A SUMMARY OF BRACHIOPOD SPECIES BELONGING TO THE ORTHIDA, RHYNCHONELLIDINA, STENOSCISMATIDINA AND ATHYRIDA FROM THE PERMIAN FAUNAS OF EAST AUSTRALIA AND NEW ZEALAND

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Contents

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

PREFACE

This study continues the summary of the occurrences of brachiopods in Permian deposits of east Australia and New Zealand, species by species, with synonymy, diagnosis, type specimens, morphological distinctions and stratigraphic range, together with facets that require further clarification. Overall procedure is to provide a diagnosis for the family group, followed by discussion with figures as a rule for the nominate genus and its constituent species, followed by brief detail of related genera which are ordered alphabetically, with their constituent species. The species within each genus are arranged by stratigraphic occurrence, starting with the oldest species. Family group and ordinal names are spelled largely as in the *Revised Brachiopod Treatise*. The addition of et seq. after the record of the original proposal of a family group implies that the same record is to be applied to the same following family group categories to save repetition .

REPOSITORIES

Fossils described throughout this report from Queensland are mostly housed in the Bulk Storage of the Queensland Museum, Hendra, Brisbane, and are registered individually by number with the prefix **UQF**. They come from localities numbered with the prefix **UQL**. Fossils from another institution are mentioned, involving **GSQ**, Geological Survey of Queensland, also stored at the Queensland Museum at Hendra, Brisbane. New Zealand repositories involve **BR**, for brachiopods kept at the Institute of Nuclear and Geological Sciences, Lower Hutt, and **OU**, Department of Geology, Otago University, Dunedin.

ACKNOWLEDGEMENTS

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

SYSTEMATIC AND STRATIGRAPHIC SUMMARY

Phylum Brachiopoda Duméril, 1806

Class RHYNCHONELLATA Williams et al. 1996

Williams et al. (1996) proposed Rhynchonellata as a class within Subphylum Rhynchonelliformea, though uncertainity over aspects of their classification, was expressed by Bassett et al. (2010), who indicated a possible close link between Subphyllum Craniiformea and Class Strophomenata, on the basis of ongoing DNA studies.

Order ORTHIDA Schuchert & Cooper, 1932

Suborder DALMANELLIDINA Moore, 1952

Superfamily **DALMANELLOIDEA** Schuchert, 1913

Family **RHIPIDOMELLIDAE** Schuchert, 1913

Subfamily **RHIPIDOMELLINAE** Schuchert, 1913

Genus ***Rhipidomella*** Oehlert, 1890

Genus ***Rhipidomella*** sp.

Fig. 1

1982 ?*Rhipidomella* sp. Waterhouse, p. 23, pl. 5b, Fig. 17A.

Fig. 1. *Rhipidomella* sp. BR 1464, x1.3 from Brunel Formation, New Zealand. s - median ridge; c - crural plates. (Waterhouse 1982).

A dorsal valve is known from the *Notostrophia zealandicus* Zone in the Brunel Formation in the Takitimu Group of western Southland in New Zealand. It was described as elongately rounded with traces of ten to eleven ribs in 1mm and shows no sulcus or fold. There are short diverging crural plates, a low median septum, and two pairs of adductor scars.

This is the only known occurrence of *Rhipidomella* in the Permian of east Australia and New Zealand.

Order RHYNCHONELLIDA Kuhn, 1949

Waterhouse (2010, p. 12) suggested that the concept of Rhynchonellida could be attributed to Schuchert (1913) on the basis that Schuchert clearly applied his new suborder Rostracea only to Family Rhynchonellidae, and included a second family Eichwaldiidae with reservations and query. Rostracea was included by Schuchert (1913) as a suborder of Order Orthacea Beecher & Schuchert. Thus the evaluation as an ordinal group was enunciated by Schuchert (1913), and his proposed name has to be corrected to one with generic stem. It was Kuhn (1949, p. 104) who was first to apply the name Rhynchonellida to an ordinal assemblage. The present grouping is close to Subclass Rhynchonellata Grunt, 2006. The non-strophic hinge and peduncular attachment and crura grading into spiralia are shared together with various internal structures by Orders Rhynchonellida, Atrypida and Athyrida. Members of Pentamerida Schuchert & Cooper, 1932 display many features in common with Rhynchonellida, but lack a pedicle and may show in later forms only simple crura. They were classed with Subclass Orthata by Afanasieva & Dagys (1989) together with Orthida.

Rhynchonellida are comparatively rare in the Permian of Australia. This stands in contrast with the abundance of genera – some twenty nine – in west Texas, according to Cooper & Grant (1976). In west Texas, a number of genera arose to display different external features of shape and ornament, but retained similar dorsal interiors to indicate relationships. The same is true of rhynchonellids in east Australia and New Zealand. Most east Australian species of Permian age belong to the one genus, *Plekonella* Campbell, and these are here classed in a separate subfamily, distinguished by their entire hinge plate which bears a median ridge. Late Permian genera *Aphaurorhynchia* Waterhouse and *Wairakiella* Waterhouse show the same entire hinge plate with median ridge as seen in *Plekonella*, and are therefore classed in the same group, though they differ markedly in ornament. An Early Permian species from New Zealand that was provisionally attributed to *Pugnoides* Weller (Petasmariidae) may well prove to have stemmed from Plekonellinae, because it also displays the median ridge, but it appears to have a septalium that is not known in *Plekonella*, and another genus represented by a few New Zealand specimens and left unassigned generically, also appears to have a septalium that bears a median ridge. *Plekonina* Waterhouse (1986, 2010) in the Dresden Limestone of southeast Bowen Basin in

Queensland lacks the median ridge, and is classed in Strigirhynchiidae Cooper & Grant. At present, members of Rhynchonellida are limited to Queensland and New Zealand, although whether this was actually the case in nature, or reflects the need for further studies in New South Wales and Tasmania, remains to be firmly established.

Suborder RHYNCHONELLIDINA Kuhn, 1949

Superfamily **WELLERELLOIDEA** Licharew, 1956

Family **WELLERELLIDAE** Licharew, 1956

Subfamily **WELLERELLINAE** Licharew, 1956

Subfamily **STRIGIRHYNCHIINAE** Cooper & Grant, 1976

[Strigirhynchiinae Cooper & Grant, 1976, p. 1996].

Diagnosis: Costate shells with undivided hinge plate, no median ridge, supported by median septum. Dental crenulations fine, or may be missing.

Discussion: Three genera were recognized for genera found chiefly in the middle Permian of west Texas by Cooper & Grant (1976). *Strigirhynchia* Cooper & Grant, 1969 of Capitanian age, though claimed to be Kazanian by Savage et al. (2002), is closely costate with fine socket crenulations; *Chaeniorhynchus* Cooper & Grant, 1976 from the Cathedral Mountain and Road Canyon Formations of Kungurian and Roadian age lacks socket crenulations and is closely costate, and *Madarosia* Cooper & Grant, 1976 is largely smooth, and has only traces of deltidial plates – it is found in the Lamar Member of the Bell Canyon Formation and in the Getaway Member of the Cherry Canyon Formation. No information was provided on whether the dental sockets are crenulate or not. All three genera have a dorsal interior close to that of *Plekonina* Waterhouse, 1986 (see the dorsal interior as well figured in Cooper & Grant 1976, pl. 508, fig. 29) and *Plekonina* is distinguished by its coarser and fewer costae.

Genus ***Plekonina*** Waterhouse, 1986

Diagnosis: Subtriangular shells with sulcus and fold, two sulcal costae and exceptionally broad costa bordering each side of sulcus. Ventral valve with dental plates. Dorsal interior without cardinal process. Inner hinge plates fused, without median trough or median ridge. Dental sockets without crenulations. Median septum of moderate length.

Type species: *Plekonina spissatella* Waterhouse, 1986 from Roses Pride Formation, southeast Bowen Basin.

Discussion: Savage (2002c, p. 1375) falsely claimed that the interior of this genus was not known. That is not correct, and he ignored or passed over the fact that a figure was provided of the dorsal interior, with detailed description, and that details were also recorded for the ventral interior. But in his defence, it should be recalled that before being given the huge task of summarizing many Rhynchonellida for the *Revised Brachiopod Treatise*, he seems to have accomplished little research on that or other fossil groups, to judge from his published record in the *Treatise*.

Plekonina spissatella Waterhouse, 1986

Fig. 2

1986 *Plekonina spissatella* Waterhouse, p. 65, pl. 14, fig. 20. 21, text-fig. 10.
2002c *Plekonina* Savage, p. 1375.

Diagnosis: Two costae in sulcus and median groove along fold, two pairs of costae laterally on each valve, posterior valve smooth.

Holotype: UQF 74104 from Dresden Limestone, figured in Waterhouse (1986, pl. 14, fig. 20, 21) and herein as Fig. 2A, B), OD.

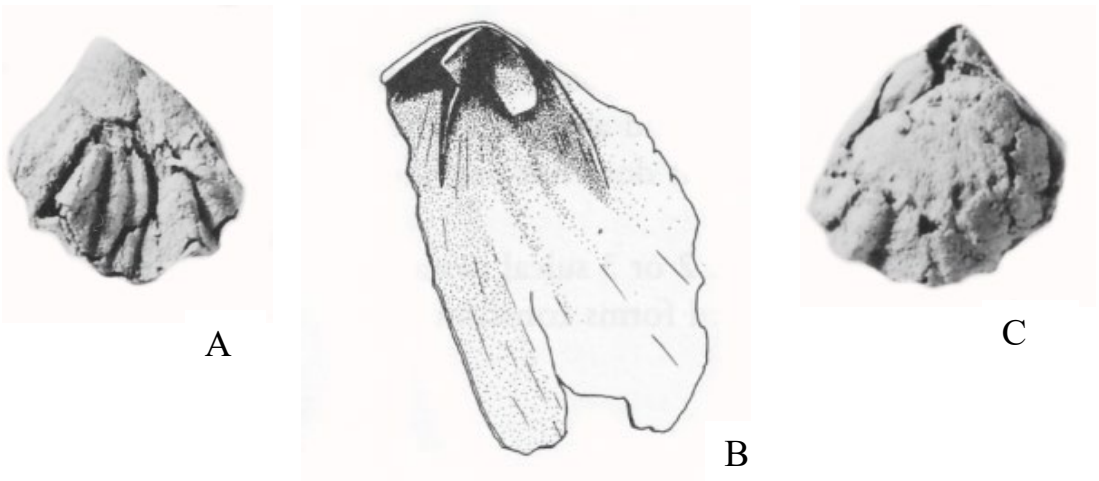


Fig. 2. *Plekonina spissatella* Waterhouse. A, C, ventral and dorsal views of holotype, UQF 74104 x4. B, interior of unregistered dorsal valve, x5. Dresden Limestone. (Waterhouse 1986).

Morphology: Many specimens are known for the genus *Plekonella*, represented by six species in east Australia and New Zealand. But all have crenulate dental sockets and a ridge over the ventral surface of the hinge plate. *Plekonina spissatella* is thus exceptional in that regard, and in my view, therefore should be distinguished, Savage (2002c) notwithstanding. The dorsal interior comes closest to that of the Strigirhynchiinae Cooper & Grant from the Early and Middle Permian of west Texas.

Stratigraphy: The species is found only in the Dresden limestone in the southeast Bowen Basin.

Subfamily **PLEKONELLINAE** Waterhouse, 2010

Diagnosis: Small, both valves ornamented by angular-crested costae of strength and length varying in different genera, fine radial lirae; deltidial plates well-developed, dental plates short, inner hinge plate entire with sturdy median ridge, supported by strong median dorsal septum, socket plates crenulate. Crura oval in section, curve towards ventral valve.

Discussion: *Plekonella* has been referred to Wellerellinae by Savage et al. (2002, pp. 1258), but costae cover or almost cover both valves, so that the genus externally approaches Strigirhynchiinae Cooper & Grant (1976, p. 1196), based on a few species found in the late Early and Middle Permian of west Texas, United States. *Strigirhynchia* is like *Plekonella* in having angular-crested costae, sulcus and fold and high dorsal septum supporting an undivided hinge plate. Differences are that in Strigirhynchinae deltidial plates tend to be reduced or absent, and the hinge plate carries no median ridge. One member of Strigirhynchiinae, *Chaeniorhynchus* Cooper & Grant first appeared in the Cathedral Mountain Formation (Kungurian) of west Texas, and displayed an open delthyrium, no deltidial plates, long median septum and uncorrugated sockets. These genera, especially *Strigirhynchia*, are moderately close to *Plekonella* and it might be argued that the differences are of no more than generic significance. However the hinge plate in *Strigirhynchia* is like that of many other rhynchonelliform genera recognized by Cooper & Grant (1976), and lacks a median ridge. In species of *Plekonella*, the hinge plate is divided by a narrow strong ridge. Because the Texan species and genera share their particular style of hinge plate, it seems likely that they are more closely related to each other than to the genus found in east

Australia and New Zealand. The similarity in internal morphology amongst so many Glass Mountains Rhynchonellida indicates a rapid proliferation of genera and species from a limited root-stock.

It is the entire hinge plate, and the presence of a median ridge that distinguishes *Plekonella* and its allies. Other rhynchonellid genera of Carboniferous and Permian age lack any sign of the median ridge. Such a ridge is limited to a few genera classed in the *Revised Brachiopod Treatise* as Rhynchotrematidae Schuchert, such as *Otarorhyncha* Nikiforova & Popov, *Pleurocornu* Havlíček, *Stegerhychus* Foerste and *Stegocornus* Durkoop as well as *Rhytidorachis* Jin & Caldwell, all of Silurian age, and *Orthorhynuloides* Williams of Ordovician age in Orthorhynchidae Cooper, and in these genera a septalium is well developed, whereas *Plekonella* has no septalium. *Lissella* Campbell, 1961, p. 452 from the Upper Carboniferous Booral Formation of New South Wales, Australia, also has a flat dorsal hinge plate with median ridge and belongs to the same subfamily Plekonellinae. The dorsal septum is strong, and costae are few and anteriorly placed.

Genus ***Plekonella*** Campbell, 1953

Fig. 3

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

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

Discussion: *Plekonella* is the most common member of Rhynchonellida found in the Permian of east Australia and New Zealand, ranging throughout most of the Permian Period. *Plekonella acuta* Campbell, *P. campbelli* Waterhouse and to lesser degree *P. southlandensis* (Fletcher) are all consistent in the number of sulcal and fold costae. *P. whitehousei* is an exception. New Zealand specimens of *Plekonella* from the *Echinalosia discinia* Zone (Kungurian) in the upper Letham Formation and from the *Wyndhamia typica* Zone in the lower Letham Formation vary in the number of sulcal and fold costae, and

Fig. 3. *Plekonella acuta* Campbell, serial sections with dorsal valve on top, showing cardinalia with median ridge in the hinge plate, x2 approx. Lower Peawaddy Formation, rearranged by Savage (2002a) from Campbell (1953).

include forms in which costae branch. These assemblages have individuals like *P. acuta*, others like *P. southlandensis*, and others different from any described species. McClung (1983, Fig. 10) figured variable specimens from GSQ locality LD 96 in the Denison Trough of the Bowen Basin, from beds equivalent to the Catherine Sandstone above the Ingelara Shale and approximately equivalent to the *Pseudostrophalosia blakei* Zone. It is not clear whether one species was involved with variable ornament, or whether an assortment of species, including *acuta, southlandensis*, and at least one distinct species, not as yet named, were present, but provisionally specimens from these assorted suites are allocated to *acuta* and *southlandensis*, with possibly a third species yet to be studied.

Plekonella whitehousei Waterhouse, 2015a

Fig. 4

2015a *Plekonella whitehousei* Waterhouse, p. 142, Fig. 96-98.

Diagnosis: Subtriangular inflated shells with well-defined sulcus and fold, sulcal and fold costae somewhat variable in number and arrangement, one to three costae on floor of sulcus, some four pairs of costae laterally, dorsal fold smooth posteriorly as a rule, three to five costae in front, dorsal septum well-developed, median ridge divides the hinge plate.

Holotype: UQF 81306 from upper middle Tiverton Formation, figured by Waterhouse (2015a, Fig. 98A) and herein as Fig. 4A, OD.

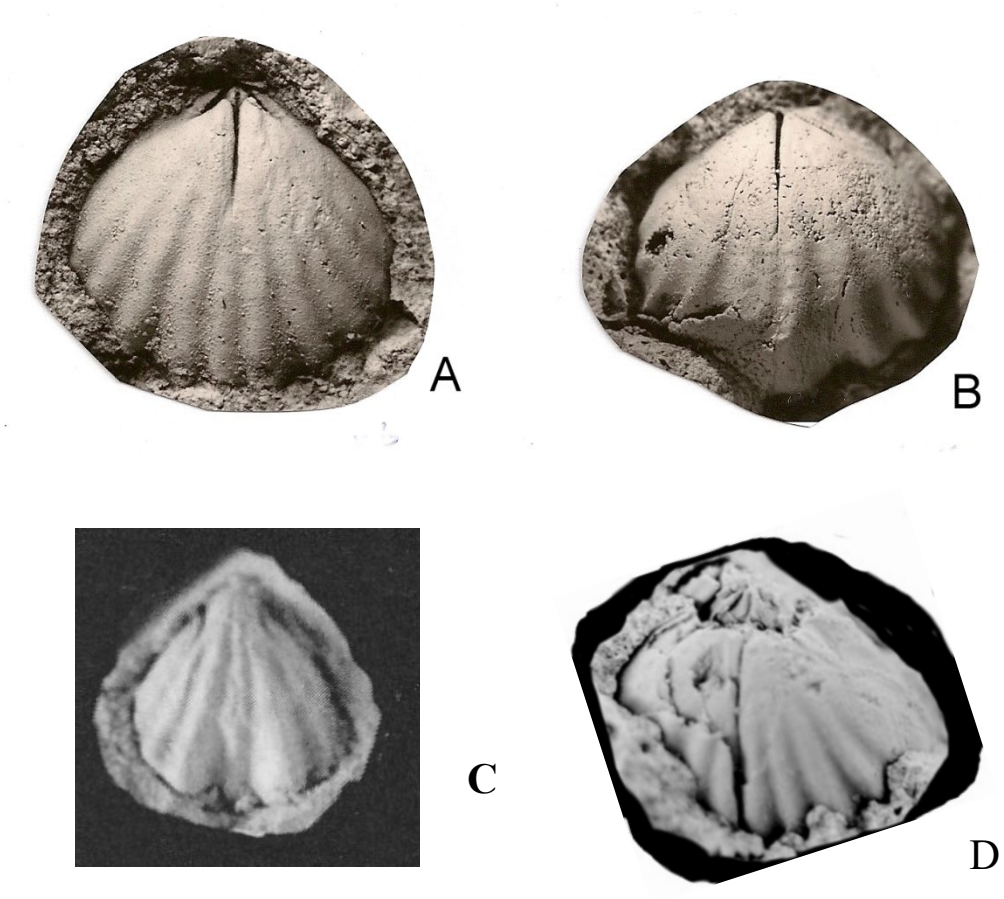


Fig. 4. *Plekonella whitehousei* n. sp. A, holotype, dorsal internal mould of UQF 81306, x4.5. B, dorsal valve internal mould UQF 81307, x4. C, ventral valve UQF 81305, x 5. D, dorsal internal mould UQF 81587, x3. Tiverton Formation. (Waterhouse 2015a).

Morphology: This species is more bulky in shape than *Plekonella acuta* Campbell, tending to have shorter ventral posterior walls that are gently convex in outline, and a variable number of moderately broad and not very high costae lie over the sulcus and fold. One or three or rarely two ribs lie along the middle of the sulcus, the dorsal valve is smooth in front of the umbo, and posterolaterally in one specimen, and one or three and rarely five costae traverse the fold, with usually three pair of lateral costae, though four costae lie on one side of fold and two on other in one specimen. Micro-ornament of fine disrupted capillae. Short dental plates and teeth in ventral valve. The dorsal median septum extends for more than a third of length of shell, a high median ridge is conspicuous on the hinge plate, and dental sockets are closely crenulate.

Stratigraphy: The species is rare in the *Capillonia armstrongi* Subzone, and more common in

Taeniothaerus subquadratus Zone in the middle Tiverton Formation of the north Bowen Basin in Queensland.

Plekonella campbelli Waterhouse, 1964

Fig. 5, 6A

1958 *Plekonella* n. sp. Waterhouse, p. 605.
1964 *P. campbelli* Waterhouse, p. 84, pl. 16, fig. 2-6, 8-12, text-fig. 32D, 34c, 36-40.

Diagnosis: Transverse, short posterior walls, three costae in the sulcus, four over the fold, lateral costae may branch into two anteriorly.

Holotype: BR 438, from Brunel Formation, figured in Waterhouse (1964, pl. 16, fig. 3-6, 8, 10, text fig. 32D), and herein as Fig. 5A- D, OD.

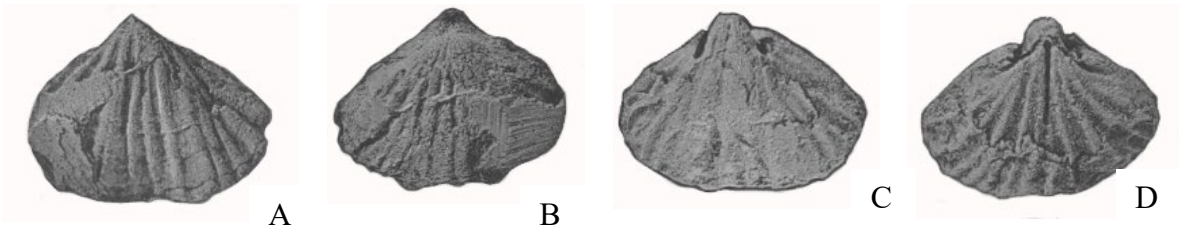


Fig. 5. *Plekonella campbelli* Waterhouse. A, B, ventral and dorsal aspects of BR 438 (PVC mould), holotype, x2. C, D, ventral and dorsal aspects of the same specimen, x2. Brunel Formation. (Waterhouse 1964).

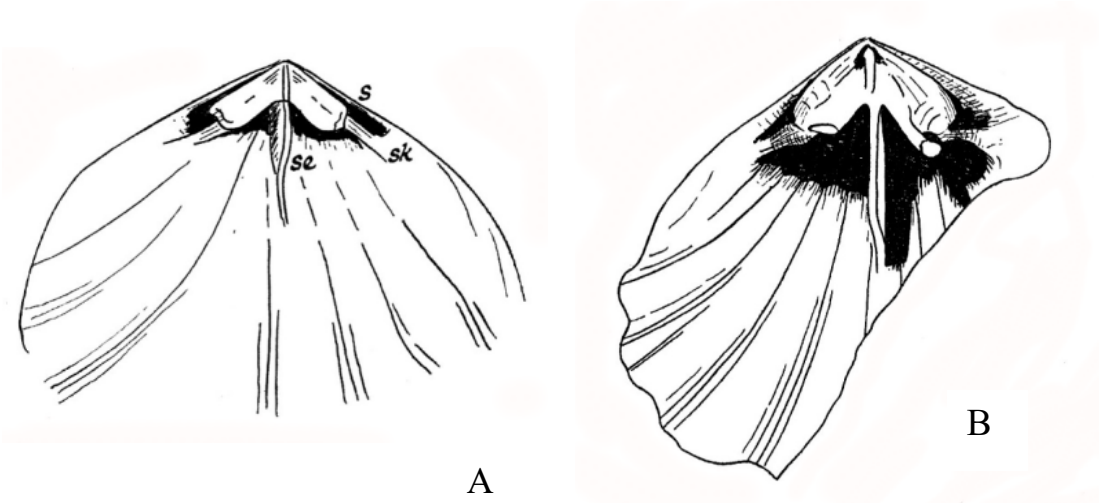


Fig. 6. A, *Plekonella campbelli* Waterhouse, dorsal interior, BR 446, x7, Brunel Formation. B, *Plekonella acuta* Campbell, dorsal interior BR 412 x7, Letham Burn Member, New Zealand (Waterhouse 1964).. s, socket; se median septum; sk, socket plate.

Morphology: The fold and sulcus commence within the posterior quarter to third of the length of the mature shell. The delthyrium is closed under the beak by two deltidial plates, and a foramen lies at the tip of the ventral beak.

Stratigraphy: The species is limited as far as is known to the *Notostrophia zealandicus* Zone in the Brunel Formation of New Zealand.

Plekonella rara Waterhouse, 1986

Fig. 7

1986 *Plekonella rara* Waterhouse, p. 64, pl. 14, fig. 22-25.

Diagnosis: Subtriangular shells with robust costae and well-defined sulcus and fold. Two costae lie within sulcus and the bordering costa to each side is subdivided, the inner branch entering the sulcus. Fold with three to five costae, four pairs laterally.

Holotype: UQF 50882 figured in Waterhouse (1986, pl. 14, fig. 22, 23) and herein as Fig. 7A, B from Roses Pride Formation, southeast Bowen Basin.

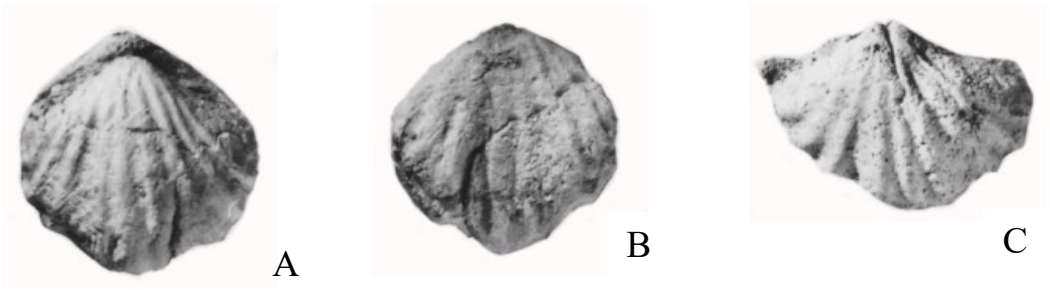


Fig. 7. *Plekonella rara* Waterhouse. A, B, ventral and dorsal views of the holotype, UQF 50882. C, dorsal internal mould UQF 74106. Specimens x1 from Roses Pride Formation. (Waterhouse 1986).

Morphology: This is a rare species, and its relatively short posterior walls that are slightly convex in outline and varying number of costae suggest that the species was derived from *Plekonella whitehousei.*

Stratigraphy: The species is limited to the Roses Pride Formation of the southeast Bowen Basin in Queensland.

Plekonella acuta Campbell, 1953

Fig. 2, 8 - 10

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.
2002 *P. acuta* – Savage, p. 1258, Fig. 858a-i.
2022a *P. acuta* – Waterhouse, p. 36, Fig. 1.

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

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

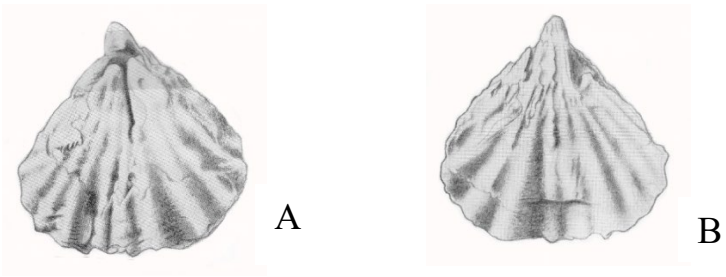


Fig. 8. *Plekonella acuta* Campbell. A, B, dorsal and ventral aspects of BR 1230, x2, from Pig Valley Limestone of Late Permian age in Nelson, New Zealand. (Waterhouse 1967).

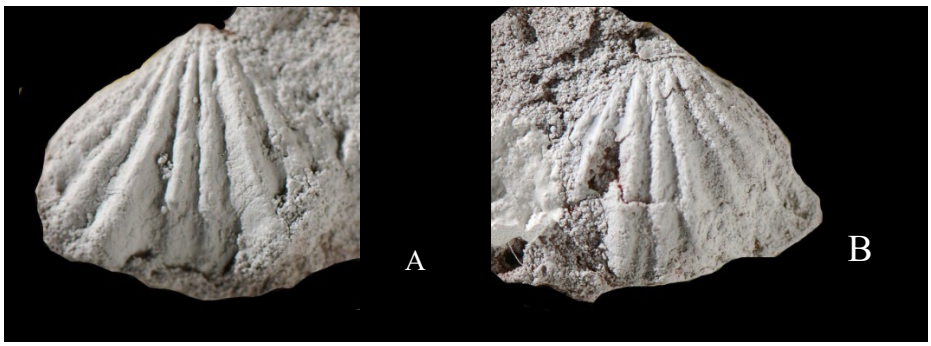


Fig. 9. *Plekonella acuta* Campbell, A, B, ventral and dorsal aspects of UQF 69671, x2. Catherine Sandstone, Queensland. (Waterhouse 2022a).

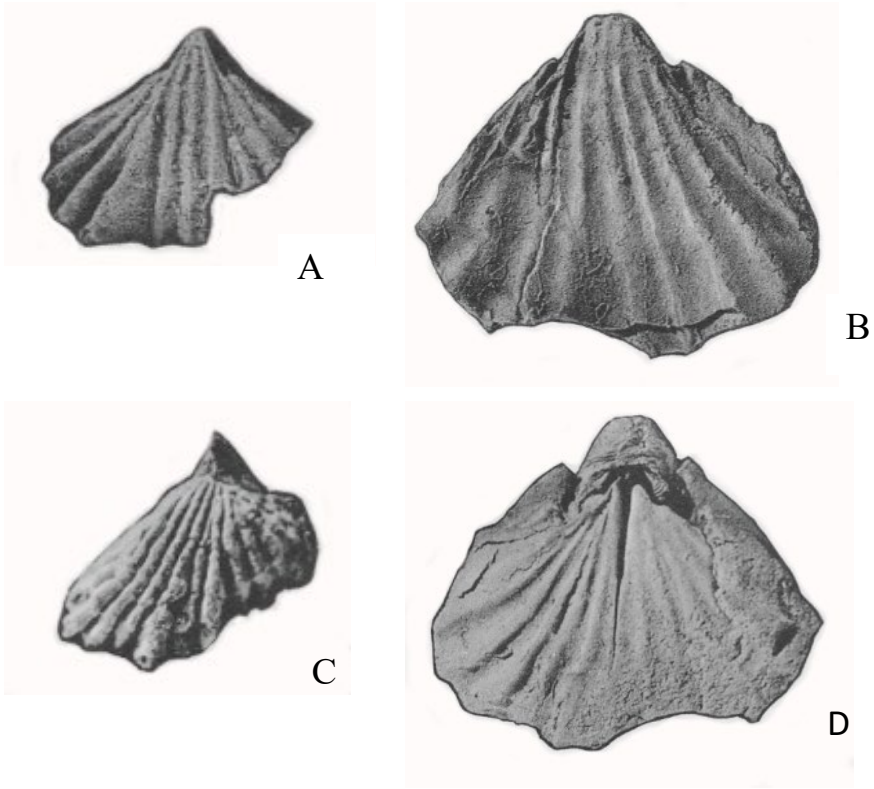


Fig. 10. *Plekonella acuta* Campbell. A, internal mould of ventral valve BR 938 x2 from middle Letham Formation. B, internal mould of ventral valve BR 405 x4 from Letham Burn Member. C, dorsal aspect of PVC cast, BR 414, x2 Letham Burn Member. D, dorsal aspect of internal mould, BR 405, x4, Letham Burn Member, New Zealand. (Waterhouse 1964).

Morphology: This species is characterized by its two sulcal costae and three costae over the fold.

Stratigraphy: The species appears to have been relatively long-lived. It first entered the Letham Formation of New Zealand and in New Zealand is found abundantly in the Letham Burn Member and as high as the *Marginalosia planata* Zone in the Pig Valley Limestone, of late, but not latest Changhsingian age. In the Bowen Basin the species is represented in the lower Peawaddy Formation and in the Catherine Sandstone, in the *Pseudostrophalosia blakei* Zone.

Plekonella southlandensis (Fletcher, 1952)

Fig. 11, 12

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.
1986 *P. southlandensis* – Waterhouse, p. 65, pl. 14, fig. 27-29.
2022a *P. southlandensis* – Waterhouse, p. 37, Fig. 2.

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

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

Fig. 11. *Plekonella southlandensis* (Fletcher). A, B, ventral and dorsal views of BR 392. C, ventral internal mould BR 391, lectotype. From Mangarewa Formation, New Zealand. (Waterhouse 1964).

Morphology: In some topotypes of this species, the median sulcal costa splits anteriorly into two. Like other topotypes, specimens from the Catherine Sandstone from the southwest Bowen Basin in Queensland show no such split (Waterhouse 2022a), 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.

Unlike the regular arrangements of costae in specimens from most collections (Waterhouse (2001, p. 87), and as stated previously, specimens with a variable number of sulcal and fold costae 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

three species, one distinguished by the variable number of sulcal and fold costae. But there are other possibilities.

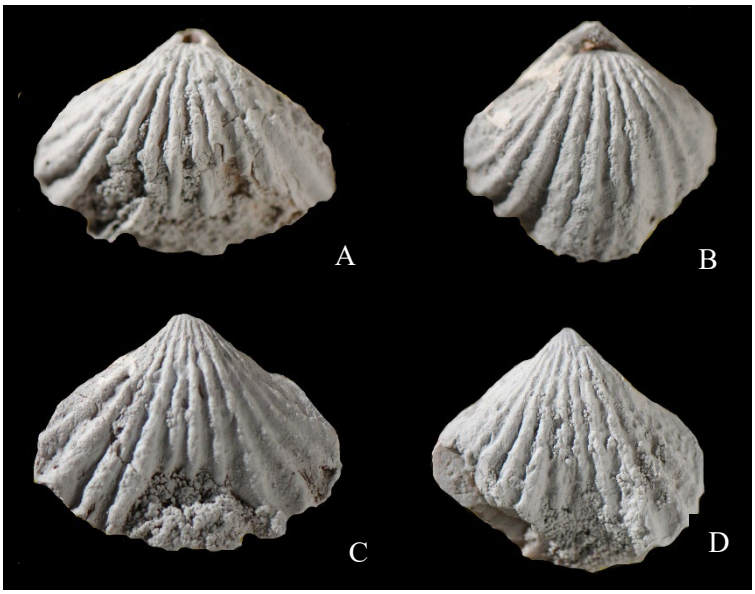


Fig. 12. *Plekonella southlandensis* (Fletcher). A, C, dorsal and ventral aspects of UQF 69672, x2. B, D, dorsal and ventral aspects of UQF 69675, x2. From Catherine Sandstone. (Waterhouse 2022a).

Stratigraphy: *Plekonella southlandensis* is found in the middle Mangarewa Formation of New Zealand, from the *Maxwellosia ovalis* Superzone, and has a longer range in the Bowen Basin, being apparently present in the Catherine Sandstone (*Pseudostrophalosia blakei* Zone) as well as the *ovalis* Superzone in the Flat Top Formation.

Plekonella multicostata Waterhouse, 1964

Fig. 13, 14

1964 *Plekonella multicostata* Waterhouse, p. 94, pl. 17, fig. 14-18, pl. 18, fig. 1, 2, text-fig. 32B, 36-39.
1969 *Plekonella* cf. *multicostata* – Runnegar & Ferguson, pl. 5, fig. 9-11.
1982 *P. multicostata* – Waterhouse, p. 52, pl. 13a-c.
2008 *P. multicostata* – Waterhouse, p. 368.

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

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

Morphology: *Plekonella southlandensis* (Fletcher, 1952) is distinguished from *P. multicostata* by having stronger ribs over the umbo, and generally being a broader shell with ribs that may bifurcate in the sulcus. Sulcal and fold costae are more variable in number and generally more numerous.

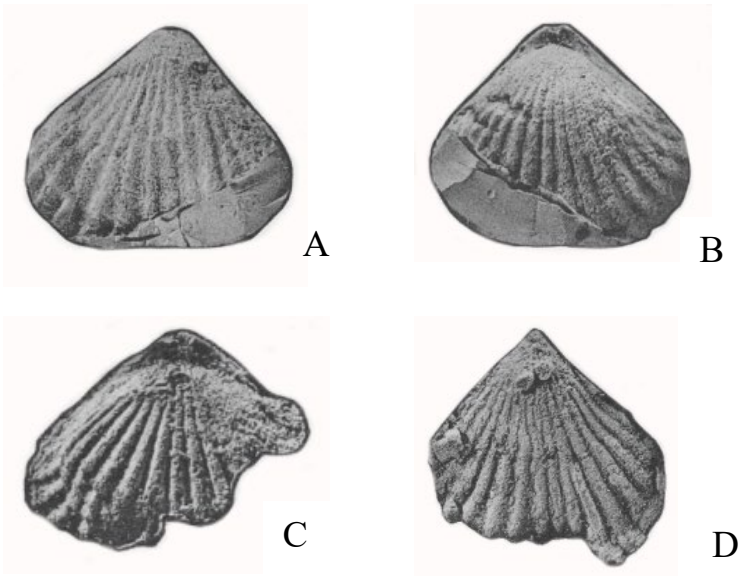


Fig. 13. *Plekonella multicostata* Waterhouse. A, B, ventral and dorsal aspects of PVC cast, BR 914, x2. C, dorsal view of latex cast, BR 434. D, ventral latex cast, ventral valve BR 431. Specimens x2 from Bagrie Formation, New Zealand. (Waterhouse 1964).

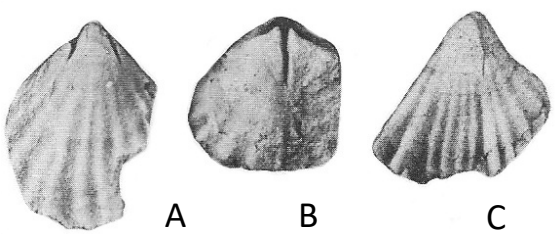


Fig. 14. *Plekonella multicostata* Waterhouse. A, internal ventral mould, UQF 47239, x2. B, dorsal internal mould UQF 27240, x2. C, clay impression of ventral exterior, UQF 47238, x1.5. See Runnegar & Ferguson (1969). Specimens from South Curra Limestone, Gympie. (Waterhouse 2015b).

Stratigraphy: *Plekonella multicostata* comes from the Arthurton Formation of New Zealand, and South Curra and Gigoomgan Limestones of the Gympie district in southeast

Queensland.

Genus ***Aphaurorhynchia*** Waterhouse, 2010

Diagnosis: Shell largely smooth, with sulcus, fold and costae limited to the anterior margin of the one known species, shell surface also marked by fine radial capillae and commarginal growth increments. Dental plates sturdy and long, dental sockets finely crenulate, hinge plate undivided, high median ridge, median septum long.

Type species: *Plekonella iniquitas* Waterhouse, 1967 from Late Permian Wairaki Breccia of New Zealand, OD.

Discussion: This genus is moderately close to *Phrenophoria* Cooper & Grant (1969, p. 12) of Wellerinae from the Glass Mountains of Texas, but has shorter ribs and *Phrenophoria* lacks the median ridge from the dorsal hinge plate. *Aphaurosia* Cooper & Grant (1976a, p. 2048) from Texas is somewhat similar externally to the New Zealand taxon but has a notched hinge plate, uncorrugated dental sockets and vestigial or no median septum. Further similarities and differences are discussed in Waterhouse (2010, p. 59), as well as in the initial publication of the species (Waterhouse 1967, pp. 86, 87). Compared with *Plekonella* Campbell, costae are much less prominent, with a largely smooth shell except anteriorly, but the interior is like that of *Plekonella*.

Aphaurorhynchia iniquitas (Waterhouse, 1967)

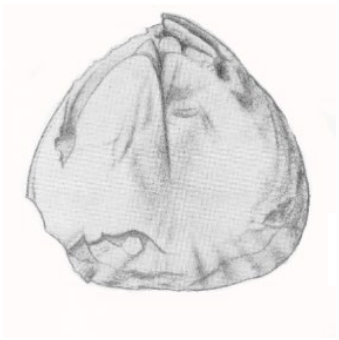
Fig. 15, 16

1967 *Plekonella iniquitas* (Waterhouse, p. 85, Fig. 5C, 9A, 11 - 13, 15.
2010 *Aphaurorhynchia* - Waterhouse, p. 59, Fig. 25.

Fig. 15. *Aphaurorhynchia iniquitas* (Waterhouse). A, dorsal interior based on BR 1236, x2.5 approx., showing mantle canals, anterior ribbing (r), median septum (s) and crenulate dental sockets (t). B, serial sections of dorsal valve at 0.5, 1.0 and 2.0mm from dorsal umbo. Based on BR 1236, x5. Wairaki Breccia. (Waterhouse 1967).

A

B



C

Fig. 16. *Aphaurorhynchia iniquitas* (Waterhouse). A, ventral internal mould BR 843. B, dorsal aspect of holotype BR 1236. C, dorsal view, internal mould BR 1273. Specimens x4 from Wairaki Breccia. (Waterhouse 1967).

Diagnosis: Costae fine over sulcus and fold, coarser laterally, restricted to anterior shell.

Holotype: BR 1236 from Wairaki Breccia, figured in Waterhouse (1967, Fig. 5c, 9A, 12, 13) and herein as Fig. 15A, B, 16B, OD.

Stratigraphy: The species is limited to the Wairaki Breccia of western Southland, New Zealand.

Genus ***Wairakiella*** Waterhouse, 1967

Diagnosis: Small plicate shells. Ventral teeth supported by massive plates fused to posterior lateral walls; adductor impressions long, diductor impressions very wide. Dorsal sockets denticulate, inner socket plates very large, fused posteriorly, cardinal or hinge plate small, bearing median ridge, supported by dorsal septum which extends almost to anterior margin; the cavity below the hinge plate becomes infilled during maturity. Two pairs of adductor scars lie in front. Crura arise from the front of the hinge plate.

Type species: *Wairakiella rostrata* Waterhouse, 1967 from Wairaki Breccia at the top of the Permian succession in Wairaki Downs, New Zealand.

Discussion: This genus was synonymized by Savage & Manceñido (2002, p. 1270) with *Pseudowellerella* Licharew, 1956, type species *P. nikchitchi* Licharew from the Late Permian of the North Caucasus, but the New Zealand species was carefully compared with

Licharew's form, and it was pointed out that *Pseudowellerella* lacked teeth, and possessed a free-standing cardinal or hinge hinge plate, without median ridge. Nor have socket crenulations been reported.

Component species of *Wairakiella* show that the hinge plate has a median ridge as in *Plekonella*, a facet completely ignored by Savage & Manceñido (2002, p. 1270). They synonymized *Wairakiella* with *Pseudowellerella*, which was placed in Allorhynchidae Cooper & Grant, 1976, a family in which various genera have low or no median dorsal septum and divided hinge plates. *Pseudowellerella* Licharew, 1956, p. 56, type species *P. nikchitchi* Licharew, has a united hinge plate, but lacks the median hinge plate ridge of *Wairakiella* and the dorsal septum is short and low.

Wairakiella sella Waterhouse, 1976

Fig. 17

1976 *Wairakiella sella* Waterhouse, p. 242, Fig. 5.2-9.

Diagnosis: Small subpentagonal shells with costae over anterior half to a third of the shell, distinct anterior sulcus, low broad anterior fold.

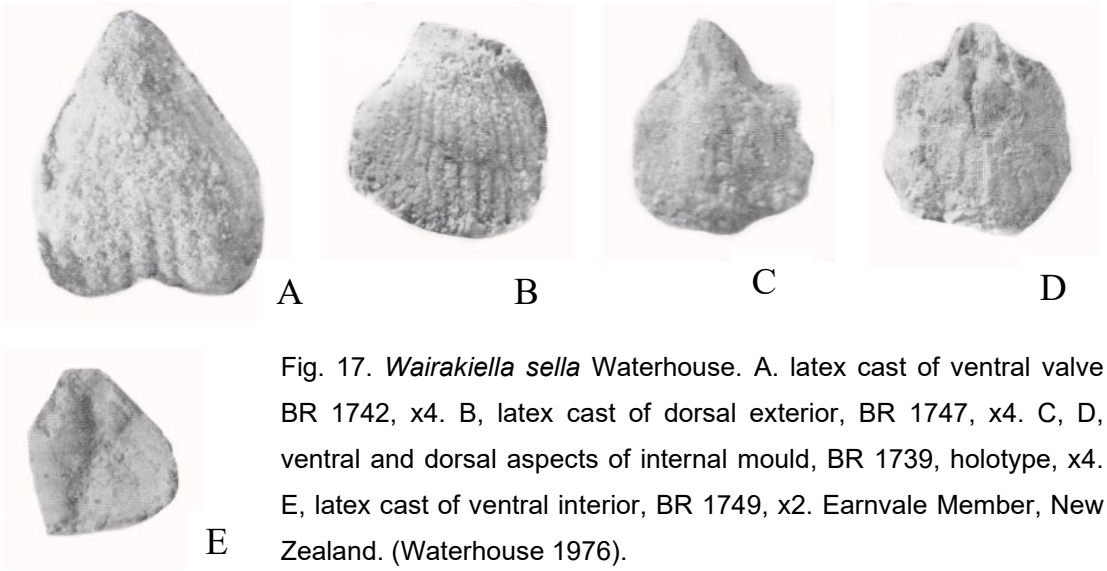


Fig. 17. *Wairakiella sella* Waterhouse. A. latex cast of ventral valve BR 1742, x4. B, latex cast of dorsal exterior, BR 1747, x4. C, D, ventral and dorsal aspects of internal mould, BR 1739, holotype, x4. E, latex cast of ventral interior, BR 1749, x2. Earnvale Member, New Zealand. (Waterhouse 1976).

Holotype: BR 1739 from Earnvale Member, Bagrie Formation, figured in Waterhouse (1976, Fig. 5.2, 3) and herein as Fig. 17C, D, OD.

Morphology: The specimens show a broader ventral umbo, and longer, wider ventral sulcus, with numerous costae that commence in front of the umbones and are a little broader than in *Wairakiella rostrata*. In at least some dorsal valves the socket crenulations are coarser, and the median septum more prominent.

Stratigraphy: The species is found in the Earnvale Member of the Bagrie Formation of New Zealand, and is deemed to be of upper Wuchiapingian age.

Wairakiella rostrata Waterhouse, 1967

Fig. 18 - 21

1967 : *Wairakiella rostrata* Waterhouse, p. 88, Fig. 5E, 6B, C, 7A, B, 16-27.

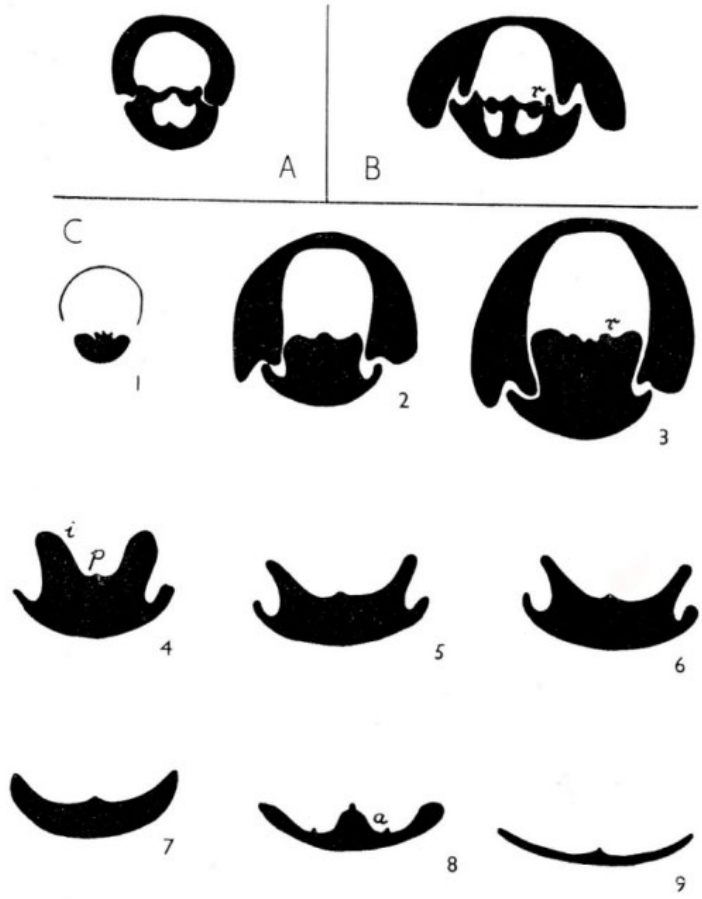


Fig. 18. A, *Pseudowellerella nikchitchi* Licharew, redrawn from Licharew 1956, text-fig. 10, p. 59. B, C, *Wairakiella rostrata* Waterhouse, B, cross-section for immature specimen BR 1281 at 2mm from tip of umbo. C, composite serial sections based on mature specimens x4 aprox. at 0.5mm intervals from tip of umbo as BR 1262 and BR 1241. a = adductor muscles divided by low septum, i = inner socket plate, p = median ridge; r = crural base, s = medium ridge. (Waterhouse 1967).

Diagnosis: Costae cover both valves. Fold low and limited to anterior shell, sulcus may be imperceptible.

Holotype: BR 1241 from Wairaki Breccia, figured by Waterhouse (1967, Fig. 6C, 21, 27) and in part Fig. 18C herein, OD.

Morphology: The species is represented by a number of specimens and has been extensively illustrated.

Stratigraphy: The species is known only from the Wairaki Breccia, of very late Permian age.

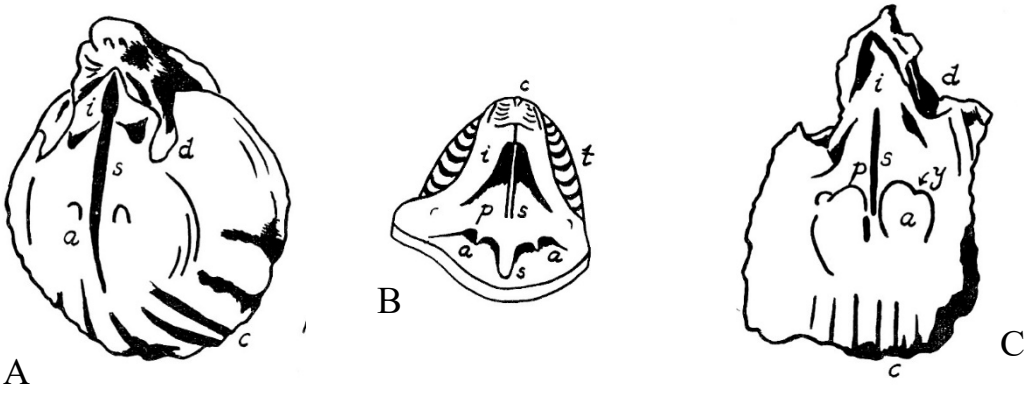


Fig. 19. *Wairakiella rostrata* Waterhouse. A, dorsal aspect of young specimen, internal mould BR 1281, x6, B, BR 1262, x4 showing cardinal process c and socket plates i. C, dorsal aspect of BR 1261 at early maturity. a = adductor muscle impressions, small in A, larger in B; Wairaki Breccia, southern New Zealand. (Waterhouse 1967). c = costae; d = dental sockets; i = cardinal plate with median septal ridge; resting on umbonal filling; l = denticulate dental sockets; p = platform in more mature specimen; r = crural bases; s = median septum; with anterior part offset in B; y = short septum dividing each adductor scar.

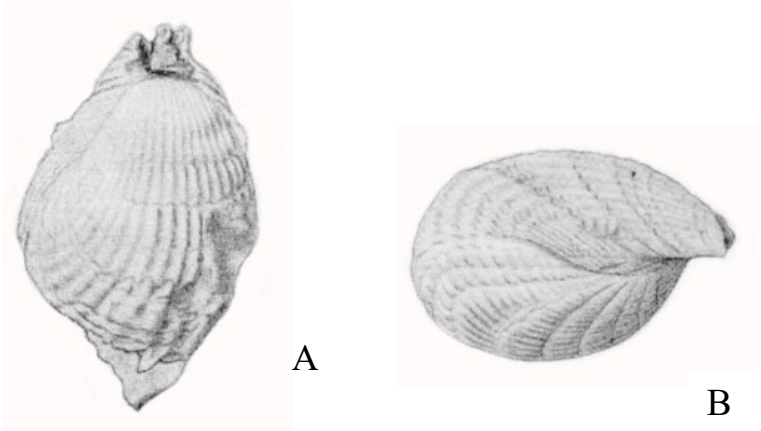


Fig. 20. *Wairakiella rostrata* Waterhouse. A, B, dorsal and lateral aspects of BR 1272, latex cast, x4. Wairaki Breccia (not Pig Valley Limestone as in 2010). (Waterhouse 1967).

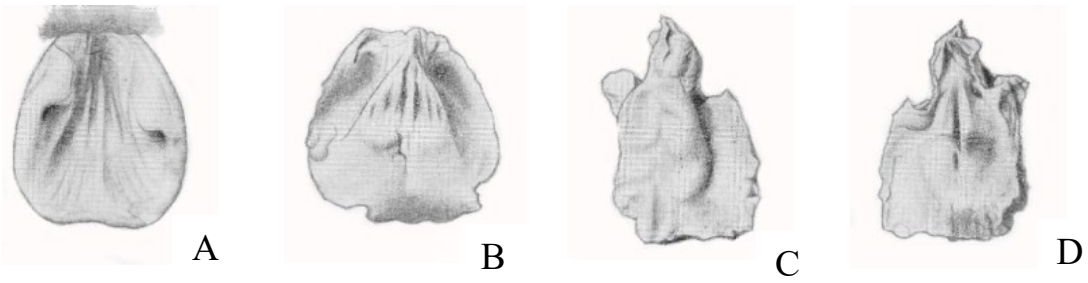


Fig. 21. *Wairakiella rostrata* Waterhouse. A, B, latex cast and internal mould of ventral valve BR 1257, showing dental plates hard against lateral walls. C, D, posterior ventral and dorsal aspects of internal mould of BR 1261, immature and showing the way the dental plates ankylose with the posterior walls. Wairaki Breccia. (Waterhouse 1967).

Incerte sedis

The classification of the following species is open to question. One was initially described as a species of *Pugnoides*, but its ribbing is distinctive, and the hinge plate carries an apparent median rib, and (like *Pugnoides*) the species appears to have a septalium. As stated previously, a median rib over the hinge plate or septalium is not known in Carboniferous and Permian rhynchonellidin genera, other than in *Plekonella* and its allies, and the constituent genera *Plekonella, Misella, Aphaurorhynchia* and *Wairakiella*, have no development of a septalium. In the treatment of Rhynchonellida by the *Revised Brachiopood Treatise*, a septalium may appear in some members of a family but not in others, and if that is accepted, then possibly some plekonellin genera developed a septalium. Therefore the species described as *tardivenus* may prove to be a plekonellin genus, as favoured by the presence of a median ridge. The genus would be new. But full analysis is hindered especially by the inadequate knowledge of the septalium deemed to be present in *tardivenus*, and it is preferred to leave the species in open nomenclature until more detail can be clarified.

"Pugnoides" tardivenus Waterhouse, 1982

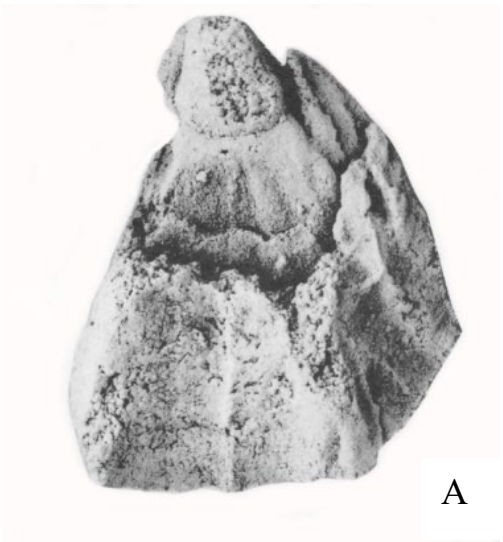
Fig. 22, 23

1982 *Pugnoides tardivenus* Waterhouse, p. 51, pl. 13d-g, Fig. 17N.

Diagnosis: Elongate with single anterior median rib in broad shallow sulcus and shallow median groove over crest of low fold, as well as up to three pairs of lateral ribs on each valve, more prominent over dorsal valve. Dental plates extend for over a quarter the length of the valve, septalium small and bearing median ridge, median septum extends for half of the length of the valve.

Holotype: BR 1455 from Brunel Formation, figured in Waterhouse (1982, pl. 13d, f; text-fig. 17N) and herein as Fig. 23A, C, 24), OD.

Morphology: Few specimens are available but shape and ribbing are distinctive, and the species seems likely to belong to a new taxon. In some regards, the shape and ornament come closer to Devonian genera recorded in the *Revised Brachiopod Treatise*.



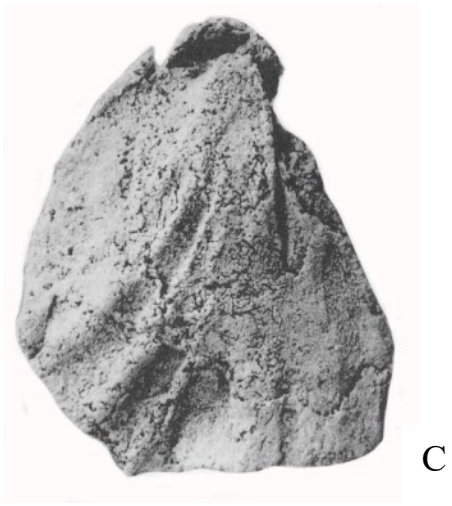


Fig. 22. "*Pugnoides*" *tardivenus* Waterhouse. A, C, ventral and dorsal aspects of holotype, BR 1455, x6. B, dorsal aspect of BR 1152, Specimens x 6 from Brunel Formation, New Zealand. (Waterhouse 1982).

Genera including *Pugnoides* that are assigned to Petasmariidae (Savage 2002b, p. 1189) in the *Revised Brachiopod Treatise* tend to have ribbed sulcus and fold, whereas the present form has only a single rib in the sulcus and a groove along the dorsal fold, and a few strong ribs lie over the lateral flanks. The septalium in Petasmariidae and in *Pugnoides* has a posterior cover, which is missing from the present form, and the present form has a median ridge in the septalium, missing from *Pugnoides*. The genus appears to be new, distinct in morphology and age, but not well represented so far in the geologic column. More material from the Brunel Formation will hopefully clarify the range of the morphology.

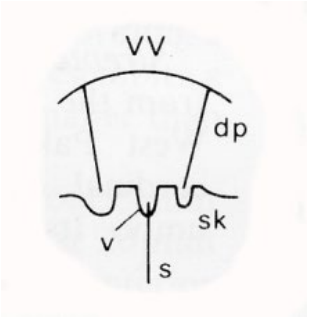


Fig. 23. "*Pugnoides*" *tardivenus* Waterhouse, diagram of interior of BR 1455. Dp = dental plate; s = dorsal septum; sk = socket; v = septalium with median ridge; VV = ventral valve, on top. Brunel Formation. (Waterhouse 1982).

Stratigraphy: The form is found in the *Notostrophia zealandicus* Zone of the Brunel Formation in the Takitimu Mountains of southern New Zealand.

Rhynchonellidin gen. & sp. incert.

Fig. 24, 25

2015a *Plekonella* sp. Waterhouse, p. 142, Fig. 95.
2020 *Plekonella* n. sp. Waterhouse & Campbell, p. 25, Fig. 7.

Diagnosis: Shells shaped like *Plekonella acuta* Campbell but externally distinguished by presence of four ribs over fold. Median ridge present in dorsal valve, but other dorsal internal features in need of confirmation and elaboration. A septalium appears to be present (Fig. 24C).

Morphology: Several fragmentary ventral valves are available from New Zealand. Two specimens show an only moderately well-defined ventral sulcus which bears two costae, and five costae on each of the lateral flanks of the shell, of which some costae show anterior

arching at the commissure (Fig. 24B). Another specimen is similar, except for the failure of further costae to appear by intercalation anteriorly (Fig. 24A). Well-developed dental plates are preserved in a fragment BR 2473. An internal mould of a specimen BR 2437 has valves conjoined, and strong ribs which number three each side of the dorsal valve. There are dental plates, and small umbonal foramen. The dorsal septum extends over the posterior third of the valve, supporting what appears to be a septalium which bears a swollen median ridge (Fig. 24C). A fragmentary dorsal valve is somewhat similar in costation, and the anterior dorsal fold has two median costae, one each side of a moderately defined median channel, and two costae diverge further back from the fold (Fig. 24C).

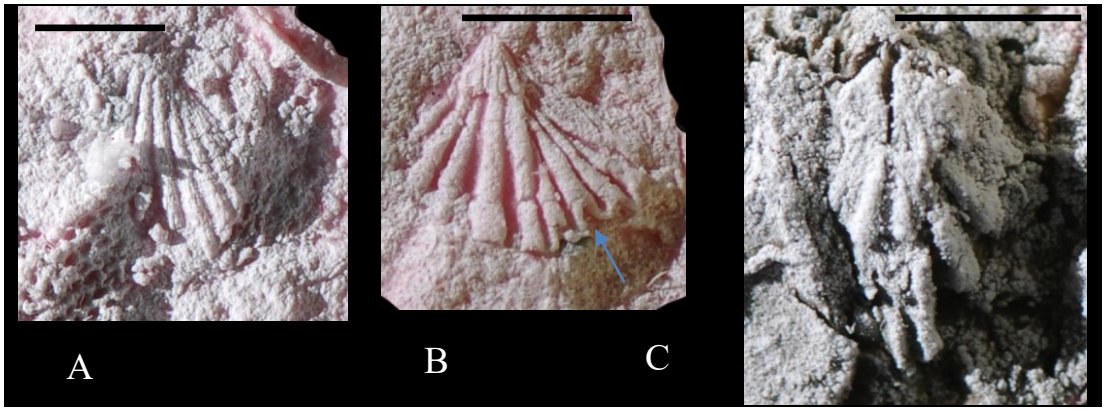


Fig. 24. Gen. & sp. indet. A, part of ventral valve, BR 2444. B, part of ventral exterior, cast, BR 2443, showing anterior arching of lateral ribs, as arrowed. C, dorsal aspect of internal mould BR 2437, suggesting the presence of a septalium. Space bar 5mm. Eglinton Subgroup of New Zealand. (Waterhouse & Campbell 2021).

Fig. 25. Rhynchonellid gen. & sp. indet., internal ventral mould UQF 81304 x3 from the lower Tiverton Formation, Queensland. (Waterhouse 2015a)

A single specimen with valves conjoined is found in the lower Tiverton Formation. It

is very like *Plekonella acuta* Campbell, 1953 in being triangular in shape with long posterior walls and two costae in the sulcus, with four costae each side (Fig. 25). Whether the form is conspecific and congeneric with the New Zealand specimens is not known, because no dorsal valve has been found.

Stratigraphy: Specimens come from the Eglinton Subgroup in the Dunton Mountains of southwest New Zealand, and a possible ventral valve comes from the Tiverton Formation of the north Bowen Basin, Queensland.

Suborder **STENOSCISMATIDINA** Waterhouse, 1981

[Stenoscismatidina Waterhouse, 1981, p. 91].

Diagnosis: Ventral valve distinguished by presence of a spondylium, formed by dental plates, sessile or as a rule supported by a median septum. Camarophorium in dorsal valve.

Discussion: In many respects members of this suborder agree with members of Rhynchonellidina Kuhn, but whereas the dental plates are separate in Rhynchonellidina, they fuse medianly to form a spondylium in Stenoscismatida (Sapelnikov & Mizens 1985, Waterhouse 1981, 2001). As a rule outer hinge plates are much reduced in the dorsal valve. Like Rhynchonellidina, Stenoscismatidina have a foramen and are attached by a pedicle, and the dorsal interior shows variations but is essentially close to that Rhynchonellidina, but muscle scars lie on the camarophorium. Members of Superfamily Rhynchotetradoidea Licharew, 1956, although small, have a spondylium much as in Stenoscismatidina, and *Camerophorina* Schmidt, 1941, classed as solitary member of Camerophorinidae Rzhonsnitskaia, is stenoscimatid, with ventral spondylium and a dorsal camarophorium.

Family **STENOSCISMATIDAE** Oehlert, 1887

Genus ***Stenoscima*** Conrad, 1839

Diagnosis: Biconvex shells with ventral sulcus and dorsal fold, Costae cover much to all of the shell in many species, ranging in other species to a few costae over the anterior sulcus and fold. Ventral spondylium supported by low median septum, dorsal hinge plate bearing a camarophorium which has a strong intercamarophorial plate and is supported by a median septum. Stolidium developed in many species.

Type species: *Stenoscisma schlottheimi* von Buch, 1834 from Zechstein of Germany. See Muir-Wood (1955) and Carlson & Grant (2002, pp. 1219, 1220).

Stenoscisma papilio Waterhouse, 1964

Fig. 26. 27

1964 *Stenoscisma papilio* Waterhouse, p. 99, pl. 18, fig. 4 - 8, Fig. 41, 42.
?2015b ?*S. papilio* – Waterhouse, p. 151, Fig. 71.

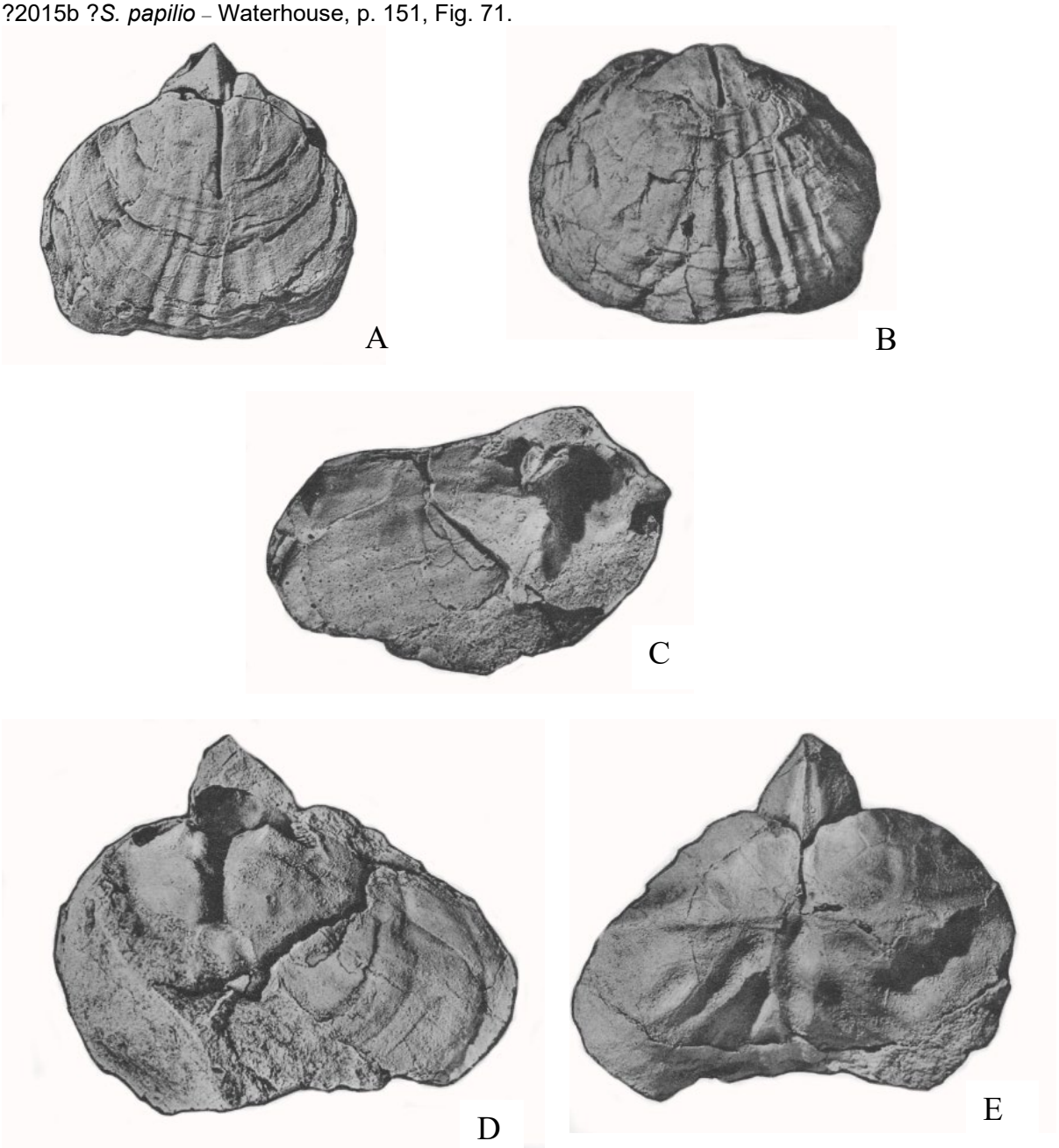


Fig. 26. *Stenoscisma papilio* Waterhouse. A, B, ventral and dorsal aspects of internal mould BR 450. C-E, BR 909, holotype, showing latex cast of dorsal interior and dorsal and ventral aspects. Specimens x2 from Kildonan Member, Bagrie Formation, New Zealand. (Waterhouse 1964).

Diagnosis: Large, roundly subtriangular moderately inflated shells with costae over anterior third to half of sulcus and fold, may have a few lateral ribs. Hinge plate convex with tiny camarophorium and intercamarophorial ridge.

Holotype: BR 909 from Bagrie Formation, New Zealand, figured in Waterhouse (1964, pl. 18, fig. 6-8, Fig. 41) and herein as Fig. 26C-E, OD.

Stratigraphy: The species is found in the upper Bagrie Formation and probably in the overlying Trig D Formation of New Zealand and possibly in the Gigoomgan Formation of southeast Queensland.

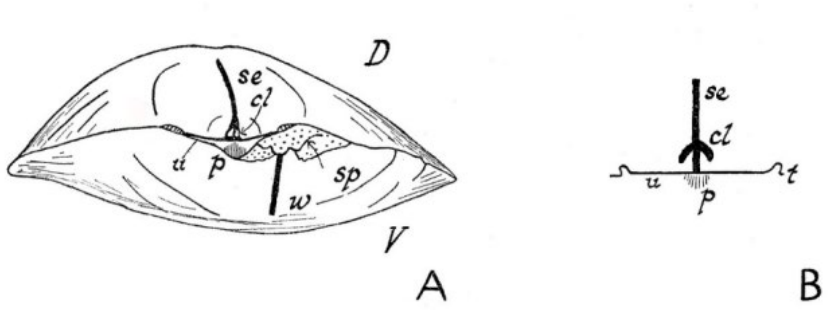


Fig. 27. *Stenoscisma papilio* Waterhouse. A, posterior aspect with ventral beak removed, matrix dotted, BR 450, x3. B, dorsal cardinalia as seen in section. cl = septalium, D = dorsal valve; p = cardinal process; se = dorsal septum; sp = spondylium; s = position of dental socket; t = tooth; u = apparently posterior shell close to or at commissure?; V = ventral valve; w = ventral septum. Kildonan Member, Bagrie Formation, New Zealand. (Waterhouse 1964).

Stenoscisma sp.

1982 *Stenoscisma* sp. Waterhouse, p. 52, pl. 12l.

Incomplete specimens of likely *Stenoscisma* have been reported from the Kildonan Membar, Bagrie Formation of the Arthurton Group (Waterhouse 1982). Specimens are more inflated with stronger ribs than in *S. papilio*.

Genus ***Coledium*** Grant, 1965

Diagnosis: Usually small with few costae limited to anterior half of shell, stolidium narrow or absent, deltidial plates small and disjunct or absent, spondylium on low median septum.

Type species: *Coledium erugatum* Grant, 1965 from Visean Moorefield Formation of Oklahoma, United States, OD.

Coledium elvinia Waterhouse, 1986

Fig. 28

1986 *Coledium elvinia* Waterhouse, p. 66, pl. 14, fig. 30-34.

Diagnosis: Small with no visible stolidium, two strong ribs in the sulcus, three ribs over fold, lateral costae anteriorly placed, short or absent.

Holotype: UQF 74112 from Elvinia Formation, southeast Bowen Basin, figured in Waterhouse (1986, pl. 14, fig. 31, 32, 34) and herein as Fig. 28A, B, OD.

Morphology: The sulcus bears a pair of anterior costae and three pairs of lateral costae are present on the ventral valve. Two costae lie on the fold, and one or two pair of costae are present laterally. The ventral spondylium is sessile posteriorly, supported by a low septum in front, and the camarophorium is small, with intercamarophorial plate and high medium septum extending for only a quarter of the length of the valve.

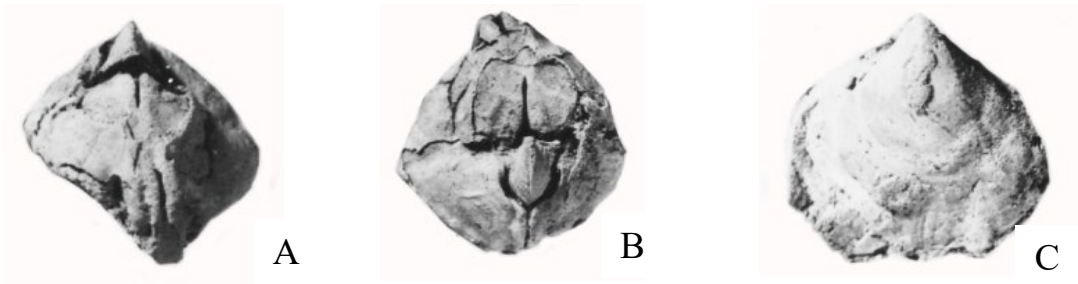


Fig. 28. *Coledium elvinia* Waterhouse. A, B, dorsal and posterior aspects (dorsal valve on top) of holotype, UQF 74112. C, latex cast of ventral valve UQF 74111. Specimens from Elvinia Formation, x2. (Waterhouse 1986).

Carlson & Grant (2002, p. 1220) without explanation claimed that some uncertainty had to be attached to the generic position of *elvinia* Waterhouse. On the other hand, no stolidium is preserved, supporting identification with *Coledium* rather than *Stenoscisma*, and the close relationship of various Himalayan and Timor species to *Coledium crassa* (Hamlet, 1928) as identified by Grant (1965, p. 97) and the Timor record of *C. nuculum* Schellwien in

Hamlet (1928) suggests that the genus was widespread in Permian faunas of at least peripheral Gondwana (Waterhouse 2004, pp. 76-82). Therefore the presence of *Coledium* in the Early Permian of the Bowen Basin, which occupied paleolatitudes somewhat lower than those of the Sydney Basin and Tasmania, would not be anomalous.

Stratigraphy: The species is found in the Elvinia Formation, of the southeast Bowen Basin in Queensland, of Sakmarian age.

Coledium ? sp.

Fig. 29

2015a *Coledium*? sp. Waterhouse, p. 145, Fig. 99.

The only known specimen comes from the middle Tiverton Formation of the Bowen Basin in the *Taeniothaerus subquadratus* Zone. It has valves conjoined, and is small, 10.5mm wide, 9.3mm long and about 5.5mm high, ventral valve damaged with beak destroyed, largely smooth, sulcus shows short anterior groove with broad floor and short median costa. The dorsal valve has a low fold over anterior third of shell length, bearing shallow median depression, with no sign of a stolidium. Ventral interior partly destroyed, preserves part of spondylium and median septum. Dorsal valve with large laminate cardinal process, short high medium septum about one quarter of length of valve, narrow camarophorium and high sturdy intercamarophorial ridge, but further detail obscure.

Fig. 29. *Coledium* ? sp. dorsal aspect of UQF 81378 from the Tiverton Formation, x4. (Waterhouse 2015a).

What is known of this specimen agrees with features of *Coledium* Grant, but preservation is far from complete, and the generic position is not secure. The material described as *Coledium elvinia* Waterhouse (1986, pl. 14, fig. 30-34) is more costate

anteriorly, with more elongate outline and apparently a narrower ventral umbo.

Genus ***Sedecularia*** Waterhouse, 2004

Diagnosis: Small to medium-sized smooth shells with rounded to oval outline and weakly uniplicate to rectimarginate outline, no stolidium, sessile spondylium with very low medium septum, high intercamarophorial plate.

Type species: *Stenoscisma glabra* Waterhouse, 1986 from Brae Formation, southeast Bowen Basin, Queensland, OD.

Discussion: The genus is compared with other stenoscimatids in Waterhouse (2004, p. 83).

Sedecularia glabra (Waterhouse, 1986)

Fig. 30, 31

1986 *Stenoscisma glabra* Waterhouse, p. 67, pl. 14, 15, pl. 15, fig. 19-21.
2004 *Sedecularia glabra* – Waterhouse, p. 82, text-fig. 21A, 22.
2007 *S. glabra* – Carlson, p. 2718, Fig. 1813.2a-i.

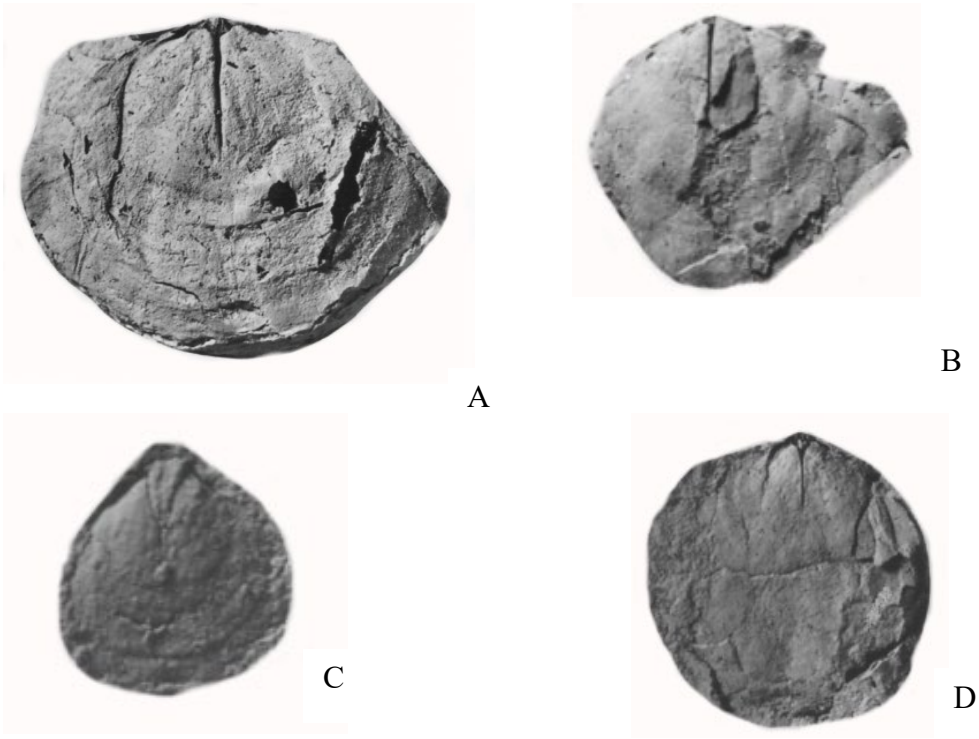


Fig. 30. *Sedecularia glabra* Waterhouse. A, dorsal internal mould UQF 70115, x1.75. B, dorsal aspect of internal mould, UQF 70116, holotype, x2. C, internal mould of small ventral valve UQF 70114, x4. D, internal mould of immature dorsal valve UQF 70117, x3. Brae Formation. (Waterhouse 1986).

Diagnosis: Small oval to subrounded shells, without costae and only a very shallow sulcus and imperceptible if any fold, spondylium largely sessile, short septum persists a little beyond the spondylium; dorsal camarophorium supported by long septum duplex, short high intercamarophorium, laminated cardinal process, well formed dental sockets.

Holotype: UQF 70116 from Brae Formation, Bowen Basin, figured by Waterhouse (1986, pl. 14, fig. 35, pl. 15, fig. 21; 2004, text-fig. 22.1, 3); Carlson (2007, Fig. 1813.2a) and Fig. 30B herein, OD.

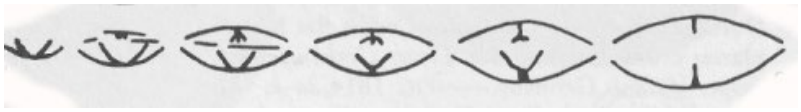


Fig. 31. *Sedecularia glabra* Waterhouse, serial sections as rearranged by Carlson (2007) from Waterhouse (2004, Fig. 21A), at 1mm intervals from left to right, ventral valve below. Brae Formation, southeast Bowen Basin.

Morphology: The nature of the delthyrium with regards deltidial plates requires clarification

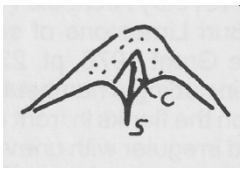
Stratigraphy: The species is found only in the Brae Formation of the southeast Bowen Basin.

Sedecularia sp.

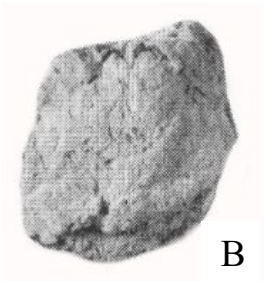
Fig. 32

2001 *Stenoscisma*? sp. Waterhouse, p. 88, pl. 5, fig. 23, text-fig. 5i.

Diagnosis: Specimens small, of uncertain maturity, no costae, slightly more inflated than *Sedecularia glabra* Waterhouse.



A



B

Fig. 32. *Sedecularia* sp. A, posterior ventral valve showing spondylium c and median septum (s), OU 18302, x1. B, dorsal valve BR 2350, x1. Hilton Limestone, New Zealand. (Waterhouse 2001).

Morphology: Several specimens are available, including ventral valves BR 2350 and OU 18301 and dorsal valve OU 18302, with other specimens. Detail as recorded in Waterhouse (2001) suggest the specimens belong to *Sedecularia* as a species distinguished from *S. glabra* by its greater inflation.

Stratigraphy: Material comes from the *Spinomartinia spinosa* Zone in the Hilton Limestone at Wairaki Downs, New Zealand.

Family **PSILOCAMARIDAE** Grant, 1965

Subfamily **PSILOCAMARINAE** Grant, 1965

Diagnosis: Shell smooth or costate, no stolidium, delthyrium unconstricted as a rule, no intercamarophorial ridge, or weak if present. Upper Carboniferous (Moscovian) to Upper Permian (Changhsingian).

Genus ***Psilocamara*** Cooper, 1956

Diagnosis: Ventribiconvex smooth shells with disjunct deltidial plates, curved camarophorium.

Type species: *Psilocamara renfroarum* Cooper from Mineral Wells Formation, Texas, United States, of Moscovian age, OD.

Psilocamara saginatum Waterhouse, 1964

Fig. 33 - 36

1958 *Psilocamara* n. sp. Waterhouse, p. 608.
1964 *Psilocamara saginatum* Waterhouse, p. 103, pl. 19, fig. 1-14, text-fig. 43-46.

Diagnosis: Moderately large for the genus, deep sulcus U-shaped in section. Spondylium with median groove, large cardinal process, small camarophorium, no intercamarophorial ridge.

Holotype: BR 451 from Brunel Formation, figured in Waterhouse (1964, pl. 19, fig. 3, 4, 6, 9, 10, text-fig. 44, 45) and Fig. 34C, D, F, 35, 36 herein, OD.

Morphology: The species is large for the genus, and size enables detail to be clarified. Unlike the type species, the cardinal process is well developed. There are only minor variations in the development of an anterior groove in the fold of some dorsal valves and minute other differences in size and shape.

Stratigraphy: The species is found chiefly in the *Notostrophia zealandicus* Zone of the Brunel Formation in the Takitimu Group, and a possible occurrence from underlying rocks of uncertain zonation.

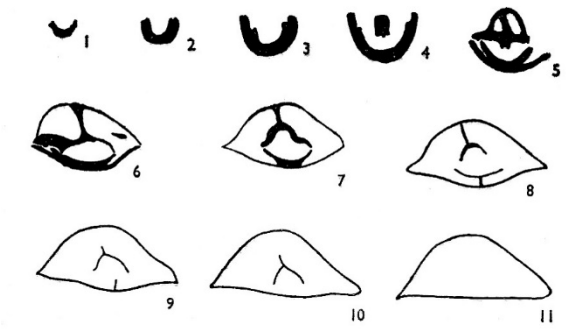


Fig. 33. *Psilocamara saginatum* Waterhouse. Serial sections at 0.5mm intervals, commencing at 0.75mm from tip of ventral beak. Dorsal valve on top. Crura not preserved. x1. Brunel Formation, New Zealand. (Waterhouse 1964).

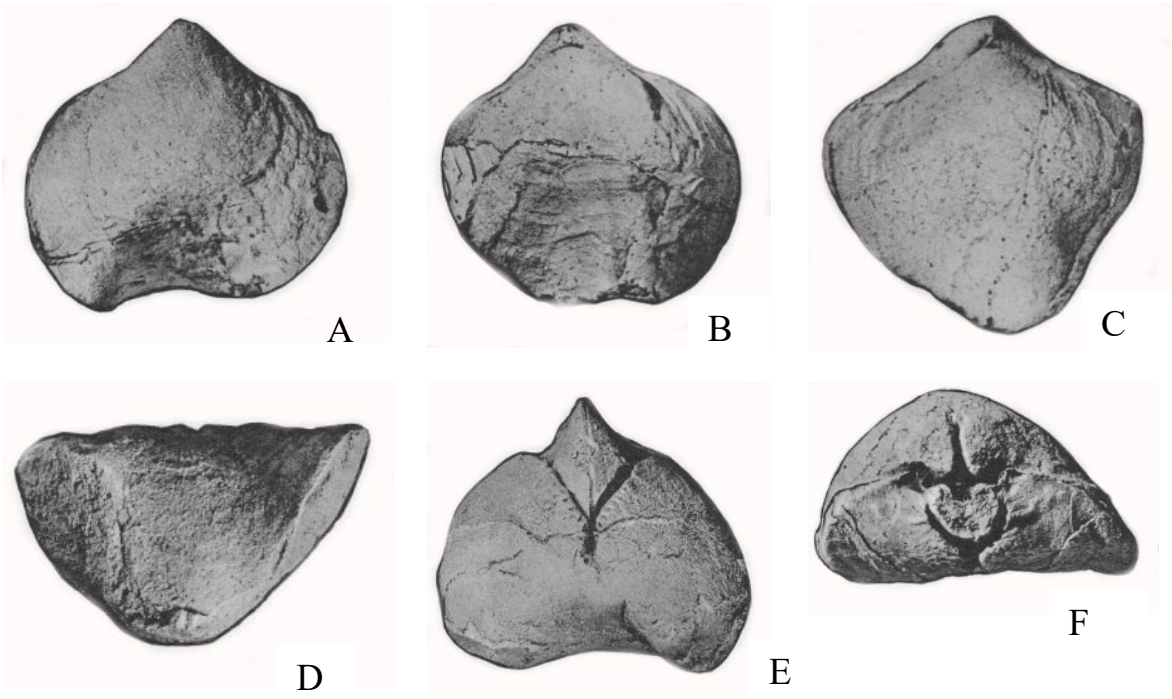


Fig. 34. *Psilocamara saginatum* Waterhouse. A, B, ventral and dorsal views of PVC cast BR 454. C, D, dorsal and anterior (ventral valve on top) aspects of holotype, BR 451, PVC cast. E, ventral internal mould, BR 452. F, posterior view of internal mould of both valves, dorsal valve on top, BR 451, holotype. Specimens x 2 from Brunel Formation, New Zealand. (Waterhouse 1964).

Fig. 35. *Psilocamara saginatum* Waterhouse, showing internal plates, dorsal valve on top, from holotype BR 451. cl = camarophorium; cm = commissure; cr = crus; p = cardinal process; s = dental socket; se = dorsal septum; sp = spondylium; t = tooth; u = hinge plate; w = ventral septum. Size approx.. x10. Brunel Formation. (Waterhouse 1964).

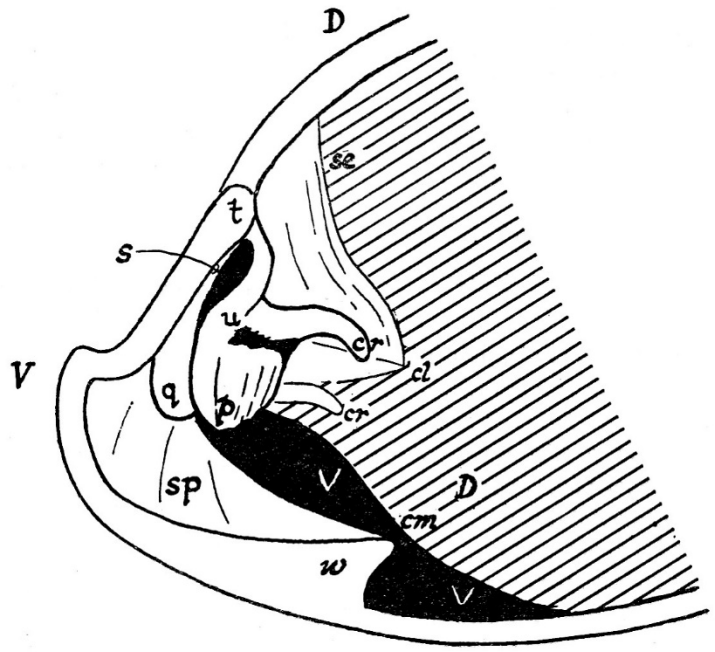


Fig. 36. *Psilocamara saginatum* Waterhouse, showing internal plates, dorsal valve on top, from latex cast of holotype BR 451. D = dorsal valve; V = ventral valve, remaining letters as in preceeding caption. Size approx. x10. Brunel Formation. (Waterhouse 1964).

Order ATHYRIDA Boucot, Johnson & Staton, 1964

Superfamily **ATHYROIDEA** Davidson, 1881

Family **ATHYRIDAE** Davidson, 1881

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

Genus ***Cleothyridina*** Buckman, 1906

Diagnosis: Rostrate shells covered by close-set growth lamellae each or mostly with a row of flat solid spines projecting from the anterior margin, sulcus and fold developed anteriorly, short low dental plates, subtriangular cardinal plate with outer ventrally concave hinge plates and inner hinge plates dorsally placed, may have flat surface. Jugum elaborate and much as in *Athyris*.

Type species: *Cleiothyridina pectinifera* (Sowerby) from Magnesian Limestone of England, of Wuchiapingian age - not Kazanian as in Alvarez & Rong (2002).

Discussion: Through C. H. C. Brunton, the authors of this segment of the *Revised Brachiopod Treatise* were able to provide magnificent illustrations of the interior of *Cleiothyridina pectinifera*. But they seem to been unable to comprehend a number of genera, and the inaccuracy of their assessments on *Cleiothyridellina, Deltachania* and *Himathyris* have been addressed in Waterhouse & Chen (2007, pp. 35-41, text-fig. 5-8) as well as Waterhouse (2018, p. 121, Fig. 93, 94; 2020, p. 238, Fig. 204-207, 208C). Some of their other interpretations of certain other genera still await further enquiry, for these appear to be inordinately close to *Cleiothyridina* itself.

Cleiothyridina sp. A

Fig. 37

19700 *Cleiothyridina* sp. Armstrong, p. 319, pl. 25, fig. 2.
2015a *Cleiothyridina* sp. Waterhouse, p. 146, Fig. 100.

A single dorsal valve with part of a ventral valve UQF 54456 was reported from the Tiverton Formation, by Armstrong (1970). This specimen (Fig. 37B) occurs on a block that contains *Capillonia armstrongi*. A fragment of another specimen UQF 81308 has been found in the overlying *Taeniothaerus subquadratus* Zone, more than 20mm across and little inflated, with strong lamellae bearing flattened spines (Fig. 37A).

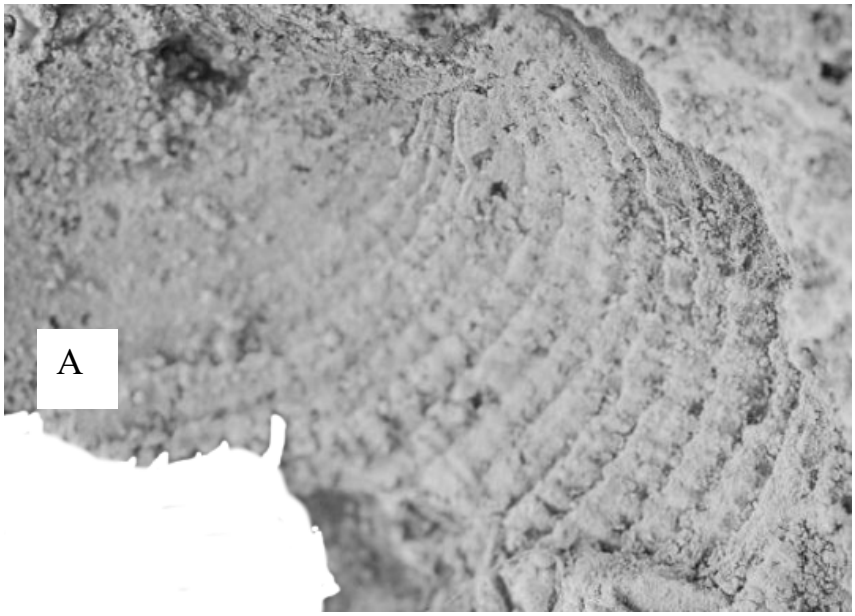


Fig. .37 *Cleiothyridina* sp. A. A, UQF 81308, x5. B, UQF 54616, x1. Upper middle Tiverton Formation. (Waterhouse 2015a; Armstrong, 1970).

B

Cleiothyridina anabathra Waterhouse, 1968

Fig. 38

1968 *Cleiothyridina anabathra* Waterhouse, p. 12, pl. 1, fig. 1-5, 7, 8, 10.
1969 *C. anabathra* – Waterhouse, p. 726.
1982 *C. anabathra* – Waterhouse, p. 53, pl. 12f, h; pl. 13h, i.

Diagnosis: Medium size with prominent umbo, dorsal valve not strongly inflated, ventral sulcus short and shallow or absent, some dorsal valves have a low fold, spines coarse at two in one mm.

Holotype: BR 1389 from upper Letham Formation, figured in Waterhouse (1968, pl. 1, fig. 1, 10) and Fig. 38A herein, OD.

Morphology: The species is extensively described with variations in Waterhouse (1968, 1986). Some Letham specimens differ from Barfield specimens described by Parfrey (1988) in having a very shallow and impersistent anterior sulcus and low anterior fold, though other topotype Letham specimens lack the fold and sulcus.

Stratigraphy: The species is found in the upper Letham Formation of New Zealand.

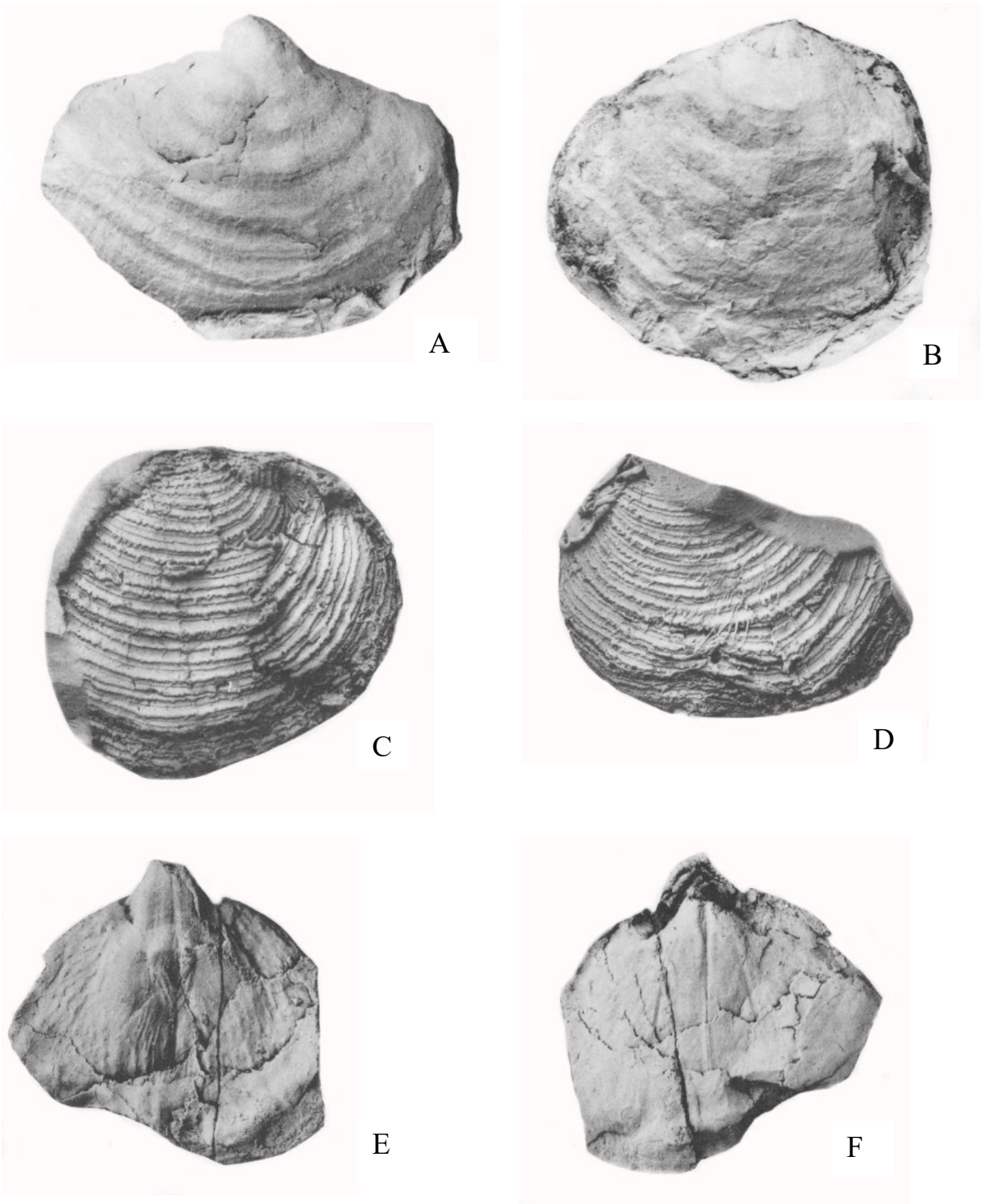


Fig. 38. *Cleiothyridina anabathra* Waterhouse. A, BR 1389, ventral valve holotype. B, decorticated dorsal valve BR 968. C, D, ventral and dorsal latex casts of exterior of BR 1422. E, F, ventral and dorsal latex casts of exterior of same specimen. Specimens x2 from upper Letham Formation, New Zealand. (Waterhouse 1968, 1982).

Cleiothyridina planus n. sp.

Fig. 39

1953 *Cleiothyridina* sp. Campbell, p. 16, pl. 3, fig.11-16.
1987 *C. anabathra* [not Waterhouse] – Waterhouse, p. 4, pl. 1, fig. 4, 6, 7.
1988 *Cleiothyridina* sp. Parfrey, p. 15, pl. 3, fig. 1-5.

Derivation: planus – even, level, flat (Lat.)

Diagnosis: Small moderately inflated oval to transversely oval shells without sulcus or fold.

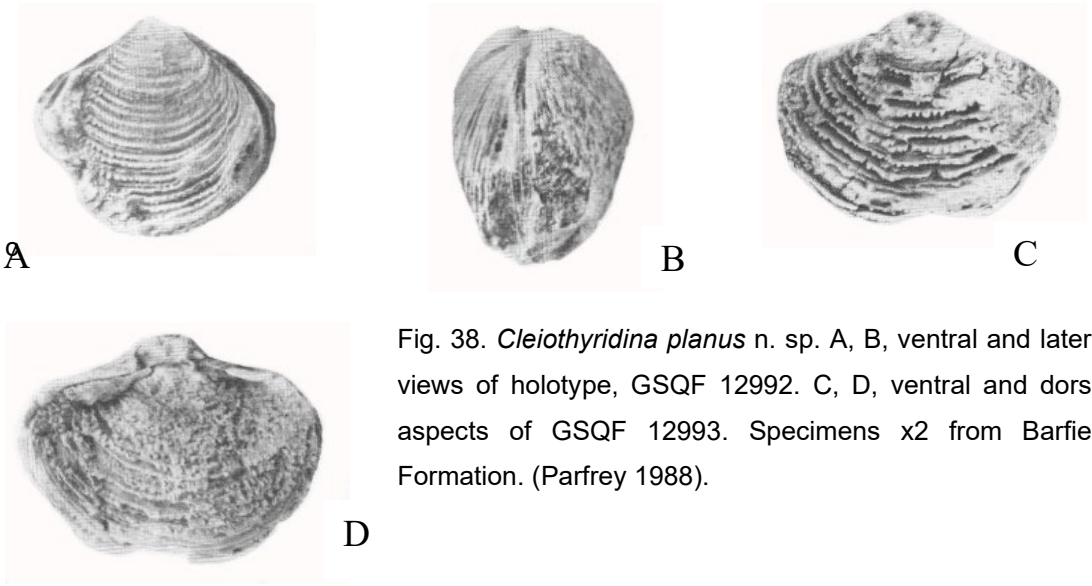


Fig. 38. *Cleiothyridina planus* n. sp. A, B, ventral and lateral views of holotype, GSQF 12992. C, D, ventral and dorsal aspects of GSQF 12993. Specimens x2 from Barfield Formation. (Parfrey 1988).

Holotype: GSQF 12992 figured by Parfrey (1988, pl. 3, fig. 3, 4) and herein as Fig. 38A, B from Barfield Formation, southeast Bowen Basin, here designated.

Morphology: The species has been described and compared in detail by Campbell (1953) and Parfrey (1988). It is moderately close to the slightly older form *Cleiothyridina anabathra*, but lacks even a shallow sulcus or low fold, and is almost twice as inflated.

Stratigraphy: *Cleiothyridina planus* comes from the lower Peawaddy Formation and Barfield Formation of the southwest and southeast Bowen Basin.

Cleiothyridina sp. B

Fig. 39

1964 *Cleiothyridina* sp. Hill & Woods, pl. P7, fig. 11, 12.
1972 *Cleiothyridina* sp. Hill et al., pl. P7, fig. 11, 12.

A *Cleiothyridina* was figured as in the above synonymy from the Ingelara Formation (probably the lower Peawaddy Member, the same level as *Plekonella acuta*) which has a slender moderately defined sulcus in each valve, unlike accompanying specimens of *Cleiothyrdina*. Armstrong (1970, p. 320) included these specimens as synonymous with *Spirigerella* of Campbell (1953, pl. 6, fig. 1-6) from the lower Peawaddy Formation of the southwest Bowen Basin, though they have a different shape with sharper umbones, long posterior walls opening out at a wider angle, and no sign of a sulcus (see Fig. 42 herein). He also included *Cleiothyridina* sp. nov. of Campbell (1953, pl. 3, fig. 11-16), specimens which are closer in shape though not in sulcation, and added fragments from the *Strophalosia* (now *Pseudostrophalosia*) *clarkei* band (Armstrong, 1970, pl. 25, fig. 1). These sulcate specimens may prove to be a variant of *C. planus*, but seem unlikely to be the same as Campbell's *Spirigerella.*

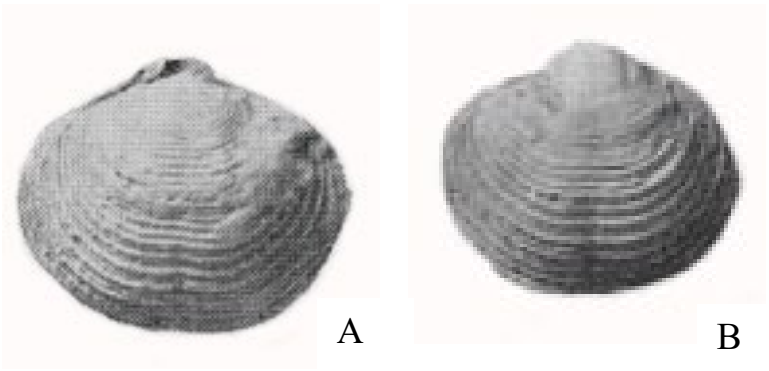


Fig. 39. *Cleiothyridina* sp. B, dorsal and ventral views of UQF 14256 x 4. Formation. (Hill et al. 1972).

Cleiothyridina elevata Waterhouse, 2022b

Fig. 40

2022b *Cleiothyridina elevata* Waterhouse, p. 159, Fig. 26 - 29.

Diagnosis: Weakly transverse oval shells with both valves weakly swollen medianly as a rule.

Holotype: UQL 82681 from just above Scottville Member, north Bowen Basin, figured by Waterhouse (2022b, fig. 26A, B) and herein as Fig. 40A, OD.

Morphology: This species appears to have part of a lineage descending from *Cleiothyridina anabathra*, with comparable weakly transverse outline, and moderately inflated, with both valves tending to be most swollen medianly towards the anterior part of the mature shell. The

Scottville specimen described by Armstrong (1970) differs in having a shallow ventral sulcus, unless of course the sulcus, which is found in several stratigraphic levels, amounts to a variant of no taxonomic significance.

Stratigraphy: The species comes from the highly fossiliferous band found immediately above the Scottville Member.

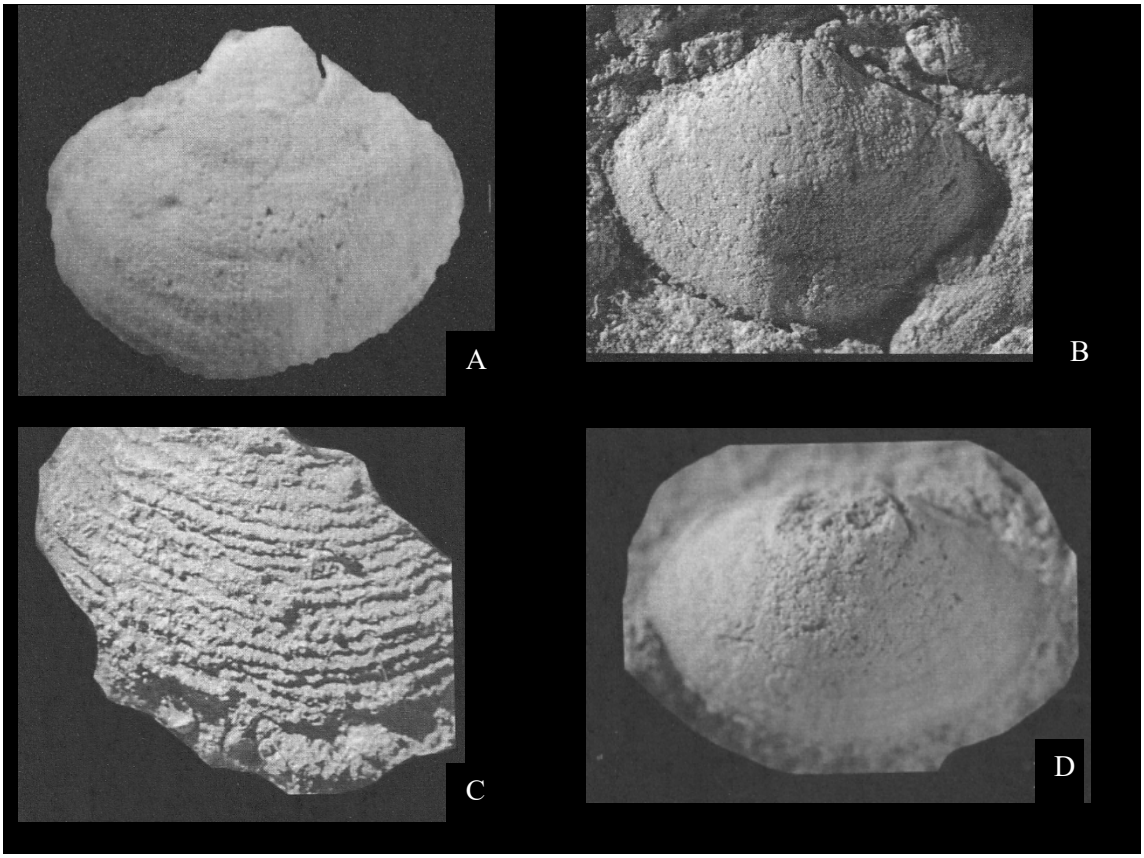


Fig. 40. *Cleiothyridina elevata* Waterhouse. A, ventral aspect of holotype UQF 82681, x3. B, internal mould, dorsal valve UQF 82682, x3. C, fragment of ventral exterior, UQF 82797, x5. D, ventral internal mould, 82687 x2. Upper Blenheim Formation, north Bowen Basin. (Waterhouse 2022b).

Cleiothyridina laqueata Waterhouse, 1968

Fig. 41

1968 *Cleiothyridina laqueata* Waterhouse, p. 14, pl. 1, fig. 6, 9.

Diagnosis: Small elongate and subglobular shells with large spines.

Holotype: BR 1253 from Kildonan Member of Bagrie Formation, figured in Waterhouse (1968, pl. 1, fig. 6) and herein as Fig. 41A, OD.

Morphology: This is a rare species, and more material would be welcome. The spines even on the small specimens available number two per mm on the anterior ventral valve.

Stratigraphy: The species is limited to the Kildonan Member, and no specimens have been found in correlative faunas elsewhere, whether at Wairaki Downs or in the Gympie successions of southeast Queensland.

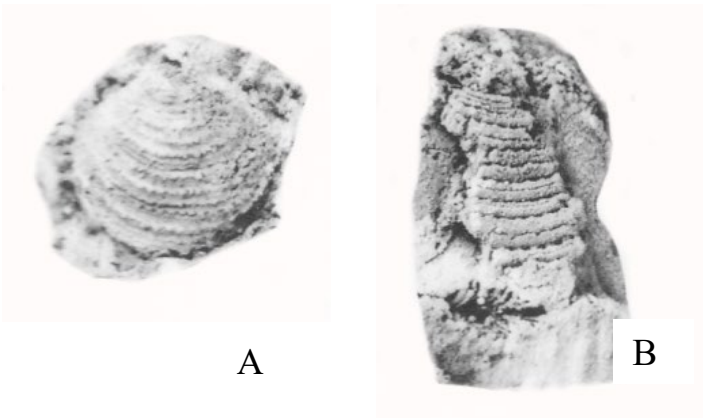


Fig. 41. *Cleiothyridina laqueata* Waterhouse. A, latex external cast of holotype BR 1253, x6. B, external mould BR 1240, x5. Kildonan Member, Bagrie Formation, New Zealand. (Waterhouse 1968).

Subfamily **SPIRIGERELLINAE** Grunt, 1965

Genus ***Spirigerella*** Waagen, 1883

Diagnosis: Shell with growth laminae, no spines. Uniplicate or parasulcate anterior margin, broad fold and sulcus, small foramen, shell may have delthyrial plate, outer hinge plates reduced, cardinal flanges may be unified, serrated, deeply impressed diductor scars, jugum much as in *Athyris*.

Type species: *Spirigerella derbyi* Waagen, 1883, p. 453 from Middle Productus Limestone (Wargal Formation, Capitanian - not Kazanian as in Alvarez & Rong (2002), OD.

Spirigerella sp.?

Fig. 42

1953 *Spirigerella* sp. nov. Campbell, p. 12, pl. 6, fig. 1-6.

Seven specimens were reported from what is now regarded as lower Peawaddy Formation in the southwest Bowen Basin, not well preserved or definitely assigned to a genus, given the reservations expressed by Armstrong (1970) as reported above, but nonetheless a possible occurrence of the genus.

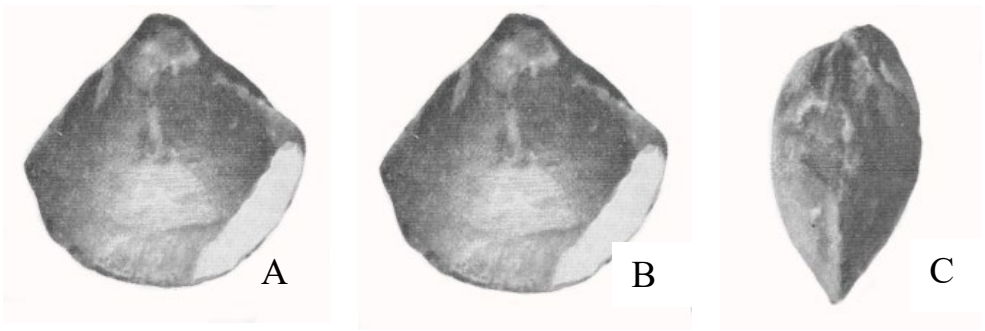


Fig. 42. *Spirigerella*? sp. ventral, dorsal and lateral aspects of UQF 14225, x1. Lower Peawaddy Formation. (Campbell 1953).

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