple, not sinuous as a rule or arranged in special rows or aggregated to form lateral brush, usually present but may be few or missing over ventral ears; spine cores over middle valve may extend well forward from spine base.

Dorsal spines fine and erect. Capillae present or absent, commarginal ornament subdued or absent.

Echinalosia denmeadi n. sp.

Fig. 26I

1969 *Wyndhamia preovalis* var. *warwicki* [not Maxwell] – Runnegar & Ferguson, pl. 2. fig. 10-12, 14 (part, not fig. 13 = sp. indet.).

1987 *Echinalosia* sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 4, 5.

1998 *Echinalosia preovalis* [not Maxwell] – Briggs, p. 76.

Derivation: Named after A. K. Denmead.

Holotype: UQ F 45409 from L 2703b, South Curra Limestone (Changhsingian), Gympie, figured by Runnegar & Ferguson (1969, pl. 2, fig. 10), here designated.

Diagnosis: Small concavo-convex moderately transverse shells with ventral spines slightly stronger postero-laterally, fine over rest of disc, dorsal spines fine, often numerous. Ventral muscle scars small to moderately elongate, and posteriorly placed.

Description: Shells small, ventral valve moderately convex, transverse to elongate, hinge less than maximum width of shell placed near mid-length; ventral umbo with cicatrix. Dorsal valve concave to moderately concave with convex nepionic portion, not thickened into wedge, ventral interarea well formed, neither unusually low or high, dorsal interarea low, no ventral sulcus or dorsal fold. Trail not distinguished from disc, except in one specimen where it is possibly affected by deformation. Ventral spines comparatively uniform on the whole, with slender suberect spines, most only 0.2-0.3mm thick over median shell. Recumbent spines fine, few. No large outer ear spine. Fine commarginal growth lamellae, and also radial capillae on some specimens, especially on UQ F 45409. Dorsal valve with commarginal growth lamellae and prominent short elongate tubercles and depressions, intermittent radial capillae, spines numerous, erect and fine, 0.15 to 0.2mm in diameter.

Ventral adductors variable, short and tear-shaped or elongate, diductor scars small and rounded in outline, overlapping adductors for 0.6 of length, lightly impressed, with fine radial grooves. Teeth small, close-set.

Resemblances*:* This species is also found in the Gundiah Bridge Greywacke and Gigoomgan Limestone of the Gigoomgan area (pp. 140, 148, Fig. 57, 67).

Strophalosia preovalis warwicki (Maxwell, 1954a) from the *Eurydesma* beds of the Stanthorpe Road block in southeast Queensland is similar in having many dorsal spines on some specimens, but ventral ear spines are well developed, and are strong close to the hinge, the ventral interarea is very low and hinge narrow, and the ventral valve is more strongly arched. Dorsal capillae are much more evident in *warwicki,* whereas they are faint and impersistent in the new form. The ventral adductor scars of the present species may be elongate, approaching those of many type *warwicki,* a feature emphasized as diagnostic by Briggs (1998). The species *warwicki* is now the type species for

Capillaria Waterhouse (2001, p. 67; Brunton 2007). It is smaller than the present species and is characterized by having a row of hinge spines, large postero-lateral ventral spines, and dorsal capillae. Specimens have been figured as *Echinalosia preovalis* (not Maxwell) by McClung (1980, pl. 19.1, fig. 1) and as *E. warwicki* by Briggs (1998, p. 73, Fig. 39A-H), but examples of *warwicki* are scarce other than in the Stanthorpe road block. Part of the Briggs' synonymy must be emended, because a ventral interior figured by Hill & Woods (1964, pl. P4, fig. 9) and Hill, Playford & Woods (1972) is deemed to belong to *Acanthalosia*, with its thick posterior shell, emphasized muscle scars, and strong spine bases on the ears, and spine tunnels. The specimen figured as *preovalis* by Clarke (1969, p. 47, pl. 6, fig. 7) was transferred to *warwicki* by Briggs (1998, p. 74), yet it was indicated as a topotype specimen of *preovalis* by Clarke (1969). The source for Clarke's other figured specimen (Clarke 1969, pl. 6, fig. 8) was not provided, and is poorly known, being an internal mould, but has muscle scars close to those typical of *preovalis*. The lack of strong ventral spines near the hinge, the less steep posterior ventral walls, the difference in ventral adductor scars, and variable presence of capillae suggest that the Gympie form *denmeadi* is not closely related to *warwicki,* and it appears to be closer to *Echinalosia* ss.

Echinalosia preovalis (Maxwell, 1954a) from the Cattle Creek Formation (lower Artinskian) of the western Bowen Basin has a lower ventral interarea and less transverse and more concavo-convex profile. Briggs (1998, p. 76) referred the Gympie material to *preovalis*, but the shape, ventral interarea and the pattern of ventral spines differ considerably, and of course the radiometric value for sediments below the South Curra Limestone which indicates a 275Ma Kungurian age, as explained on p. 120, shows that the Gympie species is younger than type *preovalis*. *E. discinia* Waterhouse, 1986a from the Brae Formation of southeast Bowen Basin is close in overall shape and height of ventral interarea, but its ventral spines are moderately differentiated. *E. maxwelli* (Waterhouse, 1964) from the Oxtrack Formation in southeast Bowen Basin and Letham Burn Formation of New Zealand is also close in shape, but differs in spine pattern and has coarser ventral spines and narrower hinge, with faint impersistent dorsal capillae.

Echinalosia sp. of Waterhouse (1976b, p. 236, Fig. 4.1) from the *Martiniopsis woodi* Zone in the Earnvale Member at the base of the Bagrie Formation (Waterhouse 2002a, p. 98) in the Arthurton Group of New Zealand is small and highly arched, without a sulcus and with narrow hinge. In its thick ventral spines and highly arched venter this specimen looks close to the South Curra specimen UQ F 45414b from UQ L 2703b as figured by Runnegar & Ferguson (1969, pl. 2, fig. 13), which has a number of coarse spines, such as are not seen in other specimens from the same locality, nor in material from Gigoomgan (see pp. 140, 148). The mix of coarse erect and fine prostrate spines is more typical of mid-Permian *Echinalosia*, but little is known about various attributes of these two specimens.

Echinalosia glabra Briggs (1998, p. 103, Fig. 54A-G) from the Flat Top Formation of southeast Bowen Basin displays numerous fine spines, but overall size and shape and height of interarea are features shared with *E. ovalis* (Maxwell), and coarse posterior ventral spines are developed. The fine and numerous spines over both valves of the present species recall the spination developed in species of *Marginalosia* Waterhouse, a late Permian form that first appeared in New Zealand at the top of the *Spinomartinia spinosa* Zone, which is equivalent to the upper South Curra Limestone. In *Marginalosia* the ventral spines are rarely if at all prostrate, and the present species *denmeadi* shows few prostrate ventral spines, though the spines are so fine that they are difficult to discriminate. Compared with *Marginalosia*, *denmeadi* has comparatively low ventral adductor scars, and the dorsal valve is not thickened, but *denmeadi* could have been a praecursor species to *Marginalosia*, a possibility requiring further study.

Suborder LINOPRODUCTIDINA Waterhouse, 2013

Superfamily **PAUCISPINIFEROIDEA** Muir-Wood & Cooper, 1960

Family **ANIDANTHIDAE** Waterhouse, 1968b

Subfamily **ANIDANTHINAE** Waterhouse, 1968b

Genus ***Anidanthia*** Waterhouse, 2013

Type species: *Anidanthus paucicostatus* Waterhouse, 1986a, p. 62 from Elvinia Formation (Sakmarian) of southeast Bowen Basin, OD.

Diagnosis: Shells with prominent radial ornament, spines limited to ventral valve, forming well defined hinge row, scattered or rare over disc and trail. Dorsal ears laterally extended, not twisted, trail long, geniculate, not thickened.

Anidanthia aplini n. sp.

Fig. 26A – H

1969 *Anidanthus springsurensis* [not Booker] – Runnegar & Ferguson, pl. 2, fig. 15-17.

Derivation: Named for C. D'Oyly H. Aplin, government geologist.

Holotype: UQ F 69231 from L 2703b, South Curra Limestone (Changhsingian), illustrated in Fig. 26C, here designated.

Diagnosis: Moderately transverse shells with strong moderately close-spaced ribs, dorsal ears usually ribbed, dorsal lamellae moderately developed.

Description: The shell is transverse as a rule, trail long and geniculate, weak dorsal fold present anteriorly. Ventral valve sulcate or medianly flattened, visceral cavity 5mm deep in a specimen of moderate size. Ventral exterior covered by radial costellae, 20-21 in 10mm at 10mm from umbo, increase mostly by intercalation, but in sulcal region increase appears to have been by bifurcation, with newly formed costellae showing sharp angular divergence from parent costella, crests round, as wide as interspaces. Ventral spines sparsely distributed, emerging at high angle from the costae which may diverge and reunite around the spine base. Spines not more abundant on ventral ears. Two clasping hinge spines preserved on UQ F 69227 emerge 3.5mm each side of the umbo, and curve toward the umbo. Dorsal radial costae average 20-21 in 10mm at 10mm from umbo, retaining this spacing evenly over disc. Costae may be weak on inner ears. Coarse dorsal commarginal growth lamellae lie evenly spaced on disc, crowded together on trail, totalling about 14 and each approximately 1.5mm apart. Nature of commarginals apparently varies from broad narrow crested ridges (UQ F 69221 from L 2703b) to ridges bearing now broken lamellae (UQ F 69224 from L 2772). Shell growth in front of each lamellum proceeded at a slightly lower level, and a few commarginal laminae of very low relief lie between major lamellae. Commarginal ornament extends across onto ears.

Ventral adductors weakly impressed, smooth, subtriangular, anteriorly divided by a median ridge; posteriorly scars undivided or very weakly divided. Fine pits lie in front of adductors, radially elongate, deeper anteriorly, arranged more or less in radial rows, up to 0.6mm apart in each direction. Diductor impressions posteriorly placed, deeply impressed, laterally ovate, crossed by six longitudinal striae, surface between striae smooth. Diductor margins entire, anterior margin well defined, weakly undulose. Ventral interior may show strong posterior thickening, particularly in front of the adductors, between the diductors, and between cardinal margins and posterior adductor margins.

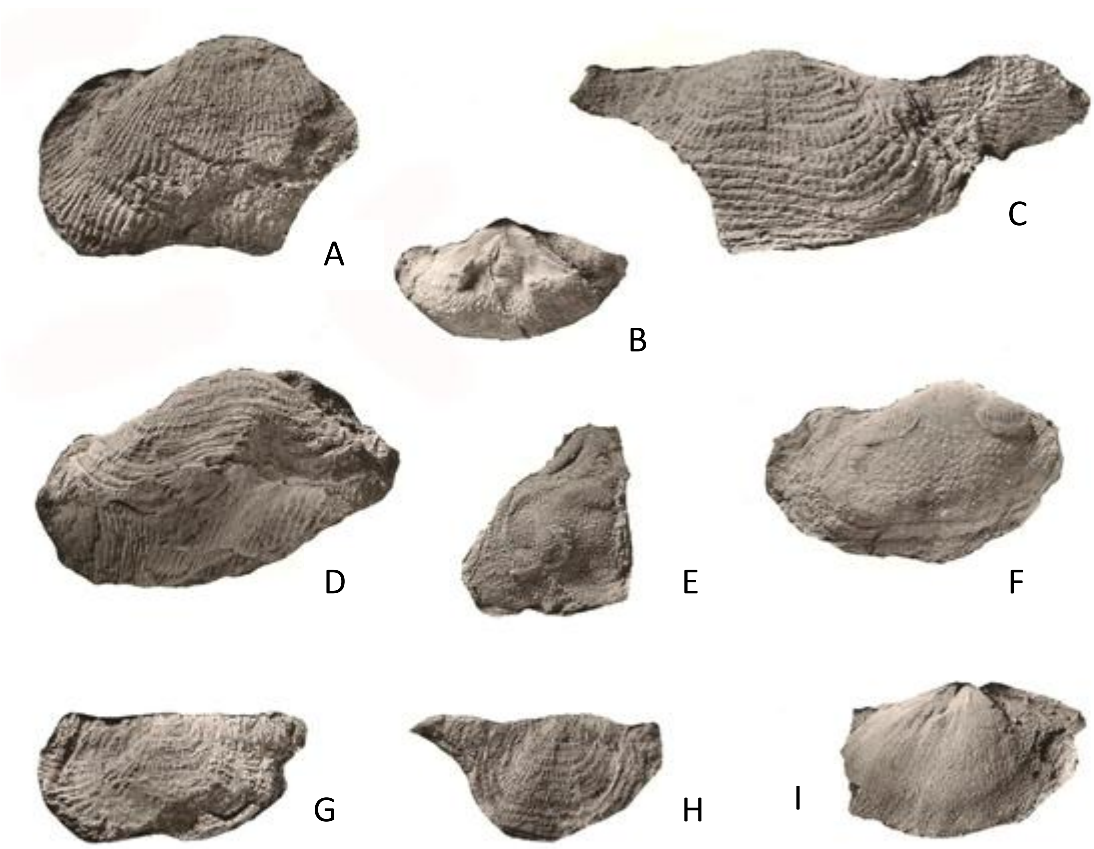


Fig. 26. A – H, *Anidanthia aplini* n. sp. A, ventral valve UQ F 69237 from L 3926, x2. B, posterior aspect of ventral internal mould UQ F 69242 from same locality, x2. C, dorsal valve holotype UQ F 69221 from L 2703b, x2. D, anterior dorsal valve and trail, UQ F 69226 from L 3926, x2. E, dorsal interior of same specimen, x2. F, ventral internal mould UQF 69234 from L 3926, x1.5. G, dorsal exterior, anterior ears lost, UQ F 69235 from L 3926, x2. H, dorsal exterior, UQ F 69229 from L 2703b, x1. I, *Echinalosia denmeadi* n. sp., ventral internal mould UQ F 69249 from L 3955, x2.

Dimensions in mm of *Anidanthia aplini*:

Specimen	Length	Width.	Height	L/H
Ventral valves:				
UQ F 69227	11	14.5	?	
UQ F 69236	9	18	5	0.50
UQ F 69237	16	26	6	0.61
UQ F 69234	16	25	10	0.61,
UQ F 69212	16.5	35	9	1.1
Dorsal valves:				
UQ F 69229	17	37	?	0.46
UQ F 69235	9	18.5	?	0.49
UQ F 69232	7.5	22	9	0.31
UQ F 69228	9	13	?	0.69
UQ F 69230	14	20	5	0.70
UQ F 69221	14	44	9.5	0.32

Dorsal median septum strong, high anteriorly. Adductor scars divided into subtriangular anterior impressions and more elongate postero-lateral impressions, both smooth. Brachial ridges strong, extending from between the adductor subdivisions, to form a smoothly curving loop closing well forward, then weakening considerably toward junction with the median septum, immediately in front of the anterior adductors.

Resemblances: This species looks close to *Anidanthia paucicostata* (Waterhouse) from the Elvinia and Tiverton Formations of the Bowen Basin, Queensland. Differences involve shape, the Gympie species being more transverse, and costation, ribs on average counted at seven to nine in 5mm on the ventral valve in *paucicostata*, compared with nine to eleven over the anterior ventral valve of the new species. Ribbing tends to be stronger on the dorsal ears in the new species, compared with ribbing on ears in *paucicostata*. *Anidanthia solita* (Waterhouse, 1968b) from the Wandrawandian Formation (early Middle Permian) of the south Sydney Basin, is closer to the present form in so far as dorsal ears may be well ribbed, and costae are fine, Briggs (1998) counting eight to twelve in 5mm, but ears are longer and anterior dorsal lamellae more strongly developed. *A. crenulata* (Briggs, 1998) has finer costae (nine to thirteen in 5mm) and rather smooth dorsal ears, but is close in its transverse outline, with smaller dorsal ears. It is also found in the Wandrawandian Formation.

Anidanthus springsurensis Booker, to which Runnegar & Ferguson (1969) had referred the material, is readily distinguished by its wedge-shaped dorsal valve and different trails, features which characterize the genus (see Waterhouse 2013, p. 327).

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Genus ***Magniplicatina*** Waterhouse, 1983

See p. 49 for typology, synonymy and diagnosis.

Magniplicatina cranfieldi n. sp.

Fig. 27

1969 *Cancrinella farleyensis* [not (Etheridge & Dun)] – Runnegar & Ferguson, pl. 2, fig. 18 (part, not ?19, ?20 = *Costatumulus randsi*?).

Derivation: Named for L. C. Cranfield.

Holotype: UQ F 45383 from L 2703b, lower South Curra Limestone (Changhsingian), Gympie, figured by Runnegar & Ferguson (1969, pl. 2, fig. 18), here designated.

Diagnosis: Small transverse shells with rugae comparatively low and closely spaced over the venter, prominent row of ventral hinge spines and a number of additional spines.

Description: Specimens of moderate size, with large ears and wide hinge, usually at maximum width, and broad ventral umbo. Ribs are fine, numbering 18-22 in 10mm, and persistent but low and narrow commarginal rugae cover both valves. A well formed row of spines with other posterior spines close by is developed along the hinge, and a few further ear spines are comparatively well developed; spines in quincunx over the venter, with slender elongate bases, up to 4mm long. The dorsal valve lacks spines, but may display slender and short dimples. Internal detail is not well preserved, the muscle scars being feebly impressed, without prominent ventral adductor platform, implying they could have been dendritic.

Fig. 27. *Magniplicatina cranfieldi* n. sp. A, ventral valve UQ F 69198 from L 3925, x1. B, ventral valve UQ F 45383 from L 2703b, x2. C, ventral valve UQ F 69190 from L 2703b, x1.

Resemblances: The rugae are stronger than seen in *Magniplicatina dunstani* n. sp. from the Rammutt Formation. There are no obvious comparisons with species from the Bowen Basin, which have stronger rugae. Other species ascribed to *Magniplicatina*, as in Briggs (1998) and Waterhouse (1986a), have fewer ear spines over the anterior ears, and in that regard approach various species identified as *Cancrinella* in Cooper & Grant (1975) and adjusted to *Magniplicatina* in Brunton et al. (2000): all have slightly finer to comparable ribs and stronger rugae, and are more arched. A specimen reported by Waterhouse (1982a) from the correlative Kildonan Member of the Arthurton Group in New Zealand differs in so far as rugae are not developed over the posterior disc, thereby coming close to *Cancrinella* Fredericks of Subtribe Cancrinellinai, as elaborated in Waterhouse (2013, p. 430). The text and caption in Waterhouse (1982a, p. 46, pl. 11f) referred to this specimen as ?*Cancrinella* sp., but it was not figured, having been replaced by a fragment of the external mould of *Terrakea pollex aurispina*. The species *cranfieldi* is also found in the Gundiah Bridge Greywacke of the Gigoomgan area (see p. 141, Fig. 58).

Family **AURICULISPINIDAE** Waterhouse, 1986a

Subfamily **AURICULISPININAE** Waterhouse, 1986a

Genus ***Costatumulus*** Waterhouse, 1986a

Type species: *Auriculispina tumida* Waterhouse in Waterhouse et al. (1983, p. 133) from Tiverton Formation (Sakmarian), Bowen Basin, OD.

Diagnosis: Radial ribs, low commarginal wrinkles often only on lateral shell, spines over ventral valve with moderately narrow short to long spine bases, spines erect over ears in one to three rows along hinge, dorsal valve without spines, visceral disc thin to moderate in thickness. Ventral adductor platform impressed and posteriorly placed, smooth to finely striate until advanced maturity, then becoming subdendritic to dendritic, posteriorly placed, diductor scars large, weakly to well defined. Dorsal adductor scars becoming dendritic during ontogenetic development, platform developed in front of cardinal process, joined by two diverging ridges subparallel to hinge.

Costatumulus randsi Balfe & Waterhouse, 2010

Fig. 28

1950 *Cancrinella farleyensis* [not Etheridge & Dun] – Hill, p. 15 (part, not pl. 7, fig. 7, pl. 8, fig. 2, 3 = *Magniplicatina undulata* Waterhouse; not pl. 8, fig. 1, 4, ?5, ?6 = *Costatumulus tumida*).

?1969 *C. farleyensis* – Runnegar & Ferguson, p. 254, pl. 2, fig. 19, 20 (part, not fig. 18 = *Magniplicatina cranfieldi*).

1987 *Costatumulus* n. sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 6.

2010 *Costatumulus randsi* Balfe & Waterhouse, p. 34, Fig. 9A-O.

2013 *Costatumulus randsi* – Waterhouse, p. 458, Fig. 21.1B-D.

Holotype: UQ F 69212 from L 3925, lower South Curra Limestone (Changhsingian), Gympie, figured in Balfe & Waterhouse (2010, Fig. 9A) and herein as Fig. 28A, OD.

Diagnosis: Concavo-convex geniculate shells, transverse as a rule, with narrow commarginal rugae which are strongest on ears and flanks, weak over disc, venter and trail. Ventral spines fine, emerging from raised somewhat broadened bases, short as a rule. Dorsal ornament without conspicuous radial pits or closely branching costellae.

Description: Shells transverse or rarely subelongate, ventral valve moderately convex, dorsal valve concave, geniculate, shells little inflated. Ears wide, sharply segregated from flanks through change in slope. Ventral umbo incurved, umbonal angle 100-110^{o}. Ventral ornament of fine radial costellae numbering 24-30 in 10mm at 10mm from the umbo. Ribs increase in number anteriorly by intercalation rather than bifurcation. Slight disruption of the costellae by low close-set commarginal wrinkles, most strongly developed on ears and flanks, continuous though faint across venter, about 1.5mm apart. Ventral spines fine and relatively few, arise from slight swellings of costellae, 1 to 2mm apart, 0.4mm in diameter, some bases extended for more than 10mm in length, spines more or less quincunxially arranged, coarser on ears (ca. 0.75mm in diameter), closely spaced, numbering six to eight, erect and in a single row near umbo, in two to three rows laterally. No dorsal spines, linear depressions rare, present as sparsely distributed elongate pits on UQ F 53951. Dorsal costellae slightly differentiated, increase by intercalation, 24 in 10mm at 10mm from the umbo. Dorsal rugae strongest over ears, continuous over disc, ca. 2mm apart at mid-valve.

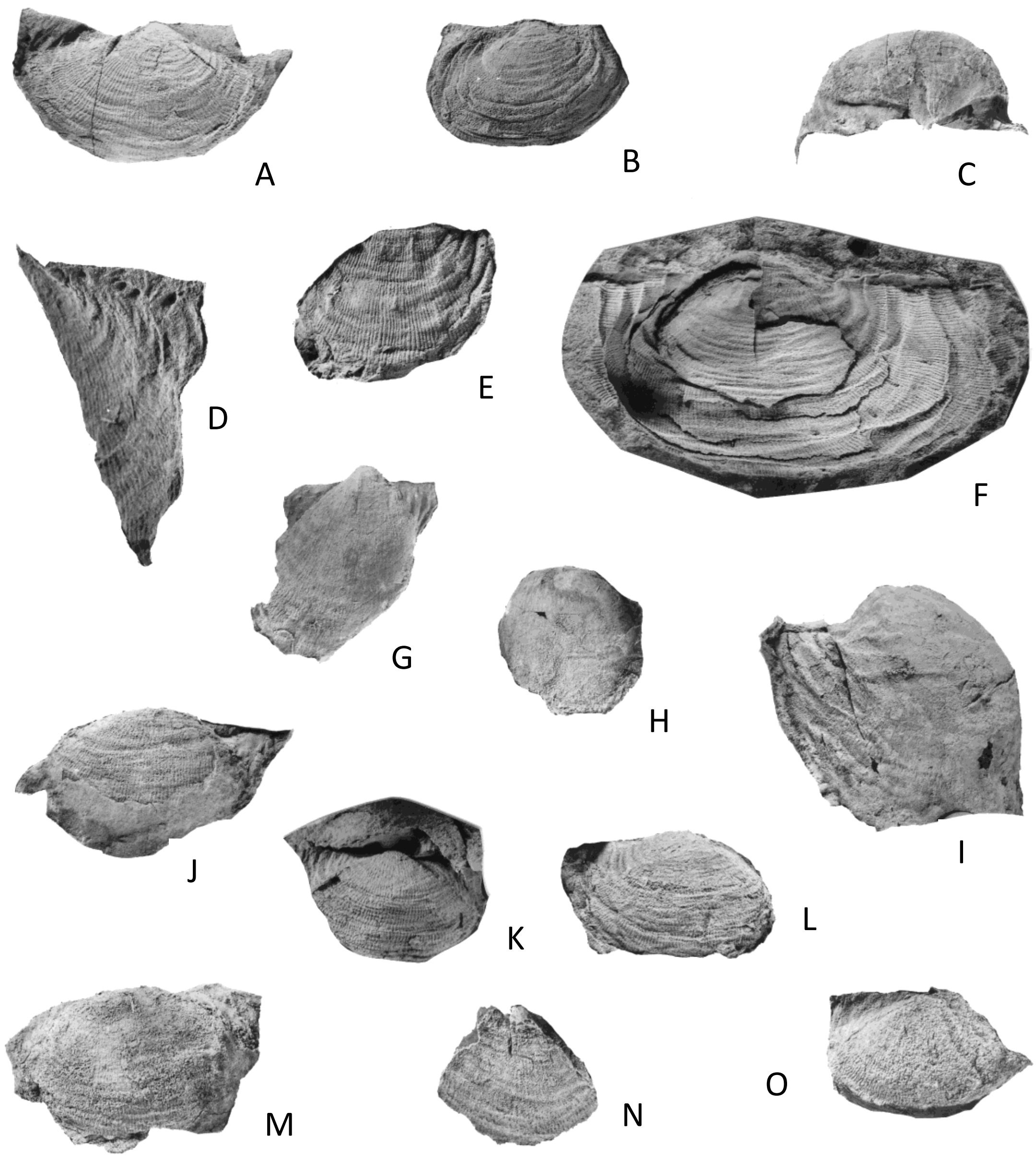


Fig. 28. *Costatumulus randsi* Balfe & Waterhouse. Specimens x1 unless otherwise indicated. A, holotype, ventral valve UQ F 69212 from L 2703b. B, ventral valve UQ F 69214 from L 3925. C, posterior view of ventral valve UQ F 69196 from L 2703b. D, external mould of ventral valve showing hinge spine bases, UQ F 69161 from L 3925, x2. E, fragment of external mould, ventral valve UQ F 69215 from L 3925, x1.5. F, ventral internal mould resting on dorsal external mould, UQ F 69121 from L 2939. G, ventral internal mould UQ F 69193 from L 2703b. H, ventral internal mould UQ F 69199 from L 3925. I, ventral internal mould UQ F 69194 from L 2703b. J, dorsal external mould UQ F 69204 from L 3925, with internal mould attached ventrally. K, dorsal external mould with part of ventral external mould attached, UQ F 45412 from L 2703b. L, dorsal external mould UQ F 69203 from L 3925. M, dorsal interior UQ F 69202 from L 2703b. N, dorsal aspect of internal mould UQ F 69204 from L 3925 (see Fig. 28J). O, dorsal interior UQ F 69197 from L 2703b.

Ventral adductors elongate, deeply impressed posteriorly to form well defined platform, with median groove and light radial striae, no flabellate pattern in any of the specimens. Diductors large, deeply impressed, subrounded to subtriangular in outline, marked by striae inclined forward antero-laterally. Posterior and lateral margins of diductor field usually well defined, smoothly curved or somewhat undulose, anterior margin of diductors poorly defined. Shell thickening in mature specimens obscures the external ribbing, and floor bears fine pits and pustules.

Dorsal interior with strongly developed median septum; muscle scars and cardinal process poorly preserved.

Resemblances: The present form is small and transverse, with shallow visceral cavity, numerous fine commarginal wrinkles, and comparatively few major spines along the ventral hinge. The species is less tumid and less elongate than other species of *Costatumulus* from east Australia, with finer ventral spines and more weakly defined ventral adductor platform, differences that may reflect ongoing development within the genus. The type species *C. tumida* (Waterhouse in Waterhouse et al. 1983, and see Waterhouse 2015, p. 134ff) has a thicker visceral disc, a wide hinge and moderately large ears. Spines exceed 1mm in diameter, and costellae are well defined and close-set, generally 24 in 10mm on the ventral valve, increasing by intercalation, and numbering 18-36 in 10mm on the dorsal valve, where ribs bifurcate frequently. Some dorsal valves carry elongate pits up to 1mm wide and 2-3mm long. Costellae in the present species have relatively wider crests and narrower interspaces, and pits are seldom developed. *Costatumulus prolongata* Waterhouse, 1986a from the Fairyland Formation and lower Tiverton Formation of the Bowen Basin, Queensland, is a narrow elongate shell with fine ventral costae, 25 in 10mm. *C. meritus* Waterhouse, 1986a from the Cattle Creek Formation of the southwest Bowen Basin is a large swollen and elongate form with some 20 ribs in 10mm anteriorly on the ventral valve and up to 24 anteriorly, and 20-24 ribs anteriorly on the dorsal valve. All these species, together with species from Western Australia and a number of others around the globe were further reviewed, with a few illustrations, in Waterhouse (2013, pp. 458-459).

Order SPIRIFERIDA Waagen, 1884

Family **AMBOCOELIIDAE** George, 1931

Genus ***Attenuocurvus*** Waterhouse, 2010a

See p. 54 for typology, synonymy and diagnosis.

Attenuocurvus incurvatus (Waterhouse, 1964)

Fig. 29

1925 Gasteropoda sp. Marwick, p. 362.

1964 *Attenuatella incurvata* Waterhouse, p. 108, pl. 20, fig. 1-12, pl. 21, fig. 1-9, text-fig. 47-52.

1969 *Attenuatella* sp. Runnegar & Ferguson, p. 254, pl. 3, fig. 5.

2010b *Attenuocurvus incurvatus* – Waterhouse, p. 64, Fig. 29A-G.

Holotype: BR 905 from Permian limestone block (Changhsingian) in Tertiary, OD, figured by Waterhouse (1964, pl. 20, fig. 3, 6, 11, pl. 21, fig. 1, 5).

Diagnosis: Small with ornament of dense uniform spines, rarely with fold over concave dorsal valve.

Description: Ventral valve small, subelongate, strongly inflated. Umbo broad, massive, incurved over the ventral interarea. Dorsal valve subsemicircular in outline, gently convex posteriorly, planar in front. Cardinal extremities rounded, maximum width near mid-valve. Ventral interarea apsacline, high, dorsal area anacline, low. Ornament not known. Ventral valve has shallow sulcus and possibly low ribbing on flanks.

Fig. 29. *Attenuocurvus incurvatus* (Waterhouse). A, ventral valve UQ F 47256 from south of L 2703b. B, dorsal aspect of specimen with valves conjoined, UQ F 69218 from L 3925.

Ventral valve shows very little umbonal thickening. Delthyrium not known. Ventral muscle scars on platform surrounded by weak ridges, platform low for genus; adductor scars minute, divided by a low ridge, surrounded by much larger diductor areas. Dorsal cardinalia involve prominent sockets at margin of notothyrium, defined by strong socket ridges. Socket plates joined by anteriorly directed crural bases, and supported by short stubby tabellae. Muscle scars and cardinal process not known.

Resemblances: *Biconvexiella convexa* (Armstrong, 1968a) from the lower Tiverton Formation of the Bowen Basin differs in having a muscle platform in which the muscle scars are more sharply differentiated, with a larger adductor area, narrower diductor area and stronger ridges bordering the platform. The groove corresponding to the sulcus is more strongly developed on *Biconvexiella convexa*, and does not fade so much anteriorly. The ventral posterior shell is more globose and the umbo more massive and the dorsal valve flat in the Gympie form, whereas the dorsal valve is gently convex in *convexa*. Details of internal plates of the dorsal cardinalia differ slightly in the two forms. The various attributes of the Gympie material agree closely with those of *Attenuocurvus incurvatus* found in the *Spinomartinia spinosa* Zone and less commonly in the *Tigillumia parallela* Zone of New Zealand. The ventral umbo is more enrolled and extended in *incurvata* than in *australis*.

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Type species: *Ingelarella angulata* Campbell, 1959, p. 340 from Ingelara Formation (Wordian), southwest Bowen Basin, OD.

Diagnosis: Medium to large plicate shells with sulcus commonly subplicate and fold bearing distinct channel, adminicula and tabellae well developed, moderately spaced, tigillum lies along anterior mid-line of ventral valve.

Ingelarella alteplica n. sp.

Fig. 30

1969 *Ambikella profunda* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 1, 2.

Derivation: altus – high; plica – fold, Lat.

Holotype: UQ F 76954 from L 2703b, lower South Curra Limestone (Changhsingian), Gympie, Fig. 30C, here designated.

Diagnosis: Medium-sized shells with well defined sulcus as a rule and deeply but narrowly channelled fold, subplicae in sulcus, three or four pair of strong high plicae as a rule on ventral flanks, dorsal innermost pair of plicae high; adminicula long, curved inward anteriorly; tabellae long, thin, upright, extending one-quarter to one-third of length of valve length.

Dimensions in mm of *Ingelarella alteplica*: (Most specimens have been distorted to some degree).

Specimen	L	W	L/H	AL	Ad
UQ F 69182b	10.5	23	0.46	4.5	ca. 10°
UQ F 69185a	13.5	23 .	0.59	9.5	10°
UQ F 69183a	17.5	27	0.7	7.0	8°
UQ F 69159	11.0	17.5	0.63	5.0	ca. 10°
UQ F 69181	13	26 .	0.50	8.5	14^o
UQ F 69184b	28	48	0.58	15	10°

AL – adminicula length, AD – divergence of adminicula.

