DESCRIPTION OF SOME MIDDLE PERMIAN BRACHIOPODA AND MOLLUSCA FROM EAST AUSTRALIA, CHIEFLY THE BOWEN BASIN OF QUEENSLAND

J. B. Waterhouse

Earthwise 20
2022
ISSN (PDF): 3021-2111

Contents

PREFACE

This volume contains information on some fossil collections from the Ingelara, Catherine and Mantuan Formations of the southwest Bowen Basin, the Barfield Formation of the southeast Bowen Basin, a summary of faunas from the Scottville Member and and more prolific faunas of the overlying beds , and finally the topmost Blenheim Formation, MacMillan Formation and other levels regarded s very late Middle Permian in age,. Correlation for these faunas is discussed for the remainder of the Bowen Basin.

REPOSITORIES

Fossils described throughout this report are housed in the Queensland Museum, Brisbane, and are registered individually by number with the prefix UQF. They come from localities numbered with the prefix **UQL**. Fossils from other institutions are mentioned, including **AMF** for Australian Museum, Sydney, **CPC** – now AGSO, former Bureau of Mineral Resources. – at Canberra ACT., **ANU**, Department of Geology Australian National University: **GSQ**, Geological Survey of Queensland, also stored at the Queensland Museum at Zillmere, Brisbane, **GST**, Geological Survey, Hobart, Tasmania, **MM** , Mining Museum, Sydney, **MVP**, Museum of Victoria, Melbourne, **UNE**, Department of Geology, University of New England, Armidale, with material transferred to the Australian Museum. Other repositories include **GSC**, Geological Survey of Canada, Ottawa, Canada, **PIN**, Paleontological Institute, Moscow, and **BR**, for brachiopods and **TM** for Mollusca kept at the Institute of Nuclear and Geological Sciences (**GNS**), Lower Hutt, New Zealand.

ACKNOWLEDGEMENTS

Throughout this study, Kristen Spring at the Queensland Museum (Bulk Storage, Hendra) has provided advice over locality details and registration numbers. This has not always been a straightforward matter, because of confusion and even replication or duplication of numbers, requiring much patience.

World Stage	East Australia macrofaunal zone	SW Bowen Basin	SE Bowen Basin	N Bowen Basin
Capitanian	*Ingelarella costata* Zone	MacMillan Ftn		Exmoor, Ftn
	Echinalosia (*Unicusia*) *minima* Zone			upper Blenheim
	Pseudostrophlosia clarkei Zone			Scottville Member
	Maxwellosia ovalis	Mantuan Ftn	Flat Top Ftn	mid-Blenheim Ftn
		Peawaddy Ftn	Barfield Ftn	
Wordian	*Pseudostrophalosia blakei*	Catherine Ss		Moonlight Member
		Ingelara Shale		
Roadian	*Echinalosia maxwelli*	Oxtrack Ftn		

Table 1. Macrofaunal biozones recognized for the Bowen Basin, and sedimentary units from which faunas are described in this study.

1. TWO BIVALVE SPECIES FROM THE INGELARA FORMATION, SOUTH-WEST BOWEN BASIN, QUEENSLAND

Abstract

?*Striochondria* sp. and *Etheripecten latus* (Fletcher) are described from the Ingelara Formation are described from the southwest Bowen Basin.

INTRODUCTION

Two bivalve species collected by L. G. Elliott while student at the Department of Geology & Mineralogy of the University of Queensland are described from the Ingelara Formation.

SYSTEMATIC DESCRIPTIONS

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linneaus, 1758

Infraclass Pteriomorphia Beurlen, 1954

Megaorder OSTREATA Férussac, 1822

Superorder OSTREIFORMII Férussac, 1822

Order PECTENIDA Gray, 1854

Suborder ANOMIIDINA Gray, 1854

Hyporder AVICULOPECTENOIDEI Starobogatov, 1992

Superfamily **CHAENOCARDIOIDEA** Miller, 1889

Diagnosis: Shell biconvex, equivalve to subequivalve with relatively small posterior wings in each valve. Right anterior auricle and byssal notch well developed. Ornament varies, coarse to fine, but no genera known to be strongly plicate. Costae tend to increase by branching and implantation is also common, growth lines often arch ventrally in interspaces and hingewards over costae. Ligament external and amphidetic, alivincular, lativincular or platyvincular, some genera with a few simple teeth.

Discussion: This is a superfamily of wide diversity, some members close in several respects to Aviculopectenidae in alivincular hinge and others close to Deltopectenidae in having small posterior wings, but overall small and somewhat rounded in shape, with not very large anterior wing or auricle as a rule.

Family **STREBLOCHONDRIIDAE** Newell, 1938

Diagnosis: Shells biconvex, almost equivalve to inequivalve, upright to slightly procrescent, well defined umbonal slopes, posterior wings small, ornament variable. The resilifer where present is more symmetrically placed than in Chaenocardiidae. Teeth rarely developed.

Subfamily **STREBLOCHONDRIINAE** Newell, 1938

Genus ***Striochondria*** Waterhouse, 1983

Diagnosis: Small acline to slightly opisthocline shells, right valve gently convex, left valve slightly more inflated. Right anterior auricle bearing a few to numerous costae, finer ribs on left anterior wing. Both valves ornamented by commarginal lirae crossed by slightly more prominent fine radial capillae. Resilifer present.

Type species: *Streblochondria auriocostata* Waterhouse, 1982 from Letham Burn Member, Wairaki Downs, New Zealand.

Discussion: The view by Newell & Boyd (1995) that this genus was unrecognizable because it was poorly illustrated, with hinge character and shell microstructure not demonstrated is false, and readers need to check the original descriptions of the type species (Waterhouse 1982, pp. 29-31, pl. 13g, pl. 14c, f, 15a-h, 16h, 21d, e, Fig. 3) to disabuse themselves of such misrepresentation.

Striochondria? sp.

Fig. 1

1953 *Streblochondria parkesi* [not Fletcher ?] - Campbell, p. 20, pl. 6, fig. 9-12.

Material: A worn and incomplete right valve and left valve from UQL 3762, stated to be Ingelara Formation.

Description: Specimens are well rounded in outline with extended anterior, short posterior wings, and very subdued growth rugae. No ribs are visible. One specimen was leached in dilute HCl, not very successfully because the matrix is somewhat calcareous, but leaching did reveal the presence of a resilifer.

Fig. 1. *Striochondria* sp, right valve UQF 65494 from UQL 3752, Ingelara Formation.

Resemblances: The present material seems likely to belong to the species recorded from the mudstone at Dry Creek, Ingelara, of the Ingelara Formation by Campbell (1953), and this is now regarded as Peawaddy Formation. Campbell identified his material as *Streblochondria parkesi* (Fletcher, 1929), which was originally described as *Aviculopecten*, from the south Sydney Basin at Wyro and North Head near Ulladulla, St George's Basin, and Gerringong, apparently within the Wandrawandian and Broughton formations. Campbell's material does not show ornament adequately, either for the auricles, wings, or body of the shell, and so cannot be identified specifically. Indeed the specimens cannot be identified to genus with complete confidence, because the anterior auricle and ear are lost, and micro-ornament imperfectly preserved, and the hinge somewhat obscure. The specimens might belong to *Striochondria*, as suggested by Waterhouse (1982, p. 32) because this genus is widespread in faunas of this age, but *Streblopteria* M'Coy, 1844 is another possibility. *Streblopteria* lacks even fine radial ornament (Amler 1994, Waterhouse 2001), and specimens have been assigned to the genus from the Tiverton, Lakes Creek and Brae Formations of the Bowen Basin and upper Letham Formation at Wairaki Downs, New Zealand, together with an unnamed species from the lower *Maxwellosia ovalis* Superzone at Wairaki Downs. But the identification of the present material remains questionable, and better preserved material is required to secure the genus and determine specific affinities.

Superfamily **HETEROPECTENOIDEA** Beurlen, 1954

Family **HETEROPECTENIDAE** Beurlen, 1954

Subfamily **ETHERIPECTENINAE** Waterhouse, 1982

Diagnosis: Ornament of intercalate costae especially on left valve, simpler on the right valve, branching exceptional, costae may be spinose. Resilifer well formed.

Note: It is preferred to retain the complete spelling of genera in family group names, such as Pecteniferinae, rather than alter the spelling to conform with arcane rules devised by modern scholars for Latin grammar.

Genus ***Etheripecten*** Waterhouse, 1963

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. Growth lines arch dorsally in interspaces. Shell aragonitic or calcitic, varying according to paleolatitude.

Type species: *Etheripecten striatura* Waterhouse, 1963, p. 195 from Kildonan Member, Bagrie Formation (Changhsingian), New Zealand, OD.

Etheripecten latus (Fletcher, 1929)

Fig. 2

1929 *Deltopecten lata* Fletcher, p. 32, pl. 5, fig. 4, 5.
1982 *Etheripecten latus* – Waterhouse, p. 18, pl. 3b, c; pl. 4a.

Diagnosis: Small specimens with narrow hinge, subeqal auricles and wings before and behind beaks, no deep byssal sinus, ornament of fine costae over the left valve in four orders, with ten to twelve primary ribs.

Holotype: Specimen figured by Fletcher (1929, pl. 5, fig. 4) from lower Maitland Group, south Sydney Basin, OD.

Material, Description: A left valve UQF 65498 from UQL 3762, Ingelara Formation, shows well defined primary ribs, numbering some nine with prominent secondary and short tertiary ribs, and very fine fourth order ventrally. The surface is worn, and ears not displayed.

Fig. 2. *Etheripecten latus* (Fletcher), decorticated left valve UQF 65498, x2. From UQL 3762, Ingelara Formation.

Resemblances: The present specimen shows some approach to *Etheripecten latus* (Fletcher) in its size and ribbing, but is not well preserved. The ribbing is close to that recorded for the species by Waterhouse (1982, p. 18). The stratigraphic source for the type material in east Australia is not entirely clear, but seems most likely to have sourced from lower Maitland beds near Ulladulla, the matter being further discussed in Waterhouse (1982) on the basis of collections at the Australian Museum. In New Zealand comparable specimens come from the *Wyndhamia typica* and *Echinalosia maxwelli* Zones, and it would appear that the present specimen in reportedly coming from the Ingelara Formation would be slightly younger, as equivalent to the *Pseudostrophalosia blakei* Zone. But there needs to be closer examination of the Australian material, to determine more precisely the morphological and stratigraphic rnages of the species and allied forms.

FOSSIL LOCALITIES

As recorded in an honours thesis at the Department of Geology & Mineralogy of the University of Queensland, by L.G. Elliott.

UQF 65494 – Locality UQL 3762; Sandy Ck., 11.3km W of ‘Springwood’, 60km S of Springsure, Queensland, Lower Permian; ‘Bivalve Zone’ 14m from top of Ingelara Formation; Springsure 1:250,000 map (grid ref. 9468 6464).

UQF 65498 – Locality UQL 3762, Sandy Creek, 11.3km west of ‘Springwood’, 60km south of Springsure, Qlueensland. Lower Permian ‘Bivalve Zone’ 14m from top of Ingelara Formation. Springsure 1:250 000 (grid ref. 9468 6464).

REFERENCES

AMLER, M. R. W. 1994: Die Gattung *Streblochondria* Newell 1938 (Bivalvia. Aviculopectinacea) im europaischen Karbon. Archaeol. Ruhrgebiet 2 Jhr 1994: 133-149.

BEURLEN, K. 1954: Las faunas lamellibranchios do sistema Genduanicos no Parana. *In* F. W. Lange (ed.). Paleontologia do Parana. Comissao de Comemoraçaos do Centenareo Parana, Curutiba: 107-136, 7pl.

CAMPBELL, K. S. W. 1953: The fauna of the Permo-Carboniferous Ingelara beds of southeast Queensland. Pap. Dep. Geol. Univ. Qld 4 (3): 1-44.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

FÉRUSSAC, A. E. J. d'AUDEBARD de 1821-1822: Tableaux Systématiques des Animaux Mollusques suivis d'un Prodrome Général pur tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles. Première Partie, Tableaux Systématiques Généraux. Arthus-Bertrand, Paris; J. B. Sowerby, London.

FLETCHER, H. O. 1929: Contributions on the Permo-Carboniferous Aviculopectinidae of New South Wales. Rec. Aust. Mus. 17: 1-35.

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

M'COY, F. 1844: A synopsis of the Carboniferous Limestone fossils of Ireland. Dublin.

MILLER, S. A. 1889: North American geology and palaeontology: 664p., 1194 text-fig.

NEWELL, N. D. 1938: Late Paleozoic pelecypods: Pectinacea. Kansas Geol. Surv. Rep. 10.

NEWELL, N. D., BOYD, D. W. 1995: Pectinoid bivalves of the Permian-Triassic crisis. Bull. Amer. Mus. Nat. Hist. 227.

STAROBOGATOV, Y. I. 1992: Morphological basis for phylogeny and classification of Bivalvia. Ruthenica 2 (1): 1-25.

WATERHOUSE, J. B. 1963: *Etheripecten*, a new aviculopectinid genus from New Zealand. N. Z. J. Geol. Geophys. 6: 193-196.

_____ 1976: New occurrences of brachiopod and bivalve species from the Arthurton Group of south Otago and Southland, New Zealand, with comments on structure and stratigraphy. J. Roy. Soc. N. Z. 6 (2): 227-252.

_____ 1982: Permian Pectinacea and Limacea (Bivalvia) from New Zealand. N. Z. Geol. Surv. Paleont. Bull. 49.

_____ 1983: New Permian invertebrate genera from the east Australian segment of Gondwana. Bull. Ind. Geol. Assoc. 16: 153-158.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

2. SOME BRACHIOPODS AND MOLLUSCA FROM THE CATHERINE SANDSTONE OF THE SOUTH-WEST BOWEN BASIN, QUEENSLAND

Abstract

A few brachiopod and molluscan species are recorded and illustrated from the Catherine Sandstone of the southwest Bowen Basin.

New taxa: *Ingelarella canalis* n. sp., ***Peruvispira* sp.**

INTRODUCTION

A few species collected by L. G. Elliott of the Department of Geology & Mineralogy, University of Queensland, Brisbane, are described from the Catherine Sandstone.

SYSTEMATIC DESCRIPTIONS

Phylum Brachiopoda Dumeril, 1806

Class Rhynchonellata Williams et al. 1996

Superorder RHYNCHONELLIFORMII Kuhn, 1949

Order RHYNCHONELLIDA Kuhn, 1949

Suborder RHYNCHONELLIDINA Kuhn, 1949

Superfamily **WELLERELLOIDEA** Licharew, 1956

Family **WELLERELLIDAE** Licharew, 1956

Subfamily **PLEKONELLINAE** Waterhouse, 2010

Genus ***Plekonella*** Campbell, 1953

Diagnosis: Strongly costate, costae arising close to umbones, also radial capillae, sulcus and fold. Dental plates present, dental sockets strongly crenulate, cardinal plate with median ridge, supported by strong median septum, no well formed septalium. Crura oval in section, curve towards ventral valve.

Type species: *Plekonella acuta* Campbell, 1953, p. 18 from the Peawaddy Formation, southwest Bowen Basin, Queensland, OD.

Plekonella acuta Campbell, 1953

Fig. 1

1917 *Rhynchonella* (?*Pugnax*) cf. *pleurodon* [not Phillips] – Trechmann, p. 59, pl. 5, fig. 6-8.
1953 *Plekonella acuta* Campbell, p. 18, pl. 3, fig. 17-26.
1964 *P. acuta* – Waterhouse, p. 86, pl. 16, fig. 13-16, pl. 17, fig. 1-8, text-fig. 32C, 34A, B, 36-40.
1964 *P. acuta* - Hill & Woods, pl. P7, fig. 9, 10.
1967 *P. acuta* – Waterhouse, p. 84, Fig. 10, 14.
1972 *P. acuta* – Hill et al., pl. P7, fig. 9, 10.
1986 *P. acuta* – Waterhouse, p. 64, pl. 14, fig. 26.
1987 *P. acuta* – Clarke, p. 266, Fig. 4A, B.
1988 *P. acuta* – Parfrey, p. 14, pl. 3, fig. 12, 13.

Diagnosis: Characterized by having two costae in the sulcus and three costae over the fold.

Holotype: UQF 14229 figured by Campbell (1953, pl. 3, fig. 17-20), repeated by Hill & Woods (1964) and Hill et al. (1972), from Peawaddy Formation, OD.

Fig. 1. *Plekonella acuta* Campbell, A, B, ventral and dorsal aspects of UQF 69671, x3.

Material: A specimen with valves conjoined, and three ventral valves.

Description, Resemblances: The specimens have two sulcal costae and three fold costae, just as in *Plekonella acuta*, though the costae are stronger than in the types. If the numbers of sulcal and fold costae are used to discriminate the species, it would appear that *acuta* has a long time range, entering the succession in New Zealand in the *Wyndhamia typica* Zone of likely Kungurian age and lasting into the *Marginalosia planata* Zone, of late Changhsingian age (Waterhouse 1967). McClung (1983) recorded material from interval F in the GSQ Eddystone 1 core of the western Bowen Basin, but allowed that sulcal costae varied in number, which places a question against his identification. He did not specify detail, and figured no specimens.

Plekonella southlandensis (Fletcher, 1952)

Fig. 2

1952 *Camarotoechia southlandensis* Fletcher, p. 13, pl. 2, fig. 27-29.
1964 *Plekonella southlandensis* – Waterhouse, p. 91, pl. 17, fig. 9-13, text-fig. 32A, 35-39.
1983 *P. acuta* [not Campbell] – McClung, p. 68, Fig. 10.5, 6, 7, 11, 12? (part, not Fig. 10. 1-4, 8-10 = *acuta)*.
1986 *P. southlandensis* – Waterhouse, p. 65, pl. 14, fig. 27-29.

Diagnosis: Sulcus with costae tending to bifurcate to number three to four. Costae commence at umbo.

Lectotype: BR 391 figured by Fletcher (1952) and Waterhouse (1964, pl. 17, fig. 11) from middle Mangarewa Formation, Wairaki Downs, New Zealand.

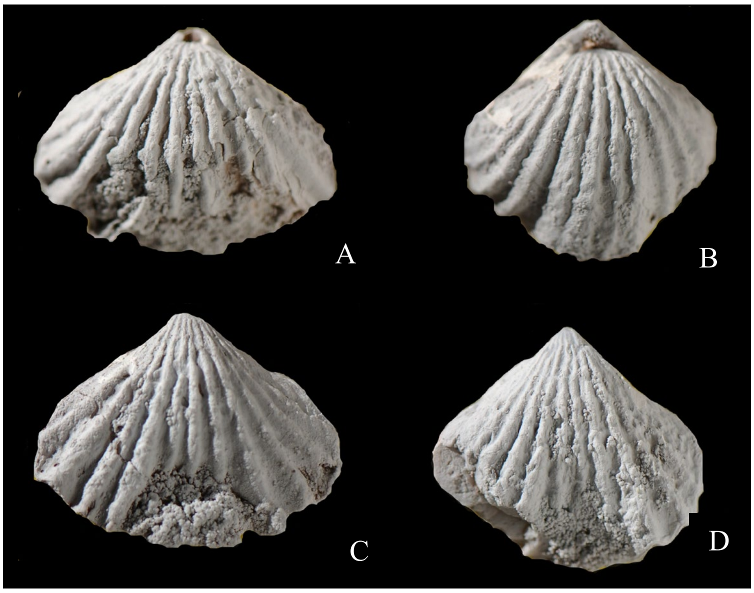

Fig. 2. *Plekonella southlandensis* (Fletcher). A, C, dorsal and ventral aspects of UQF 69672, x2. B, D, dorsal and ventral aspects of UQF 69675, x2.

Material: Two specimens with valves conjoined.

Description: The two specimens have posterior walls that are only very gently concave in outline, and sulcal costae number three and fold costae four, beginning close to the umbo.

Resemblances: Unlike *Plekonella acuta*, these specimens have broad umbones, swollen posterior walls, and three sulcal costae and four costae over the fold. They therefore approach *P*. *southlandensis* (Fletcher) from the lower Mangarewa Formation of Wairaki Downs, New Zealand, in beds assigned to the *Maxwellosia ovalis wassi* – *Paucispinauria* *solida* Zone. In some but not all topotypes of this species, the median sulcal costa splits anteriorly into two, but like other topotypes, the present specimens show no such split, possibly because they are too small, or more likely because there are intraspecific or specific differences. Specimens from the Flat Top Formation of southeast Bowen Basin (Waterhouse 1986) do not seem to show such splitting, although one specimen has two intercalated costae. *Plekonella multicostata* Waterhouse (1964) has numerous non-bifurcate costae in the sulcus, and the sulcus commences some distance in front of the umbo, and posterior costae are faint. This species is much younger than *southlandensis*, and is found in the South Curra Limestone near Gympie, Queensland (Waterhouse 2015b, p. 112), as well as Bagrie Formation of New Zealand (Waterhouse 2002).

Some collections of *Plekonella* show sulcal differences in costation between different specimens, unlike the regular arrangements in specimens from most collections (Waterhouse 2001, p. 87). Such variable specimens are found in the Catherine Sandstone of the western Bowen Basin of Queensland, and in the *Wyndhamia typica, Echinalosia discinia* and *Pseudostrophalosia blakei* Zones of New Zealand. They have sulcal costae varying between two and three, like that of the present specimens assigned to *acuta* and *southlandensis*. The overall distribution and morphology of specimens assigned to *Plekonella*, at least for the Middle Permian in the Bowen Basin and New Zealand, thus clearly require more attention, and perhaps there were two species, or even three, with one distinguished by the variable number of sulcal and fold costae. But there are other possibilities.

Superorder SPIRIFERIFORMII Waagen, 1883

Order SPIRIFERIDA Waagen, 1883

Suborder MARTINIDINA Waterhouse, 2016

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Subfamily **INGELARELLINAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Ingelarella canalis n. sp.

Fig. 3, 4

1987 *Tomiopsis ingelarensis* [not Campbell] – Waterhouse, p. 31, pl. 8, fig. 14, 16, 18; pl. 9, fig. 1-3.
1988 *Ingelarella ingelarensis* [not Campbell] – Parfrey, p. 18, pl. 4, fig. 18, 19, 20, 21.

Diagnosis: Medium size, ventral plicae low and may be absent, dorsal valve weakly plicate, ventral sulcus characterized as a rule by persistent median groove, dorsal fold rounded posterior, with broad anterior median depression as a rule. Adminicula apparently variable in length, closely to well spaced, tabellae well developed as a rule.

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

Material: Five ventral valves and two dorsal valves.

Description: Ventral umbo incurved with umbonal angle of 95° to 100° as a rule, posterior walls concave in outline and curving out to obtuse cardinal extremities, maximum width lying a little in front of mid-length. Interarea concave with open delthyrium. Dorsal umbo broad and low with umbonal angle of more than 120°; interarea low, wide in a large specimen. No specimen is strongly inflated. The ventral sulcus is shallow with angle of 30°, and typically bears a narrow median groove for its full length, and the dorsal fold is low to moderately defined, enclosed by angle of 16° to 18°, and divided anteriorly or for much of the valve ength by a shallow channel rather than well defined groove. The ventral valve as a rule bears three pairs of plicae that commence well in front of the umbo, and on one specimen the innermost pair is broad and weakly subdivided into a broad inner pair and slender outer pair. Three specimens lack plicae. Only one or two pairs of plicae appear on the dorsal valve, and the outer pair lies close to the inner pair. Micro-ornament consists of fine elongate grooves. Shell is up to 8mm thick posteriorly on the ventral valve, and is no more than 2mm thick posteriorly on the larger of the two dorsal valves.

Adminicula are long as a rule except in one specimen (Fig. 3F) and closely spaced, and the dental plates moderately high. On one specimen, pleromal plates as named by Campbell (1959) for low ridges developed along the junction between the dental plates and adminicula in other species of *Ingelarella* are larger than usual and may combine under the umbo to form a plate marked by strong growth increments which arch forward. Another

Fig. 3. *Ingelarella canalis* n. sp. A, dorsal valve UQF 69664 x1. B, ventral valve UQF 69665, x2. C, D, leached internal mould of ventral valve **UQF** showing adminicula (a) and dental plates (d), x2. E, decorticated ventral valve with long adminicula, UQF 69667, x1. F, ventral internal mould showing short adminicula, **UQF**x1.5.

specimen shows no such development. Therefore the development in this one specimen is regarded as unusual, and a variation of limited taxonomic significance. The muscle field is elongate and narrow, continuing well in front of the adminicula, with narrow adductor ridges lying between broad diductor scars. The thickened posterior floor bears fine pustules and pits.

In the dorsal valve erect diverging tabellae extend for a fifth of the length of the valve along the high sides of the fold each side of the channel.

Resemblances: The source of these specimens is reported to have come from the Catherine Sandstone, by both Elliott in his student thesis and by Parfrey (1988) in her study of fossils from the younger Permian of the southwest Bowen Basin. Parfrey (1988) identified them with *Ingelarella ingelarensis* Campbell (1960, p. 1115, pl. 135, fig. 1-3, pl. 138, fig. 4) from sandstone rocks he called Ingelara Shale exposed in Dry Creek, southwest Bowen Basin. The rocks are now regarded as restricted and true Ingelara Formation, and the overlying finer sediments, referred by Campbell to the Ingelara Formastion, are now referred to the Peawaddy Formation. The species *Ingelarella ingelarensis* was extensively figured by McClung (1978, p. 51, pl. 1, fig. 1-3, 5, 12, 17, 24, 26-28, ?10; pl. 2, fig. 16, 17) but his report in McClung (1978, pl. 10, fig. 16, 17, pl. 11, fig. 1-5) of the species from the Fenestella Shale in the Sydney Basin may requires further consideration, as they indicate small transverse specimens normally with a well-defined round-crested fold, long tabellae and short moderately well spaced adminicula. They could represent one extreme of a variable and moderately long-lived species, but are unlike canalis lack a ventral groove or dorsal channel. **RECHECK TEXT** .

The present specimens differ in several respects from the types of *ingelarensis*. Both valves have a well-developed median groove, for which there appear to be little sign except in very few specimens amongst the types. The groove in present specimens is well defined on the ventral valve, and broad and shallow in the dorsal valve. A range of dorsal valves were figured by McClung (1978, pl. 1) from LD91, described as involving the lower fossiliferous horizon in Dry Creek, Ingelara Formation, 4km WSW of Ingelara homestead. These show a fold becoming broad anteriorly, and developing a shallow anterior median channel. A number of ventral valves figured from the same locality bear strong suggestions of a median groove, but not nearly as pronounced as in the present suite, and tending to occur in plicate specimens. The tabellae are moderately well developed and well spaced, the adminicula are of moderate length and well spaced, not as close to each other nor as long as in a number of

Catherine specimens from the present collection, which are like the Catherine specimens figured by Parfrey (1988). McClung illustrated a number of specimens and assessed the variation, deciding that the specimens of *ingelarensis* graded into those described as *angulata*, and that both could be treated each as extremes of one species. This is accepted in the following studies. The tyes of both taxa were both named from the same locality. The present specimens from the Catherine Formation are shaped like *ingelarensis*, and are just as large. They differ from *ingelarensis* Campbell in having a well defined median groove

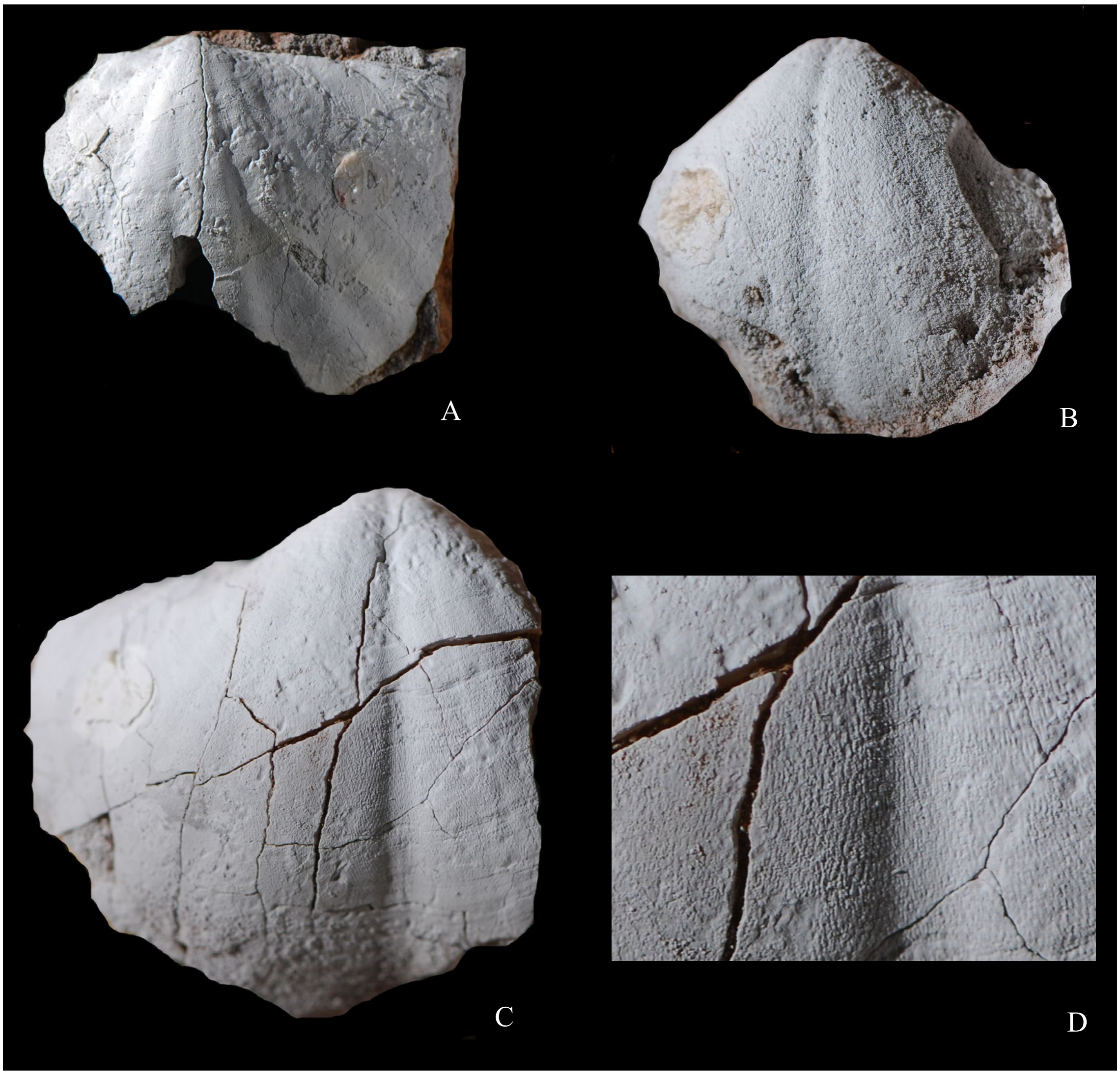

Fig. 4. *Ingelarella canalis* n. sp. A, dorsal valve UQF 69960, x1. B, broken ventral valve **UQF** x1.5. C, ventral valve **UQF** x1. D, panel of same specimen, showing micro-ornament on the same specimen, x4.

in both valves, and , for several of the specimens, having closely spaced adminicula that may be long. In these respects, they come close to shells named *Ingelarella havilensis* Campbell. The original types of *havilensis* as figured by Campbell (1960, pl. 139, fig. 3-6) also show very low and anterior ventral plicae, without clearly defined sulcal subplicae, as well as a well defined dorsal channel in the dorsal fold, and only dubious signs of dorsal plicae. There are rather well spaced short adminicula with high posterior myophragm in the only figured ventral internal mould of Campbell (cf. Fig. 5F herein), noted by Campbell as being immature, and in contrast to long closely spaced tabellae in the two figured dorsal valves. In the dorsal valve of Catherine specimens, the fold is moderately close to that of type *ingelarensis*, and unlike *havilensis*, there is a broad shallow channel rather than a dorsal median groove, helping to provide a marked and firm difference between the two taxa. The tabellae in the Campbell material are like those of the present material. In present material, adminicula are long as a rule except in one specimen (Fig. 5F) and closely spaced, and the dental plates moderately high. On one specimen, pleromal plates as named by Campbell (1959) for low ridges developed along the junction between the dental plates and adminicula in other species of *Ingelarella* are larger than usual and combine under the umbo to form a plate marked by strong growth increments which arch forward.

Specimens have been recorded from elsewhere in the Bowen Basin that resemble the Catherine material, involving large specimens from the Barfield Formation of the southeast Bowen Basin (Waterhouse 1987) as in the synonymy. The Barfield specimens have suggestions of a ventral median groove, no dorsal groove but a weakchannel, short moderately spaced adminicula and well developed tabellae. The Catherine specimens have better defined ventral groove, dorsal fold channel, short subparallel adminicula and short closely spaced tabellae. They may be deemed as conspecific with the present material.

Superorder TEREBRATULIFORMI Waagen, 1883

Order TEREBRATULIDA Waagen, 1883

Suborder TERBRATULIDINA Waagen, 1883

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **DIELASMIDAE** Schuchert, 1913

Subfamily **DIELASMINAE** Schuchert, 1913

Tribe **FLETCHERITHYRINI** Waterhouse, 2010

Genus ***Fletcherithyris*** Campbell, 1965

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

Type species: *Terebratula amygdala* Dana, 1847, p. 142 [not *T. amygdala* Catullo 1846] from Broughton Formation (Wordian), south Sydney Basin, OD, replaced by *Atrypa biundata* M'Coy, 1847, p. 231 (Waterhouse 1982, p. 58).

Fletcherithyris canni Campbell, 1965

Fig. 5

1965 *Fletcherithyris canni* Campbell, 1965

Diagnosis: Small highly inflated elongate shells with maximum width variably placed between mid-length to well forward. Posterior walls gently convex in outline, and ventral umbo broad, not attenuated. Brachidium elevated high above floor, with almost straight anterior margin and supported by high median septum.

Holotype: ANU 11988 figured by Campbell (1965, pl. 8, fig. 30, 31) from Nowra Sandstone, south Sydney Basin, OD.

Material: Two specimens and one crushed specimen, each with valves conjoined.

Dimensions in mm:

Length	Height	Width	
15.5	16	13.8	both valves

Description: The shell is small, highly inflated, with well formed foramen, commarginal growth increments and growth rugae, and dense punctae. One of the specimens was leached to clarify internal morphology was destroyed, but the interior proved to have been occupied by unfavourable matrix. Resemblances: The specimens are assigned to *Fletcherithyris canni* Campbell, sharing the same characteristic shape, involving the well curved widely diverging posterior umbonal walls The source beds were attributed by Campbell (1965) to the Nowra Sandstone, with some hesitation because of the limited nature of the outcrops, and the present source would favour this correlation rather than any attribution to the underlying Wandrawandian Formation. However it has not been possible to clarify the nature of the interior for present specimens. According to Campbell (1965), the septalium tends to be rather short. The species *canni* appears to have evolved into *Fletcherithyris galbina* Waterhouse (1982, p. 60, pl. 14c-f, pl. 15b-d, pl. 16a-k, Text-fig. 24-26) from the Mangarewa Formation of New Zealand ranges from the *Maxwellosia ovalis wassi - Paucispinauria solida* Zone into the *Terrakea elongata planidisca* Zone. A poorly preserved specimen from the *Nothalosiina*? *glabra* Zone in the Flat Top Formation was compared with the species in Waterhouse (1987a, p. 46, pl. 13, fig. 11), and other specimens are reported from the *Echinalosia* (*Unicusia*) *minima* fauna examined in this study (p.). *F. galbina* has an even more rounded posterior shell bearing the ventral umbo, and is also swollen. But its interior displays a comparatively long septalium, unlike the short septalium reported for *canni.* Some faunal lists have reported *Fletcherithyris parkesi* Campbell, 1965 from beds close to this level in age, and this species is strongly sulciplicate, unlike the present material.

Fig. 5. *Fletcherithyris canni* Campbell, dorsal and ventral aspects of UQF 69673, x2.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Infraclass Heteroconchia Hertwig, 1895

Megaorder CARDIATA Ferussac, 1822

Order CARDIIDA Férussac, 1822

Superfamily **KALENTEROIDEA** Marwick, 1953

Family **KALENTERIDAE** Marwick, 1953

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

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.

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

Stutchburia sp.

Fig. 6

A small left valve shows traces of some four ribs near the ventral margin, and so in its small size approaches *Stutchburia randsi* (Etheridge, 1892), as discussed on pp. But preservation is not good, and the similarity may be due to the imperfect preservation of the specimen.

Fig. 6. *Stutchburia* sp., UQF 69667, x2.

Class Gastropoda Cuvier, 1797

Order PATELLIDA Rafinesque, 1815

Suborder VETIGASTROPODINA Salvini-Plawen, 1980

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **EOTOMARIINAE** Wenz, 1938

Genus ***Platyteichum*** Campbell, 1953

Diagnosis: Turbiform high-spired pleurotomariids with globular or subglobular whorls in the spire, upper profile convex, flat or weakly concave in the body whorl. Slit extends for one fourth to one third of the circumference of shell, generating a concave selenizone a little above mid-height; whorl below tending to be concave above a rounded shoulder, but variably swollen or subvertical. Base phaneromphalous or cryptomphalous. Ornament of spiral ribs, crossed by radial threads.

Type species: *Platyteichum costatum* Campbell, 1953, p. 23 from sandstone, Ingelara Formation, Bowen Basin, OD.

Discussion: Dickins (1961) considered that Campbell's species was junior synonym to *Mourlonia*? *coniformis* Etheridge Jnr from Banana Creek, Dawson River, southeast Bowen Basin, and later changed his mind (in Malone et al. 1966, p. 72) to regard *coniformis* as younger than *costatum*. The sole specimen described and figured as *coniformis* by Etheridge Jnr (1892, pp. 287, 288) was recorded as an unsatisfactory specimen, and the figure strengthens that view. It could turn out to be senior synonym for the species recorded below, though the figure hardly encourages such a possibility, because it indicates a very differently shaped specimen with high spire. Short of gathering syntypes, it seems more objective to rely on the shape and ornament shown in Etheridge's figure as indicating distinction from *costatum* and *loratum*.

Platyteichum costatum Campbell, 1953

Fig. 7

1953 *Platyteichum costatum* Campbell, p. 23, pl. 7, fig. 11-14.
1964 *P. costatum* – Hill & Woods, pl. P12, fig. 17a, b.
1972 *P. costatum* – Hill et al. pl. P12, fig. 17a, b).

Diagnosis: Loosely to tightly coiled whorls in spire which has a lower angle than in some species, upper outer whorl less swollen than in some species, selenizone prominent, sited above weakly concave band of outer spire, selenizone exposed in spire above suture, spiral costae numerous, varying as a rule from three to eight over the body whorl above the selenizone, radial riblets fine and variably defined.

Holotype: UQF 14181 figured by Campbell (1953, pl. 7, fig. 11) from sandstone in Dry Creek Ingelara Formation, southeast Bowen Basin, OD.

Material: Three specimens are available.

Description: The specimens show the typical whorl profile for the spire and body whorl, and selenizone. The shell below the selenizone is not strongly concave, and may round evenly on to the base. Ornament is poorly preserved, and spirals do not appear to be so well developed as normal, though this could reflect preservation. Illustrations of the holotype and other specimens were poorly reproduced in Campbell (1953), but a greatly improved figure is provided in Hill & Woods (1964) and Hill et al. (1972).

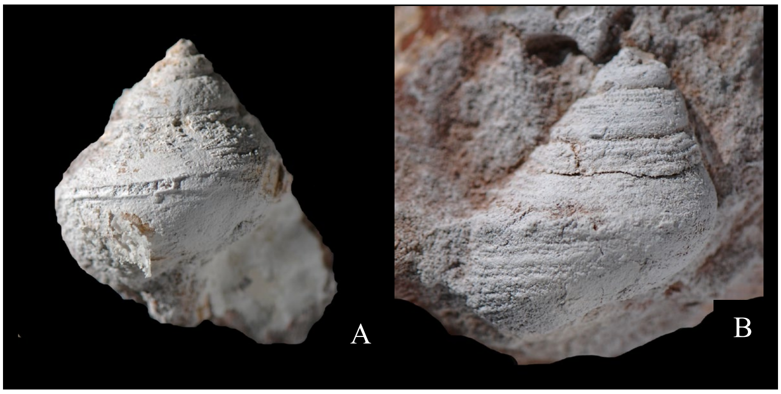

Fig. 7. *Platyteichum costatum* Campbell. A. UQF 69669, apertural view. B, lateral aspects of latex cast, UQF **69670**. Specimens x 2 from Catherine Sandstone.

The species has a narrower spire and weaker costae than observed on *Platyteichum loratum* Waterhouse, 1963a, p. 131, text-fig. 4, 37-50 from the upper Mangarewa Formation of New Zealand, and also reported from the Flat Top Formation of the southeast Bowen Basin by Waterhouse (1987b, p. 180, pl. 12, fig. 4, 17). Costae above the selenizone are fewer in *loratum* than in *costatum* Campbell, and further differences and overlaps in morphology were discussed by Waterhouse (1963a, p. 135). This species was initially described for numerous specimens from the upper Mangarewa Formation of New Zealand.

The Flat Top material figured by Waterhouse (1987b) from the southeast Bowen Basin has a slightly more swollen body chamber. A specimen that possibly comes from the *Echinalosia* (*Unicusia*) *minima* Zone is recorded on p. herein, but its stratigraphic position is not secure. Well preserved material was recorded from the MacMillan Formation by Dickins (1989), as in the references, and as discussed in Waterhouse (2001, p. 154), and further discussed herein on p. .

Subfamily **NEILSONIINAE** Knight, 1956

Genus ***Peruvispira*** Chronic, 1949

Diagnosis: Small high-spired anomphalous shells with concave or sinusoidal gently convex upper whorl profile, slit of moderate depth, selenizone bordered by prominent carinae. A third carina as a rule borders a concavulum or concave band below the selenizone. Ornament of fine radial growth ribs.

Type species: *Peruvispira delicata* Chronic, 1949, p. 146 from Permian of Peru, OD.

Discussion: Some pleurotomarioid gastropods have a well defined concave band below the selenizone, and this is here named a concavulum.

This material is exceptional in its morphology, given the fne radial threads, and it is provisionally regarded as having pbeen sourced from the Catherine Sandstone, because like the other specimens recorded in this article, the shell material is preserved in specimens from both the Catherine Sandstone and Mantuan Formation..

Peruvispira sp.

Fig. 9

Diagnosis: Shells with weakly sinusoidal upper whorl profile, shallow well-formed slit, ornament of very fine radial threads.

Material: Two well preserved specimens.

Dimensions in mm:

Specimen	Height	Width	Height last whorl
UQF 69696	5	3.8	2.5
UQF 69678	5.2	4.6	2.1

Description: Specimens small with five whorls in the spire, protoconch lost, and aperture and slit destroyed from one specimen but preserved in the other. Apical angle close to 55°, upper whorl sinusoidal and very gently convex, selenizone positioned close to middle of height of whorl, measured between the suture and base, bordered by two relatively strong carina, the lower carina more prominent and at maximum circumference. The selenizone is gently concave. Below lies a concavulum or concave band, higher than the selenizone and bordered by a peribasal carina, and a convex base without umbilicus, and inconspicuous columella. The slit is wide, and 2mm deep. Radial ornament is very faint, with very fine and subdued growth increments, six or seven in 1mm on the last-formed whorl above the selenizone.

Resemblances: These specimens are distinguished by the very faint radial ornament, in contrast to other species from older and younger stratigraphic levels in both east Australia and New Zealand that have strong radial ribs.

From the Flowers Formation of New Zealand, Waterhouse & Vella (1965, p. 78) recorded a specimen of *Peruvispira* which show only “traces of radial threads”, suggesting the possible occurrence of the same taxon in that fauna. But verification is required.

A species that comes from the Black Alley Shale of the western Bowen Basin was compared with *Peruvispira modesta* Waterhouse, 1963b by Dickins (1989, pl. 2, fig. 7-10) and some of the specimens were recorded as having faint ornament. The ascription to *P. modesta* seems unlikely, because in this species the upper whorl is concave, whereas that of the Black Alley Shale specimens is convex as in *Pleurocinctosa* Fletcher, 1958, and notwithstanding Dickins’ text, the apical angle is narrower. He registered angles of 54°, 50° and 48°, and the best preserved and measured New Zealand specimens of *modesta* have angles of 60°, 70° and 65°. Furthermore, radial ornament on the New Zealand specimens of *modesta* is strong, with well formed and clearly separated riblets. The Black Alley Shale specimens are not like *modesta*, but do come close to the present material in some respects. But the upper whorl is more convex in the Black Alley Shale specimens, and the apical angle is consistently low.

Pleurotomaria morrisiana M’Coy, 1847, p. 306, pl. 9, fig. 15, 15a from Black Head, near Gerringong in New South Wales, was judged by Fletcher (1958, p. 140) to match

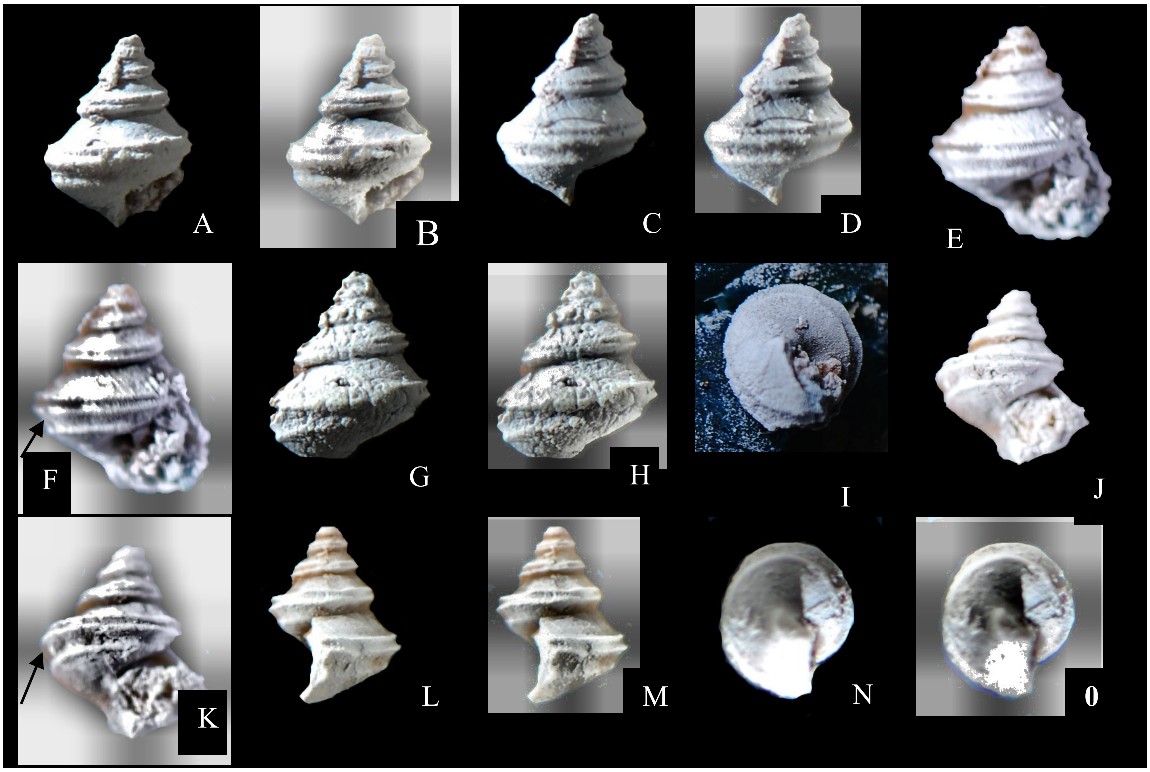

Fig. 9. *Peruvispira* sp. A-I, lateral and apertural (E, F) aspects of UQF 69676, under ordinary light and local equalization, except I, a basal view, x5 approx. J-O, lateral and basal apsects of UQF 69678 under ordinary light and local equalization, x5 approx. Examples of the concavulum are arrowed for Fig. 9F and K.

Pleurocinctosa trifilata (Dana 1847, 1849). He asserted that the upper whorl of *morrisianna* had been misrepresented as concave, when it was really convex. The radial ribbing appears to be only moderately well defined. But these features need to checked from first-hand examination of the type material at the Sedgwick Museum, Cambridge.

FAUNAL CONTENT AND CORRELATION

The species recorded in this report involve *Plekonella acuta* Campbell, *P. southlandensis* (Fletcher), *Ingelarella canalis* n. sp. , *Fletcherithyris canni* Campbell, *Stutchburia* sp., *Platyteichum costatum* Campbell, and possibly *Peruvispira* sp., though the stratigraphic source of the latter species is not secure. None of the species are leading indices for zones, but all fit well enough with a source from the Catherine Sandstone, as claimed by the collector, L. G. Elliot, when a student at the Department of Geology & Mineralogy, University of Queensland. This is the first report of possible *Fletcherithyris canni* Campbell, first described from what appears to be the Nowra Sandstone in the south Sydney Basin, which is close to being a broadly correlative unit.

The *Ingelarella* collected from the beds offers a particular challenge. In some respects, it shows aspects of size and shape normally associated with the species described as *Ingelarella havilensis* Campbell from the Havilah fauna of Dear (1972) and overlying in the uppermost Blenheim Formation of the northern Bowen Basin, and in the Black Alley Shale in the southwest Bowen Basin, as recorded by Dickins (1989) and elaborated herein (p.). The species is typified by a having a well-defined median groove in many of the ventral and dorsal valves. At first sight, the most realistic approach would be to assume that the Catherine Sandstone locality has been misplaced. But against that, Parfrey (1988, pl. 4, fig. 18, 19, 21, 22) has figured similar Catherine Sandstone specimens, calling them *I. ingelarensis*, as discussed on p. , and similar specimens have been figured from the approximately correlative Barfield Formation in the southest Bowen Basin by Waterhouse (1987). The Catherine dorsal valves differ from havilensis in having a shallow fold channel rather than groove.

The sole previous study that involved macro-fossils from the Catherine Sandstone was offered by Parfrey (1988), and her work remains the leading and first exploration of faunal content. She listed (1988, Fig. 10) the following species, with updated nomenclature: *Capillonia semicircularis* (Campbell), *Pseudostrophalosia blakei – ingelarensis* (Dear), *Magniplicatina magniplica* (Campbell), *Terrakea* sp., *Plekonella acuta* Campbell, **Aperispirifer wairakiensis* Waterhouse, **Notospirifer minutus* Campbell*, Ingelarella ingelarensis* Campbell, **I.* cf. *mantuanensis* Campbell and *Etheripecten* sp. The strength of the contribution from Campbell (1953) is obvious: he had described the fossils mostly from the nearby Ingelara sandstone, and, according to revised mapping by the Geological Survey of Queensland, the now restricted Peawaddy Formation, below the Mantuan Formation. Parfrey set out the occurrences of fossils in the local formations. Not all were described and illustrated, involving those asterisked in the preceeding list, and so require further study

FOSSIL LOCALITY

UQF 69660 to UQF69680 – In creek bed 4.9km W of Consuelo Homestead Homestead, Catherine Sandstone.

REPOSITORIES

See p. 2 herein.

ACKNOWLEDGEMENTS

Kristen Spring, Queensland Museum, greatly assisted with the assignation of registration numbers. The specimens were collected by L. G. Elliott while at the Department ofGeology & Mineralogy, University of Queensland, Brisbane.

REFERENCES

BEURLEN, K. 1954: Las faunas lamellibranchios do sistema Genduanicos no Parana. *In* F. W. Lange (ed.). Paleontologia do Parana. Comissao de Comemoraçaos do Centenareo Parana, Curutiba: 107-136, 7pl.

CAMPBELL, K. S. W. 1953: The fauna of the Permo-Carboniferous Ingelara beds of southeast Queensland. Pap. Dep. Geol. Univ. Qld 4 (3): 1-44.

_____ 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. Palaeontology 1: 333-350.

_____ 1960: The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. J. Paleont. 34: 1106-1123.

_____ 1965: Australian Permian terebratuloids. Bull. Bur. Mineral Resour. Geol. Geophys. 68.

CHRONIC, J. 1949: *In* NEWELL, N. D., CHRONIC, J., ROBERTS, T. G.: Upper Paleozoic of Peru. New York: 1-241. See also Mem. Geol. Soc. Amer. 58 (1953).

CLARKE, M. J. 1987: Late Permian (Late Lymingtonian = ?Kazanian) brachiopods from Tasmania. Alcheringa 11: 261-289.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DANA, J. D. 1847: Descriptions of fossil shells of the collections of the exploring expedition under the command of Charles Wilkes U. S. N. obtained in Australia, from the lower layers of

the coal formation in Illawarra, and from a deposit probably of nearly the same age at Harper’s Hill, valley of the Hunter. Amer. J. Sci. ser. 2, 4: 151-160.

DEAR, J. F. 1972: Preliminary biostratigraphic subdivision of the Permian brachiopod faunas in the northern Bowen Basin and their distribution throughout the basin. Rep. Geol. Surv. Qld 49: 1-19.

DICKINS, J. M. 1961: The gastropod *Platyteichum* in the Permian of Western Australia. Palaeontology 4: 131-137.

_____1983: The Permian Blenheim Subgroup of the Bowen Basin and its Time Relationships. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 269-274.

_____1989: Youngest Permian marine macrofossil fauna from the Bowen and Sydney Basins, eastern Australia. BMR J. Aust. Geol. Geophys. 11: 63-79.

DUMÉRIL, A. M. C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux: xxiv + 344pp. Allais, Paris.

ETHERIDGE, R. Jnr 1892: *In* JACK, R. L., ETHERIDGE, R. Jnr Geology and Palaeontology of Queensland and New Guinea. Publ. Geol. Surv. Queensland 92: 1-766, 68pl.

_____ 1900: Little known and undescribed Permo-Carboniferous Pelecypoda in the Australian Museum. Rec. Aust. Mus. 3: 178-187.

FERUSSAC, A. E. J. d’AUDEBARD de 1821-1822: Tableaux Systématiques des Animaux Mollusques suivis d’un Prodrome Général pur tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles. Première Partie, Tableaux Systématiques Généraux. Arthus-Bertrand, Paris; J. B. Sowerby, London. (See Carter et al. 2011, pp. 35, 36).

FLETCHER, H. O. 1952: *In* FLETCHER, H. O., HILL, D., WILLETT, R. W. Permian fossils from Southland. N. Z. Geol. Surv. Palaeont. Bull. 19: 1-17, pl. 1, 2.

_____ 1958: The Permian gastropods of New South Wales. Rec. Aust. Mus. 24: 115-164.

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

GROBBEN, C. 1894: Zur Kenntniss der Morphologie, der Verwandtschafts-verhältnisse und des systems der Mollusken. Sitzbericht. K. Akad. Wiss. (Math.-Naturwiss. Cl.) 103 (1): 61-86.

HERTWIG, R. 1895: Lehrbuch der Zoologie. 3rd edit., Gustav Fischer, Jena, xii + 599p.

HILL, D., PLAYFORD, G., WOODS, J. T. 1972: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

HILL, D., WOODS, J. T. 1964: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

KNIGHT, J. B. 1956: New families of Gastropoda. J. Washington Acad. Sci. 46 (2): 41, 42.

KOPPE, W. H. 1974: The Exmoor Formation – An addition to stratigraphic nomenclature in the North-western Bowen Basin. Qld Gov. Min. J. 75: 280-285.

KUHN, O. 1949: Lehrbuch der Paläozoologie: v + 326p. E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart.

LICHAREW, B. K. 1956: Brachiopoda. *In* L. D. Kiparaisova, B. P. Markovsky, G. P. Badchenko (ed.) Min. Geol. Okhran. Ndr. Moscow 12, n. sp. Paleont.: 5, 53, 56-61, 64-70. [Russ.]

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MALONE, E. J., JENSEN, A. R., GREGORY, C. M. 1966: Geology of the southern half of the Bowen 1:250,000 sheet area, Queensland. Rep. Bur. Mineral Resourc. Geol. Geophys. 100.

MARWICK, J. 1953: Divisions and faunas of the Hokonui System. N. Z. Geol. Surv. Paleont. Bull. 21.

McCLUNG, G. 1978: Morphology, palaeoecology and biostratigraphy of *Ingelarella* (Brachiopoda: Spiriferida) in the Bowen and Sydney Basin of eastern Australia. Geol. Surv. Qld Pub. 365, Palaeont. Pap. 39: 11-86.

_____ 1983: Faunal sequence and palaeoecology in the marine Permian in G. S. Q. Eddystone 1, Denison Trough, Queensland. Geol. Surv. Qld Pub. 384: 43-80.

M'COY, F. 1847: On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist.(ser. 1) 20: 145-157, 226-236, 298-312.

MORRIS, J. 1845: Descriptions of fossils. *In* STRZELECKI, P. E. de Physical description of New South Wales and Van Diemen's Land: 270-291. Longman, Brown, Green & Longman, London.

PARFREY, S. M. 1988: Biostratigraphy of the Barfield Formation, southeastern Bowen Basin, with a review of the fauna from the Ingelara and lower Peawaddy Formations, southwestern Bowen Basin. Rep. Qld Dep. Mines 1.

RAFINESQUE, C. S. 1815: Analyse de la Nature ou Tableau de l'Úniversité et de Corps organisés etc. 223p. Jean Barravecchia, Palermo.

RUNNEGAR, B. N., MCCLUNG, G. R. 1975: A Permian time scale for Gondwanaland. *In* K. S. W. Campbell (ed). Gondwana Geology: 425-441. Papers presented at the Third Gondwana Symposium, Canberra, Australia, 1973. Aust. Nat. Univ. Press, Canberra.

SCHUCHERT, C. 1913: Class 2. Brachiopoda. *In* ZITTEL, K. A. von Text-book of Paleontology, vol. 1, part 1, 2nd ed., translated and edited by C. R. Eastman: 355-420, fig. 526-636. MacMillan & Co. Ltd, London.

SWAINSON, W. 1840: A Treatise on Malacology of the Natural classification of shells and shell fish. VIII: 419p.

TRECHMANN, C. T. 1917: The age of the Maitai Series of New Zealand. Geol. Mag. dec. 6 4: 53-64.

WAAGEN, W. 1883: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (2): 391-546.

WASS, R. E., GOULD, I. G. 1969: Permian faunas and sediments from the South Marulan district, New South Wales. Proc. Linnean Soc. New South Wales 93: 212-226.

WATERHOUSE, J. B. 1963a: Permian gastropods of New Zealand. Part 2 – Pleurotomariacea (in part). N. Z. J. Geol. Geophys. 6 (1): 115-154.

_____1963b: Permian gastropods of New Zealand. Part 3 – Pleurotomariacea (concluded). N. Z. J. Geol. Geophys. 6 (4): 587-622.

_____ 1964: Permian brachiopods of New Zealand. N. Z. Geol. Surv. Paleont. Bull. 35: 1-287, 37pl.

_____ 1967: Upper Permian (Tatarian) brachiopods from New Zealand. N. Z. J. Geol. Geophys. 10: 74-111.

_____ 1982: New Zealand Permian brachiopod systematics, zonation and paleoecology. N. Z. Geol. Surv. Paleont. Bull. 48.

_____ 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia.

Palaeontographica A 193 (1-4): 1-76.

_____ 1987a: Late Palaeozoic Brachiopoda (Athyrida, Spiriferida and Terebratulida) from the southeast Bowen Basin, eastern Australia. Palaeontographica A 196 (1-3): 1-56.

_____ 1987b: Late Palaeozoic Mollusca and correlations from the southeast Bowen Basin, east Australia. Palaeontographica A 198 (4-6): 129-233.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2002: The stratigraphic succession and structure of Wairaki Downs, New Zealand, and its implications for Permian biostratigraphy of New Zealand and marine Permian of eastern Australia and Gondwana. Earthwise 4: 1-260.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

_____ 2015: The Permian faunal sequence at Gympie, southeast Queensland, Australia. Earthwise 12: 1-196.

WENZ, W. 1938: Gastropoda. Allgemeine Teil und Prosobranchia. *In* O. H. Schindewolf (ed.) Handbuch der Paläozoologie, Band 6. Teil 3: 481-720. Berlin.

WILLIAMS, A., CARLSON, S. J., BRUNTON, C. H. C., HOLMER, L. E., POPOV, L. E. 1996: A Supra-ordinal classification of the Brachiopoda. Philosoph. Trans. Roy. Soc. London (ser. B) 351: 1171-1193.

3. A NEW STROPHALOSIOID GENUS FROM THE BARFIELD FORMATION, SOUTH-EAST BOWEN BASIN, QUEENSLAND

Abstract

A new genus *Nonauria* is proposed for *Acanthalosia parfreyi* (Waterhouse, 2001, p. 84) from the Barfield Formation of the southeast Bowen Basin.

New taxon: *Nonauria* new genus.

INTRODUCTION

A new genus is distinguished for a species allied to *Wyndhamia* and *Pseudostrophalosia*, and distinguished by the lack of ears.

SYSTEMATIC DESCRIPTION

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Tribe **WYNDHAMIINI** Waterhouse, 2010

Genus ***Nonauria*** n. gen.

Derivation: non – not; auria – ear (Lat.)

Diagnosis: Close to *Wyndhamia*, distinguished by lack of ears from either valve.

Type species: *Wyndhamia parfreyi* (Waterhouse, 2001, p. 84) from Barfield Formation, southeast Bowen Basin, Queensland.

Discussion: This genus is close to *Wyndhamia* Booker and *Pseudostrophalosia* Clarke, but unlike these genera, lacks ears for either valve. *Wyndhamia* has few spines over the ears, and *Pseudostrophalosia* has numerous long and well developed ear spines over the ventral ears. To judge from the fossil record, *Pseudostrophalosia* was the oldest of these genera, and evolved into *Wyndhamia* by substantial diminution of ear spines, and *Nonauria* was the last genus to appear, by loss of the ears.

Nonauria parfreyi (Waterhouse, 2001)

Fig.

1986 *Wyndhamia blakei* [not Dear] – Waterhouse, p. 33, pl. 5, fig. 25?, 26, 27, 28 (part, not pl. 5, fig. 24, 29, 30, pl. 6, fig. 1, 2, pl. 15, fig. 10 = *Acanthalosia deari* (Briggs).
1988 *Echinalosia* sp. Parfrey, p. 12, pl. 2, fig. 14-17, 19.
1988 *Wyndhamia* sp. Parfrey, p. 13, pl. 2, fig. 18.
1998 *Echinalosia deari* [not Briggs] - Briggs, p. 101.
2001 *Acanthalosia parfreyi* Waterhouse, p. 84.
2010 *Wyndhamia parfreyi* Waterhouse, p. 54, Fig. 22.

Diagnosis: Small-medium shells with evenly spaced spines, coarse over ventral valve apart from a few very thin prostrate spines, fine and erect over dorsal valve. Interareas low, and no ears developed.

Holotype: GSQF 12983 figured by Parfrey (1988, pl.2, fig. 14, 19) from Barfield Formation, southeast Bowen Basin, Queensland, OD.

Discussion: The species has been described in the preceeding references: the synonymy updated slightly from that offered in Waterhouse (2001). The specimen figured in Waterhouse (1986, pl. 5, fig. 27) appears to have coarse spines like those of *parfreyi,* but that figured in pl. 5, fig. 25 appears to be shaped like *deari*.

A new species within the same genus is described herein from the Kulnurra marine incursion, starting on p.

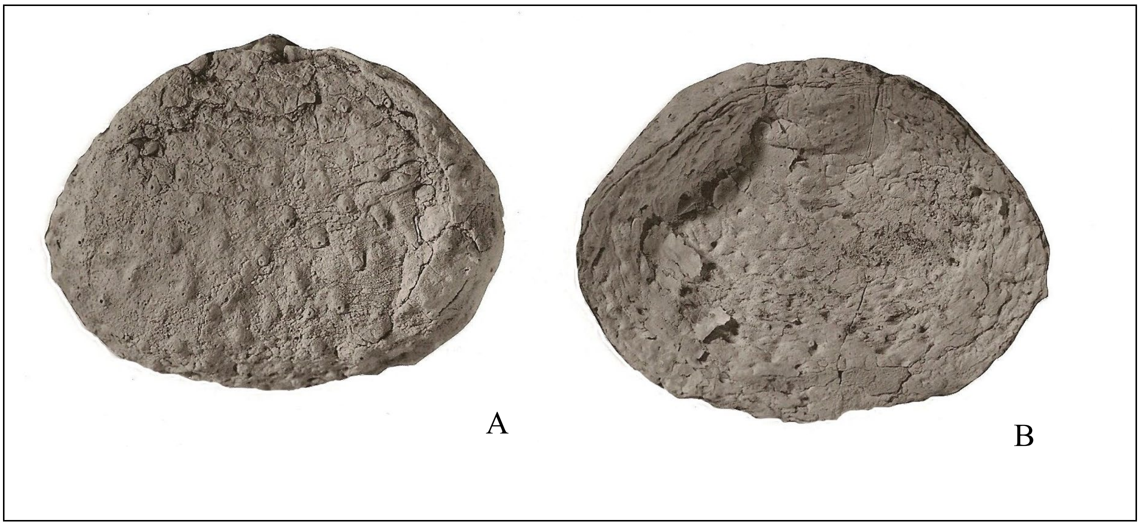

Fig. 1. *Nonauria parfreyi* (Waterhouse). A, B, ventral and dorsal aspects of UQF 69888 from Barfield Formation, southeast Bowen Basin, x2. (Waterhouse 1986, 2013).

REFERENCES

BRIGGS, J. D. C. 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and the New England orogen: systematics and biostratigraphic significance. Mem. Assoc. Aust'asian Palaeont. 19.

PARFREY, S. M. 1988: Biostratigraphy of the Barfield Formation, southeastern Bowen Basin, with a review of the fauna from the Ingelara and lower Peawaddy Formations, southwestern Bowen Basin. Rep. Qld Dep. Mines 1.

WATERHOUSE, J. B. 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

4. BRACHIOPODS AND MOLLUSCS FROM THE MANTUAN FORMATION, SOUTHWEST BOWEN BASIN, QUEENSLAND

Abstract

Species are described from the Mantuan Formation of the southwest Bowen Basin. One species of *Terrakea* belongs to a new form that was first noted by G. McClung as appearing before the species now called *Paucispinauria solida*.

New taxon: *Terrakea macrospina* n. sp.

INTRODUCTION

Species are described from the Mantuan Formation of the southwest Bowen Basin as restricted by Draper (2013). They were collected by L. G. Elliott, in the course of pursuing an Honours thesis at the Department of Geology & Mineralogy, Queensland University, Brisbane.

SYSTEMATIC DESCRIPTIONS

PHYLUM BRACHIOPODA Duméril, 1806

Class Strophomenata Williams et al. 1996

Superorder PRODUCTIFORMI Waagen, 1883

Order PRODUCTIDA Waagen, 1883

Suborder STROPHALOSIIDINA Waterhouse, 1975

Superfaly **STROPHALOSIOIDEA** Schuchert, 1913

Family **DAYSALOSIIDAE** Brunton, 1966

Subfamily **DAYSALOSIINAE** Brunton, 1966

Genus ***Maxwellosia*** Waterhouse, 2013

Diagnosis: Moderately concavo-convex, shells medium-sized to large for the genus with numerous erect spines in several orders over ventral valve, many spines in commarginal rows, but many also irregularly dispersed, and may be in clumps, prostrate spines thin to almost as strong as erect or suberect series, but may be rare, dorsal spines also crowded and largely erect, varying slightly to considerably in diameter. Ventral interior with moderately prominent spine tunnels.

Type species: *Strophalosia jukesi concava* Maxwell, 1954 from the Wallaby rocks of southeast Queensland, OD.

Discussion: Type *Echinalosia* has ventral spines of two series, and dorsal spines of a single erect series, whereas the arrangement in the present species comes closer to the arrangement in type *Maxwellosia* Waterhouse, 2013, with an array of ventral spines displaying different diameters, somewhat irregularly arranged, and mostly to nentirely erect. Dorsal spines are somewhat differentiated and erect to semirecumbent. The dorsal valve is deeply concave, in contrast to the flat or gently concave dorsal valve of *Acanthalosia* Waterhouse, 1986a. Apecies assigned to *Echinalosia* Waterhouse, 1967a from the Tiverton Formation, *E. cenula* Waterhouse, 2015a, has somewhat similar ventral spines, but dorsal spines are more uniform, and there fewer ventral spine tunnels than in the present form.

Maxwellosia ovalis (Maxwell, 1954)

Fig. 1 – 5

1954 *Strophalosia ovalis* Maxwell, p. 548, pl. 57, fig. 4-9, 13 (part, not fig. 10-12 = *minima* Dear).
1964 *S. ovalis* – Hill & Woods, pl. P4, fig. 16, pl. P5, fig. 1, 2.
1972 *E. ovalis* – Hill et al. pl. P4, fig. 16, pl. P5, fig. 1, 2.
?1975 *Wyndhamia ovalis* – Runnegar & McClung, pl. 31.2, fig. 1-3.
1983 *E. ovalis* – Waterhouse & Jell, p. 241, pl. 1, fig. 1-6.
1998 *E. ovalis* – Briggs, p. 103, Fig. 55A-G.

Diagnosis: Medium-large shells weakly transverse to weakly subelongate, moderately wide hinge, cardinal extremities subangular to obtuse, well formed ventral interarea, large and variably shaped umbonal cicatrix in some shells, dorsal valve moderately concave, not wedge-shaped or thickened, curving evenly like that of the ventral valve into a short to medium-length trail. Ventral spines of variable strength, many not arranged in commarginal rows, may be fine close to anterior margin. vary from erect to semi-recumbent. Dorsal spines preserved as fine and erect in patches, one set developed in clusters and almost twice as thick as the others; commarginal growth steps and rugae well developed over both valves.

Ventral adductor platform large and high, and dorsal adductor platform also high, moderately large.

Holotype: UQF 15630 from Mantuan Downs Productus bed, 1.5miles (2.4 km) northwest of Consuelo Homestone, Springsure District), figured by Maxwell (1954, pl. 57, fig. 5-7), OD.

Material: Five ventral valves, sixteen dorsal valves and four specimens with valves conjoined.

Dimensions in mm:

Width	Length	Height	
17.5	12.3	4.2	both valves
23.5	24	8	both valves
32	34	16	ventral valve
32.8	35.4	18.9	internal mould from UQL 998
32.5	27	7	dorsal valve
27	20	6	dorsal valve
23	22.5	7	dorsal valve

Description: Ventral valves swollen, without a sulcus, weakly elongate to weakly transverse, umbo broad and weakly incurved, with narrow to broad but obscure umbonal cicatrix, hinge less than maximum width which lies near mid-length. Interarea relatively high, with strong grooves parallel to the commissure and a narrow high pseudodeltidium. The ventral interarea is inclined posteriorly from the commissure at 45^{o} in an immature specimen, but lies almost in the plane of the commissure in a shell at early maturity. Dorsal valve gently concave as a rule, and may have a median low fold, possibly due to distortion in some specimens, but in several specimens symmetrical enough to imply a natural development. The dorsal valve is moderately thick overall, and appears to be a little thicker than the ventral valve, without becoming wedge-shaped. The dorsal interarea is low with slender raised notothyrium, and is steeply inclined from the commissure in many specimens. The trail curves evenly on from the disc and is short to moderate in length

Spines are crowded over the ventral valve. Most are erect to semi-erect, a number reaching 0.5mm to 1mm in diameter and up to 1.2mm in diameter, and fine spines are as thin as 0.1mm in diameter, and are also erect as a rule, so that there is a spectrum of diameters. Some recumbent spines, up to 0.5mm in diameter, are visible on only a few specimens. A few spines have slightly swollen bases. The spines tend to lie in short bands across the shell, and are not observably in quincunx: their arrangements are best conveyed by figures; often two or three spines lie close to each other, whereas elsewhere they are well spaced.

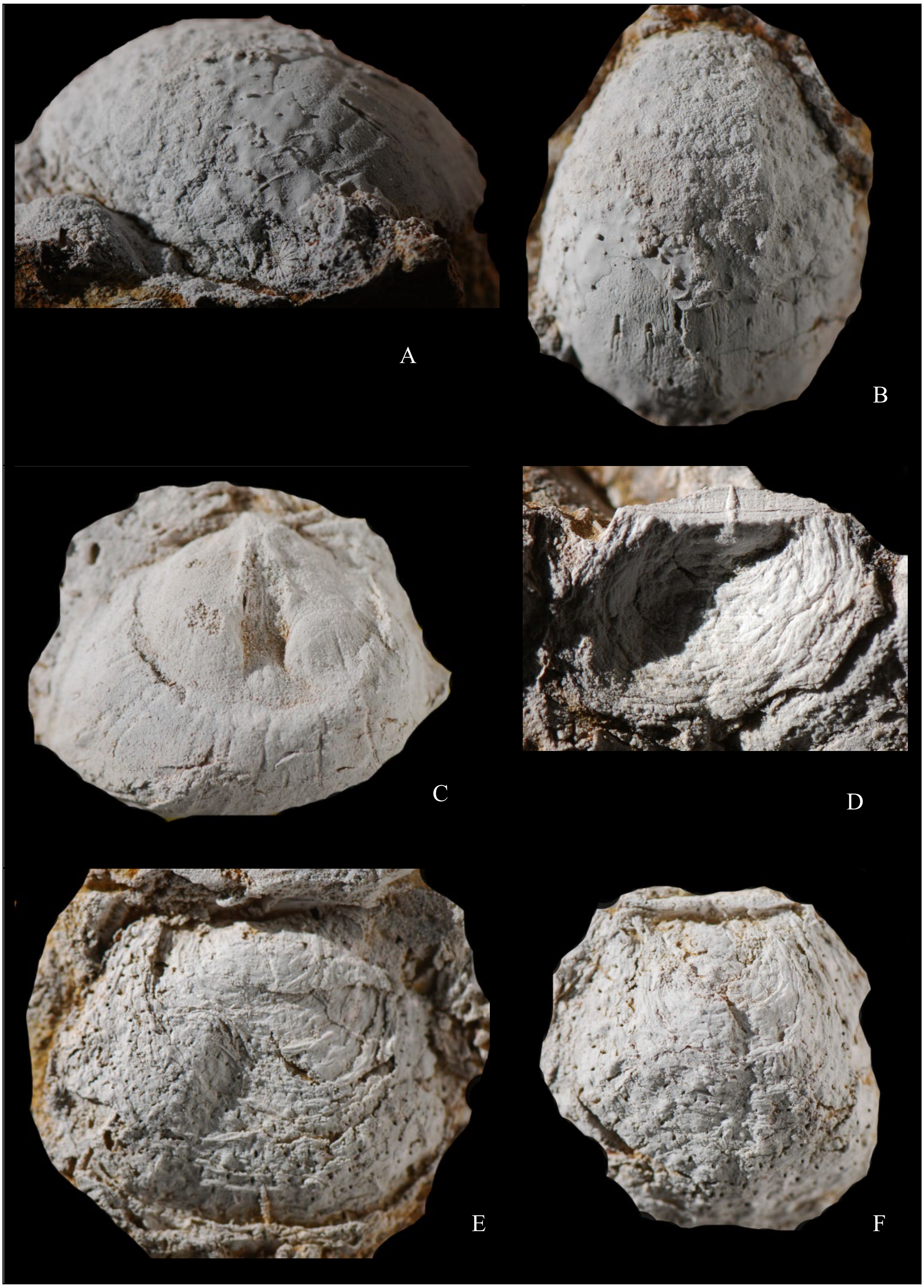

Fig. 1. *Maxwellosia ovalis* (Maxwell). A, B, lateral and ventral aspects of ventral valve, UQF 82729, x2. C, ventral internal mould, UQF 82730, x2. D, dorsal aspect of conjoined specimen, UQF 82731, x2.5 E, dorsal external mould, UQF 82732, x2. F, dorsal external mould with ventral interarea, UQF 82733,x2. spaced..

Coarse growth increments are present over the entire ventral valve, three in 1mm anteriorly over mid-valve. Dorsal valves are also crowded with spines, varying in diameter from 0.1 to 0.3mm, and largely consistent in diameter along commarginal rows, rarely irregular in spacing and along short-lived rows in some specimens but as a rule in persistent commarginal rows. The rows are separated by shell without spines and marked by fourteen to about twenty fine growth increments. No nepionic part is clearly differentiated as a rule.

Fig. 2. Slab showing external moulds of dorsal valves of *Maxwellosia ovalis* (Maxwell). UQF ,82734, UQF 82735 and UQF 82736 with part of external mould of ventral valve of *Terrakea macrospina* n. sp., UQF 82737, x1.5. The mould of a small ventral valve of *Plekonella acuta* Campbell lies to the top left, as arrowed.growth increments.

The overall surface is crowded with irregular short growth increments, five to seven in 1mm anteriorly, and these form on some shells a regular rhythym of low rugae separated by depressed channels in which growth increments are more crowded, perhaps approximating a weekly or even fortnightly pattern with between six and seven to fourteen or fifteen, or more increments. The increments and laminae undulate across the shell, and spines arise in front of the growth grooves in short commarginal rows. Locally the increments arch posteriorly. Traces of radial capillae are also present. The ventral micro-ornament is much less complex.

Teeth are small and transverse. The adductor scars in mature specimens are raised and subelongate. Diductor scars are large and subrounded, and overlap the anterior half of the adductors, but overlap more of the adductors in an immature specimen. The surface of the diductor scars is comparatively smooth with only a few shallow radial grooves, less conspicuous than those of many strophalosioid species. The floor of the valve carries fine pits and a few spine tunnels, in both immature and mature specimens. A few spine tunnels are present. Teeth are large, with clearly defined dental buttresses.

In the dorsal valve the dental sockets are well formed, and the median septum extends for half of the length of the valve. The anterior adductor scars are rounded and smooth, and posterior adductors slightly raised, and comparatively smooth. There is no clearly defined hinge ridge. Pustules lie in front of the septum and cover the anterior shell, including the start of the trail.

The small spat of a specimen with valves conjoined is 4mm wide and 3mm long, with ventral spines spreading around to attach the specimen on to a dorsal exterior of the same species (Fig. 3A). In this spat, the interareas of both valves are inclined at a steep angle and lie in one plane. Very fine erect spines lie over the dorsal valve except near the hinge. There are several other spats, most attached to larger shells, not all belonging to *Maxwellosia ovalis*.

Resemblances: This species is characterized by the nature of its ventral spines, which are largely erect, and diversified into several orders. Even the thinnest of spines are erect as a rule, rather than prostrate. Possibly the erect stance of the spines reflects the coarse nature of the matrix, implying turbulent conditions on the sea-floor. The dorsal spines are erect and numerous, dispersed irregularly in somewhat commarginal rows, and varying in diameter.

The nature of the ventral spines reinforces the one previous figure that illustrated the ventral exterior, published by Briggs (1998, Fig. 55A) from UQL 3094, of the Mantuan Formation as defined by Draper (2013). The diameter of the spines as measured from the figure varies: some are erect, others recumbent: they do not lie in the pattern normal for either *Echinalosia* or *Marginalosia*. The nature of the spines, if the specimens are correctly attributed, means that the species *ovalis* cannot be assigned to *Echinalosia*, as assumed by a number of recent authors, including the present writer. Ventral adductors are long and moderately high.

