Silurian Linguliformean Brachiopods and Conodonts from the Cobra Formation, Southeastern New South Wales, Australia

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Silurian linguliformean brachiopods and conodonts are documented and described from the type section through the Cobra Formation (Taralga Group) in Murrui Creek, near Taralga. The linguliformean brachiopod fauna includes linguloids (six taxa), discinoids (three taxa), acrofretoids (four taxa) and a siphonotretoid. These are the first Late Silurian linguliformean brachiopods to be documented from eastern Australia. New taxa include *Acrotretella diseugosa* sp. nov., upon which is based the first detailed description of the ontogeny of *Acrotretella* Ireland, 1961. Eleven multi-element conodont taxa are recognised, including the temporally significant taxon, *Koekelella maemni* Serpagli and Corradini, 1998. Based on these conodont data, and other faunal elements, the Cobra Formation in Murrui Creek appears to range from mid-Ludlow (early to mid-siluricus Zone) in age.

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KEYWORDS: Brachiopods, Cobra Formation, Conodonts, Linguliformea, Ludlow, New South Wales, Silurian.

INTRODUCTION

The Cobra Formation (Taralga Group) crops out in a thin, north-south trending belt east of Taralga in southeastern New South Wales (Fig. 1). Despite extensive studies of a number of sections through the Cobra Formation (eg. Jongmsa 1968; Roots 1969; Scheibner 1973; Morritt 1979; Powell and Fergusson 1979a; Pickett 1982; Matthews 1985), no detailed accounts or systematic descriptions of the numerous fossil groups from these sections have been published. The present investigation focuses on linguliformean brachiopods and conodonts recovered from the Cobra Formation in Murrui Creek, approximately 20 km north of Wombeyan Caves (Fig. 2).

The only report of linguliformean brachiopods from the Taralga Group is restricted to a single occurrence of *Schizotreta* sp. from the base of the Cobra Formation in Murrui Creek (Sherwin 1970). Silurian linguliformean brachiopods from eastern Australia are generally poorly known, with the only well-documented fauna being from the Early Silurian (Llandovery-Wenlock) Boree Creek Formation of central-western New South Wales (Dean-Jones 1979; Valentine and Brock 2003; Valentine et al. 2003). These are the first Late Silurian linguliformean brachiopods to be documented and described from eastern Australia.

Previous accounts of conodonts from the Taralga Group are restricted to the Wombeyan Limestone (Sherwin 1969; revised by Pickett 1982), a biothermal unit interpreted as Late Silurian in age, and stratigraphically equivalent to the base of the Cobra Formation in Murrui Creek (Naylor 1937; Jongmsa 1968; Scheibner 1973). Based on a single Pa element assigned to ‘*Spathognathodus*’ (*Pandorinella* exigua) (Philip, 1966), Sherwin (1969) suggested that the Wombeyan Limestone was Early Devonian in age. However, in his biostratigraphic review of Australian Silurian conodonts, Simpson (1995a:339) stated that this element could be a morphotype of *Ozarkodina confluens* (Branson and Mehl, 1933), a late Silurian species. No conodonts have previously been reported from the Cobra Formation.
GEOLOGY AND STRATIGRAPHY

The Early Silurian (mid-Wenlock?) to Early Devonian Taralga Group, cropping out east of Taralga, is an upward-shallowing, deepwater sequence deposited along the eastern limb of the Cookbundoon Synclinorium, on the western edge of the Capertee High in the Hill End Trough (Scheibner 1973; Powell and Ferguson 1979b; Matthews 1985) (Fig. 1). The Cobra Formation forms the basal unit of the Taralga Group and consists of ~670 m of interbedded fine-grained micrites, siltstones and limestones (Pickett 1982; Matthews 1985). Based on the fine detrital nature of the Cobra Formation, the orientation of fossil corals, and the occurrence of the calcareous alga, Pseudochaetetes Haug, 1883 in association with the tabulate coral, Entelophyllum (uppermost Formation (1979) Morritt (1985)) and the base of the Cobra Formation in Little Wombeyan Creek (Fig. 1), Pickett (1985) concluded that the Cobra Formation was of turbiditic origin. Disarticulated rhynchonelliform brachiopods from the same horizons are all deposited concave side down, suggesting post-mortem transportation via traction currents (Matthews 1985).

The Cobra Formation overlies the lower grade metamorphic shales and greywackes of the Late Ordovician to Early Silurian Burra Creek Formation (uppermost unit of the Triangle Group) (Figs 1, 2). The contact between the two units is widely stated to faulted, or a high angle unconformity, and a significant time break has been implied to exist between them (Jongsma 1968; Roots 1969; Scheibner 1973; Talent et al. 1975; Powell et al. 1976; Powell and Ferguson 1979a, b; Pickett 1982). In contrast, both Morriss (1979) and Matthews (1985) have argued that this contact is paraconformable (though sometimes faulted) as in Murrui, Kerrawary, Guineacor and Cowhorn creeks, or gradational over about 15 m as in Little Wombeyan Creek (Fig. 1).

No evidence of a high angle unconformity between the Burra Creek Formation and Cobra formations was observed in Murrui Creek. The contact is marked by a prominent, 14 m thick conglomeratic horizon, whose upper boundary marks the start of the MU section (Figs 2, 3). Matthews (1985) argued that this conglomeratic horizon only occurs where faulting (parallel and/or subparallel to bedding) exists between the Burra Creek and Cobra formations. The fault, and associated conglomerate, can occur within either formation, or as in Murrui Creek, at the contact between the two. Where faulting is absent, as in Little Wombeyan Creek, the conglomeratic horizon is also absent. Therefore, this horizon would appear to have originated through post-lithification tectonic activity (Matthews 1985).

The first 468 m of the MU section through the Cobra Formation consists of well-bedded, grey-black shales (4-25 cm thick) interbedded with pale coloured, nodular limestone bands (1-6 cm thick) and dark-grey limestone beds (up to 1.8 m thick) (Fig. 3). However, continuously exposed horizons are restricted to 126-171 m and 431-468 m above the base of the MU section (Fig. 3). Between these intervals, only sporadic outcrops of grey-black shales and nodular limestones, identical to those occurring in the interval 126-171 m above the base of the MU section, were observed.

The only linguliforme brachiopod recovered from this part of the MU section was a single dorsal valve of Orthiculioidea sp. from sample MU 21 (174.6 m above the base of the section) (Table 1). Conodonts from this part of the MU section are all predominantly long ranging forms and include Panderodus unicosatus (Branson and Mehl, 1933), Panderodus recurvatus (Rhodes, 1953) and Dapsilodus obliquicostatus (Branson and Mehl, 1933) (Table 2). This fauna is broadly suggestive of a Wenlock to Pridoli age. Jongsma (1968), Roots (1969) and Scheibner (1973) all recorded Batocara mitchelli (Foerste, 1888) within the first 175 m of their respective sections through the Cobra Formation in Murrui Creek. This species ranges from the mid-Wenlock to mid-Ludlow in Australia (Pickett et al. 2000). Corals identified by Sherwin (1969) and Pickett (1985) from the base of the Cobra Formation in Little Wombeyan Creek (Fig. 1) belong to the Hatton’s Corner coral assemblage (Strusz and Munson 1997; Munson et al. 2000) and suggests a late Wenlock to Ludlow age. Therefore, the base of the Cobra Formation would appear to be, at most, mid-Wenlock in age.

Continuously cropping out horizons occur for the last 64.2 m of the MU section, beginning 605 m above its base (Fig. 3). This part of the MU section consists of well-bedded, dark-grey limestone horizons (up to 20 cm thick) interbedded with thicker intervals of soft, light brown mudstones between 605-623.1 m above the base of the MU section. Several faults also occur in this part of the Cobra Formation (Fig. 2)—one at 623.1 m above the base of the MU section, where massive black limestones replace the mudstone horizons. These limestone horizons continue through to the top of the Cobra Formation (Fig. 3). This part of the MU section has undergone folding as part of the latest Devonian to early Carboniferous regional deformation event that affected the Hill End Trough (Powell et al. 1976).
Figure 1. Generalised regional geological map of the Taralga area showing where the Taralga Group crops out (modified after Powell and Fergusson 1979a). Study area in Murruin Creek is indicated by boxed area and enlarged in Fig. 2.
The change in lithology to massive black limestones coincides with a dramatic increase in the number of linguliformean brachiopods and conodont elements recovered. The linguliformean brachiopod fauna is dominated by acrotretoids, particularly *Opsiconidion ephemerus* (Mergl, 1982) (Table 1). This species ranges from the upper Ludlow of the Kopanina Formation to the Pridoli Požáry Formation of the Czech Republic and broadly agrees with the Ludlow age determination for the upper part of the MU section based on conodont data (see below). In fact, the Murruin Creek linguliformean brachiopod assemblage is similar to that described by Mergl (2001) from the deepwater Ludlow Kopanina Formation in the Barrandian of the Czech Republic. The Kopanina fauna, also dominated by acrotretoids,
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Flaggy sandstones and shales

Massive black limestones

Calcite bands

No outcrop

Dark - grey to black limestone beds

Light coloured nodular limestone bands

Grey - black shales and mudstones

Grey - black shales interbedded with light coloured nodular limestone bands

Sporadically cropping out horizons of grey - black shales interbedded with light coloured nodular limestone bands