Description: Shells 20-50mm wide, length generally much less than width, maximum width close to mid-length, and hinge much narrower. Both valves convex, dorsal valve less inflated than ventral. Ventral umbo high, slightly incurved, umbonal angle ca. 100^o Median sulcus broad, axially flattened, with a shallow, sometimes barely perceptible median groove, and two low subplicae. Sulcal angle typically close to 35^o. Three or four strong angular plicae lie on each slope of ventral valve, exaggerated by crushing in some shells. Dorsal exterior has sub-ovate outline, umbo low. Lateral dorsal slopes gently convex, and bear four round-crested plicae, decreasing in height laterally, innermost pair of plicae high, outer plicae low or scarcely visible. Dorsal fold moderately high, bearing a distinct broad and well defined median channel. Micro-ornament of closely spaced, quincuncially arranged, fine elongate grooves, with no c-spines. Growth lines subdued in character.

Lilttle umbonal thickening until late in ontogeny. Dental plates scapular-shaped, high, adminicula one-third to one-half valve length, converging very gently toward the anterior extremities, not thickened to any extent, bearing a little pleromal thickening under umbo. Ventral muscle field elongate, divided for most of its length by a fine median ridge with a distinct axial furrow, the area of

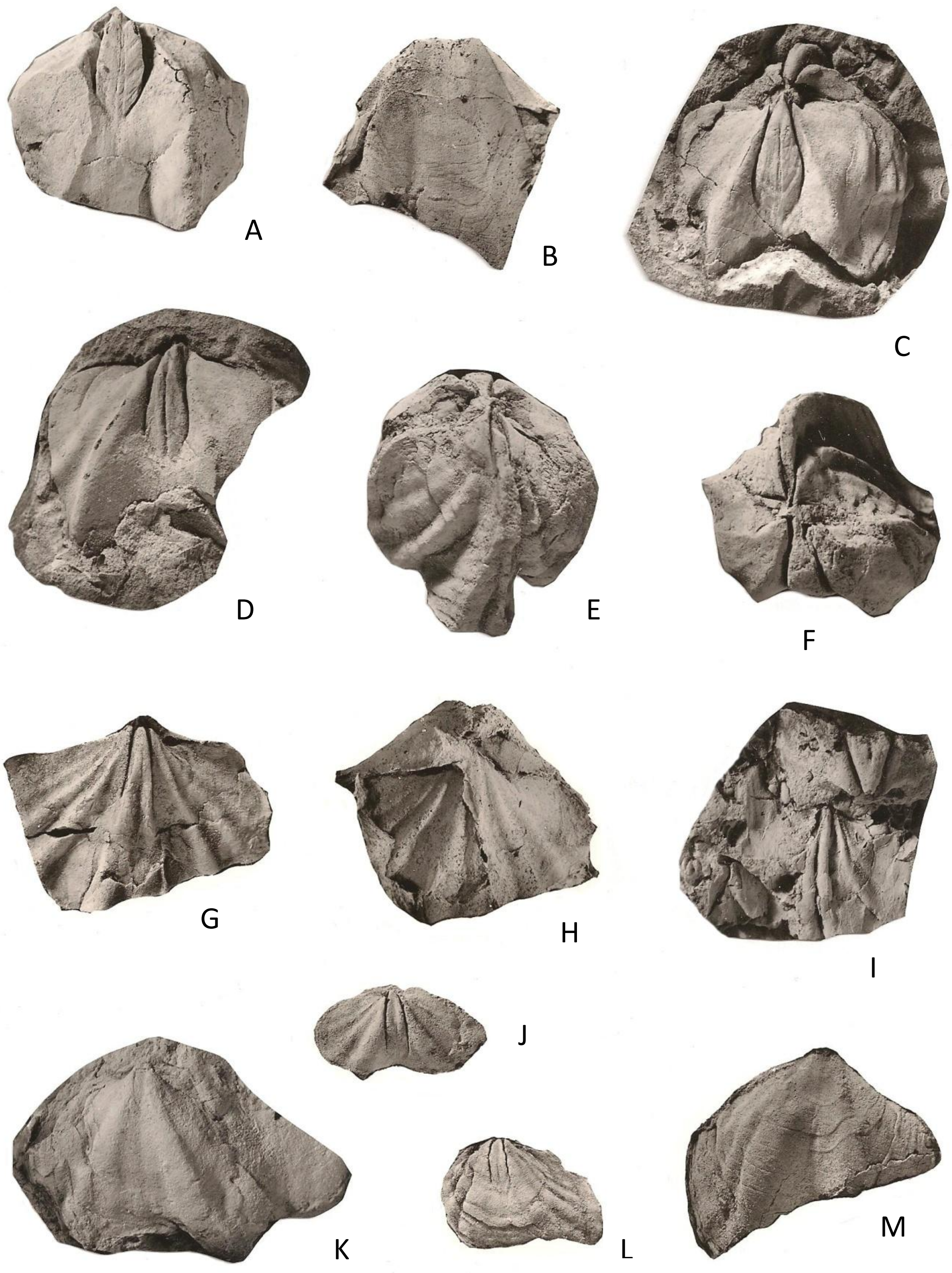


Fig. 30. *Ingelarella alteplica* n. sp. A, ventral internal mould, UQ F 45479 from L 2771. B, latex cast showing anterior ventral valve UQ F 69182. C, holotype, ventral aspect of internal mould of both valves, UQ F 76954 from L 2703b. D, ventral internal mould UQ F 45379 from L 2703b. E, F, dorsal and posterior aspects of internal mould of both valves, dorsal valve on top, UQ F 45474. G, dorsal internal mould UQ F 69182. H, dorsal aspect of latex cast, UQ F 69182. See Fig. 30B. I, dorsal internal mould UQ F 45433. J, ventral internal mould UQF 69184 from L 2703b. K, ventral valve UQ F 69185 from L 3925. L, ventral internal mould UQ F 69183 from L 3925. M, ventral valve latex cast, UQ F 69182 from L 2703b. See Fig. 30B, H. Specimens x1.

adductor attachment amounting to about one tenth of the total muscle field width. Much wider diductor scars are marked by fine oblique bifurcating ridges trending antero-axially. Shell thickening considerable posteriorly along hinge each side of the posterior adductor field. In dorsal valve, tabellae more than one-third of valve length, straight, diverging forward at about 10^{o}, in front of small laminated ctenophoridium; low crural plates; spiralia not exposed. Dorsal adductors narrow, elongate, separated by a narrow ridge. Shell thickening insubstantial, posteriorly covered with shallow slightly elongate pittings.

Resemblances: Runnegar & Ferguson (1969) referred Gympie individuals of this suite to *Ambikella profunda* (Campbell) of the Tiverton Formation, but the present specimens have a broader ventral sulcus than in *profunda*, and critically, a broad groove is present in the dorsal fold. This is not seen in *profunda*, which has a fold with rounded crest, and furthermore displays short and widely diverging tabellae as in the genus *Geothomasia* Waterhouse, 1998b, found in the early Permian of east Australia and also in Western Australia (Waterhouse 2015, p. 171ff), whereas the tabellae of *alteplica* are comparatively long and subparallel. The middle Permian New Zealand species *Ingelarella costata* Waterhouse, 1964 from Mangarewa Formation at Wairaki Downs, of Capitanian age, is closest of known species in having strong plicae and deeply grooved dorsal fold, but the plicae are even stronger in the present species, especially the inner ventral pair next to the sulcus. The fold is higher and wider anteriorly, with deeper wider channel in *costata* (see Waterhouse 1968a, pl. 12, fig. 5). A single costa traverses the sulcus in large New Zealand specimens, not seen in Gympie material, and its adminicula are slightly shorter and tabellae slightly shorter and spaced further apart.

Genus ***Johndearia*** Waterhouse, 1998b

Type species: *Ingelarella isbelli* Campbell, 1961, p. 181 from Blenheim Formation (Wordian), north Bowen Basin, OD.

Diagnosis: Large as a rule, widely spaced adminicula, well spaced tabellae of moderate length, plicae weak or absent, sulcus and fold may be subdued, secondary thickening often considerable. Tigillum may be present.

Johndearia isbelliformis (Waterhouse, 1978)

Fig. 31A, B

1978 *Tomiopsis isbelliformis* Waterhouse, p. 522, Fig. 12-15, 17, 18.
1998b *T.* (*Johndearia*) *isbelliformis* – Waterhouse, p. 22.
2001 *Johndearia isbelliformis* – Waterhouse, p. 102, pl. 8, fig. 3.

Holotype: BR 2231 from Hilton Limestone (Changhsingian), New Zealand, figured by Waterhouse (1978, Fig. 14), OD.

Diagnosis: Transverse shells with shallow ventral sulcus and short widely spaced adminicula, dorsal valve with low sulcate fold and plicae.

Description: Several specimens have the shallow ventral sulcus, heavily thickened posterior ventral wall and widely spaced adminicula typical of *Johndearia isbelliformis*. In cross profile, the sulcus curves evenly on to the lateral slopes.

Resemblances: The specimens are close to material described from the Hilton Limestone in New Zealand, but have slightly better defined sulcus and adminicula placed a little closer together.

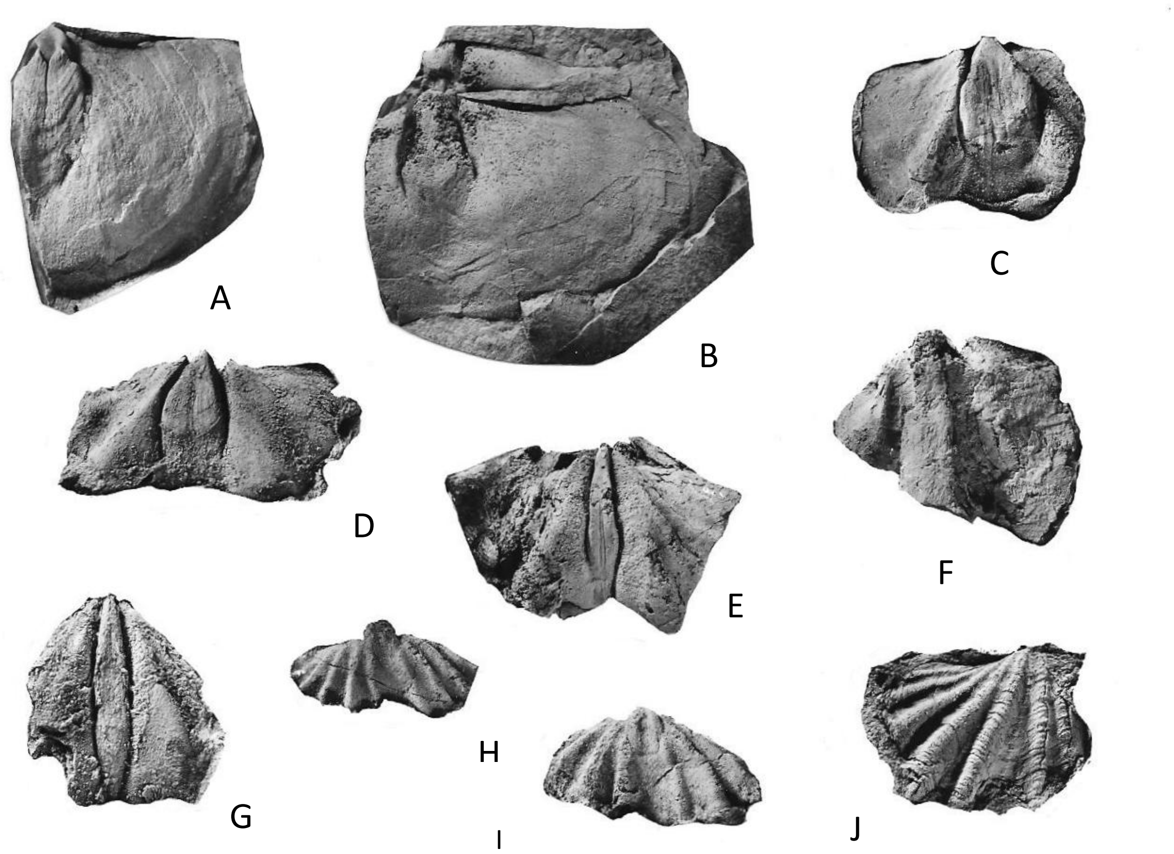


Fig. 31. A – B, *Johndearia isbelliformis* (Waterhouse). A, ventral internal mould, UQ F 76952 from L 2703b. B, ventral aspect of specimen with valves conjoined, UQ F 76953 from L 3925. C, D, *Validifera* sp. C, ventral internal mould, UQ F 76178 from L 2703b. D, ventral internal mould UQ F 69176 from same locality. E-G, *Tigillumia parallela* (Waterhouse). E, ventral internal mould UQ F 69184c from L 3925. F, broken dorsal valve UQ F 69194 from L 2703b. G, ventral internal mould UQ F 69174 from L 2703b. H – J, ?*Farmerella* sp. H, ventral internal mould UQ F 69256 from L 3926. I, ventral internal mould UQ F 69255 from same locality. J, latex cast of unregistered ventral valve from L 3926. Specimens x1.

Genus ***Tigillumia*** Waterhouse, 1998b

Type species: *Martiniopsis biparallela* Waterhouse, 1987a from the Brae Formation (Kungurian), southeast Bowen Basin, Queensland, OD.

Diagnosis: Sulcus may be very shallow, especially in older species, fold varies from low to high, with rounded crest, micro-ornament of shallow elongate grooves arranged in quincunx. Adminicula and tabellae long and close-set, tigillum or median thickening generally present along anterior mid-line of ventral valve.

Tigillumia parallela (Waterhouse, 1964)

Fig. 31E - G

1964 *Ingelarella parallela* Waterhouse, p. 166, pl. 32, fig. 9, 13, 15, pl. 35, fig. 7, pl. 36, fig. 1.

1968a *Ambikella parallela* – Waterhouse, p. 73, pl. 13, fig. 3, 5, 6, pl. 14, fig. 7 (part, not fig. 8 = *mintyi)*.

1969 *Ambikella mantuanensis* [not Campbell] – Runnegar & Ferguson, pl. 4, fig. 9-12.

1978 *A. mantuanensis* – McClung, p. 53.

1998b *Tigillumia parallela* – Waterhouse, p. 28.

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

Diagnosis: Large for genus, shallow sulcus and dorsal fold with rounded crest, some individuals weakly to moderately plicate, adminicula and tabellae well developed, tigillum weak.

Description: Shells of moderate size, transverse and little inflated, a ventral valve measuring 61mm wide, 46mm long and crushed to 14mm in height. Ventral umbo with angle at 105^{o}, moderate width, cardinal extremities well rounded. Hinge of dorsal valve broad; interareas low, concave in ventral valve, very gently concave in dorsal valve; delthyrium narrow and arch-shaped, open; notothyrium narrow with wide angle, low. Narrow groove-like sulcus commences near tip of ventral umbo; dorsal fold well defined with rounded crest. Plicae variable, may be absent or weakly defined, inner pair stronger than lateral pairs; surface worn to reveal fibrous shell.

Double ridge lies under delthyrium, dental plates low, adminicula long and close-set, with a feeble tigillum or inner sulcal ridge continuing in front along the sulcus. Tabellae are slightly shorter than adminicula and spaced further apart.

Resemblances: The Gympie specimens closely match the highly distinctive form *Tigillumia parallela* (Waterhouse, 1964), described from the Kildonan Member of the Bagrie Formation of the Arthurton Group of New Zealand (Waterhouse 2002a, p. 98). The plicae may be a little stronger in the Gympie specimens, whereas the adminicula are very similar. The adminicula in the present form are longer and much more closely spaced than in *Ingelarella mantuanensis* (Campbell), to which the Gympie specimens had been referred by Runnegar & Ferguson (1969).

Genus **_Validifera_** Waterhouse, 2015

Type species*: Ingelarella profunda valida* Campbell, 1961, p. 177 from Tiverton Formation (Sakmarian), Bowen Basin, Queensland, OD.

Diagnosis: Deeply sulcate and often plicate shells with adminicula that are placed well apart and diverge widely. Tabellae moderately well developed, subparallel.

Discussion: The well spaced adminicula and consequently broad ventral muscle scars are an unusual attribute amongst Ingelarellidae, and appear to be restricted to Permian faunas in eastern Australia.

Validifera sp.

Fig. 31C, D

Two ventral internal moulds have moderately short and widely spaced adminicula as in this genus, and the flanks of the sulcus are narrow and high, much like those of *Validifera valida* (Campbell).

Family **NOTOSPIRIFERIDAE** Archbold & Thomas, 1986

Subfamily **MESOPUNCTIINAE** Waterhouse, 1998b

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

Type species: *Farmerella exoporosa* Clarke, 1992b, p. 73 from Deep Bay Formation (Kungurian) of Tasmania, OD.

Diagnosis: Small to medium size, a few pairs of well developed plicae, ventral sulcus with narrow median costa, micro-ornament of small c-shaped spines, deep mesopunctae. Adminicula developed, tabellae short.

Discussion: The Gympie material shows a median costa along the sulcus, but other aspects remain obscure. *Farmerella* has the deep mesopunctae typical of Mesopunctiinae (see Clarke 1992a, pl. 1j), whereas the globons of genera in Notospiriferinae are much shallower.

?Farmerella sp.

Fig. 31H – J

Diagnosis: Small to moderate in size, valve transverse. Three to five pairs of flank plicae, narrow-crested with wider interspaces. Well defined sulcus with median costa. Adminicula short, ventral muscle platform small.

Dimensions in mm of ?*Farmerella* sp., ventral valves:

Specimen	Length	Width	SA	AL	PL	PW	PD
UQ F 69257a	14.6	22+	30°	1 5.	3.3.	1	2.5
UQ F 69258	12.4	24.8	?7°	1	5.9	4.1	1.1
UQ F 69256	13.6	24.6	25.5°	1	5.1	4.0	2.8
UQ F 69255	17.5	31.6	25.5°	2.3	7.2	4.4	2.3

Explanation: SA – sulcal angle; AL – adminicula length; PL – platform length; PW – platform width; PD – adductor width.

Description: Gympie specimens have five pairs of plicae, with slender sulcal rib, well developed commarginal lamellae, and vestiges of micro-ornament of grooves, though spines are obscure.

Adminicula are short and well spaced. The lack of dorsal valves, and poor preservation of micro-ornament means that the species limits are difficult to determine, but the presence of a sulcal costation suggests the genus *Farmerella*. *Glendonia* McClung & Armstrong (1978) also is close in general appearance, but has somewhat more prominent median fold along the ventral sulcus. *Farmerella* has deep pores as in Mesopunctiinae, compared with the surface grooves of *Glendonia*, but this detail is not available for the present material. Other genera classed within Mesopunctiinae, such as *Mesopunctia* and *Wairakiella*, have no costation along the midline of the sulcus.

Resemblances: *Notospirifer extensus* Campbell, 1961, pl. 28, fig. 1-4 from the Stanleigh shales of southwest Bowen Basin has a mid-sulcal rib, and the shell is mesopunctate (Armstrong 1970c, p. 291, Fig. 21; Waterhouse 1998), suggesting the genus *Farmerella.* But the present specimens seem likely to belong to a new species, distinguished by shape and ornament.

Suborder SPIRIFERIDINA Waagen, 1884

Superfamily **TRIGONOTRETOIDEA** Schuchert, 1893

Family **TRIGONOTRETIDAE** Schuchert, 1893

Subfamily **ANGIOSPIRIFERINAE** Legrand-Blain, 1985

Genus ***Unicostatina*** Waterhouse, 2004a

Type species: *Sulciplica subglobosa* Clarke, 1990, p. 64 from "Spirifer Zone" (Asselian), Maria Island, Tasmania, OD.

Diagnosis: Moderately large transverse shells with well rounded to subalate cardinal extremities, few strong plicae and a sulcal costa, which may be joined by further costae within the sulcus and over the fold. Micro-ornament cancellate.

Discussion: This genus is known only in east Australia, but is close in many respects to the more widely distributed genus *Sulciplica* Waterhouse, apart from its much less transverse shape, and presence of fewer costae, especially within the sulcus and over the fold.

Unicostatina chatsworthensis (Balfe & Waterhouse, 2004)

Fig. 32, 33

1969 "*Spirifer*" cf. *stutchburii* [not Etheridge Jnr.] – Runnegar & Ferguson, pl. 3, fig. 1-4.
1987 *Sulciplica* n. sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 7-11.
2004 *Sulciplica chatsworthensis* Balfe & Waterhouse, in Waterhouse 2004a, p. 182.

Holotype: UQ F 454266, from L 2703b, South Curra Limestone (Changhsingian), Gympie, figured by Runnegar & Ferguson (1969, pl. 3, fig. 2), OD.

Diagnosis: Three sulcal costae which may subdivide, three to five pairs of lateral plicae in ventral valve, with two or three further pairs laterally. Pair of subplicae on outer flanks of sulcus and fold; wide sulcus.

Description: Shells transverse, length-width ratio about 0.5, but variable. Shell biconvex, dorsal valve less inflated than ventral valve. Ventral umbo slightly incurved, extending over apex of open delthyrium. Sulcus broad, bearing weak median costa and five or six lateral ribs. Plicae number five to seven pairs, may bear subsidiary costae which may bifurcate anteriorly; innermost pair of ventral plicae lies within sulcus as a rule, and prominent. Dorsal fold high, narrow, may bear crestal furrow. Subsidiary pair of plicae on fold, usually three to five pairs of plicae on dorsal flanks. Width of interarea four-fifths total valve width, hinge denticulate, cardinal area crossed by growth lines which may bear tubercles. Micro-ornament of radial and commarginal lirae, intersections raised in small, knob-like protuberances.

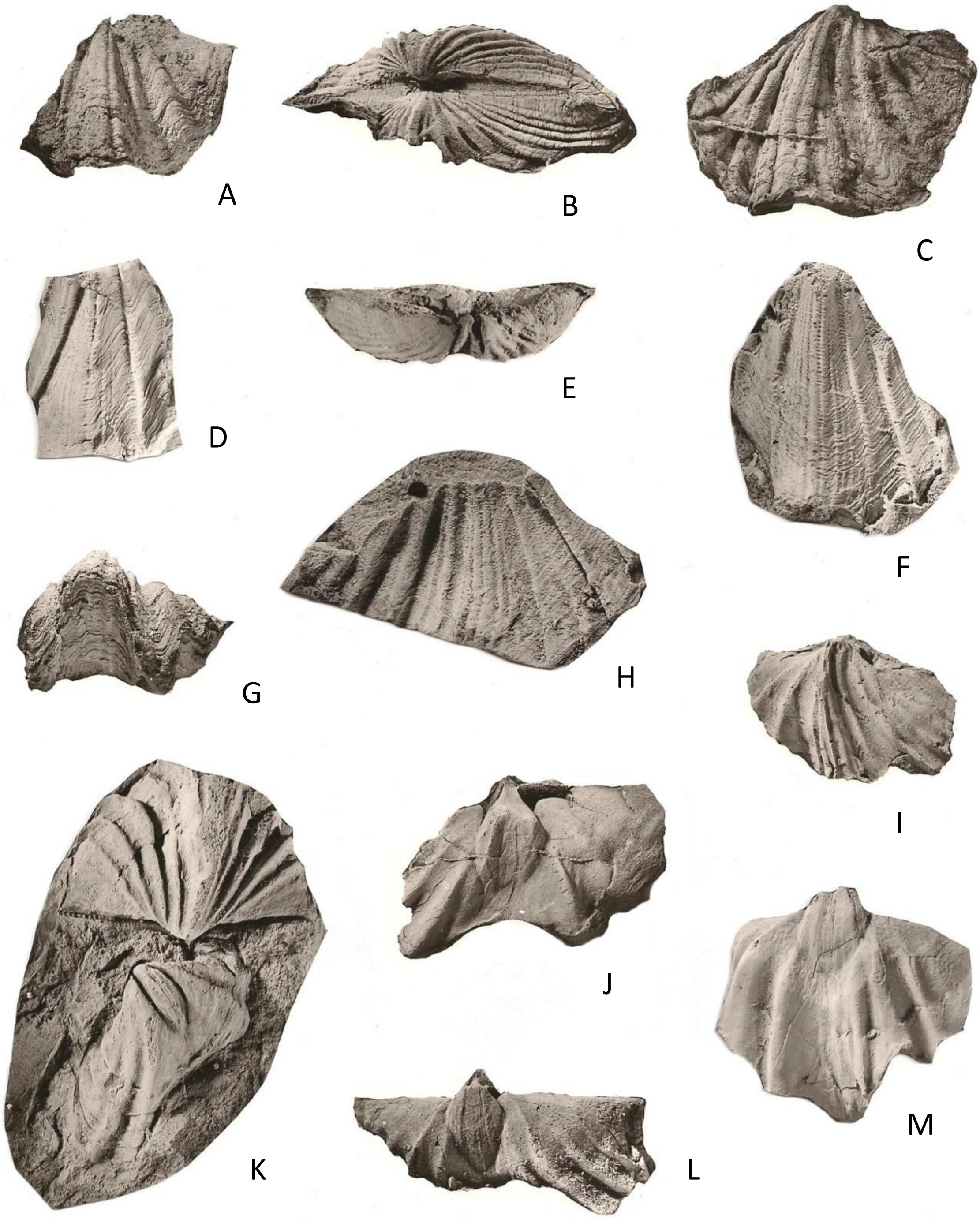


Fig. 32. *Unicostatina chatsworthensis* (Balfe & Waterhouse). A, latex cast of dorsal valve UQ F 69262. B, posterior view of latex cast of specimen with valves conjoined, UQ F 69281. C, latex cast of dorsal valve UQ F 69301. D, ventral external mould of anterior sulcus, UQ F 45428 from L 2767. E, posterior view of latex cast of ventral valve UQ F 69188. F, anterior ventral mould UQ F 45576. G, anterior view of latex cast of both valves UQ F 69262, dorsal valve on top. H, ventral anterior external mould UQ F 76951. I, dorsal internal mould UQ F 69265. J, ventral internal mould UQ F 69281. K, ventral internal mould UQ F 45378 and dorsal internal mould UQ F 59591. L, ventral internal mould UQ F 45577. M, ventral internal mould UQ F 69279. Specimens x1, from L 2073b unless otherwise stated.

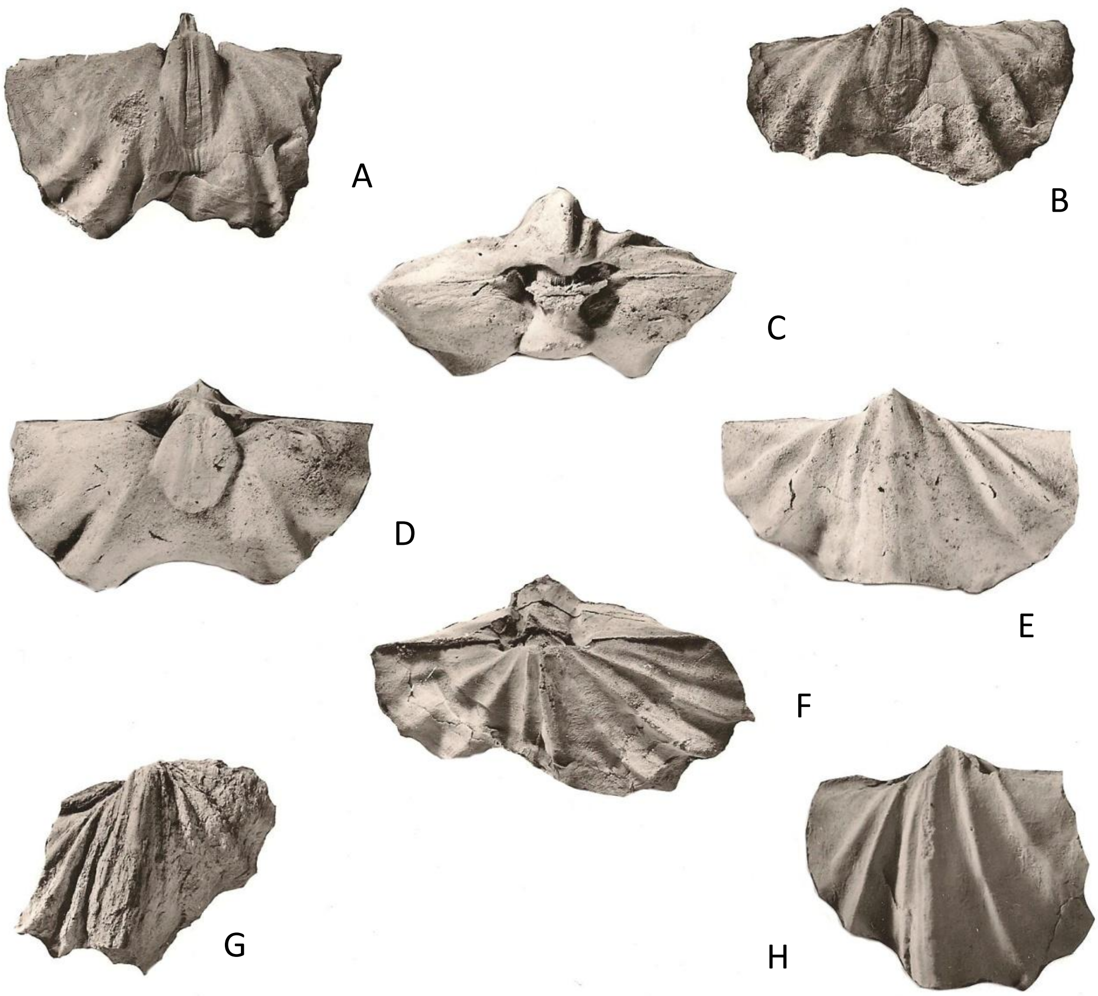


Fig. 33 *Unicostatina chatsworthensis* (Balfe & Waterhouse). A, ventral internal mould UQ F 69315. B, ventral internal mould UQ F 69267. C – E, posterior (dorsal valve on top), ventral and dorsal aspects of internal mould UQ F 45428 from L 2767. F, dorsal aspect of internal mould of both valves, UQ F 69316. G, dorsal internal mould UQ F 69269. H, dorsal internal mould UQ F 45577. Specimens x1, from L 2703b, except C-E.

Dimensions in mm of internal moulds of *Unicostatina chatsworthensis*:

Specimens	L	W	L/W	PL	PW	PW/PL
UQ F 69276	?22	44	0.50	14.1	8	0.57
UQ F 69276a	23	49	0.47	12.4	9.7	0.78
UQ F 69279b	24	55	0.44~	13.5	8.5	0 63
UQ F 69280	+19	46	0.41	13.0	8.0	0.62
UQ F 69310	26	42	0.62	13	11.1	0.83

L – length; W – width; PL – platform length; PW – platform width.

Ventral posterior shell considerably thickened by callus, as a rule enveloping adminicula. Delthyrial cavity partly occupied by callosity under beak, either bulbous, or more elongate. Muscle platform extends anteriorly for about half the length of valve, central part occupied by narrow adductor field, generally smooth, or bearing fine radial ridges and grooves, divided posteriorly by a very low median ridge; diductor field extensive, bearing striae that extend diagonally toward posterior margin of valve. Posterior part of flanks show granulate attachment impressions. Dorsal interarea with wide notothyrium; short, divergent, and curved chilidial plates. Centre of notothyrial cavity occupied by large ctenophoridium, with 16-22 laminae. Dental sockets large, anteriorly extended, no tabellae. Crural bases pass along dorso-medial edge of inner socket ridges (crural plates), and spiralia of some fourteen laterally directed whorls lie each side of umbo.

Resemblances: The closest species is *Unicostatina stutchburii* (Etheridge), with the specimen figured in Jack & Etheridge Jnr. (1892, pl. 38, fig. 4-6) designated as lectotype (Waterhouse 1968a, p. 24). This specimen comes from the Tiverton Formation of Mt. Britton in the northern Bowen Basin, and poorly preserved material was also reported from the Elvinia Formation of Bowen Basin by Waterhouse (1987a) and further material described from the Tiverton Formation by Waterhouse (2015, p. 201, Fig. 152-158). *S. chatsworthensis* has a broader ventral sulcus with different sulcal costation. In *stutchburii* the median rib is stronger than in the new species, lateral sulcal plicae are much less strongly developed, and subsidiary costae arising from lateral sulcal plicae are more strongly developed in *chatsworthensis*. Lateral plicae are lower in the new species. Over the cardinal area, lineations produce a scalloped effect in *chatsworthensis*, but in *stutchburii* lineations on the area are quite straight. Two species, *Unicostatina subglobosus* (Clarke) and *U. crassa* (Clarke), are found in the Early Permian of Tasmania, close to *stutchburii*, but with dorsal valve poorly known. Compared with the Gympie species, *Sulciplica transversa* Waterhouse, 1968a from mid-Permian faunas of Tasmania and Sydney Basin (see Clarke 1987) has more plicae, and is more transverse.

Order SPIRIFERINIDA Ivanova, 1972

Suborder SYRINGOTHYRIDINA Grunt, 2006

Superfamily **SYRINGOTHYROIDEA** Fredericks, 1926

Family **SYRINGOTHYRIDAE** Fredericks, 1926

Subfamily **PERMASYRINXINAE** Waterhouse, 1986b

Genus ***Cyrtella*** Fredericks, 1924

Type species: *Cyrtia kulikiana* Fredericks, 1916, p. 312 from the Bolshezemelskaya Tundra of northern Russia, OD.

Diagnosis: Transverse as a rule with wide cardinal extremities and numerous narrow plicae, fold with median channel, no syrellum.