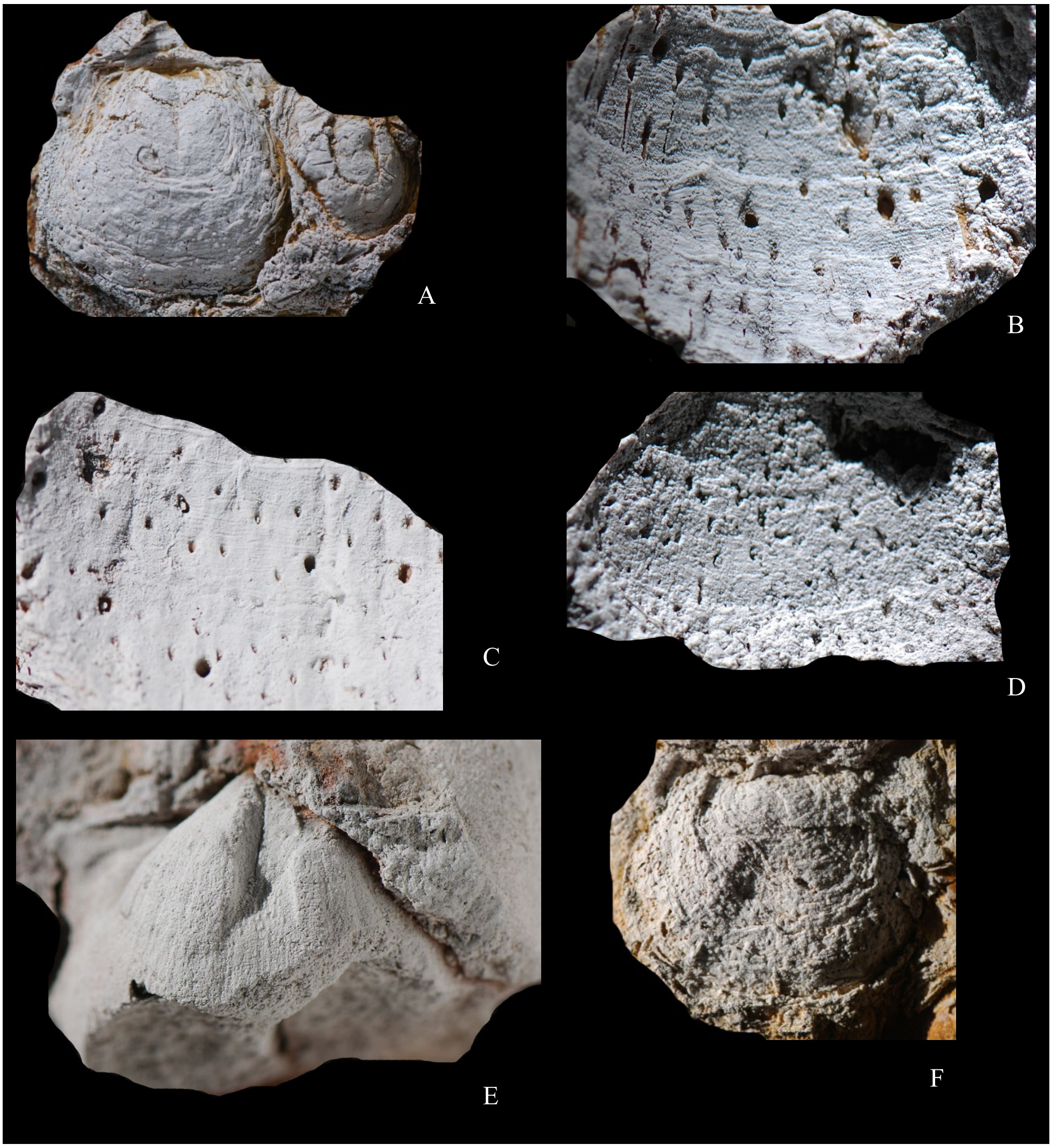

Fig. 3. *Maxwellosia ovalis* (Maxwell). A, external mould of dorsal valve UQF 82738 adjoining small ventral valve UQF 82739 with attached spat of ventral valve to right UQF 82740. B, C, D, external moulds showing distribution and nature of spines bases, UQF 82841, UQF 82742 and UQF 82743. E, ventral internal mould UQF 82744. F, dorsal external mould, **UQF**. 82745. Specimens x2.

Fig. 4. *Maxwellosia ovalis* (Maxwell). A, dorsal external mould UQF 82763, x2. B, dorsal internal mould UQF 82764, x1. C, dorsal internal mould, UQF 82765, x2. D, dorsal internal mould. UQF 82766**,** x2.

A ventral internal mould figured by Wass & Gould (1969, pl. 14, fig. 18) from South Marulan has narrow elongate adductor field as in *ovalis* but is otherwise poorly known. Some of the specimens figured from the Kulnura marine tongue in New South Wales by Dickins (1989) as *Echinalosia* cf. *minima* [not Maxwell] – Dickins, p. 75, pl. 3, fig. 10, 12-21 suggest similarities to the present species, but the varied ventral spines are a little thicker and the commarginal growth laminae stronger, and no ears are developed, so that the shells are assigned to *Nonauria*, allied to *Wyndhamia.* Other specimens figured by Dickins (1989) have more regular spines, unlike those of the present species, and are judged to belong to a distinct species of *Pseudostrophalosia*, as described on pp.) There is also some approach to a ventral internal mould figured from Parrot Creek as *Echinalosia ovalis* by Maxwell (1954, pl. 57, fig. 10-12 - part only, remainder = *ovalis*), but the specimen looks closer to specimens assigned herein to *Echinalosia* (*Unicusia*) *minima* (see p.).

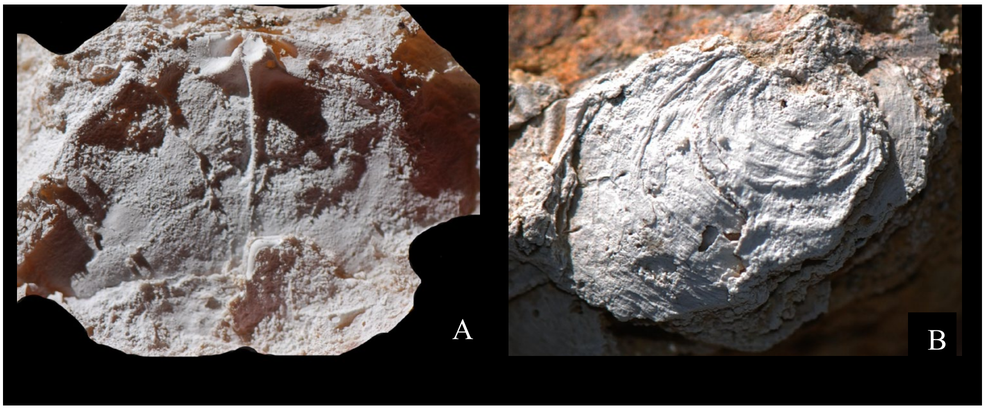

Fig. 5. *Maxwellosia ovalis* (Maxwell . A, latex cast of dorsal valve, UQF 82767 , showing dorsal interior. The cardinal process is imperfect, allowing a view of the dental sockets. B, external mould of dorsal valve UQF ,82768 with rare and scattered dorsal spines. Specimens x2.

Material probably from Mantuan Formation.

Several well preserved specimens, some with conjoined valves, were given to me by Stan Colliver, then curator at the departmental museum for the Department of Geology and Mineralogy at the Unjversity of Queensland, Brisbane. These have no locality number, which therefore requires a measure of caution, and nothing is known of their precise source. But they do appear to belong to *ovalis*, and their smaller size adds useful information on the ontogenetic development of the species. The specimens are smaller than the large specimens figured by Briggs (1998), and therefore appear to represent the species at early maturity. They are much less inflated than the mature shell, and thereby fit with earlier growth stages indicated on specimens. Spine detail conforms with that known for the material figured by Briggs (1998).

Material: Five specimens with valves conjoined and other fragments from unspecified locality within Mantuan Formation, ventral internal mould from UQL 998 may be conspecific.

Dimensions in mm: in order

Width	Length	Height	Hinge width	
37	39	15	25.3	
34.7	30.6+	12.5	22?	
27	23	7.4	20	
33.5	30.3	13.4	27.5	
32.8	35.4	18.9	25.3	internal mould from UQL 998

Description: Ventral disc convex and curving into trail nearly half as long as the disc; dorsal disc and trial more evenly concave with no sign of geniculation, no sulcus or fold. Ventral umbo varies, between a narrow 80° or so and broad and obtuse, up to 120°, and bears a variably placed almost flat cicatrix of differing size and shape. No nepionic area appears to be differentiated on the dorsal valve. The hinge is moderately wide, with subangular to obtuse cardinal extremities, and the ventral area is well formed, flat or gently concave, with narrow well defined pseudodeltidium, and the dorsal interarea is lower, planar with a very narrow notothyridium.

The ventral spines are mostly 0.5 to 0.7mm in diameter. They tend to be semirecumbent – basically erect and spaced up to 3mm apart along rows 1-4mm apart. Spines are mostly 2mm apart, in rows 2mm apart – and the spines are more crowded. Anteriorly the spines are only 0.3mm in diameter and more crowded, whereas in specimen 4, many spines are just over 1mm in diameter and have subdued prolonged bases. over the mid disc, the spines finer over the trail. But closer inspection shows that the pattern is less than regular. Often two comparatively large spines may lay close together, one just behind the other and less than 1mm apart. There even small clusters to five or six spines in a bunch. And there are scattered much finer spines. solitary or in clusters of three or four. The irregularity – or complexity, rules out any association with *Echinalosia* or *Marginalosia*, and brings the material closer to that assigned to *Maxwellosia*, though the large specimen is less transverse and more inflated, like the specimen from UQL 998. Dorsal spines are rather variable in spacing, with often two clumped together, and generally 0.2 to 0.3mm in diameter, and less commonly up to 0.5mm in diameter to some extent in rows, less crowded than in the other suite, but still somewhat variable in size and spacing.

The dorsal adductors are, for the size of the shell, large and high.

Discussion: These specimens have no locality number. The specimens are not exactly the same as those described previously, because they are much less inflated, but do have much the same complexity of spines over both valves. Whether they are immature specimens of the same species, or as seems more likely, and allied perhaps subspecies, requires further evaluation.

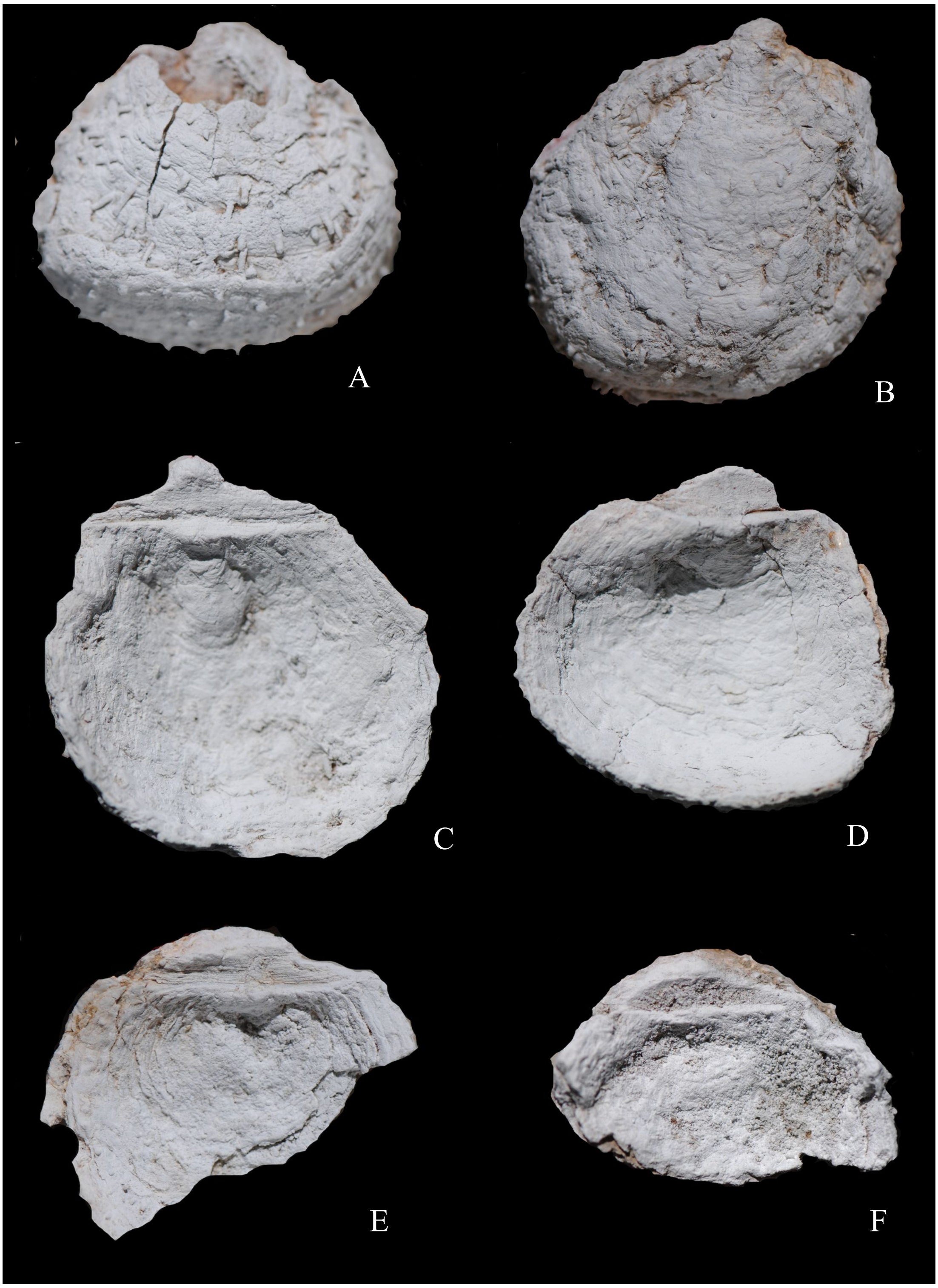

Fig.6. *Maxwellosia ovalis* (Maxwell). A, D, ventral and dorsal aspects of specimen with valves conjoined, **UQF** x1.5. B, C, ventral and dorsal aspects of l specimen with valves conjoined, **UQF** , x1.5. E, dorsal aspect of specimen with valves conjoined, UQF x? . F, dorsal aspect of specimen with valves conjoined, UQF x 1.5. Probably from Mantuan Formation, x3.

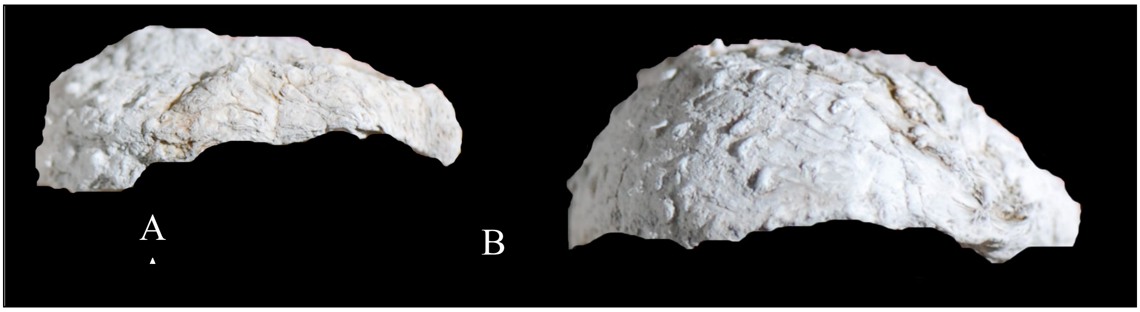

Fig. 7. *Maxwellosia ovalis* (Maxwell). A, lateral view of UQF (See Fig. 33A, D). B, lateral aspect of UQF (See Fig. 33B, C). From Mantuan Formation, x1.5.

Species referred to *Maxwellosia* Waterhouse, 2013, namely *M. concava* (Maxwell) and *M. bryani* Waterhouse from Sakmarian faunas in Queensland are distinguished by their more concave dorsal valves and larger size (see Maxwell 1954, Waterhouse 2013). Dorsal spines may be numerous, and not as varied, and dental buttresses are better developed.

Echinalosia (*Unicusia*) *minima* (Maxwell) from the Pelican Creek fauna and underlying beds above the Scottville Member has more regularly spaced ventral spines tending to be of one diameter, whereas dorsal spines are closer, but the dorsal valve surface of *minima* is diversified by more prominent pits. Older species assigned to *Echinalosia* from the early and middle Guadalupian Series in east Australia have more regularly arranged ventral spines, as a rule of two diameters, the coarser spines suberect to subrecumbent, the finer spines as a rule prostrate. On the other hand some forms from the underlying Tiverton Formation, and Buffel Subgroup of the southeast Bowen Basin of Sakmarian age and described by Waterhouse (2015a) as *Echinalosia curtosa sulcata*, *E. cenula* and *E. curvata* show somewhat similar ventral spines, though all are distinguished by other attributes involving shape, size and musculature. Spines over the dorsal valve are thin and uniform in these species.

This species is readily distinguished from taxa referred to *Acanthalosia,* which has an almost flat and wedge-shaped dorsal valve. *A. deari* (Briggs) found in the basal Flat Top Formation in the southeast Bowen Basin is small with less inflated ventral valve and flatter dorsal valve less subrounded in outline, which has a narrow hinge and crowded diverse ventral spines. From the lower Snapper Point Formation of the south Sydney Basin, *A*?.

mcclungi (Briggs, 1998, p. 79) has a gently concave dorsal valve and strong posterior lateral ventral spines. This species is not typical of the genus, and its placement requires further exploration, but the types appear to have been lost. *A. mysteriosa* Waterhouse (2010, p. 57) is close in shape, and distinguished by the numerous fine ventral spines and comparatively flat dorsal valve. It comes from the Roses Pride and correlative Cattle Creek Formation of the southeast and southwest Basin. The type species of *Acanthalosia*, *A. domina* Waterhouse (1986a, p. 32) from the Dresden Limestone and Boughyard Member of the southeast Bowen Basin has denser spines, a number more recumbent, and somewhat wedge-shaped dorsal valve.

Suborder LINOPRODUCTIDINA Waterhouse, 2013

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

Family **PAUCISPINAURIIDAE** Waterhouse, 1986

Subfamily **PAUCISPINAURIINAE** Waterhouse, 1986

Tribe **PAUCISPINAURIINI** Waterhouse, 1986

Genus ***Terrakea*** Booker, 1930

Diagnosis: Shells with well developed radial capillae over both valves. Ventral spines subrecumbent to erect over visceral disc, with elongate posterior bases as a rule, and core prolonged anteriorly through the shell, spines erect over trail, and erect, crowded and strong over lateral slopes and ears. Dorsal spines erect, crowded over visceral disc, strong laterally and anteriorly. No anterioly prolonged spine bases.

Type species: *Productus brachythaera* Morris, 1845, pl. 14, fig. 4c not G. B. Sowerby, 1844 (ICZN opinion 486, 1957),

Terrakea macrospina n. sp.

Fig. 6 - 11

1965 *Terrakea brachythaera* [not Morris] – Waterhouse & Vella, p. 64, pl. 2, fig. 2, 5-10, pl. 3, fig. 3.

Derivation: macro – large, spina - spine, Lat.

Diagnosis: Large weakly transverse shells with large ears, spines crowded, large and erect over ears and crowded over lateral slopes, closely and regularly spaced over the disc, with posterior bases prolonged but short. Dorsal spines numerous and erect, especially large over trail and lateral flanks.

Holotype: UQF 82770, Fig. 9D, 11, here designated.

Material: More than twenty specimens are available. A few show well the internal mould, but many are crushed together.

Dimensions in mm:

Width	Length	Height
47+	45	28
48	38	22
43	22	15
47+	37+	23+

Description: The specimens are large for the genus, and the disc is transverse, with large ears giving a width of almost 60mm for various specimens. The shells are swollen with broad umbo measuring close to 100°, high posterior walls, and very gently convex venter medianly, and the dorsal valve is gently concave over the disc. Ears are mostly incomplete, but are preserved as large and gently convex on fragments of the ventral valve, showing obtuse cardinal extremities, and extending to the maximum width of the shell in some specimens, and just as wide as the disc near mid-length in other specimens. Dorsal ears are gently concave. Over the venter and trail, spines lie in irregular quincunx, more or less 3mm apart, 1mm in diameter and with short raised bases 1.5 to 3mm long as a rule, rarely 4mm long. Anterior spines tend to be erect and up to 1.7mm in diameter. Over the trail, radial bands of spines are bordered by prominent growth steps or laminae, with spines of one band distinguished in diameter and spacing from those of adjoining bands, either finer or thicker. Thick erect spines lie over the lateral umbonal slopes in a cluster, generally 1.0 to 1.3mm in diameter, and extend on to the outer ears. Nearer the hinge and postero-laterally, the ears tend to be smooth in mature specimens, although small and immature specimens show a number of spines, and spine bases remain on the ventral ears of large specimens.

Internal moulds show well the large and slightly variable muscle scars, reinforced by heavy posterior thickening, whereas the anterior shell even in large specimens is thin and internally shows the nature of the external ornament. In small specimens, spine tunnels relict from th spine corses are visible over the interior of the ventral valve. Adductor scars are large and elongate, with light ridges marking the surface, especially posteriorly, divided

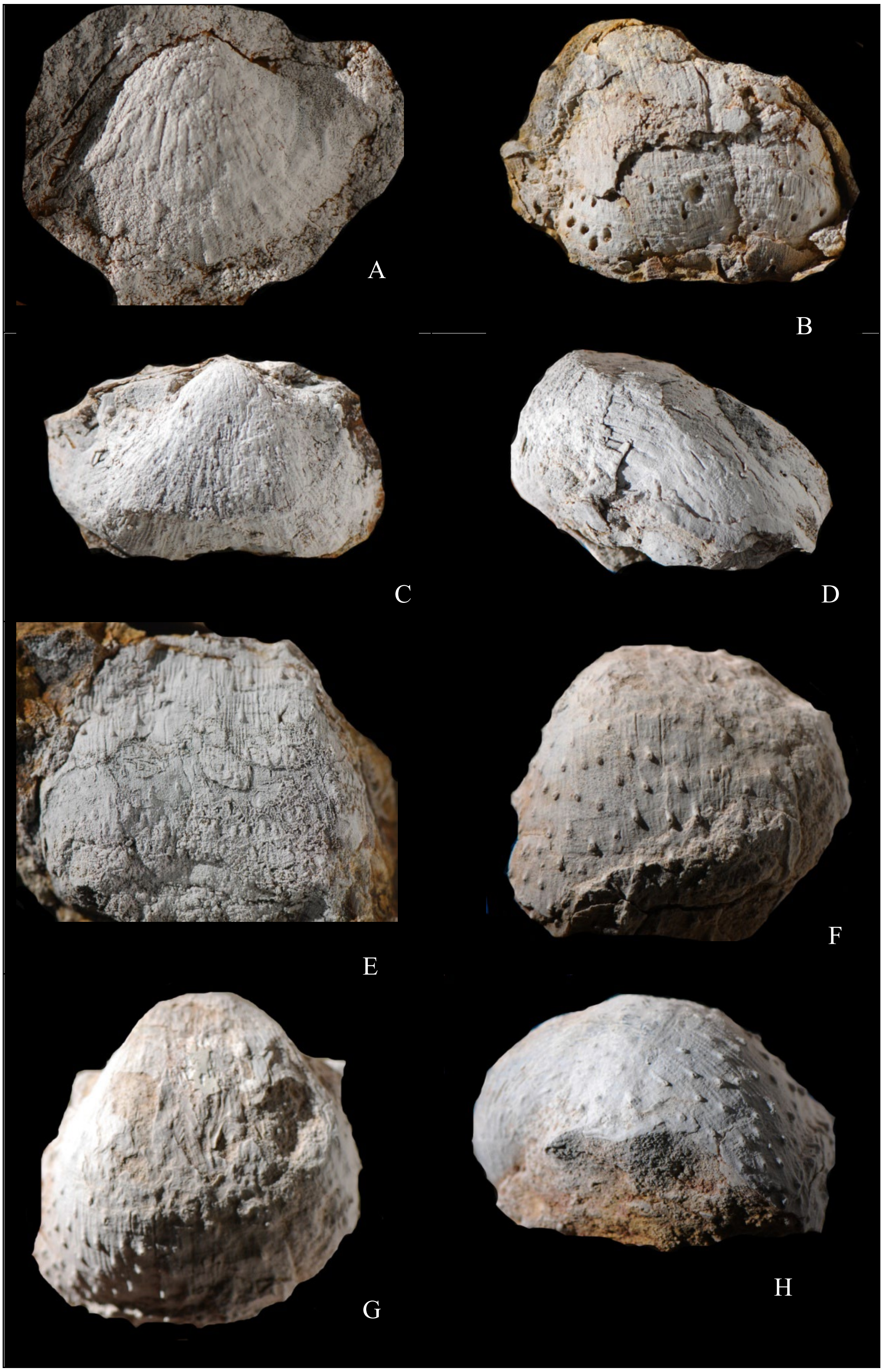

Fig. 6. *Terrakea macrospina* n. sp. A, worn ventral valve UQF 82769, x3. B, anterior aspect of internal ventral valve and dorsal external mould, **UQF** x1. C, D, ventral and lateral aspects of ventral valve, **UQF** x1. E, ventral aspect of ventral valve **UQF** x1. F, G, H, anterior ventral, posterior ventral and lateral aspects of ventral valve UQF 69656, x1.

Fig. 7. *Terrakea macrospina* n. sp. A, posterior aspect, ventral internal mould **UQF** x1. B, D, ventral and dorsal aspects of internal mould of specimen with valves conjoined, **UQF** x1. C, ventral internal mould **UQF** x1.

by a low and narrow varying to well-formed myophragm. Diductor scars are large, suboval, impressed and bearing radial ridges and grooves. The posterior floor of the valve is thickened and lightly marked by pustules and pits. The dorsal septum extends only as far as mid-length. Posterior adductor scars dis- play irregular radial ribs and grooves, and the anterior adductor scars are comparatively smooth. A low ridge lies along the hinge. One specimen UQF 69658 suggests the presence of a small brachial shield, standing well out from the adductor scars.

Resemblances: These specimens appear to have evolved into *Terrakea elongata elongata* (Etheridge & Dun, 1909) found in the succeeding macrofaunal zone in the Scottville Member

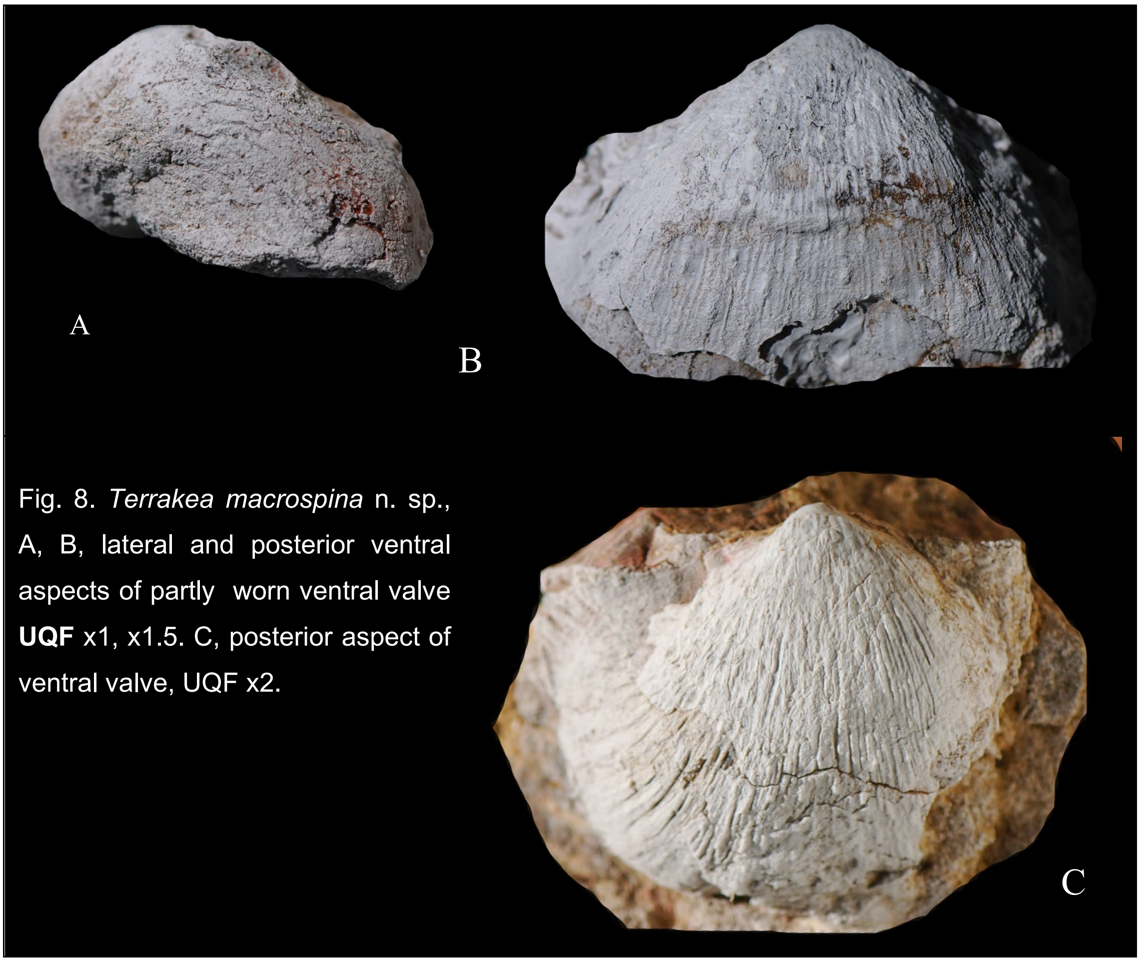

Fig. 8. *Terrakea macrospina* n. sp., A, B, lateral and posterior ventral aspects of partly worn ventral valve **UQF** x1, x1.5. C, posterior aspect of ventral valve, UQF x2.

and overlying zone named *Echinalosia* (*Unicusia) minima* with *T. elongata planidisca* n. subsp. These two ntaxa have much longer trials than in the present form. Over the mature dorsal valve, coarse erect spines lie over the inner ears and around the anterior shell. The ears near the hinge and the posterior disc may lack spines, apparently ost because spines are present in smaller specimens. Radial capillae cover both valves except for the ears, six to eight in 5mm anteriorly, and the general appearance is close to that of these two taxa. But the trail is very much shorter, so that the shell is shorter and lower than is the case for these two species. The present shells are larger, and more transverse, with I shorter trail, and the lateral burst of erect spines is more extensive over the ventral valve, and more and larger spines lie over the lateral and anterior dorsal valve. The dorsal disc of *T. elongata elongata* from the Scottville Member and *Maxwellosia ovalis (wassi*) Zone of the Mangarewa Formation in New Zealand is more concave than in the specimens *T. elongata planidisca*

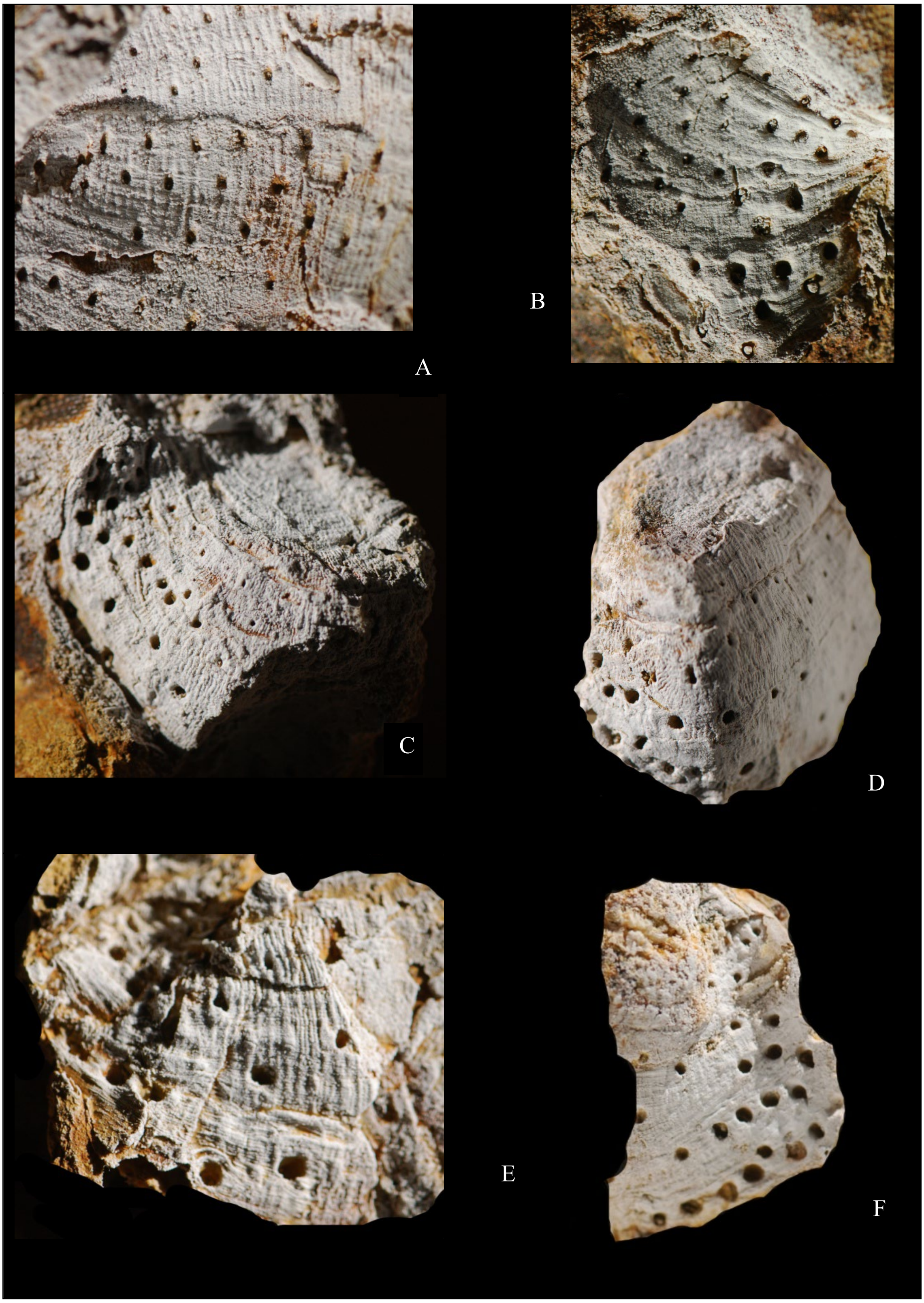

Fig. 9. *Terrakea macrospina* n. sp. A, detail of ornament on ventral external mould, **UQF** x2. B, detail of ornament on ventral external mould in front of ear, x **UQF**. C, broken external dorsal valve, showing spine bases, **UQF** x2. D, oblique aspect of complete dorsal external mould, UQF82770, x1.5. holotype. See Fig. 11. E, broken dorsal external mould, **UQF**. F, dorsal external mould, **UQF** x2.

from the band above the Big Strophalosia Band, and from the upper Mangarewa Formation of New Zealand. *Terrakea etheridgei* (Briggs, 1998, Fig. 86) is also close, coming from South Marulan, in beds of less well-established age, though rated as being younger

Fig. 10. *Terrakea macrospina* n. sp. A, detail of ornament on ventral external mould, **UQF** x2

than the *Echinalosia ovalis* Zone by Briggs (1998), as discussed further on p. . It has large ears and a very gently concave dorsal disc approaching that of *T. elongata planidisca* n. subsp. (see p.), but the ventral valve is not elongate. Moderately strong erect spines lie crowded over the ventral ears and ventral umbonal slopes, dorsal trail and posterior lateral

Fig. 11. *Terrakea macrospina* n. sp., lateral aspect of dorsal internal mould, UQF 82770**,** x 2.5. Holotype. See Fig. 10D.

slopes of *etheridgei*, but are not as strong as those of the present species, and as in the present form ventral spine bases are short.

Similar transverse specimens with similarly disposed strong erect spines were described by Waterhouse & Vella (1965) from the Flowers Formation of northwest Nelson, New Zealand, as in the synonymy. These overall are smaller, and the spines reduced in size, compared with present specimens, presumably betokening less favourable conditions for growth, but relative dimensions are scaled down, and overall the similarity is strong. Full comparison is hindered by the crushed and subschistose nature of the New Zealand material.

Superfamily **SPIRIFEROIDEA** King, 1846

Family **SPIRIFERIDAE** King, 1846

Subfamily **SPIRIFERALARIINAE** Waterhouse, 2016

Diagnosis: Large and transverse, cardinal extremities alate in type and nearby material from Texas, exterior apart from interareas covered by costae, plicae in several pairs, may fade anteriorly, micro-ornament of radial and transverse capillae. Subdelthyrial connector plate, adminicula and dental plates, no tabellae.

Discussion: Members of Spiriferalariinae are externally close to Neospiriferidae Waterhouse, 1968, but lack the external delthyrial cover plate and have a subdelthyrial connector plate like members of the Family Spiriferidae King. Only three incomplete ventral valves are known from the present fauna, with fragments, so that without the full shape, and without knowledge of the dorsal valve, it is difficult to determine the affinities of the specimens in the present collection. They are judged to be spiriferoid, because twoleached internal moulds show a well-developed subdelthyrial connector plate that is missing from most spiriferiform genera found in the Permian faunas of east Australia.

Spiriferalariin gen. & sp. indet.

Fig. 18, 19

Diagnosis: Large transverse shells with subrectangular outline and very wide hinge, ventral umbo of only moderate height, sulcus well defined, ventral plicae raised and more persistent, inner pair of plicae incorporated in the sulcus anteriorly, costae moderately high. Ventral muscle field large and elongately oval, dental plates and adminicula short, joined by subdelthyrial connector plate.

Material: Three broken ventral valves and fragments.

Description: One specimen is broadly subrectangular in shape, with well defined sulcus that is V-shaped in profile and widens at 25° , then broadens anteriorly and incorporate the inner pair of plicae. The hinge is at maximum width but cardinal extremities do not appear to have been markedly alate. Plicae are well defined posteriorly and moderately persistent, in four or five pairs, with several costae laterally. Costae are strong, typified by somewhat rounded crests, strengthening anteriorly. Fragments of external moulds show a micro-ornament of fine radial capillae crossed by more emphasized commarginal growth lines. On one of the other specimens, the ventral interarea is moderately high and only gently concave, and bears horizontal grooves, interrupted by a delthyrium with angle of over 30°, bordered by very low dental ridges.

Two specimens have been leached in HCl to show a large rhomboid or lozenge-shaped muscle field divided by a slender myophragm, with narrow ill-defined adductor ridges, and these pass anteriorly into several narrow grooves and ridges. The diductor scars are large and fine narrow grooves and ridges radiate from the adductors obliquely over the diductors. Adminicula are short and converge from the floor of the valve to support short and low subvertical dental plates. An irregular subdelthyrial connector plate lies between the junction of the adminicula with the dental plates, and is almost flat posteriorly and arched in front, marked by oblique growth lines. Fine closely spaced linear grooves lie over the thickened part of the posterior shell. There is no open network of vascular imprints of the pattern normally displayed in Trigonotretidae. A smaller specimen UQF shows a similar subdelthyrial plate concave towards the dorsal valve.

Resemblances: The specimens are too incomplete to allow secure identification, but as far as they are preserved, appear to differ from trigonotretid genera such as *Trigonotreta* Koenig, 1825 or allies such as *Aperispirifer* Waterhouse, 1968 which are common in the Middle Permian of east Australia. Unlike species of those genera, a connector plate is present and there is no swollen umbonal callosity. In addition, though less securely, there is no open network of vascular canals in the pattern normally displayed in Trigonotretidae.

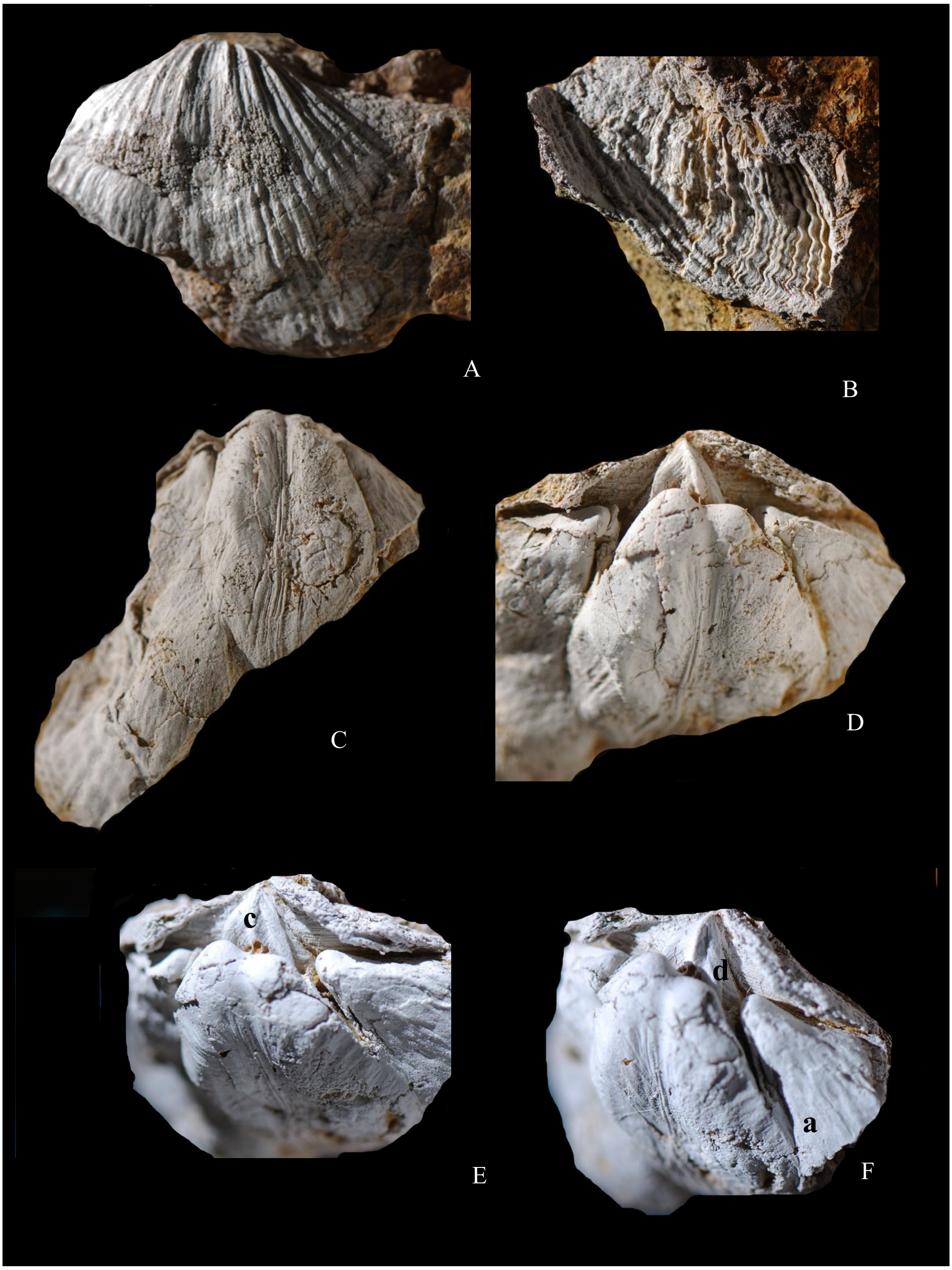

Fig. 18. Spiriferalariin sp. A, B, ventral valve UQF 69654, x1. A, external aspect, B, fragment of external mould. C-F, fragment of ventral internal mould **UQF** , showing detail of delthyrial area and connector plate. C, ventral aspect, x1. D-F, x 2.5. D, part of specimen x2.5. E, tilted aspect. F, lateral oblique aspect. a, adminiculum, c, connector plate; d dental plate.

Possibly this material is related to *Simplicisulcus* Waterhouse, 2002, p. 231, type species *Neospirifer arthurtonensis* Waterhouse, 1968 from the *Plekonella multicostata* Zone of New Zealand, a little younger than the present specimens, and possessing a subdelthyrial connector plate. But the New Zealand species has stronger costae and the innermost pair of plicae does not enter the sulcus anteriorly, unlike the arrangement in the present form. *S concentrica* (Waterhouse, 1987a, p. 21, pl. 4, fig. 7-13) from the Brae Formation of southeast Bowen Basin has a similarly constricted sulcus, and is smaller with comparatively fine costae, and diductor scars show ridges like those of the present material. A subdelthyrial plate connecting the dental plates where they join the adminicula was reported in the description (p. 22), though stated to be obscure in larger specimens. If the present Mantuan specimens are related, then they developed a larger size and broader anterior sulcus.

Fig. 19. Spiriferalariin sp., latex cast of delthyrial area with subdelthyrial plate , as shown in Fig. 18D-F, **UQF** x3.

source not known

Order SPIRIFERINIDA Ivanova, 1972

Suborder SPIRIFERINIDINA Ivanova, 1972

Superfamily **PENNOSPIRIFERINOIDEA** Dagys, 1972

Family **RETICULARIINIDAE** Waterhouse, 1975

Diagnosis: Transverse with fine plicae and well-defined sulcus and fold; micro-ornament of coarse hollow spines. In the dorsal valve the crural plates often unite to form a small cardinal plate with median ridge, and varying development of tabellae, as is also seen in some Paraspiriferinidae (Waterhouse 2020, p. 360).

Genus ***Reticulariina*** Fredericks, 1916

Diagnosis: As in diagnosis, without exceptional shape or features.

Type species: *Spirifer spinosus* Norwood & Pratten, 1855, p. 71 from Chesterian of Illinois, United States, OD.

***Reticulariina*? sp.**

Fig. 20

Material: A ventral valve.

Fig. 20. *Reticulariina*? sp. ventral valve, with arrows pointing to large punctae in the shell, **UQF**x4.

Description: The specimen has eight pairs of narrow high plicae, and large open-cored spines, as in *Reticulariina*, and fine dense punctae. Preservation is limited, and the distribution of spines not completely clear, although there is some suggestion that the spines are not limited to the crest of the plicae, unlike the arrangement in the northern hemisphere genus *Gjelispinifera* Ivanova, 1975. Only one specimen known, a pity because the genus is otherwise not known in east Australia. Spines are much coarser and fewer than in *Spiriferellina* Fredericks, 1924 or *Pustulospiriferina* Waterhouse, 1983 which are found in Permian faunas of east Australia.

Subfamily **MAORIELASMINAE** Waterhouse & Piyasin, 1970

Genus ***Maorielasma*** Waterhouse, 1964

Diagnosis: Shell large, teeth not supported by dental plates, foramen present. Dorsal valve with slender socket plates and well developed brachidium formed by inner hinge and crural (= outer hinge) plates, sessile as a rule.

Type species: *Maorielasma imperatum* Waterhouse, 1964, p. 175 from upper Mangarewa Formation, OD.

Maorielasma deflata n. sp.

Fig. 22

Derivation: deflatus – slender, deprived of thickness, Lat.

Diagnosis: Medium large but little inflated shells with full posterior shoulders, moderately long brachidium with anterior margin arching well forward.

Holotype: UQF 69659, Fig. 21A, here designated.

Material: The posterior part of a dorsal valve and a dorsal and ventral valve.

Dimensions in mm:

Width	Length	Height	
32.5	43	12	dorsal valve, UQF 69659
41	?48	14	ventral valve

Description: The ventral valve is large and not very inflated. It is broken and poorly preserved, but the dimensions can be estimated. A dorsal valve UQF 69659 shows extended dorsal umbo and well-defined growth steps. The interior is displayed on a leached fragment, which shows long narrow dental sockets, and tiny laminate cardinal process with median ridge extending anteriorly. The brachidium is large and almost sessile, with anterior margin arching forward, showing anterior growth lines over the anterior median section. Crural bases are widely spaced, lying close to the lateral margin. A very low broad ridge lies in front, with no visible median septum.

Resemblances: These specimens are assigned to a new species, even though material is sparse, because they are less inflated than other species found in immediately underlying faunas. The height of the specimens is much less than in *Maorielasma imperatum* Waterhouse, 1964 from the uppermost Mangarewa Formation, beds only slightly younger than the present suite. *M. imperatum* is very close to *M. globosum* Campbell, 1965. The distinctions suggested by Campbell between *globosum* and *M. imperatum* of the same age in New Zealand seem negligible. His assessment of age difference is incorrect, and his assumption that the brachidium in the New Zealand type for *imperatum* was shorter than in the Queensland specimens assigned to *globosum* seems unsustainable, the length of the

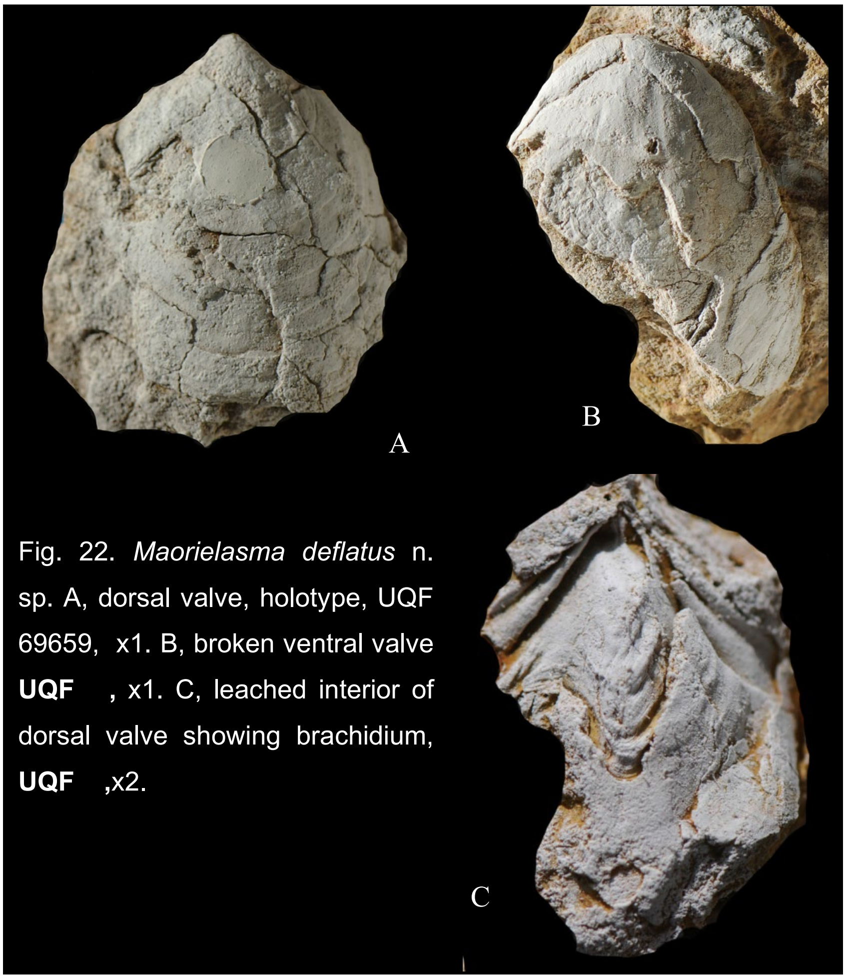

Fig. 22. *Maorielasma deflatus* n. sp. A, dorsal valve, holotype, UQF 69659, x1. B, broken ventral valve **UQF** , x1. C, leached interior of dorsal valve showing brachidium, **UQF** ,x2.

brachidium being much the same in both suites, with a length close to 0.4 in the type of *imperatum*, just the same as in *globosum*. The large umbonal foramen is found in both suites. The difference in size means little, the New Zealand specimens having a more compact ontogeny, consistent with other species. The shape of the New Zealand type is obviously affected by distortion on one side, to slightly compress the width, and some Australian specimens are narrower than others (Campbell 1965, pl. 14, fig. 13-15; Waterhouse, 1987a, pl. 13, fig. 22). The types of *globosum* came from the Mantuan Formation (Campbell 1965, pl. 4, fig. 13-16), whereas a slightly narrower specimen figured by Campbell (1965, pl. 14, fig. 13-15) came from the Scottville Member or Big Strophalosia Band, and is closer in width to *imperatum*, which came from the *Ingelarella costata* Zone in New Zealand. It seems to show a cardinal process like that of *imperatum* and the present material. The present specimens are less inflated and broader than in either *globosum* or *imperatum*.

Specimens from interval E in the GSQ Eddystone 1 bore attributed to *Maorielasma callosum* Campbell by McClung (1983, Fig. 11.1, 2) are small and do not show much similarity to the present specimens. *M. callosum* Campbell, 1965 from the Ingelara Formation, Peawaddy Formation and Flat Top Formation is less elongate than the preceeding three species, with a septalium extending for only 0.24 to 0.32 of the length of the dorsal valve.

FAUNAL CONTENT AND CORRELATION

The species described in this study are *Maxwellosia ovalis* (Maxwell), *Terrakea macrospina* n. sp., **Plekonella acuta* Campbell, *P. southlandensis* (Fletcher)?, Spiriferalariin gen. & sp. indet., ?*Reticulariina* sp., *Maorielasma deflata* n. sp., ****Promytilus mytiliformis*** **(Etheridge),** ***Etheriplica*** **sp.,** ***Stutchburia*** **sp.,** ****Platyteichum loratum*** **Waterhouse.** Asterisked species are found in allied faunas, chiefly the Flat Top Formation of the southeast Bowen Basin – **most are molluscs**. The faunal list is distinguished from that of the underlying Pelican Creek fauna and UQL 3515 from just above of the Scottville Member or Big Strophalosia Band by the absence of *Echinalosia* (*Unicusia*) *minima* (Maxwell), *Terrakea elongata* (Etheridge & Dun), *Geothomasia delicatula* n. sp., *Aperispirifer demulcatus* n. sp. and *Maorielasma imperatum* Waterhouse.

The New Zealand connection

A fauna allied to that of the *Terrakea macrospina* Zone in the north Bowen Basin is found in northwest Nelson, New Zealand. This was not part of the Gympie-New Zealand volcanic arc, but part of mainland Australia, transferred by continental displacement through the opening of the Tasman Sea to form what is called the Takaka terrane in New Zealand. The fauna was discovered and described by Waterhouse & Vella (1965), and stratigraphy was further elaborated by Campbell et al. (1998). As discussed in Waterhouse (2002, p. 144), it is preferred to retain major aspects of the Waterhouse-Vella stratigraphic classification, in which coarse clastic sediments are separated from fine-grained sediment, which means that the fossils come from the Flowers Formation as originally determined.

As indicated in the preceeding synonymies, the Flowers fauna includes a gastropod *Peruvispira* with faint radial ornament, suggesting *Peruvispira filiporta*. The fauna includes

Mesopunctia spinosa (Waterhouse & Vella), a distinctive species not found in Australia (Waterhouse 1998, pp. 41, 42),

FOSSIL LOCALITIES

No UQL numbers are assigned by the Queensland Museum. But the fossil specimens were collected from two localities, described as follows:

UQF 69654 - Anabranch of Peawaddy Ck., Mantuan Formation (recorded as the Mantuan Productus bed of the of the Peawaddy Formation). In Consuelo Holding 30km SW of Rolleston.

UQF 69655 to UQF69659 – 5.6km WNW of Consuelo Homestead, Permian, Peawaddy Fmn. (recorded as the Mantuan Productus Bed, in Consuelo Holding 30km SW of Rolleston.

ACKNOWLEDGEMENTS

Kristen Spring, Queensland Museum, greatly assisted with the assignation of registration numbers. The material was collected by L. G. Elliott in the course of preparing an Honours thesis at the Department of Geology & Mineralogy, University of Queensland.

REFERENCES

ARCHBOLD, N. W., THOMAS, G. A. 1986: Permian Ingelarellidae (Brachiopoda) from Western Australia and Argentina. J. Paleont. 60: 581-605.

ARMSTRONG, J. D. 1970: Micro-ornaments of the spiriferid brachiopods *Notospirifer, Ingelarella* and *Subansiria*. Lethaia 3: 287-300.

BEURLEN, K. 1954: Las faunas lamellibranchios do sistema Genduanicos no Parana. *In* F. W. Lange (ed.). Paleontologia do Parana. Comissao de Comemoraçaos do Centenareo Parana, Curutiba: 107-136, 7pl.

BOOKER, F. W. 1930: A review of some of the Permo-Carboniferous Productidae of New South Wales, with a tentative reclassification. J. Proc. Roy. Soc. New South Wales 64: 65-77.

BRIGGS, J. D. C. 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and the New England orogen: systematics and biostratigraphic significance. Mem.

Assoc. Aust'asian Palaeont. 19.

BRUNTON, C. H. C. 1966: Silicified productoids from the Visean of County Fermanagh. Bull. Brit. Mus. (Nat. Hist.) Geol. 12 (5): 155-243.

CAMPBELL, K. S. W. 1953: The fauna of the Permo-Carboniferous Ingelara beds of southeast Queensland. Pap. Dep. Geol. Univ. Qld 4 (3): 1-44.

_____ 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. Palaeontology 1: 333-350.

_____ 1960: The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. J. Paleont. 34: 1106-1123.

_____ 1965: Australian Permian terebratuloids. Bull. Bur. Mineral Resour. Geol. Geophys. 68.

CHRONIC, J. 1949: *In* NEWELL, N. D., CHRONIC, J., ROBERTS, T. G.: Upper Paleozoic of Peru. New York: 1-241. See also Mem. Geol. Soc. Amer. 58 (1953).

CLARKE, M. J. 1987: Late Permian (Late Lymingtonian = ?Kazanian) brachiopods from Tasmania. Alcheringa 11: 261-289.

_____ 1992: A new notospiriferine genus (Spiriferida: Brachiopoda) from the Permian of Tasmania. Pap. Proc. Roy Soc. Tas. 126: 73-76.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DAGYS, A. S. 1972: The occurrence of a Metachoresa in a Triassic spiriferinid. *In* Problems of Paleozoogeography in the Mesozoic of Siberia. Akad. Nauk SSSR, Sibir. Otdel. Inst. Geol. Geofiz. Tr. 111: 34-44, 4 fig. [Russ.]

DALL, W. H. 1898: Contributions to the Tertiary fauna of Florida with especial reference to the Miocene Silex beds of Tampa and the Pliocene beds of the Caloosahatchie River, including in many cases a complete revision of the generic groups treated and of their American Tertiary Species. Part 1V. 1. Prionodesmacea*: Nucula* to *Julia.* 2. Teleodesmacea: *Teredo* to *Ervillea*. Wagner Free Inst. Sci. Philadelphia, Trans. 3 (4): i-viii, p. 571-947, pl. 23-35.

DANA, J. D. 1847: Descriptions of fossil shells of the collections of the exploring expedition under the command of Charles Wilkes U. S. N. obtained in Australia, from the lower layers of

the coal formation in Illawarra, and from a deposit probably of nearly the same age at Harper's Hill, valley of the Hunter. Amer. J. Sci. (ser. 2) 4: 151-160.

_____ 1849: Fossils of New South Wales. *In* United States Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes, U. S. N. vol. 10 – Geology, Appendix 1: 681-720. C. Sherman, Philadelphia.

DEAR, J. F. 1972: Preliminary biostratigraphic subdivision of the Permian brachiopod faunas in the northern Bowen Basin and their distribution throughout the basin. Rep. Geol. Surv. Qld 49: 1-19.

DICKINS, J. M. 1961: The gastropod *Platyteichum* in the Permian of Western Australia. Palaeontology 4: 131-137.

_____1983: The Permian Blenheim Subgroup of the Bowen Basin and its Time Relationships. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 269-274.

_____1989: Youngest Permian marine macrofossil fauna from the Bowen and Sydney Basins, eastern Australia. BMR J. Aust. Geol. Geophys. 11: 63-79.

DRAPER, J. J. 2013. The Bowen Basin. *In* P. A. Jell (ed.) Geology of Queensland: 371-384. Dep. Nat. Resources & Mines, Brisbane.

DUMÉRIL, A. M. C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux: xxiv + 344pp. Allais, Paris.

ETHERIDGE, R. Jnr 1892: *In* JACK, R. L., ETHERIDGE, R. Jnr Geology and Palaeontology of Queensland and New Guinea. Publ. Geol. Surv. Queensland 92: 1-766, 68pl.

_____ 1900: Little known and undescribed Permo-Carboniferous Pelecypoda in the Australian Museum. Rec. Aust. Mus. 3: 178-187.

ETHERIDGE, R. Jnr, DUN, W. S. 1909: Notes on the Permo-Carboniferous Producti of eastern Australia, with synonymy. Rec. Geol. Surv. New South Wales 8: 293-304.

FERUSSAC, A. E. J. d'AUDEBARD de 1821-1822: Tableaux Systématiques des Animaux Mollusques suivis d'un Prodrome Général pur tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles. Première Partie, Tableaux Systématiques Généraux. Arthus-Bertrand, Paris; J. B. Sowerby, London. (See Carter et al. 2011, pp. 35, 36).

FLETCHER, H. O. 1952: *In* FLETCHER, H. O., HILL, D., WILLETT, R. W. Permian fossils from Southland. N. Z. Geol. Surv. Palaeont. Bull. 19: 1-17, pl. 1, 2.

_____ 1958: The Permian gastropods of New South Wales. Rec. Aust. Mus. 24: 115-164.

FREDERICKS, G. 1916: The Palaeontological Notes. 2. On some Upper Palaeozoic Brachiopoda of Eurasia. Mém. Géol. Com. 156: 88p., 5pl. [Russ.]

_____ 1924: Paleontological Studies 2. On the Upper Carboniferous spiriferids from the Urals. Izvest. Geol. Kom. 38 (3): 295-324.

GRADSTEIN, F. M., OGG, J. C., SCHMITZ, M. D., OGG, C. M. 2012: The Geologic Time Scale 2012. Elsevier, Amsterdam

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

GROBBEN, C. 1894: Zur Kenntniss der Morphologie, der Verwandtschafts-verhältnisse und des systems der Mollusken. Sitzbericht. K. Akad. Wiss. (Math.-Naturwiss. Cl.) 103 (1): 61-86.

HARRINGTON, H. J. 1955: The Permian *Eurydesma* fauna of eastern Argentina. J. Paleont. 29: 112-128.

HILL, D., PLAYFORD, G., WOODS, J. T. 1972: Carboniferous fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

HILL, D., WOODS, J. T. 1964: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

ISBELL, R. F. 1955: The geology of the northern section of the Bowen Basin. Pap. Dep. Geol. Univ. Qld 3 (11): 1-43.

IVANOVA, E. A. 1972: Main features of spiriferid evolution (Brachiopoda). Paleont. Zhurn. 1972 (3): 28-42. [Russ.]

_____1975: Some Carboniferous Spiriferinida of the Moscow Basin. Paleont. Zhurn. 1975 (2): 79-88. [Russ.]

JIN YUGAN 1976: See ZHANG & JIN.

KING, W. 1846: Remarks on certain genera belonging to the class Palliobranchiata. Ann. Mag. Nat. Hist. London 18: 26-42, 83-94.

KNIGHT, J. B. 1956: New families of Gastropoda. J. Washington Acad. Sci. 46 (2): 41, 42.

KOPPE, W. H. 1974: The Exmoor Formation – An addition to stratigraphic nomenclature in the North-western Bowen Basin. Qld Gov. Min. J. 75: 280-285.

KUHN, O. 1949: Lehrbuch der Paläozoologie: v + 326p. E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart.

LAMARCK, J. B. P. A de M. de 1809: Philosophie zoologique, ou exposition des considérations relatives à l'histoire naturelle des animaux, la diversité de leur organization et des facultés qu'ils en obtiennent, aux causes physiques qui maintennent en eux la vie, et donnent lieu aux mouvements qu'ils exécutent; enfin, à celles qui produisent les unes les sentiments, et les autres l'intelligence de ceux qui sont doués. 2 vols: 1-422, 1-473. Paris.

LAURIE, J. R., BODORKOS, S, NICOLL, R. S., CROWLEY, J. L., MANTLE, D. J., MORY, A.J., WOOD, G. R., BACKHOUSE, J., HOLMES, E. K., SMITH, T. E., CHAMPION, D. C. 2016: Calibrating the middle and late Permian palynostratigraphy of Australia to the geologic time scale via U–Pb zircon CA-IDTIMS dating. Aust. J. Earth Sci. 63: 701-730.

LICHAREW, B. K. 1956: Brachiopoda. *In* L. D. Kiparaisova, B. P. Markovsky, G. P. Badchenko (ed.) Min. Geol. Okhran. Ndr. Moscow 12, n. sp. Paleont.: 5, 53, 56-61, 64-70. [Russ.]

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MALONE, E. J., CORBETT, D. W. P., JENSEN, A. R. 1964: Geology of the Mount Coolon 1:250,000 Sheet area. Bur. Min. Res. Geol. Geophys. Rep. 64: 1-78, 15pl. + maps & sections (as in plates)

MALONE, E. J., JENSEN, A. R., GREGORY, C. M. 1966: Geology of the southern half of the Bowen 1:250,000 sheet area, Queensland. Rep. Bur. Mineral Resourc. Geol. Geophys. 100.

MARWICK, J. 1953: Divisions and faunas of the Hokonui System. N. Z. Geol. Surv. Paleont. Bull. 21.

MAXWELL, W. G. H. 1954: *Strophalosia* in the Permian of Queensland. J. Paleont. 28: 533-559.

McCLUNG, G.1981: Review of the stratigraphy of the Permian Back Creek Group in the Bowen Basin, Queensland. Geol. Surv. Qld Pub. 371. Palaeont. Pap. 44.

_____ 1983: Faunal sequence and palaeoecology in the marine Permian in G. S. Q. Eddystone 1, Denison Trough, Queensland. Geol. Surv. Qld Pub. 384: 43-80.

MCCLUNG, G., ARMSTRONG, J. D. 1978: Species of *Glendonia* gen. nov. (Ingelarellinae: Spiriferida) in the Permian of eastern Australia. Geol. Surv. Qld Pub. 365. Palaeont. Pap. 39: 1-5, 2pl.

M'COY, F. 1847: On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist.(ser. 1) 20: 145-157, 226-236, 298-312.

MEEK, F. B., WORTHEN, A. H. 1866: Descriptions of invertebrates from the Carboniferous System. Illinois Geol. Surv. 2: 143-411.

METCALFE, I., CROWLEY, J. L., NICOLL, R. S., SCHMITZ, M. 2015: High-precision U-Pb CA-TIMS calibration of Middle Permian to Lower Triassic sequences, mass extinction and extreme climate-change in eastern Australian Gondwana. Gondwana Research 28 (2015): 61-81.

MORRIS, J. 1845: Descriptions of fossils. *In* STRZELECKI, P. E. de Physical description of New South Wales and Van Diemen’s Land: 270-291. Longman, Brown, Green & Longman, London.

MUIR-WOOD, H. M., COOPER, G. A. 1960: Morphology, classification and life habits of the Productoidea (Brachiopoda). Geol. Soc. Amer. Mem. 81.

NEWELL, N. D. 1942: Late Paleozoic pelecypods: Mytilacea. Kansas Geol. Surv. Rep. 10 (2).

NORWOOD, J. G., PRATTEN, H. 1855: Notice of fossils from the Carboniferous Series of the western states, belonging to the genera *Spirifer, Bellerophon, Pleurotomaria, Macrocheilus, Natica* and *Loxonema*, with descriptions of eight new characteristic species. J. Acad. Nat. Sci. Philadelphia (ser. 2) 3: 71-77.

PARFREY, S. M. 1988: Biostratigraphy of the Barfield Formation, southeastern Bowen Basin, with a review of the fauna from the Ingelara and lower Peawaddy Formations, southwestern Bowen Basin. Rep. Qld Dep. Mines 1.

RAFINESQUE, C. S. 1815: Analyse de la Nature ou Tableau de l’Úniversité et de Corps organisés etc: 223p. Jean Barravecchia, Palermo.

RUNNEGAR, B. N., FERGUSON, J. A. 1969: Stratigraphy of the Permian and Lower Triassic sediments of the Gympie District, Queensland. Pap. Dep. Geol. Univ. Qld 4 (9): 247-281.

RUNNEGAR, B. N., McCLUNG, G. R. 1975: A Permian time scale for Gondwanaland. *In* K.

S. W. Campbell (ed). Gondwana Geology: 425-441. Papers presented at the Third Gondwana Symposium, Canberra, Australia, 1973. Aust. Nat. Univ. Press, Canberra.

SCHUCHERT, C. 1913: Class 2. Brachiopoda. *In* ZITTEL, K. A. von Text-book of Paleontology, vol. 1, part 1, 2nd ed., translated and edited by C. R. Eastman: 355-420, fig. 526-636. MacMillan & Co. Ltd, London.

SMITH, T.E., BERNECKER. T., BODORKOS, S., GORTER, J., HALL, L. S., HILL, T., HOLMES, E., KELMAN, A., KHIDER, K., LAURIE, J., LECH, M., MCKELLAR, J., MORY, A., NICOLL, R., OWENS, R., PALU, T.J., PHILLIPS, L., STEPHENSON, M., WOOD, G., 2017: The impact of recalibrating palynological zones to the chronometric timescale: revised stratigraphic relationships in Australian Permian and Triassic hydrocarbon-bearing basins. Poster given at AAPG/SEG 2017 International Conference and Exhibition, London, England, October 15–18, 2017.

SOWERBY, G. B. 1844: Palaeozoic shells from Van Diemen's Land. *In* DARWIN, C. Geological Observations on the volcanic islands visited during the voyage of H.M.S. Beagle. Geol. Voy. Beagle, pt 2: 158-160. London.

SWAINSON, W. 1840: A Treatise on Malacology of the Natural classification of shells and shell fish. VIII: 419p.

TERMIER, H., TERMIER, G. 1950: Paléontologie Marocaine. 2, Invertébrés de l'ère Primaire. Fascicule 3, Mollusques. Serv. Geol. Maroc. Notes et Mem. 78: 246p., pl. 123-183. Herman,Paris.

TRECHMANN, C. T. 1917: The age of the Maitai Series of New Zealand. Geol. Mag. dec. 6 4: 53-64.

WAAGEN, W. 1883: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (2): 391-546.

WASS, R. E., GOULD, I. G. 1969: Permian faunas and sediments from the South Marulan district, New South Wales. Proc. Linnean Soc. New South Wales 93: 212-226.

WATERHOUSE, J. B. 1963a: Permian gastropods of New Zealand. Part 2 – Pleurotomariacea (in part). N. Z. J. Geol. Geophys. 6 (1): 115-154.

_____1963b: Permian gastropods of New Zealand. Part 3 – Pleurotomariaceaa (concluded). N. Z. J. Geol. Geophys. 6 (4): 587-622.

_____ 1964: Permian brachiopods of New Zealand. N. Z. Geol. Surv. Paleont. Bull. 35: 1-287, 37pl.

_____ 1967a: Proposal of Series and Stages for the Permian in New Zealand. Trans. Roy. Soc. N. Z. Earth Sci. 5: 161-180.

_____ 1967b: Upper Permian (Tatarian) brachiopods from New Zealand. N. Z. J. Geol. Geophys. 10: 74-111.

_____ 1968: The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. Palaeontographica A 129: 1-94.

_____ 1975: New Permian and Triassic brachiopod taxa. Pap. Dep. Geol. Univ. Qld 7 (1): 1-23.

_____ 1980: Permian bivalves from New Zealand. J. Roy. Soc. N. Z. 10: 97-133.

_____ 1982a: New Zealand Permian brachiopod systematics, zonation and paleoecology. N. Z. Geol. Surv. Paleont. Bull. 48.

_____ 1982b: Permian Pectinacea and Limacea (Bivalvia) from New Zealand. N. Z. Geol. Surv. Paleont. Bull. 49.

_____ 1983: New Permian invertebrate genera from the east Australian segment of Gondwana. Bull. Ind. Geol. Assoc. 16: 153-158.

_____ 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 1987a: Late Palaeozoic Brachiopoda (Athyrida, Spiriferida and Terebratulida) from the southeast Bowen Basin, eastern Australia. Palaeontographica A 196 (1-3): 1-56.

_____ 1987b: Late Palaeozoic Mollusca and correlations from the southeast Bowen Basin, east Australia. Palaeontographica A 198 (4-6): 129-233.

_____ 1998: Ingelarelloidea (Spiriferida: Brachiopoda) from Australia and New Zealand, and reclassification of Ingelarellidae and Notospiriferidae. Earthwise 1: 1-46.

_____ 1999: Some Permian spiriferidan species (Brachiopoda) from New Zealand and Queensland. Earthwise 2: 1-16.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of

Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2002: The stratigraphic succession and structure of Wairaki Downs, New Zealand, and its implications for Permian biostratigraphy of New Zealand and marine Permian of eastern Australia and Gondwana. Earthwise 4: 1-260.

_____ 2008a: Aspects of the evolutionary record for fossils of the bivalve subclass Pteriomorphia Beurlen. Earthwise 8: 1-219.

_____ 2008b: Golden spikes and black flags – macroinvertebrate faunal zones for the Permian of east Australia. Proc. Roy. Soc. Victoria 120 (1): 345-372.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

_____ 2013: The evolution and classification of the Productida. Earthwise 10: 1-535.

_____ 2015a: Early Permian Conulariida, Brachiopoda and Mollusca from Homevale, central Queensland. Earthwise 11: 1-390.

_____ 2015b: The Permian faunal sequence at Gympie, southeast Queensland, Australia. Earthwise 12: 1-196.

_____2016: On the evolution and classification of Spiriferida (Brachiopoda). Earthwise 14: 1-434.

_____ 2020: Permian brachiopods (upper Artinskian to Wordian) from the Canadian Arctic. Earthwise 17: 1-479.

WATERHOUSE, J. B., JELL, J. S. 1983: The sequence of Permian rocks and faunas near Exmoor Homestead, south of Collinsville, north Bowen Basin. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 231-267.

WATERHOUSE, J. B., PIYASIN, S. 1970: Mid-Permian brachiopods from Khao Phrik, Thailand. Palaeontographica 125A: 83-197.

WATERHOUSE, J. B., VELLA, P. 1965: Permian fossils from Parapara Peak, northwest Nelson. Trans. Roy. Soc. N. Z. Geol. 3 (5): 57-84.

WENZ, W. 1938: Gastropoda. Allgemeine Teil und Prosobranchia. *In* O. H. Schindewolf (ed.) Handbuch der Paläozoologie, Band 6. Teil 3: 481-720. Berlin.

WILLIAMS, A., CARLSON, S. J., BRUNTON, C. H. C., HOLMER, L. E., POPOV, L. E. 1996: A Supra-ordinal classification of the Brachiopoda. Philosoph. Trans. Roy. Soc. London (ser. B) 351: 1171-1193.

5. BRACHIOPODS AND MOLLUSCS FROM THE SCOTTVILLE MEMBER, *Pseudostrophalosia clarkei* Zone, NORTH BOWEN BASIN, QUEENSLAND

Abstract

Brachiopods and bivalves are recorded from the Big Strophalosia "Zone" or Band, also called Scottville Member, in the north Bowen Basin. The zone appears to be limited to this region, not known in the rest of the Bowen Basin, or in New Zealand, and appears to represent a short-lived very cold phase in the history of the period: it is thus represented apparently by a single and outstanding fossil community. The zone is deemed to be of late Capitanian age, and despite some recent views to the contrary, younger than the widely developed *Maxwellosia ovalis* and *Pseudostrophalosia blakei* biozones, which underlie the *clarkei* zone in the northern Bowen Basin.

INTRODUCTION

One of the striking geological features in the marine Permian of the north Bowen Basin in Queensland is the "Big Strophalosia Zone", named for a band crowded with shells of *Pseudostrophalosia clarkei* (Etheridge) and varying from 18m to 30m thick, as well displayed along the banks of the Bowen River. Large glacial erratics were figured by Reid (1929, Fig. 35a, b). No comprehensive systematic study has been published for the fossils of the Big Strophalosia Zone, or as I prefer, Band, but underlying brachiopods and molluscs have been systematically described and correlated by Waterhouse & Jell (1983), and beds below those studied in Waterhouse & Jell (1983) have yielded faunas monographed by Waterhouse (1983; 2015), to cover the Tiverton Formation. Dickins (1989) criticized that study in a manner difficult to follow, but it is suggested that the Waterhouse-Jell article be read for what it says, not for what Dickins claimed. He did consider that his postulated Fauna 111a was emblematic of Fauna 111, but Waterhouse & Jell disagreed, showing that "Fauna 111a" was basically close to Dickins so-called Fauna 11, and that it was so-called Fauna 111b which was much more distinctive.

Unfortunately, little material is available for the present study, but an attempt is made to circumscribe the fauna, based on previous studies and what is presently available. An article by Runnegar (1968) is particularly useful in providing a faunal list for brachiopods and bivalves, and is included in synonymies where no other evidence is available.

Locality detail, northern Bowen Basin

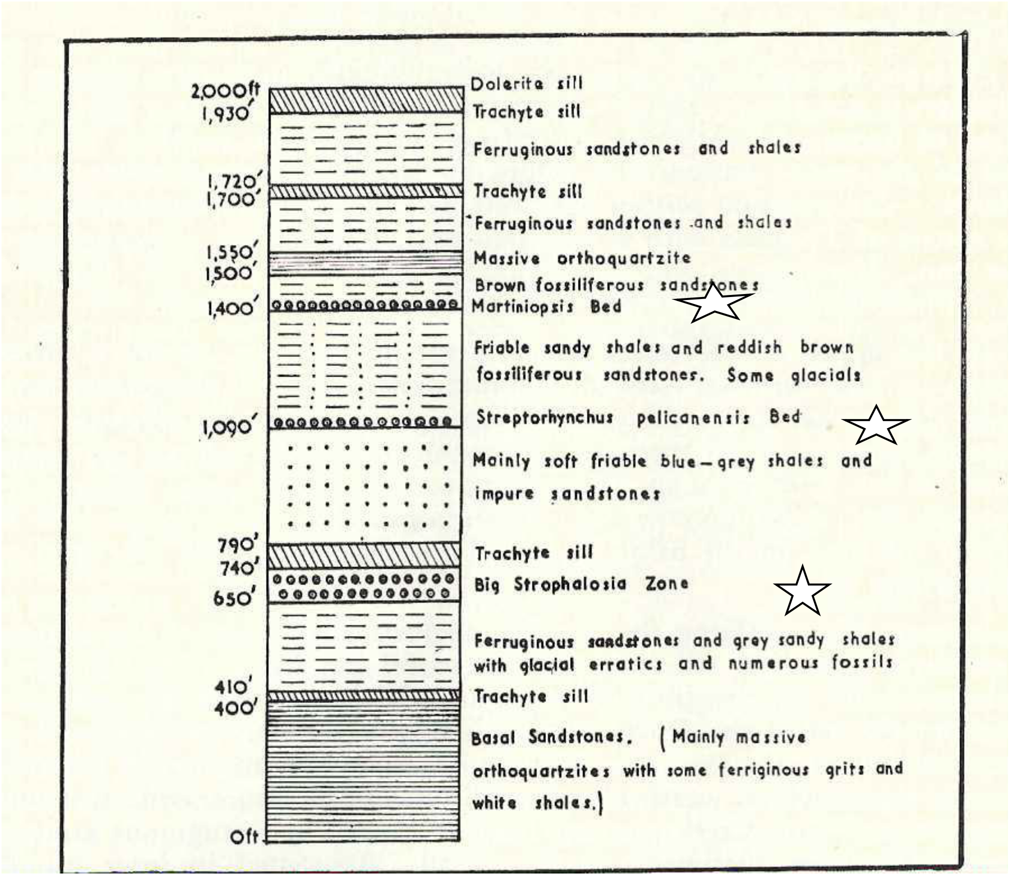

Fig. 1. Stratigraphic section at Parrot Creek, west of Havilah, north Bowen Basin, as presented by Isbell (1955, Fig. 1). The present article summarizes the fauna from the “Big Strophalosia Zone”, now named Scottville Member. The following article describes the brachiopods and molluscs from above this interval up to and including the “*Streptorhynchus pelicanensis* Bed.” The next article centres on a fauna chiefly above from the “*Martiniopsis havilensis* Bed”. These levels are starred in the figure.

UQL 1368. Scottville Member, 0.8km west of Mulgrave cattle yards. Bowen Sheet.

UQL 1760.

UQL 3136. *Strophalosia clarkei* band, in creek two thirds of a mile south of Wollombi Station, east of Peak Downs. Clermont Sheet, 148°, 17’ E, 22° 57S.

UQL 4657. The Big Strophalosia Band or Scottvile Member exposed along north (east) bank of Bowen River east of Exmoor Homestead, near middle of the band. Collected by J. S. Jell and J. B. Waterhouse.

SYSTEMATIC STUDIES

Phylum Brachiopoda Duméril, 1806

Subphylum Rhynchonelliformea Williams et al., 1996

Class Strophomenata Williams et al., 1996

Superorder PRODUCTIFORMI Waagen, 1883

Order PRODUCTIDA Waagen, 1883

Suborder STROPHALOSIIDINA Waterhouse, 1975

The treatment of the Suborder Strophalosiidina by Brunton et al. (2000) in the *Revised Brachiopod Treatise* substantially betrays the standards espoused by the Treatise series on Invertebrate Paleontology. Already, a preliminary article by Brunton et al. (1995) had claimed that Waagen (1883) had named the suborder. Not so: Waagen did not even separate *Strophalosia* as a separate subfamily. In 2000, Brunton et al. (2000) shifted ground: Now the author was supposed to be Schuchert (1913), and they claimed – falsely – that that had been established by Brunton et al. (2000). Schuchert had in fact established only the subfamily Strophalosiinae. After the main heading, and in small print, Brunton et al. (2000, p. 565) stated that the suborder was to be interpreted as set out by Lazarev (1989) and explicitly denied the view offered in the original proposal and definition by Waterhouse (1975, 1978). Waterhouse had included Richthofenioidea in the suborder, and excluded Lyttonioidea, whereas Lazarev (1987, p. 48; 1989; 1990, p. 77) had excluded Richthofenioidea and included Lyttonioidea. In spite of what Brunton et al. (2000, p. 575) claimed, the *Revised Brachiopod Treatise* did not follow Lazarev, and did follow Waterhouse, by including Richthofenioidea in Strophalosiidina and excluding Lyttonioidea which was recognized as a separate suborder. The Waterhouse view was separately acknowledged in an article purporting to be by Brunton, Lazarev & Grant (2000, p. 351), but Lazarev (2003, p. 492) complained that he had not checked that particular text, and evidently disagreed, though precisely with what was not explained. It is disheartening that authors – and it should be remembered that by then R. E. Grant was dead, and Jin Yugan had played no part in writing any of the text – should stoop to such misrepresentation. In this section of the *Revised Brachiopod Treatise*, at least one contributor – obviously the one who submitted and checked the text, deliberately misrepresented authorship and concept, even though I had explained by email to HJCB the nomenclatural history, in an effort to correct mis-statements in Brunton et al. (1995). That is unethical, and should not be tolerated, especially in science and perhaps even more so for Treatises, which purport – as well would all hope - to be an honest and impartial summary of what has been published. In this case, the values of the Treatise had been betrayed. There is no reason to suppose that the Editor-in Chief, Alwyn Williams, bore any responsible, and anyone must feel at a considerable loss to explain why the author of the lies – it is obvious who – should so attempt to corrupt the science.