Conglomerate

Black, thinly bedded shales

Burra Burra Creek Formation

Cobra Formation

Whipbird Creek Formation

Sample numbers
### Table 1

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<th>641.3</th>
<th>642.6</th>
<th>642.9</th>
<th>643.1</th>
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Table 1. Distribution and abundance of each linguliformean brachiopod species recovered from productive samples along the MU section through the Cobra Formation in Murruin Creek. Abbreviations: vv = ventral valve(s); dv = dorsal valve(s); frag = fragment(s); co = conjoined specimen(s).
| Metres above base of MU section | Sample Numbers | 1 | 2 | 3 | 6 | 8 | 9 | 10 | 11 | 12 | 13 | 20 | 21 | 25 | 26 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | Totals |
| Conodont Taxa |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Sa |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Sb |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Sc |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Sd |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| M  |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| T  |                |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Dapsilodus obliquicoiatus | M  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 10 |
|    | S  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 15 |
| Decoricoma fragilis | Sc |    | 2  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 49 |
|    | Sa |    |    |    |    | 3  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 18 |
|    | Sb |    |    |    |    |    | 4  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 20 |
|    | Sc |    |    |    |    |    |    | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 9  |
|    | M  |    |    |    |    |    |    |    | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 25 |
| Panderodus recurvatus | Sa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
|    | Sb |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
|    | Sc |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 34 |
|    | M  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
| Panderodus serratus | Sa |    |    |    |    |    |    |    |    |    | 1  |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Sb |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
|    | Sc |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
|    | M  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
| Panderodus unicosatus | Sa | 2  | 2  | 1  | 1  |    | 1  | 6  | 2  | 2  | 5  |    | 214 | 65 | 60 | 59 | 418 |
|    | Sb | 1  |    | 2  | 1  |    | 4  | 2  | 1  | 1  | 3  |    | 123 | 17 | 45 | 121 | 317 |
|    | Sc | 1  |    |    | 1  |    | 3  |    |    |    |    |    | 117 | 39 | 63 | 119 | 343 |
|    | M  | 1  |    |    | 2  | 2  |    | 2  | 1  |    |    |    | 92  | 76 | 43 | 40 | 259 |
| Coryssognathus dubius | Pa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Sb |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 3 |
| Oulodus sp. cf. Oulodus elegans | Sa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Sb |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | M  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 2 |
| Ozarkodina excavata excavata | Pa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Pb | 1  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Sa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 8  |
|    | Sb |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 13 |
|    | Sc |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 8  |
| Kockelella maenniki | Pa |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
|    | Sc |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | 1 |
| Unassigned elements |    | 2  |    | 2  | 1  |    |    |    |    |    |    |    |    |    |    | 11 |    |    |    |    |    |    | 9  | 25 |

Table 2. Distribution and abundance of each conodont species recovered from productive samples along the MU section through the Cobra Formation in Murrurin Creek.
SILURIAN BRACHIOPODS AND CONODONTS

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<th>Explanation</th>
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<td>maximum length of pseudointerarea</td>
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Table 3. Abbreviations used for measurements (in μm) of linguliforme brachiopods. Abbreviations based on those of Popov and Holmer (1994:35, fig. 39). Where applicable, all measurements are made from the posterior margin.

includes numerous small discinids and rarer occurrences of larger discinids, obolids, linguloids and a siphonotretoid (Mergl 2001).

The majority of the conodonts recovered from this part of the MU section were the same long ranging forms occurring in the lower part of the MU section (Table 2). The lenticular and triangular elements of Belodella anomalis Cooper, 1974 recovered from Murrui Creek (Table 2) are all broad-based (Fig. 4a-g). Simpson (1995b: 310) and Jeppsson (1989) noted a general morphological trend in this taxon of broad-based elements in the Ludlow (eg. Cooper 1974:pl. 1, figs 1-10; Simpson et al. 1993:fig. 4G-I; Simpson 1995b:pl. 16, fig. 15) and narrower-based elements in the Pridoli (eg. Jeppsson 1989: pl. 1, fig. 15; Simpson 1995b:pl. 16, fig. 21). Farrell (2004), however, documented a relatively broad-based population of elements from the Camelford Limestone and interpreted this sequence as Pridoli in age. Sample MU 34 (642.6 m above the base of the section) also yielded a single Pa and M element of the temporally significant taxon, Kockeella maennicki Serpagli and Corradini, 1998 (Table 2). This species is restricted to the early to mid-Silurian Zone (mid-Ludlow) of Europe and North America (Corradini and Serpagli 1999; Serpagli and Corradini 1999). In addition, a pygidium, possibly of B. mitchelli, was recovered from sample MU 28 (624.6 m above the base of the section) (Fig. 3). This is also in general agreement with the Ludlow age determination for this part of the MU section.

Conformably overlying the Cobra Formation in Cowhorn, Kerrawary, Guineacor and Little Wombeyan creeks (Fig. 1), are thinly bedded (<1 m thick), deep-water, turbiditic arenites, lutites and siltstones of the Argyle Formation (Scheibner 1973; Pickett 1982; Matthews 1985). In Murrui Creek, the Cobra Formation is conformably overlain by the Whipbird Creek Formation (Fig. 2), a turbiditic sequence of interbedded sandstones and shales that may represent a distal facies of the Argyle Formation. Matthews (1985) reported rare boundary faulting between the Cobra and Argyle formations in Little Wombeyan Creek and similar faulting occurs in the upper part of the Cobra Formation in Murrui Creek (Fig. 2). The contact between the Cobra and Whipbird Creek formations lies ~670 m above the base of the MU section (Fig. 3), compared to only 550 m reported by Scheibner (1973), Pickett (1982) and Matthews (1985). Given the folding and faulting occurring in this part of the Cobra Formation, the possibility of repeated horizons in the MU section cannot be dismissed.

SYSTEMATIC PALAEONTOLOGY

Discussion

All type, paratype and figured materials are lodged in the palaeontological collections of the Australian Museum, Sydney (AM F).

Phylum Brachiopoda Dumééril, 1806

Measurements

Measurements (in μm) of linguliforme brachiopods are based on those of Popov and Holmer (1994:35, fig. 39). Abbreviations used for the measurement of all taxa are listed in Table 3. Note that the width of some incomplete specimens was determined by measuring half the width and multiplying by two, assuming a bilaterally symmetrical organism.
Order Lingulida Waagen, 1885
Superfamily Linguloidea Menke, 1828
Family Pseudolingulidae Holmer, 1991

pseudolingulid gen. et sp. indet. 1
Fig. 4a-f

Figured material
AM F328314 (Fig. 4a-c): ventral valve; AM F128315 (Fig. 4d): dorsal valve; AM F128316 (Fig. 4e, f): dorsal valve, sample MU 36. All from sample MU 35 unless otherwise mentioned (Table 1).

Discussion
The ventral valve pseudointerarea has a well-developed pedicle notch and small, subtriangular propareas (Fig. 4b, c). The posterior margin of the dorsal valve is thickened and has an undivided, anacline pseudointerarea (Fig. 4d). The larval shell is smooth and the post larval shell ornament consists of fine concentric filae (five per 10 μm) (Fig. 4a, e, f).

'Lingula' lewisii Sowerby, 1839, from the lower Ludlow Aymetry Limestone of Wales, was questionably referred to the pseudolingulids by Holmer (1991) based on similarities in vascular impressions and muscle scars with Pseudolingula quadrata (von Eichwald, 1829). 'Lingula' lewisii differs by being more rectangular with sharper cardinal angles and is larger (average length 11.5 mm) (Chems 1979; Bassett 1986). ?Wadiglossa perlonga (Barrande, 1879) from the Ludlow Kopanina Formation of the Czech Republic, is distinguished by its acutely pointed beak and post-larval shell ornament of low, poorly developed concentric growth lines (Mergl 2001).

Family Obolidae, 1846
Subfamily Obolinae, 1846
Kosagittella Mergl, 2001

Type species

Kosagittella? sp.
Fig. 4m-o

Figured material
AM F128321 (Fig. 4m-o): ventral valve, sample MU 32 (Table 1).

Discussion
The ventral valve has a thickened posterior wall and a weakly apsacline to orthocline pseudointerarea, medially divided by a parallel sided pedicle groove that continues forward of the pseudointerarea a short distance as a shallow groove (Fig. 4n). The subcircular larval shell is smooth and located marginally. The post-larval shell ornament consists of widely spaced concentric lamellae that are best developed on the lateral slopes (Fig. 4m). These characteristics recall Kosagittella, and in particular, Kosagittella pinguis Mergl, 2001 from the Lochkovian Lochkov Formation of the Czech Republic. However, the ventral valve pseudointerarea of the Murrain Creek specimens differ from Kosagittella in lacking laterally inclined propareas (Fig. 4o).

Family Zhantellidae Koneva, 1986
Rowellella Wright, 1963

Type species
Rowellella minuta Wright, 1963.

Rowellella? sp.
Fig. 4p-r

Figured material
AM F128322 (Fig. 4p): dorsal? valve; AM F128323 (Fig. 4q, r): ventral? valve. Both from sample MU 36 (Table 1).

Discussion
Although incomplete, these specimens appear to be elongately subrectangular to subtriangular in outline (Fig. 4p). The post-larval shell ornament consists of distinct concentric lamellae (six to seven per 100 μm) separated by flat interspaces bearing filae that are initially discontinuous laterally, but become concentric during later growth stages (Fig. 4q, r). The post-larval shell microornament of Rowellella cf. R. lamellosa Popov, 1976 (in Nazarov and Popov 1976) from Middle Ordovician strata in Sweden (Holmer 1989) consists of similar sets of discontinuous filae, but these are developed over the entire shell. Rowellella distincta Bednarczyk and Biernat, 1978 from the lower Arenig of the Holy Cross Mountains in Poland (Bednarczyk and Biernat 1978) and the Arenig Klavava Formation of the Czech Republic (Mergl 1995, 2002), also has a similar post-larval shell microornament, but has more prominent and widely spaced concentric lamellae. The post-larval shell microornament of Rowellella sp. from the Early Ordovician Bjorkaholmen Limestone of Sweden and Norway (Popov and Holmer 1994) also consists of discontinuous sets of concentric filae, but these are only developed anteriorly.

The dorsal? valve interior of the Murrain Creek specimens has an elongate muscle field that
SILURIAN BRACHIOPODS AND CONODONTS

Figure 4. a-f. Pseudolingulid gen. et sp. indet. 1 all from sample MU 35 unless otherwise mentioned. a-c. Ventral valve AM F328314; a, exterior; b, interior; c, detail of pseudointerarea. d. Dorsal valve AM F128315, interior. e, f. Dorsal valve AM F128316, sample MU 36; e, exterior; f, detail of larval shell. g, h. Paterula sp. both from sample MU 36. g. Ventral valve AM F128317; interior. h. Dorsal valve AM F128318; exterior. i-k. Linguloid gen. et sp. indet. 2. Dorsal valve AM F128319, sample MU 35; i, exterior; j, interior; k, detail of pseudointerarea. l. Linguloid gen. et sp. indet. 1. Fragment of post-larval shell AM F128320, sample MU 36; exterior. m-o. Kosagittella? sp. Ventral valve AM F128321, sample MU 32; m, exterior; n, interior; o, anterior view. p-r. Rowellella? sp. both from sample MU 36. p. Dorsal? valve AM F128322; interior (scale bar equals 1000 μm). q, r. Ventral? valve AM F128323; q, exterior; r, detail of post-larval shell microornament (scale bar equals 10 μm). Unless otherwise mentioned all scale bars equal 100 μm.
expands slightly in width anteriorly, and is divided by a low, broad median ridge (Fig. 4p). This is similar to the dorsal valve interior of *Rowellella? parvicapera* Valentine, Brock and Molloy, 2003 from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales and *Lingulops barrantei* Mergl, 1999b from the Ludlow Kopanina Formation of the Czech Republic (Mergl 1999b, 2001). In comparison, the concentric ridges of the Boree Creek material are spaced at intervals of 30 μm and the concentric filae of the Czech material are confined to the concentric ridges. No evidence of a muscle supporting platform or limbus, diagnostic features of *Lingulops* Hall, 1872 (Holmer and Popov 2000), were observed.

**Family Paterulidae Cooper, 1956**

*Paterula* Barrande, 1879

**Type species**

*Paterula bohemica* Barrande, 1879.

**Figured material**

*Paterula sp.*

Fig. 4g, h

**Discussion**

The suboval outline, poorly impressed muscle scars, small pedicle notch (Fig. 4g) and dorsisibiconvex profile of the Murrum Creek specimens are similar to *P. argus* from the Llandovery Želkovicke and Wenlock Motol formations of the Czech Republic (Mergl 1999a). The Murrum Creek specimens differ in having a wider limbus that creates a distinctly flattened rim externally, particularly along the posterior margin of the dorsal valve (Fig. 4h). Internally, the ventral valve differs by possessing a prominent, raised, subperipheral rim along the posterior margin (Fig. 4g).

linguloid gen. et sp. indet. 1

Fig. 4l

**Figured material**

AM F128317 (Fig. 4g): ventral valve; AM F128318 (Fig. 4h): dorsal valve. Both from sample MU 36 (Table 1).

**Discussion**

The well-developed limbus, ?elongate outline and lack of post-larval shell pitting (Fig. 4i, j) suggest affinities with the Elliptoglobosinae. Unlike both *Elliptoglobus* Cooper, 1956 and *Lingulops*, the Murrum Creek material has a well-developed, broadly depressed and anacl ise dorsal valve pseudointerarea (Fig. 4k) and can be further differentiated from *Lingulops* by lacking a muscle supporting platform (Fig. 4j).

Superfamily Discinoidea Gray, 1840

Family Discinidae Gray, 1840

*Oribiculoidea* d’Orbigny, 1847

**Type species**

*Oribicula forbesii* Davidson, 1848.

*Oribiculoidea sp.*

Fig. 5a-g

**Figured material**

AM F128324 (Fig. 5a): ventral valve fragment, sample MU 34; AM F128325 (Fig. 5b, c): dorsal valve, sample MU 35; AM F128326 (Fig. 5d, e): dorsal valve, sample MU 32; AM F128327 (Fig. 5f, g): dorsal valve, sample MU 31 (Table 1).

**Discussion**

Known only from only a few post-larval shell fragments, these specimens have an ornament of low, broadly rounded concentric ridges spaced at regular intervals of 250 μm. The ridges, and concave interspaces, bear closely spaced, rounded concentric filae (six per 100 μm) (Fig. 4l). This is similar to the post-larval shell ornament of *Lingulops australis* Valentine, Brock and Molloy, 2003 from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales and *Lingulops barrantei* Mergl, 1999b from the Ludlow Kopanina Formation of the Czech Republic (Mergl 1999b, 2001). In comparison, the concentric ridges of the Boree Creek material are spaced at intervals of 30 μm and the concentric filae of the Czech material are confined to the concentric ridges. No evidence of a muscle supporting platform or limbus, diagnostic features of *Lingulops* Hall, 1872 (Holmer and Popov 2000), were observed.
Figure 5. a-g. *Orbiculoidea* sp. all from sample MU 35 unless otherwise mentioned. a. Fragment of ventral valve posterior slope AM F128324, sample MU 34; exterior; b, c. Dorsal valve AM F128325; b, exterior; c, lateral view. d, e. Dorsal valve AM F128326; d, exterior; e, lateral view; f, g. Dorsal valve AM F128327, sample MU 32; f, exterior; g, lateral view. h-n. *Schizotrema* sp. all from sample MU 36. h, i. Dorsal valve AM F128328; h, exterior; i, detail of larval shell. j. Ventral valve AM F128329; interior. k-n Ventral valve AM F128330; k, exterior; l, detail of larval shell; m, detail of pedicle track and foramen; n, interior. o, p. Discinid gen. et sp. indet. 1. o. Dorsal valve AM F128331, sample MU 36; interior. p. Dorsal valve AM F128332, sample MU 35; exterior. q-w. *Artiotreta longisepta* Valentine, Brock and Molloy, 2003. q-t. Dorsal valve AM F128333, sample MU 32; q, interior; r, exterior; and s, lateral views; t, interior in lateral view. u-w. Conjoined valves AM F128334, sample MU 36; u, plan; v, anterior; and w, posterior views. All scale bars equal 100 μm.
Mature dorsal valves are more elongate, with longer, more gently curved, lateral margins (Fig. 5d, f) and are weakly convex to low subconical in lateral profile (Fig. 5e, g). The ventral valves have a long, narrow, parallel-sided pedicle track covered for most of its length by a concave lirustrum (Fig. 5a). The post-larval shell ornament consists of well-developed concentric ridges arising through insertion on the lateral slopes (Fig. 5b, d, f).

Numerous Silurian discinids have been assigned to Orbiculoidea (eg. Biernat 1984; Bassett 1986; Mergl 1996, 2001). These are generally distinguishable from the Murrurin Creek specimens by their more circular dorsal valves, greater convexity, and centrally located apices. Orbiculoidea sp. C from the Pridoli Požáry and Lochkovian Lochkov formations of the Czech Republic (Mergl, 2001) is similar to the Murrurin Creek taxon. Both species have low, subconical dorsal valves with a subapical apex and an ornament of well-developed concentric ridges arising through insertion on the lateral slopes. Orbiculoidea sp. C differs in having a subcircular dorsal valve outline and by being wider and less elongate (Mergl 2001).

Schizotreta Kutorga, 1848

Type species

Orbicula elliptica Kutorga, 1846.

Schizotreta sp.

Fig. 5h-n

Figured material

AM F128328 (Fig. 5h, i): dorsal valve; AM F128329 (Fig. 5j): ventral valve; AM F128330 (Fig. 5k-n): ventral valve. All from sample MU 36 (Table 1).

Discussion

Both valves of this species from Murrurin Creek are subcircular with a weakly flattened posterior margin and have a post-larval shell ornament of low, continuous, concentric lamellae (two to four per 100 μm) that become more prominent toward the valve margins (Fig. 5h, k). The large larval shell, located submarginally in the ventral valve (averaging 438 μm long; 500 μm wide) and marginally in the dorsal valve (averaging 354 μm long; 399 μm wide), bear fine growth filae on their anterior and anterolateral slopes (Fig. 5h, k, l). The ventral valve has a short, elliptical pedicle track covered for most of its length by a concave lirustrum. The foramen, preserved in only one specimen, is quadrate and has a raised rim (Fig. 5k, m). The pedicle track continues internally as a posteriorly directed pedicle tube that is flattened along the valve floor and ends just prior to the posterior margin (Fig. 5n).

Schizotreta elliptica from the Early Ordovician of the Leningrad district in Russia, differs from the Murrurin Creek species by its elongately oval dorsal valve, submarginally located larval shell, shorter, more strongly elliptical pedicle track and elliptical foramen. Valentine et al. (2003) described two species of Schizotreta from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales. Schizotreta corrugaticus Valentine, Brock and Molloy, 2003 has a flatter dorsal valve with a submarginally located larval shell and an ornament of well-developed concentric ridges arising through insertion on the lateral slopes (Valentine et al. 2003). Schizotreta cristasus Valentine, Brock and Molloy, 2003 is distinguished by its elongately subrectangular dorsal valve outline and more widely spaced continuous concentric lamellae. Internally, the ventral valve has a low, broad, crescentic-shaped ridge bounding the anterior margin of the muscle field (Valentine et al. 2003). Schizotreta rarissima (Barrande, 1879) from the Wenlock Motol Formation of the Czech Republic, has a narrow, elongately oval dorsal valve (Mergl 2001). Biernat (1984) assigned a single dorsal valve fragment of a discinid, from the Wenlock Podlasie Depression of Poland, to Schizotreta which possesses well-developed concentric ridges arising through insertion on the lateral slopes. The ventral valve of Schizotreta sp. from the early Llandovery of Wales (Temple 1987), is flatter than the Murrurin Creek taxon and has a shorter, posteriorly widening, pedicle track. The concentric lamellae of the Welsh taxon are also more widely spaced (six per mm) and separated by concave interspaces (Temple 1987).

discinid gen. et sp. indet. 1

Fig. 5o, p

Figured material

AM F128331 (Fig. 5o): dorsal valve, sample MU 36; AM F128332 (Fig. 5p): dorsal valve, sample MU 35 (Table 1).