Discussion: The type species of this genus was well described and illustrated by Fredericks (1916), and clearly shows that a syrellum, or calcite rod, is not developed, and that a channel, sometimes shallow, is developed along the crest of the dorsal fold (see for example Fredericks 1916, pl. 2, fig. 1b, 3b, 4b). Specimens are large and transverse, whereas the Gympie species is much smaller and less transverse, and therefore far from typical. Nonetheless the Gympie species fits best within the circumscription of this genus. Carter (2006b, p. 1900) provided an incomplete diagnosis for *Cyrtella*, stating that a delthyrial plate was absent, which is true, but he added that it was simulated by thick callus. That does not seem to be fully correct – a connector plate is illustrated by Fredericks (1916, pl. 2, fig. 2b, 4b) and confirmed by Grigorieva & Kotlyar (1966, p. 49). The shell structure of Australian allies is analyzed in Armstrong (1968c) and other articles.

Cyrtella papula n. sp.

Fig. 34

1969 *Subansiria* sp. nov. Runnegar & Ferguson, pl. 3, fig. 6-7.

1970a *Subansiria procera* [not Armstrong] – Armstrong, pl. 2, fig. 18 (part, not fig. 12-16 = *procera*; not fig. 17 = *allandalensis*).

Derivation: papula – pimple, Lat.

Holotype: UQF 69188 from UQL 2703b, South Curra Limestone (Changhsingian), Gympie, figured herein as Fig. 34A, here designated.

Diagnosis: Shell of small to moderate size, width generally twice the length. Some ten pairs of lateral plicae; sulcus low, smooth; fold well-defined, furrowed. Interarea high, delthyrium arched, narrow. Adminicula very long, straight, diverging by 10-15°. Ventral muscle area elongate.

Dimensions in mm of *Cyrtella papula*:

Specimen	Width	Length	Height	Adminicular divergence	No. of ventral plicae
UQ F 69188	21	40	11	13°	10
UQ F 69189	?26	?48	14	11°	10
UQ F 45384	21	36	12	28°	8

Description: Shell of moderate size, transverse. Umbo prominent, incurved, umbonal angle of 100°, ventral interarea predominantly apsacllne but in later growth stages curves postero-dorsally, high, concave in profile, attaining catacline and eventually procline state. Surface of interarea bears fine horizontal growth lamellae and vertical striae. Delthyrium high, rather narrow, delthyrial angle about 40°. Cardinal extremities rounded, tending to be acute and attenuate. Commissure parasulcate, ventral sulcus shallow, smoothly curved in cross-profile, moderately broad, bordered by the two innermost plicae, sulcal angle of 20-22°. Up to ten plicae lie on each flank, crests relatively narrow, interspaces wide. Dorsal fold smooth, well-defined, rounded, with a shallow median groove. Dorsal flanks bear rounded plicae pairs like those of ventral valve. Shell material finely punctate, more than 1,000 punctae per square centimetre, surface ornament of tiny pustules, six to eight in 1mm at mid-length and three in 1mm anteriorly, with only traces of short elongate grooves. Growth lines well developed at intervals, six in 1mm, with growth steps.

Adminicula long and straight, diverging at a low angle of 10-15°, thin, extending approximately half of valve length. Ventral muscle field divided posteriorly by a low median ridge bearing adductors. Adductor scars widest posteriorly and divided posteriorly by a low ridge, strongly attenuated and united anteriorly, marked by very fine longitudinal striae. Diductors wide, impressed, marked by anastomosing ridges. No large dental callosity on posterior wall. Dorsal interior incompletely preserved, no strong medium septum; part of spire visible, laterally extended.

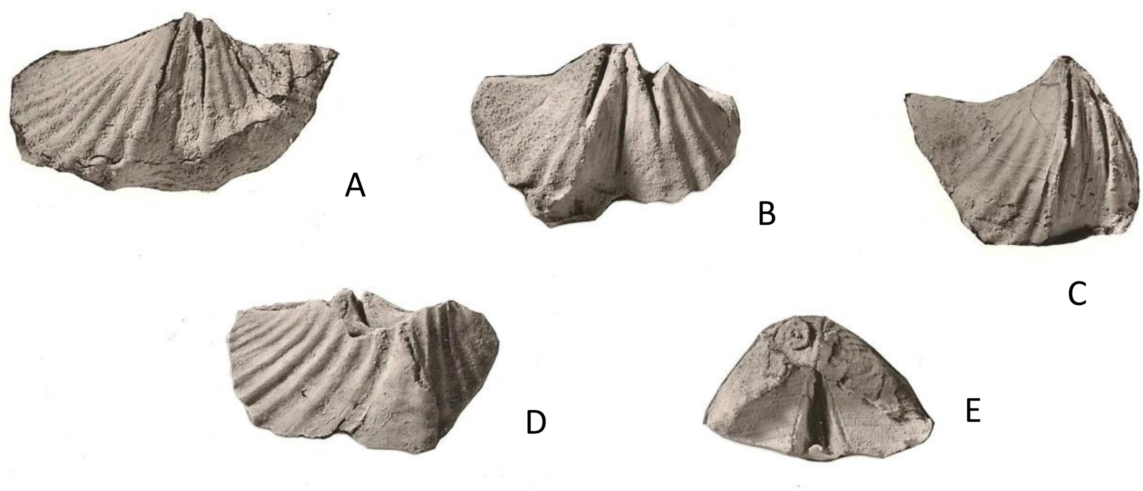


Fig. 34. *Cyrtella papula* n. sp. A, ventral internal mould holotype UQ F 69188 from L 2703b. B, ventral internal mould, UQ F 45384a from L 2703b. C, ventral internal mould UQ F 69189 from L 2773. D, dorsal aspect of internal mould UQ F 61989 from L 2703b. E, latex cast of ventral valve, posterior dorsal view, UQ F 45456 from L 2767. Specimens x1.

Resemblances: Allies of this genus and species have been described from Permian rocks of eastern Australia by Armstrong (1970a) and Waterhouse (1987a, 2015). Armstrong compared a Gympie specimen with *Subansiria procera* Armstrong, now *Permasyrinx* Waterhouse, 1983, and the interarea is high as in this species, but is more curved, and the adminicula are much shorter than in the present form, and a syrellum is present. *Pseudosyrinx* sp. of Clarke (1987, p. 283, fig. 18) from the Malbina E and Abels Bay Formations of mid-Permian age in Tasmania shows a degree of similarity in its narrow plicae, but adminicula lie between the second and third pair of plicae from the sulcus. Most species allocated to *Cyrtella*, including the type species, are more transverse and larger, with more plicae.

Olgerdia Grigorieva in Sarytcheva, 1977 is somewhat similar in appearance, but has shorter adminicula and impunctate shell. The type species, *O. zavodowskii* Grigorieva, comes from the mid-Permian Omolon Suite of Kolyma-Omolon massif, and has a slightly lower ventral interarea.

Superorder TEREBRATULIFORMII Waagen, 1883

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **DIELASMIDAE** Schuchert, 1913

Subfamily **DIELASMINAE** Schuchert, 1913

Tribe **FLETCHERITHYRINI** Waterhouse, 2010b

Genus ***Fletcherithyris*** Campbell, 1965

Type species: *Terebratula amygdala* Dana, 1847, p. 142 [not *Terebratula amygdala* Catullo, 1846 Giorn. Di Fisica 2 (5): 90], OD, replaced by *Atrypa biundata* M'Coy, 1847, p. 231 from Broughton Formation (Wordian or Capitanian), south Sydney Basin.

Diagnosis: Anterior commissure broadly sinuate or weakly sulciplicate, septalium raised on high median septum, crural points high.

Fletcherithyris runnegari n. sp.

Fig. 35

1969 *Gilledia homevalensis* [not Campbell] – Runnegar & Ferguson, pl. 2, fig. 21, 22.

1987 *Fletcherithyris* n. sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 13-15.

Derivation: Named for Bruce Runnegar.

Holotype: UQ F 45389, from L 2703b, from South Curra Limestone (Changhsingian), Gympie, figured by Runnegar & Ferguson (1969, pl. 2, fig. 21, 22), and herein as Fig. 35A, B, here designated.

Diagnosis: Large shells with rectimarginate to sulciplicate anterior margin, well developed radiating lirae over both valves.

Description: Shell large, holotype measuring approximately 29mm wide, 40mm long and 19mm wide; ventral umbo massive with relatively small foramen 2mm wide, steep but not high posterior walls, maximum width sited between mid-length and posterior third in various specimens, anterior margin rectimarginate at first, later developed broad ventral sulcus or flattening, and dorsal valve becoming gently sulciplicate. Surface covered by radiating grooves and broad ribs, six in 5mm posteriorly, increasing by intercalation to ten in 5mm anteriorly, crossing well defined unevenly spaced commarginal grooves, that indicate growth pauses and spurts. Fine punctae, 60-70 per square mm.

Dental plates sturdy, diverging slightly forward, teeth small, muscle scars not shown, and pedicle collar inconspicuous. Teeth enclosed in socket plates, which are not very thick; dorsal median septum high, supporting cardinal plate of inner and outer hinge plates; base of crura massive. Cardinal process represented by fine vertical laminae at posterior tip of septalium. Two ridges extend along posterior floor of valve under crura, floor otherwise comparatively smooth, with elongate pits anteriorly.

Resemblances: This species is distinguished by its large size and the strength of its radial ornament. *Fletcherithyris amygdala* (Dana), now *F. biundata* M'Coy (see Waterhouse 1982a, p. 62), is one of the closest species but lacks such well developed radial ornament and has a broader dorsal septum. It comes from various beds of early and middle Mid-Permian age in the Sydney Basin, and also in New Zealand (Waterhouse 1982a) and Flat Top and Barfield Formations of the Bowen Basin (Waterhouse, 1987a). One other species of *Fletcherithyris* has surface ornament of fine ribs, represented in the middle Tiverton Formation of the north Bowen Basin as *F. burdenae* Waterhouse (2015, p. 222), and this is smaller and more slender than the present species.

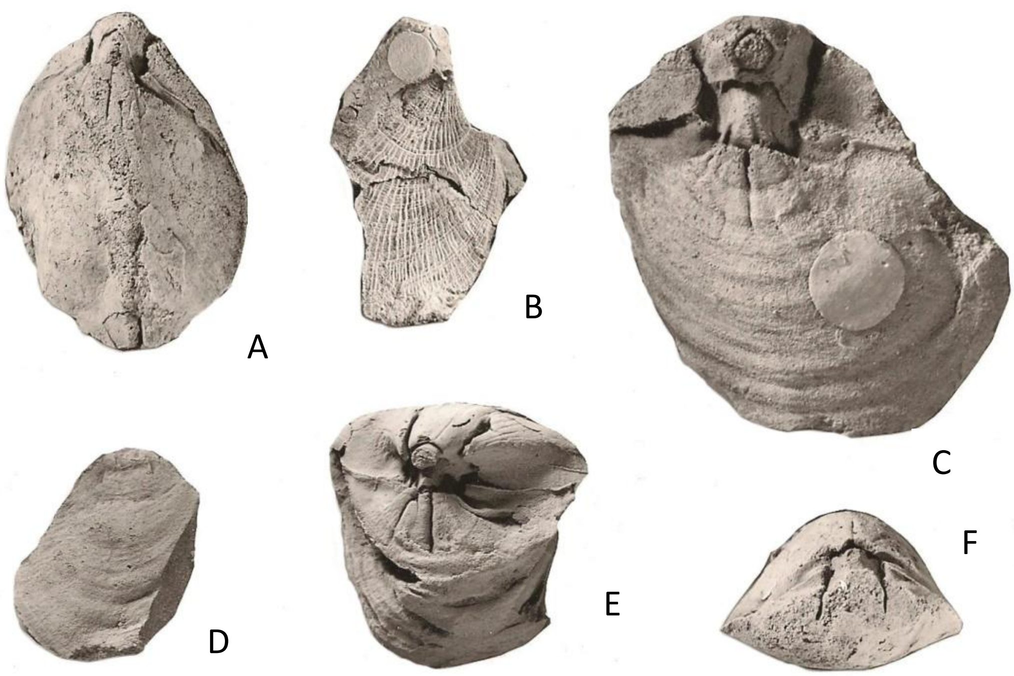


Fig. 35. *Fletcherithyris runnegari* n. sp. A, holotype, dorsal aspect of internal mould, UQF 45430 from L 2767, x1. B, external mould of ventral valve, same specimen, x1. C – F, internal mould of specimen UQF 45389 from L 2703b, dorsal view, x 1.8, ventral view, x1, posterior ventral view, x 1.5, and posterior view, dorsal valve on top, x1.

This Gympie species was referred to *Gilledia homevalensis* Campbell by Runnegar & Ferguson (1969) in their study of Gympie Permian fossils, but *Gilledia* lacks ventral dental lamellae and high dorsal median septum, and the inner hinge plates are discrete and joined to the posterior floor, rather than uniting medianly as in *Fletcherithyris*.

Phylum Mollusca Cuvier, 1797

Class Gastropoda Cuvier, 1797

Order PATELLIDA Rafinesque, 1815

Suborder PLEUROTOMARIIDINA Cox & Knight, 1960

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **NEILSONIINAE** Knight, 1956

Genus ***Pagodina*** Wanner, 1942

Type species: *Pagodina typus* Wanner, 1942, p. 166 from Basleo beds (Wuchiapingian) of Timor, OD.

Diagnosis: Moderately small shells with high spire, selenizone bordered by carina, carina also developed above and below the selenizone, with further spiral ribs on flat or concave upper whorl in some species.

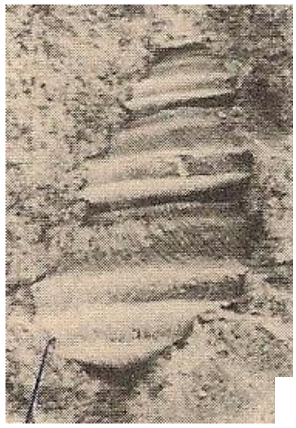
Pagodina scapulata (Runnegar & Ferguson, 1969)

Fig. 36

1969 *Bembexia scapulata* Runnegar & Ferguson, p. 264, pl. 3, fig. 11-13.

A

Fig. 36. *Pagodina scapulata* (Runnegar & Ferguson). A, apertural aspect. UQ F 64319 from UQ L 2703b, x 3. B, holotype UQF 45434 from L 2767, from Runnegar & Fergusson (1969, pl. 3, fig. 11), showing a well defined spiral rib on the upper whorl, x6.



B

Discussion: This Gympie species was placed in the Devonian gastropod *Bembexia*, but differs from that genus in its much narrower spire, concave to sinuous upper whorl, anomphalous base and other aspects of morphology. With a low spiral rib on the upper whorl, above traces of two or three more spiral ribs on some topotypes, the Gympie form comes close to *Pagodina* Wanner, originally described from Permian faunas of Timor, though the Gympie species lacks spiral ornament from the base, unlike the type species of *Pagodina*. *Pleurocinctosa* Fletcher, 1958 of eastern Australia has a convex upper whorl face, without strong spiral ornament. *Peruvispira* Chronic, 1949 is also close. The type species of *Peruvispira* lacks spiral ornament other than the ribs bordering the selenizone and defining the concave band below the selenizone, and has a concave upper whorl face. These genera are closely related and the Gympie species is a near ally, and is not *Bembexia*.

(c) Upper brachiopod fauna

Phylum Brachiopoda Duméril, 1797

Order CHONETIDA Muir-Wood, 1955

Family **RUGOSOCHONETIDAE** Muir-Wood, 1962

Genus ***Capillonia*** Waterhouse, 1973a

?***Capillonia brevisulcus*** (Waterhouse, 1964)

For typology and synonymy and diagnosis, see p. 81.

Discussion: The specimen from the upper South Curra Limestone that was figured as *Lissochonetes* sp. by Runnegar & Ferguson (1969) is very like *brevisulcus* from the Arthurton Group in New Zealand in shape and profile and interior of the ventral valve. The species is also found in the Gigoomgan Limestone (p. 148, Fig. 66).

Suborder LINOPRODUCTIDINA Waterhouse, 2013

Superfamily **PROBOSCIDELLOIDEA** Muir-Wood & Cooper, 1960

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Subfamily **PAUCISPINAURIINAE** Waterhouse, 1986a

Genus ***Paucispinauria*** Waterhouse, 1983

Type species: *Terrakea concava* Waterhouse, 1964, p. 67 from Letham Burn Formation (Roadian), New Zealand, OD.

Diagnosis: Distinguished by few erect and sturdy spines over the ventral ears and lower umbonal slopes, anterior dorsal spines thick and erect.

Paucispinauria verecunda (Waterhouse, 1982a)

Fig. 37A

1969 *Terrakea* cf. *solida* [not Etheridge & Dun] – Runnegar & Ferguson, pl. 5, fig. 1-4.

1971a *Terrakea* n. sp. Waterhouse, p. 348, text-fig. 1.

1982a *T. verecundum* Waterhouse, p. 50, pl. 12b-e, g, i, k, text-fig. 17L, M (not *multispinosa* Dear as in plate caption).

2001 *Paucispinauria verecunda* – Waterhouse, p. 41.

2008b *P. verecunda* – Waterhouse, Fig. 8J.

Holotype: BR 1181 figured by Waterhouse (1982a, pl. 12b-e, g, i, k) from Kildonan Member (Changhsingian), Bagrie Formation, Arthurton Group, New Zealand, OD.

Diagnosis: Small to medium in size with sparse erect spines over the ventral ears, spine-bases over venter comparatively short, dorsal spines comparatively fine over disc, larger anteriorly. Ribs fine.

Description: The ventral posterior wall is comprised of moderately thick shell. The dorsal valve is transverse and subgeniculate, bearing sturdy anterior spines, and the sparsity of pits over the dorsal ears shows that ear spines were few. Material is scarce, and unfortunately the critical ventral exterior is poorly known, which means that identification remains provisional, but available specimens conform with what is known of *verecunda* from the *Tigillumia parallela* Zone of southern New Zealand, although it cannot be said that the identification is completely secure.

Specimens are also found in the Gigoomgan Limestone (p. 149, Fig. 68).

Family **AURICULISPINIDAE** Waterhouse, 1986a

Subfamily **FILICONCHINAE** Waterhouse, 2001

Genus ***Filiconcha*** Dear, 1969

Type species: *Filiconcha hillae* Dear, 1969, p. 299 from Flat Top Formation (Wordian) of southeast Bowen Basin, Queensland, OD.

Diagnosis: Small and finely ribbed, with row of ventral hinge spines, spines with elongate bases over the venter, dorsal spines numerous and erect.

Discussion: The genus is discussed in Waterhouse (2013).

Filiconcha auricula Waterhouse, 1976b

Fig. 37B

1969 *Filiconcha hillae* [not Dear] – Runnegar & Ferguson, pl. 5, fig. 5-7.

1976b *Filiconcha auricula* Waterhouse, p. 238, Fig. 4. 3-14.

1978 Fam. & gen. indet. Waterhouse & Mutch, p. 519, Fig. 8, 9.

1978 *Terrakea* sp. Waterhouse & Mutch, p. 521.

1998 *Filiconcha auricula* – Briggs, p. 197.

2001 *F. auricula* – Waterhouse, p. 33.

2013 *F. auricula* – Waterhouse, p. 450, Fig. 17.50.

Holotype: BR 1703 from Trig DD Formation (Changhsingian), Arthurton Group, New Zealand, OD. Figured by Waterhouse (1976b, Fig. 3, 4).

Diagnosis: Close to *Filiconcha hillae*, ventral valve often sulcate, dorsal disc rather flat, subdued ornament of ribs and spines, short spine bases. Dorsal median septum short, weakly developed.

Description: Shells average size for genus, transverse, ventral valve convex with low broad slightly incurved umbo, wide hinge with small convex ears and obtuse cardinal extremities, shell almost as wide or slightly wider between mid-length and anterior third, trail low and steeply curved from visceral disc. Visceral disc only 1-2mm thick. Dorsal valve wide and almost flat, or gently concave with low subgeniculate trail. Well formed narrow sulcus lies over ventral valve, best developed over anterior disc, fading over trail, corresponding dorsal fold on some specimens. Ornament of radial capillae on both valves, about 40-50 in 10mm on anterior ventral valve, ribs increasing by intercalation on dorsal valve, up to 28 in 10mm at start of dorsal trail. Spines about 0.5mm in diameter developed along hinge and over ears of ventral valve, scattered in quincunx over valve, with short elongate bases 1 to 1.5mm long, and erect over anterior trail. Spines may open into trail. Dorsal spines fine, erect, growth lines number three to four per mm.

Ventral adductor platform low, broad, almost smooth, diductors also small, impressed in shell. Cardinal process broad and trilobed, with two broad median ridges in front, divided by groove which is replaced in front by low medium septum, extending to anterior third of shell length. Dorsal adductor platform with small inner subrounded pair and outer diffuse irregularly ridged pair; brachial ridges not clearly defined.

Dimensions in mm of *Filiconcha auricula*:

Specimen	Width	Length	Height
UQ F 45461	27	20	6
	?28	21	10
	32	21	7.5

Resemblances: These specimens look moderately like *Filiconcha hillae* Dear from the Flat Top Formation of the Bowen Basin but differ in having a deeper anterior ventral sulcus and inconspicuous ventral spine bases that form short radial ridges. Dear (1969) did not record any sulcus on his shells, and the venter is medianly flattened as a rule, as confirmed by Waterhouse (1986a, 2013), but occasionally is sulcate. The type species has distinctly raised short posteriorly prolonged spine bases that are fewer and less developed in the present suite, being low and rounded. The subdued nature of the ventral spine bases recalls the arrangement in *Filiconcha auricula* Waterhouse, 1976b from New Zealand, which are further like present specimens in having slightly rounded outline, and a short ventral sulcus on a few specimens, and the capillae are comparably fine, at 40-50 in 10mm, much as in *F. auricula*, compared with counts of 28-32 in 10mm on type *hillae*. Moreover the dorsal trail may carry a low median fold, as in some of the present suite. Internally, the dorsal septum is short, as in type *auricula*, and not as long as in type *hillae*.

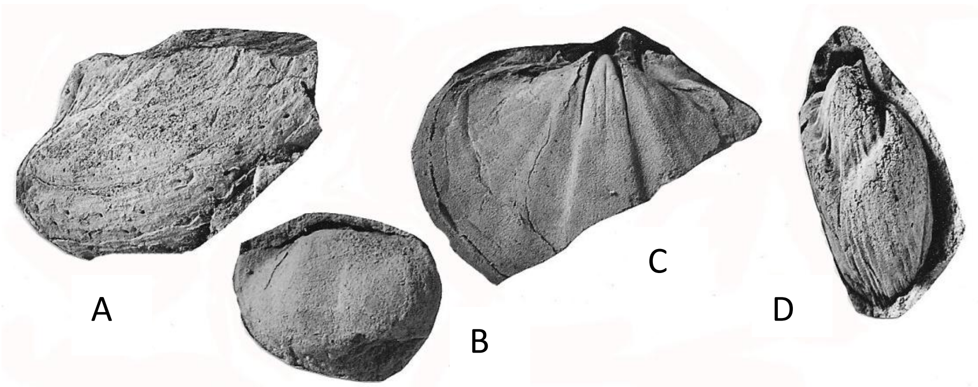


Fig. 37. A, *Paucispinauria verecunda* (Waterhouse), dorsal valve external mould UQ F 47254 from L 1950, x2. B, *Filiconcha auricula* Waterhouse, internal mould of ventral valve UQ F 45461 from L 2768. C, *Ingelarella fergusoni* n. sp., dorsal aspect of internal mould UQ F 47258 from L 2704. D, *Spinomartinia spinosa* Waterhouse, internal mould of ventral valve UQ F 53957 from L 1422. Specimens x1 for B - D.

In New Zealand, the species *auricula* is found in the *Spinomartinia spinosa* Zone in Trig DD Formation of the Arthurton Group, and in the Wether Hill Limestone and Hilton Limestone of the same zone to the south. The genus is found sparsely in the underlying *Martiniopsis woodi* Zone in the Earnvale Member of the Bagrie Formation in the Arthurton Group (Waterhouse 1982a, pl. 12j). Briggs (1998, p. 197) interpreted this specimen as a member of Overtoniidae, but the ventral muscle field clearly shows the subrectangular impressed platform typical of Filiconchinae (cf. Dear 1969, pl. 21, fig. 5) and other Auriculispinidae. Briggs correctly noted that the dorsal valve figured by Hill & Woods (1964, pl. 6, fig 2) was terrakiform, not a member of *Filiconcha*, counter to the claim by Waterhouse (1986a, p. 54). The species is also represented in the Gigoomgan Limestone (see p. 149, Fig. 69).

Superorder RHYNCHONELLIFORMII Kuhn, 1949

Order RHYNCHONELLIDA Kuhn, 1949

Superfamily **WELLERELLOIDEA** Licharew, 1956

Family **WELLERELLIDAE** Licharew, 1956

Subfamily **PLEKONELLINAE** Waterhouse, 2010b

Genus ***Plekonella*** Campbell, 1953

Type species: *Plekonella acuta* Campbell, 1953, p. 18 from the Ingelara Shale (Wordian), southwest Bowen Basin, Queensland, OD.

Diagnosis: Moderately well developed sulcus and fold, costae covering most of both valves as a rule, dental plates present and dorsal septalium bearing prominent median ridge, dental sockets crenulate, median dorsal septum long and sturdy.

Plekonella multicostata Waterhouse, 1964

Fig. 38

1964 *Plekonella multicostata* Waterhouse, p. 94, pl. 17, fig. 14-18, pl. 18, fig. 1, 2, text-fig. 32B, 36-39.

1969 *Plekonella* cf. *multicostata* – Runnegar & Ferguson, pl. 5, fig. 9-11.

1982a *P. multicostata* – Waterhouse, p. 52, pl. 13a-c.

2008b *P. multicostata* – Waterhouse, p. 368.

Holotype: BR 430, figured in Waterhouse (1964, pl. 17, fig. 14, 15), from Kildonan Member (Changhsingian), Bagrie Formation, Arthurton, New Zealand, OD.

Diagnosis: Sulcus limited to anterior shell, costae fine and number three to six in sulcus and four to eight each side, commencing well in front of umbones.

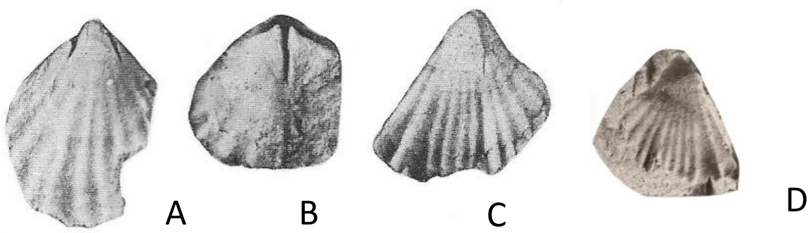


Fig. 38. *Plekonella multicostata* Waterhouse. A, internal ventral mould, UQ F 47239, x2. B, dorsal internal mould UQ F 27240, x2. C, clay impression of ventral exterior, UQ F 47238, x1.5. See Runnegar & Ferguson (1969). D, clay impression of ventral external mould, UQ F 47238, x3. Specimens from L 2766.

Discussion: Gympie material was correctly compared by Runnegar & Ferguson (1969) with *Plekonella multicostata* Waterhouse from the Arthurton Formation of New Zealand, showing the same overall triangular shape with extended and smooth ventral umbo and several ribs in the sulcus. Further specimens come from the Gigoomgan Limestone (p. 150, Fig. 70). *Plekonella southlandensis* (Fletcher, 1952) from the Mangarewa Formation of New Zealand and Flat Top Formation of the Bowen Basin (Waterhouse 1986a, p**.** 65) is distinguished from ***P.*** *multicostata* by having stronger ribs over the umbo, and generally being a broader shell with ribs that often bifurcate in the sulcus.

Order SPIRIFERIDA Waagen, 1884

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

For typology and diagnosis, see p. 94.

Ingelarella fergusoni n. sp.

Fig. 37C, Fig. 39

1969 *Ambikella ingelarensis* [not Campbell] – Runnegar & Ferguson, p. 278, pl. 4, fig. 3-5.

Derivation: Named for J. A. Ferguson.

Holotype: UQ F 44264 from L 2704, upper South Curra Limestone (Changhsingian), Gympie, figured by Runnegar & Ferguson (1969, pl. 4, fig. 5), and herein as Fig. 39, here designated.

Diagnosis: Medium in size, sulcus shallow, fold with feebly channelled crest and as a rule, steep flanks, sulcus with two low subplicae or smooth, lateral shell smooth or with up to three pair of plicae, secondary thickening moderate.

Description: Transverse shell with broad sulcus of 40-50°, may display two low subplicae; fold with steep flanks diverging at 30^{o} and broad gently channelled crest. Lateral flanks smooth, or with moderately prominent inner pair of plicae, one or two additional pair of plicae in some specimens.

Adminicula are comparatively short and widely spaced: they diverge forward at a low angle, and enclose a short wide ventral muscle field, with narrow adductor ridges and broader longitudinal ridges over the diductor scars. A myophragm is developed in the holotype, and rarely in other specimens. In the dorsal valve tabellae are well formed and comparatively long, diverging forward each side of the dorsal fold, and separated by a low median ridge below the external median channel.

Fig. 39. *Ingelarella fergusoni* n. sp., holotype UQ F 44264 from L 2704, x1. See Runnegar & Ferguson (1969).

Resemblances: This species is also found in the Gigoomgan Limestone (p. 152, Fig. 72, 73). It is very close to *Ingelarella dissimilis* Waterhouse, 1964, pl. 32, fig. 4-11 from the lower Mangarewa Formation of the Wairaki Downs in New Zealand, and from the Flat Top Formation of the southeast Bowen Basin (Waterhouse 1986b, pl. 10, fig. 5-9, 11-13, pl. 11, fig. 1), but has a dorsal fold with broad faintly sulcate crest, rather than one with a median shallow groove or sulcus. The two species *dissimilis* and *fergusoni* are close to each other, differing from most species of *Ingelarella*, and also from *Johndearia*.

Ingelarella cf. ***havilensis*** Campbell, 1960

Fig. 40

cf. 1960 *Ingelarella havilensis* Campbell, p. 1120, pl. 139, fig. 3-6.

1969 *Ambikella havilensis* – Runnegar & Ferguson, pl. 4, fig. 6-8.

cf. 1983 *Martiniopsis havilensis* – Dickins, Fig. 3 A-F.

cf. 1989 *M. havilensis* – Dickins, p. 269, pl. 4, fig. 8-17, pl. 5, fig. 1-14 (fig. 7-11 badly worn).

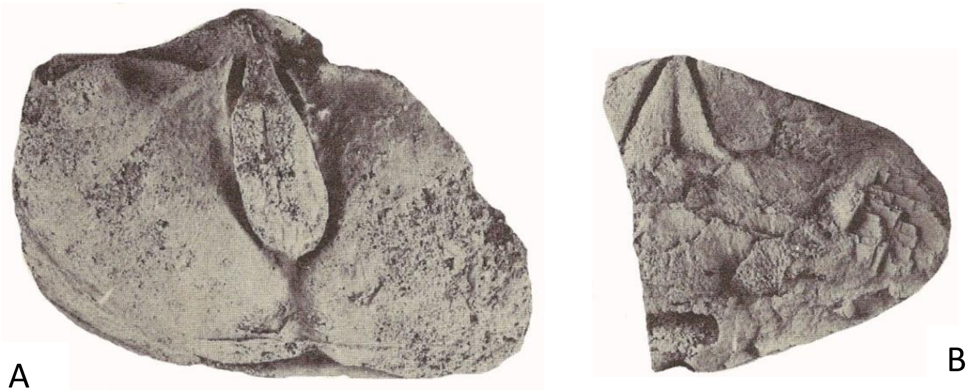


Fig. 40. *Ingelarella* cf. *havilensis* Campbell. A, ventral internal mould UQ F 47260, x1. B, internal mould of dorsal valve UQ F 54143, x1. From L 1950. See Runnegar & Ferguson (1969, pl. 4, fig. 7, 8).

Holotype: UQ F 15797, figured by Campbell (1960, pl. 139, fig. 3) from upper Blenheim Group (?lower Wuchiapingian), Queensland.

Diagnosis: Large with shallow sulcus bearing deep median groove, no plicae, adminicula not very long, well spaced, tabellae moderately long, well spaced.

Discussion: Two upper South Curra specimens were identified by Runnegar & Ferguson (1969) with *Ingelarella havilensis* Campbell. This species is found especially in the northern Bowen Basin above the Mantuan shell band and Peawaddy Formation, and also well above the *Pseudostrophalosia clarkei* band (Dickins 1983, Waterhouse & Jell 1983), corresponding with faunas possibly of early Wuchiapingian age (see p. 173). The Gympie specimens show moderately short adminicula and deep ventral sulcus, and deep median dorsal groove. One difference is that the tabellae in the Gympie specimen diverge more, although their relative length is similar to that of the types.

Genus ***Tigillumia*** Waterhouse, 1998b

For typology, synonymy and diagnosis see p. 97.

Tigillumia mintyi Waterhouse, 1998b

Fig. 41

1968a *Ambikella parallela* [not Waterhouse] – Waterhouse, 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. 9-12.

1978 *A. mantuanensis* – McClung, p. 53.

1987 *Tomiopsis* n. sp. Waterhouse & Balfe, p. 32, pl. 2, fig. 16, 17.

1999 *Tigillumia mintyi* Waterhouse, p. 22, text-fig. 1a-d.

2001 *T. mintyi* – Waterhouse, p. 99, pl. 7, fig. 6-11.

Holotype: OU 18289 from Hilton Limestone Member (Changhsingian), Wairaki Downs, New Zealand, figured in Waterhouse (1999, text-fig. 1a; 2001, pl. 7, fig. 6), OD.

Diagnosis: Large for genus, shallow sulcus and low narrow dorsal fold, some shells weakly plicate, adminicula and tabellae may be exceptionally long, tigillum developed.

