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Brachiopods of the Murrumbidgee Group, Taemas, New South Wales

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SUMMARY

A comprehensive collection of brachiopods from part of the Murrumbidgee Group of the Yass area, New South Wales, confirms the late Emsian age of the upper part of the Group. They flourished in a shallow vigorous sea.

Of the 46 species and subspecies described, belonging to 35 genera, 6 genera, 34 species, and the subspecies are new. It has been possible to trace the ontogeny of many species.

INTRODUCTION

The Devonian limestones of the Taemas-Cavan area crop out in a north-trending synclinorium, about 25 km southwest of Yass and about 55 km north-northwest of Canberra, in the southeastern part of New South Wales (Text–fig. 1). The Devonian rocks of this structure, consisting of limestone units of the Cavan and Taemas Formations and shale and sandstone of the Majurgong Formation, belong to the lower to upper Emsian (? to Eifelian) Murrumbidgee Group. The two units on which the work reported here concentrates, the *'Receptaculites'* Limestone and the Warroo Limestone, were selected because they contain rich and well preserved faunas.

Brachiopods from the area have been described and discussed by de Konwick (1876, English translation 1898), Dun (1904), Johnson (1966b), Campbell & Talent (1967), and Strusz, Chatterton, & Flood (1971); but these described forms constitute only a small part of the brachiopod fauna.

In this work 46 species and 1 subspecies of brachiopods are described. Wherever possible, descriptions of early growth stages have been included with those of more mature stages. The subspecies and 34 of the species are new. The species are included in 35 genera, 6 of which are new (see Text–fig. 4). These species all occur in the *'Receptaculites'* Limestone or the Warroo Limestone or both. Many of them also occur in lower units at Taemas. Several species found in the lower units are not described here: some rhynchonellids and a new species or subspecies of *Adrenia* gen. nov. (which is much larger than the species of that genus described on pp. 129-33). Because this Bulletin is primarily a study of the silicified brachiopod faunas, samples were obtained for digestion in acid from a comparatively small number of localities where the fossils are both common and well silicified. Other species of brachiopods may well occur at unworked localities in the *'Receptaculites'* and Warroo Limestones.

The material described is deposited either in the collection of the Geology Department, Australian National University (ANU numbers) or in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Geology and Geophysics, Canberra (CPC numbers).

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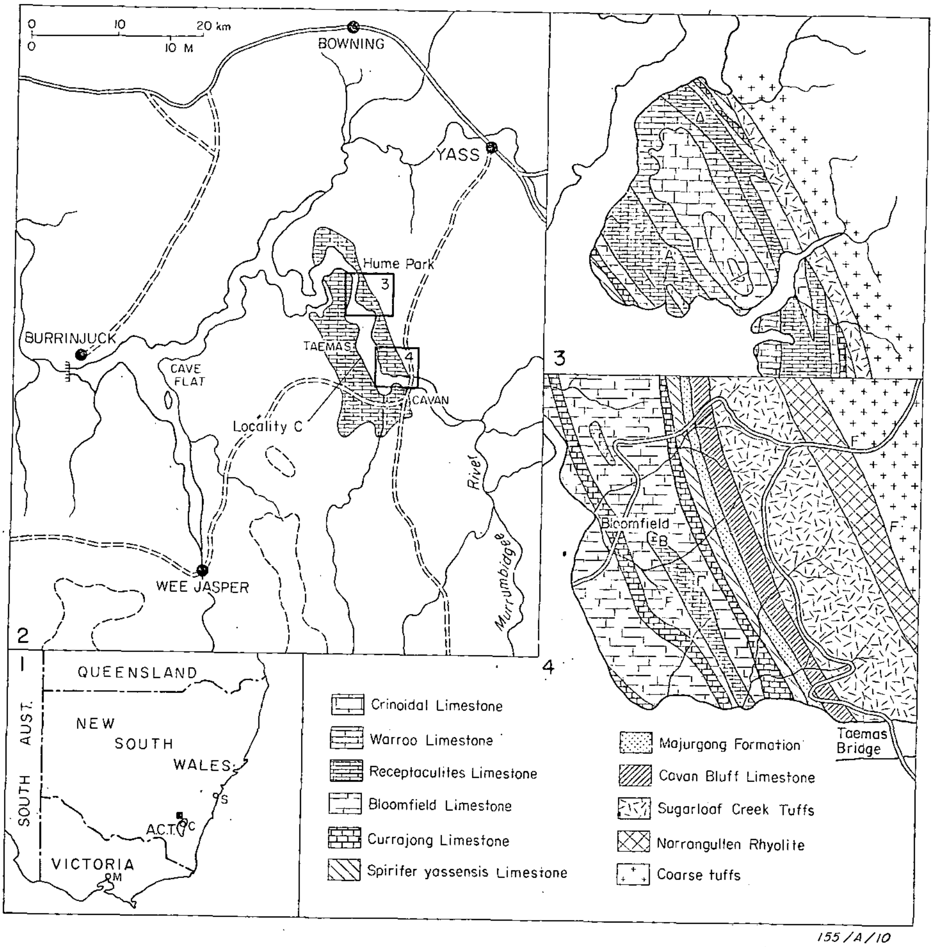

Fig. 1. Locality map of Taemas-Cavan area and type location.

STRATIGRAPHY

The *'Receptaculites'* and Warroo limestone are members of the Taemas Formation of the Murrumbidgee Group (see Pedder, 1967). Their age is probably late Emsian, but may be as young as early Eifelian. Their stratigraphic positions within the Taemas Formation are shown in Text–figure 2. Browne (1959) produced a useful sketch map of the Devonian rocks of the Taemas-Cavan area, which shows the approximate areal distribution of these units: part of it, slightly emended and showing the positions of the type localities, is reproduced in Text–figure 1. The localities are described on page 143.

The fauna of the *'Receptaculites'* Limestone differs from that of the Bloomfield Limestone, the member below it: it is richer and more varied and contains more colonial corals and receptaculitids (it also rarely contains the problematical large elongate cone-shaped fossil that is common locally in the Bloomfield Limestone). It is usually simpler in the field to separate these units upon their characteristic appearance. The Bloomfield Limestone is a poorly exposed, thin bedded and nodular, argillaceous limestone, with a fauna that apparently consists predominantly of brachiopods, molluscs, tabulate corals *(Favosites),* and occasional simple rugose corals. The *'Receptaculites'* Limestone commonly contains silicified fossils, is well exposed, and is usually more massively bedded.

Browne (1959, table A) stated that the *'Receptaculites'* Limestone is about 590 feet (180 m) thick. A section measured along the north side of the small creek that runs into Burrinjuck Dam, about 200 m south of Warroo Creek inlet, is about 185 m thick, very close to Browne's figure. The thickness of the Warroo Limestone is variable, as the Crinoidal Limestone overlies it disconformably, and is probably separated from it by a short hiatus. Browne suggested that the Warroo Limestone is about 370 feet (113 m) thick.

The faunas and rock types vary within both the *'Receptaculites'* Limestone and the Warroo Limestone (particularly in the former). The *'Receptaculites'* Limestone consists of a series of well-bedded to massive limestones that are predominantly sparse or packed biomicrites (for terminology see Folk, 1959 and 1962), but range from micrite to sorted biosparite. The Warroo Limestone consists of a series of well-bedded limestones that are predominantly sparse biomicrite and fossiliferous micrite, but range from micrite to packed biomicrite. The argillaceous content of both units varies considerably and is generally much higher in the micrites than in the sparites. None of the rocks could be classed as calcareous shale or mudstone on the basis of simple empirical tests (fissility and disintegration in hydrochloric acid). Fine shaly partings do, however, occur between some beds. The boundary between the *'Receptaculites'* Limestone below and the Warroo Limestone above is drawn within the transition from predominantly packed and sparse biomicrites with occasional beds of unsorted biosparite to predominantly packed biomicrites with occasional beds of sparse biomicrite and fossiliferous micrite. This slight and gradual change in lithology is accompanied by an abrupt and striking change in the two groups of the benthonic fauna that have been studied (brachiopods and trilobites); most if not all of the other benthonic invertebrates (corals, polyzoans, gastropods, bivalves, and ostracods) appear to have undergone a similar change. The assemblages of brachiopods and trilobites that are characteristic of the highest beds of the *'Receptaculites'* Limestone

(Assemblage A) and the lowest beds of the Warroo Limestone (Assemblage B) are listed in Table 1.

The *'Receptaculites'* and Warroo limestones are primarily used as biostratigraphical units. Where the faunas are sparse or indistinctive it becomes necessary to identify the units by recognizing their characteristic rock types or, more accurately, associations of rock types. Nearly all the beds of the *'Receptaculites'*

TABLE 1

Top of '*Receptaculites*' Limestone Assemblage A	Base of Warroo Limestone Assemblage B
Trilobita	
Acanthopyge (Mephiarges) bifida Edgell	*Leonaspis clavatus* Chatterton
Dentaloscutellum hudsoni Chatterton	*Primaspis (Taemasaspis) campbelli* Chatterton
Scutellum calvum Chatterton	*Proetus talenti* Chatterton
Ceratocephala vexilla Chatterton	*Otarion (Otarion) dabrowni* Chatterton
Xanionurus bispinosus Chatterton	
Otarion (Tricornotarion) struszi Chatterton	
Gravicalymene quadrilobata Chatterton	
Brachiopoda	
Craniops australis n. sp.	*Craniops australis* n. sp.
Aulacella stormeri n. sp.	*Isorthis spedeni* n. sp.
Cymostrophia dickinsi n. sp.	*Curranella careyi* n. gen. n. sp.
Malurostrophia minima n. sp.	*Muriferella hillae* n. sp.
Malurostrophia aura n. sp.	*Aulacella philipi* n. sp.
Schuchertella murphyi n. sp.	*Taemostrophia patmorei* n. gen. n. sp.
Protochonetes latus n. sp.	*Leptostrophia clarkei* n. sp.
Ambothyris runnegari n. sp.	*Protochonetes latus* n. sp.
Coelospira dayi n. sp.	*Septachonetes melanus* n. gen. n. sp.
Atrypa penelopeae n. sp.	*Cyrtina* aff. *C. wellingtonensis* Dun
Cyrtina aff. *C. wellingtonensis* Dun	*Hysterolites* sp.
Howittia multiplicata (de Koninck)	*Delthyris hudsoni* n. sp.
Howellella aff. *H. textilis* Talent	
Browneella browneae n. gen. n. sp.	
Eoglossinotoechia linki n. sp.	
"Pugnax" oepiki n. sp.	
Adrenia cernua n. gen. n. sp.	
Micidus shandkyddi n. gen. n. sp.	
Micidus (?) *glaber* n. gen. n. sp.	

Lists of the fossils that are occasional to common in the top of the '*Receptaculites*' Limestone and the base of the Warroo Limestone at Locality A, two miles south of Hume Park, near Yass, New South Wales.

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Limestone are highly fossiliferous. The beds in the basal 15 m of the Warroo Limestone tend to be highly fossiliferous and the higher beds sparsely fossiliferous. The use of these units is complicated by the variation within them of the faunas and lithology in both time and space; also, certain faunal assemblages occur in more than one unit. An assemblage close to that found in the top of the *'Receptaculites'* Limestone sometimes occurs near the middle of the Warroo Limestone; and the association of *Spinella yassensis* (de Koninck) with *Protochonetes culleni* (Dun), which is characteristic of the *'Spirifer yassensis'* Limestone, also occurs in the Cavan Formation, the Bloomfield Limestone, and the base of the *'Receptaculites'* Limestone. Thus, the units usually have to be recognized by their associations of faunas and not upon the occurrence of any one fauna. There are, of course, numerous examples of faunas and individual fossils that appear to be restricted to individual horizons in the Taemas-Cavan area. For example, Assemblage B has only been found in the base of the Warroo Limestone, and *Taemostrophia patmorei* gen. et sp. nov. has only been found in the Warroo Limestone. Browne's view that certain of the fossils at Taemas are restricted to narrow zones within certain units can now be modified. She stated (1959, p.121): 'A single zone of *Receptaculites australis* Salter occurs within about 20 feet of the base of this limestone [the *'Receptaculites'* Limestone], and specimens have been found at this horizon in all of the outcrops shown on the accompanying map, and not elsewhere'. Receptaculitids have since been found at a number of horizons within the *'Receptaculites'* Limestone, and even in the Warroo Limestone; and they are not always common near the base of the former. Locally, *R. australis* is common at certain horizons, but rarely for more than about a kilometre continuously along the strike. Most of the benthonic assemblages appear to have a limited areal extent at any particular level, although they are often replaced by assemblages that contain a number of the same species. The compound rugose coral *Xystriphyllum mitchelli* Etheridge, which Browne suggested could be used as a marker for the base of the *'Receptaculites'* Limestone, usually occurs in biostromal beds or lenses about 60 m above the base of that unit and seldom near its base.

The 'Crinoidal' Limestone overlies the Warroo Limestone disconformably, and has a very different lithology and fauna. The higher beds of the Warroo Limestone consist of micrites, fossiliferous micrites, and biomicrites; the lower beds of the 'Crinoidal' Limestone consist of thick beds of biosparrudite and intrabiosparrudite, many of which are strongly current-bedded and may contain a significant percentage of angular medium-sized quartz-sand grains. The fossils in the Warroo Limestone are predominantly brachiopods, arthropods, and molluscs; those of the 'Crinoidal' Limestone are predominantly crinoids and polyzoans.

The limestone units recognizable in the Taemas-Cavan area are probably restricted to a portion of the Buchan-Taemas-Molong Platform of Browne, Campbell, & Crook (1968). Some of the lower units are recognizable at Wee Jasper, about 25 km southwest of the Taemas-Cavan area (G. C. Young, pers. comm.). They have not been recognized elsewhere.

Palaeoecology

Palaeomagnetic studies place Australia at or close to the equator during the Devonian (see maps in Irving, 1964; Creer, 1967; and McElhinny, 1967). They would place the Taemas-Cavan area within the tropical climatic zone of geologically 'normal' times suggested by Fairbridge (*in* Chilingar, Bissell, & Fairbridge, 1967, p.402, table 1). A tropical or subtropical climate is also suggested by the richness and diversity of the faunas; the high percentage of prosobranchs that had planktonic

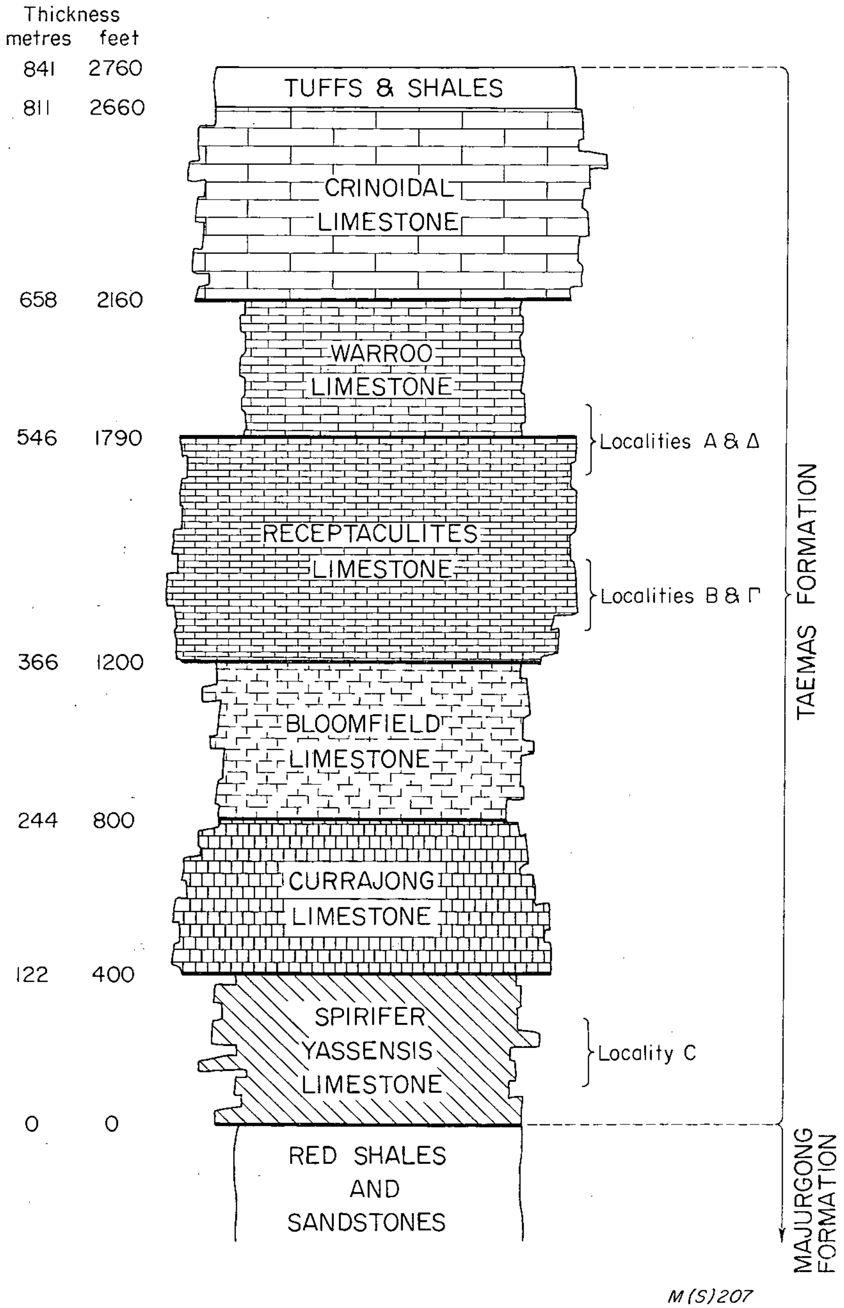

Fig. 2. Stratigraphic column of the Taemas Formation, showing the relative positions of the limestone members and the stratigraphic positions of the type localities.

larvae* and the presence of receptaculitaceans (Byrnes, 1968), of abundant compound tabulate and rugose corals in some beds (Wells, 1967, p. 364), of a thick limestone sequence (according to Browne, 1959, over 1000 m thick) and of numerous other thick limestone sequences of similar age in eastern Australia (Fairbridge, *in* Chilingar et al., 1967, p. 399).

Some of the fossils in the limestones are characteristic of normal marine salinity (articulate brachiopods — see Ager, 1967, p. 158). Such factors as the small amount of terrigenous material present (larger than clay size), the diversity of the faunas, and the fact that the limestone was probably deposited in a shallow but not very shallow sea (see below) also suggest that the sea was well oxygenated, with normal marine salinity. In contrast, it is quite possible that some of the siltstone and sandstone of the Majurgong Formation, which only contain a sparse fauna of the inarticulate brachiopod *Lingula* and some indeterminate gastropods, were laid down in conditions of reduced salinity, perhaps estuarine.

The depth of the sea from which the limestones of the Murrumbidgee were laid down varied, but was never deep. Some units, such as the Cavan Formation and the 'Crinoidal' Limestone, were deposited in very shallow water: the Cavan Formation contains abundant stromatolites and mud cracks, and the 'Crinoidal' Limestone has strong current bedding and contains medium-sized sand grains. The '*Receptaculites*' Limestone was mostly deposited in water less than 60 m deep (the maximum depth of the photic zone in contemporary subtropical seas), as calcareous algae occur at several horizons within it. Also, the currents on the sea floor were strong enough to overturn massive colonies of *Favosites* up to 30 cm in diameter, to winnow out any fine micrite or clay to produce biosparites, and to show some evidence of sorting. The energy of the environment was probably generally lower in the Warroo Limestone than in the '*Receptaculites*' Limestone, as biosparites are generally absent and there are few signs of sorting or winnowing. There are, however, possible signs of calcareous algae in the lower beds of the Warroo Limestone: fine silicified tube-like structures with a diameter of about 0.05 mm, which are attached to the surfaces of other fossils; but they do not show the rather disorganized habit of most filamentous algae. It is possible that either the Warroo Limestone was laid down in slightly deeper water than the '*Receptaculites*' Limestone, with a resultant lower energy environment, or that the local topography had so altered as to reduce the energy of the environment at the bottom of a sea of similar depth (different fetch or change of local current directions).

AGE AND CORRELATION

Previous Work

The Murrumbidgee Group crops out in two synclinoria southwest of Yass — in the Taemas-Cavan and Wee Jasper areas. The Cavan, Majurgong, and Taemas Formations are recognizable in both. The conodont faunas are similar and are close to that found in the Buchan area of Victoria. The Devonian limestones at Buchan contain a number of fossils that are close to or conspecific with forms that occur in the Taemas Formation in the Taemas-Cavan area. Many of the brachiopods that occur at Buchan, described by Talent (1965a) and Campbell & Talent (1967), either occur at Taemas — *Howittia howitti* (Chapman), *Malurostrophia*

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* More than 80 percent of prosobranchs in which apices were observed probably had planktonic larvae. These make up 60 percent of the prosobranchs in the beds examined; see Thorson, 1950 and *in* Hedgpeth, 1957.

GENUS:	CAVAN FORMATION	MAJURGONG FORMATION	'SPIRIFER YASSENSIS' LIMESTONE	CURRAJONG LIMESTONE	BLOOMFIELD LIMESTONE	'RECEPTACULITES' LIMESTONE	WARROO LIMESTONE	'CRINOIDAL' LIMESTONE
Craniops						●	●	
Isorthis							●	
Curranella							●	
Salopina			●			●		
Muriferella							●	
Aulacella						●	●	
Cymostrophia						●	●	
Taemostrophia							●	
Malurostrophia						●	●	
Leptostrophia						●	●	
Schuchertella						●	●	
Parachonetes	●		●			●	●	
Protochonetes	●	●	●		●	●	●	
Septachonetes							●	
Spinulicosta						●	●	
Ambothyris						●	●	
Coelospira						●	●	
Atrypa			●			●		
Anatrypa						●		
Athyris	●		●			●		
Cyrtina					●	●	●	
Howittia	●					●	●	
Spinella	●	●	●	●	●	●		
Quadrithyrina						●		
Howellella						●		
Cyrtinopsis						●		
Hysterolites						●	●	
Delthyris						●	●	
Callipleura (?)						●		
Browneella						●		
Eoglossinotoechia						●	●	
Pugnax (?)						●	●	
Adrenia	●					●	●	
Cydimia						●		
Micidus						●	●	

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Fig. 3. Some known occurrences of brachiopod genera in the Murrumbidgee Group (sampling below the '*Receptaculites*' Limestone was not intensive, and little was collected from the Bloomfield and Currajong Limestones).

flabellicauda Campbell & Talent, and *Athyris waratahensis* (Talent) — or are very close to species that occur at Taemas — *Parachonetes spooneri* (Talent) is close to *P. flemingi* sp. nov. and *P. konincki* sp. nov., *Malurostrophia basilica* Campbell & Talent is close to *M. bella* sp. nov., *Spinella buchanensis* Talent is close to *S. yassensis* (de Koninck) and *Protochonetes australis* (M'Coy) is close to *P. culleni* (Dun). A number of other brachiopod species that occur at Buchan are close to or conspecific with forms that occur at Taemas but as yet are undescribed (J. A. Talent, pers. comm., 1966). The same pattern is probably true of other groups of fossils. Thus the ages of the Devonian limestones of the Taemas, Wee Jasper, and Buchan areas may be considered together. Browne (1959) and Philip & Pedder (1964 and 1967a) also considered the age of the Buchan limestone to be similar to that of the Murrumbidgee Group.

De Koninck (1876) concluded that the fossils sent to him by W. B. Clarke were Middle Devonian. Hill (1941) concluded from rugose coral faunas that most of the Devonian rocks along the Murrumbidgee and Goodradigbee Rivers are Couvinian, but that beds of the Cavan 'Stage' may be as low as upper Coblenzian. Browne (1959) considered that the rocks of the Taemas-Cavan area are Middle Devonian and listed numerous authors who accepted de Koninck's conclusion.

Philip & Pedder (1964), with a small collection of conodonts and some rather negative evidence on their possible ranges, placed the Murrumbidgee and Buchan sequences in the Lower Devonian, stating 'our present conclusion, then, is that both the Buchan and Murrumbidgee sequences are wholly Lower Devonian in age and at youngest may include Lower Emsian strata'. They later (1967), however, raised the age so as to place most of the Murrumbidgee Group in the Emsian. Pedder, Jackson, & Philip (1970), using rugose coral and conodont evidence, considered the age of the Murrumbidgee Group to extend from late Siegenian to late Emsian. Their coral evidence is, however, primarily based on correlations with other Australian and New Zealand localities and not on comparisons with fossils from type European or well known American sequences. Philip & Jackson (1967) stated that '*Polygnathus linguiformis dehiscens* at present is known only from the Cavan Limestone of Taemas and Wee Jasper. In its basal excavation it is more primitive than any previously recorded form of *P. linguiformis*. A late Siegenian age would be in keeping with its stratigraphical occurrence and the associated mega-fossils'. This must, however, be regarded as negative evidence. Klapper (1969) described a form from Nevada and the Yukon Territory, *Polygnathus lenzi* Klapper, that resembles *P. dehiscens* in having a large basal excavation and similarly occurs below *P. foveolatus* Philip & Jackson. *P. lenzi*, which must be considered to occupy a parallel evolutionary position with *P. dehiscens*, occurs in rocks that are regarded as Emsian in both Nevada and Alaska — it occurs below *P. foveolatus*, in the lower half of the *Eurekaspirifer pinyonensis* zone of Nevada, which is not even considered to be earliest Emsian in age. *Polygnathus dehiscens* occurs in the Cavan Formation at Taemas and Wee Jasper. Thus, the lowest limestones of the Murrumbidgee Group should be regarded as early Emsian and not late Siegenian. *P. foveolatus* occurs in the Taemas Formation at both Taemas-Cavan and Wee Jasper. It is common in the lower half of the *'Receptaculites'* Limestone at localities B and Γ, and rare at the top of the unit. Klapper (1969) described *P. foveolatus* from the Blue Fiord Formation, Devon Island, Canada, which he regarded as being Emsian. He also stated that this species occurs in the Schönauer Kalk of the Kellerwald and near Marburg, Germany, which is upper Emsian according to Walliser (1962, p. 286), and in the upper half of the

Eurekaspirifer pinyonensis zone in Nevada. Ormiston (1967) considered, however, that trilobite evidence favours an Eifelian age for the Blue Fiord Formation. Thus, there is some doubt that the presence of *P. foveolatus* necessarily indicates an Emsian age. Pedder et al. (1970) argued that as the most common conodonts that occur in the youngest limestones of the Murrumbidgee Group are long-ranging Lower Devonian forms not found elsewhere above the Emsian — *Neoprioniodus bicurvatus* (Branson & Mehl), *Ozarkodina denckmanni* Ziegler, *Plectospathodus alternatus* Walliser, *Spathognathodus linearis* (Philip), and *Spathognathodus steinhornensis* Ziegler — the limestones of the Murrumbidgee Group do not extend above the Lower Devonian. It is possible, however, that such long-ranging and widespread forms did not die out everywhere together.

Sherrard (1967), in a work on the tentaculitids of New South Wales, placed the Garra Formation, Wellington, the limestones of Ravine (Yarrangobilly River), and the *'Spirifer yassensis'* Limestone at Taemas in the Lower Devonian primarily on the basis of the occurrence of a form which she identified as *Nowakia* aff. *acuaria* (Richter). On the other hand, she also stated (p. 242) that Boucek did not agree that specimens from Ravine are conspecific with *N. acuaria,* but thought that they are very close to a form that occurs in the uppermost Emsian of Czechoslovakia. If Sherrard's specimens are not too close to *N. acuaria,* their presence cannot be used with confidence as an argument for an early Devonian age, although, if Boucek's thesis is correct, a late Emsian age would be supported.

Pedder (1967) stated, in discussing the age of the Murrumbidgee Group: 'higher beds approximating in age to the *Teicherticeras* (Emsian in Nevada, France, Germany, Czechoslovakia and the Urals) occurrences of Victoria, have yielded such Lower Devonian genera as *Pseudamplexus, "Nadiostrophia", Cymostrophia* and *Mutationella*'. Neither *Nadiostrophia* nor *Mutationella* has been found in the Murrumbidgee Group at Taemas, although small terebratulids similar in general appearance to *Mutationella* occur. The forms referred to as *'Nadiostrophia'* are probably *Malurostrophia* Campbell & Talent, 1967, which is very common in some members of the Taemas Formation at Taemas. This genus cannot be regarded as a purely Lower Devonian genus as it occurs in the Eifelian Ukalunda Beds of Queensland (Campbell & Talent, 1965; Hill, 1967). The genus *Cymostrophia* has also been recorded from rocks younger than Lower Devonian (see p. 14).

Orvig (1969, p. 317) suggested that elements of the vertebrate faunas of Buchan and Taemas, consisting of *Ohiolepis* scales, *Ohioaspis* plates, dermal elements of early struniiform crossopterygians, and palaeoniscid scales, are very similar to faunas that occur in the lower Middle Devonian of North America (the Onandaga Formation, the Columbus Limestone, and the Delaware Formation). He also listed the occurrence of *Ohiolepis* scales in a very sparse collection made from the topmost Emsian Heisdorf beds, of pyctodontids and struniiforms in the lowermost Eifelian Lauch Beds, and of pyctodontids, struniiforms, and microfossils (some suggestive of *Ohioaspis* and others of *Ohiolepis,* but apparently none referable to either) in beds higher in the type Rhenish sequence. Thus, the occurrence of these vertebrates in the limestones of Buchan and Taemas suggests, at the present state of knowledge, a late Emsian or Eifelian age for these sequences.

The published ages for the sequence at Buchan, Victoria, are as variable as those for the Murrumbidgee Group. Teichert (1948) suggested that the Taravale Mudstone at Buchan is Eifelian, using evidence obtained from a study of an ammonoid and bactritid fauna. Erben (1965) transferred Teichert's *Convoluticeras* to *Teicherticeras* and showed that *Teicherticeras* usually occurs in the Lower Devonian (Emsian) in Europe. He suggested that one of the ammonoids in the Taravale Formation, *Talenticeras talenti* Erben, is an Eifelian derivative of *Mimosphinctes;* but as *Talenticeras* has not been found elsewhere, this occurrence cannot be used as proof of a Middle Devonian age. Hill (1950), using corals, considered that the age of the Buchan Caves Limestone is close to, probably slightly above, the junction between the Emsian and the Couvinian. Two species of *Calceola,* including a species close to *Calceola sandalina* (Linné), are present in the Taravale Formation and Murrindal Limestone at Buchan and Bindi, Victoria. A number of occurrences of *Calceola* in rocks as old as Emsian have been reported: some must be regarded as doubtful, but others, including an occurrence of *Calceola* in the Heisdorf Schichten of Germany (Werner, 1969), are genuine. Talent (1965), in a review paper of the Victorian Middle Palaeozoic, placed the Buchan sequence in the Eifelian. Philip (1966) concluded that the conodonts at Buchan suggest a late Early Devonian age for these beds. Many of the conodonts that occur at Buchan also occur in the Murrumbidgee Group at Taemas and Wee Jasper, and some of them are discussed above.

New Information

The evidence of age provided by the brachiopods in the *'Receptaculites'* and Warroo Limestones is slightly confusing as the fauna appears to consist of a mixture of forms with strong lower Middle Devonian affinities and forms usually restricted to the Lower Devonian.

A new species of *Spinulicosta, S. campbelli,* occurs in the top of the *'Receptaculites'* Limestone and in the Warroo Limestone. *Spinulicosta* has been found in the *Eurekaspirifer pinyonensis* zone of Nevada (Johnson, Boucot, & Murphy, 1967), which has been dated, using brachiopods, as Emsian. In Europe productids appear first in the Heisdorf beds, which are highest Emsian (Erben & Zagora, 1967, placed the Emsian-Eifelian boundary at the top of the Heisdorf beds). Muir-Wood & Cooper (1960, pl. 33) illustrated a form, *Spinulicosta* cf. *S. spinulicosta* (Hall), as coming from the 'Lower Devonian (upper part of Columbus limestone), Medusa Portland Cement Co. quarry, 2½ miles southwest of Sylvania, Ohio', but the Columbus Limestone is regarded as Eifelian by Oliver (1967) and Oliver et al. (1967). Thus, although productids range down into the Emsian, they are most common in Middle Devonian and younger rocks. The only other species of this genus that have been described from Australia are Middle Devonian or younger (McKellar, 1970).

A new species of *Quadrithyrina, Q. allani,* occurs in the base of the *'Receptaculites'* Limestone. Havlíček (1959) suggested that *Quadrithyrina* is a Middle Devonian derivative of *Quadrithyris.* The presence of a small ventral adminiculum in the umbo of a young specimen of *Q. allani,* but not in adult specimens, may support that suggestion. Species of *Quadrithyrina* have only been described previously from rocks of Eifelian age in Czechoslovakia, Germany, and the Urals (Havlíček, 1959; Erben & Zagora, 1967). They have not been found widely enough for their stratigraphic significance to be accurately assessed.

A species of *Anatrypa, A. erectirostris* (Mitchell & Dun), occurs in the base of the *'Receptaculites'* Limestone. Species of this genus are most common and most widespread in the Middle Devonian, but they are found in rocks of Emsian age in the Yukon Territory, Canada (Lenz, 1966) and Russia (Alekseeva, *vide*

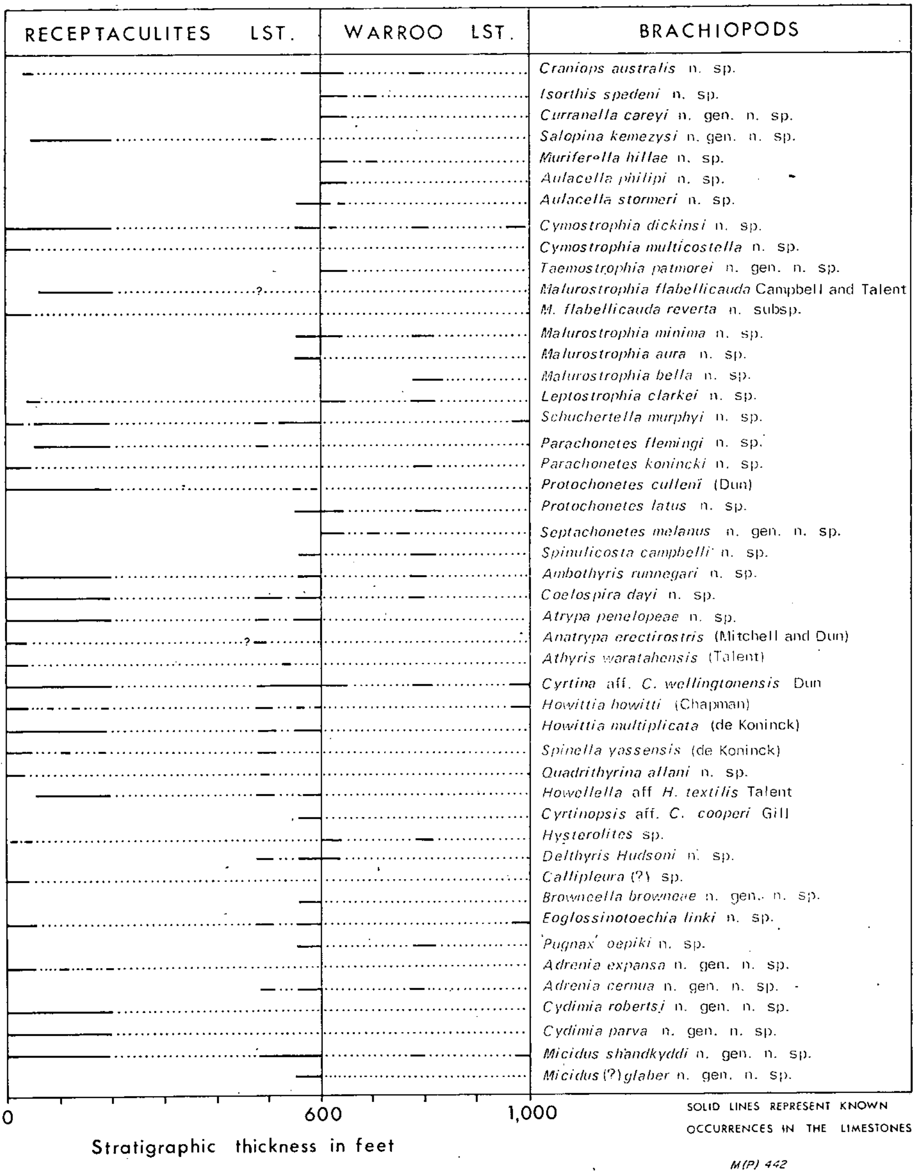

Fig. 4. The known occurrence of the brachiopods described in this Bulletin in the *'Receptaculites'* and Warroo Limestones.

Copper, 1966a). I follow Johnson (1970) in regarding *Desquamatia* Alekseeva as a junior subjective synonym of *Anatrypa* Nalivkin.

A new species of *Coelospira, C. dayi,* occurs in the *'Receptaculites'* and Warroo Limestones. It is close to *C. camilla* Hall, which Boucot & Johnson (1967), in a tentative phylogeny of the species of *Coelospira,* regarded as typical of rocks of Emsian to Eifelian age. Rickard (1964) gave the range of *C. camilla* in New York State as just below and to the top of the Onandaga Formation (the Onandaga Formation is generally regarded as Eifelian).

A new species of *Aulacella, A. philipi,* that occurs in the Warroo Limestone is close to the type species of that genus, *A. eifelensis* (Verneuil). *A. eifelensis* has been found in rocks of Middle Devonian age in Germany, Belgium, Spain, and Poland (Biernat, 1959).

The small inarticulate brachiopod *Craniops australis* sp. nov., which is common at several horizons in the *'Receptaculites'* and Warroo Limestones, is close to *Craniops patina* (Hall), which occurs in the Middle Devonian (Eifelian) 'Corniferous Limestone' at De Cewville, Ontario (the Corniferous Limestone is equivalent to the Onandaga Formation).

The septate dalmanellid *Muriferella hillae* sp. nov., which occurs in the Warroo Limestone, has characters intermediate between the Middle Devonian genus *Vallomyonia* and the predominantly Lower Devonian genus *Muriferella* Johnson & Talent. This would suggest that this species is of either latest Lower Devonian or earliest Middle Devonian age (see also page 30).

Four small species of terebratulids that occur in the *'Receptaculites'* Limestone have been included in two new genera in the Rhipidothyridinae, a subfamily which Stehli (*in* Moore, 1965) and Cloud (1942) regarded as Middle Devonian. Two other species of small terebratulids are included in a new genus that is tentatively included in the Mutationellidae, a predominantly Lower Devonian family, although some Middle Devonian mutationellids are known *(Derbyina* Clarke is thought to extend into the Middle Devonian of South America, see Harrington, 1967).

Two species of *Howittia* occur at several levels in the Murrumbidgee Group (as low as the Cavan Bluff Limestone and as high as the Warroo Limestone). *Howittia* is very close to *Adolfia* Gürich, which ranges from the Emsian to the Frasnian.

Several of the spiriferoids that occur in the *'Receptaculites'* and Warroo Limestones belong to genera that were regarded by Pitrat (*in* Moore, 1965) as no younger than Lower Devonian. These genera include *Delthyris* Dalman, *Howellella* Kozłowski, and *Hysterolites* von Schlotheim. Species of *Hysterolites* were described by Le Maitre (1952) from the Eifelian of l'Erg el Djemel, Algeria; and were listed as occurring in the Eifelian of Germany by Erben & Zagora (1967). One species of *Delthyris* was described from the Couvinian of Belgium by Vandercammen (1963), and two from the Eifelian of l'Erg el Djemel by Le Maitre (1952). Species of *Howellella* usually occur no higher than the Gedinnian in Europe, but Wallace (1969) listed an occurrence in the Frasnian of northern France; Drot (1964) described a form, *Howellella* sp. ex. gr. *koneprusensis* from Morocco, which she thought might extend as high as lower Emsian; and this genus was listed from the Emsian of northeastern Russia by Nikolaev & Rzhonsnitskaya (1967). In Australia, species of *Howellella* occur relatively commonly in rocks much younger than Gedinnian, and often in rocks at least as young as Emsian.

Eoglossinotoechia Havlíček has not been previously described from rocks younger than Lower Devonian. Drot (1964) described a form from Morocco, *Eoglossinotoechia sylphidea marocanensis* Drot, which she considered to occur in rocks as young as upper Emsian. Nikolaev & Rzhonsnitskaya (1967) listed *Eoglossinotoechia taimyrica* Nikiforova from rocks of Emsian age in northeastern Russia.

Two new species of *Cymostrophia* Caster are described from the *'Receptaculites'* and Warroo Limestones. Williams (*in* Moore, 1965) regarded *Cymostrophia* as an Upper Silurian to Lower Devonian genus. Possible early Middle Devonian forms have been described, however, from the Yükiang Formation, China (see Havlíček, 1967).

Two new species of *Parachonetes* occur in the *'Receptaculites'* Limestone. J. G. Johnson (in litt., 1968) stated 'When I published *Parachonetes* the Middle Devonian part of the range suggested was based on the Australian specimens. If that is a mistake *Parachonetes* is unknown in any proven or even likely Eifelian beds and may be a good Lower Devonian guide. It certainly is restricted to the Emsian in the Carnic Alps, western France and Bohemia, and has its highest Russian occurrence in the Salair beds'.

The trilobites that occur in the *'Receptaculites'* and Warroo Limestones at Taemas, described by Chatterton (1971), do not throw much further light on their

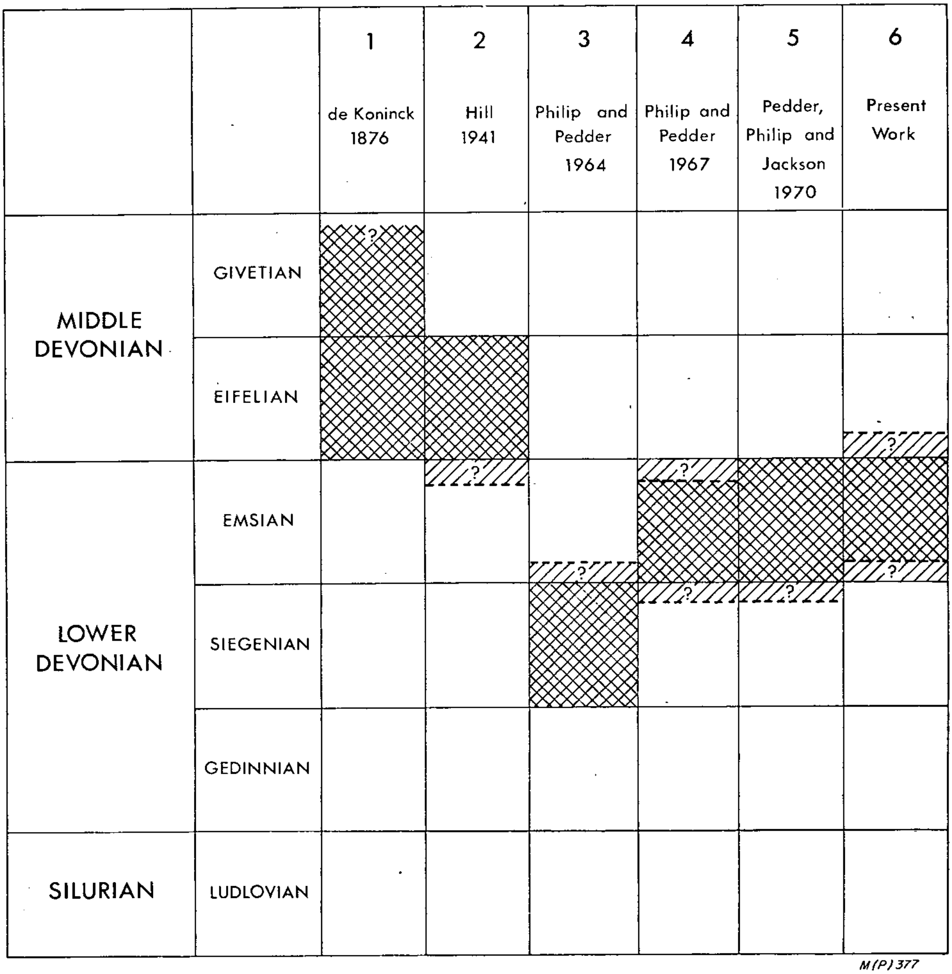

Fig. 5. A comparison between some past and present conclusions about the age of the Murrumbidgee Group.

ages. *Acanthopyge (Mephiarges) bifida* Edgell is clearly related to both *A. (Mephiarges) mephisto* Richter & Richter from the Eifelian of Europe and *A. (Mephiarges) consanguinea* (Clarke) from the Gedinnian of North America. A species of *Phacops* that occurs in the top of the '*Receptaculites*' Limestone and the base of the Warroo Limestone is at a similar evolutionary level to *Phacops fecundus degener* Barrande in that it has characters intermediate between those of the Lower Devonian and lower Middle Devonian *P. logani* group and the exclusively Middle Devonian *P. latifrons* group (see Campbell, 1967). A calymenid that has been included in *Gravicalymene* Shirley occurs in the '*Spirifer yassensis*' and '*Receptaculites*' Limestones. Whittington (*in* Moore, 1959) gave the range of *Gravicalymene* as Upper Ordovician to Lower Devonian. This large species is not, however, a very typical species of *Gravicalymene*. Modzalevskaya (1967) noted the presence of a similar large calymenid which she placed in *Calymene*, in the Eifelian of the Transbaikal region of Russia.

It may therefore be concluded that the base of the Murrumbidgee Group is no older than Lower Emsian and the top is probably Upper Emsian, but may be as young as Eifelian: if the last is so, the boundary between the Emsian and the Eifelian in the Taemas-Cavan area is probably near the top of the '*Receptaculites*' Limestone.

TERMINOLOGY

Most of the terms are used here in the same sense as they were defined in the glossary of Williams et al. (*in* Moore, 1965). Several new terms, which are thought to be useful in differentiating features characteristic of certain groups of fossils, are defined below. Some terms that are not used in exactly the same sense as Williams et al. and the meanings of some others used in the descriptions are also defined.

Lateral plates: A pair of plates that run along each side of the delthyrium. The plates either diverge distally or extend outward perpendicular to the interarea. They do not converge distally to block part of the delthyrium. They are present in some spiriferaceans, including *Howittia, Quadrithyrina, Howellella,* and *Delthyris.* They have been called deltidial plates by some authors, but do not fall within the definition of deltidial plates given by Williams et al.

Protodeltidium: A convex portion of the posteromedian part of the ventral valve. It extends from a pedicle sheath or a supra-apical foramen to the posterior margin in early neanic and brephic growth stages of some members of the Strophomenida. It deflects the posterior margin so that it is convex medially. It is not recognizable as a pseudodeltidium and occurs in some forms that do not appear to have pseudodeltidia.

Deltidial sheath: Flap-like or tube-like dorsal extensions of the deltidial plates, which surround or partly surround the pedicle. They often expand or turn outward distally. Present in some terebratulids and some rhynchonellids.

Gently, moderately, firmly, and deeply impressed: Adverbs used to indicate a sequence of the depth of depression of certain features, in order from shallow to deep (used for furrows, muscle scars, and so on).

Dental 'plates': Inverted commas are used in the description of the dental supports of some enteletaceans to underline the fact that they are not separated from the sides of the valve by a pair of lateral cavities. The supports do, however, extend to the floor of the valve beneath the teeth.

Dental lamella and ventral adminiculum: These terms are used as defined by Strusz, Chatterton, & Flood (1971).

Crural plates: Expanded proximal portions of the crura, which are fused to the floor of the valve for short or long distances. They may only be fused to the floor of the valve opposite or just in front of the cardinal process, but they are always separated from the shell laterally by cavities. This definition does not essentially depart from that given by Williams et al. It does not, however, conform with Pitrat's use of this term (*in* Moore, 1965) in describing the Spiriferidina.

Fulcral plates: The term is used throughout, in describing Orthida, in the sense of Boucot, Johnson, & Walmsley (1965).

SYSTEMATIC DESCRIPTIONS

Phylum BRACHIOPODA Dumeril, 1806
Class INARTICULATA Huxley, 1869
Order LINGULIDA Waagen, 1885
Superfamily LINGULACEA Menke, 1828
Family CRANIOPSIDAE Williams, 1963
Genus CRANIOPS Hall, 1859

Type species: Orbicula? aquamiformis Hall, 1843.

CRANIOPS AUSTRALIS sp. nov.

(Pl. 1, figs 1-7; Pl. 5, figs 26-30; Text–fig. 6)

Derivation of name: The species occurs in Australia.

Type locality: The base of the Warroo Limestone at Locality A (see Text–fig. 1), 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 17870; paratypes ANU 17871a-h and CPC 10500-2.

Occurrence: Common at several horizons within the *'Receptaculites'* and Warroo Limestones; found at localities A, B, Γ and Д (see Text–fig. 1).

Description

Exterior: The shells are small, calcareous (they have since been silicified), and convexoplane or slightly dorsibiconvex (Text–fig. 6). The largest specimen found is 2.7 mm long and 2.15 mm wide. Growth was holoperipheral, with the apices close to the posterior margin. The shell was apparently attached at some stage during its life by the cementation of the apex of the pedicle valve (?) to the substratum (rather similar scars are present at the apices of both valves, see Pl. 5, figs 26-29, but those of the pedicle valve are placed closer to the posterior margin and are thus thought to be more likely sites of attachment). There is no sign of a foramen. The ornament consists of fine concentric lamellae, in a few specimens, there are signs of fine radial striae on the lamellae anteromedially.

Interior: A raised ledge or limbus runs round the margins of both valves; it is usually broader anteriorly than posteriorly or laterally. A median raised platform is present in both valves, that of the pedicle valve being slightly the more prominent. The musculature of the two valves differs slightly (Text–fig. 6). The anterior and posterior adductor scars are joined by dermal muscle scars, which appear to mark the lateral margins of the body cavity. The anterior adductors are impressed on the median platform, and the posterior adductors along the posterior edge of the median platform.

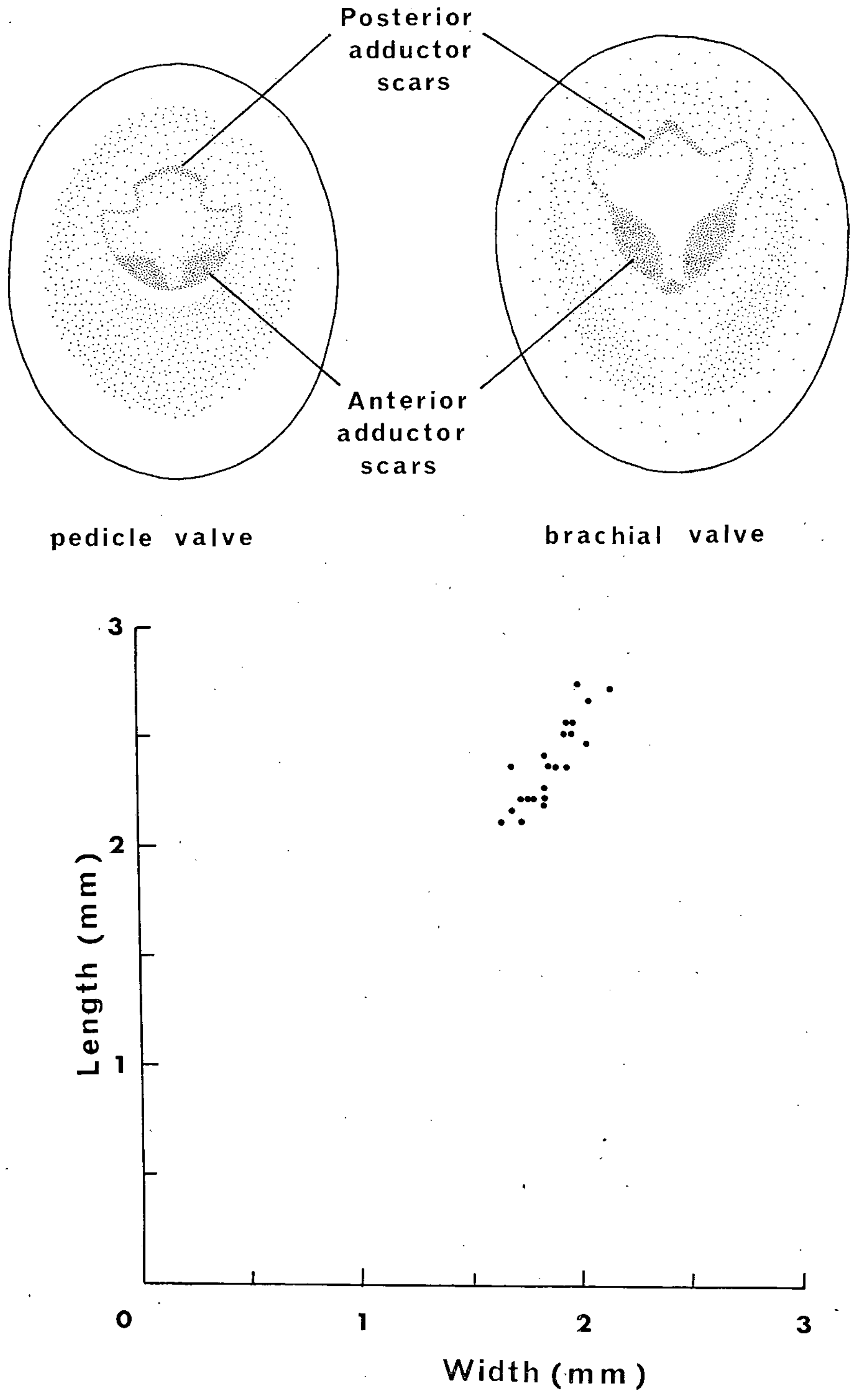

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Fig. 6. *Craniops australis* sp. nov. Specimens from the '*Receptaculites*' and Warroo Limestones.

Discussion

C. australis is not very close to the type species, *Craniops squamiformis* (Hall), but belongs to the same genus (see diagnosis of Rowell, *in* Moore, 1965). *C. australis* is, however, close to *Craniops patina* (Hall), which occurs in the Eifelian 'Corniferous' Limestone at De Cewville, Ontario. The muscle patterns and exteriors of both species are alike, but *C. australis* has no median ridge between the anterior adductor scars of the brachial valve; also the anterior adductors of the brachial valve diverge backward at a greater angle; and the beaks are closer to the posterior margin. Both species appear to have lamellar ornament with fine radial striae on the lamellae anteromedially. *Craniops ovata* (Hall) from the Gedinnian Heldeberg Group of New York is also quite close to *C. australis*, but it is not as close as *C. patina*.

Class ARTICULATA Huxley, 1869
Order ORTHIDA Schubert & Cooper, 1932
Superfamily ENTELETACEA Waagan, 1884
Family DALMANELLIDAE Schubert, 1913
Genus ISORTHIS Kozłowski, 1929

Type species: Dalmanella (Isorthis) szajnochai Kozłowski, 1929.

Owing to excessive 'splitting' within the Enteletacea, with genera sometimes founded on characters that vary intraspecifically, it has become generally rather difficult to place new species within the framework of the existing classification.

Isorthis is here regarded as including forms which have strongly anteriorly divergent dental 'plates'; an isorthoid vascular system (sensu Kemezys, 1968); subequally biconvex shells, with or without an obvious dorsal sulcus and ventral fold; and faceted ventral muscle scars (*sensu* Johnson & Talent, 1967b).

These characters would separate species of *Isorthis* from the type species of *Reeftonia, Reeftonia marwicki* Allan. Gill (1949) described two 'species' from the Lower Devonian of Sandys Creek, Gippsland, Victoria, as belonging to *Cariniferella;* Philip (1962) and Talent (1963) regarded both as belonging to the same species within *Isorthis, Isorthis alpha* (Gill). Johnson & Talent (1967b), however, included this species in *Reeftonia*. The criteria suggested above would also separate *Reeftonia alpha* (Gill) from *Isorthis*.

ISORTHIS SPEDENI sp. nov.

(Pl. 1, figs 8-22; Pl. 2, figs 1-24; Pl. 5, figs 16-24; Pl. 35, fig. 13; Text–fig. 7)

Derivation of name: After Dr I. G. Speden.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 17872; paratypes ANU 17873 a-u, CPC 10503-7 and 10641.

Occurrence: Several localities in the lower half of the Warroo Limestone, including Locality A.

Description

Exterior. The shells are medium sized, punctate, subequally biconvex and wider than long. The cardinal angles are rounded to subangular, and the outline is rounded subquadrate. The maximum width is close to the midlength. The pedicle interarea is apsacline and just over two-thirds of the maximum width of the shell. The pedicle beak is moderately incurved. The delthryium is open and wider than long. An obvious ventral fold and dorsal sulcus run forward from the beaks to the anterior margin, so that the anterior commissure is sulcate. The lateral slopes are gently convex in cross-section, but the median portion over the fold is more strongly convex and subangular. The brachial interarea is orthocline and gently incurved. The ornament consists of costellae that increase by both intercalation and unequal subdivision. There are between 15 and 17 costellae per 5 mm at a distance of 10 mm from the beak. The surfaces of the valves are usually marked by several prominent concentric growth-lines, which are present at irregular intervals, but are concentrated close to the anterior margins of many of the shells of late ephebic and gerontic stages. The anterior margin may be slightly re-entrant.

Interior. Pedicle valve: The teeth are large and subtriangular in cross-section. They are supported by strong dental 'plates' that continue forward as low muscle-bounding ridges. Crural fossettes are firmly impressed in the medial faces of the dental 'plates'. The delthyrial cavity is deep. The diductor scars are deeply impressed, subparallel to gently divergent, longer than the adductor scars, and strongly bilobed anteriorly. The adductor scars are raised on a ridge which varies in width, but is always at least moderately wide anteriorly, and which increases in height anteriorly. The muscle scars are faceted (sensu Johnson & Talent, 1967b). There are signs of ? pedicle adjustor scars along the ventromedial edges of the dental 'plates', ventral to the crural fossettes. Pallial markings are visible in some specimens (Pl. 1, figs 20-21; Pl. 2, fig. 7). A pair of strong vascula media diverges gently forward from the anterior edge of the diductor scars. The vascula genitalia consist of two large areas of interconnecting canals, which extend forward about two-thirds of the length of the valve. The canals closest to the vascula media are organized parallel with them and have fewer inter-connexions with neighbouring canals than those of more lateral regions.

Brachial valve: The brachiophores are strong, blade-like, supported by brachiophore plates, and only gently divergent distally. They diverge forward from the midline at 50-60°. The cardinal process is usually bilobed anteriorly; it is subdivided into a number of processes posteriorly and posterolaterally. The shaft narrows forward and merges with a broad low median ridge, which extends forward to just in front of the midlength, dividing the adductor scars. A pair of elongated adjustor scars is usually obvious on this ridge, a short distance in front of the cardinal process (Pl. 2, fig. 1). The sockets are slightly raised above the floor of the valve on secondary shell, but fulcral plates are not present. The adductor muscle field is divided into a larger anterior and a smaller posterior pair of scars. Each scar is slightly raised on a small platform, which is tilted so that its outer edge (lateral or anterolateral) is higher than its medial portion. There is a sharp drop in elevation along the outer edge of each scar. A pair of vascula myaria runs anterolaterally from opposite the gaps between the two pairs of adductor scars (Pl. 1, fig. 22). In some specimens, the two pairs of scars are separated by a low sub-transverse ridge; in others by a shallow furrow. Distally, the vascula myaria branch to run forward and backward parallel with the margins. There are also faint signs of a pair of vascula media along each side of the median ridge in front of the adductor scars of some specimens.

Ontogeny

Neanic to gerontic stages have been found. The smallest specimens would fall in the middle of the size range of the neanic period suggested by Biernat (1959).

In an articulated specimen 1.95 mm long and 2.85 mm wide, the primary costellae (11 in the pedicle and 12 in the brachial valve) are inserted at the margins of a relatively smooth protegular node, which is just over 0.2 mm long. A median primary costella is present in the pedicle valve, and a median pair in the brachial valve. Secondary costellae start to appear about 0.6 mm from the beaks by intercalation and unequal subdivision. The shell is ventribiconvex. A dorsal sulcus is inserted about 0.5 mm from the beak, and the anterior commissure is sulcate. The pedicle valve is most strongly convex (in cross-section) medially. The delthyrium is subtriangular and wider than high. The pedicle interarea is apsacline and about twice as high as the anacline brachial interarea. The width of the hinge-line is greater than half the maximum width, which is close to the midlength. The outline is rounded subquadrate.

In pedicle valves just under 2 mm long, the teeth are supported by very short strongly divergent dental 'plates'. The diductor scars are short, bilobate, and separated by a broad low adductor ridge. A short pedicle callist is present in the apex of the delthyrial pit. The setal grooves are obvious, and they extend inwards more than half of the distance from the margins to the muscle scars. The three most prominent setal grooves are in positions that suggest that they were opposite, and were probably joined to, a vasculum centrale and a pair of vascula media.

In brachial valves just over 2 mm long, the cardinal process is simple anteriorly, and broader, more elevated, and finely subdivided posteriorly; the brachiophores are strongly divergent and supported by brachiophore plates; the sockets are slightly raised on secondary shell material; the cardinal process only fills about a fifth of the width of the notothyrium; lateral muscle-bounding ridges are gently convergent forward, fused to the brachiophore plates anteriorly and notched near their midlength (presumably opposite the border between the anterior and posterior adductor scars); a pair of subtransverse ridges extends inwards from the anterior edges of the brachiophore plates and appears to separate the posterior adductor scars from what may be a pair of dorsal pedicle adjustor scars; and the three most prominent pairs of setal grooves are in positions that would suggest that they were opposite, and probably joined to, the vascula myaria, the vascula antemyaria (*sensu* Kemezys, 1968), and the vascula media (Pl. 2, figs 11, 14).

In growth stages between these neanic forms and late ephebic forms, the length/width ratio appears to increase slightly (Text–fig. 7); the ventral diductor scars are more firmly impressed and become more elongate; the ventral muscle scars become faceted (*sensu* Johnson & Talent, 1967b); a pair of low lateral muscle-bounding ridges appears along the sides of the ventral diductor scars; and a pair of gently divergent vascular media appears in the pedicle valve. In the brachial valve, two pairs of adductor scars become separable, and the anterior pair migrates anterolaterally so that the lateral muscle-bounding 'ridges' become subparallel with each other; a broad dorsal median ridge and notothyrial platform are deposited; the cardinal process expands posteriorly and is further subdivided; the brachial valve increases relatively in depth so that the shell becomes subequally biconvex and the brachial interarea becomes more orthocline; and the cardinal process fills about two-thirds of the notothyrium and partly blocks the delthyrium. If both the elongate depressions on the dorsal median ridges of mature specimens and the scars between the brachiophore plates of small specimens are adjustor scars, these scars must migrate inwards during growth. The material available tends to support this hypothesis, but does not prove it (Pl. 2, figs 1, 11, 14; Pl. 5, figs 19, 21, 22).

In gerontic specimens, the vascular system and muscle bounding ridges are more strongly developed.

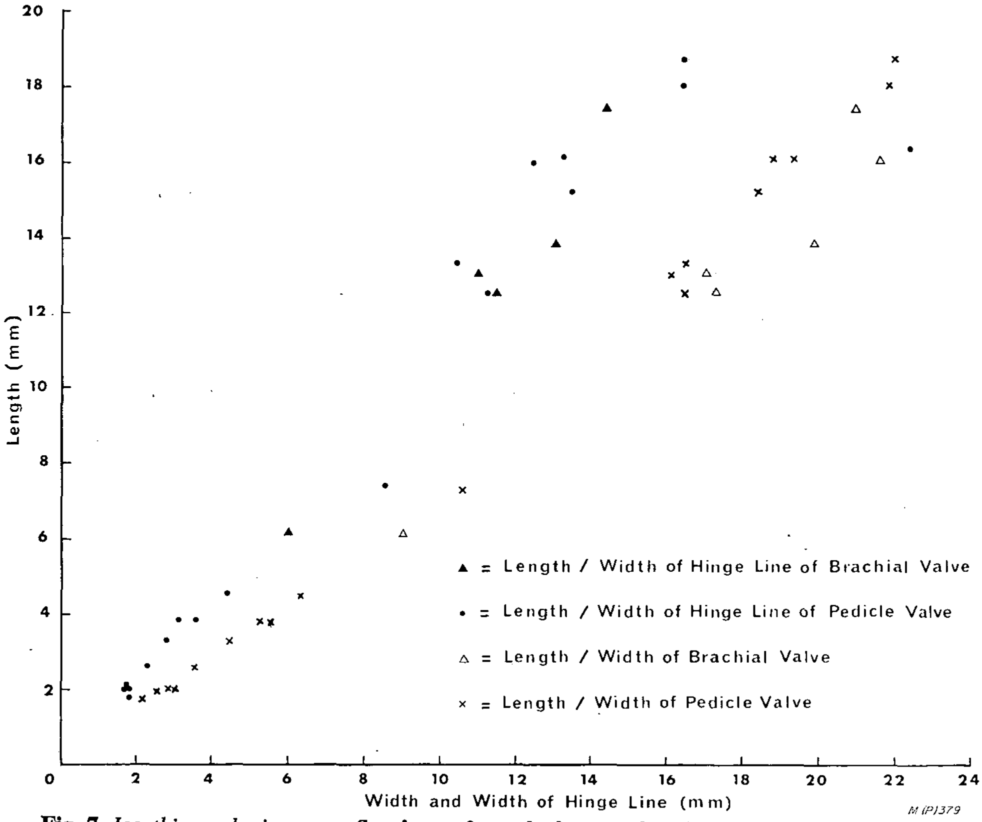

Fig. 7. ***Isorthis spedeni* sp. nov. Specimens from the base of the Warroo Limestone.**

Discussion of ontogeny

The pattern of primary costellae of the early growth stages of *Isorthis spedeni* shows that it falls within the isorthoid vascular system of Kemezys (1968). This feature, finer costellae, a more transverse and subquadrate outline, and a relatively strong fold and sulcus in late neanic stages, separate early growth stages of this species from those of the species of *Aulacella* that occur with it. Biernat (1959) described the ontogeny of *Isorthis canalicula* (Schnur). That of *I. spedeni* is similar in general features; an isorthoid vascular system; a maximum width greater than the length; a hinge-line shorter than the maximum width; and a subquadrate outline. However, as the earliest growth stages of *I. spedeni* were not found the changes described by Biernat in the late nepionic and early neanic stages of *I. canalicula* cannot be demonstrated in *I. spedeni.* Progressively older stages of the two species are more distant.

Discussion

I. spedeni is included in *Isorthis* because it has a strong pair of anteriorly divergent dental 'plates', the ventral muscle scars are faceted, the ventral diductor scars are divided by a broad anteriorly prominent adductor platform (the width of which, however, varies intraspecifically), and the dorsal adductor scars are quadripartite and placed on platforms which are tilted medially and posteromedially so as to appear to have muscle-bounding ridges laterally and anterolaterally.

It differs from *I. szajnochai* Kozłowski, the type species, in that it is not as globose and has a more prominent fold and sulcus. The interiors are quite close (compare Schuchert & Cooper, 1932, pl. 21, figs 20, 27, with this Bulletin, Pl. 1, figs 8-13). *I. spedeni,* however, does not have obvious fulcral plates (it is possible that the features mentioned by Schuchert & Cooper (1932, p. 149) are not fulcral plates *sensu* Boucot, Johnson, & Walmsley, 1965); and the posterior dorsal adductor scars tend to be relatively smaller and are only separated from the anterior adductor scars by a subtransverse ridge in a few specimens. *I. szajnochai* comes from the earliest Devonian of Podolia, USSR.

Isorthis festiva Philip, from the Lower Devonian Tyers area of Victoria, is quite close to *I. spedeni.* Both species have a prominent fold and sulcus. They differ in that *I. festiva* is unequally biconvex; its ventral interarea is 'plane'; the posterior and anterior dorsal adductor scars are subequal in size; its ventral adductor ridge is narrow; and the dorsal adductor scars appear to extend slightly farther forward (some of these features are slightly atypical for *Isorthis).*

Subfamily RESSERELLINAE Walmsley & Boucot, 1971

Genus RESSERELLA Bancroft, 1928

RESSERELLA CAREYI sp. nov.

(Pl. 3, figs 10, 16-27; Pl. 35, figs 1-3; Text–fig. 8)

Derivation of name: After Mr Tom Carey.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 17878; paratypes ANU 17879a-b, CPC 10508-10511 and CPC 10642-10644.

Occurrence: Type locality only.

Description

Exterior: The brachial valve is gently convex, the pedicle valve slightly deeper. The shell is punctate. The cardinal angles are subangular (obtuse angles). The width is only slightly greater than the length, and is greatest between the hinge-line and the midlength (usually nearer to the midlength). The outline is elongate semicircular to shield-shaped. The width of the hinge-line is over three-quarters of the maximum width of the shell. The pedicle interarea is apsacline to almost orthocline and moderate in length. It is interrupted medially by a delthyrium, which is slightly wider than high and partly closed apically by secondary shell material. The secondary shell material that closes the delthyrium may be convex dorsally and appear similar to a pseudodeltidium. The brachial beak is small and slightly incurved; the brachial interarea is anacline. A sulcus runs forward from the beak of the brachial valve to the anterior margin, so that the anterior commissure is sulcate. The lateral slopes of the pedicle valve are gently convex, and the median portion relatively strongly convex, in cross-section. The anterior margin is convex. The ornament is weakly fascicostellate, and the stronger costellae are not very regularly distributed among a greater number of finer costellae. The costellae number between 21 and 24 per 5 mm at a distance of 10 mm from the beak. Occasional prominent concentric growth-lines are present.

Interior. Pedicle valve: The teeth are large, subtriangular in cross-section, and supported by strong dental 'plates', in the medial sides of which are obvious crural fossettes. The muscle scars only extend a short distance in front of the teeth. Their anterior margin is slightly raised relative to the rest of the anterior part of the shell. The adductor scars appear to run forward subparallel with each other, and usually extend as far as the diductor scars. The diductor scars are subdivided by a few gentle subradiate ridges. There are weak signs of pallial markings in a few specimens (Pl. 3, figs 25, 27).

A pair of vascula media runs forward subparallel or diverges slightly forward before branching distally. The margins are crenulate. Raised rims are present along each side of the larger setal grooves, which are associated with the larger costellae of the external ornament.

Brachial valve: The brachiophores are strong, pointed distally, and supported by a pair of stout brachiophore plates. They diverge forward about 40° from the midline. The cardinal process is usually bilobed ventrally and subdivided into a number of small irregular lobes posteriorly. The shaft narrows forward and joins a broad low ridge, which divides and dies out at the anterior edge of the adductor scars. The adductor scars narrow gently forward, and are quadripartite; the anterior pair is smaller than the posterior pair, from which it is separated by a pair of low ridges that runs slightly forward of laterally. In some specimens, a small pair of elongate dorsal adjustor scars is present on the median ridge opposite the anterior halves of the brachiophore plates. The sockets are slightly raised above the floor of the valve on secondary shell material, but fulcral plates are not present. Pallial markings are not obvious on any of the brachial valves found.

Discussion

The only resserellids yet described from southeast Australia are *Resserella impensa* Philip from the Lower Devonian (? Gedinnian to Siegenian) of the Tyers area, Victoria, and *Visbyella cumnockens* Walmsley, Boucot, Harper, & Savage from the Wenlockian Manildra Formation near Cumnock, New South Wales (Walmsley & Boucot, 1971, exclude *Parmorthis vandiemeni* Gill, 1948, and *Parmorthis* aff. *P. allani* (Shirley) Gill, 1950, from the Resserellinae). *R. impensa* can be readily separated from *R. careyi* by its coarser costellae. The costellae of both species are semi-fascicostellate. *R. careyi* may have descended from *R. impensa* or a closely related form.

The two species closest in age to *R. careyi* are the Emsian forms *Resserella pragensis* (Havlíček) from the Zlickov limestone (Upper Emsian) of Bohemia and *Resserella triangularis* (Maurer) from Emsian rocks of the Rhineland and Emsian to Eifelian rocks of Kazakhstan (see Walmsley & Boucot, 1971). *R. careyi* differs from *R. triangularis* in that its costellae are coarser and semi fascicostellate, its ventral diductor scars are shorter, its brachial valve is not planar in profile, its dorsal median ridge is not as prominent and its teeth and sockets are not crenulate; and from *R. pragensis* in that it lacks a very prominent median ridge in the brachial valve.

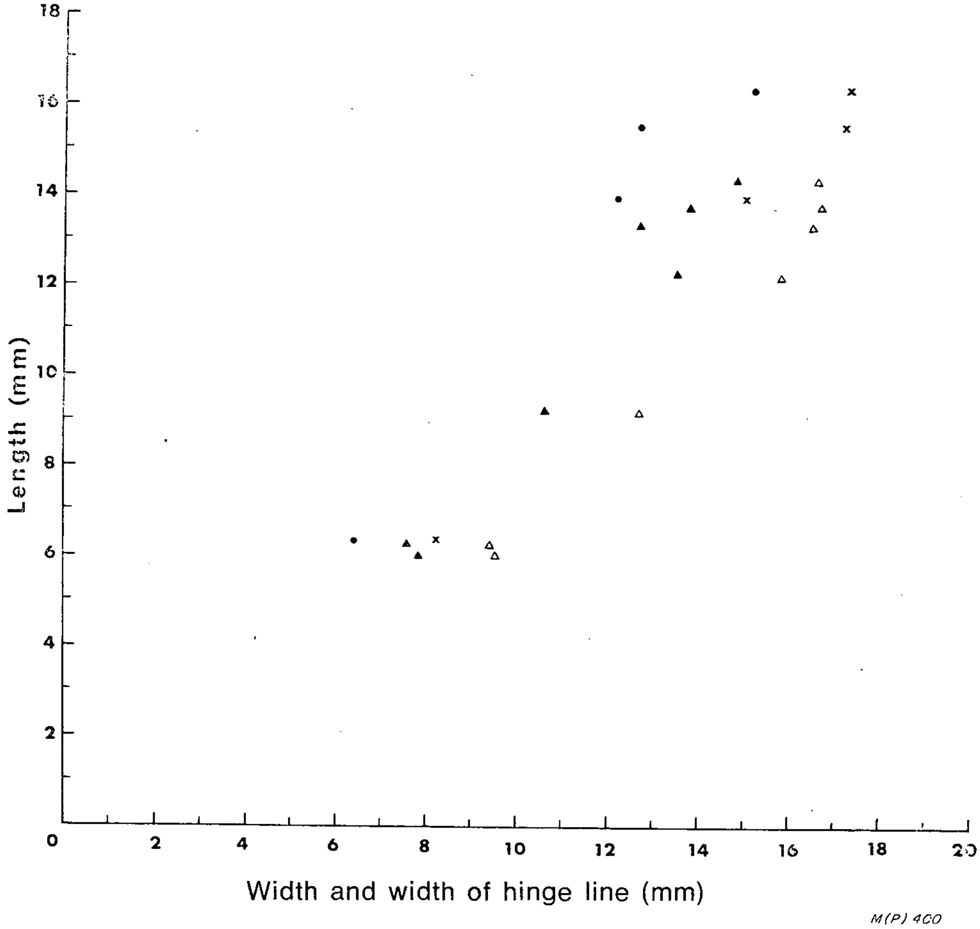

Fig. 8. *Resserella careyi* **sp. nov. Specimens from the base of the Warroo Limestone. Symbols as in Fig. 7**

R. careyi is an unusual species of the genus in that it lacks crenulated teeth and sockets and has a calcareous deposit in the apex of the delthyrium. Schuchert & Cooper (1932) noted a similar deposit in some species of *Parmorthis* Schuchert & Cooper, a genus which is now regarded as a junior subjective synonym of Resserella (Walmsley & Boucot, 1971), and stated: 'Noteworthy also in this genus is the occurrence of a small deposit of secondary shell in the apex of the delthyrium. This has nothing whatever to do with a delthyrium, being merely an apical callus such as occurs in some spiriferid genera'.