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYASIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Tribe **WYNDHAMIINI** Waterhouse, 2010

Genus ***Pseudostrophalosia*** Clarke, 1970

Diagnosis: Large suboval shells, the ventral valve moderately to well inflated with small cicatrix and dense semirecumbent to recumbent spines generally arranged in commarginal rows, in two series over disc and trail, and, as prime characteristic, close-set coarse spines clustered over the ventral ears. Dorsal valve may be heavily thickened, especially anteriorly, to become wedge-shaped, with numerous fine usually erect spines.

Type species: *Strophalosia brittoni* Maxwell, 1954, p. 543 from Tiverton Formation (Sakmarian), Bowen Basin, OD.

Discussion: There is an upward drift in morphology amongst species assigned to this genus. The cluster of spines over the ventral ears is not so well developed in the late Middle Permian species *Pseudostrophalosia clarkei* as compared with the ear spines in the Early Permian type species, *Ps. brittoni*, as shown on the left side of a figure of *clarkei* provided by Briggs (1998, Fig. 61A). In several specimens amongst the collection surveyed herein, a very few large spines emerge from especially the anterior ventral ears. In addition, the ventral spines of *clarkei* are more varied in diameter and distribution than in *brittoni*, and dental buttresses are much better and more consistently developed in older species, such as *Ps. brittoni*.

Pseudostrophalosia clarkei (Etheridge Snr, 1872)

Fig. 1-3

1872 *Productus Clarkei* Etheridge Snr, p. 334, pl. 17, fig. 2, a, b.
?1877 *P. Clarkei* – de Koninck, p. 203, pl. 10, fig. 5 (part).
1880 *Strophalosia Clarkei* – Etheridge, p. 27, pl. 9, fig. 18a, 19, 20, 21, pl. 10, fig. 22, 23-25, 28, pl. 12, fig. 32, 33? (part, pl. 10, fig. 23-25, pl. 11, fig. 29-31 = *ovalis* fide Dear 1971).
1880 *S. Gerardi* [not King] – Etheridge, p. 32, pl. 12, fig. 34-37, pl. 13, fig. 38 (fide Dear 1971).
1892 *S. Clarkei* – Etheridge, p. 258, pl. 13, fig. 12,13, 15,16, 17, pl. 14, fig. 19 (part, not pl. 13, fig. 14, 16, 17 = *ovalis* fide Dear 1971). Dear included pl. 13, fig. 13-15 as *clarkei* and Briggs considered that pl. 13, fig. 12, 16, 17 = *crassa*.
1892 *S. Gerardi* [not King] – Etheridge, p. 260, pl. 13, fig. 14, pl. 14, fig. 18 (part, not pl. 40, fig. 7, 8 (= possibly *ovalis* s. l.)
1929 *S. clarkei* – Reid, fig. 28.
1954 *S. clarkei* - Maxwell, p. 546, pl. 56, fig. 1-7.
1964 *S. clarkei* – Hill & Woods, pl. P4, fig. 11, 12.
1970b *W. clarkei* – Armstrong, p. 13ff, pl. 1-3, text-fig. 1.
1971 *W. clarkei* – Dear, p. 11.
1972 *W. clarkei* – Hill et al., pl. P4, fig. 11, 12.
1983 *W. clarkei* – Waterhouse & Jell, pp. 236, 238.
1998 *Pseudostrophalosia clarkei* – Briggs, p. 116, Fig. 61.
2001 *Ps. clarkei* – Waterhouse, p. 79.
2008 *Ps. clarkei* – Waterhouse, p. 367.

Comment: The synonymies provided for *clarkei* by Maxwell (1954), Dear (1971) and Briggs (1998) differ from author to author and seem to include a few omissions and errors. The specimens need to be re-examined at first hand, a task beyond the scope of the present study, and although tentative synonymies for nineteenth century references are suggested in the preceeding synonymy, they are highly provisional, and not based on first-hand inspection.

Diagnosis: Moderately large for the genus, ventral valve convex but not strongly inflated with median curvature diminished in a number of specimens, dorsal valve thinly wedge-shaped and gently concave to flat, small ears well developed in both valves, sharply separated from remainder of disc. Ventral spines in two series, one series fine and low-angle recumbent, the other series coarse and erect, especially prominent posteriorly, but spines may be more varied in diameter; dorsal spines fine and erect. Ventral adductor platform elongate, elevated in mature specimens, diductor scars lightly to moderately impressed, prominent in shells of late maturity, teeth large, dental buttresses variably present (less developed than in older species), spine tunnels may be prominent within ventral valve, as a rule not conspicuous.

Lectotype: Specimen QMF 2887 from Scottville Member (= Big Strophalosia Band), figured by Etheridge Snr (1872, pl. 17, fig. 2), Maxwell (1954, pl. 56, fig. 5, 6), Hill & Woods (1964, pl. P4, fig. 11), and Hill et al. (1972, pl. P4, fig. 11), SD Maxwell (1954, p. 546).

Material: A few specimens come from the Scottville Member at UQL 3136 and 4657.

Description: Ventral valve weakly convex but possibly crushed, and the dorsal valve is gently concave, with low anterior median fold, and no visible trail. The hinge is less than the maximum width which lies near mid-length, and small well-formed ears are developed on each valve, generally with sharply obtuse cardinal extremities. The ventral interarea lies largely in the plane of the commissure, bearing light striae parallel to the hinge, which are disrupted medianly by a narrow raised pseudodeltidium with angle close to 10°. Ventral

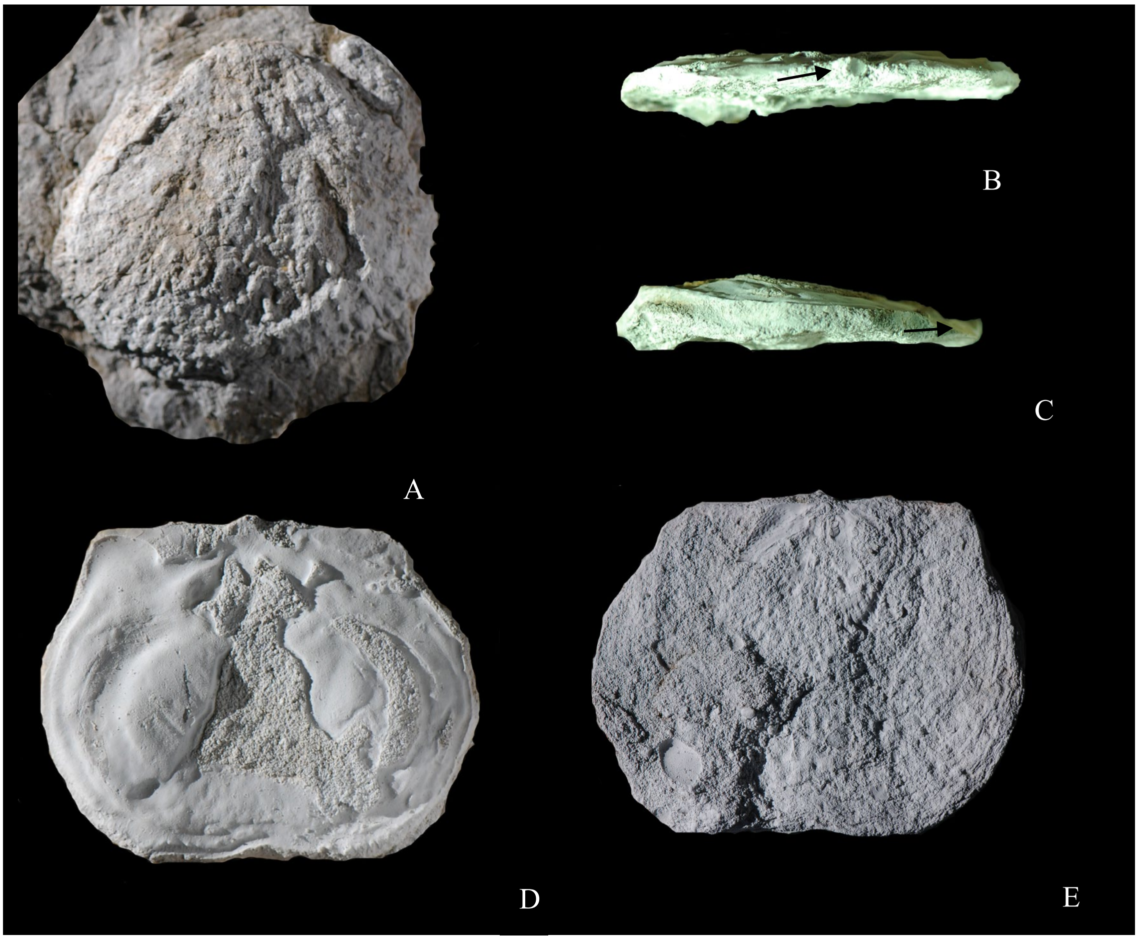

Fig. 1. *Pseudostrophalosia clarkei* (Etheridge) from Scottville Member, UQL 4657, x1. A, ventral valve **UQF** from UQL 4657. B-E, dorsal valve **UQF** from UQL 3136. B, posterior aspect, cardinal process arrowed. C, lateral aspect of same specimen, with cardinal process to right, as arrowed. D, E, dorsal external and internal aspects.

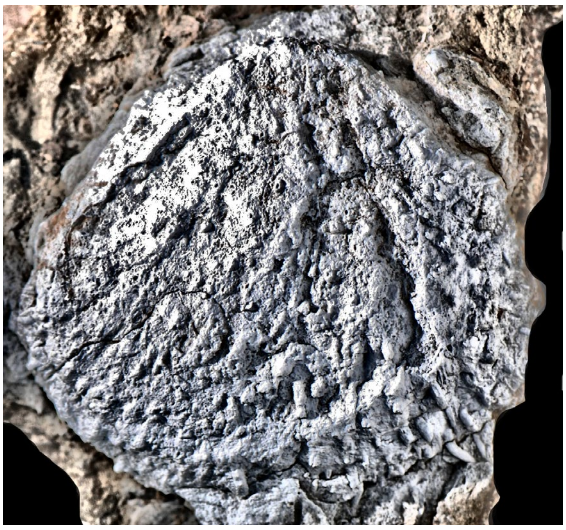

Fig. 2. *Pseudostrophalosia clarkei* (Etheridge) from Scottville Member, ventral valve UQF from UQL 4657, x1.5. (See Fig. 1A). Reproduced by local equalization.

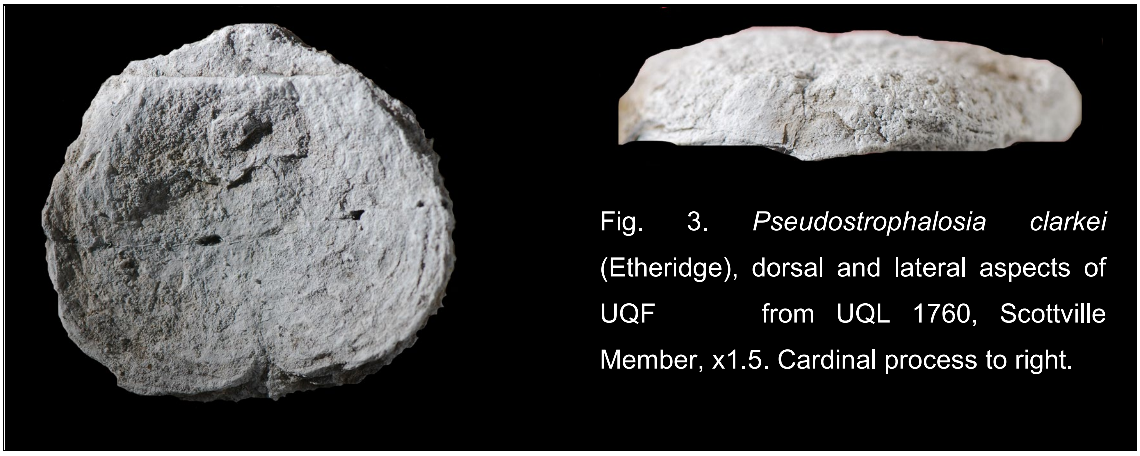

Fig. 3. *Pseudostrophalosia clarkei* (Etheridge), dorsal and lateral aspects of UQF from UQL 1760, Scottville Member, x1.5. Cardinal process to right.

recheck shell 1368?

spines are dense and subuniform, generally 0.6mm to 0.7mm in diameter interspersed with rare and fine recumbent spines.

Pseudostrophalosia ? ***gattoni*** Maxwell, 1954

Fig. 4

1954 *Strophalosia brittoni* var. *gattoni* Maxwell, p. 544, pl. 55, fig. 4-7.
1971 *Wyndhamia clarkei gattoni* Dear, p. 12.
1998 *Pseudostrophalosia clarkei* [not Etheridge] – Briggs, p. 116.

Diagnosis: Ventral valve highly inflated, dental buttresses well developed, no clearly developed spine tunnels, ventral adductor platform not high. Dorsal valve thick and wedge-shaped. Otherwise poorly known.

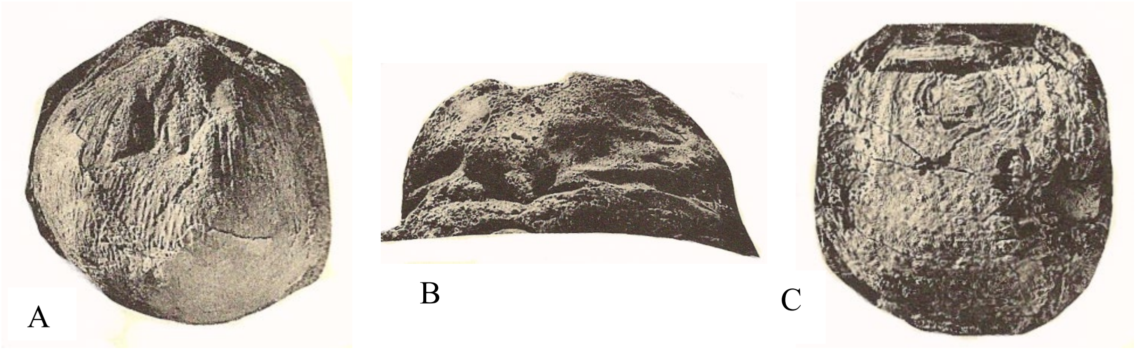

Fig. 4. *Pseudostrophalosia gattoni* (Maxwell). A, B, ventral and posterior aspects of holotype, ventral internal mould, UQF 15655 x1 approx. C, dorsal external mould UQF 15656. Specimens from Scottville Member, north Bowen Basin, x1 approx. (Maxwell 1954).

Discussion: Maxwell (1954) treated this form as a variety allied to *Strophalosia brittoni* Maxwell from the Tiverton Formation, of Sakmarian age, whereas Dear (1971) followed a suggestion by Waterhouse (1964) that the material could prove to be more closely related to *Wyndhamia clarkei* (Maxwell). Briggs (1998) simply synonymized *gattoni* with *clarkei*, providing no further information, but Dear added several important details to the circumscription of the taxon, noting the presence of moderately large dental callosities and moderately low adductor platform, and thick and wedge-shaped dorsal valve. Only a few figures have ever been provided, as reproduced herein.

The type of *gattoni* somewhat approaches *brittoni* Maxwell, 1954, pl. 54, fig. 20-22, pl. 55, fig. 1-3 from the Tiverton Formation in lacking conspicuous ventral spine tunnels from the interior of the ventral valve, but this feature is also shared with *clarkei.* This similarity of *gattoni* to *clarkei* appears to be reinforced by the strong dental buttresses recorded by Dear. The taxon called *gattoni* is closer to *brittoni* in having steep lateral walls and being more inflated than type *clarkei*, and whether this is taxonomically significant still requires verification.

Dear (1971) stated that *gattoni* ranged from the lower Big Strophalosia Band up to the *Streptorhynchus pelicanensis* band, and it would be desirable to support this through the provision of figures.

Suborder LINOPRODUCTIDIINA Waterhouse, 2013

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

Family **PAUCISPINAURIIDAE** Waterhouse, 1986

Subfamily **PAUCISPINAURIINAE** Waterhouse, 1986

Tribe **PAUCISPINAURIINI** Waterhouse, 1986

Genus ***Terrakea*** Booker, 1930

Diagnosis: Ventral valve with incurved umbo, visceral disc thick, capillae over both valves, ornament distinguished by a cluster of thick erect spines over ventral umbonal slopes and ears, some dorsal anterior disc and trail spines also thick.

Type species: *Productus brachythaerum* Morris (1845, p. 284, pl. 2, fig. 4c) from Gerringong Volcanics, south Sydney Basin, OD.

Terrakea elongata e***longata*** (Etheridge & Dun, 1909)

Fig. 5

1909 *Productus brachythaera* var. *elongatus* Etheridge & Dun, p. 299, pl. 43, fig. 5, 7 (part, not pl. 42, fig. 2, 5, 7).
1971 *Terrakea elongatus* – Dear, p. 16, pl. 4, fig. 10-12, pl. 5, fig. 1, 2.
1982 *T. elongata* – Waterhouse, pl. 12a.
1998 *T. elongata* – Briggs, p. 179.

Diagnosis: Large elongate shells with numerous erect thick spines over anterior ears and posterior lateral slopes, coarse anterior dorsal spines, dorsal disc weakly concave.

Holotype: AM F 35475 (originally F2374) from Sonoma, Queensland, figured by Etheridge & Dun (1909, pl. 43, fig. 5). The type was clarified by Fletcher (1971), in clearing up confusion by Waterhouse (1964) and Dear (1971) who wrongly thought that both figures by Etheridge & Dun showed the same specimen. The source is not clear, from either the Scottville Member or the Pelican Creek fauna (Dear 1971), and in this study the Scottville Member is selected as the likely source, because it is much more prominent as a stratigraphic unit and source of fossils, though no information on source or dorsal valve was provided in the original study.

Discussion: *Terrakea* from the Scottville Member has an elongate ventral valve, strong posterior lateral spines over the ventral valve and strong anterior dorsal spines, and a dorsal disc that is weakly concave. *Terrakea* from the overlying Pelican Creek bed is very close, but has a broader flatter dorsal disc. Therefore two subspecies are separated, *T. elongata elongata* for the shells with concave disc from the Scottville Member, and *T. elongata* *planidisca* as described herein (. p.) for the shells with flatter dorsal disc, from the Pelican Creek fauna and underlying beds above the Scottville Member, as described in the following article. But there is still uncertainty about the application of the names, because the source of the original Etheridge & Dun material is open to question.

Fig. 5. *Terrakea elongata elongata* (Etheridge & Dun), anterior aspect of external mould of specimen x1 with valves conjoined. From Scottville Member near Clermont. Note the weakly concave dorsal disc. (Waterhouse 1982).

Briggs (1998) provided no figures, and included in synonymy various specimens that fitted with his interpretation of stratigraphic succession, rather than morphological identity with *elongata*. He referred to specimens figured by Waterhouse & Jell (1983, pl. 1, fig. 14, 16-18) that are in fact much closer to *T. exmoorensis* Dear, and to two posterior ventral internal moulds figured by McClung (1983, Fig. 17.1, 2) which are far too incomplete to allow specific identification, and a small suite of better preserved material (McClung 1983, Fig. 18.1-5?) which does not show elongate ventral valves.

In New Zealand, Waterhouse (1964) described shells as Terrakea elongata, and these are now adjusted to a new subspecies (in press). They are believed to come from the *Maxwellosia ovalis wassi - Paucispinauria solida* Zone.

Class Rhynchonellata Williams et al., 1996

Superorder ATHYRIFORMII Boucot, Johnston & Staton, 1964

Order ATHYRIDA Boucot, Johnston & Staton, 1964

Suborder ATHYRIDINA Boucot, Johnston & Staton, 1964

Superfamily **ATHYROIDEA** Davidson, 1881

Family **ATHYRIDAE** Davidson, 1881

Subfamily **CLEIOTHYRIDININAE** Alvarez, Rong & Boucot, 1998

Genus ***Cleiothyridina*** Buckman, 1906

Diagnosis: Transverse to subequidimensional ovate shells with flattened spines emerging in a row from the anterior edge of commarginal laminae;dental plates, perforated hinge plate and long distinct dorsal medium septum.

Type species: *Atrypa pectinifera* J. de C. Sowerby, 1840, p. 14 from Magnesian Limestone (Wuchiapingian), England, OD.

Cleiothyridina aff. ***elevata*** n. sp.

Fig. 6A, B

1970 *Cleiothyridina* sp. B Armstrong, p. 320, pl. 25, fig. 1.

Derivation: elevato – lift up, raise, Lat.

Diagnosis: Weakly transverse and oval in shape, both valves swollen medianly as a rule.

Holotype: UQL 82681 from UQL 3135, Fig. 27A, B, as designated on p. .

Discusssion: This species is described in the following article. A specimen figured by Armstrong (1970) from the Scottville Member is close, but displays a weak ventral sulcus.

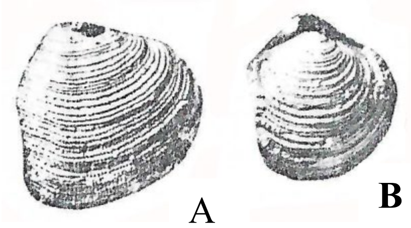

Fig. 6. Cleiothyridina aff. elevata n. sp., A, ventral and B, dorsal aspects, as figured by Armstrong (1970) from Scottville Member, x1 approx.

Superorder SPIRIFERIFORMII Waagen, 1883

Order SPIRIFERIDA Waagen, 1883

Suborder MARTINIIDINA Waterhouse, 2010

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Ingelarella mantuanensis Campbell, 1960

Fig. 7A, B

1960 *Ingelarella mantuanensis* Campbell, p. 1118, pl. 137, fig. 1-3, pl. 138, fig. 1-4.
1961 *I. mantuanensis* – Campbell, p. 185, pl. 24, fig. 1, 2.
1964 *I. mantuanensis* – Hill & Woods, p. 16, pl. P8, fig. 9-11.
1968 *I. mantuanensis* – Runnegar, p. 21.
1968 *Ambikella mantuanensis* – Waterhouse, p. 71, pl. 13, fig. 3, 5, 6, pl. 14, fig. 7, 8.
1972 *I. mantuanensis* – Hill et al., p. 16, pl. P8, fig. 9-11.
1975 *Martiniopsis mantuanensis* – Runnegar & McClung, pl. 31.1, fig. 14-16.
1978 *I. mantuanensis* – McClung, p. 53, pl. 2, fig. 18, 19, pl. 13, fig. 11, 12.
1987a *Tomiopsis mantuanensis* – Waterhouse, p. 34, pl. 9, fig. 11, 13, pl. 10, fig. 1-4.

Diagnosis: Large shells, often plicate and with sulcal subplicae, adminicula and tabellae moderately long.

Holotype: UQF 15659 from the Mantuan Productus bed, north Bowen Basin, figured by Campbell (1960, pl. 138, fig. 1-3), OD.

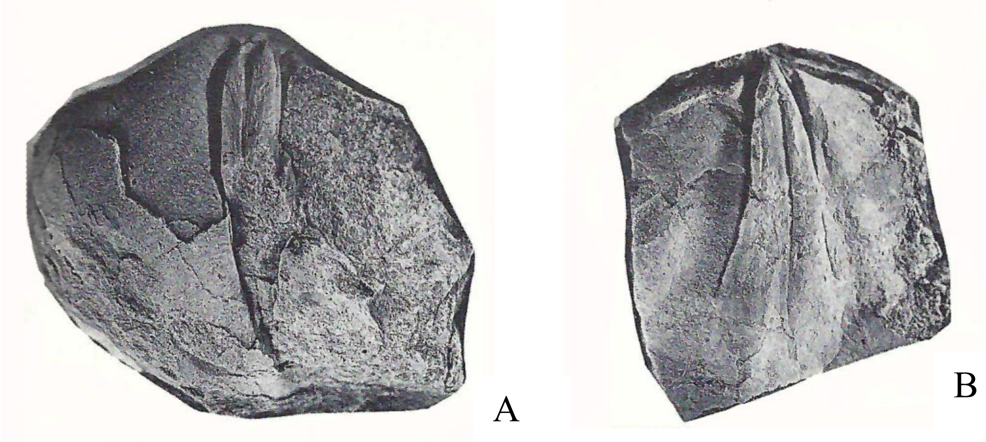

Fig. 6. *Ingelarella mantuanensis* Campbell, ventral and dorsal aspects of UQF 15659 from Scottville Member, x1. (Campbell 1961).

Discussion: This species was originally described from what is now called the Mantuan Formation in the north Bowen Basin, and Campbell (1961) figured specimens from the Big Strophalosia Zone, as repeated herein. Runnegar (1968) repeated the Campbell (1961) report. As noted by Campbell (1961), the species is found in the Flat Top Formation of the south Bowen Basin, and has been recorded from the correlative beds in the younger Mangarewa beds of Wairaki Downs, New Zealand (Waterhouse 1968).

Superorder TEREBRATULIFORMI Waagen, 1883

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **DIELASMIDAE** Schuchert, 1913

Subfamily **DIELASMINAE** Schuchert, 1913

Diagnosis: Dental plates well developed, septalium of inner and outer hinge plates, may be divided, sessile or raised on low to high septum, loop deltiform.

Tribe **FLETCHERITHYRINI** Waterhouse, 2010

Diagnosis: Septalium supported on high dorsal septum. Commissure rectimarginate to sulciplicate.

Genus ***Fletcherithyris*** Campbell, 1965

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

Type species: *Terebratula amygdala* Dana, 1847, p. 142 [not *T. amygdala* Catullo, 1846 Giorn. di Fisica 2 (5): 90] from Broughton Formation (Wordian), south Sydney Basin, OD. Finlay (1927) proposed replacing Dana's name with a new name *bensoni*, but a substitute name proposed shortly after the Dana publication appeared is *Atrypa biundata* M'Coy (1847, p. 231). [See Waterhouse 1982a, p. 62].

Fletcherithyris illawarrensis Campbell, 1965

Fig. 8

1965 *Fletcherithyris illawarrensis* Campbell, p. 40, pl. 2, fig. 14-25, pl. 15, fig. 1, text-fig. 14, 15. {Not pl. 14 as in the text).
1968 *Fletcherithyris illawarrensis* – Runnegar, p. 21.

Diagnosis: Small to medium size, strongly biconvex, sinuate or uniplicate anterior commissure, long dental sockets, massive teeth, septalium with concave anterior outline.

Holotype: UNE 6052, with figure not cited and apparently not provided, but stated to have come from the Conjola Formation near Wyro, probably the Wandrawandian Formation, south Sydney Basin. UNE types have been transferred to the Australian Museum.

Discussion: Runnegar (1968, p. 21) recorded this species from what is now called the Scottville Member, somewhat younger than the type locality. Campbell (1965) stated that the species occurred some 200ft above or below the Big Strophalosia Zone, and clearly such specimens require further further study.

Fig. 8. *Fletcherithyris illawarrensis* Campbell. A-D, ventral, dorsal, lateral and anterior aspects of UNE 6064B, “Conjola Formation”, Wyro, x1 approx. (Campbell 1965). Reported to occur in the Big Strophalosia Band by Runnegar (1968).

Fletcherithyris parkesi Campbell, 1965

Fig. 9

1965 *Fletcherithyris parkesi* Campbell, p. 43, pl. 8, fig. 1-23, text-fig. 16.
? 1965 *Fletcherithyris parkesi* – Runnegar, p. 21.

Diagnosis: Moderate in size, mature shell sulciplicate with median ventral fold and dorsal sulcus, dorsal median septum high.

Holotype: UNE 6048 figured by Campbell (1965, pl. 8, fig. 6-9) from Conjola Formation, Wyro, OD.

Discussion: Runnegar (1968) identified this distinctive species from the Big Strophalosia Zone. The type locality is found in the Wandrawandian Formation of Kungurian age in the south Sydney Basin, but Campbell also identified the species in the Gerringong Volcanics of Capitanian age in the south Sydney Basin, as well as 500ft below the Big Strophalosia Zone and from above this band and below the *Streptorhynchus pelicanensis* bed. All these occurrences need to be checked, because *Paragilledia* Waterhouse in Shi et al. (2020) is also found at some of these levels, externally close to *Fletcherithyris parkesi*, but with no septalium or high dorsal median septum.

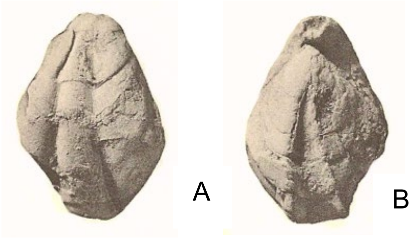

Fig. 9. *Fletcherithyris parkesi* Campbell, ventral and dorsal aspects of AMF 17069 from Gerringong Volcanics, x1 approx. (Campbell 1965). Reported to occur in the Big Strophalosia band by Runnegar (1968).

Subfamily **MAORIELASMINAE** Waterhouse & Piyasin, 1970

Genus ***Maorielasma*** Waterhouse, 1964

Diagnosis: Shell large, teeth not supported by dental plates, foramen present. Dorsal valve with slender socket plates and well developed brachidium formed by inner hinge and crural (= outer hinge) plates, sessile as a rule.

Type species: *Maorielasma imperatum* Waterhouse, 1964, p. 175 from upper Mangarewa Formation, OD.

Maorielasma imperatum Waterhouse, 1964

Fig. 10

1964 *Maorielasma imperatum* Waterhouse, p. 175, pl. 34, fig. 3-5.
1965 *Maorielasma globosum* [not Campbell] – Campbell, pl. 14, fig. 13-15 (part).

Diagnosis: Elongate shells with highly arched dorsal valve, long septalium and narrow crural plates steeply inclined from the socket plates.

Holotype: BR 896 figured by Waterhouse (1964), *Ingelarella costata* Zone, upper Mangarewa Formation, New Zealand.

Material: A partly worn specimen with valves conjoined was recorded and figured as *globosum* from the Scottville Member by Campbell (1965).

Resemblances: *Maorielasma imperatum* Waterhouse, is very close to and arguably senior synonym to *M. globosum* Campbell, 1965, and the relationship is discussed herein, starting on p.

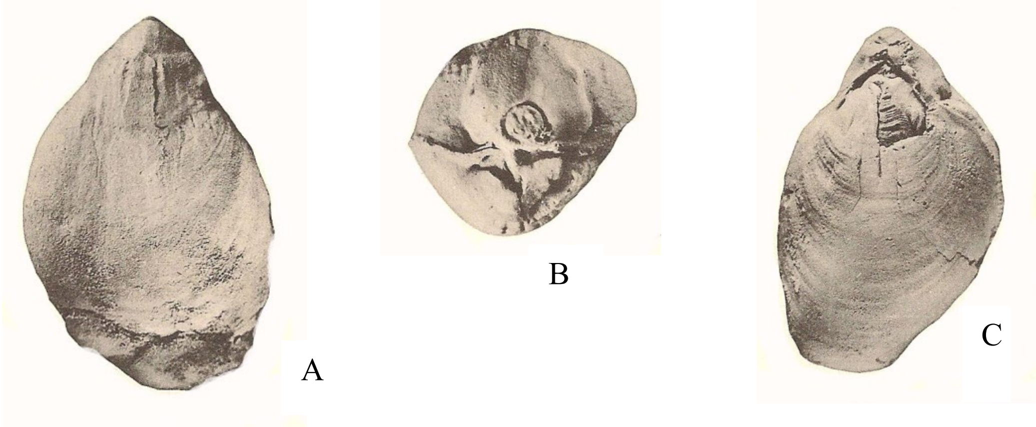

Fig. 10. *Maorielasma imperatum* Waterhouse, A-C, ventral, posterior (ventral valve on top in Fig. 9B), and dorsal aspects of specimen from Scottville Member, x1. (Campbell 1965).

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Megaorder SOLENATA Dall, 1889

Order HIATELLIDA J. Carter *in* Carter et al. 2011

Superfamily **EDMONDIOIDEA** King, 1850

Family **EDMONDIIDAE** King, 1850

Subfamily **MYONIINAE** Waterhouse (1969), 1987b, 2001

Genus ***Myonia*** Dana,1847

Diagnosis: Medium to large-sized subelongate shells, with anteriorly placed orthogyrous umbones, posterior umbonal ridge well rounded in profile and not carinate, no posterior gape or pallial sinus. No clearly developed teeth, anterior adductor joined by isthmus to extended pedal scar complex extending towards umbo.

Type species*:* *Myonia elongata* Dana, 1847, p. 158 from Gerringong Volcanics, south Sydney Basin, SD Fletcher (1932, p. 409).

Myonia carinella Runnegar, 1967

1876-7 ?*Sanguinolites undatus* [not Dana] de Koninck, p. 260, pl. 17, fig. 1.
1964 ?*Notomya* ? sp. nov. Dickins in Dickins et al., table 1.
1967 *Myonia carinella* Runnegar, p. 58, pl. 4, fig. 10, pl. 13, fig. 5-13.

Diagnosis: Subelongate shells with umbones placed near anterior third of length, posterior gape negligible, gently rounded posterior umbonal ridge, very shallow if any lateral sulcus.

Holotype: UQF 50996 from below Scottville Member, west of Parrot Creek, figured by Runnegar (1967, pl. 13, fig. 8-10), OD.

Discussion: This distinctive species was described by Runnegar chiefly from just below the Scottville Member, and further material is recorded and illustrated from the overlying *Marginalosia minima* Zone in the following section (see p.). Runnegar (1968, p. 21) recorded the species from the Scottville Member, and de Koninck recorded the species possibly from the Mulbring Formation in the north Sydney Basin.

Family **PACHYDOMIDAE** Fischer, 1887

Subfamily **ASTARTILINAE** Waterhouse, 1969

Genus ***Pleurikodonta*** Runnegar, 1965

Diagnosis: Small subrounded shells with weak teeth and costae that interlock around the ventral margin. Weak commarginal rugae.

Pleurikodonta gemma (Dana, 1847)

Fig. 11

1847 *Astarte gemma* Dana, p. 154.
1847 *Venus*? *gregaria* M'Coy, p. 305, pl. 16, fig. 5.
1849 *Astarte gemma* Dana – p. 688, pl. 3, fig. 4, 4a, b.
1929 *Astartila subgemma* Fletcher, p. 74, pl. 29, fig. 13-15.
1964 Astartidae gen. & sp. nov. Hill & Woods, pl. 12, fig. 9, 10.
1965 *Astartila* (*Pleurikodonta*) *elegans* Runnegar, p. 247, pl. 15, fig. 17-19, 21-26.
1968 *P. elegans* – Runnegar, p. 21.
1969 *Pleurikodonta* cf. *elegans* – Wass & Gould, pl. 14, fig. 15-17.
1972 *P. elegans* – Hill et al., pl. 12, fig. 9, 10.
1987 *P. elegans* – Waterhouse, p. 170, pl. 10, fig. 25, 26.
1988 *P. gemma* – Waterhouse, p. 199, pl. 19, fig. 16-19.

Diagnosis: Small subrounded shells with commarginal rugae, and short costae around ventral margin in some specimens.

Holotype: USNM 3593 figured by Dana (1849, pl. 3, fig. 4a, 4b) and Waterhouse (1988, pl. 19, fig. 16, 18) from Gerringong Volcanics, south Sydney Basin, by monotypy.

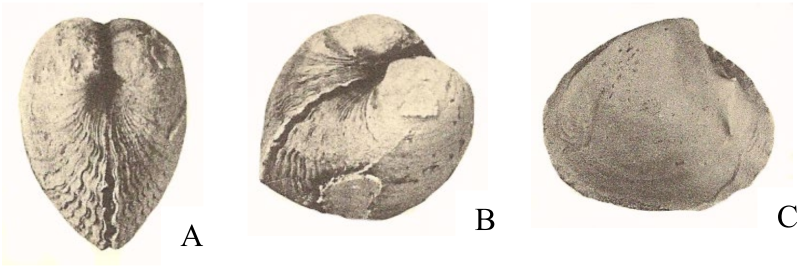

Fig. 11. *Pleurikodonta gemma* (Dana). A, anterior aspect, of specimen with valves conjoined, CPC 6808. B, oblique view of specimen with valves conjoined, CPC 6809. C, lateral aspect of internal mould, CPC 5183, holotype of *elegans* Runnegar. Specimens x1 from close to *Isbellina pelicanensis* bed, north Bowen Basin, Queensland. (Runnegar 1965).

Discussion: Runnegar (1968) listed this species from the Scottville Member. There is only modest variation between the various specimens assigned different names from the Gerringong Volcanics and Wollongong in the south Sydney Basin, the Flat Top Formation of the southeast Bowen Basin and upper Blenheim Formation of the north Bowen Basin. In addition, Wass & Gould (1969) compared material from South Marulan that appears to be conspecific.

Additional material

Runnegar (1968, p. 21) listed further species of Bivalvia, including *Myonia* (= *Myomedia*) *carinata, M. corrugata, Megadesmus grandis* and *Vacunella curvata,* which may be assessed as very likely occurrences, because except for *grandis,* they are found in beds below the Scottville Member, and in overlying beds of the *Echinalosia* (*Unicusia*) *minima* Zone, to show that the species spanned the range of the Scottville Member.

SUMMARY

This fauna is distinctive, characterized by *Pseudostrophalosia clarkei* and *Terrakea elongata elongata*, and probably the poorly known *Ps. gattoni.* Other species range more widely, including possible *Maorielasma imperatum*, and the bivalves *Myonia carinella*, *Pleurikodonta* and other forms reported in Runnegar (1968), but not yet consolidated through description or illustration. Runnegar noted that the fauna differed from that displayed by the overlying Pelican Creek fauna, and this appears to be correct, apart from *Cleiothyridina elevata*. *Terrakea elongata elongata* is close to *T. elongata planidisca. Pseudostrophalosia* persists in beds a few feet higher than the Scottville Member, but belongs to a distinctive species. The fauna from beds above the Scottville Member is distinguished primarily by the introduction of *Marginalosia minima*, and is more diverse with several restricted species, as discussed in the following section. Were zonation based on first entry data, then the present Scottville fauna would be readily distinguished by *Ps. clarkei*, and its upper limit imposed by the entry of *M. minima*. It appears that the Scottville Member and its fauna represented a short-lived, extremely localized cold-water event, limited to the northern Bowen Basin. Even in the comparatively full sequence at Wairaki Downs of New Zealand, there is no match: the beds with *Maxwellosia ovalis* and *Paucispinauria solida* are followed immediately as far as known by faunas with *Terrakea elongata planidisca* fauna that correlate with the *Marginalosia minima* and *Terrakea elongata planidisca* fauna of the beds above the Scottville Member, up to and including the Pelican Creek Member.

REPOSITORIES

See p. herein.

REFERENCES

ALVAREZ, F., RONG JIA-YU, BOUCOT, A. J. 1998: The classification of athyridid brachiopods. J. Paleont. 72: 827-855.

ARMSTRONG, J. D. 1970a: Micro-ornaments of the spiriferid brachiopods *Notospirifer, Ingelarella* and *Subansiria*. Lethaia 3: 287-300.

_____ 1970b: Microstructure of the shell of the brachiopod *Wyndhamia clarkei*. J. Geol. Soc. Aust. 17 (1): 13-19, 4pl.

BOOKER, F. W. 1930: A review of some of the Permo-Carboniferous Productidae of New South Wales, with a tentative reclassification. J. Proc. Roy. Soc. New South Wales 64: 65-77.

BOUCOT, A. J., JOHNSON, J. G., STATON, R. D. 1964: On some atrypoid, retzioid and athyridoid Brachiopoda. J. Paleont. 38: 805-822, pl. 125-128.

BRIGGS, J. D. C. 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and the New England orogen: systematics and biostratigraphic significance. Mem. Assoc. Aust'asian Palaeont. 19.

BRUNTON, C. H. C. 1966: Silicified productoids from the Visean of County Fermanagh. Bull. Brit. Mus. (Nat. Hist.) Geol. 12 (5): 155-243.

BRUNTON, C. H. C., LAZAREV, S. S., GRANT, R. E. 1995: A review and new classification of the brachiopod order Productida. Palaeontology 38: 915-936.

BRUNTON, C. H. C., LAZAREV, S. S., GRANT, R. E. 2000: Productida. *In* R. L. Kaesler (ed.) Treatise on Invertebrate Paleontology, Part H, Brachiopoda revised, vol. 3, Linguliformea, Craniiformea, and Rhynchonelliformea part: 350-362. Geol. Soc. Amer., Univ. Kansas; Boulder, Colorado & Lawrence, Kansas.

BRUNTON, C. H. C., LAZAREV, S. S., GRANT, R. E., JIN YUGAN 2000: Productidina. *In* R. L. Kaesler (ed.) Treatise on Invertebrate Paleontology, Part H, Brachiopoda revised, vol. 3, Linguliformea, Craniiformea, and Rhynchonelliformea (part).: 424-609. [Includes Strophalosiidina]. [Also] "Uncertain": 642-643. Geol. Soc. Amer., Univ. Kansas; Boulder, Colorado & Lawrence, Kansas.

BUCKMAN, S. S. 1906: Brachiopod nomenclature: *Epithyris, Hypothyris*, *Cleiothyris* Phillips 1841. Ann. Mag. Nat. Hist. (ser. 7) 18: 321-327.

CAMPBELL, K. S. W. 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. Palaeontology 1: 333-350.

_____ 1960: The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. J. Paleont. 34: 1106-1123.

_____ 1961: New species of the Permian spiriferoids *Ingelarella* and *Notospirifer* from Queensland and their stratigraphic implications. Palaeontographica A 117: 159-192.

_____ 1965: Australian Permian terebratuloids. Bull. Bur. Mineral Resour. Geol. Geophys. 68.

CARTER, J. G. et al. (51 authors) 2011: A synoptical classification of the Bivalvia (Mollusca). Paleont. Contrib. 4: 1-47.

CLARKE, M. J. 1970: A new Permian strophalosiid brachiopod genus from eastern Australia. J. Paleont. 44: 986-987.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DALL, W. H. 1889: On the hinge of pelecypods and its development, with an attempt toward a better subdivision of the group. Amer. J. Sci. Arts (ser. 3) 38 (228): 445-462.

DANA, J. D. 1847: Descriptions of fossil shells of the collections of the exploring expedition under the command of Charles Wilkes U. S. N. obtained in Australia, from the lower layers of the coal formation in Illawarra, and from a deposit probably of nearly the same age at Harper's Hill, valley of the Hunter. Amer. J. Sci. (ser. 2) 4: 151-160.

_____ 1849: Fossils of New South Wales. *In* United States Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes, U. S. N. vol. 10 – Geology. Appendix 1: 681-720. C. Sherman, Philadelphia.

DAVIDSON, T. 1881: On genera and species of spiral-bearing Brachiopoda from specimens developed by Rev. Norman Glass: with notes on the results obtained by Mr. George Maw from extensive washing of the Wenlock and Ludlow shales of Shropshire. Geol. Mag. (n. s., dec. 11) 8 (1): 1-13.

DEAR, J. F. 1971: Strophomenoid brachiopods from the higher Permian faunas in the northern Bowen Basin and their distribution throughout the basin. Geol. Surv. Qld Pub. 347. Palaeont. Paper 21: 1-39.

______ 1972: Preliminary biostratigraphic subdivision of the Permian brachiopod faunas in the northern Bowen Basin and their distribution throughout the basin. Rep. Geol. Surv. Qld 49: 1-19.

DICKINS, J. M. 1964: Permian macrofossils from Collinsville and from the area of the Clermont Sheet. *In* VEEVERS, J. J.,. RANDALL, M. A., MOLLAN, R. G., PATEN, J. R. Geology of the Clermont 1:250,000 sheet area. Bur. Mineral. Resourc., Geol. Geophys. Rep. 66: 76-86.

_____ 1989: Youngest Permian marine macrofossil fauna from the Bowen and Sydney Basins, eastern Australia. BMR J. Aust. Geol. Geophys. 11: 63-79.

DUMÉRIL, A. M. C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux: xxiv + 344pp. Allais. Paris.

ETHERIDGE, R. Snr 1872: Appendix 1: Description of the Palaeozoic and Mesozoic fossils of Queensland. *In* DAINTREE R. Notes on the geology of the colony of Queensland. Quart. J. Geol. Soc. London 28: 317-350.

ETHERIDGE, R. Jnr 1880: Report on a collection of fossils from the Bowen River coalfield and the limestones of the Fanning River, northern Queensland. Proc. Roy. Phys. Soc. Edinburgh 5: 263-328.

_____ 1892: *In* JACK, R. L., ETHERIDGE, R. Jnr Geology and Palaeontology of Queensland and New Guinea. Publ. Geol. Surv. Queensland 92: 1-766, 68pl.

ETHERIDGE, R. Jnr, DUN, W. S. 1909: Notes on the Permo-Carboniferous Producti of eastern Australia, with synonymy. Rec. New South Wales Geol. Surv. 8: 293-304.

FINLAY, H. J. 1927: New specific names for austral Mollusca. Trans. Proc. N. Z. Inst. 57: 488-533.

FISCHER, P. H. 1880-1887: Manuel de conchyliologie et de paléontologie conchyliogique: xxv + 1369p., 23pl. F. Savy, Paris.

FLETCHER, H. O. 1929: Revision of genus *Astartila*. Rec. Aust. Mus. 17: 53-75.

_____ 1932: A revision of the genus *Myonia*, with notes on allied genera from the Permo-Carboniferous of New South Wales. Rec. Aust. Mus. 18: 389-410.

_____1971: Catalogue of type specimens of fossils in the Australian Museum, Sydney. Mem. Aust. Mus. 13: 1-167.

HILL, D., PLAYFORD, G., WOODS, J. T. 1972: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

HILL, D., WOODS, J. T. 1964: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

ISBELL, R. F. 1955: The geology of the northern section of the Bowen Basin. Pap. Dep. Geol. Univ. Qld 3 (11): 1-43.

KING, W. 1850: A monograph of the Permian fossils of England. Palaeontograph. Soc. Monograph 3: 37 + 258p.

KONINCK, L. G. de 1866-77: Recherches sur les Fossiles paléozoiques de la Nouvelle Galles de Sud (Australie). Mém. Soc. Roy. Sci. Liège (ser. 2) 6, 7. [English translation by T.

W. E. David, 1898: Geol. Surv. New South Wales, Palaeont. Mem. 6].

LAZAREV, S. S. 1987: Origin and systematic position of the main group of Productida (Brachiopoda). Paleont. Zhurn. 1987 (4): 41-52. [Russ.]

_____ 1989: Systematics of Devonian brachiopods of Suborder Strophalosiidina. Paleont. Zhurn. 1989 (2): 27-39. [Russ.]

_____ 1990: Evolution and systematics of the Productida. Tr. Paleont. Inst. 242: 1-171, 40pl. [Russ.]

_____ 2003: Brachiopods of the Superfamily Linoproductoidea Stehli, 1954: a new view on their morphogenesis and taxonomic structure. Paleont. Zhurn. 37 (5): 492-500. [Russ.]

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MAXWELL, W. G. H. 1954: *Strophalosia* in the Permian of Queensland. J. Paleont. 28: 533-559.

McCLUNG, G. 1978: Morphology, palaeoecology and biostratigraphy of *Ingelarella* (Brachiopoda: Spiriferida) in the Bowen and Sydney Basin of eastern Australia. Geol. Surv. Qld Pub. 365, Palaeont. Pap. 39: 11-86.

_____ 1983: Faunal sequence and palaeoecology in the marine Permian in G. S. Q. Eddystone 1, Denison Trough, Queensland. Geol. Surv. Qld Pub. 384: 43-80.

M'COY, F. 1847: On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist. (ser. 1) 20: 145-157, 226-236, 298-312.

MORRIS, J. 1845: Descriptions of fossils. *In* STRZELECKI, P. E. de Physical description of New South Wales and Van Diemen’s Land: 270-291. Longman, Brown, Green & Longman, London.

MUIR-WOOD, H. M., COOPER, G. A. 1960: Morphology, classification and life habits of the Productoidea (Brachiopoda). Geol. Soc. Amer. Mem. 81.

NEWELL, N. D., BOYD, D. W. 1975: Parallel evolution in early Trigoniacean bivalves. Bull. Amer. Mus. Nat. Hist. 154 (2): 53-162.

REID, J. H. 1929: Geology of the Bowen River Coalfield. Pub. Geol. Surv. Qld 276: 1-107.

RUNNEGAR, B. N. 1965: The bivalves *Megadesmus* Sowerby and *Astartila* Dana from the

Permian of eastern Australia. J. Geol. Soc. Aust. 12: 227-252.

_____ 1967: Desmodont bivalves from the Permian of eastern Australia. Bull. Bur. Mineral Resour. Geol. Geophys. 96.

_____ 1968: The Permian faunal succession in eastern Australia. Univ. New England, unpub. reports in the Geological Sciences no. 1968/1: 1-81, table 1, pl. 1.

RUNNEGAR, B., McCLUNG, G. 1973: New names for marine Permian rock units in the northern Bowen Basin, Queensland. Qld Gov. Mining J. 1973: 441-443.

_____ , _____ 1975: A Permian time scale for Gondwanaland. *In* K. S. W. Campbell (ed). Gondwana Geology: Papers presented at the Third Gondwana Symposium, Canberra, Australia, 1973. Aust. Nat. Univ. Press, Canberra: 425-441.

SCHUCHERT, C. 1913: Class 2. Brachiopoda. *In* ZITTEL, K. A. von Text-book of Paleontology, vol. 1, part 1, 2nd ed., translated and edited by C. R. Eastman: 355-420, fig. 526-636. MacMillan & Co. Ltd, London.

SHI, G. R., WATERHOUSE, J. B., LEE, S. 2020: Early Permian brachiopods from the Pebbley Beach Formation, south Sydney Basin, southeastern Australia. Alcheringa 44 (3): 411-429.

SOWERBY, J. de C. 1840-1846: The Mineral Conchology of Great Britain 7: 1-80, pl. 610-648. Published by the author. London.

WAAGEN, W. 1883: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (2): 391-546.

WASS, R. E., GOULD, I. G. 1969: Permian faunas and sediments from the South Marulan district, New South Wales. Proc. Linnean Soc. New South Wales 93: 212-226.

WATERHOUSE, J. B. 1964: Permian brachiopods of New Zealand. N. Z. Geol. Surv. Paleont. Bull. 35: 1-287.

_____ 1968: The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. Palaeontographica A 129: 1-94.

. _____ 1969: The Permian bivalve genera *Myonia, Megadesmus, Vacunella* and their allies, and their occurrences in New Zealand. N. Z. Geol. Surv. Paleont. Bull. 41.

_____ 1975: New Permian and Triassic brachiopod taxa. Pap. Dep. Geol. Univ. Qld 7 (1): 1-23.

_____ 1978: Permian Brachiopoda and Mollusca from northwest Nepal. Palaeontographica A 160 (1-6): 1-175.

_____ 1982: New Zealand Permian brachiopod systematics, zonation and paleoecology. N. Z. Geol. Surv. Paleont. Bull. 48.

_____ 1983: Systematic description of Permian brachiopods, bivalves and gastropods below Wall Sandstone Member, northern Bowen Basin. Pap. Dep. Geol. Univ. Qld 10 (3): 155-179.

_____ 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 1987a: Late Palaeozoic Brachiopoda (Athyrida, Spiriferida and Terebratulida) from the southeast Bowen Basin, eastern Australia. Palaeontographica A 196 (1-3): 1-56.

_____ 1987b: Late Palaeozoic Mollusca and correlations from the southeast Bowen Basin, east Australia. Palaeontographica A 198 (4-6): 129-233.

_____ 1988: Revision of the bivalved Mollusca described by James Dwight Dana 1847-1849 from the Permian of eastern Australia. Pap. Dep. Geol. Univ. Qld 12: 165-228, 20 pl.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2008: Golden spikes and black flags – macroinvertebrate faunal zones for the Permian of east Australia. Proc. Roy. Soc. Victoria 120 (1): 345-372.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

_____ 2013: The evolution and classification of the Productida. Earthwise 10: 535p.

_____ 2015: Early Permian Conulariida, Brachiopoda and Mollusca from Homevale, central Queensland. Earthwise 11: 1-390.

WATERHOUSE, J. B., JELL, J. S. 1983: The sequence of Permian rocks and faunas near Exmoor Homestead, south of Collinsville, north Bowen Basin. *In* Permian geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 231-267.

WATERHOUSE, J. B., PIYASIN, S. 1970: Mid-Permian brachiopods from Khao Phrik, Thailand. Palaeontographica 125A: 83-197.

WILLIAMS, A., CARLSON, S. J., BRUNTON, C. H. C., HOLMER, L. E., POPOV, L. E. 1996:

A Supra-ordinal classification of the Brachiopoda. Philosoph. Trans. Roy. Soc. London (ser. B) 351: 1171-1193.

6. BRACHIOPODS AND MOLLUSCS FROM THE *Echinalosia* (*Unicusia*) *minima* ZONE, NORTH BOWEN BASIN, QUEENSLAND

Abstract

Brachiopods, bivalves and gastropods are described from beds above the Big Strophalosia "Zone" or Band, also called Scottville Member, in the north Bowen Basin in Queensland. Most fossils recorded in this report come from a thin fossil band just above the Scottville Member, and some species persist into the Pelican Creek bed, where they are joined by a new genus *Isbellina*, named for "*Streptorhynchus*" *pelicanensis* Fletcher. The zone is deemed to be of late Capitanian age. Despite some recent views to the contrary, the zone together with the underlying *Pseudostrophalosia clarkei* Zone in the Scottville Member is younger than the widely developed *Pseudostrophalosia blakei* (= *ingelarensis*) biozone and Maxwellosia ovalis biozone, which underlie the *clarkei* zone in the northern Bowen Basin.

New taxa: **Genus**: *Isbellina* n. gen. (type species *Streptorhynchus pelicanensis* Fletcher, 1952, p. 8), **Subgenus**: *Echinalosia* (*Unicusia*) n. subgen. (type species *Strophalosia clarkei* var. *minima* Maxwell, 1954, p. 547). **Species**: *Cleiothyridina elevata* n. sp., *Geothomasia delicatula* n. sp., *Aperispirifer demulceatus* n. sp., *Permasyrinx mundanus* n. sp., *Sulcicosta lata* n. sp. **Subspecies:** *Terrakea elongata planidisca* n. subsp.

INTRODUCTION

Fossils from marine beds above the Big Strophalosia band have never been systematically recorded in full, although valuable contributions were made by Maxwell (1954), Campbell (1960, 1965) and Dear (1971). The present study describes brachiopods and molluscs in the macro-fauna from a bed just above the Big Strophalosia band, collected at UQL 3135, and further fossils from the Pelican Creek fauna, named by Dear (1972) for fossils from the so-called "*Streptorhynchus* bed". (See Fig. p. herein). The species *clarkei* which typifies the underying zone in the Scottville Member of Runnegar & McClung (1975) does not extend into the zone, and several species including *minima* and *Isbellina*, are not found in the *clarkei* beds.

Locality details, northern Bowen Basin

UQL 1335 Pelican Creek fauna. L 4 M4

UQL 1384. Creek crossing on the Elphinstone-Homevale road, one quarter of a mile from the junction with the Nebo-Collinsville road, Pelican Creek Member of Dear (1972). Type locality for *minima* Maxwell (fide Dear 1971). Approximately 100m above the Big Strophalosia Band (Scottville Member). Collected by W. G. H. Maxwell, 1952,

UQL 1385. Ridge south of Homevale-Elphinstone Rd. at Bull Creek Crossing. Collected by W. G. H. Maxwell 1952.

UQL 3135. Between 0.5 and 1 mile (0.8 and 1.6km) south of Bureau of Mineral Resources locality CL 12/1 along road and about 1 mile (1.6km) along Mt Lebanon road, following Cherwell Creek from the road junction with the Nebo to Clermont road. Just above the Scottville Member. Collected by J. D. Armstrong & B. Runnegar.

SYSTEMATIC STUDIES

Phylum Brachiopoda Duméril, 1806

Subphylum Rhynchonelliformea Williams et al., 1996

Class Strophomenata Williams et al., 1996

Superorder STROPHOMENIFORMI Öpik, 1934

Order TRIPLESIIDA Moore, 1952

Suborder ORTHOTETIDINA Cooper & Grant, 1974

(See Waterhouse 2010, p. 9 and Waterhouse & Campbell 2021, p. 8)

Superfamily **ORTHOTETOIDEA** Waagen, 1884

Family **SCHUCHERTELLIDAE** Williams, 1953

Subfamily **STREPTORHYCHINAE** Stehli, 1954

Tribe **STREPTORHYCHINI** Stehli, 1954

Genus ***Isbellina*** n. gen.

Derivation: Named for R. F. Isbell.

Diagnosis: Elongately subpentagonal shells ornamented by weakly differentiated costellae, ventral interarea high, lacking perideltidium, bearing broadly convex pseudodeltidium without a conspicuous monticule, bordered by teeth ridges, vestigial or no dorsal interarea, tooth ridges not supported by plates, cardinal process high and quadrifid, crural supporting plates short, no erismata.

Type species: *Streptorhynchus pelicanensis* Fletcher, 1952, p. 8 from Pelican Creek band, north Bowen Basin, here designated.

Discussion: Compared with other Permian genera, this genus is distinguished from *Streptorhynchus* King, 1850 through the lack of perideltidia, and lack of erismata, which are long and slender plates extending in front of the cardinal process along each side of the muscle field. In these regards, the genus is close to *Arctitreta,* type species *A. pearyi* Whitfield, 1908, p. 57 from the Canadian Arctic Archipelago, as discussed and illustrated in Waterhouse (2020, p. 26, Fig. 8A, B, 9-12). The known species of *Arctitreta* have more differentiated ribbing than in *Isbellina*, and in the ventral valve the dental ridges are supported by slender plates which extend to the floor of the valve, at least in immature specimens. Such plates are not known for *Isbellina*. A low monticule lies over the pseudodeltidium in *Arctitreta* as well as in *Isbellina (*see Fig. 2A) and similar structures are visible in *Grumantia* Ustritsky, 1963, a genus of questionable validity, possibly distinguished from *Arctitreta* by its wide hinge, and in *Fissulina* Waterhouse, 2020, an Arctic genus distinguished by having a channel down the middle of the pseudodeltidium. Dental supporting plates are present in *Fissulina*, but not in *Bothrostegium* Cooper & Grant, 1974, which as a rule lacks erismata, but differs from *Isbellina* in having a pseudodeltidial channel like that of *Fissulina*. One further genus found in east Australia and New Zealand is *Notostrophia* Waterhouse 1973, 1982a, which also lacks erismata, but unlike the present form, the ventral interarea in *Notostrophia* is not very high as a rule, and the ribs on the dorsal valve are coarser than those of the ventral valve. The pseudodeltidium of the Tasmanian species of *Notostrophia* appears to have no channel or monticulus (Clarke 1990, Fig. 4, 6), and there are no perideltidia.

Isbellina pelicanensis (Fletcher, 1952)

Fig. 1, 2

1880 *Orthotetes crenistria* var. *senilis* [not Phillips] – Etheridge Jnr, p. 282, pl. 8, fig. 12-15.
1892 *Derbyia senilis* [not Phillips] – Etheridge Jnr, p. 246, pl. 12, fig. 1-6.
1929 *Derbyia senilis* [not Phillips] – Reid, Fig. 36.1.
cf. 1952 *Streptorhynchus pelicanensis* Fletcher, p. 8, pl. 1, fig. 2.
1964 *S. pelicanensis* – Hill & Woods, pl. P4, fig. 2, 3.
cf. 1964 *S. pelicanensis* – Waterhouse, p. 17, pl. 1, fig. 1, 2.
1969 *Streptorhynchus pelicanensis* – Armstrong, pp. 310-320, pl. 57, fig. 1-6, pl. 58, fig. 3-5, pl. 60, fig. 1, 2.
1971 *S. pelicanensis* – Dear, p. 2, pl. 1, fig. 1-8.
1972 *S. pelicanensis* – Hill et al., pl. P4, fig. 2, 3.
cf. 1982a ?*Grumantia* sp. – Waterhouse, p. 24, pl. 1b.
cf. 1982a ?*Grumantia pelicanensis* – Waterhouse, p. 24, pl. 1c.

Diagnosis: Large and elongate shells with high ventral interarea, ribs fine and in several orders, but only weakly differentiated.

Holotype: Specimen GSQ F1451 from Havilah Byerwin Road, south of Rosella Creek crossing, "Streptorhynchus bed", high in Blenheim Subgroup, north Bowen Basin, Queensland, figured by Etheridge Jnr (1880, pl. 7, fig. 12), Etheridge Jnr (1892, pl. 12, fig. 1), Hill & Woods (1964, pl. P4, fig. 2) and Hill et al. (1972, pl. P4, fig. 2), OD.

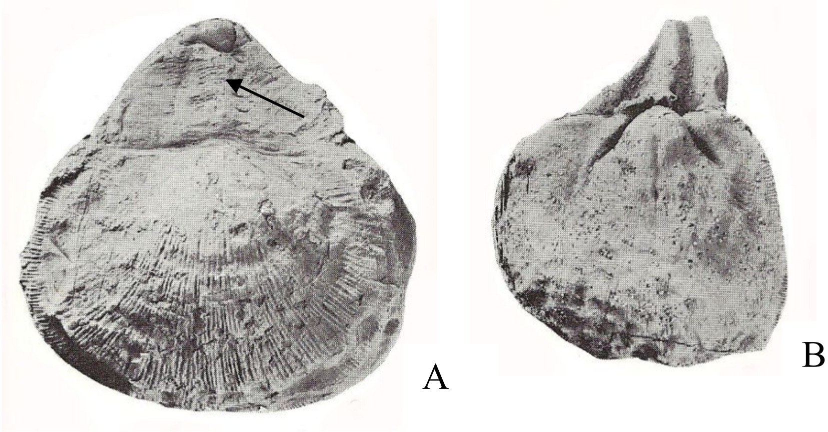

Fig. 1. *Isbellina pelicanensis* (Fletcher). A, holotype GSQF 1451 from Pelican Creek Member, Rosella Creek, showing low monticule, as arrowed. B, dorsal aspect of internal mould, GSQF 1452 from Pelican Creek. Specimens x1 from north Bowen Basin. (Hill & Woods 1964).

Description: This species is an outstanding member amongst brachiopod species found high in the marine Permian faunas of the north Bowen Basin. Specimens that are probably congeneric have been reported from slightly older faunas, as reviewed by Dear (1971, p. 4), and include specimens from the Barfield Formation, figured by Waterhouse (1986a, pl. 2, fig. 5, 6). These have a less extended ventral umbo and are unlikely to be conspecific, but better preserved material is required to consolidate their generic position, though they appear to be related. Somewhat similar specimens were reported from the Mangarewa Formation of New

Zealand (Fletcher 1952; Waterhouse 1964, 1982a), but the specimens are incomplete and not fully known. *Streptorhynchus* sp. of McClung (1983, p. 69, Fig. 12.1) from interval E of the Eddystone 1 GSQ bore possibly belongs to the genus, but with only the dorsal interior figured, is difficult to compare further without further information.

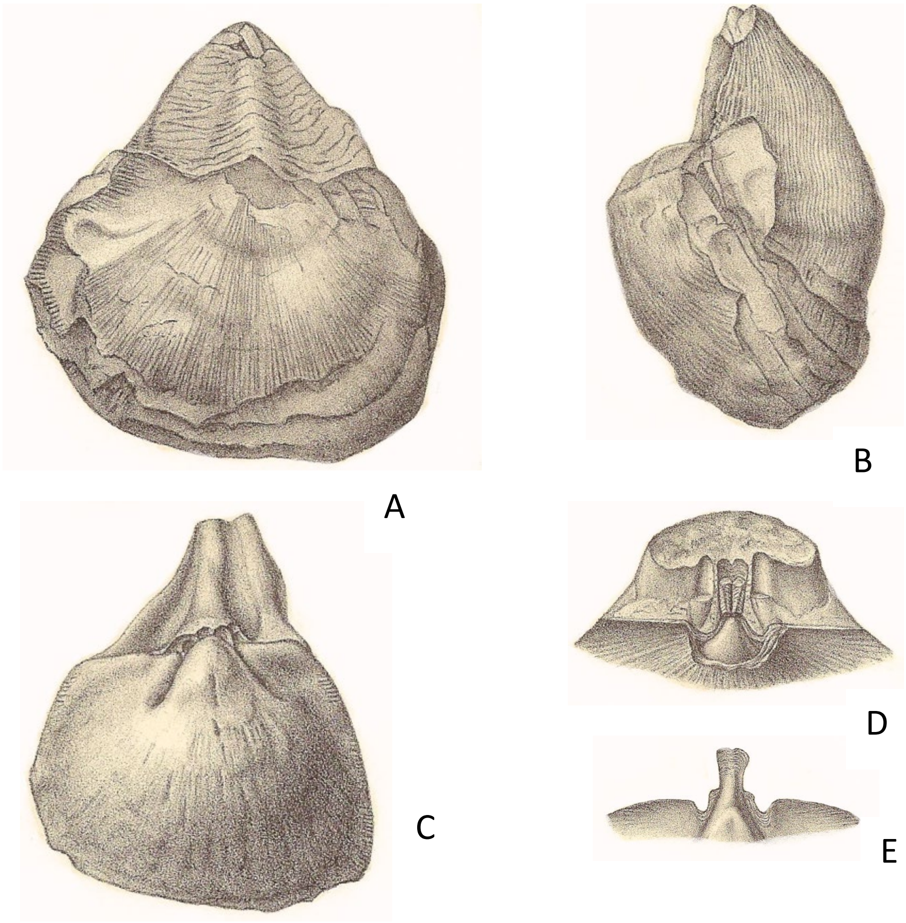

Fig. 2. *Isbellina pelicanensis* (Fletcher), figures from Etheridge (1892, pl. 12) from the Pelican Creek bed, Bowen Basin. A, B, ventral and lateral aspects of holotype GSQ F 1451. C. dorsal aspect of specimen with valves conjoined, GSQF 1452. These two specimens were refigured in Hill & Woods 1964, as in Fig. 1 herein]. D, posterior internal mould with part of umbonal region removed. E, cardinal process. Specimens x0.8 approx. (Etheridge Jnr 1892).

Superorder PRODUCTIFORMI Waagen, 1883

Order PRODUCTIDA Waagen, 1883

Suborder STROPHALOSIIDINA Waterhouse, 1975

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Tribe **ECHINALOSIINI** Waterhouse, 2001

Diagnosis: Ventral spines of two series as a rule, but may be more diverse. Dorsal valve not thickened anteriorly. (See Waterhouse & Campbell 2021, pp. 10, 11).

Genus ***Echinalosia*** Waterhouse,

Subgenus ***Unicusia*** n. subgen.

Derivation: unicus – only, single (Lat.)

Diagnosis: Ventral valve tending to have subevenly spaced suberect and sturdy spines in commarginal rows; slender suberect or prostrate spines rare. Marginal ridge well developed in both valves.

Type species: *Strophalosia clarkei* var. *minima* Maxwell, 1954, p. 547 from north Bowen Basin, here designated.

Discussion: This subgenus incorporates at least two species. As well as the nominated type species, *Echinalosia telfordi* Briggs, 1998 from the Sydney Basin and possibly *E. tasmantia* Waterhouse from the early Malbina Formation of Tasmania belong to the genus. These have recently been treated as members of *Echinalosia*, but ventral spines differ from those typical of that genus, in having fewer and inconspicuous and rare slender spines over the ventral valve: most of the spines, indeed in some specimens all of the spines, are suberect and sturdy, and regularly spaced along commarginal rows. It appears that the lineage, a minor one and limited as far as known to Middle Permian faunas of east Australia, developed from *Echinalosia* (*Echinalosia*), and that it may well have given rise to the genus *Marginalosia* Waterhouse, 1978, which is of Late Permian age, found in Nepal and New Zealand. This genus has no slender ventral spines: the spines are uniform and suberect, and the dorsal valve tended to become somewhat thickened, without being wedge-shaped. Dorsal spines were slender and erect, as in *Unicusia*, and dorsal dimples are well developed. As in *Unicusia*, the marginal ridge is well developed in both valves of *Marginalosia*.

Echinalosia* (*Unicusia*) *minima (Maxwell, 1954)

Fig. 3 - 10

1954 *Strophalosia clarkei* var. *minima* n. var. Maxwell, p. 547, pl. 56, fig. 9-11.
cf. 1954 *Strophalosia ovalis* Maxwell, pl. 57, fig. 10-12 (part, not fig. 4-9, 13, 14 = *ovalis*).
1964 *S. clarkei* var. *minima* – Hill & Woods, pl. P4, fig. 13 (part, not fig. 14 = *maxwelli*).
1964 *Strophalosia minima* = aff. *ovalis* not *clarkei* – Waterhouse, p. 41.
?1965 *Strophalosia minima* – Waterhouse & Vella, p. 62, pl. 2, fig. 11.
1971 *Echinalosia minima* – Dear, p. 7, pl. 3, fig. 11-16.
1972 *E. minima* – Hill et al., pl. P4, fig. 13 (part, not fig. 14 = *maxwelli*).
1987 *Wyndhamia minima* – Briggs, p. 140.
1998 *E. minima* – Briggs, p. 99, Fig. 52A-F.
1998 *Pseudostrophalosia crassa* [not Briggs] – Briggs, p. 119 (part).
2001 *Marginalosia*? *minima* – Waterhouse, p. 68.

Diagnosis: Transverse to subcircular, wide hinge, often weakly sulcate, moderately high subelongate ventral adductor field. Ventral spines predominantly suberect, not coarse, regularly arranged in commarginal rows, rare fine prostrate spines, dorsal valve sublamellate with moderately strong erect spines, and numerous regularly arranged pits which may be slightly elongate. Well-developed internal marginal ridge on both valves.

Holotype: UQF 16262 from Pelican Creek fauna of Dear (1972), north Bowen Basin, figured by Maxwell (1954, pl. 56, fig. 9, 10), OD.

Material: Ten ventral valves, six dorsal valves and three specimens with valves conjoined from UQL 1384, five ventral valves, two dorsal valves and a specimen with valves conjoined from UQL 1385, both in the *pelicanensis* bed, and three ventral valves, twenty dorsal valves, specimens with valves conjoined from UQL 3135.

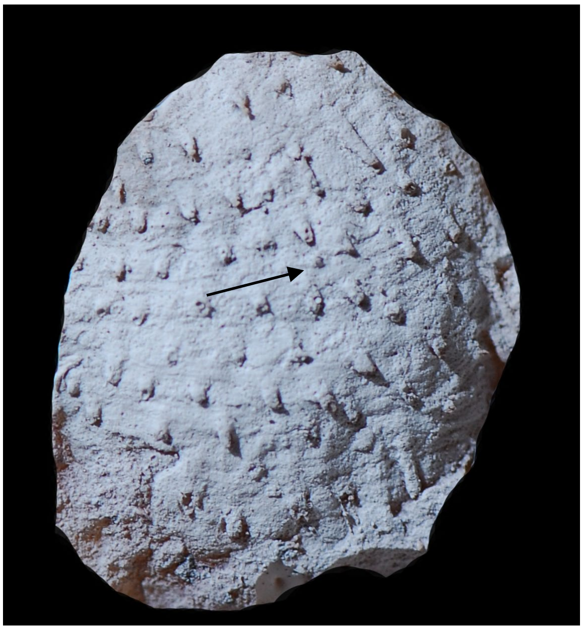

Fig. 3. *Echinalosia (Unicusia***)** *minima* (Maxwell), latex cast of part of the ventral valve, showing the characteristic subevenly spaced semirecumbent spines typical of the genus. UQF 82625 from UQL 3515, x4. A rare slender spine is arrowed.

Dimensions in mm: ventral internal mould

Width	Length	Height
34.5	27	14
37	28.5	15
22	26.5	13.5
33	31.5	14

Description: The shell is generally transverse, with median portion gently curved posteriorly, becoming shallowly sulcate in front. Broad not strongly incurved umbo with angle generally close to 100°. Posterior walls are low, maximum width placed close to mid-length, and small ears developed. A few shells are narrower and higher than usual. The hinge is wide, with moderate but not high interarea, lying either in the plane of the commissure or inclined slightly dorsad from the commissure, and bearing a narrow pseudodeltidium. The dorsal valve is moderately concave and usually without a fold or sulcus, and no conspicuous nepionic area. Its interarea is low, steeply inclined posteriorly from the commissure at 70° to 80° in fully mature specimens, and with broad but low notothyrium. Small ears are present.

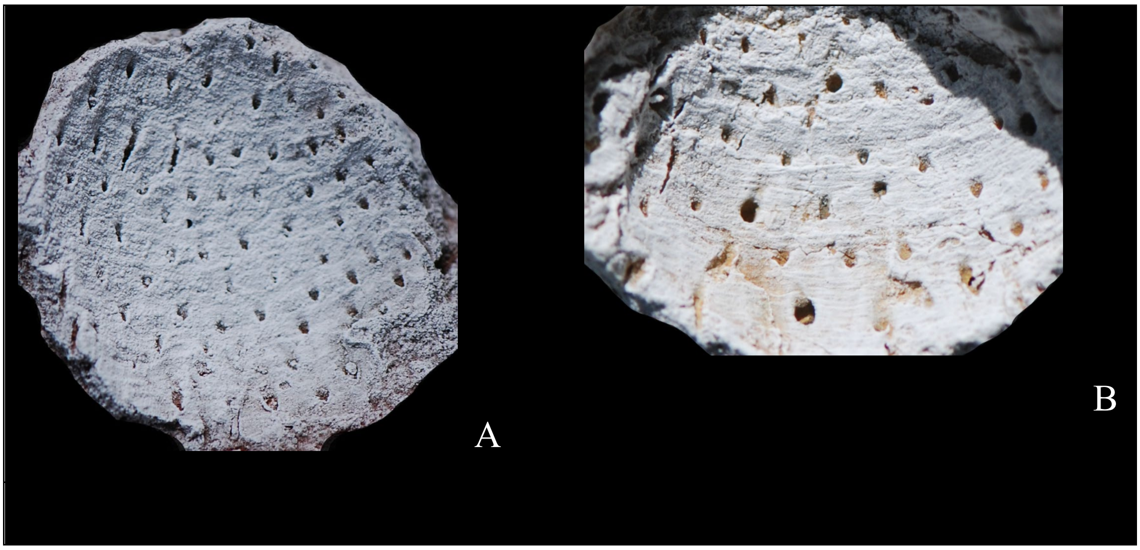

Fig. 4. *Echinalosia (Unicusia) minima* (Maxwell). external moulds showing fine as well as strong erect spine bases. A, UQF 82625, x3. (See Fig. 3). B, UQF 82667 from UQL 3135, x2, showing exceptional coarse spines. **82668 rfree**

Ventral spines are of moderate strength, 0.6 up to 0.8mm in diameter as a rule, and exceptionally just over 1mm (as in Fig. 5), most arranged in commarginal rows and to some extent in quincunx, with subdued growth lamellae or commargons. Fine recumbent spines are scattered, and may arise close to a larger spine, but are few in number. Dorsal valves that are immature or at early maturity have well developed commarginal growth laminae and dimples, and numerous erect spines 0.2 to 0.3mm in diameter, whereas growth laminae are inconspicuous in larger specimens, and spines relatively rare, although of similar diameter. There are no signs of radial capillae, but regular elongate pits cover the disc.

Fig. 5. *Echinalosia (Unicusia)* *minima* (Maxwell), exceptionally fine and crowded spines bases, possibly belonging to the species, UQF 82669, x1.2, from UQL 3135. More material might permit distinction from *minima*.

Teeth are small and closely spaced. Ventral adductors in mature specimens are raised and posteriorly placed, smooth and with a posterior myophragm in some specimens. The diductor scars are impressed, overlapping the adductors for half of their length, and strongly striate. Much of the valve floor in mature specimens is lightly pitted and pustulose,

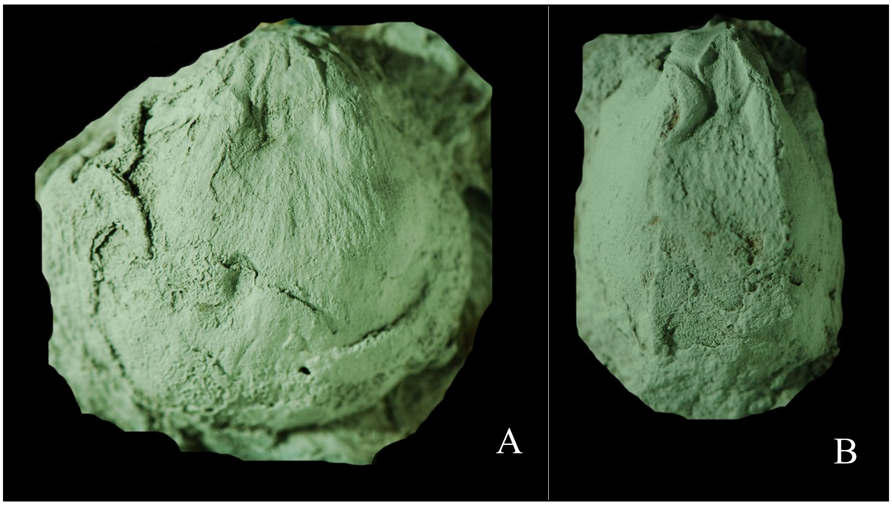

Fig. 6. *Echinalosia (Unicusia)* *minima* (Maxwell). A, ventral internal mould UQF 82634 from UQL 1384, x1.5. B, unusually narrow ventral internal mould from UQL 1384, UQF 82635, x1.5.

Fig. 7. *Echinalosia (Unicusia) minima* (Maxwell). A, ventral internal mould from UQL 1385, UQF 82630, x1.5. B, ventral internal mould from UQL 1385, UQF 82631, x2. C, ventral internal mould from UQL 1385, UQF 82632, x1.5. D, ventral internal mould from UQL 1384, UQF 82633, x2. Note the marginal ridge (in reverse), as arrowed.

especially over the posterior wall and in front of the muscle field, but there are few or no spine tunnels. A low marginal ridge encircles the valve, close to the anterior margin.