Description: Shells of moderate size, transverse and little inflated, a ventral valve measuring 61mm wide, 46mm long and squashed to 14mm in height. Ventral umbo with angle at 105^{o}, moderate width, cardinal extremities well rounded, dorsal umbo low and broad. Interareas low, concave in ventral valve, very gently concave in dorsal valve; delthyrium narrow and arch-shaped, open; notothyrium low and narrow with wide angle. Narrow groove-like sulcus commences near tip of ventral umbo and is shallow anteriorly; dorsal fold commences over anterior half of shell length, low. No plicae.

Double ridge lies under delthyrium, dental plates low, and the adminicula are close-set, with a tigillum or ridge continuing in front along the sulcus. Tabellae are slightly shorter than the adminicula and may be spaced further apart anteriorly.

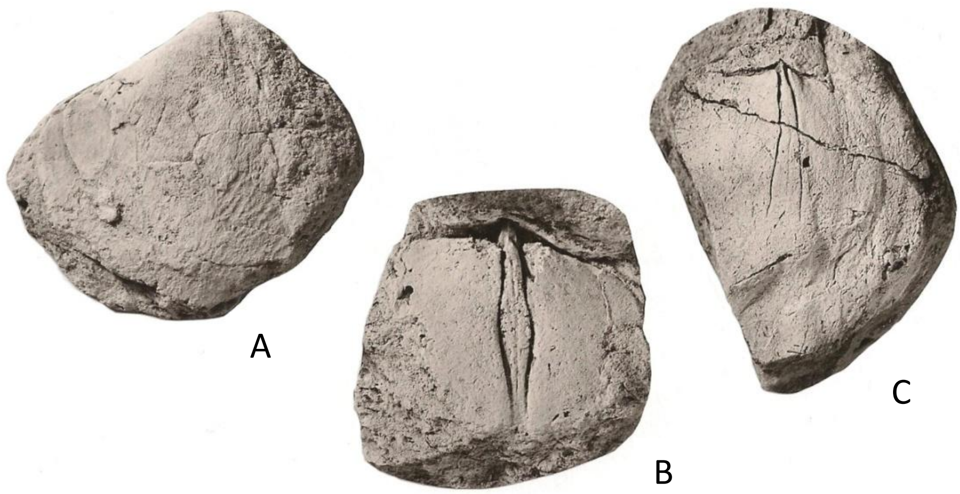


Fig. 41. *Tigillumia mintyi* Waterhouse. A, ventral valve exterior, UQ F 47263. B, ventral internal mould UQ F 47262. C, dorsal internal mould UQ F 47264. Specimens from UQ L 1950, x1.

Resemblances: The Gympie specimens closely match the highly distinctive form *Tigillumia mintyi,* which was distinguished because of its lower fold, shallower sulcus and common lack of plicae. The

Gympie material is better preserved than the types from the New Zealand and corroborates the recognition of the species as distinct from *parallela*.

Superfamily **MARTINIOIDEA** Waagen, 1883

Family **MARTINIIDAE** Waagen, 1883

Subfamily **SPINOMARTINIINAE** Waterhouse, 2010b

Genus ***Spinomartinia*** Waterhouse, 1968a

Type species: *Spinomartinia spinosa* Waterhouse, 1968a from Trig DD Formation (Changhsingian), Arthurton Group, New Zealand, OD.

Diagnosis: Small spines over the exterior; dental plates small to large, no adminicula, small delthyrial cover, very low crural plates, no tabellae, vascular imprints become reticulate, ventral adductor scars posteriorly placed.

?Spinomartinia spinosa Waterhouse, 1968a

Fig. 37D

?1968a *Spinomartinia spinosa* Waterhouse, p. 53, pl. 8, fig. 4, 5, 9-11, pl. 9, fig. 1-8, pl. 17, fig. 4.

1969 *Martinia* sp. Runnegar & Ferguson, 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, 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.

Holotype: OU 2413, figured by Waterhouse (1968a, pl. 9, fig. 2–4), Suggate et al. (1978), and Speden (1981), from Trig DD Formation (Changhsingian), Arthurton Group, New Zealand, OD.

Diagnosis: Subelongate shells with moderately well developed dental plates and well developed spines.

Description: A few poorly preserved specimens are available, chiefly as internal moulds that show little of the exterior. The pallial lines are anastomosing, unlike the simple radiate pattern observed in *Martinia*, to which Runnegar & Ferguson (1969) had referred the specimens. Rather, the shells are internally most like *Spinomartinia* Waterhouse, 1968a.

Resemblances: The specimens differ from *Spinomartinia adentata* (Waterhouse, 1964) from the Takitimu Group of New Zealand and from *S. queenslandica* Waterhouse, 1987a from the Brae Formation of the southeast Bowen Basin in being less subglobular. There is considerable approach to *Spinomartinia spinosa* Waterhouse, 1968a from the *Spinomartinia spinosa* Zone in New Zealand, but the identification cannot be confirmed in the absence of well preserved exteriors that show if spines were present. Various other species of the same New Zealand *Spinomartinia spinosa* Zone are found with the present material, suggesting that identification is highly likely.

Armstrong (1972, pl. 4, fig. 1-3, 12) compared an Oxtrack (now Brae) form of the southeast Bowen Basin with a Gigoomgan shell (pl. 4, fig. 6), and the Brae species belongs to *Spinomartinia*, although not conspecific with the present form.

Tamaree Formation

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Superorder NUCULANIFORMII Carter, Campbell & Campbell, 2000

Order NUCULANIDA Carter, Campbell & Campbell, 2000

Superfamily **NUCULANOIDEA** H. Adams & A. Adams, 1858

Family **POLIDEVCIIDAE** Kumpera, Prantl & Ružička, 1960

Genus ***Glyptoleda*** Fletcher, 1945

Type species: *Glyptoleda glomerata* Fletcher, 1945, p. 300 from Ingelara Shale (Wordian), southwest Bowen Basin, Queensland, OD.

Diagnosis: Costae form an upright V, axis generally behind the beaks, and additional small v's. Outer escutcheon ridges well developed.

Glyptoleda sp.

Fig. 42A

1969 *Nuculana* sp. Runnegar & Ferguson, p. 279, pl. 3, fig. 17.

Diagnosis: Shells with extended posterior, ribs in open V marked by numerous small v's in zigzags.

Description: Anterior shell ovally subquadrate in outline, umbones very broad with angle over 130^{o}, posterior shell markedly elongate. The ornament is also characteristic, forming, as may be discerned from faintly preserved rib pattem, an open large V, with numerous small angular flexures. An outer escutcheon ridge extends posteriorly from the umbo, and the posterior part of an inner escutcheon ridge is visible. Numerous taxodont teeth are developed along the hinge.

Fig. 42. A, *Glyptoleda* sp., latex cast of both valves, right valve aspect, UQ F 42534a from L 3256, x 1.5. B, C, *Glabrocingulum* (*Ananias*) *campbelli* Waterhouse. B, UQ F 53955 from L 3256. From Runnegar & Ferguson (1969). C, lateral aspect of UQ F53956 from same locality, latex cast.

Resemblances: This species is closest to *Glyptoleda flexuosa* Waterhouse (1965a, p. 650, pl. 98, fig. 6-12) from the upper Mangarewa Formation of New Zealand, but has a more elongate outline, and the major V is less clearly developed, and like that of *flexuosa*, is complicated by numerous small flexures. The New Zealand species is of Capitanian (late Middle Permian) age.

Class Gastropoda Cuvier, 1797

Order PATELLIDA Rafinesque, 1815

Suborder PLEUROTOMARIIDINA Cox & Knight, 1960

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **EOTOMARIINAE** Wenz, 1938

Genus ***Glabrocingulum*** Thomas, 1940

Subgenus ***Ananias*** Knight, 1945

Type species: *Phanerotrema? welleri* Newell, 1935 from Upper Pennsylvanian of Kansas, United States, OD.

Diagnosis: Gradate shells with shallow sinus, slit of moderate depth, forming concave selenizone at the periphery, bordered by two carina. Shell ornamented by granular cancellate growth lirae and spiral threads. No funicle in umbilicus.

Discussion: Sloan (1955) showed that the funicle which helps distinguish *Glabrocingulum* is not always present, and the degree to which the shell is turretted is not consistent. *Mourlonia* (*Pseudobaylea*) Dickins, 1963 is closely allied to *Ananias*, and remote from *Mourlonia*.

Glabrocingulum (***Ananias***) ***campbelli*** Waterhouse, 1963a

Fig. 42B, C

1956 Gastropod Marwick in Wood, p. 47.

1963a *Glabrocingulum* (*Ananias*) *campbelli* Waterhouse, p. 588, Fig. 4-9.

1969 *Platyteichum* sp. Runnegar & Ferguson, pl. 3, fig. 15, 16.

2008b *Glabrocingulum* (*Ananias*) *campbelli* – Waterhouse, pl. 8, fig. 8.

Holotype: OU 2405 from Trig DD Formation (Changhsingian), Arthurton Group, New Zealand, OD. Figured by Waterhouse (1963a, Fig. 4 – 6).

Diagnosis: Large, moderately gradate shells, upper profile weakly concave in the spire, weakly convex or sigmoidal in the body whorl, selenizone less prominent than in the type species. Spiral ornament of three orders.

Discussion: This genus is otherwise unknown in Permian faunas of either east Australia or New Zealand, and the Tamaree material appears to be identical in all visible aspects with the New Zealand types, including turreted shell, whorl profile, position and nature of the selenizone, and distinctive ornament and well rounded base with narrow umbilicus. It appears that the species was of limited time range at Gympie and in New Zealand.

CORRELATIONS

Basal South Curra fauna

A faunal list with illustrations for the "basal mollusc fauna" was provided by Runnegar & Ferguson (1969, p. 253). Runnegar & Ferguson (1969, p. 255) considered that "Neglecting the ammonoids, there is no paleontological evidence for concluding that the base of the South Curra Limestone is significantly younger than the Tiverton Formation at Homevale". There was one ammonoid species, identified as *Neocrimites meridionalis* Teichert & Fletcher, which was revised to *Aricoceras* (Leonova 1998, p. 159). Both genera are regarded as having a limited time range (mostly Artinskian, ranging into Kungurian), but the identification requires verification, because the analysis and figures provided by Runnegar & Ferguson do not suffice, and nothing else in the fauna indicates secure correlation with the fauna that is found with *A. meridionalis* in the Elderslie Formation of the north Sydney Basin. The identification of *Keeneia afflicta* by Runnegar & Ferguson (1969) also requires confirmation. The species was originally identified from the Fairyland Formation of the southeast Bowen Basin, and is of lower Sakmarian age (see Waterhouse 1987b, 2008b, 2015). The South Curra specimen could not be found during the re-examination of material in the present survey, and the illustration in Runnegar & Ferguson (1969, pl. 1, fig. 5) shows only the view from above, indecipherable generically. The distinct ribs characteristic of *afflicta* are not visible, possibly because of decortication. The specimens identified by Runnegar & Ferguson (1969, pl. 1, fig. 1-3) with a Farley species *Megadesmus nobilissimus* de Koninck belong to a different taxon, *M. ponderosus* Waterhouse, but give little information on age, and the same is true of *Pachymyonia*, called *morrisi* (= *morrisii*) of Asselian and Sakmarian age by Runnegar & Ferguson (1969, pl. 1, fig. 4), but clearly different: the best comparison is with upper Moonlight Member specimens from the *Pseudostrophalosia blakei* Zone in the northern Bowen Basin. Thus at present, several of the small number of fossils are not of great value in determining age, except in a negative way of not endorsing the ages implied by the Runnegar-Ferguson determinations, but neither challenging nor confirming the age implied by the identification of *Aricoceras*. Unfortunately the Gympie ammonoid material was borrowed by G. F. Glenister years ago, and never reported on, perhaps lost in transit, or regarded as indecipherable.

But *Aviculopecten* sp. nov. of Runnegar & Ferguson (1969, pl. 1, fig. 11) may be reidentified as *Etheripecten striatura* Waterhouse. This points to correlation with the Kildonan Member and *Tigillumia parallela* Zone of New Zealand, in other words, not significant older than the faunas of the overlying "lower brachiopod fauna" of the South Curra Limestone. This tie is strengthened by two further occurrences. Runnegar & Ferguson (1969) recorded *Bembexia* (now *Pagodina*) *scapulata* in common with their *Megadesmus*, and we have found loose boulders at Rammutt's farm with *M. ponderosus* and *Unicostatina chatsworthensis*. Both *scapulata* and *chatsworthensis* are otherwise typical of the "lower brachiopod fauna" in the South Curra Limestone. Thus the fauna is likely to be very slightly older. Hence the level is most likely equivalent to the *Tigillumia parallela* Zone, as a bivalve-dominated fossil community.

The significance of a radiometric age

The basal mollusc fauna has been assigned a radiometric value of approximately basal Kungurian age, to apparently resolve the uncertain indications from the fossils. This is based on a detrital zircon SHRIMP age adduced by Korsch et al. (2009, pp. 670-671), for which the youngest zircon age peak is close to 276 Ma, near the value of 275 Ma assigned to the Artinskian-Kungurian boundary. But uncertainty surrounds the actual stratigraphic level from which the sampling was made. The samples were taken supposedly from the Pengelly Sandstone, alleged to have been applied informally to the shelly sandstone at the base of the South Curra Limestone. Korsch et al. (2009) took the name Pengelly from a stratigraphic column based on coring at Eldorado Mine, interpreted by Arnold (1996) as reviewed by Sivell & Arnold (1999) and Sivell & McCulloch (2001, p. 379), and located at Gympie south of the fossil localities. In this core the name Pengelly was applied to siltstone, not sandstone, placed in turn below “the Upper Nash clastics”, 20-70m thick, in turn below a “top conglomerate”, less than 20m thick (see herein, p. 9). Arnold & Sivell reported that a top conglomerate less than 20m thick was a clast-supported unit at the base of limestone, and placed at the top of the Rammutt Formation. Their text is slightly ambiguous, because it was placed “at the base of the limestone”, which might mean that it lay below and separate from the limestone, or that it lay at the base within the limestone, but their placement in the Rammutt Formation implies the former. This band is followed by a dolerite sill, and the unit lies well above the Pengelly beds. That the Pengelly Siltstone should be interpreted as equivalent to the highly calcareous “shelly sandstone” at the base of the South Curra Limestone seems very difficult to accept – for even the “top conglomerate” lies nearly 100m below the South Curra Limestone in the core. The drill core provides a fine section, but it does not accord with the equally fine and more extensive and mapped sequence summarized from Rands (1889) and the accounts based on surface outcrop and numerous cores and mine exposures, compiled by Rands (1889), Jack & Etheridge Jnr. (1892), Dunstan (1911) and Denmead (1960). It is these sequences that incorporate the fossil horizons, not the drill core. Unless Korsch et al. (2009) were to provide more information, it appears very difficult to place any reliance on the imputed relationship between the fossils and the zircon age. Of additional concern, the zircon age was based on material from a sample described by Mortimer (2007), yet Mortimer stated that his sample came from the Upper Nash level, not the Pengelly. This Upper Nash level appears much more feasible. Basically, it does seem that there needs to be more careful correlation between the cores and the surface outcrops as far as “basal mollusc fauna” is concerned. At present, the fossils contradict the age of 275 Ma applied on the basis of an alleged correlation with basal South Curra beds, and show a much younger age.

Korsch et al. (2009) made much of the supposed correlation with the Elderslie Formation of the north Sydney Basin, and adjusted the age values to conform with a value of 275 Ma from that formation. It is here that further difficulty arises, because many of the significant species from the basal South Curra Limestone sensu Runnegar & Ferguson (1969), dubiously attributed to Pengelly by Korsch et al. (2009), are unusual, and cannot be readily correlated with known faunas in eastern Australia, including the well known and characteristic assemblage of fossils found with *Aricoceras meridionalis* (Teichert & Fletcher) in the Elderslie Formation of the northern Sydney Basin. The species from the Elderslie Formation include *Echinalosia floodi* Waterhouse, *Wyndhamia typica* Booker, *Paucispinauria paucispinosa wardenensis* Waterhouse, *Terrakea exmoorensis* Dear (syn. *T. rylstonensis* Briggs), *Aperispirifer archboldi* Waterhouse, *Tumulosulcus undulosa* (Campbell) and

Johndearia brevis (McClung & Armstrong), and the same zone is represented in the Freitag Formation of the Bowen Basin as summarized by Waterhouse (2002a, p. 178). These species help characterize the *Wyndhamia typica* Zone of Waterhouse (2008b). A different species assigned to *Neocrimites* is found in the *Ingelarella plica* Zone of the upper Tiverton Formation in the Bowen Basin, well below the Freitag Formation. Here the associated species include *Terrakea dickinsi* Dear, *Echinalosia preovalis* (Maxwell), *Kaninospirifer crassicostatus* (Waterhouse) and *Ingelarella plica* Campbell (Waterhouse & Jell 1983, p. 236). Briggs (1998) identified several species of this zone in the lower South Curra Limestone, though without adequate systematic documentation, and therefore of limited value, as further confirmed by examination of the actual fossils as in this report. The lower South Curra faunas appear to be younger, close to the Lopingian (Late Permian) faunas of the *Tigillumia parallela* and *Spinomartinia spinosa* Zones, which are represented by key species in the overlying South Curra Limestone (Waterhouse 2002a, 2008b). The age of the basal South Curra limestone is likely to be Changhsingian, and from available evidence, including the data provided by Mortimer (2007), the 275 Ma age applies to beds much older than the basal South Curra Limestone.

(b) *Tigillumia parallela* Zone (Lower brachiopod fauna)

TABLE 13. Summary of fauna from Lower South Curra Limestone.

Capillonia brevisulcus (Waterhouse)
Echinalosia denmeadi n. sp.
Anidanthia aplini n. sp.
Magniplicatina cranfieldi n. sp.
Costatumulus randsi Balfe & Waterhouse
Attenuocurvus incurvatus (Waterhouse)
Unicostatina chatsworthensis (Balfe & Waterhouse)
Ingelarella alteplica n. sp.
Johndearia isbelliformis (Waterhouse)
Validifera sp.
Tigillumia parallela (Waterhouse)
?Farmerella sp.
Cyrtella papula n. sp.
Fletcherithyris runnegari n. sp.
Pagodina scapulata (Runnegar & Ferguson)

Although the exact stratigraphic position of the radiometric age remains to be clarified, it does strongly help establish that the correlation and age allocated to overlying South Curra beds and faunas by Runnegar & Ferguson (1969) was too great, and has to be revised upwards. This strongly reinforced by the faunas. From the “lower brachiopod fauna” of the South Curra limestone, revision of the species determinations offered by Runnegar & Ferguson (1969) shows that the predominant species are either new, belonging to *Echinalosia denmeadi, Magniplicatina cranfieldi*, *Anidanthia aplini*, *Ingelarella alteplica*, *Unicostatina chatsworthensis* and *Fletcherithyris runnegari,* or belong to species identified previously from Late Permian faunas in New Zealand, as *Capillonia brevisulcus*, *Attenuocurvus incurvatus, Johndearia isbelliformis* and *Tigillumia parallela*. As shown in Part 6, some of these species are also found in the Gigoomgan Limestone nearby, but otherwise they are not known elsewhere in Australia, and because east Australian faunas are otherwise well known, and fill out all the Middle Permian stages, yet differ from South Curra faunas, these Gympie faunas are of a different age, and younger, which means they must be of Lopingian (Upper Permian) age. This is supported by the occurrence of several species shared with faunas of middle Changhsingian age in New Zealand. The fauna has a clear base – it must be younger than 275 Ma – and it is older than faunas correlated with the *Spinomartinia spinosa* Zone which are represented in the "upper brachiopod fauna" of the South Curra Limestone, and found widely in New Zealand. The fauna is younger than the *Martiniopsis woodi* Zone of New Zealand, which underlies the *parallela* and *spinosa* Zones in the Arthurton Group of New Zealand, and is represented by *Martiniopsis woodi* just above the Capitanian (late Middle Permian) fusulines *Yabeina* and *Lepidolina* in North Auckland. The *Martiniopsis woodi* Zone includes *Wimanoconcha, Wairakiella sella*, *Simplicisulcus arthurtonensis, Pustuloplica and Lamnaespina transennata* (see Waterhouse 1976b, Table 13, p. 250), not very close to members of the lower brachiopod fauna (Waterhouse 2002a), but including poorly preserved specimens of *Capillonia* and *Filiconcha*. In New Zealand the type *Martiniopsis woodi* Zone is found in a thin band of polyzoan (stenoporid) limestone.

***Spinomartinia spinosa* Zone (Upper brachiopod fauna)**

Runnegar & Ferguson (1969) correlated the upper South Curra fauna with the well known fauna of the Flat Top Formation of the southeast Bowen, later fully described in Waterhouse (1987b), but the revised species are shared not with the Flat Top Formation but with the somewhat younger Kildonan Member and Trig DD Formation of New Zealand, and the *Tigillumia parallela* and *Spinomartinia spinosa* Zones. In New Zealand, *Paucispinauria verecunda* and *Plekonella multicostata* help characterize the older zone, and *Filiconcha auricula, Tigillumia mintyi* and *Spinomartinia spinosa* characterize the upper fauna. Both faunas are believed to be of lower to middle Changhsingian age. They are overlain in New Zealand by two further marine invertebrate zones, named after *Marginalosia planata* and *Wairakiella rostrata*, for which there are no known marine equivalents in east Australia.

TABLE 14. Fauna from the upper South Curra Limestone.

Capillonia brevisulcus (Waterhouse)
Paucispinauria verecunda (Waterhouse)
Filiconcha auricula Waterhouse
Plekonella multicostata Waterhouse
Ingelarella fergusoni n. sp.
I. cf. *havilensis* Campbell
Tigillumia mintyi Waterhouse
?*Spinomartinia spinosa* Waterhouse

Tamaree Fauna

The Tamaree Formation is up to 700m thick and overlies the South Curra Limestone, but shares a gastropod species *Glabrocingulum* (*Ananias*) *campbelli* with the *Tigillumia parallela* Zone in New Zealand. Gastropods may have been long lived, and the Tamaree Formation may be younger and even of late Changshingian age, but there is no supporting faunal evidence. A bivalve is assigned to a new species of *Glyptoleda*, with ornament more complex than in Capitanian forms from New Zealand.

TABLE 15. Fossil localities for South Curra Limestone and Tamaree Formation, near Gympie. Most localities are shown on a geological map in Runnegar & Ferguson (1969) and others in Fig. 22.

UQ L 1422. Upper brachiopod fauna, South Curra Limestone. Old quarry west of track leading to Tamaree lime works quarry, Curra, one and a half miles north of Bell's Bridge.

UQ L 1950. Upper brachiopod fauna. Disused quarry between lime works and Railway Station, Tamaree.

UQ L 2703a. Basal mollusc fauna, South Curra Limestone. Near upper of two dams in third gully north of Rammutt Road, three quarters of a mile northeast of Chatsworth.

UQ L 2703b. Lower brachiopod fauna, South Curra Limestone. Slightly higher stratigraphically than UQ L 2703a.

UQ L 2704. Upper brachiopod fauna, South Curra Limestone. Top of ridge a quarter of a mile east of Allan Road, one and a quarter mile north of Chatsworth.

UQ L 2766. Upper brachiopod fauna, South Curra Limestone. 400 feet west of NW corner of Tamaree lime works quarry, Curra.

UQ L 2767. Lower brachiopod fauna, South Curra Limestone. Creek west of road running SE from Bruce Highway about one mile north of Bell's Bridge.

UQ L 2768. Upper brachiopod fauna, South Curra Limestone. Gully half a mile SW of farmhouse at head of Scrubby Creek, half a mile west of Mt. Corella.

UQ L 3256. Tamaree Formation. Crest of low ridge on East Deep Creek road, west of slaughter yards.

UQ L 3925. See Fig. 22, p. 75. Near UQ L 2703.

UQ L 3926. See Fig. 22, p. 75. Near UQ L 2703.

6. THE PERMIAN FAUNAS OF THE GIGOOMGAN AREA

SUMMARY

Brief summaries and illustrations of some of the macro-invertebrate fossils from the Permian rocks of the Gigoomgan area northwest of Gympie are provided. The fossils are largely shared with those of the Rammutt and South Curra beds of Gympie, but fossil material claimed to have come from the Teebar Formation, said to represent the youngest Permian, indicates an older – Sakmarian – age, correlative with the upper middle Tiverton Formation of the north Bowen Basin and equivalent faunal levels of the *Taeniothaerus subquadratus* Zone of east Australia. In addition a fauna from a unit which Brown (1964) discriminated as the Gundiah Bridge Greywacke is outlined. *Koenigoria browni* and *Betaneospirifer gigoomganensis* are named as new species.

INTRODUCTION

Fig. 43

A number of fossils from the Gigoomgan area are briefly reviewed and illustrated, for comparison with fossils from the Gympie area. The fossils had been collected by Brown (1964) in the course of compiling a thesis at the Department of Geology & Mineralogy, University of Queensland, Brisbane, and are housed permanently at the Queensland Museum and Science Centre Annex at Hendra in Brisbane. Only limited information is available on the stratigraphic position of various specimens, and the present appraisals cannot be regarded as complete, but are better than nothing – for more than fifty years, knowledge has remained abysmal, apart from a study of one brachiopod species by Armstrong & Brown (1968), and illustration of a martiniid by Armstrong (1972).

It is clear from the thesis by Brown (1964) that the Gigoomgan area contains a diverse assortment of fossils, and given that the area was collected for fossils only for a brief interval by one person and his helpers, the area deserves further study. The one geological publication devoted to the area is by Cranfield (1989), who presented a summary of the geology and a small scale map, reproduced as Fig. 43. Whereas Brown (1964) recognized five units likely to be of Upper Paleozoic age, Cranfield (1989) recognized only four, leaving out any reference to Brown's Gundiah Bridge Greywacke. But this has a distinctive lithology, and some distinctive fossils. Both Brown (1964) and Cranfield (1989) treated the Teebar beds, called Formation by Cranfield and Greywacke by Brown, as lying at the top of the sequence. This stratigraphic position is denied strongly by the nature of the fossil brachiopods, which show an age much older than the fossils from the Gigoomgan Limestone and Gundiah Bridge Greywacke, and emphatically fail to support any match with the fossils contained in the Tamaree Formation at Gympie. The geological conundrum posed by the fossil determinations cannot be resolved without further field study, but it may be pointed out that whereas Cranfield (1989) showed a rather simple anticline with broad limbs, exposing Mant beds at the core, overlain by Kolbar and Gigoomgan, and overlain in turn only to the northeast by Teebar Formation, it would seem likely that either a fold, fault or thrust separates the restricted Teebar from the Gigoomgan, with the boundary slightly further northeast from where shown on Cranfield's map, because Cranfield placed

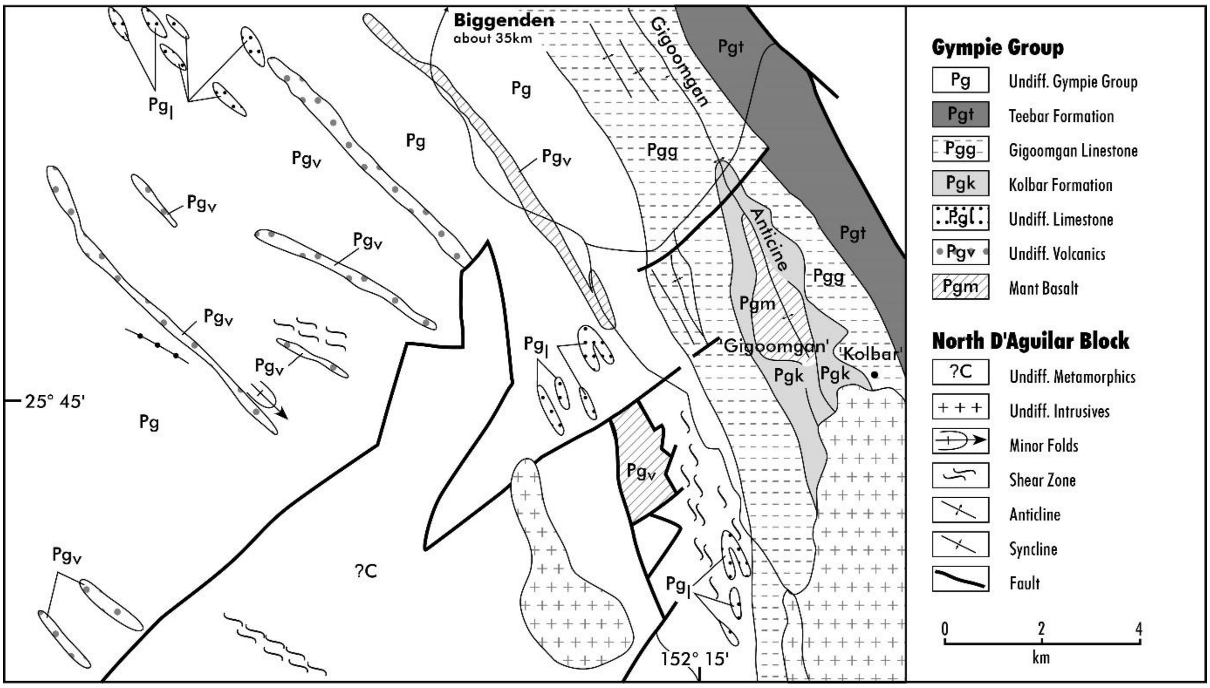


Fig. 43. The geology of the Gigoomgan area and surrounds northwest of Gympie, as conveyed by Cranfield (1989), redrafted and slightly simplified. Cranfield interpreted the Teebar Formation as younger than the Gigoomgan Limestone, as mapped, but fossils indicate a greater (Sakmarian) age, to suggest that a fault or fold axis lies between Teebar and Gigoomgan, and probably the boundary between the two units lies a little further northeast.

his boundary at a gradational contact. Brown (1964) believed that Gigoomgan overlay Teebar (Murray 1987). It seems possible that the upper Kolbar contains sedimentary equivalents of the Teebar beds and faunas, above the shale band that contains *Protoanidanthus* and *Attenuocurvus*. Whether the equivalent but barren beds are developed in the uppermost Rammutt Formation, above the Monkland faunas, remains unknown. The published map on Gigoomgan geology shows fold axes but no strikes or dips, and most of the outcrop is generalized as undifferentiated Gympie Group. Several slender belts of volcanics and limestones are shown, to suggest the likelihood of closely spaced folding, or perhaps faulting, if not both. It is reasonable to recall that Brown was an Honours student, examining his collections when detailed paleontological study on Permian invertebrate fossils had only just commenced, and fossils seem to have received limited attention during Cranfield’s geological survey.

The specimens were assigned an UQ F number, but no locality number.

KOLBAR FORMATION

Phylum Brachiopoda Duméril, 1797

Order PRODUCTIDA Waagen, 1883

Family **ANIDANTHIDAE** Waterhouse, 1968a

Genus ***Protoanidanthus*** Waterhouse, 1986a

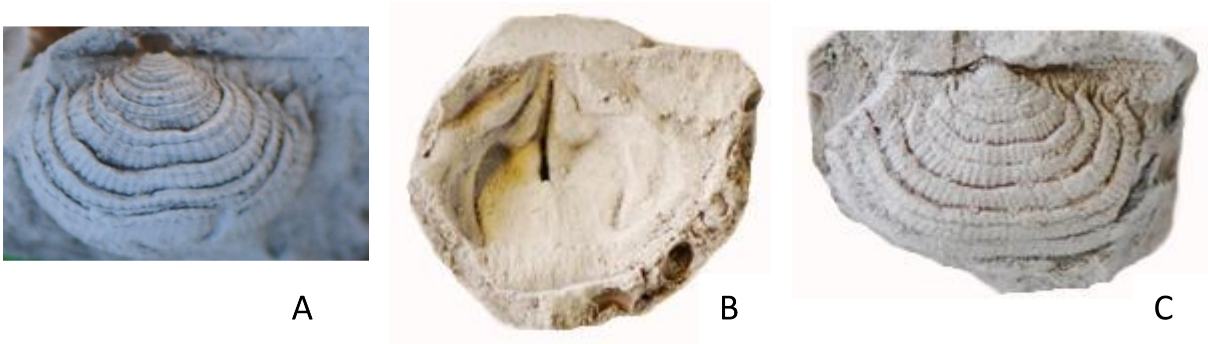


Fig. 44. *Protoanidanthus pokolbinesis* Briggs.   A, external mould of dorsal valve, UQ F 46651, x2.5. B, dorsal aspect of internal mould, UQ F 46654, x2. C, dorsal external mould UQ F 46652, x2.