Discussion

This taxon from Murrurin Creek has a large (averaging 475 μm long; 500 μm wide), smooth, submarginally located dorsal valve larval shell and a post-larval shell ornament of weakly developed, continuous concentric lamellae (Fig. 5p). However, unlike other discinids, the Murrurin Creek taxon has a transversely elliptical dorsal valve outline (Fig. 5o, p).
Order Acrotretida Kuhn, 1949
Superfamily Acrotretoida Schuchert, 1893
Family Scaphelasmatidae Rowell, 1965

Artiotreta Ireland, 1961

Type species
Artiotreta parva Ireland, 1961.

Artiotreta longisepta Valentine, Brock and Molloy, 2003
Figs 5q-w, 6a-d

Synonymy
2003 Artiotreta longisepta sp. nov. Valentine, Brock and Molloy, p. 314; pl. 2, figs 9-18.

Description

Figured material
AM F128333 (Fig. 5q-t): dorsal valve, sample MU 32; AM F128334 (Figs 5u-w, 6a): conjoined valves; AM F128335 (Fig. 6b-d): dorsal valve. All from sample MU 36 unless otherwise mentioned (Table 1).

Discussion
The Murruin Creek material is conspecific with A. longisepta from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales (Valentine et al. 2003). Some specimens from Boree Creek have a median septum with a slightly thickened posterior margin (see Valentine et al. 2003:pl. 2, fig. 16) and concentric lamellae that tend to be weaker and more irregularly developed (compare Figs 5q, r, 6b with Valentine et al. 2003:pl. 2, figs 11, 13). These minor differences are considered insufficient to exclude conspecificity.

Artiotreta krizi Mergl, 2001 from the Llandovery Želkovice and Wenlock Motol formations of the Czech Republic, has a similar dorsal valve outline to A. longisepta, although its anterior margin tends to be more rounded. The median septum of A. krizi is also shorter, arising around valve midlength (Mergl 2001:33, pl. 28, fig. 3). Artiotreta krizi attains a larger maximum size than A. longisepta (up to 1100 µm wide), but most of the material illustrated by Mergl (2001:pl. 28: figs 1, 3, 9, 10) has comparable dimensions (Table 4).

Artiotreta parva from the Wenlock Chimney Hill Limestone (Ireland 1961), Bainbridge Formation (Satterfield and Thompson 1969) and Clarita Formation (Chatterton and Whitehead 1987) of the USA, is distinguished by its rounder dorsal valve outline, shorter median septum arising around valve midlength and finer growth lamellae. Artiotreta longisepta is also larger (averaging 538 µm long; 708 µm wide; Table 4) than A. parva (averaging 400 µm

Table 4. Artiotreta longisepta Valentine, Brock and Molloy, 2003, dorsal valve dimensions (in µm) and ratios.

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Figure 6. a-d. *Artiotreta longisepta* Valentine, Brock and Molloy, 2003 both from sample MU 36. a. Conjoined valves AM F128334; lateral view. b-d. Dorsal valve AM F128335; b, exterior; c, detail of larval shell (scale bar equals 10 µm); d, detail of larval shell microornament (scale bar equals 10 µm). e-y. *Acrotretella dizeugosa* sp. nov. all from sample MU 31 unless otherwise mentioned. e, f. Ventral valve paratype AM F128336, sample MU 35; e, exterior; f, detail of larval shell (scale bar equals 10 µm). g. Ventral valve paratype AM F128337; interior. h-k. Ventral valve paratype AM F128338, sample MU 35; h, exterior; i, plan; j, posterior; and k, lateral views. l. Dorsal valve paratype AM F128339; interior. m, n. Dorsal valve paratype AM F128340; m, interior; n, lateral view. o, p. Dorsal valve paratype AM F128341; o, interior; p, lateral view. q, r. Dorsal valve paratype AM F128342; q, interior; r, lateral view. s. Dorsal valve paratype AM F128343, sample MU 35; interior. t. Dorsal valve paratype AM F128344, sample MU 32; interior. u-w. Dorsal valve holotype AM F128345, sample MU 32; u, interior; v, lateral; and w, anterior views. x, y. Dorsal valve paratype AM F128346; x, exterior; y, detail of larval shell (scale bar equals 10 µm). Unless otherwise mentioned all scale bars equal 100 µm.
long; 500 μm wide) (Ireland 1961:1138).

von Bitter and Ludvigsen (1979) documented two sizes of larval shell pits in *A. parva*—a larger set (3-6 μm in diameter) with no cross-cutting relationships and a smaller set (~0.3 μm in diameter) located on flat areas between the larger pits. *Artioretia longisepa* also possesses two sizes of larval shell pits—a larger set (4.5 μm in diameter) with none to one (occasionally two) orders of cross-cutting and a smaller set (0.2-1 μm in diameter) (Fig. 6d). A smaller set of larval shell pits has not been documented in *A. krizi*.

Family Tornyelasma tidalae Rowell, 1965

*Acrotretella* Ireland, 1961

**Type species**


**Emended diagnosis**

Ventral valve conical to subpyramidal with distinct larval shell and broad, proclive to catacline pseudointerarea. Pedicle tube and apical process absent. Dorsal valve flat to weakly convex with distinct, bulbous larval shell. Pseudointerarea broad, anactine, occasionally weakly depressed medially. Median septum low to high with dorsally concave surmounting plate on ventral margin. Anterior margin of median septum with variably developed number of spines and folds depending upon valve size and species. One to two pairs of lateral processes developed either side of dorsal valve median septum in some species.

**Discussion**

Previous authors (Bierman and Harper 1999, Mergl 2001 and Valentine et al. 2003) have defined species of *Acrotretella* based upon the presence or absence of lateral processes (sensu Bierman and Harper 1999:88) in the dorsal valve (Table 5). Despite both forms having a similar stratigraphic range, no consideration has previously been given to the possibility that the development of lateral processes may be part of an ontogenetic growth continuum. It is only in the Cobra Formation and the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales (Valentine et al. 2003), that *Acrotretella* with and without lateral processes occur in the same stratigraphic horizons (Tables 5, 6). Analysis of the ontogeny of *Acrotretella* has been prevented before because most occurrences are restricted to a handful of specimens (Table 5). A sufficient number of specimens assignable to *Acrotretella dizeugosa* sp. nov. (36 ventral valves and 39 dorsal valves; Table 2) have been recovered from the Cobra Formation to allow the first detailed ontogenetic investigation of *Acrotretella*.

The dorsal valve ontogeny of *A. dizeugosa* can be divided into four overlapping developmental growth stages (Fig. 7): (1) development of a simple dorsal valve median septum with a dorsally concave surmounting plate; (2) growth of spines along the anterior margin of the dorsal valve median septum; (3) insertion of the first pair of lateral processes; and (4) insertion of a second pair of lateral processes posterior of, and parallel to, the first pair. Although considerable overlap exists in the size range of each growth stage, each growth stage generally corresponds with an increase in dorsal valve size (Fig. 7).

During the first dorsal valve growth stage of *A. dizeugosa* (413-725 μm long; 488-788 μm wide) (Fig. 7) a simple, low median septum with surmounting plate is developed (Fig. 6m, n). The surmounting plate originates slightly posterior of valve midlength as two ridges separated by a dorsally concave plate averaging 63 μm wide. A single dorsal valve of *A. dizeugosa* from sample MU 31 (628.6 m above the base of the section) (275 μm long; 288 μm wide) has yet to develop a median septum with surmounting plate (Fig. 6l). The surmounting plate coalesces into a single blade at 56%, and continues to 86%, valve length. The median septum reaches an average height of 75 μm at 81% valve length. The anterior margin of the median septum is steep, straight to weakly curved and smooth (Fig. 6n).

Up to three spines, termed ‘septal spines’ by Popov (in Nazarov and Popov 1980:75) are developed along the anterior margin of the median septum during the second dorsal valve growth stage (563-763 μm long; 688-838 μm wide) (Fig. 7). The median septum of this growth stage is higher than in the proceeding stage, averaging 144 μm high at 75%, and extends to 87%, valve length. The anterior margin of the median septum is longer and more strongly curved than in the first growth stage (Fig. 6q, r). Septal spines also occur in numerous Ordovician acrotretoïds (eg. *Numericoma* Popov, 1980 in Nazarov and Popov 1980). Popov (in Nazarov and Popov 1980) and Holmer (1989) have linked the development of septal spines in such genera to the ontogenetic development of the median septum—from a simple, subtriangular blade in juveniles, to a complexly spinose structure in mature individuals.

The first pair of lateral processes appear during the third dorsal valve growth stage (625-950 μm long; 750-1325 μm wide) (Fig. 7). The lateral processes originate around valve midlength and are initially developed as low, short, anteriorly divergent rods...
Table 5. Locality, age, available material and dimensional data for species of *Acrotretella* with and without lateral processes. Abbreviations: vv = ventral valve(s); dv = dorsal valve(s); l = length; w = width. *Average dimensions (in µm based on dimensions given, or on illustrated material, in the accompanying reference.

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>Age</th>
<th>Available material</th>
<th>Average dimensions (µm)*</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrotretid gen. et sp. nov. (see text)</td>
<td>Kildare Limestone, Ireland</td>
<td>Ashgill</td>
<td>0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><em>Acrotretella</em> sp. A</td>
<td>Boree Creek Formation - Borenore Formation (B section), Australia</td>
<td>Llandovery - Wenlock</td>
<td>0</td>
<td>18</td>
<td>-</td>
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<tr>
<td></td>
<td>Boree Creek Formation (BM section), Australia</td>
<td>Wenlock</td>
<td>0</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Boree Creek Formation (WERR section) and Borenore Formation (DSC/B and BOR/1 sections), Australia</td>
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<td>-</td>
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<tr>
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**TABLE 5 CONTINUED ON PAGE 216**
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<th>Species</th>
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<td>Beside Limeston, Sweden</td>
<td>Acroteriella sp(a)</td>
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</tr>
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</table>
Figure 7. Length versus width for ventral valves and each dorsal valve growth stage of Acrotretella dizygosa sp. nov.

+ = ventral valves (n = 12);
○ = dorsal valve growth stage 1 (n = 4);
▲ = dorsal valve growth stage 2 (n = 4);
▼ = unknown dorsal valve growth stage (n = 7)*;
□ = dorsal valve growth stage 3 (n = 5);
● = dorsal valve growth stage 4 (n = 2).

*Note that the dorsal valve median septum of some specimens of A. dizygosa without lateral processes is not preserved. Such specimens, equivalent to dorsal valve growth stages 1 or 2, are presented here as a separate, combined group. See text for discussion on dorsal valve growth stages of A. dizygosa.
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with rounded anterior margins (Fig. 6s). The median septum of this growth stage is higher again than in the previous growth stages (averaging 188 µm high) and has a long, curved anterior margin with up to four septal spines. A positive relationship between dorsal valve size and the development of septal spines can also be demonstrated in Acrotretella spinosa Mergl, 2001 from the Přídlí Formation of the Czech Republic (see Mergl 2001:pl. 26, figs 4-6).

The final dorsal valve growth stage of A. dizeugosa (1000-1275 µm long; 1025-1500 µm wide) (Fig. 7) is characterised by the development of a second pair of lateral processes that are inserted posterior of, and parallel to, the first pair at approximately one-third valve length (Fig. 6t, u). Two specimens assignable to this growth stage were recovered from Murruiin Creek. The lateral processes of the smaller of these specimens (1000 µm long; 1025 µm wide) are developed as low, slightly elongate rods, with the posterior pair being slightly shorter than the anterior pair. The anterior ends of the first pair are weakly twisted and flattened. The median septum of this specimen was not preserved (Fig. 8t). The posterior pair of lateral processes in the larger of these specimens (1275 µm long; 1500 µm wide) are higher and longer than the anterior pair, and both pairs end in variably developed, stubby projections (Fig. 6w). The median septum of this specimen, although damaged, bears the remains of five septal spines along its anterior margin (Fig. 6v, w). Concurrent with this final dorsal valve growth stage is the initiation of folding in the median septum, with up to two folds being developed. Biernat (1973:43) demonstrated a positive relationship between valve size and the degree of folding in the dorsal valve median septum of Myotreta Górjansky, 1969. Although only one specimen of A. dizeugosa was recovered with a folded median septum, this feature does occur in the largest specimen suggesting it is also related to valve size.

Apart from Acrotretella goldapiensis Biernat and Harper, 1999 from the Llanvirn Baltic syncline of northwest Poland, no ventral valves have previously been assigned to any species of Acrotretella with lateral processes (Table 5) (Mergl 2001; Valentine et al. 2003). Ventral valves assignable to Acrotretella from the Cobra Formation co-occur with, and overlap the size range of, each dorsal valve growth stage of A. dizeugosa (Fig. 7; Table 6). A similar trend is also observable in A. goodridgei Valentine, Brock and Molloy, 2003 from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales (see species discussion for A. dizeugosa below) (Fig. 8).

Therefore, a positive relationship can be demonstrated to exist between dorsal valve size and the development of lateral processes and septal spines along the anterior margin of the dorsal valve median septum in A. dizeugosa (Fig. 7). Additional material for most Acrotretella species is required to confirm if lateral processes, and/or septal spines, were developed in all species (Table 5). Until such time, care must be exercised when relying upon the presence or absence of these features to define species. To this end, an ontogenetic growth continuum for each population of Acrotretella should be established prior to the erection of new species and the level of intraspecific variation present determined.

Acrotretella dizeugosa sp. nov. Figs 6c-y, 9a-b

Etyymology
Gr., di, two, double; Gr., zeugos, team, pair; in reference to the development of two pairs of lateral septa in the dorsal valve of mature individuals.

Table 6. Stratigraphic distribution and abundance of ventral valves and each dorsal valve growth stage of Acrotretella dizeugosa sp. nov. recovered from productive samples along the MU section through the Cobra Formation in Murruiin Creek. *Note that the dorsal valve median septum of some specimens of A. dizeugosa without lateral processes is not preserved. Such specimens, equivalent to dorsal valve growth stages 1 or 2, are presented here as a separate, combined group. See text for discussion on dorsal valve growth stages of A. dizeugosa.

<table>
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<tr>
<th>Metres above base of MU section</th>
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<th>641.3</th>
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<tr>
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<td>6</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>dorsal valve growth stage 2</td>
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<td>2</td>
<td>2</td>
<td>36</td>
<td></td>
</tr>
<tr>
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<td>3</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dorsal valve growth stage 4</td>
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<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unknown dorsal valve growth stage*</td>
<td>11</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>16</td>
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Figure 8. Length versus width for ventral valves and each dorsal valve growth stage of *Acrotretella goodridgei* Valentine, Brock and Molloy, 2003 from the BM section of Valentine et al. (2003) and the B section of Bischoff (1986) through the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales.

+ = ventral valves (n = 17);
○ = dorsal valve growth stage 1 (n = 10);
▲ = dorsal valve growth stage 2 (n = 12);
▼ = unknown dorsal valve growth stage (n = 20)*;
□ = dorsal valve growth stage 3 (n = 6);
● = dorsal valve growth stage 4 (n = 2).

*Note that the dorsal valve median septum of some specimens of *A. goodridgei* without lateral processes is not preserved. Such specimens, equivalent to dorsal valve growth stages 1, 2 or 3, are presented here as a separate, combined group. See text for discussion on dorsal valve growth stages of *A. goodridgei*. 

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Figure 9. a-b *Acrotretella dizeugosa* sp. nov. Dorsal valve paratype AM F128347, sample MU 31; a, exterior Figure; b, detail of larval shell (scale bar equals 10 μm). c-n. *Opsiconidion ephemerus* (Mergl, 1982) all from sample MU 32 unless otherwise mentioned. c, d. Dorsal valve AM F128348, sample MU 35; c, exterior; d, detail of larval shell. e, f. Dorsal valve AM F128349; e, interior; f, lateral view. g, h. Dorsal valve AM F128350; g, interior; h, lateral view. i, j. Dorsal valve AM F128351; i, interior; j, detail of pseudointerarea. k-n. Ventral valve AM F128352; k, exterior; l, anterior; m, posterior; and n, lateral views. o-q. *Opsiconidion* sp. o. Dorsal valve AM F128353, sample MU 31; interior. p, q. Dorsal valve AM F128354, sample MU 36; p, exterior; q, detail of larval shell. r-t. Siphonotretid gen. et sp. indet. 1. r, s. Dorsal valve AM F128355, sample MU 36; r, exterior; s, detail of spines (scale bar equals 10 μm). t. Dorsal valve AM F128356, sample MU 34; interior. Unless otherwise mentioned all scale bars equal 100 μm.
Table 7. *Acrotretella dizeugosa* sp. nov., ventral and dorsal valve dimensions (in μm) and ratios.

<table>
<thead>
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<th>Type material</th>
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</thead>
<tbody>
<tr>
<td><strong>Holotype:</strong> AM F128345 (Fig. 6u-w): dorsal valve, sample MU 32. Figured paratypes: AM F128336 (Fig. 86, f): ventral valve, sample MU 35; AM F128337 (Fig. 6g): ventral valve; AM F128338 (Fig. 6h-k): ventral valve, sample MU 35; AM F128339 (Fig. 6l): dorsal valve; AM F128340 (Fig. 6m, n): dorsal valve; AM F128341 (Fig. 6o, p): dorsal valve; AM F128342 (Fig. 6q, r): dorsal valve; AM F128343 (Fig. 6s): dorsal valve, sample MU 35; AM F128344 (Fig. 6t): dorsal valve, sample MU 32; AM F128346 (Fig. 6x, y): dorsal valve; AM F128347 (Fig. 9a, b): dorsal valve. All from sample MU 31 unless otherwise mentioned (Table 1).</td>
<td></td>
</tr>
</tbody>
</table>

**Diagnosis**

A species of *Acrotretella* with numerous, closely spaced growth lamellae on the ventral valve (eight per 100 μm), but more widely spaced on the dorsal valve (three to five per 100 μm). Dorsal valve larval shell with rounded, variably developed, medially depressed ridge bounding anterior and anterolateral margins. Anterior margin of dorsal valve median septum bearing up to two folds and five septal spines. Two pairs of lateral processes inserted centrally, either side of dorsal valve median septum, in mature individuals.