In the dorsal valve the dental sockets are inconspicuous, lying each side of the cardinal process, which has a short shaft, tending to be more ventrally inclined in smaller specimens, and displaying a bulbous terminal. The median septum extends to mid-length or slightly beyond. It narrows between the adductor scars, and broadens in front, ending without a terminal pillar. Inner adductor scars are subtriangular and smooth until late maturity, when a few irregular longitudinal ridges may develop. The outer adductor scars are also smooth and vary in length and position, generally lying behind the anterior scars and not extending far forward, although they are long in some specimens. The brachial shields are long and

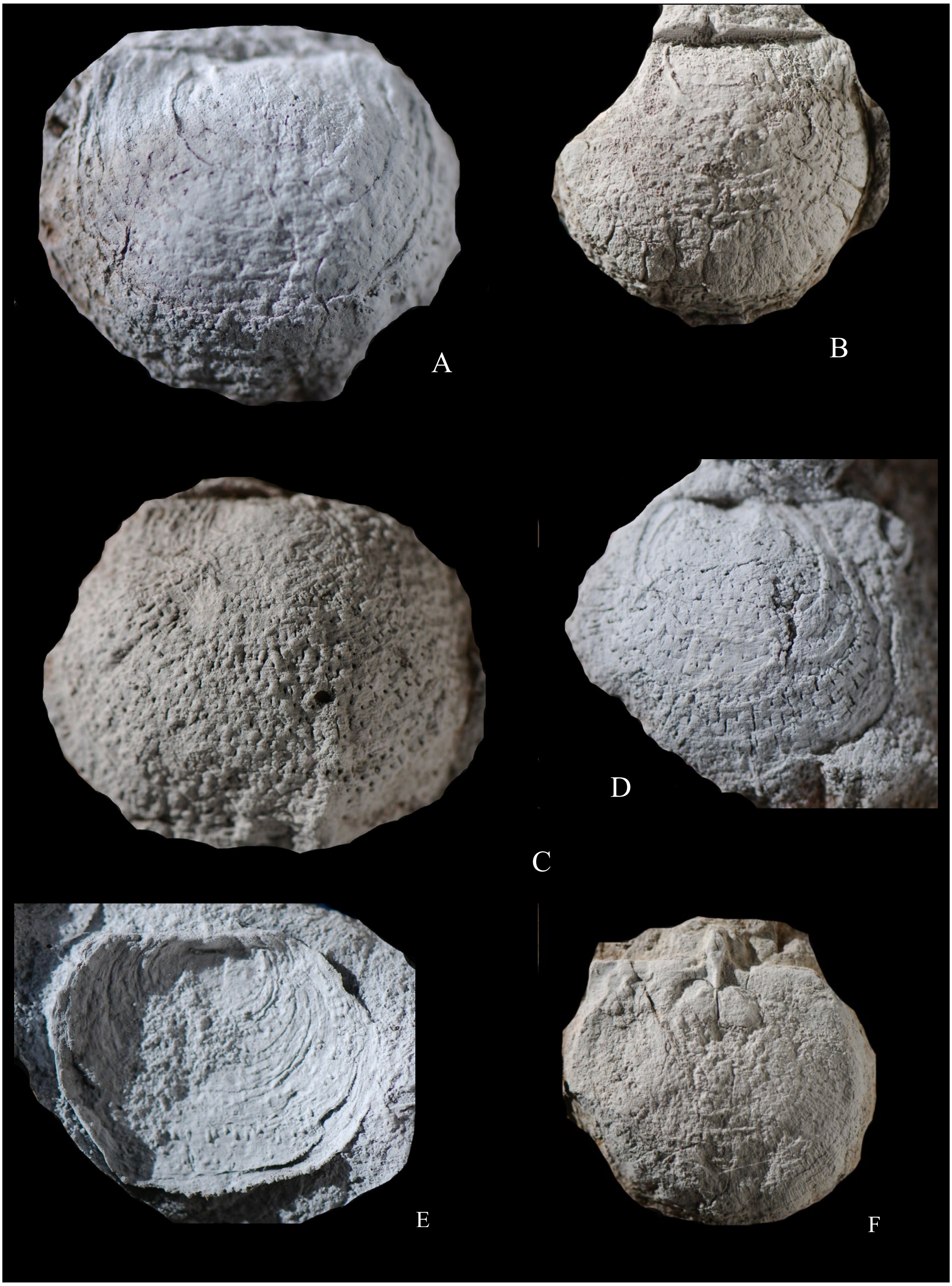

Fig. 8. *Echinalosia (Unicusia) minima* (Maxwell). A, external mould of dorsal valve from UQL 1385, UQF 82636, x2. B, dorsal external mould from UQL 1385, UQF 82637, x2. C, dorsal external mould from UQL 1385, UQF 82638, x2. D, dorsal aspect of external mould from UQL **1385**, UQF 82639, x1.5, which unusually displays a small nepionic part. E, dorsal exterior, latex cast from UQL **1385**, UQF 82640, x2. F, dorsal interior from UQL 1384, UQF 82641, x2. Note variation in the shape and size of the ears.

Fig. 9. *Echinalosia (Unicusia) minima* (Maxwell). A, external mould of dorsal valve UQF 82747 from UQL 1384, x3. B, dorsal external mould from UQL 1385, UQF 82748, x2.5.

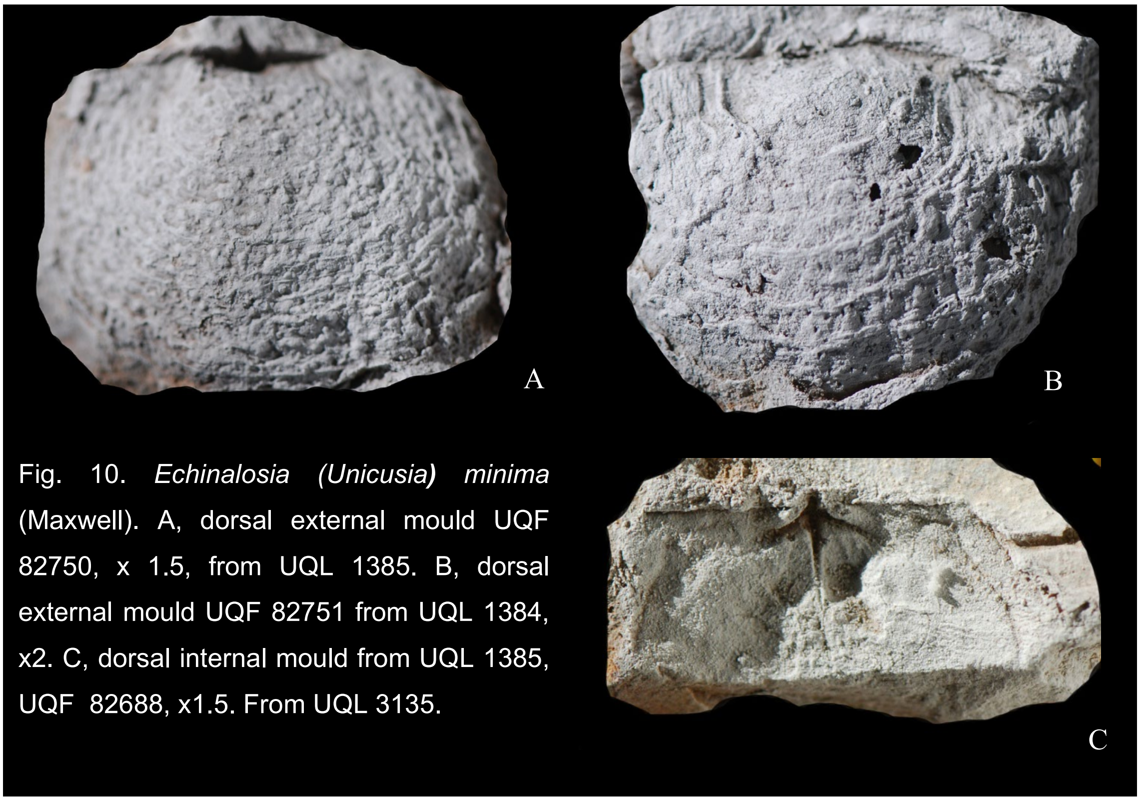

Fig. 10. *Echinalosia (Unicusia) minima* (Maxwell). A, dorsal external mould UQF 82750, x 1.5, from UQL 1385. B, dorsal external mould UQF 82751 from UQL 1384, x2. C, dorsal internal mould from UQL 1385, UQF 82688, x1.5. From UQL 3135.

narrow, enclosed by ridges which commence as a rule as lateral oblique supports for the cardinal process, although in one specimen the posterior ridge commences at the junction of the posterior lateral and anterior adductor scars, and bears a few conspicuous tubercles. The inner ridge forming the brachial loop is as a rule inconspicuous. A low marginal ridge lies inside the hinge and continues around the disc and is present at the start of a very low internal trail. The trail may bear low growth increments. Pustules are inconspicuous or absent.

Resemblances: This species is distinguished by its generally wide hinge, often with small ears, and usually transverse shell. Dorsal spines are moderately strong and ventral spines comparatively uniform and erect, as a rule arranged in commarginal rows, as well as scattered erect or subrecumbent fine spines which are generally very few in number, as well as thicker spines on a very few specimens. Dorsal valves are also moderately laminate. In the ventral valve the muscle field is posteriorly placed, not exceptionally large, and there are no conspicuous spine tunnels.

One of Maxwell's specimens treated as *ovalis* from Parrot Creek appears to belong to the species, judged from overall shape, size of adductor scars and ventral marginal ridge. It was assigned to *crassa* by Briggs (1998) without any provided evidence. Some of the specimens figured as *Echinalosia* cf. *minima* by Dickins (1989) from the Kulnura marine tongue in the Sydney Basin appear to differ in critical respects. Most have a wide hinge and rather fine spines in commarginal rows over the ventral valve. In the specimen figured by Dickins (1989, pl. 3, fig. 4), as inspected at AGSO, Canberra, there are some four stronger spines close to the posterior lateral margin, with no capillae (see p..; also p.), suggesting *Pseudostrophalosia* (see p.).

To Briggs (1998, p. 101), his taxon *Echinalosia glabra* showed a similar wide hinge and fine ventral spines, but the presence of stronger posterior lateral spines and numerous prostrate ventral spines in *glabra* suggests that any apparent approach is giving undue importance to the width of the hinge, which in fact is wide only in some of the specimens classed as *glabra*, as shown by figures of specimens in Waterhouse (1986a, pl. 5, fig. 6, 7).

Briggs (1998, p. 108) suggested that *Echinalosia voiseyi* Briggs compared with *Marginalosia kalikotei* (Waterhouse), mainly it appears because both species could have a wide hinge, but *voiseyi* has different ventral spines, arranged in two regular series, to indicate a different lineage, called *Nothalosina* Waterhouse (2010, p. 52, Fig. 20, 21). A closer ally to *kalikotei* is *Echinalosia telfordi* Briggs (1998, p. 91, Fig. 48A-F) from the Nowra Sandstone of the south Sydney Basin. The ventral valve displays mostly erect spines of fairly uniform diameter, and the dorsal valve has a well-developed marginal ridge. Only one broken external mould was figured to illustrate the ventral exterior, which is hardly sufficient to circumscribe the species. A more complete internal mould shows no spine tunnels, and does reveal the dorsal marginal ridge, though unmentioned by Briggs (1998).

Taxonomy: Maxwell (1954) erected this taxon as a new variety of *Strophalosia clarkei*. Later Waterhouse (1964, p. 41) suggested that the taxon was more closely related to *Echinalosia ovalis* than to *clarkei*, and Dear (1971) consolidated this observation by referring *minima* to *Echinalosia* Waterhouse, 1967a. Unusually, he claimed authorship of *minima* for himself. The justification behind Dear's step was scorned and treated as a self-serving invention by Briggs (1998), who criticized Dear for not following the ICZN ruling of 1985, article 45g, which allowed varieties to be rated as of subspecific rank, as endorsed in 1999. Clearly, Dear in 1971 failed to anticipate the 1985 ruling, hardly a matter that justifies criticism. Dear relied on the ICZN discussions such as in Stoll et al. 1961, which implied that rulings were open to revision by later workers and need not have formal taxonomic standing. Briggs (1998) ignored this ruling, though much more relevant to the stance by Dear (1971) than any ruling which at that time lay in future. In discussions with me, this 1961 ruling was interpreted by various workers, including the eminent paleontologist Sir Charles Fleming at the New Zealand Geological Survey, to imply that varieties had no taxonomic standing, unless they were republished at full specific rank, and no doubt Dear had received similar advice from his supervisor, Professor D. Hill. It was only later that varieties fell under a more circumscribed regime by the International Commission for Zoological Nomenclature, to be treated (quite reasonably) either as subspecies, with taxonomic standing, or as a variety with no taxonomic standing. Dear was not able to anticipate the firm decision to potentially treat varieties as subspecies. Dear's treatment was accepted by Hill et al. (1972) and Dickins (1989), though not by Runnegar (1980, photo 19.1, fig. 2). Dear was one of the most able paleontologists on Permian macro-fossils in Australia during the 1960's and 1970's, and few have matched the standard he achieved in paleontological research on that particular subject.

Tribe **WYNDHAMIINI** Waterhouse, 2010

Genus ***Pseudostrophalosia*** Clarke, 1970

Diagnosis: Medium-sized suboval shells, the ventral valve moderately to well inflated with small cicatrix and dense erect to semirecumbent spines generally arranged in commarginal rows, in two series over disc and trail, and, as prime characteristic, close-set spines clustered over the ventral ears. Dorsal valve with numerous fine generally erect spines, may be heavily thickened, especially anteriorly.

Type species: *Strophalosia brittoni* Maxwell, 1954, p. 543 from Tiverton Formation (Sakmarian), Bowen Basin, OD.

Discussion: There is an upward drift in morphology amongst species assigned to this genus, as noted on p. . The cluster of spines over the ventral ears is not so well developed in the late Middle Permian species *Pseudostrophalosia clarkei* as shown on the left side of a figure of *clarkei* provided by Briggs (1998, Fig. 61A). when compared with the number of ear spines in the Early Permian type species, *Ps. brittoni*. In several specimens amongst the collection surveyed herein, a very few large spines emerge from especially the anterior ventral ears. In addition, the ventral spines of the present species are more varied in diameter and distribution than in *brittoni*, and dental buttresses are much better developed in older species, such as *Ps. brittoni*.

Pseudostrophalosia furcalina n. sp.

Fig. 10 – 19

?1998 *Pseudostrophalosia ingelarensis* [not Dear] – Briggs, Fig. 62E-G, I (or = i*ngelarensis*, see discussion on p.).

Derivation: furca – groove, furrow, Lat.

Diagnosis: Small moderately inflated shells characterized by shape and especially by close-set spine tunnels over the ventral internal surface. Ventral spines dense and of varied diameter.

Holotype: Specimen UQF 82752 from UQL 3135, Fig. 11B, here designated.

Material: Well over fifty ventral valves and forty dorsal valves together with a very few specimens with valves conjoined are available from UQL 3135.

Description: Ventral valves are mostly mature, mean width 35.2mm, mean length 33.6mm and mean height 14.6mm, based on internal moulds (n = 20). The shells are convex, and dorsal valve gently concave with slight diminution of curvature medianly and no visible trail. Maximum width lies near mid-length, and the hinge is somewhat shorter, with small well-formed ears on each valve, generally with sharply obtuse cardinal extremities. The ventral

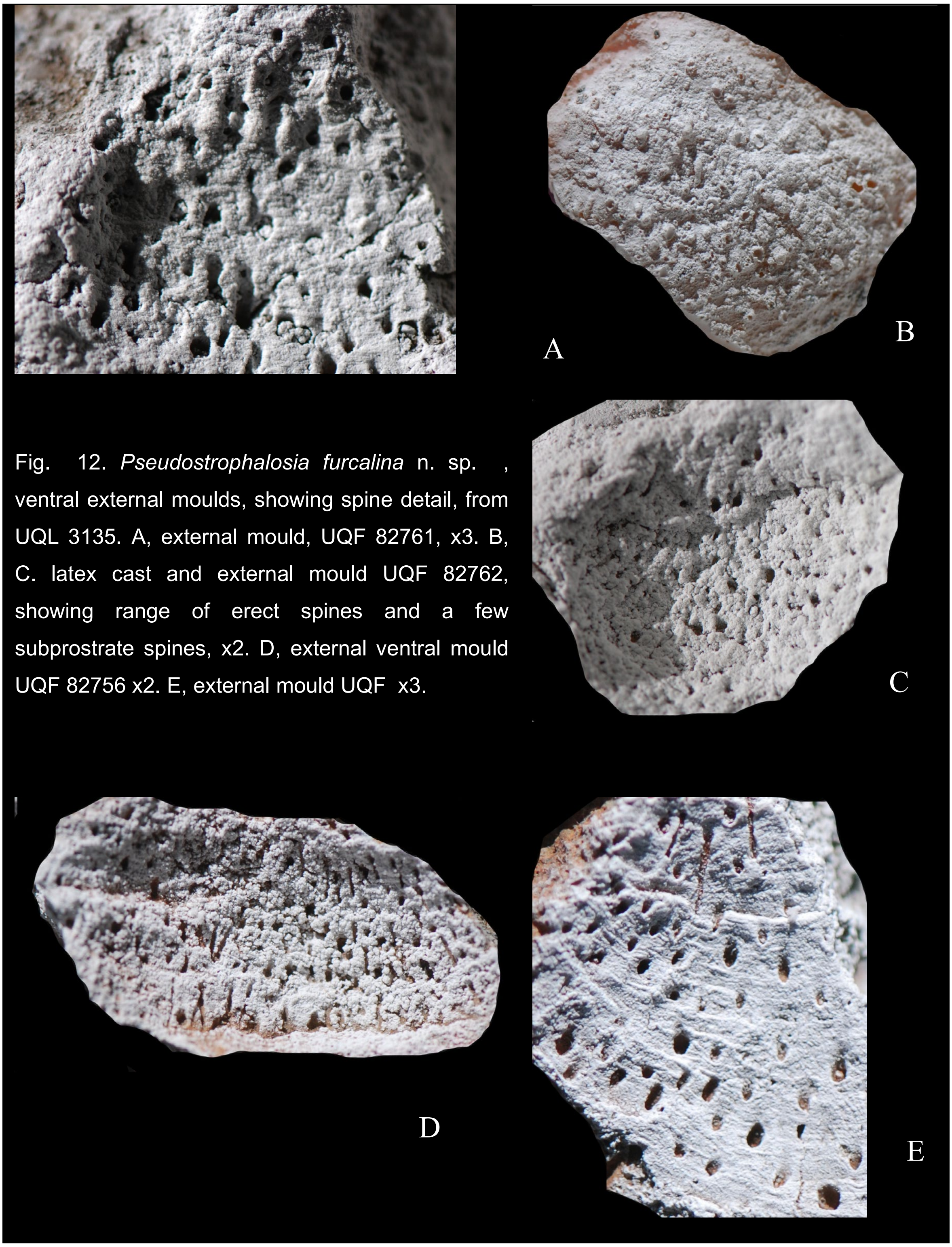

Fig. 12. *Pseudostrophalosia furcalina* n. sp. , ventral external moulds, showing spine detail, from UQL 3135. A, external mould, UQF 82761, x3. B, C. latex cast and external mould UQF 82762, showing range of erect spines and a few subprostrate spines, x2. D, external ventral mould UQF 82756 x2. E, external mould UQF x3.

need1 new numbers, see Fig.Myomed. Del D, E?

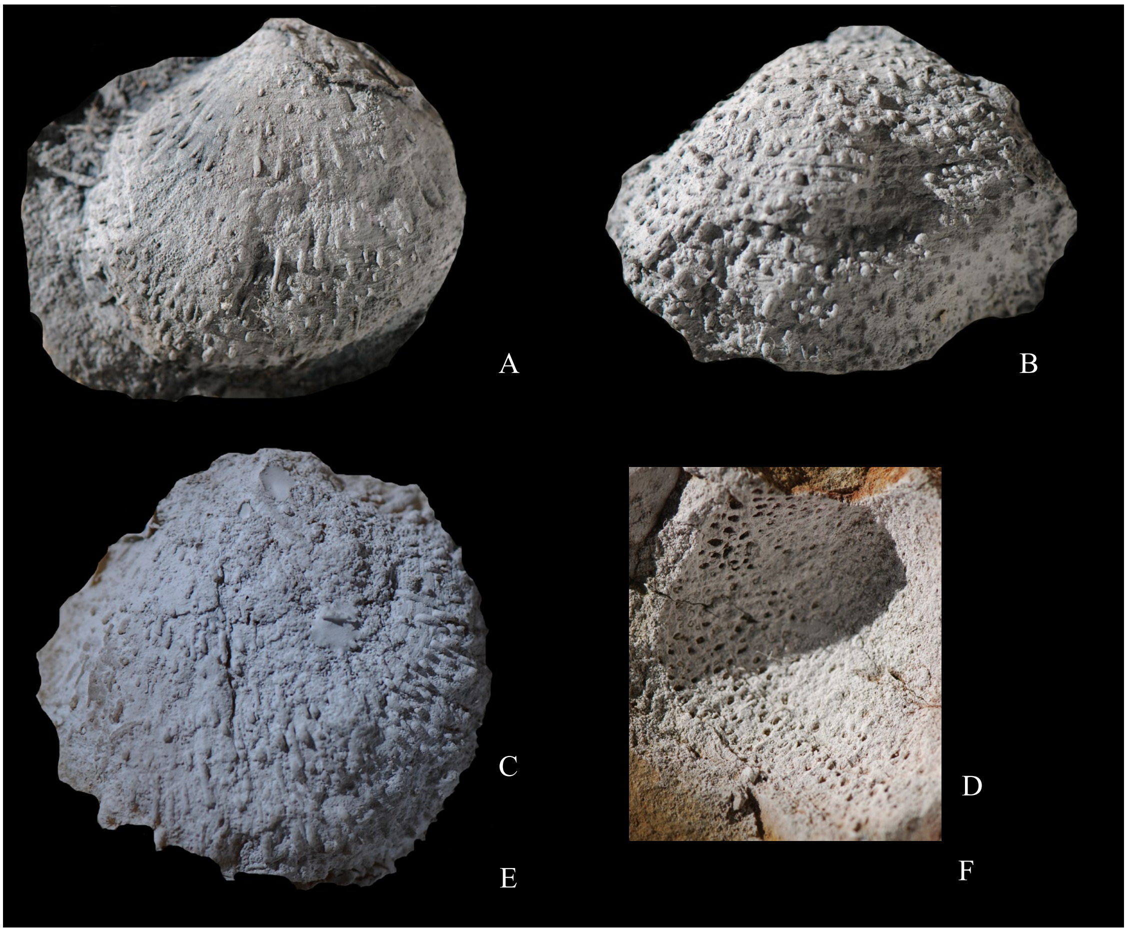

Fig. 11. *Pseudostrophalosia furcalina* n. sp. A, external ventral latex cast, UQF 82644, x1.5. B, external ventral latex cast, UQF 82752**,** x1.5. C, latex cast of ventral valve UQF 82648, x2. D, detail of ventral spines entering external mould, UQF 82649, x1.5. All specimens from UQL 3135.

interarea lies largely in the plane of the commissure, bearing light striae parallel to the hinge, and disrupted medianly by a narrow raised pseudodeltidium with angle close to 10^o. Ventral spines are dense. Fine recumbent spines are scattered over the shell, commonly up to 0.2mm in diameter, and suberect spines are dense, arranged in commarginal rows and quincunx, varying in thickness but generally 0.6mm to 0.7mm in diameter. Large specimens at late maturity show a reduction in the number of spines, with loss of prostrate spines, and spines 1mm to 1.2mm diameter are found especially around the shell margins, up to three in 5mm, and fewer medianly, with as few as two in 5mm. A few specimens show the nature of the spines over the ears, and these tend to be few and stout, especially over the anterior ears. For the dorsal valve, the disc is very gently concave, with a narrow interarea steeply inclined from the disc. Spines are fine and erect, usually close to 0.1mm in diameter, and vary from numerous and dense to scattered and few, the difference possibly reflecting preservation or degree of maturity.

In the ventral valve, teeth are comparatively small, and not always reinforced by large buttresses. The adductor platform is elongate, with either a median groove, or low median ridge, behind a groove in some specimens. Diductor scars are large, oval and gently impressed, tending to overlap the adductors for half of their length, and placed further forward in larger specimens. They bear longitudinal ridges, but not to any marked extent. Prominent spine tunnels lie over the middle and anterior shell, generally in front of the muscle field, although in some specimens a few tunnels visibly cross the diductor scars. A very low ridge may lie along the inner side of the ears, and passes into a low marginal ridge on the trail.

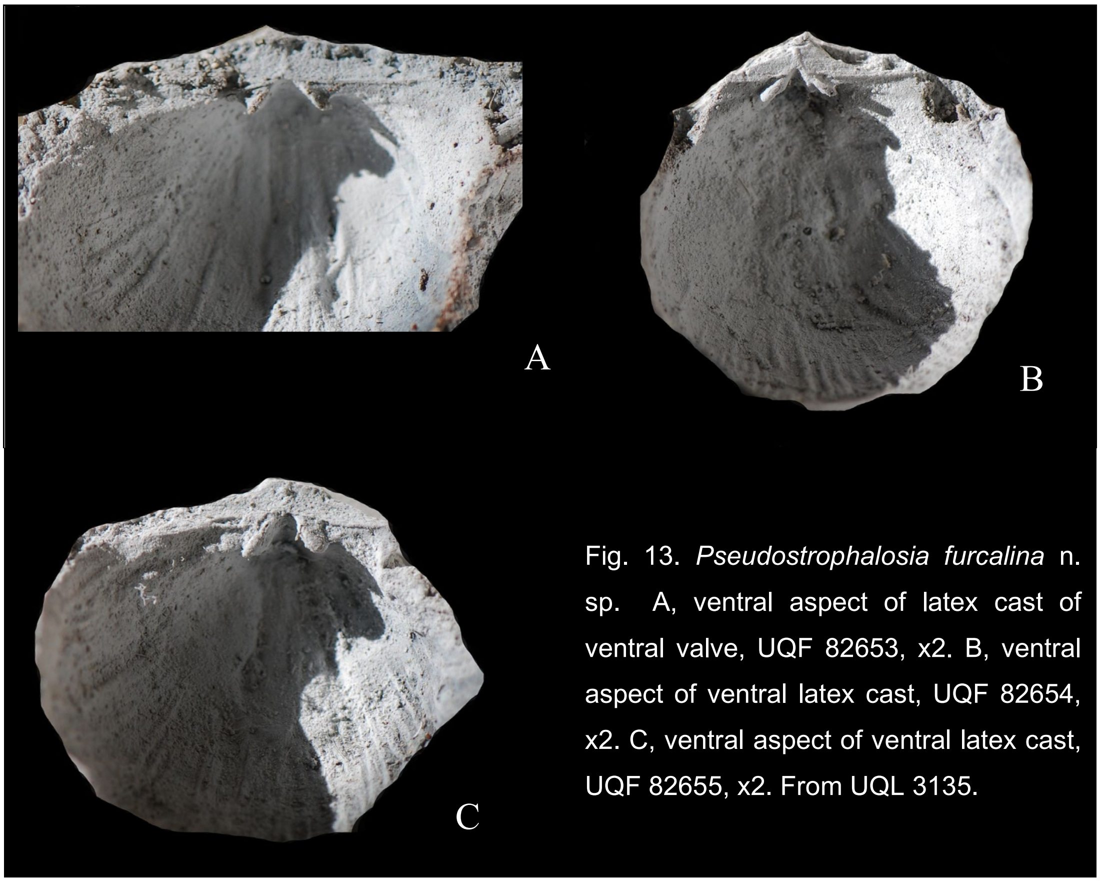

Fig. 13. *Pseudostrophalosia furcalina* n. sp. A, ventral aspect of latex cast of ventral valve, UQF 82653, x2. B, ventral aspect of ventral latex cast, UQF 82654, x2. C, ventral aspect of ventral latex cast, UQF 82655, x2. From UQL 3135.

Fig. 14. *Pseudostrophalosia furcalina* n. sp. , ventral internal moulds from UQL 3135. A, from UQL 3136, UQF 82656, x1.5. B, D, UQF 82655, x1.5, x4. C, UQF 82654, x1.5. E, UQF 82657, x2. F, UQF 82654, x2.

The dorsal interior displays an erect cardinal process and sturdy median septum extending to mid-length. Small posterior adductor scars with markings lie close to the septum, and an anterior pair of smoother adductor scars is placed further from the mid-line. Brachial shields are outlined each by a low ridge which extends far from the mid-line to lie close to the lateral margins. A low marginal ridge encircles the valve, faint posteriorly, close to the lateral margins laterally, and highest in front, where it is placed inside a low trail.

Fig. 15. *Pseudostrophalosia furcalina* n. sp. A, dorsal aspect of external mould UQF 82754 x 2. B, dorsal external mould, UQF 82755, x1.5. C, dorsal external mould UQF 82756, x1.5. D, dorsal external mould UQF 82723, x1.5,. E, dorsal external mould UQF 82669, x1.5. F, dorsal external mould UQF 82668, x2. Specimens from UQL 3135.

Resemblances: *Pseudostrophalosia brittoni* (Maxwell, 1954, pl. 54, fig. 20-22, pl. 55, fig. 1-3), also figured by Briggs (1998, Fig. 60A-F) and Waterhouse (1986a, pl. 5, fig. 19-23 (part, not pl. 15, fig. 6 = *Acanthalosia mysteriosa* Waterhouse from the Cattle Creek (Sirius Shale of the southwest Bowen Basin; 2015a, Fig. 34-40) from the mid-Tiverton Formation and Elivinia Formation of the Bowen Basin has a slightly wider hinge and more regularly spaced ventral spines and less conspicuous ventral spine tunnels. Low pustules are well displayed internally over the anterior dorsal valve, and muscle scars in both valves are often ridged. Otherwise, the dorsal interior is closely similar. These assessments are based chiefly on the description and illustrations in Waterhouse (2015a), which are based on material found in strata close to the source of the type specimen. The specimens generally have a wide hinge, with only small ears.

Pseudostrophalosia clarkei (Etheridge Snr, 1872) from the Scottville Member has been discussed in the preceeding article (see p.). The mature shells are larger and less inflated, and the internal ventral valve less affected by spine tunnels. The two forms are moderately close, suggesting that *clarkei* probably evolved into *furcalina.*

Strophalosia brittoni var. *gattoni* Maxwell, 1954 has as a rule been synonymized with *Pseudostrophalosia clarkei*, coming as it does from the lower Scottville Member. Dear (1971) treated the taxon as a new subspecies authored by Dear, and added a number of additional specimens, even considering that some specimens come from what is now the Pelican Creek fauna. The original and only figured ventral valve (Maxwell 1954, pl. 55, fig. 4-6) does not show spine tunnels, unlike the present specimens, and no illustration or even discussion of the nature of the ventral ornament has ever been provided. There remains the need for caution, and further exploration to confirm or dismiss the association between *clarkei* and *gattoni* (see pp.).

Pseudostrophalosia blakei (Dear, 1971, pl. 2, fig. 10, 11, pl. 3, fig. 1-4; Waterhouse & Jell 1983, pl. 1, fig. 7, 8, pl. 6, fig. 1) from the lower Blenheim Formation of the north Bowen Basin is highly varied in shape, and includes a number of specimens that are more triangular

Fig. 16. *Pseudostrophalosia furcalina* n. sp. A, dorsal external mould **UQF 827** x1. B, dorsal external mould, UQF 82659, x1. C, latex cast of dorsal exterior, UQF 82666, x1.5. D, latex cast of dorsal exterior, possibly slightly worn, UQF 82665, x1.5. The cardinal process has broken short. Specimens from UQL 3135.

in shape than the specimens from UQL 3135, with short hinge, small ears, and long median septum, although other specimens have a wider hinge. Spines are dense and largely uniform. A number of the specimens are close in shape, and all agree in ornament with *Ps. ingelarensis* (Dear, 1971, pl. 3, fig. 5-9) from the correlative Ingelara Formation. Waterhouse & Jell (1983) and Waterhouse (1986a) wished to merge *blakei* with *ingelarensis*. Briggs opposed this, claiming that *blakei* was subtriangular in shape, and that *ingelarensis* came from much younger beds, younger than *clarkei*. These assertions are set aside. As discussed subsequently, the two taxa were correlative, and overlap considerably in shape, size, and spine detail. Both have fine dense spines. The holotype of *blakei* is certainly subtriangular, as described above. But one of Dear's figured *blakei* (Dear 1971, pl. 3, fig. 2) has a wide hinge. Two dorsal valves from the upper Moonlight Sandstone illustrated by Waterhouse & Jell (1983, pl. 1, fig. 7, 8, pl. 6, fig. 1) have a wide hinge, and are not

Fig. 17. *Pseudostrophalosia furcalina* n. sp. dorsal internal moulds from UQL 3135. A, UQF UQF 82660, x2. B, UQF 82661 x2. See Fig. 19A. C, UQF 82756, x1.5. D, UQF 82664, x2. See Fig. 19B. E, UQF 82662, x2. F, UQF 82663, x2. From UQL 3135**.**

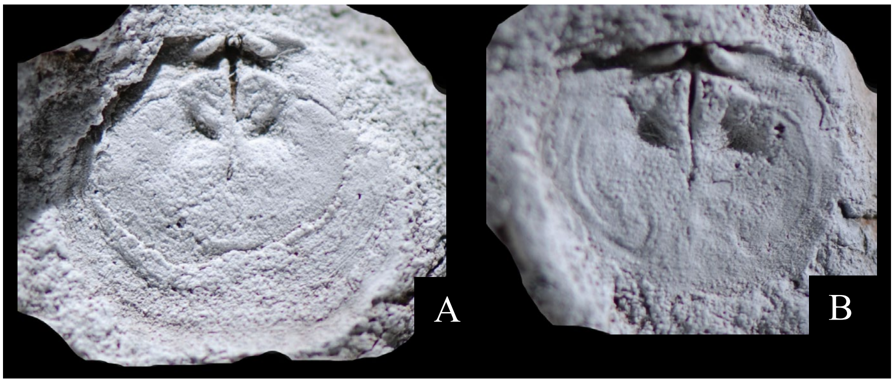

Fig. 18. *Pseudostrophalosia furcalina* n. sp. A, mould of of dorsal interior, UQF 82643. B, mould of dorsal interior, UQF 82642. Small specimens x4, from UQL 3135.

subtriangular in shape. The agreement in shape and spinosity between the two taxa led Waterhouse & Jell (1983) to suggest that the two taxa were synonymous, and could not be objectively separated.

A major error regarding *Pseudostrophalosia ingelarensis* appears to have been made, presumably inadvertently, by Briggs (1998, Fig. 62E, F, G) in identifying the species at UQL 3135. The figured specimens are amongst the best preserved of the specimens which he ascribed to *ingelarensis*, but they differ from the large suite of specimens from UQL 3135 as described in the present study in having much less conspicuous spine tunnels, possibly because the figured interior (Briggs 1998, Fig. 62E) is immature, and it is clear that the species found at UQL 3135 cannot be regarded as impeccable constituents of the taxon *ingelarensis*, without careful and first-hand re-examination. The ventral interior of Dear (1971, pl. 3, fig. 6a) shows no spine tunnels, perhaps because it is immature, and another more mature specimen (fig. 9) shows much less marked spine tunnels than in the present and much larger suite. Dear's specimens do have, like type *blakei* and type *ingelarensis*, fine ventral spines. Coarser spines rarely exceed 0.5mm in diameter, with Briggs (1998, p. 119) recording spines of the same diameter as typifying the species, and noting slightly thicker spines posterolaterally. The ventral spines of shells from UQL 3135 are more diverse and less regularly arranged than in the material he considered to have come from UQL 3135 by Briggs (1998, Fig. 62E, F, G). It is concluded that the Briggs specimens stated as coming from UQL 3135 are not typical of the locality UQL 3135, as exemplified by the figures provided in this text, and whether they were exceptional, or whether they indeed belong to *ingelarensis* sensu Dear, and did not come from UQL 3135, can not be determined with confidence, especially because the specimens cannot be now re-examined. They were registered as AMF specimens, though “borrowed” from Queensland Museum, and have now disappeared. This substantially helps to undercut the claim by Briggs (1998) that *ingelarensis* followed *clarkei* in the stratigraphic succession. It did not. The species *ingelarensis* = *blakei* preceeded *clarkei*, well shown in the north Bowen Basin along the Bowen Basin, as analysed by Waterhouse & Jell (1983). Type *ingelarensis* comes from the Barfield Formation of the southeast Bowen Basin, well below beds with *clarkei*.

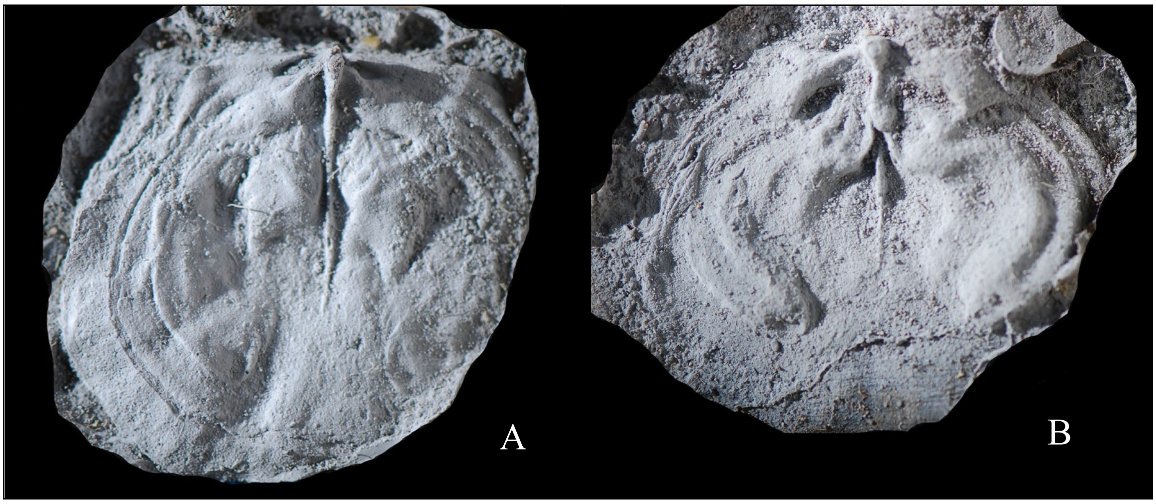

Fig. 19. *Pseudostrophalosia furcalina* n. sp., dorsal latex casts from UQL 3135. A, UQF 82661, x2. See Fig. 17B. B, UQF 82664, x2. See Fig. 17D.

Pseudostrophalosia crassa Briggs (1998, p. 119, Fig. 63A-G) from the upper Ingelara or lower Peawaddy Formation was conceived to be of large size with subcircular to transversely oval outline, wide hinge and comparatively coarse spines. Briggs designated two different specimens as holotype for *crassa*. One of the holotypes was designated for a specimen from GSQ Eddystone 1, a borehole from which McClung (1983, pl. 15, fig. 1-21) had illustrated a number of specimens. These show not only the range of shapes reported by Briggs, but some with short hinges, and the subtriangular shape (McClung 1983, Fig. 2a, b 7a, b, 10a, b, 14, 19a, b) like that shown for the holotype of *blakei* figured by Dear (1971).

McClung emphasized that he had referred the specimens to *ingelarensis* rather than *blakei* because some were sulcate. So they are. And so is one of specimens figured as *blakei* by Dear (1971, pl. 3, fig. 2). The fact is that shells available to Dear, as may be seen in the original collections, not just the figured ones assigned to *blakei,* were highly variable in shape and include a range of shells particularly within the range of available *ingelarensis* (Waterhouse 2001, p. 77). The specimens may well show a drift in spinosity as indicated by Briggs (1998), and they suggest a relationship to *blakei* and *ingelarensis*, though none of the ventral valves figured by McClung seem particularly close to *blakei* – or *ingelarensis*. The spine pattern is not identical with that of present material, McClung's ventral valves having some commarginal rows of coarse spines, as well as much less conspicuous spine tunnels, and dorsal laminae are less conspicuous. Everything points to *crassa* being a separate species derived from *blakei*. It is of limited geographic extent, with no material known beyond the particular bore hole. Ventral spine tunnels are inconspicuous. See also p.

Several of the specimens figured as *clarkei* by Etheridge (1892, pl. 13, fig. 12, 16, 17, pl. 14, fig. 19) were referred to *crassa* by Briggs (1998, p. 119), but they show no spine detail, and could well belong to *clarkei*.

New Zealand specimens from the upper Mangarewa Formation that had been figured as *clarkei* by Waterhouse (1964, pl. 8, fig. 5-9, text-fig. 7i, j, 8c, 15a-c, 18, 19) were dismissed as belonging to *Echinalosia* by Briggs (1998, p. 118). They lacked external ornament, but in shape are like *Pseudostrophalosia* (see Waterhouse 1964, text-fig. 18, 19), because no *Echinalosia* is known to display such dorsal thickening, and the brachial shields are comparable to those of *Pseudostrophalosia clarkei,* with the anterior hook shown in Waterhouse (1964, text-fig. 18C, F), as reinforced in Waterhouse (2021, Fig. 5, p. 128). This difference was ignored by Briggs (1998). He claimed that the absence of thick dental buttresses established that the species could not have been *Pseudostrophalosia*. But it is chiefly *Ps. brittoni* which shows thick buttresses. Dental buttresses are only feebly or even not developed in numerous specimens placed as *clarkei* and in the new species *furcalina* although they are present in some specimens. Well developed ears are suggested in three of the ventral valves figured by Waterhouse (1964, pl. 8, fig. 5-7). However it is judged that the considerable inflation and high lateral walls of the New Zealand species rule out *clarkei*, and indicate a different species, *Pseudostrophalosia routi* Waterhouse (2021a, p. 124), and they are more inflated than *furcalina* and do not have conspicuous spine tunnels.

Suborder LINOPRODUCTIDINA Waterhouse, 2013

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

Family **PAUCISPINAURIIDAE** Waterhouse, 1986a

Subfamily **PAUCISPINAURIINAE** Waterhouse, 1986a

Tribe **PAUCISPINAURIINI** Waterhouse, 1986a

Genus ***Terrakea*** Booker, 1930

Diagnosis: Ventral valve with incurved umbo, visceral disc thick, capillae over both valves, spine ornament distinguished by a cluster of stout erect spines over ventral umbonal slopes and ears, some dorsal anterior disc and trail spines also thick.

Type species: *Productus brachythaerum* Morris (1845, p. 284, pl. 2, fig. 4c) from Gerringong Volcanics, south Sydney Basin, OD.

Discussion: Species of the genus *Bookeria* Waterhouse, 2015a, p. 119 from the middle Tiverton Formation appear to have been progenital to *Terrakea* Booker, 1930 and *Paucispinauria* Waterhouse, 1983b of later Permian age. These genera are classed in Paucispinauriinae Waterhouse, 1986a. *Bookeria* is distinguished by the lack of thick dorsal spines, and *B. sparsispinosa* Waterhouse has few thick spines over the ventral ears, pointing to a source for *Paucispinauria concava* and *P. solida* (Etheridge & Dun) and other species, whereas another species, *B. drysdalei* Waterhouse, has numerous strong spines over the ventral ears, leading to the development of *Terrakea dickinsi* Dear and other *Terrakea*.

Terrakea elongata planidisca n. subsp.

Fig. 20 - 25

1964 *Terrakea elongata* [not Etheridge & Dun] – Waterhouse, p. 81, pl. 15, fig. 1-6, pl. 16, fig. 1, 7, text-fig. 26-30.

Derivation: plane simply, evenly – Lat; discus – brachiopod disc.

Diagnosis: Dorsal disc large, wide and almost flat, trail geniculate.

Holotype: UQF 82758 from UQL 3515, Fig. 24A, here designated.

Material: Eight fragmentary ventral valves, five dorsal valves and five specimens with valves conjoined, with fragments from UQL 3135.

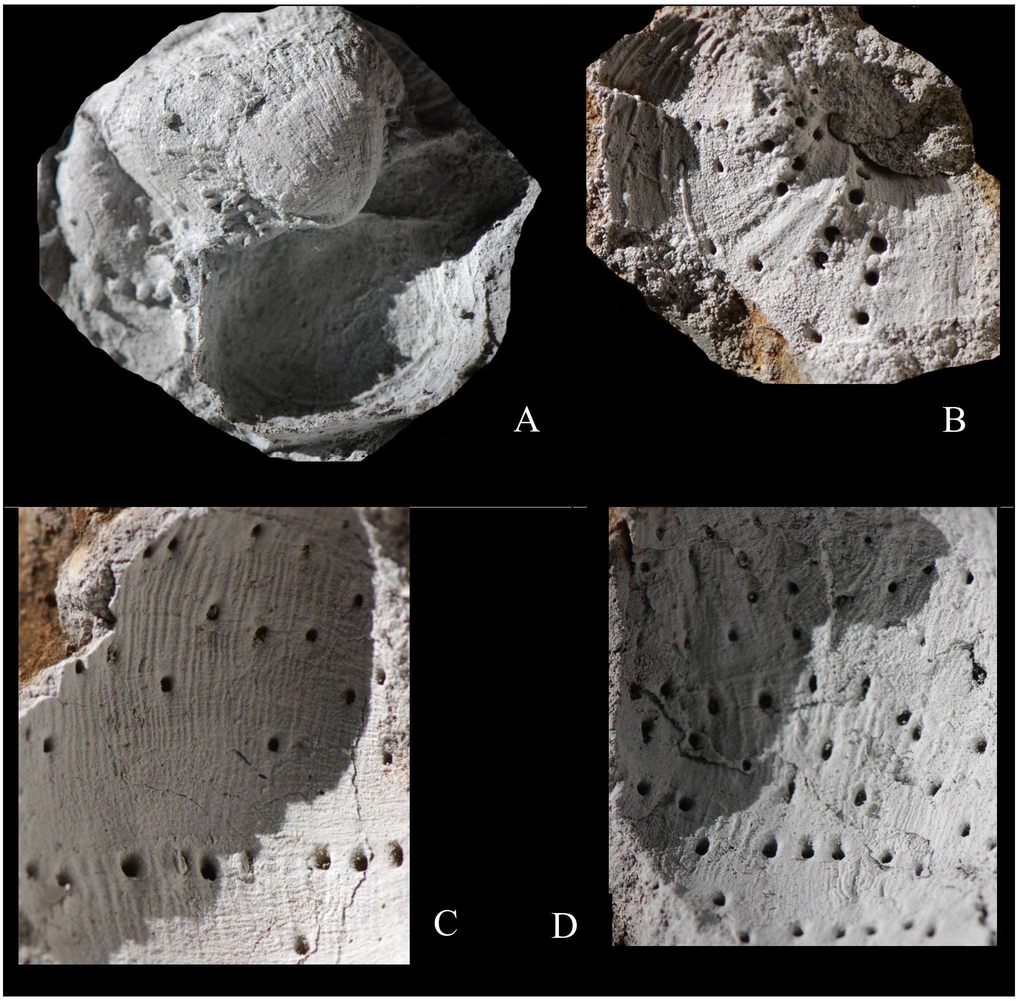

Fig. 20. *Terrakea elongata planidisca* n. subsp. A, latex cast of posterior ventral and dorsal valve, UQF 82670, x1.5. B, external mould of part of ventral valve, UQF 82671, showing large lateral spine bases, x2. C, D, panels showing ornament on ventral external moulds, UQF 82672 and UQF 82673, x2. Specimens from UQL 3135.

Description: Ventral valve elongate and inflated, one measuring 34mm wide, 44mm long and 30mm high, and another 30mm wide and 34mm long and 22mm high, another 29mm long, 30mm long and 22.5mm high. The shell is incurved posteriorly, with broad umbo measuring 80° to 90°, and very high weakly convex posterior walls, and maximum width placed in front of the hinge. The hinge lies at maximum width. Ventral ears are gently convex, and poorly

Fig. 21. *Terrakea elongata planidisca* n. subsp. external mould of part of ventral valve, UQF 82674, showing large lateral spine bases, x2. Umbo to lower left.

Fig. 22. *Terrakea elongata planidisca* n. subsp. A, B, posterior and anterior aspects of ventral internal mould, UQF 82675, x1.5. C, D, anterior and posterior aspects of aspects of ventral internal mould, UQF 82676, x2. Specimens from UQL 3135.

distinguished from the posterior umbonal slopes. The ventral median shell is broadly and very gently convex, and the trail curves evenly forward from the disc. The dorsal valve as a rule has a broad and only gently concave disc, which bends abruptly with steep curvature into a trail that is a little longer than the disc. For the dorsal valve, there are small concave ears and acute cardinal extremities. There is no median dorsal fold or ventral sulcus. An array of thick erect spines generally 1.3mm in diameter lies over the outer ventral umbonal slopes and the inner and anterior ears. Erect spines lie over the disc, and the spine bases continue forward within the shell for up to 8mm. Spines thicken over the anterior disc and over the trail, and externally lack posteriorly prolonged spine bases and internally lack the anterior spine bases which pass forward into the shell. Spines lie in rough quincunx over the posterior trail, and in erratic rows over the anterior trail, with diameter up to 1.5mm. Radial capillae are as coarse as seven in 5mm over the anterior disc and posterior trail, and may become finer over the anterior trail, with weak irregularities. Increase is by intercalation, and some intercalated capillae appear and then vanish over the posterior trail and anterior disc. Spines are fine and variable over the dorsal disc. Some specimens appear to have none, reflecting preservation, whereas other specimens have fine erect spines 0.3mm in diameter over the anterior disc. The dorsal ears and trail bear large spines, up to 1.4mm in diameter, overall scattered rather than organized in rows or quincunx. Radial capillae are well developed, nine in 5mm over the anterior disc, and seven to eight in 5mm on the anterior dorsal trail. But the density varies, and the arrangements are varied and complex. The spines disrupt two to three capillae, and a smooth area may appear in front of the spine. Over the disc, on a few specimens, the dorsal spines have external prolonged posterior bases, which is unusual for the genus.

Ventral adductors are posteriorly placed, and in smaller specimens bear two or three ridges and grooves. In more mature specimens, the posterior adductors each bear several oblique grooves and ridges, increasing anteriorly by intercalation, radiating posterolaterally, and the anterior adductor scars are raised, small, oval and smooth. The diductor scars are impressed, broadly oval in shape, and not extending as far back as the adductors. The anterior surface of the valve is marked by long spine tunnels, and the surface is very finely pitted. No dorsal interiors are known.

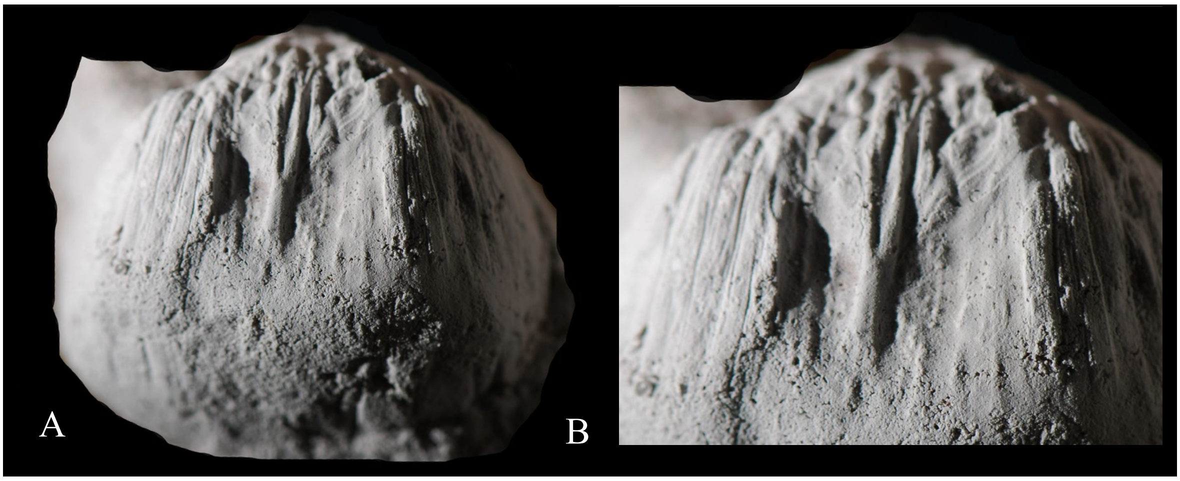

Fig. 23. *Terrakea elongata planidisca* n. subsp. A, B, posterior aspect of ventral internal mould, UQF 82719, x2, x4, from UQL 3135.

Fig. 24. *Terrakea elongata planidisca* n. subsp. A, oblique anterior aspect of specimen with valves conjoined, holotype, preserved as external mould and showing typically flat dorsal disc, UQF 82758, x2. B, anterior aspect of typically elongate and mature ventral internal mould, showing typical elongate nature, UQF 82677 from UQL 3515, x1.5.

Fig. 25. *Terrakea elongata planidisca* n. sp. A, anterior view, external mould of dorsal valve, UQF 82757, x1.5. B, external mould of dorsal valve UQF 82678 with part of ventral umbonal region, x1.5. C, external mould of dorsal valve UQF 82679, x1.5. D, external mould of dorsal valve UQF 82680, x1.5. Specimens from UQL 3135.

Resemblances: This species is close in the general aspect of the ventral valve to shells now assigned to *Terrakea elongata elongata* (Etheridge & Dun 1909, p. 299, pl. 43, fig. 5, 7) from Sonoma, north Bowen Basin, with lectotype designated as fig. 5 by Waterhouse (1964, p. 82), and deemed to have been sourced from the Scottville Member. Waterhouse (1964) and Dear (1971) had assumed that the two originally figured specimens could be different aspects of the same specimen, but this was corrected by Fletcher (1971). Little in the way of additional material has ever been figured, and Briggs (1998) offered no figures. Dear (1971, pl. 4, fig. 10-12, pl. 5, fig. 1, 2) provided some illustrations, and these indicate a similar ventral valve, but rather different dorsal valve, which is narrower with large ears and more concave disc, like that specimens assigned to *T. elongata elongata*. Spine detail is obscure. Dear (1971, p. 16) stipulated that his material came from the Big Strophalosia Band or Scottville Member. The same applies to a figure of a specimen with valves conjoined, preserved as a mould and sourced from the Big Strophalosia Band, in Waterhouse (1982a, pl. 12, fig. 1). The dorsal valve is distinctly narrower than in the present suite, and the disc gently concave rather than almost flat. Trail spines are large but few. The present dorsal valves have smaller ears, and a wide and almost flat dorsal disc.

The present specimens come close to shells from the upper Mangarewa Formation in New Zealand. (See p. herein). Interpretation of the stratigraphy was refined in Waterhouse (2002a, Table 18; 2021), to show that the specimens came from a zone above the *Paucispinifera solida* Zone in the Mangarewa Formation. The shells are comparatively large with elongate ventral valve bearing comparatively flat median disc, and dorsal valve with almost flat, broad disc and sharply geniculate long trail, bearing very large erect spines and small projecting ears (Waterhouse 1964, pl. 16, fig. 1). Some dorsal valves show the interior (Waterhouse 1964, pl. 15, fig. 6, pl. 16, fig. 1). But unkente spesent specimens, the New Zealand shells have very coarse costae.

Briggs (1998, p. 180) referred two ventral internal moulds figured as *Terrakea* cf. *brachythaera* form A of McClung (1983, p. 76, Fig. 17, fig. 1, 2) to *T. elongata*. As incomplete internal moulds, they do not allow specific identification, and perhaps the reason for referring the specimens to *elongata* was to support his interpretation of stratigraphic succession. The specimens came from interval C in the GSQ Eddystone 1 core, a level much older than *elongata*. A contender for *elongata*-related specimens with numerous ear spines, are those figured from the GSQ Eddystone 1 borehole at interval E in McClung (1983, Fig. 18.1-5) as *T.* cf. *brachythaera*, but these are small, more transverse than *elongata*, and possibly close to *brachythaera* or *exmoorensis*.

Terrakea dickinsi Dear (1971, p. 15, pl. 4, fig. 2-9; Runnegar, 1980, photo 19.1, fig. 4, 5; Waterhouse 1983a, p. 157, pl. 1, fig. 3; 1986a, p. 50, pl. 11, fig. 28-32, pl. 15, fig. 14; Briggs, 1998, p. 166, Fig. 82A-F) from the topmost Tiverton Formation and Roses Pride Formations of the north and southeast Basin, both levels in the *Echinalosia preovalis* - *Ingelarella plica* Zone, is somewhat similar, with broad gently concave dorsal disc and large trail spines. The ventral valve is less elongate and the dorsal disc narrower and slightly more concave. A New Zealand suite that shows considerable approach was described as *Terrakea pollex aurispina* (Waterhouse 1964, p. 64, pl. 10, fig. 1-5, text-fig. 23A, 24A; 1971, p. 348, text-fig. 1; 1982a, p. 47, pl. 11a-d, g-i, not 12 as in the text, text-fig. 17L, M), but belongs to *dickinsi,* as concluded by Waterhouse 2001, p. 42. These also have the gently concave but rather broad dorsal disc externally, high trail, small projecting ears, and fine disc spines and very large trail spines. The taxon comes from the *Notostrophia zealandicus* and *N. homeri* zones in the Takitimu Group, the latter correlative with the *Echinalosia preovalis* - *Ingelarella plica* Zone of east Australia. The dorsal valve bears very large erect spines, and small projecting ears (Waterhouse 1964, pl. 16, fig. 1). Some dorsal valves show the interior (Waterhouse 1964, pl. 15, fig. 6, pl. 16, fig. 1).

Terrakea etheridgei Briggs (1998, Fig. 72D, 86A-F) from South Marulan in New South Wales differs in shape, having a broad and slightly more concave dorsal disc, much less elongate ventral valve and rather large ears, but spine details come close in several respects to *T. brachythaera* **(check next vol summary)**. Briggs noted a resemblance to specimens figured from the Flowers Formation by Waterhouse & Vella (1965, p. 64, pl. 2, fig. 2, 5-10, pl. 3, fig. 3). The specimen of Waterhouse & Vella (1965, pl. 3, fig. 3) has large ears, but is a narrow elongate dorsal valve, and most of the specimens are more transverse with different spines over the ears, as in *T. macrospina* n. sp. from the Mantuan Formation of the southwest Bowen Basin (see p. herein). The Malbina E specimens of Clarke (1987, Fig. 3), though assigned to *etheridgei* by Briggs (1998) and with large ears (Fig. 30), do not show large dorsal trail spines. Briggs included a wide array of specimens from a number of disparate horizons in *etheridgei*, and it seems likely that the species will prove limited to South Marulan in New South Wales, and possibly, but not securely, from such levels that have yielded fossils referred to synonymy in Briggs (1998).

Terrakea brachythaera (Morris, 1845, pl. 14, fig. 4c) from the Broughton Formation of the south Sydney Basin is moderately close in developing a wide flat dorsal disc in some specimens, but ears tend to be large and the dorsal trail spines only moderately robust, and often fine and numerous (See Waterhouse 2021a, Fig. 10). *T. quadrata* Briggs (1998, p. 181, Fig. 89A-G) with a few additional specimens quoted by Briggs for its synonymy has a somewhat quadrate shape and large ears, and the dorsal trail spines are moderately robust. But this lacks certainty, because the figured material, assigned Australian Museum numbers by Briggs (1998) even though the material belonged to the Queensland Museum, does not show adequately the range of morphologies, and cannot be re-examined because Briggs failed to lodge the specimens to the Australian Museum or return them to the Queensland Museum, and they have disapppeared. Ventral spines near mid-length have a density of three to five in 5mm, measured from figured and other material with density slightly greater in *quadrata*. Dorsal spines range from four to five in 5mm in both *quadrata* and *multispinosa*. The difference clearly lies in the strength of the ventral spines, much greater in *quadrata*, so that the specimens strongly approach *brachythaera*. The species badly needs to be reinforced by more illustrations.

Paucispinauria solida (Etheridge & Dun, 1909, pl. 43, fig. 1-4; Dickins 1989, Fig. 4A-H; Briggs 1998, Fig. 90A-H) has broad medianly flattened disc and wide flat dorsal disc with geniculate trail. Dorsal trail spines are few and comparatively thin, though not as slender as those of *Bookeria*. The species *solida*, it is widely accepted, came from the Mantuan Formation, also called Member or “Productus” bed of the Peawaddy Formation (Dear 1971, p. 20), so that it is a little older than the present form, and clearly lies outside any trend within the genus towards the present form. Ear spines are few, and strongly reinforce the proposal in Waterhouse (2001, p. 38, pl. 1, fig. 22-27, pl. 3, fig. 1-6) that the species belongs to *Paucispinauria*, not to *Terrakea*. Briggs (1998) referred these latter specimens to *T. elongata*, but details of spines and shape differ considerably. The species *Paucispinauria solida* would appear to offer high potential to be the key fossil for a distinctive zone, but it is very limited in extent, being found only in the western Bowen Basin and New Zealand.

Class Rhynchonellata Williams et al., 1996

Superorder ATHYRIFORMII Boucot, Johnston & Staton, 1964

Order ATHYRIDA Boucot, Johnston & Staton, 1964

Suborder ATHYRIDINA Boucot, Johnston & Staton, 1964

Superfamily **ATHYROIDEA** Davidson, 1881

Family **ATHYRIDAE** Davidson, 1881

Subfamily **CLEIOTHYRIDININAE** Alvarez, Rong & Boucot, 1998

Genus ***Cleiothyridina*** Buckman, 1906

Diagnosis: Transverse to subequidimensional ovate shells with dental plates, perforated hinge plate and long distinct dorsal medium septum. Ornament of prominent commarginal laminae fringed by flattened spines.

Type species: *Atrypa pectinifera* J. de C. Sowerby, 1840, p. 14 from Magnesian Limestone (Wuchiapingian), England, OD.

Cleiothyridina elevata n. sp.

Fig. 26 - 29

Derivation: elevato – lift up, raise, Lat.

Diagnosis: Weakly transverse and oval in shape, both valves swollen medianly as a rule.

Holotype: UQL 82681 from UQL 3135, Fig. 26A, B, here designated.

Material: Two specimens with valves conjoined, preserved as internal moulds with part of the external mould of one valve, a ventral internal mould and five external moulds, from UQL 3135.

Description: The specimens vary in size, mostly small, with a complete internal mould measuring 17mm wide, 13.5mm long and 6mm high. One fragment is part of a valve that was at least 30mm wide. The valves are transversely oval with well rounded cardinal extremities, broad ventral umbo with angle of 90^{o} and bearing a comparatively large foramen, no well defined sulcus or fold, but a very low median swelling over the anterior half of most dorsal and ventral valves. The ventral valve is a little higher than the dorsal valve. Ornament is of the normal cleiothyridin type, with commarginal laminae bearing each a row of flattened spines. The laminae number about seven in 5mm over the dorsal valve of the conjoined specimen, compared with three in 5mm on the large fragment.

. Dental lamellae pass forward from the foramen, though teeth are not clearly exposed. A long and low median ridge extends from the posterior margin well forward. Muscle scars are not visible, but low transverse growth rugae are developed posteriorly, and one ventral internal mould bears fine radial grooves around the anterior margin. There are obscure indications of dental sockets in the dorsal valve, spoiled by accumulation of ferruginous

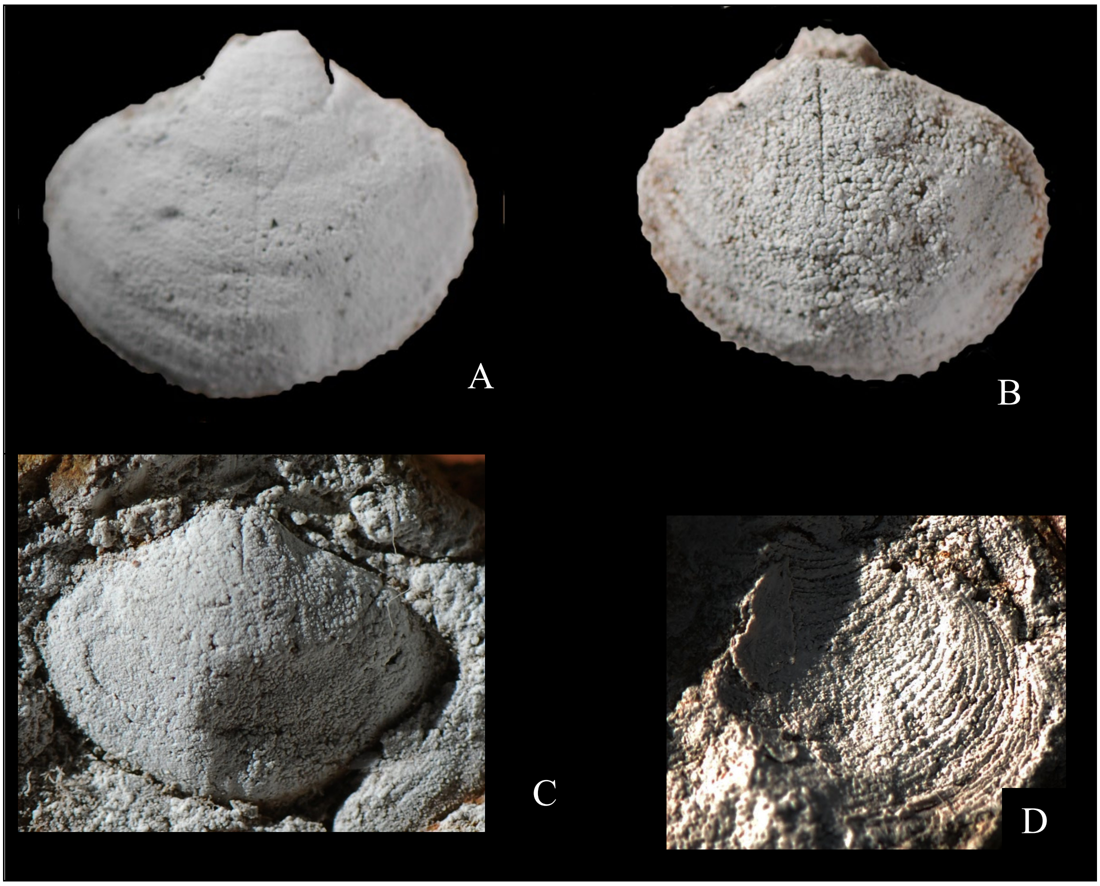

Fig. 26. *Cleiothyridina elevata* n. sp. A, B, ventral and dorsal aspects of internal mould, x3, holotype, UQF 82681. C, dorsal internal mould, UQF 82682, x3. D, external mould of ventral valve, UQF 82683, x3. From UQL 3135.

deposits, and a well-developed median septum extends to mid-length. A fragment from the Scottville Member figured by Armstrong (1970b) is closely allied (see p.).

Fig. 27. *Cleiothyridina elevata* n. sp., latex cast of ventral external mould, UQF 82684, x4, showing spines. From UQL 3135.

Resemblances: These specimens are close to a New Zealand species described as *Cleiothyridina anabathra* Waterhouse (1968, p. 12, pl. 1, fig. 1-5, 7, 8, 10; 1982a, p. 53, pl. 12, fig. f, h, pl. 13, fig. h, i) from the *Echinalosia discinia* beds of the upper Letham Formation in New Zealand, because they are of much the same shape. Most of the New Zealand types do not show any ventral anterior swelling, though some display a short anterior ventral sulcus and low dorsal fold. Similar material was recorded from the Brae Formation of the southeast Bowen Basin as *Cleiothyridina* sp. C of Waterhouse (1987a, p. 4, pl. 1, fig. 3, 5), as well as an exceptional specimen (Waterhouse 1987a, pl. 1, fig. 6) that is more elongate with low median swelling. The New Zealand and Australian material from the Letham and Brae Formations is somewhat older than the present specimens.

Cleiothyridina from the Barfield Formation of the southeast Bowen Basin as figured in Waterhouse (1987a, p. 4, pl. 1, fig. 4, 6, 7) includes a more elongate specimen with low ventral swelling, and better preserved Barfield material described by Parfrey (1988, p. 15, pl. 3, fig. 1-5) is consistently transverse and oval, without sulcus and fold, and moderately inflated.

Campbell (1953, p. 16, pl. 3, fig. 11-16) recorded small oval weakly transverse and slender specimens with no visible sulcus or fold from the upper Ingelara Formation of southwest Bowen Basin, changed to Peawaddy Formation by Armstrong (1970c, p. 320). A complete specimen figured by Hill & Woods (1964, pl. 7, fig. 11, 12) and Hill et al. (1972) from the Peawaddy Formation is close in overall shape, but has a narrow ventral and dorsal groove, unlike present specimens or *C. anabathra*. Armstrong (1970c) considered that shells assigned to *Spirigerella* by Campbell (1953, p. 15, pl. 6, fig. 1-6) belonged to *Cleiothyridina,* but whatever their generic affinities, these specimens are narrow with more triangular shape than present specimens.

Cleiothyridina is rare in the Permian of east Australia. No specimens were found in the faunas of the Blenheim Group by Waterhouse & Jell (1983), and only single specimens reported from the *Taeniothaerus subquadratus* Zone and *Svalbardia armstrongi* band of the Tiverton Formation by Armstrong (1970b) and Waterhouse (2015a, p. 146), and these are more elongate than the present specimens. A few other incomplete specimens were recorded from the Dresden and Fairyland beds of southeast Bowen Basin by Waterhouse (1987a, p. 4), but they are poorly preserved, and the Dresden specimens very small.

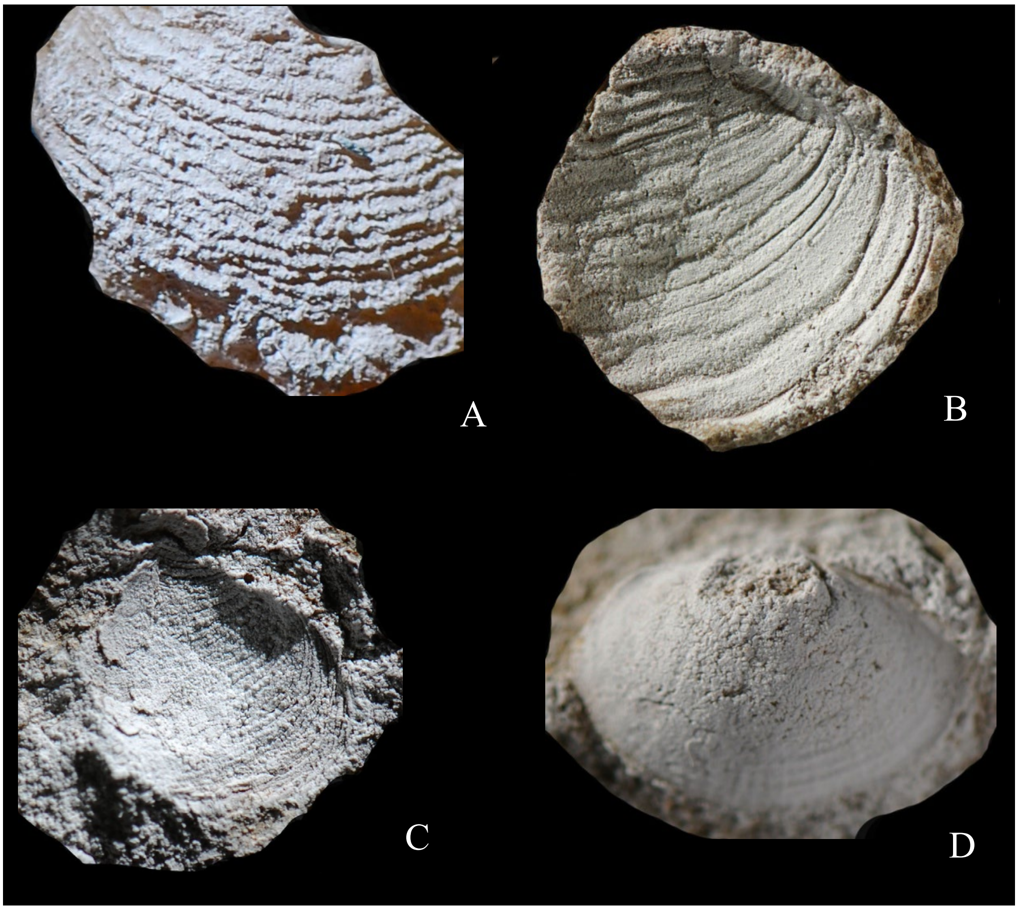

Fig. 28. *Cleiothyridina elevata* n. sp. A, latex cast of fragment of ventral exterior, **UQF** 827 , x5. B, part of external mould, UQF 82685, x2. C, fragment of ventral external mould, UQF 82686, x2. D, ventral internal mould UQF 82687, x2. From UQL 3135**.**

Fig. 29. *Cleiothyridina elevata* n. sp., ventral aspect of latex cast of specimen with valves conjoined, UQF 82658, x3, from UQL 3135.

Superorder SPIRIFERIFORMII Waagen, 1883

Order SPIRIFERIDA Waagen, 1883

Suborder MARTINIIDINA Waterhouse, 2010

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Geothomasia*** Waterhouse, 1998

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

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

Discussion: *Geothomasia* was proposed initially as a subgenus of *Tomiopsis* Benediktova, 1956 for a group of species rather similar to each other, and confined to Permian deposits of late Cisuralian to Lopingian age in Western Australia. *Geothomasia* includes the west Australian species *teicherti, hardmani, balgoensis, globosus* and *pauciplicatus*, all named as species of *Tomiopsis* by Archbold & Thomas (1986), and of Baigendzinian (late middle Early Permian) to Wuchiapingian (Late Permian) age. A geographically distinct group with similar short widely diverging tabellae is developed in east Australia, especially in Early Permian faunas (Waterhouse 2015a). In Western Australia, the adminicula of *Geothomasia* are well spaced and tend to be short and widely divergent, and the secondary thickening much less compared with east Australian material. 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 (1986, Fig. 6.4). Sulcal subplicae appear in a number of specimens in various species of *Geothomasia*, and the flanks of the fold are steep and well defined. A late Permian ally is present in the Himalaya, initially called *Tomiopsis himalayicum* Waterhouse, 1978, p. 58, named for a species described by Diener (1903, pl. 9, fig. 2-4). Older species in Western Australia ascribed to *Tomiopsis* by Archbold & Thomas (1986), including *woodwardi* and *notoplicatus* and perhaps *rarus*, have longer less divergent tabellae, and belong to *Ambikella* Sahni &

Srivastava, 1956. *Geothomasia* appeared in Asselian (early Cisuralian) times, and became rare after Aktastinian (mid-Cisuralian) times in east Australia. Somewhat similar forms are found in mid-Carboniferous faunas of northern Russia, described by several authors, and varying a little in the nature of the fold, so that it would appear that distribution apparently involved migration from Carboniferous stock from Russia into the Early Permian of east Australia, and then into Western Australia in later Cisuralian time, and in South Asia in the Late Perrmian.

Geothomasia delicatula n. sp.

Fig. 30 – 32A, cf 32B

Derivation: delicatula – delicate, Lat.

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

Holotype: UQF from UQL 3515, Fig. 30C, here designated.

Material: Six ventral valves and two dorsal valves from UQL 3135.

Dimensions in mm: ventral valves

Width	Length	Height	Umbonal angle	
40	32	9.5	100°	UQF 52565
38	38.2	10	110°	

Description: Specimens small medium in size, transverse to subequidimensional, ventral umbo slightly incurved, posterior walls low and convex, cardinal extremities obtuse. Sulcus broad with angle of 35°. Ventral interarea high, concave, posteriorly inclined from the commissure, delthyrium open with angle close to 65°. Two broad low subplicae with well rounded crests and separated by a moderately well defined median groove lie within the sulcus, and three pairs of plicae lie each side, with low broadly rounded crests, persisting for the length of the valve, apart from two specimens which are smooth. Micro-ornament of slender elongate grooves, each groove about 1mm long over mid-length of the shell and arranged in quincunx, but anteriorly the length differs, varying from short and subequidimensional pits to short grooves 0.5mm and up to 1mm in length: all densely packed, with three or usually four in 1mm across the shell. The dorsal valve is slightly less inflated than the ventral valve, with low interarea in plane of the commissure and broad notothyrium with angle close to 100°. The fold is low and broad-topped with faint depression anteriorly in some specimens, and three pairs of plicae are developed.

Teeth are supported by short dental plates which converge steeply on slightly higher and steeply inclined adminicula that diverge forward at a very low angle, and may display a slightly bowed outline. They are short, no more than a fifth of the length of the valve. The muscle field lies between and extends a little in front of the anterior end of the adminicula, comprising an adductor ridge, vaguely defined posteriorly and more clearly delineated anteriorly, with a median groove. Diductor scars are wider and comparatively smooth. The floor of the valve bears faint pits and pustules, and the posterior shell is not markedly thickened.

In the dorsal valve a small ctenophorium lies under the notothyrium, with a number of vertical laminae. Socket plates are shallow and steeply inclined, supported by short subvertical tabellae diverging at 25°. One dorsal fragment (Fig. 32B) has longer tabellae that are subparallel, and it is not clear how to treat this fragment – whether it is exceptional, or belonging to another taxon, and perhaps it raises questions of validity in separating *Geothomasia* from *Ambikella*. But the fragment is small. It does not fit with the other dorsal valves in the species and genus, given the spacing and course of the tabellae, as if it belongs to a different genus. Muscle scars are not defined, and only a short low ridge lies in front of the ctenophoridium, with no well-defined median septum.

Resemblances: Compared with *Geothomasia teicherti* (Archbold & Thomas, 1986) from the Wandagee and Nooncanbah Formations of the Carnarvon and Canning Basins in Western Australia, the present specimens have narrower sulcus and fold. *G. globosus* (Archbold & Thomas) from the Lightjack Formation of the Canning Basin is closer, especially in the fold, but is a narrower shell, and *G. balgoensis* (Archbold & Thomas, 1986, Fig. 7.5-7.12) from the same formation is the closest of all species from Western Australia, with only a slightly broader ventral beak, comparable fold, slightly better defined sulcus, and short subparallel adminicula. The age of the Lightjack Member was judged to be Kungurian by Archbold (1993, Table 1) and matched with the Coolkilya Formation, which herein is deemed to be Roadian rather than Kungurian in age, given the affinities of its ammonoids, which include

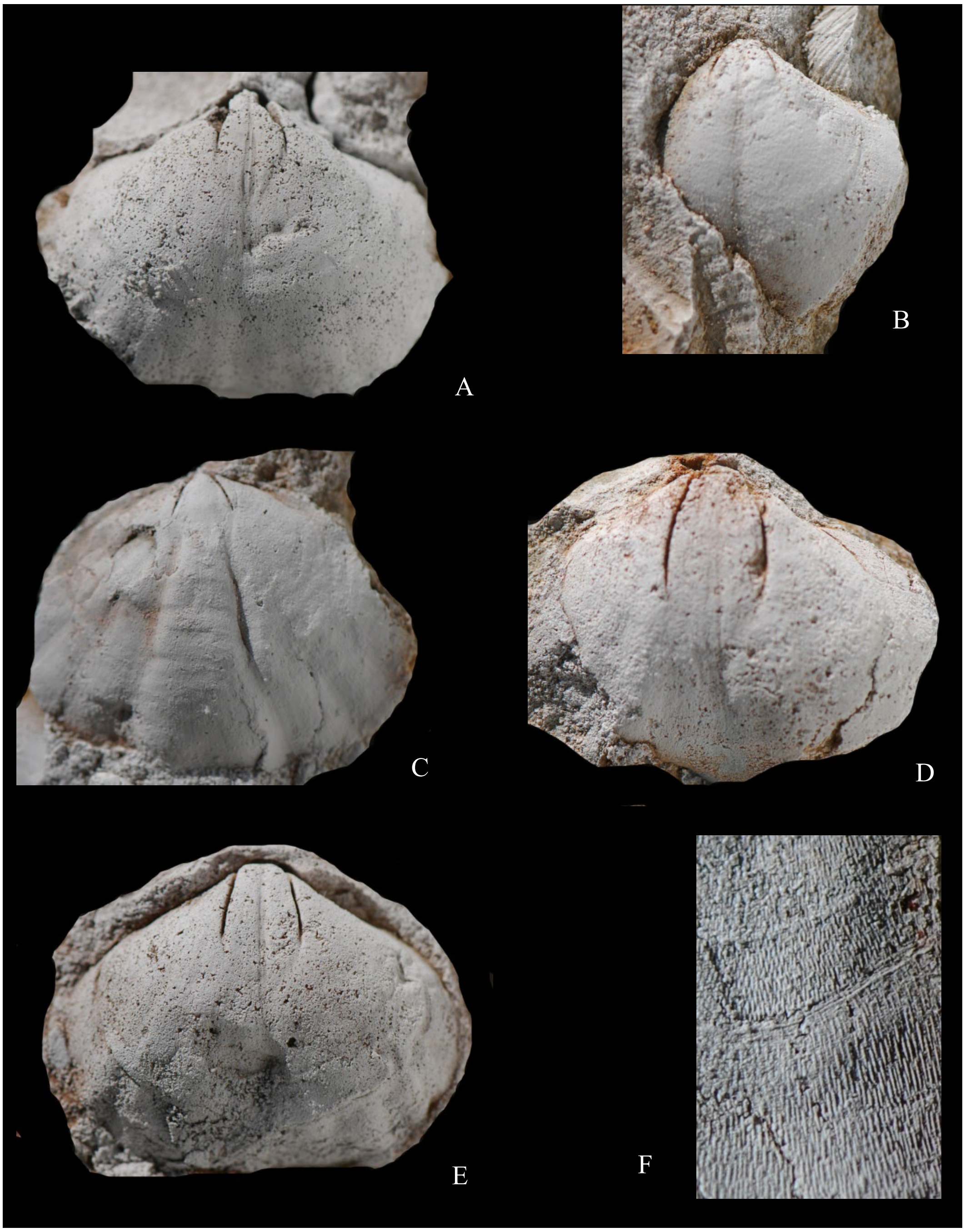

Fig. 30. *Geothomasia delicatula* n. sp. A, ventral internal mould UQF 59565**,** x1.5. B, ventral valve UQF 82760, x2. C, dorsal internal mould UQF 82689, x2, holotype. D, ventral internal mould UQF 82690, x2. E, ventral internal mould UQF 82691, x2. F, detail of micro-ornament on ventral valve, UQF 82692, **x8.** Specimens from UQL 3135**.**

Sverdrupites. *G. hardmani* (Archbold & Thomas 1986, Fig. 8.1-17) is somewhat similar, with plicae and broad ventral umbo. It comes from the Hardman Member of the Canning basin and Port Keats Group of the Bonaparte Gulf Basin, of Wuchiapingian age. Three species of *Geothomasia* recognized from the Tiverton Formation in the Bowen Basin by Waterhouse (2015a) have stronger dorsal fold, and are more strongly plicate as a rule. From the Asselian Wasp Head Formation of the south Sydney Basin, *G. simplicitas* Waterhouse (2015b, p. 169, Fig. 79) has weak plicae, slightly longer adminicula, and similar dorsal fold and tabellae. The species has been ascribed to the species *konincki* Etheridge by various authors, but has weaker plicae, wider sulcus with strong subplicae and more widely diverging tabellae. The neotype of *konincki* was selected and figured in Waterhouse et al. (1983, p. 242, pl. 10, fig. 11, 11a) and comes from the Allandale Formation of New South Wales.