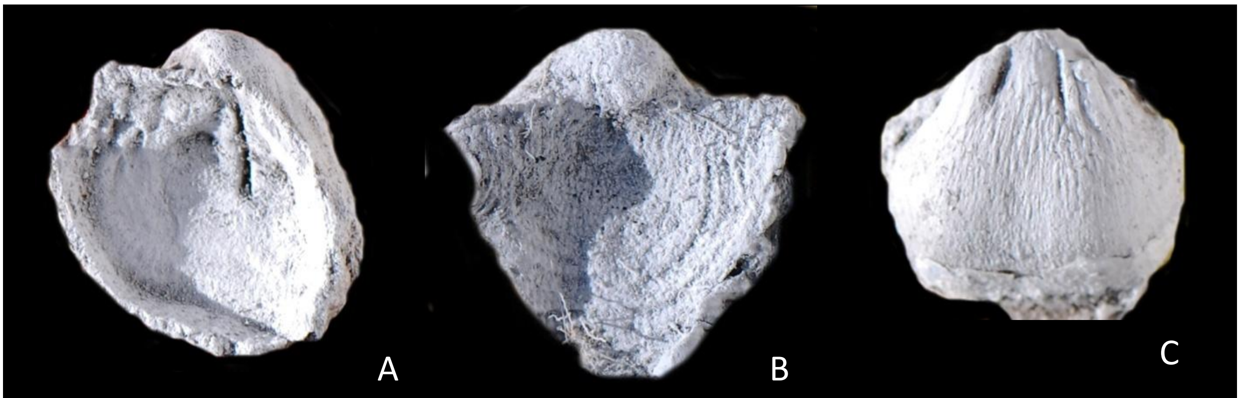
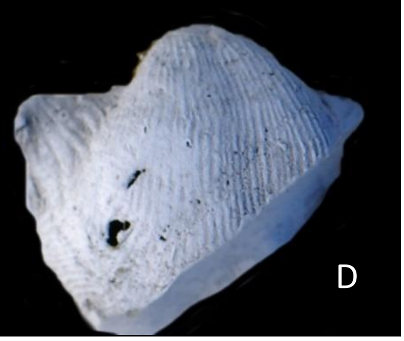


Fig. 45. *Protoanidanthus pokolbinesis* Briggs.   A, dorsal aspect of internal mould, UQ F 47095, x2.5. B, D, dorsal and ventral aspect of latex cast, UQ F 46654, x2.5. See also Fig. 44B for internal mould of same specimen. C, ventral internal mould, UQ F 47101, x3..



Protoanidanthus pokolbinensis Briggs, 1998

Fig. 44, 45

See p. 47 for typology and synonymy.

Small specimens appear to belong to this species, initially reported from New South Wales, and found in the Monkland beds at Gympie. They show the strong costae typical of the species, and the dorsal ears are small for the family. Armstrong & Brown (1968, p. 59) reported that *Anidanthus* (now *Protoanidanthus*) was found in a siltstone unit 600ft below the Gigoomgan Limestone with their species *Attenuatella australis*, one mile northeast of Gigoomgan homestead. The siltstone is likely to be correlative with the Monkland beds of Gympie.

Family **AMBOCOELIIDAE** George, 1931

Genus ***Attenuocurvus*** Waterhouse, 2010b

Attenuocurvus australis (Armstrong & Brown, 1968)

Fig. 46

See p. 55 for typology, synonymy and diagnosis.

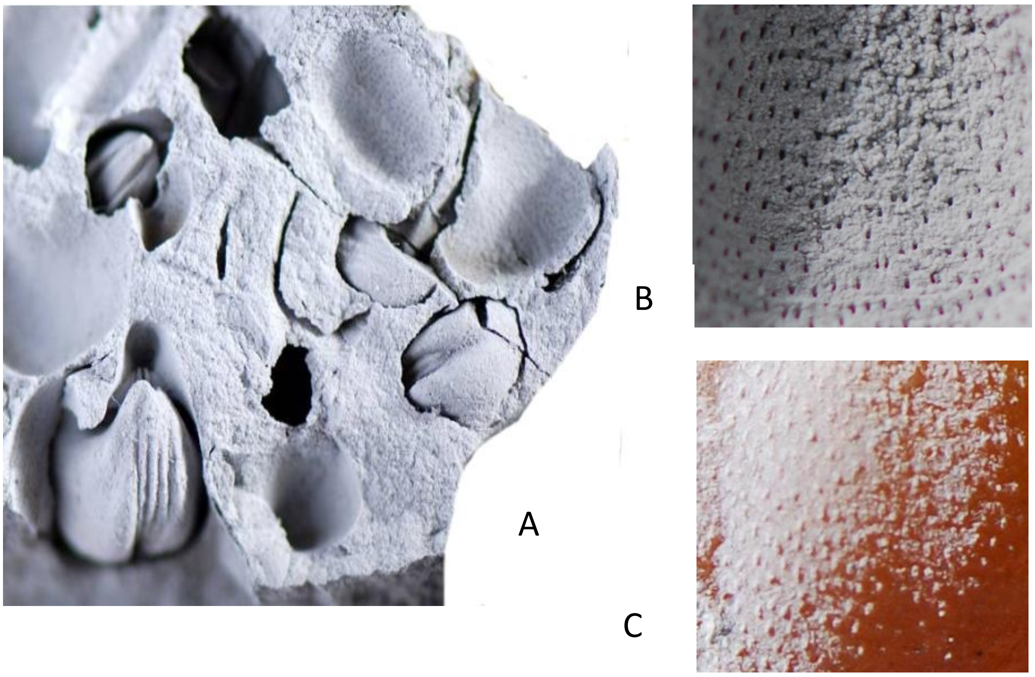


Fig. 46. *Attenuocurvus australis* (Armstrong & Brown). A, crowded ventral valves including UQ F 81603 at lower left, showing delthyrium and cover, x3.5. B, C, external mould and latex cast of left valve UQ F 81397 showing spinules, x10.

Discussion: In the descriptions of most species ascribed to *Attenuatella* s. l., the delthyrium is described as open, or bounded by very low lateral flanges (Cooper & Grant 1976a, p. 2131), and these are comparable to narrow deltidial plates preserved in some *Crurithyris*. Such flanges were said to be low or absent in the type species of *Attenuatella* (Cooper & Grant 1976a, p. 2132). Armstrong & Brown (1968) and Armstrong & Telford (1970) recorded a small convex plate in the posterior delthyrium of *Attenuocurvus australis* and *Biconvexiella convexa* respectively. Specimens of *australis* at the Queensland Museum and Science Annex at Hendra, Brisbane, show that the posterior delthyrium is closed by two slender plates, possibly equivalent to the flanges of Cooper & Grant (1976a), and these are separated by a median plate ridged posteriorly and grooved in front, and are crossed by growth striae and rugae concave forwards in outline. A few specimens show short grooves behind some spines, as noted by Armstrong & Brown (1968).

The specimens of *Attenuocurvus* described as *Attenuatella* from New Caledonia by Waterhouse (1969b, p. 252) have a delthyrium closed by a small plate v-shaped in section, ridging outwards.

Found 600ft from below the Gigoomgan Limestone, and accompanied by *Protoanidanthus pokolbinensis* Briggs, *Attenuocurvus australis* probably belongs to the *Bandoproductus macrospina* Zone.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Family **EDMONDIIDAE** King, 1850

Genus ***Pachymyonia*** Dun, 1932

See p. 80 for typology, synonymy and diagnosis.

Pachymyonia morrisii (Etheridge, 1919)

Fig. 47

1919 *Maeonia morrisii* Etheridge, p. 186, pl. 28, fig. 7, 8.

1919 *M. morrisii* var. (?) Etheridge, p. 187, pl. 30, fig. 1, 2.

1932 *Pachymyonia morrisii* – Dun, p. 412. pl. 51, fig. 1.

1932 *P. etheridgei* Dun, p. 41, pl. 2, fig. 3 (part, not pl. 52, fig. 6 = *Myomedia davidis* (Dun)).

1957 *P. morrisii* – Dickins, p. 27.

1965b *Pachymyonia morrisii* – Waterhouse, p. 376, text-fig. 3g.

1967 *Myonia morrisi* – Runnegar, pl. 20, fig. 11.

1967 *Myonia morrisi* – Runnegar, p. 53, pl. 4, fig. 3-5, pl. 5, fig. 1-11, 16, 17, pl. 12, fig. 4.

1969a *P. morrisi* – Waterhouse, p. 32, pl. 2. fig. 1-4, text-fig. 7H, 8G, 11, 12.

1974 *M. morrisi* – Runnegar, pl. 1, fig. 1, 2.

1992a *Myonia* (*Pachymyonia*) *morrisi* – Clarke, p. 30, Fig. 16A-D.

2015 *P. morrisii* – Waterhouse p. 317, Fig. 258-260.

Holotype: AMF 16978 from Allandale Formation (Asselian), Harper's Hill, New South Wales, figured by Etheridge (1919, pl. 28, fig. 7, 8), refigured by Runnegar (1967, pl. 5, fig. 15, 16), by monotypy.

Fig. 47. *Pachymyonia morrisii* (Etheridge), internal mould of right valve, UQ F 46728, x1.5.

Diagnosis: Strongly inflated shells with anteriorly placed umbones, and very high posterior umbonal carina, behind deep lateral sulcus.

Description: The specimen is a left valve, relatively small for the species, only 48mm long and 23mm wide, characterized by a very high and angular posterior carinal ridge placed towards the posterior third of the length, behind a well defined lateral sulcus below the incurved umbo. The posterior adductor scar is impressed and large.

Resemblances: This is an unmistakable species, well developed in the Allandale faunas of Asselian age in the north Sydney Basin, and found in the lower Tiverton Formation of Sakmarian age in the northern Bowen Basin, and reported widely from faunas in Queensland (Runnegar 1967; Waterhouse 2015).

Class Gastropoda Cuvier, 1797

Suborder PLEUROTOMARIIDINA Cox & Knight, 1960

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **SINUOPEIIDAE** Wenz, 1938

Subfamily **TURBONELLINAE** Knight, 1956

Genus ***Keeneia*** Etheridge, 1902

Type species: *Keeneia platyschismoides* Etheridge, 1902 from Allandale Formation (Asselian), north Sydney Basin, OD.

Diagnosis: Moderately large with sinus sited low on whorl, narrowly phaneromphalous, spiral threads and false selenizone. Spire moderately high.

Keeneia sp.

A small specimen UQ F 46727 only 20mm across belongs to *Keeneia*, as identified by Brown (1964). It is too incomplete to identify the species, but all three species described by Fletcher (1958) come from the Allandale Formation at Harper's Hill, in the Sydney Basin, New South Wales.

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **PTYCHOMPHALINAE** Wenz, 1938

Tribe **WALNICHOLLSIINI** Waterhouse, 2015

Genus ***Neoplatyteichum*** Maxwell, 1964

Type species*: Neoplatyteichum dickinsi* Maxwell, 1964, p. 20, from Rands Formation (Upper Carboniferous) of Yarrol Basin, Queensland, OD.

Diagnosis: Turbiniform medium-sized shells with weakly defined selenizone placed above mid-height on whorls, whorls globular, ornamented with low spiral ribs. Base anomphalous, cryptomphalous or phaneromphalous.

Neoplatyteichum sp.

Fig. 48

Description: Three fragments of a gastropod may belong to *Neoplatyteichum*, but are incomplete. The largest measures at least 38mm across, with three whorls preserved that are swollen and display poorly defined selenizone at or just above the periphery, and show low spiral ribs above and below, and there are faint traces of collabral ornament. The whorls are more rounded and selenizone lower placed than in *Neoplatyteichum dickinsi*. The specimens occur in a small block with *Protoanidanthus* and *Attenuocurvus* UQ F 46625 and 46626.

Fig. 48. *Neoplatyteichum* sp. UQ F 46625, x2, on block with specimens of *Protoanidanthus* and *Attenuocurvus*.

TEEBAR FORMATION

The Teebar Formation of Cranfield (1989) was said to be based on informal (ie. unpublished) subdivisions used by Brown (1964) in the Gigoomgan area, and was placed by Cranfield (1989) at the top of the local Permian sequence, above the Gigoomgan Limestone. Cranfield (1989, p. 120) stated that sparse collections from the Gigoomgan area by Brown (1964) indicated that the formation contained faunas similar to those of the Tamaree Formation of the Gympie area. Here is the Teebar fossil list compiled from Brown's thesis, slightly modified after I made a cursory check of the thesis and collections in the mid-1980's of the genera involved from Brown's collections: *Euryphyllum reidi, Lissochonetes australis* (ie. *cracowensis*), *Taeniothaerus, Anidanthus springsurensis, Cancrinella farleyensis, Ingelarella ovata, Notospirifer, Grantonia, Phestia* (now *Polidevcia*), *Atomodesma, Deltopecten, Eurydesma, Oriocrassatella stokesii*. Here is the list from the Tamaree Formation, provided by Runnegar & Ferguson (1969, p. 270): *Cladochonus, Nuculana* (now *Glyptoleda*), *Platyteichum* (now *Ananias*). Similarities? None. Whether correctly identified to species or not, the Brown collection from the Teebar Formation conveys a consistent indication of "Fauna 11", that is the *Taeniothaerus subquadratus* Zone in present terminology, without a single genus out of place. This may be compared with a list of Gigoomgan fossils: *Lissochonetes, Strophalosia, Filiconcha, Terrakea, Plekonella, Psilocamara, Ingelarella, Martinia, Neospirifer, Atomodesma*, followed by *Cladochonus, Euryphyllum*, *Anidanthus, Cancrinella* and *Grantonia* towards the top, as based on a scrutiny of Brown's collections and supplemented from Brown (1964): the genera unmistakably point to correlation with the South Curra Limestone, given the presence of distinctive *Filiconcha, Plekonella*, stenoscismatid and martiniid.

Phylum Brachiopoda Duméril, 1806

Suborder STROPHALOSIIDINA Waterhouse, 1975

Infrasuborder AULOSTEGIMORPHII Waterhouse, 2010b

Superfamily **AULOSTEGOIDEA** Muir-Wood & Cooper, 1960

Family **AULOSTEGIDAE** Muir-Wood & Cooper, 1960

Subfamily **TAENIOTHAERINAE** Waterhouse, 2002b

Diagnosis: Large shells with erect and/or prostrate spines on both valves, not rhizoid on dorsal valve, spine bases variable and patterns vary. Interior with large ventral muscle scars which often include small ancillary scars lateral to the adductors.

Genus ***Taeniothaerus*** Whitehouse, 1928

Type species: *Productus subquadratus* Morris, 1845, p. 284 from Berriedale Limestone (upper Sakmarian) of Tasmania, OD.

Diagnosis: Shells with low to moderately high ventral interarea, spines arise from short to long spine bases, spine cores extended anteriorly from base within shell over median part of valve, spines crowded on posterior flanks. Dorsal valve with regular closely spaced elongate dimples and tubercles, dorsal spines comparatively uniform, erect or semi-recumbent, arising from pustules, may be finer and arranged in rows anteriorly.

Taeniothaerus homevalensis Briggs, 1983

Fig. 49, 50A, C, D

1909 *Productus subquadratus* [not Morris] – Etheridge & Dun, p. 300, pl. 41, fig. 2-5 (part, not fig. 1 = *subquadratus*).

1950 *Aulosteges* (*Taeniothaerus*) *subquadratus* – Hill, p. 6, pl. 5, fig. 1, 2 (part, not pl. 1, fig. 1 = *subquadratus*; not pl. 6, fig. 4 = *farleyensis* Briggs).

1964 *Taeniothaerus subquadratus* – Hill & Woods, p. 10, pl. P5, fig. 5, 6.

1964 *T. subquadratus* var. *acanthophorus* [not Fletcher] – Hill & Woods, pl. P5, fig. 4? (part, not fig. 3 = *Colemanosteges acanthophorus*).

1972 *T. subquadratus* – Hill, Playford & Woods, p. 10, pl. P5, fig. ?4, 5, 6 (part, not fig. 3 = *acanthophorus*).

1974 *T. subquadratus* – McCarthy et al., Fig. 4c.

1983 *T. homevalensis* Briggs in Waterhouse et al., p. 127, pl. 2, fig. 1-7.

1986 *T. homevalensis* – Parfrey, p. 59, Fig. 2.1a, b.

1998 *T. homevalensis* – Briggs, p. 137, Fig. 67A, B.

2015 *T. homevalensis* – Waterhouse, p. 105, Fig. 55, 56.

Holotype: UQ F 72738 from Tiverton Formation (upper Sakmarian), north Bowen Basin, figured in Waterhouse et al. (1983, pl. 2, fig. 1-7) and Waterhouse (2015, Fig. 56), OD.

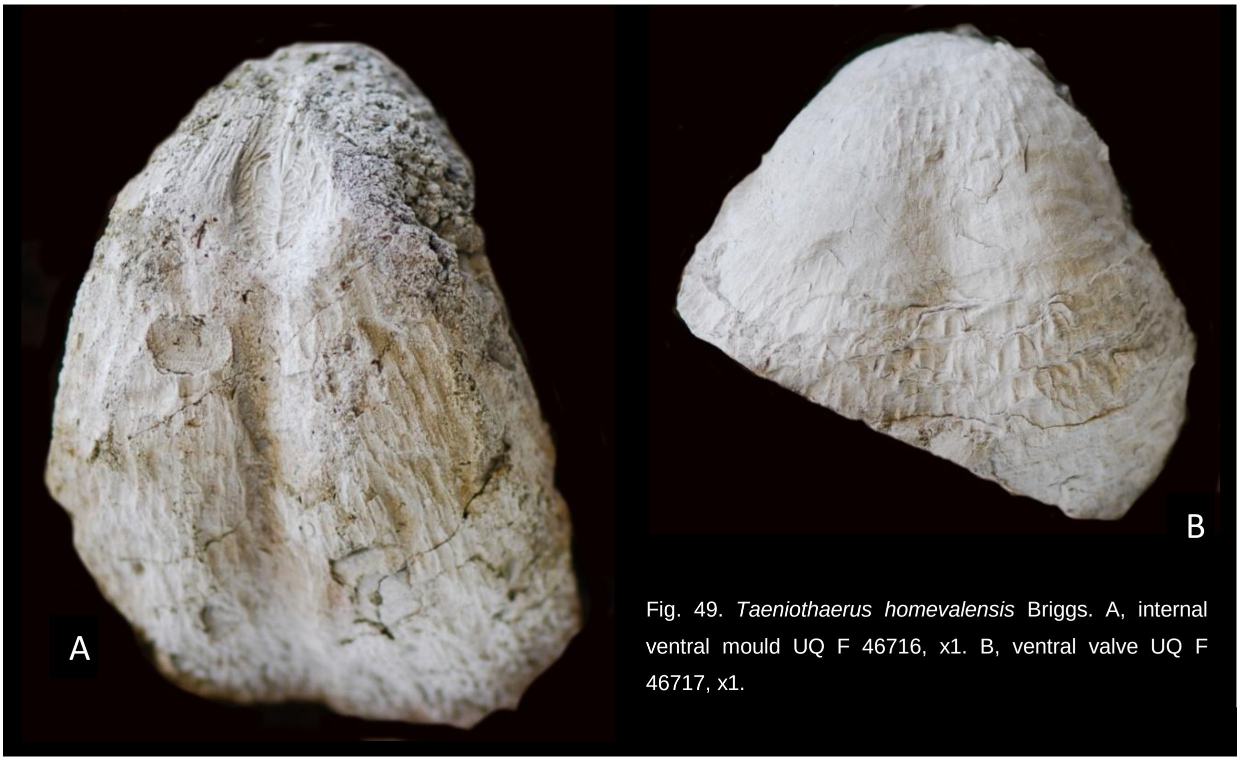


Fig. 49. *Taeniothaerus homevalensis* Briggs. A, internal ventral mould UQ F 46716, x1. B, ventral valve UQ F 46717, x1.

Diagnosis: Distinguished by body spines largely of one series and finer than those of *subquadratus*, few if any interspersed finer spines, erect or high-angle recumbent, spine ridges short, closely spaced for genus, well defined posterior lateral halteroid brush of spines. Well formed ventral sulcus and broad low dorsal fold.

Description: Specimens are large and the ventral valve is elongate with steep posterior walls, and incurved ventral umbo that is not particularly distorted. A low interarea and narrow raised pseudodeltidium are visible. The dorsal disc is comparatively flat over the posterior part, but trail and anterior are lost. The ventral sulcus is deep and narrow in one specimen, and broader and shallower in two specimens of greater width. Ventral spines are up to 1mm and usually 0.6-0.7mm in diameter, with spine bases as long as 5mm, spaced three to five in 10mm, and arranged in irregular quincunx. The dorsal exterior is not preserved. Muscle scars of both valves are well preserved, with raised ventral adductors, feathering posteriorly, and deep diductor impressions with differentiated grooves. In one dorsal valve there are two short thick buttress plates in front of the cardinal process, and posterior outer adductors are somewhat dendritic, whereas the inner anterior adductors are smooth. In the other and larger specimen, the buttress plates are less evident, thanks to greater secondary thickening. The entire adductor field is dendritic, and the posterior adductors extend around the posterior outer flanks of the anterior adductors.

A sample of rock, not labelled, shows two large cyclindrical spines (Fig. 50B), 2mm in diameter at maximum width, and possibly these belonged to *Taeniothaerus*, though much broader than those characteristic of *T. homevalensis*.

Resemblances: The specimens are incomplete, and many features cannot be recorded. But the strength of spine bases matches that of *Taeniothaerus homevalensis* Briggs in Waterhouse et al. (1983), a highly distinctive species. Some specimens are unusually transverse anteriorly.

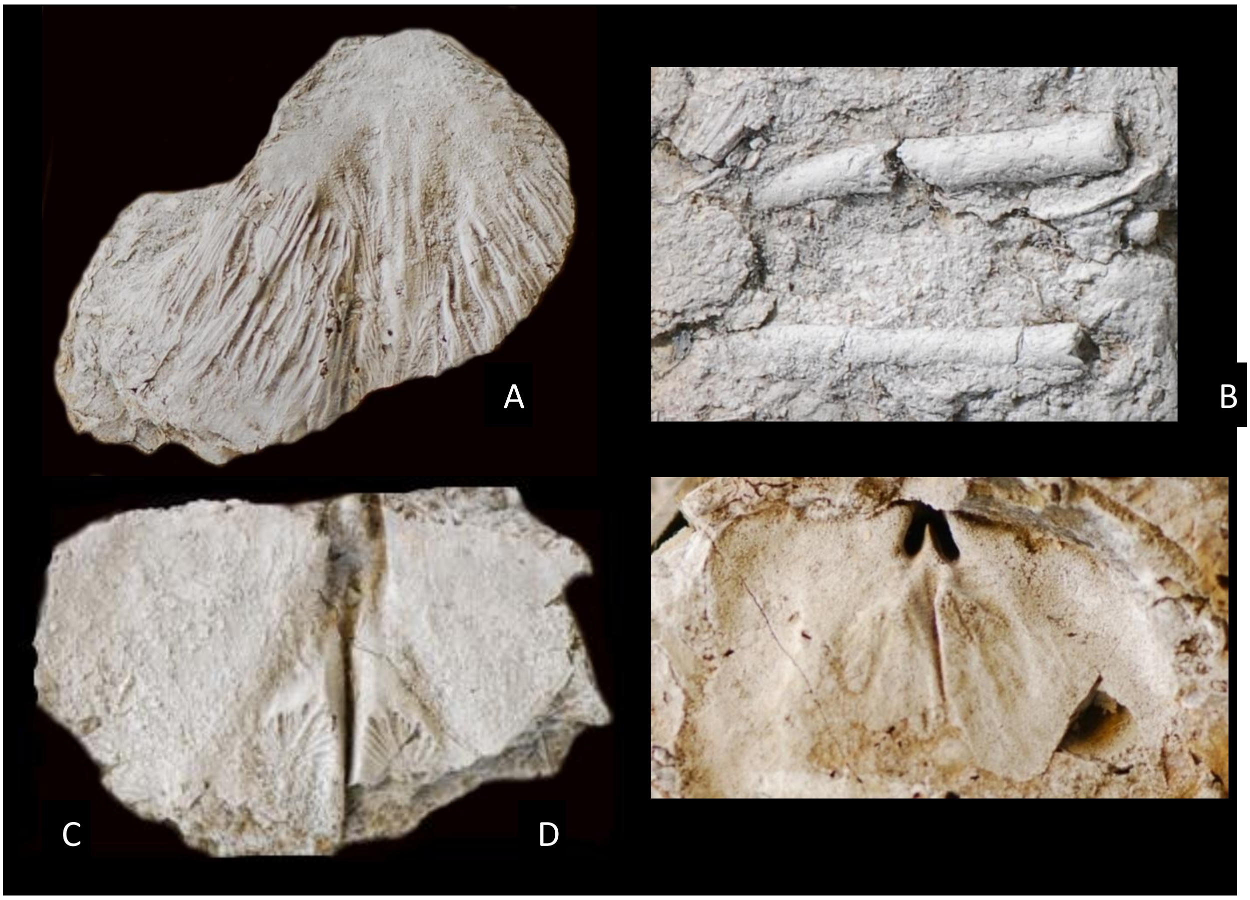


Fig. 50. A, C, D, *Taeniothaerus homevalensis* Briggs . A, part of ventral internal mould, UQ F 47714, x1.5. C, posterior dorsal internal mould, UQ F 46713, x1.2. D, posterior dorsal internal mould UQ F 46729, x1.2. B, Spine-like tubes, x3 approximately. Finer probably brachiopod spines to the left are also from an unknown species and genus.

Order SPIRIFERIDA Waagen, 1884

Family **INGELARELLIDAE** Campbell, 1959

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

For classification and further detail, see p. 17.

Ambikella ovata (Campbell, 1961)

Fig. 51

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.

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 = *Geothomasia symmetrica* (Campbell)).

1978 *I. ovata* – McClung, p. 47, 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 = *symmetrica*).

1983 *Ambikella ovata* – Waterhouse, Williams & Campbell, p. 303, text-fig. 3, 4.

1983 *Ambikella* sp. Waterhouse, Williams & Campbell, p. 303, text-fig. 5.

1986b *Homevalaria ovata* – Waterhouse, p. 110.

1987a *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.

2014 *Ambikella ovata* – Waterhouse, p. 152, Fig. 106B, 107A, B, 108-110.

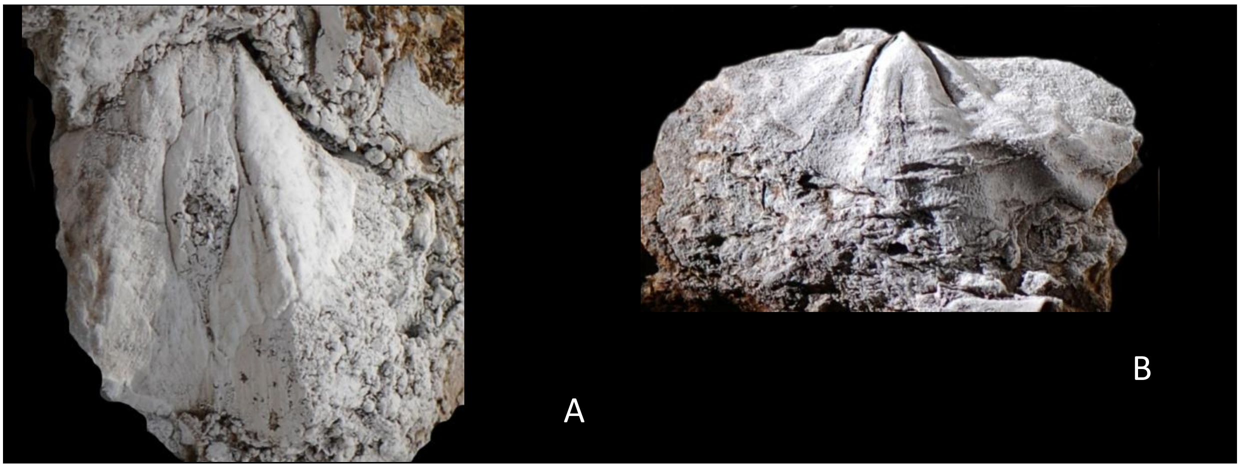


Fig. 51. *Ambikella ovata* (Campbell). A, UQ F 46721, worn ventral valve, x1. B, internal mould of dorsal valve UQ F 46725, x 1.5.

Holotype: UNE F 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, Playford et al. (1972), and Carter & Gouvennec (2006, Fig. 1160.2a-c), OD.

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

Description: A ventral valve on a small block labelled UQ F 46719 has a well defined sulcus, no lateral plicae, and long subparallel and well spaced adminicula enclosing an elongate and substantial ventral muscle field. A dorsal valve has rounded fold, three pair of plicae and moderately developed tabellae. No specimen shows the micro-ornament.

Discussion: The figure of *Ingelarella ovata* provided by Armstrong (1970b, p. 204, pl. 14, fig. 4) suggests possible *Geothomasia symmetrica* (Campbell), because the sulcus is bordered by a strong narrow-crested plication. A dorsal valve identified with *I. ovata* by Armstrong (1970b, pl. 14, fig. 5, 6) has short tabellae as in *G. profunda,* but the figure seems indicate a widely channelled fold.

Genus ***Geothomasia*** Waterhouse, 1998b

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

Diagnosis: Large shells with well formed sulcus, fold without channel, often few and strong plicae, fine surface grooves. Adminicula of moderate length and moderately well spaced, tabellae short, may diverge widely.

Discussion: *Geothomasia* was proposed initially as a subgenus of *Tomiopsis* Benediktova for species found in Permian deposits of mid-Cisuralian to Lopingian age in Western Australia. A group of species with similar short widely diverging tabellae is developed in east Australia, especially in Early Permian faunas. In Western Australia, adminicula of *Geothomasia* are well spaced and tend to be short and widely divergent, and the secondary thickening is much less than in east Australian material. Externally, no specimens of *Geothomasia* from Western Australia show the strong pair of plicae that is developed in many individuals from east Australia, apart from one dorsal valve in the type species *G. teicherti*, which has a moderately strong inner pair of plicae as figured by Archbold & Thomas (1986a, Fig. 6.4).

Geothomasia profunda (Campbell, 1961)

Fig. 52

1892 *Martiniopsis darwinii* [not Morris] – Etheridge Jnr., p. 240, pl. 39, fig. 5-7 (part, not pl. 9, fig. 13, 14 = aff. *Notospirifer*).

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.

1970b *I. profunda* – Armstrong, p. 204, pl. 13, fig. 8-10.

1970c *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?

2015 *Geothomasia profunda* – Waterhouse, p. 171, Fig. 122, 123, 138G.

Holotype: UQF 21922 from upper middle Tiverton Formation, Bowen Basin, figured by Campbell (1961, pl. 28, fig. 11), OD.

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

Description: Two ventral valves with shell preserved are transverse, and have broad incurved umbo.

One shell shows only two pair of plicae, and the other has three pair of plicae and faint suggestions of a fourth pair. The sulcus is broad with pair of subplicae, and in one specimen bears a shallow median groove.

Dimensions in mm for *Geothomasia profunda*:

Specimen	UQ	Width	Length	Height
F 46729	45	34.5	17	
F 46725	48	41	20	

Fig. 52. *Geothomasia profunda* (Campbell), two ventral valves UQ F 46725 and F 46729, x1.5.

Family **TRIGONOTRETIDAE** Schuchert, 1893

Genus ***Grantonia*** Brown, 1953

See p. 59 for typology and diagnosis.

Grantonia australis (Bion, 1928)

Fig. 53, 54

1892 *Spirifer stokesii* [not Koenig] – Etheridge Jnr., p. 232, pl. 10, fig. 2, 3, pl. 39, fig. 2-4 (part, not pl. 10, fig. 4 = indet.).

1928 *S. stokesii* var. *australis* Bion, p. 30.

1964 *Grantonia* sp. Hill & Woods, pl. P8, fig. 8.

1968a *Trigonotreta stokesi* [not Koenig] – Armstrong, p. 83, pl. 6, fig. 1-3, 5 (part, not fig. 4 = *stokesii*).

1970b *T. stokesi* – Armstrong, p. 205, pl. 15, fig. 3, 5, 6, 7, 8.

1972 *T. stokesi* – Hill, Playford & Woods, pl. P8, fig. 8 (part, not fig. 6, 7 = *cracovensis*).

1974 *T. cracovensis* [not Wass] – McCarthy et al., Fig. 4F.

1987a *T. australis* – Waterhouse, p. 17, pl. 3, fig. 14?, 18-20, pl. 4, fig. 1-3, 4?, 5, 6.

2004a *Grantonia australis* – Waterhouse, p. 170.

2015 *G. australis* – Waterhouse, p. 187, Fig. 143A, C, E, 144, 145A, B, D, 146A, 147-151.

Fig. 53. *Grantonia australis* (Bion), ventral valve UQ F 46719, x 1.25.

Holotype: GSQ F 1480 figured by Etheridge (1892, pl. 39, fig. 2-4), Hill & Woods (1964, pl. P8, fig. 8) and Hill, Playford & Woods (1972, pl. P8, fig. 8) from Tiverton Formation, Homevale, Queensland, OD.

Diagnosis: Transverse shells with pair of plicae entering sulcus and three to four well formed lateral plicae bearing high and often broad primary costae, finer lateral plicae, well defined growth lamellae, fold high with narrow crest, adminicula short and well spaced.

Fig. 54. *Grantonia australis* (Bion), ventral internal mould UQ F 46718, x1.5.

Description: A small ventral valve UQ F 46719 has five pair of well defined plicae with further prominent costae laterally. The innermost pair of plicae enters the sulcus. A broken internal mould of a transverse ventral valve UQ F 46718 belongs to this distinctive species, showing a broad and deep sulcus and strong lateral plicae persisting to the anterior margin, with sturdy costae. Dental plates are high and scapular-shaped, supported by gradually diverging and well spaced adminicula, and the adductor scars are comparatively broad, divided by a posterior myophragm, with wider diductor impressions to each side, that are not strongly marked.

Resemblances: These specimens in their transverse outline and presence of five plicae and strong median costa agree with *Grantonia australis* (Bion), well known from the Tiverton Formation of the

Bowen Basin, and described by Waterhouse (2015). The range of the species is through the *Bookeria geniculata* and *Taeniothaerus subquadratus* Zones in the Tiverton Formation of the Bowen Basin.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Order NUCULANIDA Carter, Campbell & Campbell, 2000

Superfamily **NUCULANOIDEA** H. Adams & A. Adams, 1858

Family **POLIDEVCIIDAE** Kumpera, Prantl & Ružička, 1960

Genus ***Polidevcia*** Chernyshev, 1951

Type species: *Polidevcia karagandensis* Chernyshev, 1951 from Carboniferous of Soviet Union, OD.

