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Early Carboniferous Mollusca from Gundy, Upper Hunter, New South Wales

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ABSTRACT. Minute mollusc fauna of Late Tournaisian age from thin limestone bands of the upper part of the Dangarfield Formation near Gundy, Upper Hunter, New South Wales are classified and described. Eighteen species among 38 gastropod species referable to 31 genera are described as new — Onychochilus minutissimus, Peruvispira gundeyensis, Glabrocingulum obesum, Hesperiella robertsi, Borestus costatus, Araeonema microspirulata, Microdoma angulata, Euochlis australis, Naticopsis (Naticopsis) osbornei, Acisina turgida, Stegocoelia (Stegocoelia) nodosa, Stegocoelia (Hypergonia) elongata, Stegocoelia (H.) tenuis, Loxonema elegantissima, Hemizyga (Hemizyga) decussata, Cyclozyga sinusigera, Soleniscus callosus and Donaldina filosa. Twenty European and North American generic names are introduced for the first time to the Australian gastropod fauna.

Two new scaphopod genera, Scissuradentalium and Pipadentalium, and four new species, Fissuradentalium longistriatum, Scissuradentalium runnegari, Plagiogypta numerosa and Pipadentalium protruberans, are proposed. One species of hyolitha, Hyolithes minutissimus, is described. Nine bivalve forms including two unknown taxa are illustrated, but not described here. All mollusc specimens are chloritised.


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Rich marine fossil faunas consisting of assemblages of brachiopods, gastropods, bivalves, crinoids, corals, fenestellid bryozoans, cephalopods and trilobites, are present in the calcareous mudstone and the bioclastic limestone of the upper part of the Dangarfield Formation. Microfossil faunas comprising gastropods, bivalves, scaphopods, hyoliths, ostracods, hexactinellid sponge spicules, conodonts and fish teeth were recovered from the bioclastic limestone by using standard acetic acid techniques. In this paper, a well-preserved minute molluscan fauna totalling approximately 2,000 specimens are classified.

Carboniferous molluscs have been known in New South Wales since the work of Etheridge (1890a,b, 1896, 1898, 1907) on fauna from the Port Stephens, Paterson, and Babbinoon Districts. Occasional descriptions of molluscs (de Koninck, 1898; Dun & Benson, 1920) and faunal lists (Benson, 1921) have appeared. Additional new species of molluscs have been described from Old Cannindah, Qld (Maxwell, 1961), from near Sherwood, west northwest of Kempsey (Campbell, 1961, 1962), from the Werrie and Belvue Synclines (Campbell & Engel, 1963) and from near Barrington (Campbell & McKelvey, 1971).

Materials and Methods

Each limestone sample weighing about 20 kg was acidised by using standard acetic acid techniques as applied for conodont preparation.

The residues were hand sorted beneath a low power binocular microscope. Illustrations were obtained using scanning electron microscope, JEOL JSM-U3.

All type specimens are given Australian Museum registration numbers unless stated otherwise, and are housed in the Australian Museum, Sydney.

Abbreviations used at the higher taxonomic levels are as follows: C.–Class, S.C.–Subclass, O.–Order, S.O.–Suborder, S.F.–Superfamily, T.–Tribe.

Type Locality

Bioclastic limestone lenses of the Dangarfield Formation; 70 m west to the junction of the Scone–Gundy road and the entrance to ‘Marohn’ homestead, 2.6 km southwest of Gundy, NSW. All localities mentioned in systematics (A–1, A–3, A–4, C–32, C–34 and C–36) are located within the extension of the limestone lenses as shown in Map 1.

Stratigraphy

DANGARFIELD FORMATION. The Dangarfield Formation was originally defined by Oversby & Roberts (1973) as the thick sequence of mudstone and subordinate lithic sandstone and oolitic and crinoidal limestones overlying the tuffs and tuffaceous sandstones of the Kingsfield Beds. The lowermost part of the formation which consists of lithic sandstones and siltstones grading into calcareous skeletal mudstones and wackestones was separated by Mory (1978) as a new formation and named the Macqueen Formation. He further divided the lower part of the Dangarfield Formation into two members: the Wroxley Lithic Sandstone Member and Brushy Hill Limestone Member. The name Brushy Hill Limestone was first used for the oolitic limestone sequence by Osborne (1928, 1950) in referring to sedimentary rocks now known as the Dangarfield Formation and volcanic rocks now known to belong to the Isismurra Formation. The succeeding sequence of the Dangarfield Formation is subdivided into two units, on the basis of lithology, and the lower part is named the May Farm Mudstone Member. The upper part is undivided and retained as Dangarfield Formation. The geology and stratigraphy of the study area are shown in Map 1 and Section 1.

MAY FARM MUDSTONE MEMBER. The May Farm Mudstone Member consists largely of monotonous brown and grey mudstones with minor lithic sandstone and limestone. It is delineated by the top of the underlying Brushy Hill Limestone Member and by the base of the lowest medium to coarse calcareous lithic sandstone cropping out along the western foot of the MacIntyres Mountain. This member was initially named by Mory (1975) after ‘May Farm’ homestead which lies near the northern foreshores of Lake Glenbawn, east of Brushy Hill. At the base of the member, the mudstone contains ooids gradually decreasing upwards and abundant allochthonous solitary rugose corals, as well as common brachiopods and crinoid stems. A 1.5 m thick fine grained calcareous sandstone outcropping along the strike direction through ‘May Farm’ homestead appears to be unfossiliferous. The thickness of the member is approximately 480 m.

UPPER PART OF THE DANGARFIELD FORMATION. The base of the unit is gradational and taken at the base of the lowest lithic/calcareous sandstone overlying conformably the May Farm Mudstone Member. The upper limit is the base of the Ayr Conglomerate Member of the Isismurra Formation. The unit consists of a thick sequence of greenish-grey to brownish-grey sandy mudstone, calcareous to lithic sandstone, conglomerate, and bioclastic limestone lenses. This unit outcrops on the western slope of the MacIntyres Mountain where the thickness ranges from 510 to 540 m. The lithofacies to the north of Pages River are noticeably different from that to the south of the river. About 70 m west of the entrance to ‘Marohn’ homestead, three bands of grey bioclastic limestone interbedded in mudstone, crop out at the roadside connecting Scone and Gundy (Map 1). Each limestone band ranges in thickness from 0.1 to 0.2 m and the limestones can be traced 800 m in northwest-southeast direction. The
upper part of the formation, on the upper hill of the MacIntyres Mountain consists of a greenish-grey sandy mudstone containing abundant fenestellid bryozoa as well as brachiopods, macro-gastropods and crinoid stems.

Geological Age of Fossil Assemblage

Evidence from Other Local Fauna. Research on Early Carboniferous brachiopods and conodonts has been extensively carried out in the study area (Roberts & Oversby, 1974; Jenkins, 1974; Roberts, 1975).

Four conodont zones were proposed by Jenkins (1974) in the Dangarfield Formation, and were correlated with sequences from North America and Belgium. The bioclastic limestone of the Dangarfield Formation on the Scone-Gundy road near 'Marohn' homestead lies within conodont *Gnathodus* sp. A zone. This zone, on comparison with the Belgian
Section 1. Stratigraphy of the study area and faunal zones (graphic section between Brush Hill and 'Glenburnie', modified from Roberts & Oversby, 1974).

stratotypes, correlates with Tn₃, or, more probably, Tn₃₀ (the late, not latest, Tournaision) (Jenkins, 1974).

Three brachiopod zones were identified in the Dangarfield Formation (Section 1). The bioclastic limestone lenses lie also within the brachiopod Schellwienella cf burlingtonensis zone which is widespread throughout the Rouchel district (Roberts & Oversby, 1974). Ammonoid data in this area of Germany suggest that S. cf burlingtonensis zone is Cu₁₃a in age (Jones et al., 1973) which is consistent with the age indicated by the conodonts.

EVIDENCE FROM GASTROPOD FAUNA. Thirty-four genera and subgenera of gastropods recognised in this study were originally named in Europe or North America and most of them are known to occur in both continents. However Scalitina, Hesperiella, Turbonitella and Palaeozygopleura have not yet been recorded in North America, while Rhabdotocochlis, Eucochlis, Hemizyga and Cyclozyga have not yet been recorded in Europe.

The gastropod genera found in the present study area have various ranges within the Palaeozoic and only Naticopsis persists into the Mesozoic. Two genera, Aelisina and Turbonitella, and one subgenus, Angyomphalus, are known to be restricted to the Early Carboniferous, while six genera, Paragoniozona, Eucochlis, Hemizyga (Hemizyga), Cyclozyga and Rhabdotocochlis (herein identified), are previously recorded from Pennsylvanian strata of North America but not found in the Mississippian strata and correlatives outside Australia.
Table 1. Analyses of fossil molluscs (oxides) and number of ions calculated.

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Knightites (Reticulina)</th>
<th>Eucochlis</th>
<th>Palaeozeugmata</th>
<th>Isantheopsis</th>
<th>Nuculopsis</th>
<th>Phragmophora</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>28.29%</td>
<td>28.78%</td>
<td>28.67%</td>
<td>27.73%</td>
<td>29.18%</td>
<td>27.94%</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>18.26%</td>
<td>16.94%</td>
<td>17.03%</td>
<td>16.47%</td>
<td>17.19%</td>
<td>17.6%</td>
</tr>
<tr>
<td>FeO</td>
<td>35.76%</td>
<td>34.84%</td>
<td>31.55%</td>
<td>37.66%</td>
<td>34.83%</td>
<td>34.68%</td>
</tr>
<tr>
<td>MgO</td>
<td>8.97%</td>
<td>9.3%</td>
<td>12.57%</td>
<td>8.13%</td>
<td>9.14%</td>
<td>10.63%</td>
</tr>
<tr>
<td>CaO</td>
<td>0.36%</td>
<td>0.54%</td>
<td>0.54%</td>
<td>0.49%</td>
<td>0.61%</td>
<td>0.41%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>91.62%</td>
<td>90.4%</td>
<td>90.36%</td>
<td>90.49%</td>
<td>90.94%</td>
<td>91.27%</td>
</tr>
</tbody>
</table>

Number of ions

<table>
<thead>
<tr>
<th>Element</th>
<th>Knightites (Reticulina)</th>
<th>Eucochlis</th>
<th>Palaeozeugmata</th>
<th>Isantheopsis</th>
<th>Nuculopsis</th>
<th>Phragmophora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>5.914%</td>
<td>6.182%</td>
<td>6.147%</td>
<td>5.977%</td>
<td>6.032%</td>
<td>5.899%</td>
</tr>
<tr>
<td>Al</td>
<td>2.086%</td>
<td>1.818%</td>
<td>1.853%</td>
<td>2.023%</td>
<td>1.968%</td>
<td>2.101%</td>
</tr>
<tr>
<td>Fe+2</td>
<td>2.306%</td>
<td>2.475%</td>
<td>2.413%</td>
<td>2.523%</td>
<td>2.256%</td>
<td>2.463%</td>
</tr>
<tr>
<td>Mg</td>
<td>6.139%</td>
<td>6.171%</td>
<td>6.223%</td>
<td>6.313%</td>
<td>6.851%</td>
<td>6.414% 11.81</td>
</tr>
<tr>
<td>Ca</td>
<td>3.353%</td>
<td>2.886%</td>
<td>2.960%</td>
<td>2.824%</td>
<td>2.636%</td>
<td>2.840%</td>
</tr>
<tr>
<td>(OH)</td>
<td>0.093%</td>
<td>0.138%</td>
<td>0.124%</td>
<td>0.081%</td>
<td>0.114%</td>
<td>0.102%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6.147%</td>
<td>6.223%</td>
<td>6.313%</td>
<td>6.851%</td>
<td>6.414% 11.81</td>
<td></td>
</tr>
</tbody>
</table>

Preservation

Nine specimens comprising seven gastropods, one bivalve and one scaphopod have been analysed by electron probing microanalyser. Table 1 shows the result of analyses and the number of ions which are calculated from the analyses on the basis of 28 oxygen equivalents, ignoring H₂O⁺, i.e., O₂O(O,OH)₁₆ — the same approach as Deer, Howie & Zussman (1965). The percentage of oxides and number of ions of all specimens are similar and lie within the ranges of published chlorite analyses.

Two specimens (Eucochlis and Nuculopsis) have also been analysed by X-ray diffraction at the New South Wales Institute of Technology. The diffraction data, examined by Dr E. Slansky, represent peaks at 14, 7.1, 3.55 A, indicating the presence of chlorite (and an admixture of quartz). This supports the conclusion, from electron microprobe analyses, that the fossils are chloritised. The specimens are generally greenish grey to dark grey in colour.

Chlorite replacement has made the isolation of complete shells from the limestone matrix possible and led to the preservation of delicate shell ornamentation. Thin minute shells are more perfectly preserved by chlorite replacement than big and thick shells. No macrospecimens have been isolated by acid digestion probably due to only partial replacement. Pyrite crystals are disseminated commonly in the chloritised shells.

Systematics

For systematic arrangement as well as the definition of genera, families and higher taxa, the Treatise on Invertebrate Paleontology, Part I — Mollusca (chitons, scaphopods, gastropods), Part N — Mollusca 6 (pelecypods), and Part W — Miscellanea (worms, conodonts, problematical fossils) was mainly consulted. To avoid repetition, only emended diagnoses are given in full in the systematic descriptions of taxa.

A systematic list of mollusc fauna from the investigated bioclastic limestone of the Dangarfield Formation is presented in Table 2.

C. GASTROPODA Cuvier, 1797

O. ARCHAEOGASTROPODA Theile, 1925

S.F. BELLEROPHONTACEA M'Coy, 1851

SINUITIDAE Dall, 1913

BUCANELLINAE Koken, 1925

Sinunitina Knight, 1945

Type species. Tropidocyclus cordiformis Newell, 1935: 349; from the Middle Pennsylvanian of Oklahoma.

Definition. See Knight et al., 1960: 175.

Stratigraphic range. Silurian to Middle Permian.
Table 2. A systematic list of Mollusc Fauna from a bioclastic limestone in the Dangarfield formation. + = listed only; * = listed and illustrated; ** = illustrated and described in text.

<table>
<thead>
<tr>
<th>Superfamily</th>
<th>Family</th>
<th>Genus, species and author</th>
<th>Fig.No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastropoda</td>
<td>Sinuitidae</td>
<td>* Sinuitina portulacoides Campbell &amp; Engel</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Euphemites cf. labrosa Campbell &amp; Engel</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Sinuitid n.gen.</td>
<td>7-8</td>
</tr>
<tr>
<td></td>
<td>Bellerophontidae</td>
<td>* Knightites (Retispira) calleni Campbell &amp; Engel</td>
<td>9-11</td>
</tr>
<tr>
<td>Macluritacea</td>
<td>Onychochilidae</td>
<td>* Onychochilus minutissimus n.sp.</td>
<td>12-14</td>
</tr>
<tr>
<td>Euomphalacea</td>
<td>Euomphalidae</td>
<td>*Straparollus (Straparollus) sp.</td>
<td>15-17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Straparollus (Seroplosira) sp.</td>
<td></td>
</tr>
<tr>
<td>Pleurotomariacea</td>
<td>Raphistomatidae</td>
<td>+ Scalitina sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eotomariidae</td>
<td>* Trepocrisy (Angyomphalus) sp.</td>
<td>18-20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Eotomaria sp.</td>
<td>21-24</td>
</tr>
<tr>
<td></td>
<td>Lophosphiridae</td>
<td>* Peruvissoro gundynensis n.sp.</td>
<td>29-32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Spirosca sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phymatopleuridae</td>
<td>* Glabrocingulum obesum n.sp.</td>
<td>33-35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Hesperiella robertsi n.sp.</td>
<td>36-41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Worthenia sp.</td>
<td>55-57</td>
</tr>
<tr>
<td>Platyceatace</td>
<td>Holopeidae</td>
<td>* Amanonema microspirulata n.sp.</td>
<td>46-49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Rhabdotocochlis sp.</td>
<td>50-51</td>
</tr>
<tr>
<td>Microdomatace</td>
<td>Microdomatidae</td>
<td>* Microdoma angulata n.sp.</td>
<td>58-60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Eucochlis australis n.sp.</td>
<td>61-64</td>
</tr>
<tr>
<td>Neritacea</td>
<td>Neritopsisida</td>
<td>* Naticopsis (Naticopsis) osborni n.sp.</td>
<td>65-66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Turbonitella sp.</td>
<td></td>
</tr>
<tr>
<td>Murchisoniace</td>
<td>Murchisoniidae</td>
<td>* Aclistina turgida n.sp.</td>
<td>80-81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Stegcoelida (Stegcoelid) nodosa n.sp.</td>
<td>67-71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Stegcoelida (Hypergongia) elongata n.sp.</td>
<td>73-75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Stegcoelida (Hypergongia) tenuis n.sp.</td>
<td>76-79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Stegcoelida (Hypergongia) sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Loxonema elegansitissa n .sp.</td>
<td>84-87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Palaeonysetra sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Hemizygia (Hemizygia) decussata n.sp.</td>
<td>88-91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Cyclosgya sinusigera n.sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ Microptychia sp.</td>
<td></td>
</tr>
<tr>
<td>Subulitacea</td>
<td>Subulitidae</td>
<td>* Ceraunocochlis sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Soleniscus callosus n.sp.</td>
<td>95-102</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Ianthipopsis sp.</td>
<td>103</td>
</tr>
<tr>
<td>Pyramidellacea</td>
<td>Streptacidida</td>
<td>* Donaldia filosa n.sp.</td>
<td>104-109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Donaldina sp.</td>
<td>110-111</td>
</tr>
<tr>
<td>Bivalvia</td>
<td>Nuculaceae</td>
<td>*&quot;Nucula&quot; sp.</td>
<td>112-117</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*&quot;Nuculopsis&quot; sp.</td>
<td>118-123</td>
</tr>
<tr>
<td></td>
<td>Malletiidae</td>
<td>*Palaeonello acaritana Campbell &amp; Engel</td>
<td>124-125</td>
</tr>
<tr>
<td>Nuculanaceae</td>
<td>Nuculanidae</td>
<td>+ Phesia sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pectinacea</td>
<td>+ Euchondria sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallelopodontidae</td>
<td>*Parallelodon fossa (Campbell &amp; Engel)</td>
<td>126-127</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Edmondia sp.</td>
<td>128-130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ n.gen. et n.sp.</td>
<td>131-133</td>
</tr>
<tr>
<td>Scaphopoda</td>
<td>Dentalidae</td>
<td>* Fissidentalum? longstriatum n.sp.</td>
<td>141-143</td>
</tr>
<tr>
<td></td>
<td>Laevidentalidae</td>
<td>* Scissuralimentum runnegari n.gen. et n.sp.</td>
<td>144-147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Plagiogypta numerosa n.sp.</td>
<td>148-151</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Pipidalimentum promitum n.gen. et n.sp.</td>
<td>152-154</td>
</tr>
<tr>
<td>Hyolitha</td>
<td>Hyolithidae</td>
<td>* Hyolithes minutissimus n.sp.</td>
<td>155-162, 165</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Hyolithes sp.</td>
<td>163-164</td>
</tr>
</tbody>
</table>
Australian Carboniferous species. *Sinuitina portulacoides* Campbell & Engel, 1963 seems to be the only described species from the Australian Carboniferous.

*Sinuitina portulacoides* Campbell & Engel

Figs 1–3

*Sinuitina portulacoides* Campbell & Engel, 1963: 90, pl. 6, figs 20–24.

**Type material.** Holotype (F.7573) and paratypes (F.7574–80) at the University of New England, Armidale, NSW.

**Additional material examined.** 32 specimens, from localities A-3 and C-34, 2.6 km south-west of Gundy, NSW.

**Description.** See Campbell & Engel, 1963: 90.

**Dimensions.** Fig. 2 (F.61940): largest diameter 2.42 mm, thickness of spire 1.52 mm. Fig. 3: largest diameter 1.56 mm, thickness of spire 1.43 mm.

**Type locality.** Namoi Formation; Swain’s Gully and Rangari, 15 km south-west of Somerton and 37 km north-east of Gunnedah, respectively.

**Stratigraphic range.** Middle–Upper Tournaisian.

**Remarks.** Although the examined specimens are much smaller than the types, which are 16 mm in height, the present forms are similar to the types in shell character and regarded as a same species.

**EUPHEMITINAE**

**Knightites** Warthin, 1930

**Type species.** *Bellerophon urii* Fleming, 1828; from the Lower Carboniferous of Scotland.

**Definition.** See Knight et al., 1960: 178.

**Stratigraphic range.** Lower Carboniferous to Permian.


*Euphemites labrosa* Campbell & Engel

Figs 4–6

*Euphemites labrosa* Campbell & Engel, 1963: 91, pl. 6, figs 34–39

**Type material.** Holotype (F.7569) and paratypes (F.7570–72) at the University of New England, Armidale, NSW.

**Additional material examined.** 50 juvenile specimens from localities A–3, C–32 and C–34, 2.6 km south-west of Gundy, NSW.

**Description.** See Campbell & Engel, 1963: 91.

**Dimensions.** Fig. 4: largest diameter 108 mm, thickness of spire 1.00 mm; Fig. 5: largest diameter 1.14 mm, thickness of spire 1.10 mm; Fig. 6: largest diameter 1.76 mm, thickness of spire 1.36 mm.

**Type locality.** Near the top of the Tulcumma Sandstone, 1.5 km north-east of Rangari homestead, 37 km north-east of Gunnedah, NSW.

**Stratigraphic range.** Middle–Upper Tournaisian.

**Remarks.** The juvenile specimens recovered here have smaller shells with fewer spiral cords than the types. As they grow, cords increase by intercalation, and new ones rapidly attain normal size. The present form is tentatively regarded as conspecific as *E. labrosa* until an adult shell is recovered from the same locality.

**BELLEROPHONTIDAE**

**EUPHMITINAE**

**Knightites** Moore, 1941

**Knightites (Retispira)** Knight, 1945

**Type species.** *Retispira bellireticulata* Knight, 1945: 335, pl. 49, figs la–c; from the Early Pennsylvanian age at the top of the Bend group of Texas.

**Definition.** See Knight et al., 1960: 184.

**Stratigraphic range.** Devonian to Middle Permian.

Australian Carboniferous species. *Knightites* (Retispira) *culleni* Campbell & Engel seems to be the only figured species referred to this subgenus from the Australian Carboniferous.

*Knightites (Retispira) culleni* Campbell & Engel

Figs 9–11

*Knightites (Retispira) culleni* Campbell & Engel, 1963: 89, pl. 6, figs 27–33

**Type material.** Holotype (F.7534) and paratypes (F.7535) at the University of New England, Armidale, NSW.

**Additional material examined.** 76 specimens from localities A–1, A–3 and C–34, 2.6 km south-west of Gundy, NSW.

**Description.** See Campbell & Engel, 1963: 89.

**Dimensions.** Fig. 9 (F.61943): largest diameter 3.04 mm, thickness of spire 3.60 mm; Fig. 10 (F.61943): largest diameter 1.20 mm, thickness of spire 1.18 mm; Fig. 11 (F.61943): largest diameter 1.45 mm, thickness of spire 1.60 mm; unfigured specimen: largest diameter 3.40 mm, thickness of spire 4.10 mm; unfigured specimen: largest diameter 4.36 mm, thickness of spire 5.60 mm; unfigured specimen: largest diameter 1.70 mm, thickness of spire 1.30 mm.

**Type locality.** Namoi Formation; Swain’s Gully and Rangari, 15 km south-west of Somerton, and 37 km north-east of Gunnedah, respectively.

**Stratigraphic range.** Middle–Upper Tournaisian.

**Remarks.** The specimens examined are mostly...
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juvenile and are tentatively referred to this species. The specimens differ from the holotype, which possesses a short slit and thickened parietal inductura (Campbell & Engel, 1963: 90). One specimen (Fig. 9) with flared aperture has no slit. The slit may have disappeared as it attained maturity. K. (R.) bellireticulata Knight (1945) resembles the specimens, but differs in having a convex selenizone.

S.O. MACLURITINA Cox & Knight, 1960
S.F. MACLURITACEA Fischer, 1885
ONYCHOCHILIDAE Koken, 1925
ONYCHOCHILINAE Koken, 1925

Onychochilus Lindström, 1884

Type species. Onychochilus physa Lindström, 1884 (subsequent designation by Cossmann, 1915: 252); from the uppermost limestone (bed c), Middle Silurian, Slite, Gotland, Sweden.

Definition. See Knight et al., 1960: 187.

Remarks. The type species, Onychochilus physa, is reported to occur from the Middle Silurian Gotland, Sweden. The Australian form is very similar to the type species in shell character but different in being much smaller in shell size and lacks ornamentation. There are not enough significant differences to create a new genus.

Onychochilus minutissimus n.sp.

Figs 12–14

Type material. Holotype (F.61944) and 3 paratypes (F.61945).

Additional material examined. 4 specimens.

Description. Shell minute, sinistral, pupiform, with smooth, convex whorls. Shell layer very thin; protoconch smooth, simple paucispiral. Sutures shallow, base slightly flattened with weak circumumbilical ridge, moderately phaneromphalous, lips of aperture thin, arcuate, outer lip opisthoclone, straight without sinuosity, parietal lip narrow.

Dimensions. Holotype (Fig. 12): height 0.76 mm, width 0.54 mm, pleural angle 50°, number of whorls 3.75; paratype (Fig. 13): height 0.88 mm, width 0.54 mm, height of aperture 0.32 mm, pleural angle 45°, number of whorls 4.

Type locality. Locality A-4, 2.6 km south-west of Gundy, NSW.

Remarks. This is the only species referred to the genus Onychochilus in Australia, and appears to be the only post-Silurian record of the genus.

Etymology. Derived from the latin word minutus meaning lessened and -issima meaning superlative or extreme.

S.O. PLEUROTOMARIINA Cox & Knight, 1960
S.F. PLEUROTOMARIACEA Swainson, 1840
RAPHISTOMATIDAE Koken, 1896
LIOSPIRINAE Knight, 1956

Trepospira Ulrich & Scofield, 1897

Type species. Pleurotomaria sphaerulata Conrad, 1842: 272; from the Upper Carboniferous, “inclined plane of the Alleghany Mountain”, Pennsylvania, USA.

Definition. See Knight et al., 1960: 201.

Stratigraphic range. Devonian to Middle Permian.

Trepospira (Angyomphalus) Cossmann, 1916

Type species. Eutrephus radians de Koninck, 1843: 442, pl. 23, fig. 5; from the Lower Carboniferous of Turnai, Belgium.

Definition. See Knight et al., 1960: 201.

Stratigraphic range. Lower Carboniferous.

Australian Carboniferous species. Angyomphalus depressus Campbell & Engel, 1963, from Rangari, NSW.

Trepospira (Angyomphalus) sp.

Figs 18–20

Material examined. 32 juvenile specimens from locality A-3, 2.6 km south-west of Gundy, NSW.

Description. Shell small, low spired, lenticular form with 4.5 whorls. Protoconch seemingly simple, smooth. No sharp boundary between protoconch and teleoconch. Suture shallow; upper whorl face slopes gently toward periphery, decorated by narrow radiating nodes which are slightly sigmoidal just below suture. Growth lines extended beyond nodes, prosocline above selenizone which appears to be on periphery. Growth lines below selenizone faint, swinging forward for short distance, then backward into umbilicus. Columellar lip thin next to parietal wall but with thick subtriangular section at the circumumbilical funicle, outer lip thin, sharply angulated at periphery, size of slit and lunulae unknown, phaneromphalous.

Dimensions. Fig. 18 (F.61947): thickness of spire 1.40 mm, maximum diameter of spire 2.10 mm.

Remarks. This form is different from the only Australian species, Trepospira (Angyomphalus) depressus (Campbell & Engel) which has a lower spire, more acute periphery and a greater number of closely spaced, longer nodes just below the sutures. This form is similar to the Belgian type species T. (A.) radians (de Koninck) in shell character but differs in having smaller shell. All specimens here are juveniles and may be larger when fully grown.
EOTOMARIIDAE Wenz, 1938
EOTOMARIINAE Wenz, 1938

Glabrocingulum Thomas, 1940

Type species. Glabrocingulum beggi Thomas, 1940: 38; from the Upper Calcareous Sandstone Series, Scotland.

Definition. See Thomas, 1940: 38.

Stratigraphic range. Lower Carboniferous to Upper Carboniferous.

Remarks. In this paper the genus Hesperiella is recorded for the first time in Australia, although species belonging to this genus have been discovered in many places in Europe. The coiling of shell and protoconch of Hesperiella is basically the same as in Recent species of Architectonicidae. The protoconch of both groups is inturned and the apex is seen through the umbilicus without change of coiling direction.

In the early embryonic stage, Hesperiella is dextrally coiled and Architectonicidae is sinistrally coiled, and immediately after the embryonic stage they change the direction of growth, not direction of coiling, viz. ultradextral in Hesperiella and ultrasinistral in Architectonicidae.

Knight (1941) suggested that this genus is a hyperstrophically coiled dextral shell. However the lack of a calcified operculum prevents the testing of this hypothesis (Batten, 1966).

Hesperiella robertsi n.sp.
Figs 36–41

Type material. Holotype (F.61954) and 10 paratypes (F.61955).

Additional material examined. 33 specimens from localities A–3, A–4 and C–34.

Description. Shell small, sinistral, early whorls depressed completely, hidden by later whorls. First 1.75 planispiral smooth whorl including protoconch seen through umbilicus in broken shell. Teleoconch 3.5 whorls inflated, collabral cords from suture to selenizone weaker in early whorls, gradually stronger, more widely spaced with growth, 30–32 cords in last whorl. Selenizone seen only in last whorl, concave, distinct; no lunulae. Aperture nearly round, inner lip thick, reflected, base rather flat, more numerous fine collabral cords than present above selenizone, phaneromphalous.

Dimensions. Holotype (Fig. 36): height 3.30 mm, width 2.92 mm, height of aperture 1.48 mm, pleural angle 65°, number of whorls 3.5; paratype (Fig. 38): height 2.70 mm, width 2.45 mm, height of aperture 66°, number of whorls 3.5.

Type locality. Locality C–34, 2.6 km south-west of Gundy, NSW.

Remarks. This is the only known Australian species belonging to Hesperiella. There are two described European species, H. thomsoni (de Koninck) and H. loudoni Thomas. H. thomsoni has larger and more conical shell, while H. loudoni Thomas differs from H. robertsi n.sp. in being lower spiraled with more fine collabral cords.

Etymology. This species was named after Professor J. Roberts, University of New South Wales as an
acknowledgement of his contribution to the Carboniferous geology of the Hunter Valley District, NSW.

**NEILSONIIINAE** Knight, 1956

**Peruvispira** J. Chronic, 1949

**Type species.** *Peruvispira delicata* J. Chronic, 1949; from Peru.

**Definition.** See Knight et al., 1960: 207.

**Stratigraphic range.** Lower Permian to Middle Permian.

**Australian Carboniferous species.** *Peruvispira kempseyensis* Campbell, 1962, from Sherwood, 17 km west-north-west of Kempsey; *Peruvispira kuttungensis* Campbell, 1961, from the Booral Formation, south-eastern side of the Gloucester Trough, NSW.

**Peruvispira gundyensis** n.sp.

Figs 29–32

**Type material.** Holotype (F.61950) and 20 paratypes (F.61951).

**Additional material examined.** 38 specimens from localities A–3, A–4 and C–34.

**Description.** Shell small, globose, turbiniform, with 5.5 whorls. Protoconch changes gradually to teleoconch. First 2 whorls show fine spiral threads, prosoclinal growth lines; selenizone and collabral lirae first occur at third whorl. Collabral lirae, about 42–46 in the last whorl, evenly spaced, swinging backward above selenizone, orthocline below selenizone except for short forward segment just below lower margin of selenizone. Selenizone wide, deeply concave, with almost same number of curved lunules as collabral lirae. Aperture simple, columella straight, inner lip reflected, outer lip oblique from upper suture backward above selenizone; slit at selenizone; base rounded, moderately phaneromphalous.

**Dimensions.** Holotype (Fig. 29): height 2.80 mm, width 260 mm, pleural angle 65°, number of whorls 5.5; paratype (Fig. 31): height 3.16 mm, width 2.66 mm, pleural angle 65°, number of whorls 4.75; paratype (Fig. 30): height 2.22 mm, width 2.00 mm, pleural angle 67°, number of whorls 5.5; paratype (Fig. 32): height 2.12 mm, width 1.80 mm, pleural angle 65, number of whorls 5.

**Type locality.** Locality C–34, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species differs from *P. kempseyensis* Campbell, 1962 and *P. kuttungensis* Campbell, 1961 in having smaller size of shell with a moderate umbilicus. *P. kempseyensis* has more closely spaced collabral lirae, while *P. kuttungensis* has taller spire and stronger collabral lirae.

**Etymology.** Referring to the geographical name of the township of Gundy, NSW.

**PHYMATOPLEURIDAE** Batten, 1956

**Boreust** Thomas, 1940

**Type species.** *Boreust wrighti* Thomas, 1940: 54, pl. 3, fig. 1a,b; from the Charlestown Main Limestone, Lower Limestone Group (P2), Rosocobie Quarry, Fife, Scotland.

**Definition.** See Thomas, 1940: 53.

**Stratigraphic range.** Lower Carboniferous to Middle Permian.

**Remarks.** No Australian form has previously been referred to this genus.

**Boreust costatus** n.sp.

Figs 25–28

**Type material.** Holotype (F.61956) and 5 paratypes (F.61957).

**Additional material examined.** 9 specimens from localities A–3 and C–34.

**Description.** Shell small, conical trochiform, with about 5.75 heavily sculptured whorls, showing gradual change between protoconch and teleoconch, first 2 whorls nearly evenly spaced fine spiral threads with slightly prosocline, distinct growth lines. Selenizone and collabral lirae first occur at third whorl. Collabral ornament evenly spaced, regularly developed, about 36–40 cords in the last whorl; intersecting spiral cords at nodes, first at fourth whorl in median position above selenizone. Selenizone wide, deeply concave, its margins sharply keeled. Lunules well developed, same number as collabral cords, J-shape. Base flat, reticulate ornamentation, moderately phaneromphalous.

**Dimensions.** Holotype (Fig. 25): height 3.00 mm, width 2.40 mm, apical angle 67°, number of whorls 6; paratype (Fig. 26): height 2.74 mm, width 2.00 mm, apical angle 70°, number of whorls 6.

**Type locality.** Locality C–34, 2.6 km south-west of Gundy, NSW.

**Remarks.** This is a very heavily ornamented form and is the first Australian species referred to this genus. This species resembles the Belgian species *B. similis* (de Koninck) but differs in being much smaller and in the detail of the ornamentation.

**Etymology.** Derived from the latin word *costatus* meaning costate, bearing ribs.

**S.O. TROCHINA** Cox & Knight, 1960

**S.F. PLATYCYRATAECA** Hall, 1859

**HOLOPEIDAE** Wenz, 1938

**GYRONEMATINAEC** Knight, 1956

**Araeonema** Knight, 1933

**Type species.** *Araeonema virgatum* Knight, 1933a: 52, pl. 9, fig. 3a–f; from the Labette Shale, Henrietta Formation, St. Louis, Missouri, USA.
Araeonema microspirulata n.sp.
Figs 46–49

Type material. Holotype (F.61958) and 20 paratypes (F.61959).

Additional material examined. 43 specimens from A-3, A-4 and C-34.

Description. Shell minute, thin, globose, height slightly more than width of shell. Protoconch simple, boundary between protoconch and teleoconch not distinct, teleoconch about 3.5 convex whorls, first whorl smooth then equally spaced fine spiral lirae with fine orthocline growth lines. Suture deep, inner lip thin, gently arcuate, slightly reflected, outer lip orthocline without slit of selenizone, base round, moderately phaneromphalous.

Dimensions. Holotype (Fig. 46): height 1.07 mm, width 1.12 mm, height of aperture 0.67 mm, pleural angle 90°, number of whorls 4; paratype (Fig. 47): height 1.56 mm, width 1.48 mm, height of aperture 0.80 mm, pleural angle 85°, number of whorls 4.5.

Type locality. Locality A-4, 2.6 km south-west of Gundy, NSW.

Remarks. This species is superficially similar to Araeonema virgatum Knight (1933) described from St. Louis County, Missouri, USA., but differs in having a globose shell with a larger umbilicus and more inflated whorls with finer spiral lirae. This is the first species to be referred to the genus Araeonema in Australia.

Etymology. Referring to the microspiral ornamentation of shell.

Microdoma Meek & Worthen, 1867

Type species. Microdoma conicum Meek & Worthen, 1867: 269; from the Carbondale Formation (Middle Pennsylvanian) Hodges Creek, Macoupin County, Illinois, USA.

Definition. See Knight et al., 1960: 242.

Stratigraphic range. Lower Devonian to Lower Permian.

Remarks. No form has previously been referred to this genus in Australia.

Microdoma angulata n.sp.
Figs 58–60

Type material. Holotype (F.61960) and 20 paratypes (F.61961).
records about 43 in last whorl, prosocline, 26° from (vertical) axis and much more prominent than spiral lirae. Suture deep. Aperture simple, round. Lips slightly thickened, inner lip considerably separated from base abapically, moderately phaneromphalous.

**Dimensions.** Holotype (Fig. 61): height 1.28 mm, width 1.15 mm, height of aperture 0.65 mm, pleural angle 84°, number of whorls 4.25; paratype: height 1.13 mm, width 1.20 mm, height of aperture 0.60 mm; paratype (Fig. 62): height 1.45 mm, width 1.36 mm, height of aperture 0.70 mm, pleural 84°, number of whorls 3.75; paratype: height 1.20 mm, width 1.16 mm, height of aperture 0.66 mm.

**Type locality.** Locality A-3, 2.6 km south-west of Gundy, NSW.

**Remarks.** Knight (1933) described *Eucochlis perminuta* from St. Louis, Missouri, USA. The genus *Eucochlis* has remained monotypic until now, *australis* being the second species referred to the genus. *Eucochlis australis* is the most abundant and best preserved species in this study. It is superficially similar to *Eucochlis perminuta* in its size but differs in having a lower spire, bigger umbilicus, closer collabral cords and in being more conical.

**Etymology.** Derived from the Latin word *australis* meaning southern.

S.O. NERITOPSINA Cox & Knight, 1960

S.F. NERITACEA Rafinesque, 1815

NERITOPSIDAE Gray, 1847

*Naticopsis* M'Coy, 1884

*Naticopsis* (Naticopsis) M'Coy, 1844

**Type species.** *Naticopsis philippii* M'Coy, 1844: 33 (subsequent designation by Meek & Worthen, 1866: 364); from the "Lower Limestone", Lower Carboniferous of Kilcommock, Longford, Ireland.

**Definition.** See Knight et al., 1960: 276.

**Stratigraphic range.** Middle Devonian to Triassic.

**Australian Carboniferous species.** *Naticopsis brevispira* (Ryckholt, 1847), Dun & Benson, 1920 (361, pl. 22, fig. 8) from Carroll, NSW; *Naticopsis globosa* (Hoeninghaus, 1829), Dun & Benson, 1920 (361, pl. 22, figs 15,16) from south-east of Babbinboon, NSW; *Naticopsis obliqua* Dun & Benson, 1920 (362, pl. 22, figs 13,14) from south-east of Babbinboon, NSW.

*Naticopsis* (Naticopsis) *osbornei* n.sp.

Figs 65–66

**Type material.** Holotype (F.61964) and 10 paratypes (F.61965).

**Additional material examined.** 3 specimens from locality A–3.

**Description.** Shell small, subglobular, neritopsid form with about 4 whorls, protoconch about 1.25 smooth, rounded whorls, teleoconch inflated, whorls embrace much of previous whorl, last 2 whorls ornamented by fine prosocline collabral threads displayed from suture to columellar region. Upper whorl surface flattened, with low subangular periphery. Columellar lip arcuate, parietal wall thickened with inductura which is crossed obliquely by 3 transverse rugae in parietal region, outer lip sharp and thin, anomphalous.

**Dimensions.** Holotype (Fig. 65): height 2.25 mm, width 2.20 mm, pleural angle 118°, number of whorls 4; paratype (Fig. 66): height 2.20 mm, width 2.10 mm, pleural angle 117°, number of whorls 4.5.

**Type locality.** Locality C–34, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species resembles Belgian species *Naticopsis* (Naticopsis) *consimilis* de Koninck in shell ornamentation but differs in having a taller spire and thicker parietal wall. The Australian species, *N. brevispira*, has a more globe and larger shell; *N. globosa* may have no collabral threads; *N. obliqua* has a much taller shell.

**Etymology.** This species is named after Dr G.D. Osborne, formerly of the University of Sydney for his contribution to geology of Muswellbrook-Scone District which includes the present study area.

S.O. MURCHISONIINA Cox & Knight, 1960

S.F. MURCHISONIACEA Koken, 1896

MURCHISONIIDAE Koken, 1896

*Aclisina* de Koninck, 1881

**Type species.** *Murchisonia striatula* de Koninck, 1843: 415, pl. 40, figs 7a,b (subsequent designation by S.A. Miller, 1889: 395); from the V₂b(D-D') zone, Visé, Belgium.

**Definition.** See Knight et al., 1960: 293.

**Stratigraphic range.** Lower Carboniferous to Upper Carboniferous.

**Remarks.** This is the first record of *Aclisina* in Australia.

*Aclisina turgida* n.sp.

Figs 80–81

**Type material.** Holotype (F.61966) and 15 paratypes (F.61967).

**Additional material examined.** 10 specimens from localities A–3 and C–32.

**Description.** Shell small, relatively low spired, globose form, whorl profile rounded, suture deeply incised, protoconch 1 smooth whorl, teleoconch about 5 whorls with 6 evenly spaced spiral costae. Aperture subcircular, but slightly higher than wide, inner lip slightly arcuate, outer lip thin, convex, slit unknown may be small and narrow, giving rise to an obscure selenizone, anomphalous.

**Dimensions.** Holotype (Fig. 80): height 2.12 mm,
Stegocoelia Donald, 1889

**Stegocoelia (Stegocoelia) Donald, 1889**

**Type species.** *Murchisonia (Stegocoelia) compacta* Donald, 1889: 624, pl. 20, figs 9–13; from the Upper limestone series (Lower Carboniferous), Glencart, Dalry, Scotland.

**Definition.** See Knight et al., 1960: 293.

**Stratigraphic range.** Lower Carboniferous to Upper Carboniferous.

**Remarks.** No Australian form has previously been referred to the genus *Stegocoelia.*

**Stegocoelia (Stegocoelia) nodosa n.sp.**

Figs 67–71

**Type material.** Holotype (F.61968) and 20 paratypes (F.61969).

**Additional material examined.** 150 specimens from A–3, A–4, C–32 and C–34.

**Description.** Shell small, relatively thick, tall spired, whorl profile convex. Protoconch 2 smooth whorls its labral sinus culminating in a sharp notch in periphery (see Fig. 71); teleoconch 5 whorls with 4 strong spiral carinae with fine orthocline growth lines. One spiral carina abapical to suture weaker than other 3, but has about 2–30 nodes in last whorl. Aperture simple, inner lip thin, slightly arcuate, reflexed, outer lip shallow opisthocyst just below suture, slit absent or seemingly very shallow, selenizone obscured between second and third carinae below suture, anomphalous.

**Dimensions.** Holotype (Fig. 68): height 2.40 mm, width 1.00 mm, height of aperture 0.58 mm, pleural angle 20°, number of whorls 7.5; paratype (Fig. 70): height 2.76 mm, width 1.06 mm, pleural angle 22°, number of whorls 7; paratype (Fig. 67): height 2.42 mm, width 0.92mm, pleural angle 22°, number of whorls 6.5.

**Type locality.** Locality C–34, 2.6 km south-west of Gundy, NSW.

**Remarks.** This is one of the most common species in the investigated fauna. *S. (S.) nodosa* is very similar to *S. (S.) okawensis* Thein & Nitecki (1974) from Upper Mississippian of Illinois Basin, North America in the form of the shell and type of ornamentation, but is different in having nodes on the upper spiral cords.

**Etymology.** Derived from the latin word *nodosus* meaning nodose, referring to nodes on the upper spiral cords.

**Stegocoelia (Hypergonia) Donald, 1892**

**Type species.** *Murchisonia quadricarinata* M'Coy, 1844: 42, pl. 5, fig. 9; from the Carboniferous limestone of Blacklion, Enniskillen, Northern Ireland.

**Definition.** See Knight et al., 1960: 293.

**Stratigraphic range.** Lower Carboniferous to Upper Carboniferous.

**Stegocoelia (Hypergonia) elongata n.sp.**

Figs 73–75

**Type material.** Holotype (F.61970) and 14 paratypes (F.61971).

**Additional material examined.** 7 specimens from locality C–32.

**Description.** Shell small, high spired, turriculate with flattened base, whorl profile rather flat, suture shallow. Protoconch 1 smooth whorl, prominent varix between protoconch and teleoconch forming deep labral sinus culminating in sharp notch in upper part of whorl; teleoconch about 8 whorls with 4 strong spiral carinae of which 2 middle carinae being stronger than those above and below. Slit seemingly shallow selenizone obscure between 2 uppermost carinae. Aperture almost square in shape, outer lip with slight angulations both anteriorly and posteriorly. Growth lines very faint, swing moderately backward above selenizone, forward between selenizone and lower suture, backward on base, anomphalous.

**Dimensions.** Holotype (Fig. 73): height 3.76 mm, width 1.30 mm, height of aperture 0.68 mm, pleural angle 19°, number of whorls 9.25.

**Type locality.** Locality A–4, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species resembles *Stegocoelia (Hypergonia) cincta* (Donald, 1895) from the Upper Limestone Group (~E2) of Ayrshire, but differs in that *S. (H.) cincta* has a more coeloconoid form.

**Etymology.** Derived from the latin word *elongatus* meaning elongate, referring to the tall spire of shell.

**Stegocoelia (Hypergonia) tenuis n.sp.**

Figs 76–79

**Type material.** Holotype (F.61972) and 12 paratypes (F.61973).

**Additional material examined.** 3 specimens from locality C–32.

**Description.** Shell minute, slender, tall spired, turritelliform with round base, shell profile rounded,
suture deeply incised. Protoconch about 2 smooth whorls, labral sinus culminating in sharp notch in upper part of whorl; teleoconch about 7 whorls with 3 distinct spiral cords consistently in lower half of whorl. Selenizone may be along the groove which is just below suture. Growth lines faint, slightly backward above groove, forward strongly below groove. Slit unknown. Aperture round, inner lip arcuate, slightly reflected, anomphalous.

**Dimensions.** Holotype (Fig. 76): height 1.10 mm, width 0.35 mm, pleural angle 15°, number of whorls 8; paratype (Fig. 77): height 1.07 mm, width 0.32 mm, pleural angle 14°, number of whorls 8.5.

**Type locality.** Locality A-4, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species is somewhat similar to *Donaldina filosa* n.sp. in shell size and teleoconch ornamentation but very different in the nature of its protoconch and the sharp notch between protoconch and teleoconch. Fine meandering grooves on the shell surface, which may have been caused by algae or bacteria, are common, particularly on the protoconch.

**Etymology.** Derived from the latin word *tenuis* meaning thin, slender, referring to the slender shell shape.

**O. CAENOGASTROPODA** Cox, 1959

**S.F. LOXONEMATACEA** Koken, 1889

**LOXONEMATIDAE** Koken, 1889

*Loxonema* Phillips, 1841

**Type species.** *Terebra*? *sinuosa* J. de C. Sowerby, 1839 (subsequent designation, King, 1850: 209); from Middle Silurian, near Aymestry, Shropshire, England.

**Definition.** See Knight et al., 1960: 311.

**Stratigraphic range.** Middle Ordovician to Lower Carboniferous.

**Australian Carboniferous species.** *Loxonema babbinboonensis* Etheridge Jr., 1907 (194, pl. 38, figs 5,6), from Babbinboon; *Loxonema lamellosa* Maxwell, 1961 (69, pl. 9, figs 6-11), from late Tournaisian–early Viséan, Yarrol, Qld; *Loxonema* sp. Dun & Benson, 1920 (362, pl. 22, figs 11,12), from Babbinboon; *Loxonema* sp. (cf. lefevrei) Etheridge Jr. 1907 (195, pl. 37, figs 4,5); *Loxonema acutissima* de Koninck, *L. constricta* W. Martin, *L. difficilis* de Koninck, and *L. rugifera* J. Phillips (all figured in de Koninck, 1898) do not seem to be *Loxonema.*

*Loxonema elegantissima* n.sp.

**Figs 84–87**

**Type material.** Holotype (F.61974) and 10 paratypes (F.61975).

**Additional material examined.** 16 specimens from A–3, A–4 and C–34.

**Description.** Shell minute, slender, high spired, 7–9 whorls, whorl profile rounded, sutures deep. Protoconch simple, rather slightly deviated 1.25 smooth whorls; teleoconch about 6–8 convex whorls with very fine collabral cords. Collabral cords pass obliquely backward from upper suture at an angle of about 40° to axis of shell, forward sharply across whole lower face of whorl at an angle of about 30° to axis. Aperture oval, inner lip slightly arcuate, outer lip thin, with deep rounded labral sinus culminating on high whorl; base round, anomphalous.

**Dimensions.** Holotype (Fig. 84): height 1.36 mm, width 0.50 mm, height of aperture 0.32 mm, pleural angle 15°, number of whorls 6.5; paratype (Fig. 85): height 2.50 mm, width 0.70 mm, height of aperture 0.44 mm, pleural angle 13°, number of whorls 7.5.

**Type locality.** Locality A–4, 2.6 km south-west of Gundy, NSW.

**Remarks.** *Donaldina filosa* n.sp. is similar to this species in shell shape but different in having spiral cords and a more blunt topped protoconch. *L. elegantissima* n.sp. is similar to *Donaldina* sp. (Figs 110, 111) but *Donaldina* sp. has a more deviated protoconch and spiral cords.

Bored holes appear on the shell as in Stegoceolia (*Hypergonia*) *tenuis* n.sp. Their size suggests that they are caused by algae or bacteria, not by molluscan predators.

**Etymology.** Derived from the latin word *elegantissimus* meaning most elegant.

**PSEUDOZYGOPOLEURIDAE** Knight, 1930

**Hemizyga** Girty, 1915

**Hemizyga (Hemizyga)** Girty, 1915

**Type species.** *Hemizyga elegans* Girty, 1915: 362, pl. 32, figs 7A, B; from the Cherokee Shale (Upper Carboniferous) on Honey Creek, Garland, Missouri, U.S.A. Subsequent designation Knight, 1930: 17.

**Definition.** Shell very small, cyrtoconoidal fusiform, anomphalous, high spired but relatively few whorls, with extremely fine collabral costae or lirae, base rather extended subconical, aperture somewhat elongate auriform, protoconch 3–4 whorls with fine reticulate sculpture (emend.).

**Stratigraphic range.** Lower to Upper Carboniferous.

**Remarks.** No Australian form has previously been referred to the family Pseudozygoopleuridae and its genera.

*Hemizyga (Hemizyga) decussata* n.sp.

**Figs 88–91**

**Type material.** Holotype (F.61976) and 5 paratypes (F.61977).

**Additional material examined.** 5 specimens from locality C–34.
Description. Shell minute, cryptoconoidal fusiform, whorl profile gently arched, with rapidly increasing, last whorl very much inflated. Sutures shallow, protoconch 4.25 whors, first 1.75 whors smooth, rest 2.5 whors strong decussate ornamentation, gradually transformed into teleoconch pattern; teleoconch about 2 whors with straight orthoclineal collabral cords which extend onto base. Aperture elongate auriform, inner lip thick, reflexed; outer lip thin, no sinus, arcuate; lower lip extended, siphonate; anomphalous.

Dimensions. Holotype (Fig. 88): height 2.00 mm, width 1.45 mm, height of aperture 1.20 mm, pleural angle 56°, number of whors 4+; paratype: height 1.72 mm, width 1.20 mm, height of aperture 0.74mm; veliger shell (Fig. 89): height 0.90 mm, width 0.61 mm, height of aperture 0.40 mm.

Type locality. Locality A–3, 2.6 km south-west of Gundy, NSW.

Remarks. This is the first Australian species referred to the genus Hemizyga (Hemizyga).

Etymology. Derived from the Latin word decusso meaning to divide crosswise in the shape of an X.

Cyclozyga Knight, 1930

Type species. Cyclozyga mirabilis Knight, 1930: 74, pl. 5, fig. 7; from the top of the Labette Shale, Henrietta Formation, St. Louis County, Missouri, USA.

Definition. Shell minute, protoconch first 1–1.5 whors smooth, strong collabral ornament on 2nd to 4th whors, spiral threads on adult shell, shallow sinus low on whorl (emend.).

Stratigraphic range. Lower to Upper Carboniferous.

Cyclozyga sinusigera n.sp.

Figs 92–94

Type material. Holotype (F.61978) and 1 paratype (F.61979).

Additional material examined. 2 specimens.

Description. Shell minute, slender, moderately high spired, whors rounded, sutures moderately deep, protoconch 2.5 whors, first 1 whorl smooth, blunt, rest 1.5 whors strong collabral cords shown, abrupt change to teleoconch with exceptionally deep sinus of a peculiar deep–U shape; teleoconch about 4.5 whors with 3–4 equal spiral cords, all equally spaced, confined generally to lower part of whorl, fine collabral threads inclined obliquely backward below suture but immediately turned forward with an angle of 30° to axis of shell; inner lip arcuate, somewhat reflected, outer lip thin but not well known in detail, base flat, anomphalous.

Dimensions. Holotype (Fig. 92): height 1.45 mm, width 0.50 mm, height of aperture 0.32 mm, pleural angle 20°, number of whors 7.5; paratype (Fig. 93): height 0.82 mm, width 0.40 mm, height of aperture 0.20 mm, pleural angle 22°, number of whors 6+.

Type locality. Locality A–3, 2.6 km south-west of Gundy, NSW.

Remarks. This species differs from the other known three congeneric species, C. mirabilis Knight (1930), C. carinata Knight (1930) and C. attenuata Hoare & Sturgeon (1978), all from the Pennsylvanian of USA, in having a much smaller and more slender shell, and also in having strongly oblique opisthoclinal growth lines. This species is rare in the fauna described in this paper, but is well preserved although the later whors of the paratype are slightly damaged. The high-spired larval shell with deep sinus indicates that this species had a planktotrophic development.

Etymology. Derived from the Latin words sinus meaning a curve, and gero meaning to bear; referring to the shape of the protoconch.

S.F. SUBULITACEA Lindström, 1884

SUBULITIDAE Lindström, 1884

Soleniscinae Wenz, 1938

Soleniscus Meek & Worthen, 1861

Type species. Soleniscus typicus Meek & Worthen, 1861; Upper Carboniferous, from Springfield, Illinois, USA.

Definition. See Knight et al., 1960: 321.

Stratigraphic range. Lower Carboniferous to Middle Permian.

Soleniscus calllosus n.sp.

Figs 95–102

Type material. Holotype (F.61980) and 7 paratypes (F.61981).

Additional material examined. 12 specimens from A–4 and C–34.

Description. Shell small, moderately high spired fusiform but shell profile slightly concave; whorl profile gently rounded, suture shallow, distinct; protoconch of small size, simple; teleoconch with fine transverse lirae, last whorl markedly inflated, 2 times as high as preceding spire. Aperture suboval, pointed posteriorly, rounded anteriorly; outer lip thin, arcuate; columellar lip slightly arcuate, with small siphonal notch, strong columellar fold internally in last 2 whors; parietal inductura slightly thickened, base round, anomphalous.

Dimensions. Holotype (Fig. 100): height 1.80 mm, width 1.00 mm, pleural angle 52°, number of whors 6; paratype (Fig. 101): height 1.50 mm, width 1.00 mm, pleural angle 56°, number of whors 5+; paratype (Fig. 96): height 1.43 mm, width 0.86, pleural angle 50°, number of whors 5.5; paratype (Fig. 97): height 1.80 mm, width 1.10 mm, pleural angle 55°, number of whors 5.5; paratype (Fig. 98):
height 2.50 mm, width 1.50 mm, pleural angle 53°, number of whorls 5.

**Type locality.** Locality A–3, 2.6 km south-west of Gundy, NSW.

**Remarks.** This is a very common species in the fauna here described. It displays a striking amount of variability in shell shape, whorl profile, ornament and columellar lip.

**Etymology.** Derived from the latin word *callosus* meaning calloused, referring to the columellar callus.

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**S.C. OPISTHOBRANCHIA** Milne Edwards, 1848

**O. Uncertain**

**S.F. PYRAMIDELLACEA** d’Orbigny, 1840

**STREPTACIDIDAE** Knight, 1931

*Donaldina* Knight, 1933

**Type species.** *Aclisina grantonensis* Donald, 1898: 60, pl. 4, figs 7–9; from the Calciiferous Sandstone Group, at Woodhall, near Edinburgh, Scotland.

**Definition.** See Knight et al., 1960: 322.

**Stratigraphic range.** Devonian? Lower Carboniferous to Lower Permian.

**Remarks.** This genus is introduced for the first time to the Australian fauna to accommodate *Donaldina filosa* n.sp. and *Donaldina* sp.

*Donaldina filosa* n.sp.

Figs 104–109

**Type material.** Holotype (F.61982) and 20 paratypes (F.61983).

**Additional material examined.** 9 specimens from localities A–3 and C–34.

**Description.** Shell minute, slender, high spired turriculate form. Whorl profile between sutures more or less symmetrically rounded, sutures deep, well impressed. Protoconch of 1.5 smooth whorls with flat top to slightly submerged spire. Varix between protoconch and teleoconch distinct orthocline, teleoconch about 8 convex whorls with 5–6 evenly spaced spiral cords and closely spaced collabral threads. Spiral ornamentation confined generally to lower 2/5 of each whorl. Collabral threads deflected strongly backward below suture but swinging immediately and strongly forward with an angle of 25° to axis of shell. Aperture oval, columellar lip slightly arcuate, base rounded, anomphalous.

**Dimensions.** Holotype (Fig. 105): height 1.77 mm, width 0.50 mm, pleural angle 14°, number of whorls 9; paratype (Fig. 104): height 1.66 mm, width 0.55 mm, pleural angle 15°, number of whorls 7.5.

**Type locality.** Locality A–4, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species is very similar to *Loxonema elegantissima* n.sp. in shell size, shape, protoconch and strong opisthoclinal collabral ornamentation but different from it in having spiral cords. This species is also similar to *Donaldina* sp. but that form has a more deviated protoconch.

**Etymology.** Derived from the latin word *filosus* meaning threaded, bearing threads.

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**C. SCAPHOPODA** Bronn, 1862

**O. DENTALIOIDA** Palmer, 1974

**DENTALLIIDAE** Gray, 1834

*Fissidentalium* Fischer, 1885

**Type species.** *Dentalium ergasticum* Fischer, 1882; Recent, Gulf of Gascony and Atlantic Ocean, in deep water.

**Definition.** Shell large, solid, circular in outline, sculptured with numerous longitudinal striae; apex typically with long apical fissure on convex side, rarely simple or with apical slit divided into a series of fissures (Emerson, 1962).

**Stratigraphic range.** ?Early Carboniferous; Cretaceous to Recent.

**Remarks.** The present two specimens resemble *Prodentalium* in having fine longitudinal ribs extending seemingly the entire length of tube, but differ in that *Prodentalium* is a very large scaphopod, 20 cm long, without observed slit or plug. The Recent genus *Fissidentalium* resembles those present specimens in having fine longitudinal ribs and long apical slit (Palmer, 1974), but differs in being a long tube, reaching 10 cm long. The size of complete tubes are not known as both specimens recovered here have the anterior part damaged. Therefore the present specimens are tentatively referred to *Fissidentalium*.

*Fissidentalium? longistriatum* n.sp.

Figs 141–143

**Type material.** Holotype (F.61992) and 1 paratype (F.61993).

**Additional material examined.** 2 specimens.

**Description.** Shell minute, nearly straight, circular in section, surface sculptured with numerous close very fine longitudinal ribs extending seemingly entire length of tube, posterior orifice round with relatively long, narrow apical slit.

**Dimensions.** Holotype (Fig. 141): length 3.00 mm, diameter of anterior end 0.80 mm; paratype: length 2.50 mm, diameter of anterior end 0.60 mm.

**Type locality.** Locality A–3, 2.6 km south-west of Gundy, NSW.

**Remarks.** This is the first record of a Palaeozoic species referred to this genus.

**Etymology.** Derived from the latin word *longus* meaning long, and *striatus* meaning striated.
LAEVIDENTALIIDAE Palmer, 1974

Scissuradentalium n.gen.

Type species. Scissuradentalium runnegari n.sp. (monotypy).

Definition. Shell minute to small (up to 7 mm long), slightly curved, with circular or nearly circular cross section, exterior and interior surfaces smooth, rapidly tapering posteriorly; very long, narrow apical slit on ventral side.

Stratigraphic range. Lower Carboniferous.

Remarks. Scissuradentalium n.gen. resembles Rhytiodentalium Pojeta & Runnegar (1979) in having a slightly curved smooth shell, but differs in having a very long, narrow apical slit. This genus may be an ancestor of Pseudantalis and could have evolved from Rhytiodentalium.

Etymology. Derived from the Latin word scissura meaning a slit, referring to the character of the posterior end; Dentalium, a genus of scaphopods.

Scissuradentalium runnegari n.sp.

Figs 144–147

Type material. Holotype (F.61994) and 8 paratypes (F.61995).

Additional material examined. 9 specimens.

Description. Shell small, rather short, slightly curved, slightly attenuate posteriorly. Shell smooth, composed of 2 layers. Anterior aperture large, round; posterior aperture small, round, with very long, narrow apical slit on ventral side.

Dimensions. Holotype (Fig. 144): length 6.2 mm, diameter of anterior end 1.7 mm; paratype (Fig. 147): length 7 mm, diameter of anterior end 2 mm; paratype (Fig. 145): length 5.5 mm, diameter of anterior end 1.4 mm.

Type locality. Locality A–3, 2.6 km south-west of Gundy, NSW.

Remarks. This is the first species to be referred to this genus in Australia.

Etymology. Derived from the Latin word numerosus meaning rhythical, alluding to the rhythmic change in size and frequency of the transverse wrinkles.

Plagioglypta Pilsbry & Sharp, 1897

Type species. Dentalium undulatum Münster, 1844; from Triassic, St. Cassian, Tyrol Mountains.


Plagioglypta numerosa n.sp.

Figs 148–151

Type material. Holotype (F.61996) and 20 paratypes (F.61997).

Additional material examined. 30 specimens from localities A–3, A–4 and C–34.

Description. Shell small, slightly curved, slightly attenuated posteriorly. Shell surface throughout shows close but rather strong oblique wrinkles encircling whole shell, no longitudinal sculpture. Wrinkles sometimes rhythmically change from coarse to fine. Circular in cross section, slit and pipe absent.

Dimensions. Holotype (Fig. 148): length 3.60 mm, diameter of anterior end 0.76 mm; paratype (Fig. 149): length 3.30 mm, diameter of anterior end 0.72 mm.

Type locality. Locality A–3, 2.6 km south-west of Gundy, NSW.

Remarks. This genus resembles Plagioglypta in having encircling wrinkles but differs in having a distinct apical pipe and very fine longitudinal riblets.

Stratigraphic range. Lower Carboniferous.

Etymology. Derived from the Latin word pipare meaning a tube, referring to the siphonal pipe at the posterior end; Dentalium, a genus of scaphopods.

Pipadentalium n.gen.

Type species. Pipadentalium protruberans n.sp. (monotypy).

Definition. Shell minute, tapering (up to 6 mm long), slightly curved with loosely and smoothly encircling wrinkles, very fine longitudinal riblets throughout shell. Posterior orifice a distinct pipe.

Stratigraphic range. Lower Carboniferous.

Remarks. This genus resembles Plagioglypta in having encircling wrinkles but differs in having a distinct apical pipe and very fine longitudinal riblets.

Etymology. Derived from the Latin word pipare meaning a tube, referring to the siphonal pipe at the posterior end; Dentalium, a genus of scaphopods.

Pipadentalium protruberans n.sp.

Figs 152–154

Type material. Holotype (F.61998) and 1 paratype (F.61999).

Additional material examined. 2 specimens.

Description. Shell small, slightly curved, slightly...
attenuated posteriorly, shell surface loosely and slightly oblique wrinkled, showing very fine longitudinal riblets throughout. Circular in cross section, pipe at posterior end.

**Dimensions.** Holotype (Fig. 152): length 6.2 mm, diameter of anterior end 1.0 mm.

**Type locality.** Locality A–3, 2.6 km south-west of Gundy, NSW.

**Remarks.** This species is so similar to Plagioglypta numerosa n.sp. in shell size and shape that it can be confused when the specimen has the apical pipe broken off. Its characteristics are the apical pipe and faint encircling wrinkles with fine longitudinal lirae.

**Etymology.** Derived from the Latin word protruberans meaning protruding, referring to the protruding apical pipe.

**C. HYOLITHA** Matthew, 1899

**O. HYOLITHIDA** Matthew, 1899

**HYOLITHIDAE** Nicholson, 1872

**Hyolithes** Eichwald, 1840

**Type species.** Hyolithes acutus Eichwald, 1840: 97; from Ordovician, Estonia.


**Stratigraphic range.** Lower Cambrian to Middle Permian.

**Hyolithes minutissimus** n.sp.

Figs 155–162, 165

**Type material.** Holotype (F.62000) and 10 paratypes (F.62001).

**Additional material examined.** 10 specimens from locality C–32.

**Description.** Shell minute; bilaterally symmetrical with straight or slightly curved, subtriangular cross section, embryonic portion smooth globular, sharply delimited from main part of shell; inside of embryonic chamber simple hole, wider in middle and top end than lower part of chamber, no septum between embryonic chamber and rest of shell. Shell next to embryonic chamber cylindrical but becoming subtriangular in cross section. Exterior and interior surfaces are ornamented by fine transverse striae which are coarser on exterior than interior. Lip extended from ventral side of aperture, transverse ornamentation on ventral side arched. Aperture subtriangular; operculum and arms unknown.

**Dimensions.** Holotype (Fig. 157): length 3.60 mm, maximum width 1.08 mm; paratype (Fig. 155): length 3.52 mm, maximum width 1.00 mm.

**Type locality.** Locality C–34, 2.6 km south-west of Gundy, NSW.

**Remarks.** The specimens recovered here are consistently small, ranging from 3 to 6 mm long, and the ratio of protoconch length to teleoconch averages 1:20, which may indicate the attainment of maturity. This species differs from all other Palaeozoic hyolith species in having much smaller size of shell. This is the only Carboniferous species found in Australia.

**Etymology.** Derived from the Latin word minutus p.p. of minuere, meaning lessen, and -issima meaning superlative or extreme.

**Discussion**

Large molluscan faunas have been described from the British Isles, Europe and North America. However, only a small number of species have been described from the Australian Carboniferous sediments.

During the present study, the largest assemblage of Carboniferous mollusc faunas (with other groups of marine faunas), was discovered in a bioclastic limestone lens interbedded in mudstone of the Dangarfield Formation. The limestone is interpreted to have formed in a shallow marine shelf environment. The limestone lens extends 800 m in a northwest-southeast direction, and consists of three thin bands of limestone ranging in thickness from 0.1 to 0.2 m. In this paper, gastropods, scaphopods and hyoliths are systematically classified. This mollusc assemblage (56 species including unidentified forms) is also the largest to be recovered from a single locality in Australian Palaeozoic rocks.

The faunal assemblage consists almost entirely of minute shells preserved by chlorite replacement, which has made possible the isolation of complete shells from the limestone matrix, and has led to the preservation of extremely delicate shell ornamentation.

While Recent and Tertiary micro-molluscs have received much attention in recent years, very little was known of the Australian pre-Tertiary minute molluscs. Systematic studies suggest that a large assemblage of macro- and micro-molluscs existed in the Early Carboniferous of Australia.

Thirty-four genera and subgenera of gastropods identified in this study were originally named in the British Isles–Europe and/or North America. Most of them occur in both continents. Only four genera occurring in Australia and Europe have not been found in North America, and another four genera occurring in Australia and North America have not been found in Europe. There are no endemic genera. The Australian fauna is a mixture of both European and North American affinities, of which some are restricted to the Early Carboniferous period. This agrees with the conclusion of Roberts (1987) that the Early Carboniferous marine invertebrate faunas of the Tasman Belt in Eastern Australia are cosmopolitan.

Correlates of conodont, ammonoid, brachiopod and other groups of marine assemblage from the study area with those of North America and Europe
suggest consistently that the sequence correlates with the Late Tournaisian (Early Carboniferous) of Europe.

Some species in the assemblage are recognised as typical planktotrophic gastropods which have potential dispersal ability for a wide geographical distribution. Lecithotrophic gastropods are also found. These gastropods have reduced dispersal ability.

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Figs 25–35.  


33–35 *Glabrocingulum obesum* n.sp. 33. apertural view of holotype, X38. 34. side view of paratype, X38. 35. microsculpture of last whorl of holotype, X65. Locality A–4, holotype (F.61952); paratype (F.61953).
Figs 46–57. 46–49 *Araeonema microspirulata* n.sp. 46. apertural view of holotype, X40 (F.61958). 47. apertural view of paratype, X30 (F.61959). 48, apical view, X120. 49. microsculpture of teleoconch of holotype, X100. Locality A-4. 50–51 *Rhabdotocoelis* sp. 50. apertural view, X18. 51. protoconch of Fig. 50, X85. Locality A-3 (F.62002). 52–54 “*Rhabdotocoelis*” sp. 52. apertural view, X34. 53. dorsal view, X36. 54. protoconch. Locality A-3 (F.62002). 55–57 *Worthenia* sp. 55. apertural view, X38. 56. dorsal view, X38. 57. protoconch of Fig. 55, X88. Locality A-3.
Figs 95–111.  
Figs 155–165. 155, 157–162, 165 *Hyolithes minutissimus* n.sp. 155, side view of paratype, slightly curved near posterior end, X23 (F.62001). 157, dorsal view of holotype, X22 (F.62000) 158, embryonic shell, showing smooth shell surface and fine transverse ornamentation on early stage, X280. 159, inside embryonic chamber, X280. 160, transverse ornamentation on ventral side, X30. 161, part of shelf, showing ornamentation of inside and outside the shell, X60. 162, triangular transverse section, X60. 165, dorsal view of shell, X25 (F.62001). Locality C–34. 156, 163–164 *Hyolithes* sp. 156, dorsal view of shell, X27. 163, dorsal view of shell, X23. 164, embryonic shell; elongate with sharp apex, X300. Locality C–34.