Fig. 31. *Geothomasia delicatula* n. sp. A, latex cast, ventral external mould UQF 82693**,** x3, showing micro-ornament.

Ingelarella singletonensis McClung (1978) from the Mulbring Formation in the Hunter Valley of the north Sydney Basin and possibly Gerringong Volcanics of the south Sydney Basin includes at least one specimen externally close to present specimens, though with better developed sulcal subplicae (McClung 1978, pl. 13, fig. 13, 14) and stronger plicae. Three non-plicate internal moulds from the same locality (McClung 1978, pl. 14, fig. 1-3) show better developed fold channel and moderately short and well spaced tabellae and adminicula. The specimens appear to come closer to *Ingelarella dissimilis* Waterhouse, 1964.

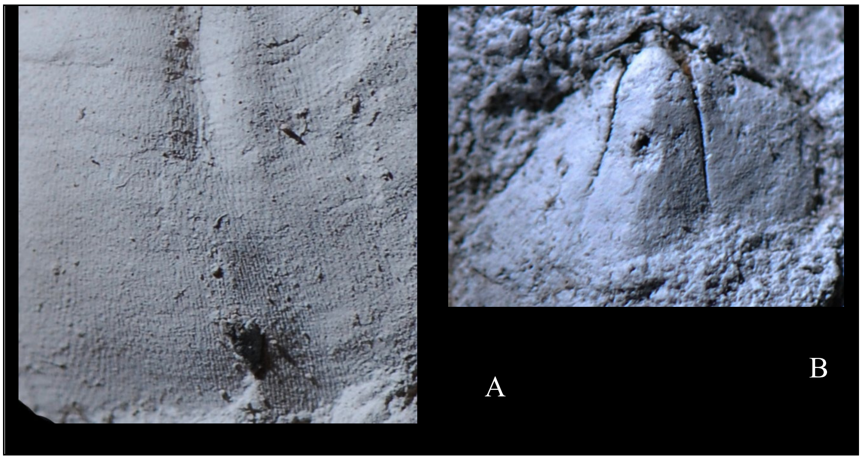

Fig. 32. *Geothomasia delicatula* n. sp. A, detail of micro-ornament on dorsal exterior, UQF 82693, x . ?B, dorsal internal mould UQF 82694, x5. The tabellae are unusually long in this specimen, which is at late maturity, possibly suggesting a different genus. From UQL 3135.

There is limited similarity to valves figured by McClung (1983, Fig. 8.3-6) from GSQ LD96 in the Denison Trough, equivalent to the Catherine Sandstone, and judged to be of Roadian age. The specimens were assigned to *Ingelarella* cf. *mantuanensis* Campbell, as also tabulated by Parfrey (1988), but differ in their swollen dorsal fold and short well spaced adminicula. The tabellae are moderately long even in small specimens, and large dorsal valves from LD96 (McClung 1983, Fig. 8.1, 2) have long tabellae, unlike those of the present suite. Further specimens figured in McClung (1983, fig. 7.3, 4) from interval E in the Eddystone 1 bore lack the regular plicae of the present suite, though some show faint anterior plicae. Several of the specimens figured from LD96 in the Catherine Sandstone as *I.* cf. *mantuanensis* by McClung (1983, Fig. 8.3, 6, 7, 8) have a narrow median ventral channel, suggestive of a poorly known lineage within the Ingelarellinae, as discussed on p. , which involved the species *confusa* Waterhouse (upper Kungurian, Roadian), *canalis* n. sp. (see p.), and of Wordian age, and *havilensis* Campbell (Capitanian).

The original figures for *Ingelarella mantuanensis* Campbell (1960, pl. 137, fig. 1-3, 138, fig. 1-3) from the Peawaddy Formation of the southeast Bowen Basin show large specimens, with indications of plicae and subplicae approaching those of the present suite, but less developed. Adminicula and tabellae are long and well developed, unlike those of the present suite. Two specimens identified with *mantuanensis* by Campbell (1961, pl. 24, fig. 1, 2) as refigured herein (Fig. 6A, B, p.) from the Scottville Member (= Big Strophalosia Band) show long adminicula, distinct fold channel and long tabellae, and the specimens are not visibly plicate like the present suite. Specimens ascribed to *mantuanensis* from the Muree Formation have adminicula and tabellae like those of type *mantuanensis.*

Ingelarella havilensis Campbell (1960, p. 1120, pl. 139, fig. 3-6) from topmost beds of the Blenheim Formation at Parrot Creek is a large species with a profound median ventral groove and distinctly channelled dorsal fold. The type lacks plicae, though other specimens from the same member show low plicae. Mature specimens have long subparallel adminicula, and long tabellae.

One species that comes moderately close to the present form is *Ingelarella subplicata* Waterhouse, described and illustrated from the upper *Echinalosia discinia* Zone of the Letham Formation in Waterhouse (1968, p. 69, pl. 12, fig. 7, 9, pl. 13, fig. 1, 2, 4, 7, text-fig. 2a; 2001, p. 101, pl. 7, fig. 12-17). The species is similar overall in shape, subplication, plication, but has stronger longer adminicula and tabellae, and has a slightly broader and flat-floored sulcus and broader deeply channelled dorsal fold. The specimens from the Fenestella Shale of the northern Sydney Basin that were figured as *I. costata* [not Waterhouse] by McClung (1978, pl. 14, fig. 4-13) are very close to this species, and possibly allied to the more plicate specimens from the same level that were assigned by McClung (1978, pl. 14, fig. 15, 16) to *Ingelarella oviformis* M'Coy, 1847.

Although there may appear to be some similarities of the present form to *Johndearia* Waterhouse, based on *Ingelarella isbelli* Campbell, 1961, this genus lacks plicae and has a straighter hinge as well as heavily thickened posterior shell. A specimen figured as *Ambikella* cf. *undulosa* by Wass & Gould (1969, pl. 15, fig. 17) shows some similarity to present specimens, but more information is needed, even allowing for the information provided by specimens compared by Wass & Gould (1969) to *isbelli*. Another shell (Wass & Gould 1969, pl. 15, fig. 15, 16) shows a wide hinge with heavy thickening, suggestive of *Johndearia pelicanensis* Campbell, as further discussed on p. ., and somewhat approaching a specimen of *I. havilensis* figured by Dickins (1989, pl. 5, fig. 13), which does have a deeper ventral groove.

Family **NOTOSPIRIFERIDAE** Archbold & Thomas, 1986

Subfamily **NOTOSPIRIFERINAE** Archbold & Thomas, 1986

Genus ***Notospirifer*** Harrington, 1955

Diagnosis: Small strongly plicate shells with micro-ornament of globons. Two subplicae in the sulcus as a rule. Adminicula, dental plates, crural plates, very short if any tabellae.

Type species: *Spirifer darwini* Morris, 1845 from the Elderslie Formation, Hunter Valley, Sydney Basin, OD.

Notospirifer minutus Campbell, 1960

Fig. 33

1955 *Martiniopsis*? sp. Isbell, p. 13.
1960 *Notospirifer minutus* Campbell, p. 1121, pl. 139, fig. 6-8.
?1969 *N.* cf. *minutus* – Wass & Gould, p. 221, pl. 15, fig. 1-5.
1970c *N. minutus* – Armstrong, p. 291, Fig. 1D.

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

Holotype: UQF 15823 from Rosella Creek, north Bowen Basin, figured by Campbell (1960, pl. 139, fig. 6a-c).

Material: A ventral valve from UQL 3135.

Description: Shell small, 25mm wide, with well defined sulcus measuring 20° and faint suggestions of a median double swelling on the internal mould, indicative of sulcal subplicae. There are four pairs of plicae. Adminicula extend along the innermost pair of interspaces from the sulcus.

Fig. 33. *Notospirifer minutus* Campbell, ventral valve UQF 82695, x2, from UQL 3135.

Resemblances: This specimen is identified with *Notospirifer minutus* Campbell, originally described from the *Isbellina pelicanensis* band with the Pelican Creek fauna at Rosella Creek. There have been reports of the species in older faunas, but they appear to have been identified mainly by their small size, leaving it difficult to determine if the identity is based on specimens not at full maturity. Well preserved material from South Marulan, south New South Wales, is close (see p.).

Subfamily **GLENDONIINAE** Clarke, 1992b

Genus ***Glendonia*** McClung & Armstrong, 1978

Diagnosis: Genus characterized by strong median subplication along sulcus, and channelled dorsal fold. Strong lateral plicae. Micro-spines suberect, with anterior groove. Tabellae may be well developed.

Type species: *Glendonia ulladullensis* McClung & Armstrong, 1978, p. 3 from Wandrawandian Siltstone, south Sydney Basin, OD.

Glendonia exigua McClung & Armstrong, 1978

Fig. 34

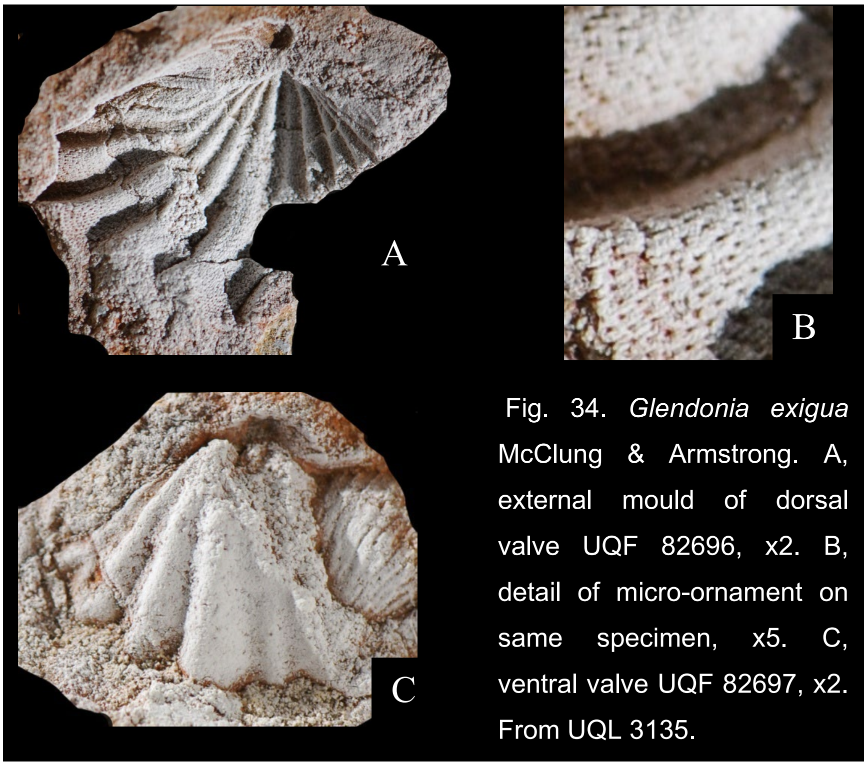

Fig. 34. *Glendonia exigua* McClung & Armstrong. A, external mould of dorsal valve UQF 82696, x2. B, detail of micro-ornament on same specimen, x5. C, ventral valve UQF 82697, x2. From UQL 3135.

1978 *Glendonia exigua* McClung & Armstrong, p. 4, pl. 1, fig. 14-20, 23.
aff. 1983 *Notospirifer* (*Glendonia*) *exigua* – Waterhouse & Jell, p. 246, pl. 2, fig. 9.

Diagnosis: Small, strongly biconvex, with three or four plicae pairs, short tabellae.

Holotype: UQF 57519 from Rosella Creek, Blenheim Formation, figured by McClung & Armstrong (1978, pl. 1, fig. 16-18), OD.

Material, Description: A broken dorsal valve and broken ventral valve from UQL 3135 indicate a channelled dorsal fold and a sulcus bearing a low median rib. The specimens clearly belong to *Glendonia exigua*, which was initially described from much the same level, possibly a little higher stratigraphically, uncertainty arising because detail was not provided in the original text.

Superfamily **TRIGONOTRETOIDEA** Schuchert, 1893

Family **TRIGONOTRETIDAE** Schuchert, 1893

Subfamily **APERISPIRIFERINAE** Waterhouse 2021b

Diagnosis: Medium to large generally transverse shells with three to six pairs of plicae as a rule, closely costate, sulcus and fold well developed, delthyrium open without stegidia or neodeltidium (= cover plate) or subdelthyrial connector plate; dental plates, adminicula, crural and socket plates without tabellae, no well formed median septum. Spiralia laterally directed.

Name genus: *Aperispirifer* Waterhouse 1968, p. 35, OD.

Genus ***Aperispirifer*** Waterhouse, 1968

Diagnosis: Shell transverse, fold well developed, high to broad with rounded crest, plicae may either fade anteriorly or extend to anterior margin, vary from three to five or less commonly six prominent pairs, costae numerous and not well differentiated, micro-ornament of radial and commarginal capillae. Delthyrium open without stegidia or cover plate, large umbonal callosity, no subdelthyrial connector plate, short dental and adminicular plates, no tabellae, scapular-shaped crural plates. Low dorsal septal ridge as a rule. Well spaced mantle canal impressions.

Type species: *Neospirifer wairakiensis* Waterhouse, 1964 from Letham Burn Member, Wairaki Downs, New Zealand, OD.

Discussion: The present species is unusual for its small size. It possesses a wide and round-crested dorsal fold and more plicae pairs than found in the type species, in this respect approaching the much larger form named *Aperispirifer parfreyi* Waterhouse from only slightly older faunas in Queensland. The nature of the spiralia is not known, hindering determination of the generic position, and the present form is identified from its closeness to *Aperispirifer parfreyi*, which is found in slightly older beds, and is represented by larger specimens.

Aperispirifer demulceatus n. sp.

Fig. 35 - 37

Derivation: demulceo – stroke down, Lat.

Diagnosis: Shells with three inner pairs of costate plicae, and two or sometimes six lateral fine plicae pairs. Sulcus well defined, fold with rounded low crest. Size small, despite maturity of shell.

Holotype: UQF 65486 from UQL 3515, Fig. 36, here designated.

Material: Three ventral valves and fragment, three dorsal valves and the internal mould of a specimen with valves conjoined from UQL 3135.

Dimensions in mm: UQF 65485, internal mould, valves conjoined, holotype.

Width	Length	Height	Height ventral
65	32	24	16

Description: Specimens small for the genus although at maturity as judged from shell thickening and interior of the specimen with valves conjoined. Ventral umbo protruding, with angle of 100° to 105°, hinge at maximum width, alate cardinal extremities, and high concave interarea, steeply inclined posteriorly from the commissure, delthyrium open and with angle just over 40°. Dorsal valve less inflated, dorsal interarea posteriorly inclined from commissure by 20° to 30°, low, notothyrium broad with angle of 115° to 120°. Interareas for both valves marked by strong growth lineations parallel to commissure. Ventral sulcus well formed withangle close to 25°, and bears two prominent median costae, with two more appearing anteriorly. There are as a rule five or six pairs of plicae, diminishing laterally in strength, but prominent as far as the anterior margin. The inner three pairs of plicae bear costae, the primary costa dominant. In some specimens the outermost shell has only growth laminae; in others, it is marked by the outermost slender plication. The dorsal fold is upstanding, with broad convex crest and four costae, the inner two arising at the posterior third of the dorsal valve length. A subplication may lie next to the fold, followed by three pairs of costate plicae and one or two ribs, but other specimens lack the subplication. Commarginal laminae are visible, but none show radial capillae, possibly because of poor preservation.

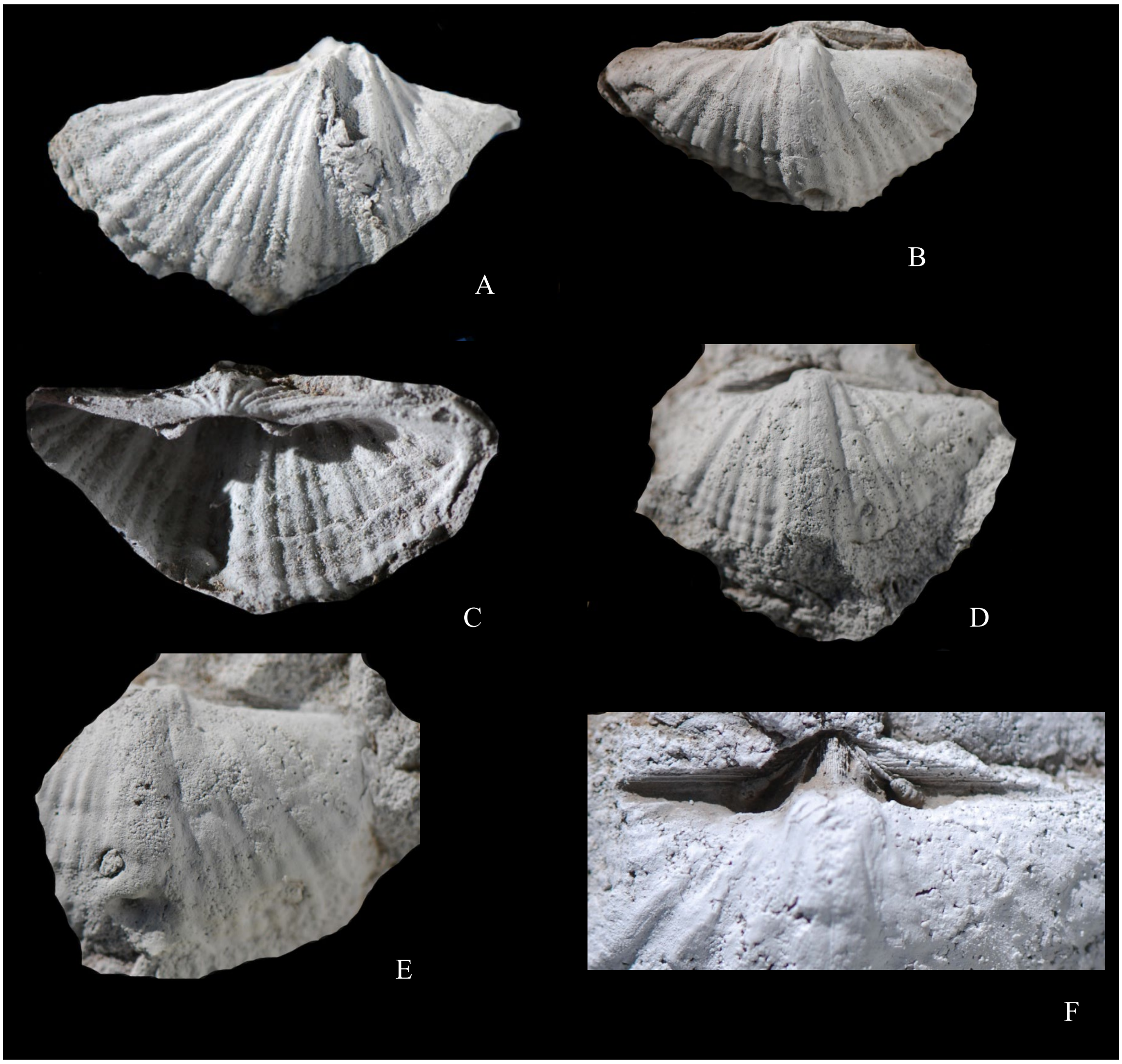

Fig. 35. *Aperispirifer demulceatus* n. sp. A, small ventral valve, latex cast, UQF 82698, x2. B, dorsal internal mould, UQF 82699, x1.5. C, dorsal valve, latex cast **of the same specimen,** x1.5. D, F, dorsal internal mould, ventral aspect, x 1.5 and posterior panel, x6, UQF 82701. E, dorsal internal mould, UQF 82702, x2. From UQL 3135.

The delthyrium is plugged apically by substantial secondary filling. The muscle field is elongate with poorly discriminated adductors divided posteriorly by a short high myophragm and wider diductor scars scored by shallow grooves, the field extending forward medianly in the usual angular style with adductors extending beyond the diductors. Massive secondary thickening extends along the hinge, and is covered over the surface by shallow ridges and grooves radiating outwards and forwards from the hinge and base of the dental plates. Teeth are broad and low, supported by dental plates converging at angle of 60°, and born on equally high adminicula which diverge to the floor at a slightly greater angle. The anterior floor of the valve bears shallow pits and pustules. No prominent umbonal callosity.

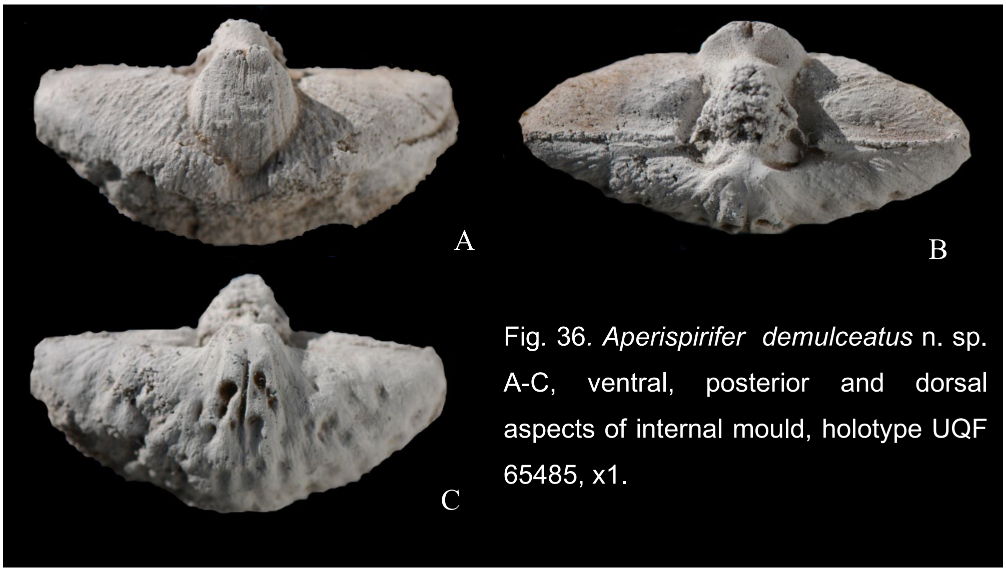

Fig. 36. *Aperispirifer demulceatus* n. sp. A-C, ventral, posterior and dorsal aspects of internal mould, holotype UQF 65485, x1.

The notothyrium is bordered by dental tracks, and the shallow dental sockets are enclosed on the inner side by crural plates which diverge forwards and slope concave inwards, with the base of the spire along the inner dorsal side. There are no tabellae. The ctenophoridium is broadly triangular and concave, bearing some eighteen vertical laminae. A low median septum arises a little in front and extends to mid-length in one specimen, and over less than the posterior third in another specimen. There is no sign of muscle scars in these specimens. But adductors are moderately well defined in the internal mould of the holotype, as elongately oval depressions each side of the septum, extending to approximately mid-length and marked by faint longitudinal striae. The anterior scars and lateral shell floor in the holotype are pocked by rounded elevations, presumably related to an different taxon, perhaps within the shell material itself. It is assumed from general shape and age that the spiralia were laterally directed. Only the holotype is likely to contain the spiralia, and it was decided not to sacrifice the specimen in order to determine their nature.

Resemblances: *Neilotreta lakeensis* Waterhouse 2021 from the Sakmarian Lakes Creek beds near Rockhampton is also a small species, slightly more elongate, with broader more prominent fold, finer costae and more prominent dental plates, but close in size and in the number of plicae. It is assumed that the spiralia differ in the two species, but this is yet to be confirmed.

Aperispirifer parfreyi (Waterhouse, 1999, 2001, p. 94), as figured by Parfrey (1988, pl. 3, fig. 14, 18, 20, 21, 23-25, pl. 4, fig. 1) and Waterhouse (1987a, pl. 5, fig. 1-3, 5-8, 10) from the Barfield and Flat Top Formations of southeast Bowen Basin, and found also in the western Bowen Basin in the restricted (former lower) Peawaddy Formation, and the overlying Mantuan Formation sensu Draper 2013 (Hill & Woods 1964, pl. P8, fig. 2-4; repeated by Hill et al. 1972) is much larger, with moderately well defined and similarly persistent plicae, similar sulcus and fold, and more costae. The species has more numerous and persistent plicae than seen in the type species of *Aperispirifer, A. wairakiensis,* but shares the same basic ornament, delthyrial construct, and shape, though significant internal attributes are yet to be clarified, and two ventral valves, considered to have come from the Mantuan Formation, have quite different morphology internally, as reported herein (p.). As a rule its fold is high and narrow rather than broad and rounded, and bears a lateral plication on each side. The chief difference from the present form is that the specimens of *parfreyi* are more costate, with more costae over the fold and sulcus, and the lateral extremities are costate, though similar in having four or five up to six pairs of persistent plicae. As well the ventral umbo is slightly broader, and the dorsal fold more elevated medianly. These differences are only in part due to the smaller size, but no lesser maturity of the present specimens. Unfortunately, no material is available to me from the Scottville Member for comparison, and Waterhouse & Jell (1983, p. 245, pl. 2, fig. 4, 5) recorded only poorly preserved specimens from a much diminished fauna deemed equivalent to the *Maxwellosia ovalis* Zone from the Blenheim Formation. From the Oxtrack Formation of the southeast Bowen Basin, *Neilotreta ovalis* (Waterhouse, 1987a) has a more oval and less transverse outline, and costae are especially fine in the sulcus and the broad fold.

Specimens of *Aperispirifer parfreyi* from the Mangarewa Formation of New Zealand, chiefly GS 3616, (Waterhouse 1968, pl. 3, fig. 15, pl. 5, fig. 1, 5, 8, pl. 6, fig. 2, text-fig. 11-13, 14D, 15) are mostly internal moulds, and show the narrow-crested dorsal fold typical of *parfreyi*. The external ventral valve figured by Fletcher (1952, pl. 1, fig. 2) and dorsal valve of Waterhouse (1968, pl. 3, fig. 15) are elongate with numerous costae and the ventral valve shows as many as six pairs of persistent plicae, as confirmed in a photograph (Waterhouse 1964, pl. 26, fig. 1). An *in situ* ventral valve figured by Waterhouse (2002a, Fig. 2.6A) is more transverse with less defined plicae. Serial sections of New Zealand material (Waterhouse 1968, text-fig. 15) show remnants of broken spiralia, and these appear to be laterally directed, rather than posteriorly directed as in *Trigonotreta victoriae* Archbold as shown in Waterhouse (2021b), *Grantonia hobartensis* (Brown ,1953)and *G. australis* (Bion, 1928). (See Waterhouse 1987).

Fig. 37. *Aperispirifer demulcateus* n. sp., latex casts of small ventral valves from UQL 3135, x2. A, UQF 82703. B, UQF 82704**.**

A specimen figured in Hill et al. (1972, pl. P8, fig. 5) from the Ingelara Formation is characterized by its rhomboid shape and other features, and was distinguished as *Aperispirifer wairakiensis hillae* by Waterhouse (1999, p. 14; 2001, p. 93), together with material figured by Campbell (1953). *Aperispirifer lethamensis* Waterhouse, 1968 is an older species, found in the *Echinalosia discinia* Zone in the upper Letham Formation of New Zealand, with numerous subpersistent and ill-defined plicae, coarse costae, and anteriorly deep sulcus. Spiralia are laterally directed (Waterhouse 1964, text-fig. 63).

Order SPIRIFERINIDA Ivanova, 1972

Suborder SYRINGOTHYRIDINA Grunt, 2006

Superfamily **SYRINGOTHYROIDEA** Fredericks, 1926

Family **SYRINGOTHYRIDAE** Fredericks, 1926

Subfamily **PERMASYRINXINAE** Waterhouse, 1986b

Genus ***Permasyrinx*** Waterhouse, 1983b

Diagnosis: Medium to 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, without syrinx, subdelthyrial connector plate, muscle field short with syrellum (ie. calcite rod) posteriorly, myoseptum may be developed between posterior adductor scars. Ctenophoridium, short subhorizontal socket plates, crural plates, low median ridge in the dorsal valve.

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

Permasyrinx mundanus n. sp.

Fig. 38, 39

Derivation: mundanus – inhabitant of the world, cosmopolitan, Lat.

Diagnosis: Transverse shells with well formed sulcus and fold with rounded crest, nearly twenty pairs of plicae in large specimens, outer plicae very fine. Sulcus narrow and without median costa.

Holotype: UQF from UQL 3135, illustrated herein as Fig. 39, here designated.

Material: Five ventral valves, five dorsal valves and two specimens with valves conjoined from UQL 3135.

Description: Specimens have wide hinge, alate cardinal extremities, low broad ventral umbo with angle of 110°, and sulcus with angle close to 18°. The dorsal umbo is broad, and the fold upstanding. The ventral interarea is high with strong horizontal striae and a narrow delthyrium with angle of only 25°. The dorsal interarea is low and planar, sloping posteroventrally from the commissure. Plicae are narrow with rounded crests and interspaces of similar width on both valves. There are sixteen to eighteen pairs in most specimens, the outer ones very fine. Micro-ornament is composed of dense small slightly elongated pustules. An outwardly convex triangular subdelthyrial connector plate is developed. The dental plates are supported by high adminicula diverging at 70°. Small elongate adductor impressions lie under the sulcus, and diductor scars with light longitudinal striae extend each side, bordered laterally by the adminicula. Dental sockets are widely divergent, with scapular-shaped crural plates, no tabellae, and horizontal socket plates. No specimen shows a median septum or muscle scars, presumably because of the unfavourable matrix.

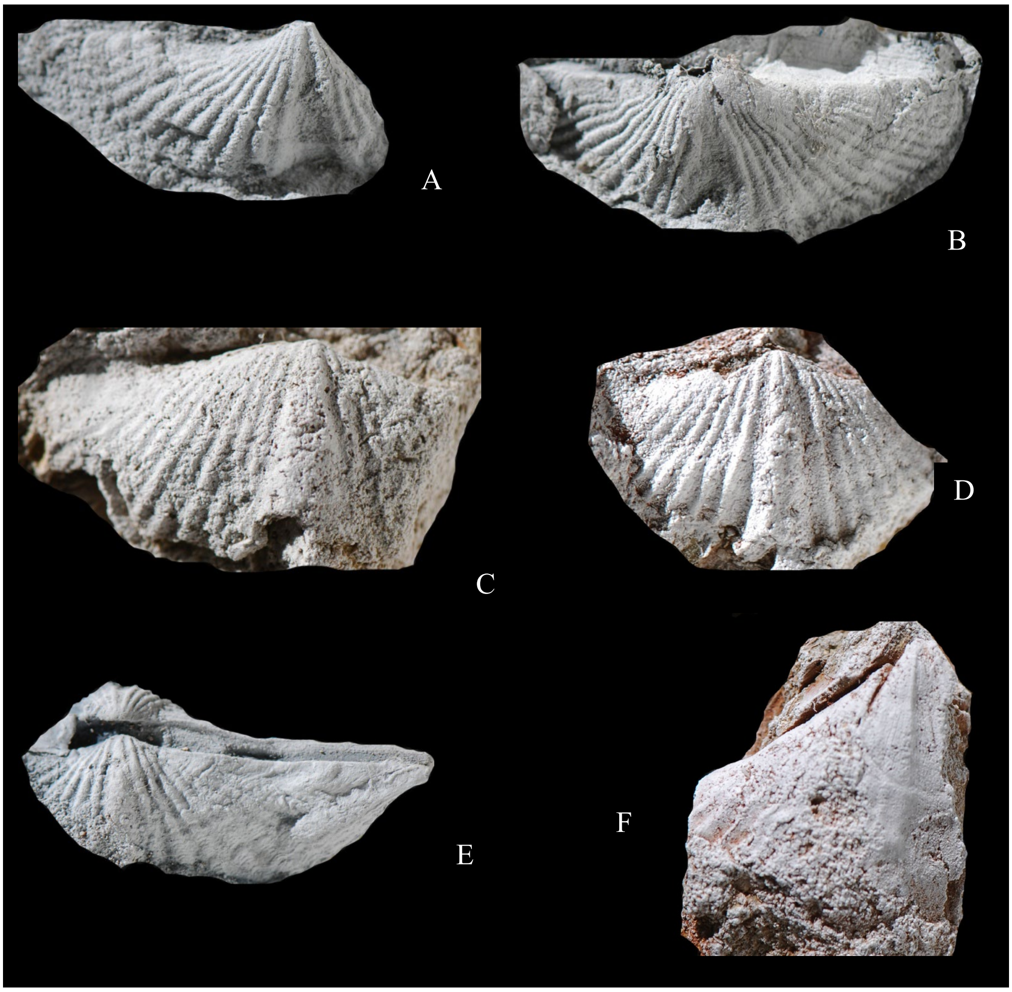

Fig. 38. *Permasyrinx mundanus* n. sp. A, ventral valve, latex cast UQF 82626, x1.5. B, ventral valve, latex cast, UQF 82627, x1.5. C, dorsal internal mould UQF 82646, x1.5. D, dorsal internal mould UQF 82651, x2. E, dorsal aspect of specimen with valves conjoined, UQF 82645, x1.5. F, ventral internal mould UQF 82647, x2. Specimens from UQL 3135.

Fig. 39. *Permasyrinx mundanus* n. sp. A, ventral valve, latex cast x4. B, detail of micro-ornament on external cast, x8, and C, on mould, x10. UQF 82650 from UQL 3135. Holotype.

Resemblances: *Permasyrinx nobilis* Armstrong, 1970a, p. 155, pl. 5, fig. 1-3, pl. 6, fig. 7-9 (part, not pl. 5, fig. 4-10, pl. 6, fig. 1, 2 = *CytellaFredericks*) from the Peawaddy Formation is very close in shape and in number of plicae, apart from the slightly different and wider sulcus which is apparently traversed by a very low median rib. *P. granulata* (Armstrong, 1970a; Waterhouse 2015a, p. 212) from the Tiverton Formation as fewer plicae and is longer, whereas *P. transversa* (Armstrong, 1970a; Waterhouse 1987a, p. 9) is transverse, but also with fewer plicae. It is known only from the Roses Pride Formation. *P. elongata* (Armstrong, 1970a) from the Tiverton Formation (see Waterhouse 2015a, p. 209) and from the Elvinia Formation (Waterhouse 1987a) is more elongate. These formations are all recognized for rocks in the Bowen Basin of Queensland.

Genus ***Sulcicosta*** Waterhouse, 1983b

Diagnosis: Transverse to elongate shells with well defined sulcus and fold that bear costae, lateral plicae numerous, delthyrial connector plate, short to medium-length adminicula, dental plates, crural plates.

Type species: *Pseudosyrinx plicata* Armstrong, 1970a, p. 142, from middle Permian of New South Wales, OD.

Sulcicosta lata n. sp.

Fig. 40 - 43

Derivation: lata – broad, Lat.

Diagnosis: Transverse small shells with eight or nine pairs of plicae, two to four sulcal costae and four costae developed over the fold, each side of well defined median channel.

Holotype: **UQF** from UQL 3515 figured herein as Fig. 40, 42. here designated.

Material: Six ventral valves, five dorsal valves and specimen with valves conjoined from UQL 3135.

Dimensions in mm:

Width	Length	Length	dorsal Height	Height dorsal	
56	56	16	21	4.3	both valves, holotype
48	26	8.5			ventral valve

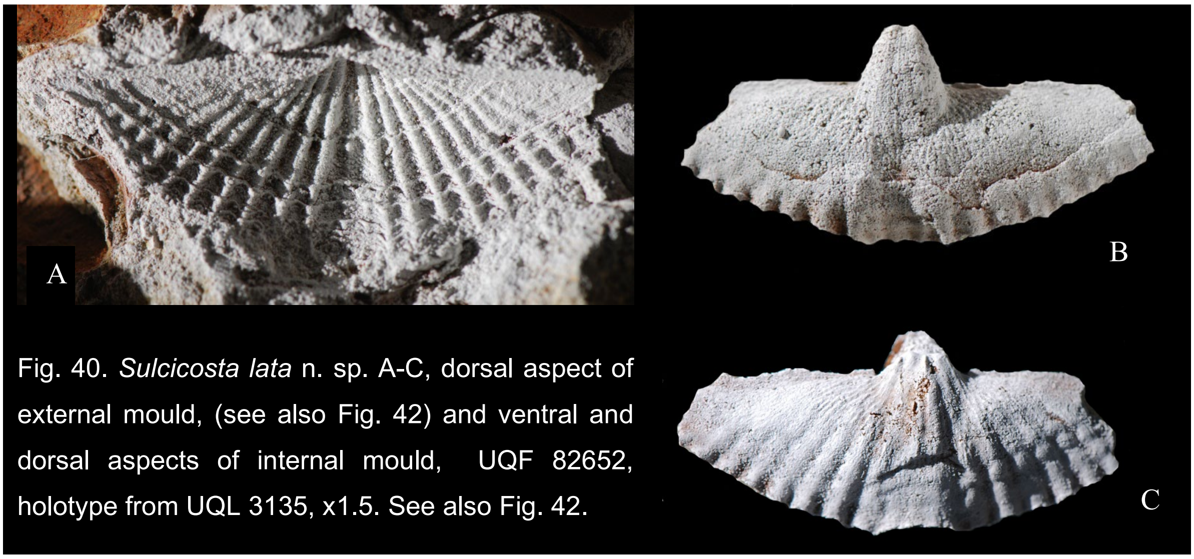

Fig. 40. *Sulcicosta lata* n. sp. A-C, dorsal aspect of external mould, (see also Fig. 42) and ventral and dorsal aspects of internal mould, UQF 82652, holotype from UQL 3135, x1.5. See also Fig. 42.

Description: Specimens transverse, ventral umbo broad, angle estimated to be 110°, ventral interarea concave and of moderate height, inclined dorsally from the commissure, with delthyrium enclosed by an angle of 38°. Dorsal valve lower than ventral valve, dorsal inter-area very low, inclined dorsally at steep angle from commissure, dorsal umbonal angle over 120°. Ventral sulcal angle close to 20°, sulcus comparatively shallow, with two low costae posteriorly, increasing to four well in front. Dorsal fold low, well defined median channel arising at umbo between two costae, joined close to anterior margin by a costa on each lateral slope. Plicae number eight or nine pairs, diminishing laterally in strength and with rounded crests of similar strength and profile on each valve. Micro-ornament of tiny dense pustules leading to pores, prominent growth laminae at intervals, especially close to the anterior margin of the holotype.

The delthyrium is underlain by a subdelthyrial connector plate that is highly convex externally. Dental plates are low, converging inwards whilst diverging forward, and supported by outwardly inclined and anteriorly divergent adminicula, which at advanced maturity come to be largely buried in secondary thickening. Adductor scars are weakly depressed, divided by a low septum and bordered by wider diductor scars with longitudinal striae. The muscle field varies in shape on different specimens, broad and short, or more elongate and extending beyond the adminicula. The hinge area is heavily thickened by secondary shell which on the surface is marked by pits and pustules.

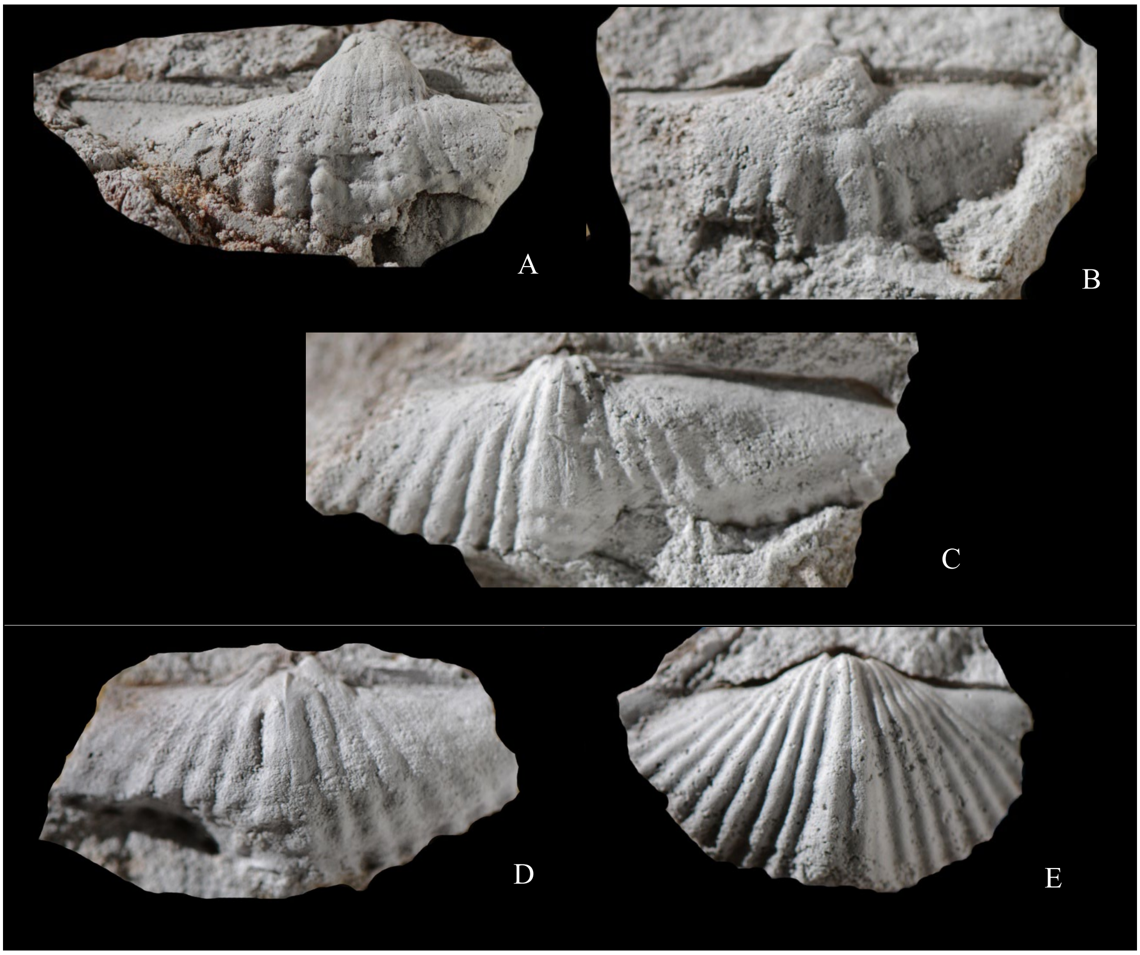

Fig. 41. *Sulcicosta lata* n. sp. A, ventral internal mould, UQF 82658, x1.5. B, ventral internal mould, UQF 82659, x2. C, dorsal internal mould UQF 82668, x2. D, dorsal internal mould UQF 82660, x2. E, dorsal internal mould UQF 82667, x2. Specimens from UQL 3135.

Crural plates are low and divergent, lying each side of a broad ctenophoridium with gently concave anterior face and bearing some sixteen vertical laminae. Poorly preserved elongate adductor scars lie immediately in front, and there is no sign of any median septum. Secondary thickening close to the hinge is considerable, and the inner valve floor is marked by long grooves and ridges, radiating laterally forward from close to the dental sockets. The outer part of the thickened floor bears numerous pits, with faint suggestions of lineations on one side of the holotype

Fig. 42. *Sulcicosta lata* n. sp., latex cast of ventral valve UQF 82652 from UQL 3135, x2.5. Holotype. See also Fig. 40A.

.Resemblances: This species is highly transverse. *Sulcicosta plicatus* (Armstrong 1970a, p. 142, pl. 2, fig. 6-11) from Middle Permian of New South Wales is more elongate with better defined sulcal costae. *S. pelicanensis* (Armstrong, 1970a, p. 152, pl. 4, fig. 11, 12, pl. 6, fig. 4) comes from the Pelican Creek bed, and has twelve to fourteen pairs of plicae, but is

Fig. 43. *Sulcicosta lata* n. sp. detail of dorsal external mould UQF 82705 from UQL 3135, x5.

decidedly more elongate than present material. The closest of other species appears to be *S. costata* Waterhouse (1987a, p. 14, pl. 1, fig. 1, pl. 3, fig. 5) from the Dresden Limestone of the southeast Bowen Basin, but some of the specimens of that species are more elongate, and the dorsal channel is better defined.

Superorder TEREBRATULIFORMII Waagen, 1883

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily **DIELASMOIDEA** Schuchert, 1913

Family **DIELASMIDAE** Schuchert, 1913

Subfamily **DIELASMINAE** Schuchert, 1913

Diagnosis: Dental plates well developed, septalium of inner and outer hinge plates, may be divided, sessile or raised on low to high septum, loop deltiform.

Tribe **FLETCHERITHYRINI** Waterhouse, 2010

Diagnosis: Septalium supported on high dorsal septum. Commissure rectimarginate to sulciplicate.

Genus ***Fletcherithyris*** Campbell, 1965

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

Type species: *Terebratula amygdala* Dana, 1847, p. 142 [not *T. amygdala* Catullo, 1846 Giorn. di Fisica 2 (5): 90] from Broughton Formation (Wordian), south Sydney Basin, OD, Finlay (1927) proposed replacing Dana's name with a new name *bensoni*, but a substitute name proposed shortly after the Dana publication is *Atrypa biundata* M'Coy (1847, p. 231). [See Waterhouse 1982a, p. 62].

Fletcherithyris galbina Waterhouse, 1982a

Fig. 44

1965 *Fletcherithyris amygdala* [not Catullo or Dana] – Waterhouse & Vella, p. 74, pl. 5, fig. 6.
1982a *Fletcherithyris galbina* Waterhouse, p. 60, pl. 14c-f, pl. 15b-d, pl. 16a-k, Text-fig. 24-26.
cf. 1987a *F*. cf. *galbina* – Waterhouse, p. 46, pl. 13, fig. 11.

Diagnosis: Small highly inflated elongate shells with maximum width variably placed between mid-length to well forward. Brachidium elevated high above floor, with almost straight anterior margin. Holotype: BR 854 figured by Waterhouse (1982a, pl. 16d-g) from upper Mangarewa Formation, New Zealand, OD.

Material, Description, Resemblances: A poorly preserved ventral valve from UQL 3135 is suboval, comparatively broad, with short dental plates (Fig. 44B), and another very small specimen with valves conjoined from the same locality (Fig. 44A) shows foramen and asymmetrical shape, the right side more like typical *galbina*, the other side matching other specimens amongst the types. They approach in shape individuals of the species *Fletcherithyris galbina* Waterhouse (1982a) from the *Echinalosia ovalis, Terrakea elongata planidisca* and *Ingelarella costata* Zones in the Mangarewa Formation of New Zealand, together with a similar-looking specimen from the Flat Top Formation of the southeast Bowen Basin (Waterhouse 1987a, pl. 13, fig. 11). The specimen shown in Fig. 44B lies at one extreme of the morphological range displayed by specimens classed as *F. galbina*. Its shape also approaches that of specimens assigned by Campbell (1965, pl. 2, fig. 9, 12) to *Fletcherithyris reidi*, from the Cattle Creek Shale of the southwest Bowen Basin. This species is of Early Permian age, and specimens are consistently broad rather than within the range of a variable species, so that the similarity appears to be to convergence.

Fig. 44. *Fletcherithyris galbina* Waterhouse. A, latex cast of specimen with valves conjoined, UQF 82706, x4. B, worn ventral internal mould, UQF 82707, x2. From UQL 3135.

Family **PSEUDODIELASMIDAE** Cooper & Grant, 1976

Genus ***Marinurnula*** Waterhouse, 1964

Diagnosis: Medium size, elongate, non-plicate, anterior commissure uniplicate, crural plates or outer hinge plates joined to floor of valve well away from mid-line, crural points long. Striate cardinal process.

Type species: *Marinurnula rugulata* Waterhouse 1964, p. 177, OD.

Discussion: In Jin, Lee et al. (2006, p. 2045), *Marinurnula* was classed in Pseudodielasmatidae Cooper & Grant, 1976 with a query. The doubt may be unnecessary, because crural plates were considered to be attached to the socket plates in *Pseudodielasma* (see Cooper & Grant 1976, pl. 760) and other genera, as appears to be the case for *Marinurnula.* But the course of the crura for *Marinurnula* remains unresolved.

Marinurnula sp.

Fig. 45

Description: Part of a dorsal internal mould from UQL 3135 exposes the dental sockets and base of the crus on one side. A very low ridge lies along the posterior mid-line, and dense punctation is displayed..

Fig. 45. *Marinurnula* sp., dorsal internal mould UQF 82708 from UQL 3515, x2.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Subclass Autobranchiata Grobben, 1894

Infraclass Pteriomorphia Beurlen, 1954

Cohort MYTILOMORPHI Férussac, 1822

Order MYTILIDA Férussac, 1822

Superfamily **MYTILOIDEA** Rafinesque, 1815

Family **MYTILIDAE** Rafinesque, 1815

Subfamily **MODIOLINAE** G. Termier & H. Termier, 1950

Genus ***Promytilus*** Newell, 1942

Diagnosis: Shell thin, beaks subterminal to terminal, anterior lobe small, broad sulcus extends from beaks to ventral marginal sinuosity, but may be scarcely developed, umbonal ridge rounded and curved in outline as a rule, hinge line smooth.

Type species: *Promytilus annosus annosus* Newell, 1942, p. 38 from Kansas City and Langsing Groups (upper Missourian), Kansas, OD.

Discussion: A summary of some recent views on *Promytilus* is provided in Waterhouse (2008a, pp. 14, 15).

Promytilus heywoodi (Waterhouse, 1987b)

Fig. 46

1987b *Volsellina heywoodi* Waterhouse, p. 138, pl. 1, fig. 22-25.

Diagnosis: Shells with umbo a little behind anterior margin, but anterior lobe inconspicuous, no carina, no well defined ornament of ribs. Posterior umbonal ridge almost straight.

Holotype: UQF 74313 from Flat Top Formation, figured in Waterhouse (1987b, pl. 1, fig. 24), OD.

Material: Two left valves from UQL 3135.

Dimensions in mm

Length	Height	Width
45.5	21	9.5
37.5	21.2	9

Description: Shell elongate, umbo subterminal with inconspicuous anterior lobe and shallow sulcus, weak ridge extending posteriorly from the umbo, well rounded rather than angular in section, only slightly curved in outline. Surface comparatively smooth apart from growth steps, no ribbing.

Resemblances: These specimens are close to *Promytilus heywoodi* in shape, involving size of the anterior lobe, position of the umbo, sulcus and outline of the posterior umbonal ridge. *Promytilus mytiliformis* (Etheridge, 1892, p. 273, pl. 14, fig. 5, pl. 41, fig. 4 only) from the Flat

Top or Barfield Formation of southeast Bowen Basin is also close in many respects, but has a more expanded posterior, so that the posterior umbonal ridge is more curved in outline. Etheridge's species has been refigured in Hill & Woods (1964, pl. P. 8, fig. 9) and Hill et al. (1972), and Waterhouse (1980, Fig. 2.6, 8) and both species have been extensively reviewed by Waterhouse (1980, 1987b, 2008a).

Fig. 46. *Promytilus heywoodi* Waterhouse, left valve UQF 82709, x1.5, from UQL 3135.

Infraclass Heteroconchia Hertwig, 1895

Cohort Uniomorphi Gray, 1854

Megaorder Unionata Gray, 1854

Order TRIGONIIDA Dall, 1889

Superfamily **TRIGONIOIDEA** Lamarck, 1819

Family **TRIGONIIDAE** Lamarck, 1819

Subfamily **EOSTARTINAE** Newell & Boyd, 1975

Genus ***Flattopia*** Waterhouse, 1987b

Diagnosis: Ovate or elongately subtriangular smooth shells with rounded posterior ridge, no escutcheon, left valve with marginal small anterior tooth and obsolete posterior tooth; right valve with large anteriorly directed tooth fitting into socket of left valve, obsolete or no posterior tooth, sockets well formed with floors, pedal retractor scars connected to adductors, pedal elevator scar minute.

Type species: *Kaibabella* (*Flattopia*) *axinia* Waterhouse, 1987b from Flat Top Formation, Bowen Basin, Queensland, OD.

***Flattopia*? sp.**

Fig. 47, 48

Diagnosis: Subtriangular prosocline shells with rounded posterior umbonal ridge, weakly sinuous or concave upwards in outline.

Material: A right valve from UQL 3515.

Description: Shell 37mm long, 35mm high and 9.5mm wide. Umbo with angle of 100°, placed near anterior third of shell length, hinge prolonged posteriorly, with angular but obtuse cardinal extremitiy, posterior umbonal ridge with rounded crest, weakly sinuous in outline. A shallow sulcus lies below and slightly behind the umbo, but whether the sulcus formed a consistent feature for specimens from this level is not known. The dentition is dominated by a large sub-triangular anterior tooth with a narrow groove on the inner side. A large and floored dental socket lies behind, followed by a low and elongate posterior ridge, with suggestions of a nymph ridge. A small deep pedal pit lies in front of the beak.

Fig. 47. *Flattopia*? sp. A, UQF 60634 right valve, x1.5. B latex cast of hinge, x3. From UQL 3515.

Resemblances: *Kaibabella boydi* Waterhouse & Jell, 1983 from the Glendoo Sandstone Member of the Gebbie Formation is more oval in shape with less defined posterior umbonal ridge. Small shells from Gerringong, south Sydney Basin, called *Astartila delicatula* Fletcher, 1929b might prove to be allied, but the dentition is not known. The taxon called *Kaibabella*

(*Flattopia*) *axinia* Waterhouse (1987b, p. 163, pl. 10, fig. 10-16) is close in its dentition, as far as known. There is a large right tooth, which shows no sign of the inner groove found in the present specimen, and slender posterior tooth and well developed platform. No specimen in this species shows any sign of a lateral sulcus.

Discussion: Only one specimen is available, and it differs from other Queensland material in having a slender but distinct lateral sulcus. There is a moderately developed posterior tooth – noted to be obsolete in allied material, and a posterior subdivision is developed in the major right valve tooth, which is not seen in other material. *Flattopia* was erected for shells close to *Kaibabella* Chronic, 1952, but distinguished by having a feeble but distinct posterior umbonal ridge, and in lacking the minor teeth of the right valve, with other differences. Two species described by Waterhouse & Jell (1983) from the Glendoo Sandstone Member are closer to *Kaibabella* in lacking an umbonal ridge.

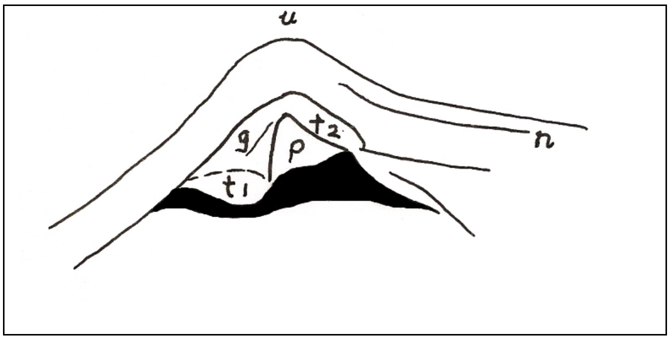

Fig. 48. *Flattopia*? sp. Sketch of hinge area for right valve UQF 60634. g = shallow groove in major tooth; n = nymph; p = platform between teeth; t1 = major anterior (cardinal) tooth; t2 = posterior tooth; u = umbo of right valve.

Megaorder OSTREATA Férussac, 1822

Superorder OSTREIFORMII Férussac, 1822

Order PECTENIDA Gray, 1854

Suborder ANOMIIDINA Gray, 1854

Hyporder AVICULOPECTENOIDEI Starobogatov, 1992

Superfamily **HETEROPECTENOIDEA** Beurlen, 1954

Family **HETEROPECTENIDAE** Beurlen, 1954

Subfamily **ETHERIPECTENINAE** Waterhouse, 1982b

Diagnosis: Ornament of intercalate costae on left and right valve, branching exceptional, costae may be spinose.

Discussion: It should be a rule for zoological nomenclature that the name of the genus is not changed for suprageneric categories, in spite of the need to conform with modern rules of grammar devised in medieval and modern times for ancient languages. In my opinion the unalterable root of the family or ordinal name should be considered to be the full name of the genus.

Genus ***Etheripecten*** Waterhouse, 1963b

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. Growth lines arch dorsally in interspaces. Shell aragonitic or calcitic, varying according to paleolatitude.

Type species: *Etheripecten striatura* Waterhouse, 1963b, p. 195 from Kildonan Member, Bagrie Formation (Changhsingian), New Zealand, OD.

Etheripecten leniusculus (Dana, 1847)

Fig. 49

1847 *Pecten leniusculus* Dana, p. 160.
1849 *P. leniusculus* – Dana, p. 704, pl. 9, fig. 6a, b.
1849 *P. mitis* Dana, p. 705, pl. 9, fig. 8.
1877 *Aviculopecten leniusculus* – de Koninck, p. 228, pl. 21, fig. 3. Also thye transaltion by David 1898.
1906 *Deltopecten leniusculus* – Etheridge & Dun, p. 28, pl. 3, fig. 1, pl. 4, fig. 1, pl. 6, fig. 1, pl. 7, fig. 1, 2, pl. 10, fig. 2, 3.
1906 *D. subquinquelineatus* [not M'Coy] – Etheridge & Dun, pl. 12, fig. 2, 3, pl. 13, fig. 2?, 8?, pl. 14, fig. 1 (part).
1927 *Deltopecten rienitsi* Mitchell, p. 107, pl. 2, fig. 1, 2.
1929a *A. sprenti* [not Johnston] – Fletcher, p. 22, pl. 12, fig. 1, 3, 5.
1965 "*Limipecten*" aff. *leniusculus* – Waterhouse & Vella, p. 75, pl. 5, fig. 10.
1982b *Etheripecten leniusculus* – Waterhouse, p. 20, pl. 5a-f, pl. 6a-c, pl. 9e.
1988 *E. leniusculus* – Waterhouse, p. 173, pl. 2, fig. 6, pl. 3, fig. 1-3.
2008a *E. leniusculus* – Waterhouse, Fig. 76.

Diagnosis: Large shells with widely diverging umbonal slopes and fine ribs in some four orders.

Lectotype: Specimen USNM 3644 figured by Dana (1849, fig. 6a, b) and Waterhouse (1982b, pl. 6e; 1988, pl. 3, fig. 1, 2), SD Waterhouse (1982b, p. 20).

Material: An external mould and an internal mould of left valves from UQL 3135.

Description: A moderately large internal mould of a left valve more than 52mm long shows large anterior auricle and well differentiated ribs, and part of an external mould of a left valve preserves fine and well differentiated ribs. Both specimens have a long hinge, and neither shows signs of spines on the costae. Specific affinities possibly lie with *Etheripecten leniusculus* (Dana, 1847) of uncertain origin on the south coast of the Sydney Basin and likely to have come from high in the marine succession, as well as *E. leniusculus delicatulus* (Fletcher, 1929a) from Wandrawandian beds of the south coast, and *E. latus mangarewensis* Waterhouse, 1982b from the Mangarewa Formation in New Zealand. The species *leniusculus* is the most likely identification for the present material, based on the original types extensively figured in Dana (1849) and Waterhouse (1982b, 1988), because *delicatulus* has more numerous ribs and *mangarewensis* has a short hinge. The species is compared with other related taxa in Waterhouse (1982b, p. 21).

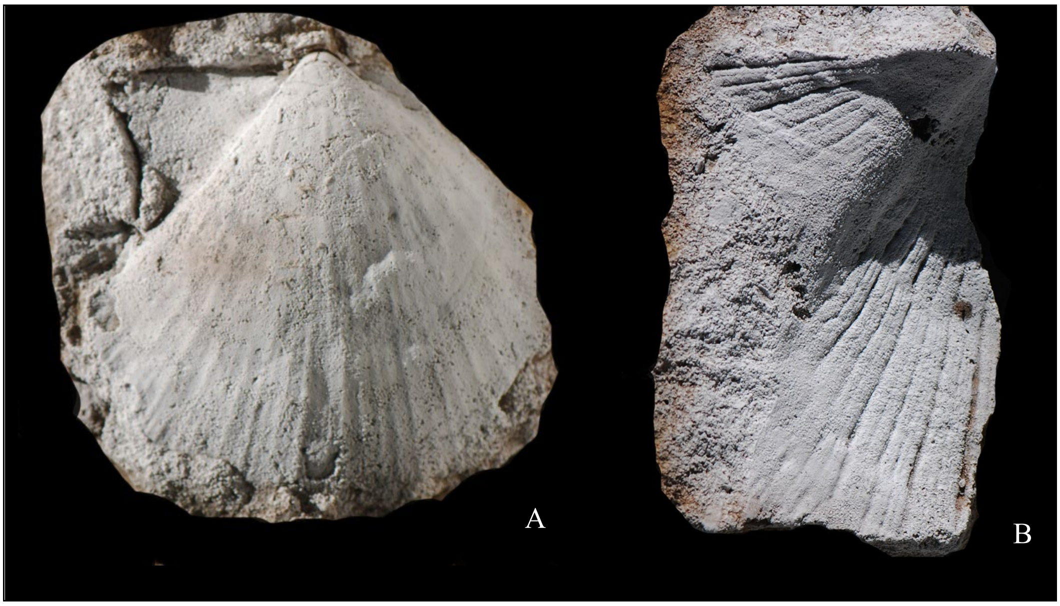

Fig. 49. *Etheripecten leniusculus* (Dana). A, left valve internal mould, UQF 82710. B, left valve external mould, UQF 82711. Specimens from UQL 3135, x1.

Genus ***Primaspina*** Waterhouse, 2008a

Diagnosis: *Etheripecten*-like shells distinguished by presence of arcuate spines arching dorsally along the crest of primary ribs.

Type species: *Aviculopecten dawsonensis* Runnegar & Ferguson, 1969, p. 262 from Flat Top Formation, Bowen Basin, OD.

Discussion: This appears to be a minor lineage, so far limited to the Permian of Queensland, and distinguished by the small C-shaped spine over the major costae.

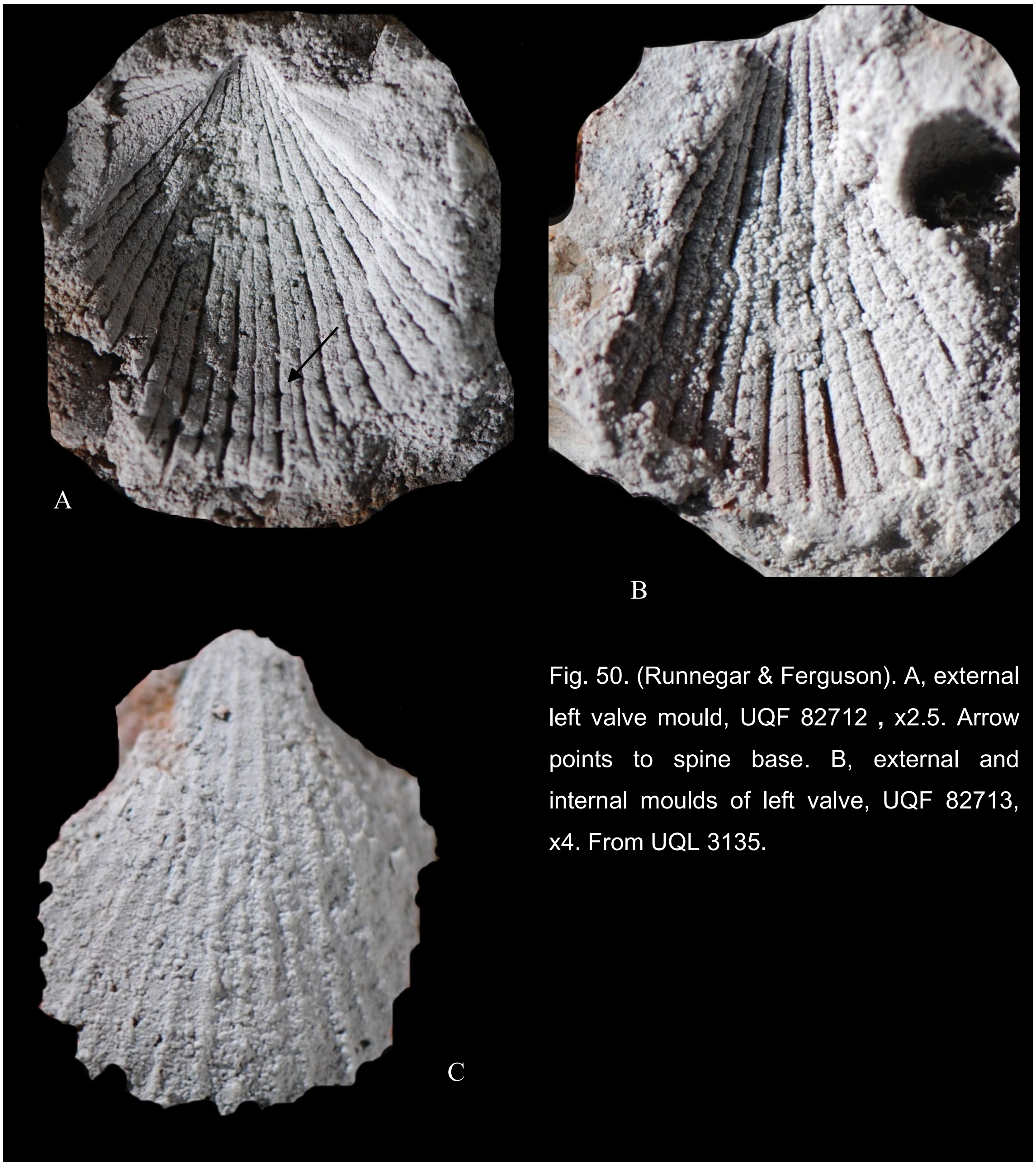

Fig. 50. (Runnegar & Ferguson). A, external left valve mould, UQF 82712 , x2.5. Arrow points to spine base. B, external and internal moulds of left valve, UQF 82713, x4. From UQL 3135.

Primaspina sp.

Fig. 50

Diagnosis: Shells with left valve ribs in three, possibly four orders, primary ribs strong and bearing c-shaped spinose lamellae at intervals, and also a few fine capillae on some ribs.

Material: Three small left valves, two preserved as external moulds, one as an internal mould from UQL 3135.

Description: Specimens are small and incomplete. They come close to *Primaspina* in so far as there are at least three orders of ribbing despite the small size of the specimens, and they show the c-shaped spines over the primary and secondary costae. Ears are large. The type species *dawsonensis,* named and figured as *Aviculopecten dawsonensis* by Runnegar & Ferguson (1969, p. 262, pl. 5, fig. 14, 15, 17-19 [part, not 16 = aff. *latus* Fletcher]; and also ecorded in Hill et al. (1972, pl. P11, fig. 16, 17), Waterhouse (1987b, p. 148, pl. 5, fig. 4, 5, 7-10, 13) and Waterhouse (2008a, p. 143, text-fig. 83) has fewer and more prominent primary costae over the left valve.

Subcohort Cardioni Férussac, 1822

Infrasubcohort Cardiidia Férussac, 1822

Megaorder CARDIATA Férussac, 1822

Order CARDIIDA Férussac, 1822

Superfamily **KALENTEROIDEA** Marwick, 1953

Family **KALENTERIDAE** Marwick, 1953

Diagnosis: Medium-sized trapezoidal to modioliform inequilateral shells, radial ribs may be present, tend to be obsolete or absent anteriorly, internal margin smooth, marginal ligament and long nymph. Cardinals partly obsolete, tuberculiform or elongate, 5b and laterals lacking in most shells, posterior lateral placed well back, that of left valve usually stronger. Anterior and pedal scars, generally thickened anterior buttress, small anterior pedal scar prominent.

Discussion: This family has been discussed by Waterhouse (2010, pp. 96, 97). Carter et al. (2011) rightly granted standing to Kalenteridae Marwick, to overturn the eurocentric position advocated by Chavan (1969, p. 543).

Genus ***Stutchburia*** Etheridge, 1900

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.

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

Stutchburia costata (Morris, 1845)

Fig. 51

1845 *Orthonota*? *costata* Morris, p. 274, pl. 11, fig. 1, 2.
1849 *Cardinia*? *costata* – Dana, p. 692, pl. 4, fig. 8a-c.
1877 *Pleurophorus morrisi* de Koninck, p. 281, pl. 20, fig. 5.
1888 *P. morrisi* Johnston, pl. 21, fig. 6.
1900 *Stutchburia costata* – Etheridge, p. 180, pl. 31, fig. 1.
1964 *S. costata* – Hill & Woods, pl. P12, fig. 2.
1969 *S. costata* – Wass & Gould, p. 219, pl. 14, fig. 1-5.
1972 *S. costata* – Hill et al., pl. P12, fig. 2.
1980 *S. costata* – Waterhouse, p. 113, Fig. 4.1, 3, 4; Fig. 5, Fig. 6.
1988 *S. costata* – Waterhouse, p. 178, pl. 5, fig. 4-7.

Diagnosis: Large, elongate, six to up to fifteen costae radiating posteriorly from umbo.

Lectotype: Specimen figured by Morris (1845, pl. 11, fig. 1), implied as type by Etheridge (1900, p. 181) and formally consolidated by Waterhouse (1980, p. 115).

Material: Two right valves and a left valve from UQL 3135 belong to the species, and a very small specimen is probably a juvenile, with costae yet to develop. A specimen with valves conjoined appears to differ in having a rib radiating from the umbo above a shallow sulcus, but is an internal mould, with external ornament therefore obscure.

Description, Resemblances: The best preserved specimen (Fig. 51D) has seven costae, and a shallow sulcus steeply inclined from the umbo, below the most anterior and ventrally placed costa. A large adductor scar is present, in front of a low ridge. Costae appear to be fewer in other specimens, and possibly some, as illustrated with a query in the caption for Fig. 51, will prove to belong to *Stutchburia compressa* (Morris, 1845, p. 274, pl. 13, fig. 4), a species that is characterized by a lack of costae. But as only internal moulds are available, the true external external ornament is not known, and all are assigned with reservations to the one

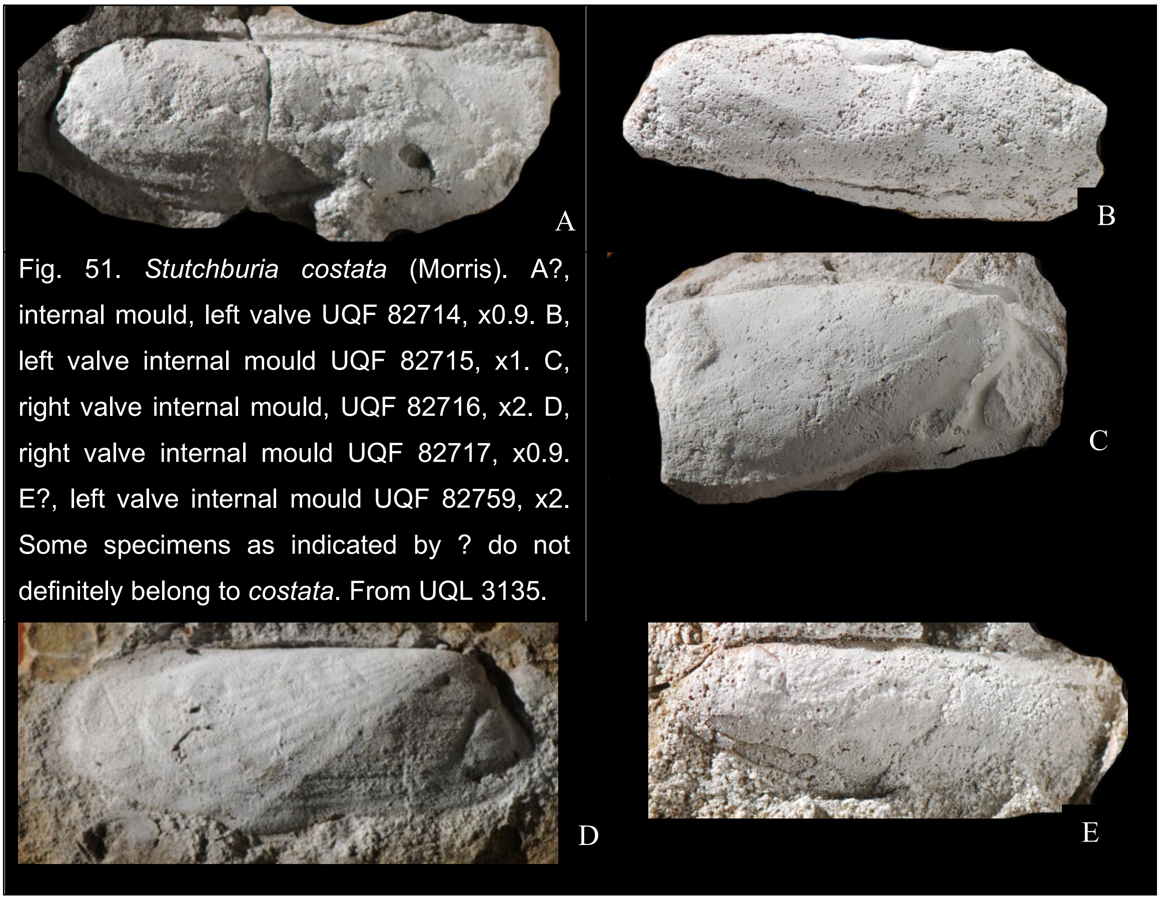

Fig. 51. *Stutchburia costata* (Morris). A?, internal mould, left valve UQF 82714, x0.9. B, left valve internal mould UQF 82715, x1. C, right valve internal mould, UQF 82716, x2. D, right valve internal mould UQF 82717, x0.9. E?, left valve internal mould UQF 82759, x2. Some specimens as indicated by ? do not definitely belong to *costata*. From UQL 3135.

E see Fig20A

species. Even those without clearly defined costae suggest faint traces of one or two costae. The number of costae in specimens from different stratigraphic levels and geographic areas of east Australia varies, to some extent consistently, as noted in Waterhouse (1980, p. 115), but present specimens are only internal moulds, and probably unreliable in displaying external ornament.

Stutchburia laminata Waterhouse, 2015a, p. 302, Fig. 248-250) from the middle Tiverton Formation is close in general appearance, with six to eight costae, and laminate surface. The species is slightly less elongate and more inflated than the present form.

Superorder PHOLADIFORMII Gray, 1854

Order PHOLADIDA Gray, 1854

Superfamily **PLEUROMYOIDEA** Zittel, 1895

Family **VACUNELLIDAE** Astafieva-Urbaitis, 1973

Genus ***Vacunella*** Waterhouse, 1965

Diagnosis: Medium-sized to large shells with moderate to substantial posterior gape, pedal gape often present, no posterior ridge or carination, umbones placed well forward, pallial sinus, anterior retractor scar connected by isthmus to anterior adductor scar.

Type species: *Allorisma curvatum* Morris, 1845, p. 270 from "Illawarra", probably Broughton Formation (Capitanian) of the Gerringong Volcanics, south Sydney Basin, New South Wales.

Discussion: The concept that *Vacunella* evolved from *Myonia,* which was championed by Runnegar (1967) and opposed by Waterhouse (1969, 2001), may now be set aside, with the demonstration that *Vacunella* not only differs morphologically from *Myonia* but is represented in Carboniferous glacial deposits (Gonzalez 2002) of western Argentina, older than the genus *Myonia* from which it supposedly evolved. There are also close allies of *Vacunella* in the Carboniferous of northern Russia, called *Praemyonia* Astafieva-Urbaitis, 1988 and *Cuvavella* Astafieva-Urbaitis, 1990 (see Waterhouse 2001, pp. 149, 150). The recent taxonomic history of *Vacunella* and its classificatory position has been overviewed by Gonzalez (2006, pp. 142, 143), summarizing the different approaches, including those by Runnegar (1974), Runnegar & Newell (1974), Astafieva-Urbaitis (1973) and Morris et al. (1991).

Vacunella curvata (Morris, 1845)

Fig. 52

1845 *Allorisma curvata* Morris, p. 270, pl. 10, fig. 1.
1847 *A. curvata* – Dana, p. 160.
1847 *A. audax* Dana, p. 160.
1849 *A. audax* – Dana, p. 687, pl. 3, fig. 1, 1b, 1c.
1849 *Pholadomya* (*Homomya*) *curvatus* – Dana, p. 686, pl. 3, fig. 2a-b.
1849 *P.* (*Homomya*) *glendonensis* Dana, p. 687, pl. 2, fig. 12.
1877 ?*Sanguinolites mitchelli* de Koninck, p. 261, pl. 16, fig. 3, 3a.
1877 *S. undatus* [not Dana] – de Koninck, p. 204, pl. 17, fig. 1.
1880 *Chaenomya* sp. Etheridge Jnr, p. 303.
1888 *S. etheridgei* [not de Koninck] – Johnston, pl. 11, fig. 13a-c.
1892 *Chaenomya*? *acuta* [not Etheridge Snr] – Etheridge Jnr, p. 280.
1929 *C. etheridgei* [not de Koninck] – Reid, pl. 36, fig. 3.
1965 *Vacunella curvata* – Waterhouse, p. 377.
1965 *Vacunella curvata* – Waterhouse & Vella, p. 252, pl. 5, fig. 10.
1966 *V. curvata* – Runnegar, fig. 1a.
1967b *V. curvata* – Waterhouse, pl. 7, fig. 1, 4, text-fig. 2A, B.
1967 *V. curvata* – Runnegar, p. 63, pl. 7, fig. 15, 16, pl. 8, fig. 1-9, pl. 9, fig. 16, pl. 12, fig. 9, 10 (part, not fig. 17?, pl. 9, fig. 15, 17?, pl. 11, fig. 14 = *bowenensis* Etheridge Jnr).
1969 *V. curvata* – Waterhouse, p. 71, pl. 3, fig. 5, 6, 8, pl. 4, fig. 1-4, pl. 5, fig. 1-6, pl. 19, fig. 2, text-fig. 7I, 8H, 14-16.
1987b *V. curvata* – Waterhouse, p. 173, pl. 11, fig. 14, pl. 14, fig. 7.
1988 *V. curvata* – Waterhouse, p. 200, pl. 19, fig. 13, 14, pl. 20, fig. 4. (With fresh figures of type *audax* Dana and *glendonensis* Dana).

Diagnosis: Large shells with weakly prosocline outline as a rule and umbones placed close to anterior third of length, moderately large posterior gape.

Lectotype: PL 3692 figured by Morris (1845, pl. 10, fig. 1) probably from the Gerringong Volcanics (s.l.), near Illawarra, New South Wales, SD Waterhouse (1965, p. 377). See also Runnegar (1967, p. 64) and Waterhouse (1965, p. 377) for synonyms proposed as *audax, mitchelli* and *glendonensis*.

Material: A left valve and broken ventral part of a specimen with valves conjoined from UQL 3135.

Description, Resemblances: The specimens agree as far as they are preserved with *Vacunella curvata*, for which a number were figured by Runnegar (1967) and Waterhouse (1969). The species is especially well represented in the Mulbring Formation of New South Wales and the younger Back Creek Group of the Bowen Basin.

Fig. 52. *Vacunella curvata* (Morris), left valve internal mould UQF 82718, x1.5, from UQL 3135.

Vacunella bowenensis (Etheridge) [= *Sanguinolites* cf. *clava* [not M'Coy] of Etheridge Jnr, 1880, p. 40, pl. 16, fig. 54; 1892 *Chaenomya*? *bowenensis* p. 280] is close to *curvata* but has more anteriorly placed umbones, with the holotype refigured by Hill & Woods (1964, pl. 10, fig. 11) and Hill et al. (1972). It comes from high in the Blenheim Formation, at Coral Creek downstream from the Sonoma Road.

Genus ***Australomya*** Runnegar, 1969

Diagnosis: Elongate shells with subparallel dorsal and ventral margins, anteriorly placed low umbones, lateral sulcus varies from absent to moderately developed, dorsal margin linear to weakly and upwardly concave, posterior shell rounds smoothly into hinge without forming any marked shoulder or carina. No pedal gape, and pallial sinus shallow or absent. Adductor scars, anterior, posterior and umbonal retractor scars.

Type species: *Australomya hillae* Runnegar, 1969, p. 285 from Wasp Head Formation of south Sydney Basin, OD.