Diagnosis: Shell prolonged behind the beaks, beaks opisthogyrous, lunule and escutcheon developed, escutcheon divided by a pair of inner escutcheon ridges and bordered externally by outer escutcheon ridge. Ornament of commarginal costae, teeth taxodont, number subequal in front of and behind the chondrophore, up to three umbonal scars on short internal ridge. Pallial line entire.

Polidevcia sp.

Fig. 55

Description: The latex cast of an external mould UQ F 46732 has the shape, ornament, escutcheon with inner escutcheon ridge and posterior taxodont teeth typical of *Polidevcia.* Anterior shell lost.

Discussion: This is the only form that remotely resembles any species found in the Tamaree Formation of Gympie, but it belongs to a genus quite distinct from *Glyptoleda* in that formation. The ribs in this specimen are linear and parallel to the ventral margin, whereas the ribs in *Glyptoleda* have zigzags and may lie at a high angle to the ventral margin.

Fig. 55. *Polidevcia* sp. UQ F 46732, latex cast of posterior shell, x3.

Order PECTINIDA Gray, 1854

Family **DELTOPECTINIDAE** Dickins, 1957

Genus ***Squamuliferipecten*** Waterhouse, 1986b

For typology and diagnosis see p. 29.

Squamuliferipecten mitchelli (Etheridge & Dun, 1906)

Fig. 56

1849 *Pecten illawarrensis* [not Morris] – Dana, p. 705, pl. 9, fig. 9, 9a.

?1877 *Aviculopecten illawarrensis* – de Koninck, p. 163, pl. 22, fig. 1.

1892 *Deltopecten illawarrensis* – Etheridge Jnr., p. 269, pl. 41, fig. 3 (part, not pl. 43, fig. 2 = *Etheripecten playfordi* Waterhouse).

1906 *A. mitchelli* Etheridge Jnr. & Dun, p. 11, pl. 1, fig. 1-3, pl. 2, fig. 1, pl. 10, fig. 5, pl. 12, fig. 5, pl. 13, fig. 3, pl. 14, fig. 2, 3.

1924 *A. mitchelli* – Richards & Bryan, pl. 20, fig. 2.

1928 *A. mitchelli* – Whitehouse, p. 282.

1929 *A. mitchelli* – Fletcher, p. 15.

1953 *"A." mitchelli* – Kegel, p. 1, Fig. 1-3.

1957 *Deltopecten mitchelli* – Dickins, p. 40, pl. 7, fig. 8, pl. 8, fig. 10, text-fig. 8.

1963 *D. limaeformis* [not Morris] – Dickins, pl. 12, fig. 1, 2, ?3.

1977 *D. illawarensis* – Webb, p. 56, pl. 2, fig. 4.

1987b *D. illawarrensis* – Waterhouse, p. 154, pl. 6, fig. 9 (part, not fig. 6 = *squamuliferus* (Morris).

cf. 1992a *D. illawarrensis* – Clarke, p. 41, Fig. 25A-I, 26A-F.

2008a *Squamuliferipecten mitchelli* – Waterhouse, p. 85, text-fig. 41A-C.

2015 *S. mitchelli* – Waterhouse, p. 246, Fig. 198A, B, 199A, 200, 201, 202B, C.

Fig. 56. *Squamuliferipecten mitchelli* (Etheridge Jnr. & Dun), fragment of external mould of left valve UQ F 46780, x1.

Lectotype: AMF 35304 figured by Etheridge Jnr. & Dun (1906, pl. 1, fig. 1, 2) from Allandale Formation (Asselian), north Sydney Basin, SD Waterhouse (2008a, p. 88).

Diagnosis: Biconvex shells with some 20 to 27 coarse ribs, some of which may carry median groove, and rare secondary ribs. Commarginal lamellae well developed and well spaced on both valves.

Description: A fragment UQ F 46720 of a large left valve shows strong and well spaced round-crested ribs and evenly concave interspaces, crossed by strong lamellae. The number of ribs, now incomplete, is likely to have been more than twenty and less than thirty, pointing to *Squamuliferipecten mitchelli*, a species found in Asselian and Sakmarian faunas of east Australia.

GUNDIAH BRIDGE GREYWACKE

Brown (1964) recognized a unit he called Gundiah Bridge Greywacke for medium to fine grained volcanigenic sandstone, some layers with coarse granules. It was not mentioned by Cranfield (1989), and was grouped with Kolbar, because its lithology approaches bands of that formation. It is a unit too thin to have been mapped at the scale employed by Cranfield for the geology of Gigoomgan area.

Phylum Brachiopoda Duméril, 1806

Order PRODUCTIDA Waagen, 1883

Family **DASYALOSIIDAE** Brunton, 1966

Genus ***Echinalosia*** Waterhouse, 1967a

Echinalosia denmeadi n. sp.

Fig. 57

See p. 84 for synonymy, typology, diagnosis etc.

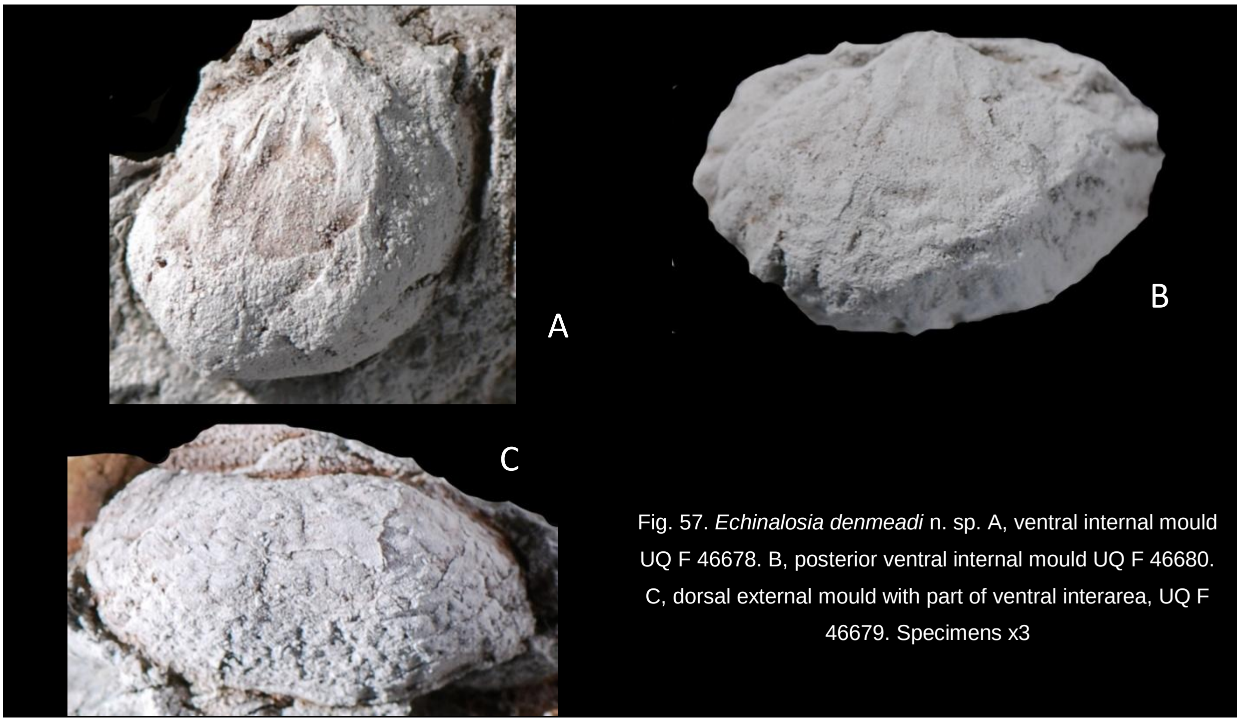


Fig. 57. *Echinalosia denmeadi* n. sp. A, ventral internal mould UQ F 46678. B, posterior ventral internal mould UQ F 46680. C, dorsal external mould with part of ventral interarea, UQ F 46679. Specimens x3

Dimensions in mm for *Echinalosia denmeadi*, ventral internal moulds, all deformed:

Specimen UQ	Width	Length	Height
F 46678	18.5	19	10.5
F 46679	19	17	10
F 46680	27	23	14

Description: An incomplete external mould shows ventral interarea of moderate height in plane of commissure, and dorsal valve with numerous fine erect spines 0.2mm in diameter. There is a small broad convex nepionic area on the dorsal valve. Several internal moulds of ventral valves show short low subtriangular adductor scars, little impressed diductor scars, and strong radial rugae over the anterior disc and trail. The ventral valves as a rule are somewhat distorted and the umbonal part of the shell particularly distorted, making illustration difficult. The specimens appear to be identical with the specimens from the South Curra Limestone, which are preserved as shell material, to give a degree of complementarity.

Family **ANIDANTHIDAE** Waterhouse, 1968a

Genus ***Anidanthia*** Waterhouse, 2013

Anidanthia aplini n. sp.

See p. 86 for typology and diagnosis.

Description: A ventral internal mould UQ F 46675 shows the well developed smooth adductor platform typical of the family, and traces of the ornament suggest that anterior costae are as coarse as those of *Anidanthia aplini* n. sp. from the lower South Curra Limestone. An external fragment of a ventral valve UQ F 46618 shows the radial ribs and part of the hinge spine row.

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Genus ***Magniplicatina*** Waterhouse, 1983

Magniplicatina cranfieldi n. sp.

Fig. 58

See p. 88 for typology, synonymy and diagnosis.

Description: Ventral valve UQ F 46683 is 25mm wide and 23mm long, with wide hinge, large ears, fine ribs (10-13 in 5mm), moderately elongate spine bases, and fine commarginal rugae. Ribs increase by branching, and some by intercalation at the start of the trail. The illustration appears to indicate a number of ear spines, but this is an artefact. The hinge spines form a well defined row, with a few spines nearer the hinge, and a few additional ear spines, moderately close to the arrangement of spines in the holotype as figured by Runnegar & Ferguson (1969, pl. 4, fig. 18). A small specimen UQ F 46737 is conspecific.

Fig. 58. *Magniplicatina cranfieldi* n. sp., ventral valve UQ F 50265, x2.8.

Resemblances: This specimen is identified with *Magniplicatina cranfieldi* n. sp. from the lower brachiopod fauna of the South Curra Limestone, displaying similar shape, moderately subdued commarginal rugae, and other details.

Order SPIRIFERIDA Waagen, 1883

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Ingelarella alteplica n. sp.

Fig. 59

See p. 94 for typology and diagnosis.

Fig. 59. *Ingelarella alteplica* n. sp., internal mould of dorsal valve UQ F 46658, x2.

A dorsal valve on the same block as *Echinalosia denmeadi* n. sp. (UQ F 46676), and another dorsal valve with *Koenigoria browni* (UQ F 46678) both show the high dorsal fold with deep narrow channel, and lateral high narrow plicae typical of this species from the South Curra Limestone. Another dorsal fragment, unnumbered, is similar.

Genus ***Johndearia*** Waterhouse, 1998b

Johndearia isbelliformis (Waterhouse, 1978)

Fig. 60B

For diagnosis and typology, see p. 96.

Description: The sulcus of this specimen is shallow and is not bordered by high margins with narrow crest. This specimen has no lateral plicae. The ventral muscle field shows the usual arrangement of narrow raised adductor ridges, separated on each side by a slender bordering ridge from broader diductor scars marked by oblique growth markings parallel to the anterior margins, and the specimen appears to be conspecific with ventral valves from the lower South Curra Limestone. No dorsal valve is known from the Gundiah Bridge Greywacke.

Genus ***Validifera*** Waterhouse, 2015

For diagnosis and typology, see p. 98.

***Validifera*? sp.**

Fig. 60A

A ventral valve displays the widely spaced adminicula typical of the genus. The high and narrow-crested flanks to the ventral sulcus approach those of *Validifera valida* (Campbell), but do not seem to be as raised as usual: on the other hand the shape is close to that of *Validifera* than the subrectangular outline normal for *Johndearia.*

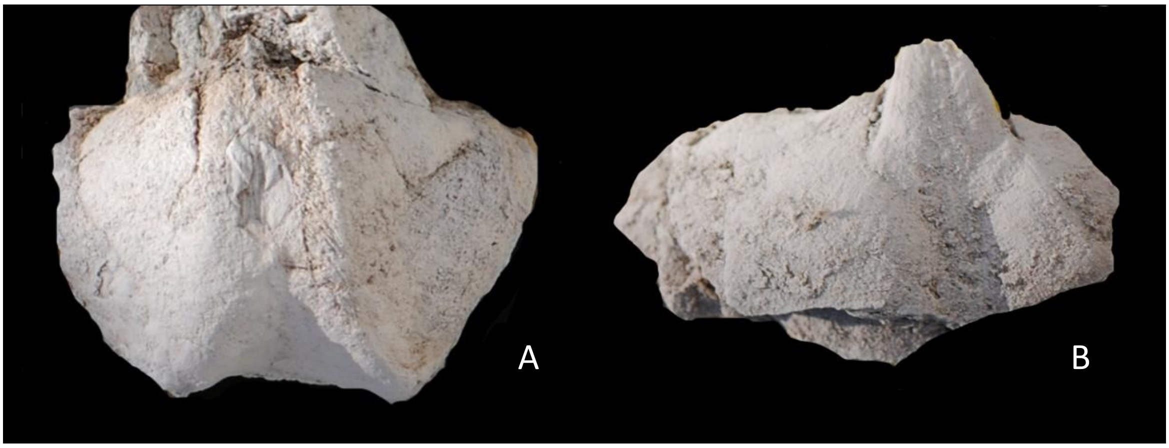


Fig. 60. A, *Validifera*? sp. ventral valve UQ F 46683, x2. B, *Johndearia isbelliformis* (Waterhouse), ventral internal mould UQ F 46671, x3.

Genus ***Tigillumia*** Waterhouse, 1998b

Tigillumia parallela (Waterhouse, 1968a)

Fig. 61

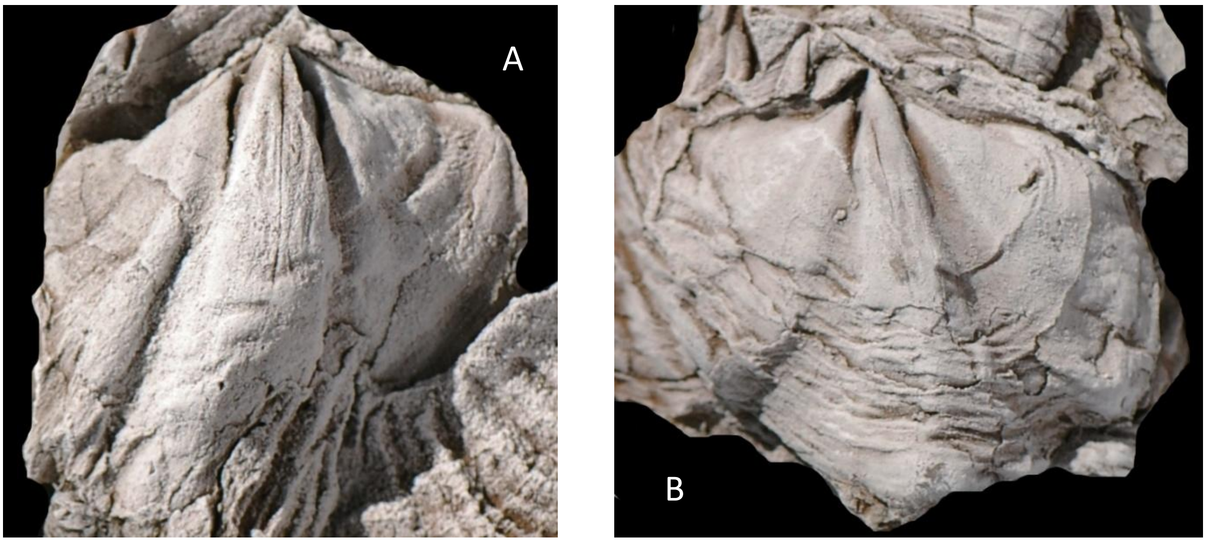


Fig. 61.*Tigillumia parallela* (Waterhouse). A, dorsal internal mould UQ F 46668, with part of external mould of *Koenigoria*, UQ F 46666 at lower right, x2. B, dorsal aspect of internal mould, UQ F 46669, on same block, x3.

See p. 98 for typology and further detail.

Several dorsal valves, including UQ F 46685 and also three on a block that include UQ F 46668 and 46669 are placed in this distinctive species. A number of other specimens are also present with other species. The high dorsal fold and moderately strong innermost pair of plicae resemble aspects of the topotype dorsal valve figured in Waterhouse (1968a, pl. 13, fig. 3), allowing for distortion. The crest of the fold is rounded, and the tabellae diverge forwards at a low angle and are moderately long. There is a very low median septum, and large longitudinally striate gently impressed adductor scars. The ctenophoridium lies at the slender tip of the dorsal fold, and is very small. Further analysis is hindered by the lack of well exposed ventral valves.

Family **TRIGONOTRETIDAE** Schuchert, 1893

Genus ***Koenigoria*** Waterhouse, 2004a

Type species: *Trigonotreta neoaustralis* Archbold & Thomas, 1986b, p. 152 from Callytharra Formation (Sakmarian), Western Australia, OD.

Diagnosis: Triangular shells with wide hinge and lateral margins converging forward, subalate cardinal extremities, plicae usually in four pair, costae numerous.

Koenigoria browni n. sp***.***

Fig. 62 - 64

Derivation: Named for C. D. Brown.

Holotype: UQ F 46673 from Gundiah Bridge Greywacke (Changhsingian), Gigoomgan area, south-east Queensland, shown in Fig. 64A, B, here designated.

Fig. 62 *Koenigoria browni* n. sp., ventral and dorsal aspect of internal mould, UQ F 46672, x1.

Diagnosis: Comparatively small and transverse, four pair of plicae, and primary costa remaining high especially on dorsal valve. Ventral muscle field moderate in width, posterior thickening heavy.

Description: Outline transverse, cardinal extremities alate with angle of 50^{o}, ventral umbo broad with angle of 90-100^{o}, not strongly incurved, and well formed sulcus widening at 30^{o} with evenly concave or subangular floor. Dorsal fold narrow posteriorly and high, flaring anteriorly. Ventral interarea largely in plane of commissure, concave under umbo, divided by open delthyrium, sides of delthyrium diverge at 60°, dorsal interarea lower and also in plane of commissure, with notothyrium, sides diverging at 100°. Both interareas bear longitudinal and vertical striae. Ventral valve with four pairs of sturdy plicae, persisting to anterior margin, innermost pair incorporated anteriorly in the sulcus, and further coarse costae or narrow plicae present laterally. Dorsal valve with four or in one specimen five pairs of plicae, the inner pair hugging the flanks of the fold. Costae are sturdy, and number at least ten over the anterior sulcus, and four over the crest of the inner plicae, and three then two costae over lateral plicae. Costation is particularly distinctive on the dorsal valve, increasing over 10mm from the umbo one each side of a prominent median costa, with fewer or no costae on the lateral plicae. The surface of the shell is too poorly preserved to show the nature of micro-ornament.

Fig. 63. *Koenigoria browni* n. sp. A, ventral internal mould UQ F 46681, x3. Little is known about the stratigraphic position, and the matrix is volcanogenic. B, ventral internal mould, UQ F 46674, x1.

The delthyrium is open with no well developed apical callosity, heavy pleromal thickening, short well spaced adminicula diverging to the floor of the valve and diverging dental plates. The adductor platform is almost as broad as each diductor scar, from which it is divided by a low ridge in some specimens, and diductor scars are marked by weak longitudinal and commarginal growth ridges, varying in each specimen. Posterior thickening is heavy, and the posterior floor bears pits.

Ctenophoridium small, short socket plates and low crural plates, median septum short and low, adductor scars not clearly marked.

Resemblances: This species is distinguished by its plication and costation, the primary costae notably higher on the dorsal valve than on the ventral valve, and commencing well in front of the dorsal hinge. Further distinctions involve small size, alate cardinal extremities, and heavy posterior thickening. *Koenigoria neoaustralis* is distinguished by its finer costae, but is close in plication and shape, and the umbonal callosity may be small or moderate, yet no specimen shows a delthyrial plate. *K. dickinsi* (Archbold & Thomas, 1986b) from the Nooncanbah Formation of Western Australia is less close in shape and has weaker dorsal ribbing. From the Lightjack Formation of Roadian age in Western Australia, *K. lightjacki* (Archbold & Thomas, 1986b) is smaller and less triangular in shape with somewhat similar plicae and costae. (See also Archbold et al. 1993, pl. 41). *Koenigoria lyonsensis* (Archbold & Thomas 1986b) from the Lyons Group of the Carnarvon Basin in Western Australia is particularly transverse with extended cardinal extremities. Other trigonotretid species of Changhsingian age, best known as *Aperispirifer nelsonensis* Waterhouse from New Zealand, are large with subrectangular outline, heavy umbonal callosity, finer ribs and fading plicae.

Dimensions in mm for *Koenigoria browni* n. sp.:

Specimen	Width	Length	Height (both valves)
UQ F 46673	57	37	17.5

Fig. 64. *Koenigoria browni* n. sp. A, B, holotype, dorsal and ventral aspects of UQ F 46673, x 1.3. C, dorsal internal mould UQ F 46684, x2.

Order TEREBRATULIDA Waagen, 1884

Suborder TEREBRATULIDINA Waagen, 1884

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **PSEUDODIELASMIDAE** Cooper & Grant, 1976b

Genus ***Marinurnula*** Waterhouse, 1964

Type species: *Marinurnula rugulata* Waterhouse (1964, p. 477) from Kildonan Member (Changhsingian), Bagrie Formation, Arthurton Group, New Zealand, OD.

Diagnosis: Medium in size, not plicate, no dental plates, small teeth and reduced dental sockets, crural plates arise directly from floor of dorsal valve, no septalium.

Discussion: Because the loop of *Marinurnula* is not known, classification remains uncertain, though it would seem likely that its loop is not as complex as that of Heterelasminidae Licharew. But there is scope for further consideration of the Heterelasminidae and Pseudodielasmatidae, and other families assigned to Dielasmoidea, with the possibility that either loop or internal plates varied in a more complex manner within families than allowed in the Treatise.

Marinurnula rugulata Waterhouse, 1964

Fig. 65

1964 *Marinurnula rugulata* Waterhouse, p. 177, pl. 34, fig. 6-8, text-fig. 81.

1982a *M. rugulata* – Waterhouse, p. 67.

2001 *M. rugulata* – Waterhouse, p. 106, pl. 8, fig. 10.

Holotype: BR 900 figured by Waterhouse (1964, pl. 34, fig. 6-8, text-fig. 81) from Kildonan Member (Changhsingian), Bagrie Formation, Arthurton Group, New Zealand, OD.

Diagnosis: Moderately large for genus, extended posterior walls, low even commarginal rugae.

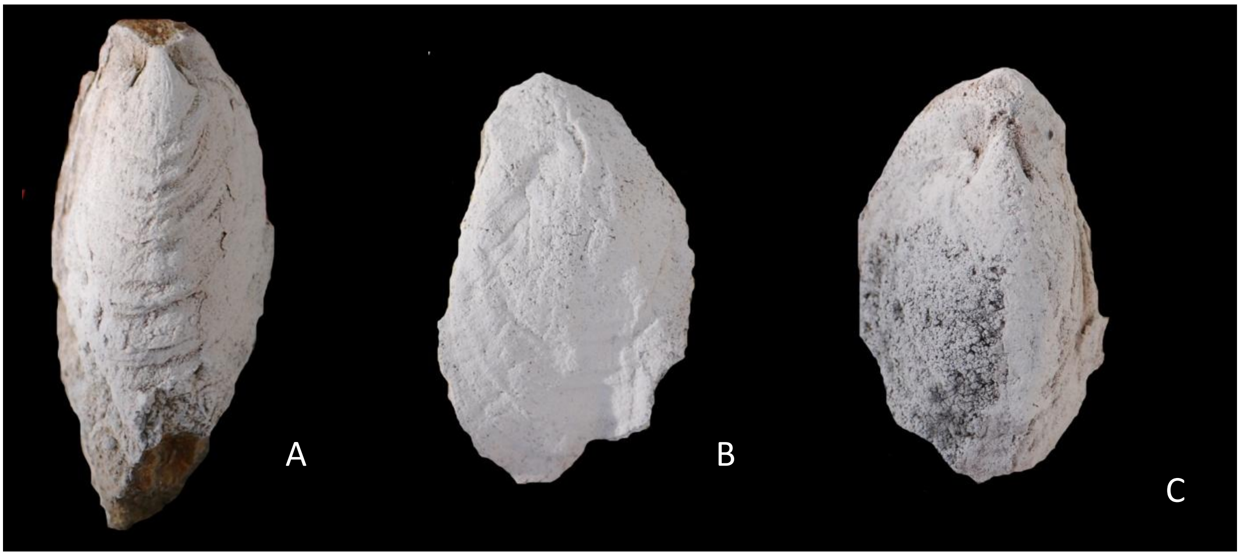


Fig. 65. *Marinurnula rugulata* Waterhouse. A, dorsal aspect of internal mould UQ F 46632, laterally crushed. B, C, ventral and dorsal aspects of internal mould UQ F 46631. Specimens x1.

Dimensions in mm of *Marinurnula rugulata*:

Specimen	Width	Length	Height
UQ F 44631	42	26.5	16

Description: Shells medium in size, with prolonged umbonal walls and maximum width well forward, dorsal valve higher than ventral valve, anterior ventral sulcus broad, both valves crossed by well defined well spaced commarginal rugae. Small well defined pedicle collar, no dental plates, small teeth, cardinal “process” with a number of laminations, no septalium, crura-bearing hinge plates rest on floor of the valve.

Resemblances: These specimens agree in size, shape and ornament with *Marinurnula rugulata* from the Kildonan Member near Arthurton and the lower clastics of the Glendale Formation at Wairaki Downs in New Zealand. The laminated cardinal area in the New Zealand material is smaller than in the present specimen UQ F 44631.

Several other species are known in east Australia (Campbell 1965, Waterhouse 1987a) and New Zealand (Waterhouse 2001), but none are close.

GIGOOMGAN LIMESTONE

Phylum Brachiopoda Duméril, 1806

Order CHONETIDA Muir-Wood, 1962

Family **RUGOSOCHONETIDAE** Muir-Wood, 1962

Genus ***Capillonia*** Waterhouse, 1973

Capillonia brevisulcus (Waterhouse, 1964)

Fig. 66

See pp. 81, 82 for typology, diagnosis and descriptions.

Description: Several specimens, mostly ventral valves with smooth exterior, including UQ F 46616.

Fig. 66. *Capillonia brevisulcus* (Waterhouse). A, internal ventral mould UQ F 46616, x3. B, dorsal interior and part of ventral valve, UQ F 46617, x 2.5.

Order PRODUCTIDA Waagen, 1883

Family **DASYALOSIIDAE** Brunton, 1966

Genus ***Echinalosia*** Waterhouse, 1967a

Echinalosia denmeadi n.sp

Fig. 67

See p. 84 for typology, diagnosis and synonymy.

Description: A ventral valve external mould UQ F 46646 measures 30mm wide, 29mm long and approximately 7mm high and is covered by fine spines with diameter less than 0.5mm. Most spines are evenly spaced and are erect or have short bases 1-1.5mm long. A large dorsal valve UQ F 46710 27mm wide, as estimated from half shell, is concave with no distinct nepionic area, and no discriminated trail. Numerous fine erect spines are usually 0.1mm in diameter, up to 0.3mm in diameter.

Fig. 67. *Echinalosia denmeadi* n. sp., dorsal external mould UQ F 46710, x2.

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Genus ***Paucispinauria*** Waterhouse, 1983

Paucispinauria verecunda (Waterhouse, 1982a)

Fig. 68

See p. 110 for typology, diagnosis and synonymy.

Fig. 68. *Paucispinauria verecunda* (Waterhouse), dorsal external mould UQ F 46698, x 2.

Description: A poorly preserved dorsal valve and a ventral valve are overall close to *Paucispinauria verecunda*, but do not show the critical ventral ears and their ornament very well. However dorsal valve UQ F 46698 as figured shows that the dorsal ears bear commarginal rugae and there is little trace of hollows which normally oppose the ventral ear spines, suggesting that ear spines were few. Anterior spines over the trail are few and twice as broad as those at the start of the trail and over the disc.

Family **AURICULISPINIDAE** Waterhouse, 1986b

Genus ***Filiconcha*** Dear, 1969

Filiconcha auricula Waterhouse, 1976b

Fig. 69

See p. 109 for typology and further detail.

Fig. 69. *Filiconcha auricula* Waterhouse, ventral internal mould, backlit, UQ F 50263 x2.

An external mould of a specimen with characteristic subrectangular shape is found on a block UQ F 46698, together with *Paucispinauria verecunda* Waterhouse. Another specimen UQ F 50263 is a ventral valve covered by fine radial capillae and long smooth subrectangular adductor scars. At Gympie the two species also occur in the same zone, whereas they are mostly found in two successive zones in New Zealand.

Order RHYNCHONELLIDA Kuhn, 1949

Family **WELLERELLIDAE** Licharew, 1956

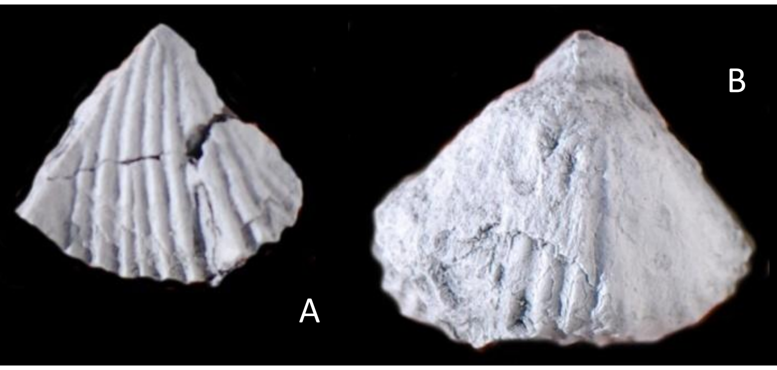
Genus ***Plekonella*** Campbell, 1953

Plekonella multicostata Waterhouse, 1964

Fig. 70

See p. 112 for synonymy, typology, classification and diagnosis.

Fig. 70. *Plekonella multicostata* Waterhouse. A, ventral valve UQ F 46711. B, dorsal aspect, UQ F 46712, with valves conjoined, x 2.



Dimensions in mm for *Plekonella multicostata,* both valves:

Specimen	Width	Length	Height
UQ F 46712	23	19	17
UQ F 46711	14	9.5	9

Description: Two specimens show the shape and strong costation typical of the species, with four stout costae on the floor of the sulcus in the larger specimen, and faint traces of an additional lateral pair. This specimen is larger and more inflated than any previously recorded member of the species. The other specimen has five costae on the floor of the sulcus, with the median costa unusual because it divides anteriorly. The species is highly distinctive, and is limited in time range to deposits of lower Changhsingian age in southeast Queensland and New Zealand.

Suborder STENOSCISMATIDINA Waterhouse, 1981

Superfamily **STENOSCISMATOIDEA** Oehlert, 1887

Family **STENOSCISMATIDAE** Oehlert, 1887

Subfamily **STENOSCISMATINAE** Oehlert, 1887

Genus ***Stenoscisma*** Conrad, 1839

Type species: *Terebratula schlottheimi* von Buch, 1834 from Zechstein (Wuchiapingian) of Germany, OD.

Diagnosis: Costae over sulcus and fold and often flanks, broad stolidium in adult form. Spondylium and camarophorium.

Discussion: The nomenclature and authorship of *Stenoscisma* have been unravelled by Carlson & Grant (2002, p. 1219), and the genus was considered to range from Lower Carboniferous to ?Tatarian, with the type species supposedly middle Upper Permian. Such age terminology has been long superseded, and the type species is of lower Late Permian age, ie. Wuchiapingian, not much older than the present occurrence, and the genus ranges well into the Changhsingian, youngest of the Permian stages.

?Stenoscisma papilio Waterhouse, 1964

Fig. 71

Fig. 71. ?*Stenoscisma papilio* Waterhouse, external mould of anterior ventral valve, UQ F 46709, x1.5

Discussion: The external mould of a ventral valve shows a broad shallow anterior sulcus ornamented by four low evenly rounded and evenly spaced costae, and traces of a fifth, all commencing at the start of the sulcus. The lateral flanks of the shell are almost smooth, showing only traces of costae. These attributes agree with those of *Stenoscisma papilio* Waterhouse (1964, p. 99, pl. 18, fig. 4-8, text fig. 41, 42) from the Kildonan Member of the Bagrie Formation of New Zealand. Although the present specimen is incomplete, it seems likely in view of the similarities of the general faunas of the two regions that it belongs to the same species that is represented in New Zealand.

Order SPIRIFERIDA Waagen, 1883

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Ingelarella fergusoni n. sp.

Fig. 72, 73

See p. 113 for typology and diagnosis.

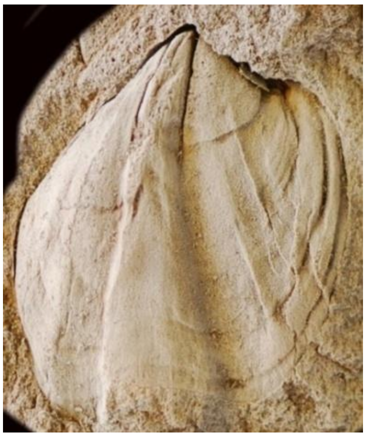


Fig. 72*. Ingelarella fergusoni* n. sp., UQ F 46685, internal mould of dorsal valve, x1. Possibly stretched longitudinally.

Description: UQ F 46686 is a specimen with valves conjoined, showing low plicae on both valves, wide sulcus and broad fold with steep flanks and plane crest which is feebly sulcate anteriorly, and moderately well spaced comparatively short adminicula and moderately long subparallel but well spaced tabellae.