Family SCHIZOPHORIIDAE Schuchert & Le Vene, 1929

Subfamily DRABOVIINAE Havlíček, 1950

Genus SALOPINA Boucot, 1960

Type species: Orthis lunata Sowerby, 1839.

Discussion

The diagnosis of Walmsley, Boucot, & Harper (1969) is used here.

SALOPINA KEMEZYSI sp. nov.

(Pl. 2, figs 15-31; Text–fig. 9)

Derivation of name: After Dr K. J. Kemezys.

Type locality: The basal 60 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 17874; paratypes ANU 17875a-h and CPC 10512-10516.

Occurrence: The basal 60 m of the *'Receptaculites'* Limestone at localities B and Γ.

Description

Exterior: The shells are small and slightly ventribiconvex. The outline is transversely ovate to subcircular. The cardinal extremities are subangular, with obtuse angles. The maximum width is close to or slightly behind the midlength. The largest specimen found is 7.2 mm wide and 5.0 mm long. The pedicle beak is small and slightly incurved. The pedicle interarea is apsacline, slightly concave, and about three-quarters of the maximum width. The delthyrium is open and higher than wide. The median portion of the pedicle valve is more convex than the lateral slopes in cross-section. The height of the brachial interarea is only about a third to half that of the pedicle valve. The brachial interarea is anacline; the beak slightly incurved. A gentle sulcus runs from near the brachial beak to the anterior margin so that the anterior commissure is sulcate. The anterior margin is gently convex. The ornament is costellate; the costellae, which increase by both intercalation and unequal subdivision, number about 14 per 2.5 mm at a distance of 5 mm from the beak. Prominent concentric growth-lines are not usually present.

Interior. Pedicle valve: Moderate-sized teeth are supported by a pair of dental plates, which are fused anteriorly to a pair of muscle-bounding ridges that are convex laterally. The lateral muscle-bounding ridges do not extend as far forward as the midlength; they are usually restricted to the posterior quarter or third of the valve. The dental plates diverge forward from the midline at 40-50°. The anterior margin of the diductor scars is rarely delineated precisely. The diductor scars are short; they may be convex or slightly bilobate anteriorly; and they may be separated by a broad low adductor ridge. Adductor scars may be visible on the adductor ridge. The pattern of the costellae and the faint signs of pallial trunks conform to the isorthoid vascular system of Kemezys (1968). A vasculum centrale and a pair of vascula media are faintly visible in some specimens.

Brachial valve: Blade-like brachiophores, whose apices are pointed and divergent, are supported by a pair of brachiophore plates. The anterior margins of the brachiophore plates are fused to a pair of low lateral muscle-bounding ridges, which extends forward slightly divergent as far as the midlength. Gently impressed adductor scars are elongate and not obviously separated into anterior and posterior pairs of scars. They extend forward anterolaterally to merge with a pair of vascula media, which diverges gently forward. They may be partly divided by a low median ridge, which is usually more prominent in young than in mature specimens. The cardinal process is simple anteriorly, and divided into a few irregular processes posteriorly. The sockets are raised on a pair of fulcral plates. Vascula media and a pair of vascula myaria extent distally to join setal grooves.

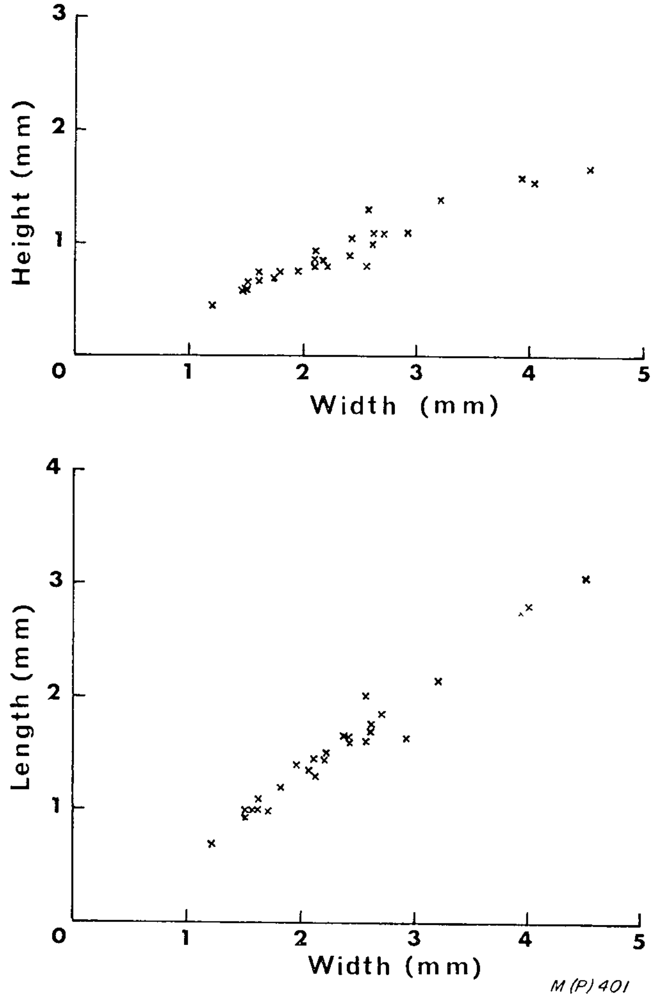

Fig. 9. ***Salopina kemezysi*** **sp. nov. Specimens from '*Receptaculites*' Limestone.**

Discussion

S. kemezysi is close to some undescribed forms that occur in the Ludlovian rocks of the Yass Basin. Of the species of *Salopina* described by Walmsley et al. (1969), it is probably closest to the Eifelian form *Salopina hazardensis* Walmsley, Boucot, & Harper. Both species have deep interspaces between the crenulations that persist for at least a third of the valve length; both are small; and the dorsal muscle field is weakly impressed and usually lacks strongly defined margins. *S.*

kemezysi, however, is weakly sulcate, and the median raised area of the brachial valve does not always obviously expand forward.

The species is not very close to any previously described Australian enteletacean brachiopods.

Genus MURIFERELLA Johnson & Talent, 1967

Type species: Muriferella masurskyi Johnson & Talent, 1967.

MURIFERELLA HILLAE sp. nov.

(Pl. 3, figs 1-9, 11-15; Pl. 35, figs 4-5; Text–figs 10, 11)

Derivation of name: After Professor Dorothy Hill.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 17876; paratypes ANU 17877a-d. CPC 10517-10519 and CPC 10645.

Occurrence: Several localities in the lower half of the Warroo Limestone.

Description

Exterior: The shells are small, ventribiconvex, and slightly wider than long (Text–fig. 10). The cardinal angles are subangular (obtuse angles) to rounded. The anterior margin is convex, and the outline is subcircular. The anterior commissure is sulcate. A sulcus runs from the brachial beak to the anterior margin. The median portion of the pedicle valve is more convex than the lateral slopes in cross-section. The pedicle beak is moderately incurved; the pedicle interarea is moderate in length, apsacline, and about three-quarters of the maximum width. The delthyrium is partly blocked apically by deposition of secondary shell material, and laterally by a pair of long and very narrow 'deltidial plates'. Its height is subequal to its width. The brachial beak is small and little incurved; and the brachial interarea is anacline. The valves are ornamented by numerous hollow costellae, which increase by intercalation and unequal subdivision. There are about 10 costellae per 2.5 mm at a distance of 5 mm from the beak. The largest specimen found is 7.0 mm long and 8.1 mm wide.

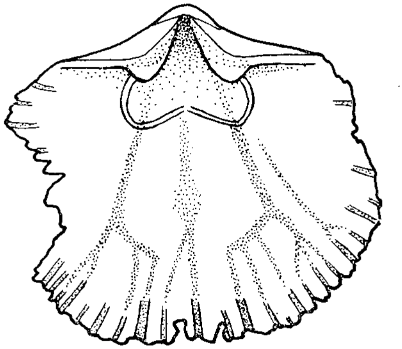

Fig. 10. ***Muriferella hillae*** **sp. nov. A view of the interior of a pedicle valve. Note the vascula media and vasculum centrale.**

Interior. Pedicle valve: The teeth are supported by well developed dental plates, which are separated from the lateral portions of the valve by a pair of shallow lateral cavities. The muscle scars only extend a short distance in front of the dental plates. The anterior margin of the muscle scars is usually gently convex, but may be gently bilobate, with the diductor scars extending a short distance in front of the adductors. The dental plates diverge strongly forward. Pallial markings are gently impressed in some specimens; and it is possible to recognize a vasculum centrale and a pair of vascula media, which slightly diverges forward from the front of muscle scars (Text–fig. 10). The margins of the valve are crenulate. Fine ridges are present along each side of some of the larger setal grooves.

Brachial valve: The brachiophores are blade-like, pointed, and attached to the floor of the valve by a pair of anteriorly divergent brachiophore plates. The sockets are 'cylindroidal' and raised above the floor of the valve on a pair of fulcral plates. The cardinal process may be bilobed or irregular ventrally and is further subdivided posteriorly. It is raised on a prominent notothyrial platform, which runs forward into a high triangular median septum. The median septum increases in height forward so that its anteroventral margin is adjacent to the anteromedial portion of the inner surface of the pedicle valve; its posteroventral edge may be straight or concave and is usually slightly thicker than the rest of the septum; and its anterior edge is flush with the anterior margin of the valve. A pair of muscle-bounding ridges is present on either side of the long adductor scars, which extend forward two-thirds of the length of the valve. The adductor scars are not obviously divided into anterior and posterior pairs. The muscle-bounding ridges are not always directly fused to the brachiophore plates. No brachial valves showed obvious pallial markings.

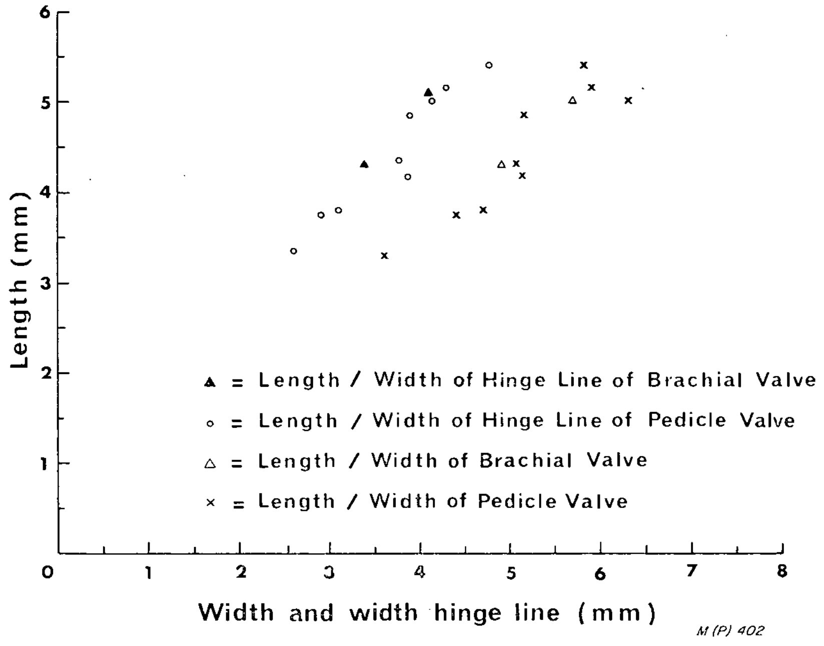

Fig. 11. ***Muriferella hillae*** **sp. nov. Specimens from the Warroo Limestone.**

Discussion

In most of its characters *Muriferella hillae* fits the genus *Muriferella,* but it differs from other known species of that genus in having a high triangular dorsal median septum. In this character it is closer to *Vallomyonia* Johnson, from which it differs in having obvious dental plates in mature specimens. Small specimens of *Vallomyonia* have fine dental plates, but larger specimens lack them. Johnson &

Talent (1967a, p. 45) stated: 'Morphologic comparisons and stratigraphic occurrence also support the probability that *Muriferella* gave rise to *Vallomyonia*. probably some time in the Eifelian'. *Muriferella hillae* sp. nov. is in many ways intermediate morphologically between the two genera; if this is phylogenetic also, a late Emsian or early Eifelian age is suggested. This would fit in with other data on the age of the '*Receptaculites*' and Warroo Limestones (see p. 11).

M. hillae differs from the type species *M. masurskyi* Johnson & Talent from the *Eurekaspirifer pinyonensis* zone, Nevada (Emsian), in that it possesses a high triangular dorsal median septum; it is smaller; the sulcus in the brachial valve is not as pronounced; and the anterior margin is more convex.

It differs from *M. punctata* (Talent) from the Lower Devonian of the Mitchell and Wentworth rivers, Tabberabbera, Victoria, in that it has a high triangular dorsal median septum; the pedicle interarea is apparently not as 'steep'; and the vascula media of the pedicle valve do not converge forward in any of the specimens where they were seen. It is clear that these two species are quite close and differ predominantly in the height of the dorsal median septum.

Family RHIPIDOMELLIDAE Schuchert, 1913

Genus AULACELLA Schuchert & Cooper, 1931

1953 *Dalejina* Havlíček, p. 5.
1965 *Dalejina* Havlíček; Boucot, Johnson, & Walmsley, p. 337.

Type species: Orthis eifelensis Schnur, 1853.

The diagnoses given by Williams & Wright (1963 and *in* Moore, 1965) of *Aulacella* suggest that it differs from *Mendacella* Cooper (and *Dalejina* Havlíček, which they included in *Mendacella* as a junior subjective synonym) in that its ventral diductor scars do not surround the adductor scars; the shallow dorsal sulcus and low ventral fold are 'rarely reversed' in adult shells; and the cardinal process is usually trilobed.

Boucot, Johnson, & Walmsley (1965, p. 336) separated *Dalejina* from *Mendacella* and stated: 'In *Dalejina,* the broad flabellate diductor impressions, separated only by a narrow median ridge and enclosing the adductor impressions in the pedicle valve (pl. 46, figs 1, 19, 21, 22, 23, 24, 26) (not well shown on other specimens of *D. Hanusi* owing to small size) contrast with the relatively narrow, elongate, non-flabellate diductor impressions of *Mendacella* (pl. 45, figs 6, 10, 11, 12, 15, 16, 23, 27, 28), in which they are separated by a relatively broad median ridge. *Dalejina* and *Mendacella* cannot be regarded as congeneric as stated by Williams and Wright.'

They also said (1965, p. 334): 'Williams and Wright (1963, p. 27) state that in *Aulacella* the diductors do not enclose adductors. The figures 10-15 of Biernat (1959, pl. 1) show variation to conspicuously flabellate diductor impressions enclosing the adductors. Williams and Wright also state that the cardinal process is trilobed. Biernat's text–figure 9 (1959, p. 29) shows that it may be bilobed or trilobed.'

If this statement is accepted it is difficult to see how *Dalejina* may be easily separated from *Aulacella*. They cannot be separated on the basis of the rarity of the reversal of the fold and sulcus at the anterior margins of mature specimens, as nearly all the specimens of the type species *Aulacella eifelensis* figured by Biernat

(1959, pl. 2, figs 6s-10d) show this character. Nor can they be separated easily on the basis of only a narrow ridge separating the anteromedial portions of the ventral diductor scars in *Dalejina,* as the specimens of *Dalejina hanusi* Havlíček, the type species of *Dalejina,* and of *Dalejina* cf. *D. hanusi* illustrated by Boucot, Johnson, & Walmsley (1965, pl. 46) do not show this character any more clearly than the specimens of *A. eifelensis* figured by Biernat. Thus, it is suggested that *Dalejina* should be suppressed as a junior subjective synonym of *Aulacella.*

The considerable variation in the distance between the anteromedial portions of the ventral diductor scars of *Aulacella philipi* sp. nov. tends to support this view. *Aulacella* can be separated from *Mendacella* on the basis of its more flabellate ventral diductor scars, which surround or almost surround the adductor scars.

The presence in the early ontogenetic stages of both *Aulacella stoermeri* sp. nov. and *A. philipi* of a rhipidomelloid vascular system (*sensu* Kemezys, 1968) supports the suggestion by Boucot, Johnson, & Walmsley (1965) that *Aulacella* should be removed from the Dalmanellidae to the Rhipidomellidae.

AULACELLA PHILIPI sp. nov.

(Pl. 4, figs 13-20; Pl. 5, figs 9-15; Pl. 35, figs 10-11; Text–fig. 12)

Derivation of name: After Professor G. M. Philip.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18913; paratypes ANU 18914a-i, CPC 10520-10522 and CPC 10646-10647.

Occurrence: The base of the Warroo Limestone at Locality A.

Description

Exterior: The shells are medium-sized, punctate, and subequally biconvex. The cardinal extremities are rounded, and the hinge-line is usually less than half the maximum width (Text–fig. 12). The maximum width is in front of the midlength. The anterior margin is gently convex to slightly emarginate. A median sulcus is present in the brachial valve, and in some specimens degenerates anteriorly. In all the mature specimens examined, a ventral sulcus and a dorsal fold render the anterior commissure plicate. The pedicle beak is small and incurved, and the interarea concave, short, and apsacline. It is interrupted by an open delthyrium, which is slightly wider than long and almost completely blocked, in articulated specimens, by the cardinal process. The brachial interarea is short and orthocline. The ornament consists of hollow costellae, which increase both by intercalation of new costellae along the sides of older costellae and by division into two costellae of different sizes. There are between 8 and 11 costellae per 5 mm at a distance of 10 mm from the beak. Occasional strong concentric growth-lines are visible. They tend to be concentrated near the anterior margins of mature specimens (late ephebic and gerontic stages).

Interior. Pedicle valve: The teeth are strong and subtriangular in cross-section. They are supported by dental 'plates', which are fused to the sides of the valve laterally and diverge forward at 40-50° from the midline. They are fused to the posterior ends of a pair of low lateral muscle-bounding ridges, which runs forward as far as the midlength. A pair of obvious crural fossettes is impressed in the

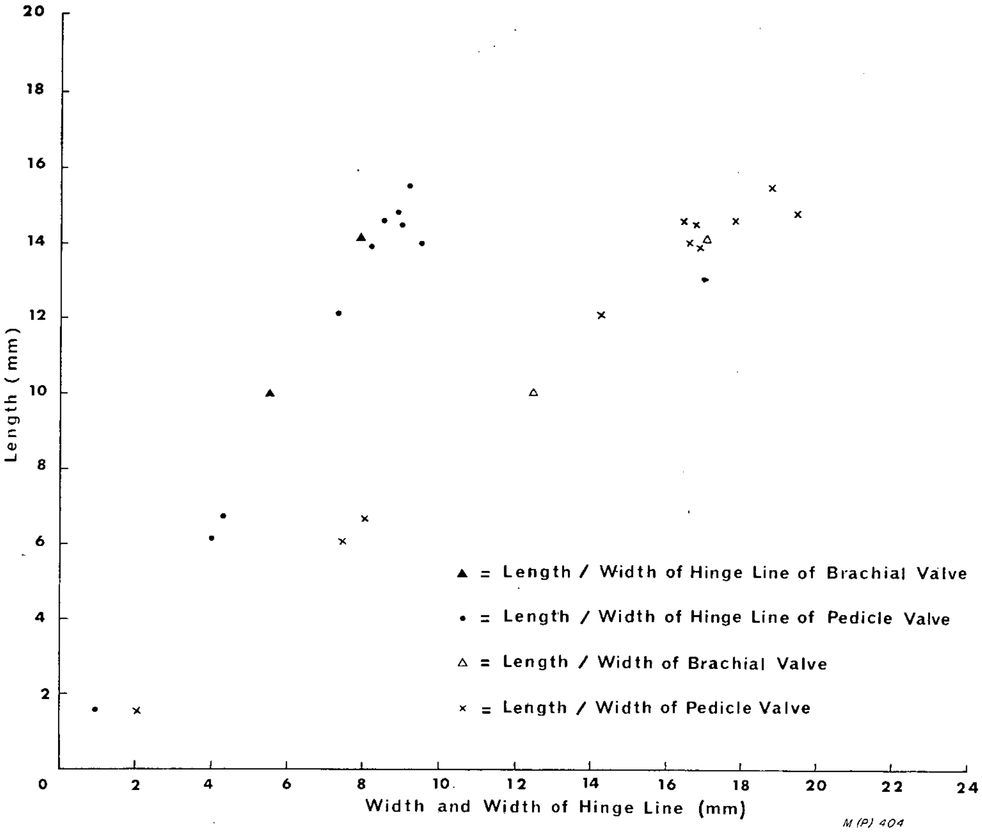

Fig. 12. ***Aulacella philipi*** **sp. nov. Specimens from the Warroo Limestone.**

dorsomedial portions of the dental 'plates'. The delthyrial pit is deep and has a large and obvious pedicle callist, which is slightly raised above the rest of the floor of the valve. The adductor scars are elongately oval, and may be raised slightly above or impressed slightly below the adductor scars. They are usually surrounded by the diductor scars anteriorly, and are subdivided by and partly raised on a median ridge, which reaches its maximum height at the anterior edge of the adductor scars and disappears at the anterior edge of the diductor scars; it separates the anteromedian portion of the diductor scars, and may be either narrow or relatively broad (Pl. 4, figs 13, 14, 18). The diductor scars are flabellate and their lateral margins are scalloped and run forward subparallel or gently divergent. Pallial markings were not obvious on any of the specimens discovered. The margins are crenulate; and the crenulae are flat in cross-section and subdivided by a median groove.

Brachial valve: The brachiophores are blade-like, pointed anteroventrally, and supported by brachiophore plates. They diverge strongly distally. The sockets are raised slightly above the floor of the valve on secondary shell material, but fulcral plates are not present. The cardinal process is usually simple and shaft-like anteriorly and subdivided into numerous small processes posteriorly; one specimen was found with a cardinal process trilobate ventrally. The shaft narrows anteriorly and joins a low median ridge, which extends forward just over half the length of the valve and subdivides the adductor scars. The adductor scars are very gently impressed and are divided into anterior and posterior pairs by a pair of very gentle subtransverse ridges; the anterior pair is slightly the larger. These scars are delineated laterally by very gentle muscle-bounding ridges, which are interrupted between the two pairs and between the posterior pair and the brachiophore plates. Gentle pallial markings are apparent in one specimen; a pair of vascula myaria extends anterolaterally from the edge of the scars opposite the ridges that separate the two pairs; a pair of vascula media appears to branch directly in front of the adductor scars, and the branches run anterolaterally and just laterally of anterior.

Ontogeny

A small articulated specimen 1.5 mm long and 1.9 mm wide has a subround pedicle opening; an apsacline pedicle interarea and an anacline brachial interarea; 13 primary costellae on the brachial valve and 12 on the pedicle valve, which are inserted at the distal edges of a smooth protegular node, just over 0.2 mm long; a median costella on the pedicle valve; an outline similar to mature individuals, with the maximum width in front of the midlength; a ventribiconvex form; a hinge-line just under half the maximum width; a sulcate anterior commissure; and a dorsal sulcus, which appears about 0.7 mm from the beak.

A pedicle valve 1.55 mm long shows the following features: the teeth are not supported by obvious dental plates; the diductor scars are short and bilobed, and do not surround the adductor scars; a short pedicle callist is present in the apex of the delthyrium; the internal expression of the costellae, or setal grooves, are long and little infilled by secondary shell material; and the lateral muscle-bounding ridges are very weak.

In a brachial valve 1.75 mm long, the cardinal process is simple and shaft-like anteriorly, and slightly expanded, elevated, and finely subdivided posteriorly; a pair of brachiophores is strongly divergent and supported by brachiophore plates; the gently impressed adductor scars are not obviously quadripartite; the sockets are slightly raised on secondary shell material; and the cardinal process only fills one-fifth of the width of the notothyrium.

Few specimens were found between these neanic stages and late ephebic stages. During this phase of development the following changes apparently take place: ventral muscle scars increase in length, differentiate, and become more flabellate; obvious scalloped muscle-bounding ridges appear; the ventral diductor scars surround or almost surround the adductor scars and a median ridge becomes more obvious; the cardinal process increases in width and elevation posteriorly so that it fills two-thirds of the width of the notothyrium and partly blocks the delthyrium; the dorsal adductor scars become more elongate, are differentiated into an anterior and a posterior pair, and are slighthly more firmly impressed; secondary costellae are added by intercalation and unequal subdivision; the beaks incurve so that the brachial interarea is anacline-orthocline; and a dorsal fold and ventral sulcus appear toward the anterior margin so that the anterior commissure is plicate (the plication of the anterior commissure is usually flattened medially because the original dorsal sulcus usually persists to the anterior margin).

Discussion of ontogeny: Biernat (1959) described the ontogeny of *A. eifelensis* (Verneuil), the type species of *Aulacella*. Unfortunately, the early ontogenetic material of *A. philipi* is neither complete nor perfectly preserved, and Biernat's material consisted predominantly of articulated shells. Some comparisons may be noted, however. Similarities include the presence of a median costella in the pedicle valve (rhipidomelloid vascular pattern of Kemezys, 1968); the pedicle opening is subrounded in early neanic stages (Pl. 5, fig. 9); specimens about 1.5 mm long are ventribiconvex, and later stages become biconvex; the dorsal sulcus appears between 0.5 and 1 mm from the beak; and the primary costellae are inserted between 0.2 and 0.3 mm from the beak. On the other hand, *A. philipi* appears to have slightly more primary costellae (the few specimens found appear to have 13 on the brachial valve and 12 on the pedicle valve, whereas *A. eifelensis* has 11 and 10 respectively); early stages are not subquadrate; and the hinge-line of early stages of *A. philipi* appears to be relatively shorter.

The ontogeny of *A. philipi* is fairly similar to that of *A. stoermeri* sp. nov., but the outline of young specimens of *A. philipi* is not as quadrate, and the maximum width is usually in front of the midlength. In general, however, too few small individuals of both species were found to attempt to draw fine distinctions between them. Both species have a median primary costella in the brachial valve and a median pair in the pedicle valve.

Discussion

Aulacella philipi sp. nov. occurs at a similar stratigraphic level to *A. stoermeri* sp. nov., but only rarely at the same locality; usually the faunal associations are slightly different. They differ in that in *A. stoermeri* the maximum width is usually close to the midlength; the length of the hinge-line is more than half the maximum width; and the ventral diductor scars are not as flabellate, with lateral muscle-bounding ridges that are usually not as scalloped.

A. philipi is close to *A. eifelensis* (Verneuil), the type species of *Aulacella* from the Middle Devonian (Eifelian) of Germany and Poland. It differs in having less rounded costellae, and rather smaller brachiophore plates and teeth. It is difficult to separate mature individuals of these species on other characters owing to the variability of both species.

AULACELLA STOERMERI sp. nov.

(Pl. 4, figs 1-12; Pl. 5, figs 1-8; Text–fig. 13)

Derivation of name: After Professor L. Stφrmer.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 17880; paratypes ANU 18912a-h and CPC 10523-10526.

Occurrence: Common in the top of the *'Receptaculites'* Limestone and rare in the base of the Warroo Limestone. It was found at localities A and Д.

Description

Exterior: Shells medium sized, subequally biconvex, punctate, with rounded cardinal extremities and with a rounded quadrate outline. The width is greater than the length, and the maximum width is close to the midlength. The pedicle beak is small and incurved; the pedicle interarea is apsacline, and usually extends outward just over half the width of the shell (Text–fig. 13); and the delthyrium is open and wider than high (it is partly blocked by the cardinal process).

A gentle ventral keel and dorsal sulcus run forward from the beaks, but towards the anterior margin they degenerate into a gentle dorsal fold and ventral sulcus so that the anterior commissure is plicate. The dorsal sulcus may persist to the anterior margin, where it is present on the more obvious dorsal fold. The brachial beak is small and suberect; and the brachial interarea is slightly shorter than that of the pedicle valve, and anacline to orthocline. The ornament consists of hollow costellae that increase by both intercalation along the sides of older costellae and unequal subdivision. The costellae number between 10 and 12 per 5 mm, at a distance of 10 mm from the beak. The surfaces of the valves are usually marked by a series of prominent growth-lines at irregular intervals, but tending to be concentrated at the anterior margins of late ephebic and gerontic specimens.

Interior. Pedicle valve: The teeth are strong and subtriangular in cross-section. They are supported by short thick dental 'plates', which diverge at 40-50° from the midline. Firmly impressed crural fossettes are present along the dorsomedial edges of the dental 'plates'. The delthyrial cavity is deep, and contains a pedicle callist, which is slightly raised above the floor of the valve (Pl. 5, fig. 8). The dental 'plates' abut low muscle-bounding ridges, which may reach forward as far as the midlength. The anterior portions of the diductor scars are not very often delimited by muscle-bounding ridges in the ephebic stages. The adductor scars are elongately oval. They are surrounded to the anterior by the diductor scars, and are partly positioned on and partly divided by a median ridge, which increases in height forward so that it reaches its maximum height in front of the anterior ends of the adductor scars. This ridge is usually apparent at the posterior end of the adductor scars, but it may only appear half way towards their anterior margin of the diductor scars. The lateral margins of the diductor scars run forward subparallel with each other or converge slightly. The anterior margin of the diductor scars is bilobate, and the lateral margins may be more or less scalloped. The pallial markings are not obvious, although a series of fine branching furrows runs sublongitudinally, anteromedially in some specimens.

Brachial valve: The cardinal process is simple and shaft-like anteriorly, and trilobed or irregularly divided posteriorly. It is higher posteriorly than anteriorly. The shaft narrows forward and passes into a broad low ridge that runs forward to the midlength, subdividing the adductor scars. The brachiophores are blade-like, supported by brachiophore plates, and strongly divergent distally. The sockets are raised slightly on secondary material, but fulcral plates are not present. The adductor scars are gently impressed, quadripartite, and bounded laterally by a pair of very low ridges, which is slightly suppressed and convergent between the two pairs of adductor scars. The two pairs are similar in size, and are separated by a pair of very low subtransverse ridges. The margins are crenulate, and the crenulae are flat in cross-section, with a medial groove. Pallial markings are not obvious.

Ontogeny

The smallest individual discovered is 2.6 mm long and 3.2 mm wide. Its outline is similar to that of a mature individual (Pl. 5, fig. 2); secondary costellae are apparent (within 1.5 mm of the apex); the primary costellae appear at the margins of a protegular node, about 0.2 mm from the beak; there appear to be about 13 primary costellae in the brachial valve and 12 in the pedicle valve; the pedicle valve is slightly deeper than the brachial, and the apsacline pedicle interarea is about twice as high as the anacline brachial interarea; the pedicle opening is subtriangular and slightly wider than long; and a gentle dorsal sulcus and ventral fold are present so that the anterior commissure is sulcate. The costellar pattern, with a central primary costella in the brachial valve, suggests that this species has a rhipidomelloid vascular system (*sensu* Kemezys, 1968).

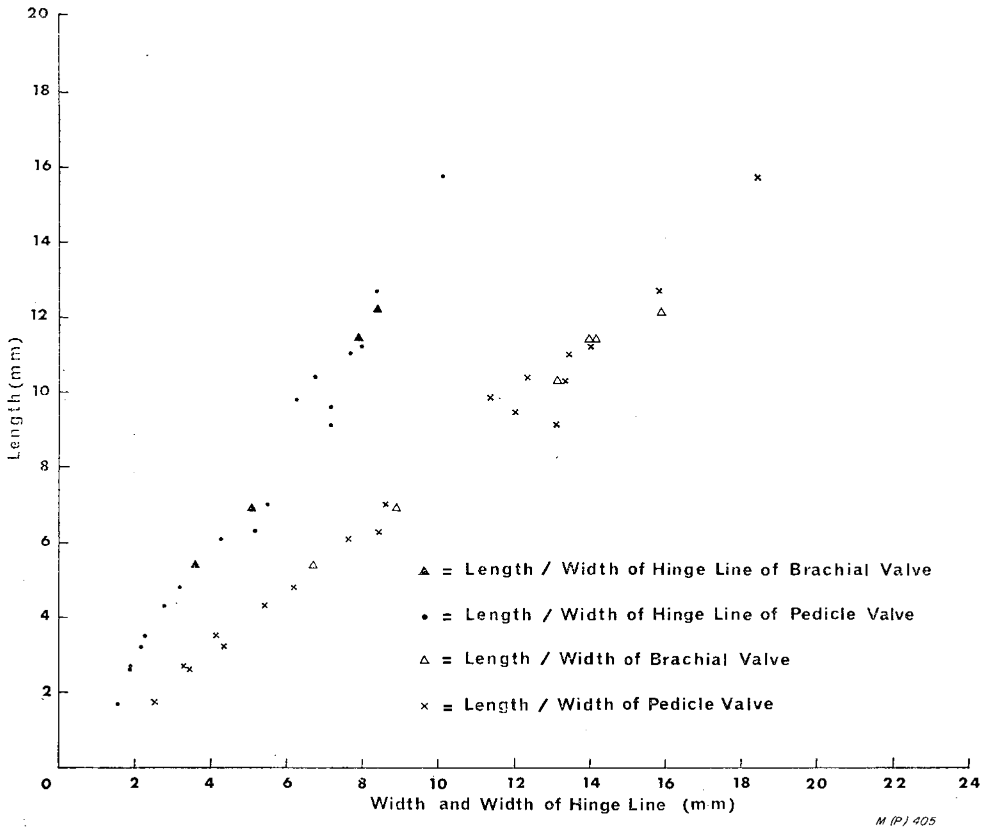

Fig. 13. ***Aulacella stoermeri*** **sp. nov. Specimens from the top of the** ***'Receptaculites'*** **Limestone.**

A pedicle valve 3.3 mm long and 4.1 mm wide has a pair of moderate sized teeth, which is supported by a pair of short dental 'plates' that is not separated from the lateral portions of the valve by lateral cavities. The dental 'plates' are fused anteriorly to low lateral muscle-bounding ridges, and are pitted dorsomedially by a pair of crural fossettes. The bilobate diductor scars are moderate in length and do not surround the adductor scars anteriorly. A low median ridge divides the muscle scars. A short pedicle callist is present.

An incomplete brachial valve (Pl. 5, fig. 1), 3.1 mm long, has a pair of strongly divergent brachiophores supported by a pair of brachiophore plates; sockets, slightly raised on secondary shell material; a cardinal process simple anteriorly, finely divided posteriorly, and raised on a low notothyrial platform; and gently impressed quadripartite adductor scars subdivided by a low median ridge and a pair of low subtransverse ridges, and bounded by very low ridges.

Between these and late ephebic stages the following changes took place; the depth of the brachial valve increased relatively so that the shells became subequally biconvex; a dorsal fold and ventral sulcus appeared anteriorly so that the anterior commissure became plicate; the cardinal process became higher, wider, and more obviously divided posteriorly; the notothyrial platform and median ridge increased in height slightly; the ventral diductor scars increased in length and surrounded the adductor scars anteriorly; the median ridge of the ventral valve increased in height slightly; the costellae increased in number; and the lateral muscle-bounding ridges of the ventral valve became more prominent.

Discussion

Aulacella stoermeri was placed in *Aulacella* because of its similarity to *A. philipi* sp. nov., which is close to the type species *A. eifelensis* (Verneuil). *A. stoermeri* and *A. philipi* are compared on page 34.

A. stoermeri is in some features close to *Mendacella,* but may be distinguished by its slightly more flabellate central diductor scars, which are usually only separated by a narrow ridge anteriorly.

At first glance, *A. stoermeri* resembles *Reeftonia marwicki* Allan from the Lower Devonian of Reefton, New Zealand. Unlike that species, however, it has a dorsal fold and ventral sulcus anteriorly so that the anterior margin is plicate; the ventral diductors tend to be slightly more flabellate; the dorsal adductors are more obviously quadripartite, and do not show the characteristic cortezorthinid pattern of muscle-bounding ridges described by Johnson & Talent (1967b); subsidiary sockets are not obvious in the ventral valve; the setal grooves are longer; the crenulae are more obviously grooved medially; and the pedicle callist is larger and not as greatly raised above the floor of the valve. Similar characters may be used to separate *A. stoermeri* from *Reeftonia alpha* (Gill).

Order STROPHOMENIDA Opik, 1934
Superfamily STROPHOMENACEA King, 1846
Family STROPHEODONTIDAE Caster, 1939
Subfamily STROPHEODONTINAE Caster, 1939
Genus CYMOSTROPHIA Caster, 1939

Type species: Leptaena stephani Barrande, 1879.

CYMOSTROPHIA DICKINSI sp. nov.

(Pl. 5, figs 31-33; Pl. 6, figs 1-9; Pl. 7, figs 1-23; Pl. 13, figs 1-5; Text–figs 14, 15)

Derivation of name: After Dr J. M. Dickins.

Type locality: The basal 60 m of the '*Receptaculites*' Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18917; paratypes ANU 18915a-e and CPC 10527-8.

Occurrence: Common at several localities in the '*Receptaculites*' Limestone including localities A, B, Γ, and Д, and has been found in the Warroo Limestone.

Description

Exterior: Shells large, alate, wider than long, and strongly concavoconvex. The anterolateral portions of the shell are convex, so the margin is concave in front of the cardinal angles. The maximum width is along the hinge-line. Shells are divided into a visceral disc and a trail. The margin of the visceral disc of the pedicle valve is very little more convex than the rest of the shell. The visceral region of the brachial valve is not as concave as that of the pedicle valve is convex. The ornament is parvicostellate, with 3-7 fine capillae (lirae) separating strong rounded costellae. There are between 10 and 14 costellae per cm measured parallel with, and 1 cm from, the hinge-line. Wavy concentric rugae are present between, and are interrupted by, the costellae. Rugae are only present on the visceral disc. Fine growth-lines are visible in well preserved specimens. They number about 14 per mm. The costellae are slightly more elevated and abundant on the trail than on the visceral disc; and the costellae are more prominent on the visceral disc of the pedicle valve than that of the brachial valve. Capillae increase by intercalation, and new costellae appear by expansion of one of the capillae halfway between two costellae. The interarea of the pedicle valve is low and anacline. It is interrupted by a broad triangular delthyrium, which is filled laterally by broad flat dental traces and medially by a small convex pseudodeltidium. The hinge-line is denticulate for about half its length. A small supra-apical foramen has a diameter of about 0.1 mm. The pedicle tube does not open onto the inner surface of the pedicle valve. The interarea of the brachial valve is very low, hypercline, and interrupted by a small triangular notothyrium, whose width is approximately equal to its height. The notothyrium is filled by a small chilidium, which expands ventromedially into a small lobe.

Interior. Pedicle valve: The cardinal process pits are deep, and separated by an obvious ventral process. A low broad tooth is present on each side of the delthyrium. In some specimens, the teeth are partly separated from the hinge-line by a pair of grooves that would have accommodated the posteromedial portions of the socket ridges. The inner edge of the interarea, alongside the delthyrium, is thickened to fit along the posterolateral edges of the socket ridges. These thickened portions extend laterally to form a pair of short plate-like protuberances, which are separated from the hinge-line by a pair of shallow cavities (Pl. 5, figs 32, 33). The muscle field is subcircular to slightly elongate, and the maximum width of the diductor scars is close to or slightly in front of their midlength. The adductor scars are obviously impressed posteriorly, and may be slightly raised on a median ridge anteriorly. They form a small elongate oval area in the posteromedian portion of the valve, and in many specimens are divided by a low median ridge, which is in turn divided posteriorly by a firmly impressed groove. The diductor scars are large and flabellate and surround the adductor scars anteriorly. They are surrounded laterally by strong arcuate muscle-bounding ridges, which may extend round the anterior margins of the diductor scars. In specimens in which the muscle-bounding ridges are strong, the ridges overhang medially behind their midlength and may overhang slightly anterolaterally in front of their midlength. The diductor scars are partly subdivided by sublongitudinal ridges and grooves. The median ridge which divides the adductor scars increases in height in front of them to a maximum just behind the anterior margin of the diductor scars. The interior of the valve is pustulose, with the largest pustules concentrated in the areas lateral to the muscle-bounding ridges. A vasculum cardinalium is present close, and at a small angle, to the hinge-line. It is most deeply impressed, as a setal groove, close to the cardinal angle.

Brachial valve: The cardinal process is bilobed and the two lobes are disjunct distally and grooved posterodistally. The lobes are triangular in cross-section; they diverge from each other at 40-60°; they expand distally in lateral profile; and they are directed backward at about 70° to the floor of the valve. A pair of blade-like socket ridges is directed at about 20° to the hinge-line (in ventral view). The lateral muscle-bounding ridges are typically gently arcuate and slightly pustulose; they expand posteriorly and merge with a pair of ridges that extends anterolaterally and then laterally from the cardinal process; and anteriorly they converge gently towards the midline and almost meet the transmuscle septa. A low median septum merges with the base of the cardinal process. It usually separates the adductor scars, but its height is variable and in some specimens it is only elevated in front of the adductor scars. The transmuscle septa are subdued under muscle callus where they cross the adductor scars. In front of the adductor scars they are strongly pustulose and convex laterally; they diverge forward initially at 30-40°, but then trend subparallel. The areas lateral to the muscle-bounding ridges and the transmuscle septa are strongly pustulose.

Ontogeny

Several small specimens were found in the top of the '*Receptaculites*' Limestone at Locality A. However, *Malurostrophia minima* sp. nov. also occurs there, and the earliest growth stages of the two species could not be separated. The specimens described in the next two paragraphs may belong to either species.

The smallest specimens found are slightly less than 0.5 mm long and 0.5 mm wide (Text–fig. 14). At this stage, the shells are planoconvex, with a rounded subquadrate outline and a convex anterior margin; the maximum width is close to the midlength; the ornament consists of fine concentric wrinkles, with signs of a few incipient costellae at the margins; a ventral sulcus or median depression extends from slightly in front of the pedicle sheath forward to the anterior margin so that the anterior commissure is plicate; the posteromedian portion of the brachial valve is convex, and this convex portion (the protegular fold) extends forward to the anterior margin as a gentle fold; a supra-apical foramen is present at the apex of a subventrally directed pedicle sheath, which is placed at the ventral edge of a prominent convex protodeltidium (see page 16); and the protodeltidium fits closely against the posteromedian margin of the brachial valve.

In slightly larger specimens, about 0.7 mm long, there are three pairs of costellae in the brachial valve; the cardinal process is directed posteriorly and slightly ventrally, and bilobate; muscle scars, muscle-bounding ridges, and septa are not visible; and a median costella and three pairs of lateral costellae are present in the pedicle valve.

In larger specimens, individuals of this species can be separated from those of *M. minima* by the presence of fewer and coarser costellae, and incipient rugae.

Capillae (lirae) appear soon after the primary costellae. Secondary costellae appear by the expansion of one of the capillae between two costellae. The capillae increase by intercalation.

In the smallest specimens, the cardinal angles are rounded to obtuse and the maximum width is close to the midlength; in later stages, the width of the hinge-line increases relative to that of the rest of the shell so that the cardinal angles become alate and the maximum width is at the hinge-line. The shells are alate and the maximum width is at the hinge-line in specimens about 2 mm wide. This increase in the width of the hinge-line is apparently associated with a slight increase of the width/length ratio during growth (Text–figs 14 and 15).

In early neanic stages, a pedicle tube is deposited in the posterior end of the pedicle valve. The pedicle tube is soon covered over, but not closed, by secondary shell to form a ventral process. It is closed by secondary shell, however, in shells larger than about 6 mm long.

In the smallest brachial valves, the cardinal process is bilobate and directed posteriorly and slightly ventrally. In later stages, deposition takes place on its

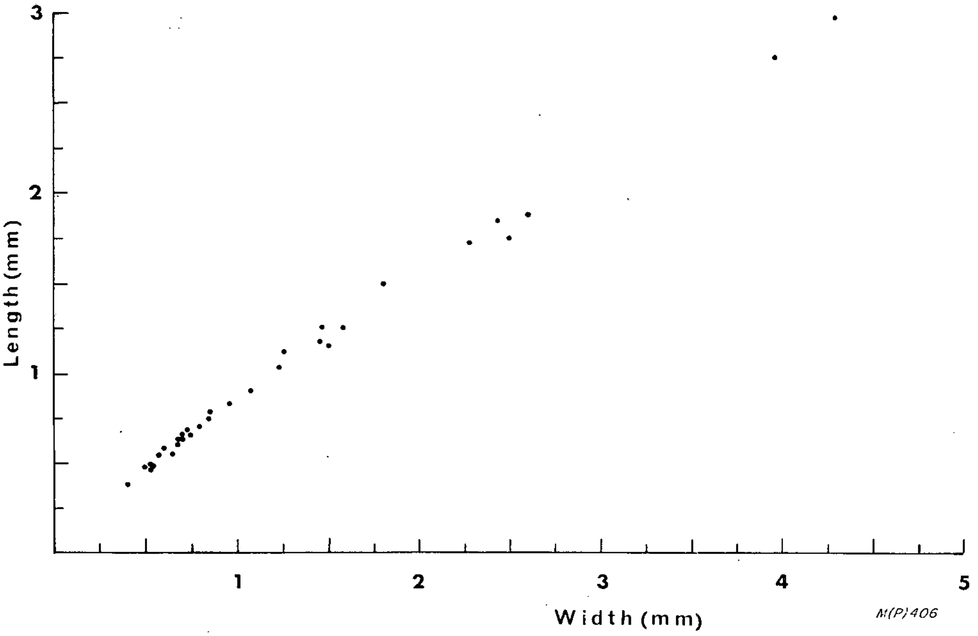

Fig. 14. *Cymostrophia dickinsi* **sp. nov. Specimens from the top of the** *'Receptaculites'* **Limestone.**

ventral surface and resorption along its posterior edge so that it is directed posteroventrally. The first ridges to appear in the brachial valve are the transmuscle septa, which appear first as several isolated pustules on each side of the grooves that are the internal expression of the median pair of primary costellae (Pl. 7, fig. 5). In later stages, the pustules increase in number and partly coalesce to form the transmuscle septa. Shortly after the appearance of the first signs of the transmuscle septa (in specimens about 1.5 mm wide), a pair of fine socket ridges appears at a low angle to the hinge-line. In early stages, there is still a prominent alveolus in front of the cardinal process over the region of the protegular node. This disappears in specimens about 10 mm long owing to secondary thickening associated with the posterior end of the median septum. Lateral muscle-bounding ridges in the dorsal valve only appear in specimens about 10 mm wide. They appear first as patches of relatively coarse pustules, which increase in number and coalesce in later stages. Ventral lateral muscle-bounding ridges appear in similar sized specimens.

In late ephebic stages, the ventral muscle-bounding ridges increased in height and spread forward to virtually surround the muscle scars; the ventral median ridge increased in height; and the regions lateral of the muscle bounding ridges become more strongly pustulose.

Discussion

Cymostrophia dickinsi sp. nov. is placed in *Cymostrophia* because it falls within Caster's original conception of the genus (1939). It almost falls within the diagnosis of the genus given by Havlíček (1967), which is based on the type species *Cymostrophia stephani* (Barrande); but it has a small convex pseudodeltidium,

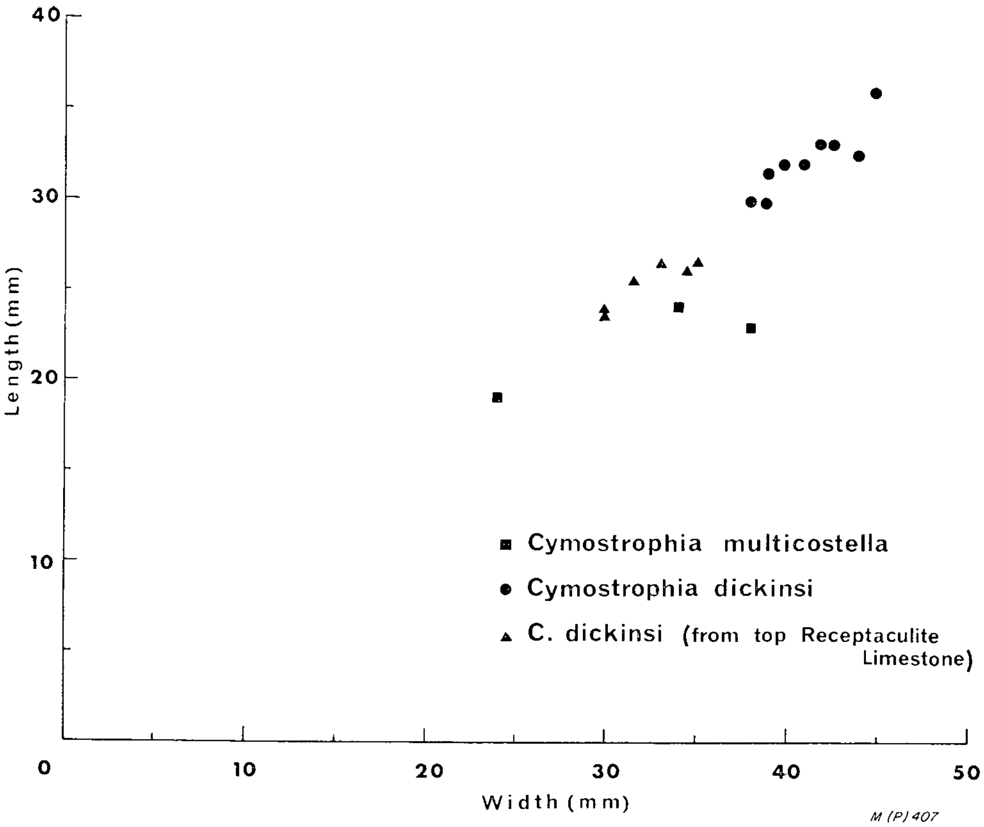

Fig. 15. A comparison between two species of *Cymostrophia.*

whereas Havlíček's diagnosis stated that *Cymostrophia* has a flat pseudodeltidium. This feature is not, however, regarded as of generic significance.

Cymostrophia bellarugosa Talent, from the Lower Devonian of Tabberabbera, Victoria, is rather smaller than *C. dickinsi* (the largest specimen found is 16 mm long and 38 mm wide); the shells are more transverse; the trail is bent down rather than evenly curved; pallial trunks are more obvious anteromedially; the ventral process is stronger, and branches more often anteriorly; the ventral adductor scars are relatively larger and appear to be divided into a smaller dendritic posterolateral pair of scars and a larger non-dendritic anteromedian pair; and the ventral muscle-bounding ridges of mature individuals are more strongly scalloped. The ornament of *C. bellarugosa* is not, however, very dissimilar to that of *C. dickinsi.*

Cymostrophia cresswelli (Chapman), from the Silurian of Walhalla, Victoria, is much smaller; it has fewer costellae for the same size; and a greater number of capillae separate each pair of costellae (between 9 and 12).

Cymostrophia euglyphoides (Chapman) from the Lower Devonian of Lilydale, Victoria, has a more sharply downturned trail; it is more transverse; the anterolateral margins of the shell are not as convex, so that the outline is subtriangular; the visceral disc is not as convex; and the ventral median ridge and ventral adductor scars are not as obvious (no brachial valves of this species are known).

Philip (1962) described some cymostrophiid fragments from the Lower Devonian of the Tyers area, Victoria, but these are not sufficiently well preserved to compare them properly with the material from Taemas.

Individuals of *C. dickinsi* that differ slightly from the type specimens occur in the top of the *'Receptaculites'* Limestone at Locality A. They have a smaller maximum size, although some specimens have been found in the Warroo Limestone that are similar in size to the types; they have a slightly greater number of costellae per cm measured 1 cm from the hinge-line (12-16 as opposed to 10-14); and the maximum width of the diductor scars tends to be closer to their anterior margin. A Student's t test was carried out to test the difference between the mean of the number of costellae per cm, measured 1 cm from the hinge of specimens of the type locality and of specimens from the top of the *'Receptaculites'* Limestone. They were found to differ at greater than the 99.9% level of significance. It was decided, however, not to create two different subspecies for the two forms as the values for the numbers of costellae overlap; some specimens obtained from the Warroo Limestone are as large as the types; and it would probably be difficult to recognize them as different forms elsewhere.

See also under the discussion of *Cymostrophia multicostella* sp. nov., page 43.

CYMOSTROPHIA MULTICOSTELLA sp. nov.

(Pl. 6, figs 10-16; Text-fig. 15)

Derivation of name: Latin *multi-,* many; *costa,* a rib; and *-ella,* a diminutive.

Type locality: The basal 9 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Station, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18919; paratypes ANU 18918a and CPC 10529-30.

Occurrence: The base of the *'Receptaculites'* Limestone at localities B and Γ.

Description

Exterior: The shell is medium sized, alate, transverse, and moderately to strongly concavoconvex. The ornament is parvicostellate. The costellae are separated by between 0 and 3 capillae. Wavy concentric rugae are present in the region of the visceral disc. They are interrupted and relatively subdued by numerous costellae, which number between 21 and 26 per cm measured parallel with, and 1 cm from, the hinge-line. The brachial valve is not as concave, in the region of the visceral disc, as the pedicle valve is convex. The pedicle valve is most strongly convex in long-section close to the beak, and it may also be relatively strongly convex at the margin of the visceral disc. The ears are relatively flat. The maximum width is at the hinge-line. The capillae increase by intercalation, and the costellae by the growth in size of a capilla halfway between two costellae. Some of the costellae are visible within about 0.5 mm of the beak. A low orthocline to anacline pedicle interarea is interrupted medially by a broad delthyrium, which is filled laterally by a pair of large flat dental traces and medially by a small convex pseudodeltidium. The brachial interarea is low and hypercline. Denticular ridges are present on the interareas of most specimens, probably because the primary layer was lost during or before burial. The denticles extend outward for about two-thirds of the width of the hinge-line. The pedicle foramen is supra-apical, and the pedicle tube has a diameter of about 1.15 mm. The ornament on the visceral disc of the brachial valve is more subdued than that of the pedicle valve.

Interior. Pedicle valve: The interior is similar to that of *Cymostrophia dickinsi* sp. nov. except that the muscle scars are not as circular, the maximum width of the diductor scars is in front of their midlength, and the denticles extend somewhat farther out along the hinge-line.

Brachial valve: The few incomplete and rather poorly preserved brachial interiors that were found are not obviously different from those of *C. dickinsi.*

Discussion

C. multicostella is close to *C. dickinsi* in a number of features, but has a greater number of costellae (21-26 per cm, measured 1 cm from the hinge-line, as opposed to 10-14 in the types of *C. dickinsi*); weaker rugae; denticles which extend farther along the hinge-line; a smaller maximum size (too few specimens were found to be sure of this character); and diductor scars which tend to have their maximum width closer to their anterior margin.

C. multicostella is closer to *C. dickinsi* than to any previously described Australian cymostrophiid.

Genus TAEMOSTROPHIA nov.

Type species: Taemostrophia patmorei sp. nov. from the Upper Emsian or possibly Lower Eifelian Warroo Limestone at Taemas, New South Wales.
Derivation of name: After the property Taemas and the suffix strophia signifying strophomenid affinities.

Diagnosis: Shells transverse and alate; ornament parvicostellate; anterior and anterolateral margins geniculate to form short dorsally directed trail; in regions immediately proximal to geniculated portions, pedicle valve concave, dorsal valve convex, except anteromedially where pedicle valve convex and dorsal valve less strongly convex; lateral muscle-bounding ridges of pedicle valve converging halfway forward to give waisted appearance to muscle scars; ventral diductor scars surrounding adductor scars, not obviously bilobate anteriorly; short ventral median septum in front of adductor scars.

Discussion

Taemostrophia is apparently closely related to *Malurostrophia* Campbell & Talent, and at one stage during the ontogeny of the type species the lateral margins are gently curved ventrally and the anteromedial portion of the shell is curved gently dorsally (the pattern in mature specimens of *Malurostrophia* and *Leptodontella*). The ventral diductors of mature specimens of *Taemostrophia,* unlike those of *Malurostrophia,* are waisted close to their midlength; they are not obviously bilobate anteriorly; and they surround the adductors anteriorly. The ventral diductor scars of young specimens of *Taemostrophia* are, however, bilobate anteriorly, not waisted, and do not surround the adductors. The brachial interiors of the two genera are quite close and both may have a short medium septum, which divides anteriorly and is replaced farther forward by an anteriorly directed arrow-shaped or anchor-shaped ridge (compare Pl. 8, figs 9 and 12, with Pl. 9, figs 2 and 20, and Pl. 11, figs 2 and 8). Thus, *Taemostrophia* appears to be closely related to *Malurostrophia;* and if some of the features of the ontogeny of the type species are indicative of a recapitulation of the phylogeny, it might be regarded as a descendant of *Malurostrophia.* The only representative of the genus known so far comes from the Warroo Limestone at Taemas. Several species of *Malurostrophia* occur at various levels within the underlying *'Receptaculites'* Limestone. As *Malurostrophia* was undergoing considerable, and apparently very rapid, adaptive radiation at this time the relationship is quite feasible.

The external form of *Taemostrophia* is similar to that of *Nadiastrophia* Talent, a genus whose interiors are similar to those of *Malurostrophia. Taemostrophia* differs from *Nadiastrophia,* however, in that during its ontogeny it mimics *Malurostrophia:* the anteromedian portion of the shell has a dorsal curvature at a time when the anterolateral portions are gently curved ventrally; and the ventral diductor scars are waisted, not bilobate anteriorly, and surround the adductor scars. It is possible that the external form of *Taemostrophia* was produced by selective pressure on a form of *Malurostrophia* in order that it might efficiently utilize an ecological niche similar to that of *Nadiastrophia.*

Range: The only species that can be included in the genus, at present, is the type species *Taemostrophia patmorei* sp. nov. from the Upper Emsian or possibly Lower Eifelian Warroo Limestone at Taemas, near Yass, New South Wales.

TAEMOSTROPHIA PATMOREI gen. et sp. nov.

(Pl. 8, figs 1-19; Pl. 13, figs 6-9; Text–fig. 16)

Derivation of name: After Mr Noel Patmore.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18922; paratypes ANU 18923a-o and CPC 10531-2.

Occurrence: Common in the lower half of the *'Receptaculites'* Limestone at Locality A.

Description

Exterior: Shells are strongly alate and transverse. At a length of about 9-10 mm the margins of the shell curve gently dorsally medially, and ventrally anterolaterally. In mature specimens, however, the anterior and lateral margins are turned dorsally. The ornament is parvicostellate, consisting of costellae and fine capillae. The capillae increase in number by intercalation, and the costellae by the expansion of a capilla halfway between two costellae. All the costellae become slightly more prominent on the ventral side of the very short dorsally directed 'trail'. The hinge-line is denticulate for just under half of its length. The pedicle interarea is low, apsacline, and interrupted by a delthyrium, which is wider than long and filled laterally by thin 'dental traces' (obvious teeth are not present) and medially and apically by a small convex pseudodeltidium. A small supra-apical foramen is visible in some well preserved specimens. The pedicle tube does not open to the interior of mature specimens. The dorsal interarea is linear. A triangular notothyrium, which is wider than high, is filled by a small convex chilidium. The chilidium is apparently grooved posteromedially.

Interior. Pedicle valve: The ventral diductor scars are bounded by strong lateral muscle-bounding ridges, which converge halfway forward so that the muscle scars are strongly waisted. They are not obviously bilobate anteriorly and surround the adductor scars. A pair of firmly impressed process pits and an obvious ventral process are present posteriorly. The adductor scars are slightly more firmly

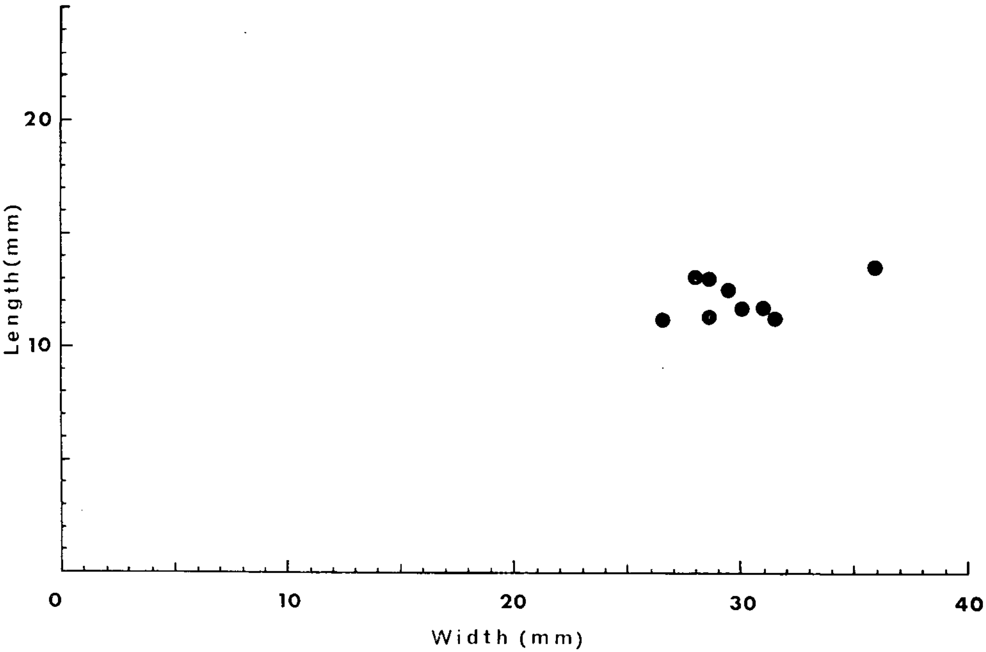

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Fig. 16. *Taemostrophia patmorei* **gen. et sp. nov. Specimens from the base of the Warroo Limestone.**

impressed than the diductor scars and form an elongately oval area in front of the ventral process. They may be divided by a fine ridge. A high median septum is present for a short distance just in front of the adductor scars. Farther forward it loses height abruptly, narrows, and becomes a low ridge that separates the anterior portions of the diductor scars. The lateral muscle-bounding ridges are higher posteriorly than anteriorly. They overhang laterally behind, and medially at, the waisted portion; in front of it they do not usually overhang. In many specimens the ridges are slightly scalloped anterolaterally. A pair of kidney-shaped depressed brachial areas is present laterally and anterolaterally to the diductor scars. The internal surface is pustulose (except for the muscle scars) and the pustules are strongest to either side of the posterior half of the muscle-bounding ridges. Branching pallial trunks, distal to the brachial areas, are gently impressed furrows or slightly raised ridges. A firmly impressed setal groove near each cardinal angle runs posterolaterally at a low angle to the hinge-line, and is joined to a vasculum cardinalium (see Pl. 8, fig. 17). The articulating mechanism consists of a row of denticles and a pair of 'teeth', which projects inwards from the sides of the delthyrium and fits behind the cardinal process lobes. The denticles are placed on a ridge, and fit into a denticulate groove in the brachial valve.

Brachial valve: The cardinal process lobes are disjunct and directed ventrally to posteroventrally. Each lobe expands slightly distally and is grooved posteriorly and distally. A gentle alveolus is present at the base of the anterior side of the cardinal process. A pair of blade-like socket ridges diverges from the hinge-line at between 30° and 40°. The lateral muscle-bounding ridges are relatively short and anteriorly directed; they do not join the transmuscle septa. At their anterior margins, they are usually fused to a pair of low ridges that runs along the lateral margins of a pair of vascular myaria, which is convex laterally. Posteriorly, they expand and join a pair of ridges that runs laterally from the cardinalia. The transmuscle septa are subdued by the adductor muscles, but in front of the adductors they are strongly pustulose and elongate. They diverge forward from each other at about 60°. The lateral adductor scars are bean-shaped and moderately impressed. The median adductors are tear-shaped and placed on a low platform of muscle callus. A median septum divides the adductor scars. It bifurcates in front of them and is replaced farther forward by another ridge which extends forward to become an anchor or arrow-shaped ridge whose lateral arms extend posterolaterally to join or almost join the distal ends of the transmuscle septa. This ridge was probably associated with the delineation of the anterior edge of the visceral area. The interior of the valve is relatively coarsely pustulose on either side of the lateral muscle-bounding ridges, and finely pustulose elsewhere. The vascular system is usually only weakly impressed (Pl. 8, figs 9, 12). A pair of gently impressed brachial areas is present distal to the visceral region.

Ontogeny

A pedicle valve 0.7 mm long and 0.7 mm wide is convex; its outline is rounded subquadrate, with a convex anterior margin; the ornament consists of fine costellae, which are inserted about 0.4 mm from the beak; and a single median and a pair of anterolateral costellae are slightly larger, and appear to have been inserted slightly earlier, than the other costellae (see Pl. 13, figs 6, 7). Fine concentric growth-lines are present. A supra-apical foramen is present at the apex of a posteroventrally directed pedicle sheath, placed at the apex of a convex protodeltidium. The hinge-line extends outwards about two-thirds of the maximum width of the shell, which is close to the mid-length. A gentle sulcus or median depression starts a short distance in front of the pedicle sheath and extends forward to the anterior margin.

A brachial valve 0.75 mm long and 0.8 mm wide is sub-planar. It has a short bilobed and posteriorly directed cardinal process. The posteromedian portion of the valve is convex, extends forward into a gentle fold, and is subdivided posteriorly by several fine furrows so that lateral nodes may be distinguished from a protegular fold (for terminology see Kemezys, 1965). A radial ornament of costellae is inserted about 0.35 mm from the cardinal process. Two pairs of primary costellae appear to be inserted slightly earlier than the other costellae (Pl. 13, fig 9).

The ornament is recognizably parvicostellate in specimens about 1 mm long.

In the smallest specimens, the hinge-line is about two-thirds of the maximum width. In later stages, the width of the hinge-line increases relative to the rest of the shell so that in specimens 1.5 mm long the maximum width is at the hinge-line, and in mature specimens the shells are strongly alate.

Young stages are planoconvex. At a stage about 9 mm long the anterolateral margins start to curve ventrally and the anteromedian portion of the margin curves very gently dorsally. In slightly larger stages the entire anterior and anterolateral margins turn subdorsally to form a short 'trail'.

Ventral muscle scars are not visible in the smallest stages, but in specimens about 3 mm long they appear as gently impressed and rather indefinite bilobate scars, which are subdivided by a low ridge (Pl. 8, fig. 15). In specimens about 8 mm long, the diductor scars are more firmly impressed. They are still bilobate anteriorly; they do not surround the adductor scars; and they are delineated by low muscle-bounding ridges, which are highest posteriorly (Pl. 8, figs 10, 11). In specimens 9-10 mm long the muscle-bounding ridges are higher and their posterior portions overhang laterally; and the median ridge is raised slightly for a short distance in front of the adductor scars (Pl. 8, fig. 14). After this stage, the anterior portions of the diductors expand so that they surround the adductors anteriorly, are no longer bilobate, and are wider than the more posterior portions of the diductor scars (Pl. 8, figs 13, 18). In the final stage, both the posterior and the anterior portions of the diductor scars expand so that they are subequal in width and separated by a narrower waisted medial portion. At this stage, the median septum is present as a short high ridge at the anterior edge of the adductor scars.

A functional pedicle was present in the early growth stages. A pedicle tube is covered by secondary shell to form a ventral process in specimens about 5.5 mm long. The tube passes through the shell at a low angle to the plane of commissure. The pedicle apparently atrophied in specimens between 6 and 8 mm long, as the pedicle tube was closed by secondary shell at about this stage.

In young brachial valves, the transmuscle septa are not as obviously subdued posteriorly by the adductor scars, and they extend backwards as far as the base of the cardinal process. The early brachial valves figured in Plate 8, figures 7, 8, and 16, differ from mature brachial valves in that the ridges that run laterally from the cardinalia are not as prominent; the median septum is only incipient; and there is no obvious anchor or arrow-shaped ridge anteromedially.

The cardinal process of the earliest stages is directed subposteriorly, but in later stages deposition takes place anteriorly and ventrally so that the cardinal process lobes are directed subventrally or slightly behind ventrally in mature specimens.

Discussion

See under the discussion of the genus.

Genus MALUROSTROPHIA Campbell & Talent, 1967

Type species: Malurostrophia flabellicauda Campbell & Talent, 1967.

Species of *Malurostrophia* were undergoing rapid evolution and adaptive radiation during the time that the *'Receptaculites'* and Warroo Limestone were laid down; so slightly different communities occur, whose biostratigraphic and phylogenetic relationships are rather complicated. Because of the difficulties of recognizing forms that are responding slightly differently to different environments, and the dangers of excessive 'splitting', only the forms that can be relatively easily separated from each other on qualitative as well as purely statistical grounds are named and described. Intermediate forms are only mentioned and discussed as intermediates. Text-figure 4 shows the stratigraphic relationships of the various forms at Taemas; Text-figures 17 and 18 show in graphical form some of their dimensions; and Text-figure 19 gives a summary of the inferred phylogenetic relationships of the forms occurring in southeast Australia.

Three new species, *Malurostrophia bella, M. aura,* and *M. minima,* and a new subspecies of *M. flabellicauda* Campbell & Talent, *M. flabellicauda reverta,* are described. They can be distinguished from each other and from *M. flabellicauda flabellicauda* by the size of mature individuals, the length from the pedicle beak to the initial dorsal deflection of the anteromedian portion of the shell (length ϕ), the degree of alation, the angle that the cardinal setal groove makes with the hinge-line, the presence or absence of a dorsal reversal of growth of the lateral margins, and the ratios of height to width and length to width.

Forms that are apparently phylogenetically intermediate between *M. flabellicauda* and *M. minima,* and between *M. flabellicauda* and *M. bella,* were found at intermediate horizons. Through the form intermediate between *M. flabellicauda* and *M. minima* is significantly separable from both by using Student's t tests on single characters, it was thought that to name and describe it separately would render the systematics of the group excessively cumbersome (see Table 2). Well-preserved specimens of another form, regarded as intermediate between *M. flabellicauda* and *M. bella,* were too few to give significant results to such a test. This form was recognized by such features as a moderate height/width ratio, overall size, a lack of strong alation, and a setal groove at a moderate angle to the hinge-line.

The characters used to distinguish the species and subspecies of *Malurostrophia* found in the *'Receptaculites'* and Warroo Limestones are summarized below.

M. flabellicauda flabellicauda is characterized by a maximum width of less than 14 mm; a width greater than 10.5 mm of specimens which have geniculated valve margins and are otherwise mature in aspect; a length ø between 4.7 and

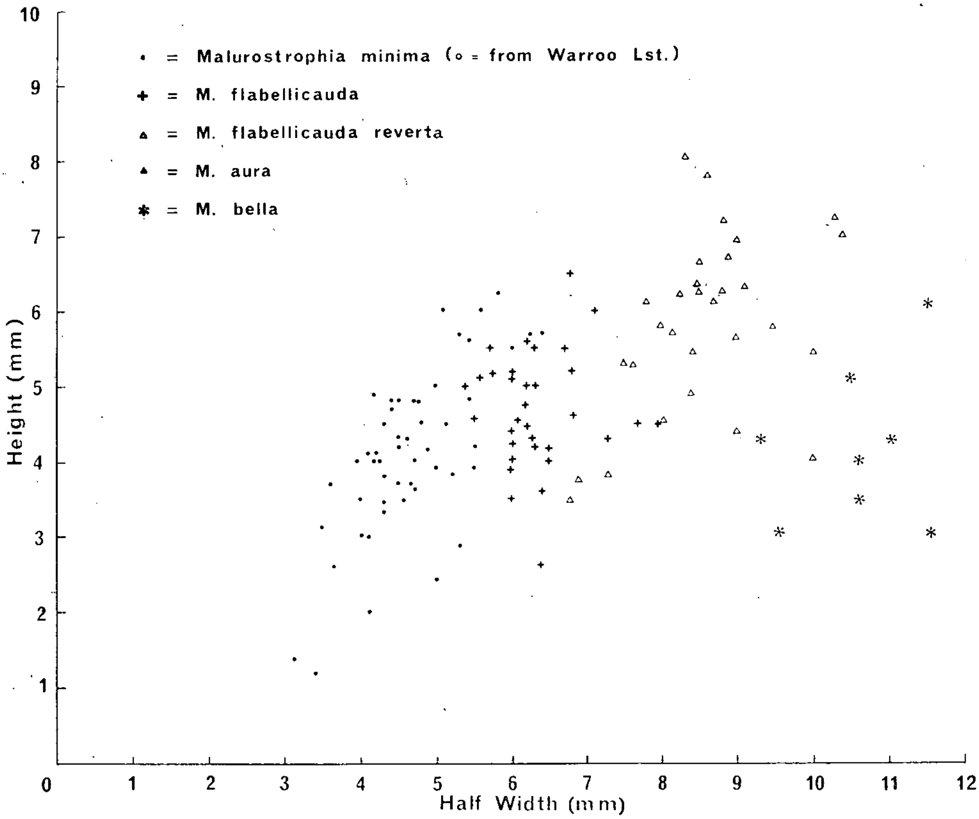


Fig. 17. A comparison of several species of *Malurostrophia*. Specimens from the *'Receptaculites'* and Warroo Limestones.

6.0 mm; low cardinal angles; cardinal setal grooves at a low angle (10-15°) to the hinge-line; and a lack of dorsally reflexed lateral margins.

M. flabellicauda reverta is characterized by a maximum width of less than 20 mm; a width greater than 15 mm of specimens which have geniculated valve margins and are mature in aspect; a length ø between 5.2 and 6.0 mm; moderate to low cardinal angles; cardinal setal grooves at a low angle to the hinge-line; a low length/width ratio (0.5); and dorsally reflexed lateral margins in mature specimens.

TABLE 2

Student's t tests on some species and subspecies of *Malurostrophia* in order to test the difference in the means of certain variables.