Discussion: Members of this genus are very close to *Vacunella,* and the distinction depends on placing narrow limits on both genera.

Australomya sp. cf. ***dawsonensis*** (Runnegar, 1967)

Fig. 53

cf. 1964 ?*Sanguinolites* sp. nov. Dickins in Veevers et al. p. 82.
cf. 1966 *Chaenomya*? n. sp. Runnegar, fig. 1d.
cf. 1967 *Vacunella*? *dawsonensis* Runnegar, p. 73, pl. 11, fig. 1-8, pl. 13, fig. 1-4.
cf. 1969 *Australomya*? *dawsonensis* – Runnegar, p. 288, Fig. 53Ae.
cf. 1987b *Vacunella dawsonensis* – Waterhouse, p. 174, pl. 11, fig. 3.

Diagnosis: Elongate shells with subparallel dorsal and ventral margins and low inconspicuous anteriorly placed umbones.

Holotype: UQF 51000 figured by Runnegar (1967, pl. 13, fig. 1-3) from Flat Top Formation, southeast Bowen Basin, OD. A second holotype was also cited in the caption by Runnegar (1967, pl. 11, fig. 5) as CPC 7358 from the upper Barfield Formation east of Baralaba. Waterhouse (1987b, p. 174) selected the first mentioned specimen as holotype and set aside Runnegar's other choice.

Fig. 53. *Australomya* cf. *dawsonensis* (Runnegar), left valve UQF 82719 from UQL 3135, x1.

Description: A left valve from UQL 3135 is available, comparatively featureless, with no sign of a lateral sulcus, and the posterior shell destroyed.

Resemblances: The specimen falls only moderately close to *Australomya dawsonensis*, which tends to be more elongate and slightly less smoothly rounded in vertical profile.

Megaorder SOLENATA Dall, 1889

Order HIATELLIDA J. Carter *in* Carter et al. 2011

Superfamily **EDMONDIOIDEA** King, 1850

Family **EDMONDIIDAE** King, 1850

Diagnosis: Edmondioid shells with no posterior gape, hinge teeth feeble or absent, hinge plate or septum present or poorly developed.

Subfamily **MYONIINAE** Waterhouse (1969), 1987b, 2001

Diagnosis: Large upright shells without internal plate other than vestigal, accessory muscle scars more numerous than in Edmondiinae.

Genus ***Myonia*** Dana,1847

Diagnosis: Medium- to large-sized subelongate shells, with anteriorly placed orthogyrous umbones, posterior umbonal ridge well rounded in profile and not carinate, no posterior gape or pallial sinus. No clearly developed teeth, anterior adductor joined to extended pedal scar complex extending towards umbo.

Type species*: Myonia elongata* Dana, 1847, p. 158 from Gerringong Volcanics (s. l.), south Sydney Basin, SD Fletcher (1932, p. 409).

Myonia carinella Runnegar, 1967

Fig. 54

1876-7 ?*Sanguinolites undatus* [not Dana] – de Koninck, p. 260, pl. 17, fig. 1.
1964 ?*Notomya* ? sp. nov. Dickins in Dickins et al., table 1.
1967 *Myonia carinella* Runnegar, p. 58, pl. 4, fig. 10, pl. 13, fig. 5-13.
1968 *M. carinella* – Runnegar, p. 21.
2002a *M. carinella* – Waterhouse, Table 13.
2022 *M. carinella* – Waterhouse, p.

Diagnosis: Subelongate shells with umbones placed near anterior third of length, posterior gape negligible, gently rounded posterior umbonal ridge, very shallow or negligible lateral sulcus.

Holotype: UQF 50996 from below Scottville Member, west of Parrot Creek, figured by Runnegar (1967, pl. 13, fig. 8-10), OD.

Material: Six internal moulds of specimens with valves conjoined, and a small block with crowded specimens, including two with valves conjoined, and several single valves, including external moulds, from UQL 3135.

Description, Resemblances: The specimens conform well in shape and size with the type material. Runnegar (1967) reported a feeble tooth in the right valve, but this cannot be observed in present material. On the other hand specimens show the elongate accessory muscle scar extending behind the anterior adductor scar, as figured for *Myonia* in Waterhouse (1969, Fig. 7G), and a pallial line without a sulcus, and there is no posterior gape. A comparable specimen was listed from the *Paucispinifera solida* Zone of the Mangarewa Formation unit 7 in New Zealand by Waterhouse (2002a, Table 13).

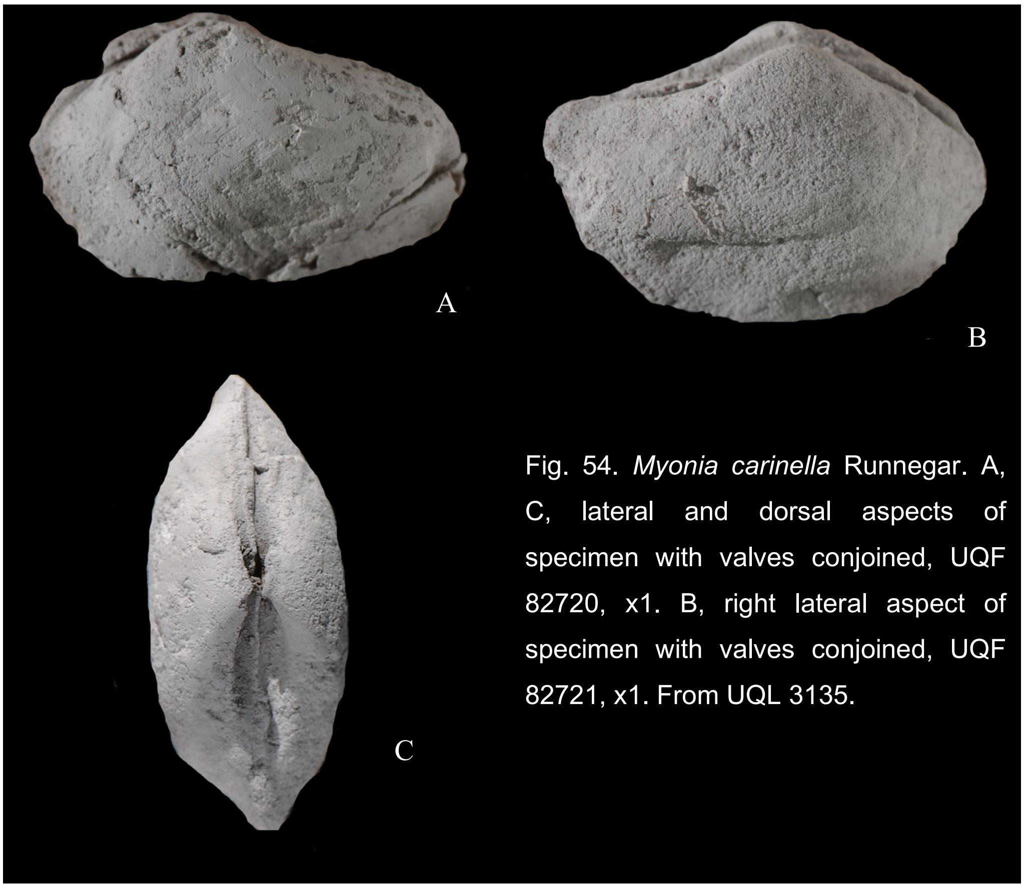

Fig. 54. *Myonia carinella* Runnegar. A, C, lateral and dorsal aspects of specimen with valves conjoined, UQF 82720, x1. B, right lateral aspect of specimen with valves conjoined, UQF 82721, x1. From UQL 3135.

Discussion: Runnegar (1967) noted similarities to material described by other authors, including de Koninck (1876-7). De Koninck had referred his specimen, likely to have come from Mulbring according to Runnegar (1967, p. 59), to *Sanguinolites undatus* Dana, a feature of the type species of *Myonia*, *M. elongata* Dana , and is regarded as a typical feature of the genus.

The holotype of *Myonia carinella* and a number of other specimens came from just below the Big Strophalosia band, now Scottville Member, according to Runnegar (1967). The present material is somewhat younger, coming from just above the Scottville Member, and Runnegar (1968, p. 21) recorded the species in the Scottville Member.

Genus ***Myomedia*** Waterhouse, 1969

Diagnosis: Shells with weakly carinate posterior umbonal ridge, elongate and slender to moderately inflated.

Type species: *Pachydomus carinatus* Morris (1845, p. 273) from “Illawarra, New South Wales”, OD.

Myomedia carinata (Morris, 1845)

Fig. 55, 56

1845 *Pachydomus carinatus* Morris, p. 273, pl. 11, fig. 3 (part, not fig. 4 = *Myonia elongata*).
1847 *P. carinatus* – M’Coy, p. 301.
1849 *Maeonia*? *carinata* – Dana, p. 696, pl. 6, fig. 1.
1849 *M. fragilis* Dana, p. 696, pl. 6, fig. 2, 3.
1880 *Pachydomus*? *carinatus* – Etheridge, Jnr, p. 300, pl. 16, fig. 53.
1887 *Notomya* (*Maeonia*) *elongata* [not Dana] – Ratte p. 139, pl. 3.
1888 *Pachydomus carinatus* – Johnston, pl. 11, fig. 15, 15a?
1932 *Myonia carinata* – Fletcher, p. 401, pl. 49, fig. 1-3.
1932 *M. carinata etheridgei* [not de Koninck] – Fletcher, p. 407.
1950 *M. carinata* – David, pl. 36, fig. d.
1964 *M. carinata* – Hill & Woods, pl. P10, fig. 9, 10.
1965 *M. carinata* - Waterhouse & Vella, p. 77, pl. 5, fig. 11.
1967 *M. carinata* – Runnegar, p. 50, pl. 4, fig. ?8, 9 (part not pl. 4, fig. 11-13 = *Pachymyonia*?), pl. 5, fig. 20, pl. 12, fig. 7, 14.
1967 *M. elongata* [not Dana] – Runnegar, pl. 5, fig. 12-15, 18, 19.
1969 *M.* (*Myomedia*) *carinata* – Waterhouse, p. 67, pl. 1, fig. 2.
1972 *M. carinata* – Hill et al. , pl. P10, fig. 9, 10.
1983 *M.* (*Myomedia*) *carinata* – Waterhouse & Jell, p. 251, pl. 5, fig. 7, pl. 6, fig. 14.
1987b *M.* (*Myomedia*) *carinata* – Waterhouse, p. 171, pl. 10, fig. 24.
1988 *M.* (*Myomedia*) *carinata* – Waterhouse, p. 183, pl. 7, fig. 3, pl. 15, fig. 6.
2010 *M. (Myomedia) carinata?* – Shi et al., pl. 11, fig. 18, 19.

Diagnosis: Elongate shells with subdued posterior carina and convex posterior lateral shell.

Lectotype: BM (NH) L 6155 figured by Morris (1845, pl. 11, fig. 3), SD Waterhouse & Vella (1965, p. 77).

Material: Four specimens with valves conjoined from UQL 3135.

Description, Resemblances: The present specimens accord well with material figured widely from the Sydney and Bowen Basins, and from the Flowers Formation of New Zealand, but not with the specimens from the Taimyr Peninsula and Verchoyan of northeast Russia, though recorded as conspecific by Muromseva (1984). That of Muromseva (1984, pl. 45, fig. 1) is particularly close to *Myonia elongata* (Dana). She clearly relied on the flawed interpretation of Runnegar 1967, which confused *M carinata* with *elongata*, but her figures in pl. 45, fig. 2, 9) are somewhat less elongate. The other specimens in Muromseva (1984, pl. 45, fig. 8, pl. 46, fig. 1-6) are only moderately elongate, with well-rounded non-carinate posterior umbonal ridge.

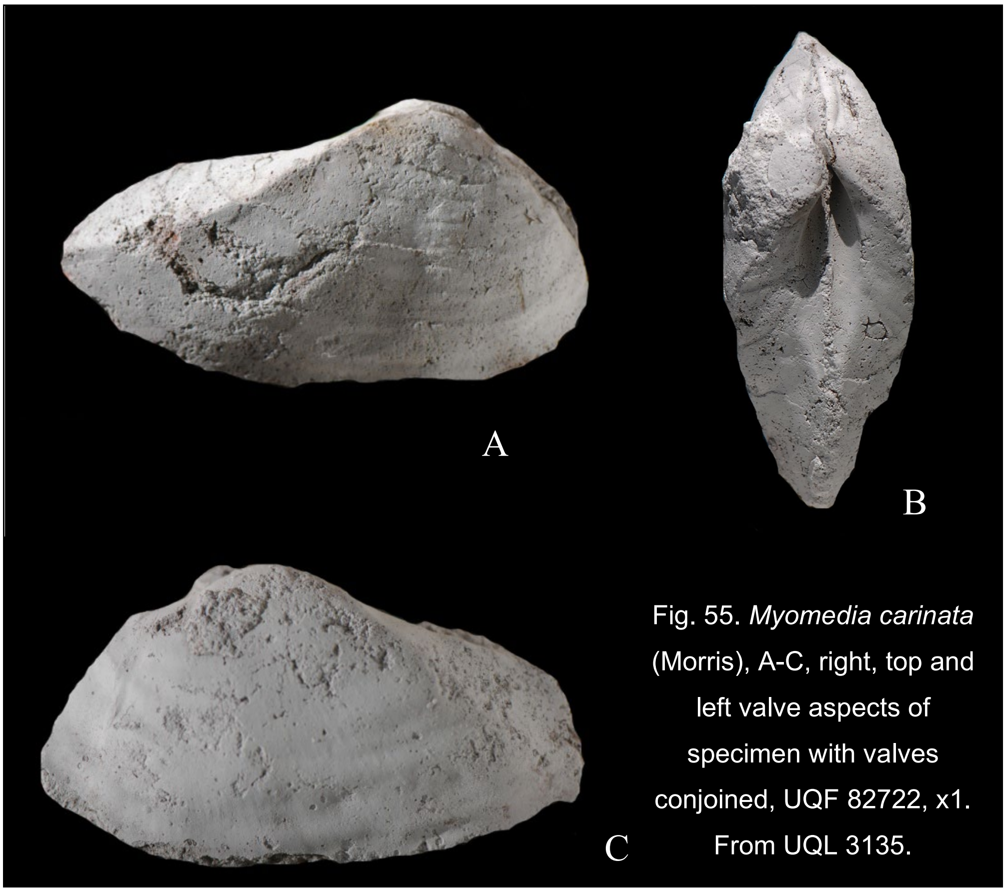

Fig. 55. *Myomedia carinata* (Morris), A-C, right, top and left valve aspects of specimen with valves conjoined, UQF 82722, x1. From UQL 3135.

Fig. 56. *Myomedia carinata* (Morris), dorsal aspect of specimen with valves conjoined, UQF 82700, x0.9, from UQL 3135.

Myomedia corrugata (Fletcher, 1932)

Fig. 55

1932 *Myonia corrugata* Fletcher, p. 404, pl. 50, fig. 3, 4.
1969 *Pachymyonia corrugata* – Waterhouse, p. 68, pl. 16, fig. 6.
1987b *P. corrugata* – Waterhouse, p. 172, pl. 11, fig. 6.

Diagnosis: Large elongate shells with strong commarginal rugae and thick shell, posterior carina of moderate strength.

Holotype: AMF 30014 figured by Fletcher (1932, fig. 3) from Wandrawandian Formation near Ulladulla, OD.

Material: A small right valve, fragment of a left valve and external mould of the posterior portion of a specimen with valves conjoined and splayed open, from UQL 3135.

Description: The small specimen has a well-developed carina and closely spaced growth rugae. The large specimen shows part of the posterior shell, with strong rugae over the lateral face, angling abruptly onto a high gently concave and rugose posterior lateral face, with intervening but not very high carina.

Resemblances: The species *corrugata* was originally described from near Ulladulla, south Sydney Basin, and has been reported from younger levels in the Flat Top Formation of the Bowen Basin, and upper Mangarewa Formation of New Zealand. The present material is close in age to the latter occurrence.

Fig. 57. *Myomedia corrugata* (Fletcher), broken external mould of specimens with valves conjoined, UQF 82763**,** x1. From UQL 3135.

Discussion: There is ambivalence about the generic position of this species. Fletcher (1932) classed it as *Myonia*, rather than *Pachymyonia*, presumably because it is elongate like *Myonia elongata* and not very wide. On the other hand, it has a carina, like that of *Pachymyonia,* and unlike *Myonia*. Deciding that some species were intermediate in their attributes between *Myonia* and *Pachymyonia*, Waterhouse proposed a subgenus *Myomedia* for *Myonia carinata* – which is elongate, not as inflated as type *Pachymyonia*, and carinate, unlike *elongata*. The species *corrugata* falls within this *Myomedia* group. Although *Pachymyonia* is predominantly of Early Permian age, one species *P. triangulata* Waterhouse, 1969 is a strongly inflated and strongly carinate species found in the *Echinalosia ovalis* – *Paucispinauria solida* and *Ingelarella costata* Zones of New Zealand, and a further species is represented as *Pachymyonia* sp. at the base of the South Curra Limestone in southeast Queensland (Waterhouse 2015b, p. 80).

Another New Zealand species showing some similarity to *Myomedia corrugata* in its large size and moderately strong commarginal rugae was described as *Notomya gigantissima* Waterhouse, 1969, now referable to *Pyramus,* It comes from the *Maxwellosia ovalis wassi* Zone, and does, from the figure of the holotype (Waterhouse 1969, pl. 21, fig. 1) appear to have a short posterior carina just behind the umbo. However this may be due to compression, and no ridge is seen on a second specimen (pl. 20, fig. 5) or on other specimens. This form became very large, one specimen having been measured as 18cm long.

Class Gastropoda Cuvier, 1797

Subclass Protobranchiata Milne-Edwards, 1848

Order PLEUROTOMARIIDA Swainson, 1840

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **EOTOMARIINAE** Wenz, 1938

Genus ***Mourlonopsis*** Fletcher, 1958

Diagnosis: Large shells with high spire and swollen turbinate whorls, selenizone near mid-height. Surface smooth apart from fine growth increments, fine spiral ornament on best preserved specimens.

Type species: *Pleurotomaria strzeleckiana* Morris, 1845, p. 287 from the Maitland Group, Sydney Basin, OD.

Mourlonopsis strzeleckiana (Morris, 1845)

Fig. 58

1845 *Pleurotomaria strzeleckiana* Morris, p. 287, pl. 18, fig. 5.
1858 *P. strzeleckiana* – Plews, pl. 3, fig. 4.
1929 *Mourlonia Strezleckiana* – Reid, Fig. 38.11.
1951 *Mourlonia strzeleckiana* – Campbell, p. 33, pl. 1, 2.

1952 *Pleurotomaria* aff. *strzeleckiana* – Fletcher, p. 17 (part, not pl. 2, fig. 1, 2 = *Platyteichum loratum*).
1958 *Mourlonopsis strzeleckiana* – Fletcher, p. 129, pl. 9, fig. 9-11.
1963a *M. strzeleckiana* – Waterhouse, p. 122, Fig. 2A, 21, 22.
1987b *M. strzeleckiana* – Waterhouse, p. 179, pl. 12, fig. 11, 12.
2001 *M. strzeleckiana* – Waterhouse, p. 153, pl. 10, fig. 2-4.

Diagnosis: Large shells with high spire and swollen turbinate whorls, selenizone near mid-height. Surface smooth apart from fine growth increments and signs of spiral ornament on some specimens.

Holotype: PL 3921, sole specimen figured by Morris (1845) and refigured by Waterhouse (2001, pl. 10, fig. 2-4) from Wollongong or Glendon, New South Wales.

Material: External moulds of three somewhat squashed fragments and a shell with upper spire lost from UQL 3135.

Description: Specimens small and varying in preservation. They show the turbinate high spire with selenizone near mid-height, and fine collabral growth increments, and subdued spiral threads. In one specimen the slit appears to extend for about one fifth of the circumference.

Resemblances: One of the specimens is moderately well preserved though incomplete and is close in shape to the original type of the species, and shows signs of the faint spirals reported on some specimens by Fletcher (1958), in this regard better preserved than the decorticated holotype figured in Morris (1845) and Waterhouse (2001). Other specimens from the present collection are more deformed.

The identification of specimens from the Kulnura marine tongue of New South Wales with this species by Dickins (1989, p. 69, pl. 2, fig. 12-19) is rejected. These specimens have much stronger spiral as well as collabral ornament, as well shown in his illustrations, unlike the ornament of *Mourlonopsis*, and the upper whorl is gently convex or flat, and the lower whorl is steep and subvertical and concave, before curving abruptly on to the base. The whorl profile in *Mourlonopsis* is much more swollen: convex above and below the selenizone. As shown in Waterhouse (2001, p. 154), the Dickins specimens are identical with *Platyteichum loratum* Waterhouse (1963a, p. 131, text-fig. 4, 37-50) from the upper Mangarewa Formation of New Zealand (see also p.). Dickins (1989) further erred in referring *Mourlonia impressa* Waterhouse, 1966 to *Mourlopsis strzeleckiana*. The species *impressa*, sardonically named, was suggested by Waterhouse (2001) to be possibly close to *Neoplatyteichum* Maxwell (1964, p. 20, pl. 4, fig. 18-24) from the Upper Carboniferous Rands Formation of the Yarrol

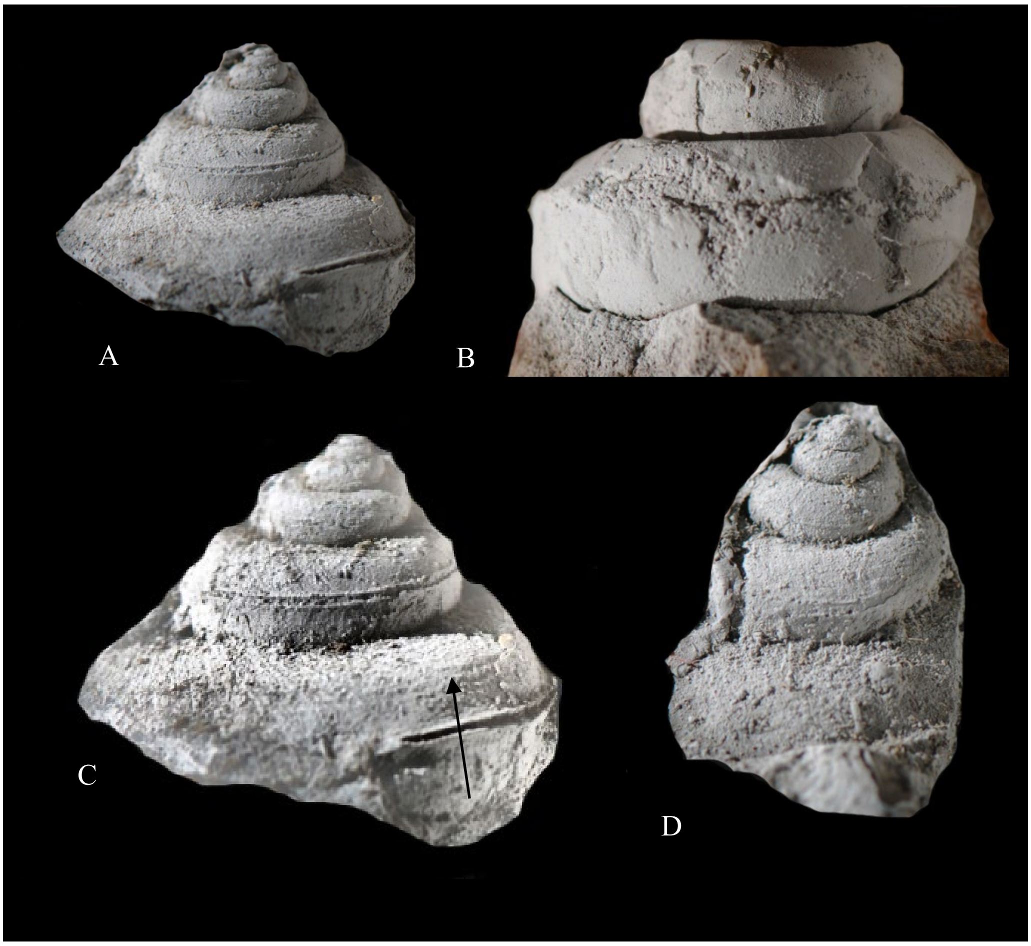

Fig. 58. *Mourlonopsis strzeleckiana* (Morris). A, latex external mould, UQF 82724, x2. C, same specimen reproduced by local equalization, x3. B, internal mould of part of spire, UQF 82725, x2. D, latex external mould of part of spire, UQF 82726, x2. From UQL 3135. The faint ribs are arrowed for one specimen.

Basin. *Neoplatyteichum* has swollen whorls, faint spiral and collabral ornament, but the selenizone is less developed than in *impressa*. There is a much closer approach of *Mourlonia impressa* to *Mourlonia* (*Mourlonia*) sp. figured by Runnegar (1969, pl. 280, pl. 18, fig. 15) from the Asselian Wasp Head Formation of the south Sydney Basin. Its generic position requires more study, because the Australian and New Zealand specimens have swollen whorls and higher spire than in *Mourlonia* de Koninck, which is based on the Lower Carboniferous species *M. carinata* (Sowerby) from England, as revised by Dickins (1976).

Genus ***Walnichollsia*** Fletcher, 1958

Diagnosis: Turbinate whorls and low spire, selenizone placed near mid-height of whorls, distinctive ornament of finely cancellate lirae formed by collabral and spiral ribbing.

Type species: *Pleurotomaria subcancellata* Morris, 1845, p. 288, OD.

Walnichollsia subcancellata (Morris, 1845)

Fig. 59, 60

1845 *Pleurotomaria cancellata* Strzelecki, p. 91 (nom. nud.).
1845 *P. subcancellata* Morris, p. 288, pl. 18, fig. 6.
1847 *P. subcancellata* – M'Coy, p. 305.
1854 *P. cancellata* – Grange, p. 89.
1877 *P. subcancellata* – de Koninck, p. 322, pl. 23, fig. 15.
1958 *Walnichollsia subcancellata* – Fletcher, p. 143, pl. 13, fig. 1-6.
1963a *W. subcancellata* – Waterhouse, p. 129, Fig. 2B
1987b *W. subcancellata* – Waterhouse, p. 179, pl. 12, fig. 18.

Diagnosis: Large shells with turbinate whorls and low spire, selenizone placed near mid-height of whorls, distinctive ornament of finely cancellate lirae formed by collabral and spiral ribbing.

Holotype: Sole specimen figured by Morris (1845) by monotypy, from Illawarra, south Sydney Basin.

Fig. 59. *Walnichollsia* cf. *subcancellata* (Morris), part of external mould UQF 82727, including spire showing ornament, x4.

Material: One external mould from UQL 3135.

Description: The specimen shows the typical ornament and part of the spire.

Fig. 60. *Walnichollsia subcancellata* (Morris). latex cast of spire, UQF 8262**7**, x4. From UQL 3135.

Subfamily **EOTOMARIINAE** Wenz, 1938

Genus ***Platyteichum*** Campbell, 1953

Diagnosis: Turbiform high-spired pleurotomariids with globular or subglobular whorls in the spire, upper profile convex, flat or weakly concave in the body whorl. Slit extends for one fourth to one third of the circumference of shell, generating a concave selenizone a little above mid-height; whorl below tending to be concave above a rounded shoulder, but variably swollen or subvertical. Base phaneromphalous or cryptomphalous. Ornament of spiral ribs, crossed by radial threads.

Type species: *Platyteichum costatum* Campbell, 1953, p. 23 from Ingelara Formation, Bowen Basin, OD.

Platyteichum loratum Waterhouse, 1963a

Fig. 61

1963a *Platyteichum loratum* Waterhouse, p. 131, text-fig. 4, 37-50.
1987b *P. loratum* – Waterhouse, p. 180, pl. 12, fig. 4, 17.
1989 *Mourlonia* (*Mourlonia*) *strzeleckiana* [not Morris] – Dickins, p. 69, pl. 2, fig. 13-18 (part, not fig. 12 = *impressa*).
2002a *P. loratum* – Waterhouse, p. 126, Fig. 3.9 (3).

Diagnosis: Loosely to tightly coiled whorls in spire which is lower than in some species, upper outer whorl more convex than in some species, selenizone prominent, sited above gently concave band visible in outer spire, selenizone exposed in spire above suture, spiral costae numerous, varying as a rule from three to eight over the body whorl above the selenizone, radial riblets fine and variably defined.

Holotype: TM 3251 figured by Waterhouse (1963a, text-fig. 37, 39, 49) from upper Mangarewa Formation, New Zealand, OD.

Material: An external mould is available from a sample stored with the collections from UQL 3135. A latex cast was prepared by possibly the collectors (J. Armstrong, B. Runnegar) like that of other latex casts prepared from a few specimens from UQL 3135. But there is no locality number on the specimen. Accompanying brachiopods belong mostly to *Pseudostrophalosia furcalina* n. sp., so it is considered that the sample may have come from UQL 3135, or allied level.

Description: The specimen is close to the specimens described from the overlying *Ingelarella costata* Zone.

Fig. 61. *Platyteichum loratum* Waterhouse, latex cast UQF 82728 from beds above the Scottville Member (UQL 3135?) possibly correlative with the *Echinalosia (Unicusia) minima* Zone, x2. Fig. 61A slightly tilted away from the observer whereas Fig. 61B is upright.

SUMMARY OF THE MACRO-FAUNA

Any assessment of macrofaunal biozones in east Australia is handicapped to a degree by the lack of any full and published study of fossils from the Big Strophalosia band, also called the Scottville Member (Runnegar & McClung 1973). The present discussion is based on fossils from the immediately overlying beds, with Runnegar & McClung indicating that the upper contact is gradational. Brachiopods described in this report are *Echinalosia* (*Unicusia*) *minima* (Maxwell), *Pseudostrophalosia furcalina* n. sp., *Terrakea elongata planidisca* n. subsp., *Cleiothyridina elevata* n. sp., *Geothomasia delicatula* n. sp., *Notospirifer minutus* Campbell, *Glendonia exigua* McClung & Armstrong, *Aperispirifer demulceatus* n. sp., *Permasyrinx mundanus* n. sp., *Sulcicosta lata* n. sp., *Fletcherithyris galbina* Waterhouse and *Marinurnula* sp. The species *Echinalosia* (*Unicusia*) *minima* was described first from the *Streptorhynchus* bed (Pelican Creek fauna) according to Dear (1971), and is shown to be present in the underlying beds at UQL 3135, just above the Scottville Member, or Big Strophalosia band. Dear (1971, p. 7) indicated that the species *minima* was not present in the Big Strophalosia band, and it would be useful to confirm this. Isbell (1955) reported that two strophalosiid species were present in the Big Strophalosia band. One was *clarkei* and the other was presumably Maxwell's species *gattoni*, which still requires elucidation. *Aperispirifer* and *Sulcicosta* at UQL 3135 also mark, as far as known, the entry of new forms, and they were joined higher in the succession by *Isbellina pelicanensis* and *Johndearia pelicanensis.* Higher in the sequence*, Ingelarella havilensis* appeared, to mark the commencement of a new and younger biozone, as analysed in the following article, starting on p. . Even though information is incomplete, it appears that the entry of *Echinalosia* (*Unicusia*) *minima* coincided with the replacement of several species, accompanied by the gradual introduction of further new forms, and the persistence of others. Several species especially amongst Mollusca indicate a persistence of *ovalis*-zone fossils in higher beds. The bivalve list for species recorded in this report is *Promytilus heywoodi* (Waterhouse), *Flattopia* sp., *Streblopteria*? sp., *Etheripecten leniusculus* (Dana), *Primaspina* sp., *Stutchburia costata* (Morris) and possibly *S. compressa* (Morris), *Vacunella curvata* (Morris), *Australomya dawsonensis* (Runnegar), *Myonia carinella* Runnegar, *Myomedia carinata* (Morris) and *M. corrugata* (Fletcher), and the gastropods *Mourlonopsis strzeleckiana* (Morris), *Walnichollsia* *subcancellata* (Morris), and possibly *Platyteichum loratum* Waterhouse. *Flattopia* sp. appears to be the only molluscan species that finds no match in older faunas.

No comparable faunas are known from elsewhere in east Australia. But an allied and largely contemporaneous fauna is well represented in the upper Mangarewa Formation of southern New Zealand, developed over a marine shelf bordering the same volcanic arc that is found at Gympie, southeast Queensland. The fossils include numerous brachiopod, bivalve and gastropod species, systematically described and figured, as summarized in Waterhouse (2002a, Tables 17, 18). Species that link the faunas with those of Queensland include *Terrakea elongata planidisca* n. subsp*.,* and *Gilledia pelicanensis*: this latter species though not present in the suite described herein, was described from the Pelican Creek fauna by Campbell (1965). Strikingly, the *Terrakea* close to *elongata* shows the same flat dorsal disc found in material from UQL 3135. In New Zealand this zone, now named after *Terrakea elongata planidisca*, overlies faunas assigned to the *Maxwellosia ovalis* and *Paucispinauria solida* Zone, which also contains such species as *Plekonella southlandensis,* possible *Aperispirifer parfreyi*, *Ingelarella mantuanensis* with other species. There are a few uncertainites: for instance *Isbellina pelicanensis* was recorded from this level, but material is not well preserved and requires further study, and the strophalosioid material, originally assigned to "*Echinalosia" ovalis*, needs to be reexamined: Briggs (1998) reallocating the species to the contemporaneous *E. wassi* Briggs. There is no clear match in New Zealand with the *Pseudostrophalosia clarkei* Zone and Scottville Member of the north Bowen Basin.

One obscure aspect of the New Zealand fauna lies in the report of possible *Johndearia pelicanensis* (Campbell) in Waterhouse (1964, p. 165, pl. 32, fig. 12, 14, 16, pl. 33, fig. 2) at GS 6071, principal locality for the overlying *Ingelarella costata* Zone (see herein, p.). The occurrence seems anomalous, and perhaps the fossil has been reworked, or it mayb Hve been a late survivor, as discussed in Waterhouse (2021, p. 137). The specimen is now assessed as being a close ally of *Johndearia isbelliformis* Waterhouse, found in slightly younger beds (Waterhouse in prep. pp.).

Although some Australian authorities have in the past matched the *ovalis* zone faunas, or elements of that zone, with the *Plekonella multicostata* Zone in New Zealand (eg. Armstrong & Telford 1967, McClung 1978), this zone is much younger and differs markedly in its constituent species, with different species of *Paucispinauria, Filiconcha, Marinurnula, Tigillumia, Simplicisulcus* and other forms.

CORRELATION THROUGHOUT EAST AUSTRALIA

North Bowen Basin

The faunas described herein come from near the top of the marine succession in the Permian Period. The overall distribution of Permian deposits in the Bowen Basin has been mapped in Dickins & Malone (1973), with detailed faunal succession in the Exmoor area in the northern Bowen Basin provided by Waterhouse & Jell (1983) in a map for part of the area, fossil localities plotted directly on to a published aerial photograph, stratigraphic summary, and systematic study of the fossils. Here the early Permian Tiverton Formation is overlain by the Wall Sandstone, and Glendoo Sandstone Member, classed within the Gebbie Formation, which is a partial equivalent of the Collinsville Coal Measures. The Glendoo Member has a distinctive eurydesmid bivalve *Glendella dickinsi* Runnegar (1970), and the remainder of the Glendoo macro-fauna was described by Waterhouse & Jell (1983). Dickns had treated this fauna as Fauna 111b, but Waterhouse & Jell (1983) assessed his Fauna 111a, from the upper Tiverton Formation, as much closer to his Fauna 11. Higher in the succession, the Moonlight Sandstone, regarded as a member of the Gebbie Formation in McClung (1981, p. 10), but arguably best separated as a formation, or better, as in Draper (2013, p. 380), placed at the base of the Blenheim Formation, contains a lower fauna dominated by bivalves with a few brachiopods (Waterhouse & Jell 1983), their generic positions adjusted herein to *Pseudostrophalosia blakei* (Dear), *Terrakea exmoorensis* Dear and *Tumulosulcus magna* (Campbell), followed by an upper fauna with numerous *Pseudostrophalosia blakei* (Dear), accompanied by *Terrakea exmoorensis* Dear*, Tumulosulcus magna* (Campbell), *Johndearia isbelli* (Campbell), and *Paragilledia ulladullaensis* (Campbell).

Three fossil localities in the overlying Blenheim Formation yielded a distinctive fauna that included *Maxwellosia ovalis* (Maxwell), *Terrakea brachythaera* (Morris) *Ingelarella mantuanensis* Campbell), *Glendonia exigua* McClung & Armstrong, *Marinurnula mantuanensis* Campbell and other species (Waterhouse & Jell 1983, p. 243; Waterhouse 2001, p. 65). Briggs (1998, p. 99) challenged aspects of the identification for one species, assigning specimens thought to be *Echinalosia ovalis* to *denisoni* Archbold, 1987. But the spine pattern differs from that typical of *denisoni* and proves to be close to that of *ovalis*, together with other features involving height of the interareas, and muscle scars. The spines are finer over the ventral valve and more numerous over the dorsal valve when compared with *denisoni*, as acknowledged by Briggs. The species *denisoni* is older, coming from level C in the GSQ Eddystone 1 core as explained in Waterhouse (2021c, p. 230), and the brachiopods accompanying the specimens identified as *ovalis* are all consistent with a Mantuan-aged fauna, not with a *denisoni* fauna, a matter in no way considered by Briggs (1998), because whole fauna attributes were beyond his self-imposed mandate, except on an anecdotal level where one or two species appeared to support his thesis.

Above the *Marginalosia ovalis* fauna comes the Scottville Member (Big Strophalosia band), dominated by valves of *Pseudostrophalosia clarkei* (Etheridge). No systematic study of all the macro-fossils from this band appears to have been published, though some species have been covered by Maxwell (1954), Campbell (1961) and Dear (1971). Dickins in Malone et al. (1966, p. 82 ff) and Runnegar (1968, p. 21) provided lists, as elaborated herein in an article starting on p. . The faunas in the present study come from the beds overlying the Scottville Member, and embrace the stratigraphic interval in the main from the top of that member up to and incorporating the Pelican Creek fauna, with its fauna dominated by *Streptorhynchus*, now *Isbellina, pelicanensis*.

Southeast Bowen Basin

Dickins & Malone (1973) proposed to include all of the marine Permian in the Bowen Basin into the Back Creek Group, subdivided into three subgroups, Tiverton, Gebbie and Blenheim Subgroups, based on interpretation of outcrops in the northern Bowen Basin. This is deemed far too simplistic, as cautioned by McClung (1981, p. 6). The faunal sequence in the northern Bowen Basin may be compared and contrasted with that of the southeast Bowen Basin, as monographed by Parfrey (1988) and Waterhouse (1986a, 1987a, b). Here the early Permian is named the Buffel Subgroup, upgraded by Waterhouse (1983c) from formational status proposed by Wass (1965), and this is followed by the Mount Ox Subgroup of Waterhouse (1986a), starting with the largely non-marine Pindari Formation, which partly matches the Gebbie Formation, Wall Sandstone and Collinsville Coal Measures of the north. The overlying Brae Formation of Flood et al. (1981) has a diverse fauna assigned to the *Echinalosia discinia* Zone. Above the Brae beds comes the Oxtrack Formation, with a distinctive fauna, including several species characteristic of the *Echinalosia maxwelli* Zone, and *Echinalosia* itself is close to *maxwelli* but has thicker posterior spines, as in subspecies *robusta*. These formations and their faunas have not been recognized in surface outcrop of the northern or southwestern Bowen Basin, though the faunas are represented in the Sydney Basin and in New Zealand. **BUT CHANGE THIS**

Above the Oxtrack Formation, the Barfield Formation at the base of the Coteeda Subgroup contains shells identified as *Pseudostrophalosia ingelarensis* (Dear), which has spine detail as in *Ps. blakei* Dear from the Moonlight Sandstone and lower Blenheim Formation. The original types of *ingelarensis* came from the Ingelara Formation in the southwest Bowen Basin, and were recorded by Parfrey (1988) as extending into the Catherine Sandstone below the Peawaddy Formation. Differences between *ingelarensis* and *blakei* are subtle, and have been exaggerated by Briggs (1998) in stressing the short hinge and somewhat triangular shape of *blakei*, as figured by Dear (1971). Such specimens form only part of the collections at the Queensland Museum at Zillmere, Brisbane (formerly kept at the Geological Survey of Queensland), and Waterhouse & Jell (1983) regarded the two species as likely to prove synonymous. If two separate species or arguably subspecies are to be recognized, they have to be regarded as correlative, and typifying different substrates. Brachiopods accompanying *Pseudostrophalosia* in the upper Barfield Formation include *Ingelarella ingelarensis* Campbell and *I. angulata* Campbell, whereas ingelarellids of the north from the Gebbie Formation and Moonlight beds belong largely to *Johndearia* and *Tumulosulcus*. As shown in Waterhouse (1987b, Table 15), the upper Barfield faunas are dominated by *Saetosina multispinosa* (Dear), *Magniplicatina magniplica* (Campbell), *Cleiothyridina anabathra* Waterhouse, *Aperispirifer parfreyi* Waterhouse, *Spiriferellina quadriplicata* Waterhouse and bivalve *Glyptoleda glomerata* Fletcher with other forms. Much remains to be learned about the Barfield faunas. They have been studied mostly from near Theodore to Cracow, where the faunas come from a thick band, described as upper Barfield by Parfrey (1988), though upper middle might be more precise. Barfield strophalosiids belong mostly to *Ps. ingelarensis*, but also include some short-lived species, such as *Nonauria* *parfreyi* (Waterhouse, 2010). To the north near Banana, Dear et al. (1971) erected three members for the Barfield Formation, with faunal content not known. From the study by Parfrey (1988), it is clear that the lower Barfield beds could have contained different brachiopods, but so far they have yielded little in the way of macro-fauna.

Faunas in the Flat Top Formation at the top of the marine sequence in the southeast Bowen Basin belong to two levels. A minor level is based on *Acanthalosia deari* (Briggs), found chiefly in the basal Flat Top Formation with numerous specimens of *Ingelarella dissimilis* Waterhouse (see Waterhouse 1987a, pl. 10, fig. 5-9, 11-13, pl. 11, fig. 1), a species described originally by Waterhouse (1964, pl. 32, fig. 4-8, 10, 11, pl. 35, fig. 6) from the middle Mangarewa Formation just below the *Paucispinauria solida* Zone. Updating the generic names, the basal Flat Top fauna was tabulated by Waterhouse (1987b, p. 222) as including ?*Capillonia semicircularis* (Campbell), *Acanthalosia deari* (Briggs), *Saetosina multispinosa* (Dear), *Filiconcha hillae* Dear and *Aperispirifer parfreyi* Waterhouse, as a mix of upper Barfield and higher Flat Top species. Above come very diverse faunas described in nearly fifty species (Waterhouse 1987b, Table 18) from 35 localities in the lower but not basal Flat Top Formation, carefully collected and tabulated in sequence where possible. These were classed as belonging to the *Echinalosia* (now *Maxwellosia) ovalis* Zone, but although species and genera are shared with the Mantuan faunas, *ovalis* itself is not to be found in the Flat Top Formation. Briggs (1998) assigned the specimens of *Echinalosia* to a different species, *E. glabra* Briggs, a form very limited in distribution. Briggs (1998, p. 101) thought that *glabra* was closest to *E. minima* (Maxwell) mainly it appears because of the wide hinge. The claim that *glabra* was characterized by its wide hinge cannot be sustained: a number of the specimens from the same Flat Top faunas have narrow hinges, as shown in Waterhouse (1986a, pl. 5, fig. 5-8).

Southwest Bowen Basin

Macro-faunas of the southwest Bowen have not been comprehensively monographed, so that gaps remain in our knowledge of these particular faunas. The relevant sequence starts with the Aldebaran Sandstone, which is non-marine, and the lower part is likely to be substantially correlative with the Collinsville Coal Measures and Wall Sandstone of the northern Bowen Basin, and the Pindari Formation of the southwest Bowen Basin. According to palynomorphs, the upper Aldebaran beds are slightly but significantly younger. Certainly it is younger by superposition, but according to macro-fauna, not very much younger, because the overlying Freitag Formation has yielded brachiopods described in Waterhouse (2001) as *Wyndhamia typica crassispina* Waterhouse, *Paucispinauria paucispinosa wardenensis* Waterhouse, *Aperispirifer archboldi* Waterhouse, and *Tumulosulcus undulosa* (Campbell). The *Wyndhamia* specimens are allied to *typica* Booker, a significant guide fossil for the Snapper Point and Elderslie beds of the Sydney Basin. *Paucispinauria paucispinosa* is found with *Wyndhamia typica* in the lower Letham Formation of New Zealand, and the subspecies *wardenensis* is found at Warden Head in the lower Wandrawandrian Formation of the south Sydney Basin. *Aperispirifer archboldi* is found also in the middle Letham Formation of New Zealand, with *Wyndhamia typica*. *Tumulosulcus undulosa* (Campbell) occurs in the northern Bowen Basin in an unnamed siltstone of the upper Gebbie Subgroup, in beds a little younger than the *Glendella dickinsi* fauna of the Glendoo Member**.** McClung (1978, pl. 8, fig. 1-3, 7) reported the species from the Elderslie Formation, and specimens occur in the Wandrawandian Formation of the Sydney Basin. Specimens are very close to if not synonymous with *Tumulosulcus cessnockensis* (McClung, 1978, p. 49, pl. 2, fig. 10, 11, pl. 10, fig. 4-15, 18, 19) from the Elderslie Formation of the north Sydney Basin (Waterhouse 1998, pp. 12-14; 2001, p. 100). There remains some uncertainty, because of only weak indications of an anterior sulcal swelling in internal moulds of *cessnockensis*, suggesting *Tumulosulcus*, and external moulds or shelly specimens not figured or described by McClung (1978) are needed for confirmation. McLoughlin (1988, text-fig. 4) also considered that the Freitag Formation matched the upper part of the range for *undulosa* and also showed the Freitag as overlapping the lower part of the range for *Johndearia isbelli*, though I am not aware of macro-faunal support for this suggestion, and palynomorphs do not appear to offer indications of such refined correlation, as interpreted currently, though this assessment can probably be improved. On available evidence from macro-fauna, *Wyndhamia typica crassispina* Waterhouse (2001, p. 72, pl. 5, fig. 12-16, ?17) from the Freitag Formation is little if at all younger than *Wyndhamia typica*, and decidedly older than *W. parfreyi* in the Barfield Formation, where *Ingelarella canalis* and *Pseudostrophalosia blakei* (= *ingelarensis*) are prominent.

The species *Terrakea exmoorensis* Dear, 1971 was initially described from the basal Blenheim Group. The species was briefly described and illustrated, and Briggs (1998) offered no further illustrations. At present, the species seems indistinguishable from *T. rhylstonensis* Briggs, 1998, an underdescribed species not sufficiently validated through comparisons with other species. It was named for material from the Snapper Point Formation and overlying Wandrawandian Formation of the south Sydney Basin. Waterhouse (2001, p. 43) could not separate the two species from the descriptions and figures provided, especially for *rhylstonensis*, and referred the material to *exmoorensis*, but whilst allowing that the two are certainly close to each other, further collections may well allow separation, because the types of the two taxa differ slightly in age, and fuller description with closer analysis may yet justify *rhylstonensis*.

Above the Freitag Formation, in the Ingelara Formation, Campbell (1953) recognized a lower sandstone fauna with *Ingelarella ingelarensis* and *I. angulata*, accompanied by *Glyptoleda glomerata* Fletcher, and an overlying mudstone with more species, with *Magniplicatina magniplica, Capillonia semicircularis, Plekonella acuta* and *Cancellospirifer maxwelli*, species mostly named by Campbell (1953, 1959, 1960). Parfrey (1988, p. 27) clarified the succession, reporting that the sandstone was to be retained in the Ingelara Formation, and the mudstone shifted to the Peawaddy Formation. An intervening Catherine Sandstone has been recognized, which includes locality LD96 with some fossils figured by McClung (1983). Briggs (1998) claimed to recognize "*Echinalosia*" [now *Acanthalosia*] *deari* Briggs in the collection of fossils from LD96 but the specimens look more like *blakei,* to judge from McClung's figures. Several other fossils from LD96 were illustrated and discussed by McClung (1983), including shells assigned to *Paucispinauria solida* (Etheridge & Dun) though they are indeterminate from the figures, and so-called *Plekonella acuta* (McClung 1983, Fig. 10) were remarked on by Waterhouse (2001, p. 87) as showing more variation in the number of sulcal and fold costae than is normal for Campbell's types and other reports, and they fit with a compination of two species, *acuta* and *southlandensis*, or a separate species varying between the two, with further permutations. As well, so-called *Trigonotreta* sp. D of McClung from LD96 (Catherine Sandstone) is suggestive of *Aperispirifer lethamensis* s. l., and *Trigonotreta* sp. from interval E in the GSQ Eddystone core 1 of McClung (1983, Fig. 9) appears to belong to *Aperispirifer parfreyi*. Various LD96 specimens were figured as *Ingelarella* cf. *mantuanensis*, including at least one with heavy posterior thickening and short adminicula. The moderately short adminicula and the suggestion of a ventral median channel within the sulcus of some specimens (McClung 1983, Fig. 8.3, 6-8) recall features of *I. confusa* (Waterhouse) from the Letham Burn Member and *I.* cf. *confusa* from older beds in New Zealand, suggesting the possibility that they belonged to a subfusc lineage which included *I. canalis* and culminated in *I. havilensis* Campbell) at the top of the marine beds in Queensland. The faunas from the Ingelara, Catherine and lower Peawaddy Formations need up-to-date systematic study to reinforce and underpin the overview by Parfrey (1988). Only a few species have been described in this volume.

Perhaps the most distinctive unit of the sequence in the southwest Bowen Basin is offered by the so-called Mantuan Productus Bed, herein called Mantuan Formation following Draper (2013), at the top of the Peawaddy Formation named by Mollan et al. (1964). Parfrey (1988, p. 32) listed *Echinalosia ovalis, Paucispinauria solida, Ingelarella mantuanensis, Maorielasma callosum*, and *Marinurnula mantuanensis*, as described by Etheridge & Dun (1909), Maxwell (1954), and Campbell (1960, 1965). Apart from Dear (1971) and Briggs (1998), there has been little recent revision of the Mantuan fauna. Yet it offers a highly distinctive assemblage, and merits a prominent position in the overall correlation scheme for the marine Permian of eastern Australia (Briggs 1998; Waterhouse 2008b). The problem in assigning its fauna to a zone is that *Paucispinauria solida* is somewhat restricted in distribution geographically and through time to the southwest Bowen Basin and Wairaki Downs of New Zealand, *Maxwellosia ovalis* is less geographically limited, occurs in the southwest and north Bowen Basin, and its subspecies wassi in the southeast Bowen Basin and Wairaki Downs. Ingelarellids and trigonotretoids, and terebratulids range much more widely, so that they are highly significant for delineating extensive and robust biozones, but the critical species are less restricted in duration.

Early attempts at basin-wide correlation

In early post-World War 2 essays in correlation Permian faunas of the Bowen Basin, it is not surprizing that there were substantial misconceptions, with great tracts of outcrop unexamined, and numerous fossils yet to be studied. Maxwell (1954, Table 1) believed that the Big Strophalosia band represent a condensed series of species, with the lower 20ft equivalent to the Ingelara and Oxtrack Formations, and the upper 70ft slightly older than the Mantuan Productus beds, matching the Catherine Sandstone of the Springsure district. The Flat Top Formation, as represented by the “Fossil Hill” bed, was matched with the Mantuan unit, but Campbell (1965, p. 5) regarded the Mantuan Productus bed as older than the Flat Top Formation. Dear (1972) identified a spectrum of productid and especially strophalosioid species at various levels throughout the basin, but as in preceeding views, the interpretations were not buttressed by published systematic descriptions of the fossils, and indeed were misled by provisional interpretations. McClung (1981, Fig. 7, p. 26) offered a view on correlation with little in the way of discussion of paleontological evidence, matching the Blenheim Formation with the Oxtrack Formation, a view also floated by Dear (1971, 1972), though without adequate documentation. Even the Freitag Formation was thought to be correlative with the Oxtrack Formation. The MacMillan Formation of the central west Bowen Basin was matched with the lower Peawaddy Formation, but was proven to be younger by Dickins (1989). McClung (1981, Fig. 2), supported by Briggs (1998), correlated the *clarkei* bed with the middle Aldebaran Sandstone, below the Freitag Formation and below the Oxtrack Formation, an extraordinary interpretation. McClung’s study on the GSQ Eddystone 1 core log did not touch on larger aspects of correlation, other than referring in the broadest of terms to views published by several workers, generally without systematic support, and certainly unsubstantiated by scrupulous analysis.

The preferred correlation in McClung (1981) was somewhat discordant with the correlation scheme set forward by Runnegar & McClung (1975, table 31.2), in which the species *havilensis* from the Havilah bed was shown as correlative with the *ovalis* Zone, qualified by a cautionary note by Runnegar (1967, p. 5) in which he noted that species such as *pelicanensis* and *havilensis* could prove to be possible a “younger part of Fauna 1V”, which proves to be correct. McClung (1978, Fig. 1) provided what briefly had become a standard interpretation of the Bowen Basin stratigraphy, showing the Blenheim Formation as correlative with the Peawaddy and Flat Top Formations as based on a broad overview of ingelarellid species. This was largely the view of J. M. Dickins, who had provided numerous fossil lists for the extensive mapping programme especially in the northern Bowen Basin.

Dickins (1964; *in* Mollan et al. 1972, p. 107; 1989) made it clear that the Big Strophalosia Band and the Pelican Creek and Havilah faunas were younger that the Mantuan beds. He relied on detailed and extensive mapping by the team of well-qualified geologists from the Bureau of Mineral Resources, Geology & Geophysics, Canberra, with participation from the Geological Survey of Queensland at Brisbane, before the Geological Survey of Queensland undertook further mapping. In the southeast Bowen Basin, systematic studies of especially the brachiopods and molluscs by Parfrey (1988) and Waterhouse (1986a, 1987a, 1987b) were emphatic that the Flat Top faunas were approximately correlative with those of the Mantuan Productus bed, not substantially older, as claimed by McClung (1981).

However these views were opposed by Briggs (1998), in an extensive survey of Productida (Brachiopoda) from eastern Australia, summarizing the stratigraphy, paying attention to publications on palynomorphs, and describing a number of species to try to underpin the views of McClung (1981), as later endorsed by Draper (2013), who acknowledged in turn that the stratigraphic interpretations expressed in Draper et al. (1990) had played a major role. [On the one hand, Briggs had been a major contributor to that study, on the other, the views of Dickins (eg. 1989) and the systematic studies in Waterhouse (1986a, 1987a, b) were ignored, and astonishingly, copies of the 1983 overview of southeast Bowen Basin geology as in the reference Waterhouse 1983c had been destroyed, as inimical to the prevailing correlation model, though that of course was not the official reason]. To Briggs (1998), the critical aspect was that the younger marine Permian of the Bowen Basin substantially postdated the marine Permian of the Sydney Basin, and the biozones were contrived, not altogether convincingly, to show this by postulating a sequence *clarkei, ingelarensis* and *crassa* below *ovalis*. The sequences were considered to be well developed especially in the western and northern Bowen Basin, through study of strophalosiids and some productids. As shown throughout the succeeding Earthwise volume (21), starting with the first article on *Echinalosia* and allied taxa, this postulated succession crumbles under close examination, and is denied by the accompanying macro-fossils. On the other hand, aspects do conform overall with palynomorph interpretations, although these are too coarse to resolve finer details of correlation, and no palynomorph evidence supports the placement of the Mantuan Formation with its *ovalis* Zone above the *clarkei* Zone, because both macrofaunal zones with several others are lumped into one massive and long-lasting palynomorph zone, named after *Dulhuntysporites parvithola*.

Problems over correlation

McClung (1981, Fig. 7, p. 26) summarized various views on correlation within the Bowen Basin. Both Dear (1972) and McClung (1978) regarded the Freitag Formation as correlative with lower so-called Fauna 1V, roughly matching the Big Strophalosia band or Scottville fauna of the north Bowen Basin, and the Oxtrack Formation of the southeast Bowen Basin. These are no better than gross miscorrelations, and all three levels are highly disparate in terms of fauna and therefore age. The proferred correlations in McClung (1981) were made largely on the basis of substantially incomplete faunal analyses that never achieved publication.

The GSQ Eddystone 1 core

One quasipaleontological study that McClung did venture to undertake was a summary of the fossils from the GSQ Eddystone 1 stratigraphic bore in the Denison Trough, in the southwest Bowen Basin. Brief summaries and illustrations were issued for a number of fossils, after the core had been divided conceptually into levels A to F. Listed but unfigured fossils from level A included *Echinalosia* cf. *preovalis, Ingelarella plica, Taeniothaerus subquadratus*, not a fully convincing assemblage, but sufficient to indicate a Cattle Creek and upper Tiverton correlation, pending systematic study, and beyond the purview of the present review. Level B yielded the most useful of indices for correlation, through *Glendella dickinsi* Runnegar, the species also found in the Glendoo Member of the Gebbie Formation, for which the fauna was described by Runnegar (1970) and Waterhouse & Jell (1983), with faunal elements recognized in the uppermost Pebbley Beach Formation of the Sydney Basin (Shi et al. 2020). It is older than the Brae Formation of the southeast Bowen Basin.

Fossils from Level C were listed as *Sulciplica* cf. *phalaena* [now type species of *Anguloplica* Waterhouse 2016, p. 255, Fig. 328, see Waterhouse 2021b, p. 34], *Ingelarella undulosa, Terrakea* cf. *brachythaera* form A, *Echinalosia* sp. nov. and *Streptorhynchus* sp. nov. Not all of them were described, let alone figured, but the *Echinalosia* sp. of McClung (1983, Fig. 13) named *E. denisoni* by Archbold (1987), appears to come close to specimens found in the Elderslie Formation of the Sydney Basin in New South Wales and possibly Brae

Formation, given its relatively coarse spines over both valves. McClung (1983, Fig. 17.1, 2) provided two figures for ventral internal moulds of "*Terrakea* cf. *brachythaera*" form A, that were identified as *T. elongata* (Etheridge & Dun) by Briggs (1998, p. 180), but the specimens are broken internal moulds and convey little of practical use. *Tumulosulcus undulosa* is reliably found in faunas stratigraphically below and older than faunas with *Ps. clarkei* or *Ps. ingelarensis*, coming as shown by McClung (1981), from the upper Gebbie Formation, modified to lower Blenheim Formation in Draper (2013), well below the Scottville Member with *Ps. clarkei*. *Sulciplica* (now *Anguloplica*) cf. *phalaena* was reported, the species having been first described from Eaglehawk Neck (younger Guadalupian) of Tasmania. **check**

Interval D yielded a few forms of *Ingelarella*, including *angulata* Campbell, which could well match those of the Ingelara Formation. The fossil list and figures for material from level E suggest correlation with part of the Peawaddy Formation, involving possible *Terrakea brachythaera* (Morris) form B, as well as *Magniplicatina magniplica*, *Ingelarella mantuanensis, Marinurnula mantuanensis* and *Maorielasma callosum*, all species named by Campbell. The level includes a short-lived and little dispersed form, *Pseudostrophalosia crassa* Briggs, and specimens provisionally assigned to the more widely found species *Aperispirifer parfreyi* Waterhouse, which certainly requires further study because of the need to determine internal plates, but pending that, appears to range from the Catherine Sandstone through the lower and upper Peawaddy, including Mantuan band, upper Barfield and lower Flat Top faunas in the Bowen Basin and lower middle Mangarewa faunas in New Zealand. Level F involves somewhat similar but fewer fossils, too few to allow confident assignment of age, other than on stratigraphic grounds.

It was Briggs (1998) who made considerable use of the GSQ Eddystone 1 core to advance his views on correlations throughout the upper marine beds of the Bowen Basin, citing material figured by McClung (1983) from level E for one of the two holotypes proposed by Briggs for his species *crassa*, and pointing to other drill-core specimens. Briggs (1998, Fig. 35) proposed that a succession of three species of *Pseudostrophalosia* named *clarkei, ingelarensis* and *crassa* underlay fossils of the *Echinalosia deari* and *E. ovalis* zones. This scheme agrees largely with the present arrangement, except for *clarkei*, which is ly out of place. Yet Briggs (1998, p. 101) contradicted his own arrangement, in identifying *deari* as represented by McClung (1983, p. 72, Fig. 14.1, 2, 6) from GSQ LD96. This locality is clearly from the Catherine Sandstone, which underlies the Peawaddy Formation, so that the occurrence of *deari* in the sandstone would place the species well below *crassa*. However it seems that the LD96 specimens were misidentified by Briggs (1998). They are internal moulds and difficult to identify in the absence of adequate description and information about ornament. The species *blakei* (= *ingelarensis*) and *crassa* are likely to come from the equivents of the Peawaddy Formation (McClung 1983, Parfrey 1988), and the Ingelara Formation was source of the type material of *ingelarensis*[1] which ranged through the Ingelara and Catherine Formations of the southwest Bowen Basin, as shown by Parfrey (1988). Elsewhere, approximately correlative sediments with the same taxon, this time called *blakei*, included the Barfield Formation in the southeast (Parfrey 1988), and Moonlight Formation or Member in the lower Blenheim Formation) of the north Bowen Basin (Waterhouse & Jell 1983).

Pseudostrophalosia crassa Briggs (1998, Fig. 63) is found at level E from GSQ Eddystone 1, with a large suite figured by McClung (1983, Fig. 15 - not pl. 15 as in Briggs 1998). One specimen figured as *crassa* by Briggs (1998, Fig. 63D) came from GSQ L 2117, described as ?Ingelara Formation, not a fully convincing identification to judge from the illustration, because the ventral disc spines are somewhat finer than in his other figured specimens. Other specimens came from locality BMR CL50/1, which was informatively described as coming from the Back Creek Group in the Capella Block by Briggs (1998), with no detailed stratigraphy or data on accompanying fossils. Dickins in Mollan et al. (1964) described the locality as coming from the *clarkei* band – or overlying pelecypod beds – without any more stratigraphic detail. The question is further discussed on p. . Type *crassa* based on Eddystone material is associated with shells externally like *Aperispirifer parfreyi* Waterhouse, which ranges through the time ranges of the upper *Ps. ingelarensis, Acanthalosia deari* and *Maxwellosia ovalis* Zones, but does not extend as high as the *Echinalosia* (*Unicusia*) *minima* or *Ingelarella costata* zones, as discussed in this report. Whether *crassa* is present in the Scottville faunas below those zones and above the faunas with *E. ovalis* is not known. The material figured from BMR CL50/1 differs from the Eddystone *crassa* in its arrangement of coarse and fine spines, and could even prove to an early form of *clarkei* with slightly coarser spines.

The status allocated to a *Pseudostrophalosia crassa* “Zone” by Briggs (1998) seems inflated, because there appear to be no other characteristic species that support the reality of the zone – it is based meagrely on a local development from one species, that is extremely limited in extent. Zones for practical value in correlation and interpretation of climatic regime should reflect biological realities of wide extent, in which evolutionary change and climatic and environmental impacts affected many concurrent species.

Pseudostrophalosia clarkei was reported by Briggs (1998) from two stations in the Serocold Anticline in the western part of the basin, GSQ L2115 in the Eddystone 1 core at about 805m depth, and at GSQ L239, in another core. No description or illustrations were provided to support the identification, and nothing in the way of accompanying fossils was recorded by Briggs. As summarized previously on p. , McClung (1983, Fig. 2, p. 50) listed two spiriferids (*phalaena* and *undulosa*) from close to the 800m interval in the Eddystone 1 core which strongly point to an age much greater than beds with *clarkei*.

The faunal succession in the northern Bowen Basin provides even more evidence against the Briggs template. Briggs claimed that *Echinalosia* recorded in Waterhouse & Jell (1983) below the Scottville Member belonged to *E. denisoni* Archbold. But the spines (Waterhouse & Jell 1983, pl. 1, fig. 1-6) are not as coarse as those of *denisoni,* as Briggs (1998) allowed, and accompanying fossils, which include *Terrakea brachythaera* (Morris), *Sulciplica transversa* Waterhouse*, Ingelarella mantuanensis* Campbell*, Notospirifer macropustulosus* Waterhouse and *Marinurnula mantuanensis* Campbell are typical of the *Maxwellosia ovalis* Zone and Mantuan fauna in particular, and none of these species are found with type *E. denisoni* or other occurrences of the species. The Waterhouse-Jell specimens do indeed appear to be close to *ovalis*. That undercuts the Briggs claim that the *E. ovalis* zone does not occur below the *Ps. clarkei* Zone. On the contrary, *ovalis* does underlie *clarkei*, just as maintained by field geologists from the Bureau of Mineral Resources, and Geological Survey of Queensland in their extensive geological mapping during the 1960’s, as supported by the paleontological assessments by J. M. Dickins. Furthermore none of the distinctive species found with the specimens that Briggs (1998) identified with *Ps.*

ingelarensis at UQL 3135, such as *Echinalosia* (*Unicusia*) *minima* (Maxwell), *Terrakea elongata* (Etheridge & Dun) and *Ingelarella pelicanensis* Campbell, are found with type *Ps. ingelarensis* in the Ingelara Formation, or in Barfield Formation: instead quite different species of the same or related genera are found, and these are widespread. There has never been any documented, established, or checkable report of *clarkei* being found below *blakei - ingelarensis* in the Barfield or Ingelara - Catherine and lower Peawaddy beds of the southeast and southwest Bowen Basin, let alone the Sydney Basin. **below put sooner?**

The distinction between *ingelarensis* and *blakei* does not depend on shape: the understanding that *blakei* always has a narrow hinge is contradicted in the substantial collections kept at the Geological Survey of Queensland, now at the Queensland Museum, Brisbane. The species *blakei* is much more variable in shape than allowed by Briggs (1998). In so far as some specimens of *blakei* have a wide hinge, and share a sulcus and short hinge and low interarea with some *ingelarensis*, the valid separation of the two species depends on the nature of the ventral ornament. That of *blakei* generally consists of semirecumbent to suberect spines about 0.55-0.6 and rarely up to 0.75mm in diameter in *blakei*, compared with erect spines 0.5mm, reaching 0.65mm and rarely up to 0.75mm in diameter in *ingelarensis,* as measured on specimens when kept at the Geological Survey of Queensland. There is room for some variation in the measurements, but overall, differences are minor, and explicable in terms of coarse substrate for *blakei,* and finer sediment for *ingelarensis.*

In summary, the evidence that *clarkei* preceeded the *ingelarensis* and *ovalis* faunas, is not sound. What of the southeast Bowen Basin, more thoroughly examined than any other part of the basin in terms of published descriptions of macro-fossils? There is no support for the Briggs thesis. The *ovalis* and *deari* faunas follow the *blakei* (or *ingelarensis*) faunas. There is no sign of *crassa*, and no sign of *clarkei*. The upper Flat Top Formation, as far as I am aware might well have accumulated at the same time as the *Ps. clarkei* fauna flourished in the north Bowen Basin, but upper Flat Top fossils, such as they are, have yet to be described. Of course, this negative evidence, ie. lack of support for the Briggs thesis is not in itself sufficient. The acknowledgement by Briggs (1998) that *ingelarensis* occurs in the Ingelara (and Catherine Sandstone, and lower Peawaddy Formation) in the southwest Bowen Basin, and lack of *clarkei* from that region, reinforces the occurrences of various taxa associated with *ingelarensis* in that region which are found also with *ingelarensis-blakei* in the northern Bowen Basin, below *clarkei*, in the middle Blenheim Formation.

Sydney Basin

There are no reports of *blakei - ingelarensis, crassa* or *clarkei* in the Sydney Basin, either in Briggs (1998) or Waterhouse (2001, 2002a, pp. 178-200). Although Dickins (1989) reported *Echinalosia* (now *Echinalosia* (*Unicusia*) cf. *minima* in the youngest known marine beds in the Sydney Basin, called the Kulnura marine tongue, these specimens are revised and considered to come close to *Pseudostrophalosia routi* Waterhouse, 2021a of the *Ingelarella costata Zone* n. sp., found immediately above the *Echinalosia* (*Unicusia*) *minima* Zone as elaborated in this article, and above *Maxwellosia ovalis* Zone and its equivalents. The Kulnurra marine tongue is definitely younger than the upper Mulbring beds, as well as the Broughton, Berry and Nowra beds of the south Sydney Basin, which share a number of spiriferiform and terebratulid taxa with the upper Blenheim, Peawaddy Formation and Flat Top Formation of the Bowen Basin. Specimens described by Dickins (1989, pl. 3, fig. 12-21) from the Kulnurra marine tongue from NSW Geological Survey Bore DDH3 were allocated by Briggs (1998) to *crassa*. Only one ventral valve exterior was figured by Dickins (1989, pl. 3, fig. 13) and some of its spines are coarse, but they are not arranged in clear commarginal rows and interspersed with finer erect spines according to the pattern displayed by McClung's figured material from the Eddystone core. Instead the specimen is closer to the alternative *crassa* of Briggs, recorded from the *clarkei* band in the Clermont sheet at BMR LC50/1. Dorsal valve spines are slightly finer and commarginal laminae stronger than in the Eddystone material, so that the material is judged to belong to a distinct species of *Nonauria*, as described herein (p.). Dickins (1989, pl. 3, fig. 7-9) compared two ventral internal moulds and a dorsal external mould from DM Camden 75 in New South Wales with *Echinalosia ovalis*, but the figures show no external ornament, and the identification requires confirmation.

Tasmania

Fossiliferous sequences are known for Tasmania, as shown by Clarke & Banks (1975). The faunal lists show (after updating the generic names) *Tumulosulcus undulosa* and *Johndearia magna* with *Ingelarella ingelarensis*, but no productid, occurring in Faunizone 6, followed by

Faunizone 7 with *Paucispinauria concava* and *Aperispirifer lethamensis*. Higher, Faunizone 9 contains listed *Johndearia isbelli* and *Tumulosulcus magna*. But there has never been any systematic description of these species and genera, leaving the identifications suggestive, but unverifiable.

New Zealand

From the marine apron that accumulated off-shore from the Brook Street - Highbury volcanic arc which constituted part of New Zealand and the Gympie Province of Queensland, a well-established and comprehensively monographed succession of faunas has been mapped for Wairaki Downs, southern New Zealand, at 1:12 500 in Waterhouse (2002a), a scale far preferable for fossil resolution than the scale of 1: 250 000 which understandably had to be employed in Queensland. The stratigraphy and fossils confirm the sequence for east Australia adduced in Waterhouse (2008b, 2011) and contradict aspects of the Briggs template. The relevant succession at Wairaki Downs in south New Zealand commences with depauperate faunas, starting with almost barren beds with *Attenuatella altilis* Waterhouse, ascribed to basal Kungurian (Saranian), and followed by the lower Letham Formation with *Terrakea* sp. and *Anidanthus*, and a few molluscs, as well as laharic tillite deemed to be correlative with the *Glendella dickinsi* Zone of the Glendoo marine tongue. The overlying succession of strophalosiids proceeds with *Wyndhamia typica,* followed by *Echinalosia discinia* which is associated, it has been reported, with *E. denisoni,* followed in turn by macro-faunal zones successively named after *E. maxwelli, Pseudostrophalosia blakei,* reported *Echinalosia wassi* (fide Briggs 1998), shown in press to be closely allied to *Maxwellosia ovalis)* and with *Paucispinauria solida,* and at the top of the Mangarewa Formation, *Ingelarella costata*. Accompanying fossils of Plekonellinae, Ingelarellidae, Notospiriferidae, Aperispiriferinae and Terebratulida all reinforce the strong ties with the Bowen Basin and their respective faunal zones. The *elongata planidisca* and *costata* zones come above the *ovalis* Zone. As shown in the systematic section, there are several very close links between the penultimate *elongata planidisca* fauna of the New Zealand upper Mangarewa Formation and the faunas described herein, the faunas including *Terrakea elongata planidisca* and *Fletcherithyris galbina*, with species of *Maorielasma* and *Marinurnula*. Above comes mainly clastic sediments with brachiopod and mollusc links as well as reported but undescribed

Ingelarella havilensis Campbell to the *Ingelarella costata* Zone at the top of the youngest marine Permian of the Bowen Basin.

Summary of macro-faunal succession

In summary, the faunal and stratigraphic evidence consistently points to the likelihood that Briggs (1998) has reversed part of the natural sequence of strophalosioid species, putting *clarkei* below *ingelarensis* and *crassa*, and putting *ovalis* above instead of below *clarkei*. His evidence is precarious: it cannot be sustained for the northern Bowen Basin, and much of his evidence is contradicted by the available fossils. That leaves only the identification, without supporting illustrations or detailed text, of alleged specimens of *clarkei* from two bore-holes. Furthermore, much of his overall construct is without consideration of the accompanying faunas, which to the best of available data, contradict his thesis. This is far from being the only example of inverted succession against the natural order in the study by Briggs (1998). From slightly older faunas of the Bowen Basin in Queensland and Maitland and Shoalhaven Groups of the Sydney Basin, he inverted the succession of *Echinalosia discinia* and *E. maxwelli*, claiming that *maxwelli* preceeded *discinia* on the basis of a mistake by Mutch (1972) in his geological map, and corrected in Waterhouse (1993, p. 375) and confirmed by Waterhouse (2001, 2002a), with the correct geographic position mapped in the folder at the rear of Waterhouse (2002a). Briggs identified his Australian specimens according to his understanding of the sequence in New Zealand, instead of by the morphology of the species in question. Shi & Weldon (2002) and Shi, Weldon & Pierson (2010) have shown something of the correct sequence of strophalosioid species for the Shoalhaven Group of the south Sydney Basin, thereby correcting the Briggs' interpretation.

Freitag Formation in the southwest Bowen Basin

Price (1973, 1976) claimed that palynomorphs from the upper, but not topmost Aldebaran Sandstone are shared with the "*clarkei* bed" and belonged to lower Stage 5b, and this view was supported by McLoughlin (1988). Given that *parvithola* ranges through the *typica, discinia, maxwelli, ingelarensis-blakei, ovalis, clarkei, perplexa* and *costata* zones, and into overlying coal measures, the "correlation" means little. The Aldebaran Sandstone lies above the Cattle Creek Formation and below the Freitag and Ingelara Formations. McClung (1981, p. 11) stated that his faunal analyses showed that a fauna from subsurface Aldebaran and

Freitag was most comparable with faunas from the lower Blenheim Formation, which is not too discrepant from present assessments, but he published no specific evidence. Fossils of the Freitag Formation show that the beds are older than the Scottville Member and Big Strophalosia Band. Freitag fossils include *Wyndhamia typica crassispina* Waterhouse (2001, pl. 5, fig. 12-16, 17?), which have a few spines over the ventral ears and a much wider hinge than that of *parfreyi* Waterhouse, 2001, p. 84; 2010, p. 54), as figured by Waterhouse (1986a, pl. 5, fig. 26, 28, 27?) and Parfrey (1988, pl. 2, fig. 14-19). The species *Nonauria parfreyi has* no ears, and is type species of *Nonauria* Waterhouse, and is further distinguished by its robust and well-spaced ventral spine bases. *Wyndhamia typica* is typical of the Elderslie Formation and Snapper Point Formations of the Sydney Basin. As documented in Waterhouse (1998; 2001, p. 100, pl. 7, fig. 18, 19, 21, pl. 8, fig. 1, 2), *W. typica crassispina* is accompanied by *Tumulosulcus,* identified in Waterhouse (2001) as *undulosa* (Campbell, 1961) from the upper Gebbie and Moonlight beds of the north Bowen Basin, well below the Big Strophalosia Band with *Pseudostrophalosia clarkei* as exposed along the Bowen River (Waterhouse & Jell 1983).

Geographical and paleolatitudinal controls for the distribution of fossils

Why are there no occurrences of *Pseudostrophalosia blakei-ingelarensis, crassa*, and *clarkei*, or reports of *Acanthalosia deari* in the Sydney Basin or Tasmania? To Briggs (1998, Fig. 4), that was no problem: the *Ps. blakei* Zone was treated as very short-lived [which it wasn’t], and the other three zones were younger than any marine deposits found in the Sydney Basin or Tasmania. For the correlation scheme favoured herein, that explanation fits for the *clarkei, minima* and *costata* Zones, and even so, evidence suggests that *costata*-zone strophalosioids are present in the Kulnurra marine tongue, exceptionally young marine Permian for the Sydney Basin. The *blakei-ingelarensis* Zone is found below the *ovalis* zone in the southeast Bowen Basin. The *crassa* “zone”, found mostly if not entirely in a drill core, is of very limited distribution, even in the Bowen Basin. The overall correlation chart offered by Briggs (1998, Fig. 4) is based on his model for the succession of strophalosioid species. A chart based on overall faunal affinities, taking account of all known brachiopods and molluscs, differs hugely. For the younger marine Permian, the principal difference concerns the position of the *ovalis* Zone, and the supposed *ingelarensis, crassa* and *clarkei* zones.

Whereas Briggs showed these zones as younger than any marine faunas in the Sydney Basin, the invertebrate brachiopod and molluscan fossils – all of them, not just strophalosioids – show that the faunas of the Broughton, Berry and Nowra and Mulbring Formations of the Sydney Basin share fossil species with the Peawaddy and Mantuan Formations, upper Blenheim Formation and Flat Top Formation of the Bowen Basin. The Briggs assertion that his so-called zones based on *hanloni, robusta, runnegari* of the Nowra, Berry, Broughton and Mulbring Formations in the north and south Sydney Basin underlay the *Pseudostrophalosia ingelarensis* (= *blakei*) Zone of the Bowen Basin lacks any macrofaunal evidence whatsoever. None of those taxa are to be found in the sequences of Queensland, and *ingelarensis* is not found in the Sydney Basin. The smooth ears of *runnegari* Briggs from the Mulbring Formation of the north Sydney Basin betokens a significant development, enabling subgeneric distinction as *Glabauria* Waterhouse, 2010, p. 51). Briggs failed to note this feature. But the differences are picayune, and the assemblage of taxa are closely related to each other, and to my mind are variations and geographic and ecologic deviations and developments from Kungurian and Roadian members of the genus *Echinalosia*. The Briggs taxa were far too short-lived and geographically limited to serve as zonal indices throughout the Permian System of east Australia. The fossils accompanying the so-called key species of the Sydney Basin are reasonably diverse and closely studied, and are not found anywhere below the *blakei* faunas in the Bowen Basin. Instead they are found, some of them, higher in the Bowen Basin succession, in the Flat Top and Peawaddy Formations.

That being so, the question may be asked: does the apparent absence of *Pseudostrophalosia* species in the Sydney Basin imply that there were gaps in the Sydney Basin succession? That may be assessed, as in Waterhouse (2001, p. 179,) from collections kept at AGSO (formerly Bureau of Mineral Resources, Geology and Geophysics) in Canberra, the Australian Museum in Sydney, and at the University of New England in Armidale, as well as field excursions by the writer, starting with K. S. W. Campbell in 1958. But detailed correlation requires monographic examination of the faunas, not yet available, and present suggestions are provisional. In the north Sydney Basin, **the Fenestella Shale** below the Belford Formation contains *Echinalosia denisoni* Archbold, as in the Brae Formation (*E. discinia* Zone), Eddystone 1 core of southwest Bowen Basin, and upper

Letham Formation (*E. discinia* Zone) of New Zealand. Waterhouse (2002a, p. 179) indicated that *robusta* Briggs of the lower Belford Formation was no more than a variety of *maxwelli* Waterhouse, and accompanied by *Paucispinauria concava, Aperispirifer* close to *wairakiensis* as well as *lethamensis,* to suggest correlation with the *Echinalosia maxwelli* Zone. *Ingelarella ingelarensis* and *I. angulata* are present with "*robusta*" in the middle Belford Formation, indicating correlation with the Ingelara Formation of the southwest Bowen Basin and Letham Burn Formation of New Zealand, which contains *maxwelli, Paucipinauria concava* and *Aperispirifer wairakiensis***.** The Muree Formation includes such species as putative *Maxwellosia* aff. *ovalis*, *Terrakea* aff. *brachythaera, Ingelarella dissimilis* and *Aperispirifer parfreyi*, species which also appeared in the lower Mangarewa Formation, as well as two distinct forms *Echinalosia* (*Glabauira*) *telfordi* Briggs and *Oviformia oviformis* (M'Coy). Briggs (1998) also recorded *E.* (*Glabauria*) *hanloni* Briggs*,* with its prominent semirecumbent coarse and prostrate fine spines, and ears like those of *Glabauria and Terrakea etheridgei* Briggs, the latter appearing to be a coarse-spined variant of *T. brachythaera* (Morris) and allied to *T. brachythaera quadrata* Briggs from the lower middle Flat Top Formation of the southeast Bowen Basin. Fossils are few in the Mulbring Formation at the top of the marine Permian, and include *E*. (*Glabauria*) *runnegari* Briggs.