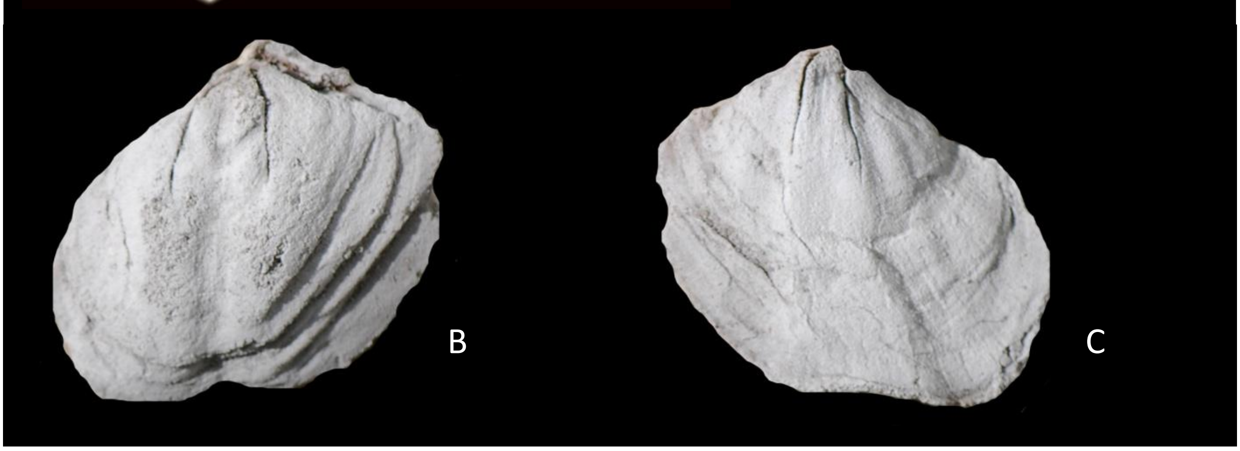


Fig. 73*. Ingelarella fergusoni* n. sp. A, dorsal aspect of internal mould UQ F 46686, x2. B, C, ventral and dorsal aspects of UQ F 46687, x2.

A dorsal valve UQ F 46685 has a well defined fold with steep lateral flanks, and indications of a median channel, narrow and moderately well defined posteriorly, but broad and shallow anteriorly. A pair of narrow low plicae lie to each side, and a faintly defined second pair of plicae is developed laterally. There is a posterior median septum between comparatively long and close-set tabellae. Muscle scars between the tabellae are too faintly impressed to be clearly visible.

Resemblances: This species is characterized by its rather low inflation and subdued plicae, with broad low dorsal fold channelled by a broad shallow sulcus, and moderately defined ventral sulcus with no sign of subplicae, unlike the sulcus of *Ingelarella ingelarensis* or *I. angulata*. The present species does display a median sulcal channel in the dorsal valve of the holotype, limited to the anterior in a larger specimen. There is considerable approach to *Ingelarella dissimilis* Waterhouse, 1964 from the mid-Permian of Wairaki Downs, New Zealand, in the moderately long adminicula and moderately long and well spaced tabellae and transverse shape and widely channelled fold, though plicae are lower and the shell less transverse in the new species. Whilst *dissimilis* was referred to *Johndearia* by Waterhouse (1998b), the species does not fit well there, and yet *dissimilis* is not a fully typical *Ingelarella,* unlike *I. angulata* Campbell or *I. ingelarensis* Campbell, and with *fergusoni*, formed a small cline of its own.

Genus ***Johndearia*** Waterhouse, 1998b

Johndearia isbelliformis Waterhouse, 1978

Fig. 74

For diagnosis, synonymy and typology, see p. 96.

Description: A large ventral valve UQ F 50259, 61mm wide, 45mm long and 24mm high has slightly incurved ventral umbo, high but short ventral interarea, well rounded cardinal extremities, broad sulcus without subplicae, and no lateral plicae. The specimen is likely to belong to *Johndearia isbelliformis*, because of the nature of the sulcus and lack of plicae, and although the umbonal region may be deemed to be more prominent than in type and other *isbelliformis*, with slightly lower umbonal angle, it seems likely that this lies within natural limits of variation. The sulcus is better defined than usual, but its borders are well rounded, unlike those normal for *Validifera*.

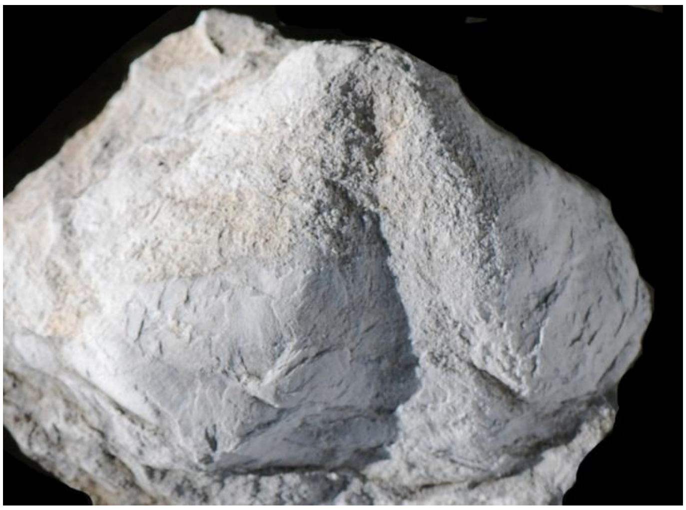


Fig. 74. *Johndearia isbelliformis* (Waterhouse), ventral valve UQ F 50259, x2.

Family **MARTINIIDAE** Waagen, 1883

Genus ***Spinomartinia*** Waterhouse, 1968a

Spinomartinia spinosa Waterhouse, 1968a

See p. 116 for typology, synonymy and diagnosis.

Specimen UQF 50261 only shows the general shape and interior, but a more complete specimen was figured from the formation by Armstrong (1972).

Family **NEOSPIRIFERIDAE** Waterhouse, 1968a

Genus ***Betaneospirifer*** Gatinaud, 1949

For diagnosis and typology, see p. 22.

Discussion: Carter (2006a, p. 1789) and Carter et al. (1994) provisionally recognized *Betaneospirifer,* explaining that the micro-ornament of *Neospirifer* Fredericks was not known, preventing full assessment of that genus, and henceforth any prospective difference from *Betaneospirifer*. But so many forms of overall similarity share a cancellate micro-ornament that it seems most unlikely that the micro-ornament will provide any means of distinction between the two genera. The hinge and ligament area of type *Neospirifer*, as refigured in Carter (2006a, Fig. 1185.1a), is much shorter than in type *Betaneospirifer* (see Carter 2006a, Fig. 1185.2d), and this provides a ready distinction between the two genera. Poletaev (1997) further studied *Neospirifer*, but introduced some confusion through the supposed identification with Late Permian *Betaneospirifer* from the Salt Range, Pakistan, much younger and geographically and morphologically distinct from type *Neospirifer*, and confused Russian *Neospirifer* figured and sectioned by Waterhouse (1968, pl. 16, fig. 7, text-fig. 7A3) with *Gypospirifer*. This cannot be sustained (Waterhouse 2004, p. 107).

Neither *dubius* (p. 22) nor the present species fully conform with *Betaneospirifer*, because they are smaller, and more importantly, do not have a high narrow crested dorsal fold; instead the fold is moderately low and of moderate width in *dubius*, and broad and low in *gigoomanensis.*

Betaneospirifer gigoomganensis n. sp.

Fig. 75

1968a *Neospirifer arthurtonensis* Waterhouse, p. 28, pl. 3, fig. 4, 6 (part, not pl. 2, fig. 14, 16, pl. 3, fig. 1-3, 5, 7-9, pl. 17, fig. 1, 3, text-fig. 7C, D, 9A, 10-13 = *arthurtonensis*).

1976b *Neospirifer arthurtonensis* [not Waterhouse] – Waterhouse, p. 244, Fig. 6.5, 7.7.

1978 ?*Neospirifer* sp. Waterhouse & Mutch, p. 521, Fig. 11 (part, not fig. 10 = *Crassispirifer*).

1999 *Neospirifer*? sp. Waterhouse, p. 10.

2001 *Neospirifer* sp. Waterhouse, p. 91.

Derivation: Named from Gigoomgan Station.

Holotype: UQ F 46697 from Gigoomgan Limestone (Changsingian), near Gympie, southeast Queensland, figured as Fig. 75, here designated.

Diagnosis: Small finely costate shells with posterior plicae up to 15mm long before splitting, four or five plicae over ventral valve, commarginal laminae well developed.

Dimensions in mm of *Betaneospirifer gigoomganensis,* both valves:

Specimen	Width	Length	Height
UQ F 46697	33	22	12.5

Description: Shell small, holotype with extended hinge and alate cardinal extremities, ventral umbo pointed with narrow angle of 85^{o} and low umbonal walls fading rapidly, ventral interarea wide and highly concave with delthyrium, horizontal markings, vertical striae feeble. Dorsal interarea moderately high and concave, with now apparently open notothyrium measuring angle of 110^{o}. Ventral sulcus commences at beak and broadens at angle of 20^{o}. Dorsal fold distinctly elevated, broad but not very high. Ventral plicae narrow and low, numbering five pair on holotype, with well rounded crests, outer pairs weakly defined; innermost pair of plicae lies along the edge of the sulcus for 17mm (Fig. 75), and then gradually enters the sulcus, and a median costa lies along the middle of the sulcus. On the dorsal valve three pair of plicae developed, with one or two additional pairs suggested laterally. Fine costae arise up to 15mm from the beak on the ventral valve and 6-10mm from the dorsal beak, number three over inner plicae, and fewer laterally, and strength varies a little. Costae are present laterally, and the ears are comparatively smooth. Commarginal lamellae prominent over anterior shell of both valves, number three to four in 1mm, and cover most of the valves and the cardinal extremities.

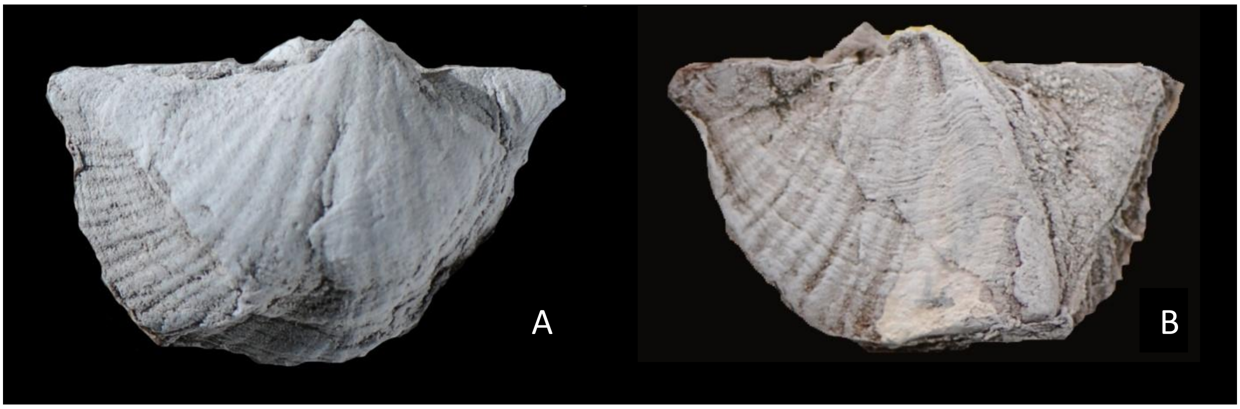


Fig. 75. *Betaneospirifer gigoomganensis* n. sp. A, B, dorsal and ventral aspects of UQ F 46697, holotype, x2.

The external mould of a ventral valve UQ F 47062, labelled as L 2925 Biggenden 1 mile, and coming from the Teebar Conglomerate, is found in highly calcareous fine beds like those of the Gigoomgan limestone, and appears to belong to this species, and not to *Grantonia australis*.

Resemblances: The species is distinguished by its alate cardinal extremities and fine costae, which may arise some distance from the umbones. The same species is developed in the Kildonan Member of the Bagrie Formation and in the Nemo Member and Hilton Limestone Member in southern New Zealand, where some specimens are somewhat larger, developing more extended antero-lateral margins, and more costae anteriorly, especially in the sulcus and over the fold, but they retain the characteristics of the Gigoomgan specimen, and display internal features including delthyrial plate, stubby teeth, short adminicula largely buried in secondary thickening, and broad ventral muscle field, divided by myophragm, low broad adductor ridges and broad diductor scars (see Waterhouse 1999, p. 10). Waterhouse (1968a, 1976b) referred material from the Kildonan Member of the Arthurton Group in New Zealand to the species *Simplicisulcus arthurtonensis*, but the costae are much finer than in *arthurtonensis* sensu stricto, and the dorsal fold is broad and low like that of the type (Waterhouse 1976b, Fig. 7), not high and narrow as in *arthurtonensis. A* small delthyrial cover is developed.

Simplicisulcus concentricus Waterhouse (1987a, p. 21, pl. 4, fig. 7-13) from the Brae Formation of southeast Bowen Basin in Queensland, of Roadian (Middle Permian) age, has delthyrial plate, well developed commarginal laminae and comparatively fine costae which develop some distance in front of the beaks, though they are slightly coarser and more differentiated than in the present species. The Brae species differ in shape, being more elongate with obtuse cardinal extremities and slightly narrower fold, and the innermost pair of plicae does not enter the sulcus. *Aperispirifer ovalis* Waterhouse, 1987a, has wide hinge and fine costae, rarely with subplicae pair within sulcus, but the umbonal callosity is large, with no delthyrial plate. *Spirifera dubius* Etheridge Snr., 1872 from the Rammutt Formation at Gympie as described on p. 22, Fig. 6 is distinguished from the present species by its elongate shell, stronger commarginal laminae and small size.

Betaneospirifer moosakhailensis (Davidson, 1862) from Pakistan is large with wide sulcus and fold bearing narrow peaked crest, and species described from mostly the Late Permian of the Himalayan region, as in Waterhouse (1978, 2004), also have wide ventral adductor field, as well as large size, high peaked fold and fine costae. One well defined plicae pair lies within the sulcus.

Subfamily **FUSISPIRIFERINAE** Waterhouse, 2004

Genus ***Crassispirifer*** Archbold & Thomas, 1985

Type species: *Spirifer rostalinus* Hosking, 1931, p. 24 from Madeline Formation (Artinskian), Carnarvon Basin, Western Australia, OD.

Diagnosis: Transverse shells with low ventral umbo, fine to strong costae, and up to two pair of plicae incorporated in sulcus.

?***Crassispirifer*** sp.

Fig. 76

1978 ?*Neospirifer* sp. Waterhouse & Mutch, p. 521, Fig. 10 (part, not Fig. 11 = *Betaneospirifer gigoomganensis*).

Description and Resemblances: A ventral internal mould UQ F 46699 shows an arched delthyrial cover bearing several prominent laminae and no umbonal callosity. A pair of plicae border the wide sulcus, and two pair of plicae lie within the sulcus. Any further plication is masked by heavy secondary thickening. A transverse ventral valve from the Nemo Formation = Hilton Limestone in New Zealand

(Waterhouse & Mutch 1978, Fig. 10) is likely to be conspecific.

Fig. 76. ?*Crassispirifer* sp., tilted posterior aspect of ventral internal mould, showing delthyrial cover with numerous laminae below umbo in the delthyrium, UQ F 46699, x3.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Order PECTINIDA Gray, 1854

Family **HETEROPECTINIDAE** Beurlen, 1954

Genus ***Etheripecten*** Waterhouse, 1963b

See p. 76 for typology and diagnosis.

Etheripecten spp.

Fig. 77

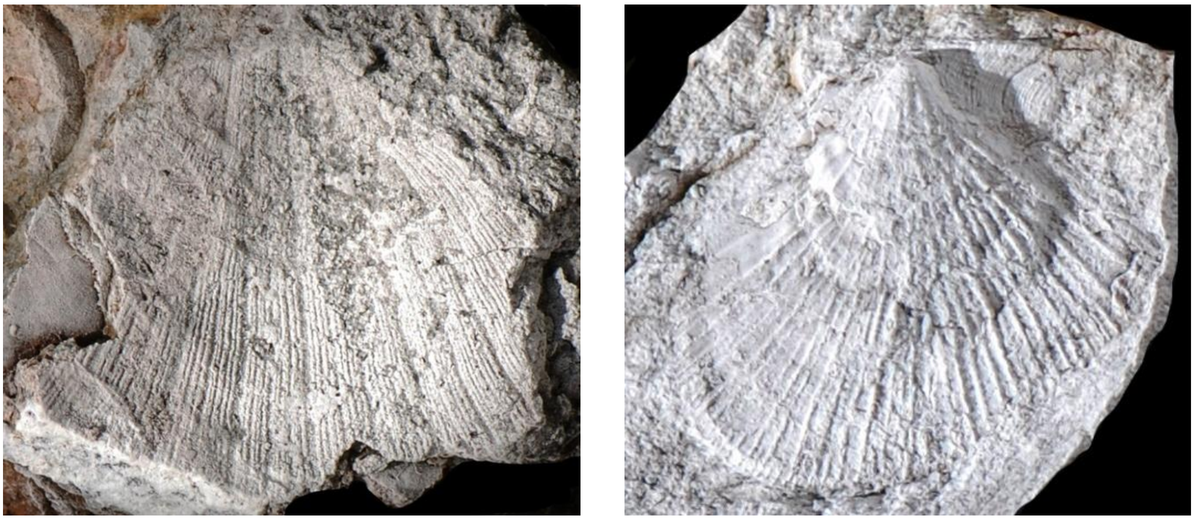


Fig. 77. *Etheripecten* sp. or spp. A, external mould of left valve UQ F 50265, x1.5. B, left valve UQ F 46662, x2.

Description: A fragment of a left valve UQ F 50265 indicates closely spaced ribbing, with some eight to ten primary ribs bearing rounded crests without riblets, and moderately prominent secondary ribs, finer tertiary ribs, and a further order of ribs, the fine ribs splitting anteriorly. Commarginal laminae inconspicuous. A smaller left valve is more completely preserved, with eight primary ribs, and secondary ribs arising about 5mm from the umbo. Two further orders of ribs commence further from the umbo, and the ribs although low are moderately upstanding with steep flanks, and are linked by commarginal growth lamellae, weakly arched hingewards, or more commonly straight in the interspaces. The umbonal angle is 80^o, and the posterior wing large with acute cardinal angle, not extending posteriorly as far as the posterior margin, and marked by commarginal growth filae, with a few fine ribs.

Resemblances: These two specimens may belong to different species, or be members of a high variable species – further specimens are needed to allow a more complete analysis. The large fragment has finer and more closely spaced ribbing, less differentiated than that described for *Etheripecten striatura* Waterhouse, 1963a, and the primary rib crests lack riblets. The smaller specimen has differentiated ribs that are more closely spaced than in *E. striatura*, and the exterior of the ribs is not preserved. The posterior wing of this specimen has very subdued ribs, whereas ribs are stronger in type *E. striatura*.

CORRELATIONS

Too little is known about the detailed stratigraphic succession and source of the fossils to be able to offer other than a very generalized assessment of the Kolbar, Teebar, Gundiah Bridge and Gigoomgan faunas, and verification from field mapping and from inspection of the thesis by Brown (1964), if that is still extant, would be desirable. Even so, one generalization is significant. The equivalents of the east Australian biozone named after *Taeniothaerus subquadratus* (Morris) is well represented in the Teebar Formation, pinpointed by the distinctive and short-lived species of *Taeniothaerus homevalensis* Briggs, and reinforced by *Geothomasia profunda* (Campbell) and *Grantonia australis* (Bion). These species and overall Teebar fauna are nowhere to be found in the neighborhood of Gympie. Beds of comparable age may or may not be represented between the *Bandoproductus*-bearing "Monkland beds" of the upper Rammutt Formation and the basal South Curra beds but no fossils are known, and conceivably the zone is represented by cryptic unconformity or structural thrust in the Gympie area.

Kolbar Formation

Beds equivalent to the middle Rammutt fauna with its distinctive fauna include specimens of *Pachymyonia morrisii* Dun and *Keeneia* sp. The latter genus is found mainly in the Allandale fauna of the north Sydney Basin, and *morrisii* is found in this fauna and ranges higher into Sakmarian beds.

The upper Rammutt fauna appears to be represented in the Kolbar Formation by silty beds which contain specimens belonging to *Protoanidanthus pokolbinensis* Briggs and *Attenuocurvus australis* (Armstrong & Brown), as well as the gastropod *Neoplatyteichum* originally described from the Upper Carboniferous Rands Formation of the Yarrol Basin. These species are correlative with those of the Monkland beds in the upper Rammutt Formation at Gympie, of late Asselian age.

Teebar Formation

Ambikella ovata (Campbell), *Geothomasia profunda* (Campbell), *Grantonia australis* (Bion) and *Squamuliferipecten mitchelli* (Etheridge & Dun) all strongly point to correlation with the *Bookeria geniculata* and *Taeniothaerus subquadratus* Zones of upper Sakmarian age, represented in the

Farley Formation of the Sydney Basin and Elvinia and Tiverton Formation of the north Bowen Basin, and *Taeniothaerus homevalensis* is limited to the *Taeniothaerus subquadratus* Zone. The fauna is substantially older than the Tamaree Formation of Gympie, with which it has been correlated in recent reports (eg. Jell & Cranfield 2013), and is different from any fauna known at Gympie, where beds, if correlative, appear to be barren of fossils.

Gundiah Bridge Greywacke

Species include *Echinalosia denmeadi* n. sp., *Tigillumia parallela* (Waterhouse), *Ingelarella fergusoni* n. sp., *Koenigoria browni* n. sp. and *Marinurnula rugulata* Waterhouse, as well as fragmentary specimens belonging to *Anidanthia aplini* n. sp. and *Ingelarella alteplica* n. sp. Apart from the new species of *Koenigoria* and *M. rugulata*, the species are all found in the South Curra Limestone, mostly the lower beds or "lower brachiopod fauna" of the formation. Although the Gundiah Bridge Greywacke was not distinguished by Cranfield (1989) or subsequent articles (eg. Jell & Cranfield 2013), it has a distinct lithology and distinct fauna.

TABLE 16. The occurrence of brachiopod species in the Changsingian faunas of Gympie and Gigoomgan, showing the formations, and counterpart members or formations in New Zealand.

	GYMPIE		GIGOOMGAN		NEW ZEALAND	
Species	Lower South Curra	Upper South Curra	Gund-iah Bridge	Gigoom gan	Kildonan	Trig DD Hilton
Capillonia brevisulcus (Waterhouse)	x	x		x	x	x
Echinalosia denmeadi n. sp.	x		x	x		
Anidanthia aplini n. sp.	x		x			
Paucispinauria verecunda (Waterhouse)		x		x	x	
Magniplicatina cranfieldi n. sp.	x		x			
Costatumulus randsi Balfe & Waterhouse	x					
Filiconcha auricula Waterhouse		x		x		x
Plekonella multicostata Waterhouse		x		x	x	
Stenoscisma papilio Waterhouse				?	x	x
Attenuocurvus incurvata (Waterhouse)	x				?	x
Ingelarella fergusoni n. sp.		x		x		
Ingelarella alteplica n. sp.	x		x			
Ingelarella cf. *havilensis* Campbell		x				
*Johndearia isbelliformis (*Waterhouse)	x		x	x		x
Validifera sp.	x		?			
Tigillumia parallela (Waterhouse)	x		x		x	
Tigillumia mintyi Waterhouse		x				x
?*Farmerella* sp.	x					
Spinomartinia spinosa Waterhouse		x		x		x
Koenigoria browni n. sp.			x			
Unicostatina chatsworthensis (Balfe & Waterhouse)	x					
Betaneospirifer gigoomganensis n. sp.				x	x	x
?*Crassispirifer* sp.				x		x
Cyrtella papula n. sp.	x					
Fletcherithyris runnegari n. sp.	x					
Marinurnula rugulata Waterhouse			x		x	

Gigoomgan Limestone

As summarized in Table 16, a number of species are shared with the Gundiah Bridge Greywacke and with the lower and upper brachiopod faunas of the South Curra Limestone, The fauna includes such species as *Stenoscisma papilio* and *Betaneospirifer gigoomganensis*, and ties with the upper South Curra limestone through *Paucispinauria verecunda*, *Ingelarella fergusoni* and *Spinomartinia spinosa*. Overall there are strong links with the Late Permian faunas of New Zealand, in the *Tigillumia parallela* Zone and especially the *Spinomartinia spinosa* Zone, and these zones are believed to be of lower Changhsingian age (Waterhouse 2002a).

TABLE 16. Locality data for Permian collections from the Gigoomgan area. This data is taken from cards that accompany the fossil specimens and refer to the thesis by C. D. Brown. Some specimens of different species are found together on the same block. The specimens and localities were not assigned locality numbers.

KOLBAR FORMATION

Protoanidanthus pokolbinensis Briggs. UQ F 46651, 46652, 46654, 47095, 47101, 47103. Shale 600 ft below Gigoomgan Limestone, one mile NE of Gigoomgan Homestead.

Attenuocurvus australis (Armstrong & Brown). UQ F 46646, 46647, 46648, 52673, 52674, 52680, 81397, 81603. Shale 600 ft below Gigoomgan Limestone, one mile NE of Gigoomgan Homestead. Fide Armstrong & Brown (1968).

UQ F 46624, 46626 and others. One and a half miles ESE of Gigoomgan Station on hillside.

Pachymyonia morrisii (Etheridge). UQ F 46728. Locality detail not available, but the matrix is the same as that for *Keeneia* sp.

Keeneia sp. UQ F 46727. No locality data is available, but Brown (1964) listed this distinctive form only from the Kolbar Formation.

Neoplatyteichum sp. UQ F 46625, same locality as *Attenuocurvus australis,* UQ F 46626 and *Protoanidanthus pokolbinensis,* one and a half miles ESE of Gigoomgan Station on hillside.

TEEBAR GREYWACKE

Taeniothaerus homevalensis (Briggs). UQ F 46713, 46714, 46716, 46717, 46729. Teebar Creek, north bank on 10 chain road, from Teebar Greywacke.

Ambikella ovata (Campbell). UQ F 46721 and 46725. Teebar Creek, north bank on 10 chain road, from Teebar conglomerate.

Geothomasia profunda (Campbell). UQ F 47623, 47624. North bank of Teebar Creek, with unregistered specimen of *Ambikella ovata*.

Grantonia australis (Bion). UQ F 46718, 46719. Teebar Creek, north bank on 10 chain road from the

Teebar conglomerate.

Polidevcia sp. UQ F 46732. Gully on creek flowing north into Teebar Creek. This specimen was listed as *Phestia*, and as coming from the Teebar unit by Brown (1964).

Squamuliferipecten mitchelli (Etheridge & Dun). UQ F 46720. No locality card, but the specimen was recorded by Brown (1964) as *Deltopecten* in his thesis as occurring in the Teebar beds.

GUNDIAH BRIDGE GREYWACKE

Echinalosia denmeadi n. sp. UQ F 46677, 46678, 466780. Gundiah Bridge Greywacke in gully running north to Spring Creek.

UQ F 46679. Locality detail not available, possibly same locality as above.

Anidanthia aplini n. sp. UQ F 46675. Matrix like that of Gundiah Bridge unit. No locality detail.

A ventral valve fragment UQ F 46618 together with *Marinurnula rugulata* UQ F 46631 (see below).

Magniplicatina cranfieldi n. sp. UQ F46683. Gully running north to Spring Creek, one mile SSE of Gigoomgan Station.

UQF 46737. Junction of Woologar Biggenden-Aramara Roads.

Ingelarella alteplica n. sp. UQ F 46676. Fragmentary specimens with *Echinalosia denmeadi, Magniplicatina cranfieldi, Tigillumia parallela* and *Koenigoria browni.* Gully running north to Spring Creek.

UQ F 46658, 46656. Large fragments of dorsal valve with *Koenigoria browni*, UQ F 46684. Gully running north to Spring Creek.

Johndearia fergusoni n. sp. UQ F 46671. Matrix is that of Gundiah Bridge unit.

Validifera? sp. UQ F 46682 with *Magniplicatina* UQ F 46683. Gully running north to Spring Creek, one mile SSE of Gigoomgan Station.

Tigillumia parallela (Waterhouse). UQ F 46667, 46668, 46669. Amarama – Glenbar Road half a mile NW of Glenbar.

Koenigoria browni n. sp. UQ F 446670, 46672-46674, 46684. Gully running north to Spring Creek.

UQ F 46681. Gully running north to Spring Creek one mile SSE of Gigoomgan Station. Matrix particularly volcanigenic, differing from other collections.

UQ F 46666 External mould of dorsal valve on same block as *Tigillumia parallela* UQ F 46668. Amarama – Glenbar Road half a mile NW of Glenbar.

Marinurnula rugulata Waterhouse. UQ F 46631, UQ F 46632, and small unnumbered ventral valve

with UQ F 46631. Two hundred yards north of road half a mile north of Glenbar Station.

GIGOOMGAN LIMESTONE

Capillonia brevisulcus (Waterhouse). UQF 46616, 46617. Gully half a mile SE of Gigoomgan Station.

Echinalosia denmeadi n. sp. UQ F 46710, 46646. Locality data not available.

Unregistered specimen with UQ F 46709 (?*Stenoscisma*), from one and three quarters of a mile due east of Gigoomgan Station.

Paucispinauria verecunda (Waterhouse). UQ F 46707. North bank of Teebar Creek.

UQ F 46698. Amarama – Glenbar Road, half a mile NW of Glenbar. Matrix coarse.

Filiconcha auricula Waterhouse. UQ F 46696 (same block as *Paucispinauria* UQ F 46698). Amarama – Glenbar Road, half a mile northwest of Glenbar.

UQ F 50263, same block as *Johndearia isbelliformis*.

Plekonella multicostata Waterhouse. UQ F 46711, 46712. One and three quarters of a mile east of Gigoomgan Station. Listed by Brown (1964) from the Gigoomgan (= ”Biggenden”) Limestone.

?*Stenoscisma papilio* Waterhouse. UQF 46709. One and three quarters of a mile due east from Gigoomgan Station.

Ingelarella fergusoni n. sp. UQ F 46685, UQ F 46686, UQ F 46687. Amarama – Glenbar Road, half a mile NW of Glenbar.

Johndearia isbelliformis (Waterhouse. UQ F 50265 (with *Filiconcha*), UQ F 50259. No locality data for either specimen, but matrix fine and calcareous.

Spinomartinia spinosa Waterhouse. UQF 50261. Three quarters of a mile NW of Gigoomgan head station.

UQ F 46689. Half a mile NW of Glenbar on the Aramara to Glenbar Road near Gigoomgan.

Betaneospirifer gigoomganensis n. sp. UQ F46697. Amarama – Glenbar Road half a mile NW of Glenbar.

UQ F 47062. UQ L 2925 Biggenden one mile.

?*Crassispirifer* sp. UQ F 46699, locality not indicated, matrix fine and calcareous.

Etheripecten sp. or spp. UQ F 46662. No locality detail, matrix fine and calcareous.

UQ F 50265. No locality detail, found with *Filiconcha auricula*.

7. THE SIMILARITY TO NEW ZEALAND

A number of articles have pointed to geological similarities between aspects of Permian geology at Gympie and in the South Island of New Zealand (eg. Harrington 1983). The Highbury Volcanics are to some extent matched geochemically with the Brook Street Volcanic Group, especially the Owhai Volcanics of central South Island, the South Curra Limestone matched with the Wooded Peak Subgroup, and the Kin Kin Formation with the Greville beds in the younger Maitai Supergroup, as summarized in Waterhouse (2002a, Table 23, p. 108). Arguably the greatest degree of similarity is demonstrated by the limestones. Whereas thick carbonate deposits of Permian age elsewhere in Queensland are of Sakmarian (Lower Permian) age, such as the Dresden Limestone of the southeast Bowen Basin, or the Yarrol Limestone of the Yarrol Basin, and thinner limestone of mid-Permian age (Oxtrack Formation), the limestones at Gympie are of Late Permian age, the same general age as the major limestone band in New Zealand, called Wooded Peak Subgroup of the Maitai Supergroup.

But in detail, there are many differences between the rocks of the two regions, not least involving their age limits, as cautioned by Waterhouse & Sivell (1987). The Highbury Volcanics appear to be mostly pre-Permian, whereas the Brook Street volcanics are Early and perhaps early Middle Permian, and the history of the two suites, traced in detail by Sivell & McCulloch (2001) for the Highbury, suggest that if the two did once form part of a single arc complex, they were well separated by space and time. Given that difference, it is not surprising that the overlying volcaniclastic sediments with minor volcanics and intrusions of the Rammutt Formation contain faunas much older than any known in early Permian rocks in New Zealand, though the barren Longwood Volcanic Group of southern New Zealand may well be correlative.

The greatest similarities are displayed by the limestones, in having an important component of their composition made up of fragments from the bivalve Atomodesmidae, as well as by their position in the stratigraphic sequence, and by their sharing of a number of brachiopod and molluscan species. In detail, the South Curra Limestone seems less pure and less well bedded, but the Wooded Peak limestones and their correlates in New Zealand cover a much larger area, and vary to a degree in their lithologic content and variation. Over much of the Maitai Basin, the limestone is succeeded by the Tramway and Little Ben Formations, of fine and coarse sandstone respectively, as itemized in Waterhouse & Sivell (1987b, p. 52), and it is precisely these two formations which are correlative with the South Curra Limestone, so that the underlying Wooded Peak Limestone is Wuchiapingian, or lower Lopingian, older than the South Curra Limestone. The Tramway and Little Ben faunas are dominated by bivalve *Maitaia trechmanni* Marwick, followed by bivalve *Trabeculatia trabeculum* (Waterhouse), neither known at least as complete specimens at Gympie. In the Maitai trough, the Little Ben Sandstone is followed by the Greville Subgroup, which shows considerable approach to Kin Kin rocks of Gympie, consisting of laminites and fine bedded clastics, barren for a substantial thickness, and bearing late Scythian or early Anisian ammonoids (*Durvilleoceras woodmani* Waterhouse 1973b, 2002a, p. 134) in the South Arm Formation, high in the Greville Subgroup. At Gympie, the South Curra Limestone is followed by the Tamaree Formation, then the Kin Kin beds: the Tamaree beds are similar in age to the upper South Curra beds, and the top Kin Kin is overlain by conglomerate and Traveston beds with mid-Scythian ammonoids (Runnegar 1969b). Some authorities amalgamate Kin Kin with Traveston.