Forms	Variable	t	Degrees of freedom	P
A versus B	length ϕ	3.5	36	.001
B versus C	length ϕ	13.96	38	.0001
B versus C	height/width	5.02	45	.0001
C versus BC	length ϕ	5.03	28	.0001
B versus BC	length ϕ	4.04	28	.0001

P = probability that the means of the two populations are the same.
A = *Malurostrophia flabellicauda reverta* subsp. nov.
B = *Malurostrophia flabellicauda flabellicauda* Campbell & Talent.
C = *Malurostrophia minima* sp. nov.
BC = form ? intermediate between *M. flabellicauda* and *M. minima*.

Length ϕ is the length from the pedicle beak to the point where the anteromedian portion of the shell turns dorsally to form the tail.

Among the small numbers of *M. aura* discovered, the maximum width was 23.5 mm and the length ϕ between 6.9 and 8.1 mm. The species has a relatively alate outline; elongate ventral diductor scars in the late ephebic and gerontic stages; and lateral margins not dorsally reflexed.

M. minima is characterized by a maximum width of less than 12 mm; a width greater than 7 mm of specimens which have geniculated margins and are mature in aspect; a length ϕ between 3.0 and 4.5 mm (usually between 3.5 and 4.5); low alate cardinal angles; cardinal setal grooves at a low angle to the hinge-line; and lateral margins not dorsally reflexed.

M. bella is characterized by a maximum width of less than 24 mm; a width greater than 18 mm of specimens which have geniculated valve margins and are mature in aspect; a length ϕ between 8.3 and 10 mm; a relatively low height/width ratio; a moderate length/width ratio (0.5); an outline only slightly alate; high cardinal angles (between 65° and 90°); cardinal setal grooves at a moderate angle to the hinge-line (between 30° and 50°); and lateral margins not reflexed dorsally.

MALUROSTROPHIA FLABELLICAUDA Campbell & Talent, 1967

(Pl. 9, figs 11-22; Text–figs 17-19)

1967 *Malurostrophia flabellicauda* Campbell & Talent, p. 311, pl. 47-50.

Locality: The type locality is the basal 60 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Material: Topotypes ANU 18926a-f and CPC 10533-6.

Occurrence: Common in the lower half of the *'Receptaculites'* Limestone.

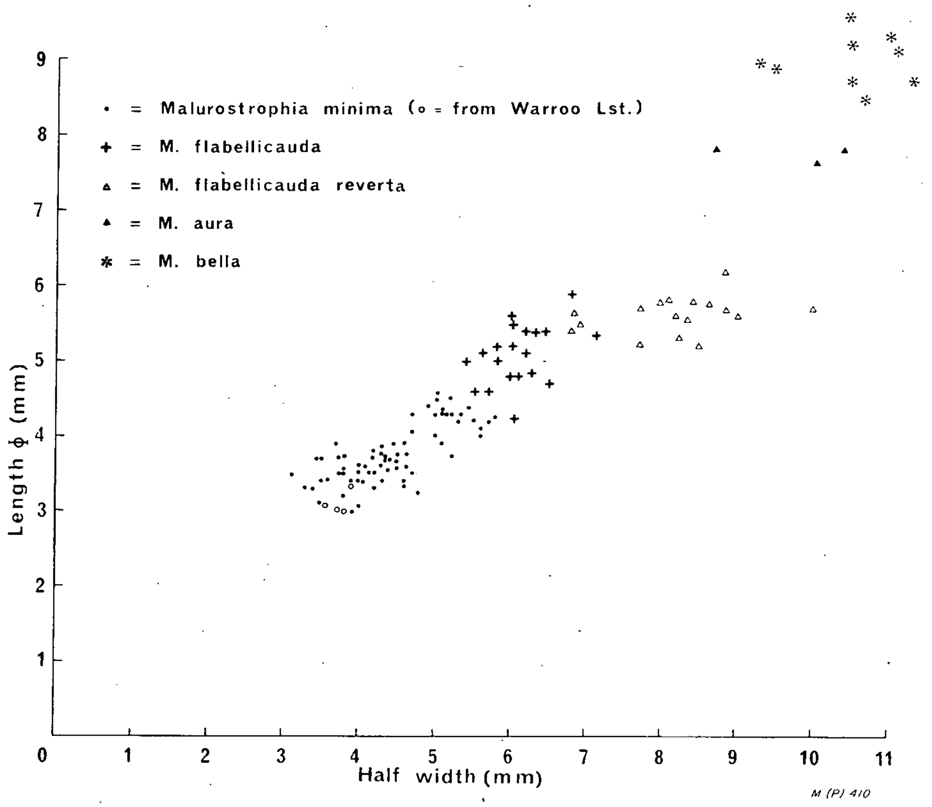


Fig. 18. A comparison of several species of ***Malurostrophia.*** **Specimens from the** ***'Receptaculites'*** **and Warroo Limestones.**

Discussion

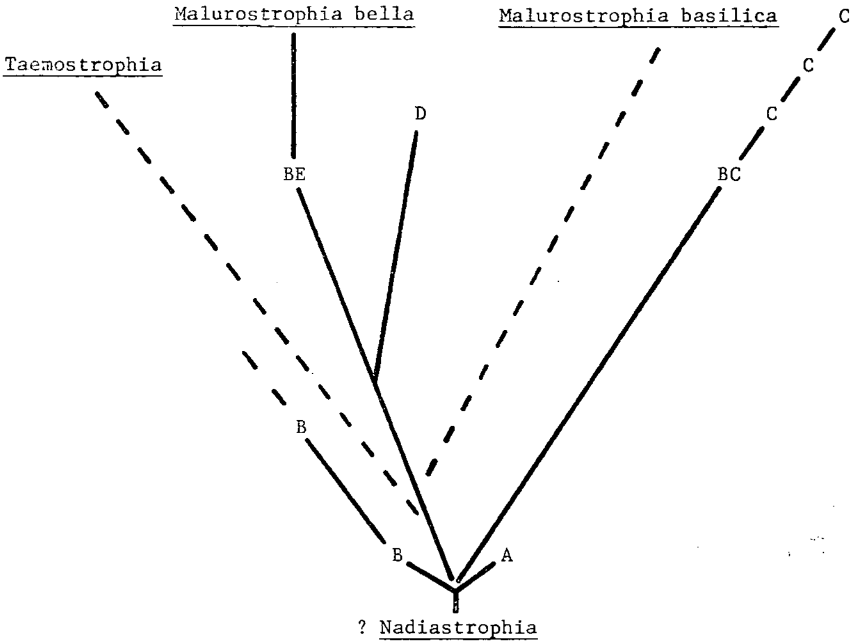
M. flabellicauda was adequately described by Campbell & Talent (1967), together with its ontogeny and functional morphology. It is here split into two subspecies, *M. flabellicauda flabellicauda* Campbell & Talent and *M. flabellicauda reverta* subsp. nov., which are associated with different faunal assemblages. *M. flabellicauda reverta* occurs in the basal 15 m of the *'Receptaculites'* Limestone, associated with a fauna which is dominated by bivalves, the atrypids *Atrypa penelopeae* sp. nov. and *Anatrypa erectirostris* (Mitchell & Dun), a few simple rugose corals, some gastropods, and small colonies of tabulate corals. *M. flabellicauda flabellicauda* is common in beds between 25 and 60 m above the base of the *'Receptaculites'* Limestone, and occurs with a fauna dominated by gastropods, small terebratulids, massive and laminar tabulate corals, and large concavoconvex brachiopods such as *Parachonetes flemingi* sp. nov. and *Cymostrophia dickinsi* sp. nov.

MALUROSTROPHIA FLABELLICAUDA REVERTA subsp. nov.

(Pl. 9, figs 1-10; Text–figs 17-19)

1967 *Malurostrophia flabellicauda* Campbell & Talent, p. 311, pl. 47, figs 14-15, pl. 48, figs 15, 16, 19 and 20.

Derivation of name: Latin *revertus,* turned back.



A = *Malurostrophia flabellicauda reverta* n. subsp.

B = *Malurostrophia flabellicauda flabellicauda* Campbell and Talent

C = *Malurostrophia minima* n. sp.

D = *Malurostrophia aura* n. sp.

BE = form ? intermediate between *M. flabellicauda* and *M. bella*.

BC = form intermediate between *M. flabellicauda* and *M. minima*.

Suggested phylogeny of south east Australian species of *Malurostrophia*, and the closely related genera *Nadiastrophia* Talent and *Taemostrophia* n. gen. The species from Taemas are placed in their relative stratigraphic positions; and the Victorian forms, *M. basilica* and *Nadiastrophia*, are placed in approximate relative stratigraphic positions.

M(P) 443

Fig. 19.

Type locality: The basal 15 m of the '*Receptaculites*' Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18924; paratypes ANU 18925a-d and CPC 10537-8.

Occurrence: The base of the '*Receptaculites*' Limestone at localities B and Γ.

Discussion

M. flabellicauda reverta differs from *M. flabellicauda flabellicauda* in that mature specimens attain a greater size (width of between 15 and 20 mm as opposed to between 10.5 and 14 mm); and the lateral margins are recurved dorsally in front of the cardinal extremities. A Student's t test was carried out on the two subspecies in order to test the difference in the means of distances from the pedicle beak to the point where the anteromedian portion of the shell starts to grow dorsally (length ϕ). They differ at greater than the 99% level of significance (see Table 2). Intermediate sized individuals of this subspecies were difficult to separate from mature individuals of *M. flabellicauda flabellicauda,* and thus it was decided that the two forms could only be distinguished at a subspecific level.

It could be argued that *M. flabellicauda reverta* is identical with *M. flabellicauda flabellicauda,* but that the specimens are phenotypically different because they lived in a different environment. This is thought to be unlikely, however, as the assemblages and environments in which they are found are by no means uniform, and one would expect at least a few specimens of *M. flabellicauda flabellicauda* to show a greater maximum size or an incipient dorsal reversal of growth of the lateral margins, or both, in the beds in which it is common.

The types of *M. flabellicauda* were examined and the following paratypes are removed from *M. flabellicauda flabellicauda* and included in *M. flabellicauda reverta:* ANU 14614, 14615, 14624, 14989, and 14990. All these specimens except ANU 14615 were figured by Campbell & Talent (1967).

MALUROSTROPHIA MINIMA sp. nov.

(Pl. 10, figs 11-29; Text–figs 17-19)

Derivation of name: Latin *minimus,* smallest.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18930; paratypes ANU 18931a-i and CPC 10539-41.

Occurrence: Common in the top of the *'Receptaculites'* Limestone and occasional in the Warroo Limestone.

Description

Exterior: The shells are small, wider than long, and alate, with the maximum width at the hinge-line. The cardinal angles are usually between 20 and 50°. The visceral region of the pedicle valve is gently convex, and that of the brachial valve gently concave. The anteromedian portion of the shell is curved ventrally and then turned dorsally to form a relatively high subdorsally directed tail; and the anterolateral portions of the shell are curved strongly ventrally. The ornament is parvicostellate, with fine costellae separated by varying numbers of capillae; there may be as few as 1-2 capillae posteromedially, and as many as 20 posterolaterally. Capillae increase by intercalation, and costellae by the expansion of a capilla halfway between two costellae. The number of costellae present at the margin of a mature specimen may vary considerably. The costellae may be slightly more numerous on the dorsally directed tail of the pedicle valve. The distance from the beak of the pedicle valve to the region where the anteromedian portion of the shell started to grow dorsally (length ϕ) ranges between 3.0 and 4.5 mm (most specimens fall within the range of 3.5-4.5 mm). The pedicle interarea is low, apsacline, and interrupted medially by a broad delthyrium, which is filled laterally by thin broad flat 'dental traces' and medially by a small, high, narrow, convex pseudodeltidium.

The interarea of the brachial valve is very low and anacline. There appears to be a small triangular notothyrium, which is filled by a small chilidium that is flush with the surface of the interarea.

Interior. Pedicle valve: The ventral diductor scars are strongly bilobed, and do not surround the adductor scars anteriorly. They are surrounded by muscle-bounding ridges, strong posterolaterally and weak anteriorly, and are separated medially by a low adductor ridge, which is highest at the anterior end of the adductor scars. The lateral portions of the muscle-bounding ridges overhang inwards just behind their midlength, and outwards next to the hinge-line. The adductor scars are gently impressed posteriorly, and raised on the adductor ridge anteriorly. They are elongately oval. A pair of firmly impressed process pits is divided by a ventral process, which is grooved posteromedially. The teeth are so subdued that only thin 'dental traces' are obvious. The inner edge of the interarea is slightly thickened for a short distance either side of the delthyrium to fit against the posterior edges of the socket ridges. The inner surface of the valve is pustulose. The pustules appear to be arranged subradially, and are not obviously larger lateral to the muscle-bounding ridges. Obvious setal grooves are present close to the margin, under the costellae. A pair of larger grooves at the cardinal extremities is directed posterolaterally at 10-25° to the hinge-line, and is usually joined to a pair of weakly impressed vascula cardinalia. The articulating mechanism consists of a pair of denticulated ridges, fitting into matching grooves in the brachial valve. The ridges extend outwards between half and three-quarters of the width of the hinge-line; each bears between 15 and 18 denticles. There is usually a ridge around the anterolateral and lateral portions of the valve close to the region of geniculation, separating a brachial area from a marginal area.

Brachial valve: The cardinal process lobes are disjunct and directed posteroventrally at 60 to 70° to the valve floor. Each lobe is grooved posteroventrally. A pair of blade-like socket ridges diverges from the hinge-line at between 20 and 30°. The posterior portions of the lateral muscle-bounding ridges diverge strongly forward, before turning to run forward. They may overhang slightly laterally. Posteriorly, they join a pair of low ridges that runs sublaterally from the cardinalia. The median pair of adductor scars does not subdue the posterior ends of the transmuscle septa very effectively, although the latter are not pustulose in the region of the muscle scars. The transmuscle septa are strongly pustulose in front of the adductor scars, and diverge from each other at about 30-40°. The adductor scars may be separated posteriorly by a broad low ridge, which is not obviously a median septum. A median ridge is, however, usually visible between and in front of the anterior portions of the transmuscle septa. It may extend forward in mature specimens to join a subdued arrow-head or anchor-shaped ridge. A gently impressed vasculum myarium extends forward from the join between the two pairs of adductor scars, and bifurcates opposite the anterior margin of the transmuscle septum. It is sometimes partly delineated laterally, opposite the transmuscle septum, by a low ridge (Pl. 10, fig. 16). The interior of the valve is pustulose.

Ontogeny

The earliest stages appear to be almost identical with those of *Cymostrophia dickinsi* sp. nov. (see p. 39). Slightly larger stages (width about 2 mm) may be separated from those of *C. dickinsi* by their rather finer costellae and lack of any rugae.

During growth, the shell becomes alate; deflections of the anterior and lateral margins occur; and the characteristic pattern of denticles, muscle scars, and ridges appears. The pedicle tube is usually closed at a shell length of about 3.0-3.5 mm, just before or just after the margins started to geniculate.

The ontogeny of *M. minima* is discussed, with those of other stropheodontids, on pp. 62-3.

Discussion

Malurostrophia minima is separated from the other members of this genus that occur at Taemas on the basis of the characters summarized under the discussion of the genus.

MALUROSTROPHIA AURA sp. nov.

(Pl. 10, figs 1-10; Text–figs 18, 19)

Derivation of name: Latin *aura,* wind.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18928; paratypes ANU 18929a-f and CPC 10542-3.

Occurrence: Infrequent in the top of the *'Receptaculites'* Limestone at localities A and Д.

Description

The few well preserved specimens discovered occur in the same beds as more abundant individuals of *Malurostrophia minima* sp. nov. Both appear to have acted as true species, as no obvious intermediates were found. They are readily separated because mature individuals of *M. aura* are twice the size of those of *M. minima.*

Exterior: The shells are transverse and alate, with the maximum width at the hinge-line (the cardinal angles of late ephebic stages are smaller than those of early or middle ephebic stages). The visceral region of the pedicle valve is gently convex, and that of the brachial valve gently concave. The anteromedial portion of the shell is deflected ventrally and then dorsally; the anterolateral portions are curved ventrally. The ornament is parvicostellate, with fine costellae usually separated by 3 to 6 fine capillae. The ornament is dominantly costellate on the dorsally directed tail of the pedicle valve. The distance from the pedicle beak to the region where the anteromedian portion of the shell starts to grow dorsally (length ϕ) varies between 6.9 and 8.1 mm. The width of the dorsally directed tail ranges between about 6 and 7 mm. The pedicle interarea is low, apsacline, and interrupted medially by a broad delthyrium, which is filled laterally by a pair of broad flat 'dental traces' and medially by a small, high, narrow convex pseudodeltidium. The interarea of the brachial valve is very low and anacline. A small triangular notothyrium is filled by a small chilidium.

Interior. Pedicle valve: The ventral diductor scars are strongly bilobate anteriorly, and are delineated laterally by a pair of strong muscle-bounding ridges. In mature specimens, the diductor scars almost surround the adductor scars. The adductor scars are elongately oval, and are partly raised on a broad low ridge. An arrowhead-shaped ventral process separates a pair of firmly impressed process pits. The teeth are so subdued that only a pair of thin 'dental traces' is present. The inner edge of the interarea is thickened for a short distance either side of the delthyrium to fit against the posterior edges of the socket ridges. The interior of the valve is pustulose and the pustules are strongest in the posterior half of a depressed brachial area. Setal grooves are moderately impressed under the costellae, at the margins of the valve. A pair of strong setal grooves is present in the cardinal angles, at about 5-15° to the hinge-line. It is joined to a pair of weakly impressed vascula cardinalia. Numerous gently impressed vascular canals branch distally and join the setal grooves. A row of denticles extends outwards between a third and half of the width of the hinge-line. On the holotype, the denticles number about 20 on each side of the beak.

Brachial valve: The disjunct cardinal process lobes are grooved posterodistally, and project posteroventrally at 60 to 80° to the valve floor. A pair of blade-like socket ridges diverges from the hinge-line at between 30 and 40°. The lateral muscle-bounding ridges diverge strongly anterolaterally, run forward, and then curve inwards. Posteriorly, they join a pair of ridges that runs sublaterally from the cardinalia. Anteriorly, they may join a pair of low ridges that runs outside a pair of vascula myaria. A pair of strong pustulose transmuscle septa diverges forward at 40-50°. It is partly obscured posteriorly by the median pair of adductor scars. A medium septum is present just in front of the cardinal process as a short, broad, low ridge, which bifurcates and dies out opposite or just behind the anterior margin of the adductor scars. It is replaced farther forward by a median ridge, which extends forward to join a low arrow-head or anchor-shaped ridge. The interior surface is pustulose, and the pustules are strongest lateral to the muscle-bounding ridges. A brachial area is gently impressed. Numerous weakly impressed vascular canals are visible, in some specimens, branching towards the margins and joining the setal grooves distally.

Ontogeny

It may be seen from Plate 10, figures 1-4 that during the ephebic period alation increased, as did the length of the ventral diductor scars in proportion to the length of the shell. The brachial area only became obviously impressed in late ephebic or gerontic stages.

Discussion

M. aura may be separated from the other species that occur at Taemas by using the characters summarized on pp. 48-50.

MALUROSTROPHIA BELLA sp. nov.

(Pl. 11, figs 1-17; Text–figs 17-19)

Derivation of name: Latin *bellus,* handsome.

Type locality: The middle of the Warroo Limestone, 200 m west of Locality Д, 1¼ km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18932; paratypes ANU 18933a-i and CPC 10544-6.

Occurrence: Several localities at horizons near the middle of the Warroo Limestone.

Description

Exterior: The shells are medium sized and slightly transverse, with the maximum width at or just in front of the hinge-line. The cardinal extremities vary between moderately alate (cardinal angle 65°) and almost perpendicular. The length/width ratio is usually greater than 0.5. The visceral region of the pedicle valve is gently convex, and that of the brachial valve is subplanar. The anteromedial portions of the shell are deflected ventrally and then dorsally to form a dorsally directed tail; the anterolateral portions are curved ventrally. The ornament is parvicostellate, with fine costellae separated by three to six fine capillae. The capillae increase by intercalation, and the costellae increase by the expansion of a capilla halfway between two costellae. The ornament is dominantly costellate on the dorsally directed tail of the pedicle valve (not of the brachial valve). The distance from the pedicle beak to the region where the anteromedian portion of the shell starts to grow dorsally (length ϕ) varies between 8.3 and 9.8 mm. The width of the dorsally directed tail varies between 7.5 and 8.5 mm. The pedicle interarea is low, apsacline, and interrupted medially by a broad delthyrium. The delthyrium is filled laterally by broad flat 'dental traces', and medially by a high narrow convex pseudodeltidium. The interarea of the brachial valve is low and anacline. A small triangular notothyrium, which is wider than high, is filled by a small chilidium, flush with the rest of the interarea, except where it is grooved medially.

Interior. Pedicle valve: The ventral diductor scars are strongly bilobed and surrounded laterally, and usually anteriorly, by a pair of strong muscle-bounding ridges. The ridges are highest, and tend to overhang inwards, posteriorly. The diductor scars do not surround the adductor scars. The adductor scars are moderately impressed; they have an elongate oval outline; they are divided posteriorly by an anterior extension of the ventral process; and they are raised on a broad low ridge anteriorly. A pair of firmly impressed process pits is divided by an arrowhead-shaped ventral process, which is grooved anteromedially. The teeth are so subdued that only thin 'dental traces' are visible. The inner edge of the interarea is thickened for a short distance either side of the delthyrium to fit against the posterior edges of the socket ridges. The internal surface is pustulose; and the pustules are largest either side of the posterior half of the lateral muscle-bounding ridges. Obvious setal grooves are present around the margins of the valve. A larger groove at each cardinal extremity subtends an angle of 30 to 50° to the hinge-line; it is joined to a weakly impressed vasculum cardinalium. Numerous gently impressed vascular trunks branch towards the margins and join the setal grooves distally. The articulating mechanism consists of a row of denticles, which extends outward between half and a third of the width of the hinge-line. The denticles number between 14 and 22 on each side of the beak. They are placed on a ridge, and fit into a denticulate groove in the brachial valve. A ridge near the margins of the valve, where they geniculate, separates a brachial area from a marginal area.

Brachial valve: The cardinal process lobes are disjunct and directed posteroventrally at about 70° to the floor of the valve. Each lobe is grooved posteriorly and distally. A pair of blade-like socket ridges diverges from the hinge-line at about 30°. The muscle-bounding ridges diverge anterolaterally before curving to run forward. They expand slightly posteriorly and join a pair of ridges that runs slightly in front of laterally from the cardinalia. The two tear-shaped adductor scars are separated by a rather indefinite median septum, which is grooved medially. The median septum bifurcates at the anterior margin of the adductor scars, and is replaced farther forward by a median ridge (perhaps a continuation of the median septum), which runs forward to join an arrow-head or anchor-shaped ridge. The median pair of adductor scars partly obscures, with muscle callus, the posterior ends of the transmuscle septa. In front of the adductor scars, the transmuscle septa are strongly pustulose and diverge from each other at between 40° and 50°. A pair of vascula myaria runs anterolaterally (Pl. 11, figs 3 and 8). The interior of the valve is pustulose, the pustules being largest alongside the posterior half of the muscle-bounding ridges.

Ontogeny

The ontogeny of *M. bella* is only known from late neanic or early ephebic stages to late ephebic and gerontic stages.

A pedicle valve 3.8 mm long and 5.5 mm wide is gently alate, with the maximum width at the hinge-line. A few denticles are present along the hinge-line. A pair of diductor scars is bounded laterally by a pair of low pustulose ridges, and divided by a low median ridge. Distal to the muscle scars, fine pustules are subradially arranged. A pedicle tube is open to the interior. A supra-apical foramen is present at the apex of a subposteriorly directed pedicle sheath.

In a pedicle valve 4.7 mm long the pedicle tube is still open to the internal surface, but in a specimen 8.5 mm long and 14.2 mm wide the pedicle tube is closed by secondary thickening. In the latter specimen, the anteromedian portion of the margin is curved ventrally; this suggests that the pedicle may have atrophied at about the time that the margins of the shell started to geniculate.

In later stages, the lateral and anterolateral margins curved ventrally; the anteromedian portion of the margin recurved dorsally to form a tail; the ventral diductor scars lengthened; the ventral muscle-bounding ridges became more pronounced and overhung medially posteriorly; the denticles increased in number; and branching pallial trunks were gently impressed.

In the small brachial valve figured in Plate 11, figure 10 (length of fragment is 5.3 mm), the median septum is only incipient; the transmuscle septa, disjunct cardinal process lobes, and socket ridges are obvious; and the muscle-bounding ridge is obvious posteromedially, but only consists of a slightly raised arcuate area of more prominent pustules anteriorly.

Discussion

M. bella is close in size and outline to *Malustrophia basilica* Campbell & Talent, but has a much lower height/width ratio, and the tip of the dorsally directed tail is dorsal relative to the rest of the shell (compare Pl. 11, figs 4 and 5, with Campbell & Talent, 1967, pl. 50, figs 4 and 5). Also, the costellae of *M. bella* do not appear to be as prominent as those of *M. basilica*.

The characters used to separate *M. bella* from other forms occurring in the '*Receptaculites*' and Warroo Limestones are summarized on pp. 48-50.

Subfamily LEPTOSTROPHIINAE Caster, 1939

Genus LEPTOSTROPHIA Hall & Clarke, 1892

Type species: Stropheodonta magnifica Hall, 1857.

Cocks (1967) used the genus *Leptostrophia* very broadly, and even included *Protoleptostrophia* Caster in his synonymy, stating in his generic diagnosis that socket plates are present, except in some of the later species. Most authors (including Havlíček, 1967, who calls them brachiophores) regard the presence or absence of socket ridges in leptostrophiids as being of generic significance. This practice has been followed here.

The species described below, *Leptostrophia clarkei* sp. nov., belongs to a group of southeast Australian leptostrophiids that are not very close to the type species, *L. magnifica* (Hall) from the Oriskany of North America. This group also includes *L. plateia* (Gill), *L. alata* Chapman, *L. affinalata* (Gill), and *L.* sp. aff. *affinalata* (Gill) of Philip (1962). Unlike *L. magnifica* these forms are parvicostellate; their cardinal process lobes are not as distant from each other; they tend to be smaller and less strongly concavoconvex; and the transmuscle septa, where recognizable, consist of areas or prominent pustules rather than discrete ridges.

LEPTOSTROPHIA CLARKEI sp. nov.

(Pl. 12, figs 1-13; Pl. 13, figs 10-17; Pl. 35, figs 12 & 14; Text–fig. 20)

Derivation of name: After Mr M. J. Clarke.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18934; paratypes ANU 18935a-m and CPC 10547-50.

Occurrence: Near the base of the *'Receptaculites'* Limestone and at several horizons within the Warroo Limestone, at localities A, Г and above Д.

Description

Exterior: Shell gently concavoconvex, with the visceral region of the brachial valve almost plane. The outline is truncated subellipsoidal, with the length similar to the width. The valves are not alate, and the cardinal angles are close to or greater than a right angle. The maximum width is usually close to the midlength. The ornament is parvicostellate, with fine costellae separated by fine capillae (or lirae). The ornament is not visible within 2-3 mm of the beak. The ornament of the brachial valve is more subdued than that of the pedicle valve, with the costellae only slightly more obvious than the capillae. Fine concentric growth-lines, about 25 per mm, are visible in particularly well preserved specimens. Rugae are absent. The low apsacline pedicle interarea is interrupted medially by a broad triangular delthyrium, which is partly filled apically by a convex pseudodeltidium. The line-like brachial interarea is interrupted by a broad notothyrium, which is filled by a convex chilidium. The chilidium is gently grooved medially, and has a small tongue medially that extends forward a short distance between the cardinal process lobes (Pl. 35, fig. 12). The hinge-line is denticulate for about three-quarters of its width.

Interior. Pedicle valve: The diductor scars are gently impressed, and usually extend forward over half the length of the valve. They expand forward and are widest close to their anterior margin. The lateral muscle-bounding ridges are strong, pustulose, and sublinear. They diverge from each other at 75° to 90°, and extend forward about half the length of the muscle scars. The adductor scars are more firmly impressed than the diductor scars, sub-fusiform, and separated by a fine low ridge that extends forward from the ventral process. The ventral process is grooved medially and shaped like a posteriorly directed arrowhead. The cardinal process pits are firmly impressed. Teeth are not obvious. The internal surface is pustulose (except for the muscle scars); the pustules are coarsest either side of the muscle-bounding ridges, and tend to be more or less arranged in radial rows. Numerous pallial trunks may be seen extending from the anterior and anterolateral portions of the diductor scars of some specimens (Pl. 12, fig. 4). They branch towards the anterior margin, and join moderately impressed setal grooves distally.

The number of dorsally directed denticles on each side of the beak ranges between 25 and 35.

Brachial valve: The cardinal process is bilobed and the two lobes are disjunct and grooved posterodistally. A pair of blade-like socket ridges is adjacent to the process lobes. It diverges from the plane of commissure at 40-50°. A pair of gently pustulose lateral muscle-bounding ridges diverges forward at a relatively high angle before curving to run forward and die out. A pair of ridges runs laterally from the socket ridges, at a low angle to the hinge-line. The medial portions of these ridges may overhang slightly to the anterior. A median septum merges with the base of the cardinal process posteriorly and dies out gently forward. Transmuscle septa are usually present as concentrations of prominent pustules, but they may not be very obvious (Pl. 12, figs 3 and 12). The interior surface of the valve is finely pustulose, and gentle setal grooves are present close to the margins.

Ontogeny

An articulated specimen 0.8 mm wide and 0.65 mm long is planoconvex. It has an outline close to a major segment of a circle, with the maximum width just in front of the hinge-line; the ornament consists of fine concentric wrinkles; a very weak ventral median depression is present posteromedially, and the posteromedial portion of the brachial valve is inflated; the inflated portion of the brachial valve is delineated posterolaterally by a pair of furrows that runs at a low angle to the hinge-line, and subdivided by a pair of furrows that runs anterolaterally to form a protegular fold and a pair of lateral nodes; a supra-apical foramen is present at the apex of a posteroventrally directed pedicle sheath; the base of the pedicle sheath is fused to the ventral edge of a convex protodeltidium, which fits closely against the posterior margin of the cardinalia; and the cardinal regions are more horizontal than the median portions of the shell.

In later stages, weak costellae appear about 2.5 mm from the beak, followed rapidly by the appearance of capillae.

In small specimens the cardinal angles are obtuse, with the maximum width in front of the hinge-line; in specimens about 10 mm long the cardinal angles are acute and the maximum width is at the hinge-line; and in mature specimens the cardinal angles are usually obtuse and the maximum width is in front of the hinge-line. Intermediate sized specimens are more transverse than either neanic or late ephebic stages. Denticles are not present in very small specimens; in specimens about 9 mm wide they extend out about half the width of the hinge-line; and in mature specimens they extend out about three-quarters of the width of the hinge-line. A short pedicle tube, about 0.1 mm long, appears in specimens about 2 mm long; in specimens about 10 mm long it has lengthened and is covered but not closed by secondary shell, forming a ventral process; and in specimens 15 mm long the pedicle has atrophied and the pedicle tube is closed by secondary shell. The pattern of muscle scars and ridges is relatively mature in specimens about 10 mm long, but the ventral diductors do not diverge at as great an angle (Text–fig. 20); the adductor scars are not as obviously impressed; and the dorsal muscle-bounding ridges do not turn forward as obviously distally as in mature specimens. Lateral muscle-bounding ridges are not obvious in a ventral valve 2.3 mm wide.

Discussion of the ontogeny: In some characters *L. clarkei* sp. nov. is closer in its early ephebic stages than in its mature form to mature individuals of *L. affinalata* (Gill): the ventral muscle-bounding ridges do not diverge from each other at as great an angle; and the shells are more transverse and alate, with the maximum width at the hinge-line. These characters suggest that the two species may be phylogenetically related. See also p. 62.

Discussion

Gill (1948) described *Leptostrophia plateia* (Gill) from two ventral steinkerns. I have examined the types, and on the same piece of rock as the holotype, National Museum of Victoria number 14563, there are internal moulds of two brachial valves, and an external mould of a portion of a pedicle valve. These specimens show that the species has parvicostellate ornament and a pair of socket ridges. It has a similar outline to *Leptostrophia clarkei* sp. nov.; the ventral muscle-bounding ridges diverge at a similar angle; the process pits and ventral process are similar; and the denticles extend outward for a similar distance along the hinge-line. However, neither of the two brachial valves of *L. plateia* appears to have an obvious dorsal median septum.

L. clarkei differs from *L. alata* Chapman in that the shell is not as transverse; is not alate; the maximum width is not at the hinge-line; and the dorsal muscle-bounding ridges turn forward more obviously distally.

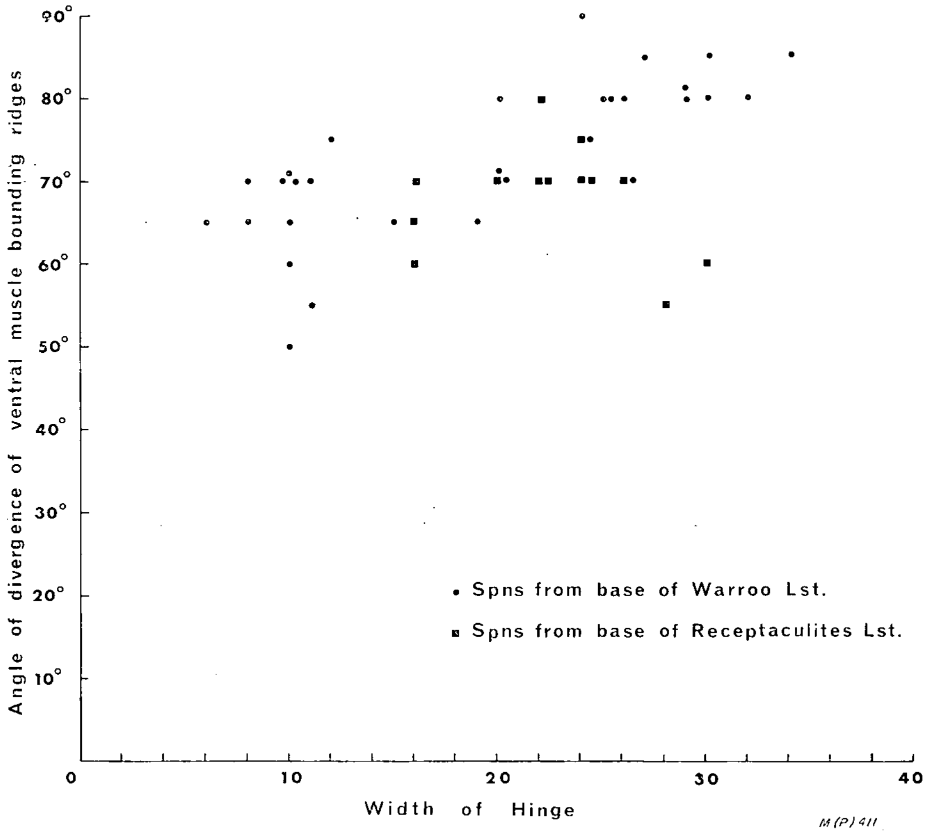


Fig. 20. *Leptostrophia clarkei* **sp. nov. Specimens from the base of the** *'Receptaculites'* **Limestone and from the base of the Warroo Limestone.**

In *L. affinalata* (Gill) the ventral muscle-bounding ridges diverge at smaller angles (30-60° as opposed to 75-90°) and extend farther forward relative to the muscle scars; the shells are more transverse and alate; and the maximum width is at the hinge-line.

The specimens of *L. clarkei* from the base of the *'Receptaculites'* Limestone differ from those from the type horizon, the base of the Warroo Limestone, in that their ventral muscle-bounding ridges do not diverge at quite as great an angle (Text–fig. 20; the mean for specimens at least 20 mm wide along the hinge-line is 69°, as opposed to 79.7° for the types). The angles of divergence of the ventral muscle-bounding ridges of specimens whose width of hinge-line exceeds 20 mm, for the two forms, were compared by a Student's t test. They differ at greater than the 99.9% level of significance. The palaeontology of southeast Australia, however, is too poorly known to burden the literature with the names of very closely related forms that could be distinguished only when a number of well preserved individuals were available. These two forms are separated stratigraphically by 190 m of limestone. The presence in the older form of ventral muscle-bounding ridges that do not diverge as greatly as those of the types may support the suggestion made above that *L. clarkei* may be phylogenetically related to *L. affinalata,* a form found in rocks that are regarded as rather older than the *'Receptaculites'* and Warroo Limestones.

ONTOGENY OF STROPHEODONTIDS

Growth series from specimens less than 1 mm long were found for *Cymostrophia dickinsi* sp. nov., *Taemostrophia patmorei* gen. et sp. nov., *Malurostrophia minima* sp. nov., and *Leptostrophia clarkei* sp. nov. From these, a number of features in common can be discussed.

Kemezys (1965) described some features which he believed to occur in the protegula of the Strophomenoidea, Chonetoidea, and Productoidea: 'the basic features are a median fold (the protegular fold) on the exterior of the dorsal protegulum and a median depression, often accompanied by lateral swellings, on the ventral protegulum'. He also believed that median costellae occur in both valves, and suggested that that of the brachial valve is strongly associated with the protegular fold. The statement quoted was found to be true for the stropheodontids at Taemas, and protegular folds and ventral median depressions are present in all the early stages examined. The protegular folds are associated with a pair of variably developed lateral nodes. Though many young ventral valves are rather swollen on either side of the median depression, no specimen contained discrete lateral nodes. Median costellae are present close to the beaks of ventral valves of *C. dickinsi, M. minima,* and *T. patmorei,* but are not as obvious on the brachial valves. Dorsal median costellae appear farther from the beaks than those on the pedicle valves, and they do not appear to be very strongly associated with the protegular folds (*L. clarkei* is not discussed in this context as its costellate ornament appears several millimetres from the beaks). The most prominent primary costellae of the brachial valves consist of one or more pairs of costellae. There is usually a strong pair of costellae, which diverges forward from the anterior margin of the protegular fold (Pl. 7, fig. 15, and Pl. 13, figs 1, 5 and 9).

Features that are common to the early growth stages of all four species include: (a) a supra-apical foramen at the apex of a postero-ventrally directed pedicle sheath; (b) a protodeltidium between the pedicle sheath and the posterior margin; (c) a planoconvex or ventribiconvex profile (depending on whether one regards the protegular fold as prominent enough to call the brachial valve convex); (d) fine concentric wrinkles, perhaps growth-lines, as the earliest ornament; (e) a protegular fold and a pair of lateral nodes in the brachial valve (the lateral nodes are not always obvious); (f) a median depression in the ventral valve, in front of the pedicle sheath; (g) a small bilobate sub-posteriorly directed projection which constitutes the earliest recognizable cardinal process; and (h) a hinge-line less than the maximum width.

The first appearance of the costellae is variable; costellae appear within 0.5 mm of the beaks in *C. dickinsi* and *T. patmorei,* but only about 2.5 mm from the beaks in *L. clarkei.*

Changes that commonly take place in the ontogenies of these forms include: (1) an increase in the width of the hinge-line relative to the width of the rest of the shell so that the shell becomes alate (in *C. dickinsi, M. minima,* and *T. patmorei,* and apparently in *L. clarkei,* in early ontogeny, before the width of the hinge-line becomes relatively reduced in mature stages); (2) an increase of the length of the ventral diductors relative to the length of the shell; (3) the appearance of ridges and septa, which are usually heralded by the appearance of a number of prominent pustules (probably taleolate) that later fuse or coalesce to form the ridges or septa; (4) the appearance of denticles in intermediate-sized specimens, and their spread laterally along the hinge-line in later stages; (5) the appearance of a pedicle tube, which first becomes covered with secondary shell material to form a ventral process, and then becomes blocked by the secondary shell; and (6) deposition on the ventral surface of the cardinal process and resorption along its posterior margin so that the cardinal process is directed posteroventrally.

Certain characters of the earliest growth stages of the stropheodontids are also apparent in the smallest specimens of *Protochonetes latus* sp. nov. and *Spinulicosta campbelli* sp. nov. These include: a protegular fold and a pair of lateral nodes on the protegula of the brachial valves; a median depression in the protegula of pedicle valves (this feature is not very obvious in *S. campbelli*); a supra-apical foramen; an early ornament of concentric wrinkles or growth lines; a planoconvex, or perhaps ventribiconvex, profile; and, in *P. latus,* signs of a rudimentary pedicle sheath.

Superfamily DAVIDSONIACEA King, 1850

Family SCHUCHERTELLIDAE Williams, 1953

Subfamily SCHUCHERTELLINAE Williams, 1953

Genus SCHUCHERTELLA Girty, 1904

Type species: Streptorhynchus lens White, 1862.

Schuchertella murphyi sp. nov. falls within the diagnosis of *Schuchertella* given by Williams *in* Moore (1965). Havlíček (1967), however, separated a new genus, *Drahanostrophia,* from *Schuchertella* on the basis of its impunctate shell; straight widely divergent brachiophores; and brachiophores that are neither concave in cross-section, nor rest on the bottom of the valve close to the hinge-margin. Williams, however, stated in his diagnosis of *Schuchertella* that it has an impunctate shell. The brachiophores of *S. murphyi* are not as widely divergent as those of *Drahanostrophia ficneri,* the type species of *Drahanostrophia.* Thus, although in some features *S. murphyi* is close to *Drahanostrophia,* it is placed in *Schuchertella.*

SCHUCHERTELLA MURPHYI sp. nov.

(Pl. 14, figs 1-17)

Derivation of name: After Mr Bruce Murphy, former manager of Bloomfield Property, near Yass.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18938; paratypes ANU 18937a-h and CPC 10551-10552.

Occurrence: Several horizons within the *'Receptaculites'* and Warroo Limestones, including localities A, B, Г, and Д.

Description

Exterior: The shells are small, irregular in shape. planoconvex to ventribiconvex, and slightly transverse. Punctae are not visible. The outline is sub-semicircular to irregular, with the pedicle beak often twisted. The cardinal angles are subangular to angular, with the angles close to a right angle. The width of the hinge-line is usually equal to the maximum width. The largest specimen found is 5.3 mm long and 8.0 mm wide. The pedicle valve is usually gently convex in long-section, but may be flat or even concave in front of the umbo. The brachial valve is also usually more convex close to the beak than farther forward. The ornament is costellate. The costellae are rounded in cross-section; they increase by intercalation and unequal subdivision; and there are between 6 and 8 costellae per 2.5 mm at a distance of 5 mm from the beak. In some specimens, a single prominent concentric growth-line is present. The pedicle beak is small and may be slightly incurved. The pedicle interarea is of moderate height, apsacline, and almost flat. The delthyrium is usually higher than wide, and covered by a convex pseudodeltidium. Horizontal growth-lines are visible on both the interarea and the pseudodeltidium. The brachial interarea is linear; the brachial beak is very small. A notothyrium is blocked laterally by a pair of fine blade-like chilidial plates.

Interior. Pedicle valve: A pair of teeth is not supported by dental plates. Thickened dental traces run along each side of the delthyrium, but are not fused to the floor of the valve. A pair of adductor scars is present on a slightly elevated elongately oval area in front of the delthyrium. It is slightly depressed medially; divided by a fine ridge; and appears to be almost entirely surrounded to the anterior by a pair of larger slightly flabellate diductor scars (Pl. 14, figs 11 and 12). There is no median septum.

Brachial valve: The cardinal process is bilobed posteriorly, but may be further subdivided into four small lobes. The anteromedian portion of the cardinal process is usually convex forward. A pair of crural plates or brachiophores is fused to the cardinal process laterally. The crural plates diverge from the midline at about 50°; terminate in short pointed crura; are gently convex anteromedially; and are fused to the floor of the valve along the medial edges of the sockets. The muscle scars are only gently impressed, and are not surrounded by muscle-bounding ridges.

Discussion

Schuchertella murphyi is clearly close to *S. burrenensis* (Savage) from the early Siegenian Mandagery Park Formation, New South Wales. Both species have recurved socket plates (and not the straight widely divergent socket plates of *Drahanostrophia*). They are also similar to each other in the other characters of the cardinalia, the number of costellae per unit length of margin, the size of the costellae, and the shape of the dental supports. They only appear to differ significantly in the maximum size attained by mature individuals. The largest specimens of *S. murphyi* discovered are less than half the size of some of the specimens of *S. burrenensis* illustrated by Savage (1971). Since a large number of specimens of *S. murphyi* were collected from several different horizons within the *'Receptaculites'* Limestone and since the benthonic environments of the different horizons were clearly varied it is considered that the maximum size of *S. murphyi* was primarily controlled by its gene pool and not by the expression of the environment on the phenotype. In view of the age difference between the occurrences of these two forms, I consider that they should be differentiated at the specific rather than the subspecific level.

The exteriors and interiors of a form illustrated by Johnson (1966a, pl. 23, figs 18-22) as *Schuchertella* sp. from the Middle Devonian of the Roberts Mountains, Central Nevada, show considerable similarity in size and form to *S. murphyi*. The American form, however, appears to be slightly larger and thicker-shelled.

The interiors of brachial valves of *Schuchertella becraftensis* (Clarke) from the Lower Devonian of New York, figured by Amsden & Ventress (1963; Clarke's types are refigured) are close to those of *S. murphyi;* and the description of the pedicle valves of this species also suggests that they are close. *S. becraftensis* is also small but it is larger than the specimens of *S. murphyi* found at Taemas.

Suborder PRODUCTIDINA Waagen, 1883
Superfamily CHONETACEA Bronn, 1862
Family CHONETIDAE Bronn, 1862
Subfamily DEVONOCHONETINAE Muir-Wood, 1962
Genus PARACHONETES Johnson, 1966

Type species: Chonetes macrostriata Walcott, 1884.

PARACHONETES FLEMINGI sp. nov.
(Pl. 15, figs 9-14, 16-23; Text–fig. 21)

1966 *Parachonetes* cf. *Parachonetes macrostriatus* (Walcott); Johnson, pl. 63, figs 9-14.

Derivation of name: After Dr C. A. Fleming.

Type locality: Between 27 and 59 m above the base of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type of material: Holotype ANU 18944; paratypes ANU 18943a-e and CPC 10553-5.

Occurrence: Common in the lower half of the *'Receptaculites'* Limestone.

Description

Exterior: Shells are medium to large, strongly concavoconvex, and transversely shield-shaped. The largest specimen found is 28 mm long and 35 mm wide. The shells are slightly auriculate, and the maximum width is usually along the hinge-line. The ears are flatter than the rest of the shell. The ornament consists of low irregular rounded gently radiating costae that emanate from both the beak and the hinge-line. Costae increase by both bifurcation and intercalation; they number between 10 and 11 per cm, at 2 cm from the beak. Faint concentric growth-lines may be visible. Numerous spines project from the ventral edge of the cardinal area of the pedicle valve. The spines near the beak are smaller and shorter, and project at higher angles (as great as 80°) to the hinge-line, than those near the cardinal extremities. The more lateral spines are long and usually project posterolaterally at 30 to 40° to the hinge-line before turning laterally to run subparallel with it. The pedicle interarea is low and anacline; the brachial interarea is hypercline and lower than that of the pedicle valve. The pedicle interarea is interrupted medially by a broad delthyrium, which is partly filled anterolaterally by the bases of the teeth and apically by a very short pseudodeltidium so that the delthyrial opening is semicircular. The pedicle beak is small and moderately incurved. A notothyrium is broad and filled laterally by a pair of chilidial plates, which extend ventrally halfway up the posterior face of the cardinal process. The delthyrium is blocked by the cardinal process. The visceral region of the brachial valve is almost as concave as that of the pedicle valve is convex. Anterior margins of mature specimens are recurved forward.

Interior. Pedicle valve: Teeth are of moderate size and divergent; they may be supported by very short ventrally divergent 'dental plates'. The dental traces are not usually, however, fused to the floor of the valve. The valve is thin and the external ornament corrugates most of the internal surface. Muscle scars are gently to moderately impressed posteriorly and not obvious anteriorly. Broad flabellate diductor scars are usually delineated by short low muscle-bounding ridges along the median portions of their posterolateral margins. Adductor scars are elongate, and their posterior margins extend a short distance behind the diductor scars. A low median septum extends forward, from just in front of the apex of the delthyrium, less than a third of the length of the valve. The interiors of the lateral spines open to the interior of the valve, but secondary thickening has blocked the openings of more medial spines. The posterolateral portions of the valve are pustulose, owing to the projection inwards of pseudopunctae.

Brachial valve: The cardinal process is bilobate anteriorly and quadrilobate posteriorly. A pair of broadly divergent socket ridges is fused medially to the pair of 'plates' that form the cardinal process. These socket ridges extend anterolaterally into a pair of low rounded ridges that die out a few millimetres from the sockets. The cardinal process surrounds a gently impressed alveolus posteriorly and laterally, and is fused anterolaterally to a pair of lateral septa or anderidia. The anderidia diverge at about 15-20° from the midline, and increase in height forward to a point halfway along their length, where they give off a pair of spines that is directed anterolaterally in the same direction as the anderidia, which continue anterolaterally at a lower elevation. These spines, which are mostly less than 0.5 mm long, are probably brachial supports. A median septum is low posteriorly and highest towards its anterior margin. It extends forward about a third of the length of the valve. In some specimens, the posterior end of the median septum divides and the two halves fuse with the two 'plates' that form the cardinal process. External ornament corrugates most of the internal surface. The posterolateral and anteromedial portions of the valve are pustulose.

Discussion

Johnson (1966b) illustrated some specimens collected from the '*Receptaculites*' Limestone at Taemas, and regarded them as being close to *Parachonetes macro-*

striatus (Walcott), from the *Eurekaspirifer pinyonensis* zone (Emsian) of central Nevada, USA. He noted, however, that 'consistent differences may be seen in the thickness of the shell of the two species'. This observation is confirmed; *Parachonetes flemingi* sp. nov. also differs from *P. macrostriatus* in that the interiors are more strongly corrugated by the external ornament; the alveolus is not as strongly impressed; and the papillae are not as prominent.

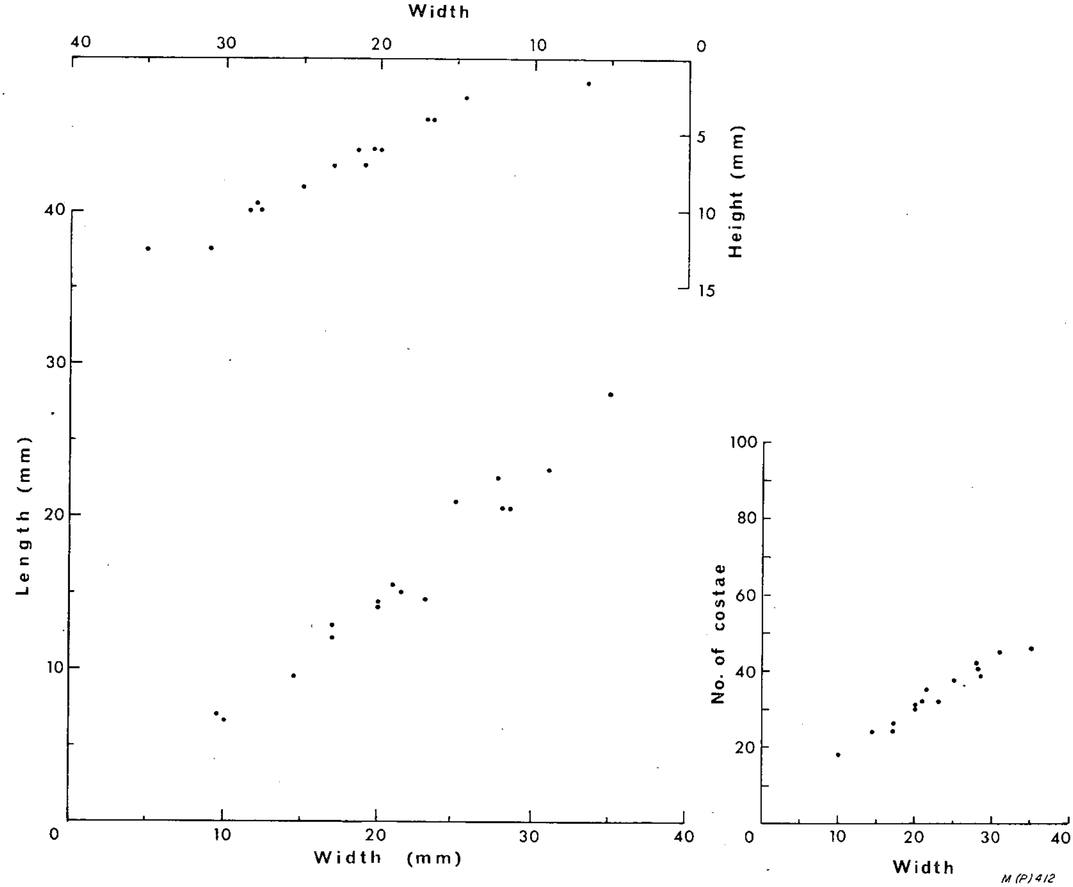


Fig. 21. *Parachonetes flemingi* **sp. nov. Specimens from the** *'Receptaculites'* **Limestone.**

P. flemingi appears to be close to *Parachonetes spooneri* (Talent) from the upper Lower Devonian (or possibly lower Middle Devonian) of Buchan, Victoria. Unfortunately, the type material of *P. spooneri* includes only a couple of imperfectly preserved specimens. The holotype, Melbourne University Geology Department 2186, is the interior of a brachial valve, which shows the characters of a brachial valve of *Parachonetes*. The number of costae on these specimens of *P. spooneri* appears to be intermediate between the number in *P. flemingi* and the number in *P. konincki* sp. nov. Better preserved material of *P. spooneri* may show this form to be very close to the forms from Taemas.

The species described by de Koninck (1876) as *Leptaena subaequicostata* is probably one of the species of *Parachonetes* that occur at Taemas. It is suggested that the name *Leptaena subaequicostata* should be suppressed because the type specimens were lost in the Garden Palace fire in Sydney (1882), the descriptions and illustrations are not good enough to ensure certainty of identification, and more than one species of *Parachonetes* occurs within the area mentioned by de Koninck, 'a black limestone near Yass'.

P. flemingi differs from *Parachonetes baragwanathi* (Gill), from the Lower Devonian of Tabberabbera, Victoria, in that the median septum is as prominent as the anderidia; the dental plates are usually not as pronounced; the interior of the pedicle valve is not as generally pustulose (see Talent, 1963, pl. 36, fig. 6); and the small ridges between the adductor and diductor scars are rarely visible. It is difficult to compare the gross morphology of the two species as the type material of *P. baragwanathi* is incomplete and rather distorted. From *Parachonetes suavis* (Talent), from the Lower Devonian of Tabberabbera, Victoria, *P. flemingi* differs in that its dorsal median septum is much shorter and may fuse with the cardinal process posteriorly; the ventral median septum is rather longer; the interiors are more strongly corrugated and less papillose; the socket ridges do not turn laterally distally to run parallel with the hinge-line; and it is larger (mature individuals of *P. flemingi* are at least twice the size of the types of *P. suavis*).

See also page 69.

PARACHONETES KONINCKI sp. nov.

(Pl. 15, figs 1-8, 15; Text–fig. 22)

Derivation of name: After L. G. de Koninck.

Type locality: The basal 15 m of the *'Receptaculites'* Limestone at localities B and Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18942; paratypes ANU 18941a-d and CPC 10556-7.

Occurrence: The base of the *'Receptaculites'* Limestone. A very similar form was found in the middle of the Warroo Limestone, but too few specimens were found to be certain of its relationship to *P. konincki.*

Description

Exterior: The shells are large, strongly concavoconvex, and wider than long. The largest complete specimen is 34 mm long and 40 mm wide, but fragments of larger specimens were found. The valves are not usually obviously auriculate, and the maximum width is sometimes in front of the hinge-line. The cardinal regions are rather flatter than the posteromedial portions of the shell. The ornament consists of low rounded gently radiating costae that emanate from both the beak and the hinge-line. The costae increase by both bifurcation and intercalation. Bifurcation is more common on the pedicle valve, and intercalation on the brachial valve. The costae number between 15 and 20 per cm at 2 cm from the beak. Numerous spines project from the ventral edge of the interarea of the pedicle valve. The medial spines are smaller, shorter, and more posteriorly directed than more lateral spines, which project posterolaterally at about 30-40° to the hinge-line, and distally curve to run sublaterally. The pedicle interarea is low and anacline, and the brachial interarea is even lower and hypercline. The broad delthyrium is partly closed apically by a very short pseudodeltidium and laterally by the bases of the teeth. The pedicle beak is small and moderately incurved. A broad notothyrium is filled laterally by a pair of chilidial plates, which extends ventrally halfway up the cardinal process. The delthyrium is blocked by the cardinal process. The visceral region of the brachial valve is almost as concave as that of the pedicle valve is convex. The anterior margins of mature specimens may be slightly recurved forward. *Interior. Pedicle valve:* The teeth are of moderate size, divergent, and usually supported by a pair of dental plates, which is fused to the floor of the valve for a very short distance. The valve is thin and the external ornament corrugates most of the internal surface. Muscle scars are not obvious anteriorly and moderately impressed posteriorly. Broad flabellate diductor scars are delineated posterolaterally by a pair of short low muscle-bounding ridges. The adductor scars are elongate, and their posterior margins start a little way behind the diductor scars. A low median septum extends forward about a fifth of the length of the shell. The adductor scars are usually separated from the diductor scars posteriorly by a pair of low ridges. Only the more lateral spines show spine apertures (*sensu* Muir-Wood, *in* Moore, 1965). The inner surface of the valve is finely pustulose distal to the muscle scars.

Brachial valve: The cardinal process is bilobate anteriorly and quadrilobate posteriorly. A pair of broadly divergent socket ridges is fused to the pair of 'plates' that form the cardinal process. The socket ridges continue anterolaterally for a short distance as a pair of low rounded ridges. The cardinal process surrounds a gently impressed alveolus anteriorly and laterally, and is fused anterolaterally to a pair of lateral septa or anderidia. The anderidia diverge forward at about 20° from the midline, and increase in height anteriorly to a point halfway along their length, where they give off a pair of spines that point anterolaterally in the same direction as the anderidia. The anderidia die out gradually in front of the spinose projections, which in some specimens attain a length of 1.5 mm (Pl. 15, fig. 15). The median septum is low posteriorly and high anteriorly. It extends forward about a third of the length of the valve, and it usually divides posteriorly to join the anterolateral margins of the cardinal process where they are fused to the posterior ends of the anderidia. The external ornament corrugates most of the internal surface. The posterolateral and anteromedial portions of the valve are pustulose.

Discussion

P. konincki is very close to *P. flemingi* sp. nov. It differs in that it has more and finer costae (Text–figs 21 and 22); the external ornament does not corrugate the internal surface quite as strongly; the shells are not as alate, with the maximum width sometimes in front of the hinge-line; the spines on the anderidia are rather longer; the dental plates are often fused to the floor of the valve; and low ridges between the adductor and diductor scars are more obvious. It is not as easy to separate early ephebic stages of the two species, which may be closely related.

P. konincki is not very close to *Parachonetes suavis* (Talent). It is more like *P. baragwanathi* (Gill), in that both species have low ridges that separate the posterior portions of the ventral diductor scars from the adductor scars, and a pair of very short dental plates. *P. konincki,* however, has more and smaller costae and a median septum which is as prominent as the anderidia.

P. konincki differs from *P. macrostriatus* (Walcott) in that the ornament is finer; the costellae divide more frequently; the alveolus is not as strongly impressed; the papillae are not as prominent; and the internal surface is more obviously corrugated.

The ornament of *P. konincki* is similar to that of *P. verneuili* (Barrande) from the Upper Koneprusy Limestone (late Siegenian to early Emsian of Czechoslovakia, but that species has a larger and more firmly impressed alveolus.

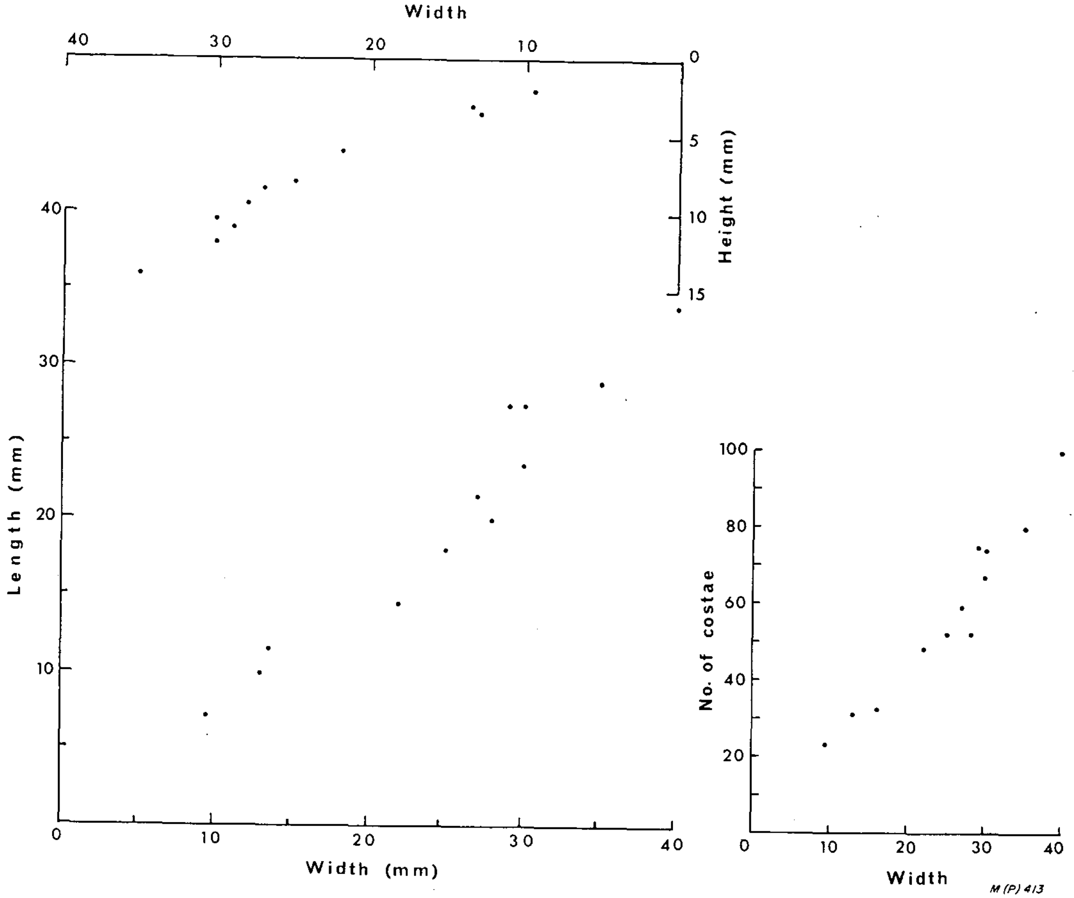


Fig. 22. ***Parachonetes konincki*** **sp. nov. Specimens from the base of the '*Receptaculites*' Limestone.**

Genus PROTOCHONETES Muir-Wood, 1962

Type species: Protochonetes ludloviensis Muir-Wood, 1962.

PROTOCHONETES CULLENI (Dun, 1904)

(Pl. 16, figs 1-22; Text–figs 23, 24)

1904 *Chonetes culleni* Dun, p. 321, pl. 61, fig. 1.

Type locality: The '*Spirifer yassensis*' Limestone at 'Shearsby's Wallpaper', about 1½ km south of Taemas Property, portion 65, parish of Taemas, near Yass, New South Wales.

Material: Topotypes ANU 18947a-c and CPC 10558. Specimens ANU 18945a-f and CPC 10559-62 (from the '*Receptaculites*' Limestone).

Occurrence: Common in the '*Spirifer yassensis*' Limestone and the base of the '*Receptaculites*' Limestone.

Description

The description is of topotype material from the *'Spirifer yassensis'* Limestone.

Exterior: The shells are of medium size, concavoconvex, and slightly transverse. The shell is slightly auriculate, with the cardinal angles usually between 60 and 80° in mature specimens; the maximum width may be at the hinge-line, but is usually in front of it and close to the midlength. The anterolateral margins of the shell are convex. Between 10 and 15 spines project from the edge of the pedicle interarea (only a few specimens were found which show this character). The spines near the beak project at a higher angle to the hinge-line than those near the cardinal angles, which project posterolaterally at between 40 and 50° from the hinge-line and distally may curve rearwards (Pl. 16, figs 15 and 16). The spines are hollow. The ornament consists of medium-sized costae; those on the brachial valve tend to increase by intercalation and those on the pedicle valve by bifurcation, although both types occur in each valve. At 5 mm from the hinge-line there are about 11 costae per 5 mm of arc. There are 48 costae at the margin of a specimen 15 mm wide. There is no micro-ornament, but fine concentric growth-lines may or may not be visible. The pedicle interarea is short, slightly concave, and apsacline to orthocline. The delthyrium is broad and triangular, with an apical angle of between 80 and 100°. The bases of the teeth partly fill in the posterolateral portions of the delthyrium so that, together with the pseudodeltidium, they cause the shape of the delthyrial opening to be roughly semicircular. The small convex apical pseudodeltidium is subdorsally directed. The brachial interarea is much shorter than that of the pedicle valve and anacline. A pair of chilidial plates partly blocks the notothyrium laterally.

Interior. Pedicle valve: A pair of moderate-sized teeth diverges forward. A short high median septum is present posteriorly. In most specimens, it is only high for a short distance in front of the beak, after which it loses height abruptly and disappears. (Not all the silicified specimens from the *'Receptaculites'* Limestone show this abrupt loss of height.) The muscle field expands forward and has a convex anterior margin. The diductor scars are broad and flabellate, and surround the adductor scars anteriorly. They are moderately impressed posteriorly and gently impressed or not obvious anteriorly. The adductor scars lie on each side of, and in front of, the median septum. They are elongate and bilobate anteriorly (Pl. 16, fig. 17), and may be separated from the diductor scars by a low ridge or a shallow furrow. In front of and alongside the muscle scars, the valve is pustulose owing to the projection inwards of pseudopunctae. The pustules are concentrated over the furrows of the external ornament. The visceral and brachial areas are sometimes gently or firmly impressed in this valve (Pl. 16, fig. 17); they are surrounded by a low ridge that is strongest posterolaterally. Most of the interior of the valve is corrugated by the impress of the costae.

Brachial valve: The cardinal process is anteriorly humped and gently bilobate, and posteriorly quadrilobate. The two inner lobes of the four posterior lobes are conjunct, and project farther backward than the outer lobes. A pair of sockets is strongly divergent, and is bounded medially by a pair of low socket ridges which diverge from the hinge-line at about 25°. The socket ridges merge with the cardinal process medially. A broad flat median septum is fused to the anterior edge of the cardinal process; it becomes narrower and slightly higher forward, reaching its maximum height just before it dies out near or slightly in front of the midlength. The posterior portion of the median septum is fused to the posterior portions of a pair of anderidia (or lateral septa), which diverge forward from the median septum at between 25 and 35°. The anderidia increase in height anterolaterally and then suddenly lose height at a point where a pair of small spines projects from them (anterolaterally, in the same direction as the anderidia). They die out slightly in front of the spinose projections. The portions of the valve lateral to and in front of the visceral area are pustulose. The pustules are concentrated over the impressions of the furrows of the external ornament.

Discussion

P. culleni has been placed in *Protochonetes* because the genus has been used in the sense of Boucot & Harper (1968), who stated: '*Protochonetes* Muir-Wood, 1962, is here considered to include all species which are similar to *Chonetes* Fischer de Waldheim, 1830, s.s., externally and in their pedicle valve interiors and cardinalia, and which have a median septum and anderidia, but no accessory septa in the brachial valve. It is considered to include forms with an enlarged median costella and forms having a pedicle valve with a median septum that does not bifurcate posteriorly'. In *Protochonetes culleni,* the ventral median septum does not bifurcate posteriorly. In this, it differs from the species group around *P. ludloviensis* Muir-Wood — the type species — and *P. striatellus* (Dalman), in which the ventral median septum is invariably bifurcated; but Boucot & Harper have pointed out that this feature is highly variable in *P. novascoticus* (Hall), from the Wenlock to Lower Gedinnian rocks of the Arisaig Series, Nova Scotia. *P. culleni* is also more strongly concavoconvex and more coarsely costate than the type species.

Mature specimens of topotype material of *P. culleni* from the '*Spirifer yassensis*' Limestone are larger than any specimens from the base of the '*Receptaculites*' Limestone (Text–fig. 23); their length/width ratio is slightly greater; and they tend to be slightly less alate. The few specimens that retain spines appear to have more than the '*Receptaculites*' Limestone specimens — 10-15 against 7-11; but this may be simply because they are larger shells.

A third form, *Protochonetes latus* sp. nov., occurs in the top of the '*Receptaculites*' Limestone and the base of the Warroo Limestone. It appears to continue the divergence from the prototypes of *P. culleni* noted above: its maximum size appears to be less (Text–fig. 23); it is more alate; its length/width ratio is slightly lower; and it has only 5 or 6 spines along the hinge-line. A further complication is that specimens of *P. latus* from the base of the Warroo Limestone tend to be slightly larger and to have slightly more costae than those from the top of the '*Receptaculites*' Limestone; but not enough specimens from either horizon have been found to determine whether the differences are sufficient to warrant subspecific separation.

Other closely related forms of *Protochonetes* occur in the Lower Devonian (or possibly lower Middle Devonian) rocks of Victoria. *Protochonetes australis* (M'Coy), which occurs at Buchan in rocks of similar age to those at Taemas, is very close to *P. culleni* in a number of features; it appears to differ only in that the anderidia are placed on a pair of low ridges that divide anteriorly, and the socket ridges extend distally into a pair of ridges that are longer and more prominent than those of *P. culleni.* Further work may either separate the two species more definitely or show that they are sufficiently variable that *P. culleni* should be considered a junior subjective synonym of *P. australis.*

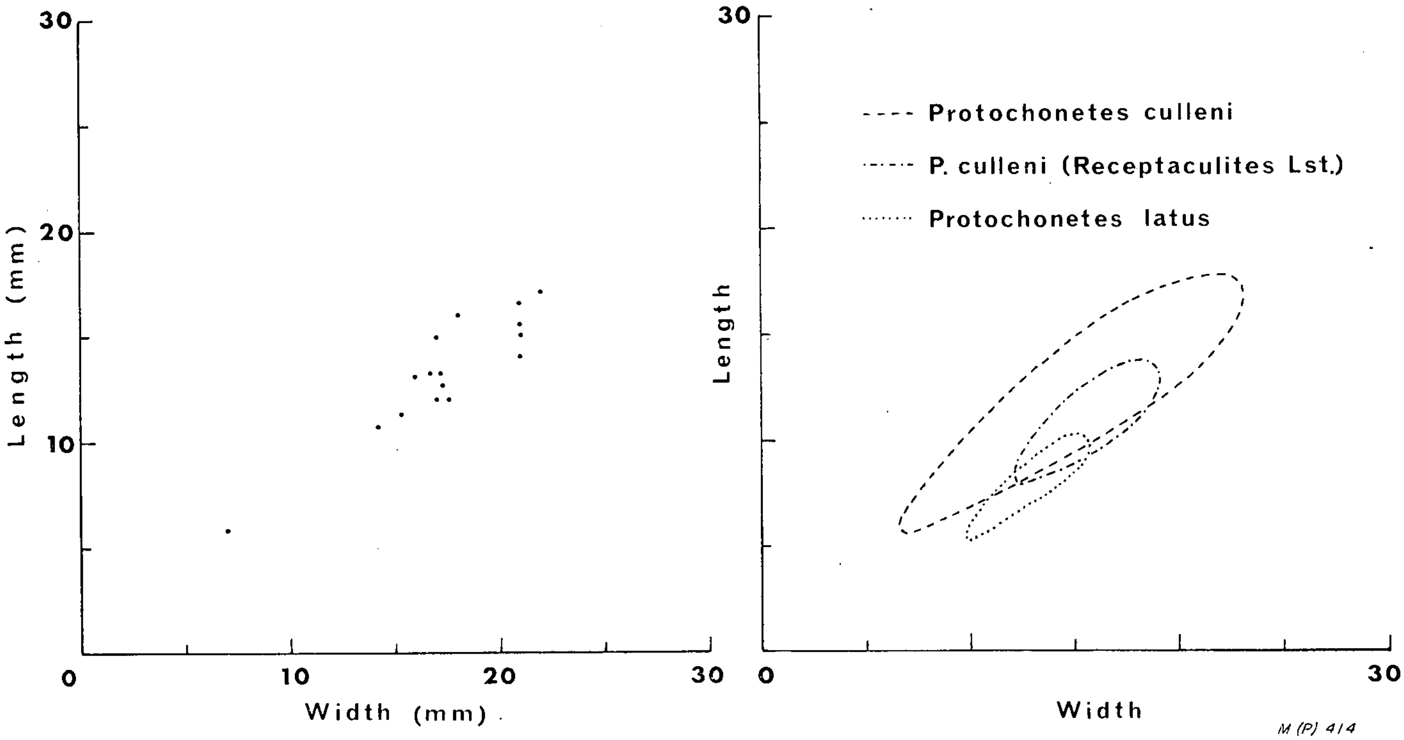


Fig. 23. *Protochonetes culleni* (Dun). Specimens from the type locality; and a composite diagram showing the envelopes that surround the points in the graphs of length against width included in Text–figs 23-25.

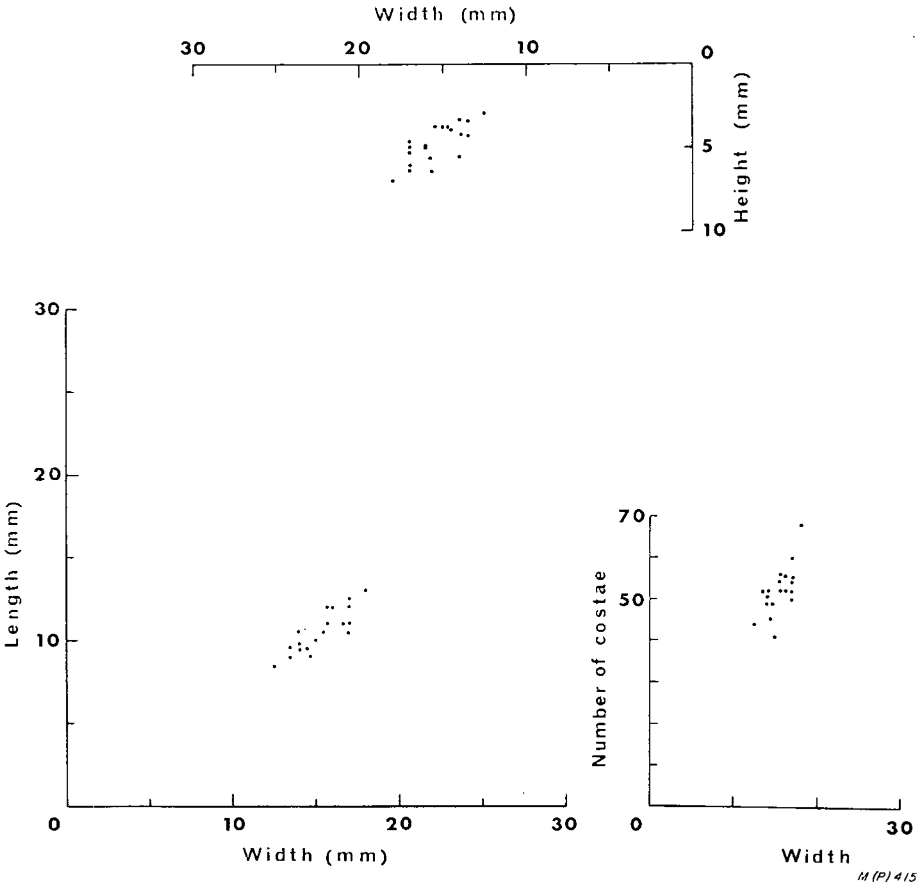


Fig. 24. *Protochonetes culleni* **(Dun). Specimens from the base of the '*Receptaculites*' Limestone at localities B and Г.**

Protochonetes cresswelli (Chapman) is also close (but not as close) to *P. culleni*. It differs in that its dorsal median septum is very weak close to the cardinal process; the socket ridges extend into ridges that are longer and more prominent; the spines project from the hinge-line at a higher angle; the ventral median septum tends to be narrower; and the ventral interior does not appear to have a gentle ridge surrounding the brachial area.

PROTOCHONETES LATUS sp. nov.

(Pl. 17, figs 3-24; Text–figs 23 and 25)

Derivation of name: Latin *latus*, a side or flank.

Type locality: The top of the '*Receptaculites*' Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18948; paratypes ANU 18949a-k and CPC 10563-5.

Occurrence: Several localities in the top of the '*Receptaculites*' Limestone and in the lower half of the Warroo Limestone, including localities A and Д.

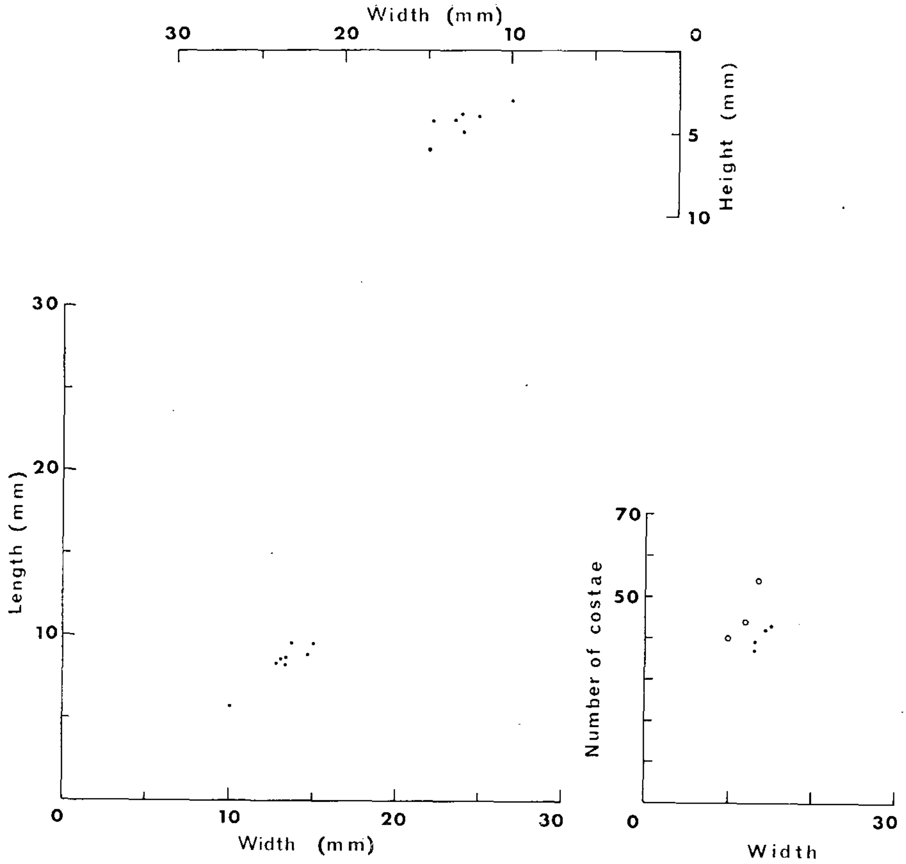


Fig. 25. ***Protochonetes latus*** **sp. nov. Dots indicate specimens from the top of the '*Receptaculites*' Limestone and circles indicate specimens from the Warroo Limestone.**

Description

Exterior: The exterior is close to that of *Protochonetes culleni* (Dun), but differs in that the maximum size of the shells is less (Text–fig. 23); they are more alate, with the maximum width always at the hinge-line; they are more strongly concavoconvex; the anterolateral margins are less expanded and convex; and they have 5-6 spines as against 10-15 on the topotypes of *P. culleni.*

Interior: The interiors are close enough to those of *P. culleni* to render it difficult to separate them meaningfully on the relatively small amount of material available. A character that may prove to be significant is the firmly impressed brachial grooves that occur in some specimens (Pl. 17, fig. 23).

Ontogeny

Several small specimens of *P. latus* were found in the base of the Warroo Limestone. A specimen 0.8 mm long and 1.0 mm wide is planoconvex. The maximum width is halfway between the hinge-line and the midlength. A spine base is present on the hinge-line of the pedicle valve, at the right cardinal angle, viewed ventrally, with the hinge-line uppermost. A small supra-apical foramen is present at the apex of a pedicle sheath which is obvious anteriorly, but recumbent posteriorly. The pedicle sheath is at the ventral margin of a protodeltidium. The apical region of the brachial valve is in a posterodorsal plane, leaving a gap between it and the protodeltidium (Pl. 17, fig. 9). The interareas are linear. A ventral median depression lies just in front of the pedicle sheath. The cardinal regions are flatter than the more medial portions of the pedicle valve. The posteromedian portion of the brachial valve is more convex than the rest of the valve, and is divided by four furrows into a protegular fold and a pair of lateral nodes (*sensu* Kemezys, 1965). The furrows are firmly impressed posteromedially becoming shallow anteriorly and laterally so that neither they nor the protegular fold, nor the lateral nodes, are very obvious near the margins. Fine concentric growth-lines are apparent on both valves.

In larger stages, the foramen becomes closed; the protegular fold and lateral nodes of the brachial valve die out about 1 mm from the beak; and a very weak ornament of costae appears about 1 mm from the beak (with a median costa appearing first in the pedicle valve). The first spine is at least 0.6 mm long in one specimen 1.05 mm long excluding the spine.

A specimen 1.25 mm long is already obviously concavoconvex, and the cardinal angles are only slightly greater than a right angle. In still larger stages the second spine appears on the right side of the hinge-line (ventral view, hinge uppermost), the third spine on the left side, so on in order alternately to right and left; the costae increase in number; and the shells become more strongly concavoconvex and more alate. The cardinal process, socket ridges, and anderidia appear before the median septum. The first spine is directed towards and the later spines away from the midline.

Discussion of ontogeny: Boucot & Harper (1968), Muir-Wood (1962), and others have used the angle between the spines and the hinge-line as a character of systematic importance. As the angles change during the ontogeny of *Protochonetes latus, Protochonetes culleni* (Dun), *Parachonetes flemingi* sp. nov., and *Parachonetes konincki* sp. nov., it is felt that this character should be qualified so that the angle of divergence of the more medial spines is taken into account as well as that of the more lateral spines (this feature was described in Viséan chonetids from Northern Ireland by Brunton, 1968).

The presence of the first two spines on the right side of the hinge-line followed by later spines on alternate sides is interesting, as it does not fit into the usual pattern of bilateral symmetry of the Brachiopoda. This pattern is present in *P. latus, P. culleni,* and *Septachonetes melanus* gen. et sp. nov. (in which only the first two spines are present). It was not possible to tell whether this pattern occurs in the two species of *Parachonetes* described here, as the early stages and the umbonal regions of adult shells are not as well preserved. This character may be of use taxonomically. Some of the Viséan chonetids described by Brunton (1968) appear to have a symmetrical distribution of spines. One species, *Globosochonetes parseptus* Brunton, apparently does show an asymmetric pattern, but the first two spines are introduced on the left side of the hinge-line (Brunton, 1968, pl. 7).

Kemezys (1968) suggested that members of the Chonetoidea possess a ventral median depression, a dorsal protegular fold, and lateral nodes in early growth stages. These characters are present in the early growth stages of *P. latus*.

The pedicle sheath present in *P. latus* is not as prominent or as protuberant as the pedicle sheath of a small Carboniferous chonetid figured by Brunton (1964, pl. 109), or the sheaths of *Rugosochonetes silleesi* Brunton and *Globosochonetes parseptus* Brunton, figured by Brunton (1968).

Discussion

Protochonetes latus sp. nov. is very close to *P. culleni* (Dun). The two species can be separated according to the criteria discussed above under the description of *P. culleni*. *P. latus* may be phylogenetically descended from *P. culleni* through the specimens that occur in the base of the *'Receptaculites'* Limestone (at an intermediate stratigraphic level, see Text–fig. 2), in which the number of spines, maximum size, and degree of alation are intermediate between the topotypes of *P. culleni* and the types of *P. latus*.

See also the discussion on pp. 72-4.

Genus SEPTACHONETES nov.

Type species: Septachonetes melanus sp. nov. from the Upper Emsian or possibly Lower Eifelian Warroo Limestone at Taemas, New South Wales.

Derivation of name: Septum, a partition, and *chonetes.*

Diagnosis: Small costate concavoconvex shells; with a short median septum and a convex pseudodeltidium in the pedicle valve; anderidia and pustulose additional lateral septa in the brachial valve; no dorsal median septum; cardinal process gently bilobate anteriorly and quadrilobate posteriorly, with a gentle alveolus at its anterior margin; and one small and one larger spine, which project posteriorly at a high angle to the hinge-line on the right side of the beak only (in ventral view, hinge uppermost).

Discussion

Septachonetes is regarded as an aberrant form of the Devonochonetinae. It differs from the other genera of this subfamily in having only two spines on one side of the hinge-line, no dorsal median septum, and pustulose additional lateral septa. Mature specimens of the type species, *Septachonetes melanus* sp. nov., are not very close to any of the genera described by Boucot & Harper (1968). Early growth stages of *Protochonetes latus* sp. nov. are in some ways similar to the adults of *S. melanus:* the first two spines of *P. latus* appear on the right side of the hinge-line (as do the only two spines of *S. melanus*), and the early brachial valves of *P. latus* lack a median septum at a stage where anderidia are obvious. Thus, *S. melanus* could be an example of neotony. The additional lateral septa appear to be formed of pustules that have coalesced. As the anteromedial portions of the brachial valves of many members of the Devonochonetinae have fairly prominent pustules that are usually concentrated on the furrows of the external ornament, it does not seem a great step to a type in which some of these pustules have partly coalesced to form several additional lateral septa.

Though *Septachonetes* is similar to most of the Anopliinae in lacking a dorsal median septum and having several pairs of additional lateral septa, it differs from them in having a finely costate ornament and a rather less strongly concavoconvex growth form. It may be regarded as an aberrant devonochonetid with characters intermediate between the Devonochonetinae and the Anopliinae.

Several small species of chonetids from Victoria may either belong to or be closely related to *Septachonetes*. For instance, Gill (1951b, p. 63), when discussing *'Chonetes' micrus* Gill, stated: 'Spines do not appear on the type specimens but are seen on specimens 14705-14706, which show two long thin spines on one side of the umbo so placed as to suggest that this was the full number for each side, i.e. a total number of four'. *'C.' micrus*, then, could, like *S. melanus*, have only two spines on one side of the beak; it differs from *S. melanus* in that it has a low flat-topped dorsal median septum and lacks additional lateral septa.

'Chonetes' teicherti is also close to *S. melanus* in having only two spines, both on the right side of the hinge-line (ventral view, hinge uppermost). The material makes it difficult to compare interiors. The dorsal median septum described by Gill (1951b) is probably a protegular fold (*sensu* Kemezys, 1965) and not a median septum. Other features of the two species are fairly close to each other, except that *S. melanus* does not have thickened spine bases or a larger median costa in the pedicle valve.

Range: The type species, *S. melanus* sp. nov., occurs in the Upper Emsian or possibly Lower Eifelian Warroo Limestone of the Taemas area, New South Wales. *Septachonetes* may also include one or two of the small chonetids from the Lower Devonian of Victoria, which are not as yet sufficiently well known to be placed with certainty in any genus.

SEPTACHONETES MELANUS gen. et sp. nov.

(Pl. 14, figs 18-25; Pl. 17, figs 1-2)

Derivation of name: Greek *melas,* black.

Type locality: The base of the Warroo Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18940; paratypes ANU 18939a-d and CPC 10566-8.

Occurrence: Several horizons within the Warroo Limestone.

Description

Exterior: The shells are small, slightly transverse, and moderately concavoconvex. The largest specimen found is 3.8 mm long and 5.3 mm wide. The maximum width may be at the hinge-line, but is usually as far forward as the midlength; and the cardinal angles may be slightly less, but are usually slightly greater, than a right angle. The ornament consists of fine costae, which increase by both bifurcation and intercalation. There are about 45 costae at the margin of a specimen 5 mm wide. Occasional fine growth-lines are visible. One small and one larger spine project from, and at a high angle to, the hinge-line on the right side of the beak (ventral view, hinge uppermost). The small spine projects from the hinge-line about 0.25 mm and the large spine about 1.0 mm from the beak. The low apsacline pedicle interarea is interrupted by a delthyrium, which is partly closed by a small convex pseudodeltidium. The interarea of the brachial valve is very low to linear; and no chilidium or chilidial plates were observed (the brachial valves were not well enough preserved to be sure that they were absent).

Interior. Pedicle valve: The teeth are of moderate size and are not supported by dental plates. The posterolateral portions of the inner surface are strongly pustulose. A median septum extends forward less than a quarter of the length of the valve.

The external ornament only corrugates the interior close to the margins, although the pustules are arranged in rows over the furrows of the external ornament.

Brachial valve: The cardinal process is anteriorly bilobate and posteriorly finely quadrilobate (in some poorly preserved specimens it appears to be trilobate, as the median pair of lobes is conjunct). In most specimens a pair of small anderidia diverges forward at about 35° to the midline. A pair of socket ridges curves gently sublaterally from the cardinal process. Between 3 and 5 pairs of additional lateral septa are present anteromedially over the furrows of the external ornament (for terminology see Boucot & Harper, 1968, p. 148). They appear to be formed of prominent pustules that have coalesced; and they do not reach as far forward as the anterior margin. The anteromedial portions of the valve are more prominently pustulose than the posterolateral portions. The pustules are arranged over the furrows of the external ornament. There is no median septum.

Discussion

See under the discussion of the genus.

Superfamily PRODUCTACEA Gray, 1840
Family PRODUCTELLIDAE Schuchert & Le Vene, 1929
Subfamily PRODUCTELLINAE Schuchert & Le Vene, 1929
Genus SPINULICOSTA Nalivkin, 1937

Type species: Productella spinulicosta Hall, 1857.

SPINULICOSTA CAMPBELLI sp. nov.

(Pl. 18, figs 1-26)

Derivation of name: After Dr K. S. W. Campbell.

Type locality: The top of the *'Receptaculites'* Limestone at Locality Д, about 1.2 km south of Hume Park, near Yass, New South Wales (see Text–fig. 1).

Type material: Holotype ANU 18950; paratypes ANU 18951a-1 and CPC 10569-73.

Occurrence: The top of the *'Receptaculites'* Limestone at Locality Д and several localities about halfway up the Warroo Limestone.

Description

Exterior: The shells are elongate to slightly transverse, strongly concavoconvex, and have short convex trails and steep flanks. The visceral disc of the pedicle valve is strongly convex; that of the brachial valve is not quite as concave. The interareas of both valves are sublinear, but that of the pedicle valve is slightly higher than that of the brachial valve medially. The pedicle beak is strongly incurved. A delthyrium is open and wider than long. The maximum width is in front of the hinge-line, and usually between the hinge-line and the midlength. Scattered spines are present on the pedicle valve. They are long, slightly curved, usually recumbent on the flanks, and project from spine ridges. A row of spines is present along the hinge-line, but the more lateral are slightly farther from the hinge-line than the medial spines. No spines are present on the brachial valve;

and the ornament consists of elongate pits under the spine ridges of the pedicle valve and rarely of a faint concentric ornament of rugae near the cardinal angles. Occasional concentric growth-lamellae are prominent on the pedicle valve. A supra-apical foramen is blocked internally by secondary shell material in mature specimens. The valves are slightly auriculate, and the ears are flatter than the rest of the shell.

Interior. Pedicle valve: A pair of moderate-sized teeth is not supported by dental plates. There are signs of faintly impressed flabellate diductor scars enclosing narrower, more elongate, and slightly more firmly impressed adductor scars. The scars are gently impressed posteriorly and disappear anteriorly. A low median septum extends forward from a low ventral process as a fine ridge, and separates the muscle scars. The external ornament corrugates most of the internal surface of the valve.

Brachial valve: The cardinal process is bilobed, and the two lobes are disjunct distally and incised posterodorsally so that the external face is quadrilobate. A cushion of secondary shell material is usually present at the anterior edge of the cardinal process, and secondary deposition may partly or completely join the two lobes along their anterior margins. A median septum extends forward less than half the length of the shell. It is low posteriorly and reaches its maximum height half way along its length. A pair of lateral septa or anderidia (these features are thought to be homologous with the anderidia of chonetids) reaches forward about a third of the length of the median septum. The anderidia diverge from each other at about 50°. A pair of short protuberances projects from them near their anterior margins (see Pl. 18, fig. 15). A pair of socket ridges runs anterolaterally at 20-30° to the hinge-line. The adductor scars are obscure. The interior of the valve is pustulose owing to the ingrowth of pseudopunctae. The external ornament corrugates most of the internal surface.

Ontogeny

Some fragments of early neanic individuals, about 1.5 mm long and 1.5 mm wide, were found (Pl. 18, figs 7 and 8). The shells are plano-convex. There is a weak median depression in the pedicle valve, and a protegular fold and a pair of short lateral nodes in the brachial valve. A relatively large pedicle foramen is supra-apical and placed slightly in front of the hinge-line. It is flanked posterolaterally by a pair of strong posterolaterally directed spines. The ornament consists of fine concentric wrinkles or growth-lines. A convex protodeltidium is present at the anterior margin of the foramen, and extends from the foramen to the commissure. There is no pedicle sheath.

Discussion

In later stages, the shells become concavoconvex; the foramen is closed by secondary shell in a specimen about 2.5 mm long; spines are introduced anteriorly and laterally at irregular intervals, with spine ridges becoming more obvious anteriorly; a pair of anderidia is apparent in a brachial valve about 2.5 mm wide (Pl. 18, fig. 3); an alveolus that is present in front of the cardinal process of early stages (over the protegular fold) is filled by secondary shell material; and secondary deposition along the anterior margin of the cardinal process may partly or completely join the anterior portions of the two process lobes. In all ephebic stages, a fairly well defined row of spines is present close to the hinge-line (the more lateral spines are slightly farther from the hinge-line than the medial spines).

At all growth stages the outermost spines tend to be directed posteroventrally. The spines on the flanks of the pedicle valve project initially at a moderate to high angle to the shell surface, but a short distance away from it they bend so as to project in a direction that is closer to parallel with the external surface of the shell.

S. campbelli has been included in *Spinulicosta* Nalivkin because it has linear or sublinear interareas; spine ridges on the pedicle valve; no pseudodeltidium; teeth and sockets; concentric lamellae on the pedicle valve; long curved spines on the flanks; and a subcircular to elongate outline.

The long narrow ventral adductor scars and fine median ridge of *S. campbelli* are also apparently present in *S. spinulicosta* (Hall) (see Muir-Wood & Cooper, 1960, p. 154), the type species from the Middle Devonian Marcellus Shale of New York (for the age of this unit see Rickard, 1964). The lectotype of *S. spinulicosta,* figured by Muir-Wood & Cooper (1960, pl. 32), differs from *S. campbelli* in that the cardinal angles are less than a right angle; the maximum width is at the hinge-line; and the umbo does not extend as far behind the hinge-line. I was unable to find a suitable illustration of a brachial interior of *S. spinulicosta,* but Imbrie (1959, p. 399) stated that the brachial interiors are similar to those of forms from the Middle Devonian Traverse Group of Michigan.

Spinulicosta mutacosta Imbrie from the Traverse Group is very similar to *S. campbelli* in outline and general morphology, and both have a weak pair of anderidia and lack an obvious alveolus in front of the cardinal process of mature specimens. *S. campbelli,* however, has less obvious concentric ornament and slightly more obvious ventral muscle scars and median ridge.

S. campbelli is one of the earliest known productoids, and its morphology and ontogeny could be expected to have some value in a study of the ontogeny of the Productidae, if not of the Productacea. Muir-Wood & Williams (*in* Moore, 1965, p. 439) suggested that the productoids evolved from the strophomenoids and stated: 'Both stocks (strophalosiacean and productacean) are clearly unrelated to the chonetoids, formerly considered to be ancestors of the productoids, and it is probable that they were derived from some Silurian or Early Devonian strophomenoid such as the genus *Leptaenisca,* in which the brachial ridges are prominently developed'. Muir-Wood & Cooper (1960) stated: 'The view that the productoids rose out of the chonetoids has now been abandoned following the lead of Ivor Thomas (1914, p. 256) and Chao (1928, p. 6)'. Ivor Thomas and Chao do not, however, provide very clear reasons for their preference of strophomenoids to chonetoids as an ancestral stock for the productoids. Muir-Wood & Cooper appeared to suggest that *Leptaenisca* may be related to the productoids on the basis of spiral brachial ridges, somewhat dendritic muscle scars, and a bilobed cardinal process. They suggested a noncementing leptaeniscoid as a possible productoid ancestor, but also stated: '*Leptaenisca* seems a more likely ancestor to the Strophalosiidae than to the Productellidae, but both could have arisen from the same leptaeniscid. There is a possibility, however, that the Productoidea may be polyphyletic'.

Several features of such early productellids as *Spinulicosta* and *Productella* seem to be incompatible with their views. These genera do not have dendritic muscle scars. The 'anderidia' of *S. campbelli* and *S. mutacosta* are not homologous with the prominent and highly evolved brachial ridges of *Leptaenisca.* Since these 'anderidia' are similar in form, similar in position relative to the muscle scars, and have similar spinose processes to the anderidia or lateral septa of chonetoids, it is argued that they are homologous. Thus, *S. mutacosta* and *S. campbelli* have a feature that is common in the chonetoids and rare or absent in the strophomenoids. The spinose processes half way along the lengths of the anderidia are common in numerous chonetoids, including *Protochonetes culleni* (Dun), *Protochonetes latus* sp. nov., and *Parachonetes konincki* sp. nov. On the whole, the early productoids lack the complicated brachial ridges of *Leptaenisca* and many of the later productoids. Curved brachial ridges are, however, present in some chonetoids, so one should not be surprised at their appearance in a stock that arose from the chonetoids. The spines of *S. campbelli* are only present on the pedicle valve; so are those of the chonetoids. Spines are not restricted only to the hinge-lines of chonetoids, as spinules away from the hinge-lines have been described in such forms as *Rugosochonetes hindi* Muir-Wood (Muir-Wood, 1962, Pl. 6). Brunton (1968, p. 47), however, disagreed that the specimen figured by Muir-Wood has spinules. Although such strophomenoids as *Barbaestrophia* Havlíček have spines along the hinge-line of the pedicle valve, these spines are solid, whereas the spines of chonetoids and productoids are hollow and have central canals. The ornament of spine ridges or irregular costae that is present in *Spinulicosta* and *Helaspis* could more readily have arisen from a costate chonetoid than a costellate or capillate strophomenoid such as *Leptaenisca.* It is possible that the budding-off of portions of the edge of the mantle to form spines (probably at the regions where the mantle was deflected to produce costae) would have disrupted the costate pattern, and produced a pattern similar to that of *Spinulicosta* or *Helaspis,* in which the irregular costae or spine ridges disappear in front of the spines. The partial loss of costae may have rendered them inefficient or unnecessary and resulted in their further reduction and complete loss to produce forms like Productella.

The cardinal processes of the early productoids show characters in common with both the strophomenoids and the chonetoids, and do not appear to be obviously closer to one of these stocks than the other. The foramina of the early growth stages of *S. campbelli* do not have a pedicle sheath (at least, in specimens about 1.5 mm long); whereas practically all, if not all, of the known early growth-stages of the strophomenoids do have pedicle sheaths; for example, *Leptaena* described by Kozłowski (1929), *Fardenia* illustrated by Brunton (1964), and species of *Cymostrophia, Malurostrophia, Taemostrophia* gen. nov. (stropheodontid), and *Leptostrophia,* which are described in this work. The early growth-stages of *Protochonetes latus* sp. nov. have a pedicle sheath which has degenerated posteriorly and is only obvious along its anterior edge. This might be regarded as the first stage towards the loss of a pedicle sheath. On the other hand, Brunton (1964, 1968) described and illustrated pedicle sheaths in the productoids *Productina margaritacea* (Phillips) and *Eomarginifera* sp., and the chonetoids *Globosochonetes parseptus* Brunton and *Rugosochonetes silleesi* Brunton, from the Visean of Northern Ireland. Thus, though the absence of a pedicle sheath in some productoids may favour the chonetoids slightly as their ancestors, the presence of pedicle sheaths in other productoids and chonetoids by no means rules out the possibility that the strophomenoids are the ancestors of the productoids. Brunton (1968, pp. 46-47) also argued that the Productacea and the Strophalosiacea differentiated from a chonetacean-like stock. He suggested that the Productacea are close to the Chonetacea as both have functional pedicles in early stages, comparable gross morphology, pseudopunctation, and spine development, and both tend to gigantism in the Lower Carboniferous.

In the light of all the information discussed above, a relatively unspecialized irregularly costate chonetoid such as *Parachonetes* seems to be a more likely ancestor for the productellids (if not also for the productoids) than a relatively specialized strophomenoid such as *Leptaenisca,* although *Parachonetes* is not put forward as a direct ancestor of the productellids.

Order SPIRIFERIDA Waagen, 1883
Suborder ATHYRIDIDINA Boucot, Johnson & Staton, 1964
Superfamily ATHYRIDACEA M'Coy, 1844
Family ATHYRIDIDAE M'Coy, 1844
Subfamily ATHYRIDINAE M'Coy, 1844
Genus ATHYRIS M'Coy, 1844

Type species: Terebratula concentrica von Buch, 1834.

ATHYRIS WARATAHENSIS (Talent, 1956)

(Pl. 29, figs 11-20; Pl. 35, fig. 9; Text–fig. 26)

Locality: The specimens described were obtained from about 20 m below the top of the *'Receptaculites'* Limestone in the outcrop overlooking the Murrumbidgee River in the northern end of Bloomfield Property, and the base of the *'Receptaculites'* Limestone at Locality Γ. Specimens were also found in the *'Spirifer yassensis'* Limestone at Locality C (see Text–fig. 1), and at several localities in the Cavan Formation.

Material: Specimens ANU 18972a-d, ANU 18998, and CPC 10574.

Description

Exterior: Shells are medium sized, subequally biconvex, and subcircular in outline. The maximum width is close to the midlength. The largest specimen found in the *'Receptaculites'* Limestone is 17 mm long; larger specimens have been found in the *'Spirifer yassensis'* Limestone, at Locality C of Text–figure 1. A dorsal fold and ventral sulcus are obvious in the anterior half of the shell, but are not present close to the beaks. The anterior commissure is plicate to slightly parasulcate. Numerous prominent growth lamellae extend distally into frills; they are spaced at roughly equal intervals over the surface of the shell. The ventral palintrope is curved, and is not separated from the rest of the shell by an obvious beak ridge. The foramen is round and could probably be regarded as epithyridid; but as the beak ridge is not obvious it is difficult to be sure. The brachial valve has no interarea. The pedicle beak is moderately incurved.

Interior. Pedicle valve: The teeth are supported by a pair of short stout dental plates that is very gently concave medially. There is no medium septum. The muscle scars are not obviously impressed. A pedicle callist may or may not be recognizable between the dental plates.

Brachial valve: A cardinal plate (inner hinge-plate) is perforate apically. Its anterior margin is convex, and a low median ridge is generally present on its ventral surface. The cardinal process may or may not be present as a low median ridge, visible on the floor of the valve through the perforation in the cardinal plate. There is no median septum, but a gentle myophragm is visible posteriorly in some specimens (particularly in immature specimens, between a pair of elongate adductor scars). The crura curve ventrally from the anterior margin of the cardinal plate and then curve slightly anteroventrally before turning sharply backward to become the primary lamellae. The primary lamella curves backwards and then dorsally and forward to produce the first whorl of the laterally directed spiralium, which has about 10 whorls in a specimen 17 mm long. At the midlength of the dorsal half of the first whorl of the spiralium, a jugal process extends ventromedially to join the jugal process of the opposite spiralium and form a strong anteriorly protuberant jugal saddle. A rod-like process extends slightly behind ventrally from the posterior edge of the jugal saddle to a position not far from the floor of the pedicle valve. At this point, this rod bifurcates and forms two fine calcareous ribbons, which diverge from each other posteriorly and then curve round parallel with the primary lamellae, between the first and second whorls of the spiralia (see Text–fig. 26). The calcareous ribbon of the first whorl of the spiralium is much wider than that of later whorls.

Discussion

A. waratahensis has been included in *Athyris* because the interiors of the valves, including the brachial supports, are typical of that genus. Talent (1956) included the species in *Buchanathyris* Talent, because of its external similarities —he had no interiors—to *Buchanathyris westoni* Talent, the type species of *Buchanathyris.* He distinguished it from *B. westoni* on the presence of numerous regularly spaced growth lamellae. The brachidium of *A. waratahensis* differs from that described by Talent for *B. westoni* in that it has an obvious jugal saddle and a rod-like process, which extends subventrally from the anterior margin of the jugal saddle before bifurcating to form two calcareous ribbons that curve parallel with the first whorls of the spiralia, between the first and second whorls.

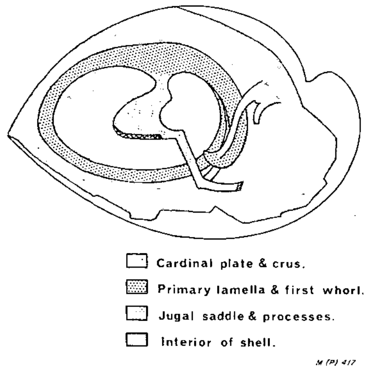


Fig. 26. *Athyris waratahensis* **(Talent). Interior of specimen, showing part of the brachidium.**

The types of *A. waratahensis* come from the Lower Devonian or lower Middle Devonian rocks of Buchan, Jackson's Crossing, and Bell Point, Victoria. They appear to differ slightly from the material from Taemas in that they have slightly weaker folds.

Suborder ATRYPIDINA Moore, 1952
Superfamily DAYIACEA Waagen, 1883
Family ANAPLOTHECIDAE Schuchert, 1894
Subfamily COELOSPIRINAE Hall & Clarke, 1894
Genus Coelospira Hall, 1863

Type species: Leptocoelia concava Hall, 1857.

COELOSPIRA DAYI sp. nov.

(Pl. 19, figs 15-36; Pl. 35, figs 6-8; Text-figs 27 and 28)

Derivation of name: After Dr R. W. Day.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales. The following paratypes were collected from the base of the *'Receptaculites'* Limestone at Locality Γ: ANU 18955 a, b, and h.

Type material: Holotype ANU 18954; paratypes ANU 18955a-k, CPC 10575-8 and 10648-50.

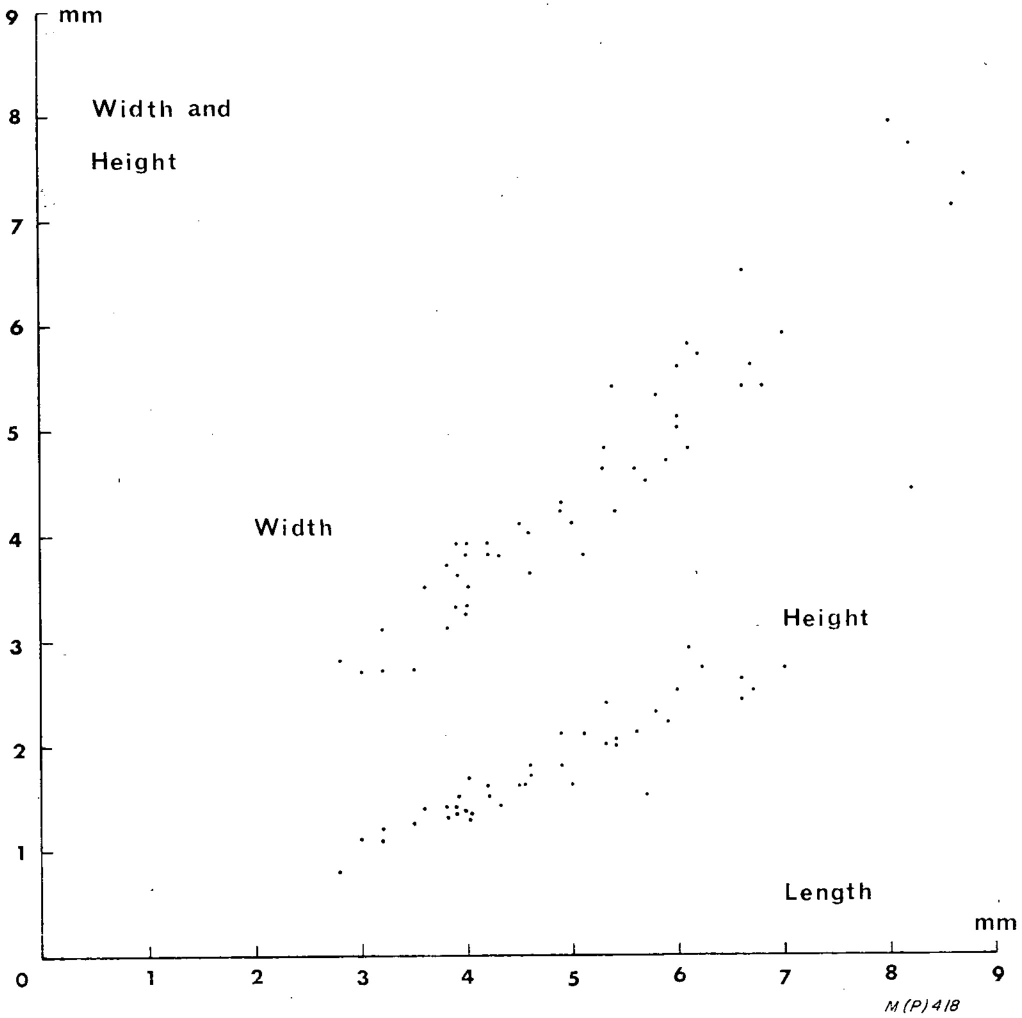


Fig. 27. *Coelospira dayi* **sp. nov. Specimens from the** *'Receptaculites'* **Limestone.**

Occurrence: Several localities and horizons within the *'Receptaculites'* and Warroo Limestones.

Description

Exterior: The shells are small, concavoconvex, and suboval, tending to be slightly elongate (see Text–fig. 27). The hinge-line is short. The ventral beak is incurved. The concavity of the brachial valve is emphasized by a broad sulcus. On either side of a fine median plication of the pedicle valve, a larger pair of plications bifurcates towards the anterior margin. A pair of corresponding plications is added to the brachial valve by intercalation (Pl. 19, figs 19-21). The plications and the interspaces between them are subrounded. Poorly developed growth-lines may be present at irregular intervals. The pedicle valve has a very short interarea and an open delthyrium; the brachial valve has no interarea. Some specimens appear to have a micro-ornament of radiating capillae, but on close examination this appears to be a function of preservation rather than a primary feature.

Interior. Pedicle valve: A pair of prominent teeth, elongate anterolaterally, are attached to the inside of the posterolateral margins of the valve. Crural fossettes are present along the posteromedial portions of the teeth. The diductors expand and extend forward for a third of the length of the valve. They are moderately impressed and not obviously raised anteriorly on a platform, although a gentle ridge is present at the anterior margin of the diductors. They are divided by a relatively narrow ridge-like myophragm. A slight thickening in the umbo may be a pedicle layer. In some specimens, a pair of rounded or elongate depressions is present in front of the teeth, close to the lateral margins. These depressions are usually partly delineated posteromedially by a low curved ridge and their margins may be scalloped. They may have been associated with brood pouches or vascula genitalia (see under discussion).

Brachial valve: The prominent broadly divergent socket ridges are not parallel with the posterior margin of the valve. They curve laterally at their anterior ends. A median ridge or dorsal myophragm is broad posteriorly. It narrows and increases in height forward, between the adductor scars, before dying out at the anterior margins of the adductor scars. The adductor scars are subtriangular, broad posteriorly and narrow anteriorly. The cardinal process fills the posterior portion of the space between the socket ridges. It is low and mound-like, and in some specimens appears to be gently bilobate or trilobate. The crura project slightly medially of anteroventrally, from the inner edges of the socket ridges halfway towards their anterior margins. There are no crural plates. The brachial structures are complicated (Text–fig. 28). The primary lamellae (or proximal portions of the first whorls of the brachidium) are broad; and they join the distal ends of the crura at a high angle (Pl. 19, fig. 28). From the crura, the primary lamellae curve laterally and dorsally, and then anteromedially to the midline against the brachial valve. At this point, they fuse to form a jugum, which projects slightly behind ventrally almost as far as the pedicle valve before dividing to become the second pair of whorls. The second pair of whorls spirals in the same sense as, and is subparallel with, the first pair, and their dorsal portions fuse at the top of the jugum. From this point, the brachidium extends anterolaterally along the surface of the brachial valve as a long thin rod. Close to the anterior margin, the brachidium curves ventromedially, becomes ribbon-like, and then curves backward to form a spiralium whose apex is directed outward towards a flank of the pedicle valve (Text–fig. 28, and Pl. 19, figs 27 and 32-34). The spiralium curves in the

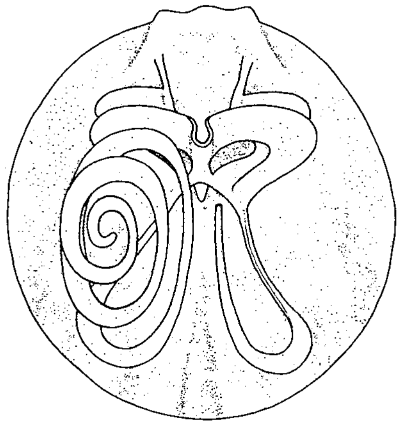


Fig. 28. *Coelospira dayi* **sp. nov. Ventral view of a brachial valve with a reconstruction of the brachidium (incomplete on the right side of the diagram).**

same sense as the first two whorls of the brachidium. Neither the jugum nor the spiralia are spinose. There may be up to seven whorls in the spiralia of mature individuals, including the first two whorls of the brachidium.

Discussion

Coelospira dayi falls within the diagnosis of *Coelospira* given by Boucot & Johnson (1967). It is close to *C. camilla* Hall, which occurs in the upper Emsian to Eifelian rocks of New York, but its cardinal process is not as prominent; its muscle scars do not extend as far forward; it tends to be elongate rather than transverse; and some pedicle valves have a pair of depressed areas anterolateral to the teeth. The similarities between *C. camilla* and *C. dayi* and the occurrence of both in rocks of Emsian or Eifelian age fit in well with Boucot & Johnson's (1967) tentative phylogeny of the species of *Coelospira,* though their statement (1967, p. 1226) that 'Devonian species of *Coelospira* are restricted to the Western Hemisphere with the exception of a single specimen from Turkey' must be modified.

The depressions in front of the teeth of ventral valves of *C. dayi* are obvious in some specimens, absent in some, and faintly impressed in others. It is possible that these features are sex-linked, but by no means certain: the weakness of the depressions in some forms could be an intermediate stage between prominence and total loss, or could be simply fortuitous. They cannot be either adductor or diductor scars because of their position, and their size and position are strongly against their being pedicle adjustor scars. In the live brachiopod, they would probably have been close to the anterior margin of the visceral region, lateral to the brachidia and close to the valve margin. If they are not muscle scars, they were presumably depressions of the shell that contained organs that either required some slight protection or required more space than the concavoconvex shape of this species otherwise allowed for.

Rudwick (1964) discussed the possible occurrence of brood pouches in the Middle Devonian brachiopod *Uncites,* and related them to those of the Recent brachiopods *Argyrotheca* (Terebratulacea) and *Lacazella* (Thecidacea) and of the bivalve *Thecalia.* The depressions in *C. dayi* are closer to the brood pouches of the Recent forms than are the features described by Rudwick, because they are internal. Like those of *Argyrotheca* they are present laterally; and like *Lacazella* they are impressed in the floor of the pedicle valve. *Lacazella* has a single median depression of the pedicle valve, which is sex-linked. It is much more obvious than those of *C. dayi,* and is so deep that it causes a corresponding external bulge of the shell (Hyman, 1959). It is quite possible, therefore, that the depressions in *C. dayi* signify brood pouches; it is also possible that they were associated with a pair of gonads.

The brachidia of *C. dayi* are similar to those of *Coelospira kennethensis* Boucot & Johnson, (1967, Pl. 166, figs 20-21); but they lack spines, and have two initial whorls fused to the jugum. Other features of *C. dayi* are not close to those of *C. kennethensis*.

Superfamily ATRYPACEA Gill, 1871
Family ATRYPIDAE Gill, 1871
Subfamily ATRYPINAE Gill, 1871
Genus ATRYPA Dalman, 1828

Type species: Anomia reticularis Linné, 1758.

ATRYPA PENELOPEAE sp. nov.

(Pl. 20, figs 15-16; Pl. 21, figs 12-23 - 25-29; Pl. 22, figs 1-10;
Text–figs 29, 30)

1920 *Atrypa desquamata* Sowerby; Mitchell & Dun, p. 271, pl. 15, figs 12, 13.

Derivation of name: After Penelope.

Type locality: The base of the *'Receptaculites'* Limestone at Locality B, Bloomfield Property, parish of Warroo, near Yass, New South Wales. Some of the paratypes come from Locality Γ at the same horizon, about 250 m south of Locality B.

Type material: Holotype ANU 18960; paratypes ANU 18946, 18958a-j, 18959a-b, and CPC 10579-80.

Occurrence: Several horizons within the *'Receptaculites'* Limestone, at localities A, B, Γ and Д.

Description

Exterior: The shells are medium to large (maximum size, not including frill, is about 45 mm wide and 34 mm long). Mature specimens are strongly globose and rather transverse. The brachial valve is much deeper than the pedicle valve, which is rather flat and concave anterolaterally. A dorsal fold and ventral sulcus are present towards the anterior margin, and the anterior commissure is plicate. The maximum width is usually between the hinge-line and the midlength. The ornament consists of relatively coarse costae, numbering 9-10 per cm at 2 cm from the beak. The costae increase predominantly by bifurcation on the pedicle valve and intercalation on the brachial valve. Prominent growth-lines usually extend into frills close to the anterior and lateral margins. The frills of mature individuals range in length from less than 1 mm to 12 mm. The pedicle beak does not generally extend behind the most posterior portion of the brachial valve. It is incurved and has been resorbed anteriorly so that the deltidial plates and foramen, which are present in younger stages, are lacking at maturity. The delthyrium has been almost completely resorbed. A short pedicle interarea (see Copper, 1967a) extends out as far as the cardinal extremities (excluding the frills). Its ventral margins are angular. The brachial beak is strongly incurved, and not exposed to the exterior. In disarticulated valves, the beak can be seen to be obliquely angled. The umbonal region of the brachial valve is slightly flattened, and has a gentle sulcus that dies out a few millimetres in front of the apex.

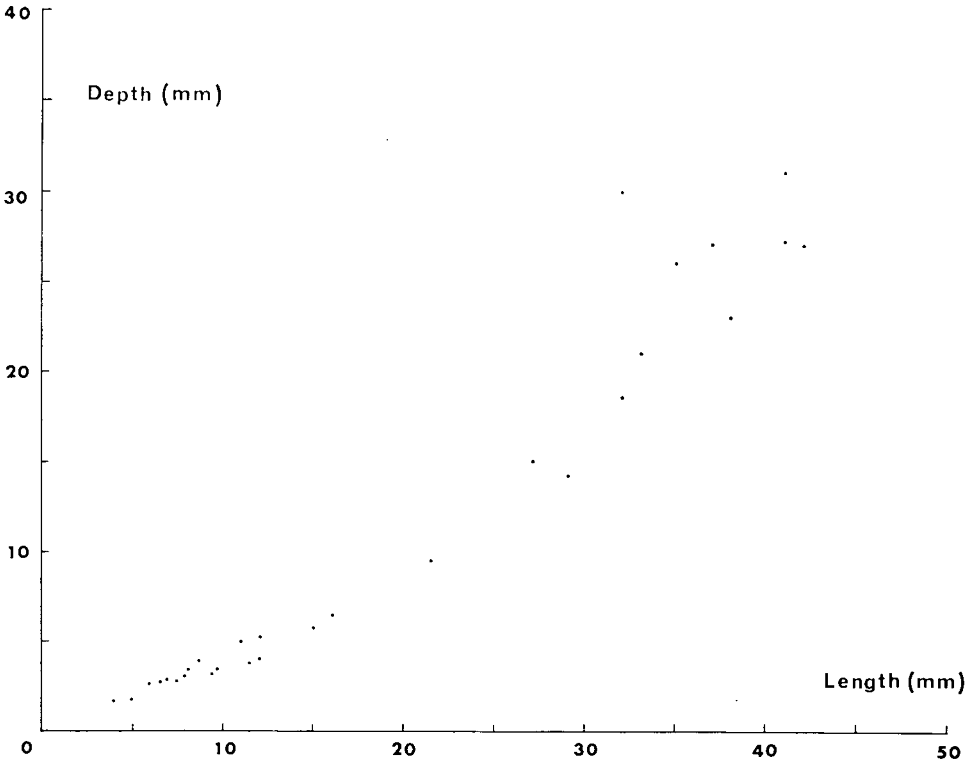
Interior. Pedicle valve: A pair of strong teeth is supported by a pair of thick dental plates, which reaches the floor of the valve and is partly separated from the rest of the valve laterally by a pair of small shallow lateral cavities. Along the inner edge of the delthyrium is a ledge of secondary thickening about 2 mm long medially, and tapering laterally to die out near the teeth. It would have fitted closely against the umbo of the brachial valve. A pair of crenulated grooves runs posteromedially across the dorsal surfaces of the teeth, so that each tooth is subdivided into two ridges (Pl. 22, fig. 9). The valve is considerably thickened in late ephebic and gerontic stages. The adductor scars are deeply impressed posteriorly and gently anteriorly; they form an oval area, divided posteriorly by a fine median ridge; and they extend about 2 mm behind the hindmost part of the diductor scars. The diductor scars are subcircular, strongly impressed, delineated anteriorly and laterally by broad low muscle-bounding ridges, and divided by gentle subradiate grooves. The distance from the anterior margin of the diductor scars to the beak is about 0.7 of the length of the valve (excluding the frill). The portion of the valve alongside and in front of the muscle scars is pitted. A pair of broad ridges, very low in some specimens, prominent in others, runs forward on either side of a median depression just in front of the diductor scars, and dies out a short distance from the anterior margin. A pair of sharp high ridges runs forward from the cardinal extremities along the lateral margins of the valve as far as the sides of the dorsally directed tongue.

Brachial valve: The cardinal process consists of a number of fine subradiate ridges in the posterior end of the notothyrial pit, and also on the posterior ends of the crural bases and socket ridges. The crural bases are curved and diverge from each other at about 70-90°; the socket ridges diverge at a greater angle. A crenulate ridge runs along the middle of the socket. The deep notothyrial pit is separated anteriorly from the rest of the valve by a broad rounded ridge, which is weakly to strongly grooved medially. The adductor scars are subcircular; divided by subradiate ridges; moderately impressed; and surrounded by a low ridge, which is pitted gently laterally and strongly posterolaterally. A low median ridge divides the posterior half of the adductor scars. The rest of the interior surface of the valve is either weakly pitted or grooved by a series of fine furrows, which are internal expressions of the ornament. The crura curve from the cardinalia in a direction that is lateral of anteroventral. They join the primary lamellae anterolateral to their bases. The more ventral whorls of the spiralia are pointed anteriorly in dorsal view than the dorsal whorls. The jugal processes are not fused to each other and are finely hooked apically (Pl. 21, fig. 29). There are about 19 whorls in a mature spiralium. The apices of the spiralia are close to the interior surface of the brachial valve, just in front of the adductor scars. The most ventral whorls of the spiralium are convex ventrally.

Ontogeny

The smallest specimen found is 2.0 mm long and 1.8 mm wide. The shell is biconvex, with a gentle brachial sulcus and a pedicle fold in the form of a gentle keel. The median costa in the pedicle valve has bifurcated once and a corresponding median costa has appeared in the brachial valve by intercalation (Pl. 21, fig. 21). There are seven costae at the margins of the brachial valve. The pedicle interarea is apsacline, and that of the brachial valve is very low. A delthyrium is partly filled anterolaterally by a pair of small deltidial plates.

In slightly later stages the 'median incipient costula' of the pedicle valve bifurcates again to show the pattern of 'double bifurcation' of Biernat (1964).



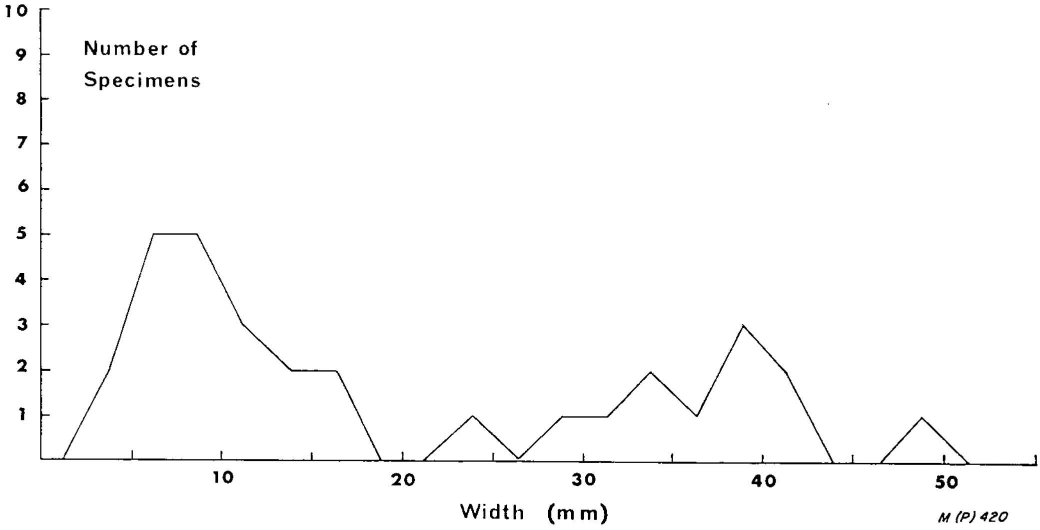


Fig. 29. *Atrypa penelopeae* **sp. nov. Specimens from the '*Receptaculites*' Limestone.**

Crural bases, socket ridges, and sockets with crenulate ridges running along them are recognizable in a brachial valve 4.9 mm long (Pl. 21, fig. 17); and a pair of adductor scars extends forward just under half the length of the valve.

A relatively well preserved pedicle valve 5.1 mm long has a pair of teeth with fine crenulate furrows running anterolaterally across their distal ends; a pair of dental plates that is separated from the valve laterally by obvious lateral cavities; and faintly impressed adductor scars that extend forward about 0.7 of the length of the valve.

In later stages, the pedicle atrophied; the deltidial plates and foramen were resorbed; a plate of secondary material was deposited along the inner edge of the delthyrium; the brachial valve increased in depth, and the pedicle valve became concave anterolaterally (the graph of depth against length in Text–fig. 29 is suggestive of a curve, with depth increasing relative to length during ontogeny); the brachial beak rotated until it was hidden behind the apex of the pedicle valve; ridges appeared along the lateral margins of the inner surface of the pedicle valve; the pedicle valve became relatively strongly thickened; and a fold and sulcus appeared near the anterior margin. Frills are present in some immature specimens (Pl. 21, fig. 19), but they only become common at the margins of mature specimens.

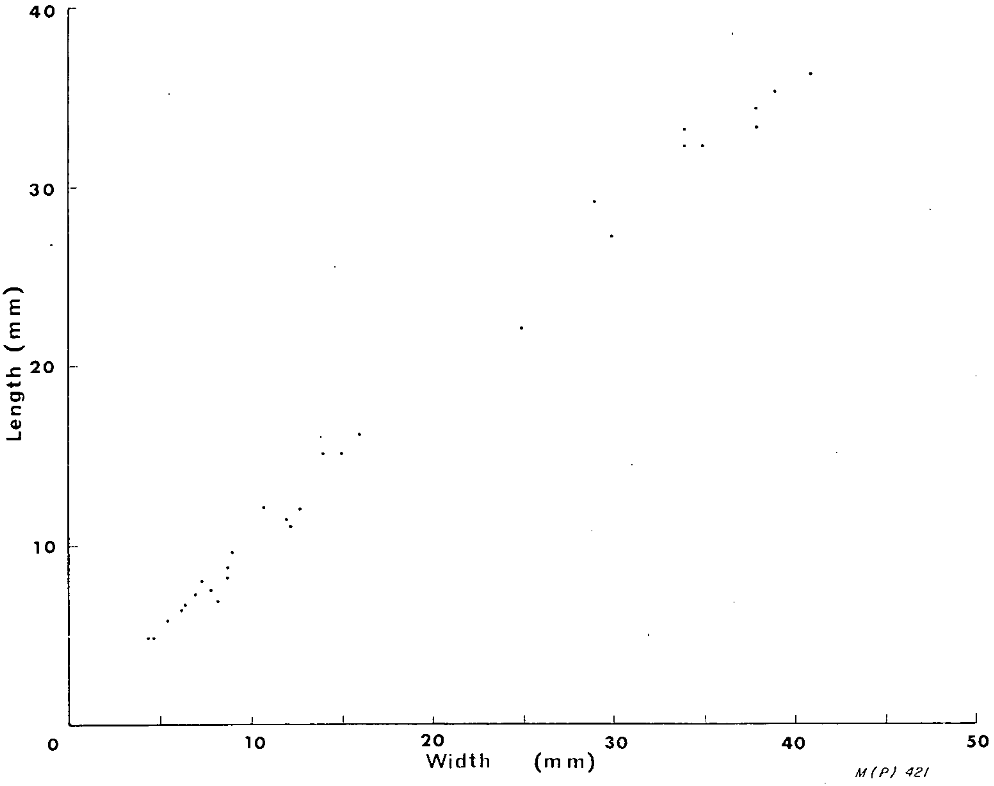


Fig. 30. *Atrypa penelopeae* **sp. nov. Specimens from the** *'Receptaculites'* **Limestone.**

Discussion of ontogeny: Rudwick (1960) suggested that atrypids have lateral inhalent currents and a median exhalent current. In the discussion of the ontogeny of *Anatrypa erectirostris* (Mitchell & Dun) (see p. 97), it is implied that a shell with a deep brachial valve and a shallower pedicle valve with concave anterolateral margins was well adapted to a life position with the shell resting on its brachial valve while being tethered to the substrate by a pedicle. *Atrypa penelopeae* was not tethered by a pedicle, and it probably lay on its pedicle valve: it could only have been stable in this positon. Ontogenetic morphological changes from early ephebic stages, which were tethered by a pedicle and probably rested on the brachial valve, to the mature stages which lay loose on the pedicle valve, may reflect past phylogenetic changes. The adaptations to this different mode of life apparently include a relative thickening of the pedicle valve to lower the centre of gravity of the shell; the appearance of frills at the margin, which would have increased the stability of the shell and helped to keep the commissure away from the sediment-water interface; and the appearance of a pair of high, sharp ridges along the lateral margins of the interior of the pedicle valve, which would have helped to exclude sediment by acting as a trap. The concave anterolateral curvature of the pedicle valve was retained; it would provide a relatively stable base for a form resting on its pedicle valve. Had this form not had lateral inhalent currents and a median exhalent current, it would probably not have required the prominent lateral ridges in the pedicle valve, (which are much stronger than the anteromedian ridge in *A. erectirostris*).

Discussion

Numerous Australian atrypids have been described and identified as *Atrypa reticularis* (Linnaeus) or *Atrypa desquamata* Sowerby. Probably few, if any, actually belong to these species. De Koninck (1876) placed some specimens from the Devonian, near Yass, in these two species. Unfortunately, he neither figured nor described the specimens, and they were lost in the Garden Palace fire of 1882. Neither species was found in the Taemas area; he probably identified *Atrypa penelopeae* sp. nov. as *A. reticularis* and *Anatrypa erectirostris* (Mitchell & Dun) as *A. desquamata.*

Alexander (1948) redescribed *Atrypa reticularis* (Linnaeus) and also described a number of British atrypids as varieties of that species. *A. penelopeae* differs from the type of *A. reticularis* in that it has a relatively flat pedicle valve with concave anterolateral margins; fewer larger costae (9-10 per cm as opposed to 14 per cm); and no obvious vascular impressions. *A. penelopeae* is probably closest in general form to the variety described by Alexander as *Atrypa reticularis* var. *sowerbyi* from the Aymestry Limestone, Sedgley, Staffordshire, but is more transverse, and has fewer and larger costae (costae 9-10 per cm as opposed to 14-16).

A. penelopeae differs from *Atrypa thomsonensis* Talent, from the Lower Devonian of Marble Creek, Thomson River, Victoria, in that it is larger and more transverse; is dorsi-convex, with the anterolateral margins of the pedicle valve concave; and has fewer costae (9-10 per cm as opposed to about 36 per cm).

A. penelopeae differs from the form described by Talent (1963) from the Lower Devonian of Tabberabbera as *Atrypa* cf. *reticularis* (Linné) in that its cardinal extremities are not well rounded; and the costae are larger and fewer (9-10 per cm as opposed to about 16). Both forms are transverse, and mature pedicle valves are concave anterolaterally.

The specimen illustrated by Mitchell & Dun (1920, Pl. 15, figs 12 & 13) as *Atrypa desquamata* Sowerby from Cave Flat, near the junction of the Murrumbidgee and Goodradigbee rivers, county of Harden, New South Wales, comes from approximately the same stratigraphic level as the types of *A. penelopeae,* from an area only about 27 km away. It almost certainly belongs to *A. penelopeae.*

Genus ANATRYPA Nalivkin, 1941

Type species: Orthis micans von Buch, 1840.

ANATRYPA ERECTIROSTRIS (Mitchell & Dun, 1920)

(Pl. 20, figs 1-14, 17; Pl. 21, figs 1-11, 24, 30-32; Pl. 22, figs 11, 12; Text–figs 31-33)

1920 *Atrypa erectirostris* Mitchell & Dun, pp. 267-268, pl. 15, figs 10 and 11, pl. 16, figs 17 and 18.

Locality: The basal 15 m of the *'Receptaculites'* Limestone at localities B and Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Material: Specimens ANU 18956a-i, ANU 18957a-j, and CPC 10581-10584.
Occurrence: Several localities in the lowest beds of the *'Receptaculites'* Limestone.

Description

The types of *Anatrypa erectirostris* (Australian Museum numbers Fn 29177, 29413, 29414 and 29415) were examined and the material described below (collected from the *'Receptaculites'* Limestone in the Taemas area) is regarded as being conspecific with these specimens. The horizon that the Taemas specimens were collected from is regarded as being approximately stratigraphically equivalent to that of the type locality, Cave Flat, Burrinjuck, near Yass, New South Wales (the type locality is believed to be in a low limestone outcrop slightly north of Cave Island, normally, at present, covered by the waters of Burrinjuck Dam — see position marked on Text–fig. 1). Localities B and Γ are 27 km from the type locality. The species is redescribed on the basis of the silicified material from the Taemas area because the external morphology of the types falls within the range of variation of the specimens from Taemas, and the internal morphology is readily visible in the silicified material, but not obvious in the calcareous types (which would have to be destroyed by serial sectioning). The problems of collecting topotype material from a locality normally covered by water are obvious.

Exterior: The shells are medium to large (maximum size is about 4 cm long and 4 cm wide). The length/width ratio varies, but tends to be close to unity (Text–fig. 33). The shape of the shells varies from roughly semicircular or subtriangular in wide forms to semielliptical in long forms. Globose forms are common, and slightly deformed specimens are not uncommon. The pedicle beak projects 2-3 mm behind the brachial apex. It is obliquely angled in ventral view, and erect so that the plane of the interarea (see Copper, 1967a, p. 1166, for discussion of terminology) is roughly orthocline. The foramen is about 1.7 mm long and 1.2 mm wide in mature individuals. It is subhypothyridid (Copper, 1967a, p. 1167). The delthyrium is obvious and somewhat angular at its apex. Two large hollow deltidial plates (length 2-2.2 mm, width 2-2.5 mm) are conjunct anteromedially. A foraminal ring is present on the deltidial plates. The interarea is wide and not very long; it is sharp-edged apically and round-edged laterally. The pedicle valve is convex near

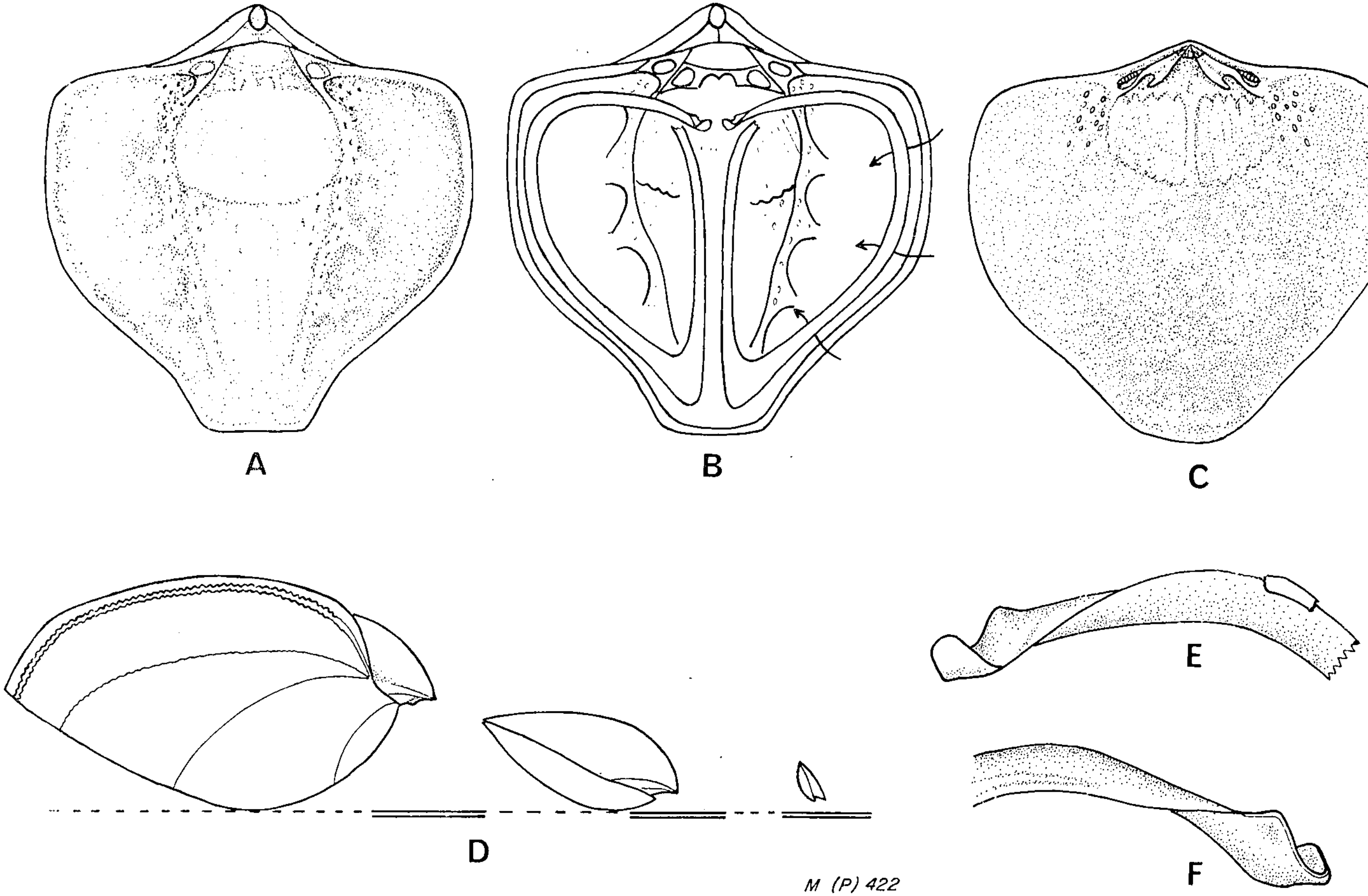
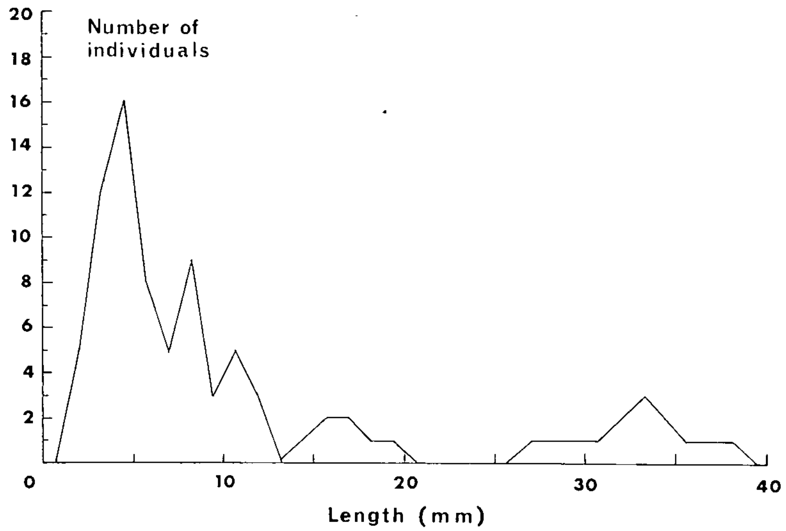


Fig. 31. *Anatrypa erectirostris* (Mitchell & Dun). A, Interior of pedicle valve; B, interior of pedicle valve showing positions of first whorls of spiralia; C, interior of brachial valve (without brachidium); D, inferred life positions of various growth stages; E and F, dorsal and ventral views of a jugal process.

the umbo, but curves ventrally anterolaterally so that the commissure is deflected ventrally in front of the cardinal extremities. The commissure is dorsally deflected by a gentle sulcus in the anteromedial part of the pedicle valve. The ornament on the pedicle valve consists of fine long tubular ribs that bifurcate distally, and diminish in size towards the beaks. There are usually between 20 and 30 ribs per cm, between 1 and 2 cm from the beak. A few obvious growth lamellae are present close to the margins of mature specimens, but they do not extend outward into frills. Fine growth-lines — as many as 7 per mm — are visible on some well preserved specimens. The brachial valve is moderately to strongly convex. The apex of the brachial beak is hidden in front of the deltidial plates. In disarticulated valves, the angle of the beak may be seen to be oblique. The umbonal region of the brachial valve is rather flattened and has a gentle sulcus, which dies out a few millimetres in front of the apex. The maximum convexity is just in front of the apex in profile and close to the midline in cross-section. The ornament is similar to that of the pedicle valve, but the ribs usually increase by intercalation (in a few specimens some ribs can be seen to branch dichotomously near the beak). A gentle brachial fold becomes obvious only towards the anterior margins of mature specimens.

Interior. Pedicle valve: A pair of strong teeth is supported by dental plates, which are separated from the rest of the valve laterally by obvious lateral cavities. Each tooth is divided by a crenulate groove, which runs anteromedially across its dorsolateral portion. The adductor scars are gently impressed posteriorly, and are not distinguishable from the diductor scars anteriorly. Their posterior margins lie slightly behind those of the diductor scars. A thin pedicle layer is present in the beak, in front of the diductor and adductor scars. A pair of ventral adjustor scars lies behind the diductor scars, in front of the pedicle layer, and lateral to the posterior portion of the adductor scars (see arrow in Pl. 20, fig. 13). A pair of lateral muscle-bounding ridges runs forwards and slightly outwards from the anterior margins of the dental plates. The anterior edge of the diductor scars is delineated by a very low ridge that is gently convex forward. The lateral muscle-bounding ridges continue forwards, in front of the diductor scars, as a pair of pallial sinuses which are gently convex laterally. The pallial sinuses may branch occasionally (the branches extend laterally) and die out near the anterior margin; they occur as ridges which in some specimens are low, in others strong and sharp. The inner surface of the valve may be grooved by subradial furrows associated with the external ornament (see Pl. 20, fig. 14); they are rather indefinite in late ephebic and gerontic stages, where they are subdued by the deposition of secondary shell. The lateral muscle-bounding ridges and the areas distal to the diductor scars that are close to the muscle-bounding ridges and the pallial sinuses are pitted.

Brachial valve: The cardinal process consists of a relatively large number (up to 40) of fine irregular sub-radiate ridges in the posterior end of the notothyrial pit and on the posterior ends of the crural bases and socket ridges. The elongate socket ridges diverge at about 120°. A pair of crenulate ridges runs along the sockets. There is a low median ridge in the posterior portion of the valve. The subcircular adductor scars are moderately impressed posteriorly, and gently anteriorly; their lateral margins are delineated by a pair of low pitted ridges, higher posteriorly than anteriorly; and they are divided by a number of gentle subradiate ridges. A prominent traverse ridge runs across the internal surface of the fold, close to the anterior margin.



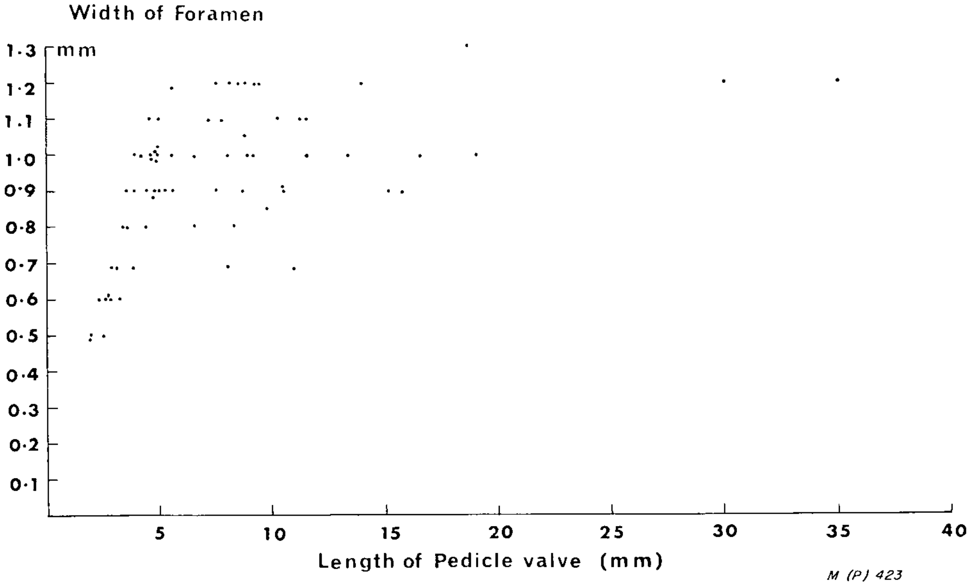


Fig. 32. *Anatrypa erectirostris* **(Mitchell & Dun). Specimens from the base of the *'Receptaculites'* Limestone.**

Each crus curves slightly ventrally of anterolaterally and then turns laterally to join the primary lamella of the spiralium. The crura, unlike the hinge-plate and primary lamella, appear to consist of a number of coarse curved lamellae. In many specimens the crura disintegrated and the still complete spiralia moved from their life position before lithification. (Copper, 1965, pp. 314-5, and 1967b, p. 1178, described the crystal structure of atrypoid crura as loosely bunched feathered crystals. This appears to fit the loose lamellar structure found in this species.) Jugal processes are present, with hooked jugal plates at their medial extremities (Text–fig. 31 and Pl. 21, figs 30 and 31). They were not fused to each other. There are about 18 whorls in a mature spiralium, whose shape varies with their position. The most ventral whorls are more pointed anteriorly and the calcareous ribbon is much broader (in dorsal view) at the anterior end than in the rest of the whorl (Pl. 20, fig. 3). In lateral view, the more ventral whorls are slightly convex ventrally. The spiralia grew dorsally towards the deepest portion of the brachial valve, which was just in front of the adductor scars.

Ontogeny

The smallest specimen found is 2.1 mm long and 2.35 mm wide. It is subequally biconvex, but the pedicle valve is deeper because it has a prominent apsacline interarea, whereas the brachial valve has little or none. There is a broad angular keel in the pedicle valve and a sulcus in the brachial valve. The dorsolateral corners of a large (0.7 mm wide) triangular delthyrium are filled by small deltidial plates that are not conjunct. The ornament consists of costae that increase dominantly by bifurcation in the pedicle valve and intercalation in the brachial valve, though the median costa of the brachial valve increases by bifurcation. The rib pattern appears to show the 'double bifurcation' of Biernat (1964).

In intermediate sized specimens (width about 13 mm), the shells are subequally biconvex with neither fold nor sulcus at the anterior margin; mature specimens (about 35 mm wide) have deeper brachial than pedicle valves and a dorsal fold and a ventral sulcus near the anterior margin.

In young specimens the size of the foramen increases rapidly with an increase in size of the animal (Text–fig. 32) until the length of the shell is about 5 mm, after which the foramen increases in size little, if at all. The pedicle interareas of young specimens are apsacline and those of mature specimens orthocline.

During growth, the deltidial plates increase in size and become conjunct medially. A foraminal ring appears soon after they become conjunct, when the shells are between 8 and 9 mm long.

Two spiralia were observed in a specimen 9.0 mm long and 8.5 mm wide (Pl. 21, fig. 11). The spiralia moved from their life positions before lithification. They have five whorls and hooked jugal processes.

Dental plates and lateral cavities are visible in specimens only 3.5 mm wide (the smallest pedicle interiors examined). Cardinalia are relatively mature, with socket ridges, crural bases, and subventrally directed crura distinguishable, in a brachial valve 3.8 mm wide. Muscle scars are only obviously impressed in middle and late ephebic stages.

Discussion of ontogeny: The changes in convexity, relative depths of the valves, and size of the foramen relative to the size of shell during growth appear to have been associated with a change from a small shell supported above its surface of attachment on its pedicle, to a mature shell tethered only by its pedicle. In the earliest stages examined, the pedicle was relatively stout, and probably functioned both as an anchor and a support to keep the small shell above the sediment surface. The size of the pedicle would have necessitated a pedicle valve convex in cross-section. With a convex pedicle valve, the simplest method of separating the inhalent currents would be a dorsal sulcus and a ventral fold (or keel). The rapid increase

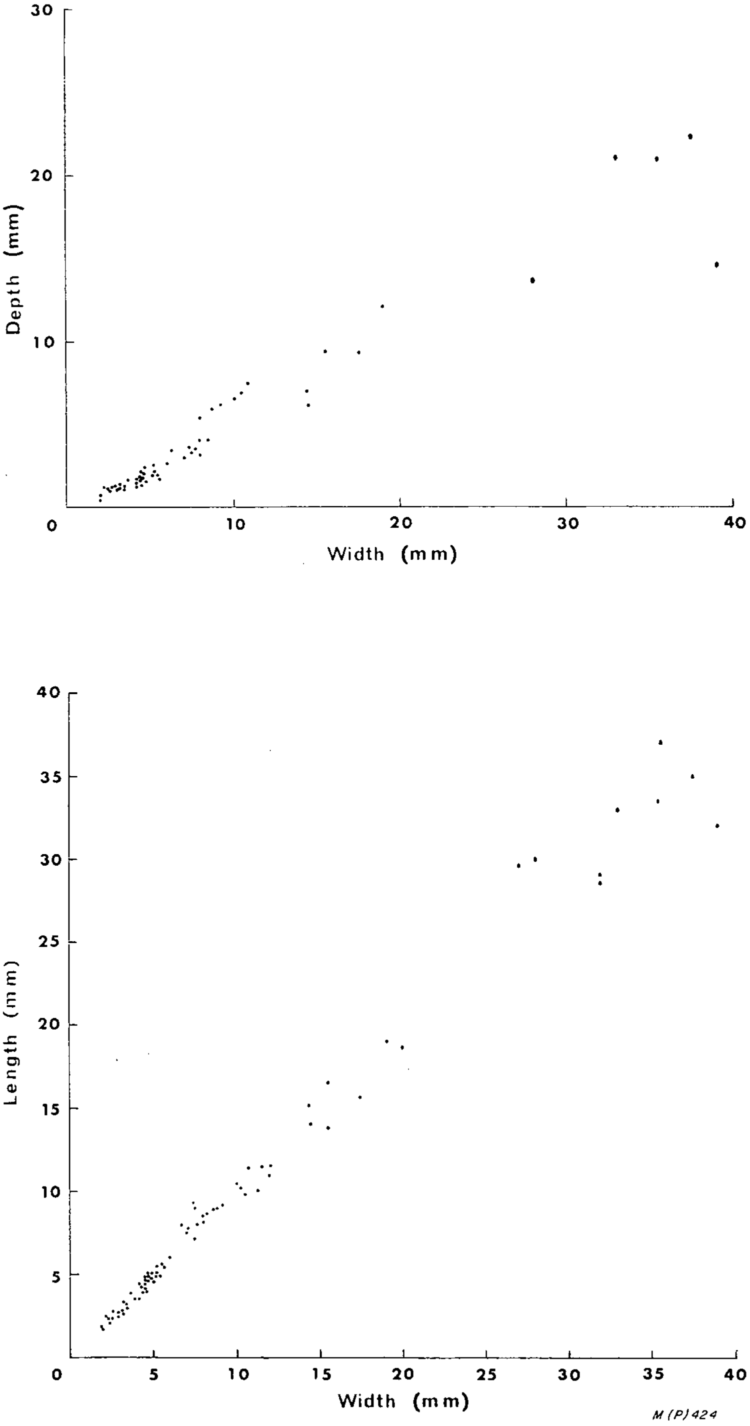


Fig. 33. *Anatrypa erectirostris* **(Mitchell & Dun). Specimens from the base of the '*Receptaculites*' Limestone.**

in size of the foramen during growth of shells shorter than 5 mm and its virtually constant size in larger shells is probably associated with this change in function of the pedicle from a support — which would have had to increase its diameter to support the extra mass as the shell grew — to a tether, for which its diameter was adequate, so that it probably only lengthened in more mature stages. The changes in convexity were probably adaptions to ensure that the regions of the commissure at which currents were inhaled were not so close to the sediment surface as to risk the animal's being choked by excess sediments. Rudwick (1960) suggested that the inhalent currents of atrypids were lateral. The morphology of adults of *A. erectirostris* is such that the lateral commissure was deflected away from the sediment surface.

Discussion

Johnson (1970) placed *Desquamatia* Alekseeva in synonymy with *Anatrypa* Nalivkin. As Johnson's arguments appear to be valid, his decision has been followed.

Anatrypa erectirostris does not fit very easily into either of the two subgenera proposed by Copper (1966a), *Synatrypa* and *Variatrypa*. It is larger than *Synatrypa* and has a pedicle valve that is concave anterolaterally; and unlike *Variatrypa* it lacks a frill and has somewhat finer and more closely spaced ribs. It is probably closest to forms that have been placed in *Variatrypa*.

A. erectirostris shows some similarities to *Anatrypa (Variatrypa) licta* Johnson from the Eifelian of central Nevada, but has a smaller and more erect beak, a more pronounced fold and sulcus, longer ventral muscle scars, and a more pitted interior with pallial sinuses. It is probably closer to *A. (Variatrypa) zonata* (Schnur) and *A. (Variatrypa) subdivita* (Copper) from the Middle Eifelian of Germany (see Copper, 1966a). It differs from *A. (V.) zonata* in that it lacks a frill and is more finely ribbed; and from *A. (V.) subdivita* in that its ventral valve is more concave laterally, it is more dorsibiconvex, it is slightly more finely ribbed, and it has a larger foramen.

No other species of *Anatrypa* have been described from southeastern Australia.

Suborder SPIRIFERIDINA Waagen, 1883
Superfamily CYRTIACEA Frederiks, 1919 (1924)
Family AMBOCOELIIDAE George, 1931
Genus AMBOTHYRIS George, 1931

Type species: Spirifera infima Whidbourne, 1893.

Ambothyris runnegari sp. nov. almost fits the diagnosis of *Ambothyris* given by Havlíček (1959). It has a rod-like plate in the apex of the delthyrium (Havlíček did not mention the presence of such a plate), and the crural plates do not touch each other to form a cruralium (Havlíček, p. 256, suggested, however, that members of the genus do not necessarily have a cruralium when he stated that the crural plates 'converge dorsally and by their inner edges touch almost or completely each other so that a form reminiscent of a cruralium is produced'). The crural plates of *A. runnegari* are variable, and converge dorsally in some of the brachial valves found. In other genera, species such as *Ladjia saltica* Veevers and *Crurithyris apena* Veevers have crural plates which may either extend to the floor of the valve or fuse medially to form a sessile cruralium. Thus, this character is apparently variable intraspecifically in ambocoeliids, and should not be used as a character of generic significance.

A. runnegari also shows some affinities with *L. saltica,* the type species of *Ladjia* from the Frasnian of the Fitzroy Basin, Western Australia: both species have a rod-like plate in the apex of the delthyrium, and similar interiors. Unlike *L. saltica,* however, its anterior commissure is sulcate; it lacks prominent radial striae (although fine radial striae may be present); the pedicle interarea may be procline; the shell is more strongly ventribiconvex; cruralia were not found in any of the brachial valves examined (cruralia do not occur in all the brachial valves of *L. saltica);* and no specimens were found with dental plates (which occur in rare specimens of *L. saltica).*

On the balance of the information available the new species is included in *Ambothyris.*

AMBOTHYRIS RUNNEGARI sp. nov.

(Pl. 19, figs 1-14; Text–fig. 34)

Derivation of name: After Dr B. N. Runnegar.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18952; paratypes ANU 18953a-h and CPC 10585-7.

Occurrence: At several horizons within the *'Receptaculites'* and Warroo Limestones, localities A, Г, and Д.

Description

Exterior: The shells are small, strongly ventribiconvex, and equidimensional to slightly transverse in outline (Text–fig. 34). The cardinal angles are rounded and the hinge-line is shorter than the maximum width, which is in front of the hinge-line and behind the midlength. The concave apsacline to procline pedicle interarea is interrupted medially by a delthyrium, which is higher than wide and partly filled apically by a small rod-like plate* (Pl. 19, fig. 10). The pedicle valve has a fine sulcus, and the brachial valve a slightly stronger sulcus, which deflects the anterior commissure ventrally so that it is gently sulcate. The lateral slopes are bald. A beak ridge is usually present, but in some specimens it is not very obvious. The pedicle beak is moderately incurved. The interarea of the brachial valve is low, anacline, and divided by a broad open notothyrium. The micro-ornament consists of fine growth lamellae. In some specimens there are signs of fine radial striae, but they could be simply an outcome of the type of silicification.

Interior. Pedicle valve: Dental traces are present under small teeth, but ventral adminicula are lacking in all specimens. The 'pedicle plate' has wing-like lateral extensions that curve round the anterior edges of the ventral portions of the dental traces; and its posterodorsal portion is lobed medially so that it appears rod-like in posterior view. A low median ridge or myophragm in the posterior two-thirds of the valve is flanked on each side by a pair of gently impressed very elongate muscle scars. A thickened band, about 0.2 mm wide, runs round the margins of

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* Veevers (1959) called this a pedicle plate; but that term is defined differently by Williams et al. (*in* Moore, 1965).

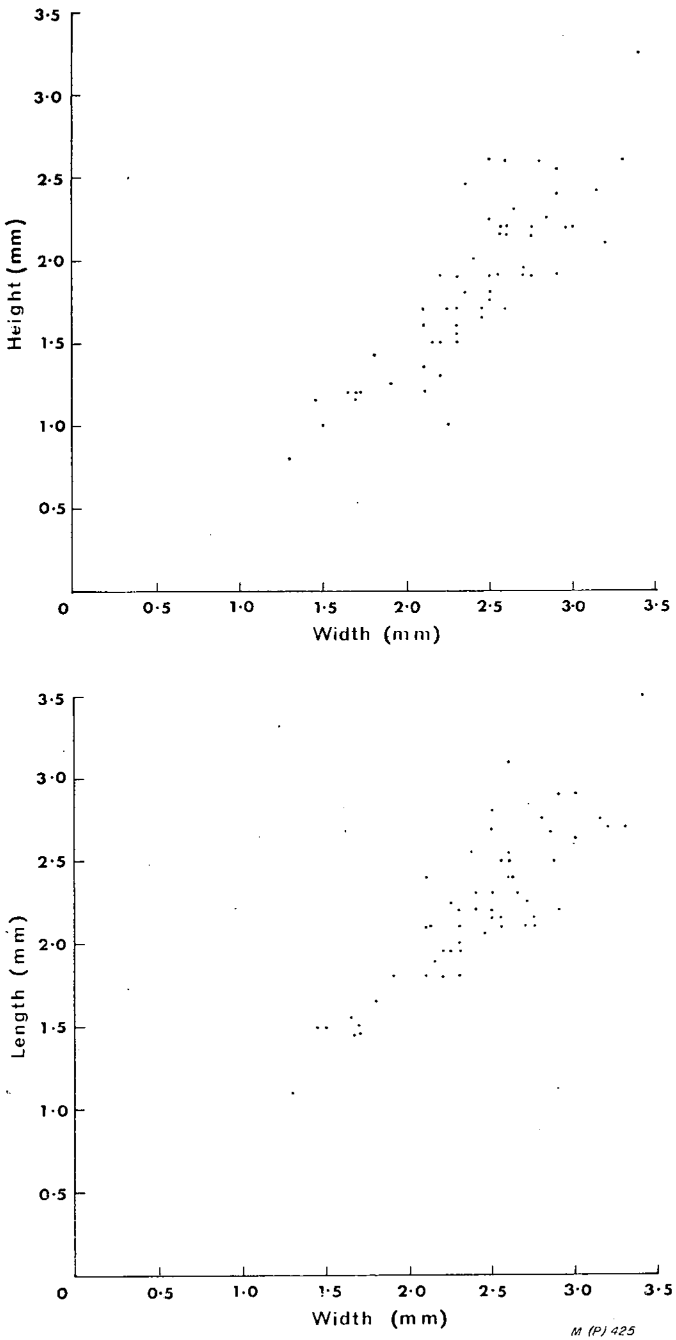


Fig. 34. *Ambothyris runnegari* **sp. nov. Specimens from the '*Receptaculites*' Limestone.**

some valves, about 0.1-0.2 mm from the commissure; it presumably helped to strengthen the valve.

Brachial valve: The cardinal process is small, triangular, apparently divided into irregular sublongitudinally arranged lamellae, and raised above the floor of the valve on a small notothyrial platform. A pair of crural plates is fused to the floor of the valve for some distance in front of the cardinal process, close to the midline or up to 0.2 mm from the midline, but the plates are not fused to each other in any specimens. The posterior portions of the anterolaterally directed sockets are covered over. The very gently impressed adductor scars extend relatively far forward and are faintly subdivided into four individual scars. The shell is slightly thickened within 0.25 mm of the commissure. The primary lamellae, which are approximately collinear with the crura, diverge gently forward. Short pointed posteroventrally directed jugal processes separate relatively narrow crura from broader primary lamellae (Pl. 19, fig. 1). The spiralia are directed laterally, and mature spiralia appear to have three or four whorls.

Discussion

Ambothyris runnegari sp. nov. is not very close to the ambocoeliid described by Talent (1956b) as *Ambocoelia minuta* from the Lower Devonian of Marble Creek, Thomson River, Victoria: it is smaller and more strongly ventribiconvex, and has a fine ventral sulcus.

See also under the discussion of the genus.

Superfamily SUESSIACEA Waagen, 1883

Family CYRTINIDAE Frederiks, 1912

Genus CYRTINA Davidson, 1858

Type species: Calceola heteroclita Defrance, 1828.

CYRTINA aff. CYRTINA WELLINGTONENSIS Dun, 1904

(Pl. 23, figs 1-25; Text-fig. 35)

Locality: The *'Receptaculites'* and Warroo Limestones at Taemas, near Yass, New South Wales.

Material: Specimens ANU 18961a-o and CPC 10588-92.

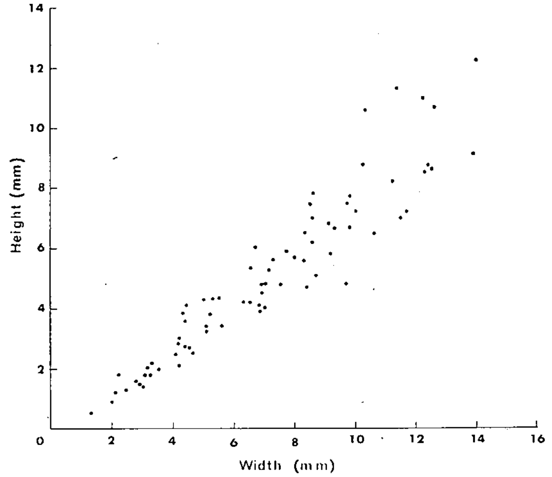
Occurrence: Common at several horizons in the *'Receptaculites'* and Warroo Limestones.

Description

Both size and shape are highly variable; thus mature specimens at one horizon may be more than twice as large as those at another. Though morphological groups at the extremes of variation can be recognized, they may occur at the same locality, and are connected by morphological intermediates. It is difficult to decide if the disparate communities are taxonomically distinct, but variations in the benthonic environment could well have exercised considerable control over the size, and possibly the shape, of this species.

Exterior: The shells are small to medium sized, strongly ventribiconvex, and wider than long (Text-fig. 35). The cardinal angles range between 70° and 110°; and the maximum width is at or close to the hinge-line. The brachial valve is shallow; the pedicle valve is deep and hemipyramidal. A dorsal fold and ventral sulcus are not subdivided. The lateral slopes of mature brachial valves have three, or rarely four, rounded plications. The micro-ornament consists of irregularly spaced growth lamellae. The high pedicle interarea is almost planar to obviously concave, and apsacline to procline. Many specimens have twisted pedicle valves, and very few specimens are bilaterally close to the apex. A delthyrium is covered by a convex pseudodeltidium (or henidium). At the apex of the delthyrium is a subhypothyridid foramen (see Copper, 1967a, p. 1167). The brachial interarea is narrow and inconspicuous.

Interior. Pedicle valve: Moderate-sized teeth are supported by strong dental lamellae and ventral adminicula, and the latter are fused to a median septum to form a spondylium. A pair of crural fossettes is present at the bases of the teeth. A tichorhinum runs along the posteromedial edge of the spondylium. It is bisected by the posterior portion of the median septum, which usually passes through it to project as a ridge along its posterior margin. The dorsal edge of the median septum is thinner than the more ventral part, where the dental supports are fused



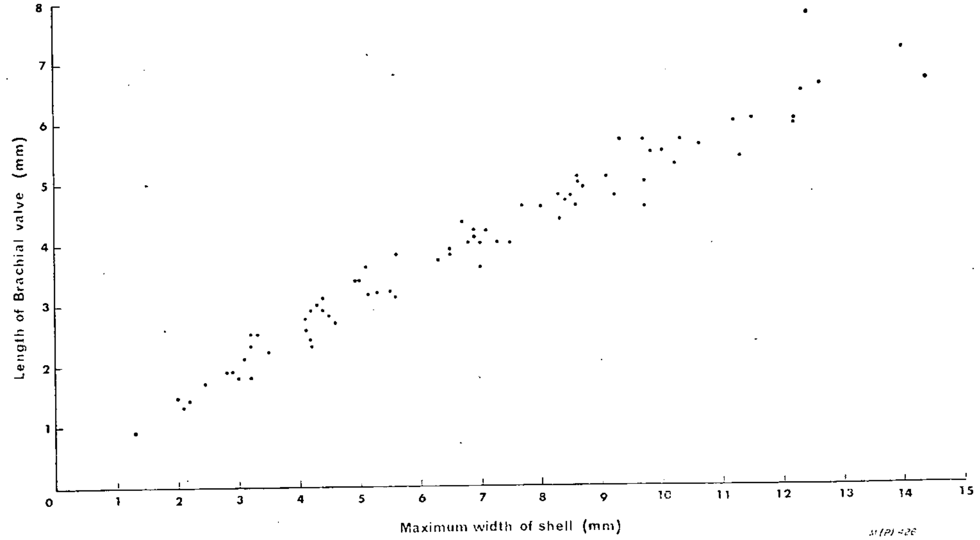


Fig. 35. *Cyrtina* **aff.** *C. wellingtonensis* **Dun. Specimens from the** *'Receptaculites'* **Limestone and the base of the Warroo Limestone.**

to the median septum. The portion of the median septum opposite the open end of the tichorhinum is sometimes sparsely ridged dorsoventrally, and it is apparently a muscle scar. The diductor scars are visible, in only a few specimens, as slightly thickened or depressed areas lateral to the anterior portion of the median septum.

Brachial valve: The cardinal process is generally gently bilobate ventrally, subtriangular, posteriorly striate, and formed anteriorly of two very low non-striate ridges that converge forward. Strong socket plates are fused to the crural bases. There are no crural plates. The fine crura expand slightly posteriorly to fuse with the crural bases. In some specimens a stout 'median septum' supports a hinge-plate medially, forming a stout 'septalium'; the septum is commonly indistinct at the anterior edge of the hinge-plate, and rarely extends beyond it. The ventral surface of the hinge-plate is generally pitted by a pair of dorsal pedicle adjustor scars (see the reconstruction of the pedicle by Williams *in* Moore, 1965, p. 115). A pair of very fine ridges separates the sockets from the interarea posteriorly. The crura converge gently, or run forward subparallel with each other, as far as the jugal processes, which are pointed and directed slightly medially of anteroventrally. In most specimens, the jugal processes did not join medially, but some have anteromedial extensions which may have joined medially. The primary lamellae diverge in front of the jugal processes and then curve to form spiralia whose axes are directed ventrolaterally. The adductor scars are moderately impressed posteriorly and gently impressed or indistinct anteriorly. They are elongate, and in some specimens appear to be quadripartite, with a small posterior pair of scars and a larger anterior pair (Pl. 23, fig. 20). A weak myophragm is usually present posteriorly.

If the adductor muscles passed behind the jugal processes and between the crura, they must have converged towards the posterodorsal edge of the median septum. The pair of muscle scars at the posterodorsal edge of the ventral median septum, opposite the open end of the tichorhinum, is therefore probably a pair of adductor scars.

Ontogeny

A small specimen 1.9 mm wide is ventribiconvex. A dorsal fold and ventral sulcus extend forward from close to the beaks (Pl. 23, figs 6 and 7); the interarea is catacline and gently concave; a pair of gentle plicae is present on the lateral slopes of the brachial valve; and a low median septum is visible in the apex of the delthyrium; it is not possible to tell whether the septum is fused to the dental supports to form a spondylium at this stage.

In slightly larger shells a short median septum and spondylium are present. In one small specimen (Pl. 23, fig. 14) the anterior edge of the primary lamella is spinose, unlike mature spiralia.

During growth, the plicae increase in number, the median septum in length and height, and the spondylium in size; the pedicle valve becomes relatively deeper (Text–fig. 35); and the pseudodeltidium (or henidium) apparently appears in the manner suggested by Ivanova (1967), though too few specimens with well preserved early pseudodeltidia were found to prove this point.

Discussion

The specimens from the '*Receptaculites*' and Warroo Limestones vary so much that some closely resemble topotype material of *Cyrtina wellingtonensis* Dun from the Lower Devonian Garra Formation of the Wellington-Molong district, New South Wales; but most specimens from Taemas are not as transverse; their pedicle interareas are more concave; the pedicle valves are more twisted and most are bilaterally symmetrical; and the ventral median septa are slightly longer and higher. Also, a few specimens of *C. wellingtonensis* have five or six plicae on each lateral slope of the brachial valve, although most have only three or four. No specimens were found at Taemas with more than four.

The form from Taemas is also close to *Cyrtina heteroclyta gregale* Talent from the Lower Devonian of Tabberabbera, Victoria, in that it has a similar number of plicae, and a deep pedicle valve that may be twisted. Unfortunately, the material from Tabberabbera consists of moulds, some of which are rather distorted, rendering detailed comparisons with *C. wellingtonensis* and the form from Taemas difficult.

Cyrtina subbiplicata Chapman, unlike the species discussed, has no plicae on its lateral slopes.

Superfamily SPIRIFERACEA King, 1846
Family DELTHYRIDIDAE Waagen, 1883
Subfamily DELTHYRIDINAE Phillips, 1841
Genus DELTHYRIS Dalman, 1828

Type species: Delthyris elevata Dalman, 1828.

DELTHYRIS HUDSONI sp. nov.
(Pl. 29, figs 21-33)

Derivation of name: After the late Professor R. G. S. Hudson.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18974; paratypes ANU 18973a-e and CPC 10593-5.

Occurrence: At localities A and Д in the top of the *'Receptaculites'* Limestone and the lower half of the Warroo Limestone.

Description

Exterior: The shells are small and ventribiconvex. The width is greater than either the height or the length. The cardinal angles are usually less than 90°, but are slightly more in some specimens; and the maximum width is either at or just in front of the hinge-line. A fold is present in the brachial valve and a sulcus in the pedicle valve. In many specimens the fold is divided by a shallow furrow, but the sulcus is not divided. Usually five, but occasionally four, high subrounded plicae are present on each lateral slope of the brachial valve. Prominent concentric growth lamellae are common, but they vary in number and size between individuals. They usually project distally, but do not turn outward and become frills, although they are prominent enough, in some specimens, to be regarded as slightly frilly. The micro-ornament consists of fine growth lamellae with superposed capillae; it was not possible to tell whether the capillae extend into spines at the edges of the growth lamellae. The pedicle interarea is wider than high, apsacline, concave, and ornamented with transverse grooves. It is divided by an open delthyrium, which is flanked laterally by fine dental traces and a pair of obvious lateral plates. The pedicle beak is small and incurved. The brachial interarea is short and orthocline. The notothyrium is broad and open.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by well developed dental lamellae and ventral adminicula, which joint each other at an obtuse angle. An obvious median septum extends forward just under half the length of the valve. It ends relatively abruptly, sometimes with a serrated anterior margin. The muscle scars are not obviously impressed.

Brachial valve: The cardinal process is deeply striate posteriorly and non-striate for a short distance anteriorly; it may or may not be slightly bilobed. A pair of short crural plates is fused to the sides of the cardinal process. Deep anterolaterally directed sockets are impressed in the hinge-plate. A very low myophragm is present in the posterior half of the valve. The adductor scars are gently impressed, and are apparently long, narrow, and confined to the area of the fold.

Discussion

Delthyris hudsoni has been included in *Delthyris* because of its open delthyrium, median septum, well developed dental lamellae and ventral adminicula, and short crural plates. The rather irregular prominent growth lamellae are, however, reminiscent of the Kozlowskiellinae. The strong lateral plates of *D. hudsoni* are not as strong as the deltidial plates usually found in species of *Kozlowskiellina,* and they do not tend to join each other medially to form a henidium. *D. hudsoni* also lacks the prominent secondary thickening that is present in *Kozlowskiellina strawi* Boucot, the type species of *Kozlowskiellina* from the Wenlock of the British Isles. *D. hudsoni* differs somewhat from the diagnosis of *Delthyris* suggested by Boucot (1957b) in that the growth lamellae could be regarded as slightly frilly. The length and number of prominent lamellae vary within the species to such a degree that it is thought unwise to separate it from *Delthyris* on the basis of this character. Since *D. hudsoni* is younger than most described species of *Delthyris,* such divergences from the norm are not unexpected.

Subfamily ACROSPIRIFERINAE Termier & Termier, 1949

Genus SPINELLA Talent, 1956

Type species: Spinella buchanensis Talent, 1956.

SPINELLA YASSENSIS (de Koninck, 1876)

(Pl. 26, figs 1-13; Pl. 30, figs 16-20)

1971 *Spinella yassensis* (de Koninck, 1876); Strusz, Chatterton, & Flood, p. 176, pl. 7, figs 1-14; pl. 8, figs 1-3, 7, 9, 10; pl. 9, fig. 16; text–figs 5.1-3, 6-10 (with synonymy).

Locality: The base of the *'Receptaculites'* Limestone below Locality A, 3 km south of Hume Park; the basal 60 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property; the *'Spirifer yassensis'* Limestone at Good Hope; and the *'Spirifer yassensis'* Limestone at Locality C, portion 65, parish of Taemas, the type locality (see Text–fig. 1).

Material: Specimens ANU 18966a-m and ANU 18995a-c.

Discussion

Spirifer yassensis has been redescribed and discussed by Strusz, Chatterton, & Flood (1971), who compared silicified material from the base of the *'Receptaculites'*

Limestone morphologically and statistically with material from the type locality in the *'Spirifer yassensis'* Limestone. The statistical treatment suggested that the form from the *'Receptaculites'* Limestone could be a different subspecies. However, too few specimens were recovered from the *'Receptaculites'* Limestone for these tests to be conclusive, and the form was described as *Spinella yassensis* n.subsp. ? It is illustrated on Plate 26, and its micro-ornament is compared with that of material from the *'Spirifer yassensis'* Limestone on Plate 30.

Genus HOWELLELLA Kozłowski, 1946

HOWELLELLA aff. HOWELLELLA TEXTILIS Talent, 1963

(Pl. 27, figs 1-19)

Locality: The top of the *'Receptaculites'* Limestone at Locality A, and the basal 60 m of the *'Receptaculites'* Limestone at localities B and Γ in the Taemas-Cavan area, near Yass, New South Wales.

Material: Specimens ANU 18967a-i and CPC 10606-7.

Occurrence: Occasional in the top and bottom of the *'Receptaculites'* Limestone, localities A, B, Γ, and Д.

Description

Exterior: The shells are small, subequally biconvex to slightly ventribiconvex, and transverse. The cardinal angles are rounded, and the maximum width is usually behind the midlength and in front of the hinge-line. There is a prominent fold in the brachial valve and a sulcus in the pedicle valve. Each lateral slope of the brachial valve has up to four low rounded plicae. The micro-ornament consists of capillae that become fimbriate at the anterior edges of the growth lamellae. The growth lamellae are prominent, but they do not extend distally into frills. The largest specimen found is a brachial valve 9.5 mm long and 14.5 mm wide. The pedicle interarea is wider than high, concave in profile, and apsacline. The delthyrium is open; its width is subequal to its height, but shorter than its length measured along the interarea. A prominent pair of lateral plates runs along each side of the delthyrium (Pl. 27, fig. 3). The brachial interarea is concave, orthocline, and interrupted by a broad open notothyrium. The beaks of both valves are incurved, with the pedicle beak the most strongly incurved.

Interior. Pedicle valve: Small teeth are supported by strong dental lamellae and ventral adminicula, which extend a short distance in front of the teeth. The join between a dental lamella and a ventral adminiculum is marked by a low angular ventromedially directed ridge. The dental lamellae converge slightly ventrally, and the ventral adminicula diverge slightly anteroventrally. The anterior margins of the dental supports are sigmoid in profile. A low median ridge or myophragm is visible in the posterior portions of some specimens, but there is no obvious median septum. The muscle scars are not obviously impressed; and there is no thickening in the umbonal region.

Brachial valve: The cardinal process is subtriangular in anteroventral view, and is subdivided into a series of longitudinally arranged lamellae. It may or may not be bilobed. Short crural plates are fused to the floor of the valve opposite and just in front of the cardinal process. Deep sockets trend anterolaterally. There is no median septum, but a fine myophragm is usually present posteriorly. The muscle scars are either very gently impressed or not impressed. The crura converge slightly forward as far as the jugal processes, and then the primary lamellae diverge slightly towards the anterior margin. The jugal processes are pointed and directed ventrally. Eleven whorls are present in the spiralia of a specimen 13 mm wide.

Ontogeny

In early growth stages (length about 5 mm) plicae are less numerous; the outline of the shell is less transverse; and the ventral adminicula are relatively shorter (Pl. 27, figs 6 and 7).

Discussion

The specimens appear to be much larger than the type specimens of *Howellella textilis* from the Mitchell and Wentworth Rivers, Tabberabbera, Victoria; and the plicae are usually not as strong. These differences are not, however, regarded as sufficient to separate the forms specifically at present.

They are also close to *Howellella scabra* from the Lower Devonian Tyers area, Gippsland, Victoria, but there are usually at least three or four plicae on each of the lateral slopes of the brachial valve and not two; there is a definite cardinal process; and there is usually a fine myophragm in the brachial valve.

They are close to the Siegenian form *Howellella nucula australis* Savage from the Mandagery Park Formation, New South Wales. They have more plicae than *H. uncula australis,* a stronger fold and sulcus, and are more transverse.

Genus HYSTEROLITES von Schlotheim, 1820

Type species: Hysterolites hystericus (von Schlotheim, 1820).

HYSTEROLITES sp.

(Pl. 29, figs 1-10)

Locality: The base of the Warroo Limestone at Locality A and the base of the *'Receptaculites'* Limestone at Locality B in the Taemas-Cavan area, near Yass, New South Wales.

Material: Specimens ANU 18971a-f.

Occurrence: Infrequent in the lower half of the *'Receptaculites'* Limestone and in the Warroo Limestone, at localities A, B, Г, and Д.

Description

Exterior: Shells medium sized, ventribiconvex, and transverse. The cardinal angles appear to be acute, and the maximum width is at or close to the hinge-line. A dorsal fold and a ventral sulcus are obvious; the fold may be subdivided by a very gentle furrow, but the sulcus is not subdivided. There are usually 7-9 prominent subrounded plicae on each lateral slope of the pedicle valve. The micro-ornament is imperfectly preserved but appears to consist of fine radiating capillae. The pedicle interarea is apsacline, almost flat to gently concave, and may be ornamented with fine transverse grooves. An open delthyrium is higher than wide. A pair of fine dental traces runs along each side of the delthyrium. The pedicle beak is small and moderately incurved apically. The brachial interarea is orthocline to apsacline and interrupted by a broad open notothyrium. The small brachial beak is slightly incurved.

Interior. Pedicle valve: A pair of small teeth is supported by dental lamellae and ventral adminicula, which extend forward about a third of the length of the valve. A short sharp ridge projects submedially into the delthyrial chamber along the medial edge of the join between a dental lamella and a ventral adminiculum. The dental lamellae converge slightly ventrally, and the ventral adminicula diverge ventrally (Pl. 29, fig. 3). The umbonal cavities are not filled by secondary deposition. A small delthyrial plate is present in the apex of the delthyrial cavity. There is no obvious median septum, but a low median ridge or myophragm may be present in the posterior half of the valve. The muscle scars are not obviously impressed, but a few shallow longitudinal grooves may be visible between the bases of the ventral adminicula.

Brachial valve: The cardinal process is slightly raised above the floor of the valve on a small cushion of secondary material, and consists of longitudinally arranged lamellae. A pair of short crural plates is fused to the floor of the valve along the sides of the cardinal process. A low myophragm may be present in the posterior half of the valve. The adductor scars are not obviously impressed.

Discussion

Too few well preserved specimens were found to describe the form as a new species. It does not appear to be very different from specimens of *Hysterolites hystericus* (Schlotheim), the type species of *Hysterolites* from the Siegenian of Europe, redescribed by Solle (1963). It differs from *H. hystericus hystericus* in having fewer plicae, and slightly less thickening in the umbo. The cardinalia of *H. hystericus pachypleura* Solle, figured by Solle (1963, Pl. 9, fig. 16b) are similar to those of the form from Taemas.

Talent (1963) described and figured numerous forms of *Hysterolites* from the Lower Devonian of the Mitchell and Wentworth Rivers, Tabberabbera, Victoria. The Taemas form appears to be closest to the form he described as *Hysterolites* sp. B, though preservation renders close comparison difficult. *Hysterolites piger* Talent and *Hysterolites tritus* Talent differ in having obvious concentric growth lamellae; and the form he described as *Hysterolites* n. sp. has a different micro-ornament.

Subfamily CYRTINOPSINAE Boucot, 1957

Genus CYRTINOPSIS Scupin, 1896

Type species: Spirifer undosus Schnur, 1853

CYRTINOPSIS aff. CYRTINOPSIS COOPERI Gill, 1942

(Pl. 28, figs 2-14)

Locality: The top of the '*Receptaculites*' Limestone, on the side of the hill 300 m northwest of Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Material: Specimens ANU 18970a-f and CPC 10608-9.

Occurrence: Only in the top of the '*Receptaculites*' Limestone, at the locality mentioned above, and one specimen at Locality A.

Description

Exterior: The shells are large, ventribiconvex, and transverse. The cardinal angles are acute in mature stages, and the maximum width is along the hinge-line. A prominent fold, with in some specimens a weak furrow, is present in the brachial valve, and an undivided sulcus in the pedicle valve. Each lateral slope of the brachial valve is divided by four to five subangular plicae. Numerous prominent growth lamellae extend distally into short frills, and are so finely crenulate as to appear superficially capillate. There are 4-5 crenulae per mm on the frills. The pedicle interarea is relatively high, wider than high, and apsacline to almost orthocline. An open delthyrium is higher than wide. Weak dental traces are present along the margins of the delthyrium. The brachial interarea is relatively short, concave medially, orthocline to apsacline, and interrupted by a broad open notothyrium.

Interior. Pedicle valve: A pair of small teeth is supported by a pair of strong dental lamellae and ventral adminicula. The ventral adminicula are fused to the median septum to form a large spondylium. The median septum extends forward about three-quarters of the length of the valve, and backward to form a ridge along the posteromedial surface of the spondylium. This ridge is obscured apically by secondary thickening. A considerable amount of secondary thickening is present in the umbonal regions of mature valves. The muscle scars are not obviously impressed.

Brachial valve: The cardinal process consists of a number of subradial lamellae on the posterior portions of the socket ridges, crural plates, and notothyrial pit. A pair of short crural plates is fused to the socket ridges laterally and to the floor of the valve medially opposite, and for a short distance in front of, the cardinal process. Secondary thickening has almost filled the cavities that are normally present lateral to a pair of crural plates. The part of the valve in front of the cardinal process and between the crural plates is also slightly thickened. A low myophragm extends forward from a little way in front of the crural plates to near the midlength. Elongate adductor scars are gently impressed along each side of the myophragm.

Ontogeny

Spondylia are present in small pedicle valves about 8 mm long. The umbonal regions are not filled by secondary thickening, and the valves have fewer plicae than mature specimens. The growth-lines show that immature stages were not as alate as mature stages.

Discussion

The specimens from Taemas are close to the specimens of *Cyrtinopsis cooperi* Gill, figured by Gill (1942, pl. 6, figs 6 and 7) from the Lower Devonian of Mooroolbark, Victoria: they have a spondylium and a similar external morphology. Unfortunately, the interiors of the Victorian form are imperfectly known. The form described by Talent (1963) as *Megakozlowskiella cooperi* (Gill), from the Lower Devonian of Tabberabbera, Victoria, is not as close: it has fewer plicae on the lateral slope of the brachial valve (about two as against about five); and the umbonal regions of the pedicle valve are not as strongly thickened. This form is assigned to *Cyrtinopsis* rather than *Megakozlowskiella* because it has a spondylium and an open delthyrium; species of *Megakozlowskiella* usually have strong deltidial plates, which may fuse medially to form a henidium. Talent stated (1963, p. 83) that he could find no significant difference between the material from Tabberabbera and topotype material from Mooroolbark. One of the specimens figured by Gill has at least five plicae on each lateral slope of the brachial valve, whereas the Tabberabbera material usually only has two plicae on the lateral slope of a brachial valve (this does not appear to be a function of size, as the two are almost of the same size). Thus, the form from Tabberabbera should probably be included in *Cyrtinopsis,* but probably not in *C. cooperi.*

A cyrtinopsid from the Lower Devonian Baton River Beds, New Zealand, described by Shirley (1938) as *Spirifer (Cyrtinopsis) perlamellosus* (Hall), was later referred to by Gill (1952) as *Cyrtinopsis* aff. *C. cooperi* Gill. It appears to be close to the form from Taemas, but the material is such that it is difficult to compare the two in detail. They appear to differ in that the New Zealand form has obviously impressed ventral muscle scars.

The southeast Australian cyrtinopsids differ from *C. undosa* (Schnur), the type species of *Cyrtinopsis* from the Emsian and Eifelian of Western Europe, in that they have fewer plicae; the fold and sulcus tend to be slightly narrower; and the growth lamellae are not quite as crenulate, and appear more papillate. No specimens have been found with the fine apical pseudodeltidium described by Boucot (1957a). *C. cooperi* is not as close to *C. brachyptera* (Mailleux) as it is to *C. undosa* (see comparison in Boucot, 1957a). Vandercammen (1963), however, placed *C. brachyptera* in synonymy with *C. undosa* and stated: 'Le genre est représenté en Belgique par une seule espèce, *Cyrtinopsis undosa* (J. Schnur)'.

Family SPINOCYRTIIDAE Ivanova, 1959

Genus HOWITTIA Talent, 1956

Type species: Spirifer howitti Chapman, 1905

Talent originally described *Howittia* as having a ventral median septum. He now believes (pers. comm., 1967) that the medium septum he illustrated (1956a, Text–fig. 8) is only apparent and is a function of the angle at which the serial section was made. Both of the species described here lack a median septum but have a fine low median ridge or myophragm. One is identified as the type species, *Howittia howitti* (Chapman).

Howittia is close to *Adolfia* Gurich in that it has a subdivided fold and sulcus; strong fairly numerous plications; no median septum in the pedicle valve; dental lamellae and ventral adminicula; no deltidial plate; and a similar micro-ornament. It differs in that it lacks a delthyrial plate, a character given some taxonomic importance by Vandercammen (1957, 1965), Drot (1964), and Pitrat (*in* Moore, 1965). An emended diagnosis of *Howittia* is given below.

Diagnosis: Shells transverse and subequally biconvex to slightly ventribiconvex; fold and sulcus usually subdivided; plicae on lateral slopes strong, fairly numerous, and simple or increasing in number next to fold and sulcus; micro-ornament of fine radiating capillae, not necessarily parallel with tops of plicae, and fine subsidiary spines on capillae; delthyrium open, with no delthyrial plate; obvious lateral plates border delthyrium; no ventral median septum, but fine ventral myophragm may be present; obvious dental lamellae and ventral adminicula; longitudinally striate cardinal process which may or may not be bilobate; short crural plates.

Range: Howittia at present only includes two species, *H. howitti* (Chapman) and *H. multiplicata* (de Koninck), both of which occur in rocks of late Early Devonian or possibly early Middle Devonian age in southeast Australia. *H. howitti* occurs at Buchan and Bindi, Victoria, as well as at Taemas, New South Wales.

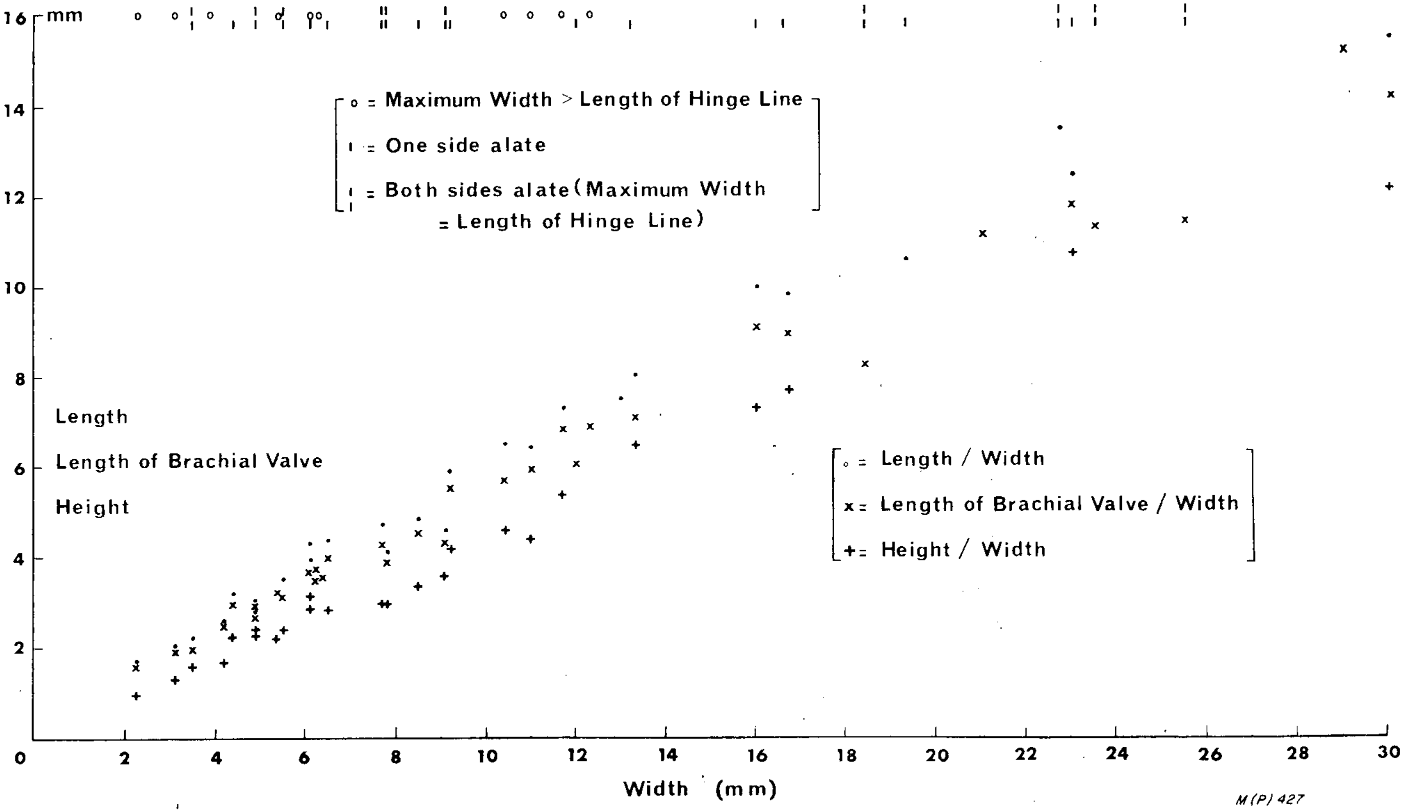


Fig. 36. *Howittia howitti* (Chapman). Specimens from the '*Receptaculites*' Limestone.

HOWITTIA HOWITTI (Chapman, 1905)

(Pl. 24, figs 1-20; Text–fig. 36)

1905 *Spirifer howitti* Chapman, pp. 18-19, pl. 5, figs 4-6.
1956 *Howittia howitti* (Chapman); Talent, pp. 34-36, pl. 2, figs 13-17, text–fig. 8.

Locality: The basal 60 m of the *'Receptaculites'* Limestone at Taemas near Yass, New South Wales, at Locality Г and below Locality A.

Material: Specimens ANU 18962a-j and CPC 10596-600.

Occurrence: Common in rocks as low as the Cavan Formation and as high as the Warroo Limestone. Found at localities A, B, Г and Д.

Description

The specimens from Taemas are conspecific with the type specimens of species, which were examined.

Exterior: The shells are medium sized, gently ventribiconvex, and transverse. The cardinal angles are usually alate in mature specimens (see Text–fig. 36), with the maximum width usually at the hinge-line, but between the hinge-line and the midlength in some non-alate individuals. A dorsal fold and ventral sulcus are obvious. The fold is divided by a firmly impressed median furrow that extends forward from close to the beak; and it may be further subdivided by a pair of furrows inserted towards the anterior margin (Pl. 24, fig. 20). The sulcus is correspondingly subdivided (Pl. 24, figs 5 and 14). There are usually about 9 strong subangular plicae on each lateral slope of a mature brachial valve; they are usually simple at Taemas, but the holotype has plicae that increase in number next to the fold and sulcus. The micro-ornament consists of fine radiating capillae, which converge slightly towards the summits of the plicae and from which fine spines project. The capillae appear to be superposed on fine growth lamellae. The pedicle interarea is moderate in height, broader than high, gently concave, apsacline, and ornamented by fine longitudinal and more obvious transverse grooves. The delthyrium is open and flanked by a pair of obvious lateral plates. The brachial interarea is low, concave, and orthocline to apsacline. A broad notothyrium is open.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by prominent dental lamellae and ventral adminicula, which extend a short distance in front of the teeth and have a sigmoid anterior profile. The teeth are subrectangular in cross-section; their long axes run anterolaterally. The dental lamellae converge slightly ventrally; the ventral adminicula diverge slightly anteroventrally; and the join between them is obvious. The umbo is not preferentially thickened. The muscle scars are gently impressed between the ventral adminicula. The adductor scars are long and narrow, separated from the diductor scars by a pair of fine low ridges, and divided by a fine myophragm. The diductor scars are elongate; they extend in front of the bases of the ventral adminicula, and surround the adductor scars to the anterior (Pl. 24, fig. 13).

Brachial valve: The cardinal process is divided by a series of fine deep furrows into longitudinally arranged lamellae. It is roughly diamond-shaped and may or may not be weakly bilobed. Short crural plates are fused to the floor of the valve along the sides of and just in front of the cardinal process (Pl. 24, figs 17 and 18). The sockets are deep and their posterior portions are covered by secondary shell. The crura converge forward as far as the jugal processes, and then the primary lamellae diverge forward. The jugal processes are pointed and subventrally directed. A low median ridge or myophragm may extend forward about half the length of the valve.

Discussion

H. howitti is close to *Howittia multiplicata* (de Koninck): both species have similar interiors (except for the shorter crural plates with sub-horizontal median extensions of *H. multiplicata*), outlines, micro-ornament, delthyria, lateral plates, and subdivided folds and sulci. But the fold of a mature specimen of *H. multiplicata* is subdivided by at least five furrows and that of *H. howitti* never by more than three; the plicae on the lateral slopes of *H. multiplicata,* next to the fold and sulcus, generally subdivide near the umbo, whereas those of *H. howitti* are usually simple; *H. multiplicata* has more plicae on its lateral slopes; and the crural plates of *H. multiplicata* are shorter, and have short subhorizontal extensions that extend medially just in front of the cardinal process.

The range in variation of the number of plicae in the fold and sulcus, between different species of this genus, is no greater than in *Adolfia,* in which some species are almost bald and others have at least 8 furrows dividing the sulcus, like *Adolfia faniensis* (Mailleux) from the Frasnian of Belgium (see Vandercammen, 1965, pl. 3, fig. 1).

H. howitti and *H. multiplicata* appear to be close to *Adolfia glypta* Talent from the Lower Devonian of the Mitchell and Wentworth Rivers, Tabberabbera, Victoria. If *A. glypta* lacks a delthyrial plate it could well be included in *Howittia.* Both *H. howitti* and *H. multiplicata* differ from *A. glypta* in having more obviously divided folds and sulci.

HOWITTIA MULTIPLICATA (de Koninck, 1876)

(Pl. 24, figs 21-26; Pl. 25, figs 1-14; Pl. 30, figs 21-22; Text–fig. 37)

1876 *Spirifer multiplicatus* de Koninck, pp. 102-103, pl. 3, fig. 5 (English translation, 1898, p. 81, pl. 3, fig. 5).

Type locality: The neotype was obtained from the top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales. Other figured specimens came from this locality and from the basal 60 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass.

Type material (here chosen): Neotype ANU 18964; neoparatypes ANU 18963a-d, ANU 18965a-f, ANU 18997f, and CPC 10601-5.

Occurrence: From the Cavan Formation to the top of the *'Receptaculites'* Limestone, collected from localities A, B, Γ, and Д.

Description

Exterior: Shells are medium to large, subequally biconvex to slightly ventribiconvex, and transverse. The cardinal angles are usually close to or less than a right angle, and the maximum width is at or just in front of the hinge-line. An obvious dorsal fold and ventral sulcus are present. The fold, sulcus, and lateral slopes are subdivided by numerous subangular plicae. On the fold and sulcus, the plicae increase by intercalation and unequal subdivision; and on the lateral slopes they increase by addition of new plicae laterally, and intercalation or unequal subdivision next to the sulcus and fold, respectively. There are 11 plicae in the fold and about 19 on each lateral slope of a brachial valve 16.8 mm long (Pl. 25, fig. 5). The micro-ornament consists of fine concentric growth lamellae and fine radiating capillae, which converge slightly towards the summits of the plicae and from which small spines project at slightly irregular intervals (Pl. 30, fig. 22). The pedicle interarea is moderate in height, wider than high, concave, apsacline, and ornamented by both longitudinal and transverse grooves. The delthyrium is open and flanked by a pair of prominent lateral plates (Pl. 25, figs 1 and 8). The brachial interarea is short, concave, and orthocline to apsacline. A broad notothyrium is open.

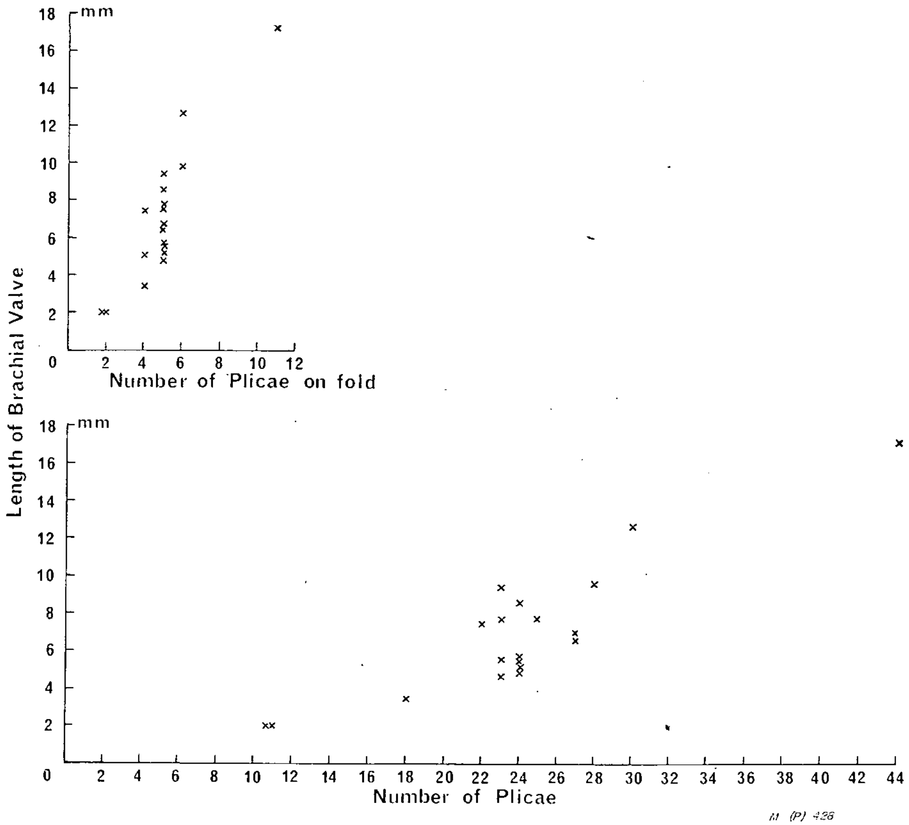


Fig. 37. *Howittia multiplicata* **(de Koninck). Specimens from the '*Receptaculites*' Limestone.**

Interior. Pedicle valve: A pair of moderate-sized teeth is rectangular to elongate in cross-section, with long axes directed anterolaterally. The teeth are supported by obvious dental lamellae and ventral adminicula, which extend a short distance in front of the teeth and have a sigmoid anterior profile. The joins between the lamellae and the adminicula are obvious, and are usually defined by low angular ridges. The dental lamellae converge gently ventrally and the adminicula diverge gently forward. The muscle scars are only gently impressed. They are usually divided by a low myophragm and gentle sublongitudinal ridges and grooves.

Brachial valve: The cardinal process is composed of sublongitudinally arranged lamellae. It is roughly triangular, and may or may not be bilobate. The postero-dorsal edges of the short crural plates are expanded and incurved so as to form medial extensions subparallel with the plane of the commissure. The ventral surfaces of these extensions appear to be pitted; the pits may be dorsal pedicle adjustor scars. The crural plates are fused to the floor of the valve along the sides, and just in front, of the cardinal process. The sockets are deep, and their posterior portions are covered but not filled. A low myophragm or median ridge is present in the posterior halves of some valves. The adductor scars are not obviously impressed. The jugal processes are pointed and subventrally directed.

Discussion

De Koninck's original types of *Spirifer multiplicata* were lost in the Garden Palace fire of 1882. De Koninck described the species as coming from a grey, very compact limestone in the Yass district: the description would fit the *'Receptaculites'* Limestone. The specimens appear to fit de Koninck's description and illustration (1876), and are the only known spiriferoid specimens from a limestone near Yass that could represent his species. Therefore it was decided to redescribe the species and erect a neotype.

See also under the discussion of *Howittia howitti* (Chapman).

Superfamily RETICULARIACEA Waagen, 1883
Family RETICULARIIDAE Waagen, 1883
Genus QUADRITHYRINA Havlíček, 1959

Type species: Quadrithyrina ivanovae Havlíček, 1959

QUADRITHYRINA ALLANI sp. nov.

(Pl. 27, figs 20-27; and Pl. 28, fig. 1)

Derivation of name: After Professor R. S. Allan.

Type locality: The basal 9 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18968; paratypes ANU 18969 and CPC 10610-11.

Occurrence: Rarely in the basal beds of the *'Receptaculites'* Limestone at localities B and Γ. A single specimen was found about 30 m below the top of the *'Receptaculites'* Limestone at Locality A.

Description

Exterior: Shells are medium sized, transverse, and ventribiconvex; the largest specimen found is 8.5 mm long and 12 mm wide. The height:width ratio of the holotype is about 0.7. An obvious dorsal fold and ventral sulcus extend forward from the beaks, and the anterior commissure is plicate. A gentle rounded plication is present on each lateral slope of the brachial valve. Growth lamellae are present. Faint signs of capillae can be seen on the lamellae of some specimens, but the preservation is such that it is difficult to be sure of their presence. The cardinal angles are rounded and the maximum width is close to the midlength. Both the concave apsacline pedicle interarea and the open delthyrium are slightly wider than high. The delthyrium has lateral plates along each side, strong close to the apex and directed laterally so as to be almost parallel with the interarea (Pl. 27, fig. 25). The interarea of the brachial valve is much lower than that of the pedicle valve and apsacline. It is interrupted by a broad open notothyrium. The beaks of both valves are moderately incurved.

Interior. Pedicle valve: Moderate-sized teeth, transversely elongate in cross-section, are supported by a pair of dental lamellae. Ventral adminicula are not visible in mature shells. Some valves are moderately thickened umbonally, others only slightly. A strong high subtriangular median septum extends forward three-quarters of the length of the valve. It is highest anteriorly, and has a gently concave anterodorsal edge. The margin of one pedicle valve is grooved along the commissure (Pl. 27, figs 20 and 25). This groove may have acted as a receptacle for a ridge on the commissural margin of the brachial valve and thus have provided a tight fit between the two valves.

Brachial valve: A small bilobate cardinal process, which apparently consists of fine longitudinally arranged lamellae, is present in the apex of the valve. A pair of very short crural plates is fused to the floor of the valve on each side of the cardinal process. Muscle scars are not obvious.

Ontogeny

A single fragment of an immature pedicle valve was found in which a very short ventral adminiculum could be identified between a dental lamella and the floor of the umbo (Pl. 28, fig. 1). This adminiculum was either obscured by secondary thickening or resorbed during growth in other shells.

Discussion

Quadrithyrina allani is included in *Quadrithyrina* Havlíček rather than *Quadrithyris* Havlíček because it lacks a pair of ventral adminicula in mature individuals, and has some umbonal thickening. Havlíček (1959) included two species in *Quadrithyrina: Q. ivanovae* Havlíček, the type species, from the Eifelian of Czechoslovakia, and *Q. mesodevonica* (Nalivkin) from the Middle Devonian of Turkestan.

Q. allani differs from *Q. ivanovae* in that it has a weak plication on each side of the fold, and is not as strongly thickened umbonally; and from *Q. mesodevonica* in having a pair of plications laterally and a more obvious fold.

The only species of *Quadrithyrina* previously recorded from eastern Australia is that figured, but not described, by Hill, Playford, & Woods (1967, pl. DXII, fig. 7), as *Quadrithyrina* sp. nov. from the Eifelian Ukalunda Beds of Bowen Basin, Queensland.

Havlíček (1959) suggested that *Quadrithyrina* is a Middle Devonian derivative of *Quadrithyris,* which is a predominantly Lower Devonian genus. This hypothesis is partly supported by the presence of very short adminicula in an immature specimen of *Quadrithyrina.* Too few occurrences of *Quadrithyrina* have been described, however, to be sure that the genus is restricted to the Middle Devonian. If the hypothesis is correct, *Q. allani* could be closely related to a form like *Quadrithyris robusta molongensis* Savage, which occurs in the Siegenian Mandagery Park Formation, New South Wales. *Q. allani* differs from that subspecies in that it has a gentle plica on each slope of the brachial valve, and no ventral adminicula.

Order RHYNCHONELLIDA Kuhn, 1949
Superfamily RHYNCHONELLACEA Gray, 1848
Family RHYNCHOTREMATIDAE Schuchert, 1913
Subfamily ORTHORHYNCHULINAE Cooper, 1956
Genus CALLIPLEURA Cooper, 1942

Type species: Rhynchospira nobilis Hall, 1860

CALLIPLEURA? sp.

(Pl. 31, figs 23-26 and 28-30)

Locality: The basal 9 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Material: Specimens ANU 18979a-c and CPC 10612.

Occurrence: At a number of localities in the basal beds of the *'Receptaculites'* Limestone.

Description

Too few well preserved specimens of this form were found to erect a new species or compare it properly with previously described species.

Exterior: Shells are medium sized and rounded subtriangular to rounded subpentagonal in outline. The hinge-line is short and straight, and at its ends are small wing-like extensions of the shell. The brachial interarea is short and apsacline to orthocline. The ventral beak is truncated by a large round mesothyridid foramen. The delthyrium is partly closed anteriorly by a pair of deltidial plates conjunct medially. The plicae are strong and angular or subangular. They are crossed by numerous fine concentric striae, which do not appear to form knots on the crests of the plicae. A gentle dorsal fold and ventral sulcus are present anteriorly. The anterior and lateral slopes are not steep. The commissure is denticulate and plicate.

Interior. Pedicle valve: A pair of stout teeth is supported by a pair of thick dental plates, concave medially, and partly separated from the sides of the valve by a pair of shallow narrow lateral cavities. They extend forward as low muscle-bounding ridges, about a third of the length of the valve (Pl. 31, fig. 28). The adductor scars are moderately impressed and elongate. They are surrounded by a pair of gently impressed slightly flabellate diductor scars, which extends forward to a point just in front of the anterior edges of the muscle-bounding ridges.

Brachial valve: The cardinal process consists of a small elongate ridge in the apex of the valve. It is usually conjoint with a low median ridge, which extends forward less than half the length of the valve, and may not be very obvious. The crural bases diverge dorsally and are fused to the inner edges of the hinge-plates: they do not extend to the floor of the valve as crural plates. A pair of stout projections extends medially from the crural bases and is usually conjunct medially in front of the cardinal process (Pl. 31, figs 26 and 30). The distal ends of the crura appear to be slightly expanded and spoon-shaped. The crura diverge forward and then curve ventrally.

Discussion

The species appears to differ slightly from the diagnosis of *Callipleura* given by Schmidt (*in* Moore, 1965) in that the concentric striae do not appear to form knots on the crests of the plicae, and a pair of processes is conjunct between the crural bases.

The species does not appear to be close to any previously described southeast Australian rhynchonellid.

Family TRIGONORHYNCHIIDAE McLaren *in* Moore, 1965

Genus BROWNEELLA nov.

Type species: Browneella browneae sp. nov. from the Upper Emsian or possibly Lower Eifelian *'Receptaculites'* Limestone at Taemas, near Yass, New South Wales.

Derivation of name: After Professor W. R. Browne.

Diagnosis: Shells small and subpentagonal in outline; brachial valve more vaulted than pedicle valve; front and flanks steeply sloping to truncated; gentle dorsal fold and ventral sulcus present anteriorly; weak dorsal sulcus present posteriorly; plicae strong, angular, beginning at beaks, simple anteriorly and usually increasing by intercalation and unequal subdivision posteriorly; commissure denticulate and plicate; dental plates short and anteriorly divergent; septalium low, often sessile on thickened floor of valve and usually open (not covered by a pair of inwardly directed plates); weak dorsal myophragm or median septum may be present, but does not form an obvious feature, except posteriorly.

Discussion

Browneella is unusual for the Trigonorhynchiidae in that its septalium is sometimes sessile on the thickened floor of the brachial valve.

It is superficially similar to *Trigonorhynchia* Cooper, but the median septum is not as obvious, and the septalium is often sessile and not covered over anteriorly. It also shows some similarities to *Cupularostrum* Sartenaer, but the pedicle valve is not as inflated, the anterior and lateral margins are steeper, and the septalium is open.

Occurrence: The only species that can be placed in the genus at present is the type species. *Browneella browneae* sp. nov., from the upper Emsian or possibly lower Eifelian *'Receptaculites'* Limestone.

BROWNEELLA BROWNEAE gen. et sp. nov.

(Pl. 32, figs 1-24; Text–figs 38 and 39)

Derivation of name: After Ida A. Browne.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18980; paratypes ANU 18981a-i and CPC 10613-5.

Occurrence: Very common in the top of the *'Receptaculites'* Limestone, and collected from localities A and Д.

Description

Exterior: The shells are small, moderately to strongly dorsibiconvex, and subpentagonal in outline. The maximum width is in front of the midlength. The largest specimen found is 6.5 mm long, 7.7 mm wide, and 4.2 mm high. The anterior and lateral margins are steep or subvertical. The ornament consists of high angular plicae. There is a gentle fold in the anterior portion of the brachial valve, and a sulcus in the pedicle valve. A shallow sulcus in the umbonal region of the brachial valve dies out about 1 mm from the apex. The plicae increase anteriorly by intercalation and unequal subdivision in the posterior half of the shell. The commissure is denticulate, and a tongue is present in the pedicle valve. The palintrope is small and curved. The delthyrium is about as wide as long, but is constricted laterally by long narrow deltidial plates, forming a hypothyridid pedicle opening that is longer than wide. The deltidial plates are not conjunct medially. The beaks of both valves are moderately incurved, and that of the pedicle valve forms an obtruse angle in ventral view. There are usually between 10 and 20 plicae at the margins of mature specimens (Text–fig. 38).

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by short ventrally divergent dental plates. The muscle scars are gently to moderately

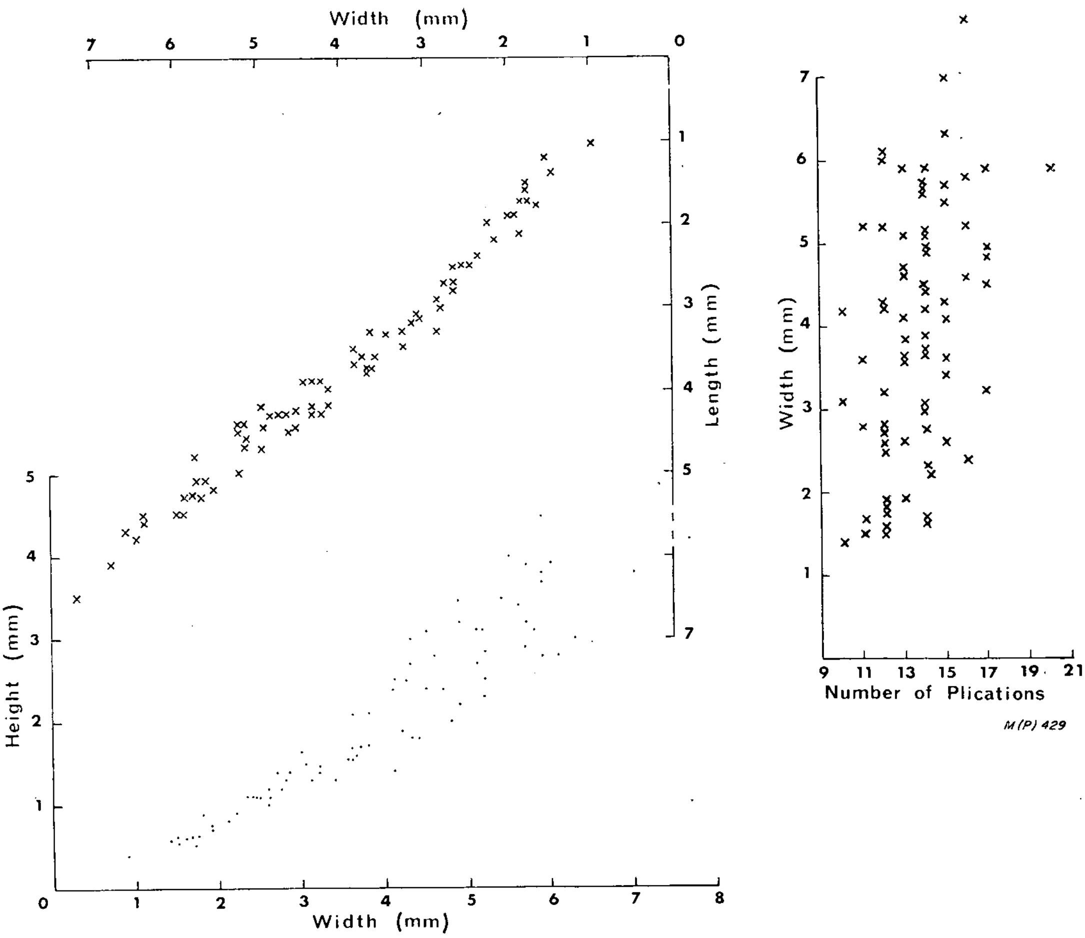


Fig. 38. *Browneella browneae* **gen. et sp. nov. Specimens from the** *'Receptaculites'* **Limestone.**

impressed, but not very well preserved. They are broad; extend forward about a third of the length of the valve; and have a convex anterior margin. The adductor scars could not be distinguished from the diductor scars, probably because of the poor preservation.

Brachial valve: The cardinal process is not obvious. The cardinalia appear to be variable. An inner hinge-plate is depressed and fused to either a low median septum or the thickened floor of the valve to produce a low septalium. A pair of short plates extends medially over the septalium, but is not conjunct. The cardinalia are not very well preserved in any of the specimens, and are considered to be difficult to interpret: a reconstruction is given in Text-figure 39. In some specimens, the anteromedial corners of the deltidial plates fit into small 'accessory sockets' on either side of the beak. The adductor scars are large and fill most of the posterior third of the valve. They may be divided by a myophragm or a low median septum.

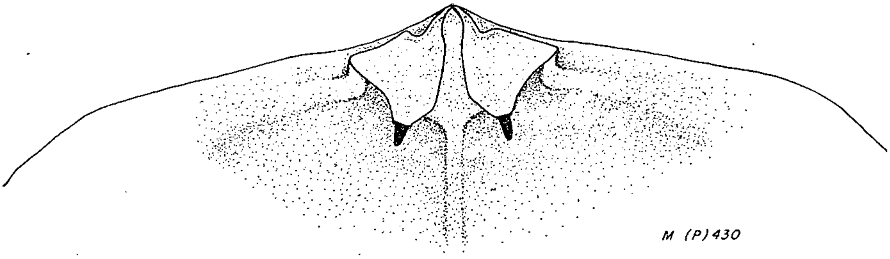


Fig. 39. ***Browneella browneae*** **gen. et sp nov. Anteroventral view of a reconstruction of a cardinalium (the crura are missing).**

Ontogeny

The plicae appear at the distal edges of a small protegular node, about 0.2 mm long. A gentle dorsal sulcus and ventral keel are present in early stages, but they die out about 1 mm from the beaks. A dorsal fold and ventral sulcus appear in late ephebic stages. The height/width ratio increases slightly and the length/width ratio decreases slightly during growth. These changes are probably associated with the appearance of steep anterior and lateral margins in late ephebic stages. The relative increase in height is due to inflation of the brachial valve.

Discussion

See under the discussion of the genus.

Family UNCINULIDAE Rzhonsnitskaya, 1956
Subfamily UNCINULINAE Rzhonsnitskaya, 1956
Genus EOGLOSSINOTOECHIA Havlíček, 1959

Type species: Eoglossinotoechia cacuminata Havlíček, 1959.

EOGLOSSINOTOECHIA LINKI sp. nov.
(Pl. 31, figs 1-22 and 27; Text–fig. 40)

Derivation of name: After A. G. Link.

Type locality: The top of the '*Receptaculites*' Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18978; paratypes ANU 18977a-i and CPC 10616-20.

Occurrence: Several horizons within the '*Receptaculites*' and Warroo Limestones; collected at localities A, Г, and Д.

Description

Exterior: Shells are moderate in depth, subequally biconvex to slightly dorsibiconvex, and rounded pentagonal to rounded septagonal. A dorsal fold and ventral sulcus are only developed anteriorly. The anterior and lateral margins are subvertical in mature individuals. A dorsally directed tongue is moderately developed. The commissure is denticulate, and the ornament consists of gentle rounded plicae, which are only present anteriorly and laterally. The plicae are almost flat, and are subdivided by fine shallow grooves, on the vertical faces of the shell. Small specimens tend to be more elongate than mature individuals (Text–fig. 40). The number of plicae at the margins of mature individuals ranges between

20 and 28. The beaks of both valves are moderately incurved so that the apex of the brachial valve is covered by the deltidial plates. The deltidial plates are usually conjunct, and the foramen is mesothyridid. The palintrope is curved, and the beak ridge is not very obvious.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by dental plates that extend forward as far as, or slightly in front of, the teeth. A pedicle muscle scar is moderately impressed between the dental plates. A pair of small adductor scars is separated from, and in front of, the pedicle muscle scars; they are firmly impressed posteriorly and gently anteriorly, where they merge with the diductor scars. The diductor scars are larger than the adductor scars, moderately to faintly impressed, and, in some specimens, appear to be horseshoe-shaped, with the prongs extending backwards a short distance behind the adductor scars laterally (Pl. 31, fig. 14). In other specimens, they are not horseshoe-shaped and do not extend as far back as the adductor scars. At the margins, the apices of the denticles of the commissure extend dorsally into acicular spines that fit along the inner surface of the vertical portions of the brachial valve. A row of shallow or obvious pits may be present along the inner edge of the vertical portions of the valve, opposite the acicular spines of the brachial valve.

Brachial valve: The cardinal process apparently consists of a series of short irregular subradiate ridges on the posterior portion of the cardinalia. The inner hinge-plate is either conjunct or fused in front of the cardinal process. The crural bases are much more obvious as ridges along the dorsal surface of the hinge-plate than on the ventral surface. The very low median septum is only fused to the hinge-plate behind its anterior margin, to form a septalium. A dorsally directed ridge runs along the dorsomedial surface of the anterior portion of the inner hinge-plate, over the median septum. The crura curve ventrally distally. A pair of moderately impressed small and elongate ovate adductor scars may be visible some distance in front of the cardinalia (they cross the midlength). They are subdivided by the anterior portion of the median septum.

Discussion

Eoglossinotoechia linki is placed in *Eoglossinotoechia* Havlíček rather than *Glossinotoechia* Havlíček because it has an obviously convex pedicle valve; the cardinal process is well developed, although not large; and the anterior portion of the septalial cavity is free.

It differs from *E. cacuminata* Havlíček, the type species of *Eoglossinotoechia* from the Silurian and Lower Devonian of Czechoslovakia, in that the pedicle valve is not quite as convex; the cardinal process is more obviously bilobate; and the plicae are not as numerous.

E. linki is not very close to either *E. mystica* Havlíček, from the Silurian of Bohemia, or *E. sylphidea* (Barrande), from the Lower Devonian of Bohemia; the plicae are fewer and do not extend as close to the beaks. It is also not very close to the Lower Devonian members of the genus described from Morocco by Drot (1964).

No other species of *Eoglossinotoechia* have been previously described from southeastern Australia, although a closely related form occurs in the Lower Devonian Garra Formation near Wellington, New South Wales.

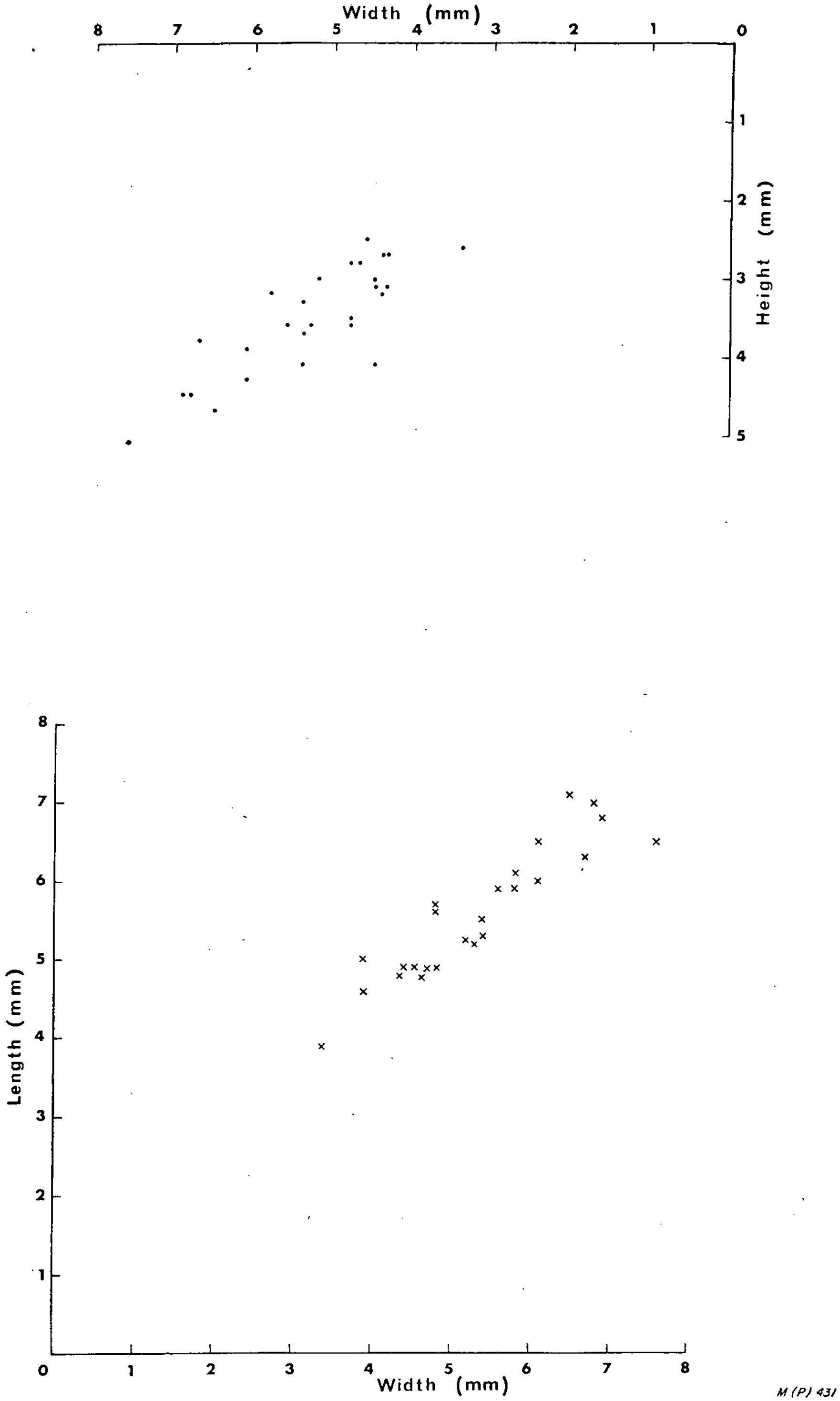


Fig. 40. *Eoglossinotoechia linki* **sp. nov. Specimens from the** *'Receptaculites'* **Limestone.**

Family PUGNACIDAE Rzhonsnitskaya, 1956

Genus PUGNAX Hall & Clarke, 1893

Type species: Terebratula acuminata Sowerby, 1822

'PUGNAX' OEPIKI sp. nov.

(Pl. 32, figs 25-41; Text–figs 41-42)

Derivation of name: After Dr A. A. Opik.

Type locality: The top of the *'Receptaculites'* Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18982; paratypes ANU 18983a-i and CPC 10621-3.

Occurrence: The top of the *'Receptaculites'* Limestone and the middle of the Warroo Limestone. Specimens were collected from Locality A and from 200 m west of Locality Д.

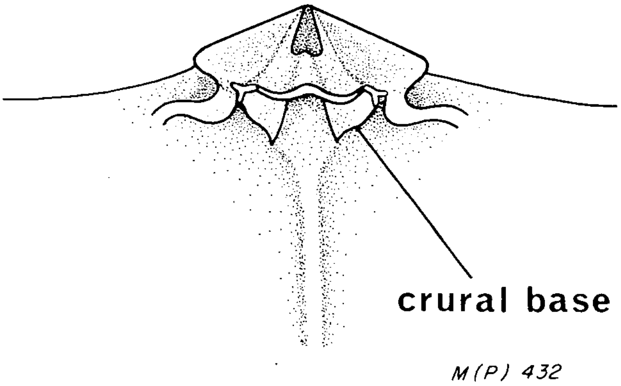


Fig. 41. ***'Pugnax' oepiki*** **sp. nov. Anteroventral view of a reconstruction of the cardinalia (the crura are not included).**

Description

Exterior: The shells are medium sized and dorsibiconvex, with a gently convex pedicle valve and a higher and more strongly convex brachial valve. A dorsal fold and ventral sulcus are present in the anterior half of the shell. The ornament consists of strong rounded-angular plicae, which are restricted to the anterior and lateral portions of the shell. Three to five plicae are in the fold, and four to six on each lateral slope of the brachial valve. The beaks are gently incurved. The foramen is hypothyridid. The outline of the shell is rounded subtriangular to subpentagonal, with the maximum width in front of the midlength. The height of mature specimens varies considerably (Text–fig. 42). High forms may appear subtetrahedral. The commissure is uniplicate and strongly denticulate. There is no fine ornament of capillae.

Interior. Pedicle valve: The teeth are supported by a pair of short dental plates. There is no median septum. The muscle scars are not obviously impressed in any of the few specimens examined.

Brachial valve: The posterior portions of the crural bases extend dorsally to fuse with the floor of the valve (Text–fig. 41). They do not converge towards a median

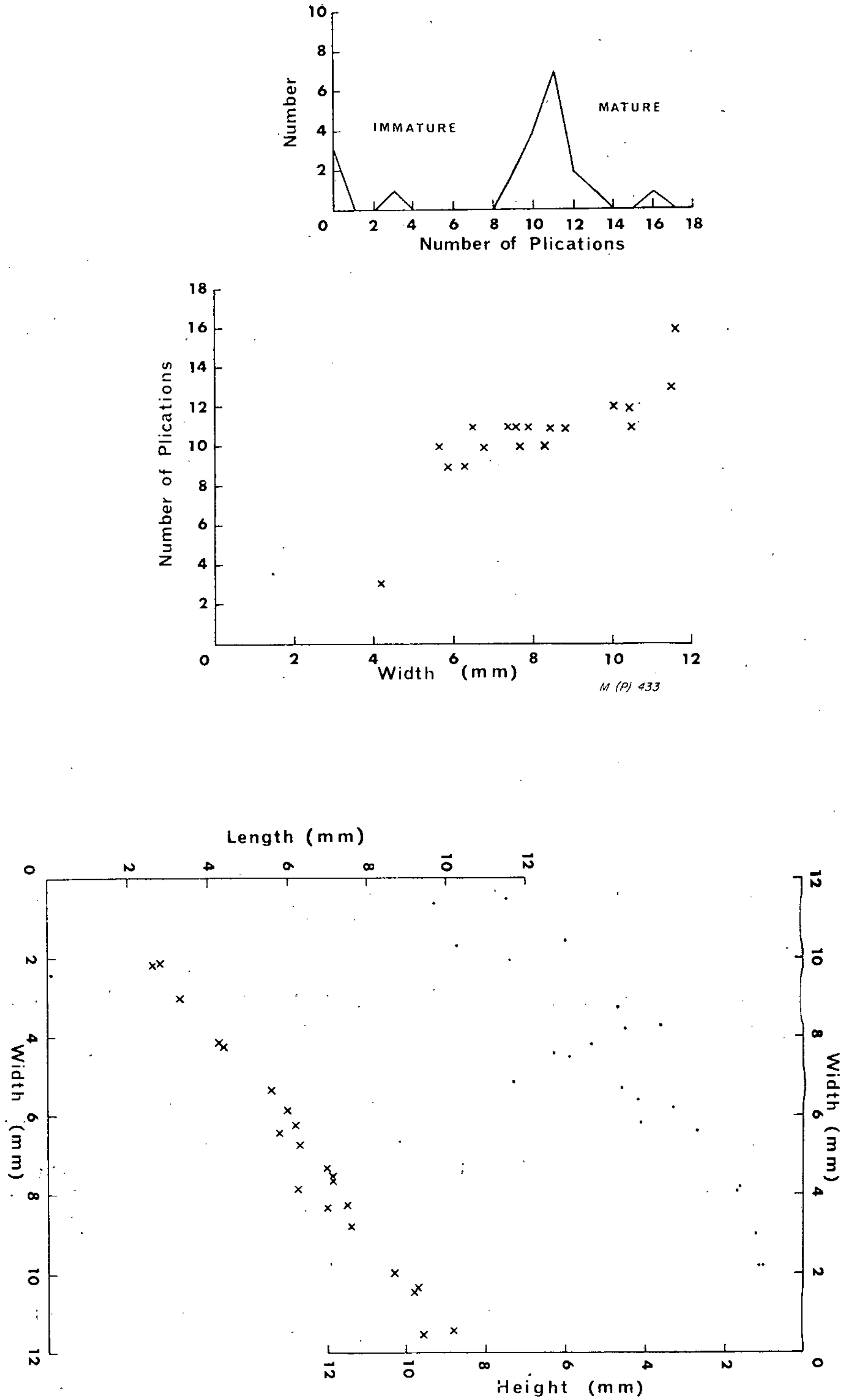


Fig. 42. *'Pugnax' oepiki* sp. nov. Specimens from the top of the *'Receptaculites'* Limestone.

septum to form a septalium. A low myophragm extends forward about half the length of the valve. A thin inner hinge-plate joins the crural bases in the only well preserved brachial interior found. The inner hinge-plate is perforate posteriorly, and it has a gentle median ridge on its ventral surface. There is no obvious cardinal process.

Ontogeny

The early ephebic stages tend to be more elongate than mature specimens, and have lower height/width ratios, mainly because mature specimens have steeper anterior and anterolateral margins. Plicae are, of course, only present in late ephebic and gerontic stages.

Discussion

'Pugnax' oepiki shows some characters characteristic of *Pugnax* and others characteristic of *Parapugnax* Schmidt. It has been tentatively included in *Pugnax* because the crural bases extend dorsally and fuse with the floor of the valve (Text-fig. 41) and do not converge towards a median septum to form a septalium. It is similar to *Parapugnax* in that the fold and sulcus are relatively well defined, and the pedicle valve is not flat or concave posteriorly. It differs from most previously described pugnacids in that a thin inner hinge-plate, which is perforate posteriorly, joints the crural bases.

'Pugnax' oepiki is not very close to *P. acuminatus* (Sowerby), the type species of *Pugnax*. It has more plicae; it is not as high; it has a more obviously convex pedicle valve; and the fold and sulcus are more obvious. It is closer to *P. pugnus* (Martin), but has a more obvious fold and sulcus; the plicae lack the median insertions mentioned by Parkinson (1954); the pedicle valve is more convex; and the highest part of the brachial valve is at, not behind, the anterior edge of the fold.

'P.' oepiki differs from *P. brevicostatus* Talent from the Lower Devonian of Marble Creek, Thomson River, Victoria, in that it tends to have a greater number of plicae; the fold and sulcus are more obviously marked; the plicae do not extend as close to the beaks; and the anterior margin is less convex. It is not very close to any of the species of *Pugnax* described by Veevers (1959) from the Devonian of the Fitzroy Basin, Western Australia.

Order TEREBRATULIDA Waagen, 1883
Suborder CENTRONELLIDINA Stehli *in* Moore, 1965
Superfamily STRINGOCEPHALACEA King, 1850

Numerous small terebratulids with centronelliform loops occur in the *'Receptaculites'* Limestone. They are separated into six species. Unfortunately, only a few well preserved brachial interiors were found. The cardinalia appear to be rather variable.

The four species which have median septa (included in the new genera *Cydimia* and *Adrenis*) either have short inner hinge-plates that are depressed and fused to the median septa to form short low septalia, or inner hinge-plates so short that the septalia, if present, are not obvious. These species also have a pair of plates that project medially from the inner edges of the posterior ends of the crura; they may either be short and separate or longer and conjunct medially, to form a plate which is free, not fused to the median septum. The two species without median septa (included in the new genus *Micidus*) have either discrete crural bases or a short inner hinge-plate that is depressed and fused to the floor of the valve so that the crural bases are apparently discrete. They also have a pair of plates that project medially from the inner edges of the posterior portions of the crura, and may or may not be conjunct or fused to form a plate that is free of the floor of the valve.

The intraspecific variability of the cardinalia appears to be great enough to throw some doubt on the value of the characters of the cardinalia in differentiating forms at the subfamily or family level (the presence of a septalium is regarded as important in the diagnosis of the Rhipidothyrididae by Cloud, 1942, and by Stehli *in* Moore, 1965). It was decided, however, that not enough sufficiently well preserved cardinalia of these and other previously described similar forms have been found to attempt to reorganize the classification of small terebratulids with centronelliform loops. The genera with a median septum, a septalium in some species, and foramina that are usually hypothyridid are included in the Rhipidothyrididae (*Cydimia* and *Adrenia*). The genus without a median septum, with crural bases that appear to be discrete, and foramina that are usually submesothyridid or mesothyridid, is included (provisionally) in the Mutationellidae *(Micidus)*.

All four species included in the Rhipidothyrididae have deltidial plates produced dorsally to form a deltidial sheath. The sheath expands distally, presumably to leave enough room for some movement of the pedicle, and probably acted as a protective shield for the pedicle. It is not present in either of the species included in the Mutationellidae.

Cydimia is distinguished from *Adrenia* primarily by the presence of a subdued ornament close to the beaks, a vertical plate in the loop, and a median plica in the brachial valve. Species of *Adrenia* have obvious plicae close to the beaks, no vertical plate in the loop, and a median plica in the pedicle valve. These characters appear to be constant both within and between species. Cardinalia vary so much that although the cardinalia of *Cydimia robertsi* sp. nov. and *Adrenia expansa* sp. nov. tend to have obvious short low septalia, and those of *Cydimia parva* sp. nov. and *Adrenia cernua* sp. nov. tend to lack septalia, this does not hold true for all the specimens found; some specimens of *C. robertsi* and *A. expansa* were found without obvious septalia. Thus, within this group of brachiopods, the presence or absence of a vertical plate in the loop and the presence or absence of prominent plicae close to the beaks are relatively stable characters interspecifically, and should be useful for differentiation at a generic level; the presence or absence of a small septalium in the cardinalia appears to be variable intraspecifically and should not be regarded as being significant at a generic level.

Family RHIPIDOTHYRIDIDAE Cloud, 1942

Subfamily RHIPIDOTHYRIDINAE Cloud, 1942

Genus ADRENIA nov.

Type species: Adrenis expansa sp. nov. from the Upper Emsian or possibly Lower Eifelian *'Receptaculites'* Limestone at Taemas, New South Wales.

Derivation of name: Greek *adrenes,* feeble or inactive.

Diagnosis: Shells small, subcircular to elongate, subequally biconvex to slightly ventribiconvex and entirely plicate. Dorsal sulcus and ventral fold may or may not be obvious, and anterior commissure may or may not be sulcate. Plicae obvious close to beaks; median plica in pedicle valve. Short dental plates in pedicle valve. Inner hinge-plate (cardinal plate) depressed posteriorly and fused to low median septum to form short low septalium, not invariably obvious. Pair of plates of variable size along inner edge of the crura for a short distance in front of septalium; may or may not be conjunct medially. Brachidium a centronelliform loop; no vertical plate or rod anteriorly. Deltidial plates produced dorsally to form deltidial sheath. Foramen hypothyridid.

Discussion

Adrenia gen. nov. and *Cydimia* gen. nov. both have deltidial plates produced dorsally to form a deltidial sheath; a hypothyridid foramen (some specimens may be slightly sub-mesothyridid in both genera, but the flared deltidial sheaths tend to obscure the exact relationships of the foramen to the delthyrium in well preserved individuals); an inner hinge-plate depressed posteromedially to join a low median septum and form a low septalium; and a tendency to a slightly sulcate anterior commissure with a dorsal sulcus and a gentle ventral fold. Unlike *Adrenia, Cydimia* has a ventrally directed vertical plate at the anterior end of the loop; the median plica is in the brachial valve; and the plicae are subdued close to the beaks, particularly in the brachial valve.

Adrenia appears to differ from *Rhipidothyris* Cooper & Williams in that the foramen is usually hypothyridid; the deltidial plates may or may not be conjunct anteriorly (Cloud, 1942, p. 87, stated in his diagnosis of *Rhipidothyris* that the deltidial plates are conjunct); the deltidial plates are produced into a deltidial sheath; and the median plica is in the pedicle valve (in the type species of *Rhipidothyris, R. plicata* Cooper & Williams, the median plica is in the brachial valve).

It differs from *Septothyris* Cooper & Williams in having plicae; usually a hypothyridid foramen; and deltidial plates that are produced dorsally to form a deltidial sheath.

Occurrence: The only species included in *Adrenia* at present, *A. expansa* gen. et sp. nov. and *A. cernua* sp. nov., occur in the Upper Emsian or possbily Lower Eifelian *'Receptaculites'* and Warroo Limestones at Taemas, New South Wales. Another species or subspecies of *Adrenia* has been collected from the Cavan Formation in Spring Creek, but is not described here.

ADRENIA EXPANSA gen. et sp. nov.

(Pl. 33, figs 18-32; Text–figs 43 and 45, la-d).

Derivation of name: Latin *expansus,* expanded.

Type locality: The basal 9 m of the *'Receptaculites'* Limestone below Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18986; paratypes ANU 18987a-f and CPC 10624-5.

Occurrence: Common in the basal 60 m of the *'Receptaculites'* Limestone; collected from localities B and Γ, and from the base of the *'Receptaculites'* Limestone below Locality A.

Description

Exterior: Shells are small, subcircular to slightly elongate, and subequally biconvex to slightly ventribiconvex. The largest specimen found is 7.3 mm long, 7.3 mm

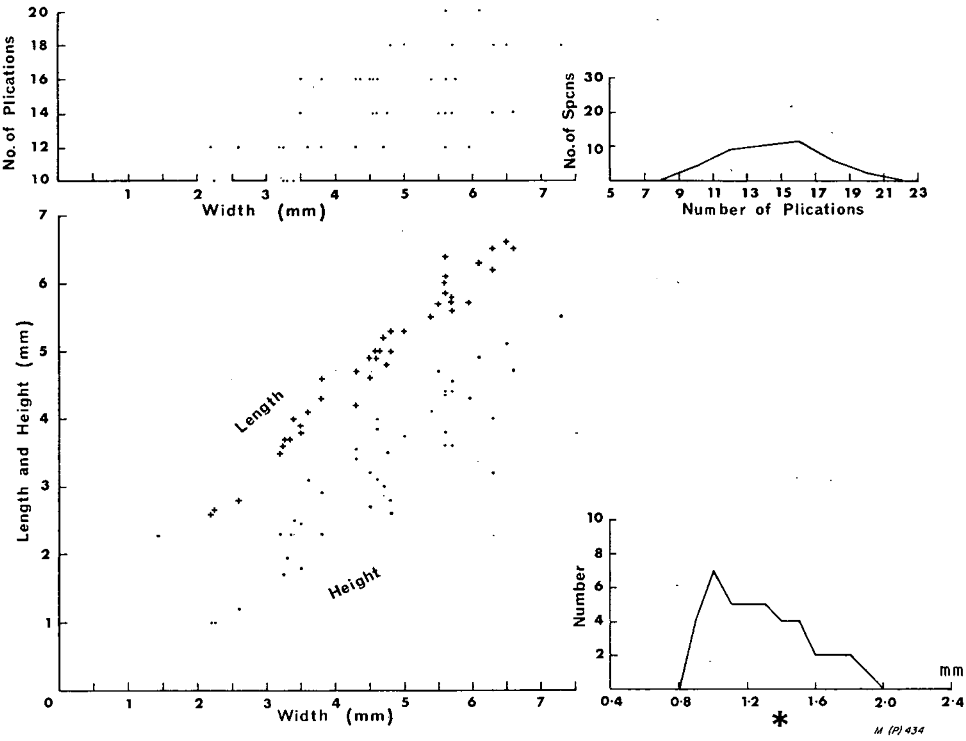


Fig. 43. ***Adrenia expansa*** **gen. et sp. nov. Specimens from the base of the** ***'Receptaculites'*** **Limestone.**

wide, and 5.5 mm high. The valves are plicate, and the subangular plicae are obvious close to the beaks. The median plica is present in the pedicle valve. A gentle ventral fold and dorsal sulcus are present, and the anterior commissure is sulcate. There are between 12 and 20 plicae at the margins of a brachial valve. The distance from the apex of the pedicle valve to the region where the plicae become obvious medially on the brachial valve ranges between 0.9 and 1.9 mm (this measurement is represented by an asterisk in Text–fig. 43). The mean of the length/width ratios is 1.08; and of the height/width ratios, 0.72. The palintrope is relatively flat and the beak ridge is obvious, but it is more angular posteromedially than anterolaterally. The foramen is hypothyridid. A pair of deltidial plates partly fills the anterolateral and lateral portions of the delthyrium. The deltidial plates are usually not conjunct anteromedially, and they are produced dorsally to form a deltidial sheath, which expands distally (Pl. 33, fig. 25). The pedicle beak is moderately incurved. The brachial valve has no interarea.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by a pair of short dental plates. There is no median septum. The muscle scars are not impressed.

Brachial valve: The inner hinge-plate is depressed posteromedially and fused to a low median septum to form a short low septalium (Pl. 33, figs 24 and 27). A pair of plates along the inner edges of the crura is narrow, and is not conjunct medially in any of the specimens examined. A cardinal process may be present as two areas of fine irregular sublongitudinal ridges, one on each side of the posterior portion of the cardinalia (Text–fig. 45, 1b). The median septum is low, and extends forward about half the length of the valve. The brachidium consists of a centronelliform loop, which extends forward slightly over half the length of the valve. It is convex anterodorsally, in lateral view, and does not have a vertical plate anteriorly. The crural points are moderate in length, ventromedially directed, and angular to pointed.

Discussion

Adrenia expansa differs from *A. cernua* sp. nov. in its smaller length/width ratio (mean 1.08 as against 1.21) and greater height/width ratio (mean 0.72 as against 0.55); the dorsal sulcus and ventral fold are more obvious; the pair of plates along the inner edges of the crura are reduced and not conjunct; and the inner hinge-plate is longer, so that the septalium is a more obvious feature.

See also under the discussion of the genus.

ADRENIA CERNUA sp. nov.

(Pl. 33, figs 1-17; Text–figs 44 and 45, 2a-d)

Derivation of name: Latin *cernuus,* turned towards the earth.

Type locality: The top of the '*Receptaculites*' Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18984; paratypes ANU 18985a-h and CPC 10626-8.

Occurrence: Several horizons in the top of the '*Receptaculites*' Limestone and in the Warroo Limestone, at localities A and Д.

Description

Exterior: Shells are small, elongate, and subequally biconvex. The largest specimen found is 5.9 mm long, 4.9 mm wide, and 2.7 mm high. The valves are plicate, and the subangular plicae are obvious close to the beaks. The median plica is present in the pedicle valve. The anterior commissure is usually rectimarginate and denticulate, but in some specimens it is gently sulcate, as a gentle sulcus is present in the dorsal valve. There are between 12 and 18 plicae at the margins of the brachial valve. The distance from the apex of the pedicle valve to the region where the plicae become obvious on the median portion of the brachial valve ranges between 0.7 and 1.3 mm (this measurement is represented by an asterisk in Text–fig. 44). The mean of the length/width ratios is 1.21; and of the height/width ratios, 0.55. The beak ridge is not very prominent, and is more obvious posteriorly than anterolaterally. The delthyrium is partly filled anterolaterally and laterally by a pair of deltidial plates, which may be conjunct anteriorly. The deltidial plates are produced dorsally into a deltidial sheath, which expands distally. The foramen is usually hypothyridid, but in rare specimens may be submesothyridid. The pedicle beak is not obviously incurved. The brachial valve has no interarea.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by dental plates. There is no median septum. The muscle scars are not obviously impressed.

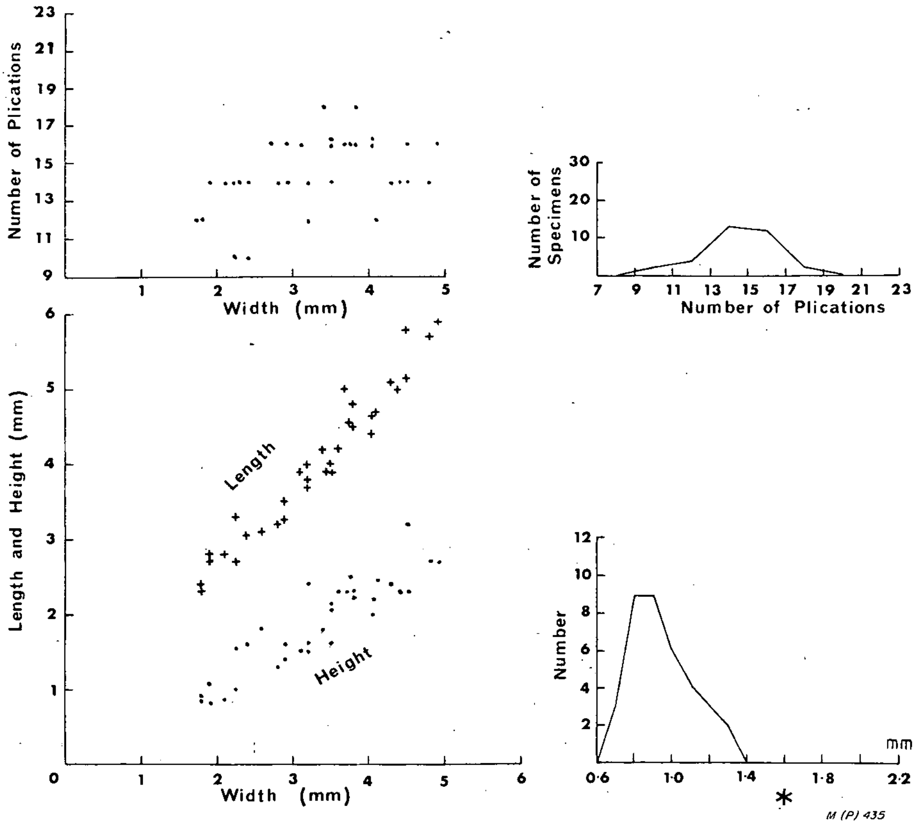


Fig. 44. *Adrenia cernua* **sp. nov. Specimens from the top of the** *'Receptaculites'* **Limestone.**

Brachial valve: The cardinal process is not obvious. A very short inner hinge-plate is depressed posteriorly and fused to a low median septum to form a low septalium, often so short as to be difficult to recognize. A pair of plates is present along the inner edge of the crura. In some specimens these plates are conjunct medially, but they are not joined to the median septum. The median septum extends forward between a third and half of the length of the valve. The brachidium consists of a centronelliform loop, which is convex anterodorsally in lateral view. The crural points are moderate in length, angular, and directed subventrally. The calcareous ribbon of the loop is broadest where the two halves join anteromedially along a suture line. There is no rod or vertical plate in the anteromedial portion of the loop. The loop extends forward slightly less than half the length of the brachial valve.

Discussion

See under the discussions of *Adrenia expansa* gen. et sp. nov. and the genus.

At least half a dozen specimens of *A. cernua* were found with the loop preserved intact. These loops do not show the wide range of variation found by Kozłowski (1929) in *Mutationella podolica* (Siemeradzki).

Genus CYDIMIA nov.

Type species: Cydimia robertsi sp. nov. from the Upper Emsian or possibly Lower Eifelian *'Receptaculites'* Limestone at Taemas, near Yass, New South Wales.

Derivation of name: Greek *kydimos,* glorious or renowned.

Diagnosis: Shells small, subcircular to elongate, and subequally biconvex to slightly ventribiconvex. Plicae subdued close to beaks, becoming strong only towards anterior and lateral margins. Gentle ventral fold and dorsal sulcus may or may not be obvious; anterior commissure may or may not be sulcate. Median plica in brachial valve. Short dental plates in pedicle valve. Inner hinge-plate depressed posteriorly and fused to low median septum to form a very short low septalium. Pair of plates along inner edges of crura for short distance in front of septalium may or may not be conjunct medially. Loop centronelliform, with ventrally directed vertical plate where two lateral bands join anteromedially (for terminology see Cloud, 1942). Foramen hypothyridid. Pair of deltidial plates, which may or may not be conjunct anteriorly, produced dorsally or posterodorsally to form deltidial sheath.

Discussion

Cydimia is included in the Rhipidothyridinae rather than the Globithyridinae because the shells are neither large nor entirely costate; they are plicate, and the plicae are subdued close to the beaks.

It differs from *Rhipidothyris* Cooper & Williams in that its foramen is hypothyridid; the deltidial plates are produced dorsally to form a deltidial sheath; and the anterior commissure tends to be sulcate rather than plicate. It is similar in that the plicae tend to be subdued close to the beaks (in the type species of *Rhipidothyris, R. plicata* Cooper & Williams, see Cloud, 1942, p. 88); the median plica is in the brachial valve; and the inner hinge-plate is depressed and fused to the median septum to form a septalium.

It differs from *Septothyris* Cooper & Williams in that it has plicae, a hypothyridid foramen, and a deltidial sheath.

See also under the discussion of *Adrenia* gen. nov.

Occurrence: The only species included in *Cydimia* at present are *C. robertsi* gen. et sp. nov. and *C. parva* sp. nov., which both occur in the Upper Emsian or possibly Lower Eifelian *'Receptaculites'* Limestone at Taemas, New South Wales.

CYDIMIA ROBERTSI gen. et sp. nov.

(Pl. 34, figs 25-37; Text–figs 45, 4a-d, and 46)

Derivation of name: After Dr J. Roberts.

Type locality: The base of the *'Receptaculites'* Limestone below Locality A, 3 km south of Hume Park, near Yass, New South Wales.

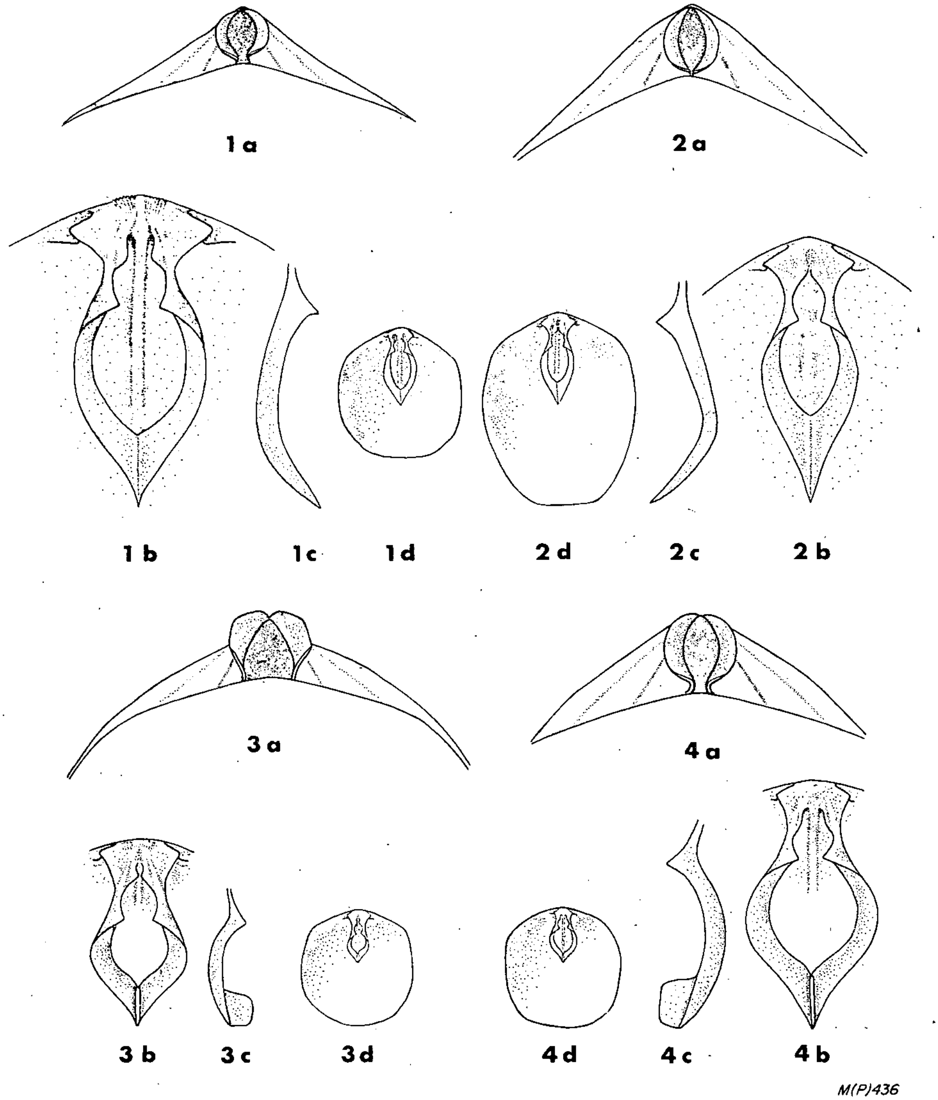


Fig. 45. 1, *Adrenia expansa* **gen. et sp. nov.**
2, *Adrenia cernua* **sp. nov.**
3, *Cydimia parva* **sp. nov.**
4, *Cydimia robertsi* **gen. et. sp. nov.**
a = dorsal view of apex of pedicle valve; b = ventral view of brachidium; c = lateral view of brachidium; and d = ventral view of brachial valve.

Type material: Holotype ANU 18992; paratypes ANU 18993a-e and CPC 10629-31.

Occurrence: Common in the basal 60 m of the *'Receptaculites'* Limestone, at localities B and Γ and below Locality A.

Description

Exterior: Shells are small, subcircular, and subequally biconvex to ventribiconvex. The largest specimen found is 6.0 mm long, 6.0 mm wide, and 3.8 mm high. A gentle ventral fold and dorsal sulcus are present anteriorly. Plicae are subdued near the beaks and obvious anteriorly and anterolaterally. There are between 7 and 13 subrounded plicae in a mature brachial valve. The median plica is in the brachial valve. The distance from the apex of the pedicle valve to the region of the brachial valve where the plicae are strong ranges between 1.3 and 2.5 mm. The mean of the length/width ratios is 1.04, and of the height/width ratios 0.71. The delthyrium is partly filled anterolaterally by deltidial plates, which are occasionally conjunct anteromedially. The deltidial plates are produced dorsally into a tubelike deltidial sheath, which expands distally. The pedicle beak is moderately incurved. The brachial valve has no interarea.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by a pair of dental plates. There is no median septum. The muscle scars are not obviously impressed.

Brachial valve: The inner hinge-plate is depressed medially so that it joins a low median septum and forms a short septalium. The brachidium consists of a centronelliform loop, which has a vertical plate anteromedially. It extends forward less than half the length of the brachial valve. The loop is convex dorsally in profile.

Discussion

Cydimia robertsi differs from *C. parva* sp. nov., the other species of the genus, in that it has a greater height/width ratio (0.71 as against 0.41); a slightly lower length/width ratio (1.04 as against 1.15); a smaller number

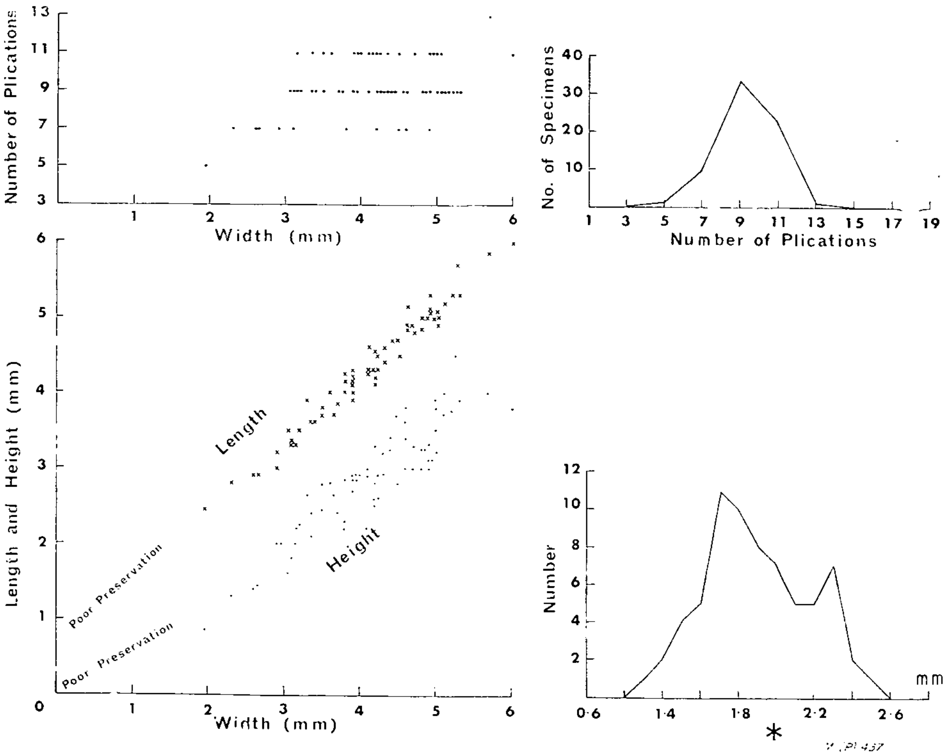


Fig. 46. *Cydimia robertsi* gen. et sp. nov. Specimens from the base of the '*Receptaculites*' Limestone.

of plicae in mature specimens (5-11 as against 9-21, see Text–figs 46 and 47); the fold and sulcus are slightly more obvious; the deltidial plates are closer to each other anteromedially; and the deltidial sheath is tube-like.

See also under the discussion of the genus.

CYDIMIA PARVA sp. nov.

(Pl. 34, figs 13-24; Text–figs 45, 3a-d, and 47).

Derivation of name: Latin *parvus,* small.

Type locality: The basal 60 m of the *'Receptaculites'* Limestone at Locality Γ, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18990; paratypes ANU 18991a-f and CPC 10632-4.

Occurrence: Occasional to common in the basal 60 m of the *'Receptaculites'* Limestone at localities B and Γ.

Description

Exterior: Shells are small, subcircular to slightly elongate oval, shallow, and subequally biconvex. A very gentle ventral fold and dorsal sulcus may be present anteriorly. Plicae are subdued near the beaks, but are obvious anteriorly and anterolaterally. There are between 9 and 21 subround plicae at the margins of mature brachial valves (Text–fig. 47). The distance from the apex of the pedicle valve to the region of the brachial valve where the plicae may be considered to be obvious ranges between 1.7 and 3.7 mm (Text–fig. 47). The mean of the length/width ratios is 1.15, and of the height/width ratios 0.41. The delthyrium is partly filled anterolaterally by deltidial plates which are not conjunct medially. The deltidial plates are produced into a deltidial sheath, which does not resemble a tube, but looks more like a pair of flaps bent outwards and backwards (Pl. 34, figs 15, 16, 19, and 21-23). The pedicle beak is not incurved. The brachial valve has no interarea.

Interior. Pedicle valve: No well preserved pedicle interiors were found. The teeth are supported by a pair of dental plates.

Brachial valve: The inner hinge-plate is slightly depressed posteromedially, but does not form a very obvious septalium in the only reasonably preserved specimen found (Pl. 34, fig. 24). A pair of plates along the inner edges of the crura is almost conjunct medially. The brachidium consists of a centronelliform loop, which has a vertical plate anteromedially. It extends forward about half the length of the valve. A low median septum is present in the posterior half of the valve. The crural points are moderate in length and angular. The cardinal process consists of fine lamellae arranged longitudinally on the posterior portions of the cardinalia.

Discussion

See under the discussion of the genus and of *Cydimia robertsi* gen. et sp. nov.

Family MUTATIONELLIDAE Cloud, 1942

Subfamily MUTATIONELLINAE Cloud, 1942

Genus MICIDUS nov.

Type species: Micidus shandkyddi sp. nov. from the upper Emsian or possibly lower Eifelian *'Receptaculites'* Limestone at Taemas, New South Wales.

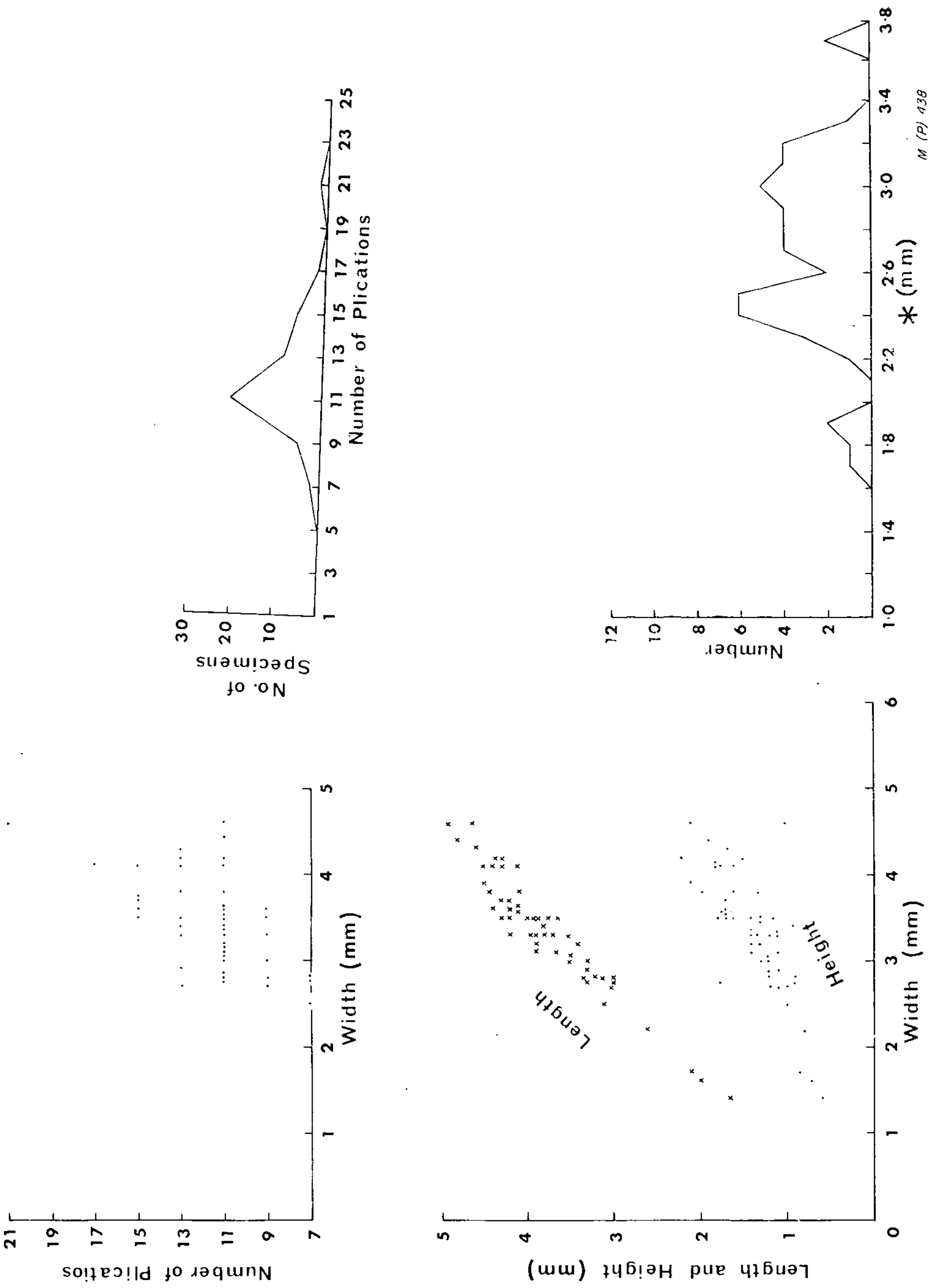


Fig. 47. *Cydimia parva* sp. nov. Specimens from the lower half of the '*Receptaculites*' Limestone.

Derivation of name: Latin *micidus,* thin, poor, or lean.

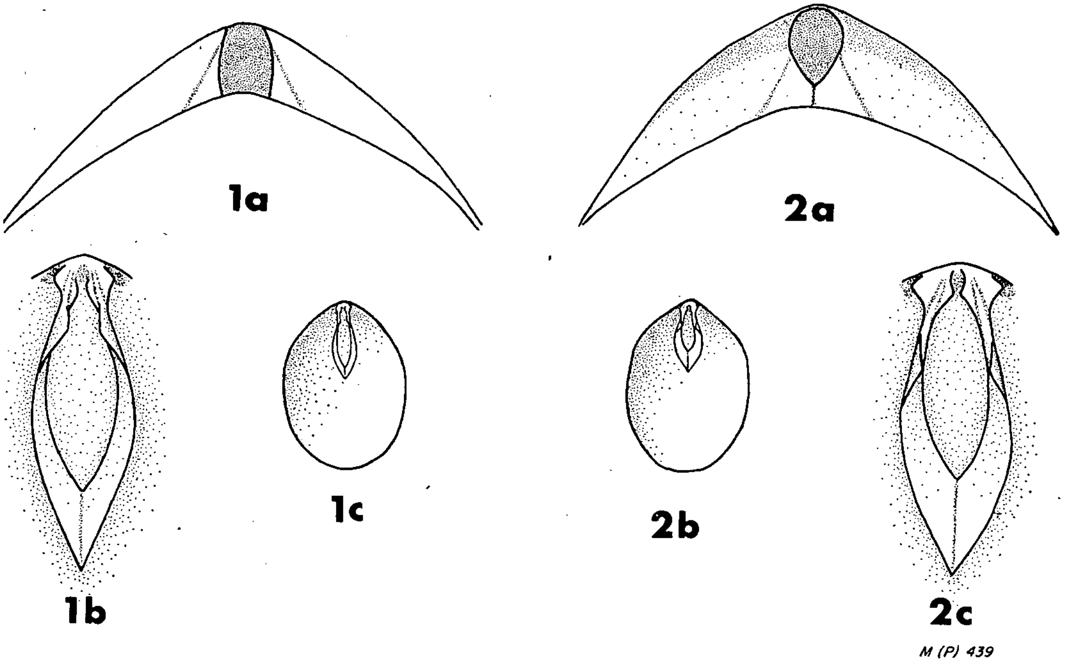
Diagnosis: Shells small, tending to be elongate oval, and subequally biconvex to slightly ventribiconvex. Dorsal sulcus and ventral fold weak or absent. Smooth close to beaks; may be gently plicate distally. Short dental plates in pedicle valve. No median septa in either valve, but weak myophragms in some. Crural bases discrete, or appear so because of short inner hinge-plate depressed and fused to floor of valve. Pair of plates along inner edges of posterior portions of crura; some conjunct or fused medially to form free plate, perforate apically. Brachidium a centronelliform loop, with no vertical plate or rod anteriorly. Deltidial plates not produced dorsally to deltidial sheath. Foramen usually submesothyridid or mesothyridid; rarely almost hypothyridid.

Discussion

Micidus gen. nov. includes two species that are obviously distinct. *M.? glaber* sp. nov. is provisionally included in *Micidus* because it has a similar interior (cardinalia, loop, and dental plates) to *M. shandkyddi.* It differs significantly in having a smooth, non-plicate shell.

In having its ornament only developed marginally — or not at all, if *M.? glaber* truly belongs in the genus — *Micidus* is unlike most mutationellids. It resembles *Mutationella* Kozłowski in having plates along the edges of the crural bases, which are discrete or 'united to form perforate cardinal plate' (Stehli, *in* Moore, 1965 p. H750). But the loop, in lacking a rod or plate anteriorly, is more like that of *Paranaia* Clarke. *Podolella* Kozłowski has similarly restricted ornament, but has a vertical plate anteriorly between the two lateral blades of the loop.

Occurrence: The only known species of *Micidus* occur in the upper Emsian or possibly lower Eifelian *'Receptaculites'* and Warroo Limestones.



1a and 2a, dorsal view of apex of pedicle valve; 1b and 2c, ventral view of brachidium; and 1c and 2b, ventral view of brachial valve.

Fig. 48. 1, *Micidus shandkyddi* gen. et sp. nov.
2, *Micidus? glaber* sp. nov.

MICIDUS SHANDKYDDI gen. et sp. nov.

(Pl. 34, figs 1-12; and Text–figs 48, 1a-c and 49)

Derivation of name: After Peter Shandkydd, owner of Bloomfield Property.

Type locality: The basal 60 m of the '*Receptaculites*' Limestone at Locality Г, Bloomfield Property, parish of Warroo, near Yass, New South Wales.

Type material: Holotype ANU 18988; paratypes ANU 18989a-g and CPC 10635-6.

Occurrence: Several horizons in the '*Receptaculites*' and Warroo Limestones, at localities A, B, Г, and Д.

Description

Exterior: Shells are small, elongate, and subequally biconvex to slightly ventribiconvex. The largest specimen found is 4.3 mm long, 3.8 mm wide, and 1.9 mm high. The valves are plicate, but the subrounded plicae are only present towards the anterior and anterolateral margins. The central plica is in the brachial valve. A very gentle dorsal sulcus and ventral fold are present anteriorly in some

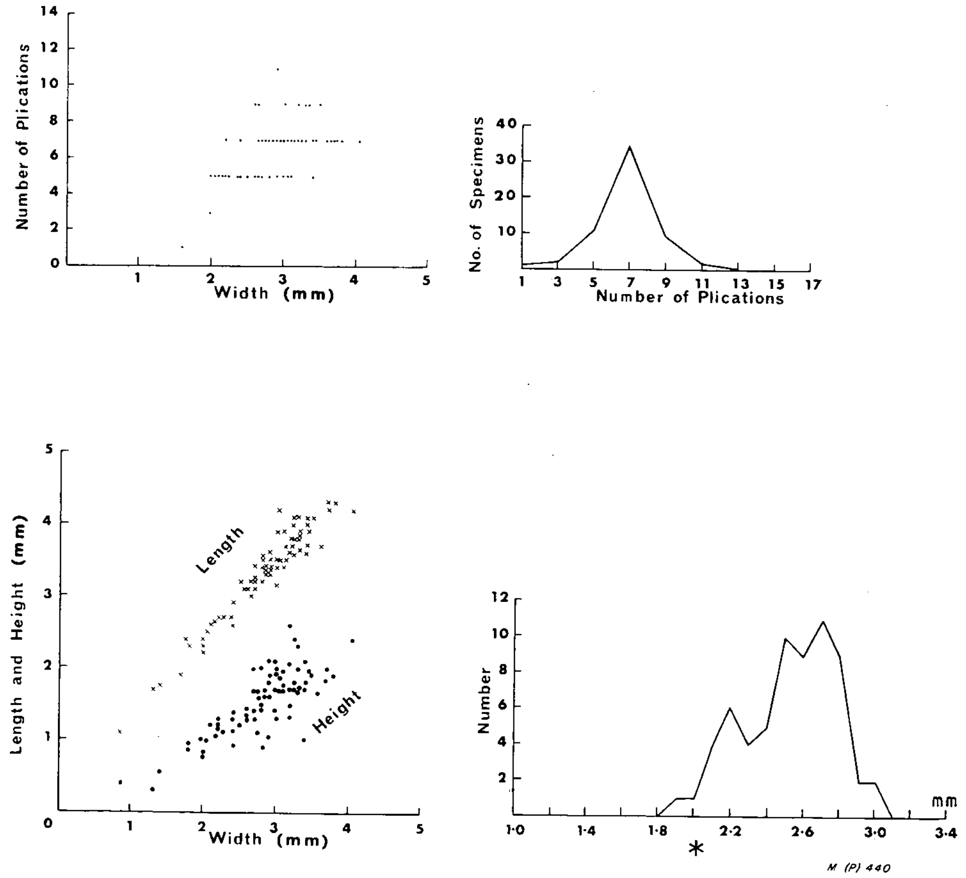


Fig. 49. ***Micidus shandkyddi*** **gen. et sp. nov. Specimens from '*Receptaculites*' Limestone.**

specimens. The anterior commissure is denticulate and weakly sulcate to rectimarginate. There are between 5 and 11 plicae at the margins of the brachial valve. The distance from the apex of the beak of the pedicle valve to the region where the plicae become obvious on the medial portion of the brachial valve ranges between 1.9 and 3.0 mm (represented by an asterisk in Text–fig. 49). The mean of the length/width ratios is 1.24; and of the height/width ratios 0.57. The sub-mesothyridid (? to hypothyridid) foramen is partly filled anterolaterally and laterally by a pair of thin deltidial plates. The deltidial plates are not conjunct, and are not produced dorsally to form a deltidial sheath.

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by dental plates, which extend some distance in front of the teeth as a pair of low muscle-bounding ridges (Pl. 34, fig. 8). A low myophragm is visible in some specimens between a pair of very gently impressed muscle scars.

Brachial valve: The hinge-plates (crural bases) are discrete. A weak myophragm may be present in some specimens. The brachidium consists of a centronelliform loop, which extends forward slightly less than half the length of the valve. The loop is gently convex dorsally in profile, and does not have a rod or a vertical plate anteromedially. The crural points are short and obtuse-angled.

Discussion

M. shandkyddi differs from *M.? glaber* sp. nov. in having plicae anterolaterally; a sub-mesothyridid (? to hypothyridid) foramen; no raised pedicle callist in the apex of the pedicle valve; and, in some specimens, a weak dorsal sulcus and ventral fold, and a sulcate anterior commissure. Both species have a similar loop; similar cardinalia; a foramen that is usually not hypothyridid; and umbonal regions that are devoid of radial ornament.

See also under the discussion of the genus.

MICIDUS? GLABER sp. nov.

(Pl. 30, figs 1-15; Text–figs 48, 2a-c, and 50)

Derivation of name: Latin *glaber,* smooth.

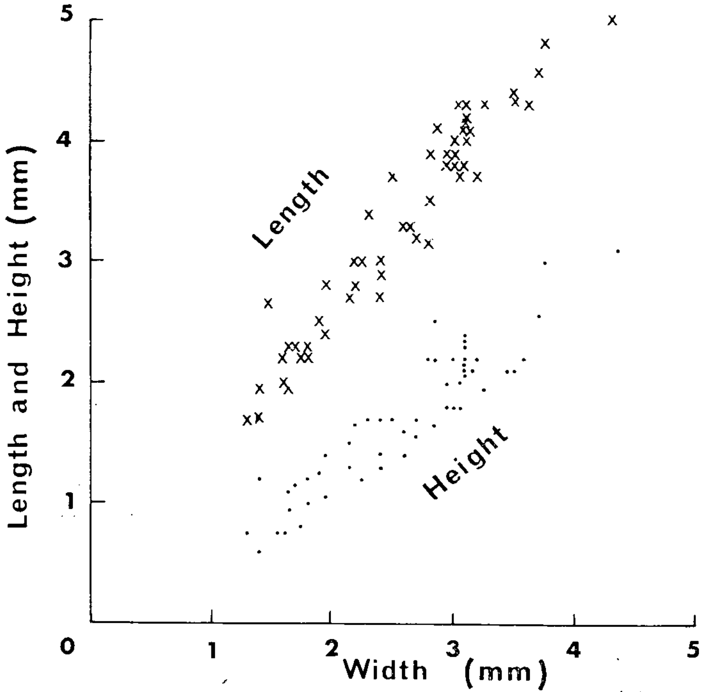
Type locality: The top of the '*Receptaculites*' Limestone at Locality A, 3 km south of Hume Park, near Yass, New South Wales.

Type material: Holotype ANU 18976; paratypes ANU 18975a-e and CPC 10637-40.

Occurrence: The top of the '*Receptaculites*' Limestone at localities A and Д.

Description

Exterior: Shells are small, elongate, and subequally biconvex to slightly ventribiconvex. The largest specimen found is 5.1 mm long, 4.3 mm wide, and 3.1 mm high. The valves are smooth; there are no plications. Occasional irregularly spaced concentric growth-lines are visible in some specimens. The delthyrium is partly filled posterolaterally by a pair of deltidial plates, which may be conjunct anteriorly and are not produced dorsally to form a deltidial sheath. The foramen is mesothyridid. The pericle beak is moderately incurved. The anterior commissure is rectimarginate. The mean of the length/width ratios is 1.30, and of the height/width ratios 0.64.



M (P) 441

Fig. 50. *Micidus? glaber* **sp. nov. Specimens from the top of the *'Receptaculites'* Limestone.**

Interior. Pedicle valve: A pair of moderate-sized teeth is supported by short dental plates. There is no median septum, but a very weak myophragm may be present in some specimens. The muscle scars are not obviously impressed. The apex of the pedicle valve has a small pedicle callist, which is raised some distance above the floor of the valve.

Brachial valve: The hinge-plates are either discrete or a 'cardinal plate'* is present with an apical perforation, the appearance perhaps depending on preservation. There is no median septum, but a very weak myophragm is visible in some specimens between a pair of weakly impressed adductor scars. The brachidium consists of a centronelliform loop, which usually extends forward less than half the length of the valve. It is gently convex dorsally in profile. The crural points are short and obtuse-angled. There is no rod or vertical plate in the anteromedial portion of the loop. The lateral blades join anteromedially along a suture-line.

Discussion

M.? glaber is superficially similar to the rhipidothyridid *Septothyris septata* Cooper & Williams, but is rather more elongate, and has no median septum fused to a depressed inner hinge-plate (cardinal plate) to form a septalium.

See also under the discussion of *Micidus shandkyddi* gen. et sp. nov. and of the genus.

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* The 'cardinal plate' was seen in two specimens. It is apparently a result of the fusion medially of the two plates that extend inwards from the inner faces of the posterior portions of the crura.

LOCALITY DESCRIPTIONS

LOCALITY A: The top of the *'Receptaculites'* Limestone and the base of the Warroo Limestone on the west side of a broad spur on the eastern bank of the small creek that flows south into the north bank of the Warroo Creek inlet of Burrinjuck Reservoir. The locality is about two-thirds of the distance from the highwater mark of the dam to the source of the creek (which is usually dry), about 3 km south of Hume Park, near Yass, New South Wales (Goulburn 1 : 250 000 Sheet, grid reference 182.682).

LOCALITY B: The basal half of the *'Receptaculites'* Limestone in the prominent outcrop of the northeastern tip of a syncline plunging gently south (farther south, the *'Receptaculites'* Limestone is only preserved in the eastern limb of this syncline; it is faulted out in the western limb), located about 400 m east-southeast of the homestead on Bloomfield Property, Parish of Warroo, near Yass, New South Wales (see Text-fig. 1).

LOCALITY Д: The top of the *'Receptaculites'* Limestone and the base of the Warroo Limestone on the east side of a deeply notched dry creek bed (the creek would flow northwest into Burrinjuck reservoir), about 1200 m south of Hume Park, near Yass, New South Wales (Goulburn 1 : 250 000 Sheet).

LOCALITY Г: The prominent outcrop of the basal half of the *'Receptaculites'* Limestone at the brow and north slope of a low hill, about 400 m south of Locality B, Bloomfield Property, Parish of Warroo, near Yass, New South Wales (Canberra 1 : 250 000 Sheet).

LOCALITY C: The *'Spirifer yassensis'* Limestone at and below the historic locality known as Shearsby's Wallpaper (both topographically and stratigraphically), portion 65, Parish of Taemas, County Cowley, New South Wales (148°49′23″E, 35°2′19″S, on Canberra 1 : 250 000 Sheet).

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PLATE 1

Figures 1-7—*Craniops australis* sp. nov. 1, Interior of pedicle valve ANU 17871z x8. 2, Interior of pedicle valve CPC 10500 x8. 3, Interior of **holotype** brachial valve ANU 17870 x8. 4, Interior of brachial valve CPC 10501 x8. 5, Exterior of brachial valve CPC 10502 x8. 6, Interior of pedicle valve ANU 17871b x8. 7, Lateral view of ANU 17871c x8.

Figures 8-22—*Isorthis spedeni* sp. nov. 8, Interior of brachial valve ANU 17873a x1.6. 9, Interior of brachial valve CPC 10503 x2. 10, Interior of brachial valve CPC 10504 x2. 11, Interior of pedicle valve CPC 10505 x1.6. 12, Interior of brachial valve ANU 17873b x2.5. 13, Interior of brachial valve ANU 17873c x2. 14, Anterior view of brachial valve CPC 10503 x1.5. 15, 17 and 18, Anterior, lateral, and posterior views of **holotype** ANU 17872 x1.5. 16, Interior of pedicle valve ANU 17873d x1.6. 19, Exterior of brachial valve CPC 10503 x1.5. 20, Interior of pedicle valve ANU 17873e x1.6. 21, Interior of pedicle valve CPC 10506 x1.8. 22, Interior of brachial valve ANU 17873f x2.5.


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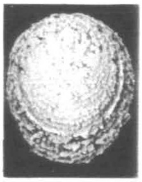
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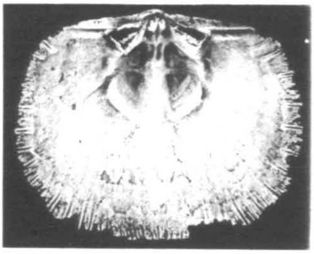
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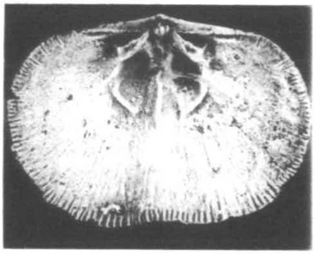
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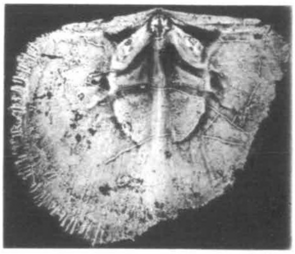
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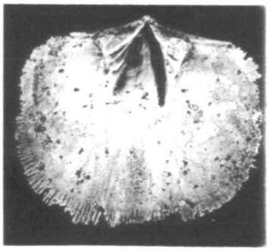
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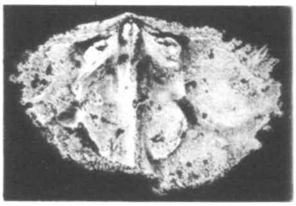
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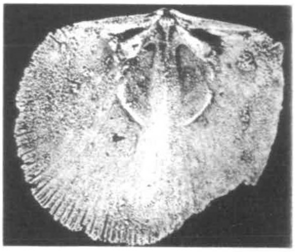
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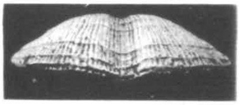
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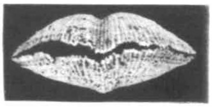
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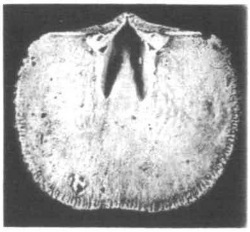
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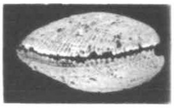
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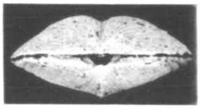
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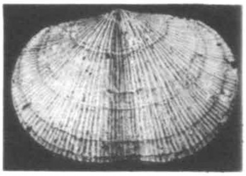
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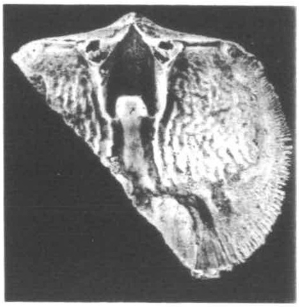
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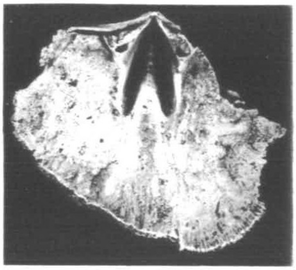
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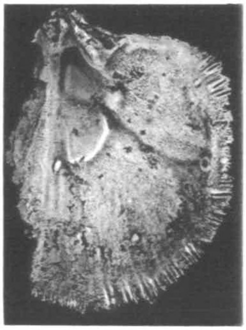
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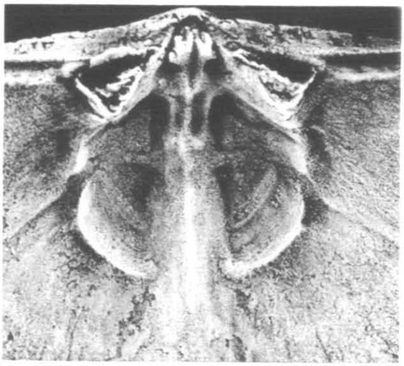
PLATE 2

Figures 1-14—*Isorthis spedeni* sp. nov. 1, Interior of portion of brachial valve ANU 17873a x4.6. 2, Exterior of pedicle valve ANU 17873d x1.6. 3, Dorsal view of ANU 17873g x3. 4, 5, and 8, Lateral, dorsal, and posterior views of ANU 17873h x7. 6, Interior of pedicle valve ANU 17873i x3.75. 7, Interior of pedicle valve CPC 10507 x1.5. 9, Posterior view of ANU 17873g x2. 10, Interior of pedicle valve ANU 17873j x4. 11, Interior of brachial valve x6. 12, Interior of pedicle valve ANU 17873k x8. 13, Interior of pedicle valve ANU 17873l x4. Interior of brachial valve ANU 17873m x8.

Figures 15-31—*Salopina kemezysi* gen. et sp. nov. 15, Interior of brachial valve ANU 17875a x8. 16, Interior of pedicle valve ANU 17875b x8.75. 17, Interior of pedicle valve CPC 10512 x6. 18, Interior of pedicle valve ANU 17875c x4.5. 19, Interior of brachial valve CPC 10513 x6. 20, Interior of brachial valve ANU 17875d x6. 21, Interior of brachial valve CPC 10514 x9. 22, Interior of pedicle valve ANU 17875e x6. 23, Dorsal view of specimen x9. 24, Dorsal view of CPC 10515 x5.25. 25, Exterior of brachial valve ANU 17875d x5.25. 26 and 31, Interior and posteroventral views of brachial valve ANU 17875f x8. 27, Posterior view of CPC 10516 x5.5. 28, Posterior view of **holotype** ANU 17874 x3.7. 29, Anterior view of ANU 17875g x4.75. 30, Lateral view of ANU 17875h x4.2.



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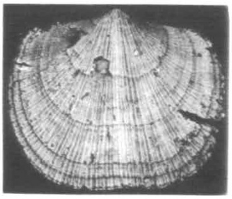

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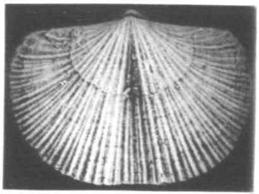

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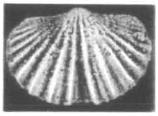

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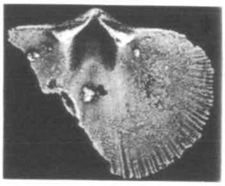

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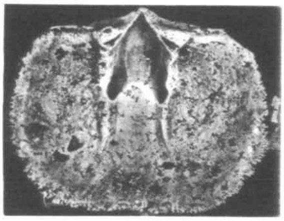

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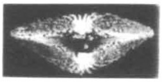

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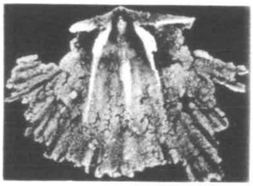

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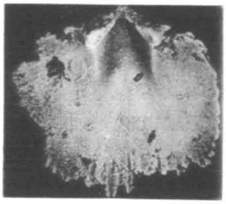

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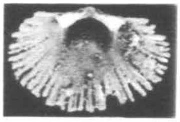

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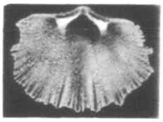

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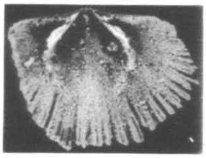

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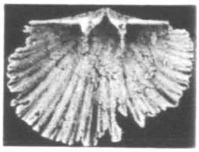

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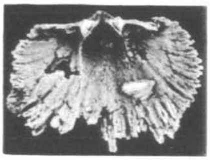

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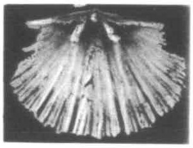

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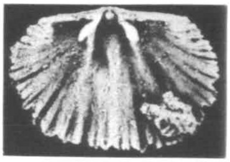

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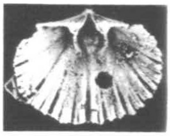

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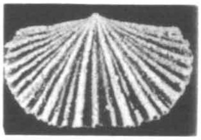

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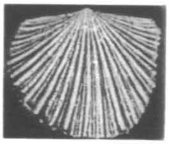

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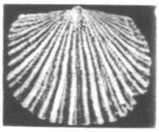

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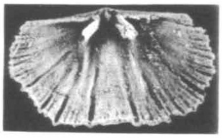

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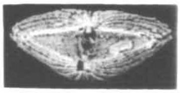

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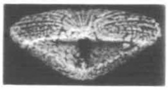

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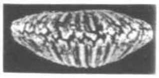

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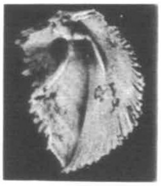
PLATE 3

Figures 1-9 and 11-15—*Muriferella hillae* sp. nov. 1 and 2, Ventrolateral and interior view of **holotype** brachial valve ANU 17876 x4.5. 3, Interior of pedicle valve CPC 10517 x5. 4, Lateral view of brachial valve CPC 10518 x5. 5, Lateral view of brachial valve ANU 17877a x4.75. 6, Interior of portion of brachial valve ANU 17877b x10. 7, Ventrolateral view of brachial valve CPC 10518 x5. 8, Interior of pedicle valve ANU 17877c x5. 9, Interior of portion of **holotype** ANU 17876 x9. 11, Anterior view of ANU 17877d x4.8. 12, Lateral view of CPC 10519 x6.6. 13, Dorsal view of specimen x5. 14, Ventral view of pedicle valve CPC 10517 x3.4. 15, Lateral view of ANU 17877d x5.8.

Figures 10 and 16-27—*Resserella careyi* sp. nov. 10, Anterior view of **holotype** ANU 17878 x1.3. 16, Exterior of brachial valve ANU 17879a x2.5. 17, Interior of brachial valve ANU 17879a x2.5. 18, Lateral view of **holotype** ANU 17878 x1.4. 19, Lateral view of brachial valve ANU 17879b x1.4. 20, Exterior of pedicle valve **holotype** ANU 17878 x1.3. 21, Interior of pedicle valve CPC 10508 x1.6. 22, Interior of brachial valve CPC 10509 x1.8. 23, Interior of brachial valve CPC 10510 x1.7. 24, Exterior of brachial valve ANU 17879b x2. 25, Interior of **holotype** pedicle valve ANU 17878 x2.5. 26, Interior of brachial valve ANU 17879b x2.5. 27, Interior of pedicle valve CPC 10511 x2.5.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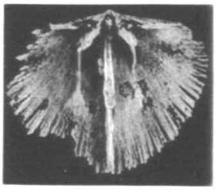
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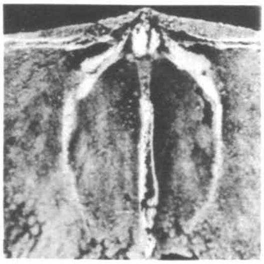
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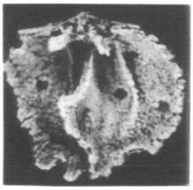
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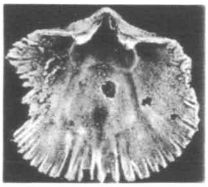
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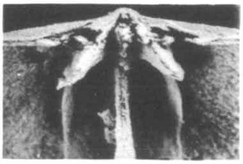
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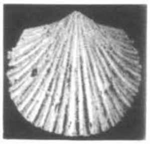
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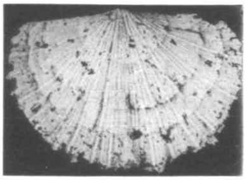
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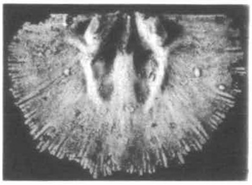
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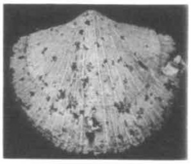
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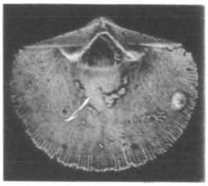
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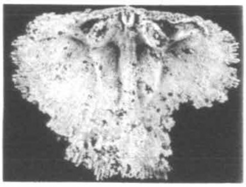
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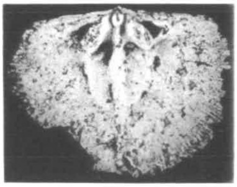
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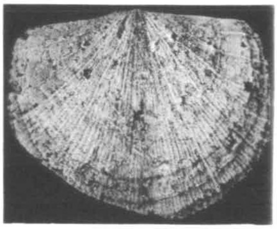
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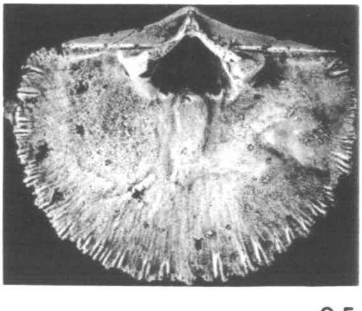
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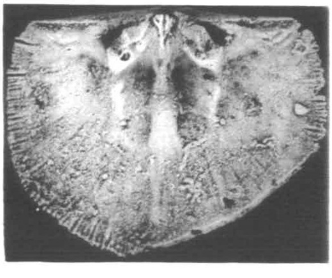
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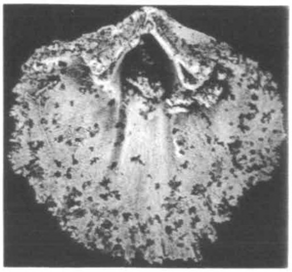
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PLATE 4

Figures 1-12—*Aulacella stoermeri* sp. nov. 1, Lateral view of ANU 18912h x3.5. 2, 3, Lateral and dorsal views of **holotype** ANU 17880 x1.4. 4, Interior of brachial valve CPC 10532 x2.3. 5, Exterior of pedicle valve CPC 10524 x2.2. 6, 7, Anterior and posterior views of **holotype** ANU 17880; 6, x1.3; 7, x1.5. 8, Anteroventral view of CPC 10525 x2.1. 9, Interior of pedicle valve ANU 18912a x3. 10, Interior of brachial valve ANU 18912b x3. 11, Interior of pedicle valve ANU 18912c x3. 12, Interior of pedicle valve CPC 10526 x3.

Figures 13-20—*Aulacella philipi* sp. nov. 13, Interior of pedicle valve ANU 18914a x2.4. 14, Interior of pedicle valve ANU 18914b x2.4. 15, Interior of pedicle valve CPC 10520 x1.4. 16 and 17, Lateral and anterior views of **holotype** ANU 18913 x1.4. 18, Interior of pedicle valve CPC 10521 x2.4. 19, Interior of brachial valve ANU 18914c x2.4. 20, Interior of brachial valve CPC 10522 x2.4.


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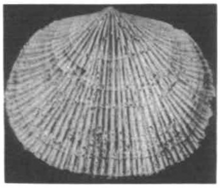
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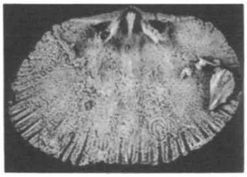
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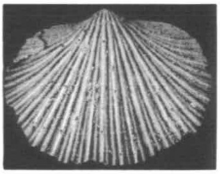
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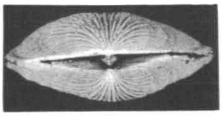
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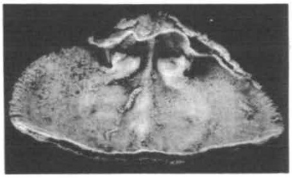
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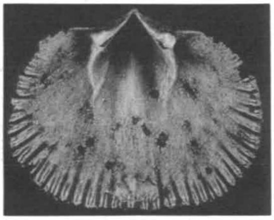
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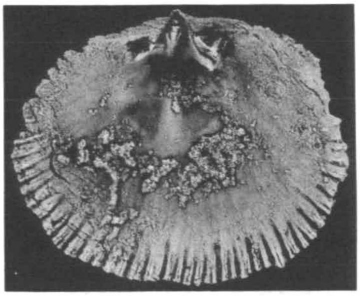
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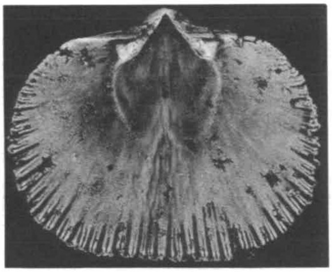
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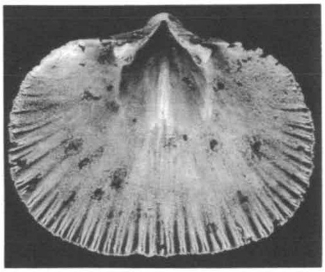
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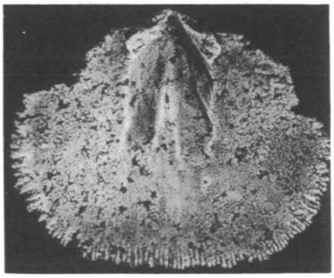
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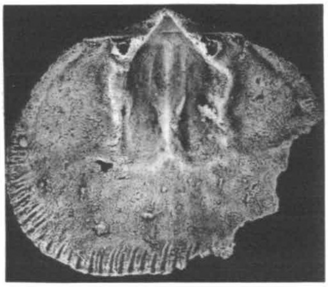
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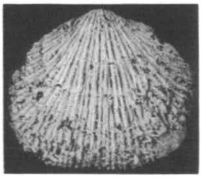
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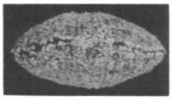
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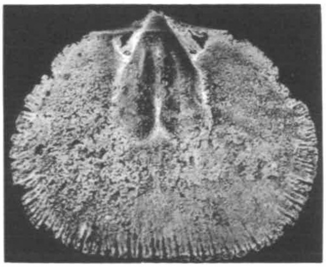
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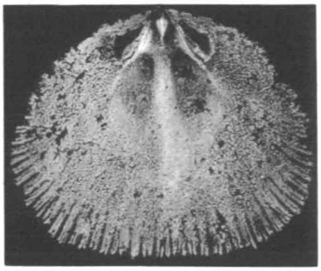
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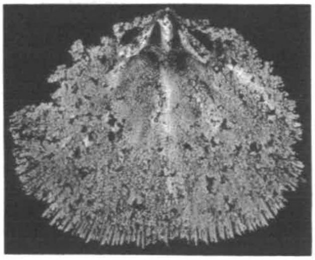
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PLATE 5

Figures 1-8—*Aulacella stoermeri* sp. nov. 1, Interior of brachial valve ANU 18912d x2. 2, 3 and 4, Dorsal, lateral, and posterior views of ANU 18912e x5.75. 5, Anterior view of ANU 18912f x2.8. 6, Interior of pedicle valve ANU 18912g x3.7. 7, Interior of pedicle valve CPC 10524 x2.4. 8, Dorsolateral view of portion of pedicle valve x4 (note pedicle callist).

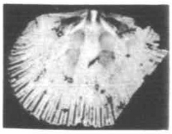
Figures 9-15—*Aulacella philipi* sp. nov. 9, Posterior view of ANU 18914d x10.5. 10, Dorsal view of ANU 18914d x8.5. 11, Interior of pedicle valve ANU 18914e x5.6. 12, Interior of brachial valve ANU 18914f x8.2. 13, Interior of pedicle valve ANU 18914g x11.4. 14, Interior of pedicle valve ANU 18914h x10.5. 15, Interior of pedicle valve ANU 18914i x3.6.

Figures 16-24—*Isorthis spedeni* sp. nov. 16, Interior of brachial valve ANU 17873n x3.4. 17, Interior of brachial valve ANU 17873o x2.3. 18, Interior of portion of pedicle valve CPC 10507 x3.5. 19, Interior of brachial valve ANU 17873p x8.2. 20, Interior of pedicle valve ANU 17873q x8.2. 21, Interior of brachial valve ANU 17873r x5. 22, Interior of brachial valve ANU 17873s x8. 23, Dorsal view of ANU 17873t x7.5. 24, Interior of pedicle valve ANU 17873u x7.5.

Figure 25—*Coelospira dayi* sp. nov. Interior of ANU 18955k x4.

Figures 26-30—*Craniops australis* sp. nov. 26, Exterior of brachial valve ANU 17871d x12. 27, Exterior of pedicle valve ANU 17871e x12. 28, Exterior of pedicle valve ANU 17871f x12. 29, Exterior of brachial valve ANU 17871g x16.5. 30, Interior of brachial valve ANU 17871h x9.4 (without ammonium chloride).

Figures 31-33—*Cymostrophia dickinsi* sp. nov. 31, Interior of brachial valve ANU 18915d x2.2. 32, Interior of portion of pedicle valve x2. 33, Interior of portion of pedicle valve ANU 18915e x3.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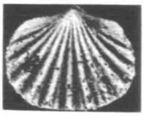
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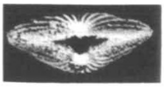
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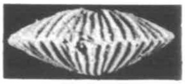
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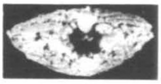
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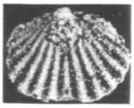
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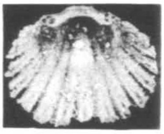
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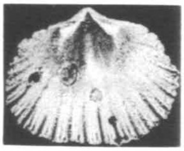
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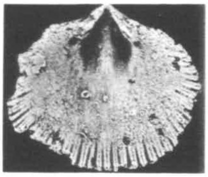
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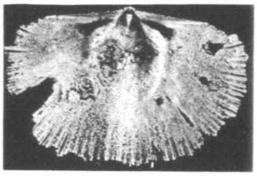
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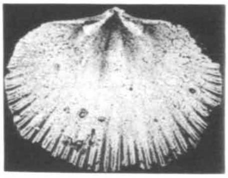
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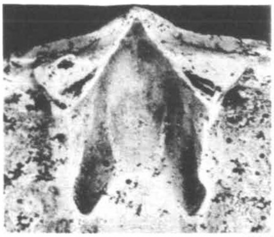
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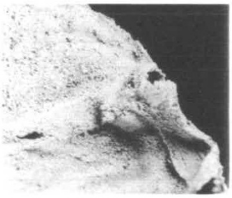
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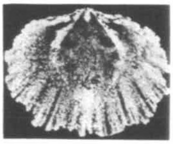
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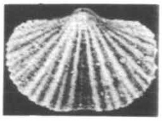
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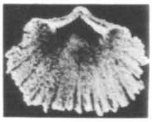
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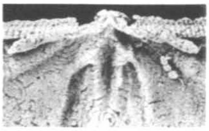
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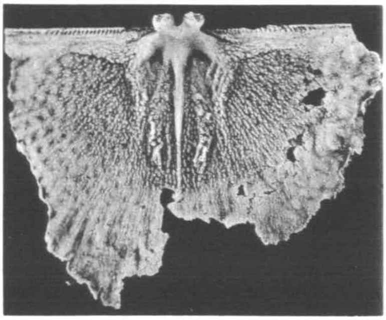
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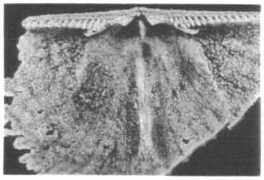
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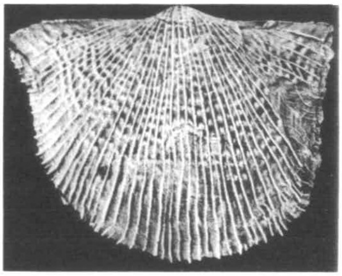
PLATE 6

Figures 1-9—*Cymostrophia dickinsi* sp. nov. 1, Ventral view of **holotype** ANU 18917 x1.2. 2 and 3, Ventrolateral views of **holotype** x1.2. 4, and 7, Anteroventral and ventral views of pedicle valve ANU 18915a x1. 5, Interior of brachial valve ANU 18915b x1.2. 6, Interior of brachial valve CPC 10527 x1.5. 8, Ventral view of CPC 10528 x1. 9, Posterior view of cardinalia of brachial valve ANU 18915b x3.8.

Figures 10-16—*Cymostrophia multicostella* sp. nov. 10, Lateral view of CPC 10529 x1.4. 11, Dorsal view of ANU 18918a x1.2. 12, Ventral view of ANU 18918a x1.45. 13, Ventral view of portion of ANU 18918a x6. 14, Ventral view of **holotype** ANU 18919 x1.3. 15, Ventral view of CPC 10529 x1.4. 16, Interior of pedicle valve CPC 10530 x1.4.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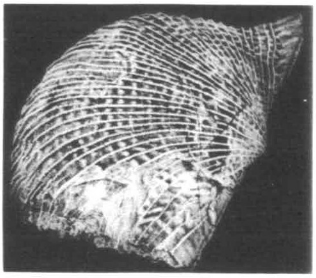
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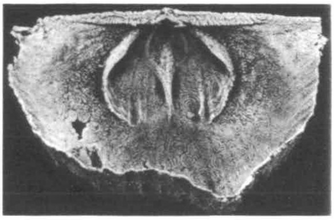
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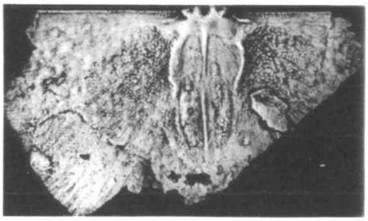
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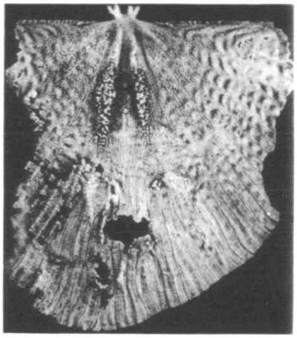
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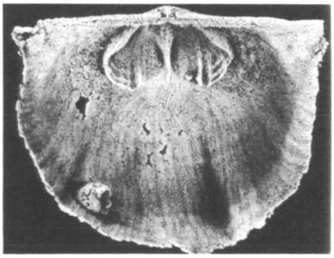
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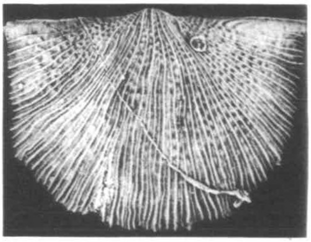
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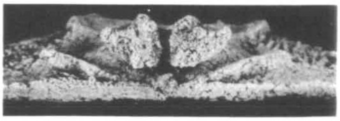
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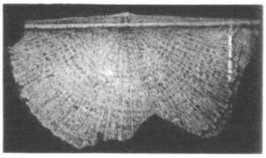
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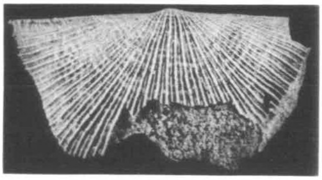
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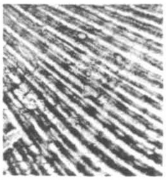
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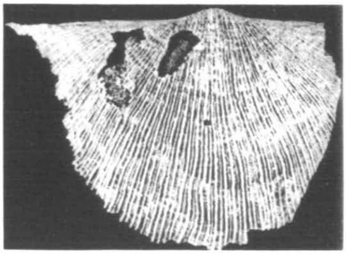
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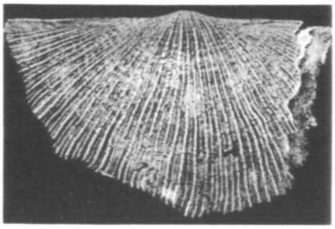
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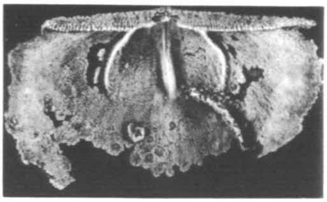
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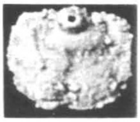
PLATE 7

Figures 1-16 and 18-23—*Cymostrophia dickinsi* sp. nov. (specimens from the top of the '*Receptaculites*' Limestone). 1, Stereo pair. Ventral view of ANU 18920a x27. 2, Dorsal view of ANU 18920b x27. 3, Dorsal view of ANU 18920c x8. 4, Dorsal view of specimen x8. 5, Interior of brachial valve ANU 18920d x8.5. 6, Dorsal view of specimen x6. 7, Interior of pedicle valve ANU 18920e x17. 8, Ventral view of ANU 18920f x10. 9, Interior of brachial valve ANU 18920g x9. 10, Interior of brachial valve ANU 18920m x2. 11, Interior of brachial valve ANU 18920h x1.25. 12, Lateral view of ANU 18920l x1.3. 13, Ventral view of ANU 18920i x16. 14, Ventral view of ANU 18920j x8. 15, Exterior of brachial valve x25. 16, Ventral view of ANU 18920l x 1.2. 18, Interior of pedicle valve ANU 18920n x1.3. 19, Interior of a portion of a pedicle valve x5. 20 and 21, Lateral and ventral views of ANU 18920o x1.4. 22, Dorsal view of ANU 18920o x1.2. 23, Interior of pedicle valve ANU 18920k x1.3.

Figure 17—*Cymostrophia dickinsi* sp. nov. (specimen from type locality). Ventral view of ANU 18915c x1.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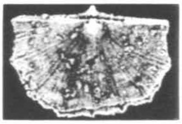
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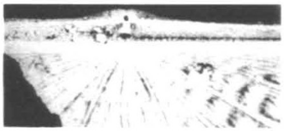
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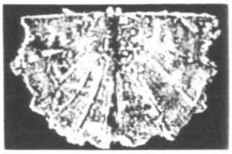
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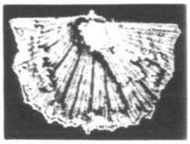
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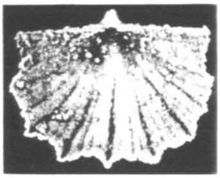
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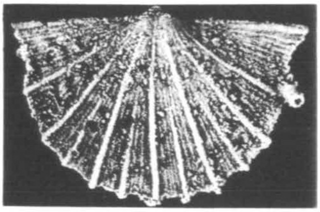
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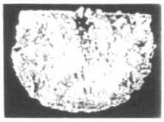
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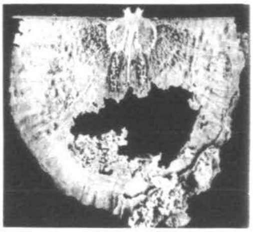
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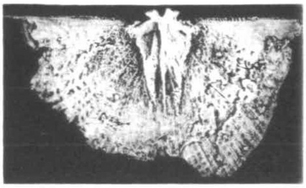
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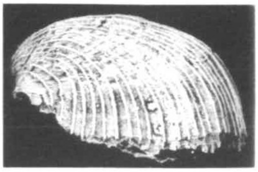
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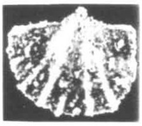
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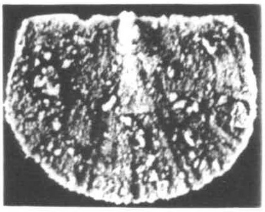
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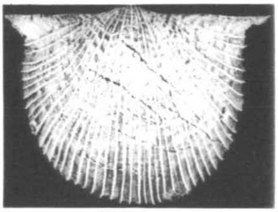
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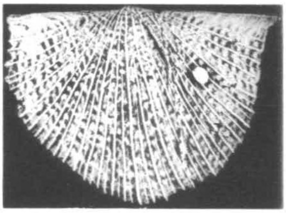
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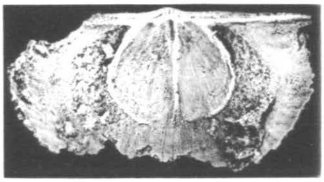
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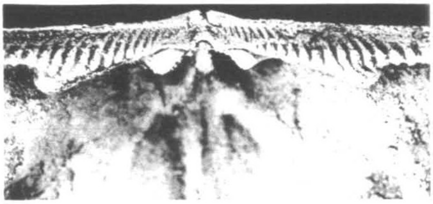
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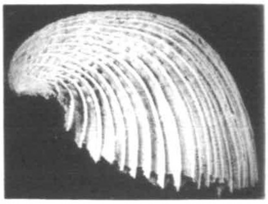
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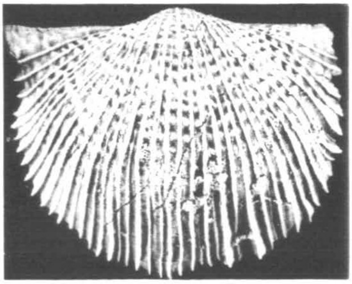
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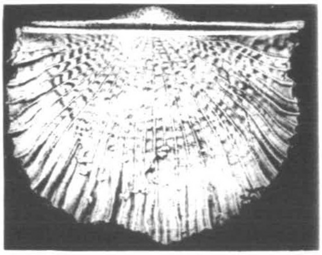
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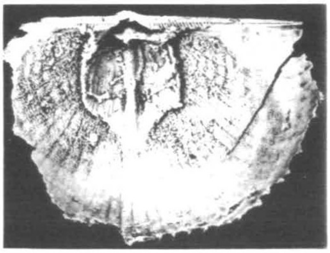
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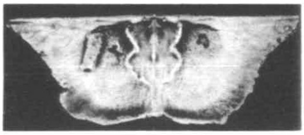
PLATE 8

Figures 1-19—*Taemostrophia patmorei* gen. et sp. nov. 1 and 2, Interior and exterior views of **holotype** ANU 18922 x1.25. 3, Posterodorsal view of portion of **holotype** ANU 18922 x4.5. 4, Ventral view of pedicle valve ANU 18923a x1.8. 5, Exterior of pedicle valve ANU 18923b x1.8. 6, Interior of pedicle valve CPC 10531 x1.7. 7, Interior of brachial valve ANU 18923c x3. 8, Interior of brachial valve ANU 18923d x2.6. 9, Interior of brachial valve ANU 18923e x2.5. 10, Interior of pedicle valve ANU 18923f x4.7. 11, Interior of pedicle valve ANU 18923g x2.9. 12, Interior of brachial valve CPC 10532 x2.5. 13, Interior of pedicle valve ANU 18923b x2.8. 14, Interior of pedicle valve ANU 18923a x2.5. 15, Interior of pedicle valve ANU 18923h x5. 16, Interior of brachial valve ANU 18923i x3.1. 17, Interior of **holotype** ANU 18922 x2.25. 18, Interior of pedicle valve ANU 18923j x2.5. 19, Interior of pedicle valve ANU 18923k x2.5.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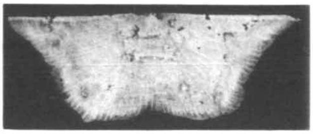
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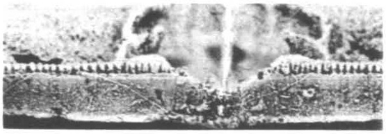
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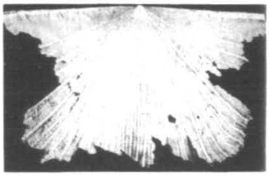
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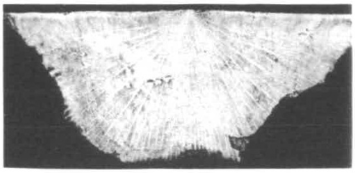
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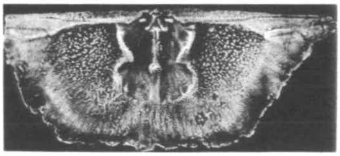
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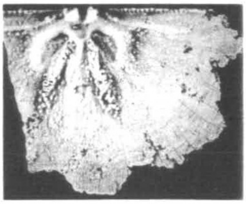
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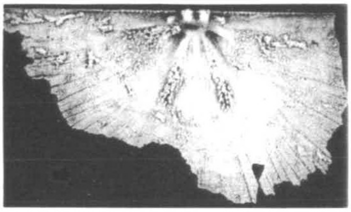
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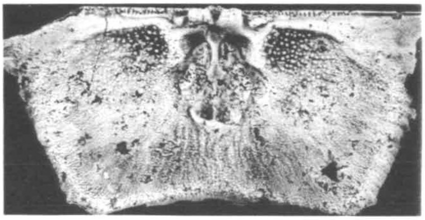
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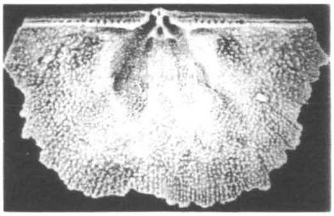
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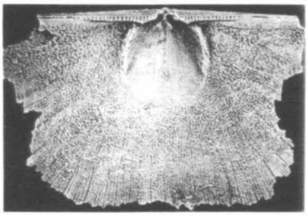
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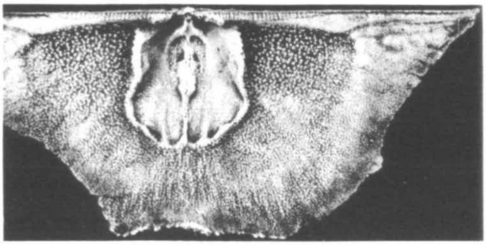
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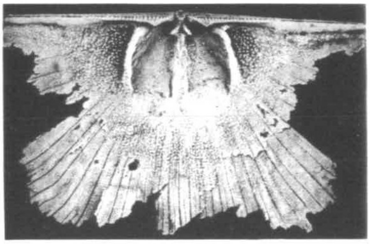
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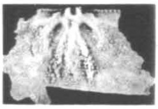
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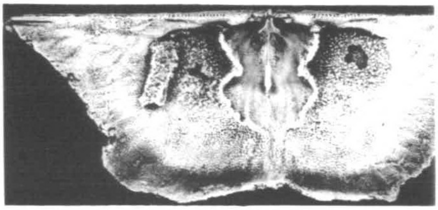
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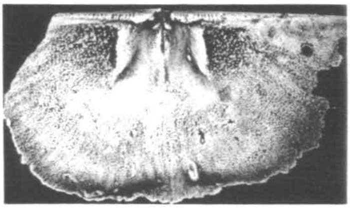
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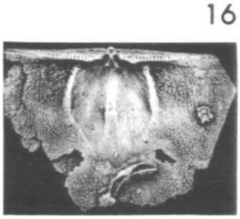
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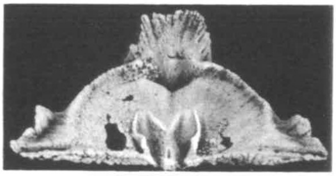
PLATE 9

Figures 1-10—*Malurostrophia flabellicauda reverta* subsp. nov. 1, Posterodorsal view of pedicle valve ANU 18925a x2.3. 2, Interior of brachial valve ANU 18925b x2.3. 3, Exterior of **holotype** ANU 18924 x2.3. 4, Dorsal view of CPC 10537 x2.3. 5, Interior of **holotype** ANU 18924 x2.3. 6, Interior of pedicle valve CPC 10538 x2.4. 7, Anterior view of pedicle valve ANU 18925c x1.8. 8, 9 and 10, Posterodorsal, dorsal, and ventral views of immature pedicle valve ANU 18925d x2.5.

Figures 11-22—*Malurostrophia flabellicauda* Campbell & Talent. 11, Dorsal view of pedicle valve ANU 18926a x3.4. 12, Interior of pedicle valve CPC 10533 x3. 13, Interior of pedicle valve ANU 18926b x3. 14, Interior of immature pedicle valve ANU 18926c x3. 15, Interior of pedicle valve CPC 10534 x2.5. 16, Posterodorsal view of pedicle valve ANU 18926b x2.4. 17, Lateral view of ANU 18926d x2.1. 18, Exterior of pedicle valve CPC 10535 x2.1. 19, Ventral view of ANU 18926d x2.3. 20, Interior of brachial valve ANU 18926e x5. 21, Dorsal view of CPC 10536 x2.4. 22, Interior of pedicle valve ANU 18926f x2.3.



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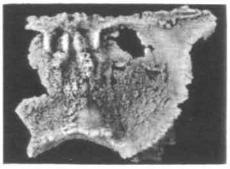

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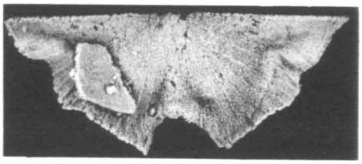

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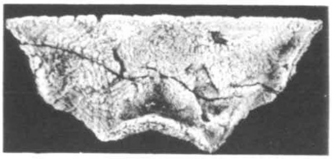

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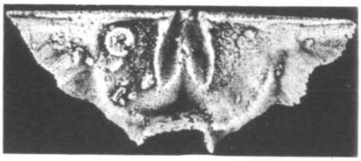

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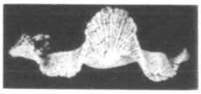

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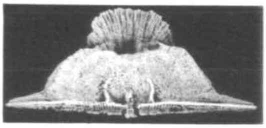

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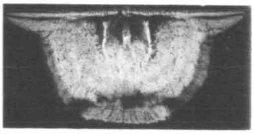

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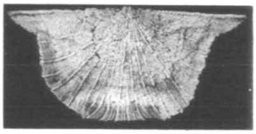

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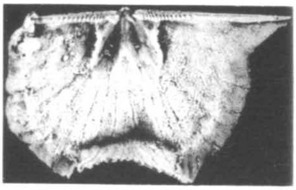

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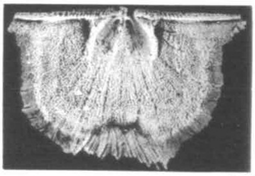

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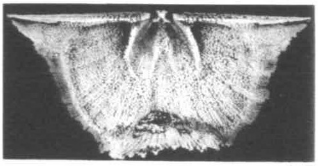

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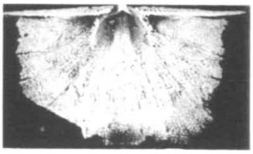

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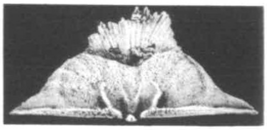

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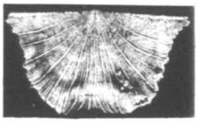

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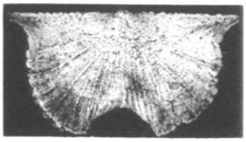

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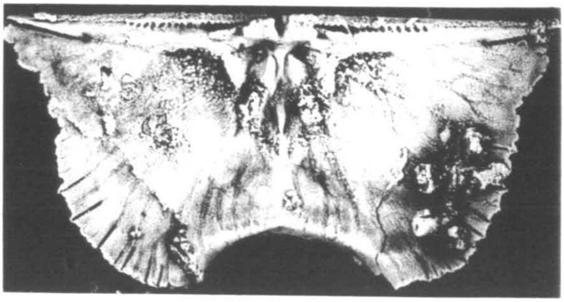

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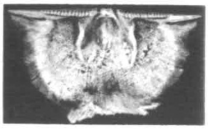

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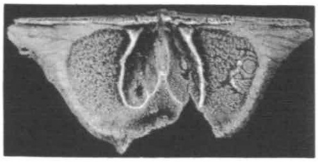
PLATE 10

Figures 1-10—*Malurostrophia aura* sp. nov. 1, Interior of **holotype** pedicle valve ANU 18928 x1.8. 2, Interior of pedicle valve ANU 18929a x2.5. 3, Interior of pedicle valve ANU 18929b x2.5. 4, Interior of pedicle valve ANU 18929c x2.5. 5 and 6, Anteroventral and interior views of brachial valve ANU 18929d x2.7. 7, Interior of brachial valve ANU 18929e x2.5. 8, Interior of brachial valve CPC 10542 x2.4. 9, Dorsal view of CPC 10543 x2.3. 10, Dorsal view of ANU 18929f x2.25.

Figures 11-29—*Malurostrophia minima* sp. nov. 11, Dorsal view of ANU 18931a x10. 12, Ventral view of ANU 18931b x7. 13, Ventral view of small pedicle valve x25. 14, Ventral view of ANU 18931c x20. 15, Posterodorsal view of small pedicle valve ANU 18931d (from the Warroo Limestone) x2.8. 16, Interior of brachial valve ANU 18931e x3.6. 17, 21 and 29, Lateral, dorsal, and posterodorsal views of **holotype** ANU 18930 x3.6. 18, Ventral view of CPC 10539 x3. 19 and 20, Posterodorsal and dorsal views of pedicle valve CPC 10540 x3.6. 22, Anterior view of pedicle valve ANU 18931f x 2.8. 23, Ventral view of ANU 18931g x3.6. 24, Interior of portion of ANU 18931h x9. 25, Interior of pedicle valve ANU 18931h x3.6. 26, Interior of brachial valve CPC 10541 x5. 27, Interior of pedicle value ANU 18931i x5. 28, Interior of pedicle valve x6.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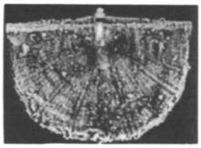
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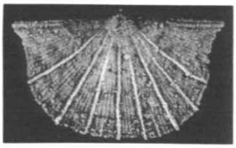
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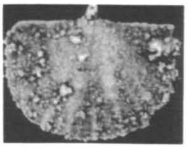
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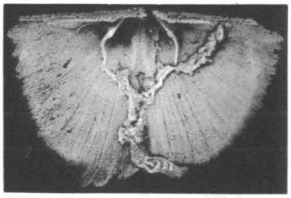
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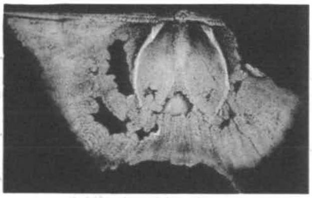
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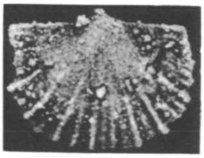
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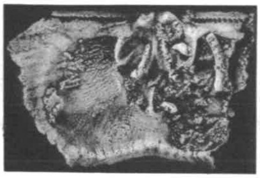
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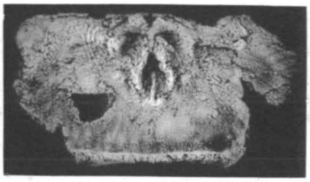
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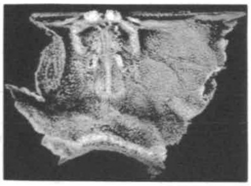
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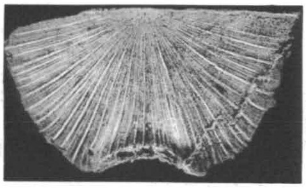
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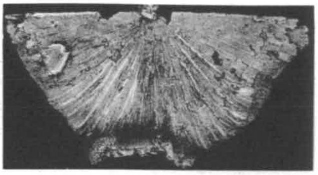
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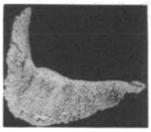
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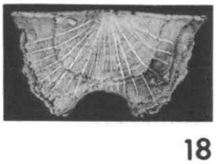
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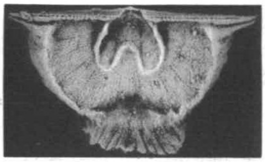
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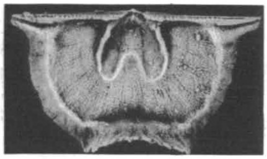
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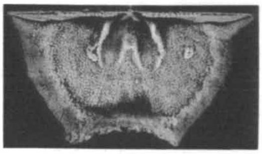
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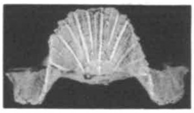
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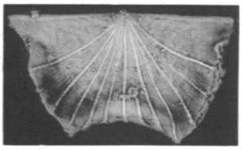
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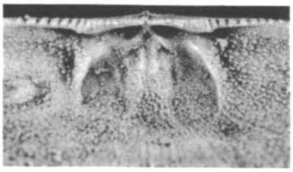
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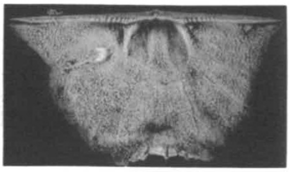
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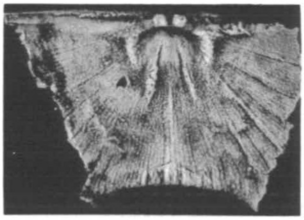
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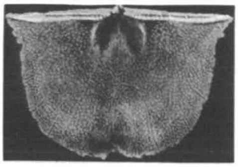
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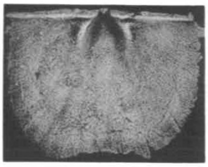
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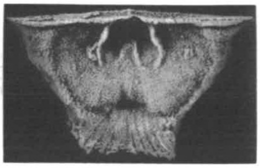
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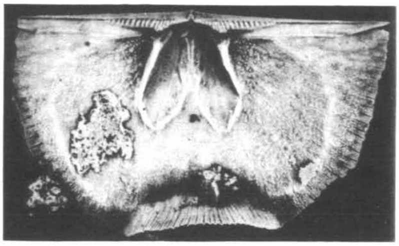
PLATE 11

Figures 1-17—*Malurostrophia bella* sp. nov. 1, Interior of pedicle valve CPC 10544 x2.5. 2, Interior of brachial valve CPC 10545 x1.5. 3, Interior of portion of brachial valve ANU 18933a x5. 4 and 5, Anterior and lateral views of ANU 18933b x1.2. 6, Interior of pedicle valve ANU 18933c x2. 7, Dorsal view of **holotype** ANU 18932 x1.7. 8, Interior of brachial valve ANU 18933d x2.4. 9, Stereo pair of ventral valve ANU 18933e x2. 10, ANU 18933f x3.3. 11, Exterior of pedicle valve CPC 10544 x2. 12, Dorsal view of CPC 10546 x2. 13, Interior of pedicle valve ANU 18933g x2.5. 14, Interior of pedicle valve ANU 18933h x4.8. 15, Interior of pedicle valve ANU 18933e x3.1. 16, Interior of pedicle valve ANU 18933i x3.7. 17, Interior of pedicle valve ANU 18933f x2.4.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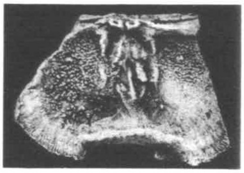
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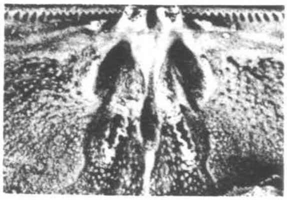
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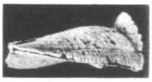
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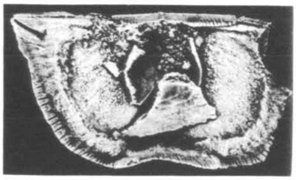
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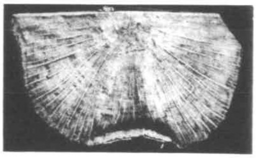
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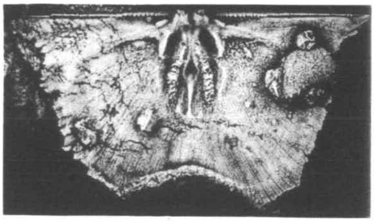
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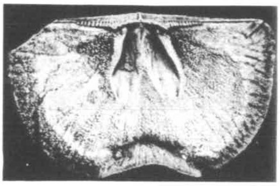
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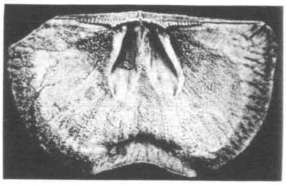
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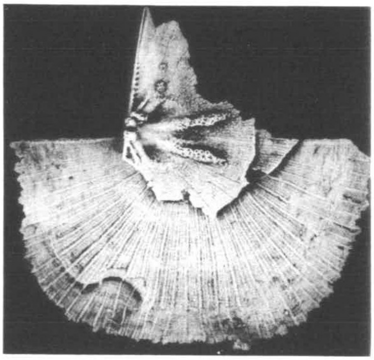
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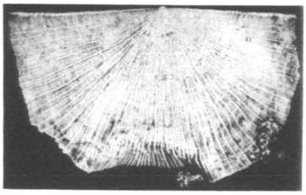
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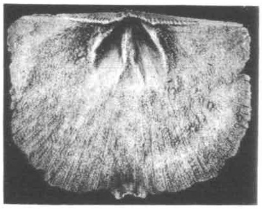
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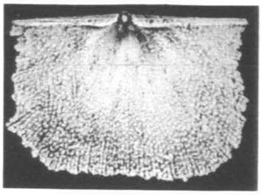
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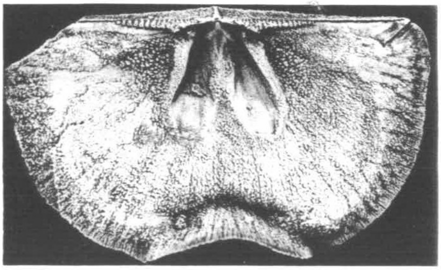
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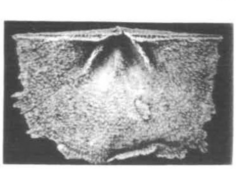
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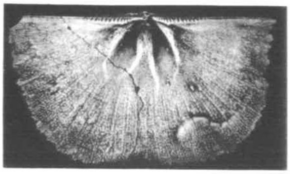
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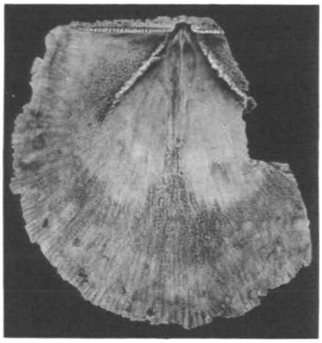
PLATE 12

Figures 1-13—*Leptostrophia clarkei* sp. nov. 1 and 2, Interior and exterior views of **holotype** ANU 18934 x1.3. 3, Interior of brachial valve CPC 10547 x2.4. 4, Interior of pedicle valve CPC 10548 x1.5. 5, Posterodorsal view of a portion of ANU 18935a x6.4. 6, Dorsal view of brachial valve ANU 18936 (from the bottom of the '*Receptaculites*' Limestone) x5. 7, Interior of pedicle valve ANU 18935b x2.8. 8, Interior of brachial valve CPC 10549 x1.2. 9, Interior of brachial valve ANU 18935c x2.4. 10, Interior of pedicle valve CPC 10550 x1. 11, Interior of pedicle valve ANU 18935d x1.2. 12, Interior of brachial valve ANU 18935e x2.2. 13, Interior of pedicle valve ANU 18935f x5.6.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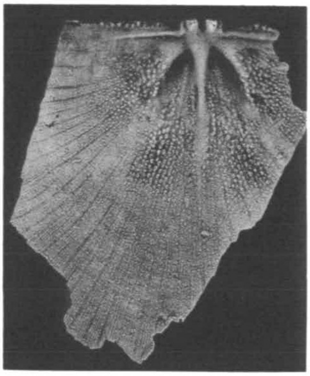
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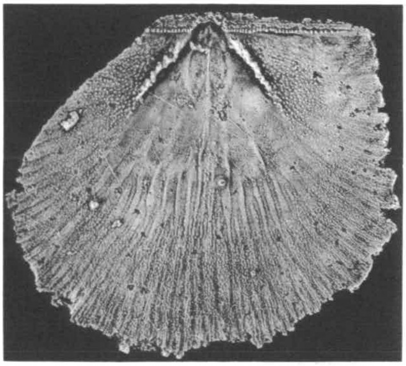
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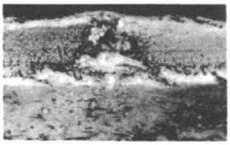
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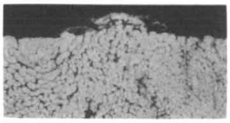
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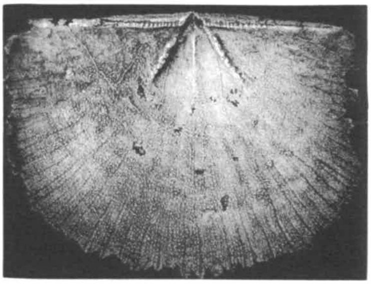
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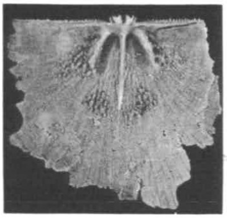
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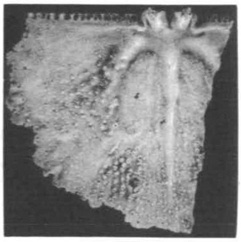
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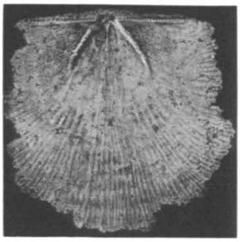
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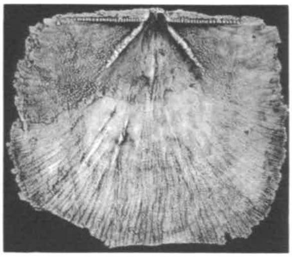
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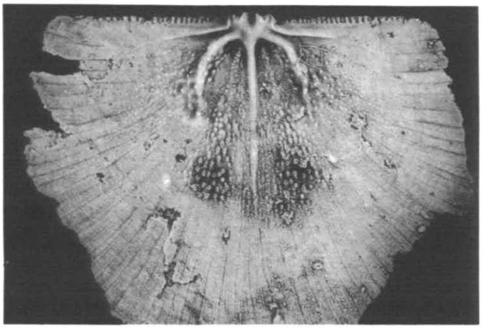
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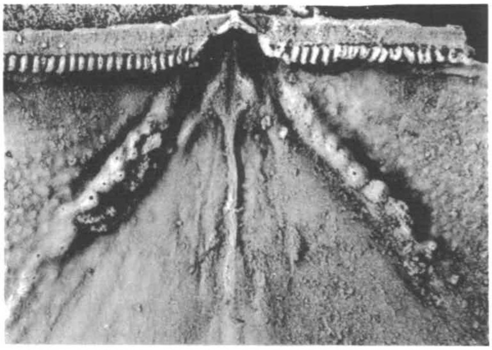
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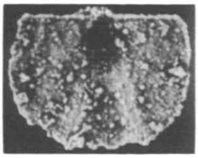
PLATE 13

Figures 1-5—*Cymostrophia dickinsi* sp. nov. (specimens from top of '*Receptaculites*' Limestone). 1, Interior of brachial valve x25. 2, Interior of brachial valve ANU 18920g x12. 3, Exterior of damaged pedicle valve x6. 4, Exterior of pedicle valve ANU 18921a x25. 5, Interior of brachial valve ANU 18921b x25.

Figures 6-9—*Taemostrophia patmorei* gen. et sp. nov. 6, Exterior of pedicle valve ANU 18923l x23. 7, Exterior of pedicle valve ANU 18923m x17. 8, Interior of pedicle valve ANU 18923n x29. 9, Exterior of brachial valve ANU 18923o x27.

Figures 10-17—*Leptostrophia clarkei* sp. nov. 10, Posteroventral view of a portion of brachial valve ANU 18935g x5. 11, Interior of brachial valve ANU 18935h x3.2. 12, Exterior of pedicle valve ANU 18935i x11.7. 13, Exterior of pedicle valve x7. 14, Dorsal view of ANU 18935j x27.5. 15, Exterior of pedicle valve ANU 18935k x24. 16, Interior of pedicle valve ANU 18935l x4.6. 17, Interior of pedicle valve ANU 18935m x2.7.

Figures 18-23—*Cymostrophia dickinsi* sp. nov. (from top of '*Receptaculites*' Limestone). 18, Ventral view of ANU 18921c x3.25. 19, Ventrolateral view of a portion of ANU 18921d x6.3. 20, Exterior of a portion of pedicle valve ANU 18921e x4. 21, Ventrolateral view of a portion of pedicle valve ANU 18921f x6.7. 22, Exterior of a portion of pedicle valve ANU 18921g x4.5. 23, Anterior view of a portion of pedicle valve ANU 18920l x4.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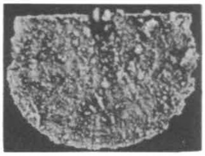
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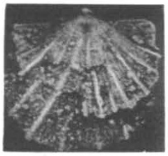
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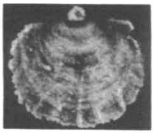
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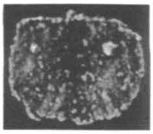
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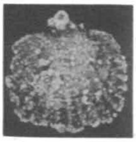
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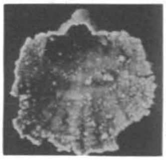
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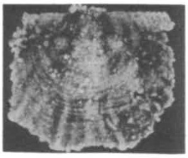
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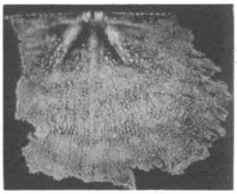
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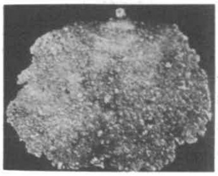
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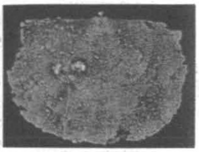
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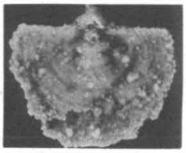
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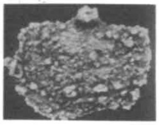
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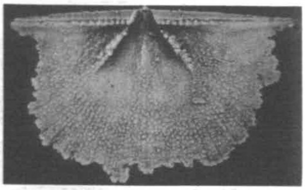
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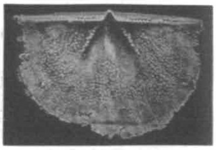
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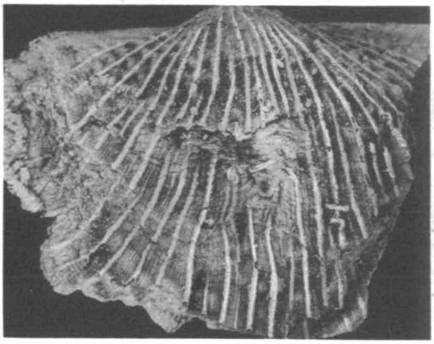
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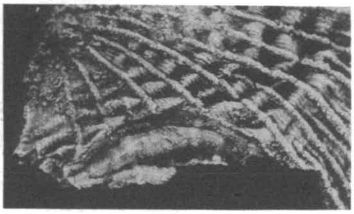
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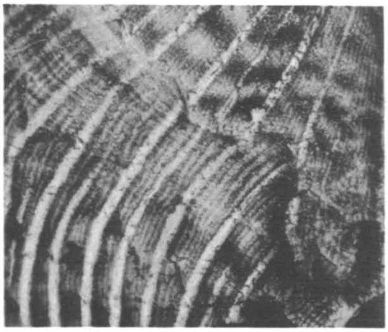
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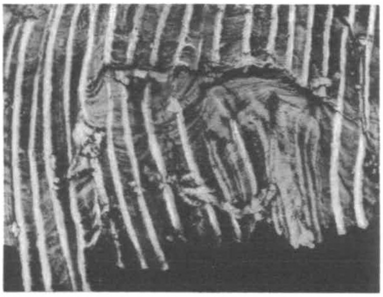
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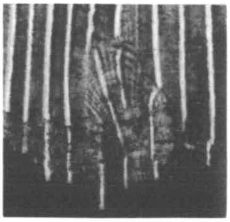
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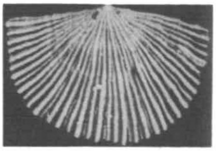
PLATE 14

Figures 1-17—*Schuchertella murphyi* sp. nov. 1, Exterior of pedicle valve ANU 18937a x3.5. 2, Interior of brachial valve ANU 18937b x3.5. 3, Exterior of pedicle valve CPC 10551 x4. 4, Exterior of brachial valve CPC 10552 x2.8. 5, Interior of brachial valve ANU 18937c x4. 6, Dorsal view of ANU 18937d x5.4. 7, Dorsal view of small specimen x25. 8, Exterior of brachial valve ANU 18937e x4.7. 9, Interior of brachial valve CPC 10552 x4.4. 10, Interior of brachial valve ANU 18937f x7.75. 11, Interior of pedicle valve ANU 18937h x4.5. 12, Anterodorsal view of pedicle valve ANU 18937a x5.1. 13, Interior of pedicle valve ANU 18937g x3.6. 14, Posterodorsal view of brachial valve CPC 10552 x10. 15 and 16, Lateral and posterodorsal views of **holotype** ANU 18938 x4.3. 17, Posterodorsal view of pedicle valve ANU 18937a x2.8.

Figures 18-25—*Septachonetes melanus* gen. et sp. nov. 18, Lateral view of pedicle valve CPC 10566 x3.9. 19, Exterior of brachial valve ANU 18939a x7.7. 20, Interior of **holotype** ANU 18940 x5.5. 21 and 22, Interior and exterior views of pedicle valve CPC 10567 x5.7. 23, Interior of pedicle valve ANU 18939b x10. 24, Interior of brachial valve ANU 18939a x10. 25, Interior of pedicle valve ANU 18939c x20.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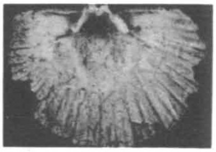
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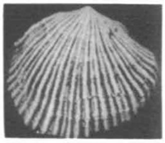
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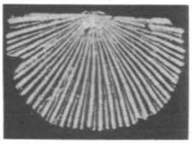
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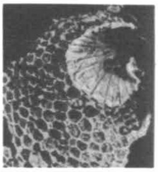
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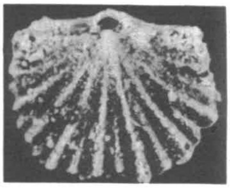
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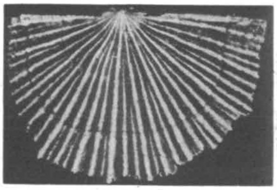
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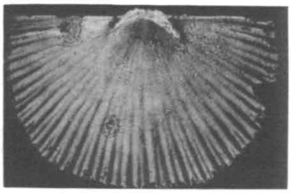
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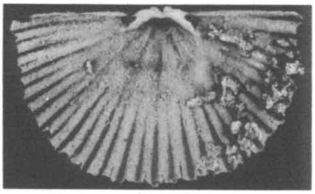
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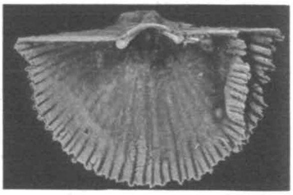
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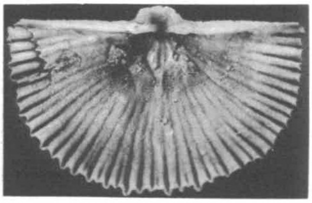
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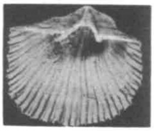
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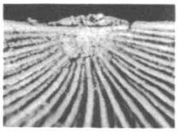
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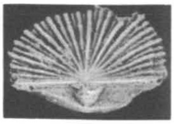
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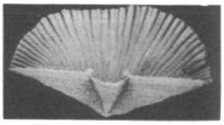
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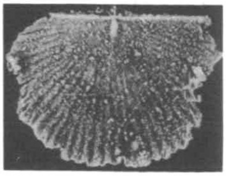
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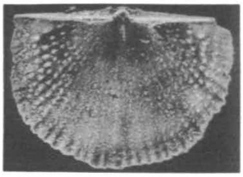
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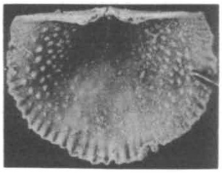
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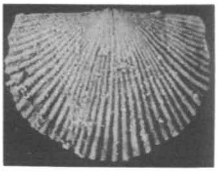
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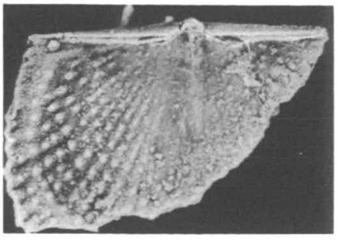
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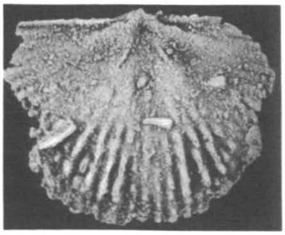
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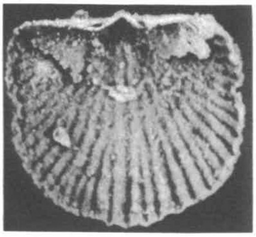
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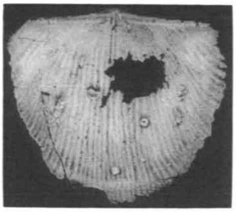
PLATE 15

Figures 1-8 and 15—*Parachonetes konincki* sp. nov., 1, Interior of pedicle valve ANU 18941a x1. 2, Interior of brachial valve CPC 10556 x2.1. 3, Interior of brachial valve ANU 18941b x2.3. 4, Ventral view of **holotype** ANU 18942 x0.9. 5, Ventral view of CPC 10557 x0.9. 6, Interior of pedicle valve ANU 18941c x5. 7, Interior of pedicle valve ANU 18941c x2.3. 8, Ventral view of **holotype** ANU 18942 x0.9. 15, Ventrolateral view of ANU 18941d x3.

Figures 9-14 and 16-23—*Parachonetes flemingi* sp. nov. 9, Ventral view of CPC 10553 x0.9. 10, Ventral view of **holotype** ANU 18944 x0.9. 11, Posterior view of cardinalia of brachial valve ANU 18943a x8. 12 and 13, Anterodorsal and dorsal views of pedicle valve ANU 18943b x2.6. 14, Lateral view of **holotype** ANU 18944 x0.9. 16, Ventrolateral view of brachial valve ANU 18943c x2.6. 17, Interior of brachial valve CPC 10554 x2.1. 18, Posteroventral view of brachial valve ANU 18943d x3.8. 19, Posteroventral view of brachial valve ANU 18943c x2.6. 20, Anteroventral view of a portion of brachial valve ANU 18943d x3.8. 21, Dorsal view of **holotype** ANU 18944 x1.2. 22, Interior of pedicle valve CPC 10555 x1.25. 23, Exterior of pedicle valve ANU 18943e x0.9.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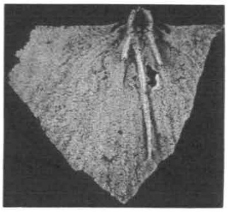
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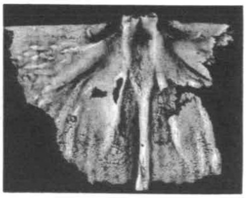
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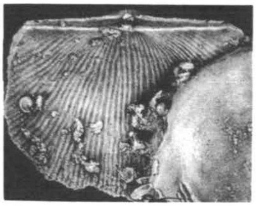
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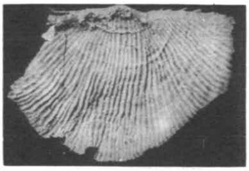
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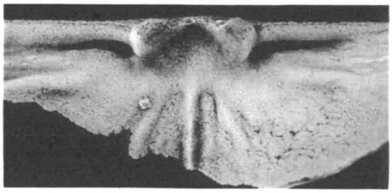
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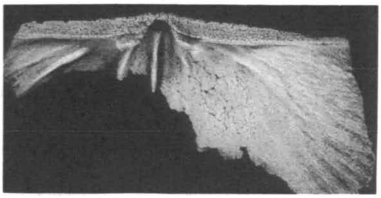
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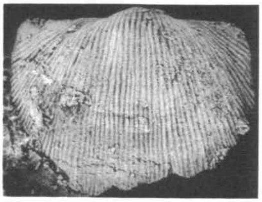
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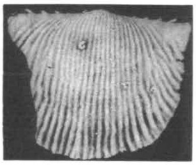
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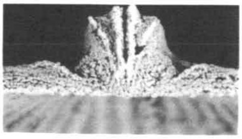
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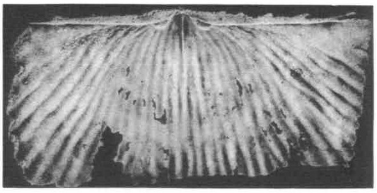
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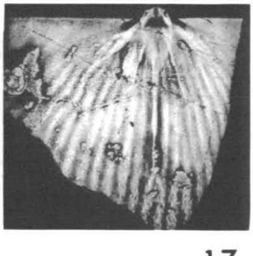
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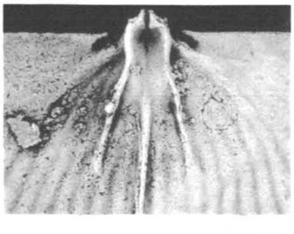
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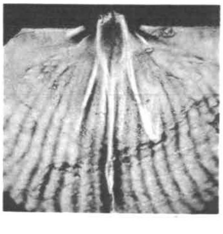
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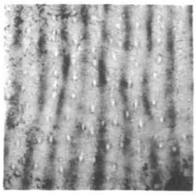
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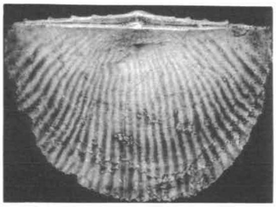
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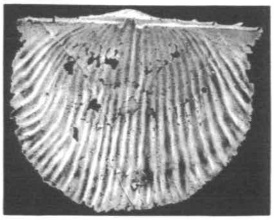
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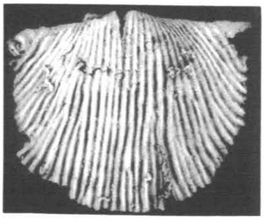
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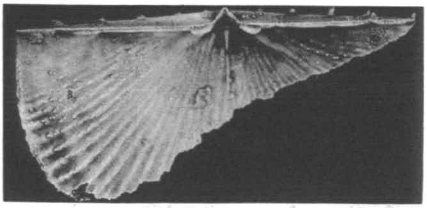
PLATE 16

Figures 1-14—*Protochonetes culleni* (Dun) (specimens from '*Receptaculites*' Limestone). 1, Interior of broken pedicle valve ANU 18945a x3. 2, Interior of small brachial valve ANU 18945b x5. 3, Interior of small brachial valve x10. 4, Interior of brachial valve ANU 18945c x6. 5, Interior of brachial valve CPC 10559 x6. 6, Interior of pedicle valve ANU 18945f x3.4. 7, Dorsal view of CPC 10560 x2.4. 8 and 9, Exterior and interior views of brachial valve ANU 18945d. x2.4. 10, Lateral view of ANU 18945f x1.4. 11, Interior of small pedicle valve CPC 10561 x3. 12, Exterior of small pedicle valve ANU 18945e x2.7. 13, Exterior of pedicle valve CPC 10562 x2.3. 14, Exterior of pedicle valve ANU 18945f x2.

Figures 15-22—*Protochonetes culleni* (Dun). (Topotype material from Shearsby's Wallpaper.) 15, Dorsal view of rubber mould of ANU 18947a x2. 16, Ventral view of rubber mould of ANU 18947b x2.3. 17, Interior view of rubber mould of pedicle valve CPC 10558 x2. 18, Interior of brachial valve on ANU 18947c x1.8. 19, Interior of brachial valve on ANU 18947c x1.8. 20, Exterior of brachial valve on ANU 18947c x1.8. 21, Interior of pedicle valve on ANU 18947c x1.8. 22, Exterior of brachial valve on ANU 18947c x1.8.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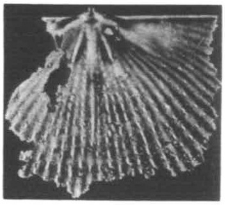
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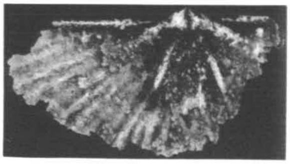
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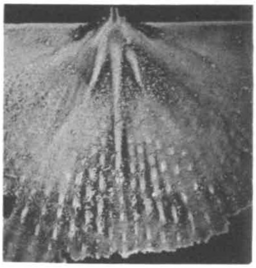
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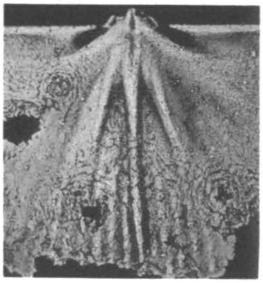
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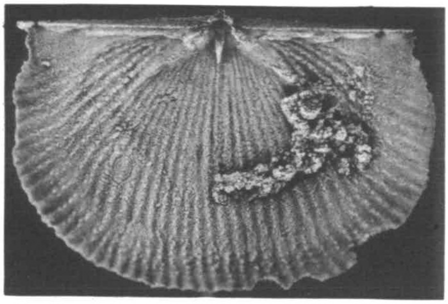
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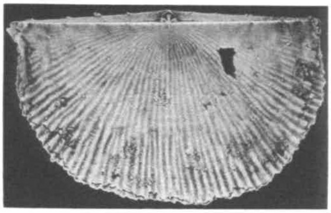
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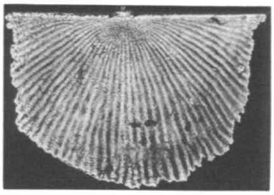
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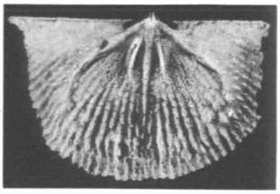
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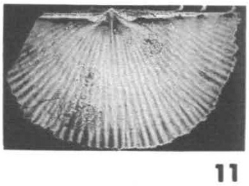
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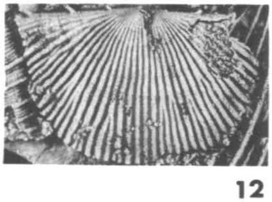
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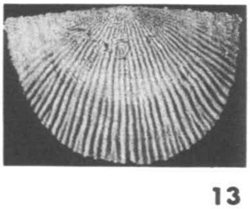
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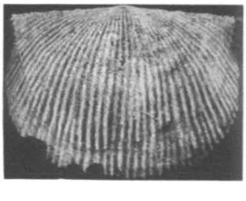
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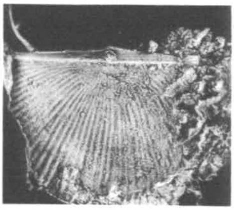
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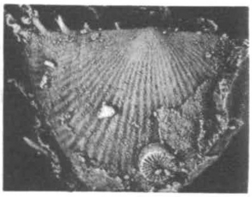
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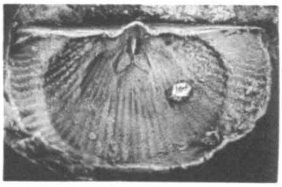
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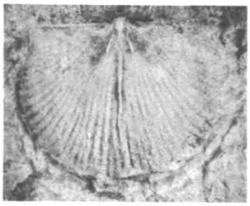
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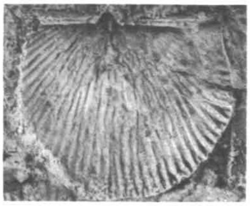
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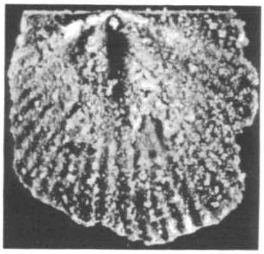
PLATE 17

Figures 1-2—*Septachonetes melanus* gen. et sp. nov. 1, Interior of small brachial valve ANU 18939d x21. 2, Interior of brachial valve CPC 10568 x10.

Figures 3-24—*Protochonetes latus* sp. nov. 3, Anteroventral view of pedicle valve ANU 18949a x2.4. 4, Exterior of small pedicle valve x18. 5, Ventral view of ANU 18949b x5. 6, Anteroventral view of ANU 18949c x35. 7, Anteroventral view of pedicle valve x35. 8, Ventral view of ANU 18949d x11. 9, Dorsal view of ANU 18949e x11. 10, Exterior of pedicle valve ANU 18949f x2.5. 11, Exterior of pedicle valve ANU 18949g x1.7. 12, Exterior of pedicle valve CPC 10563 x2.5. 13, Exterior of pedicle valve CPC 10564 x2.3. 14, Exterior of pedicle valve ANU 18949h (from Warroo Limestone) x2.3. 15, Interior of pedicle valve ANU 18949g x2.2. 16, Exterior of pedicle valve CPC 10564 (from Warroo Limestone) x2.3. 17, Exterior of pedicle valve CPC 10565 x2.3. 18, Lateral view of **holotype** ANU 18948 x1.9. 19 and 20, Ventral and dorsal views of **holotype** ANU 18948 x2.2. 21 and 24, Anterodorsal and dorsal views of pedicle valve CPC 10565 x3. 22, Interior of pedicle valve ANU 18949i (from Warroo Limestone) x3. 23, Interior of brachial valve ANU 18949j (from Warroo Limestone) x3.5.



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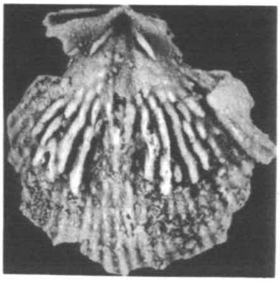

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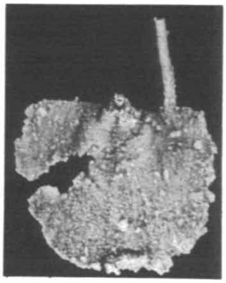

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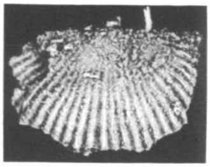

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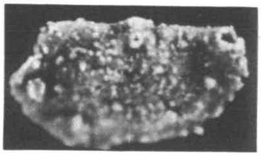

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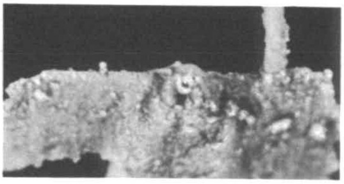

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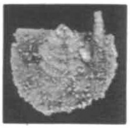

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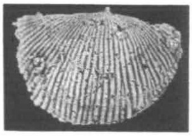

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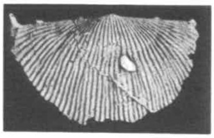

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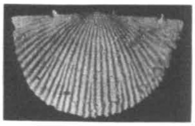

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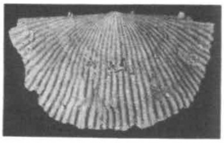

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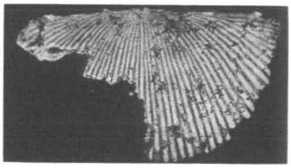

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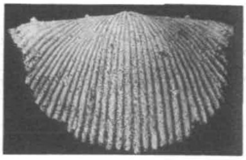

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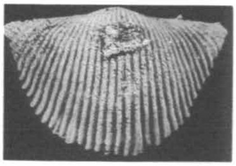

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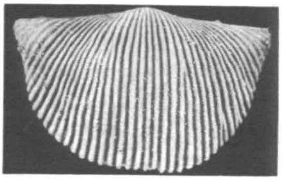

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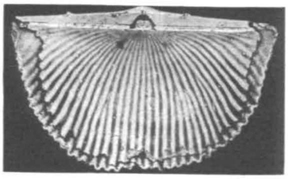

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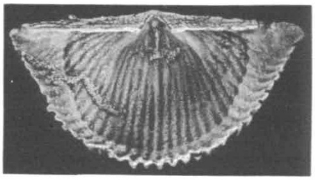

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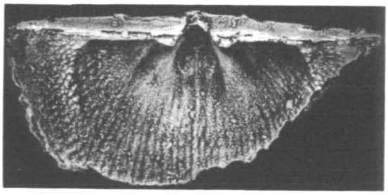

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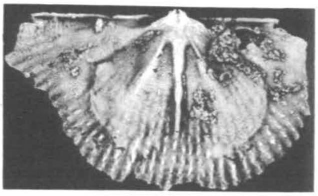

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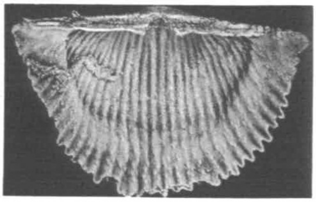

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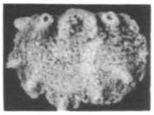
PLATE 18

Figures 1-26—*Spinulicosta campbelli* sp. nov. 1, Ventral view of ANU 18951a x10. 2, Posteroventral view of ANU 18951b x7.5. 3, Interior of small brachial valve x10. 4, Interior of small brachial valve x5. 5, Dorsal view of ANU 18951c x6. 6, Ventral view of ANU 18951d x9. 7, Interior of small brachial valve x15. 8, Exterior of broken pedicle valve x15. 9, Interior of brachial valve x4. 10, Lateral view of ANU 18951e x2.5. 11, Ventral view of brachial valve ANU 18951f x2.25. 12, Exterior of CPC 10569 x1.8. 13 and 14, Lateral and ventral views of **holotype** ANU 18950 x1.8. 15, Interior of portion of brachial valve ANU 18951g x10 (note processes on the anderidia). 16, Anteroventral view of ANU 18951h x1.8. 17, Lateral view of CPC 10570 x3. 18, Ventral view of CPC 10571 x2.2. 19, Ventral view of ANU 18951i x3.2. 20, Ventral view of ANU 18951j x2.2. 21, Interior of brachial valve CPC 10572 x3.8. 22, Interior of pedicle valve ANU 18951k x4. 23, Posterior view of brachial valve ANU 18951l x3.5. 24, Ventral view of specimen x3. 25, Ventral view of brachial valve ANU 18951l x2.7. 26, Exterior of brachial valve CPC 10573 x4.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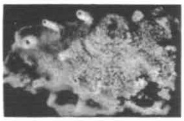
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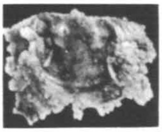
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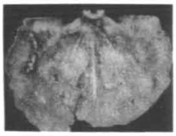
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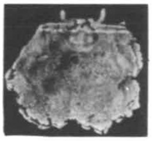
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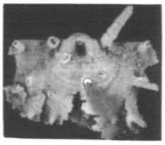
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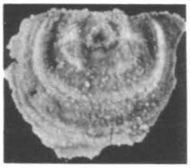
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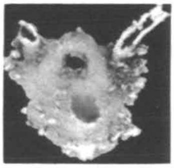
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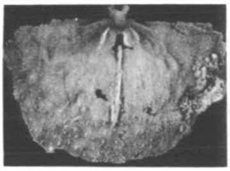
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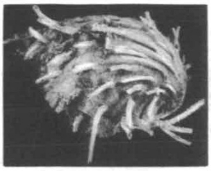
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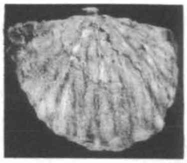
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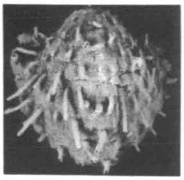
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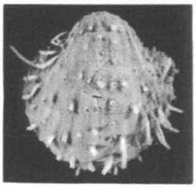
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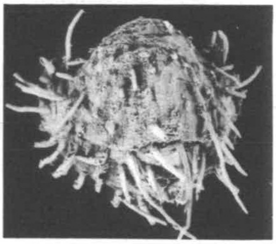
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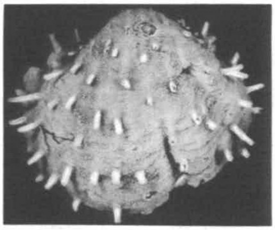
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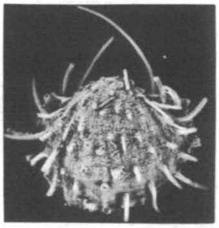
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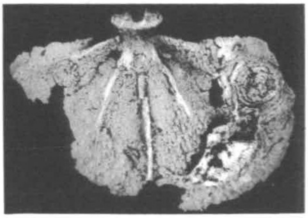
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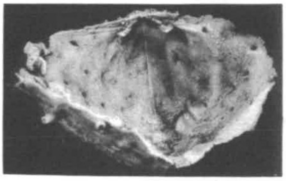
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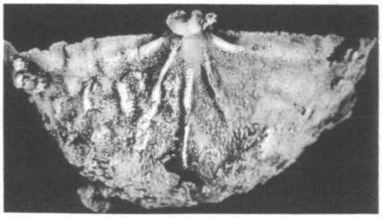
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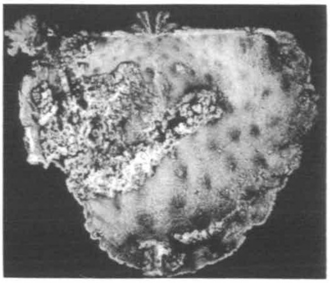
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PLATE 19

Figures 1-14—*Ambothyris runnegari* sp. nov. 1, Lateral view of ANU 18953a x7.5. 2 and 3, Lateral and anterior views of ANU 18953b x5.75. 4, Lateral view of **holotype** ANU 18952 x5.2. 5, Posterior view of CPC 10585 x6. 6, Anterior view of **holotype** ANU 18952 x6. 7, Lateral view of ANU 18953c x6.7. 8, Lateral view of CPC 10586 x8.5. 9, Lateral view of ANU 18953d x8.5. 10, Interior of pedicle valve ANU 18953e x7.6. 11, Posterior view of ANU 18953f x6.8. 12, Interior of pedicle valve CPC 10587 x7.5. 13, Interior of brachial valve ANU 18953g x9. 14, Interior of brachial valve ANU 18953h x9.

Figures 15-36—*Coelospira dayi* sp. nov. 15, Ventral view of ANU 18955a x9. 16, Posterior of **holotype** ANU 18954 x3. 17, Anterolateral view of ANU 18955b x3.4. 18, Anterior view of CPC 10575 x3.5. 19, Dorsal view of ANU 18955c x3. 20, Dorsal view of CPC 10576 x2.2. 21, Ventral view of ANU 18955d x5. 22, Ventral view of **holotype** ANU 18954 x4.6. 23, Dorsolateral view of ANU 18955e x6. 24, Lateral view of **holotype** ANU 18954 x3. 25, Interior of pedicle valve CPC 10577 x2.8. 26, Interior of pedicle valve ANU 18955f x2.9. 27, Ventral view of ANU 18955g x3.7. 28, Dorsal view of a portion of ANU 18955h x5.2. 29, Interior of brachial valve ANU 18955i x3.6. 30, Interior of pedicle valve CPC 10578 x3.4. 31 and 36, Anterodorsal and dorsal views of pedicle valve ANU 18955e x3.9. 32 and 33, Ventral and ventrolateral views of ANU 18955j x4.8. 34, Lateral view of portion of ANU 18955h x5.2. 35, Dorsal view of holotype x3.5.


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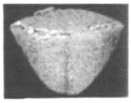
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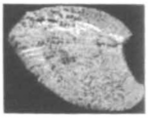
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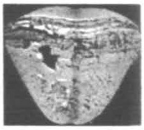
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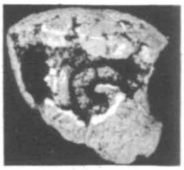
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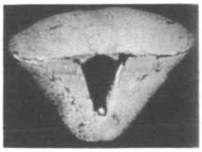
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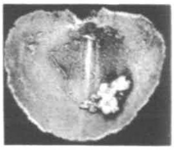
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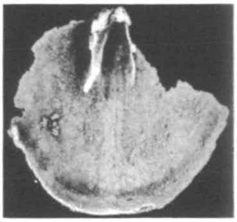
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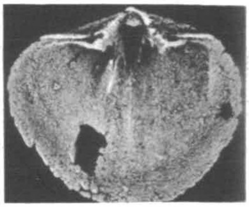
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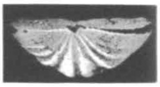
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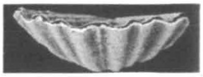
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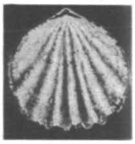
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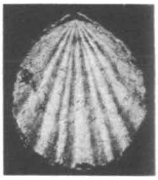
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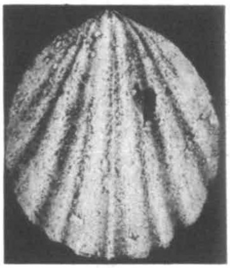
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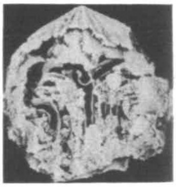
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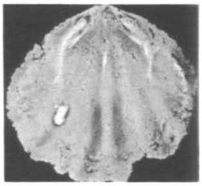
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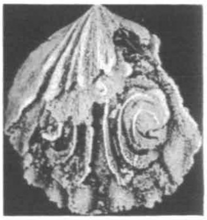
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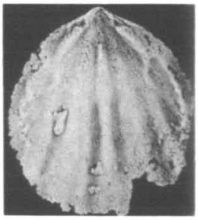
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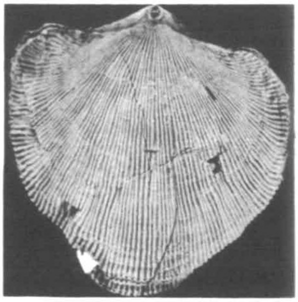
PLATE 20

Figures 1-14 and 17—*Anatrypa erectirostris* (Mitchell & Dun). 1 and 2, Dorsal and ventral views of ANU 18956a x1.1. 3, Ventral view of ANU 18956b x1.1. 4, Anterodorsal view of CPC 10581 x1. 5, Dorsal view of pedicle valve ANU 18956c x1.2. 6, Ventral view of ANU 18956d x1.25. 7, Lateral view of ANU 18956a x0.9. 8, Anteroventral view of ANU 18956e x1. 9 and 10, Dorsal and ventral views of ANU 18956f x0.84. 11, Posterior view of ANU 18956a x0.9. 12, Posterodorsal view of ANU 18956g x1.4. 13, Anterior view of CPC 10582 x4 (arrow points to pedicle adjustor scar). 14, Dorsal view of ANU 18956h x1. 17, Dorsomedial view of ANU 18956i x2.

Figures 15-16—*Atrypa penelopeae* sp. nov. 15 and 16, Ventral views of ANU 18946 x4 and x2. (C = crus and p.l. = primary lamella.)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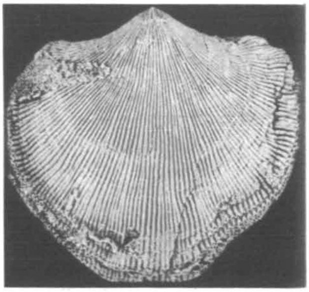
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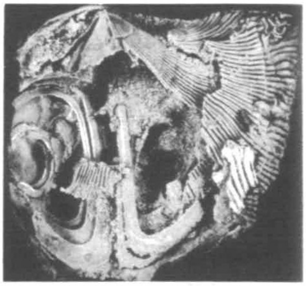
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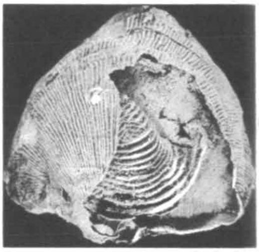
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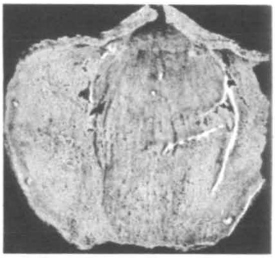
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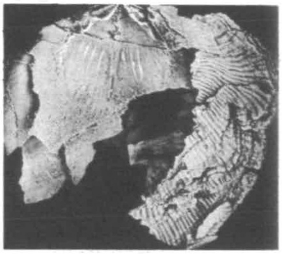
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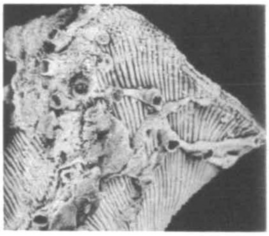
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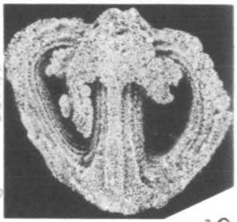
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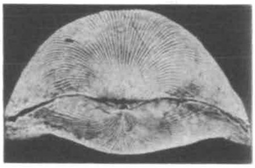
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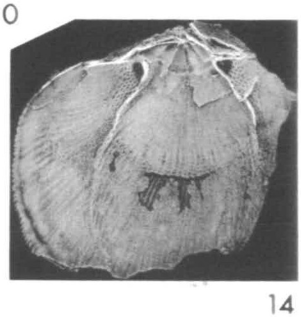
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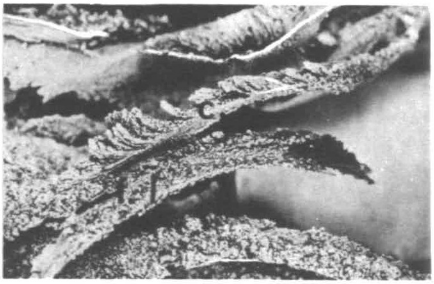
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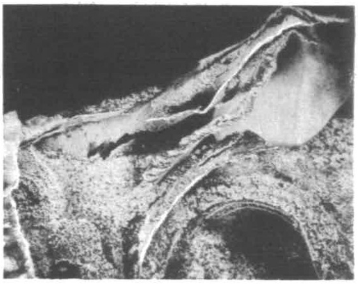
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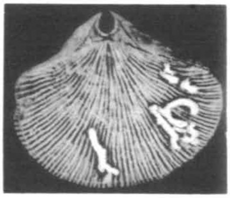
PLATE 21

Figures 1-11, 24 and 30-32—*Anatrypa erectirostris* (Mitchell & Dun). 1 and 2, Posterodorsal and dorsal views of ANU 18957a x2. 3, Interior of pedicle valve ANU 18957b x7.5. 4, Interior of pedicle valve ANU 18957c x2.3. 5, Posterodorsal view of ANU 18957d x2. 6, 7 and 9, Lateral, dorsal and posterodorsal views of ANU 18957e x3.4. 8, Interior of pedicle valve ANU 18957f x3.4. 10, Interior of brachial valve ANU 18957g x7. 11, Dorsolateral view of ANU 18957h x3.5. 24, Dorsal view of a portion of ANU 18956a x4.4. 30 and 31, Dorsal and posterior views of jugal process ANU 18957i x3. 32, Interior of fragmentary pedicle valve ANU 18957j x2.4 (note hollow deltidial plate).

Figures 12-23 and 25-29—*Atrypa penelopeae* sp. nov. 12, Exterior of pedicle valve ANU 18958a x3.6. 13, Interior of pedicle valve ANU 18958a x3.2. 14, Interior of pedicle valve ANU 18958b x5. 15, Dorsal view of ANU 18958c x3.6. 16, Ventral view of ANU 18958d x6. 17, Interior of brachial valve ANU 18958e x4.4. 18, Dorsal view of ANU 18958f x3. 19, Dorsal view of ANU 18958g x2.75. 20, Dorsal view of ANU 18958h x2.4. 21, Ventral view of small specimen x18. 22 and 23, Dorsal and lateral views of ANU 18958d x4.75. 25, Dorsal view of a portion of ANU 18958c x10. 26, Posterior view of jugal process ANU 18958i x3.5. 27 and 29, Anterior and posterior views of ANU 18958j x3.5. 28, Dorsal view of a portion of **holotype** ANU 18960 x2.3.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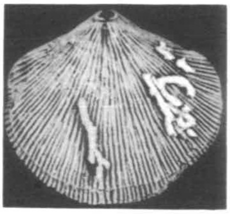
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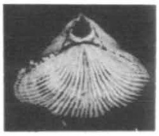
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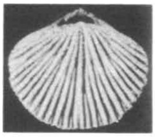
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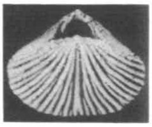
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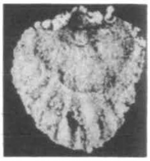
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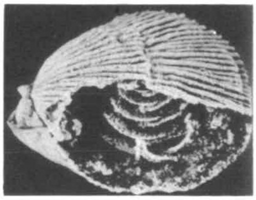
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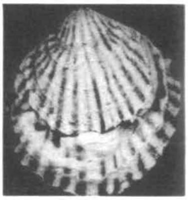
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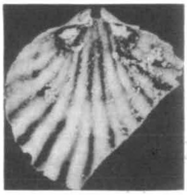
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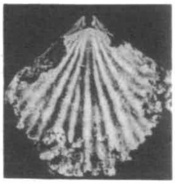
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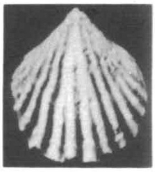
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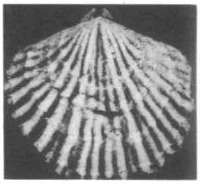
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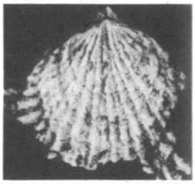
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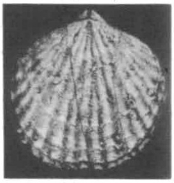
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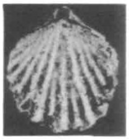
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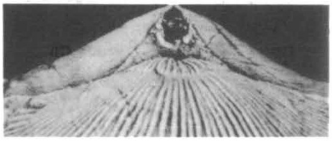
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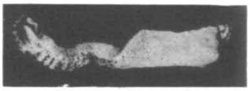
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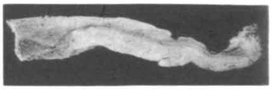
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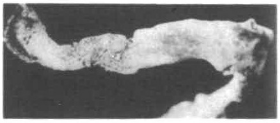
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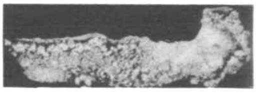
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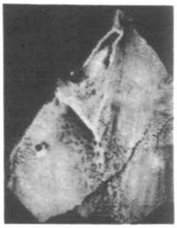
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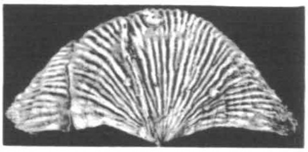
PLATE 22

Figures 1-10—*Atrypa penelopeae* sp. nov. 1, Posterior view of brachial valve ANU 18959a x0.9. 2, Interior of pedicle valve CPC 10579 x1.1. 3, Interior of a rubber mould of CPC 10580 x2.2. 4, Anteroventral view of brachial valve ANU 18959a x1.1. 5 and 6, Lateral and dorsal views of **holotype** ANU 18960 x0.9. 7 and 8, Interior and exterior views of brachial valve ANU 18959a x0.9. 9 and 10, Interior and exterior views of pedicle valve ANU 18959b x1.1.

Figures 11-12—*Anatrypa erectirostris* (Mitchell & Dun). 11, Posterior view of CPC 10583 x0.95. 12, Dorsal view of CPC 10584 x1.05.



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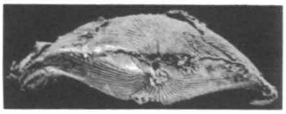

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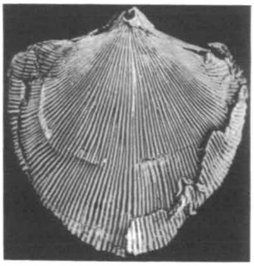

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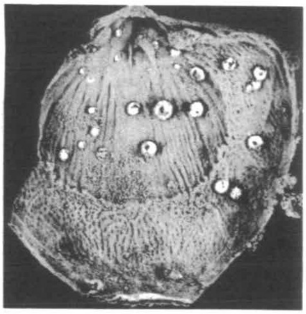

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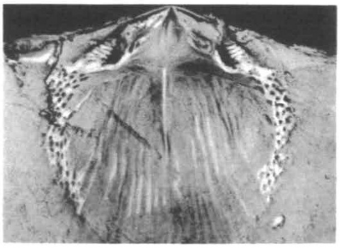

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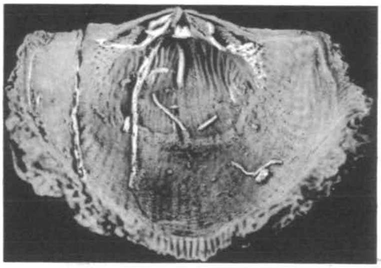

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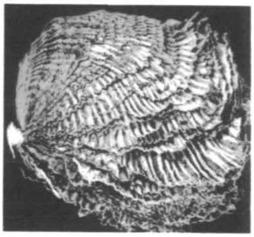

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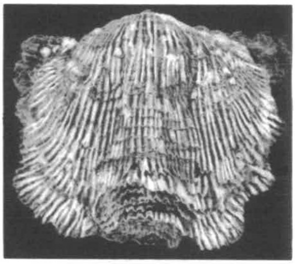

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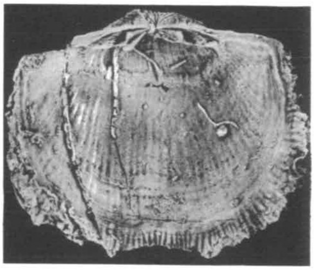

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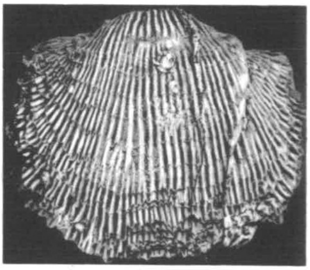

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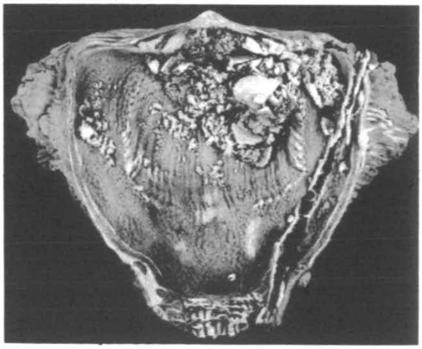

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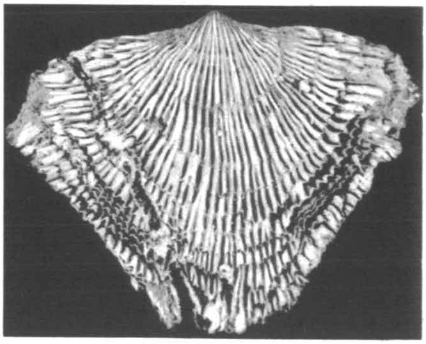

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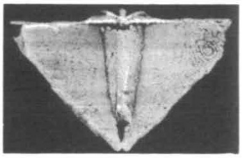
PLATE 23

Figures 1-25—*Cyrtina* aff. *Cyrtina wellingtonensis* Dun. 1, Posterior view of ANU 18961a x2.4. 2, Posterior view of ANU 18961b x1.6. 3, Posterior view of CPC 10588 x3. 4, Posterior view of ANU 18961c x3.5. 5, Interior of brachial valve CPC 10589 x6.75. 6 and 7, Dorsal and posterior views of ANU 18961d x7. 8, Interior of ANU 18961e x5. 9, Lateral view of ANU 18961c x3.1. 10, Posterior view of CPC 10590 x2.5. 11, Lateral view of CPC 10588 x2.1. 12, Posterior view of ANU 18961f x3. 13, Interior of CPC 10591 x3.5. 14, Lateral view of ANU 18961g x10. 15, Dorsal view of ANU 18961b x1.6. 16, Lateral view of ANU 18961b x4. 17, Interior of brachial valve ANU 18961i x6.8. 18, Posterior view of pedicle valve ANU 18961j x3.4. 19, Interior of brachial valve x3. 20, Interior of brachial valve CPC 10592 x3.6. 21, Interior of brachial valve ANU 18961k x7.7. 22, Interior of pedicle valve ANU 18961l x3.5. 23, Dorsal view of ANU 18961m x3.5. 24, Portion of interior (cardinal process) of ANU 18961n x9.25. 25, Ventrolateral view of ANU 18961o x3.5.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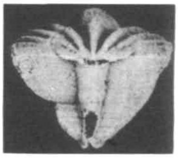
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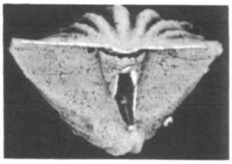
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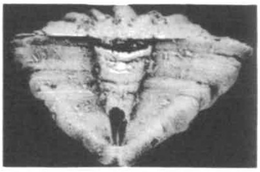
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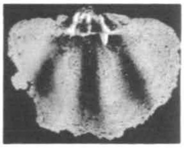
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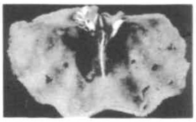
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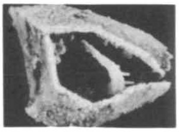
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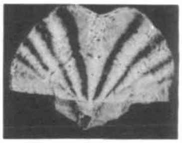
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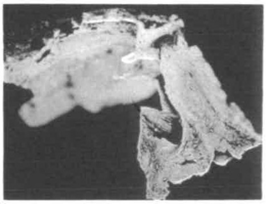
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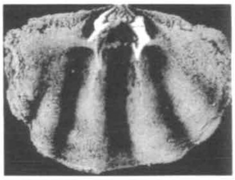
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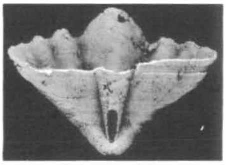
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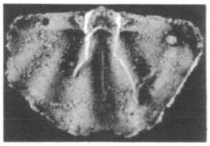
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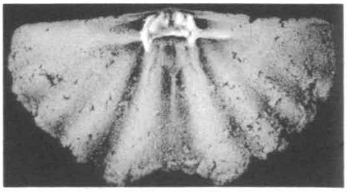
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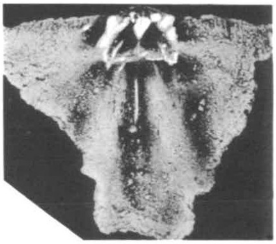
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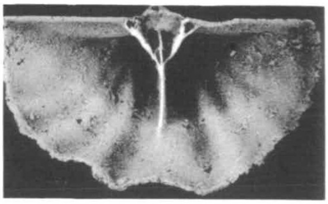
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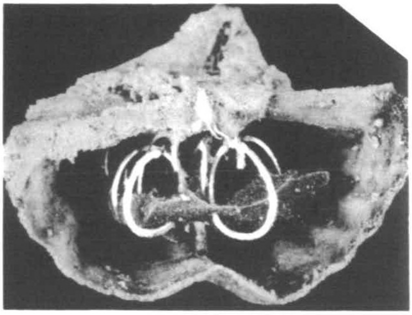
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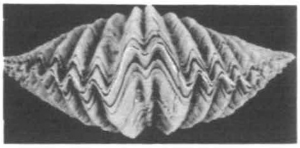
PLATE 24

Figures 1-20—*Howittia howitti* (Chapman). 1, 2, 3 and 4, Anterior, posterior, lateral and dorsal views of ANU 18962a x1.3. 5, Ventral view of ANU 18962a x1.4. 6, Interior of pedicle valve CPC 10596 x3. 7, Interior of brachial valve CPC 10597 x2.9. 8, Interior of pedicle valve ANU 18962b x1.75. 9, Anterolateral view of pedicle valve ANU 18962c x2. 10, Interior of brachial valve ANU 18962d x1.7. 11, View of micro-ornament x10. 12, View of micro-ornament on ANU 18962e x10. 13, Interior of pedicle valve CPC 10598 x1.7. 14, Exterior of ANU 18962f x1.7. 15, Posterior view of ANU 18962g x2.9. 16, Lateral view of a portion of brachial valve CPC 10599 x3.5. 17, Interior of portion of brachial valve ANU 18962h x5.25. 18, Anteroventral view of brachial valve CPC 10600 x1.6. 19, Anterior view of ANU 18962i x1.2. 20, Exterior of brachial valve ANU 18962j x1.6.

Figures 21-26—*Howittia multiplicata* (de Koninck). 21 and 22, Dorsal and posterior views of ANU 18963a x5. 23, Anterior view of CPC 10601 x2.2. 24, Posterior view of ANU 18963b x3. 25, Posterior view of ANU 18963c x2.4. 26, Lateral view of ANU 18963d x2.25.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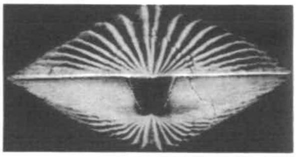
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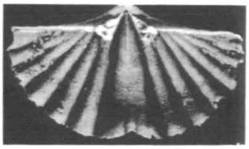
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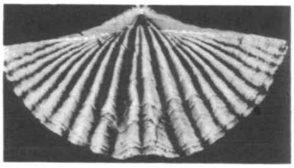
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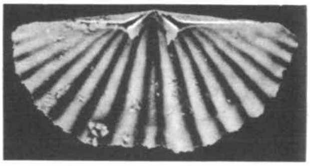
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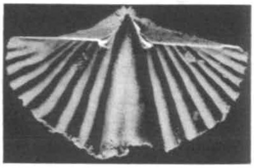
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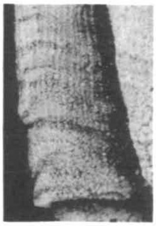
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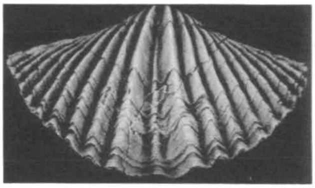
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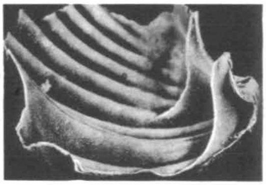
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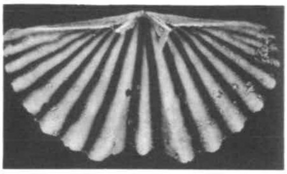
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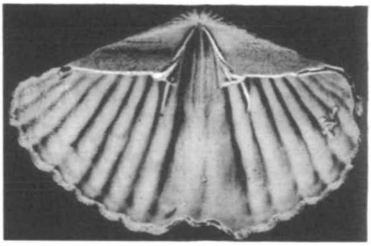
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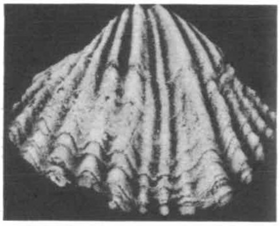
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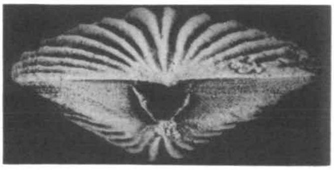
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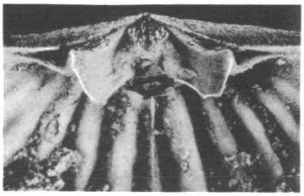
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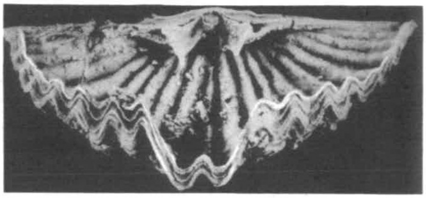
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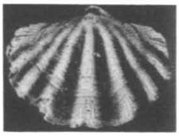
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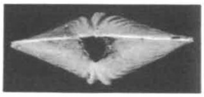
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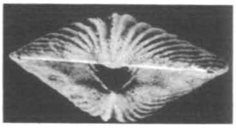
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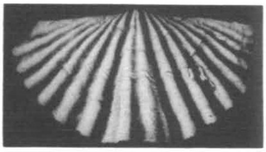
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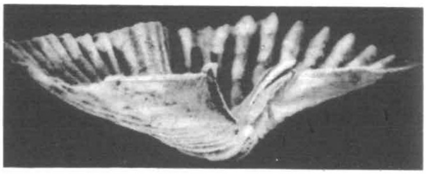
PLATE 25

Figures 1-14—*Howittia multiplicata* (de Koninck). 1, Posterolateral view of pedicle valve CPC 10602 x3.4. 2, Dorsal view of ANU 18965a x3.25. 3, Interior of pedicle valve CPC 10603 x4.3. 4, Exterior of brachial valve ANU 18965b x2.3. 5, Exterior of **neotype** ANU 18964 x1.2. 6, Exterior of pedicle valve ANU 18965c x2.3. 7, Interior of portion of brachial valve ANU 18965d x7.5. 8, Posterolateral view of portion of pedicle valve ANU 18965e x5. 9, Interior of portion of **neotype** ANU 18964 x4.5. 10, Interior of pedicle valve ANU 18965f x2.3. 11, Interior of pedicle valve CPC 10604 x1.9. 12, Interior of brachial valve ANU 18965d x2.3. 13, Anteroventral view of **neotype** ANU 18964 x1.9. 14, Ventral view of **neotype** ANU 18964 x1.8.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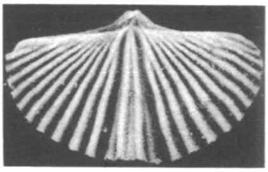
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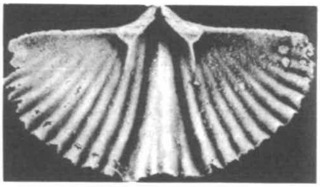
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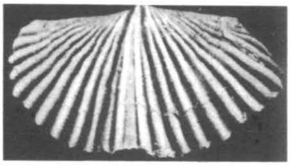
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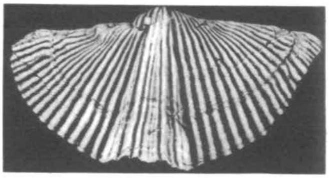
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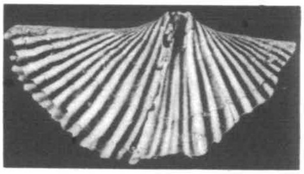
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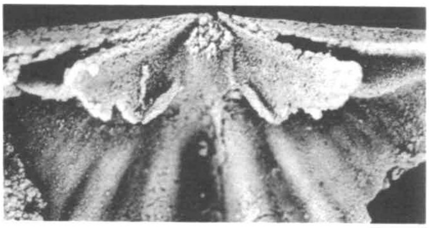
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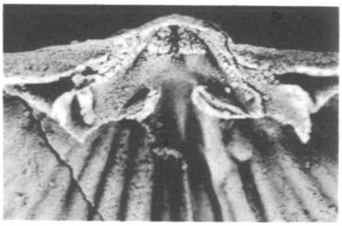
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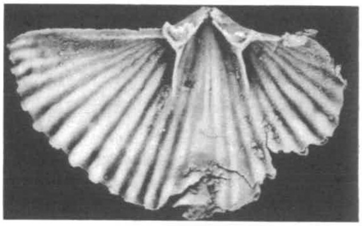
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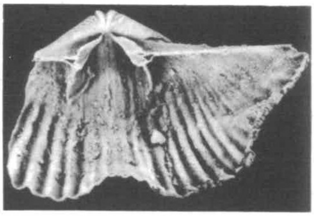
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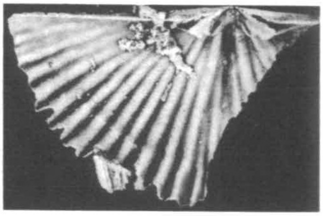
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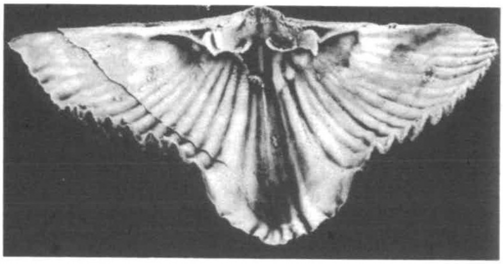
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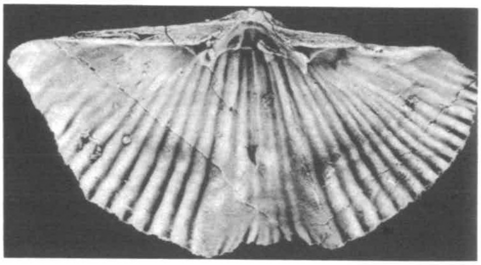
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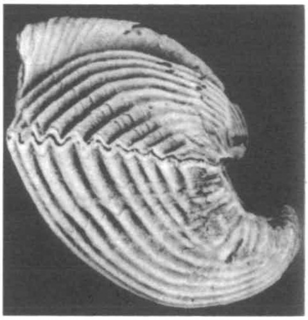
PLATE 26

Figures 1-13—*Spinella yassensis* (de Koninck). 1, Lateral view of ANU 18966a x2. 2, Interior of portion of brachial valve ANU 18966b x3. 3, Posterodorsal view of ANU 18966c x1.4. 4 and 7, Posterior and dorsal views of ANU 18966d x2. 5 and 6, Dorsolateral and dorsal views of incomplete pedicle valve ANU 18966e x2. 8, Interior of brachial valve ANU 18966f x2. 9, Dorsal view of ANU 18966j x2. 10, Lateral view of broken specimen ANU 18966g x4 (note join between dental lamella and ventral adminiculum). 11 and 12, Dorsal and posterior views of small specimen ANU 18966h x5. 13, Interior of pedicle valve ANU 18966i x2.



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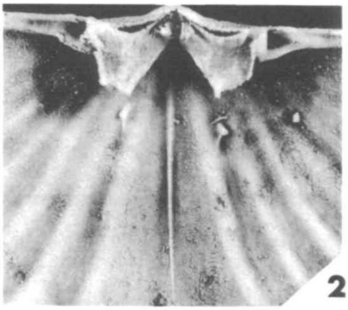

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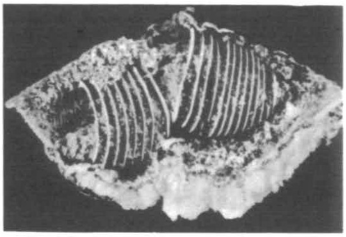

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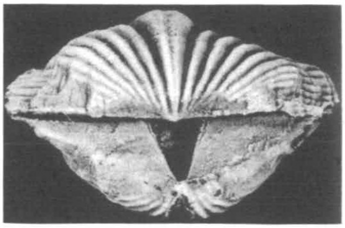

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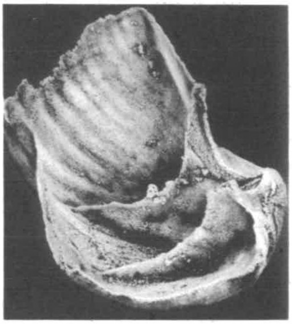

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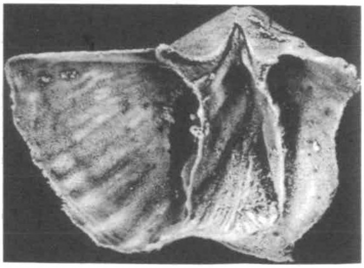

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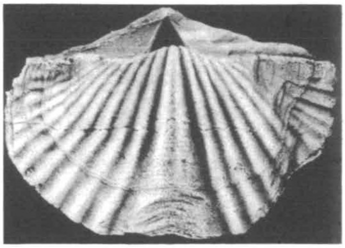

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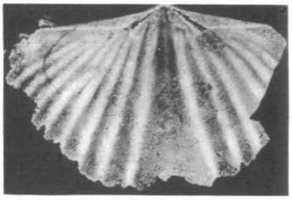

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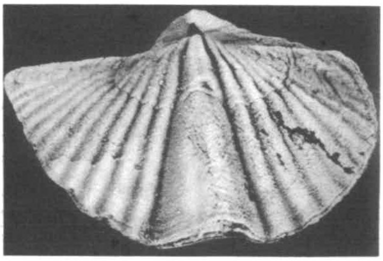

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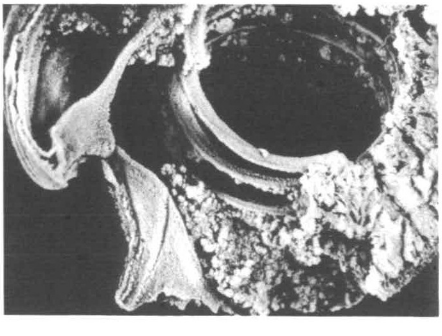

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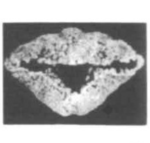

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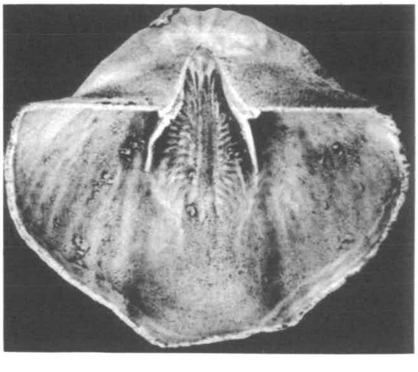

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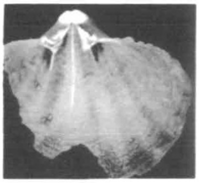
PLATE 27

Figures 1-19—*Howellella* aff. *Howellella textilis* Talent. 1, 2 and 3, Dorsal, anterodorsal and posterolateral views of pedicle valve ANU 18967a x2.5. 4, Interior of brachial valve CPC 10606 x4.6. 5, Portion of interior of brachial valve ANU 18967b x7. 6, Dorsal view of ANU 18967c x7. 7, Interior of pedicle valve ANU 18967d x3.3. 8, Dorsal view of brachial valve ANU 18967e x2.6. 9, Exterior of brachial valve ANU 18967f x2.3. 10, Portion of interior of brachial valve ANU 18967g x5. 11, Dorsal view of ANU 18967h x2.5. 12, Portion of exterior of ANU 18967e x10. 13, Interior of brachial valve CPC 10607 x2.3. 14, Interior of brachial valve ANU 18967g x2.3. 15, Interior of brachial valve ANU 18967e x3.8. 16, 17 and 19, Posterior, dorsal and lateral views of ANU 18967i x3. 18, Anterior view of ANU 18967i x2.4.

Figures 20-27—*Quadrithyrina allani* sp. nov. 20, Dorsolateral view of pedicle valve CPC 10610 x2.4. 21, Anteroventral view of brachial valve CPC 10611 x4.5. 22 and 23, Dorsal and posterior views of **holotype** ANU 18968 x2.3. 24, Ventral view of brachial valve CPC 10611 x4.5. 25, 26 and 27, Dorsal, anterior and lateral views of pedicle valve CPC 10610 x2.4.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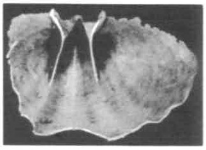
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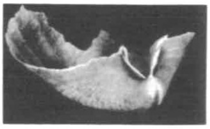
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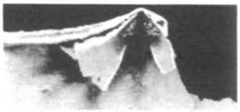
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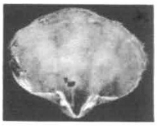
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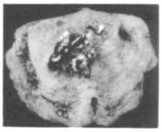
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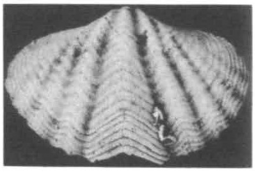
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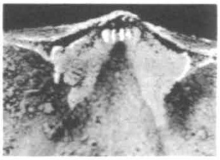
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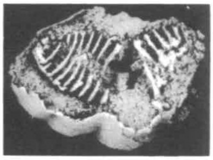
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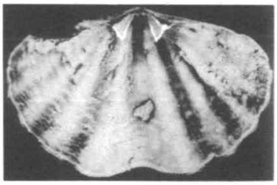
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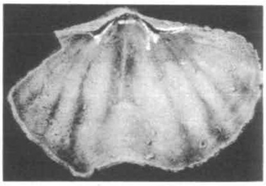
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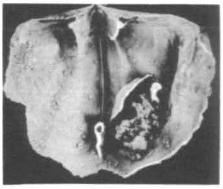
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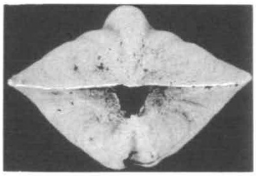
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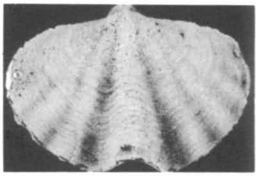
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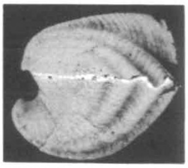
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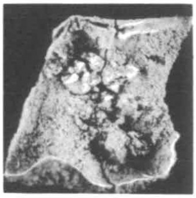
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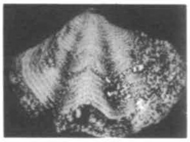
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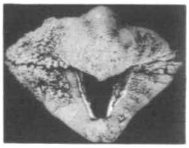
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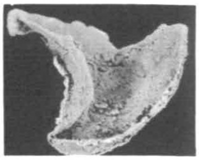
PLATE 28

Figure 1—*Quadrithyrina allani* sp. nov. 1, Interior of a portion of a small pedicle valve ANU 18969 x5.

Figures 2-14—*Cyrtinopsis* aff. *Cyrtinopsis cooperi* Gill. 2 and 3, Dorsal and posterodorsal views of small pedicle valve ANU 18970 x2.9. 4, Micro-ornament of ANU 18970b x6.5. 5, Dorsolateral view of pedicle valve ANU 18970c x0.7. 6, Anterior view of micro-ornament of ANU 18970b x6.5. 7, Micro-ornament x10. 8, Dorsal view of incomplete pedicle valve CPC 10608 x1.5. 9, Lateral view of pedicle valve ANU 18970c x1.6. 10, Portion of interior of brachial valve ANU 18970d x3.7. 11, Interior of brachial valve CPC 10609 x4. 12, Dorsal view of brachial valve ANU 18970e x1.7. 13, Posterodorsal view of pedicle valve ANU 18970c x1.6. 14, Dorsal view of worn fragment of pedicle valve ANU 18970f x2.4.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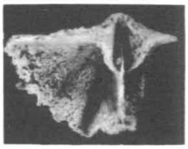
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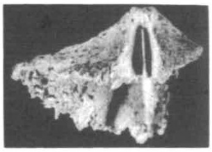
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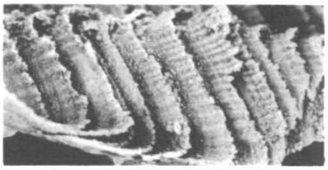
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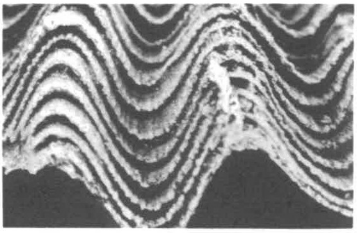
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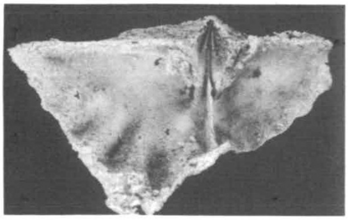
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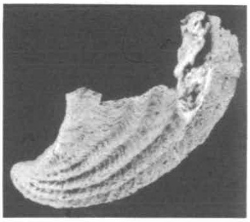
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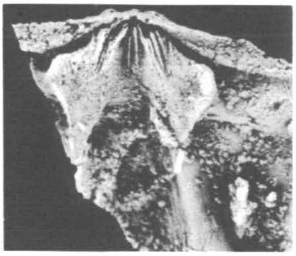
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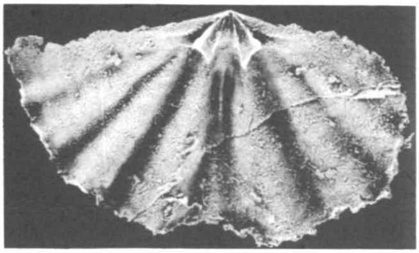
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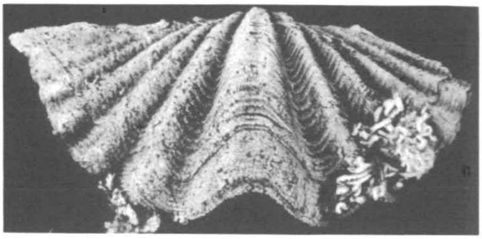
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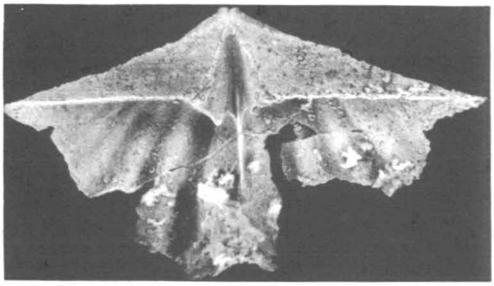
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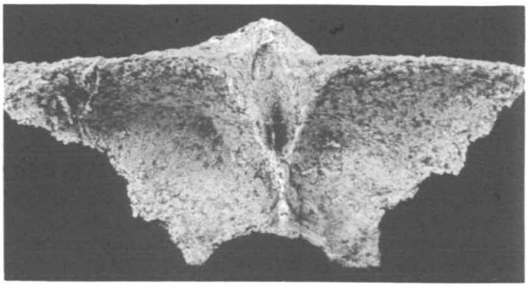
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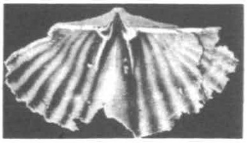
PLATE 29

Figures 1-10—*Hysterolites* sp. 1, Interior of pedicle valve ANU 18971a x2.2. 2, Exterior of pedicle valve ANU 18971b x 3. 3, Interior of pedicle valve ANU 18971c x3. 4, Interior of pedicle valve ANU 18971b x2.5. 5 and 6, Exterior and interior of brachial valve ANU 18971d x3.6. 7, Posterodorsal view of pedicle valve ANU 18971c x3. 8, Interior of brachial valve ANU 18971e x3.6. 9, Interior of pedicle valve ANU 18971f x2.8. 10, Anterior view of pedicle valve ANU 18971c x3.5.

Figures 11-20—*Athyris waratahensis* (Talent). 11 and 12, Ventral and lateral views of CPC 10574 x3.8. 13 and 14, Dorsal and lateral views of ANU 18972a x1.8. 15, Interior of a portion of brachial valve ANU 18972b x3.5. 16 and 17, Posterior and anterior views of ANU 18972a x1.8. 18, Interior of brachial valve ANU 18972c x3.8. 19, Anterodorsal view of pedicle valve ANU 18972d x3.5. 20, Dorsal view of pedicle valve x5.

Figures 21-33—*Delthyris hudsoni* sp. nov. 21, Lateral view of CPC 10593 x4.5. 22, Interior of brachial valve ANU 18973a x3.6. 23, Exterior of pedicle valve CPC 10594 x2.9. 24, Dorsal view of ANU 18973b x5.25. 25, Posterolateral view of ANU 18973b x5.25. 26, Anterior view of CPC 10593 x3.6. 27, Interior of brachial valve ANU 18973d x8. 28, Interior of portion of brachial valve ANU 18973a x11. 29, Exterior of pedicle valve ANU 18973e x3.3. 30, Dorsolateral view of **holotype** ANU 18974 x3. 31, Exterior of portion of pedicle valve ANU 18973e x12. 32 and 33, Posterodorsal and dorsal views of CPC 10595 x4.5,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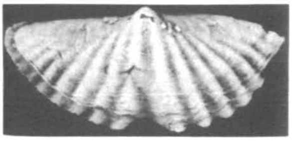
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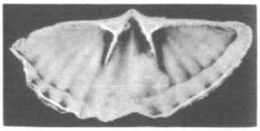
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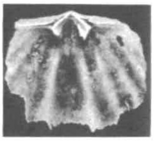
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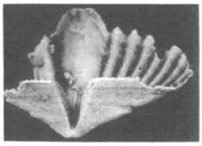
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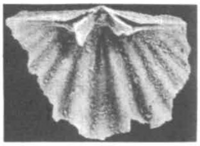
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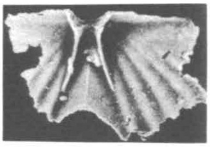
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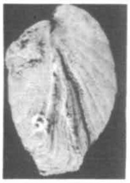
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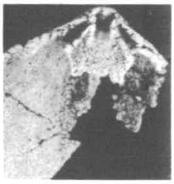
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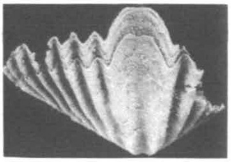
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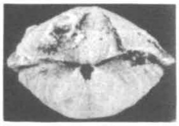
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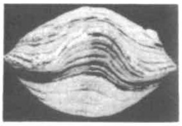
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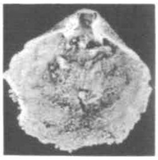
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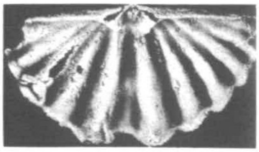
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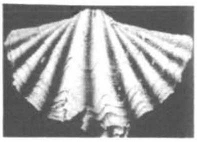
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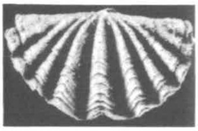
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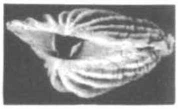
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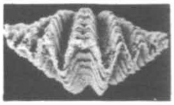
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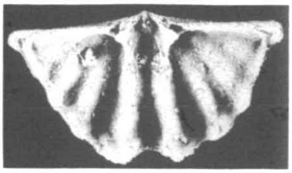
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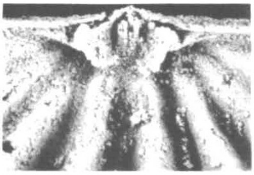
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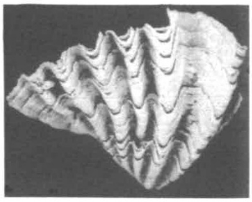
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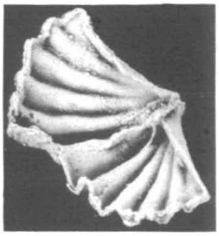
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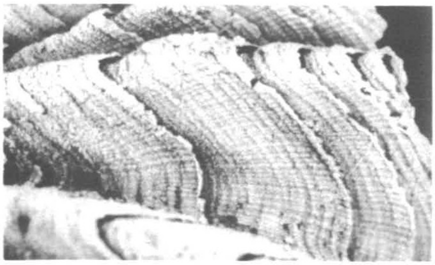
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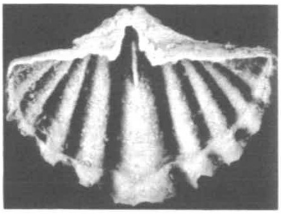
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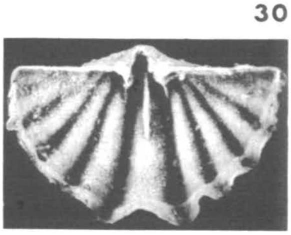
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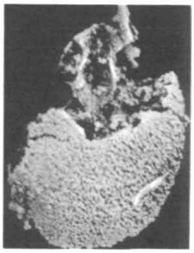
PLATE 30

Figures 1-15—*Micidus? glaber* sp. nov. 1, Ventral view of specimen with loop x10. 2, Interior of incomplete pedicle valve ANU 18975a x7.7. 3, Interior of brachial valve ANU 18975b x7.7. 4, Interior of brachial valve ANU 18975c x7.7. 4, Interior of brachial valve CPC 10637 x7.7. 6, Anterior view of **holotype** ANU 18976 x6. 7, Dorsal view of CPC 10638 x4.5. 8, Interior of brachial valve x6. 9, Anterodorsal view of pedicle valve ANU 18975a x7.7. 10, Interior of pedicle valve CPC 10639 x10. 11, Dorsal view of ANU 18975e x6. 12, Lateral view of ANU 18975d x5.5. 13, Ventral view of CPC 10640 x5.6. 14 and 15, Dorsal and lateral views of **holotype** ANU 18976 x5.

Figures 16-20—*Spinella yassensis* (de Koninck). 16, Micro-ornament of calcareous specimen from the '*Spirifer yassensis*' Limestone, ANU 18966l x10. 17, Micro-ornament on a rubber mould of a specimen from the '*Spirifer yassensis*' Limestone x10. 18, Anterior view of a rubber mould of a specimen from the '*Spirifer yassensis*' Limestone x5. 19, Anterior view of a silicified specimen from the '*Receptaculites*' Limestone, ANU 18966k x8. 20, Anterior view of micro-ornament in a rubber mould of a specimen from the '*Spirifer yassensis*' Limestone x14 (the spines are curved because the rubber was distorted upon removal from the external mould).

Figures 21-22—*Howitta multiplicata* (de Koninck). 21, Exterior of a portion of pedicle valve ANU 18965c x8.5. 22, Micro-ornament of a portion of pedicle valve ANU 18965c x25.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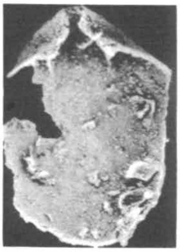
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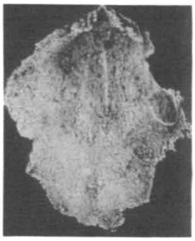
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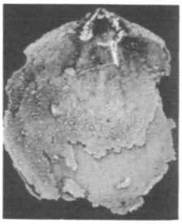
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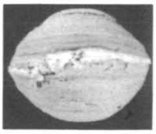
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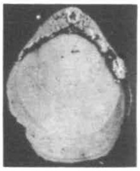
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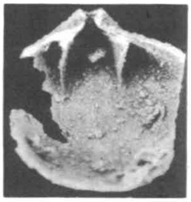
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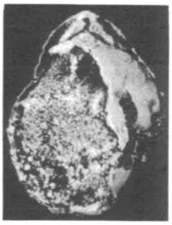
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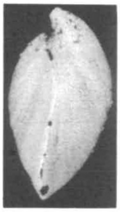
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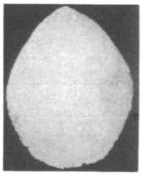
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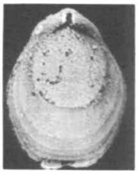
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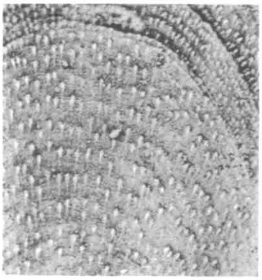
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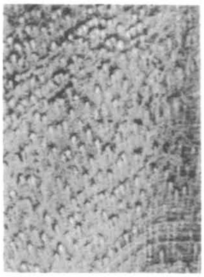
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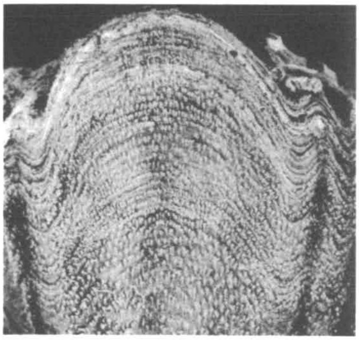
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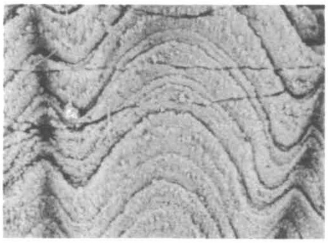
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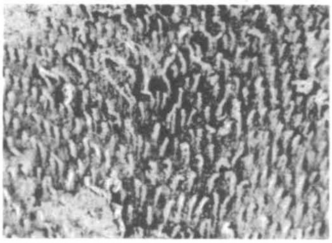
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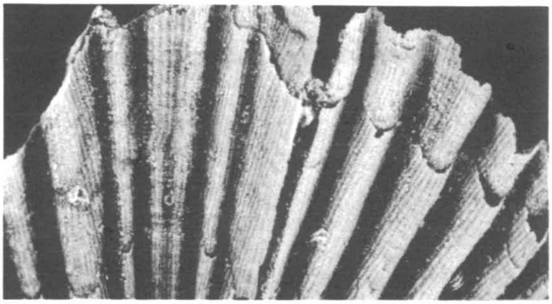
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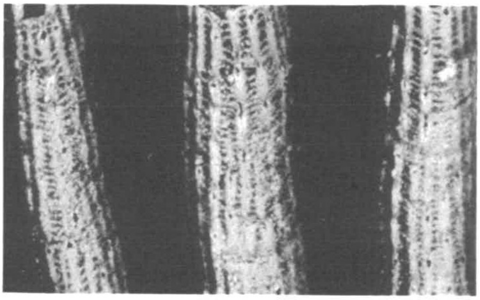
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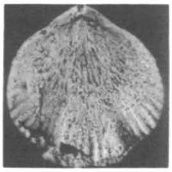
PLATE 31

Figures 1-22 and 27—*Eoglossinotoechia linki* sp. nov. 1 and 2, Dorsal and lateral views of ANU 18977a x3. 3, Dorsal view of CPC 10616 x3. 4 and 5, Lateral and dorsal views of **holotype** ANU 18977b x3. 8, Anterior view of CPC 10617 x3.5. 9, Interior of anterior portion of a specimen ANU 18977c x4.2. 10, Anteroventral view of incomplete brachial valve ANU 18977d x5. 11, Anteroventral view of brachial valve ANU 18977j x4. 13, Interior of a portion of brachial valve ANU 18977f x4.2. 14, Anterodorsal view of pedicle valve CPC 10618 x4.2. 15, Interior of pedicle valve ANU 18977g x3.5. 16, Dorsal view of ANU 18977h x3.5. 17, Dorsal view of CPC 10619 x3.5. 18, Ventral view of ANU 18977i x3.6. 19, Ventral view of ANU 18977j x4. 20, Interior of pedicle valve CPC 10620 x4.2. 21, Interior of brachial valve ANU 18977e x4.2. 22, Dorsal view of beak of ANU 18977k x10. 27, Dorsal view of ANU 18977l x4.

Figures 23-26 and 28-30—*Callipleura?* sp. 23, Ventral view of ANU 18979a x1.1. 24 and 25, Dorsal lateral views of incomplete brachial valve ANU 18979b x1.4. 26, Anterodorsal view of a portion of ANU 18979a x3.8. 28, Stereo pair. Dorsal view of ANU 18979a x1.5. 29, Dorsal view of CPC 10612 x2.3. 30, Anterior view of fragmentary specimen of posterior portions of a brachial and a pedicle valve, ANU 18979c x4.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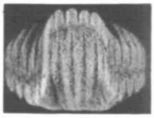
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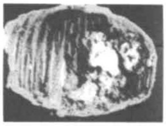
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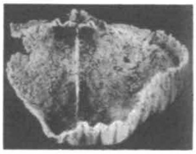
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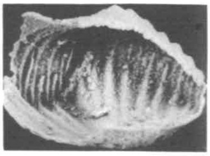
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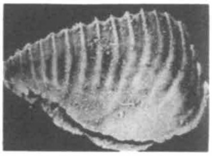
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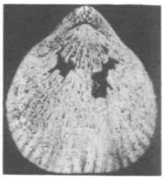
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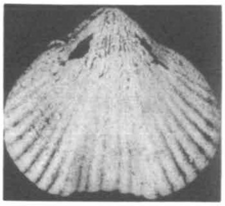
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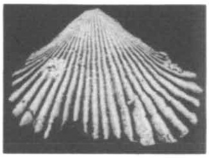
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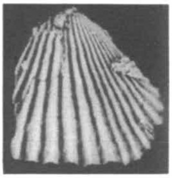
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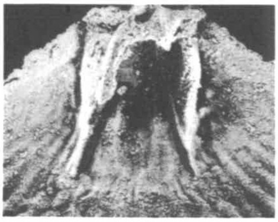
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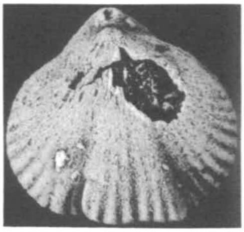
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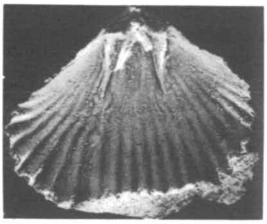
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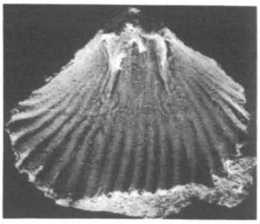
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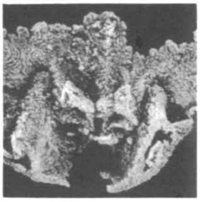
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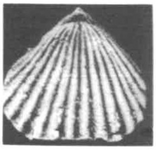
PLATE 32

Figures 1-24—*Browneella browneae* gen. et sp. nov. 1 and 2, Dorsal and lateral views of ANU 18981a x3.2. 3 and 4, Dorsal and lateral views of CPC 10613 x3.2. 5 and 6, Lateral and dorsal views of **holotype** ANU 18980 x3.2. 7 and 8, Dorsal and lateral views of ANU 18981b x3.2. 9, Anterior view of CPC 10613 x2.5. 10, Ventral view of **holotype** ANU 18980 x2.75. 11 and 12, Ventrolateral and ventral views of ANU 18981c x5. 13, Dorsal view of ANU 18981d x15. 14, Lateral view of CPC 10614 x3.2. 15, Interior of pedicle valve ANU 18981e x3.5. 16, Ventral view of ANU 18981f x9. 17 and 18, Lateral and dorsal views of **holotype** ANU 18980 x3.7. 19 and 22, Anterodorsal and dorsal views of pedicle valve ANU 18981g x5. 20, Dorsal view of portion of CPC 10615 x9.5. 21, Interior of brachial valve ANU 18981h x4.8. 23, Dorsal view of ANU 18981b x6. 24, Anteroventral view of ANU 18981i x7.25.

Figures 25-41—*'Pugnax' oepiki* sp. nov. 25, Dorsal view of ANU 18983a x5. 26, Dorsal view of CPC 10621 x2.2. 27, Dorsal view of ANU 18983b x2. 28 and 29, Dorsal and lateral views of ANU 18983c x 4.3. 30, 33 and 40, Dorsal, anterior and lateral views of **holotype** ANU 18982 x2.5. 31, Anterior view of ANU 18983d x3.1. 32, Anterior view of CPC 10622 x3.4. 34, Anterior view of ANU 18983e x3. 35, Dorsal view of ANU 18983f x4.3. 36, Anterodorsal view of fragmentary pedicle valve ANU 18983g x5.1. 37, Interior of brachial valve ANU 18983h x2.4. 38, Anterior view of CPC 10623 x3.1. 39, Lateral view of ANU 18983i x2.5. 41, Lateral view of CPC 10621 x3.6.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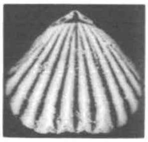
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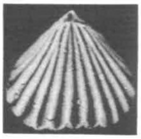
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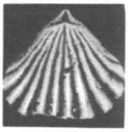
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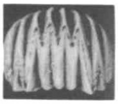
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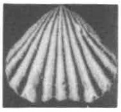
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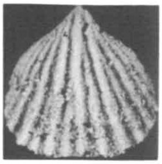
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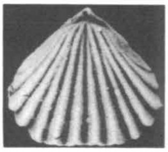
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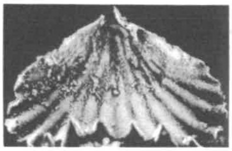
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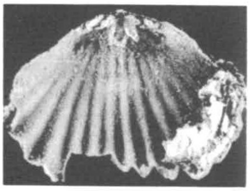
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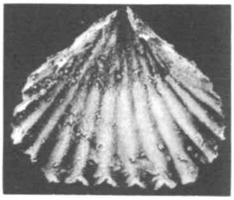
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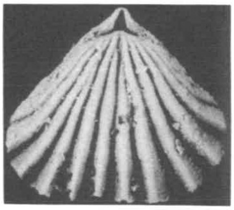
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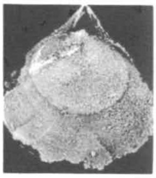
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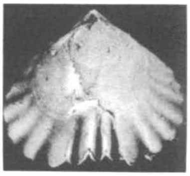
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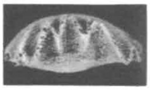
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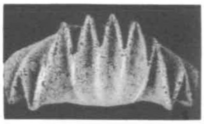
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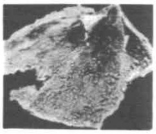
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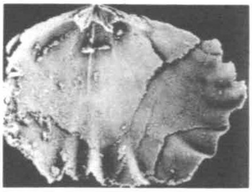
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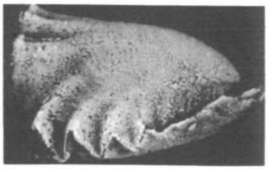
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PLATE 33

Figures 1-17—*Adrenia cernua* sp. nov. 1, Ventral view of ANU 18985a x6.1. 2, Ventral view of brachial valve ANU 18985b x8.4. 3, Ventral view of CPC 10626 x5.7. 4, Ventral view of ANU 18985c x9.25. 5, Anterior view of **holotype** ANU 18984 x3.5. 6, Anterior view of CPC 10626 x3.5. 7, Lateral view of specimen x3.5. 8, Dorsal view of CPC 10627 x6.1. 9 and 10, Ventrolateral and lateral views of ANU 18985d x4.6. 11 and 12, Ventral and dorsal views of **holotype** ANU 18984 x4.1. 13, Interior of brachial valve ANU 18985e x6.4. 14, Dorsal view of ANU 18985f x5.9. 15, Dorsal view of CPC 10628 x5.4. 16, Dorsal view of pedicle valve ANU 18985g x6.8. 17, Interior of brachial valve ANU 18985h x5.1.

Figures 18-32—*Adrenia expansa* gen. et sp. nov. 18, 19 and 20, Ventral, dorsal and lateral views of **holotype** ANU 18986 x3.8. 21, Lateral view of **holotype** x3.6. 22, Dorsal view of ANU 18987a x3.5. 23, Interior of brachial valve ANU 18987b x5.4. 24, Interior of a portion of ANU 18987c x11. 25, Dorsal view of a portion of ANU 18987a x11. 26, Interior of a portion of ANU 18987d x17.5 (specimen photographed under water to show punctae). 27, Interior of ANU 18987d x7.6. 28, Dorsal view of CPC 10624 x3.5. 29, Dorsal view of CPC 10625 x3.5. 30, Interior of a portion of brachial valve ANU 18987e x11.4. 31, Dorsal view of ANU 18987f x3.8. 32, Anterior view of **holotype** ANU 18986 x3.8.


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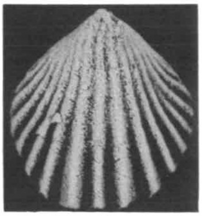
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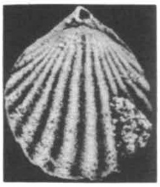
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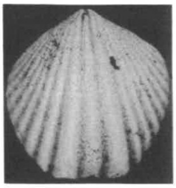
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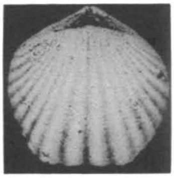
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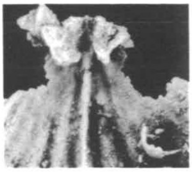
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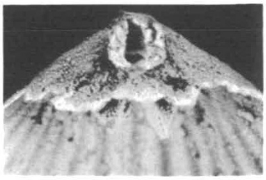
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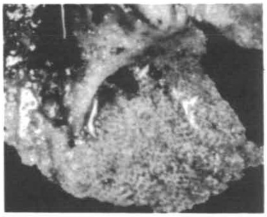
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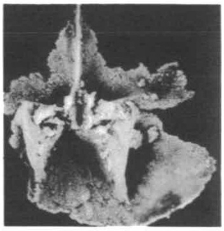
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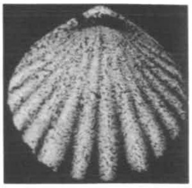
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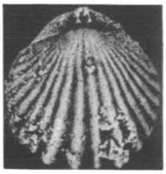
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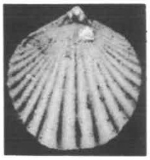
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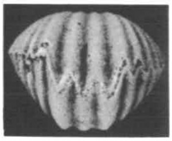
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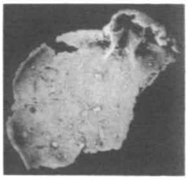
PLATE 34

Figures 1-12—*Micidus shandkyddi* gen. et sp. nov. 1, Interior view of ANU 18980a x4.6. 2, Dorsal view of ANU 18989b x4.8. 3, Dorsal view of small specimen x5.6. 4, Dorsal view of CPC 10635 x4.7. 5, Dorsal view of **holotype** ANU 18988 x4.7. 6, Ventral view of CPC 10636 x4.7. 7, Dorsal view of ANU 18989c x5.8. 8, Interior of incomplete pedicle valve ANU 18989d x11.3. 9, Dorsal view of ANU 18985e x5.5. 10, Ventral view of ANU 18985e x4.7. 11, Lateral view of ANU 18985f x4.7. 12, Dorsal view of ANU 18985g x4.7.

Figures 13-24—*Cydimia parva* sp. nov. 13, Lateral view of specimen x4.5. 14, Lateral view of ANU 18991a x4. 15, Dorsal view of CPC 10632 x5. 16, Dorsal view of ANU 18991b x6. 17, Ventral view of CPC 10633 x4.5. 18, Ventral view of ANU 18991a x4.25. 19, Dorsal view of ANU 18991c x4.1. 20, Dorsal view of ANU 18991d x5.8. 21, Dorsal view of CPC 10634 x5.8. 22, Dorsal view of ANU 18991e x5.8. 23, Dorsal view of **holotype** ANU 18990 x5. 24, Ventral view of ANU 18991f x8.

Figures 25-37—*Cydimia robertsi* gen. et sp. nov. 25, Anterior view of **holotype** ANU 18992 x3.6. 26, Anterodorsal view of fragments of a pedicle valve ANU 18993a x4. 27, Ventral view of CPC 10629 x3.5. 28, Interior of brachial valve ANU 18993b x5.3. 29 and 30, Lateral and ventral views of **holotype** ANU 18992 x3.6. 31, Dorsal view of CPC 10630 x3.5. 32, Dorsal view of ANU 18993c x3.5. 33, Dorsal view of ANU 18993d x3.5. 34, Dorsal view of fragmentary pedicle valve ANU 18993a x4. 35, Dorsal view of ANU 18993e x3.5. 36 and 37, Ventral and dorsal views of CPC 10631 x3.5.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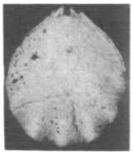
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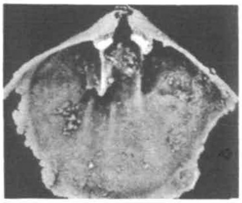
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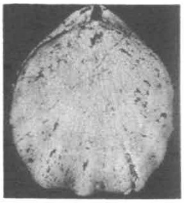
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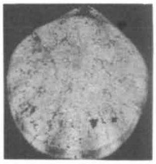
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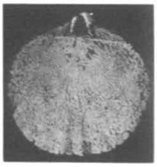
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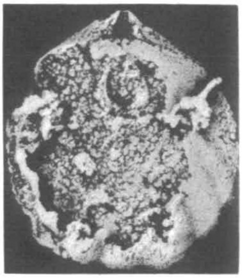
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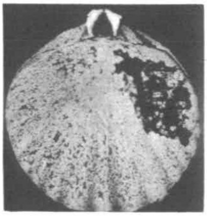
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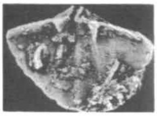
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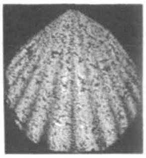
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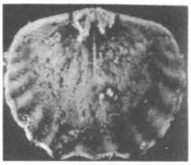
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PLATE 35

Figures 1-3—*Curranella careyi* gen. et sp. nov. 1, Interior of brachial valve CPC 10642 x3.2. 2 and 3, Dorsal and lateral views of CPC 10643 x3.

Figures 4-5—*Muriferella hillae* sp. nov. 4 and 5, Dorsal and lateral views of CPC 10645 x5.5.

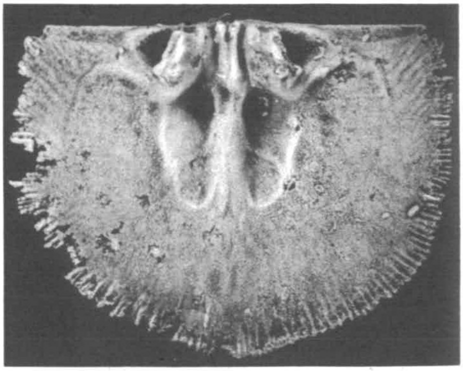
Figures 6-8—*Coelospira dayi* sp. nov. 6, Dorsal view of CPC 10648 x5. 7, Interior of pedicle valve CPC 10649 x5. 8, Interior of brachial valve CPC 10650 x5.

Figure 9—*Athyris waratahensis* (Talent). Lateral view of ANU 18998 x2. Note the jugal saddle, crura and part of the first whorl of a spiralium.

Figures 10-11—*Aulacella philipi* sp. nov. Interior of pedicle valve CPC 10646 x3. 11, Dorsal view of CPC 10647 x3.

Figures 12, 14—*Leptostrophia clarkei* sp. nov. 12, Posterior view of a portion of a brachial valve x8. 14, Exterior pedicle valve ANU 18994e x3.5.

Figure 13—*Isorthis spedeni* sp. nov. Interior view of pedicle valve CPC 10641 x30.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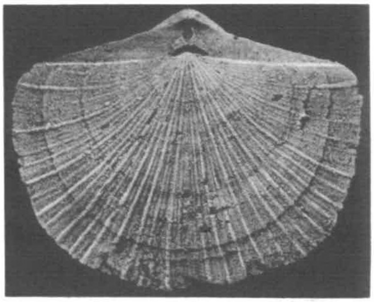
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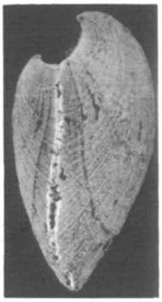
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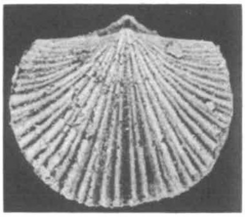
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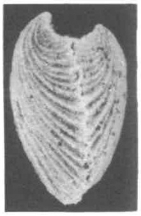
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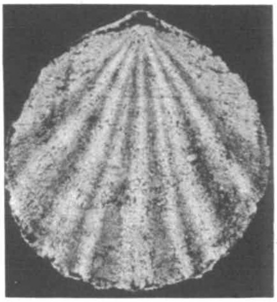
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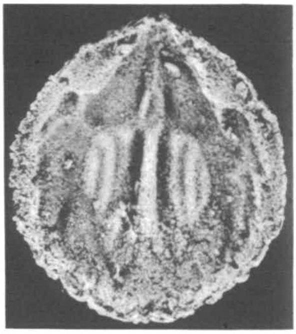
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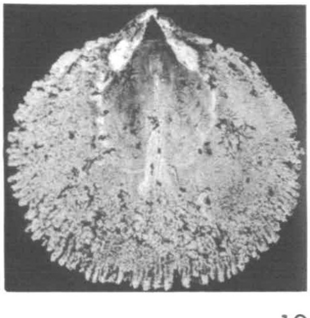
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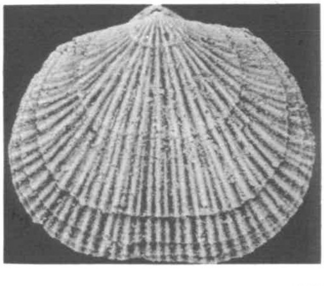
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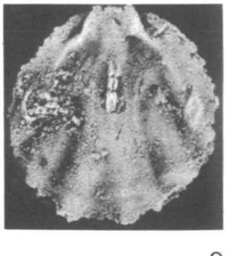
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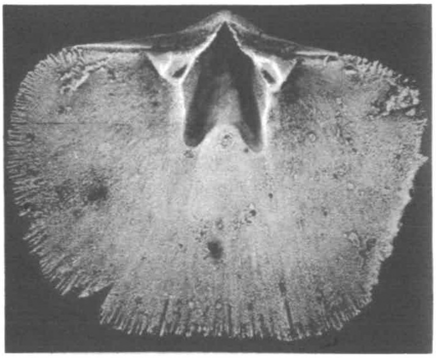
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