In the south Sydney Basin, the lower Wandrawandian Formation contains representatives of early Middle Permian and latest Lower Permian (ie. Kungurian) zones with *Echinalosia discinia* and *Terrakea exmoorensis* Dear and *Paucispinauria paucispinosa wardenensis* Waterhouse. Above the Wandrawandian Formation, the Nowra Formation contains *Oviformia oviformis* and *Ingelarella dissimilis*, with possible *Aperispirifer parfreyi* and *Echinalosia* (*Glabauria*) *hanloni* Briggs, accompanied by the distinctive *E.* (*Glabauria*) *telfordi* with uniform ventral spines*. Terrakea brachythaera* or ally appears to be present. In the Bowen Basin*,* supposed *Terrakea brachythaera* occurs in the Peawaddy Formation, (**check exmoorensis**?) rather than *Paucispinauria solida* found in the Mantuan Formation. The fossils through *dissimilis* strongly suggest correlation with the lower Flat Top Formation of the Bowen Basin. The overlying Berry Formation contains *E.* (*Glabauria*) *runnegari* Briggs, *E.* (*Glabauria*) *telfordi* Briggs, *Terrakea brachythaera*, possible *Aperispirifer parfreyi* Waterhouse, *Johndearia dissimilis* (Waterhouse) and *Ingelarella mantuanensis* Campbell, and the following Broughton Formation includes some of these species together with *Maxwellosia ovalis wassi* Briggs. There is no reason to suppose, at least from macro-fossil evidence, that the formation is very different in age from the lower Flat Top Formation of the Bowen Basin. Waterhouse (2002a) recorded *Terrakea brachythaera* at these intervals, but reassessment is required to show more exact affinities.

Such a summary implies that there is an apparent gap between the Belford and Muree Formations of the north Sydney Basin, and between the Wandrawandian and Nowra Formations of the south Sydney Basin, either because the *Pseudostrophalosia blakei* Zone is missing, in which case the gap is real, or because this zone merged southwards from the Bowen Basin into one of other of the underlying or overlying zones of the Sydney Basin. I favour the ecological explanation, as based on paleolatitudinal differences, the Sydney Basin having been of higher paleolatitude and lower temperature. Species did not extend forever around the globe. They had geographic constraints, and with east Australia oriented then more or less as now, more genera and species would have entered the more northerly paleolatitudes. *Pseudostrophalosia* is common in Queensland and New Zealand (which lay offshore from east Australia, further from ice-sheets), and rare to absent from the Sydney Basin, and absent from Tasmania. Other species that accompanied *blakei* in the north Bowen Basin included *Terrakea exmoorensis* Dear, *Johndearia magna* (Campbell), ***J. isbelli*** (Campbell), *Marinurnula mantuanensis* Campbell, and these are found in the Sydney Basin.

Input from radiometry

Regrettably the recent radiometric ages as interpreted by Laurie et al. (2016), Nicholl et al. (2017) and Smith et al. (2017) appear to have little direct input to detecting whether there was sedimentary continuity or gap in the succession to explain the lack of *Ps. ingelarensis – blakei* from the Sydney Basin. The palynomorph record also indicates no gap, although the absence of sampling from area critical, as far as the macrofossil record is concerned, and the rather relaxed attitude to full systematic description leave uncertainties, compounded by inattention to the full floral content provided by the complete plant record. What both sets of records strongly suggest is that any gap must have been very short lived, a few hundreds of thousands of years at most, so the gap would not be easy to detect. But on the other hand, it cannot be expected that species extended for ever, and it would seem reasonable to assume that the environment and climate were unsuitable of *Pseudostrophalosia* in the Sydney Basin. A thorough search of the Sydney Basin faunas is needed to determine whether or not there was a gap, or whether the full fauna of the *blakei* Zone in the Bowen Basin feathered out to the south, and was replaced by longer-lasting faunas of the underlying *Echinalosia maxwelli* Zone, or earlier entrants of the overlying and broadly understood *Maxwellosia ovalis* Superzone.

The nature of fossil biozones

The zonation of the east Australian Permian rests very much on the conception and practise of what constitutes a faunal biozone. Briggs (1998) relied on selecting a series of short-lived species of Productida, mostly limited to *Echinalosia* and *Pseudostrophalosia* in the Sydney and Bowen Basins. This procedure is favoured by the demonstrably short-lived nature of the species, which certainly avoids potential pitfalls of relying on first appearances of long-lived taxa or form taxa, because it is all too easy to overlook a first entry, or have the key not preserved for a time, so that its first supposed entry postdated other first entries of the same form elsewhere. Reliance on FAD (First Appearance Datum) depends not only on infallible identification of species, and adequate documentation of those species so that they are independently verifiable, but on the guarantee that the appearance of the following FAD taxon was infallibly simultaneous everywhere and always findable and identifiable, so there was no possibility of confusion caused by species which outlived their designated zonal constraints. When for marine faunas, no allowance is made for the possibility that environmental parameters ever controlled the presence or absence of a species, let alone its appearance, the proposition verges on the absurd, because it is so divorced from nature. By contrast, fossil palynomorphs were wind-blown, and so independent of many ecological constraints, a disadvantage in many respects, but a great boon for assisting temporal control. The temptation to identify taxa by succession – which is sensible, but open to encouraging error, cannot be dismissed. That is what seems to me to explain the Briggs' interpretation of the upper *Pseudostrophalosia* zones, which lack any convincing support. A preferable procedure is to incorporate assessment of associated species, which will broaden and thereby strengthen ties for recognizing a biozone. Under this approach, a zone may be named from one leading species, but other leading or even rare species are evaluated as well. In the methodology favoured herein (Waterhouse (eg. 2008b, 2011, as well as earlier studies), due attention has been paid not only to Strophalosioidea, but especially to Paucispinauriidae (mostly *Terrakea* and related forms), the genus *Plekonella*, the numerous genera of *Ingelarella* and related forms, the trigonotretid and neospiriferid *Trigonotreta*, *Neilotreta, Grantonia*, *Aperispirifer*, and *Koenigoria*, as well as various members of Syringothyridae and Terebratulida. In addition weight is given to Mollusca, making use of the studies by Etheridge, Etheridge & Dun, Fletcher, Dickins and Runnegar. The Briggs opinion that he "corrected" the succession favoured in previous studies is indeed challengeable. Moreover the studies by Maxwell (1954, 1964), Campbell (eg. 1959, 1960, 1965), Dear (1971), McClung (1978) and Parfrey (1988) were fully incorporated in the presentation by Waterhouse (2008b), not just anecdotally as in Briggs (1998) in seeking an occasional line of support, but contributing an essential part of the framework. There is a great difference between relying on a tenuous line of single species after species (which lacked the dispersal ability of palynomorphs), and an assortment of species making up real and contemporaneous communities. Species are biological entities. They flourished here, struggled there; realistically, they also varied, both within populations, and from place to place. To infallibly identify each species in a supposedly inflexible sequence irrespective of lithology and latitudinal constraints may become an article of faith, resulting in an interpretation of brachiopods or some other biotic reality as clockwork entities that functioned independently of their substrate, food availability and other ecologic parameters, rather than living entities responding to many constraints. Surely it is wiser to give due and varying weight to a cluster of species, so that where a species fails, is not collected, or deviates from the norm as part of the natural evolution within taxa, other species are there, with their own evidence, to contribute to recognition of the biozone. A principal failing of the Briggs edifice was not only the turning upside down of some sequences, but the refusal to give due weight to so many taxa, studied by a number of paleontologists.

This brings up another matter, highly relevant to the present discussion. As written above, the temptation to identify taxa by succession – which is sensible, but open to encouraging error, cannot be dismissed. It must be a precarious procedure where reliance depends upon assessment of a single species (or even less than a species, in the case of conodonts and palynomorphs). But where there are a dozen species – more or less – each of those dozen carries implications for the key or name species. Variation must exist within a species, related not only to substrate, but available food, the climate, the competition, the geographic distance, and ontogenetic development. And, sadly but realistically, the preservation, and dare one whisper, the fallibility of the researcher, certainly including my own. Furthermore it should be recognized that species did follow an ontogenetic path, and senile specimens varied considerably from neanic, immature and mature specimens, an important aspect to systematic study, not adequately assessed in many studies. The placement of poorly preserved material is therefore biologically acceptable if conjectural, though not biostratigraphically reliable, depending not only on what is preserved of morphology and understanding of ontogenetic growth, but on the nature of associated species, and on the stratigraphic position of the specimens. Not that that guarantees the identification, but it does allow a provisional approximation.

To repeat, a fossil species needs to be treated not like a clock-work style of taxa that isplayed an undeviating morphology. Rather species were biological realities, with all the variations, some unexpected and even perplexing, that are found amongst living species.

Correlation with the World International Standard

There have been many attempts to correlate what is herein called the *Pseudostrophalosia clarkei* Zone and *Echinalosia* (*Unicusia*) *minima* Zone, which incorporate the Big Strophalosia Band to the *pelicanensis* bed (ie. Scottville Member and Pelican Creek fauna), followed by the *Ingelarella costata* Zone, to be described shortly, but most attempts, including my own in the 1960's, need to be set aside: they were either made too early to know much about the zone, or initiated before the current scheme for world standard correlation was launched (Waterhouse 1983d, Jin 1996, Jin et al. 1994) as consolidated in Jin et al. (1997), with ongoing and increasing refinements (Henderson 2018). Based on various lines of evidence, including succession of faunas and familiarity with the world standard stratotypes in Texas, Waterhouse came to favour a Capitanian age, at the top of the Guadalupian Series, or Middle Permian, for what is now the *clarkei* zone, as shown in Waterhouse (2002a, inside cover). Particularly compelling is the relationship of these zones to fusulines centred on *Yabeina* and *Lepidolina*. The *Ingelarella costata* faunal assemblage is followed in the Southland Synclinorium of New Zealand principally by a diverse assemblage based on *Capillonia* *brevisulcus, Plekonella multicostata* and other forms, all systematically described (eg. Waterhouse 1964, 1968, 1982a, b, 1998, 2001), and well represented in the South Curra Limestone of Gympie region (Waterhouse 2015b). On the northern limb of the Southland Synclinorium, this fauna is underlain by a highly distinctive faunal assemblage named after *Martiniopsis woodi* Waterhouse. This key species is also found in North Auckland, just above fusuline faunas described by Hornibrook et al. (1989), Vachard & Ferrière (1991) and Leven & Grant-Mackie (1997). The fusulines include *Yabeina parvula* and *Lepidolina*, arguably either *L. multiseptata* (Deprat) or *L. multiseptata shiraiwensis* Ozawa (see Sakamoto et al. 2000). These fusulines are regarded as indices for a late Capitanian age, as supported by the description of accompanying compound corals by Leed (1956). *Martiniopsis woodi*[3] found in overlying beds must be younger. The overall composition of the *woodi* fauna is summarized in Waterhouse (2002a, pp. 151, 152). The species suggests correlation between North Auckland and Southland, and points to a post-Capitanian age for *Martiniopsis woodi*, which lies above the *Ingelarella costata* Zone, as discussed on p. . A Wuchiapingian correlation is indicated by this stratigraphic evidence, and is supported by faunal similarities to the Wuchiapingian of the Salt Range in Pakistan. On stratigraphic evidence, the *Ingelarella costata* faunal assemblage lies directly below Lopingian faunas in New Zealand, and is most likely to be Capitanian in age, given the rather full sequence of zones.

Palynomorphs

The upper Capitanian age favoured in this report agrees with the upper Capitanian age indicated by Smith et al. (2017) and Nicoll et al. (2017) for the Kulnura marine tongue in the Sydney Basin, which contains shells close to those of the *Ingelarella costata* Zone. Those authors pointed to a middle Capitanian age for the Gerringong Volcanics and Broughton Formation, here assigned as being equivalent to a slightly extended *Echinalosia wassi* Zone, equivalent to the upper lower Flat Top faunas of southeast Bowen Basin, as discussed on pp. . A tuff yielded a CA-IDTIMS age of lower Capitanian (Metcalfe et al. 2015, Fig. 17). Both the Gerringong and Broughton Formations were placed in the *Didecitriletes ericianus* palynomorph zone by Smith et al. (2017). But Bowen Basin equivalents with the same macrofaunas were placed in the younger *Dulhuntyispora parvithola* palynomorph zone, with the Blenheim Formation allegedly slightly older than the Ingelara beds, and correlated with the Wuchiapingian Stage. In 1997, Price asserted that the Oxtrack Formation of the southeast Bowen Basin belonged to the APP.5 palynomorph Zone, much younger than the underlying so-called Buffel “Formation” [that is Subgroup] and specifically the Elvinia Formation and Roses Pride Formation of Waterhouse (1986a, 1987a, 1987b) in that subgroup. Those particular formations are considered to be Sakmarian and lower Artinskian in age (Waterhouse 2008b, 2015a). To judge from Price (1997), several palynomorph zones were missing, including those named after *Praecolpatites sinuosus* (APP3.2), *Microbaculispora villosa* (APP3.3), *Dulhuntyispora granulata* (APP4.1), *Didecitriletes ericianus* (APP4.2) and *Dulhuntyispora dulhuntyi* (APP4.3). The absence of these zones was claimed to reflect a substantial pause in marine deposition and accumulation of fossils (Draper 2013). That was not a new concept, though unacknowledged. It had already been shown that the macro-faunal biozones named after *Wyndhamia typica, Glendella dickinsi, Attenuocurvus altilis, Echinalosia conata, Spinomartinia adentata, Echinalosia preovalis-Ingelarella plica* and *Taeniothaerus subquadratus* were missing from the outcrops near Cracow in the southeast Bowen Basin (Waterhouse 1987b). Price (1997) and Draper (2013) incorporated the underlying Brae Formation exposed below the Oxtrack Formation (Flood et al. 1981), as if the Brae beds were not distinct. But the Brae beds are different from the overlying Oxtrack beds, and contain a systematically described different fossil assemblage, dominated by *Echinalosia discinia*. Moreover, north of Cracow, another formation enters the succession, the Roses Pride Formation, containing fossils of the *Echinalosia preovalis-Ingelarella plica* biozone, with all brachiopods and molluscs described systematically. The complexities and published faunal content of these units were ignored in Draper et al. (1990), and Draper (2013), who seem to have largely preferred a return to the much earlier study of the stratigraphy by Wass (1965). Those interested should compare the pioneering Wass study with the accounts in Waterhouse (1986a, 1987a, b).

Brae and Oxtrack fossils are found in the Sydney Basin, especially in the Wandrawandian Formation, and Briggs (1998, Fig. 25) **listed *Echinalosia* “*maxwelli*” (in fact *discinia*) followed by “*discinia*” (in fact *maxwelli*) from the lower Wandrawandian beds in the south Sydney Basin, and** recorded “*maxwelli*” and other Oxtrack-type fossil species from the upper Elderslie Formation in the northern Sydney Basin (Briggs 1998, Fig.

25). His study does not support the palynomorph assignments for the middle marine sequences of the Bowen Basin and Sydney Basin, and does provide some support for the present interpretation. That is not to deny the identification of *Dulhuntyisporites parvithola* in the Oxtrack Formation. Indeed Foster (1983, p. 88) had already identified *parvithola* in the overlying Barfield Formation. By contrast, the first known appearance of *parvithola* in the Sydney Basin was recorded by McMinn (1985) in the upper (or at least sampled) Kulnura marine tongue in drill cores Millers Ironbark 54 and DM Stockton 54.

According to Nicoll et al. (2017) and Smith et al. (2017), the younger marine Permian of the Bowen Basin is substantially younger than the younger marine Permian of the Sydney Basin, and a great gap was supposed to be present in the Bowen Basin. This marks one of the differences from the present and other interpretations. Fielding et al. (2001, Fig. 1) provided a so-called time-space diagram that in general terms, and although not expressing exact concordance with the present view, provided no inkling of such a great discrepancy between the two basins. Nor is it only sedimentary interpretations: brachiopods and molluscs also challenge the palynomorph model. Palmieri et al. (1994) showed that the foraminifer *Pseudonodosaria borealis* (Gerke), found in Kazanian faunas of Russia, was present also in the Ingelara Formation of the southwest Bowen Basin. According to the interpretation of palynomorphs favoured by Smith et al. (2017), the formation spans the range of *parvithola*, and is of Changhsingian age, significantly younger than Kazanian. The foraminiferal evidence does not agree, and helps indicate that *parvithola* in the Bowen Basin had an extraordinarily long time range.

If the formations contain palynomorphs differing from those of what are regarded as their Sydney Basin counterparts, then on the evidence to which I attach greatest weight, the closely studied and substantially if still incompletely monographed macro-faunas, suggest that distribution had been influenced by climatic zonation, and that floras changed in character, through a distance of 2000 km. That would not be surprising. Present day floras in eastern Australia certainly change over that same distance, and changes in Permian marine faunas exhibit considerable change. Given that seas were much more equable in their temperature regime and water availability than on-land conditions, it would hardly be surprising to learn that land-based floras changed more than marine faunas from north to south.

In Smith et al. (2017, Fig. 11), the Peawaddy Formation of supposedly lower Changhsingian (Late Permian) in the western Bowen Basin was shown as younger than all of the Blenheim Formation in the northern Bowen Basin. Yet they share the same macrofaunas, and supposedly the same key palynomorph. And in the Sydney Basin, the Mulbring, Broughton, Gerringong Volcanics, Berry, Nowra beds and Fenestella Shale were rated as lower Capitanian and upper Wordian. Again, the marine faunas of these formations are much the same, in sequence, as those of the Bowen Basin.

To slightly change a pronouncement by Dr G. A. Cooper, distinguished American paleontologist, should we propose that brachiopods do not speak to palynomorphs? Yet that is not entirely true. The correlation scheme adduced by Smith et al. (2017) for Western Australia shows a reasonably close agreement with the proposed correlations forwarded for Western Australia by Waterhouse (2015a). The deviation therefore seems to lie within eastern Australia, between the Sydney and Bowen Basins. and between students of paleontology, rather than the fossils themselves. I retain some reservations about aspects of palynomorph studies. One would think that the ideal model for palynomorph studies of sediments strongly affected by a regime of glacial and interglacial climatic changes would be offered by pollen studies of Pleistocene sediments. For Late Tertiary and Pleistocene time, it has been common practise to distinguish, from pollen studies, various coeval plant communities, generally with the pollen matched with to the source plant, linking the palynomorph to the entire plant species, and the distribution of the communities and nature of the plants interpreted according to climatic change, with advance and retreat of different plants and communities, as well as ongoing evolution, in response to waxing and waning glaciation and interglacial episodes. A similar approach for the Permian palynomorphs of east Australia would be most interesting. In a less complex way, this has already been attempted for macrofossils of east Australasia, with ongoing refinement since Waterhouse (1963c, 1964, 1977, 1979). The marine faunas have been interpreted as indicative of changing temperature regimes, and long pre-empted the approach by some more recent authors (Fielding et al. 2008a, b) who falsely claimed to be the first to recognize separate glacial episodes in east Australia. In palynological zoning, the practise of assessing first entries of long-lived form-taxa has the merit of offering an initial mode of initial assessment, but should always be further refined to avoid error from fluctuating inputs, and persistent time ranges, as reinforced by subdivision into long-lasting and massive zones scarcely more refined than the stages and series used to crudely divide the periods.

Or is there a problem with radiometric assessments. Is it entirely wise to rely on radiometric correltions for palynomorph assessments? Is the currently faviouréd CA TIMS metholodoly, with all its adjustments, prone to error, just like preceeding assessments by radiometry?

FOOTNOTES

1. Some studies of *Pseudostrophalosia ingelarensis* contain perplexing aspects. In the text by Briggs (1998, p. 119), he excluded the specimen figured by Dear (1971, pl. 3, fig. 7a, b), stating that it lacked ventral spine tunnels. But he included the very same specimen in the synonymy of *ingelarensis* (see p.). Confusion was not only on the part of Briggs. One figure in Dear (1971, pl. 3, fig. 7) shows an external ventral valve, with little if anything of the interior visible. The caption described fig. 7a as an internal mould, yet external spines can be clearly seen. The dorsal valve aspect was described as partly exfoliated, implying that some shell is left, whereas the figure shows a well preserved internal mould. Figures for *ingelarensis* provided by Briggs (1998, Fig. 62) came from Dry Creek, presumably Ingelara Formation, and BMR Ed78, Ingelara Formation, Dry Creek, and Du387, with no clear indication of stratigraphic source. Further specimens illustrated as *ingelarensis* (Briggs 1998, Fig. 62E-I) were reported as coming from UQL 3135. This is a well-exposed band definitely above the Scottville Member with *Pseudostrophalosia furcalina* n. sp. It provides, apparently, unquestionable evidence that *ingelarensis* followed *clarkei* in the stratigraphic succession, in contradistinction to the other reports in Briggs (1998) which admitted that specimens came from the Ingelara Formation. But UQL 3135 is the locality which has yielded a large and well preserved fauna, as described herein. There are numerous *Pseudostrophalosia*, and all differ substantially from *ingelarensis*, and strongly indicate a new species. It is necessary to conclude that at best, the material assigned by Briggs (1998, Fig. 62E, F, G, I) to *ingelarensis* from UQL 3135, if it truely came from that station, was not typical of the collection from that locality, and cannot be trusted as providing evidence that *ingelarensis* followed *clarkei.* Instead, the stratigraphic and paleontological evidence is clear that *ingelarensis* preceeded

clarkei (Waterhouse & Jell 1983). Significantly, the specimens although sourced from a UQL locality and belonged to the Queensland Museum were taken and allocated Australian Museum numbers in the text, a matter that clearly evaded any totally warranted challenge from the editor and referees. Why? What were they doing? Were they really checking the manuscript? Some editor! Some referees. It is clear that the fossils despite the Briggs monograph cannot be found in either the Australian Museum or the Queensland Museum. Nor can they be found anywhere else, like so many other specimens featured, even as holotypes, in the study by Briggs (1998).

2. From South Marulan, an inland area west of the Shoalhaven River in New South Wales, Wass & Gould (1969) listed many species, including *clarkei* and *minima*, but illustrated only some of the taxa, including the Flat Top form *Pleurikodonta* Runnegar, 1965, which is definitely found in a range of faunas (Waterhouse 2001, p. 146). The figured *Gilledia* (Wass & Gould 1969, pl. 15, fig. 8, 9) is more plicate than the species from the Pebbley Beach Formation (Shi et al. 2020), approaching specimens from the Wandrawandian and Snapper Point Formations in the south Sydney Basin (Campbell 1965), and the internal moulds figured from South Marulan as *Ambikella* cf. *isbelli* and *A.* cf. *undulosa* include one (Wass & Gould, 1969, pl. 15, fig. 15) which recalls *Johndearia pelicanensis* (Campbell, 1960, pl. 140, fig. 5a-c), giving support for a comparatively young Middle Permian age. The full South Marulan faunas need to be systematically and comprehensively re-examined. (See also p.).

3. The presence of *Martiniopsis woodi* in beds above this fauna has been challenged, on the basis that the author of the challenge could not find more specimens, and to his mind, that reflected on the claimants who said they found such fossils, not on him who failed to find the same fossil. That complaint was comprehensively dismissed with documentation over the original and subsequent collectors, and analysis of the nature of the matrix, and evidence for erosion by sea in Waterhouse (2004, p. 153), pertinent to fossils found in North Auckland. Our "authority" who questioned the occurrence of *woodi* in North Auckland asserted that it had come from inland Southland. Related fossils in Southland are only found far from the coast, and show no sign of marine erosion. Working at the New Zealand Geological Survey in 1953, I was told of the find of *woodi* at North Auckland by premier and genuine authorities Dr. J. Marwick and C. A. Fleming, and to this day I see no reason to disbelieve their accounts,

especially as I later found a large fragment of what could be the same species in what was probably the source rock.

ACKNOWLEDEMENTS

J. D. Armstrong and B. Runnegar collected the bulk of the fossils described in this report, from UQL 3135, and the collection they made is a very fine one. Kristen Spring, Queensland Museum, has greatly assisted with the registration of specimens.

REFERENCES

ALVAREZ, F., RONG JIA-YU, BOUCOT, A. J. 1998: The classification of athyridid brachiopods. J. Paleont. 72: 827-855.

ARCHBOLD, N. W. 1987: Studies on Western Australian Permian brachiopods 7. The strophalosiid genera *Wyndhamia* Booker, 1929, *Lialosia* Muir-Wood and Cooper, 1960 and *Liveringia* gen. nov. Proc. Roy. Soc. Victoria 99: 19-35.

______1993: A zonation of the Permian brachiopod faunas of Western Australia. *In* Gondwana Eight, Assembly, evolution and dispersal 1991: 313-321. Balkema, Rotterdam.

_____ 1997: Studies on Western Australian Permian brachiopods. 14. The fauna of the Artinskian High Cliff Sandstone, Perth Basin. Proc. Roy. Soc. Victoria 109: 199-231.

ARCHBOLD, N. W., SIMANAUSKAS, T. 2001: New Strophalosiidae (Brachiopoda) from the early Permian of Argentina. Proc. Roy. Soc. Victoria 113: 217-237.

ARCHBOLD, N. W., THOMAS, G. A. 1986: Permian Ingelarellidae (Brachiopoda) from Western Australia and Argentina. J. Paleont. 60: 581-605.

ARMSTRONG, J. D. 1969: The cross-bladed fabrics of the shells of *Terrakea solida* (Etheridge & Dun) and *Streptorhynchus pelicanensis* Fletcher. Palaeontology 12: 310-320, pl. 57-60.

_____ 1970a: Syringothyrid brachiopods from the Permian of eastern Australia. N. Jb. Geol. Paläont. Abh. 136: 135-165.

_____ 1970b: Queensland Permian species of the spiriferid brachiopods *Punctospirifer* and *Cleiothyridina*. Mem. Qld Mus. 15: 315-322, pl. 25.

_____1970c: Micro-ornaments of the spiriferid brachiopods *Notospirifer, Ingelarella* and

Subansiria. Lethaia 3: 287-300.

ASTAFIEVA, M. M. 1993: Permian inoceramiform bivalved Mollusca of Russia. Trudy Paleont. Inst. 246. [Russ.]

ASTAFIEVA-URBAITIS, K. A. 1973: On the systematics of the Megadesmidae (Bivalvia). Paleont. Zhurn. 1973 (1): 13-19. [Russ.]

_____ 1988: Genus *Praemyonia* – new representative of Family Vacunellidae (Bivalvia). Paleont. Zhurn. 1988 (2): 14-20. [Russ.]

_____1990: *Vacunella* Waterhouse and *Cuvanella* gen. nov. (Bivalvia) from the Upper Paleozoic of the USSR. Paleont. Zhurn. 1990 (1): 39-48. [Russ.]

BENEDICTOVA, R. N. 1956: Spiriferidae of the Ostrogsk Series of the Kuzbass. Voprosy Geol. Kuzbass 1: 169-182. [Russ.]

BEURLEN, K. 1954: Las faunas lamellibranchios do sistema Genduanicos no Parana*. In* F. W. Lange (ed.). Paleontologia do Parana. Comissao de Comemoraçaos do Centenareo Parana, Curutiba: 107-136, 7pl.

BOOKER, F. W. 1930: A review of some of the Permo-Carboniferous Productidae of New South Wales, with a tentative reclassification. J. Proc. Roy. Soc. New South Wales 64: 65-77.

BOUCOT, A. J., JOHNSON, J. G., STATON, R. D. 1964: On some atrypoid, retzioid and athyridoid Brachiopoda. J. Paleont. 38: 805-822, pl. 125-128.

BRIGGS, J. D. C. 1987: Permian productid zones of New South Wales. Advances in the study of the Sydney Basin. Proc. 21st Newcastle Symposium: 98-101. Dep. Geology, Univ. Newcastle.

_____ 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and the New England orogen: systematics and biostratigraphic significance. Mem. Assoc. Aust'asian Palaeont. 19.

BRUNTON, C. H. C. 1966: Silicified productoids from the Visean of County Fermanagh. Bull. Brit. Mus. (Nat. Hist.) Geol. 12 (5): 155-243.

BUCKMAN, S. S. 1906: Brachiopod nomenclature: *Epithyris, Hypothyris*, *Cleiothyris* Phillips 1841. Ann. Mag. Nat. Hist. (ser. 7) 18: 321-327.

CAMPBELL, K. S. W. 1951: The geology of the Cressbrook Buaraba area. Pap. Dep. Geol. Univ. Qld 3 (15): 1-44.

_____ 1953: The fauna of the Permo-Carboniferous Ingelara beds of southeast Queensland. Pap. Dep. Geol. Univ. Qld 4 (3): 1-44.

_____ 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. Palaeontology 1: 333-350.

_____ 1960: The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. J. Paleont. 34: 1106-1123.

_____ 1961: New species of the Permian spiriferoids *Ingelarella* and *Notospirifer* from Queensland and their stratigraphic implications. Palaeontographica A 117: 159-192.

_____ 1965: Australian Permian terebratuloids. Bull. Bur. Mineral Resour. Geol. Geophys. 68.

CARTER, J. G. et al. (51 authors) 2011: A synoptical classification of the Bivalvia (Mollusca). Paleont. Contrib. 4: 1-47.

CHAVAN, A.. 1969: Superfamily Carditacea. *In* R. C. Moore (ed.) Part N. Bivalvia vol. 2. Treatise on Invertebrate Paleontology: 543-561. Geol. Soc. Amer., Univ. Kansas

CHRONIC, H. 1952: Molluscan fauna from the Permian Kaibab Formation, Walnut Canyon, Arizona. Bull. Geol. Soc. Amer. 63: 95-166, pl. 1-11.

CLARKE, M. J. 1970: A new Permian strophalosiid brachiopod genus from eastern Australia. J. Paleont. 44: 986-987.

_____ 1987: Late Permian (Late Lymingtonian = ?Kazanian) brachiopods from Tasmania. Alcheringa 11: 261-289.

_____ 1990: Late Palaeozoic (Tamarian; Late Carboniferous - Early Permian) cold-water brachiopods from Tasmania. Alcheringa 14: 53-76.

_____ 1992a: Hellyerian and Tamarian (Late Carboniferous - Lower Permian) invertebrate faunas from Tasmania. Bull. Geol. Surv. Tasmania 69: 1-52.

______1992b: A new notospiriferine genus (Spiriferida: Brachiopoda) from the Permian of Tasmania. Pap. Proc. Roy. Soc. Tasmania 126: 73-76.

CLARKE, M. J., BANKS, M. R. 1975: The Stratigraphy of the Lower (Permo-Carboniferous) Parts of the Parmeener Super-Group, Tasmania. *In* K. S. W. Campbell (ed.) Gondwana Geology, Papers from the Third Gondwana Symposium, Canberra, Australia: 453-467.

COOPER, G. A., GRANT, R. E. 1974: Permian brachiopods of west Texas 11. Smithson.

Contrib. Paleobiol. 15.

_____ , _____ 1976: Permian brachiopods of west Texas V. Smithson. Contrib. Paleobiol. 24.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DALL, W. H. 1889: On the hinge of pelecypods and its development, with an attempt toward a better subdivision of the group. Amer. J. Sci. Arts (ser. 3) 38 (228): 445-462.

DANA, J. D. 1847: Descriptions of fossil shells of the collections of the exploring expedition under the command of Charles Wilkes U. S. N. obtained in Australia, from the lower layers of the coal formation in Illawarra, and from a deposit probably of nearly the same age at Harper's Hill, valley of the Hunter. Amer. J. Sci. (ser. 2) 4: 151-160.

_____ 1849: Fossils of New South Wales. *In* United States Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes, U. S. N. vol. 10 – Geology. Appendix 1: 681-720. C. Sherman, Philadelphia.

DAVID, T. W. E. 1950: The Geology of the Commonwealth of Australia.Vol. 1. (W. R. Browne (ed.) : 1-747. Edward Arnold & Co, London.

DAVIDSON, T. 1881: On genera and species of spiral-bearing Brachiopoda from specimens developed by Rev. Norman Glass: with notes on the results obtained by Mr. George Maw from extensive washing of the Wenlock and Ludlow shales of Shropshire. Geol. Mag. (n. s., dec. 11) 8 (1): 1-13.

DEAR, J. F. 1971: Strophomenoid brachiopods from the higher Permian faunas in the northern Bowen Basin and their distribution throughout the basin. Geol. Surv. Qld Pub. 347. Palaeont. Paper 21: 1-39.

______ 1972: Preliminary biostratigraphic subdivision of the Permian brachiopod faunas in the northern Bowen Basin and their distribution throughout the basin. Rep. Geol. Surv. Qld 49: 1-19.

DEAR, J. F., McKELLAR, R. G., TUCKER, R. M. 1971: Geology of the Monto 1: 250,000 Sheet area. Geol. Surv. Qld Rep. 46.

DICKINS, J. M. 1964: Permian macrofossils from Collinsville and from the area of the Clermont Sheet. *In* VEEVERS, J. J., RANDALL, M. A., MOLLAN, R. G., PATEN R. J.: Geology of the Clermont 1:250,000 sheet area. Bur. Mineral Resourc. Geol. Geophys. Rep.

66: 76-86.

_____ 1972: Appendix 2. Permian marine macrofossils from the Mundubberra and Monto sheet areas. *In* MOLLAN, R. G., FORBES, V. R., JENSEN, A. R., EXON, N. F., GREGORY, C. M.: Geology of the Eddystone, Taroom and western part of the Mundubbera Sheet areas, Queensland. Bur. Mineral Resour. Geol. Geophys. Rep. 142:106-120.

_____ 1976: Relationship of *Mourlonia* and *Ptychomphalina*, Upper Palaeozoic Gastropoda. Bull. Bur. Mineral Resour. Geol. Geophys. 192: 45-48.

_____ 1989: Youngest Permian marine macrofossil fauna from the Bowen and Sydney Basins, eastern Australia. BMR J. Aust. Geol. Geophys. 11: 63-79.

DICKINS, J. M., MALONE, E. J. 1973: Geology of the Bowen Basin, Queensland. Bull. Bur. Mineral Resour. Geol. Geophys. 130.

DICKINS, J. M., MALONE, E. J., JENSEN, A. R. 1964: Subdivision and correlation of the Permian Middle Bowen beds, Queensland. Rep. Bur. Mineral Resour. Aust. 70.

DIENER, C. 1903: Permian fossils of the central Himalayas. Palaeont. Indica (ser 15) 1 (5).

DRAPER, J. J. 2013. The Bowen Basin. *In* P. A. Jell (ed.) Geology of Queensland: 371-384. Dep. Nat. Resources & Mines, Brisbane.

DRAPER, J. J., PALMIERI, V., PRICE, P. L., BRIGGS, J. D. C., PARFREY, S. M. 1990: A biostratigraphic framework for the Bowen Basin. Bowen Basin Symposium 1990, Proceedings: 26-35. Bowen Basin Geologists Group, Mackay & Geol. Soc. Aust., Qld Div. Brisbane.

DUMÉRIL, A. M. C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux: xxiv + 344pp. Allais. Paris.

DUN, W. S. 1932: The Lower Marine forms of *Myonia* with notes on the proposed new genus *Pachymyonia*. Rec. Aust. Mus. 18: 411-414.

ETHERIDGE, R. Snr 1872: Appendix 1: Description of the Palaeozoic and Mesozoic fossils of Queensland. *In* DAINTREE, R.: Notes on the geology of the colony of Queensland. Quart. J. Geol. Soc. London 28: 317-350.

ETHERIDGE, R. Jnr 1880: Report on a collection of fossils from the Bowen River coalfield and the limestones of the Fanning River, northern Queensland. Proc. Roy. Phys. Soc. Edinburgh 5: 263-328.

_____ 1892: *In* JACK, R. L., ETHERIDGE, R. Jnr Geology and Palaeontology of Queensland and New Guinea. Publ. Geol. Surv. Queensland 92: 1-766, 68pl.

_____ 1894: Additional notes on the palaeontology of Queensland. Part 1, Palaeozoic. Proc. Linn. Soc. New South Wales 19: 518-539, pl. 39-41.

_____ 1900: Little-known and undescribed Permo-Carboniferous Pelecypoda in the Australian Museum. Rec. Aust. Mus. 3: 178-187, pl. 31-33.

ETHERIDGE, R. Jnr, DUN, W. S. 1906: A monograph of the Carboniferous and Permian Invertebrata of New South Wales, volume 2 – Pelecypoda, part 1 – The Palaeopectens. New South Wales Geol. Surv. Palaeont. 5: 1-39.

_____ , _____ 1909: Notes on the Permo-Carboniferous Producti of eastern Australia, with synonymy. Rec. New South Wales Geol. Surv. 8: 293-304.

FÉRUSSAC, A. E. J. d'AUDEBARD de 1821-1822: Tableaux Systématiques des Animaux Mollusques suivis d'un Prodrome Général pur tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles. Première Partie, Tableaux Systématiques Généraux. Arthus-Bertrand, Paris; J. B. Sowerby, London. (See Carter et al. 2011, pp. 35, 36).

FIELDING, C. R., FRANK, T. D., BIRGENHEIER, L. P., RYGEL, M. C., JONES, A. T., ROBERTS, J. 2008a: Stratigraphic imprint of the Late Palaeozoic Ice Age in eastern Australia: a record of alternating glacial and non-glacial climatic regime. J. Geol. Soc. London 165: 129-140.

FIELDING, C. R., FRANK, T. D., BIRGENHEIER, L. P., RYGEL, M. C., JONES, A. T., ROBERTS, J. 2008b: Stratigraphic record and facies associations of the late Paleozoic ice age in eastern Australia (New South Wales and Queensland). *In* C. R. Fielding, T. D. Frank, & J. L. Isbell (ed.) Resolving the Late Paleozoic Ice Age in Time and Space. Geol. Soc. America Spec. Pap. 441: 41–57.

FIELDING, C. R., SLIWA, R., HOLCOMBE, R. J., JONES, A. T. 2001: A new palaeogeographic synthesis for the Bowen, Gunnedah and Sydney Basins of eastern Australia. *In* K. C. Hill & T. Bernecker (ed.) Eastern Australian Basin Symposium. Petrol. Explor. Soc. Aust. Spec. Publ. : 269-278.

FINLAY, H. J. 1927: New specific names for austral Mollusca. Trans. Proc. N. Z. Inst. 57: 488-533.

FLETCHER, H. O. 1929a: Contributions on the Permo-Carboniferous Aviculopectinidae of New South Wales. Rec. Aust. Mus. 17: 1-35.

_____ 1929b: Revision of genus *Astartila*. Rec. Aust. Mus. 17: 53-75.

_____ 1932: A revision of the genus *Myonia*, with notes on allied genera from the Permo-Carboniferous of New South Wales. Rec. Aust. Mus. 18: 389-410.

_____1952: *In* FLETCHER, H. O., HILL, D., WILLETT, R. W. Permian fossils from Southland. N. Z. Geol. Surv. Palaeont. Bull. 19: 1-17, pl. 1, 2.

_____ 1958: The Permian gastropods of New South Wales. Rec. Aust. Mus. 24: 115-164.

_____ 1971: Catalogue of type specimens of fossils in the Australian Museum, Sydney. Mem. Aust. Mus. 13: 1-167.

FLOOD, P. G., JELL, J. S., WATERHOUSE, J. B. 1981: Two new Early Permian stratigraphic units in the southeastern Bowen Basin, central Queensland. Qld Gov. Min. J. 82: 179-184.

FOSTER, C. 1983: Review of the time-frame for the Permian in Queensland. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 107-120.

FREDERICKS G. 1926: Table for determination of the genera of the family Spiriferidae King. Acad. Nauk SSSR, Izvest (ser. 6): 20 (5-6): 393-422, 1pl. [Russ.]

HERTWIG, R. 1895: Lehrbuch der Zoologie. 3rd edit. Gustav Fischer. Jena. xii + 1-599.

GONZALEZ 2002: Bivalves from Carboniferous glacial deposits of western Argentina. Paläont. Zeit. 76 (1): 127-148.

_____ 2006: Lower Permian bivalves from central Patagonia, Argentina. Paläont. Zeit. 80 (2): 130-155.

GRANGE, M. J. 1854: *In* “Geology” in DUMONT d’URVILLE: Voyage au Pol Sûd. Geol. 2.

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

GROBBEN, C. 1894: Zur Kenntniss der Morphologie, der Verwandtschafts-verhältnisse und des systems der Mollusken. K. Akad. Wiss. (Math.-Naturwiss. Cl.) Sitzbericht. 103 (1): 61-86.

GRUNT, T. A. 2006: Order Spiriferinida Cooper & Grant [Sic – Ivanova 1972]. *In* Upper Permian of the Kanin Peninsula. Russian Acad. Sci., Urals Branch, Science Centre Inst. Geol.: 151-163. [Russ.]

HARRINGTON, H. J. 1955: The Permian *Eurydesma* fauna of eastern Argentina. J. Paleont.

29: 112-128.

HEDINGER, S. 1993: Upper Jurassic (Oxfordian – Volgian) Foraminifera from the Husky Formation, Aklavik Range, District of MacKenzie, Northwest Territories. Geol. Surv. Canada Bull. 439: 1-173.

HENDERSON, C. M. 2018: Permian conodont stratigraphy. *In* S. G.. Lucas, S. Z. Shen (ed.) The Permian Time-scale. Geol. Soc. London Spec. Pub. 450: 119-142.

HERTWIG, R. 1895: Lehrbuch der Zoologie. 3rd edit.Gustav Fischer. Jena: xii + 1-599.

HILL, D., PLAYFORD, G., WOODS, J. T. 1972: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

HILL, D., WOODS, J. T. 1964: Permian fossils of Queensland. Palaeontograph. Soc. Brisbane: 1-32.

HORNIBROOK, N. de B., BRAZIER, R. C., STRONG, C. P. 1989: Manual of New Zealand Permian to Pleistocene foraminiferal stratigraphy. N. Z. Geol. Surv. Paleont. Bull. 56.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE (= ICZN) 1999: International Code of Zoological Nomenclature. Also 1985.

ISBELL, R. F. 1955: The geology of the northern section of the Bowen Basin. Pap. Dep. Geol. Univ. Qld 3 (11): 1-43.

IVANOVA, E. A. 1972: Main features of spiriferid evolution (Brachiopoda). Paleont. Zhurn. 1972 (3): 28-42. [Russ.]

JIN YUGAN 1996: A global chronostratostratigraphic scheme for the Permian System. Two decades of the Permian Subcommission. Permophiles 28: 4-9.

JIN YUGAN, GLENISTER, B. F., KOTLYAR, G. V., SHENG, J.-Z. 1994: An operational scheme of Permian chronostratigraphy. Palaeoworld 4: 1-14.

JIN YUGAN, LEE, D. E., SUN DONG-LI, SMIRNOVA, T. N., DAGYS, A. S., SANDY, M. R. 2006: Dielasmatoidea. *In* R. L. Kaesler (ed.) Treatise on Invertebrate Paleontology, Part H, Brachiopoda revised, vol. 5, Rhynchonelliformea (part). Geol. Soc. Amer., Univ. Kansas: 2029-2053.

JIN YUGAN, WARDLAW, B. R., GLENISTER, B. F., KOTLYAR, G. V. 1997: Permian chronostratigraphic subdivisions. Episodes 20 (1): 10-15.

JOHNSTON, R. M. 1888: Systematic account of the geology of Tasmania: 408p. W. T. Strutt, Gov. Printer, Hobart.

KING, W. 1850: A monograph of the Permian fossils of England. Palaeontograph. Soc. Monograph 3: 37 + 258p.

KLETS, A. G. 2005: Upper Paleozoic of marginal seas of Angarida. Inst. Petrol. Geol. UIGGM SB – RAS, Novosibirsk: 1-242. [Russ.]

KONINCK, L. G. de 1866-77: Recherches sur les Fossiles paléozoiques de la Nouvelle Galles de Sud (Australie). Mém. Soc. Roy. Sci. Liège (ser. 2) 6, 7. [English translation by T. W. E. David, 1898 Geol. Surv. New South Wales, Palaeont. Mem. 6].

LAMARCK, J. B. P. A de M. de 1809: Philosophie zoologique, ou exposition des considérations relatives à l'histoire naturelle des animaux, la diversité de leur organization et des facultés qu'ils en obtiennent, aux causes physiques qui maintennent en eux la vie, et donnent lieu aux mouvements qu'ils exécutent; enfin, à celles qui produisent les unes les sentiments, et les autres l'intelligence de ceux qui sont doués. 2 vols: 1-422, 1-473. Paris.

LAURIE, J. R., BODORKOS, S, NICOLL, R. S., CROWLEY, J. L., MANTLE, D. J., MORY, A. J., WOOD, G. R., BACKHOUSE, J., HOLMES, E. K., SMITH, T. E. & CHAMPION, D. C. 2016: Calibrating the middle and late Permian palynostratigraphy of Australia to the geologic time scale via U–Pb zircon CA-IDTIMS dating. Aust. J. Earth Sci. 63: 701-730.

LEED, H. 1956: Permian reef-building corals from North Auckland Peninsula, New Zealand. N. Z. Geol. Surv. Paleont. Bull. 25: 15-24.

LEVEN, E. Y., GRANT-MACKIE, J. A. 1997: Permian fusulinid Foraminifera from Wherowhero Point, Orua Bay, Northland. N. Z. J. Geol. Geophys. 40: 473-486.

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MALONE, E. J., JENSEN, A. R., GREGORY, C. M. 1966: Geology of the southern half of the Bowen 1:250,000 sheet area, Queensland. Rep. Bur. Mineral Resourc. Geol. Geophys. 100.

MARWICK, J. 1953: Divisions and faunas of the Hokonui System. N. Z. Geol. Surv. Paleont. Bull. 21.

MAXWELL, W. G. H. 1954: *Strophalosia* in the Permian of Queensland. J. Paleont. 28: 533-559.

_____ 1964: The geology of the Yarrol region. Part 1. Biostratigraphy. Pap. Dep. Geol. Univ. Qld 5 (9): 1-79, 14pl.

McCLUNG, G. 1978: Morphology, palaeoecology and biostratigraphy of *Ingelarella* (Brachiopoda: Spiriferida) in the Bowen and Sydney Basin of eastern Australia. Geol. Surv. Qld Pub. 365, Palaeont. Pap. 39: 11-86.

_____ 1981: Review of the stratigraphy of the Permian Back Creek Group in the Bowen Basin, Queensland. Geol. Surv. Qld Pub. 371, Palaeont. Pap. 44.

_____ 1983: Faunal sequence and palaeoecology in the marine Permian in G. S. Q. Eddystone 1, Denison Trough, Queensland. Geol. Surv. Qld Pub. 384: 43-80.

McCLUNG, G., ARMSTRONG, J. D. 1978: Species of *Glendonia* gen. nov. (Ingelarellinae: Spiriferida) in the Permian of eastern Australia. Geol. Surv. Qld Pub. 365, Palaeont. Pap. 39: 1-5, 2pl.

M'COY, F. 1844: A synopsis of the Carboniferous Limestone fossils of Ireland. Dublin.

_____ 1847: On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist. (ser. 1) 20: 145-157, 226-236, 298-312.

_____ 1851: Descriptions of some new Mountain Limestone fossils. Ann. Mag. Nat. Hist. (ser. 2) 7.

McLOUGHLIN, S. 1988: Geology of the Inglis Dome, Denison Trough, central Queensland. Dep. Geol. Univ. Qd 12 (2): 229-264.

McMINN, A. 1985: Palynostratigraphy of the Middle Permian coal sequences of the Sydney Basin. Aust. J. Earth Sci. 32: 301-309.

METCALFE, I., CROWLEY, J. L., NICOLL, R. S., SCHMITZ, M. 2015: High-precision U-Pb CA-TIMS calibration of Middle Permian to Lower Triassic sequences, mass extinction and extreme climate-change in eastern Australian Gondwana. Gondwana Research 28 (2015): 61-81.

MITCHELL, J. 1927: A new *Deltopecten* from the Illawarra District, New South Wales. Proc. Linnean Soc. New South Wales 52: 104, pl. 2, fig. 1, 2.

MOLLAN, R. G., KIRKEGAARD, A. G., EXON, N. F., DICKINS, J. M. 1964: Note on the Permian rocks of the Springsure area and proposal of a new name, Peawaddy Formation. Qld Gov. Min. J. 65: 576-581.

MOLLAN, R. G., FORBES, V. R., JENSEN, A. R., EXON, N. F., GREGORY, C. M. 1972: Geology of the Eddystone, Taroom and western part of the Mundubbera Sheet areas, Queensland. Bur. Mineral Resourc. Geol. Geophys. Rep. 142

MOORE, R. C. 1952: Brachiopods. *In* MOORE, R. C., LALICKER, C. G., FISCHER A. G. Invertebrate fossils. McGraw-Hill, New York: 197-267.

MORRIS, J. 1845: Descriptions of fossils. *In* STRZELECKI, P. E. de Physical description of New South Wales and Van Diemen's Land: 270-291. Longman, Brown, Green & Longman, London.

MORRIS, N. J., DICKINS, J. M., ASTAFIEVA-URBAITIS, K. 1991: Upper Palaeozoic anomalodesmatan Bivalvia. Bull. Brit. Mus. Nat. Hist. (Geol.) 47 (1): 51-100.

MUIR-WOOD, H. M., COOPER, G. A. 1960: Morphology, classification and life habits of the Productoidea (Brachiopoda). Geol. Soc. Amer. Mem. 81.

MUROMSEVA, V. A. 1984: Permian marine deposits and bivalved Mollusca from the Soviet Arctic. Trudy VNIGRI 336: 1-154. [Russ.]

MUTCH, A. R. 1972: Geology of the Morley Subdivision District (S 159). N. Z. Geol. Surv. Bull. 78: 1-104.

NEWELL, N. D. 1938: Late Paleozoic pelecypods: Pectinacea. Kansas Geol. Surv. Rep. 10.

_____ 1942: Late Paleozoic pelecypods: Mytilacea. Kansas Geol. Surv. Rep. 10 (2).

_____ 1956: Primitive desmodont pelecypods of the Australian Permian. Amer. Mus. Nat. Hist. Novitates 1799: 1-13.

NEWELL, N. D., BOYD, D. W. 1995: Pectinoid bivalves of the Permian-Triassic crisis. Bull. Amer. Mus. Nat. Hist. 227.

NICOLL, R. S., BOCKING, M., SMITH, T. E., CROWLEY, J. L., BODORKOS, S., HOLMES, E. K., MANTLE, D., WOOD, G. R. 2017: Dating of marine incursions and unconformities in the Sydney and Gunnedah basins of New South Wales using U–Pb zircon CA-IDTIMS dating of intercalated tuffs. Extended Abstract, 40th Sydney Basin Symposium. Hunter Valley, New South Wales.

ÖPIK, A. A. 1934: Ueber Klitamboniten. Univer. Tartuensis (Dorpatensis) Acta et Comment. (ser. A) 26 (5): 239p., 48pl., 55 fig.

PALMIERI, V., FOSTER, C. B., BONDAREVA, E. V. 1994: First record of shared species of

Late Permian small foraminiferids in Australia and Russia: time correlations and plate reconstructions. AGSO J. Aust. Geol. Geophys. 15: 359-365.

PARFREY, S. M. 1988: Biostratigraphy of the Barfield Formation, southeastern Bowen Basin, with a review of the fauna from the Ingelara and lower Peawaddy Formations, southwestern Bowen Basin. Rep. Qld Dep. Mines 1.

PLEWS, H. T. 1858: On the coalfield of New South Wales. Mining Inst. J. 6 (3).

PRICE, P. L. 1973: Permian palynostratigraphy, Denison Trough area, ATP 119P. Bowen Basin, Queensland. Mines Admin. Pty Ltd. Palynol. Rep. 17/3.

_____ 1976: Permian palynology of the Bowen Basin. *In* A. R. Jensen, N. F. Exon, J. C. Anderson, W. H. Koppe (ed.) A guide to the geology of the Bowen and Surat Basins in Queensland. 25th Internat. Geol. Congr. Exursion Guide 3C: 44-47.

_____ 1997: Permian to Jurassic palynostratigraphic nomenclature of the Bowen and Surat Basins. *In* P. M. Green (ed.) The Surat and Bowen Basins southeast Queensland. Minerals and Energy Review Series: 137-138.

RAFINESQUE, C. S. 1815: Analyse de la Nature ou Tableau de l'University et des Corps Organisés, etc. Jean Barravecchia. Palermo.

RATTE, F. 1887: On the muscular impression of the genus *Notomya* (*Maeonia*). Proc. Linn. Soc. New South Wales 12: 139, pl. 3.

REID, J. H. 1929: Geology of the Bowen River Coalfield. Pub. Geol. Surv. Qld 276: 1-107.

RUNNEGAR, B. N. 1965: The bivalves *Megadesmus* Sowerby and *Astartila* Dana from the Permian of eastern Australia. J. Geol. Soc. Aust. 12: 227-252.

_____ 1966: Systematics and biology of some desmodont bivalves from the Permian of eastern Australia. J. Geol. Soc. Aust. 13: 373-386.

_____ 1967: Desmodont bivalves from the Permian of eastern Australia. Bull. Bur. Mineral Resour. Geol. Geophys. 96.

_____ 1968: The Permian faunal succession in eastern Australia. Univ. New England, unpub. reports in Geol. Sciences no. 1968/1: 1-81, table 1, pl. 1.

_____ 1969: Permian fossils from the southern extremity of the Sydney Basin. *In* K. S. W. Campbell (ed.) Stratigraphy and palaeontology, essays in honour of Dorothy Hill: 276-298. Aust. Nat. Univ. Press, Canberra. **so in fact 82729 to 45 still free! and 82763-70 unused**

_____ 1970: *Eurydesma* and *Glendella* gen. nov. (Bivalvia) in the Permian of eastern Australia. Bull. Bur. Mineral Resourc. Geol. Geophys. 116: 83-118.

_____ 1974: Evolutionary history of the bivalve Subclass Anomalodesmata. J. Paleont. 75: 904-939.

_____ 1980: Biostratigraphy of the Shoalhaven Group. New South Wales Geol. Surv. Bull. 26: 377-382, 1 fig.

RUNNEGAR, B. N., FERGUSON, J. A. 1969: Stratigraphy of the Permian and Lower Triassic sediments of the Gympie District, Queensland. Pap. Dep. Geol. Univ. Qld 4 (9): 247-281.

RUNNEGAR, B. N., McCLUNG, G. R. 1973: New names for marine Permian rock units in the northern Bowen Basin, Queensland. Qld Gov. Mining J. 1973: 441-443.

_____ , _____ 1975: A Permian time scale for Gondwanaland. *In* K. S. W. Campbell (ed). Gondwana Geology: Papers presented at the Third Gondwana Symposium, Canberra, Australia, 1973: 425-441. Aust. Nat. Univ. Press, Canberra.

RUNNEGAR, B., NEWELL, N. D. 1974: *Edmondia* and the Edmondiacea: shallow-burrowing Paleozoic pelecypods. Amer. Mus. Novitates 2533.

SAKAMOTO, T., SUGIMURA, A., ISHIBASHI, T. 2000: *Codonofusiella* Zone of the Akiyoshi Limestone Group, southwest Japan. Bull. Akiyoshi-dai Mus. Nat. Hist. 35: 21-37, pl. 10-18.

SAHNI, M. R., SRIVASTAVA, J. P. 1956: Discovery of *Eurydesma* and *Conularia* in the eastern Himalayas, and description of associated faunas. J. Palaeont. Soc. India 1 (1): 202-214.

SCHUCHERT, C. 1893: Classification of the Brachiopoda. American Geologist 11: 141-167, pl. 5.

_____ 1913: Class 2. Brachiopoda. *In* ZITTEL, K. A. von: Text-book of Paleontology, vol. 1, part 1, 2nd ed., translated and edited by C. R. Eastman: 355-420, fig. 526-636. MacMillan & Co. Ltd, London.

SHI, G. R., WATERHOUSE, J. B., LEE S. 2020: Early Permian brachiopods from the Pebbley Beach Formation, south Sydney Basin, southeastern Australia. Alcheringa 44 (3): 411-429.

SHI, G. R., WELDON, E. A. 2002: Permian stratigraphy, sedimentology and palaeontology of the southern Sydney Basin, eastern Australia. Pre-4 Field Excursion Guidebook. Deakin Univ., Melbourne.

SHI, G. R., WELDON, E. A., PIERSON, R. R. 2010: Permian Stratigraphy, Sedimentology and Palaeontology of the Southern Sydney Basin, southeast Australia. Assoc. Aust'asian Palaeont. Field Guide Ser. no. 1: 1-61, 11pl.

SMITH, T. E., BERNECKER. T., BODORKOS, S., GORTER, J., HALL, L. S., HILL, T., HOLMES, E., KELMAN, A., KHIDER, K., LAURIE, J., LECH, M., McKELLAR, J., MORY, A., NICOLL, R., OWENS, R., PALU, T. J., PHILLIPS, L., STEPHENSON, M., WOOD, G., 2017: The impact of recalibrating palynological zones to the chronometric timescale: revised stratigraphic relationships in Australian Permian and Triassic hydrocarbon-bearing basins. Poster given at AAPG/SEG 2017 International Conference and Exhibition, London, England, October 15–18, 2017.

SOWERBY, J. de C. 1840-1846: The Mineral Conchology of Great Britain 7: 1-80, pl. 610-648. Published by the author. London.

STAROBOGATOV, Y. I. 1992: Morphological basis for phylogeny and classification of Bivalvia. Ruthenica 2 (1): 1-25.

STEHLI, F. G. 1954: Lower Leonardian brachiopods of the Sierra Diablo. Bull. Amer. Mus. Nat. Hist. 105: 257-358.

STOLL, N. R. (ed.) 1961: International Code of Zoological Nomenclature adopted by the XV International Congress of Zoology (ed. 2), London: xx + 176pp.

STRZELECKI, P. E. de 1845: Physical description of New South Wales and Van Diemen's Land: xviv + 462p. Longman, Brown, Green & Longman, London.

SWAINSON, W. 1840: A Treatise on Malacology of the Natural classification of shells and shell fish. VIII, 419p.

TERMIER, H., TERMIER, G. 1950: Paléontologie Marocaine. 2, Invertébrés de l'ère Primaire. Fascicule 3, Mollusques. Herman, Paris. Serv. Geol. Maroc. Notes et Mem. 78: 246p., pl. 123-183.

USTRITSKY V. I. 1963: *In* USTRITSKY, V. I., CHERNYAK, G. E. Biostratigraphy and brachiopods of the Upper Paleozoic of Taimyr. Trudy Nauch.-Issled. Geol. Inst. Ark. (NIIGA) 34: 1-139. [Russ.]

VACHARD, D., FERRIÈRE, J. 1991: An assemblage with *Yabeina* (fusulinid foraminifera) from the Midian (Upper Permian) of Whangaroa area (Orua Bay, New Zealand). Revue de

Micropal. 34: 201-230.

VEEVERS, J. J., RANDAL, M. A., MOLLAN, R. G., PATEN, R. J. 1964: The Geology of the Clermont 1:250,000 Sheet area, Queensland. Bur. Mineral Resour. Geol. Geophys. Rep. 66.

WAAGEN, W. 1883: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (2): 391-546.

_____ 1884: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (3): 547-610, pl. 50-57.

WASS, R. E. 1965: The marine Permian formations of the Cracow district, Queensland. J. Proc. Roy. Soc. New South Wales 98: 159-167.

WASS, R. E., GOULD, I. G. 1969: Permian faunas and sediments from the South Marulan district, New South Wales. Proc. Linnean Soc. New South Wales 93: 212-226.

WATERHOUSE, J. B. 1963a: Permian gastropods of New Zealand. Parts 1-4. N. Z. J. Geol. Geophys. 6: 88-112, 115-154, 587-622, 817-842.

_____ 1963b: *Etheripecten*, a new aviculopectinid genus from New Zealand. N. Z. J. Geol. Geophys. 6: 193-196.

_____ 1963c: The Permian faunal succession in New Zealand. J. Geol. Soc. Aust. 19: 587-622.

_____ 1964: Permian brachiopods of New Zealand. N. Z. Geol. Surv. Paleont. Bull. 35: 1-287.

_____ 1965: Generic diagnoses for some burrowing bivalves of the Australian Permian. Malacalogia 3: 367-380.

_____ 1966: The age of the Croisilles Volcanics, eastern Nelson. Trans Roy. Soc. N. Z. 3 (13): 175-181.

_____ 1967a: Proposal of Series and Stages for the Permian in New Zealand. Trans. Roy. Soc. N. Z. Earth Sci. 5: 161-180.

_____ 1967b: *Oblicarina*, a new Permian bivalve genus. Mem. Qld Mus. 15 (1): 53-57, pl. 7.

_____ 1968: The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. Palaeontographica A 129: 1-94.

_____ 1969: The Permian bivalve genera *Myonia, Megadesmus, Vacunella* and their allies, and their occurrences in New Zealand. N. Z. Geol. Surv. Paleont. Bull. 41.

_____ 1971: The Permian brachiopod genus *Terrakea* Booker, 1930. *In* J. T. Dutro (ed.) Paleozoic Perspectives: A Paleontological tribute to G. Arthur Cooper. Smithson. Contrib. Paleont. 3: 347-361.

_____ 1973: New brachiopod genera from the New Zealand Permian. J. Roy. Soc. N. Z. 3 (1): 35-42.

_____ 1975: New Permian and Triassic brachiopod taxa. Pap. Dep. Geol. Univ. Qld 7 (1): 1-23.

_____ 1976: New occurrences of brachiopod and bivalve species from the Arthurton Group of south Otago and Southland, New Zealand, with comments on structure and stratigraphy. J. Roy. Soc. N. Z. 6 (2): 227-252.

_____ 1977: Chronologic, ecologic and evolutionary significance of the phylum Brachiopoda. *In* E. G. Kauffman, J. E. Hazel (ed.) Concepts and methods in biostratigraphy: 497-518. Stroudsburg, Pa. Dowden, Hutchinson & Ross. [References at end of the book].

_____ 1978: Permian Brachiopoda and Mollusca from northwest Nepal. Palaeontographica A 160 (1-6): 1-175.

_____ 1979: The Role of Fossil communities in the Biostratigraphic Record and in Evolution. *In* J. Gray, A. J. Boucot (ed.) Historical Biogeography, Plate Tectonics and the changing environment: 249-257. Oregon State University Press, Corvallis.

_____ 1980: Permian bivalves from New Zealand. J. Roy. Soc. N. Z. 10: 97-133.

_____ 1982a: New Zealand Permian brachiopod systematics, zonation and paleoecology. N. Z. Geol. Surv. Paleont. Bull. 48.

_____ 1982b: Permian Pectinacea and Limacea (Bivalvia) from New Zealand. N. Z. Geol. Surv. Paleont. Bull. 49.

_____ 1983a: Systematic description of Permian brachiopods, bivalves and gastropods below Wall Sandstone Member, northern Bowen Basin. Pap. Dep. Geol. Univ. Qld 10 (3): 155-179.

_____ 1983b: New Permian invertebrate genera from the east Australian segment of Gondwana. Bull. Ind. Geol. Assoc. 16: 153-158.

_____ 1983c: Back Creek Group. *In* J. B. Waterhouse (ed.) 1983 Field Conference. Permian of the Biloela-Moura-Cracow area. Geol. Soc. Aust. Qld Div. Brisbane: 26-51.

_____ 1983d: An early Djulfian (Permian) brachiopod faunule from upper Shyok Valley, Karakorum Range, and the implications for dating of allied faunas from Iran and Pakistan. Contrib. Himal. Geol. 2: 188-233.

_____ 1986a: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 1986b: New late Palaeozoic invertebrate taxa. Bull. Ind. Geol. Assoc. 19: 1-8.

_____ 1987a: Late Palaeozoic Brachiopoda (Athyrida, Spiriferida and Terebratulida) from the southeast Bowen Basin, eastern Australia. Palaeontographica A 196 (1-3): 1-56.

_____ 1987b: Late Palaeozoic Mollusca and correlations from the southeast Bowen Basin, east Australia. Palaeontographica A 198 (4-6): 129-233.

_____ 1988: Revision of the bivalved Mollusca described by James Dwight Dana 1847-1849 from the Permian of eastern Australia. Pap. Dep. Geol. Univ. Qld 12: 165-228, 20 pl.

_____ 1993: Middle and Late Permian brachiopod succession in New Zealand. *In* R. H. Findlay, R. Unrug, M. R. Banks, J. J. Veevers (ed.) Gondwana Eight: 375-379, 3 fig. Balkema, Rotterdam.

_____ 1998: Ingelarelloidea (Spiriferida: Brachiopoda) from Australia and New Zealand, and reclassification of Ingelarellidae and Notospiriferidae. Earthwise 1: 1-46.

_____ 1999: Some Permian spiriferidan species (Brachiopoda) from New Zealand and Queensland. Earthwise 2: 1-16.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2002a: The stratigraphic succession and structure of Wairaki Downs, New Zealand, and its implications for Permian biostratigraphy of New Zealand and marine Permian of eastern Australia and Gondwana. Earthwise 4: 1-260.

_____ 2002b: Classification within Productidina and Strophalosiidina (Brachiopoda). Earthwise 5: 1-60.

_____ 2004: Permian and Triassic Stratigraphy and fossils of the Himalaya in northern Nepal. Earthwise 6: 1-285.

_____ 2008a: Aspects of the evolutionary record for fossils of the bivalve subclass Pteriomorphia Beurlen. Earthwise 8: 1-219.

_____ 2008b: Golden spikes and black flags – macroinvertebrate faunal zones for the Permian of east Australia. Proc. Roy. Soc. Victoria 120 (1): 345-372.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

_____ 2011: Origin and evolution of Permian brachiopods of Australia. Mem. Assoc. Aust'-asian Palaeont. 41: 205-228.

_____ 2013: The evolution and classification of the Productida. Earthwise 10: 535p.

_____ 2015a: Early Permian Conulariida, Brachiopoda and Mollusca from Homevale, central Queensland. Earthwise 11: 1-390.

_____ 2015b: The Permian faunal sequence at Gympie, southeast Queensland, Australia. Earthwise 12: 1-196.

_____ 2016: On the evolution and classification of Spiriferida (Brachiopoda). Earthwise 14: 1-434.

_____ 2020: Permian brachiopods (Upper Artinskian to Wordian) from the Canadian Arctic. Earthwise 17: 1-477.

_____ 2021a: New species of *Pseudostrophalosia* and *Terrakea* from the upper Mangarewa Formation, Wairaki Downs. Earthwise 18: 123-142.

_____ 2021b:*Trigonotreta victoriae* Archbold from the Lochinvar Formation, New South Wales and the Trigonotretoidea. Earthwise 19: 9-52.

_____ 2021c: Macro-faunal biozones and correlations for the Early Permian (Asselian – Kungurian) marine beds of eastern Australia and New Zealand. Earthwise 19: 181-268.

WATERHOUSE, J. B., BRIGGS, D. J. C., PARFREY, S. M. 1983: Major faunal assemblages in the Early Permian Tiverton Formation near Homevale Homestead, north Bowen Basin, Queensland. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div.: 121-138.

WATERHOUSE, J. B., CAMPBELL, H. J. 2021: Early Perman brachiopods and molluscs from the Dunton Range, west Otago. Earthwise 18: 65-77.

WATERHOUSE, J. B., JELL, J. S. 1983: The sequence of Permian rocks and faunas near Exmoor Homestead, south of Collinsville, north Bowen Basin. *In* Permian geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 231-267.

WATERHOUSE, J. B., VELLA, P. 1965: Permian fossils from Parapara Peak, northwest Nelson. Trans. Roy. Soc. N. Z. Geol. 3 (5): 57-84.

WENZ, W. 1938: Gastropoda. Allgemeine Teil und Prosobranchia. *In* O. H. Schindewolf (ed.) Handbuch der Paläozoologie, Band 6. Teil 3: 481-720. Berlin.

WHITFIELD, R. P. 1908: Notes and observations on Carboniferous fossils and semifossil shells, brought home by members of the Peary expedition of 1905-1906. Amer. Mus. Nat. Hist. Bull. 24: 51-58, 4pl.

WILLIAMS, A. 1953: The classification of the strophomenoid brachiopods. Washington Acad. Sci. J. 43: 1-13.

WILLIAMS, A., CARLSON, S. J., BRUNTON, C. H. C., HOLMER, L. E., POPOV, L. E. 1996: A Supra-ordinal classification of the Brachiopoda. Philosoph. Trans. Roy. Soc. London (ser. B) 351: 1171-1193.

ZITTEL, K. A. von 1895: Grundzüge der Paläontologie (Paläozoologie) 1 Abteilung, Invertebrata. Oldenburg. München and Leipzig: viii + 971p.

7. ***Undopecten*** **FROM THE BLENHEIM FORMATION, NORTH BOWEN BASIN, QUEENSLAND**

Abstract

A specimen with valve conjoined and belonging to *Undopecten* is described.

INTRODUCTION

A moderately well preserved specimen with valves conjoined is described. Unfortunately the registration number inked on the specimen does not convey accurate information in the records held by the Queensland Museum, but the matrix strongly suggests a source from the upper Blenheim Formation.

SYSTEMATIC DESCRIPTION

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Subclass Autobranchiata Grobben, 1894

Infraclass Pteriomorphia Beurlen, 1954

Order PECTINIDA Gray, 1854

Suborder ANOMIIDINA Gray, 1854

Hyporder AVICULOPECTINOIDEI Starobogatov, 1992

Superfamily **AVICULOPECTENOIDEA** Meek & Hayden, 1864

Family **AVICULOPECTENIDAE** Meek & Hayden, 1864

Subfamily **HAYASAKAPECTENINAE** Boyd & Newell, 2000

Hayasakapecteninae incorporates an array of biconvex shells with resilifer. In *Hayasakapecten* Nakazawa & Newell, 1968 which was first described from the Permian faunas of Japan, the plicae are not-costate, whereas in *Undopecten* Waterhouse, 1982, which is based on a species from the mid-Permian of Tasmania, Australia, the plicae are covered by fine costae. The proposal of Hayasakapecteninae (as Hayasakapectininae) was based on a correction by Fang & Morris (1999) of the Newell's interpretation for *Aviculopecten*. The subfamily is here regarded as a senior synonym of Undopecteninae

Waterhouse, 2001, which was further discussed in Waterhouse (2008, pp. 72-81), and the classification improved by Carter et al. (2011). Incidentally in proposing Undopectininae, there was no intention to signifiy that the group was allied to Limida Rafinesque, 1815.

Genus ***Undopecten*** Waterhouse, 1982

Syn. *Morrisipecten* Muromseva & Guskov in Muromseva, 1984; *Altaipecten* Yang & Chen, 1985.

Diagnosis: Left valve inflated, right valve less convex, right anterior auricle large with small byssal notch, wings large. Both valves plicate and costate. Growth lines arch ventrally in interspaces. Hinge with well-formed resilfer.

Type species*: Pecten fittoni* Morris, 1845 from Mt Wellington, Tasmania, OD.

Undopecten sp.

Fig. 1, 2

Material: A specimen UQF 12870 with valves conjoined, preserved as exterior of right valve and internal mould with shell attached of both valves. Hinge largely destroyed and left valve wings broken.

Dimensions in mm:

Length	Height	Width
68 est.	70	21

Description: Valves biconvex and subequally inflated, maximum length placed near mid-height, and hinge less extended. The right anterior auricle is long and bears four costae, increasing in strength towards the hinge, above a byssal notch that extends for half the length of the auricle. The posterior wing of the right valve bears well defined growth increments, without costae. Like the wings of the left valve, it is broken short, and the left valve wings appear to lack ribs, but are decorticated. Both valves bear gently convex opposing plicae with broadly rounded crests separated by corresponding concave interspaces: the plicae are irregular in strength and width, and number twelve or so. Costae cover both valves, numbering seven in 10mm at the ventral margin, and are of uneven strength, most persistent, some increasing through intercalation. According to Waterhouse (1982, p. 37), the primary costae pass along the interspaces in the left valve in type *Undopecten*, as well shown on the original specimen of *fittoni* Morris (see Morris 1845, pl. 14, fig. 2; Waterhouse 1982, pl. 19, fig. b), but it is not possible to verify this for the present specimen, which may imply a significant difference. Little of the ligament area remains, and no muscle scars are visible.

Fig. 1. *Undopecten* sp., external impression of right valve UQF 12870, with some shell intact, x1.

Resemblances: Type and allied material from Tasmania and the Maitland Group of New South Wales in the north and south Sydney Basin have a well rounded outline and fine costae, as displayed by specimens figured by Morris (1845, pl. 14, fig. 2; refigured in Koninck (1877, pl. 21, fig. 4, 4a), Etheridge & Dun (1906, pl. 8, fig. 1-3, pl. 10, fig. 6), Fletcher (1929, pl. 8, fig. 1, 2) and Waterhouse (1982, pl. 19, fig. b). Specimens figured from Ravensfield Quarry in the upper Dalwood Group of the north Sydney Basin by Waterhouse (1982, pl. 19, fig. c, e) look somewhat similar, but appear to have stronger plicae, though not well preserved. Waterhouse (1982, p. 37) hesitated over the identification of an internal mould of a left valve figured from Ravensfield Quarry in the Farley Formation by Etheridge & Dun (1906, pl. 16, fig. 1), because the figure does not show plicae. Koninck (1877, pl. 21, fig. 4, 4a) added figures, and Dickins (1981, pl. 2, fig. 17) reported a broken left valve impression from Warwick, south Queensland.

Deltopecten depressus Fletcher, 1929 from Kioloa near Ulladulla in the south Sydney Basin is allied. The lectotype, designated in Waterhouse (1982, p. 37) as the specimen AMF 19098 of Fletcher (1929, pl. 9, fig. 1), is more elongate than usual for *fittoni.*

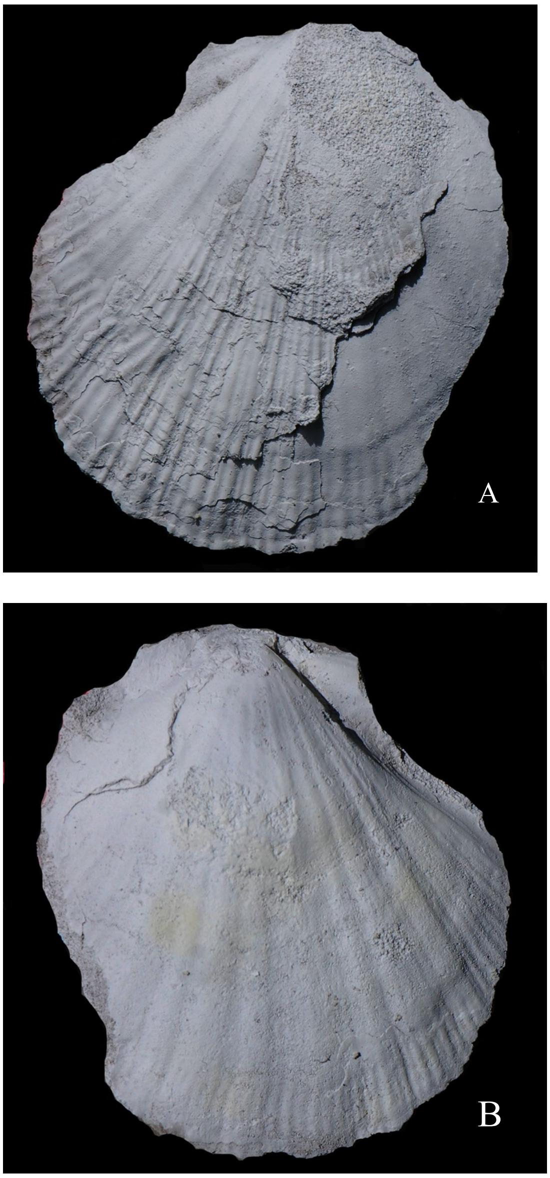

Fig. 2. *Undopecten* sp., UQF 12870 from Blenheim Formation, x1, left and right valve aspects of specimen with valves conjoined. This fitted into the external mould shown in Fig. 1.

Specimens from the same locality that were figured as the same species by Fletcher (1929, pl. 10, fig. 1, 2) look more more like *Etheripecten*.

Aviculopecten? *imbricatus* Etheridge Snr (1872, p. 327, pl. 14, fig. 2) from the Rammutt Formation in the Gympie Province of southeast Queensland has finely costate and numerous plicae, according to the illustration, to constitute a distinctive species which is judged to be of Asselian (basal Permian). Unfortunately the specimen cannot now be found, and no further specimens were recorded amongst the specimens from the Rammutt

Formation and kept at the Queensland Museum and Museum of Victoria in Melbourne by Waterhouse (2015, p. 33).

REFERENCES

BEURLEN, K. 1954: Las faunas lamellibranchios do sistema Genduanicos no Parana. *In* F. W. Lange (ed.). Paleontologia do Parana. Comissao de Comemoraçaos do Centenareo Parana, Curutiba: 107-136, 7pl.

BOYD, D. W., NEWELL, N. D. 2000: The importance of recently reported specimens of the Late Paleozoic bivalve *Aviculopecten planoradiatus* McCoy [sic = M'Coy]. Acta Palaeont. Sinica 39 (4): 533-534.

CARTER, J. G. et al. (51 authors) 2011: A synoptical classification of the Bivalvia (Mollusca). Paleont. Contrib. 4: 1-47.

CUVIER, G. 1797: Tableau élémentaire de l'histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DICKINS, J. M. 1981: A Permian invertebrate fauna from the Warwick area, Queensland. Bull. Bur. Mineral. Resourc. Geol. Geophys. 208: 23-43.

ETHERIDGE, R. Snr 1872: Appendix 1: Description of the Palaeozoic and Mesozoic fossils of Queensland. *In* DAINTREE R. Notes on the geology of the colony of Queensland. Quart. J. Geol. Soc. London 28: 317-350.

ETHERIDGE, R. Jnr, DUN, W. S. 1906: A monograph of the Carboniferous and Permian Invertebrata of New South Wales, volume 2 – Pelecypoda, part 1 – The Palaeopectens. New South Wales Geol. Surv. Palaeont. 5: 1-39.

FANG ZONG-JIE, MORRIS, N. J. 1999: On the genera *Aviculopecten* and *Heteropecten*. Acta Palaeont. Sinica 34 (2): 148-154. **get from Guang**

FLETCHER, H. O. 1929: Contributions on the Permo-Carboniferous Aviculopectinidae of New South Wales. Rec. Aust. Mus. 17: 1-35.

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

GROBBEN, C. 1894: Zur Kenntniss der Morphologie, der Verwandtschafts-verhältnisse und des systems der Mollusken. K. Akad. Wiss. (Math.-Naturwiss. Cl.) Sitzbericht. 103 (1): 61-86.

KONINCK, L. G. de 1866-77: Recherches sur les Fossiles paléozoiques de la Nouvelle Galles de Sud (Australie). Mém. Soc. Roy. Sci. Liège (ser. 2) 6, 7. [English translation by T. W. E. David, 1898 Geol. Surv. New South Wales, Palaeont. Mem. 6].

LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MEEK, F. B., HAYDEN, F. V. 1964: Palaeontology of the Upper Missouri. Smithson. Contrib. Knowledge 14 (5, 172): 135p.

MORRIS, J. 1845: Descriptions of fossils. *In* STRZELECKI, P. E. de Physical description of New South Wales and Van Diemen's Land: 270-291. Longman, Brown, Green & Longman, London.

MUROMSEVA, V. A. 1984: Permian marine deposits and bivalved Mollusca from the Soviet Arctic. Trudy VNIGRI 336: 1-154. [Russ.]

NAKAZAWA, K., NEWELL, N. D. 1968: Permian bivalves of Japan. Mem. Fac. Sci. Kyoto Univ. Ser. Geol. Mineral. 35 (1): 1-108.

RAFINESQUE, C. S. 1815: Analyse de la Nature ou Tableau de l'University et des Corps Organisés, etc. Jean Barravecchia. Palermo.

STAROBOGATOV, Y. I. 1992: Morphological basis for phylogeny and classification of Bivalvia. Ruthenica 2 (1): 1-25.

WATERHOUSE, J. B. 1982: Permian Pectinacea and Limacea (Bivalvia) from New Zealand. N. Z. Geol. Surv. Paleont. Bull. 49.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2008: Aspects of the evolutionary record for fossils of the bivalve subclass Pteriomorphia Beurlen. Earthwise 8: 1-219.

_____ 2015: The Permian faunal sequence at Gympie, southeast Queensland, Australia. Earthwise 12: 1-196.

YANG ZHI-RONG, CHEN JIN-HUA 1985: Some new material of Carboniferous pectinoid bivalves from Tian Shan Mountains and Junggar (Dzungarian) Basin of Xinjian, northwest China. Acta Paleont. Sinica 24 (4): 377-387. [Chin.]