At Wairaki Downs in the far south of the South Island of New Zealand (Waterhouse 1998a, 2002a), the upper Permian sequence commences with fine siltstones and sandstones somewhat similar to Tramway Formation. Faunas from a further band of limestone (Hilton Limestone) at Wairaki Downs match the faunas of the Little Ben Sandstone and upper South Curra Limestone, and are followed by a distinct fauna in clastics (Wairaki Breccia) with late Permian brachiopods, not found at Gympie.

TABLE 17. The intercorrelations between Gympie Late Permian and New Zealand formations of lower Changhsingian and Wuchiapingian age.

	QUEENSLAND	NEW ZEALAND					
STAGE	**GYMPIE**	**NORTH LIMB SOUTHLAND SYNCLINORIUM**		**WAIRAKI DOWNS**		**NELSON**	**NORTH AUCKLAND**
Changh singian	Tamaree Upper South Curra	Trig DD		Hilton Limestone		Little Ben Sandstone	
	Lower South Curra	Kildonan		Glendale clastics		Tramway Formation	
Wuchia pingian		Earnvale	Otaria Lime-stone		Glendale limestone	Wooded Peak limestones	Wherowhero
Capitanian				Mangarewa			Orua

The rock sequence and faunas of Gympie are closest to those of the Arthurton area along the northern limb of the Southland Synclinorium in New Zealand, even though the Arthurton rocks and faunas accumulated well seaward of the volcanic arc, and the Arthurton carbonates, called Otaria Limestone, look like the South Curra carbonates, being less porcellanous and less well bedded than the Wooded Peak limestones of the Maitai trough in Nelson and Hollyford Valley etc. The Kildonan Member near Arthurton shares faunas with the lower South Curra Limestone at Gympie, and Trig DD Formation near Arthurton shares fossils with the upper South Curra Limestone at Gympie. It is followed near Arthurton by the Popotunoa Group of Bishop (1965) with thin Greville Formation, at least partly equivalent to Gympie Kin Kin and Traveston (Waterhouse 2004, p. 100).

This is a very generalized summary for New Zealand – more detail is provided in Waterhouse (2002a). The match between South Curra faunal zones and those of New Zealand is not straightforward. The relevant New Zealand succession commences with the *Martiniopsis woodi* Zone, with a few other characteristic fossils, notably *Lethamia collina* Waterhouse and *Wairakiella sella* Waterhouse. These are not found at Gympie, nor indeed elsewhere in New Zealand, except in North Auckland, where *Martinopsis woodi* is found just above fusuline beds with *Yabeina* and *Lepidolina* of late Capitanian age (see Waterhouse 2002a, pp. 148-154). The claim by Campbell (1992) that *woodi* had come from the South Island is rejected because the material was found in North Auckland according to J. Marwick (pers. comm.), and the Wether Hill limestone in Southland, conjured by Campbell as a possible source, has no *Martiniopsis*, and the sample of *M. woodi* from North Auckland is water-worn, pointing to erosion by water, and coastal waves are active around the fusuline localities. By contrast, the Wether Hill localities and locality for type *woodi* near Arthurton are in hill country, far from any possibilities of erosion currently by sea-waves or even rivers.

The *Martiniopsis woodi* Zone is found in the Earnvale Member, a thin and highly calcareous tuffaceous and shelly bryozoan limestone, and it is this level that shares faunal affinities with the late Wuchiapingian Kufri Member at the base of the Chhiddru Formation in the Salt Range of Pakistan. Immediately above lies the Kildonan Member, classed with Earnvale as Bagrie Formation, with faunas of a moderately distinctive zone, previously named after *Paucispinauria verecunda* or *Plekonella multicostata*, and now renamed after *Tigillumia parallela*, because both of the afore-mentioned species are found in the overlying zone at Gympie and Gigoomgan. None of the well known species characteristic of the *Martiniopsis woodi* Zone persist, though more obscure and rare species might well do so. The overlying *Spinomartinia spinosa* Zone is found in fine and coarse sandstone of the Trig DD Formation and in the Hilton Limestone Member, and some species continue from the underlying zone. The Gympie succession strongly indicates that a number of species thought to have been restricted to the Kildonan Member and its correlates range into equivalents of the overlying zone at Gympie, including the species *Paucispinauria verecunda* and *Plekonella multicostata,* and *Johndearia isbelliformis* is found in the lower South Curra Limestone of Gympie as well as in the younger Gigoomgan Limestone near Gympie and Hilton Limestone of New Zealand. The chonetid *Capillonia brevisulcus* is to be found rarely below the *Spinomartinia spinosa* Zone in New Zealand, in the Kildonan Member and elsewhere, but is represented in the lower as well as upper South Curra Limestone, so that the Gympie succession demands a degree of reassessment of the key species critical for recognising and discriminating the two zones. It appears that ingelarellid species are highly useful, just as judged by Runnegar & McClung (1975), and now that the confusing array of morphological variations in Ingelarellidae has been hopefully clarified (see Waterhouse 2015), their proposal deserves further consideration. Thus the two zones at Gympie as in New Zealand may be characterized by *Tigillumia parallela*, followed by *T. mintyi*, although *Spinomartinia spinosa* is just as restricted as *mintyi*, and was used first. Other species restricted to the lower zone include *Marinurnula rugulata* and *Maitaia trechmanni* Marwick, and the upper zone is still characterized by *Filiconcha auricula, Spinomartinia spinosa* and *Trabeculatia trabeculum*.

There are clear differences and some significant similarities between the Gympie and New Zealand successions, which strongly suggest that the two regions occupied very different parts of a distinct geological entity, involving a volcanic arc (Mant, Highbury, Brook Street and Takitimu volcanics), a subducting trough (Rammutt, South Curra and younger beds, Kolbar and younger beds, Maitai Supergroup in New Zealand), and a spreading mid-ocean ridge (Dun Mountain complex, Patuki and Croisilles Volcanic Groups, limited to New Zealand), all gathered in the Medusan entity called Durvillia (Waterhouse 1987c, 2002a, p. 166). And in turn, the constituent parts have undergone very different tectogenesis – indeed New Zealand segments, in Nelson and Hollyford-Eglinton Valleys, and Gore-Arthurton, and Wairaki Downs, have each undergone differing and very complicated structural trajectories, during Cretaceous orogenesis when thrusting or sliding was an important component (Waterhouse 1993), and during the much younger Kaikoura Orogeny under a regime of strike slip displacement along the Alpine Fault, limited to New Zealand (Suggate et al. 1978, Fig. 10.1). The original position of the rocks at Gympie is difficult to assess. Nothing in the composition of the Early Permian (mid-Asselian) faunas points to a position very different – ie. climatically and therefore latitudinally different – from the faunas of the Early Permian in the Sydney Basin as far as the middle Rammutt faunas are concerned, perhaps indicating a time when cold conditions prevailed widely, in Tasmania, New South Wales and Queensland. But the Gympie faunas of the *Bandoproductus macrospina* Zone include a stenoscismatid and martiniid rare in east Australia, and unknown anywhere south of Queensland during Permian time. There is little basis for comparison of South Curra faunas, in so far as equivalents are not known elsewhere in east Australia. Compared with New Zealand equivalents, the South Curra faunas are distinctly less diverse and lack or have few of the paleotemperate to subtropical elements found in New Zealand, such as *Lamnaespina, Martiniopsis, Cleiothyridina, Wairakiella* and *Wimanoconcha*, but given that the South Curra Limestone faunas come from such a limited area, the differences may reflect sampling inadequacies. Nothing is known that would rule out an originally more northerly location – that is lower paleolatitudes – for the New Zealand outcrops, until Australia was displaced northwards under sea-floor spreading.

That still leaves the question of relationships and original position of the outcrops and faunas of New Caledonia. To one author, the question was so awkward that the outcrops had to be dismissed as Mesozoic in age (Harrington 2008). Not so: the rocks are like those of the volcanic apron making up the Takitimu Group in New Zealand, and the fossils are irredeemably Permian (Campbell 1984a, b, Waterhouse 1969b). The New Caledonian fauna, which includes *Maitaia trechmanni, Trabeculatia* cf. *trabeculum* and *Attenuocurvus mepailensis*, is correlative with those of the middle and upper South Curra limestone, and clearly deposited closer to the volcanic arc, which at this location, appears to have been possibly younger than the arc in east Australia or New Zealand. In spite of some geochemical differences in the sediments from region to region, all regions are linked by displaying a progression from volcanics through volcanic sediment to Late Permian carbonates, often dominated by atomodesmid bivalves, and spanning a considerable range in paleolatitudes, but all sharing many faunal elements. Even the component rocks and faunas of North Auckland in New Zealand (Waterhouse 2004, pp. 148-154) formed part of Durvillia, extending far north of the other severed segments into temperate paleolatitudes, and reinforcing the model of a trough, arc and spreading ridge that progressively extended in length through time (Waterhouse 1987c).

8. SUPPLEMENT: NEW PERMIAN BRACHIOPOD GENERA AND SPECIES FROM EAST AUSTRALIA

SUMMARY

New genera *Briggsia* (Subfamily Lyoniinae, Family Auriculispinidae), type species *Bandoproductus hastingensis* Briggs, and *Tumulosulcus* (Family Ingelarellidae), type species *Ingelarella magna* Campbell, are proposed for Permian brachiopods in east Australia. Three new species are also named, *Ambikella bundellaensis* based on *Tomiopsis elongata* of Clarke, 1990 [not McClung & Armstrong, 1975], *Monklandia mcclungi* n. sp., based on *Ingelarella strzeleckii* McClung (1978 part) [not de Koninck], and *Geothomasia simplicatas*, based on *Ingelarella* or *Ambikella konincki* [not Etheridge Jnr.] of McClung (1978) and Runnegar (1969a).

INTRODUCTION

New genera and species are named for Permian brachiopods from east Australia, to help to clarify relationships and correlations.

SYSTEMATIC DESCRIPTIONS

Superfamily **PROBOSCIDELLOIDEA** Muir-Wood & Cooper, 1960

Family **AURICULISPINIDAE** Waterhouse, 1986b

Subfamily **LYONIINAE** Waterhouse, 2001

Genus ***Briggsia*** new genus

Fig. 78

Derivation: Named for D. J. C. Briggs.

Type species: *Bandoproductus hastingsensis* Briggs, 1998, p. 149 from "Giro beds" (?Asselian) of New South Wales, here designated.

Diagnosis: Shells moderately large for subfamily, ventral spines comparatively fine over venter and trail, each spine base not swelling and little if at all prolonged, hinge spines coarse and in a row along hinge. Posterior thickening substantial and ventral adductor scars very long.

Discussion: The New South Wales species described as *Bandoproductus hastingsensis* and *B. youdalensis* by Briggs (1998) are outstanding in the nature of their costae which are little disrupted by the ventral spines, whereas the ventral body spines on type and other species typical of *Bandoproductus* have bases that are swollen and affect the costae strongly. *Lyonia* Archbold, 1983b, p. 244 and *Nambuccalinus* Waterhouse, 2001, p. 33 are distinguished by the presence of dorsal spines, and *Ainimia* Waterhouse, 2013, p. 447 has a wide hinge, and body spines with swollen prolonged bases. *Nambdoania* Waterhouse, 2002b, p. 52 has comparatively narrow hinge and numerous body spines with swollen but short spine bases, and less prominent row of ventral hinge spines, whereas *Nikitinia* Kotlyar, Zakharov & Polubotko, 2004, p. 521 has prominent commarginal rugae and elongate ventral spine bases. The genus *Masitoshia* Waterhouse, 2013, p. 446 also has prominent commarginal rugae. Its hinge spines are fine and body spines few without prominent bases. The genera are reviewed by Brunton (2007, p. 2656 ff) and Waterhouse (2013, p. 445 ff).

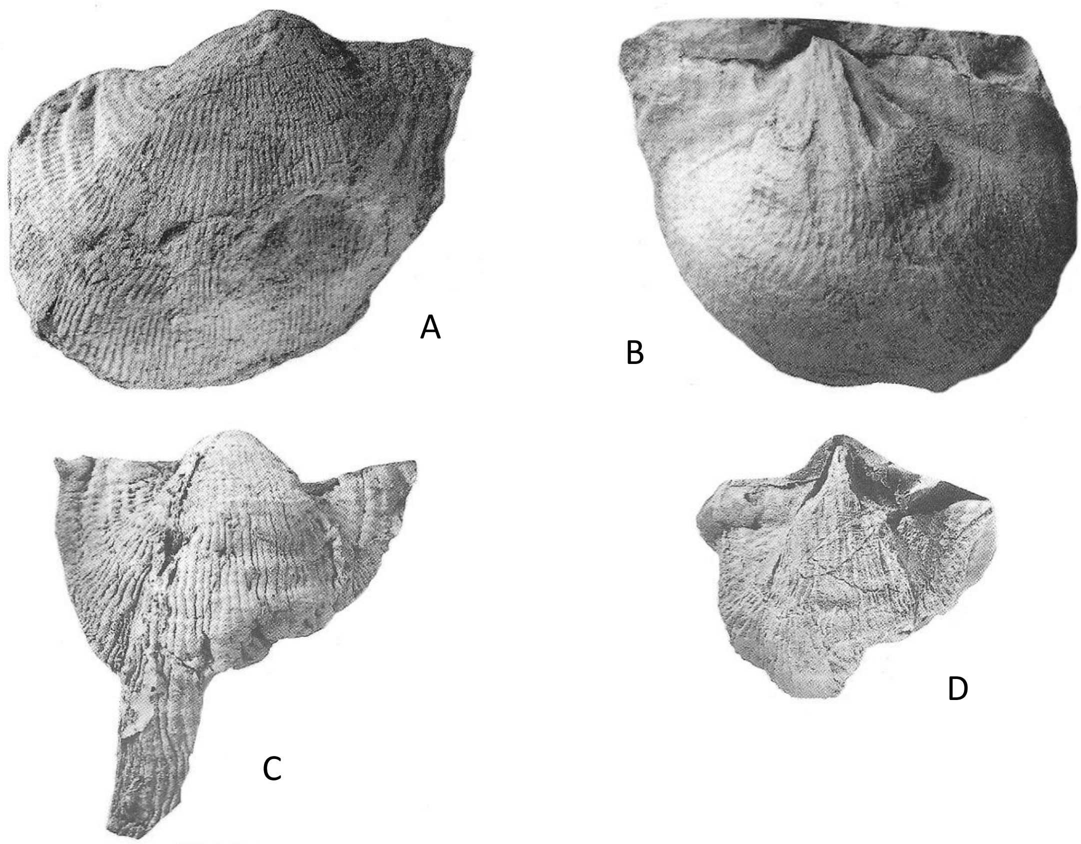


Fig. 78. A, B, *Briggsia hastingsensis* (Briggs). A, latex cast of ventral exterior, holotype, UQ F 75296. B, internal mould of ventral valve, showing long embedded adductor scars, UQ F 75297. C, D, *Briggsia youdalensis* (Briggs). C, latex cast of external ventral valve holotype AM F 96252. D, ventral internal mould of same specimen. Specimens x1.5, from Hastings block, New South Wales. From Briggs (1998, Fig. 75, 76).

Superfamily **INGELLARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

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

(See p. 17 for systematic position and typology etc.).

Ambikella bundellaensis n. sp.

1990 *Tomiopsis elongata* [not McClung & Armstrong] – Clarke, p. 64, Fig. 10A-L.

1992a *T. elongata* – Clarke, p. 22, Fig. 10A-L.

Derivation: Named from Bundella Formation, source of the species.

Holotype: GST 14151 from basal Bundella Formation (basal Asselian), Tasmania, figured by Clarke (1990, Fig. 10A, B) and Clarke (1992a, Fig. 10A, B), here designated.

Diagnosis: Narrow elongate shells, distinguished by posterior tabellae diverging widely in front of hinge.

Discussion: This species has been described and figured as *elongata* by Clarke (1990, 1992a) from the basal Bundella Formation and Inglis Formation of Tasmania. In many respects, the specimens are similar to *elongata* McClung & Armstrong (1975), also figured by McClung (1978) and Archbold (2003), with shells laterally smooth or weakly plicate and suggestions of two low subplicae in the sulcus and rounded dorsal fold. But there are differences from type *elongata*. The outline is distinctly less transverse, with posterior walls diverging less, and the sulcus is often narrower. The adminicula are short to moderately long and subparallel anteriorly, and in a number of specimens 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, although closer inspection is required. The specimens figured by Clarke (1992a, Fig. 10B, D, F) have tabellae extending for about a fifth to a third of the length of the valve, and adminicula extend for a quarter up to half of the length of the valve and are subparallel to parallel. The posterior tabellae diverge widely in the Tasmanian shells, whereas the tabellae in type *elongata* diverge more gradually. A few Tasmanian ventral valves are weakly plicate, dorsal valves especially showing weak plicae, and rarely some ventral valves suggest the presence of sulcal subplicae, and similar variation is seen in type *elongata*. The differences displayed by the Tasmanian material suggest a different species, certainly closely allied and apparently ancestral to *elongata*. The Tasmanian species is of early Asselian age, whereas type *elongata* is judged to be slightly younger and late Asselian in age. The sulcus is particularly narrow in two specimens allocated to *elongata* from the Spirifer Zone of Maria Island, Tasmania, by Briggs (1998, Fig. 18B, C), but the nature of the tabellae is not known for material from this stratigraphic level.

Genus ***Geothomasia*** Waterhouse, 1998b

For typology and diagnosis, see p. 135.

Geothomasia simplicatas n. sp.

Fig. 79

1969a *Ambikella konincki* [not Etheridge Jnr.] – Runnegar, p. 294, pl. 20, fig. 2-4, ?5 (part, not fig. 1 = ?*Monklandia gympiensis*).

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,* not fig. pl. 3, 4-6 = *konincki*).

2014 *Tomiopsis konincki* – Cisterna & Shi, p. 538, Fig. 6.1-6.11.

Derivation: simplicitas – simple, plain, Lat.

Holotype: UNE F 12243 from Wasp Head Formation (Asselian), figured by McClung (1978, pl. 2, fig. 3, 4, pl. 3, fig. 1, 2), here designated. See Fig. 79.

Diagnosis: Small with four pair of weak plicae as a rule, round-crested fold, sulcus without well defined subplicae, adminicula moderately long, tabellae short and widely diverging.

Description and Resemblances: This species is based on shells that are older than the species *branxtonensis* Etheridge Jnr., *profunda* Campbell and *symmetrica* Campbell, which have been described by Campbell (1961) and Waterhouse (2015). These are larger shells, with better defined sulcus and fold, and as a rule, plicae are more strongly developed, especially in *branxtonensis* and *profunda*. The adminicula are slightly shorter and spaced further apart in the new species. Specimens were recorded from the Wasp Head Formation of the south Sydney Basin, and from the Allandale Formation in the north Sydney Basin by Runnegar (1969a) and McClung (1978, pl. 2, fig. 3, 4, pl. 3, fig. 1, 2), the latter adding Lochivar material. They are discriminated from *Monklandia gympiensis* and *M*?. *konincki* by their short widely diverging tabellae, and by the rounded dorsal fold, and fainter subplicae, if any, in the ventral sulcus, and more subdued plicae.

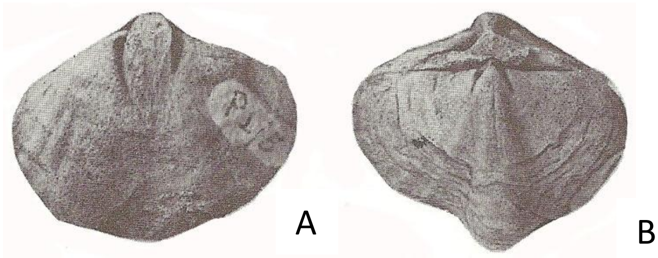


Fig. 79. *Geothomasia simplicatas* n. sp. A, B, holotype UNE F 12243, internal aspects of ventral and dorsal valve, x1, from Wasp Head Formation. See McClung (1978, pl. 3, fig. 1, 2). Now at Australian Museum.

Cisterna & Shi (2014) in their synonymy of *konincki* omitted reference to the original type specimen and to its replacement neotype, perhaps justifiably, because type *konincki* from the Allandale Formation of New South Wales has a narrower ventral sulcus with strong subplicae, lower, broader and weakly to well channelled fold, and much less widely diverging tabellae (see de Koninck 1877, p. 242, pl. 10, fig. 11, 11a, the original type, and neotype in Waterhouse et al. pl. 3, fig. 14). and further Allandale material in McClung (1978, pl. 3, fig. 4-6). *Geothomasia simplicatas* has fine surface grooves normal for *Geothomasia* (Nillsen 1982), whereas the micro-ornament of *konincki* is yet to be clarified.

Genus ***Tumulosulcus*** n. gen.

Fig. 80

Derivation: tumulo – mound; sulcus – furrow, Lat.

Type species: *Ingelarella magna* Campbell, 1959, p. 1117 from upper Moonlight Sandstone (Roadian), north Bowen Basin, here designated.

Diagnosis: Medium to large, characterized by anterior swelling in ventral sulcus, dorsal fold crest rounded, without channel, no or only very subdued lateral plicae, no sulcal subplicae. Adminicula of moderate length and well spaced, heavy posterior thickening. Tabellae moderately well spaced, subparallel anteriorly.

Discussion: This genus is closest to *Oviformia* new genus (see herein, p. 68), based on *oviformis* M'Coy, 1847, and differs in the absence of the sulcus traversing the length of the dorsal fold. The type species of the present form is large, with heavier posterior thickening and little in the way of lateral plicae. A species of comparable size, *Johndearia isbelli* (Campbell, 1961), has dorsal sulcus along the fold, and no medium swelling in the ventral sulcus. The species *magna* is possibly present in the

Elderslie Formation of the Sydney Basin (McClung 1978, pl. 8, fig. 8?). Somewhat similar specimens have been described from the early Middle Permian (Roadian) of the Canadian Arctic by Waterhouse (1971b, p. 77, pl. 17, fig. 1, 2, 4, 5, 9, 10), but the dorsal fold of these Canadian shells has a broad crest with shallow median and anterior depression, suggesting an alliance with *Oviformia*. A species allied to *magna* has been described as *Ingelarella warneri* McClung (1978, p. 52, pl. 13, fig. 1-10) from the Middle Permian Bickham and Porcupine Formations in the Murrurundi-Gunnedah area of northern New South Wales. This species is smaller than *magna*, and was judged to occur in the *isbelli* Zone of the Sydney Basin and New England Orogen by McClung (1978). It has secondary thickening, a rounded dorsal fold, and internal plates are somewhat shorter than in *magna*, with plicae variably developed.

Another species that is congeneric is *Ingelarella undulosa* Campbell (1961, pl. 26, fig. 4-9) from the Gebbie Subgroup below the Moonlight Sandstone in the north Bowen Basin, and also recorded from the middle Wandrawandian Siltstone in the southern Sydney Basin, and top of the Elderslie Formation in the northern Sydney Basin (McClung 1978, pl. 8, fig. 1-3, 7) and from the Freitag Formation of the southwest Bowen Basin (Waterhouse 2001, pl. 7, fig. 18, 19, 21, pl. 8, fig. 1, 2). *Ingelarella cessnockensis* McClung, 1978 from the Elderslie Formation appears to be identical with *undulosa* (see Waterhouse 2001, p. 100).

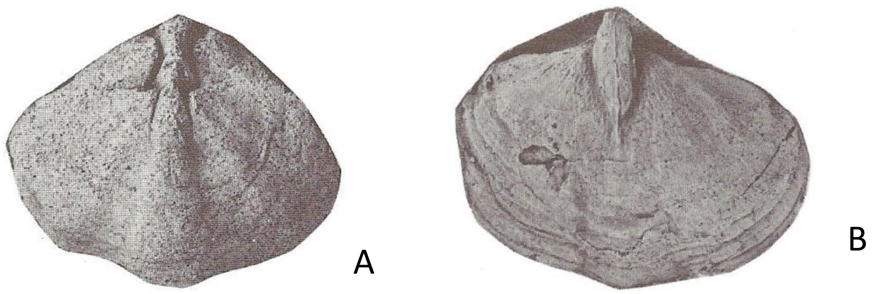


Fig. 80. *Tumulosulcus warneri* (McClung). A, dorsal aspect of internal mould UNE F 12507 from Porcupine Formation, x1. B, ventral aspect of internal mould, UNE F 12348 fom Bickham Formation. Specimens from New South Wales, now kept at Australian Museum, x0.7. From McClung (1978, pl. 13, fig. 8, 10).

Family **NOTOSPIRIFERIDAE** Archbold & Thomas, 1986a

Genus ***Monklandia*** Waterhouse, 1998b

(See p. 18 for diagnosis and typology).

Monklandia mcclungi new species

Fig. 81

?1978 *Ingelarella konincki* [not Etheridge Jnr.] – McClung, pl. 3, fig. 3 (part, not pl. 2, fig. 3, 4, pl. 3, fig. 1, 2 = *Geothomasia simplicatas* n. sp., not pl. 3, fig. 4-6 = *konincki*].

1978 *Ingelarella 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, cf. ?12 = *branxtonensis* Etheridge).

1998 *I. strzeleckii* [not de Koninck] – Briggs, p. 33.

Derivation: Named for Graham McClung.

Holotype: UNE F 12244 (now transferred to Australian Museum, Sydney), from upper Rutherford Formation (Sakmarian), north Sydney Basin, here designated. See McClung (1978, pl. 4, fig. 9, 10) and Fig. 81.

Diagnosis: Small transverse shells with usually four pair of plicae, sulcus on dorsal fold may be weakly developed, tabellae lie next to fold within innermost pair of interspaces.

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 de 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. Such an interpretation would result in an inconsistent distribution of fossils. *Bandoproductus walkomi* Briggs comes from the lower Rutherford Formation, and from the Monkland or Pengelly beds at Gympie, above so-called *strzeleckii* (now *Monklandia gympiensis*) at Gympie and below in New South Wales. Were the fossils to be 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. They do look like the original figures by de Koninck (1877), which are deemed to be oversimplified.

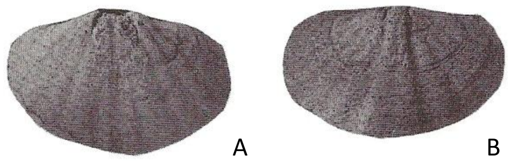


Fig. 81. *Monklandia mcclungi* n. sp., ventral and dorsal aspects of holotype, internal mould, formerly registered as UNE F 12244, now at Australian Museum. From upper Rutherford Formation, Hunter Valley. See McClung (1978, pl. 4, fig. 9, 10).

A dorsal valve figured from the Cranky Corner beds of the Cranky Corner Basin by McClung (1978, pl. 3, fig. 3) is like the holotype of *mcclungi* in terms of number of plicae and well defined sulcate fold, and parallel tabellae. The ventral valve from Allandale Formation figured by Runnegar (1969a, pl. 20, fig. 1) as *konincki* has only four pair of plicae, but the outer shell is large and smooth, and its well defined subplicate sulcus and large size and shape suggest *gympiensis*, but the absence of knowledge about the dorsal valve prevents surety.

Ingelarella davidi McClung (1978, pl. 9, fig. 15?, 16-24) from the Elderslie Formation shows some approach in sulcation, fold and plicae, but plicae are narrower and higher, and the nature of the micro-ornament is not known. Tabellae seem to be moderately well developed, as in *Ingelarella* and in *Monklandia*, but lie between the first and second pair of plicae from the dorsal fold. The species *glendonensis* Waterhouse, 1998, p. 39 from Muree Formation (Wordian) from north Sydney Basin has stronger plicae and median fold along the sulcus. Although referred to *Monklandia* by Waterhouse (1998), it belongs to *Glendonia*, and Clarke (1987, p. 282; 1992b, p. 76) was right to refer the material to that genus.

9. APPENDIX: THE WUCHIAPINGIAN STAGE IN EAST AUSTRALIA AND NEW ZEALAND

Marine representation in east Australia and New Zealand of the Wuchiapingian Stage, basal unit of the Lopingian Series, would appear to be limited, to judge from the local biozones as summarized in Table 1, p. 4, of this monograph. This is partly a reflection of the need to conduct more studies on rocks and faunas of the stage in both east Australia and New Zealand, and partly because comparatively thick rocks occupying a stratigraphic position below Changhsingian faunas and above Capitanian faunas have few fossils. In a modification of the zonation proposed by Waterhouse (2008b), a basal Wuchiapingian biozone is potentially represented by *Ingelarella havilensis* Campbell, 1960 at the top of the marine sequence in the northern Bowen Basin, called the Havilah fauna by Dear (1972): otherwise it is very late Capitanian. This biozone is found in the upper part of the Blenheim Formation and in the MacMillan Formation and Black Alley Shale, as elaborated by Dickins (1983, 1989), and lies above a transitional fauna exemplified by what Dear (1972) called the Pelican Creek fauna, which shares a number of species with the underlying Scottville fauna including *Pseudostrophalosia clarkei* (Etheridge Snr.) and *Terrakea elongata* (Etheridge Jnr. & Dun), dated as Capitanian of the Middle Permian Guadalupian Series (Waterhouse 2002a, 2008b). All three faunas as categorized by Dear need a degree of amplification, and only the *Pseudostrophalosia clarkei* Zone, with elements of the Pelican Creek fauna, is represented at Wairaki Downs in New Zealand (Waterhouse 1998a, 2001, 2002a).

Metcalfe et al. (2014) have added a valuable time-line from U-Pb zircon TIMS analysis of a tuff band in the upper middle of the Black Alley Shale, above *Ingelarella havilensis*, suggesting that this located the boundary between Wuchiapingian and Changhsingian stages. They did note that the Wuchiapingian was under poor control radiometrically, and there always disadvantages in relying on a single point – or bed - for age determination, but the age does not conflict with the proposed recognition of *Ingelarella havilensis* as early Wuchiapingian. However misgivings remain, pointing to the need for further study. Fig. 12 in Metcalfe et al. (2014) shows how the Black Alley Shale rests above the Mantuan Productus bed in the western Bowen Basin, and the Mantuan has been correlated faunally with the Broughton Formation of the south Sydney Basin, from which a tuff has yielded a CA-IDTIMS tuff age of lower Capitanian age (Metcalfe et al. 2014, Fig. 17). Although Briggs (1998) considered that the Mantuan band was younger than other marine faunas in the Bowen Basin, Dear (1971), Dickins 1983, fig. 1, 1989, and Waterhouse (2001, 2002a, 2008b) showed that the *Pseudostrophalosia clarkei* and *Johndearia pelicanenensis* faunas were younger, and may be treated as upper Capitanian. This implies that the Black Alley Shale is possibly highly condensed, or that considerable revision is required. Faunally, the Permian sequences of the western Bowen Basin are highly incomplete, and therefore difficult to fit into any comprehensive scheme for age calibration – or sedimentary regime – without considerable compromise and uncertainty. What is clear from the present study is that any consideration of Late Permian and Early Triassic marine rocks and faunas in east Australia may be aided through analyses of the Gympie sequences, in which a number of tuffs and other igneous rocks are present.

The topmost zone for the Wuchiapingian Stage in east Australia – New Zealand is represented by the *Martiniopsis woodi* Zone. This has been correlated through *Martiniopsis woodi* and *Simplicisulcus arthurtonensis* and other species with the lower Chhidru Formation, Kufri Member, of the Salt Range, Pakistan (Waterhouse 2002a, pp. 212-213), and the lower Chhidru beds have late Wuchiapingian conodonts (Wardlaw & Mei 1999, Shen et al. 2003). The zone is best represented in the Earnvale Member at Arthurton, and further study is required of possible passage beds or prolonged fossil ranges in the area of Wairaki Downs (Waterhouse 2001, 2002a).

In New Zealand, thick limestone and minor sandstones of the Wooded Peak Subgroup lie below the *Martiniopsis woodi* Zone and above the *Pseudostrophalosia clarkei* Zone, and probably represent the bulk of the Wuchiapingian Stage. There are only scattered and often solitary fossils as a rule, involving the brachiopod *Capillonia* and rare *Paucispinauria.* A lens at Wairaki Downs contains distinctive species of *Neospirifer* sensu lato and *Spiriferella* sensu lato (Waterhouse 2002a, p. 65). The bivalve *Mytilidesmatella woodi* (Waterhouse) is found in carbonate units of the Wooded Peak Subgroup, in the Otaria Formation at Arthurton (Waterhouse 2002a, p. 99) and in the Waimahaka Limestone near Kuriwao (Waterhouse 2002a, p. 94). A related species *M. sivelli* Waterhouse is found in an overlying sandstone unit, called Barrington Sandstone (Waterhouse 2002a, p. 233).

It is clear that further study is required to clarify the relationships and nature of fossils in the Capitanian and early Wuchiapingian Stages of east Australia, and New Zealand. Until this is done, the Wuchiapingian Stage is not accurately or fully represented in correlation charts or proposed correlations.

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INDEX

List of genera and species mentioned in the text (excluding tables and figures)