**Description**

Ventral valve subpyramidal, subtending apical angle of 85° in anterior view. In lateral profile posterior slope straight to weakly convex; anterior slope long, flat to weakly convex. Valve height (Table 7) averaging 56% valve length and 46% valve width.
Beak directed ventrally. Pseudointerarea catacline to weakly apsicline, subtending apical angle of approximately 80°, separated from remainder of valve by gentle flexure. Intertrochtega vaguely defined in some specimens, subtending apical angle of approximately 20°. Larval shell subcircular, averaging 164 μm long, 191 μm wide, 85 μm high. Foramen confined to larval shell, subcircular, averaging 37 μm long and 33 μm wide. Narrow, subparallel sulcus extending anteriorly from foramen, dividing larval shell into two lateral swellings, occasionally continuing into juvenile portion of post-larval shell. Larval shell bearing shallow, circular, flat-bottomed pits averaging 5 μm in diameter. Post-larval shell ornament of well-defined, closely spaced, continuous concentric lamellae (eight per 100 μm) with rounded crests. Concentric lamellae on juvenile portion of post-larval shell less well-defined. Lamellae becoming disordered and less distinct on pseudointerarea, especially across intertrochtega.

Ventral valve interior of some specimens with weakly impressed, elongate adductor scars on posterior slope. No other muscle scars or mantle canal patterns observed. Pedicle tube and apical process absent.

Dorsal valve outline subquadrate to transversely elongate, with straight posterior margin, weakly to strongly curved lateral margins, and straight to weakly curved anterior margin. Maximum width occurring slightly posterior of valve midlength. Anterior slope of juveniles long and flat in lateral profile, becoming depressed medially and raised anteriorly in mature specimens. In anterior view, lateral slopes of juveniles short and flat, developing raised margins in mature specimens. Larval shell bulbous, subcircular, averaging 163 μm long and 161 μm wide, with flattened lateral and posterior margins and separated from post-larval shell by raised rim. Larval shell with rounded, variably developed, medially depressed ridge bounding anterior and anterolateral margins. Pitted larval shell microornament similar to that of ventral valve. Post-larval shell ornament similar to that of ventral valve, but concentric lamellae more widely spaced (three to five per 100 μm) separated by flat interspaces bearing finer growth filae.

Dorsal valve interior with analine pseudointerarea extending approximately 50% valve width. Median plate broadly subtriangular, weakly depressed medially, merging almost imperceptibly with propareas laterally. Anterior margin of pseudointerarea raised slightly above valve floor medially. Cardinal muscles scars weakly impressed, suboval, located posterolaterally, extending anteriorly approximately one-third valve length. Anterocentral muscle scars and mantle canal patterns not observed. Median septum subtriangular in lateral profile, extending 83% valve length, bearing dorsally concave surmounting plate on posterior margin for 70% of length. Surmounting plate originating slightly posterior of valve midlength as two ridges, separated by dorsally concave plate, merging into single blade at 56% valve length. Anterior margin of median septum bearing up to two folds and five hollow, septal spines. Two pairs of lateral processes developed centrally in mature individuals—first pair originating slightly posterior of valve midlength; second pair posterior of, and parallel to, first pair, originating at approximately one-third valve length. Both pairs of lateral processes initially developed as low, rounded, anteriorly divergent (at approximately 90°) rods with rounded anterior margins. Lateral processes becoming longer and higher anteriorly with increasing valve size, extending to 60% valve length. Stubby projections variably developed along anterior margins of both pairs of lateral processes. Second pair of lateral septa in mature specimens longer and higher than first pair.

Discussion

Mature dorsal valves of Acrotretella dizeugosa are easily distinguished from other Acrotretella by the development of two pairs of centrally located lateral processes (Fig. 6t, u). In comparison, most other Acrotretella with lateral processes only possess a single pair. The closely spaced concentric lamellae (eight per 100 μm) on the ventral valve of A. dizeugosa (Fig. 6e, h-k), and the variably developed low, rounded, medially depressed ridge bounding the anterior and anterolateral margins of the dorsal valve larval shell (Figs 6y, 9b), are also unique to the species.

Wright and McClean (1991: fig.1 H-l) figured a single acrotretoid dorsal valve from the Ashgill Kildare Limestone of Ireland with two pairs of lateral processes and a complexly folded median septum bearing a dorsally concave surmounting plate along its ventral margin. Although Wright and McClean (1991) referred to this specimen as a new, but unnamed, acrotretid genus, these features suggest assignment to Acrotretella. However, unlike A. dizeugosa, the Irish taxon has a transversely oval dorsal valve outline and both pairs of lateral processes are located posteromedially (Wright and McClean 1991).

Valentine et al. (2003) recognised two species of Acrotretella in the Llandover-Wenlock Boree Creek Formation near Orange in central-western New South Wales—Acrotretella goodridgei (without lateral processes) and Acrotretella sp. A (with
lateral processes) (Table 5). Recovery of additional specimens of *A. goodridgei* from the Boree Creek Formation and study of Dean-Jones' (1979) material, indicates that *A. goodridgei* passed through a similar ontogenetic growth continuum to *A. dizeugosa* (Fig. 8). *Acrotretella* sp. A is therefore considered synonymous with *A. goodridgei* herein. The first two ontogenetic dorsal valve growth stages of *A. goodridgei* are similar to those of *A. dizeugosa*. The third dorsal valve growth stage of *A. goodridgei* differs in developing a folded dorsal valve median septum, prior to the development of lateral processes.

Valentine et al. (2003) believed that the folded dorsal valve median septum of *Acrotretella* was restricted to individuals with lateral processes, but the additional material from the Boree Creek Formation indicates this feature can also occur in specimens without lateral processes. *Acrotretella goodridgei* developed only a single pair of centrally located lateral processes during the fourth dorsal valve growth stage (Fig. 10). However, one damaged, gerontic dorsal valve (1625 μm wide) with a highly folded median septum and well-developed lateral processes, possesses a secondary pair of lateral processes inserted anteromedially, midway between the median septum and the first pair of lateral processes (see Valentine et al. 2003:pl. 2, fig. 26). *Acrotretella goodridgei* is also distinguished by having up to six septal spines and four folds along the anterior margin of the dorsal valve median septum in mature individuals.

Family Biematidae Holmer, 1989
*Opsiconidion* Ludvigsen, 1974

**Type species**
*Opsiconidion arcticon* Ludvigsen, 1974.

*Opsiconidion ephemerus* (Mergl, 1982)
Fig. 9c-n

**Synonymy**

See Mergl (2001:33) plus the following:
1984 *Opsiconidion podlasiensis* n. sp. Biemat, p. 97; pl. 26, figs 1a-c, 2; pl. 27, fig. 1a-e; pl. 28, figs 1a-c, 2a, b, 3; pl. 29, figs 2a, b, 3; pl. 30, figs 1, 2, 3a, b; pl. 31, figs 1a-c, 2.
2003 *Opsiconidion ephemerus* (Mergl);
Williams; pl. 2, fig. 2.

**Description**


**Figured material**

AM F128348 (Fig. 9c, d): dorsal valve, sample MU 35; AM F128349 (Fig. 9e, f): dorsal valve; AM F128350 (Fig. 9g, h): dorsal valve; AM F128351 (Fig. 9i, j): dorsal valve; AM F128352 (Fig. 9k-n): ventral valve. All from sample MU 32 unless otherwise mentioned (Table 1).

**Discussion**

The Murruin Creek material is characterised by a subcircular dorsal valve outline with maximum width occurring around valve midlength. The dorsal valve pseudointerarea is anacline and broadly subtriangular with a shallowly depressed median plate bearing fine growth lines. The anterior margin of the pseudointerarea is weakly arcuate (occasionally straight) and raised above the valve floor (Fig. 9c, e, g, i, j). These features are identical to *O. ephemerus* (Mergl 1982, 2001) and *O. podlasiensis* from the Wenlock Podlasie Depression of Poland (Biemat 1984). Biemat (1984) noted variations in the dorsal valve outline, and in the height and width of the dorsal valve pseudointerarea of *O. podlasiensis*. Similar variations also occur in the dorsal valve outline and pseudointerarea of the Australian (Fig. 9c, e, g, i, j) and Czech material (see Mergl 1982:pl. 1, figs 5, 6, 8-11).

The dorsal valve holotype of *O. ephemerus* is 700 μm long and 700 μm wide, and Mergl (1982:116) noted dimensional uniformity within his population. Biemat (1984:97) listed the dimensions of the dorsal valve holotype of *O. podlasiensis* as 690 μm long and 840 μm wide. On average, the Australian material is smaller, only 553 μm long and 622 μm wide, but its size range encompasses both the Czech and Polish material (Table 8). Ventral valves of the type material of *O. ephemerus* and *O. podlasiensis* are strongly conical and can reach over 1000 μm in height. In comparison, the most complete ventral valve of the Australian material is only 475 μm high and not as strongly conical (Fig. 9k-n).

The larval shell microornament of *O. ephemerus* and *O. podlasiensis* consists of circular, flat-bottomed pits (3-6 μm in diameter) with few, or no, cross-cutting relationships (Fig. 11d). This differs from the more commonly observed cross-cutting type of larval shell pitting observed in *Opsiconidion*. The Czech and Polish material also possess a smaller set of pits (0.3-0.5 μm in diameter) located on the smooth, level areas between the larger pits. No evidence of a smaller set of pits were observed in the Murruin Creek specimens (Fig. 9d).

Dorsal valves of *Opsiconidion simplex* Mergl, 2001 from the Pridoli Požáry Formation of the Czech Republic, have a rounder outline than *O. ephemerus* and a median septum that is consistently shorter.
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Table 8. *Opsiconidion ephemerus* (Mergl, 1982), ventral and dorsal valve dimensions (in μm) and ratios.

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<th></th>
<th></th>
<th>Fa</th>
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<tr>
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<td>71.9%</td>
<td>6.3%</td>
<td>24.0%</td>
<td>65.2%</td>
<td>9.6%</td>
<td>57.1%</td>
<td>19.1%</td>
</tr>
<tr>
<td><strong>MAX</strong></td>
<td>111.6%</td>
<td>28.6%</td>
<td>55.3%</td>
<td>95.2%</td>
<td>30.4%</td>
<td>121.4%</td>
<td>65.2%</td>
</tr>
</tbody>
</table>

(only 65-70% valve length) and lower compared to other members of the genus (see Mergl 2001: pl. 30, figs 6, 7, 9-13). *Opsiconidion aldridgei* (Cocks, 1979) from the Llandovery of the Welsh Borderlands (Cocks 1979), the Llandovery-Wenlock of Saaremaa Island, Estonia (Popov 1981) and the Llandovery-Wenlock of the Boree Creek Formation near Orange in central-western New South Wales (Valentine et al. 2003) has a similar circular dorsal valve outline to *O. ephemerus*, but has a shorter dorsal valve pseudointerarea with a straight anterior margin and a well-defined median plate. The dorsal valve pseudointerarea of *O. angustus* Valentine, Brock and Molloy, 2003 from the Llandovery-Wenlock Boree Creek Formation near Orange in central-western New South Wales, extends approximately 40% valve width and has an arcuate anterior margin and an indistinct median plate. *Opsiconidion angustus* also has a transversely suboval dorsal valve outline (Valentine et al. 2003).

*Opsiconidion* sp.

Fig. 9o-q

Synonymy
cf. 1999 *Opsiconidion* sp. Cockle; pl. 5, fig. 15.

cf. 2003 *Opsiconidion* sp. A Valentine, Brock and Molloy, p. 317; pl. 3, figs 16, 17.

Figured material
AM F128353 (Fig. 9o): dorsal valve, sample MU 31; AM F128354 (Fig. 9p, q): dorsal valve, sample MU 36 (Table 1).

Discussion
The Murrin Creek specimens differ from most *Opsiconidion* by their transversely elliptical dorsal valve outline (Fig. 9o, p). The anacline dorsal valve pseudointerarea is broadly subtriangular with a weakly depressed median plate and a straight anterior margin that is raised above the valve floor (Fig. 9o). The median septum is low and subtriangular in lateral profile. Elliptical *Opsiconidion* also occur in the Wenlock Borenore Limestone near Orange in central-western New South Wales (Cockle 1999; Valentine et al. 2003). The Borenore specimens have a dorsal valve pseudointerarea with a more strongly depressed median plate and a gently arcuate anterior margin, but insufficient material is currently available from both localities to determine if these differences are significant. Mergl (2001) also documented an elliptical *Opsiconidion*, *Opsiconidion* sp. A, from

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the Llandovery Želkovice Formation of the Czech Republic. The Czech material is not as strongly elliptical as the Murrui Creek specimens (compare Fig. 9o, p with Mergl 2001:pl. 29, figs 9, 12) and has a dorsal valve pseudointerarea with a more strongly depressed median plate.

Order Siphonotretida Kuhn, 1949
Superfamily Siphonotretidae Kutorga, 1848
Family Siphonotretidae Kutorga, 1848

siphonotretid gen. et sp. indet. 1
Fig. 9r-t

Figured material
AM F128355 (Fig. 9r, s): dorsal valve, sample MU 36 (Fig. 3); AM F128356 (Fig. 9t): dorsal valve, sample MU 34 (Table 1).

Discussion
The Murrui Creek siphonotretid differs from Orbaspina in lacking a pitted post-larval shell and possesses erect spines that are scattered evenly across the valve surface (Fig. 9r). Schizambonine sp. B from the Pragian Praha Formation of the Czech Republic also lacks a pitted post-larval shell, but is distinguished by its well-developed dorsal valve sulcus and prostrate spines that tend to be restricted to the valve margins (Mergl 2001:pl. 36, figs 11-13). Acanthambonine sp. from the Pragian Dvorce-Prokop Limestone of the Czech Republic, whilst also lacking a pitted post-larval shell, has more widely spaced, suberect spines and a submarginal dorsal valve larval shell (Mergl 2001:pl. 36, figs 1, 4, 5-7). Little is known concerning the internal morphology of any of these species. The apsacline dorsal valve pseudointerarea of the Murrui Creek siphonotretid is well-developed and shelf-like (Fig. 9t), similar to the dorsal valve pseudointerarea of Orbaspina.

Phylum Conodonta Pander, 1856
Genus Belodella Ethington, 1959

Type species
Belodod devonicus Stauffer, 1940.
Belodella anomalis Cooper, 1974
Fig. 10a-i

Synonymy
See Farrell (2004:947) plus the following:
1993 Belodella sp. aff. B. anomalis Cooper; Simpson et al., p. 153; fig. 4J.

Figured material
AM F128283 (Fig 10a): Sb element; AM F128284 (Fig. 10b): Sb element; AM F128285 (Fig. 10c): Sb element; AM F128286 (Fig. 10d): Sd element; AM F128287 (Fig. 10e): Sc element; AM F128288 (Fig. 10f): t element; AM F128289 (Fig. 10g): fragment of t element; AM F128290 (Fig. 10h): M element; AM F128291 (Fig. 10i): M element. All from sample MU 34 (Table 2).

Description

Discussion
This species from Murrui Creek is reconstructed recognising all five elements recorded by Farrell (2004), ie. Sa, Sb, Sc, Sd and t or tortiform elements, plus an adenticulate M element. The presence of the adenticulate M element in reconstructions of the genus has been discussed by Barrick and Klapper (1992) and is often still recognisable in small collections (eg. Mawson et al. 1995). The M element of B. anomalis (Fig. 10h, i) is more strongly curved than the M element of Belodella resina (see Mawson et al. 1995: pl. 4, fig. 1) and Belodella cf. B. resina (see Barrick and Klapper 1992:pl. 1, fig. 7) and is more robust and broad-based than the M element of Belodella anfracta (see Barrick and Klapper 1992:pl. 1 fig. 9).

Cooper (1974) established the diagnostic characteristic of B. anomalis as the denticulated anterior margin, but also noted the distinctive apical 'fan-like' structure of denticles. Simpson et al. (1993: fig. 4J) illustrated a specimen from the Cowombat Formation at Cowombat Flat in eastern Victoria lacking the distinctive fan-like denticulation near the cusp and assigned it, with some doubt, to B. anomalis. It is now included within the species concept because the serrated nature of the anterior margin represents putative denticulation.

Genus Coryssognathus Link and Druce, 1972

Type Species

Coryssognathus dubius (Rhodes, 1953)
Fig. 11e, f

Synonymy
See Simpson and Talent (1995:163) and Farrell (2004:959), plus the following:
2002 Coryssognathus dubius (Rhodes); Talent et al.; pl. 2, figs U-W; pl. 4, figs F, G.
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Figure 10. a-i. Belodella anomalis Cooper, 1974, all from sample MU 34. a. Sb element AM F128283; lateral view. b. Sb element AM F128284; lateral view. c. Sb element AM F128285; lateral view. d. Sd element AM F128286; lateral view. e. Sc element AM F128287; lateral view. f. t element AM F128288; lateral view. g. fragment of ?t element AM F128289; lateral view. h. M element AM F128290; lateral view. i. M element AM F128291; lateral view. j-l. Dapsilodus obliquicostatus (Branson and Mehl, 1933) all from sample MU 37 unless otherwise mentioned. j. M element AM F128292; lateral view. k. M element AM F128293, sample MU 38; lateral view. l. M element AM F128294; lateral view. m. Decoriconus fragilis (Branson and Mehl, 1933). Sc element AM F128295, sample MU 34; lateral view. n, o. Panderodus recurvatus (Rhodes, 1953), both from sample MU 34. n. Sc element AM F128296; lateral view. o. Sb element AM F128297; lateral view. p. Panderodus unicoostatus (Branson and Mehl, 1933). M element AM F128302, sample MU 34; lateral view. All scale bars equal 100 μm.

Description
See Miller and Aldridge (1993:246).

Figured material
AM F128303 (Fig. 11c): Pa element; AM F128304 (Fig. 11f): partly preserved Sb element. Both from sample MU 34 (Table 2).

Discussion
The partially preserved Sb element from Murrain Creek has a prominent cusp and the remains of a lateral...
Figure 11. a, b. *Panderodus unicostatus* (Branson and Mehl, 1933), both from sample MU 34. a. Sa element AM F128300; lateral view. b. M element AM F128301; lateral view. c, d. *Panderodus serratus* Rexroad, 1967, both from sample MU 34. c. Sc element AM F128299; lateral view. d. Sb element AM F128298; lateral view. e, f. *Coryssognathus dubius* (Rhodes, 1953), both from sample MU 34. e. Pa element AM F128303; lateral view. f. Partly preserved Sb element AM F128304; lateral view. g, h. *Oulodus* sp. cf. *Oulodus elegans* (Walliser, 1964), both from sample MU 34. g. Sb element AM F128305; lateral view. h. Sa element AM F128306; lateral view. i–m. *Ozarkodina excavata excavata* (Branson and Mehl, 1933) all from sample MU 34 unless otherwise mentioned. i. M element AM F128307, sample MU 38; inner lateral view. j. Sa element AM F128308; lateral view. k. Sb element AM F128309; inner lateral view. l. Sc element AM F128311; inner lateral view. m. Pa element AM F128310; lateral view. n, o. *Kockelella maenniki* Serpagli and Corradini, 1998, both from sample MU 34. n. Sc element AM F128312; inner lateral view. o. Pa element AM F128313; oblique upper view. All scale bars equal 100 μm.

process bearing a single denticle adjacent to the break in the lateral process. The cusp is evenly curved toward the posterior and tapers evenly toward the apex. The denticulate process projects downward from a broad 'dished' area at the base of the cusp. The basal margin of the process curves toward the anterior from the 'dished' area (Fig. 11f). The poorly preserved scaphate Pa element has an erect, triangular cusp only slightly larger than the other denticles. No denticles were observed on the lateral process and it may therefore represent a juvenile Pa element (Fig. 11e) (Miller and Aldridge 1993).
Genus *Dapsilodus* Cooper, 1976

**Type species**
*Distacodus obliquicostatus* Branson and Mehl, 1933.

*Dapsilodus obliquicostatus* (Branson and Mehl, 1933) 
[Fig. 10j-l]

**Synonymy**
See Armstrong (1990:70), plus the following:
1990 *Dapsilodus obliquicostatus* (Branson and Mehl) Uyeno, p. 98; pl. 2, figs 11-16.
?1992 *Dapsilodus* sp. Barrick and Klapper, p. 44; pl. 2, fig. 2.
1994 *Dapsilodus obliquicostatus* (Branson and Mehl); Sarmiento et al.; pl. 1, figs 1, 6.
1999 *Dapsilodus obliquicostatus* (Branson and Mehl); Cockle, p. 119; pl. 4, figs 13-19.

**Description**
See Cooper (1976:212).

**Figured material**
AM F128292 (Fig. 10j): M element; AM F128293 (Fig. 10k): M element, sample MU 38; AM F128294 (Fig. 10l): M element. All from sample MU 37 unless otherwise mentioned (Table 2).

**Discussion**
It has not been possible to separate the Sb and Sc elements from Murrui Creek as morphologies appear gradational and they have therefore been tabulated together (Table 2). The M elements recovered (Fig. 4j-l) are recurved with a prominent costa almost centrally positioned in lateral view. Oblique striations are present along the anterior margin in some elements. Among the M elements, the point of maximum curvature shows some variability in relation to the generally shallow basal cavity.

Genus *Decoriconus* Cooper, 1975

**Type species**

*Decoriconus fragilis* (Branson and Mehl, 1933) 
[Fig. 10m]

**Synonymy**

**Description**
See Barrick (1977:53).

**Figured material**
AM F128295 (Fig. 10m): Sc element, sample MU 34 (Table 2).

**Discussion**
The Sc elements of *D. fragilis* from Murrui Creek are of the typical 'drepanodoni-form' first identified by Cooper (1975). These distinctive elements are inclined, with an almost straight anterior margin and are generally compressed, but expanded around the small basal cavity (Fig. 10m).

Genus *Kockelella* Walliser, 1957

**Type species**
*Kockelella variabilis* Walliser, 1957.

*Kockelella maenmiki* Serpagli and Corradini, 1998 
[Fig. 11n, o]

**Synonymy**

**Description**

**Figured material**
AM F128312 (Fig. 11n): Sc element; AM F128313 (Fig. 11o): Pa element. Both from sample MU 34 (Table 2).

**Discussion**
The laterally compressed Pa element of this taxon from Murrui Creek is curved, slightly arched and narrow with a strongly asymmetrical platform. The anterior portion of the blade has ten closely packed, compressed denticles. The posterior portion of the blade arches downwards and bears six closely spaced, laterally compressed denticles. The outer lateral process has five aligned, but slightly proclined denticles. The shorter inner lateral process appears to bear a single small denticle fused to the cusp (Fig. 11n). It should be noted that not all of Serpagli and Corradini's (1999:pl. 3, fig. 10) specimens have denticulate lateral processes. The Sc element is slender and has well-spaced denticles with a slightly twisted and downwardly deflected, antero-lateral process (Fig. 11n).

The stratigraphic range of *K. maenmiki* is interpreted as restricted to the lower to middle part of the *P. sciliricus* Zone (Corradini and Serpagli 1999; Serpagli and Corradini 1999). Corradini et al. (1998) reported that the genus *Kockelella* became extinct.
before the close of the siluricus Zone and that K.
maenniki therefore represents the terminal taxon of the
genus. Kockelella maenniki also occurs in the Ludlow
Coral Gardens sequence of the Jack Formation in
northern Queensland, where it occurs just below the
youngest occurrence of P. siluricus.

Genus Oulodus Branson and Mehl, 1933

Type Species
Oulodus serratus Stauffer, 1930.
Oulodus sp. cf. Oulodus elegans (Walliser, 1964)
Fig. 11g, h

Figured material
AM F128305 (Fig. 11g): Sb element; AM F128306 (Fig. 11h): Sa element. Both from sample
MU 34 (Table 2).

Discussion
The ramiform elements possess discrete, peg-like
denticles and a prominent cusp that curves toward the
lateral view. The anterior process of the Sb elements
bear six or seven denticles and the posterolateral
process six denticles (Fig. 11g). The Sa elements are
bilaterally symmetrical about the lateral processes
which possess four denticles (Fig. 11h).

Genus Ozarkodina Branson and Mehl, 1933

Type species
Ozarkodina typica Branson and Mehl, 1933.
Ozarkodina excavata excavata (Branson and Mehl, 1933)
Fig. 11i-m

Synonymy
Simpson and Talent (1995:147) and Farrell
(2003:123) covered the majority of published
accounts. However, at least an additional 20 illustrated
records pre- and postdating the synonymies cited above
exist, but due to space limitations it was not possible
to include them. This will be undertaken in another
publication where the primary focus is conodont
taxonomy.

Description

Figured material
AM F128307 (Fig. 11i): M element, sample MU
38; AM F128308 (Fig. 11j): Sa element; AM F128309
(Fig. 11k): Sb element; AM F128311 (Fig. 11l): Sc
element; AM F128310 (Fig. 11m): Pa element. All
from sample MU 34 unless otherwise mentioned
(Table 2).

Discussion
This species from Murruin Creek shows the long,
discrete denticles and well-developed basal cavity
typical of this ubiquitous Silurian to Early Devonian
taxon (Fig. 111-m). The Sa elements show some
variation in the angle between the processes (Fig. 11i),
but Farrell (2003, 2004) reported similar variations in
his material from the Late Silurian to Early Devonian
Camelford Limestone and the Early Devonian Garra
Limestone at Wellington in central-western New
South Wales. The Pa and Pb elements display the
typical anterior and posterior process morphology with
closely packed compressed denticles and a prominent
cusp (Fig. 11m, o).

Genus Panderodus Ethington, 1959

Type Species
Paltochus unicostatus Branson and Mehl, 1933.
Panderodus recurvatus (Rhodes, 1953)
Fig. 10n, o

Synonymy
See Simpson and Talent (1995:117) and Farrell
(2003:122), plus the following:
1995 Panderodus recurvatus (Rhodes);
Colquhoun, p. 354; pl. 3, fig. 4.
1999 Panderodus recurvatus (Rhodes); Cockle,
p. 120; pl. 5, figs 9-14.
2002 Panderodus recurvatus (Rhodes); Aldridge;
pl. 4, figs 4-7.
2002 Panderodus recurvatus (Rhodes); Talent et
al.; pl. 2, figs J, K.
2002 Panderodus recurvatus (Rhodes); Zhang
and Barnes, p. 31; figs 16.1-16.27.
2004 Panderodus recurvatus (Rhodes); Farrell, p.
958; pl. 3, figs 9, 12, 13.

Description
See Barrick (1977:54).

Figured material
AM F128296 (Fig. 10n): Sc element; AM F128297 (Fig. 10o): Sb element. Both from sample
MU 34 (Table 2).

Discussion
The available elements of P. recurvatus from
Murruin Creek are all broken to a greater or lesser
extent, but are distinctly recurved, lack ornament and
possess a longitudinal groove developed along the middle to posterior portion of one lateral surface (Fig. 10n, o).

_Panderodus serratus_ Rexroad, 1967
Fig. 11c, d

**Synonymy**

1997 _Panderodus serratus_ Rexroad; Jeppsson, p. 107; fig. 7.4.

**Description**


**Figured material**

AM F128299 (Fig. 11c): Sc element; AM F128298 (Fig. 11d): Sb element. Both from sample MU 34 (Table 2).

**Discussion**

Jeppsson (1997:107) noted a close similarity between _P. serratus_ and _P. unico status_, and indicated they could only be separated by the serrat posterior margin of the arcuiform (Sc) element of _P. serratus_. He did not, however, indicate whether serrations were present on other elements. The Murrui Creek specimens are rare (Table 2), but there are clear examples of a serrate Sc element (Fig. 11c) and one interpreted as a Sb element (Fig. 11d).

_Panderodus unico status_ (Branson and Mehl, 1933)
Figs 10p; 11a, b

**Synonymy**

See Simpson and Talent (1995:118) and Farrell (2004:959), plus the following:

1997 _Panderodus unico status_ (Branson and Mehl); Jeppsson, p. 107; fig. 7, 7.3.
1999 _Panderodus unico status_ (Branson and Mehl); Cockle, p. 120; pl. 5, figs 1-8.
2002 _Panderodus unico status_ (Branson and Mehl); Aldridge, pl. 4, figs 8-17.
2002 _Panderodus unico status_ (Branson and Mehl); Talent et al.; pl. 2, fig. 1.
2002 _Panderodus unico status_ (Branson and Mehl); Zhang and Barnes, p. 32; figs 15.1-15.24.

**Description**


**Figured material**

AM F128302 (Fig. 10p): M element; AM F128300 (Fig. 11a): Sa element; AM F128301 (Fig. 11b): M element. All from sample MU 34 (Table 2).

**Discussion**

Despite being a ubiquitous component of many Silurian conodont faunas, the taxonomy of _P. unico status_ is poorly understood. Specimens typically vary morphologically in terms of shape, total height and in the degree and location of strongest curvature (Jeppsson 1975; Simpson and Talent 1995). This variation between elements is such that distinction between S series elements is often problematic and intergradational morphologies possibly exist (Dzik and Drygant 1986; Sweet 1988). Jeppsson (1997) considered that internal structures of _Panderodus_, such as the form of the basal cavity and white matter distribution, to be taxonomically significant. Although over a thousand elements of this taxon were recovered from Murrui Creek (Table 1), many are broken at, or near the basal cavity termination.

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