9. MACRO-FOSSILS OF THE *Ingelarella costata* ZONE IN THE UPPER BLENHEIM FORMATION AND CORRELATES OF THE BOWEN BASIN, QUEENSLAND

Abstract

A small fauna from the upper marine deposits in the Bowen Basin is summarized from the account by Dickins (1989), involving a few brachiopods and more molluscs from the upper Blenheim Formation, Exmoor Formation, MacMillan Formation and other levels. The zone is named after *Ingelarella costata*, but there needs to be clarification of fossil localities and expansion of the fossil content. The zone is judged to be correlative with uppermost beds of Mangarewa Formation in New Zealand, which contains some of the same and characteristic brachiopod and bivalve species and clearly lies above faunas of earlier Guadalupian age..

New taxon: *Pseudostrophalosia routi cryptica* n. subsp.

INTRODUCTION

This article discusses small faunas from the Bowen Basin which appear to be correlative with each other and which come from the youngest marine levels of the Bowen Basin. Collection MC 803 kept at the AGSO, formerly Bureau of Mineral Resources, Geology & Geophysics at Canberra, ACT, was first described and illustrated by Dickins (1989) in an overview of what he considered to be the youngest marine fossils to be found in the northerly outcrops of the Bowen Basin. The locality was described in Malone et al. (1964, p. 63) as coming 2.5 miles north-north-west of Blenheim Homestead, and shown near the top of a stratigraphic column in Malone et al. 1964, plate 4, column E, approximately 800ft higher than MC fossil locality MC802, which appears to have come from the Scottville Member (= Big Strophalosia band), with *Strophalosia* (now *Pseudostrophalosia*) *clarkei* (Etheridge) identified by Dickins in Malone et al. (1964, p. 63). This thickness compares with estimates provided by Dear (1972, p. 11) for the Pelican Creek fauna (see p.) commencing some 300ft above the Big Strophalosia band, with allied fossils 100ft above the *pelicanensis* bed, and the Havilah Member, found approximately 300ft above the *pelicanensis* bed, and it therefore appears that the MC803 fauna comes from a slightly younger level. Dickins (1989) did not provide any data on the relationship of the MC803 fauna to the Havilah fauna, but the fauna he described, even before adjusting the identifications, shows nothing in common with the fossils described herein from the Pelican Creek bed but shares *Ingelarella havilensis* Campbell with what Dear (1972) called the Havilah fauna. This fauna is other wise undescribed. The implication from articles by Dickins (1983, 1989) is that the fauna was younger than the Pelican Creek or other faunas, including those from the Scottville Member or Big Strophalosia Band, the Mantuan band and other faunas. This is strongly supported by the nature of two critical Productida, which are generically and specifically distinct from Productida of the underlying Scottville and Pelican Creek faunas. Some of the molluscs on the other hand are related to those of the younger Guadalupian Series in the Sydney Basin.

Several of the same or closely related bivalves were identified by Dickins at localities UDC1 and UDC2 from the MacMillan Formation (originally a member) of the Comet Shelf, east of the Denison Trough in the southwest Bowen Basin (Derrington & Morgan 1960, Derrington 1961, Paten 1969, Fig. 6, Malone et al. 1969, Table 2, p. 48).

Moderately well preserved specimens found in the upper Blenheim beds at Tay Glen Crossing in the Clermont Sheet (Veevers et al. 1964) are identified with a distinctive brachiopod found with the same bivalves in New Zealand. The locality CL21/5 was noted by Dickins in Veevers et al. (1964, p. 83) as being above the *clarkei* bed, and the relationships are further illustrated by Veevers et al. (1964, Fig. 22).

Fossil localities, from Dickins (1989)

B 1572. Bowen 1:250 000 Sheet area 20°47’15” S, 147°44’45”E. Upper part of Blenheim Subgroup.

MC 292. Mount Coolon 1:250 000 Sheet area. (BMR report no. 66). Collinsville road crossing of Blenheim Creek, Exmoor Formation.

MC 803. Mount Coolon 1: 250 000 Sheet area; 4 km NNW of Blenheim Homestead; upper part of Blenheim Subgroup.

UDC1. (Utah Development Co.) Duaringa 1: 250,000 Sheet area (BMR Report No. 121); on fence about 4km NE of Lyra Park homestead; MacMillan Formation.

UDC2. Duaringa 1:250,000 Sheet area (BMR Report No. 121); Cattle Creek, 8km northwest of Mount Stuart homestead; MacMillan Formation.

Black Alley Shale. Springsure 1: 250,000 Sheet area; about 2m above base of type section, in the main west branch of Dry Creek, about 3km SE of Black Alley Peak.

Tay Glen Crossing, and **CL21/5**. Clermont 1: 250 000 Sheet area (BMR Report no. 66), crossing of Phillips Creek immediately north of Tay Glen homestead. Upper part of Blenheim Subgroup.

SIGNIFICANCE OF THE FAUNAL ASSEMBLAGE

At first sight, this article by Dickins (1989) appears to be of limited significance. It does not follow the accepted procedures of taxonomy and systematic description, omitting synonymies and statement of type specimens for most taxa, providing only brief summaries of locations for fossil localities, with grid references far too coarse to be of any practical use, and full of grievances against other workers in the field. Moreover the ideas on correlation stand in sharp conflict to those advocated by McClung (1981 etc), Briggs (1998), and Draper (2013), let alone a number of palynomorph studies, as summarized in Smith et al. (2017). In his understanding of Bowen Basin stratigraphy and correlation with the rocks and faunas of the Sydney Basin, Dickins was guided by extensive and expert field mapping over many years by teams of geologists from the then Bureau of Mineralogy, Geology and Geophysics at Canberra with help from the Geological Survey of Queensland. My own reasonably extensive – and intensive – field work and systematic studies have largely endorsed that understanding, in the face of much misrepresentation and misunderstanding. Dickins (1989) on the basis of field-work by his Canberra colleagues summarized the marine macro-fossils in the northern and western Bowen Basin. Re-examination of these specimens, including inspection of his material kept at AGSO, Canberra, confirms that most of the species differ from those of the underlying macro-faunal biozones present in the Scottville Member (*Pseudostrophalosia clarkei* Zone) and overlying beds up to and including the *Streptorhynchus* (now *Isbellina*) *pelicanensis* bed with the Pelican Creek fauna of Dear (1972), now classed in the *Marginalosia minima* Zone (see pp. herein). These faunas are very different from the still older Mantuan Formation, which has widely if inaccurately been proclaimed as containing the youngest marine fauna of the Bowen Basin (McMinn 1985). What is known of the fossils studied in the present article strongly suggests that they constitute a valid and recognizable zone, here named after *Ingelarella costata.* One of two accompanying Productida, as revised herein, shows some approach to a productid from beds with *Ingelarella costata* in New Zealand: the other also approaches a species from the same New Zealand fauna, but is too incompletely preserved to allow full analysis. A number of bivalves are also distinctive, and gastropods include the longer-lived *Platyteichum loratum* Waterhouse. To judge from preliminary fossil lists provided by Dickins in the reports on 1:250,000 sheet studies, a number of other fossils remain to be described.

But although a macro-faunal zone is recognized, it fails to meet the standards set for other zones in this monograph as in Part 11, starting on p. . The chief difficulty lies in the sparse stratigraphic information and locality data provided in the reports from the Bureau of Mineral Resources, Geology and Geophysics or Dickins (1989). The very large-scale mapping and the oversimplified stratigraphic columns do not locate the fossil localities with any degree of precision: in other words – the geological aspect has short-comings. It would be preferable to anchor the zone to adequately scaled geological maps (ie. certainly scaled at no more than 1: 50 000) to show the source of fossil collections, and reinforced where desirable by measured stratigraphic columns, and further documented if possible by field and aerial photographs. Such information is not available for this zone in Australia. On the other hand, there remains considerable value in recognizing a zone, if only provisionally, with the hope that sometime in the future, the challenge of providing much fuller stratigraphic detail may be met.

There is further value to gained from the Dickins article and the zonal concept. Evidence suggests that the zone is also present in the upper Mangarewa Formation of New Zealand. The particular beds contain very much more substantial and extensively described faunas than so far uncovered in the Bowen Basin, as discussed at the end of this article, and these beds and fossil localities have been mapped at a scale of 12 500, with supporting field photographs and sketches (Waterhouse 2002, 2021).

SYSTEMATIC DESCRIPTIONS

Phylum Coelenterata Frey & Lenckhart, 1847

Class Scyphozoa Gotte, 1887

Subclass Conulata Miller & Harrington, 1956

Order **CONULARIIDA** Miller & Gurley, 1896

Family **CONULARIIDAE** Walcott, 1886

Subfamily **PARACONULARIINAE** Sinclair, 1952

Genus ***Gondaconularia*** Waterhouse, 1986

Diagnosis: Corner furrows well defined, smooth and not crossed by transverse ribs, which lie over the faces but stop at the furrows. Ribs not inflected apically or adapically at corner grooves, no interspatial ribs.

Type species: *Gondaconularia elviniaria* Waterhouse 1986, p. 15 from Elvinia Formation, southeast Bowen Basin, OD.

Discussion: Another east Australian Permian ally is *Nothoconularia* Thomas, 1969, which has a well developed rib along each of the corner furrows.

Gondaconularia? sp.

1989 Conulariid indet. Dickins, p. 77, pl. 5, fig. 15.

A specimen was reported from the MacMillan Formation, at UDC1. The figure is uninformative, but Dickins stated that the ribs in the single preserved furrow were obscure, which suggests the genus *Gondaconularia*.

Phylum Brachiopoda Duméril, 1806

Subphylum Rhynchonelliformea Williams et al., 1996

Superorder PRODUCTIFORMI Waagen, 1883

Order PRODUCTIDA Waagen, 1883

Suborder STROPHALOSIIDINA Waterhouse, 1975

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Tribe **WYNDHAMIINI** Waterhouse, 2010

Genus ***Pseudostrophalosia*** Clarke, 1970

Diagnosis: Suboval shells, the ventral valve moderately to well inflated with small cicatrix and dense semirecumbent to recumbent spines generally arranged in commarginal rows, in two series over disc and trail, and, as prime characteristic, close-set spines clustered over the ventral ears. Dorsal valve with numerous fine spines, and may be heavily thickened, especially anteriorly.

Type species: *Strophalosia brittoni* Maxwell, 1954, p. 543 from Tiverton Formation (Sakmarian), Bowen Basin, OD.

Pseudostrophalosia routi cryptica n. subsp.

Fig. 1, 2

1989 *Echinalosia* cf. *minima* [not Dear] – Dickins, p. 75, pl. 3, fig. 2-5, 11 (part, not fig. 1, 6? = *Terrakea densispinosa* Waterhouse; not fig. 10, 12-21 = *Nonauria laminata* n. sp. – see p. .

Derivation: crypta – cave, pit; Lat.

Diagnosis: Small shells with wide hinge, ventral spines subuniform and erect, evenly spaced in quincunx over the disc, coarse and few over the ears, dorsal spines fine, erect.

Holotype: CPC 25285 figured by Dickins (1989, pl. 3, fig. 4), from MC 803, uppr Blenheim beds, Mt Coolon, here designated.

Description: Shells small, little over 20mm wide, with wide hinge, maximum width placed towards anterior third of shell length, broad umbo with angle more than 150°, low ventral interarea in plane of disc and low dorsal interarea steeply inclined to the commissure. There is no sulcus or fold. Ventral spines over the disc are close to 1mm in diameter and regularly spaced over the disc in quincunx, with only a few thinner and recumbent spines irregularly disposed. The posterior lateral spines are coarse and few, preserved on the holotype as confirmed through examination of the material at the then Bureau of Mineral Resources, Geology & Geophysics (now AGSO), Canberra, and they arise from shell that extends from the small ears forward along the lateral margin. Commarginal growth rugae and increments are low over the ventral valve, and are more noticeable on the dorsal valve. Dickins (1989) reported a number of irregularly arranged dorsal spines.

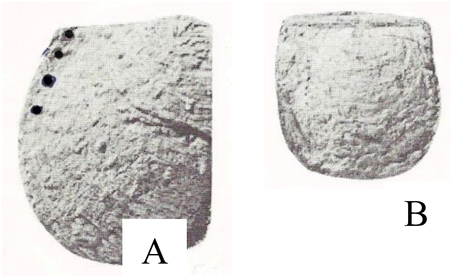

Fig. 1. *Pseudostrophalosia cryptica* n. sp. A, ventral valve holotype CPC 25285, x1. Black dots show position of large spines, based on inspection at Canberra. B, dorsal external mould with ventral interarea, CPC 25287. Specimens x1, from MC803, upper Blenheim Subgroup. (Dickins 1989).

The adductor platform is narrow and high, bordered by deeply impressed diductor scars. There are short grooves in front of the muscle field (Dickins 1989, pl. 3, fig. 2), but spine tunnels are not strongly developed. The dorsal interior is not known.

Resemblances: This species is highly distinctive in size, shape and ornament. It is readily distinguished from *Echinalosia* (*Unicusia*) *minima* from the underlying Pelican Creek bed through the presence of coarse posterior lateral spines over the ventral valve, and lacks many of the features of *minima*, such as marginal ridge and well defined muscle field, narrower ventral umbo and other features, Dickins (1989, p. 75) allowing that he could not readily distinguish between the species *clarkei, minima*, *ovalis* and *gattoni*, though even this range is not broad enough, because he also included two specimens of a paucispinaurian amongst the shells he compared with *minima*. Even by the 1980’s. it would have been only Dickins who ws willing to state that he could not distinguish between these species and

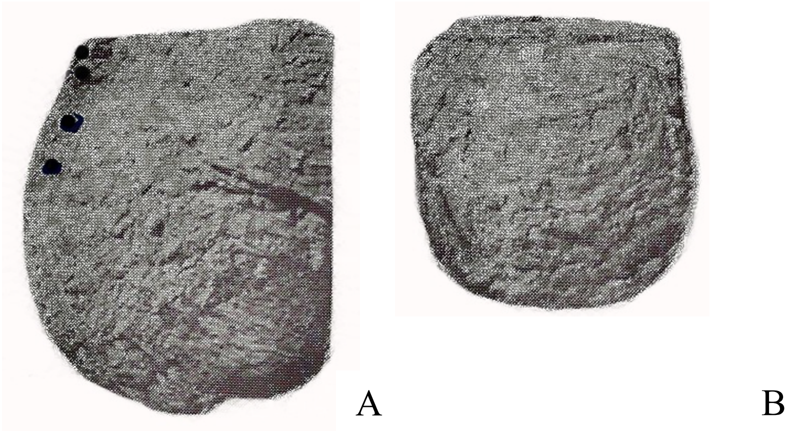

Fig. 2. *Pseudostrophalosia inflata cryptica* n. subsp. A, ventral valve holotype CPC 25285, x2. Black dots show position of large spines. B, dorsal external mould CPC 25290, x2. From MC803, reproduced by local equalization. (Dickins 1989).

genera, which had been competently segregated by Maxwell (1954) and other authors, going back as far as Etheridge and Booker.

The specimens are regarded as a subspecies of *Pseudostrophalosia routi* Waterhouse (2021, p. , Fig. 1-5) from the *Ingelarella costata* Zone in the upper Mangarewa Formation of New Zealand. The present form shares the generic position and age, and wide hinge with *routi*, but is much smaller, possibly reflecting environmental conditions. The Queensland specimens show spine detail, which is not yet available for the New Zealand form. *Pseudostrophalosia blakei* and its junior synonym *Ps. ingelarensis* differ in their more variable shape and better defined ventral muscle field, but do include specimens approaching *cryptica* in shape and as a rule lacks prominent spine tunnels.

Suborder LINOPRODUCTIDINA Waterhouse, 2013

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

Family **PAUCISPINAURIIDAE** Waterhouse, 1986

Subfamily **PAUCISPINAURIINAE** Waterhouse, 1986

Tribe **PAUCISPINAURIINI** Waterhouse, 1986

Genus ***Terrakea*** Booker, 1930

Diagnosis: Ventral valve with incurved umbo, visceral disc thick, capillae over both valves, spine ornament distinguished by a cluster of thick erect spines over ventral umbonal slopes and ears, dorsal anterior disc and trail spines may also be thick.

Type species: *Productus brachythaerum* Morris (1845, p. 284, pl. 2, fig. 4c) from Broughton Formation, Gerringong Volcanics, south Sydney Basin, OD.

Terrakea densispinosa Waterhouse, 2021

Fig. 3, 4

1964 *Terrakea brachythaera* [not Morris] – Waterhouse, p. 73, pl. 12, fig. 1-8, pl. 13, fig. 1-12, pl. 14, fig. 1-13, pl. 37, fig. 1. Text-fig. 23c, 24D, E, 26-31.
1978 *T. brachythaera* – Suggate et al., text-fig. 4.5, Fig. 4, 5, 11.
1981 *T. brachythaerum* – Speden, pl. 5, fig. 4, 5, 11.
1989 *Echinalosia* cf. *minima* [not Maxwell] – Dickins, p. 75, pl. 3, fig. 1, 6 (part, not fig. 2-5, 11 = *Pseudostrophalosia routi* n. subsp. not fig. 10, 12-21 = *Nonauria laminata* n. sp.
2021 *T. densispinosa* Waterhouse, p. 131, Fig. 6-9.

Diagnosis: Shells transverse as a rule, but some specimens slender and elongate, disc as a rule gently transverse, lateral walls high, dorsal disc curves sharply into a trail of moderate but not exceptionally great height, radial ornament strongly developed and totalling some 120 ribs across the valve. Spines crowded over both valves, with short elongate bases over ventral disc, strong, erect and crowded over ventral ears; numerous and erect over dorsal valve.

Holotype: BR 66, figured in Waterhouse (1964, pl. 13, fig. 12) and Waaterhouse (2021, Fig. 6B) from GS 6071 (D44/ f9622), upper Mangarewa Formation, Wairaki Downs, Southland, OD.

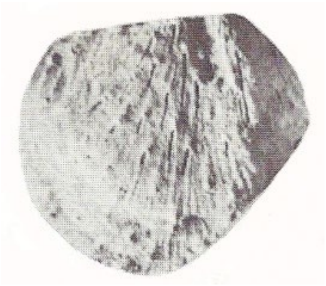

Fig. 3. *Terrakea densispinosa* Waterhouse, ventral, aspect of specimen CPC 25285 from MC803. This was compared by Dickins (1989) to *Echinalosia minima* [not Maxwell], x1.5. (Dickins 1989).

Description: Dickins (1989) measured one specimen as 36mm wide, 28mm long and approximately 20mm high. The Queensland specimens are moderately transverse with umbonal slopes diverging at varying angles, relatively high disc, no sulcus or fold, and trail of only moderate height. Capillae are well developed over both valves, and the dorsal disc is crossed by prominent commarginal subrugae. Ventral disc spine bases are moderately coarse, over 1mm in diameter, but have very short bases, and two capillae may converge into one spine base. A specimen kept at AGSO, Canberra, that was not figured has a few erect spines over one ear, varying in diameter, and a specimen figured as *Echinalosia* by Dickins (1989, pl. 3, fig. 1) shows two or three moderately strong spines on the inner ears.

Ventral adductor scars are very narrow and elongate, and the diductor impressions oval with deep narrow ridges and grooves, extending a little in front of the adductor scars. The dorsal adductor scars are rounded and raised and comparatively smooth, and the slender median septum extends well forward almost to the anterior end of the visceral disc. The outline of the brachial shield is preserved on one side of the measured specimen.

Resemblances: This species is close in several respects to *Terrakea densispinosa*

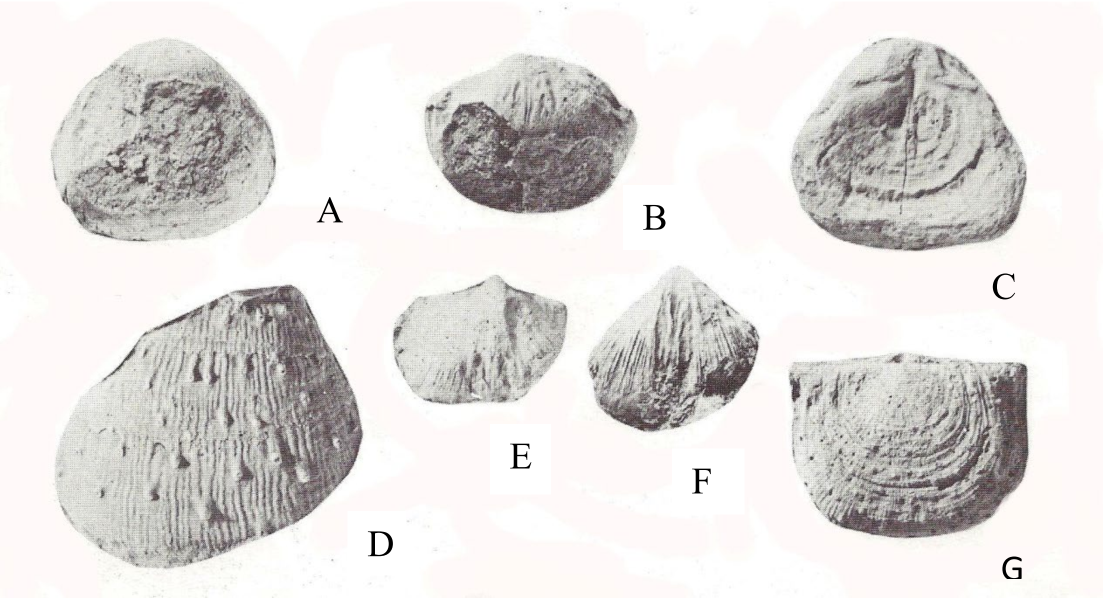

Fig. 4. *Terrakea densispinosa* Waterhouse. A-C, ventral, ventral posterior and dorsal aspects of measured specimen, CPC 25280, x1. D, detail of ventral exterior, CPC 25281, x2. E, F, ventral internal moulds CPC 25282 and CPC 25284, x1. G, dorsal external mould CPC 25283, x1. From MC803. (Dickins 1989).

Waterhouse (2021, p. , Fig. 6-9, also described in Waterhouse, 1964, p. 73, pl. 12, fig. 1-8, pl. 13, fig. 1-12, pl. 14, fig. 1-13, pl. 37, fig. 1. Text-fig. 23c, 24D, E, 26-31) from the uppermost Mangarewa Formation at Wairaki Downs, New Zealand. It has a comparatively high ventral disc and short ventral disc spine bases. Radial capillae are moderately well developed, dorsal spines numerous, and muscle scars are also similar. The two suites come from correlative beds. However, the present specimens are much less well known. No specimen figured by Dickins (1989) shows ventral ear spines adequately, and another specimen not figured by Dickins shows some five erect spines over the ear of a very small specimen.

Class Rhynchonellata Williams et al., 1996

Superorder SPIRIFERIFORMII Waagen, 1883

Order SPIRIFERIDA Waagen, 1883

Suborder MARTINIIDINA Waterhouse, 2010

Superfamily **INGELARELLOIDEA** Campbell, 1959

Family **INGELARELLIDAE** Campbell, 1959

Genus ***Ingelarella*** Campbell, 1959

Ingelarella havilensis Campbell, 1960

Fig. 5

1960 *Ingelarella havilensis* Campbell, p. 1120, pl. 139, fig. 3-6.
1965 *I. ingelarensis* [not Campbell] – Waterhouse & Vella, p. 68, pl. 4, fig. 1, 4-6 (part, fig. 3, 4 indet]. **recheck WV id**
1965 *I. mantuanensis* [not Campbell] – Waterhouse & Vella, p. 69, pl. 5, fig. 1.
1965 *I. dissimilis* [not Waterhouse] – Waterhouse & Vella, p. 69, pl. 5, fig. 2.
?1969 *Ambikella havilensis* – Runnegar & Ferguson, p. 254, pl. 4, fig. 6-8.
1982 *Tomiopsis ingelarensis* [not Campbell] – Waterhouse, p. 56, pl. 23e, j.
1983 *I. havilensis* – Dickins, Fig. 3A-E, ?F.
1989 *Martiniopsis havilensis* – Dickins, p. 77, pl. 4, fig. 15-17?, pl. 5, fig. 1-5, ?13, 14 (part, not pl. 4, fig. 8-14 = *I. costata*, pl. 5, fig. 6-11 = plicate transverse shells from Exmoor Ftm).
?2015 *I.* cf. *havilensis* – Waterhouse, p. 114, Fig. 40A, B.

Discussion: *Ingelarella havilensis* was reported from MC803, upper part of the Blenheim Formation by Dickins (1989). He had included three different species as *havilensis*, and the MC803 specimens are moderately close to type *havilensis* (Dickins 1989, pl. 5, fig. 1, 2, 5, 14), though one ventral interior has well spaced adminicula.

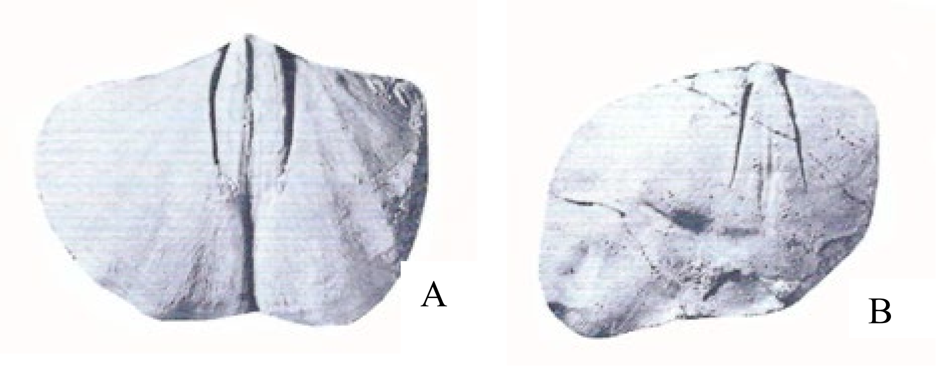

Fig. 5. *Ingelarella havilensis* Campbell. A, ventral valve CPC 25298 from MC803, x1. B, dorsal valve CPC25297 from UDC2, x1. (Dickins 1989).

Dickins (1989, pl. 5, fig. 6-11) also reported specimens from MC292 in the Exmoor Formation of Koppe (1974), defined as the uppermost unit of the Blenheim Subgroup, with type section based on a drill-core. These specimens, figured only as ventral valves, are transverse with strong plicae, and no strikingly well developed median sulcal groove. They belong to an indeterminate species, in need of clarification of the dorsal valve and internal attributes, unless they are badly worn or feebly plicate specimens of *costata*, at early maturity. Specific affinities of other ventral valves figured by Dickins (1989, pl. 5, fig. 12, 13) are also uncertain. These come from locality B1572, from the upper part of the Blenheim Subgroup, and the larger specimen (fig. 13) is a transverse internal mould with widely spaced adminicula, no plicae, and deep anterior median groove. The hinge is wide and posterior shell thick, to suggest an approach to *Johndearia pelicanensis* (Campbell, 1960), and perhaps the known range of this species needs to be extended. This specimen is moderately close to a specimen figured from South Marulan by Wass & Gould (1969, pl. 15, fig. 15), but other ingelarellids from South Marulan have a gently concave ventral sulcus, without median groove, in contrast to the deep groove of the specimens from B 1572. .

Ingelarella costata Waterhouse, 1964

Fig. 6

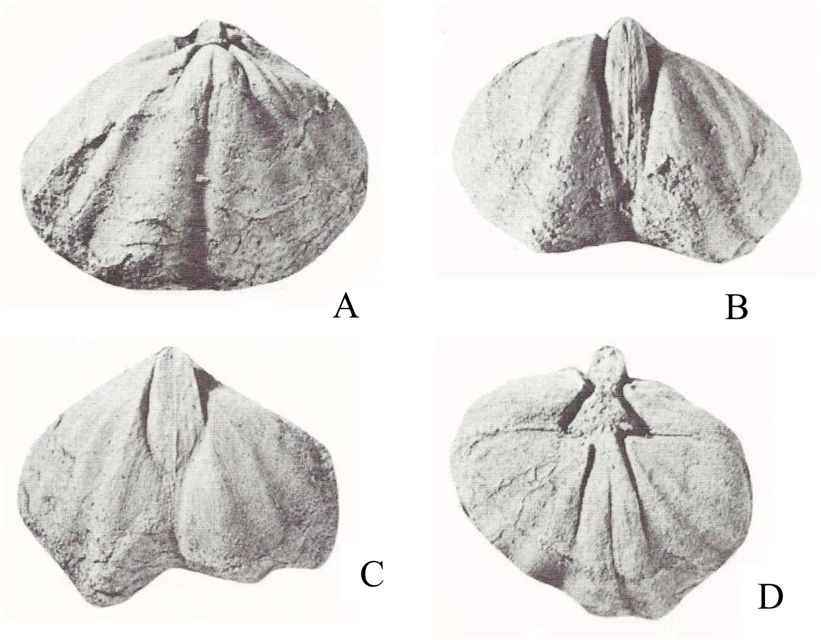

Fig. 6. *Ingelarella costata* Waterhouse. A, B, dorsal and ventral aspects of internal mould, CPC 29291, x1. C, ventral aspect, internal mould, CPC 29293, x1. D, ventral aspect, internal mould CPC 29294, x1. From Tay Glen Crossing. (Dickins 1989).

1964 *Ingelarella costata* Waterhouse, p. 159, pl. 31, fig. 6, 9-15, pl. 32, fig. 1-3, pl. 35, fig. 2, 3, Text-fig. 75, 76.
1968 *Ambikella costata* – Waterhouse, p. 67, pl. 12, fig. 2-5, 11.
1982 *Tomiopsis costata* – Waterhouse, p. 57, pl. 14F.

1989 *Martiniopsis havilensis* [not Campbell] – Dickins, p. 77, pl. 4, fig. 8-14 (part, not fig. 15, 16, 17?, pl. 5, fig. 2-5, 13, 14 = *havilensis*, pl. 5, fig. 6-11 = sp. indet.). **cf p. 296**

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

Holotype: BR 613 from uppermost Mangarewa Formation, New Zealand, figured by Waterhouse (1964, pl. 31, fig. 6, 11, 13, 15, pl. 35, fig. 2, 3), OD.

Phylum Mollusca Cuvier, 1797

Class Bivalvia Linnaeus, 1758

Clade Eubivalvia J. G. Carter *in* Carter et al. 2011

Superorder **NUCULIFORMII** Dall, 1889

Superfamily **NUCULOIDEA** Gray, 1824

Family **NUCULIDAE** Gray, 1824

Subfamily **PALAEONUCULINAE** Carter, 2001

Genus ***Pseudonucula*** Dickins, 1989, 2022

Derivation: pseudo – false, Lat., nucula, generic name.

Diagnosis: Hinge taxodont, no resilifer present, ornament of ribs.

Type species: *Pseudonucula bradshawensis* Dickins, 1989 from upper Blenheim Formation, Queensland, OD.

Discussion: Dickins (1989) did not follow the prescribed rules for proposing a new genus for his *Pseudonucula bradshawensis,* claiming that his proposal was a “nom. nov.” because he was not sure if it was really new, which means he was uncertain, to imply that the name was provisional. That is one area where scientific caution clashes with rules mandated for taxonomic nomenclature, which insist that proposals must be without cautions (ICZN 1999, Article 15.1). To retrieve the situation, and avoid any possibility of a third party claiming the genus for his or her own, the name is here repeated as a proposed new genus rather than nom. nov. and ascribed to J. M. Dickins. Consequently the date of publication can be either 1989 or 2022.

Pseudonucula bradshawensis Dickins, 1989

Fig. 7

1989 *Pseudonucula bradshawensis* Dickins, p. 66, pl. 1, fig. 1-7.

Diagnosis: Slightly transverse shells with subrounded outline and broad umbo placed near anterior third, exterior smooth apart from commarginal growth threads. Dentition extends from mid-height around posterior shell, without resilifer.

Holotype: CPC 25255 from MC803, upper Blenheim Subgroup, figured by Dickins (1989, pl. 1, fig. 6, 7) and herein as Fig. 7, OD.

Discussion: This species was recorded by Dickins from the upper Blenheim Formation (MC803) and the MacMillan Formation at UDC1 (pl. 1, fig. 4, 5).

Fig. 7. *Pseudonucula bradshawensis* Dickins, internal view of holotype CPC 25255 from MC803, x4. (Dickins 1989).

Family **NUCULANIDAE** H. & A. Adams, 1853-59

Subfamily **POLIDEVCIINAE** Kumpera, Prantl & Rûžicka, 1960

Genus ***Glyptoleda*** Fletcher, 1945

Diagnosis: Costae form a V pointing towards the ventral margin, outer escutcheon ridges present.

Type species: *Glyptoleda reidi* Fletcher, 1945 from Ingelara Formation, OD.

Glyptoleda flexuosa Waterhouse, 1965b

Fig. 8

1965b *Glyptoleda flexuosa* Waterhouse, p. 650, pl. 98, fig. 6-12, text-fig. 5.
1989 *G. flexuosa* – Dickins, p. 68, pl. 1, fig. 11-13 (part, not fig. 9 = *simplicata*).

Diagnosis: Costae form opisthocline V, not well defined, a number of small V's. Subrounded anterior portion, beaks close to mid-length.

Holotype: TM 3511 from upper Mangarewa Formation, New Zealand, figured in Waterhouse (1965, pl. 98, fig. 7-9), OD.

Discussion: This form was reported from MC 803, upper Blenheim Formation, and also from the MacMillan Formation by Dickins (1989, pl. 1, fig. 8, 9). The original specimens came from the upper Mangarewa Formation of New Zealand, in the *Ingelarella costata* Zone.

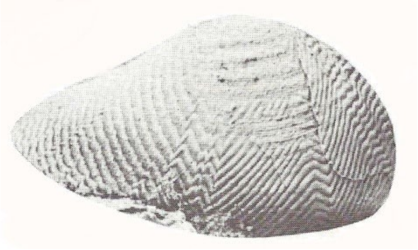

Fig. 8. *Glyptoleda flexuosa* Waterhouse, right valve CPC 25260 from MC803, x2. (Dickins 1989).

Glyptoleda simplicata Waterhouse, 1965b

Fig. 9

1965b *Glyptoleda simplicata* Waterhouse, p. 652, pl. 98, fig. 13-15, text-fig. 5.
1989 *Glyptoleda flexuosa* [not Waterhouse] – Dickins, p. 68, pl. 1, fig. 9 (part, not fig. 11-13 = *flexuosa*).

Diagnosis: Costae form simple V with few zigzags. Shell moderately elongate and high, beaks well in front of mid-length.

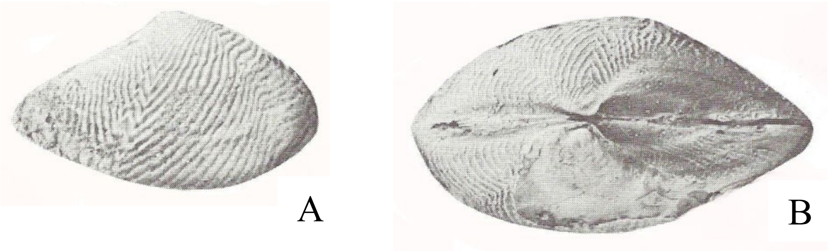

Fig. 9. *Glyptoleda simplicata* Waterhouse. A, latex cast of right valve CPC 25263. B, dorsal aspect, latex cast of both valves CPC 25264. From UDC1, x2. (Dickins 1989).

Holotype: TM 3529 from upper Mangarewa Formation, New Zealand, figured in Waterhouse (1965b, pl. 98, fig. 13-15), OD.

Discussion: The ribs in this specimen form a large simple V with minor deflections. It is found at locality UDC1 in the MacMillan Formation.

Genus ***Nucundata*** Waterhouse, 1965b

Diagnosis: Nuculanid shells with costellae that intersect the lower ventral margin at an angle. Ribs tend to be disrupted or form a gentle angle or even an inverted V behind the beaks.

Type species: *Nucundata undata* Waterhouse, 1965 from upper Mangarewa Formation, New Zealand, OD.

Nucundata cf. ***prolonga*** Waterhouse, 1965.

Fig. 10

cf. 1965b *Nucundata prolonga* Waterhouse, p. 648, pl 97, fig. 14-17, text-fig. 4D.
1989 *Paleyoldia* sp. Dickins, p. 66, pl. 1, fig. 16-18.

Diagnosis: Elongate shells with costae passing obliquely into posterior ventral margin, not forming well defined inverted V.

Fig. 10. *Nucundata* cf. *prolonga* Waterhouse, left valve CPC 25259 from UDC1, x2. (Dickins 1989).

Holotype: TM 3470, pl. 97, fig. 16 from upper Mangarewa Formation, New Zealand, OD.

Discussion: Material was reported from the MacMillan Formation at UDC1. The best preserved specimen is broken posteriorly, so that full identity is not secure.

Subclass Autobranchiata Grobben, 1894

Infraclass Pteriomorphia Beurlen, 1944

Subcohort OSTREIONI Férussac, 1822

Megaorder MYALINATA Paul, 1939

Order MYALINIDA Paul, 1939

Family **INOCERAMOIDEA** Giebel, 1852

Family **ATOMODESMIDAE** Waterhouse, 1976

Subfamily **ATOMODESMINAE** Waterhouse, 1976

Genus ***Aphanaia*** de Koninck, 1877

Diagnosis: Shells inequivalved, left valve swollen, lacking in radial ornament. Similar striate ligament area in each valve, with umbonal septum and large posterior adductor scar. Shell prismatic.

Type species: *Inoceramus mitchelli* M'Coy, 1847, p. 299 from south Sydney Basin, New South Wales, OD.

Aphanaia sp.

1989 *Atomodesma* sp. Dickins, p. 68, pl. 1, fig. 19.

Only a small right valve is known, from the MacMillan Formation at locality UDC1. it shows a moderately long hinge and strong ventral wrinkles. In shape the specimen comes moderately close to that of *Aphanaia mitchelli* (M'Coy, 1847, p. 299, pl. 14, fig. 1) from high marine faunas near Wollongong in the south Sydney Basin, but is so small that any identification would have to be regarded as conjectural. Further specimens were ascribed to M'Coy's species by Dickins (1963, pl. 9, fig. 13-17), but they have more prominent and regular commarginal rugae. Allied material reported as cf. *mitchelli* comes from the upper Mangarewa Formation of New Zealand by Waterhouse (1963c, p. 706, p. 100, fig. 8-10; pl. 101, fig. 1, pl. 105, fig. 8, 9), and this was later treated as immature material belonging to the distinctive form *Aphanaia proiectus* Waterhouse (2001, p. 108, pl. 8, fig. 13, 14, pl. 9, fig. 1-3), a large shell with projecting umbones and strong commarginal rugae. The Dickins specimen could prove to belong to this form, but is too small and incompletely known to allow any measure of certainty.

Superorder PHOLADIFORMII Gray, 1854

Order PHOLADIDA Gray, 1854

Superfamily **PLEUROMYOIDEA** Zittel, 1895

Family **VACUNELLIDAE** Astafieva-Urbaitis, 1973

Genus ***Vacunella*** Waterhouse, 1965a

Diagnosis: Medium-sized to large shells with moderate to substantial posterior gape, pedal gape often present, no posterior carination, umbones placed well forward, pallial sinus, anterior retractor scar connected by isthmus to anterior adductor scar.

Type species: *Allorisma curvatum* Morris, 1845, p. 270 from "Illawarra", Broughton Formation, south Sydney Basin, New South Wales.

Vacunella curvata (Morris, 1845)

See p. for synonymy and diagnosis etc.

1989 *Vacunella curvata* – Dickins, p. 69, pl. 1, fig. 15.

A small and broken right valve was figured from the MacMillan Formation.

Class Gastropoda Cuvier, 1797

Superfamily **BELLEROPHONTOIDEA** M'Coy, 1851

Family **SINUITIDAE** Dall, 1913

Subfamily **EUPHEMITINAE** Knight, 1956

Genus ***Warthia*** Waagen, 1880

Diagnosis: Shells deeply involute, planospirally coiled, without spiral ornament, ornament of growth lines and wrinkles. Sinus broad, usually with short slit, selenizone obscured by inductural level. Umbilicus filled as a rule.

Type species: *Warthia brevisinuata* Waagen, 1880, from Salt Range, Pakistan, SD de Koninck (1882, p. 81).

Warthia perspecta Fletcher, 1958

Fig. 11

1849 *Bellerophon micromphalus* [not Morris] – Dana, p. 708, pl. 10, fig. 6a, b.
1894 *Goniatites* (*Prolecanites*?) *micromphalus* – Etheridge, p. 36, pl. 7, fig. 10, 11 (part, not fig. 9, 12, 13, 14).
1907 *Goniatites* (*Agathiceras*) *micromphalus* – David, pl. 37.
?1929 *Bellerophon* (*Warthia*) *micromphala* – Reid, Fig. 38. 12.
1953 *Warthia* sp. Campbell, p. 25, pl. 7, fig. 1-5.
1958 *Warthia perspecta* Fletcher, p. 149, pl. 15, fig. 3-10.
1963a *W. perspecta* – Waterhouse, p. 93, Fig. 1, 10, 12, 13, 15, 17, 18, Table 3.
1989 *W. perspecta* – Dickins, p. 74, pl. 2, fig. 1-6.

Diagnosis: Moderately inflated shell with width/length ratio over 0.7. Sinus broad and slit very shallow.

Holotype: Specimen figured by Dana (1849, pl. 10, fig. 6a, b) from Gerringong Volcanics, south Sydney Basin. Kept at U. S. National Museum, Washington D. C.

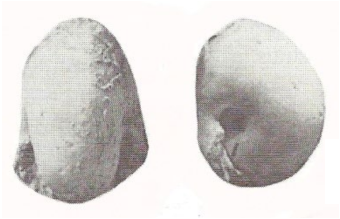

Fig. 11. *Warthia perspecta* Fletcher, dorsal and lateral aspects of specimen CPC 25277 from MC803, x1. (Dickins 1989).

Order PATELLIDA Rafinesque, 1815

Suborder VETIGASTROPODINA Salvini-Plawen, 1980

Superfamily **PLEUROTOMARIOIDEA** Swainson, 1840

Family **EOTOMARIIDAE** Wenz, 1938

Subfamily **EOTOMARIINAE** Wenz, 1938

Genus ***Platyteichum*** Campbell, 1953

Diagnosis: Turbiform high-spired pleurotomariids with globular or subglobular whorls in the spire, upper profile convex, flat or weakly concave in the body whorl. Slit extends for one fourth to one third of the circumference of shell, generating a concave selenizone a little above mid-height; whorl below tending to be concave above a rounded shoulder, but variably swollen or subvertical. Base phaneromphalous or cryptomphalous. Ornament of spiral ribs, crossed by radial threads.

Type species: *Platyteichum costatum* Campbell, 1953, p. 23 from Ingelara Formation, Bowen Basin, OD.

Platyteichum loratum Waterhouse, 1963a

Fig. 12

1963b *Platyteichum loratum* Waterhouse, p. 131, text-fig. 4, 37-50.
1987 *P. loratum* – Waterhouse, p. 180, pl. 12, fig. 4, 17.
1989 *Mourlonia* (*Mourlonia*) *strzeleckiana* [not Morris] – Dickins, p. 69, pl. 2, fig. 13-18 (part, not fig. 12 = *impressa*).
2002 *P. loratum* – Waterhouse, p. 126, Fig. 3.9 (3).

Diagnosis: Loosely to tightly coiled whorls in spire which is lower than in some species, upper outer whorl more convex than in some species, selenizone prominent, sited above concave band of outer spire, selenizone exposed in spire above suture, spiral costae numerous, varying as a rule from three to eight over the body whorl above the selenizone, radial ribs fine and variably defined.

Holotype: TM 3251 figured by Waterhouse (1963b, text-fig. 37, 39, 49) from upper Mangarewa Formation, New Zealand, OD.

Discussion: See p. . The species was reported from MC803, but all figured specimens (Dickins 1989, pl. 2, fig. 13-18) came from UDC1.

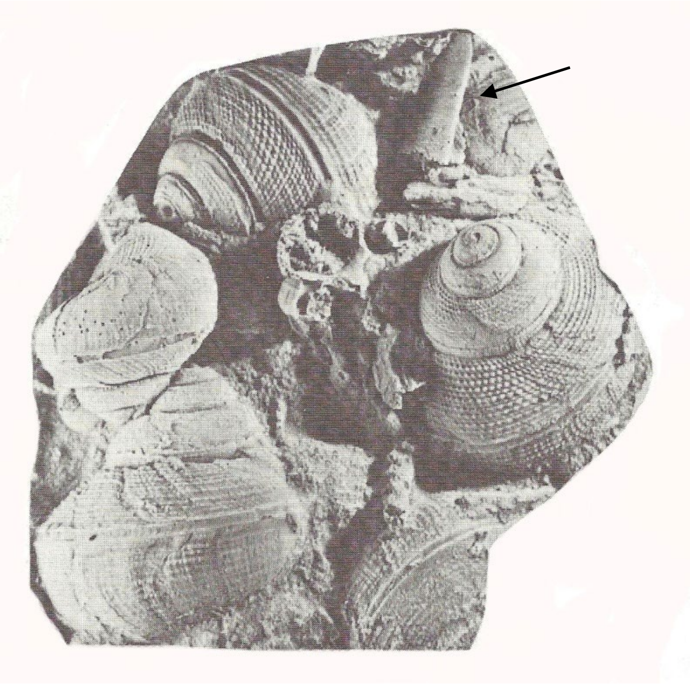

Fig. 12. *Platyteichum loratum* Waterhouse, latex cast of block CPC 25272 from UDC1, x2. (Dickins 1989). A scaphopod specimen *Plagioglypta*?, not recognized in Dickins (1989), is present near the top of the figure, as arrowed.

Subfamily **NEILSONIINAE** Knight, 1956

Genus ***Pleurocinctosa*** Fletcher, 1958

Diagnosis: Small highly turretted shells with swollen upper whorl, well formed selenizone, moderately formed to weak concavulum, anomphalous base, radial ornament.

Type species: *Pleurotomaria trifilata* Dana, 1847, from Westley Park Tuff, Gerringong Volcanics, New South Wales, OD.

Pleurocinctosa trifilata (Dana, 1847)

Fig. 13

1845 *Pleurotomaria* sp. Morris, p. 288.
1847 *P. trifilata* Dana, p. .
1849 *P. morrisiana* [not M'Coy] – Dana, p. 706, pl. 9, fig. 15, 15a.

1877 *P. morrisiana* – Koninck, p. 321, pl. 23, fig. 12.
1958 *Pleurocinctosa trifilata* Fletcher, p. 140, pl. 11, fig. 3-6.
1989 *Peruvispira modesta* [not Waterhouse] – Dickins, p. 71, pl. 2, fig. 8-10 (part, fig. 7 uncertain).

Discussion: Unlike *Peruvispira* Chronic, 1949, these specimens have a swollen upper whorl, like that of *Pleurocinctosa* Fletcher, 1958. *Peruvispira modesta* Waterhouse, 1963b was mistakenly reported from the present fauna by Dickins (1989). This species from the much younger *Marginalosia planata* Zone in the lower Stephens Formation (now Goat Hill Group) of New Zealand has a concave not convex upper whorl profile, and has stronger radial ornament than in these specimens. Dickins, it has to be allowed, was anxious to establish that east Australia had faunas fully as young as those of New Zealand, and so claimed that *P. modesta* was to be found in what is here being called the *Ingelarella costata* Zone. His other studies on New Zealand faunas were infected with same persuasion, and actual morphologies were ignored. Here, the MC803 material is identified with the Dana species described from the Gerringong Volcanics of the south Sydney Basin, New South Wales. Dickins (1989, Fig. 7) shows material from the Black Alley Shale, which seems much the same.

Pleurotomaria morrisiana M'Coy (1847 p. 306, pl. 17, fig. 5) from Black Head, near Gerringong, was synonymized with *P. trifilata* by Fletcher (1958), but has a concave upper whorl, and although this rendition in the MÇoy figure was questioned by Fletcher, the matter needs to be verified from first-hand inspection.

Fig. 13. *Pleurocinctosa trifilata* – (Dana), apertural view of specimen CPC 25275 from MC803, x3. (Dickins 1989).

Family **PHYMATOPLEURIDAE** Batten, 1956

Genus ***Discotomaria*** Batten, 1956

Discotomaria sp.

1989 *Discotomaria* sp. Dickins, p. 74, pl. 2, fig. 19.

A specimen was reported by Dickins (1989) from UDC1.

SUMMARY

The fossils that come from the upper Blenheim Formation and MacMillan Formation include these species: *Gondaconularia*? sp., *Pseudostrophalosia routi cryptica* n. subsp., *Terrakea densispinosa* Waterhouse, *Ingelarella havilensis* Campbell, *I. costata* Waterhouse, *Pseudonucula bradshawensis* Dickins, *Nucundata* cf. *prolonga* Waterhouse, *Glyptoleda flexuosa* Waterhouse, *G. simplicata* Waterhouse, *Aphanaia* sp. [cf. *A. mitchelli* (M'Coy) and *A. proiectus* Waterhouse], *Vacunella curvata* (Morris), *Warthia perspecta* Fletcher, *Platyteichum loratum* Waterhouse, *Pleurocinctosa trifilata* (Dana) and *Discotomaria* sp., with the scaphopod *Plagioglypta*. Of these species*, Ingelarella havilensis* is found widely in the Bowen Basin, first appearing in the Havilah Member, and found in the current faunas, and in the lower Black Alley Shale, and reportedly in the South Curra Limestone of Gympie. *Aphanaia mitchelli* was first recorded from Glendon and Wollongong of the Sydney Basin and *A. proiectus* in the uppermost Mangarewa Formation of New Zealand. The three molluscs *Vacunella curvata, Warthia perspecta* and *Platyteichum loratum* are found widely and appear to range through several zones of mostly or entirely Capitanian age. *Pleurocinctosa trifilata* was first described from the Westley Park Tuff of the Gerringong Volcanics in the south Sydney Basin. *Plagioglypta* and *Gondaconularia*? need closer examination to determine specific affinities. The remaining seven species are restricted to the zone, as far as known, in east Australia, making up half of the species.

A substantial number of the species are found in the upper Mangarewa Formation at Wairaki Downs in New Zealand, involving *Ingelarella costata*, *Nucundata prolonga*, *Glyptoleda flexuosa*, *G. simplicata*, possible *Aphanaia proiectus*, *Vacunella curvata*, *Warthia perspecta, Platyteichum loratum* and *Plagioglypta*? The fossils are found in topmost beds of the formation, north of southerly and more carbonate-rich deposits that contain exemplars of the *Terrakea Maxwellosia ovalis* wassi - *Paucispinauria solida* Zone. The upper Mangarewa Formation was assigned to the *Pseudostrophalosia clarkei* Zone by Waterhouse (2002), but this is now adjusted in view of some reassessment of the stratigraphy and distribution of faunas. The *ovalis-solida* and the *elongata* (s. l.) fossil assemblages came from outcrops, mostly carbonates, from the last major east tributary of Letham Burn and further south, whereas the fossils with links to the east Australian faunas under discussion come from more clastic sediments north of the last major east tributary of Letham Burn, as shown in a map in Waterhouse (2021, Fig. 13, p. 139). These include critical productids in *Pseudostrophalosia routi* Waterhouse, 2021 formerly misidentified as *Ps. clarkei, Terrakea densispinosa* Waterhouse, 2021, formerly misidentified as *T. brachythaera* (not Morris) and later in Waterhouse (2001, 2002) as *T. elongata*, *Ingelarella costata*, and *Glyptoleda flexuosa, G. simplicata,* and *Nucundata prolonga*. Waterhouse (2002) believed that the *Ingelarella costata* assemblage formed part of the sedimentary change. It seems likely that the *costata* assemblage with its characteristic and limited fossils belonged to a level slightly younger than the *elongata planidisca* level. Fossil lists are provided in Waterhouse (2002, table 18, p. 57, 58) with the columns headed by numbers 9622 and 9623 showing a very substantial fauna, with a particularly large assemblage of Mollusca. Some corrections are necessary. The *Terrakea* material belongs to two species*, elongata* (Etheridge & Dun), now *T. elongata planidisca* in the carbonates, and what was identified as *Terrakea brachythaera* (Morris) in the clastics. This species was very profusely illustrated in Waterhouse (1964), and its identity was endorsed by Briggs (1998). It is moderately similar to *brachythaera* (Morris), originally described from the Broughton Formation at the top of the marine succession in the south Sydney Basin, but close examination in Waterhouse (2001, 2002) showed that the disc was more inflated than in *brachythaera*, and ventral posterior walls higher, and coarse spines extend more in front of the ventral ears. The specimens were thus considered to show attributes of *elongata*, and Waterhouse (2021) concluded that the species differs from *brachythaera* in the shape of the ventral valve, and strength of capillae, and in the strength and density and distribution of the spines. In several respects these features brought the specimens closer to *elongata*, but this species has a much longer trail in both valves. The differences warranted recognition of a distinct species, *Terrakea densispinosa*. Unfortunately few Spiriferida are found, other than *Ingelarella costata*, but rare specimens have been identified with *Johndearia cf. isbelliformis*, to suggest a tie with Lopingian faunas in Queensland and New Zealand. Most of the bivalves and gastropods are otherwise found in the *elongata planidisca* and even *Paucispinauria solida* beds from the Wairaki Downs, but some unusual species are restricted to the uppermost Mangarewa Formation and to the particular faunas segregated by Dickins (1989) and recorded herein.

In conclusion, the upper and more northerly outcrops and faunas of the Mangarewa Formation of Wairaki Downs, New Zealand, are linked through *Ingelarella costata* and a number of unusual bivalves with the upper Blenheim and correlative Bowen Basin faunas and regarded as indicating a distinct macrofaunal biozone. Aspects of the zone remain unsatisfactory, because of the limited information about the east Australian fossil localities, which have been located in vague terms. Published and extremely generalized stratigraphic columns provide little stratigraphic information about the localities, and the localities are not indicated on any maps. Provided grid references are so coarse that they cannot be used to locate any locality. Moreover the very scarcity of localities suggests that many remain to be found. Quite possibly, to judge from lists in earlier reports by Dickins to accompany the geological reports such as by Veevers et al. (1964), Malone et al. (1964, 1966, 1969), a number of species remain to be described. That is strongly suggested by the fossil localities revealed by Campbell (1961), Waterhouse (1986, 1987, 2015) and Waterhouse & Jell (1983), which far outnumber the few localities mentioned by the geological reports in question. The zone is named after New Zealand fossils, which have been monographed, with localities described and mapped. It is suggested that the east Australian outcrops contained a number of significant fossils yet to be uncovered and examined, and they may well prove superior to those of New Zealand.

Selected REFERENCES

ADAMS, H., ADAMS, A: 1854-1858: The genera of Recent Mollusca 3: 661p, 136pl. London.

ASTAFIEVA-URBAITIS, K. A. 1973: On the systematics of the Megadesmidae (Bivalvia). Paleont. Zhurn. 1973 (1): 13-19. [Russ.]

BATTEN, R. L. 1956: Some new pleurotomarian gastropods from the Permian of west Texas. J. Washington Acad. Sci. 46 (2): 42-44.

BEURLEN, K. 1944: Beiträge zur Stammesgeschichte der Muscheln. Math.- Naturwiss. Abt. Bayersisch. Akad. Wiss. Munchen Sitzber. 1944 (1, 2): 133-145.

BOOKER, F. W. 1930: A review of some of the Permo-Carboniferous Productidae of New

South Wales, with a tentative reclassification. J. Proc. Roy. Soc. New South Wales 64: 65-77.

BRIGGS, J. D. C. 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen Basin and the New England orogen: systematics and biostratigraphic significance. Mem. Assoc. Aust'asian Palaeont. 19.

BRUNTON, C. H. C. 1966: Silicified productoids from the Visean of County Fermanagh. Bull. Brit. Mus. (Nat. Hist.) Geol. 12 (5): 155-243.

CAMPBELL, K. S. W. 1953: The fauna of the Permo-Carboniferous Ingelara beds of southeast Queensland. Pap. Dep. Geol. Univ. Qld 4 (3): 1-44.

_____ 1959: The *Martiniopsis*-like spiriferids of the Queensland Permian. Palaeontology 1: 333-350.

_____ 1960: The brachiopod genera *Ingelarella* and *Notospirifer* in the Permian of Queensland. J. Paleont. 34: 1106-1123.

_____ 1961: New species of the Permian spiriferoids *Ingelarella* and *Notospirifer* from Queensland and their stratigraphic implications. Palaeontographica A 117: 159-192.

CARTER, J. G. 2001: Shell and ligament microstructure of selected Silurian and Recent palaeotaxodonts (Mollusca: Bivalvia). Amer. Malacol. Bull. 16 (1): 217-238.

CARTER, J. G. et al. (51 authors) 2011: A synoptical classification of the Bivalvia (Mollusca). Paleont. Contrib. 4: 1-47.

_____ et al. (20 authors) 2012: Illustrated glossary of Bivalvia. Treatise Online 48: 1-209, 327. Univ. Kansas Paleont. Inst. ISSN 2153-4012.

CHRONIC, J. 1949: *In* NEWELL, N. D., CHRONIC, J., ROBERTS, T. G.: Upper Paleozoic of Peru. New York: 1-241. See also Mem. Geol. Soc. Amer. 58 (1953).

CLARKE, M. J. 1970: A new Permian strophalosiid brachiopod genus from eastern Australia. J. Paleont. 44: 986-987.

CUVIER, G. 1797: Tableau élémentaire de l’histoire naturelle des animaux: xvi + 710p., 14pl. Paris.

DALL, W. H. 1889: On the hinge of pelecypods and its development, with an attempt toward a better subdivision of the group. Amer. J. Sci. Arts (ser. 3) 38 (228): 445-462.

DANA, J. D. 1847: Descriptions of fossil shells of the collections of the exploring expedition under the command of Charles Wilkes U. S. N. obtained in Australia, from the lower layers of

the coal formation in Illawarra, and from a deposit probably of nearly the same age at Harper’s Hill, valley of the Hunter. Amer. J. Sci. (ser. 2) 4: 151-160.

_____ 1849: Fossils of New South Wales. *In* United States Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes, U. S. N. vol. 10 – Geology. Appendix 1: 681-720. C. Sherman, Philadelphia.

DAVID, T. W. E. 1907: The Geology of the Hunter River Coal Measures, New South Wales. Mem. Geol. Surv. New South Wales Geol. 4.

DEAR, J. F. 1972: Preliminary biostratigraphic subdivision of the Permian brachiopod faunas in the northern Bowen Basin and their distribution throughout the basin. Rep. Geol. Surv. Qld 49: 1-19.

DERRINGTON, S. S. 1961: Tectonic framework of the Bowen Basin, Queensland. A. P. E. A. Conference Papers.

DERRINGTON, S. S., MORGAN, K. H. 1960: South-eastern and south central Bowen Basin. *In* D. Hill & A. K. Denmead (ed.) The Geology of Queensland. The Geol. Soc. Aust. 7: 204-212, Fig. 29, 30.

DICKINS, J. M. 1963: Permian pelecypods and gastropods from Western Australia. Bull. Bur. Mineral Resour. Geol. Geophys. 63.

_____1983: The Permian Blenheim Subgroup of the Bowen Basin and its Time Relationships. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 269-274.

_____ 1989: Youngest Permian marine macrofossil fauna from the Bowen and Sydney Basins, eastern Australia. BMR J. Aust. Geol. Geophys. 11: 63-79.

DRAPER, J. J. 2013. The Bowen Basin. *In* P. A. Jell (ed.) Geology of Queensland: 371-384. Dep. Nat. Resources & Mines, Brisbane.

DUMÉRIL, A. M. C. 1806: Zoologie analytique ou méthode naturelle de classification des animaux: xxiv + 344pp. Allais. Paris.

ETHERIDGE, R. Jnr 1894: Palaaeontologia Novae Cambriae Meridionalis: Occasional Descriptions of New South Wales Fossils. No. 1. Rec. Geol. Surv. New South Wales 4: 32-37.

FÉRUSSAC, A. E. J. d’AUDEBARD de 1821-1822: Tableaux Systématiques des Animaux

Mollusques suivis d'un Prodrome Général pur tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles. Première Partie, Tableaux Systématiques Généraux. Arthus-Bertrand, Paris; J. B. Sowerby, London. (See Carter et al. 2011, pp. 35, 36).

FLETCHER, H. O. 1945: A new genus *Glyptoleda* and a revision of the genus *Nuculana* from the Permian of Australia. Rec. Aust. Mus. 21: 293-312.

_____ 1958: The Permian gastropods of New South Wales. Rec. Aust. Mus. 24: 115-164.

GIEBEL, C. G. 1852: Allgemeine Palaeontologie: Entwurf einer systematischen Darstellung der Fauna und Flora der Vorwelt: 413p. Ambrosius Abel, Leipsig.

GRAY, J. E. 1824: A supplement to the Appendix of Captain Parry's Voyage for the Discovery of a North West Passage from the Atlantic to the Pacific, in the Years 1819-1820, Containing an Account of the Subjects of Natural History. *In* W. E. Parry (ed.) Journal of a Second Voyage for the Discovery of a Northwest Passage…J. Murray, London. Appendix X. Natural History, Shells: ccxl-cclvi.

GRAY, J. E. 1854: On the division of ctenobranchous gasteropodous Mollusca into larger groups and families. Proc. Zool. Soc. Lond. 21: 32-44.

GROBBEN, C. 1894: Zur Kenntniss der Morphologie, der Verwandtschafts-verhältnisse und des Systems der Mollusken. Kaiser. Akad. Wissen. (Math.-Natur. Classe) Sitzber. 103 (1): 61-86.

KNIGHT, J. B. 1956: New families of Gastropoda. J. Washington Acad. Sci. 46 (2): 41, 42.

KONINCK, L. G. de 1866-77: Recherches sur les Fossiles paléozoiques de la Nouvelle Galles de Sud (Australie). Mém. Soc. Roy. Sci. Liège (ser. 2) 6, 7. [English translation by T. W. E. David, 1898: Geol. Surv. New South Wales, Palaeont. Mem. 6].

_____ 1882: Notice sur la famille de Bellerophontidae suivi de la description d'un nouveau genre de cette familie. Ann. Soc. Géol. Belgique 9: 72-90.

KOPPE, W. H. 1974: The Exmoor Formation – An addition to stratigraphic nomenclature in the North-western Bowen Basin. Qld Gov. Min. J. 75: 280-285.

KUMPERA, O., PRANTL, F., RUZICKA, B. 1960: Revision of the Nuculanidae from the Ostrava-Karvina District. Nàrod. Musea Praze, Sbornik 16B: 17-122. LINNAEUS, C. A. 1758: Regnum Animale. London. Photographic facsimile of 10th edition (1758). Reprinted Trustees British Museum (Natural History) 1956. For full reference see Carter et al. 2011, p. 40.

MALONE, E. J., CORBETT, D. W. P., JENSEN, A. R. 1964: Geology of the Mount Coolon 1:250,000 Sheet area. Bur. Mineral Resour. Geol. Geophys. Rep. 64: 1-78, 15pl. + maps & sections (as plates).

MALONE, E. J., JENSEN, A. R., GREGORY, C. M. 1966: Geology of the southern half of the Bowen 1:250,000 sheet area, Queensland. Rep. Bur. Mineral Resourc. Geol. Geophys. 100: 1-68, 4pl. + maps.

MALONE, E. J., OLGERS, F., KIRKEGAARD, A. G. 1969: The Geology of the Duaringa and Saint Lawrence 1: 250, 000 Sheet Areas, Queensland. Rep. Bur. Mineral Resourc. Geol. Geophys. 121: 133p., 5 pl., maps.

MAXWELL, W. G. H. 1954: *Strophalosia* in the Permian of Queensland. J. Paleont. 28: 533-559.

McCLUNG, G. 1981: Review of the stratigraphy of the Permian Back Creek Group in the Bowen Basin, Queensland. Geol. Surv. Qld Pub. 371. Palaeont. Pap. 44.

M'COY, F. 1847: On the fossil botany and zoology of the rocks associated with the coal of Australia. Ann. Mag. Nat. Hist. (ser. 1) 20: 145-157, 226-236, 298-312.

_____ 1851: Description of some new Mountain Limestone fossils. Ann. Mag. Nat. Hist. (ser. 2) 7: 45-63.

MORRIS, J. 1845: Descriptions of fossils. *In* P. E. de STRZELECKI Physical description of New South Wales and Van Diemen’s Land: 270-291. Longman, Brown, Green & Longman, London.

MUIR-WOOD, H. M., COOPER, G. A. 1960: Morphology, classification and life habits of the Productoidea (Brachiopoda). Geol. Soc. Amer. Mem. 81.

PATEN, R. J. 1969: Geology and Petroleum Exploration. Central and south-western Bowen Basin. In 1969 Field Conference. Mineral Resources Central Queensland. Qld Division, Geol. Soc. Australia: 29-35.

PAUL, H. 1939: Die Muscheln des Magdeburger Kulmgrauwacke. Abh. Berichte Mus. Nat. Vorge. Natureiss. Verein Magdeburg 7 (1): 165-181, pl. 12.

PILSBRY, H. A., SHARP, B. 1897: Scphopoda. *In* TRYON, G. W. Manual of Conchology 17: 1-280, 39pl.

RAFINESQUE, C. S. 1815: Analyse de la Nature ou Tableau de l’Úniversité et de Corps organisés etc.: 223p. Jean Barravecchia, Palermo.

REID, J. H. 1929: Geology of the Bowen River Coalfield. Pub. Geol. Surv. Qld 276: 1-107.

RUNNEGAR, B. N., FERGUSON, J. A. 1969: Stratigraphy of the Permian and Lower Triassic sediments of the Gympie District, Queensland. Pap. Dep. Geol. Univ. Qld 4 (9): 247-281.

SCHUCHERT, C. 1913: Class 2. Brachiopoda. *In* ZITTEL, K. A. von Text-book of Paleontology, vol. 1, part 1, 2nd ed., translated and edited by C. R. Eastman: 355-420, fig. 526-636. MacMillan & Co. Ltd, London.

SINCLAIR, G. W. 1952: A classification of the Conulariida. Fieldiana Geology 10 (13): 135-145.

SMITH, T. E., BERNECKER. T., BODORKOS, S., GORTER, J., HALL, L. S., HILL, T., HOLMES, E., KELMAN, A., KHIDER, K., LAURIE, J., LECH, M., MCKELLAR, J., MORY, A., NICOLL, R., OWENS, R., PALU, T. J., PHILLIPS, L., STEPHENSON, M. & WOOD, G., 2017: The impact of recalibrating palynological zones to the chronometric timescale: revised stratigraphic relationships in Australian Permian and Triassic hydrocarbon-bearing basins. Poster given at AAPG/SEG 2017 International Conference and Exhibition, London, England, October 15–18, 2017.

SWAINSON, W. 1840: A Treatise on Malacology of the Natural classification of shells and shell fish. VIII: 419p.

THOMAS, G. A. 1969: *Notoconularia*, a new conulariid genus from the Permian of eastern Australia. J. Paleont. 43: 1283-1290, pl. 149, 150.

VEEVERS, J. J., RANDALL, M. A., MOLLAN, R. G., PATEN, R. J. 1964: The Geology of the Clermont 1: 250,000 Sheet Area, Queensland. Bur. Mineral. Resourc. Geol. Geophys. Rep. 66: 1-85, 12pl. + fig.

WAAGEN, W. 1880: Salt Range Fossils. Part 2. Pisces and Gastropods. India Geol. Surv. Palaeont. Ind. (ser. 2) 13 (1): 75-183.

_____ 1883: Salt Range Fossils 1. Productus Limestone Fossils, Brachiopoda. Palaeont. Indica (ser. 13) 4 (2): 391-546.

WASS, R. E., GOULD, I. G. 1969: Permian faunas and sediments from the South Marulan district, New South Wales. Proc. Linnean Soc. New South Wales 93: 212-226.

WATERHOUSE, J. B. 1963a: Permian gastropods of New Zealand. Part 2 –

Pleurotomariacea (in part). N. Z. J. Geol. Geophys. 6 (1): 115-154.

_____ 1963b: Permian gastropods of New Zealand. Part 3 – Pleurotomariacea (concluded). N. Z. J. Geol. Geophys. 6 (4): 587-622.

_____ 1963c New Zealand species of the Permian bivalve *Atomodesma* Beyrich. Palaeontology 6: 699-717.

_____ 1964: Permian brachiopods of New Zealand. N. Z. Geol. Surv. Paleont. Bull. 35: 1-287.

____ 1965a: Palaeotaxodont bivalves from the Permian of New Zealand. Palaeontology 7: 630-655.

_____ 1965b: Generic diagnoses for some burrowing bivalves of the Australian Permian. Malacalogia 3: 367-380.

_____ 1968: The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. Palaeontographica A 129 (1-3): 1-94.

_____ 1975: New Permian and Triassic brachiopod taxa. Pap. Dep. Geol. Univ. Qld 7 (1): 1-23.

_____ 1976: New occurrences of brachiopod and bivalve species from the Arthurton Group of south Oago and Southland, New Zealand, with comments on structure and stratigraphy. J. Roy. Soc. N. Z. 6 (2): 227-252.

_____ 1980: Scaphopod, Gastropod and Rostroconch species from the Permian of New Zealand. J. Roy. Soc. N. Z. 10 (2): 195-210.

_____ 1982: New Zealand Permian brachiopod systematics, zonation and paleoecology. N. Z. Geol. Surv. Paleont. Bull. 48.

_____ 1983: New Permian invertebrate genera from the east Australian segment of Gondwana. Bull. Ind. Geol. Assoc. 16: 153-158.

_____ 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 1987: Late Palaeozoic Mollusca and correlations from the southeast Bowen Basin, east Australia. Palaeontographica A 198 (4-6): 129-233.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New

Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2002: The stratigraphic succession and structure of Wairaki Downs, New Zealand, and its implications for Permian biostratigraphy of New Zealand and marine Permian of eastern Australia and Gondwana. Earthwise 4: 1-260.

_____ 2010: New taxa of Late Paleozoic Brachiopoda and Mollusca. Earthwise 9: 1-134.

_____ 2013: The evolution and classification of the Productida. Earthwise 10: 1-535.

______2015: Early Permian Conulariida, Brachiopoda and Mollusca from Homevale, central Queensland. Earthwise 11: 1-390.

_____ 2016: On the evolution and classification of Spiriferida (Brachiopoda). Earthwise 14: 1-434.

_____ 2021: New species of *Pseudostrophalosia* and *Terrakea* from the upper Mangarewa Formation, Wairaki Downs. Earthwise 18:

WATERHOUSE, J. B., JELL, J. S. 1983: The sequence of Permian rocks and faunas near Exmoor Homestead, south of Collinsville, north Bowen Basin. *In* Permian Geology of Queensland. Geol. Soc. Aust. Qld Div., Brisbane: 231-267.

WATERHOUSE, J. B., MUTCH, A. R. 1978: Description and paleoecology of Permian brachiopods from the Nemo Formation near Ohai, South Island, New Zealand. N. Z. J. Geol. Geophys. 21 (4): 517-530.

WATERHOUSE, J. B., VELLA, P. 1965: Permian fossils from Parapara Peak, northwest Nelson. Trans. Roy. Soc. N. Z. Geol. 3 (5): 57-84.

WENZ, W. 1938: Gastropoda. Allgemeine Teil und Prosobranchia. *In* O. H. Schindewolf (ed.) Handbuch der Paläozoologie, Band 6. Teil 3: 481-720. Berlin.

WILLIAMS, A., CARLSON, S. J., BRUNTON, C. H. C., HOLMER, L. E., POPOV, L. E. 1996: A Supra-ordinal classification of the Brachiopoda. Philosoph. Trans. Roy. Soc. London (ser. B) 351: 1171-1193.

ZITTEL, K. A. von 1895: Grundzüge der Paläontologie (Paläozoologie) 1 Abteilung, Invertebrata. Oldenburg. München and Leipzig: viii + 971p.

9. A NEW STROPHALOSIOID SPECIES FROM THE KULNURRA MARINE TONGUE OF THE NEW SOUTH WALES PERMIAN

Abstract

A new species of the strophalosioid genus *Nonauria* is reported from the Kulnurra marine tongue of upper Guadalupian age in New South Wales..

New taxon: *Nonauria laminata* new species.

INTRODUCTION

A new species is distinguished for a species allied to *Wyndhamia* and *Pseudostrophalosia*, and distinguished by the lack of ears. It comes from the Kulnurra marine tongue of New South Wales and is of upper Guadalupian age.

SYSTEMATIC DESCRIPTION

Superfamily **STROPHALOSIOIDEA** Schuchert, 1913

Family **DASYALOSIIDAE** Brunton, 1966

Subfamily **ECHINALOSIINAE** Waterhouse, 2001

Tribe **WYNDHAMIINI** Waterhouse, 2010

Genus ***Nonauria*** Waterhouse, 2022

Diagnosis: Close to *Wyndhamia*, distinguished by lack of ears from either valve.

Type species: *Wyndhamia parfreyi* (Waterhouse, 2001, p. 84) from Barfield Formation, southeast Bowen Basin, Queensland.

Discussion: This genus is close to *Wyndhamia* Booker and *Pseudostrophalosia* Clarke, but unlike these genera, lacks ears for either valve. *Wyndhamia* has few spines over the ears, and *Pseudostrophalosia* has numerous long and well developed ear spines over the ventral ears. To judge from the fossil record, *Pseudostrophalosia* was the oldest of these genera, and evolved into *Wyndhamia* by substantial diminution of ear spines, and *Nonauria* was the last genus to appear, by loss of the ears.

Nonauria commarginalis n.sp.

Fig. 1

1989 *Echinalosia* cf. *minima* [not Dear] – Dickins, p. 75, pl. 3, fig. 13-21 (part, not fig. 1-3 = *Terrakea* cf. *densispinosa* Waterhouse, fig. 4-11 = *Pseudostrophalosia routi cryptica* Waterhouse.

Diagnosis: Medium size, ventral valve gently convex, dorsal valve almost flat, slightly thickened, no distinguishable trail, low interareas, no ears. Ventral spines close-set, varying in diameter, many coarse, suberect to semirecumbent. Dorsal spines crowded, subuniform, comparatively thick.

Holotype: Specimen figured herein as Fig. C, F) reproduced from Dickins (1989, pl. 3, fig. 17, 18) from NSW Geological Survey Bore DDH3, New South Wales, here designated.

Material: Dickins (1989) figured one ventral valve and several well preserved dorsal valves from the Kulnurra marine tongue derived from the DDH3 bore in the Newcastle Sheet area (See Dickins 1989, p. 77) in the Newcastle Sheet Area.

Description: The shells, examined at the then Bureau of Mineral Resources at Canberra, are of medium size, with gently convex ventral valve and gently concave dorsal valve, with slender body corpus. Both valves lack ears, and the interareas are low., and no trail is clearly developed. No cicatrix is clear developed on the ventral valve, but only one specimen is known, and more material is needed. Ventral spines are semirecumbent and crowded, many coarse, some slightly narrower, and a few comparatively slender. Dorsal spines are also crowded, much more commarginally aligned, suberect and comparatively strong and suberect. The external dorsal valve is particularly striking because of the well developed commarginal laminae.

No internal detail is known for the ventral valve. The dorsal interior is well preserved, with unexceptional cardinal process, and very long median septum. A strong lateral supporting ridge extends from each side. An inner pair of ovally subtriangular adductor scars lie inside a small pair of elongately subrounded and impressed posterior lateral adductor scars. There is a low marginal ridge, and the course of the brachial ridge suggested in Dickins (1989, p. 3, fig. 21 as in Fig. 21E herein shows a slightly more open anterior hook than that of *Pseudostrophalosia* illustrated by Waterhouse (2021, Fig. 5B), but much less conspicuous than that of *Echinalosia* (Waterhouse 2021, Fig. 5A).

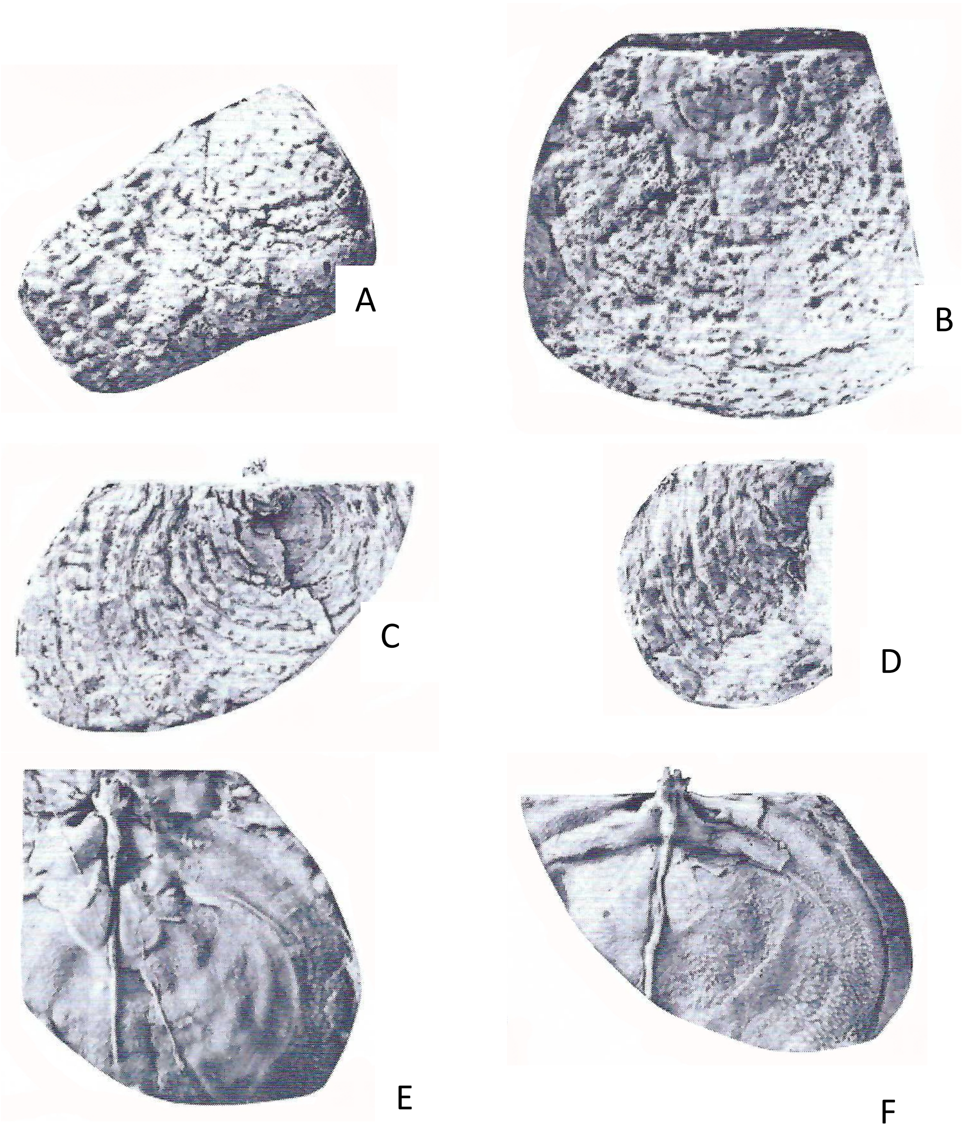

Fig. 1. *Nonauria comarginalis* sp. A, ventral valve, holotype. B, C, D, exterior of dorsal valves. C, F, external and internal aspects of dorsal valve, F a latex cast. E, latex cast of interior of dorsal valve, with faintly preserved brachial ridge. Specimens from New South Wales Bore DDH3, x2, figured by Dickins (1989, pl. 3).

Resemblances: This species like the older species *Nonaura parfreyi* in its lack of ears, but has more diverse spines, and conspicuous commarginal laminae, especially over the dorsal valve.

REFERENCES

BRIGGS, J. D. C. 1998: Permian Productidina and Strophalosiidina from the Sydney-Bowen

Basin and the New England orogen: systematics and biostratigraphic significance. Mem. Assoc. Aust'asian Palaeont. 19.

PARFREY, S. M. 1988: Biostratigraphy of the Barfield Formation, southeastern Bowen Basin, with a review of the fauna from the Ingelara and lower Peawaddy Formations, southwestern Bowen Basin. Rep. Qld Dep. Mines 1.

WATERHOUSE, J. B. 1986: Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica A 193 (1-4): 1-76.

_____ 2001: Late Paleozoic Brachiopoda and Mollusca, chiefly from Wairaki Downs, New Zealand, with notes on Scyphozoa and Triassic ammonoids and new classifications of Linoproductoidea (Brachiopoda) and Pectinida (Bivalvia). Earthwise 3: 1-195.

_____ 2010: New Late Paleozoic brachiopods and molluscs. Earthwise 9: 1-134.

_____2022: 3. A new strophalosioid genus from the Barfield Formation, southeast Bowen Basin, Queensland. Earthwise 20: