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DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BULLETIN 56

CARBONIFEROUS AND EARLY PERMIAN BRACHIOPODS FROM WESTERN AND NORTHERN AUSTRALIA

BY

G. A. THOMAS
University of Melbourne

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ERRATA SLIP FOR BULLETIN No. 56

ERRATA

P. 32 table 2, line 3, Add 'Ha' above 'V' and 'D'

P. 34, line 14, 'propsed' should be 'proposed'

P. 38, table 4, For S. weaberensis CPC 3657, dimension '9.70' should be '5.70'

P. 44, line 23, 'and' should be 'angle'

P. 50, line 22, 'alterations' should be 'alternations'

P. 69, line 32, Add 'of' before 'Kinghiria, and 'K. prima Litvinovitch,' before 'from'

P. 75, line 13, '24b, e' should be '24, a, b, c,'

P. 78, line 31, 'delthyrium' should be 'deltidium'

P. 86, table 9, W/L for CPC 1544 should be '1.61', not '0.61'

P. 92, line 8, 'sinal' should be 'sulcal'

P. 114, table 14, for CPC 1606, W/L should be '1.00', not '1.99'

P. 118, line 20, 'sinal' should be 'sulcal'

P. 124, line 24, '3' should be '4'

P. 126, line 17 'approximately' should be 'appropriately'

P. 127, line 9, Add '130' after 'p.'

P. 138, line 18, 'adminiculae' should be 'adminicula'

P. 178, Figure 67, 'CPC 1682' should be 'CPC 1683'

P. 182, line 14, 'CPC 3856' should be 'CPC 6115'

P. 188, Figure 73 legend, 'aff.' should be 'cf.'

Plate 28, Figure 4 is inverted

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SUMMARY

Most of the Carboniferous brachiopods (excepting productoids and rhynchonellids) so far collected from the Carnarvon, Canning (Fitzroy), and Bonaparte Gulf Basins of Northwest Australia are described. The faunas of the Bonaparte Gulf Basin are the least well represented.

Six Carboniferous brachiopod zonal assemblages are distinguished: two of Tournaisian, one of late Tournaisian to possibly Visean, two of Visean and one of late Visean to possibly Namurian age. The described faunas include species of *Rhipidomella, Leptagonia, Schellwienella, Schuchertella, Rugosochonetes?, Prospira, Unispirifer, Spirifer, Anthracospirifer, Ectochoristites?, Brachythyris, Kitakamithyris, Torynifer?, Syringothyris, Punctospirifer, Cleiothyridina, Composita,* and an unnamed new spiriferid genus. At least 23 species are new. Affinities with world-wide Dinantian faunas are suggested for the majority. The brachiopods are distributed through the Moogooree Limestone and Yindagindy Formations of the Carnarvon Basin, the Laurel Formation of the Fitzroy Basin, and the Burt Range Formation, Enga Sandstone, Septimus Limestone, Utting Calcarenite, Burvill Beds and Point Spring Sandstone of the Bonaparte Gulf Basin.

Four Permian spiriferacean species are also described from the Carnarvon and Canning Basins. They comprise the Sakmarian Lyons Group species *Trigonotreta narsarhensis occidentalis* subsp. nov., and *Cyrtella nagmargensis australis* subsp. nov., and the Artinskian *Pseudosyringothyris dickinsi* sp. nov. from the Callytharra Formation and *Pseudosyrinx? sinuosa* sp. nov. from the Madeline Formation. The species support a correlation of the Lyons Group with the Umaria beds of India, part of the Agglomeratic Slate of Kashmir, and early Permian beds of Arabia. Boreal affinities are suggested for *P. dickinsi* sp. nov.

Generic morphological features are discussed. Points of interest include the composite nature of the dental plates in *Schellwienella,* the initial dental plates of certain Spiriferidae, the adductor muscle attachment function of the syrinx in *Syringothyris* and the adductor muscle scars on the delthyrial plate in *Pseudosyringothyris.* The taxonomy of certain families is discussed, notably the Syringothyridae.

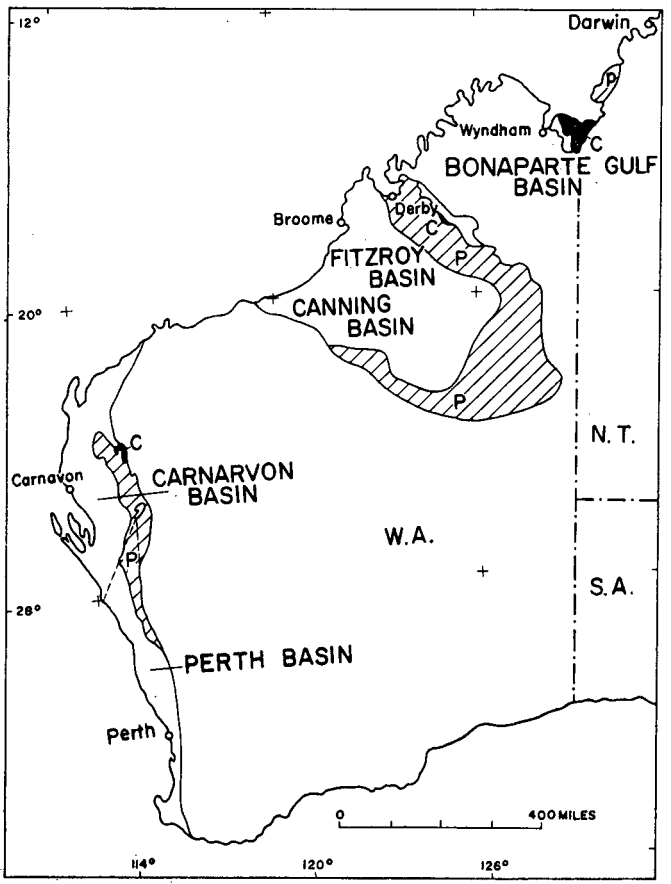

Fig. 1. Carboniferous and Permian outcrop in northwestern Australia.

INTRODUCTION

This Bulletin is a study of part of the Carboniferous and Permian brachiopod faunas from the sedimentary basins of northwestern Australia. The majority of the Carboniferous species (except for productoids and rhynchonellids) and four Permian spiriferaceans are described. They are from the Carnarvon, Canning (Fitzroy), and Bonaparte Gulf Basins. Collections described from the Carnarvon and Fitzroy Basins are fairly comprehensive, but the Bonaparte Gulf collections were greatly augmented in 1963 and 1964 and are now being analysed by J. Roberts of the Bureau of Mineral Resources. The numerous Permian brachiopods (mainly Spiriferida) so far undescribed from all three Basins are now being studied by the writer. Previous work on northwest Australian Carboniferous brachiopods includes that of Glenister (1955) on some of the spiriferaceans, Veevers (1959) on rhynchonellids, and Thomas (1965a) on *Delepinea*. The descriptions were originally prepared as part of a thesis submitted for the degree of Ph.D. at Melbourne University in January 1961. Collections obtained since 1960 are not described in this study.

Collections

Nearly all the specimens described are in the Commonwealth Palaeontological Collection in Canberra. Collections have been made by myself and colleagues of the Bureau of Mineral Resources. Other specimens have been provided by West Australian Petroleum Pty Ltd, Westralian Oil Ltd, and Mines Administration Ltd. A few are from the collections of the Geology Department, University of Western Australia. I gratefully acknowledge my indebtedness to the administration and staff of all these institutions. Specimens in the Commonwealth Collection are housed in the Bureau of Mineral Resources in Canberra. Their numbers are preceded by the letters CPC or F. Specimens from the University of Western Australia have numbers preceded by UWA.

Terminology, Morphology, and Classification

The terminology is for the most part standard. Generally the terms used by Cooper (1944) are followed. Commonly the terminology outlined in the Treatise on Invertebrate Paleontology, Part H, is adopted, but not invariably. Special or new usages are indicated in the chapters introducing orders, superfamilies, or families; thus the terminology for the Spiriferacea is reviewed on p. 50. The morphology and classification in the groups where the Treatise is followed are not discussed in detail, but where there is a different viewpoint this is discussed more fully.

Methods

Measurements of specimens were made in the conventional manner for length and width; maximum thickness was measured at right angles to the 'plane' of commissure where obvious or to a line joining the middle of hinge-line and

front commissure. The abbreviations used in the tables of dimensions for species are listed in Table 1. Graphical scatter plots, to the nearest half millimetre, are provided for many species. They are intended to supplement the descriptions. The length of the median curved surface of the ventral valve of spiriferid species, including growth stages, was recorded where possible.

TABLE 1: ABBREVIATIONS USED IN TABLES OF DIMENSIONS

L	length of ventral valve
Lc	length of ventral valve on curved median surface
Lb	length of dorsal valve
Lbc	length of dorsal valve on curved median surface
Whl	width at hinge line
Wm	maximum width
T	thickness of shell
Ha	height of interarea
Dw	width of delthyrium at hinge line
Da	delthyrial angle
Aa	apical angle
Pa	perideltidial angle
Wsf	width of sulcus in front
Wff	width of fold in front
I	inclination of interarea to line joining middle of hinge line and middle of front commissure
S	sulcus
Lms	length of ventral diductor muscle scars
Wms	width of ventral diductor muscle scars
DPa	angle of inclination of dental plates
Ldp	length of dental plates
Lmsd	length of dorsal muscle scars
Wmsd	width of dorsal muscle scars
CPa	angle of inclination of crural plates
e	estimated
c.	circa

Transverse sections (Text-figs 8, 13, 17, 18, 24, 29, 34, 35, 37, 39, 40, 44, 47, 48, 50, 52, 55, 56, 58, 61, 63, 64, 67) are measured in cm from the umbonal apex.

Longitudinal sections are measured in cm from the middle surface of the dorsal valve.

Parallel serial sections were ground and etched in the usual manner. The specimens were embedded in a clear cold-setting plastic ('Plastrene'). Peels were made of the etched surfaces on sheet 'celluloid' moistened with a solution of 'celluloid' in amyl acetate and acetone under the pressure of a finger clamp. The peels were projected on to photographic paper. Outlines were accurately traced; oriented calcite fibres, laminae, and crystalline structures are shown semi-diagrammatically. Some sections are shown in outline only. Transverse sections are shown with dorsal valve on top. Sketches of the profile and front views were made with the aid of a camera-lucida and are included in the text-figures for each species; they are usually not separately referred to in the text.

ACKNOWLEDGMENTS

I acknowledge with pleasure the help of many members (mostly former colleagues) of the Bureau of Mineral Resources, Canberra, in particular Drs J. M. Dickins, J. Roberts, J. J. Veevers, and A. A. Öpik, Mr S. D. Henderson, Mr K. A. Townley, and Mr E. H. Morgan.

Of the many from whom assistance has been obtained, I wish to thank particularly Dr G. A. Cooper, for helpful discussion and the use of collections, while I was a Senior Visiting Research Associate at the Smithsonian Institute, Washington in 1967. Valuable discussion was also held with Dr R. E. Grant of the United States Geological Survey, Washington. Dr K. S. W. Campbell of the Australian National University, Professor D. Hill and Dr W. G. H. Maxwell of the University of Queensland, and Professor R. T. Prider and Dr P. J. Coleman of the University of Western Australia are all thanked for the use of collections and for information. Dr E. P. Utting, consultant geologist of Perth, formerly Chief Geologist of Westralian Oil Ltd, is gratefully thanked for valuable collections and stratigraphic information, as are Dr J. Glover, now at the University of Western Australia and formerly with Mines Administration Ltd, Brisbane, and Dr W. H. R. McWhae of West Australian Petroleum Ltd, Perth.

I wish to thank all the following for access to collections while I was travelling early in 1968; Professor B. Kummel of the Museum of Comparative Zoology, Harvard University; Professor C. MacClintock and Mrs M. Dasch of the Peabody Museum, Yale University, who kindly lent specimens; Professor H. B. Whittington and Dr C. L. Forbes, of the Sedgwick Museum, Cambridge University; Professor H. K. Erben and Dr G. Plodowski (also thanked for helpful discussion) of Bonn University; Professor T. Birkelund of the Mineralogical Museum of the University, Copenhagen, and Dr V. Jaanusson, then at the Swedish Natural History Museum, Stockholm, who kindly lent specimens. Dr C. H. C. Brunton, British Museum (Natural History) was particularly helpful with discussion and presentation of plastotypes. Dr A. Vandercammen of the Institut royal des Sciences naturelles de Belgique, Bruxelles, was also helpful.

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In India, Mr M. V. A. Sastry and Mr S. C. Shah kindly showed me the valuable classic collections of the Geological Survey of India, in Calcutta. Mr Shah was very helpful in discussion problems of Indian stratigraphy.

I am grateful for discussion and encouragement to Dr O. P. Singleton and Professors E. S. Hills and C. M. Tattam of Melbourne University.

STRATIGRAPHY

The brachiopods described in this bulletin were collected in the Carnarvon, Canning, and Bonaparte Gulf Basins. The relevant stratigraphy (including biostratigraphy) of the Carboniferous and Permian rocks is briefly reviewed. The affinities and ages of the brachiopods are discussed in a later chapter.

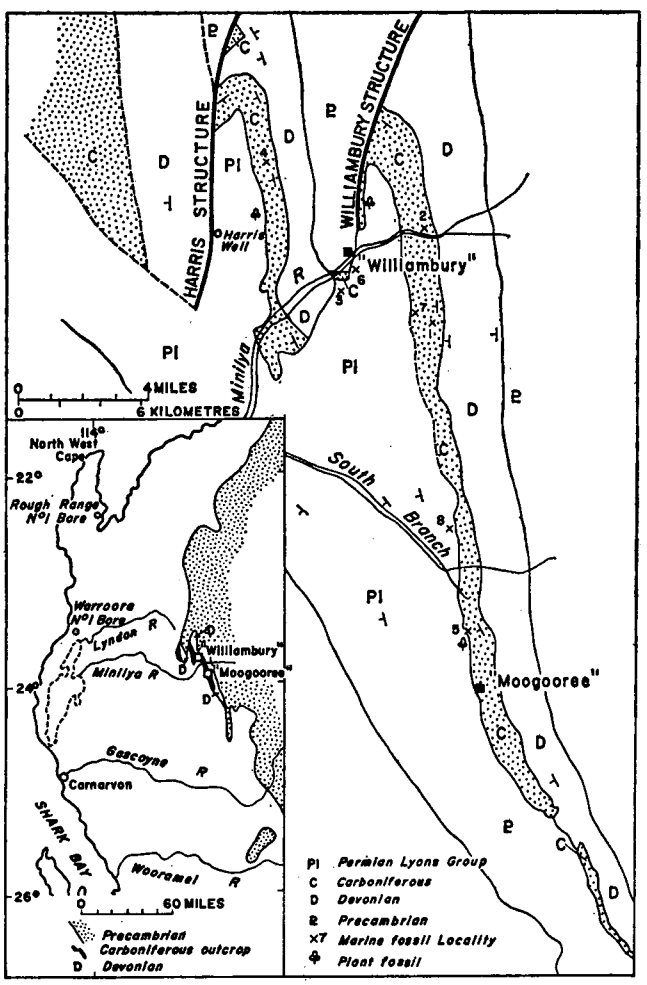

Fig. 2. Upper Palaeozoic outcrop and Carboniferous localities in the Carnarvon Basin.

DISTRIBUTION OF BRACHIOPOD SPECIES IN THE CARNARVON, CANNING, AND BONAPARTE GULF BASINS

	MOOGOOREE LIMESTONE	YINDAGINDY LIMESTONE	LAUREL FORMATION	SEPTIMUS LIMESTONE (Mt Septimus)	SEPTIMUS LIMESTONE (near Spirit Hill)	BURVILL BEDS	BURT RANGE FORMATION Sandy Creek	BURT RANGE FORMATION Flapper Hills	BURT RANGE FORMATION Spirit Hill	BURT RANGE FORMATION NW of Burt Ra	ENGA SANDSTONE
Rhipidomella michelini?	x		x	x	x			?	?		x
Leptagonia analoga				x							x
Schuchertella dorsiplana			x								
Schellwienella minilyensis	x										
Schellwienella cf. minilyensis			x								
Schellwienella australis				x							
Schellwienella aff. australis				x							
Schellwienella weaberensis						x					
Rugosochonetes? sp. A.			x								
Rugosochonetes? sp. B.							?	x	x	?	
Prospira laurelensis			x								
Prospira aff. laurelensis	x										
Prospira travesi				x							
Prospira? incerta							x	x	x	x	
Unispirifer fluctuosus	x		x								
Unispirifer septimus				x							
Unispirifer cf. septimus					x						
Spirifer spiritus			x		x						
Spirifer sp.				x							
Anthracospirifer milliganensis						x					
Anthracospirifer aff. milliganensis						x					
Ectochoristites? arenatus							x	x	x	x	
Ectochoristites? arenatus var. latus							x				
Ectochoristites? sp. nov.						x					
Brachythyris cf. peculiaris				x							
Brachythyris latercardinalis				x							
Kilakamithyris moogooriensis	x										
Torynifer? dorsiseptatus				x							
Spiriferidae gen. et.sp. nov. cf. S. duplicicostus						x					
Syringothyris spissus	x										
Syringothyris sp. nov. A				x							
Syringothyris sp. nov. B						x					
Spiriferidina gen. et sp. ind			x								
Punctospirifer plicatosulcatus	x		x								
Punctospirifer uttingi				x							
Punctospirifer mucronatus	x			x							
Punctospirifer sp. nov.	x										
Cleiothyridina minilya	x		x	x	x						x
Cleiothyridina gloveri							x				
Cleiothyridina cf. gloveri				x	x						
Cleiothyridina? sp. nov.					x						
Composita carnarvonensis	x										
Composita hendersoni			x								
Composita bonapartensis				x	x						
Composita variabilis		x									

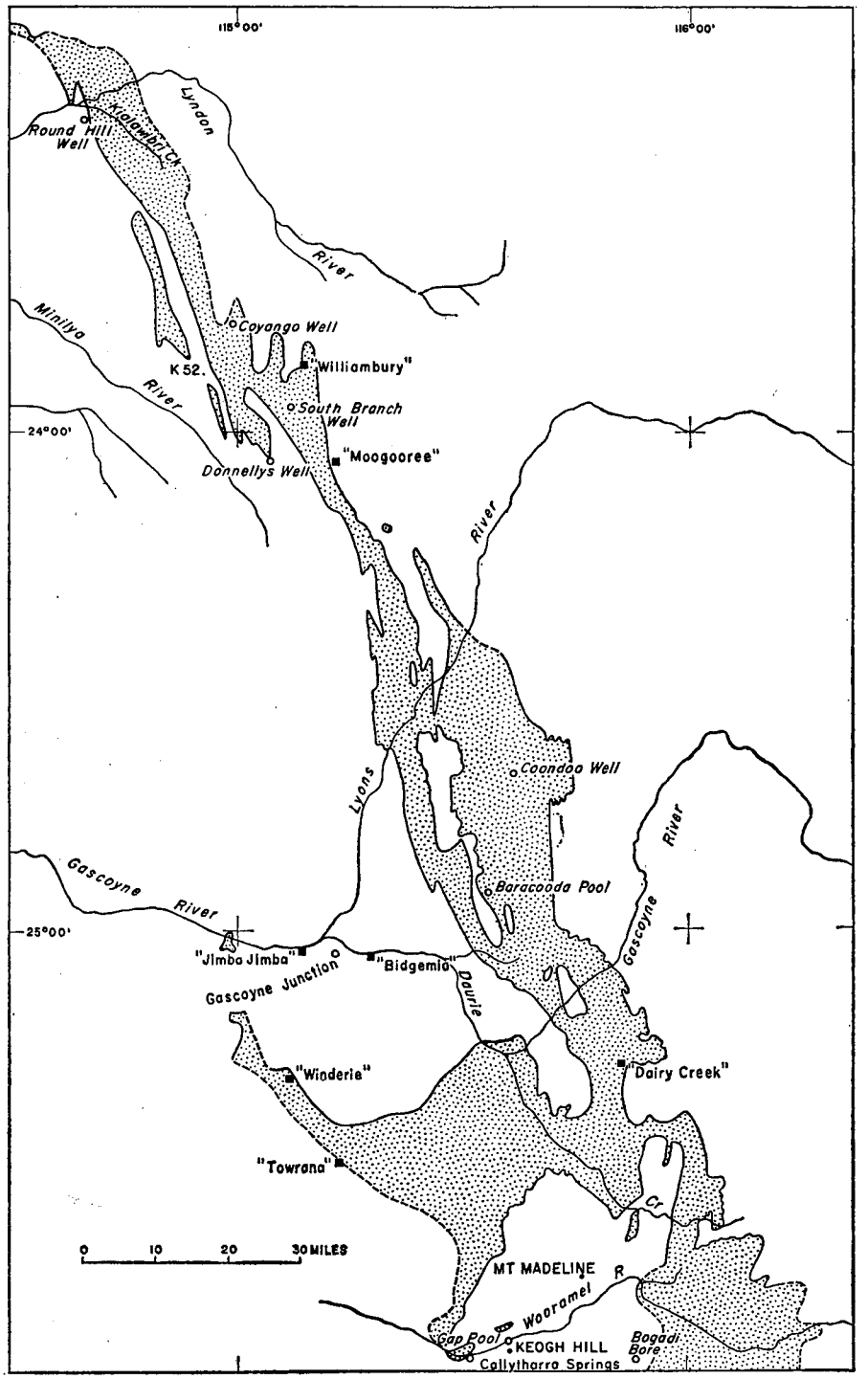

Fig. 3. Distribution of the Lyons Group between the Lyndon and Wooramel Rivers.

Carnarvon Basin

Late Devonian and Carboniferous outcrops are known only from the eastern edge of the Basin (Text-fig. 2). The succession has been discussed by Teichert (1949, 1950), Condon (1954, 1965), McWhae et al. (1958), and Thomas (1962b). The late Devonian to Carboniferous beds in ascending order comprise: the Willaraddie Formation, Moogooree Limestone, Williambury Formation, Yindagindy Formation.

Under the Willaraddie Formation is the unfossiliferous Munabia Formation, which overlies the Gneudna Formation which contains a rich Frasnian neritic fauna. The Willaraddie and Williambury Formations consist of coarse to fine cross-bedded arenaceous sediments and so far have not yielded identifiable fossils. The Moogooree Limestone lies disconformably to unconformably on the Willaraddie Formation and consists of well bedded calcarenite with rare dolomitic and oolitic beds. The lower and upper beds are friable and poorly exposed. Much of the formation is poorly fossiliferous, but fossils are rich at certain levels. The faunas described herein come mainly from the type section (Text-fig. 2, locality 1) and from beds at locality 2 on the Minilya River. Condon (1965, fig. 25) has recalculated the type section as 1070 feet thick. The richest fossiliferous sequences occur from about 460 to 560 feet above the base. Most brachiopods are silicified, and fairly well preserved; both isolated valves and complete shells are present. At about 730 feet above the base less well preserved brachiopod moulds and casts occur in dolomitic rock. The isolated outcrop locality 3 also provided specimens.

Brachiopods predominate in the faunas. They are accompanied by fenestellids, ostracods, and *Syringopora* sp. in the beds from 460 to 560 feet. *Syringopora* also occurs in scattered masses (about 2 feet across) near the top of the formation. The lowest known fossil collection, at 140 feet, is listed in Thomas (1962b, p. 735). It contains gastropods, pelecypods, indeterminate ostracods, and *'Camarotoechia' amnica* Veevers, which also occurs higher. So far only the brachiopod faunas have been studied in detail. As discussed below they indicate a Tournaisian age.

The Yindagindy Formation overlies the Williambury Formation conformably and transitionally. It has a maximum thickness of about 380 feet and consists of tough dense calcarenite and interbedded soft friable beds. Scattered pebbles are common. It contains a small varied infraneritic fauna consisting of several small brachiopod species, ostracods, bryozoa, euomphalid gastropods, and *Spongiostroma*-like algae. The impoverished brachiopod fauna is inadequate for definitive correlation but is suggestive of a Visean age. The other faunas have not been studied in detail.

No Upper Carboniferous marine rocks are known. The Yindagindy Formation is overlain unconformably by the marine Lyons Group (Sakmarian) or in places by the non-marine Harris Sandstone at the base of the Lyons Group.

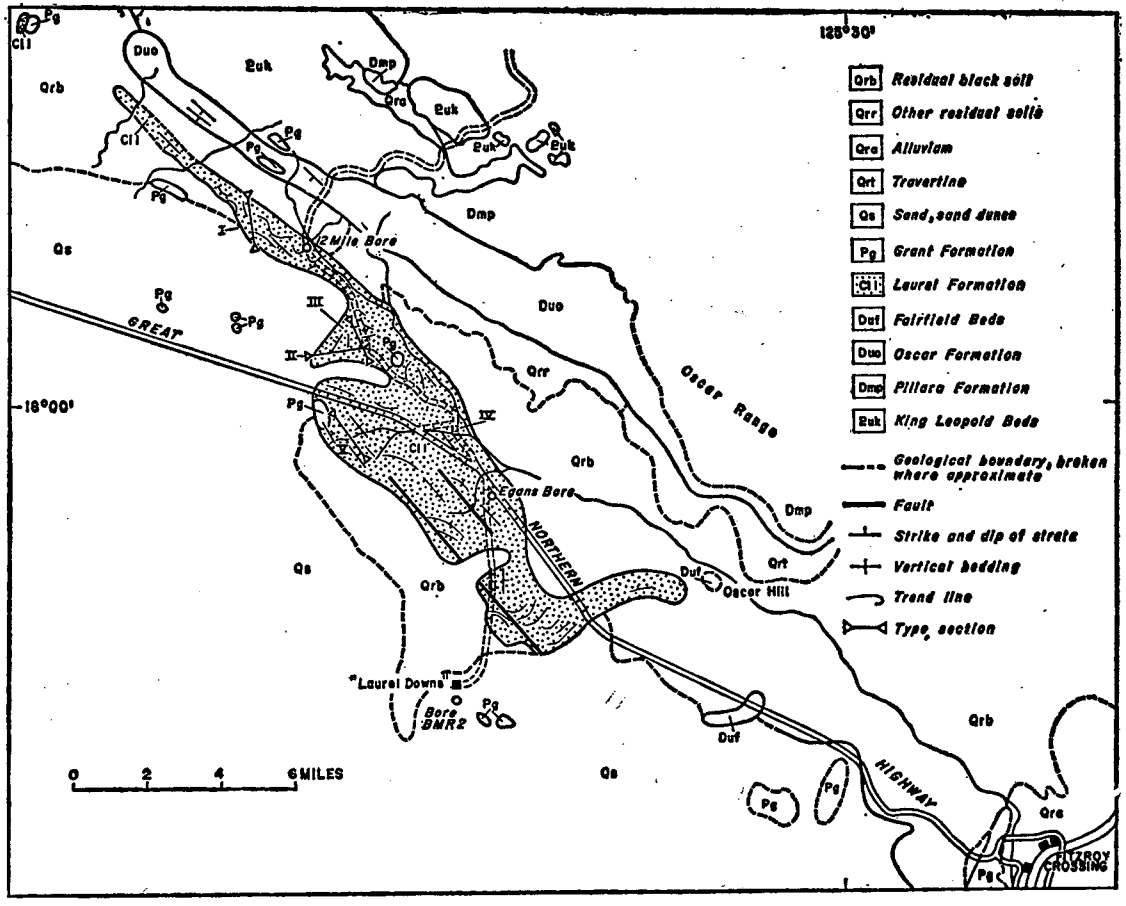

Fig. 4. Carboniferous outcrops and specimen localities in the Canning Basin.

Lepidodendroid plants of possibly Upper Carboniferous age characterize the Harris Sandstone. The Lyons Group (Text-fig. 3) consists of marine partly glacigene sediments which attain a thickness of 4600 feet (Condon, 1954). The faunas are distributed throughout the sequence and were reviewed by Dickins & Thomas (1959), who considered them to be of Sakmarian age.

The higher Permian sequence has been described by Condon (1954), McWhae et al. (1958), and Konecki et al. (1958). Comparative sections for the northern and southern parts of the Carnarvon Basin as well as other West Australian basins are shown in Text-figure 7, reproduced from Dickins (1963, fig. 2), who has described many of the Permian molluscan fossils. References to Permian stratigraphy can be found in Dickins. Four Permian spiriferacean species are described here.

Canning Basin

Lower Carboniferous outcrops occur in the area south of the Oscar Range (Text-fig. 4). These were preliminarily mapped by Thomas (1957a, 1959) and named the Laurel Formation. Thomas recorded about 1500 feet of section made up of two overlapping sections. Thickness estimates were stated to be subject to revision. Two lithological members were distinguished. The lower 750 feet of beds are incompletely exposed; the outcrops are mainly grey sandy poorly fossiliferous calcarenites. The upper 750 feet are interbedded grey siltstone and yellowish calcarenite with a rich varied neritic fauna. This is dominantly of brachiopods but includes also pelecypods, solitary Rugosa, *Michelinia* sp. and small *Syringopora* masses, Bryozoa, Ostracoda, conodonts, sharks' teeth, and rare ammonoids. Preservation of the brachiopods is fair, with both complete shells and isolated valves.

Some additional unpublished mapping of the Laurel Formation was done by F. Williams and M. McKellar of West Australian Petroleum Ltd in 1957, but there is need for detailed mapping and collecting in the beds to establish the relationship with the Upper Devonian formations. Thomas (1959, 1962b, and herein) considers that the brachiopods of the upper member are Tournaisian in age. A Lower Carboniferous age was supported by the work on ostracods by Jones (1959, 1961; see also Thomas, 1959, 1962a). Jones considered that ostracods from outcrop at locality IV (Text-fig. 4) and from 250 to 1010 feet in BMR 2 Laurel Downs bore, close to the outcropping area, showed Chester affinities. Balme (1960, 1964) and F. M. Fowler (quoted in Playford & Lowry, 1966, p. 95) have described Lower Carboniferous spores from BMR 2 bore and Meda No. 1 and No. 2 bores. Hill, as quoted in Thomas (1959), identified *Syringopora* sp. ex *S. reticulata* Goldfuss (Lower Carboniferous) from the base of the formation and also from the upper member. A Lower Carboniferous age was also seemingly supported by conodont identifications by Glenister (1960, p. 215) from the Laurel Downs bore and from a surface locality near 12 Mile Bore which he regarded as of Middle Mississippian age, not older than late

Osagean. 12 Mile Bore is in the lower member. Glenister also reported rare specimens of the Tournaisian ammonoid *Imitoceras rotatorium* (de Koninck) from a locality apparently near IV of Text-figure 4. More recently Glenister & Klapper (1966) have described conodonts from the Geological Survey of Western Australia locality 3240, a spot collection, which appears also to be close to locality IV. They recorded *Spathognathodus aculeatus, ?Scaphignathus velifera, Polygnathus glabra* subsp. indet., and *Prioniodina? smithi,* and 'Imitoceratid n. gen.', each represented by one to three specimens, from GSWA 3240. Glenister & Klapper placed the assemblage in their topmost Devonian conodont zone, which is correlated with the 'Lower or Middle *Spathognathodus costatus* zone' of the German succession. They also recorded locality 3240 as part of the Fairfield Beds. They did not refer to Glenister's earlier identification of Mississippian conodonts or to *Imitoceras rotatorium* (de Koninck). Glenister is quoted in Playford & Lowry (1966, p. 95) as regarding the latter as a new genus of Imitoceratidae.

The fauna listed in Thomas (1959, p. 27) from locality IV was collected by me from KC13, and by S. D. Henderson from nearby SDH8, which is probably from the same bed. Locality IV is about 4 miles from type section II of the upper member, and its stratigraphical relationship to it has not been established. This is true also of collections from near Egans Bore. The brachiopods from IV and near Egans Bore are different generically and specifically from those of the Fairfield Formation elsewhere in the Canning Basin and show distinct Tournaisian affinities. Most of the species also occur in section II (in the upper member), which contains a more varied brachiopod fauna of definitely middle to late Tournaisian aspect and which indicates a correlation with the Moogooree Limestone.

Brachiopods and other macrofossils are sparsely represented in my collections from the lower member, but the few brachiopod species appear to be conspecific with forms in the upper member. J. Roberts (pers. comm.) collected, in 1966, conodonts and macrofossils from both members. He considers that the brachiopods, and conodonts (identified by E. C. Druce), from the lowest exposed beds are correlated with fossils from about the middle of the Burt Range Formation (between 625 and 700 feet above the base) of upper Cu I age. He advises that the majority of species listed by me from the upper member also occur in the upper part of the Burt Range Formation. E. C. Druce (pers. comm.) reports that the conodonts of the upper part of the formation suggest a correlation with the lower part of the Enga Sandstone (Tournaisian, Cu II$_\alpha$ age—Jones & Druce, 1966).

The relationships of the Laurel Formation and the Famennian Fairfield Formation are in need of definitive study. Thomas (1959, 1962b) suggested the possibility of an unconformity between them. Playford & Lowry (1966, p. 92-3) have suppressed the name Laurel Formation and included the beds in the Fairfield Formation, which is said to range from late Famennian to Tournaisian

in age. They show very little detail in their map (pl. 2) of the area, south of the Oscar Range, originally mapped as Laurel Formation (Thomas, 1959). They state (p. 93) that they found it impracticable to map the Laurel Formation as a separate rock unit. I do not consider that they have established the lithological equivalence of the Laurel Formation, especially the upper member, with the widespread Fairfield 'Beds' described by Guppy et al. (1958) and Veevers & Wells (1961). Outcrops of the Fairfield Formation, not including the Laurel Formation as shown in Text-figure 4, have yielded only Famennian fossils. These include a rich Famennian brachiopod fauna—the *'Avonia' proteus* zone of Veevers (1959). The costate Spiriferida have lately been studied by M. J. Garratt and myself. They are rich in Cyrtospiriferidae of Famennian aspect. Glenister & Klapper (1966, p. 782) show the conodonts to be of Upper Devonian toIV-toV age. Playford & Lowry (1966, p. 94-5) list the Upper Devonian corals described by D. Hill, and the bryozoans described by J. R. P. Ross. They also list the Devonian ostracods recorded by P. Jones and the spores recorded by B. E. Balme and C. W. Hassall from bores.

The faunas recorded from outcrops of the Laurel Formation are Tournaisian. The brachiopods indicate a middle Tournaisian age and suggest a considerable age difference between the outcropping Laurel and Fairfield Formations. Consequently two formations are distinguished in this study.

The Laurel Formation is overlain in the type area by unfossiliferous sandstone beds which have been referred to the Grant Formation of Lower Permian age. Subsurface occurrences of Lower Carboniferous rocks are discussed in Thomas (1962b), Veevers & Wells (1961), Jones (1959, 1961), Glenister (1960), and Playford & Lowry (1966). Upper Carboniferous (Westphalian?) rocks are known only in the subsurface and are described in McWhae et al. (1958) and Veevers & Wells (1961).

The Permian stratigraphy has been reviewed in Veevers & Wells (1961). One brachiopod species, *Pseudosyringothyris dickinsi* sp. nov., is described here from the lower beds of the Poole Sandstone in the St George Range. This species supports the evidence for correlation of the basal Poole Sandstone and the Callytharra Formation. It is present also in the Cuncudgerie Sandstone at Well 27 on the Canning Stock Route.

Bonaparte Gulf Basin

The Upper Palaeozoic sequences of the Bonaparte Gulf Basin have lately been studied in detail by geologists of oil companies and of the Bureau of Mineral Resources. The Carboniferous stratigraphy was reviewed by Thomas (1962a), mainly on work up to 1958. Veevers, Roberts, Kaulback, & Jones (1964) have summarized later work and the sequence has been analysed in detail by Veevers & Roberts (1968). Jones & Druce (1966) have outlined the

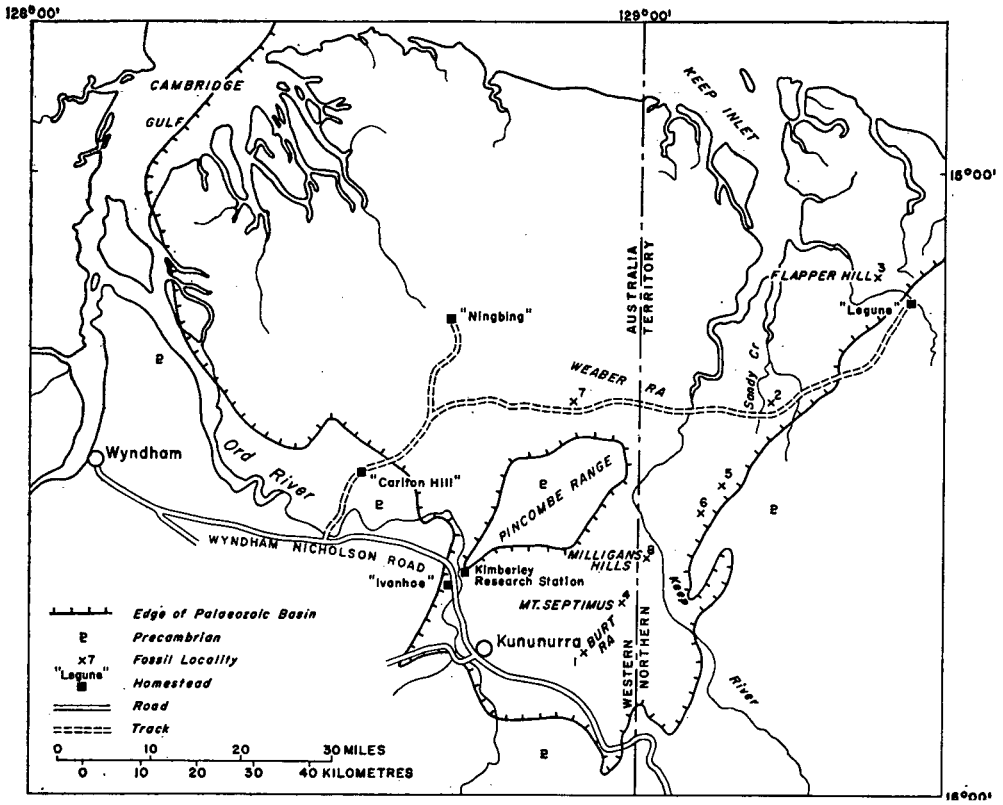

Fig. 5. The Bonaparte Gulf Basin and Carboniferous collecting localities.

conodont correlations, and Druce (1969) has described the conodonts and amplified their stratigraphical significance.

The sequence of Carboniferous rocks in the area south of the Weaber Range comprises, in ascending order: Burt Range Formation, Enga Sandstone, Septimus Limestone, Zimmermann Sandstone—a newly named formation in the Burt Range, and Milligans Beds, known only in subsurface. Overlying the Milligans Beds in the Milligans Hills are the Burvill Beds, which also crop out in the Weaber Range and which comprise the lower part of the sequence called the Point Spring Sandstone in Thomas (1962a) and Veevers et al. (1964). The Burvill Beds are overlain in the Weaber Range by the Point Spring Sandstone (redefined) and this disconformably by the Border Creek Formation. The previously unnamed calcarenite formation northwest of Point Spring and north of Ningbing (Thomas, 1965a; Veevers et al., 1964) is the Utting Calcarenite. Isolated outcrops at Flapper Hills and Sandy Creek are correlated with the Burt Range Formation, as also is the Spirit Hill Limestone. (See Veevers & Roberts, 1968).

Brachiopods are described in this Bulletin from a number of the listed formations.

Burt Range Formation. None of the specimens described here came from the main outcropping area of this formation west and northwest of the Burt Range. Several species are described from specimens collected from the dolomitic limestone at Sandy Creek, the sandstone at Flapper Hills, and the dolomite at Spirit Hill. All these beds are correlated by Veevers & Roberts (1968) with the Burt Range Formation, which is now placed in the Lower Carboniferous. Jones & Druce (1966) report that the conodonts indicate a Tournaisian Cu I - Cu II age. Veevers et al. (1964) had already placed the formation in the Carboniferous. It was originally included in the Upper Devonian by Traves (1955) and earlier writers. Thomas (1961, unpublished report for Alliance Oil Development N.L.) had suggested a Lower Carboniferous age for at least the upper half of the formation, based on small brachiopod collections from the Ivanhoe Pastoral Company Bores 2 and 3. Much richer collections of brachiopods are now being studied by J. Roberts.

The specimens described from Sandy Creek and Flapper Hills are rather poorly preserved, being either ferruginized and silicified replacements or poor moulds and casts. Their affinities appear to be consistent with a Tournaisian age. They were referred to the lower Carboniferous by Thomas (1962a).

The *Enga Sandstone* overlies the Burt Range Formation conformably. It contains conodonts like those of the upper Burt Range Formation, indicating a Tournaisian (Cu II$_\alpha$ zone) age (Jones & Druce, 1966). Lower Carboniferous pelecypods were previously known. J. Roberts is describing newly collected brachiopods. Thomas (1962a, p. 727, locality 1, fig. 1) listed six brachiopod species from beds then regarded as 50 feet below the top of the Burt Range Formation but now considered to be within the lower part of the Enga Formation (J. Roberts, pers. comm.). Two of the species were regarded as conspecific with Septimus Limestone species, suggesting a Lower Carboniferous age. Specimens of one of them, *Leptagonia analoga* (Phillips), are described in this Bulletin. The specimens of the other species, *Rhipidomella michelini?* (Léveillé), were not used in describing that form.

The *Septimus Limestone* overlies the Enga Sandstone; the lower beds are poorly exposed. The fossils described in this study come from the upper beds, and were collected by E. P. Utting and myself. Utting, quoted in Thomas (1962a, p. 728), measured a section about 600 feet thick on the west side of Mount Septimus. The upper 150 feet contains a large varied silicified fauna. Commonest are brachiopods, less abundant are pelecypods, gastropods, corals, crinoids, rugose and tabulate corals, rare blastoids, rare echinoids—*Oligoporus?* sp. Thomas (1965b)—nautiloids, conodonts, ostracods, and trilobites. Thomas (1962a) distinguished four fossil assemblages at Mount Septimus, one at 100 feet above the base and three at 450-500, 500-550, and 550-600 feet. The

species described come mainly from the three higher assemblages. Two isolated limestone localities, sampled by Utting in 1957 (Westralian Oil Ltd Localities A & B), north of Spirit Hill, contain silicified brachiopods which are conspecific with some of those from Mount Septimus. The beds apparently are extensions of the Septimus Limestone and are not part of the Spirit Hill Limestone as was previously assumed (Thomas, 1962a). The Septimus Limestone is well exposed in the Burt Range, but no collections were available when the descriptions were originally prepared in 1960.

Thomas (1962a) suggested a late Tournaisian to early Visean age for the brachiopod faunas. This was supported by the conodont evidence of Jones & Druce (1966). Druce (1969) now considers the Septimus Limestone to be upper Tournaisian (uppermost K or lower Z zones of the Avonian).

No specimens are described here from the Zimmermann Sandstone or the Milligans Beds. A varied fauna from the latter was listed by Thomas (1962a). The Milligans Beds of shale and siltstone, known only in subsurface, underlie the Burvill Beds near the Milligans Hills.

The Burvill Beds are distinguished by Veevers & Roberts (1968) as the lower part of the succession exposed in the southern scarp of the Weaber Range near Point Spring. They consist of sandstone, shale, and interbedded coarse sandy limestone, and are incompletely exposed. They contain the fauna listed by Thomas (1962a, p. 731) from the Weaber Range scarp, 1 mile east of Point Spring. The formation occurs elsewhere in the Weaber Range and in the Milligans Hills, from which a fauna is also listed in Thomas (1962a). The brachiopods, excluding the productoids and chonetids, are described here. The fauna is varied, comprising brachiopods, pelecypods, large gastropods, *Syringopora,* conulariids, ostracods, conodonts, and land plants, suggestive of shallow neritic conditions.

The brachiopods indicate a late Visean to possibly Namurian age, and this is confirmed by conodont evidence according to Druce (1969). Conformably overlying the Burvill Beds in the Weaber Range is the *Point Spring Sandstone,* restricted now to the cross-bedded and laminated quartz sandstone above the Burvill Beds. Veevers & Roberts have collected marine fossils, brachiopods and pelecypods, as well as land plants from these beds. They state that the brachiopods are like those in the Burvill Beds. The Point Spring Sandstone is disconformably overlain by the conglomerate and sandstone of the Border Creek Formation, from which no marine fossils have been collected.

No brachiopods are described from the *Utting Calcarenite.* Jones & Druce (1966) have recorded Visean (Cu IIδ-IIIα) conodonts. Druce (1969) has described the conodonts, regarding them as lowermost Visean in age. Thomas (1965a) described *Delepinea uttingi* Thomas and listed a fauna which he also suggested was early Visean, intermediate in age between the Septimus Limestone and Burvill Beds faunas. The brachiopod faunas are now being studied by J. Roberts.

AFFINITIES OF THE CARBONIFEROUS BRACHIOPOD FAUNAS AND SUGGESTED CORRELATIONS

The Carboniferous brachiopods described in this study can mostly be fairly closely compared with (and some identified with) Dinantian species from various parts of the world, notably Europe, Asia, and North America. As many of the world-wide faunas are inadequately known, it is premature at this stage to delineate migration routes. There is in general a notable contrast between the mondial affinities of the Dinantian faunas and the more provincial character of the Permian faunas of northwest Australia. In this region post-Namurian Upper Carboniferous articulate brachiopod faunas have not been found.

In the following discussions the name Tournaisian is used for the earliest Carboniferous age, but excluding the Strunian, which was included by Demanet (1958). In 1958 and also in the *Lexique Stratigraphique Internationale,* Europe, 1957, Demanet placed the base of the Lower Carboniferous (Dinantian) below the 'Assise d'Hastière et d'Etroeungt'—Tn 1. He thus ignored the decision of the Second International Carboniferous Congress, Heerlen, 1935, which placed the Devonian-Carboniferous boundary between the *Wocklumeria* and *Gattendorfia* ammonoid zones of the Ardennes-Rhineland succession and at the top of the Strunian in France and Belgium. It seems that the *Wocklumeria* zone extends even higher than the 'zone d'Etroeungt' in Belgium since Demanet (1958) lists *Striatoclymenia euryomphala* Schindewolf in Tn 2a, the lowest subdivision of the 'Assise de Maredsons'—Tn 2.

Practice in the USSR has also been to place the *Wocklumeria* zone and the equivalents of the Strunian or 'zone d'Etroeungt' as basal Tournaisian in the Carboniferous (Stepanov, 1962, 1965).

It is appreciated that complete faunal studies will be needed to make definitive international correlations of the Western Australian late Devonian and Carboniferous successions. The available evidence provided by other faunal studies known to the writer is outlined in the chapter on stratigraphy.

Six Carboniferous brachiopod zonal assemblages have been distinguished in the collections available to me, but the more complete collections which have lately been made in the Bonaparte Gulf Basin will probably show that additional useful zonal assemblages can be recognized. The assemblages distinguished here are, in order of probable decreasing age: (A) Tournaisian brachiopods from part of the Burt Range Formation and equivalent beds in the Bonaparte Gulf Basin, (B) Tournaisian brachiopods from the Moogooree Limestone and the Laurel Formation, (C) late Tournaisian to possibly early Visean brachiopods from the Septimus Limestone, (D) Visean brachiopods from the Utting Calcarenite (not described here), (E) Visean(?) brachiopods from the Yindagindy Formation, and (F) Visean to possibly Namurian brachiopods from the Burvill Beds and probably the Point Spring Sandstone.

A. *Tournaisian brachiopods from part of the Burt Range Formation and correlated outcrops in the Bonaparte Gulf Basin.* The brachiopod faunas of the Burt Range Formation are sparsely represented in this study. Few collections were available from the main sequence of the Burt Range Formation, west and northwest of the Burt Range, when the descriptions were first prepared. The species described here are mainly represented by collections from the isolated limestone at Sandy Creek, the sandstone at Flapper Hills, and, for one species, the dolomite at Spirit Hill. They are present also in the main sequence, where the faunal distribution is being studied by J. Roberts. Much richer collections are now available. Roberts (pers. comm.) has recognized some of the species of the Laurel Formation (*Unispirifer fluctuosus* zonal assemblage) in the middle and upper beds of the Burt Range Formation and will discuss the correlations elsewhere. None of the Burt Range Formation species described here, excepting possibly *Rugosochonetes?* sp. B, which may be conspecific with *Rugosochonetes?* sp. A, were represented in my collection from the Laurel Formation.

The Sandy Creek fossils are rather coarsely silicified and ferruginized and are thus imperfectly known. *Prospira? incerta* sp. nov. appears to belong in *Prospira* Maxwell; the obsolescence of sulcal costae suggests affinity with *P. typa* Maxwell, from the late Tournaisian to early Visean of Queensland. *Ectochoristites?*

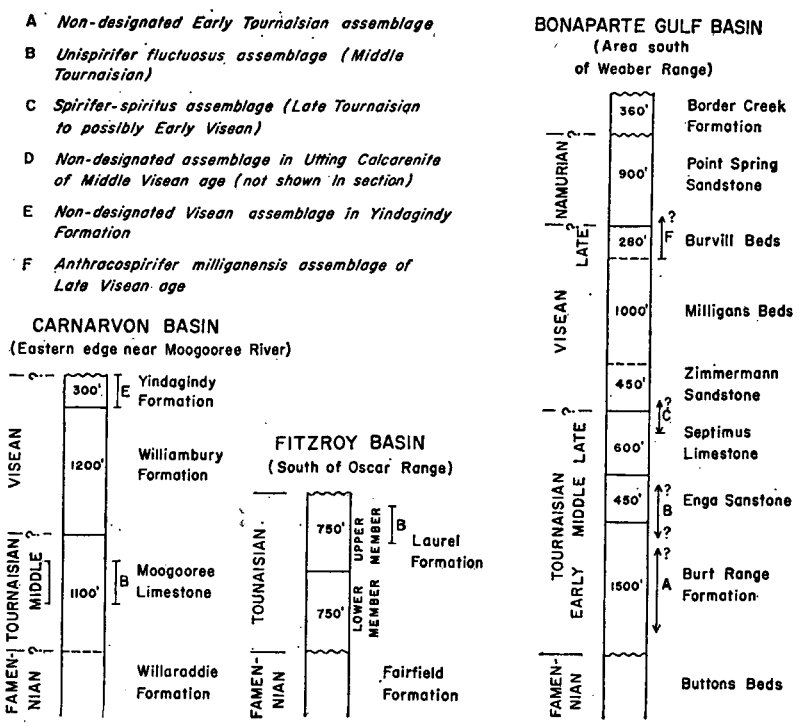

Fig. 6. Brachiopod assemblages in the Carboniferous of northwestern Australia.

arenatus sp. nov. is of problematic affinities. *E.? arenatus* has a superficial resemblance to *Choristites mosquensis* Fischer of the Moscovian. *Cleiothyridina gloveri* sp. nov. is distinctive but with some resemblance to various Mississippian species, notably *C. sublamellosa* (Hall) from the Chester. *Rugosochonetes?* sp. B from Flapper Hills may be conspecific with the species A in the Laurel Formation. Accompanying it are *Schuchertella? sp.* (undescribed) and *Ectochoristites? arenatus.* Veevers (1959, p. 12) listed *'Camarotoechia' septima* Veevers from Sandy Creek; however, J. Roberts (pers. comm.) considers that the Sandy Creek forms may differ from the Septimus Limestone species.

In itself the sparse fauna described from the Burt Range Formation in this study suggests only a broad Dinantian age. Conodont evidence presented by Jones & Druce (1966) and Druce (1969) indicate a Tournaisian Cu I-Cu IIα age for the Burt Range Formation as a whole, i.e. early to middle Tournaisian.

B. *Tournaisian brachiopods from the Moogooree Limestone and the Laurel Formation.* The Tournaisian *Unispirifer fluctuosus* zonal assemblage appears to be generally younger than assemblage A, but there is probably some overlap. The assemblage characterizes the fossiliferous beds of the Moogooree Limestone from about 460 feet to 730 feet above the base, and the upper member of the Laurel Formation, particularly the beds from about 260 to 625 feet above the base of that member (Section II, Thomas, 1959, p. 26). These two sequences are correlated on the common presence of at least six brachiopod species. Common species include: *Rhipidomella michelini* Léveillé, *Cleiothyridina minilya* sp. nov. (both also in the Septimus Limestone), *Unispirifer fluctuosus* (Glenister), *Punctospirifer plicatosulcatus* Glenister, and probably *Schellwienella minilyensis* sp. nov. and *Prospira laurelensis* sp. nov. Undescribed productids including cf. *Ovatia* sp. also occur in both sequences.

Rhipidomella michelini and closely allied species are well known from Tournaisian and Visean deposits in Europe and elsewhere. *Cleiothyridina minilya* seems closest to *C. obmaxima* (McChesney) from the upper Kinderhook, Burlington, and Keokuk of the Mississippian, which are equivalent to Tournaisian to Visean (Cu IIα-Cu IIδ) according to the conodont correlations of Collinson, Scott, & Rexroad (1962). *C. obmaxima* is also reported from the Rundlean of Alberta, the upper Tournaisian of the Karagandian Basin and northeast Kazakhstan, and from Kweichow, China. *C. glabristria* Phillips, from the Visean of Bolland, Yorkshire, appears also to be similar. *Schellwienella minilyensis* appears to resemble externally the Kinderhook species *S. planumbona* Weller and also the British Visean species *S. rotundata* Thomas. *Punctospirifer plicatosulcatus* Glenister seems similar to the small upper Tournaisian Chernyshinsk species from the Moscow Basin described as *P. partitus* (Portlock) by Sokolskaya (1941). It also resembles *P. orlowi* Tschernjak from the Visean C_1d of Taimyr and the Kinderhook species *P. solidirostris* White and the small Nova Scotia species *P. verneuili* Bell from the Upper Windsor (Visean). It appears to be a close ally of *P. uttingi* sp. nov. from the Septimus Limestone.

The spiriferids *Unispirifer fluctuosus* and *Prospira laurelensis* are perhaps the most sensitive for correlation. *U. fluctuosus* seems to be very similar to the large typical specimens of *Spirifer tornacensis* de Koninck (1883, 1887) from the 'calcschiste de Tournai'. Demanet (1958, p. 39) stated that the exact provenance of de Koninck's specimens is not known but that they must have come from formations known and worked before 1887, that is, from the 'sous assises Tn 3b, Tn 3a, Tn 2c', the upper part of the Tournaisian. *U. fluctuosus* is also fairly close to *U. striatoconvolutus* Benson & Dun from the upper Tournaisian to middle Visean of New South Wales. The Nepalese Tournaisian species *'Fusella' mucronata* Waterhouse may be allied. *Prospira laurelensis* seems congeneric with *P. typa* Maxwell from the late Tournaisian to early Visean of Mount Morgan, Queensland, but is wider and has more strongly developed median costae.

Small striate spiriferids broadly comparable with *P. laurelensis* appear to be widespread in Lower Carboniferous deposits in Belgium, Britain, the USSR, and North America. Of these the USSR examples are the most fully described. Recent authors, Besnossova (1959), Bublitchenko (1956), Gretchischnikova (1966), and others, have referred them to *Fusella*. Species are known from the Moscow, Donetzk, and Kuznetzk basins, Kazakhstan, the Rudny Altai, and elsewhere. They appear to be generally characteristic of the higher Tournaisian beds, but are also known in the Strunian of Central Kazakhstan and Rudny Altai, e.g., *'Fusella' praeulbanensis* Bublitchenko. The closest to *P. laurelensis* appear to be *'Fusella' ussiensis* Tolmatchow from the Taidonsk horizon of the Kuznetzk Basin and the small species described as *Spirifer tornacensis* de Koninck by Sarytcheva & Sokolskaya (1952) from the Chernyshinsk horizon of the Moscow Basin. The most nearly comparable North American species appears to be the small striate form *P. minnewankensis* (Shimer), described by Brown (1952) from the Upper Banffian of Alberta. The Kinderhook species *S. platynotus* Weller and *S. legrandensis* Weller seem to be similar in form, but Weller did not record striae in either, though this may result from poor preservation.

Four brachiopod species are known so far only from the Moogooree Limestone: *Syringothyris spissus* Glenister, *Kitakamithyris moogooriensis* sp. nov., *Composita carnarvonensis* sp. nov., and *'Camarotoechia' amnica* Veevers. Of these *S. spissus* is broadly comparable with *S. hannibalensis* Swallow from the Louisiana Limestone of Missouri and the Sappington Formation of Montana. The age of the Louisiana Limestone has been debated. Regarded by Weller (1914), Williams (1943), and other workers as Mississippian, it was placed in the Upper Devonian by Branson et al. (1938), by Collinson, Scott, & Rexroad (1962), and by Conkin & Conkin (1964). Recently Rodriguez & Gutschick (1967, p. 368), who regard the Sappington and Louisiana faunas as Mississippian in aspect, quoted a personal letter from Collinson stating that the conodonts now also indicate a Mississippian age. *S. hannibalensis* has also been identified in the upper Tournaisian of the Kuznetzk and Moscow Basins and in Kazakhstan. *Kitakamithyris moogooriensis* appears to be allied to *K. tyoanjiensis* Minato from the Tournaisian Hikoroiti and

Arisu formations of Japan and to the late Tournaisian and early Visean species *'Phricodothyris' lineata* Maxwell, 1954, from Mount Morgan, Queensland. *Composita carnarvonensis* is distinctive but broadly comparative with various Carboniferous species, notably *C. megala* Tolmatchow of the Tournaisian and early Visean of the Kuznetsk Basin. *'Camarotoechia' amnica* Veevers is a distinctive species.

The Laurel Formation contains four species so far peculiar to it. Of these, *Schuchertella? dorsiplana* sp. nov. is distinctive; *Cleiothyridina? fitzroyensis* sp. nov. broadly resembles several Mississippian species. *Rugosochonetes?* sp. A is inadequately known but resembles various small late Devonian and Tournaisian species. *Composita hendersoni* sp. nov. is distinctive; it may have affinities with a specimen called *Spirigera subtilita* (Hall) by Diener (1915) from the *Syringothyris* Limestone of Eishmakam, Kashmir. There are also some undescribed productoid species.

In general the brachiopods of the *Unispirifer fluctuosus* assemblage show a distinctly Tournaisian or Kinderhookian aspect. Devonian survivors such as *Cyrtospirifer* spp., *Sphenospira julei* (Dehee), *'Spinocyrtia', Tenticospirifer* spp., *Hunanospirifer* spp., and others which characterize the Strunian of Western Europe and the USSR are missing. Furthermore there are no species and few genera in common with the Famennian Fairfield Beds of the Fitzroy Basin. J. Roberts (pers. comm.) has recognized most of the species of this assemblage in the uppermost part of the Burt Range Formation and the Enga Sandstone. Druce (1969) suggests a correlation of the higher Laurel Formation and the Enga Sandstone on conodont evidence (Tournaisian Cu II_α age). The assemblage thus is of middle Tournaisian age.

C. *Late Tournaisian to possibly early Visean brachiopods of the Septimus Limestone.* The *Spirifer spiritus* assemblage characterizes the upper beds of the Septimus Limestone from about 450 to 600 feet above the base at Mount Septimus, where subzonal assemblages can be distinguished (Thomas, 1962a, p. 729). The brachiopod faunas, notably *S. spiritus* sp. nov., suggest a late Tournaisian or possibly early Visean age for the assemblage. However, Druce (1969) now indicates a late Tournaisian age for the Septimus Limestone on conodont evidence, modifying the correlation suggested in Jones & Druce (1966).

Two species, *Rhipidomella michelini?* and *Cleiothyridina minilya,* occur in common with the Laurel Formation, Moogooree Limestone, and Enga Sandstone. *Punctospirifer mucronatus* sp. nov. occurs in both Moogooree and Septimus faunas, but more abundantly in the latter. It is a distinctive species but resembles to some extent *P. transversus* (McChesney) from the Chester of North America. *Schellwienella australis* sp. nov. resembles some Belgian representatives of *S. crenistria* Phillips and also *S. burlingtonensis* Weller from the Burlington (an early Visean equivalent) and the Chernyshinsk horizon (upper Tournaisian) of the Moscow Basin. *Prospira travesi* sp. nov. is a distinctive species. *Unispirifer*

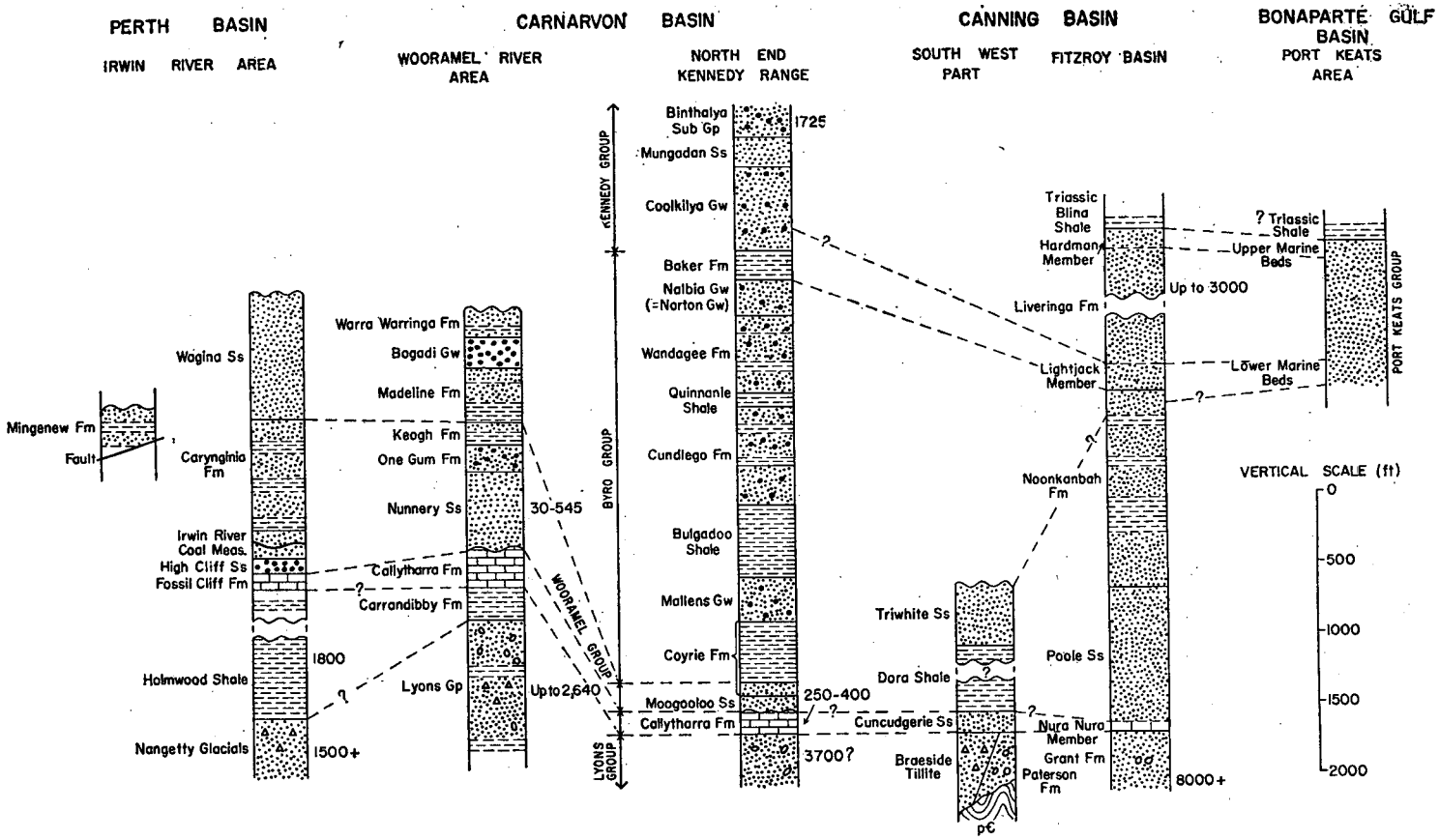

Fig. 7. Correlations of Permian sections in northwestern Australia (after Dickins, 1963).

septimus sp. nov. resembles to some degree *S. pentagonus* Sokolskaya and *S. ventricosus* Sokolskaya from the Tournaisian of the Moscow Basin, also *S. mediocris* Tolmatchow and *S. similis* Tolmatchow from the Taidonsk and Nizhnetersinsk horizons (Tournaisian) of the Kuznetzk Basin, and possibly some of de Koninck's Tournaisian species such as *S. ventricosus, S. pentagonus,* and *S. suavi. Spirifer spiritus* sp. nov. appears to be close to *S. attenuatus* Sowerby, a widespread species known from the late Tournaisian to early Visean of Britain and Belgium, the late Tournaisian of the Kuznetzk Basin and Rudny Altai, and the Visean (C_1d) of Taimyr. The Mississippian species *S.subaequalis* Hall from the Keokuk and Warsaw is somewhat similar. A small incompletely known species of *Brachythyris* is apparently close to *B. peculiaris* (Shumard) from the Kinderhook, and reported also from the Banffian, and the Tournaisian of the Moscow, Karagandian, and Kuznetzk basins. *B. latecardinalis* sp. nov. is distinctive. *Torynifer? dorsiseptatus* sp. nov. is not completely known but is possibly near the Mississippian species *T. pseudolineatus* (Hall), which is also recorded from the Moscow and Kuznetzk Basins. *Punctospirifer uttingi* sp. nov. is fairly close to *P. plicatosulcatus* Glenister and also close to the Taimyr Visean species *P. orlowi* Tschernjak and possibly the Kinderhook species *P. solidirostris* (White), though rather larger than both. *Composita bonapartensis* sp. nov. is distinctive. *'Camarotoechia' septima* Veevers (1959, p. 12) has Tournaisian affinities. An undescribed species of *Schizophoria* and various productoids are also present in the assemblage. *Syringothyris* sp. nov. A has not yet been fully studied.

Some of the characteristic species of the Septimus Limestone, notably *Spirifer spiritus, Composita bonapartensis, Cleiothyridina* sp. nov. cf. *C. gloveri,* possibly *Unispirifer septimus,* and also *Rhipidomella michelini* occur at locality WAA9, Mines Administration Ltd (Utting's Locality B) near Spirit Hill in an isolated outcrop of limestone.

D. *The Visean brachiopod fauna of the Utting Calcarenite* is not described here, though some species of the *Spirifer spiritus* assemblage may range up into it. *Delepinea uttingi* Thomas was described and the associated fauna discussed in Thomas (1965a).

E. *The Visean (?) brachiopod assemblage of the Yindagindy Formation* is sparse. The only species described here is *Composita variabilis* sp. nov., which resembles *C. trinuclea* Hall from the Meramec and Chester of the Mississippian. *C. trinuclea* has also been identified in late Tournaisian to Visean beds in the Karagandian basin and northeast Kazakhstan. *C. variabilis* may be represented by a trilobate specimen collected by E. P. Utting, from Locality S northeast of Ningbing homestead, probably from the Burvill Beds, Bonaparte Gulf Basin. A poorly preserved small productid cf. *Protoniella ? parvus* (Meek & Worthen), of the Chester, is also present. Veevers (1959) described *'Camarotoechia'* sp. ind. II, which resembles a Famennian species from the Moscow Basin.

F. *The late Visean to possibly Namurian brachiopods of the Burvill Beds.* The *Anthracospirifer milliganensis* zonal assemblage characterizes the Burvill Beds in the Weaber Range and in the Milligans Hills. The brachiopods include *Schellwienella weaberensis,* which is close to *S. ornata* Demanet from the Belgium upper Visean and to *S. reprinki* Sokolskaya from the middle Visean of the Moscow Basin. *Anthracospirifer milliganensis* is similar to *A. bisulcatus* Sowerby sensu stricto and to its near allies of the late Visean and Namurian of Britain and Belgium. *Spirifer parabisulcatus* Semichatova, from the late Visean of the Moscow Basin, seems also to be similar. The nearest North American species seems to be *Spirifer nox* Bell, from the Upper Windsor of Nova Scotia. An unnamed new species seems to be allied to *'Spirifer' duplicicostus* Phillips, one of the group of species occurring in the late Tournaisian and Visean of Britain and Belgium and Visean of the Moscow Basin. *Syringothyris* sp. nov. is possibly allied to *S. curzoni* (Diener) from the *Syringothyris* limestone of Lipak, Spiti, and Kashmir. *Cleiothyridina?* sp. and *Ectochoristites?* sp. are inadequately known but are broadly comparable with Dinantian species. Productids cf. *Dictyoclostus* sp. of Dinantian type are also present.

This assemblage appears to extend into the Point Spring Sandstone. The brachiopods are of decided Visean aspect, but as the *Anthracospirifer bisulcatus* group is known to range into the Namurian of western Europe, the possibility of that later age is mentioned. Druce (1969) considers the conodonts of the Burvill Beds to be of uppermost Visean or possibly basal Namurian age.

AFFINITIES OF THE PERMIAN SPIRIFERACEANS

The Sakmarian Lyons Group of the Carnarvon Basin contains an interesting fauna which shows many links with cold-water eastern Australia and other Gondwana faunas. These fossils were reviewed by Dickins & Thomas (1959). The brachiopods comprise 11 species, which include *Trigonotreta narsarhensis occidentalis* subsp. nov. and *Cyrtella nagmargensis australis* subsp. nov. The first seems closely allied to *T. narsarhensis* Reed from the Umaria beds of India. The latter closely resembles *C. nagmargensis* (Bion), which was originally described by Bion (1928) from the Nagmarg beds of the Agglomeratic Slate of Kashmir at Kimsar, Marbal Valley, and Yal Nar, and by Reed (1932) from Bren Spur. *C. nagmargensis* has been described from southeast Arabia and from the Caracorum. The new subspecies extends into the early Artinskian Callytharra Formation, where it is accompanied by the much more abundant *Pseudosyringothyris dickinsi* sp. nov., which is also present in the basal Poole Sandstone and the Cuncudgerie Sandstone of the Canning Basin. *P. dickinsi* is a distinctive species which appears to be congeneric with the rare species *Pseudosyringothyris karpinskii* Fredericks from the Bolshezemelskaya Tundra, Northern Russia, and with *Pseudosyringothyris borealis* Gobbett from the Svalbardian of Spitzbergen. *Pseudosyrinx? sinuosa* sp. nov. from the Madeline Formation of the Carnarvon Basin is of uncertain affinities. It may be referable to the Licharewiinae.

SYSTEMATIC DESCRIPTIONS

Order ORTHIDA Schuchert & Cooper, 1932

[nom. transl. et correct. Moore, 1952 (ex suborder Orthoidea Schuchert & Cooper, 1932)] (emend. Williams & Wright, 1965)

Family RHIPIDOMELLIDAE Schuchert, 1913

Genus RHIPIDOMELLA Oehlert, 1890

Type species: *Terebratula michelini* Léveillé, 1835

Generic features: See Wright (1965, p. H342).

RHIPIDOMELLA MICHELINI? (Léveillé)

(Pl. 21, figs 1-16; Pl. 25, figs 2, 5, 6; Text-figs 8-10)

Material: Several hundred specimens; unaltered shells and isolated valves from the Fitzroy Basin and silicified shells and valves from the Carnarvon and Bonaparte Gulf Basins.

Description: The specimens are all slightly abraded. They are of medium to large size (maximum 3.05 cm wide and 2.85 cm long); the width generally exceeds length but in a few is less. The ventral outline varies from rounded, the maximum width at the midlength, to subpentagonal in a few. The ventral valve is gently convex posteriorly, flat in front and rarely slightly sulcate. The hinge-line is short, from two-fifths to half the shell width; the interarea is low and small, slightly concave and apsacline; umbo small and obtusely rounded. The dorsal valve is moderately convex and rounded with a low orthocline interarea and small obtuse umbo. The commissure is rectimarginate.

The dental plates are short, diverging at 77° to 99° (in one specimen 112°). The delthyrium is wide and open. When the valves are closed it is almost completely filled by chilidium and cardinal process, leaving very little if any room for a functional pedicle. The teeth are prominent and blade-like, with faint longitudinal ridges on the delthyrial side. A slightly elevated 'pedicle callist' is present at the back of the delthyrial chamber. The flabellate diductor is large and well impressed, variable in size and outline, and completely encloses the elliptical adductor scars, which are narrower in some specimens than in those illustrated. Numerous genital pits commonly lie in front of the muscle scars.

The dorsal valve has strong anteroventrally directed pointed brachiophores, diverging at 82°-92°, fused to the shell floor by secondary deposits and forming the inner edge to the sockets. The low dorsal area forms the outer socket edge.

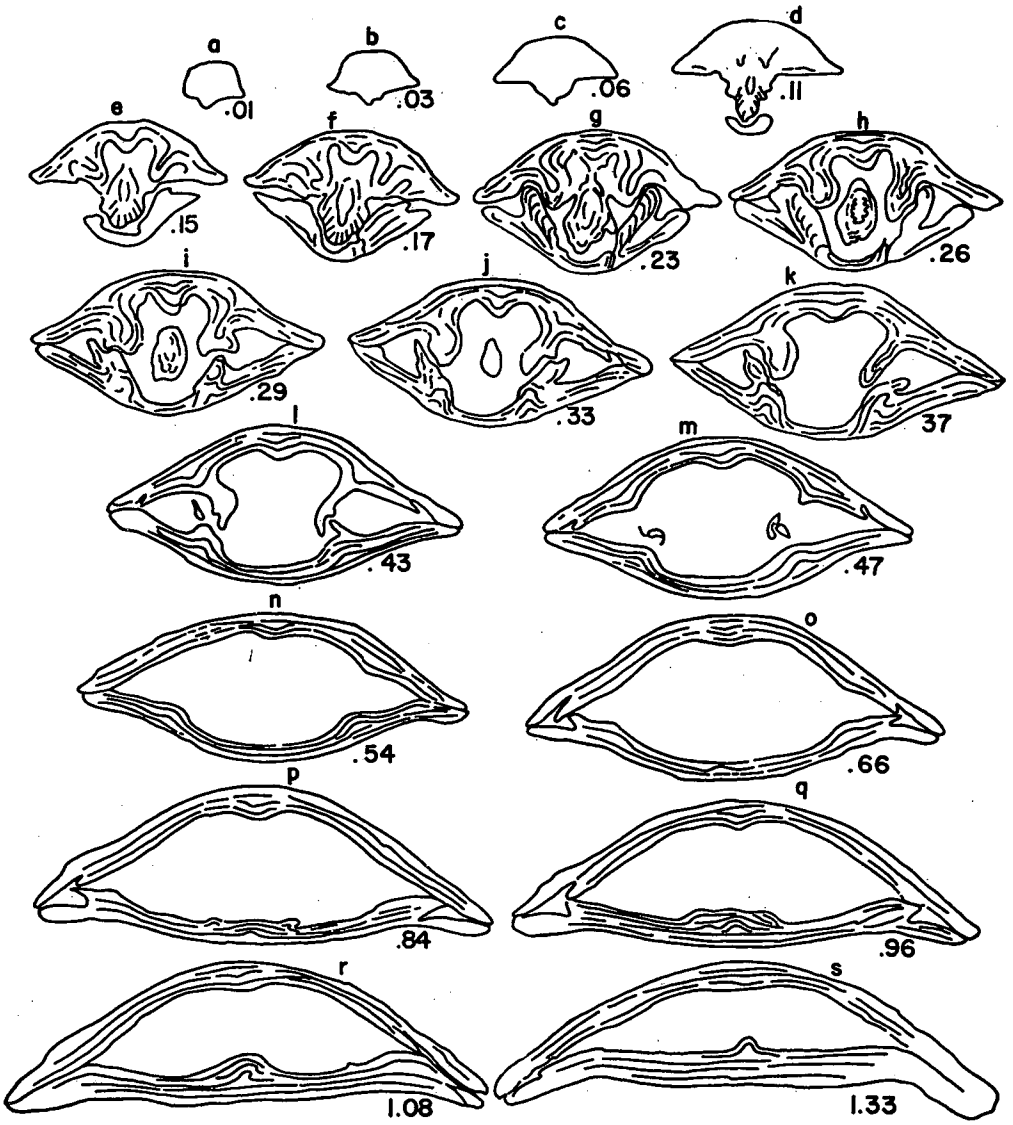

Fig. 8. *Rhipidomella michelini?* **Lev. CPC3697. Transverse sections, dorsal valve on top. Punctae not shown. Ventral valve crushed in anterior sections, x30.**

The myophore carries deep radiating longitudinal platelets (Text-fig. 8). Its stem is commonly secondarily thickened and behind is a small divided chilidium. In front is a ridge which separates the faint posterior pair of adductor scars; the anterior pair are stronger.

The shell of both valves is thick and the vascular pattern is not discernible except for the ovarian pits and the marginal radiating internal ribs. Externally the costellae are fine, rounded and even, numbering 13-15 in 5 mm near the

midline in front, increasing apparently by bifurcation. The concentric lamellae become more numerous in front.

The shell structure is shown in Plate 25, figures 2, 5, 6. The outermost layers have been abraded. The endopunctae average about 0.025 mm across, with a density of 140 to 180 per sq. mm. They are arranged in radial rows, cross-sections of which show the punctae to be bent and fanning out to the inner and outer surfaces. In consequence, the appearance of tangential sections varies with the depth of the cut. About the middle of the wall the rows of punctae are flanked by clear shell; towards inner and outer surfaces the whole shell appears punctate. Internal structures are impunctate. No surface spines were detected.

Discussion: The specimens from all the Carboniferous beds in Western Australia are provisionally included under *R. michelini*. Scatter plots of length/width ratios are similar and overlapping. The variation of size and proportions of the ventral muscle field is similar in each group (Text-figs 9, 10). There is however a difference in size distribution. The specimens from the Septimus Limestone are generally smaller. Possibly these collections contain more immature individuals than those from the other regions.

The type material of *R. michelini* (Léveillé) has not been restudied in recent years. Interpretation of the species is based on Demanet (1934), who described other specimens from Tournai. He did not record measurements, but a plot of the dimensions of his figures fits the scatter plots of our specimens for length/width ratios and size and shape of ventral muscle scars. Demanet distinguished three varieties. In relative width and position of maximum width our specimens are closer to his *R. michelini* var. *divaricata* (M'Coy), but in other features, such as size and depth of muscle impressions, strength of the median ridges and brachiophore supports, they are variable enough to come within the range of either *R. michelini* s.s. or var. *divaricata*. In Belgium, *R. michelini* occurs in the Tournaisian and the Visean. It is widely reported from the Dinantian of Western Europe and Russia. Brunton (1968) has described the species from the Visean of Fermanagh. His specimens are comparatively small, are nearly equally biconvex, and appear to lack posterior dorsal adductor scars.

A more detailed analysis of variability of topotype specimens of *R. michelini* will be needed to confirm the identification of the Western Australian specimens.

R. australis (M'Coy) from the lower Burindi of New South Wales appears to be somewhat smaller and has slightly less divergent dental plates and brachiophores (Campbell, 1957). *R. fortimusculus* Cvancara, 1958, also from the lower Burindi, has a consistently larger muscle field, wider hinge-line, and less divergent dental plates.

Geological Age: Tournaisian to Visean.

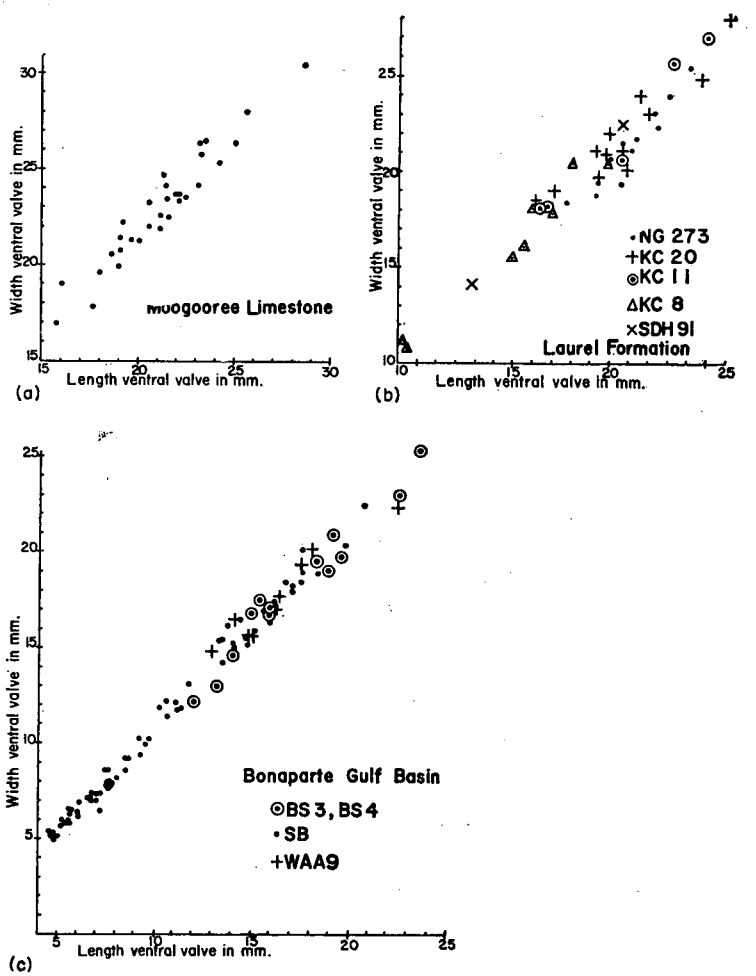

Fig. 9. Length/width ratios of *R. michelini?*

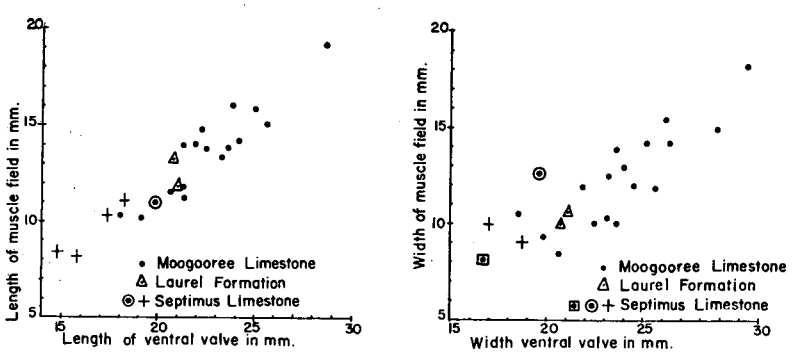

Fig. 10. *R. michelini?* Ratio of (a) length, (b) width of ventral valve and muscle field.

Occurrence: CPC3680-2, 3684-7, F17957-87 are from TP42, 440 feet above base of Moogooree Limestone, Carnarvon Basin. CPC3688-93, F17973-7, F17988-21274, from Septimus Limestone section at Mount Septimus, 500 to 560 feet above base. F21275-83, from WAA9, probably Septimus Limestone. CPC3694, 3695, F21285, 6, from KC11, 1310 feet above base of Laurel Formation, Fitzroy Basin. CPC3696, 3697, F21287, F21299, from KC13, Laurel Formation, upper beds. F21300-8 from SDH8, F21300-12, from SDH91, and F21312-23 from Ng273, all from Laurel Formation, upper beds.

TABLE 2: Dimensions of *Rhipidomella michelini?* (Lév.)
(in mm)

Specimen Number	L	Wm	Whl	Ha	Lms	Wms	DPa
VENTRAL VALVES (Moogooree Limestone specimens)							
CPC3680	21.4		10.0	1.4			
CPC3681	28.4	30.3	14.0	2.0	19.2	18.2	80°
CPC3682	19.0	20.6			10.2	8.5	79°
CPC3684	21.1	21.8	11.0	1.8	13.9	12.0	77°
F17957	21.1	32.2	10.4	1.8	11.3	10.4	85°
F17958	23.3	36.3			14.5	13.1	
F17959	24.8	26.3	11.8	2.2	15.8	14.3	79°
F17960	17.9	18.5			10.2	10.5	
F17961	20.5	23.2			11.5	10.1	82°
F17962	23.0	24+	11.2	1.8	13.8	13.0	83°
F17963	21.8	23.6			14.0	13.9	85°
F17964	25.5	27.8			15.0	15.0	90°
F17965	23.1	25.6			13.4	11.9	81°
F17966	21.1	22.5			11.7	10.0	82°
F17967	24.2	25.2			14.2	14.2	85°
F17968	18.9	19.8			11.1	9.4	80°
F17969	22.1	23.3			14.7	12.6	77°
F17970	28.1	26.2			16.0	15.5	112°
F17971	22.4	24.5	10.0	2.4	13.8	12.0	78°
(Laurel Formation specimens)							
CPC3694	20.6	20.8	9.0	1.8	11.9	10.1	90°
CPC3695	25.0	27.2					
CPC3696	20.6	21.2	9.5	2.1	13.3	11.1	79°
(Septimus Limestone specimens)							
CPC3688	17.4	18.9					
CPC3689	18.2	18.7	7.0	1.3	11.0	9.1	76°
CPC3691	19.2	21.8					
CPC3692	19.7	19.6			11.0	12.6	80°
CPC3693	22.7	22.9					
F17973	15.6	—	8.0	1.0	8.1	7.8	70°
F17974	17.3	17.0			10.3	10.2	90°
F17975	14.7	16.4	7.8	1.4	8.4	8.0	90°
	L	Wm	Lmsd	Wmsd			CPa
DORSAL VALVES (Moogooree Limestone specimens)							
CPC3686	26.8	28.7	11.7	10.5			90°
CPC3687			11.0	9.8			90°
F17972	23.5	26.7	12.0	10.0			
(Septimus Limestone specimens)							
CPC3690	15.3	15.7	9.5	7.5			82°
F17976	20.0	20.8	10.0	8.0			90°
F17977	14.0	15.1	8.5	5.2			82°

Order STROPHOMENIDA Öpik, 1934

(nom. transl. Moore, 1952, ex suborder Strophomenoidea Öpik, 1934; emend. Muir-Wood & Williams, 1965)

Superfamily STROPHOMENACEA King, 1846

(nom. transl. Schuchert, 1896, ex Strophomenidae King, 1846)

Family LEPTAENIDAE Hall & Clarke, 1894

Diagnosis: See Williams (1965, p. H391).

Genus LEPTAGONIA M'Coy, 1844

Type species: *Producta analoga* Phillips, 1836.

Generic features: See Brunton (1968, p. 21).

Discussion: *Leptagonia* M'Coy was revived as a generic name by Cvancara (1958, p. 859), who pointed out that *Leptaenella* Sarycheva & Sokolskaya, 1952, was an objective synonym of *Leptagonia* M'Coy. According to Williams (1965, p. H393), *Leptaenella* Sarycheva & Sokolskaya is a homonym of *Leptaenella* Fredericks, 1917, itself a synonym of *Leptaena* Dalman. M'Coy's designation of *L. analoga* as type species of *Leptagonia* is quite explicit.

Sokolskaya (1954), Campbell (1957), Cvancara (1958), Williams (1968), and Brunton (1958) have discussed the characters of *Leptagonia.* Brunton has discussed in some detail the distinctions from *Leptaena* Dalman.

Spondylium was rejected by Williams (1965) as the term for the raised and rimmed ventral muscle field of the leptaenids; Brunton uses pseudospondylium.

The type specimen of *L. analoga* (Phillips), if surviving, from Bolland or Redesdale, has not been adequately described. Interpretation of the species has been mainly based on other British examples described by Davidson (1861) and more recently on Belgian specimens described by Demanet (1934). Williams (1965, fig. 254) has illustrated but not discussed examples from the Lower Carboniferous of Wales.

LEPTAGONIA ANALOGA (Phillips)

(Pl. 18, figs 1-8; Text-fig. 11a-d)

Material: Nineteen silicified valves and shells, mostly incomplete.

Description: The specimens are of average size for the species; CPC3699 (Pl. 18, fig. 1a, b) has a maximum width of 5.4 cm and hinge-line of 5.1 cm.

The outline is trapezoidal, widest at the hinge-line. The ventral valve is gently convex in the region of the visceral disc and slightly more inflated at the umbo. Farther forward and to the sides it becomes strongly geniculate, with the trail inclining nearly 90° to the visceral disc. In CPC3699, the visceral disc is about 3.8 cm long and the trail about 1.35 cm. The apical angle is wide, ranging from 160° to 170°. The interarea is low, triangular, and nearly orthocline, with a height of 3 mm; it is transversely striated by growth-lines. The delthyrium is widely divergent, with a small convex pseudodeltidium which is concave in front. The umbo is not prominent and is obtusely rounded.

The dorsal valve is flat to slightly concave in the region of the visceral disc, and is abruptly geniculated at the front of the disc, at a distance of 2.25 cm from the umbo in the best preserved dorsal valve, CPC3700 (Pl. 18, fig. 7a, b). The dorsal area is triangular, anacline, and low (1.9 mm in CPC3700). A large grooved chilidium is present and seems to nearly close the delthyrial opening.

The trail of both valves is flexed upwards at the sides as well as the front; as a result the maximum width exceeds the length of the hinge-line at which it is situated. There is no fold or sulcus in the visceral region, but some specimens show a broad rounded sulcus on the trail.

The surface ornament is not very well preserved. Fine rounded radiating costellae, 13 to 14 in 5 mm, occur near the front margin of F21324. F21325 carries 13 in 5 mm on the front of the dorsal visceral disc at about 2.45 cm from the umbo. CPC3706 (Pl. 18, fig. 2a, b), from the top of the Burt Range Limestone, is provisionally associated with the specimens from the Septimus Limestone. It carries 14-15 costellae in 5 mm at the front of the visceral disc in both valves and 17-18 in 5 mm on the front of the trail. The costellae increase mainly by intercalation, but also by occasional bifurcation. They are even-sized and slightly nodular where crossed by the concentric rugae. The rugae are fairly regular, but are occasionally interrupted, or may be bifurcated. In the larger specimens there are 15-16 rugae on the visceral disc with an additional 4-5 fainter and less distinct ones on the trail; they are mucronate on the outer flanks in the larger specimens. CPC3706 has 12-13 rugae on the dorsal visceral disc, 14 on the ventral disc, and 2-3 on the trail. The dorsal trail is strongly lamellose and considerably thickened at the front. At the trail, both valves are closely apposed.

The ventral interior is not known from complete specimens. Several young specimens display the widely divergent dental plates and the elevated muscle field on the pseudospondylium with its flanking ridge which is continuous with the dental plates; a median septum lies in front. Examples are illustrated in

TABLE 3: Dimensions of *Leptagonia analoga* (Phillips) (in cm)

Specimen Number	L	Lc	Lvv	Lvd	Whl	Wm	V	D	Aa	Dw	W/L	Ltv	Ltd	Rugae Vdv	Rugae Vdd	Total Rugae V	Total Rugae D
CPC3699	3.1	4.50	2.80	2.10	5.10	5.40	.30		160°	0.9	1.74	1.3			c.15		
CPC3700				2.20	5.1e	5.40		.19							15-16		
CPC3706	2.20	3.20	1.90	1.70	3.85	4.0+			170°		1.82	1.9		14	12-13	16-17	15-16
F21324	3.10	4.65	2.60		4.2e	4.4e			c.170°		1.42	1.6		16		20+	
F21325				2.70	4.20										17		
F21326			2.8e		4.10												
F21328	2.55	3.90	2.00	1.90	3.75	3.9+			166°		1.53	1.4	0.5				
F21329	2.65	4.35	1.90	1.90	4.25	4.25	.25		170°	0.77	1.60	1.9	0.5	13			
F21330	2.30	3.25	1.90		3.80	3.80	.25	.15	163°		1.65	1.3					

Lvv—Length of visceral disc, ventral valve
Lvd—Length of visceral disc, dorsal valve
Ltv—Length of trail, ventral valve
Ltd—Length of trail, dorsal valve
Vdv—Visceral disc, ventral valve
Vdd—Visceral disc, dorsal valve
(Visceral disc measured from umbo to geniculation in each valve)

Plate 18, figure 3 (CPC3703) and figure 5 (CPC3705). CPC3705 is very youthful and preserves the pedicle foramen at the apex of the delthyrial cavity, piercing the umbo.

In CPC3703, the foramen has been obliterated by shell thickening. In general, pedicle openings appear to be present in the smaller specimens but not in the larger. Thus CPC3701 (Pl. 18, fig. 6a, b) has an opening on the umbonal apex but CPC3699 has not. The median adductor platform on the spondylium is seen in Plate 18, figure 3, but the details of the adductor scar which lie on each side cannot be made out clearly. The teeth are widely divergent, but are not well preserved. The anterior parts of the ventral valve are not known.

The interior of the dorsal valve is shown by CPC3702 (Pl. 18, fig. 4a, b) a youthful specimen, and by CPC3700 (Pl. 18, fig. 7a, b) a mature one. The cardinal process is broken on the larger specimen, but was a bilobed structure

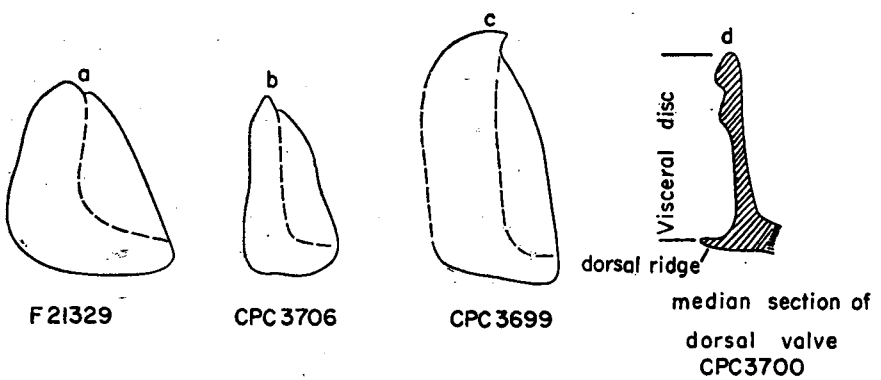

Fig. 11. *Leptagonia analoga* **Phill. Profiiles of specimens illustrated in Plate 18.**

supported by low divergent socket ridges which flank the adductor muscle scar. The outside margin of the socket groove is formed by the edge of the notothyrium. The area is low and tapers to the outer extremities. A large chilidium, divided in the middle, lies behind the cardinal process and nearly fills the delthyrial opening in closed valves, e.g. Plate 18, figures 2b and 6b. A small depression lies in front of the cardinal process. The adductor muscle scar forms a prominent raised area, roughly pear-shaped, divided by a median septum. Posterior and anterior adductors can be distinguished; the latter are more distinct and are a pair of rounded scars. The septum becomes more elevated at the front. Surrounding the visceral disc in CPC3700 is a prominent acute ridge (Text-fig. 11d) which extends back to the hinge-line, originating apparently at about 0.7 cm from the end of the hinge-line. The ridge is at least 0.5 cm above the floor of the valve at its maximum. The vascular pattern of this specimen, as far as it can be seen, is similar to the illustration in Davidson (1861, pl. 28, fig. 10).

Discussion: The specimens described appear to fall within the limits of *L. analoga* as illustrated by Demanet (1934), Williams (1965), Davidson (1861, in part), and Brunton (1968). None of the specimens show the convexity of the dorsal valves as strongly as those of Williams (1965, fig. 254) or Brunton (1968, pl. 3, figs 29, 30). This appears to be a variable feature, however: Davidson (1861, pl. 28, figs 1, 2) for instance shows both flat and convex valves.

L. analoga has been widely reported from the Lower Carboniferous of Western Europe, Russia, Asia, North Africa, North America, and eastern Australia in beds of upper Tournaisian to Visean age. Muir-Wood (1948) reviewed the Asian occurrences and Sokolskaya (1954) the Russian.

Geological Age: Tournaisian to early Visean.

Occurrence: Septimus Limestone, on western slope of Mount Septimus: CPC3701 from 550 to 600 feet above the base of section; CPC3699, 3700, 3702, 3704, F21324-6 from 500-550 feet; CPC3703, 3705 from 450 to 500 feet. Low in Enga Sandstone, at locality E (Westralian Oil Ltd): CPC3706, F21238-330.

Superfamily DAVIDSONIACEA King, 1850

(nom. transl. Williams, 1965, ex Davidsoniinae King, 1850)

Family SCHUCHERTELLIDAE Williams, 1953

(nom. transl. Stehli, 1954, ex Schuchertellinae Williams, 1953)

Subfamily Schuchertellinae Williams, 1953

Diagnosis: See Williams (1965, p. H408).

Genus SCHUCHERTELLA Girty, 1904

Type species: *Streptorhynchus lens* White, 1862.

Generic features: See Williams (1965, p. H408).

Discussion: Williams' definition includes 'shell substance impunctate'. This is correct for Devonian species which have been referred to the genus, such as *Schuchertella dromeda* Veevers, 1959. However, a preliminary study of sections of the type species *S. lens* (White) from the Louisiana Limestone, Louisiana, Missouri, seems to show that the structure is punctate and rather similar to that of *Streptorhynchus* (see Thomas, 1958, p. 34). My sections of *Streptorhynchus* have also been examined by Kemezys (1965, p. 320), who has confirmed that the structure is punctate. Armstrong (1969) has demonstrated punctae in *Streptorhynchus pelicanensis* Fletcher. Further studies of the shell structure in *Schuchertella* and *Streptorhynchus* are in progress and will be published elsewhere. Brunton (1968) propsed a new genus *Serratocrista* for silicified *Schuchertella*-like forms which apparently have a shell structure like *Streptorhynchus* and are spinose. The new species *Schuchertella? dorsiplana* is pseudopunctate. It is doubtfully placed in *Schuchertella* pending further study of the type species of that genus.

SCHUCHERTELLA? DORSIPLANA sp. nov.

(Pl. 16, figs 7, 9; Pl. 29, fig. 6; Pl. 25, figs 1, 4; Text-figs 12, 13)

Diagnosis: Medium-sized symmetrical species; ventral valve gently convex, with moderately high apsacline area (0.7 cm); dorsal valve flat; outline rounded; costellae fine and even (10 in 0.5 cm at front).

Material: Fifteen incomplete shells or valves and numerous fragments.

Description: A composite reconstruction is shown in Text-figure 12a, b. The holotype, CPC3667, an incomplete ventral valve, is illustrated on Plate 29, figure 6. The valve is gently convex longitudinally and transversely, with the slightly greater convexity near the umbo. The interarea is gently convex and apsacline. It is up to 0.75 cm high and about 3.5 cm wide at the hinge-line. The delthyrium is moderately wide; it is exposed only in a few youthful specimens, in one of

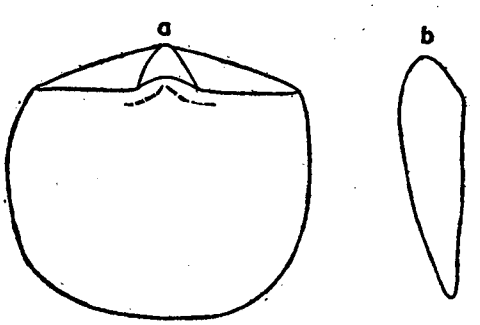

Fig. 12. *Schuchertella? dorsiplana* **sp. nov. Composite outline prepared from incomplete shells in dorsal and profile views.**

which it was about 0.45 cm wide on a hinge-line 2.3 cm wide. The apical angle is wide, averaging about 160°, and the umbo is obtusely pointed. The perideltidial angle is not accurately measurable. The outline is subrounded, with the maximum width near the midlength. The pseudodeltidium is strongly convex with a concave front margin which, in the available specimens, leaves an opening. The dorsal chilidium probably filled the opening in life, but it is apparently much abraded in our specimens, and the base of the cardinal process is exposed, leaving a gap between the process and the front of the pseudodeltidium.

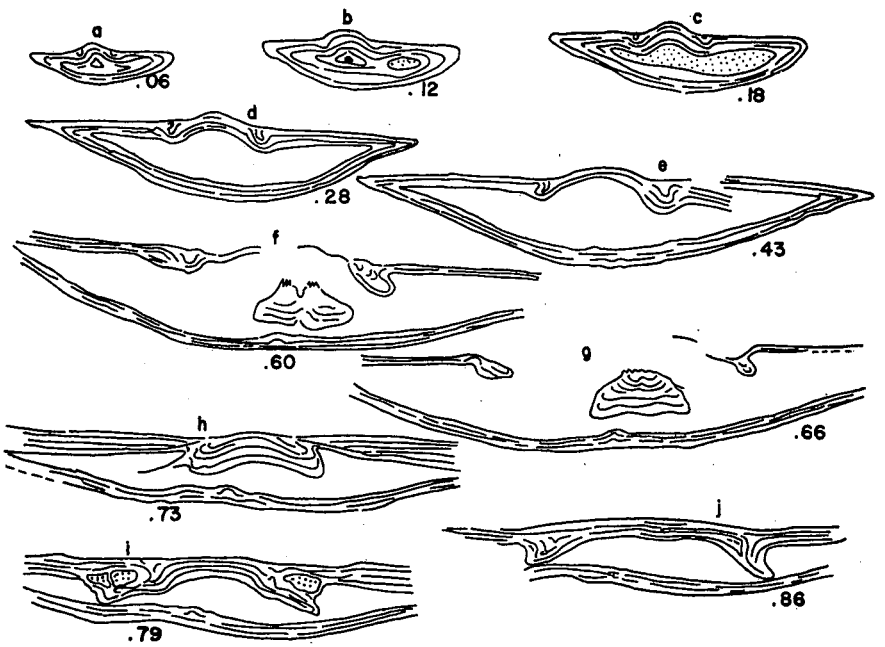

Fig. 13. *S? dorsiplana.* **CPC3671, an incomplete shell. Transverse sections. Dorsal valves on top, x3.9.**

The dorsal valve is flat or nearly so and possesses a low highly anacline area. The dorsal umbo is only slightly developed. Abrasion in most specimens reveals the bases of the widely divergent socket plates. Examples are seen in Plate 16, figures 7, 8, 9.

Internally, the ventral valve possesses dental ridges (or flanges); the teeth are prominent and rounded. Pseudodeltidium, dental ridges, and remainder of the shell wall are built up by laminar growth of the fibrous or secondary layer of the shell. The outermost lamellar layer is abraded in all specimens.

The ventral muscles, as seen in section in Text-figure 13, are not deeply impressed, and possess a low median ridge. The dorsal valve possesses a bilobed cardinal process and divergent socket plates, the outer front edge of which has

a prominent process. In the crushed specimen CPC3669 (Pl. 16, fig. 8a, b), the socket plate processes are seen impressed on the ventral valve.

The internal surfaces of both valves are costellate. The external surface is ornamented with fine, fairly even, radiating rounded costellae which increase by intercalation and are separated by wider intertroughs. There are 10 per 5 mm at 2.1 cm mesially from the umbo in the holotype. In F17953, there are 11 in 5 mm at 2.2 cm from the dorsal umbo. All shells are somewhat abraded, but occasional step-like concentric lamellae and finer growth-lines can be discerned. The abraded surface displays a rough concentric undulation of the shell laminae, somewhat resembling that in *Schellwienella weaberensis,* though not as dense or as regular. Transverse and tangential thin sections are illustrated on Plate 25, figures 1 and 4. The outer primary or lamellar layer is missing from Figure 4. The pseudopunctae are seen to be conical flexures of the laminae which form pustules directed inwards. Their superposition in transverse section simulates a rod, but true taleolae were not detected in any of the specimens. The disposition of the pseudopunctae, as shown in Plate 25, figure 1, is irregular.

Discussion: The flat dorsal valve of *S. dorsiplana* appears to distinguish it from other Carboniferous species. It is larger than *S. lens* (White), which is similar in outline but has a gently convex dorsal valve. It is readily distinguished from the Upper Devonian species *S. dromeda* Veevers, which occurs in the beds of the Fairfield Formation underlying the Laurel Formation. That species commonly has a higher and more irregular area and a gently convex dorsal valve. Small specimens of *S. prava* Hall from the Upper Devonian (Hackberry) of the Cerro Gordo of Iowa, presented by Dr G. A. Cooper, have nearly flat dorsal valves. This species, according to Fenton & Fenton (1924), has generally a convex dorsal valve.

Orthis caduca M'Coy (1844, pl. 22, fig. 6) from the lower Carboniferous of Ireland, and also illustrated by Davidson (1858, pl. 26, fig. 4a) as a specimen of *S. crenistria,* shows a flat dorsal valve. The internal details are unknown. It resembles *S. dorsiplana* in outline but is much larger.

Geological Age: Tournaisian.

Occurrences: All localities are in the upper member of the Laurel Formation of the Fitzroy Basin. CPC3667, 3668 are from KC11, about 1380 feet in composite type section; CPC3669-71, from KC18; CPC3672, 3, F17953, 4 are from SDH8; F17955 from Ng51; F17956 from KC13.

Family MEEKELLIDAE Stehli, 1954
(nom. transl. Williams, 1965 (ex Meekellinae Stehli, 1954))

Subfamily MEEKELLINAE Stehli, 1954
(= Omboniinae Sokolskaya, 1960)

Genus SCHELLWIENELLA Thomas, 1910

Type species: *Spirifera crenistria* Phillips, 1836.

Generic features: See Williams (1965, p. H407).

Discussion: Thomas did not describe the dorsal cardinalia of *S. crenistria* or other British species in detail. Cardinalia of Russian species have been described by Sokolskaya (1964), of American species by Sanders (1958), and of *S. radialis* (Phillips) by Brunton (1968). The new species described here appear to be similar to *S. umbonata* Sanders and to *S. radialis* in their cardinalia. A chilidium is present behind the cardinal process. Williams' definition that the chilidium is obsolescent needs modification. A low dorsal area extends across the shell behind the chilidium. The socket plates in our specimens are relatively short, divergent on the valve floor but recurved to the hinge-line on their posterior surfaces.

The structure of the dental plates was determined in *S. weaberensis* sp. nov. The plates consist of two components which coalesce on development of shell thickening. A ridge, like the ventral adminiculum of the spiriferids, joins a dental flange, secreted at the delthyrial edge (Text-figs 21, 22). The two components are connected together by early secretion of additional secondary shell. Very youthful silicified specimens of *Schellwienella* sp. aff. *S. australis* sp. nov. have dental plates in various stages of development. Some specimens resemble *Schuchertella;* others have small normal dental plates.

The shell structure in *Schellwienella* has not been described in detail, so far as I know. Demanet (1934) noted the presence of 'granules spiniformes' on the internal surfaces of his forms. These presumably are pseudopunctae or taleolae. The internal surfaces of *S. australis* sp. nov. and *S. minilyensis* sp. nov. are too coarsely silicified to preserve them. The shells of *S. weaberensis* are exfoliated and unsuitable for sectioning. Surface inspection did not reveal taleolae or pseudopunctae. It seems possible that the numerous flexures formed by intersection of the fine radial and concentric markings which extend throughout the shell wall, serve to strengthen the shell, and take the place of the pseudopunctae.

Sokolskaya (1954) and Williams (1965) regard *Pulsia* Ivanov, 1925, as a subgenus of *Schellwienella. S. (Pulsia)* is known from the Upper Carboniferous, whereas *S. (Schellwienella)* is of Devonian and Dinantian to Namurian age. It is fairly widespread, with occurrences in Western Europe and Russia, including the Moscow and Kuznetzk Basins. It is also common in the Mississippian of North America and has lately been reported from the Lower Carboniferous of Queensland by Hill & Woods (1964, p. 10).

SCHELLWIENELLA (SCHELLWIENELLA) MINILYENSIS sp. nov.

(Pl. 17, figs 1-6; Text-fig. 14a-e)

Diagnosis: Medium-sized symmetrical species, width slightly exceeds length; outline rounded, maximum width at midlength; ventral valve nearly flat to

resupinate, interarea moderately high, apsacline, apical angle 155°; dorsal valve moderately convex; costellae fine and fairly even (11 in 5 cm); dental plates thick.

Material: Eight more or less complete isolated silicified valves and a number of fragments.

TABLE 4: Dimensions of species of *Schellwienella*

Specimen Number	L	Lb	Whl	W/L	W/Lb	Wm	Dw	Ha	Aa	Costellae per 5 mm
S. australis sp. nov.										
CPC1699	4.10		5.15	1.25		5.15?	0.45			
CPC3650	3.8+			1.44		5.5+		0.5e	157°	10 at 3 cm from umbo
CPC3649		4.1	c.6.2		1.5	6.2e				10 at 3 cm from umbo
S. minilyensis sp. nov.										
CPC3651	3.75		3.85	1.12		4.20	0.50	0.80	155°	11 at 3.7 cm from umbo
CPC3652		3.66	3.8e		1.3	4.75				
CPC3653		3.6e	4.0e							
CPC3654		2.05	2.05				0.55	0.80		
CPC3655	4.20		3.85	1.16		4.75		0.70		11 at 3.5 cm from umbo
CPC3656	4.90			1.09		5.35				11 at 4.3 cm from umbo
F17947			3.65					0.90		
F17948	Incompl.					5.80				11 at front
S. weaberensis sp. nov.										
CPC3657	3.65			1.56		9.70		c.160-170°		
CPC3658		4.00	4.6		1.48	5.9e				
CPC3659	3.6+		4.7e	1.58		5.7e				
CPC3660	3.20									
CPC3661	3.80			1.3+		5.0+		c.170-175°		
CPC3663		1.20			1.30	1.55				
CPC3664		2.30			1.05	2.40				
CPC3665		1.00			1.60	1.60				
S. sp. cf. *S. minilyensis*										
CPC3666	3.80			1.06		c.4.0				12 at front
F17952		3.45								

Description: *S. minilyensis* is of average size for the genus, the largest individual being 5.35 cm wide and 4.9 cm long. The description is derived from the holotype, CPC3651, a ventral valve (Pl. 17, fig. 1a, b), and paratypes CPC3652-6, all illustrated on Plate 17. The ventral valve is nearly flat to slightly concave, with a wide apical angle of about 155° and a circular to subquadrate outline. The maximum width considerably exceeds the width of the hinge-line and is at about the midlength or in front of it. The umbo is not prominent and the interarea is flat, up to 0.90 cm high and apsacline at a low angle. The pseudodeltidium is gently convex and the delthyrium is 0.50 cm and 0.54 cm wide in two specimens. The dorsal valve is moderately convex longitudinally and transversely with slightly greater convexity near the umbo. The anterior commissure is rectimarginate.

Both valves are ornamented with fine rounded costellae, spaced at 11 in 5 mm at 3.5 to 4.3 cm from the umbo and near the middle. The costae are somewhat obscured by silicification. They appear to be rounded, with deep equidimensional troughs, and increase by intercalation.

Internally, the ventral valve possesses thickened dental plates which diverge at an angle of about 65° in CPC3651 and about 70° in CPC3654 (Pl. 17, fig. 4a, b). The shell is considerably thickened in the umbonal region; in CPC3654 the delthyrial cavity is much reduced and the lateral umbonal cavities are nearly obliterated. CPC3651 is not thickened as much and the cavities can be distinguished. Faint ridges extend forward along the floor from the dental plates and skirt the posterior end of the rounded muscle scars, which are about 1.8 cm in width and length in CPC3651. The scars are longitudinally lineated but are not sufficiently well preserved for the adductor and diductor impressions to be distinguished.

The dorsal valve possesses a low, apparently tapering area, about 1 mm high at its maximum. The notothyrium is not widely diverging and is occupied by a chilidium which appears to be continuous though slightly notched in the middle. The socket plates are short, widely divergent, and recurved. The socket grooves are inwardly directed conical hollows which are flanked on the front side by what appears to be a ridge extending out from near the chilidium. On the posterior side the socket groove was apparently overhung by the area, but this is somewhat eroded. The cardinal process, which is supported by the socket plates, is bilobed with a wide muscle groove on the posterior side of each lobe. The grooves carry fine transverse ridges which are not well preserved. An anterior median ridge on the process is sometimes developed, as shown in CPC3653 (Pl. 17, fig. 6a, b). CPC3652 (Pl. 17, fig. 2a, b) is smooth on the anterior surface. Cardinal process and socket plates arise abruptly from the floor of the valve on their front surfaces. The muscle scar is fairly deeply impressed and lies in front of the socket plates. In CPC3653, it is rounded and about 1.5 cm wide and 1.4 cm long.

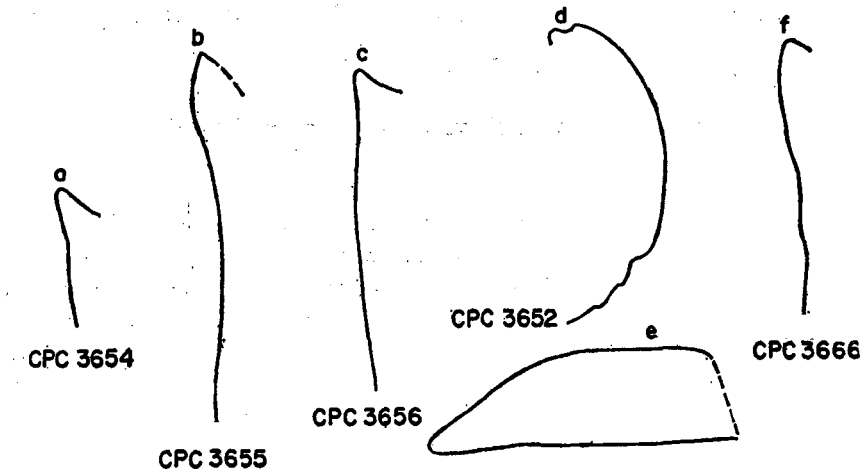

Fig. 14. *S. minilyensis* **sp. nov. Outlines of specimens illustrated in Plates 16 and 17. (a)-(c) Profiles of ventral valves; (d), (e) Profile and anterior of dorsal valve; (f) Profile of ventral valve of** *S.* **cf.** *minilyensis***. Natural size.**

The inner surface of both valves is not costellate, but appears to be pitted and slightly striate; the inside margin is costellate.

Discussion: *S. minilyensis* resembles, in its outline and proportions and size of costellae, *S. rotundata* Thomas, described by Sokolskaya (1954) from the late Visean beds of the Moscow Basin. Our species is larger and has a lower area and is less convex at the ventral umbo. Thomas' topotypes from Britain are smaller than the Russian examples.

Weller's species *S. planumbona* from the Kinderhook also has a general resemblance. It is a little smaller and relatively wider than our species and has rather finer costellae. Sokolskaya in Sarycheva et al. (1963) and other Russian authors have placed *S. planumbona* in *Schuchertella* on the basis that Weller (1914) did not record large dental plates. However, the shape of *S. planumbona* with convex dorsal valve and flatter ventral valve is closer to that of usual *Schellwienella* species than to *Schuchertella lens* (White). *Schellwienella aspis* Smyth, 1930, from the Z zone of Hook Head, Wexford, Eire, is also broadly comparable externally with *S. minilyensis*.

S. minilyensis has similar ornament to *S. australis* but is less wide and has a somewhat higher apsacline area. Its ornament differs from that of *S. ornamenta* and it is not as wide.

Geological Age: Tournaisian.

Occurrences: Specimens CPC3651-6, F17947-8 are from beds at about 440 feet above the base of the Moogooree Limestone, at TP42, Carnarvon Basin.

SCHELLWIENELLA (SCHELLWIENELLA) sp. cf. S. MINILYENSIS sp. nov.

(Pl. 16, fig. 6; Text-fig. 14f)

Material: One incomplete ventral valve, one incomplete dorsal valve, and fragments.

Discussion: The rather sparse collection from the Laurel Formation indicates the presence of a species of *Schellwienella* which seems comparable with *S. minilyensis*. The illustrated specimen, CPC3666, is a ventral valve embedded in tough calcareous rock. In its dimensions (length 3.8 cm, maximum width 4.0 cm), it corresponds to *S. minilyensis*. The apical angle of 170° is wider. The valve is resupinate, being very slightly convex at the umbo and distinctly concave further forward. The interarea cannot be clearly made out but is apsacline.

The dorsal valve F17952 is incomplete and is 3.45 cm long. It is moderately convex longitudinally and transversely, but less so than the topotypes of *S. minilyensis*. The internal features of neither valve are known adequately.

The surface of CPC3666 is abraded, but it carries fine fairly even costellae, of which there are 12 in 5 mm at the front near the midline. The costellae increase by intercalation and are crossed and joined transversely by fine concentric undulations of the shelly layers. These resemble the undulations of *S. weaberensis*, but there are none of the finer costellae of that species.

Geological Age: Tournaisian.

Locality: CPC3666 is from KC13, Fitzroy Basin, from the higher beds of the Laurel Formation. F17952 is from Ng247 (W.A. Petroleum Ltd), Fitzroy Basin; the higher beds of the Laurel Formation, probably the same bed as KC13.

SCHELLWIENELLA (SCHELLWIENELLA) AUSTRALIS sp. nov.

(Pl. 15, figs 6a, b, 7, 9a, b; Pl. 28, fig. 8; Text-fig. 15)

Diagnosis: Medium-sized species; ventral valve flat to slightly resupinate, interarea low, apsacline, apical angle wide; width from 1.25 to 1.44 times length, maximum near hinge-line; dorsal valve strongly convex; costellae fine (10 in 5 mm); dental plates thin; cardinal process stout.

Material: Seven more or less complete isolated valves and some fragments.

Description: *S. australis* is of average size for the genus. The description is based mainly on the holotype CPC3649, a dorsal valve (Pl. 15, figs 6a, b, 9a, b) and paratypes CPC3650 (Pl. 28, fig. 8) and CPC1699 (Pl. 15, fig. 7).

The shell is evidently rather wide, and is widest at the hinge-line. The ventral valve, as appears to be characteristic in this genus, is nearly flat, and the dorsal valve is strongly convex; it is very slightly resupinate and has a wide

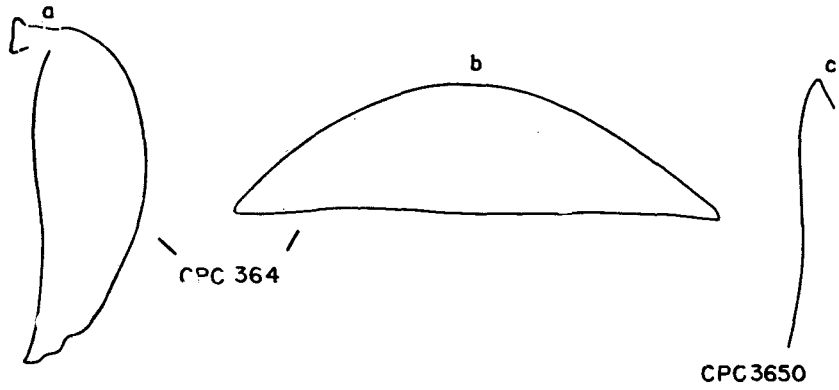

Fig. 15. *S. australis* **sp. nov. Outline of specimens illustrated on Plate 15. (a), (b) Profile and anterior view of dorsal valve; (c) Profile of ventral valve. Natural size.**

apical angle (157° in CPC3650). The interarea is not clearly revealed but is apsacline and rather low, about 5 cm high in CPC3650. The umbo is not at all prominent. A convex pseudodeltidium covers the delthyrium, which is 0.47 cm wide in CPC1699. Neither of the figured ventral valves is complete, but the maximum width appears to be at the hinge-line, as it is in the dorsal valve CPC3649. The front margin is smoothly rounded. The dorsal valve is fairly evenly convex transversely and slightly unevenly convex longitudinally, becoming slightly concave on the outer slopes near the hinge-line. The anterior commissure is rectimarginate.

The ventral and dorsal surfaces are covered by very fine and fairly even costellae. The costellae are rounded and have deep equidimensional troughs. They widen gently to the front and increase mainly by intercalation in at least two generations. In CPC3650, there are 10 in 5 mm at 3.6 cm from the umbo near the middle and in CPC3649 the same number at 3 cm from the umbo. The size is similar in the unfigured specimens. The surface is crossed by concentric growth-lines and lamellae. The lamellae are more numerous and are step-like towards the front, especially in CPC3649, which is rather well preserved for a silicified shell.

Internally, the ventral valve possesses prominent diverging dental plates. These are best shown in CPC1699, in which they diverge at about 90° and extend radially from the umbo for about 1.3 cm; they are thin and not greatly augmented by secondary shell matter. They appear to flank the posterior margin of the muscle scar, which cannot be very clearly made out. It seems to be rounded and has median longitudinal ridges.

The dorsal valve possesses a low nearly parallel-sided catacline area, about 0.15 cm high. The silicification is too coarse to preserve the finest details and the notothyrium cannot be clearly made out. It seems to be largely occupied by a prominent chilidium which is notched at the middle (Pl. 15, fig. 6b). The cardinal process is bilobed, with deep rounded muscle grooves. It was distorted, presumably in life, in CPC3649, with the left lobe larger, in interior view. The socket plates are short and recurved, but appear to have front extensions on the floor of the valve, flanking the muscle scar. The socket grooves are rounded, and are fairly shallow and rather overhung by the area, which appears to fuse with the posterior part of the chilidium. The front inner margin of the socket groove extends outwards as a rounded short process. The adductor muscle scar is not deeply impressed and appears to be large and rounded.

Both valves are fairly smooth on the internal surface, as far as can be seen, but are ribbed on the inner front margins. The finer details of shell structure are unknown.

Discussion: *S. australis* resembles the Belgian examples of *S. crenistria* in outline, but is smaller and more regular, and has a lower area and finer

costellae. *S. burlingtonensis* Weller from the Burlington of the Mississippi Valley is similar in proportions, though a little larger, and has more mucronate growth-lines in its younger stages. Weller did not figure a dorsal valve. The ornament is similar to that of our form. Sokolskaya (1954) has described *S. burlingtonensis* from the Upper Tournaisian Chernyshin beds of the Moscow Basin. Her examples have finer ornament (15 costellae in 5 mm) and more convex dorsal valves. The proportions are similar and the growth-lines resemble those in our form.

S. umbonata Sanders from the early Mississippian of Sonora, Mexico, has a similar though narrower dorsal valve. The details of the cardinalia are a little different also. Other described species show less resemblance. *S. australis* sp. nov. differs considerably in proportions from *S. minilyensis*. The dental plates are thinner and the interarea is lower. It differs from *S. weaberensis* in having equidimensional costellae, and the dorsal valve is more evenly convex.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1699, 3649, 3650, and F17943-6, all from the Septimus Limestone on the western slopes of Mount Septimus, Bonaparte Gulf Basin, about 450 to 500 feet above base of formation.

SCHELLWIENELLA (SCHELLWIENELLA) sp. aff. S. AUSTRALIS sp. nov.

(Pl. 15, figs 1-5, 8; Pl. 28, fig. 9)

Material: Twenty-one small silicified valves.

Discussion: The collection here described was obtained from several pieces of limestone collected in the upper part of the Septimus Limestone. They may well be juveniles of *Schellwienella australis* sp. nov., but as no large individuals of that species were collected from the same beds they are provisionally separated. The specimens are all very small. They appear to be relatively wide, although most are incomplete. The growth-lines show that they are wider than long. The ventral valves are flat with very wide apical angles and nearly catacline interareas. The delthyria are widely divergent and completely closed by convex pseudodeltidia. The teeth are prominent and inclined to the hinge-line.

The dorsal valves are gently convex, longitudinally and transversely. Both valves carry fine rounded costellae increasing by intercalation. They appear uneven in size, but this is probably because the numerous intercalated costellae have not attained maximum size in such young individuals.

The internal features of the ventral valve are of some interest. There is a variation, from shells with dental flanges but no dental plates seen in one specimen (CPC3677, Pl. 15, fig. 4a, b), to shells with short divergent dental

plates, the more common condition (e.g. CPC3674, Pl. 15, fig. 2a, b, and Pl. 28, fig. 9).

The dorsal cardinalia consist of a bilobed cardinal process supported by divergent recurved socket plates. The socket grooves are overhung by the interarea, which appears to pass behind the chilidium as in *S. australis*. The front ventral edge of the socket plate is flanged. The posterior surface of each lobe of the cardinal process possesses a longitudinal muscle groove.

Dorsal valves are illustrated in Plate 15, figures 3a, b, 5a, b and 8a, b.

The inner surface of both valves is radially ribbed and the muscles are very lightly impressed.

This collection, whether or not it is properly included with *S. australis*, is of interest. It confirms the observations on *S. weaberensis* sp. nov. that the dental plate in *Schellwienella* is a composite structure formed from two components.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC3674-9 are from the Septimus Limestone on the eastern slope of Mount Septimus, Bonaparte Gulf Basin, about 550 to 600 feet above the base.

SCHELLWIENELLA (SCHELLWIENELLA) WEABERENSIS sp. nov.

(Pl. 16, figs 1-5, 10; Pl. 17, figs 7-9; Text-figs 16-18)

Diagnosis: Medium-sized symmetrical species; width about 1.5 times length, maximum near midlength; ventral valve slightly resupinate, interarea low, apical and very wide (c. 170°); dorsal valve strongly convex but flat to slightly concave near umbo; distinctive ornament with fine costellae of two sizes; dental plates with two components.

Material: Twelve fairly complete valves and numerous shell fragments embedded in calcareous rock, and several moulds of dorsal valves.

Description: The shell is medium-sized for the genus and relatively wide; the holotype CPC3675 is 5.7 cm wide and 3.6 cm long, and CPC3658 (Pl. 16, fig. 1), a dorsal valve, is about 5.9 cm wide and 4.0 cm long. The ventral valve is commonly symmetrical with a very wide apical angle of 160°-175°. The umbo is not prominent. The valve varies in convexity from being nearly flat with slight inflation near the umbo to being distinctly resupinate. The holotype is nearly flat with slight irregularities, and paratype CPC3660 (Text-fig. 16) is resupinate; CPC3661 (Pl. 16, fig. 4) is gently resupinate. The complete

outline is not seen in any of the ventral valves, but is more or less oval, with the maximum width near the midlength. The interarea is not exposed in any of the specimens, but from sections it is seen to be low and at a high apsacline to nearly orthocline angle. Thus, in CPC3661 (Text-fig. 17) it is probably not much more than 0.25 cm high and is at a high apsacline angle. The delthyrium, as seen in section, is wide and divergent and covered by a convex pseudodeltidium.

The dorsal valve is strongly convex longitudinally with greatest convexity towards the front. Near the umbo, it is flat to slightly concave and gently convex on the posterior slopes in large specimens. Small, evidently youthful, specimens like the moulds CPC3663-5 (Pl. 17, figs 7, 8, 9) are entirely slightly concave. Consequently, the profile of the dorsal valve varies in convexity from back to front.

The outline of the shell is oval and the front commissure in mature specimens is nearly rectimarginate. Growth-lines, which are clearly visible on the surfaces, indicate that the maximum width was only slightly greater than the hinge-line in the early stage but considerably more so in maturity. In CPC3658, the only readily measurable shell in this respect, the maximum width is 5.9 cm and the length of the hinge-line 4.7 cm. The lateral profile changed markedly with growth, especially in the resupinate individuals.

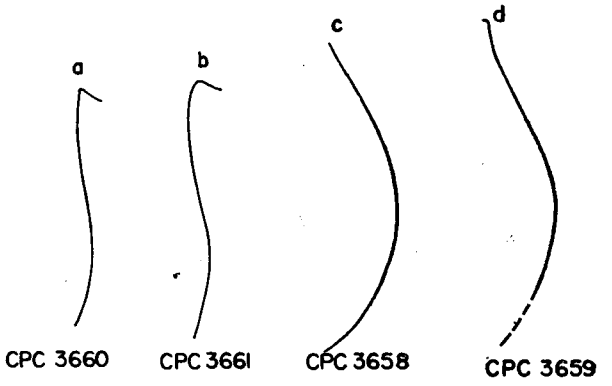

Fig. 16. *S. weaberensis* **sp. nov. Outlines of specimens illustrated in Plate 16. (a). (b) Profiles of ventral valves; (c), (d) Profiles of dorsal valves. Natural size.**

The ventral interior is known only from sections and abraded shells. Several sections show widely divergent dental plates which join the floor of the valve (Text-figs 17, 18). They are initially formed by secretion of a dental flange or ridge formed on the delthyrial margin, which reaches a low component deposited in the valve floor. After this junction is formed, secondary shell layers are deposited on both sides. The plates extend farther forward than the interarea. The length varies in accordance with the inclination of the area. The muscles appear to be very lightly impressed and the inner surface is costellate. The shell wall is very thin, even the umbonal region.

The dorsal valve possesses widely divergent recurved socket plates and a low bilobed cardinal process. The dorsal area is low but could not be measured

in the larger specimens. The illustrated examples, Plate 17, figures 7, 8, 9, are very youthful individuals, but the larger specimens appear to be similar. No details of the chilidium could be made out. The dorsal adductor muscles appear to be very slightly impressed. The inner surface of the valve is costellate.

The surface ornament is quite distinctive. It varies over the shell surface. Nearly all the shells are somewhat exfoliated, but even the inner layers preserve a pattern similar to the surface. The surface is finely costellate and generally two sizes of costellae can be distinguished. Thus in the holotype stouter costellae are separated by 3, 4, or 5 finer costellae over the whole surface. Costellae increase by intercalation and they do not widen greatly to the front, where commonly the stouter costellae are more numerous and are less widely spaced. Fine concentric undulations of the shell lie between the stouter costellae and cross the finer costellae. They become coarser and more prominent to the front. The enlarged surface of CPC3658 is illustrated in Plate 16, figure 10 (x8). This has the outermost shell layer removed but represents the characteristic surface aspect of the shell in all the specimens. In CPC3658, at the front, the stouter costellae have nearly excluded the fine ones and number about 10 in 5 mm. Further back at 2 cm from the umbo there are 5-6 stouter costellae with between them 18 finer costellae in 5 mm. The costellae multiply, mainly if not entirely, by intercalation.

Discussion: The striking ornament of this species distinguishes it from the other Australian species. Very similar ornament has been described in *Schellwienella ornata* Demanet from the Upper Visean of Belgium. That species has three to five very fine costellae between larger costellae. It is, however, smaller and is more nearly equal in length and width. *S. reprinki* Sokolskaya is another species with similar ornament. It is also smaller and not as wide and has a higher area. It occurs in the middle Visean beds of the Moscow Basin.

Schuchertella fascifera (Tornquist), which has been described from the Visean of Germany by Paeckelmann (1930), and from Belgium by Demanet (1934), possesses a similar ornament. It is a very large species with convex dorsal valve and resupinate ventral valve. Demanet (1934, p. 92) reports that the dental plates are non-existent or little visible. Whatever its generic status, the species is much larger than *S. weaberensis*. It is reported from the late Tournaisian and Visean of Belgium.

Ornament of similar type was illustrated for a Visean species from Yunnan which Reed (1927, pl. 8, figs 6, 7) named *S. crenistria*. The form of the shell and its internal structures are unknown and it cannot therefore be compared with *S. weaberensis*. H. & G. Termier (1950, pl. 81, fig. 12) illustrated a somewhat similar ornament for a species which they referred to *Derbyia gigantea* Thomas. It occurs in the Visean of Algeria.

It would appear that the elaborate ornament of this type characterizes a number of species of Lower Carboniferous davidsoniaceans. If the generic

assignment given by authors to the various species is correct, it is a feature appearing independently in several homeomorphic lineages.

In *S. weaberensis,* the ornamental pattern is not merely superficial but is an integral part of the shell wall.

Geological Age: Visean to possibly Namurian.

Occurrence: CPC3657-60 and F17949-51 are from WAA3 (Mines Administration Ltd), Milligans Yard Hills, Bonaparte Gulf Basin, Burvill Beds; CPC3661-5, from BW7, about 1 mile east of Point Spring, Burvill Beds.

Suborder CHONETEDINA Muir-Wood, 1955

(nom. correct. Muir-Wood, 1965, pro suborder Chonetoidea Muir-Wood, 1955)

Family CHONETIDAE Bronn, 1862

Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus RUGOSOCHONETES Sokolskaya, 1950

Type species: *Orthis hardrensis* Phillips, 1841.

Generic features: See Muir-Wood (1965, p. H430).

RUGOSOCHONETES? sp. A

(Pl. 29, figs 5a, b)

Material: One incomplete shell.

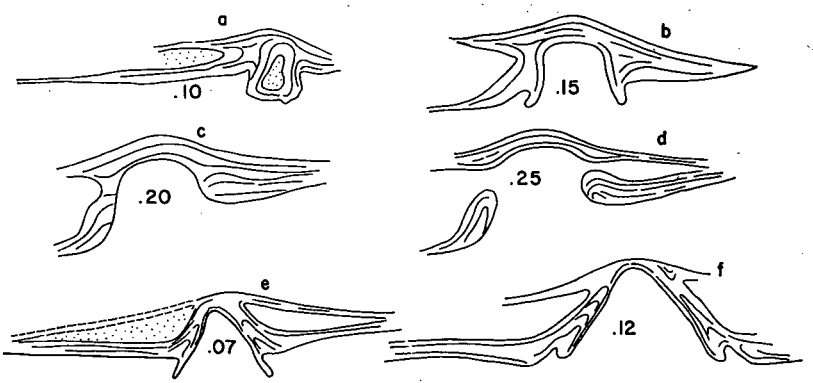

Fig. 17. *S. weaberensis.* **Transverse sections. (a)-(d) CPC3660, incomplete ventral valve, x5.9; (e), (f) incomplete ventral valve, x4.2.**

Description: The sole specimen, CPC6127, is somewhat crushed. It is 1.10 cm long and an estimated 1.8 cm wide. The sides are rounded and the maximum width is at about one quarter of the length from the umbo. The ventral valve is moderately and evenly convex longitudinally and transversely, somewhat flattened in the middle towards the front. The dorsal valve is concave and lies in close contact with the ventral valve. The ventral umbo is only slightly elevated and the apical angle is wide. Both valves possess low interareas, the dorsal being reflexed. Three posterolaterally directed spine-bases lie on the shoulder. The surface is ornamented with fine, rounded, even, radial capillae which multiply by division; they number 28 in 5 mm at the middle of the front margin, which is straight. The front commissure is rectimarginate. The internal structures are unknown. The capillae are a little abraded but appear to be crossed by very fine concentric lirae. A few coarser growth-lines are present near the front.

Discussion: This solitary specimen is undoubtedly a chonetid. Its general shape and fine even capillae suggest either *Chonetes* or *Rugosochonetes,* though generally the species of *Rugosochonetes* tend to have their greatest width at the hinge-line. However, the reflexed dorsal interarea points to *Rugosochonetes* and the fine concentric ornament is similar to that figured by Sokolskaya (1950, pl. 3, fig. 7) for specimens which she named *Rugosochonetes hardrensis.* In dimensions it is comparable with the British Tournaisian species *R. vaughani* Muir-Wood and the Visean *R. celticus* Muir-Wood, though its maximum width seems farther forward than in either of those species, which also have more numerous spine-bases. *R. znamanskensis* Sokolskaya, of early Tournaisian age, is similar in shape. The specimen differs from Eastern Australian species of *Rugosochonetes.*

Geological Age: Tournaisian.

Occurrence: CPC6127 comes from KC13, Fitzroy Basin; from the top beds of the Laurel Formation.

TABLE 5: Dimensions of species of *Rugosochonetes?* (in cm)

Specimen Number	L	Lb	Whl	Wm
Rugosochonetes? sp. A				
CPC6127	1.10		1.36	1.8e
Rugosochonetes? sp. B				
CPC6128		1.05	1.46	1.65
CPC6129	1.10		—	1.66
CPC6130		1.05	1.45	1.70

RUGOSOCHONETES? sp. B

(Pl. 29, figs 2-4)

Material: Numerous poorly preserved impressions and internal moulds.

Description: The outline and size are similar to those of *Rugosochonetes?* sp. A. The front commissure is rectimarginate. The ventral valve has a more or less oval outline with low umbo and very wide apical angle; it is strongly and evenly convex longitudinally and transversely, and lacks a sinus. The cardinal spines are not preserved. The dorsal valve is nearly flat to gently concave, slightly geniculate at the margin.

The ventral internal structures are poorly preserved. Some specimens (not figured) have a low medium septum extending half the valve length. The teeth are broad, flat, and transverse (CPC6129, Pl. 29, fig. 2). The dorsal valve has a nearly flat visceral region and slightly geniculate outer margin. The five radiating ridges, characteristic of the Rugosochonetinae, can be made out. The socket ridges are widely diverging. An alveolus is present and in front of it, the low and short lateral septa diverge at about 37°. The medium septum is long, apparently extending to near the front of the visceral region. Muscle scars and brachial ridges could not be discerned. The surface ornament is poorly preserved but is apparently capillate.

Discussion: The form, rectimarginate commissure, and internal structures of these specimens suggest inclusion in *Rugosochonetes*. More adequate material is now available of the species for description elsewhere. The above description is included in explanation of the specimens illustrated on Plate 29, figures 2-4. They appear to be comparable with specimens from the Burt Range Formation

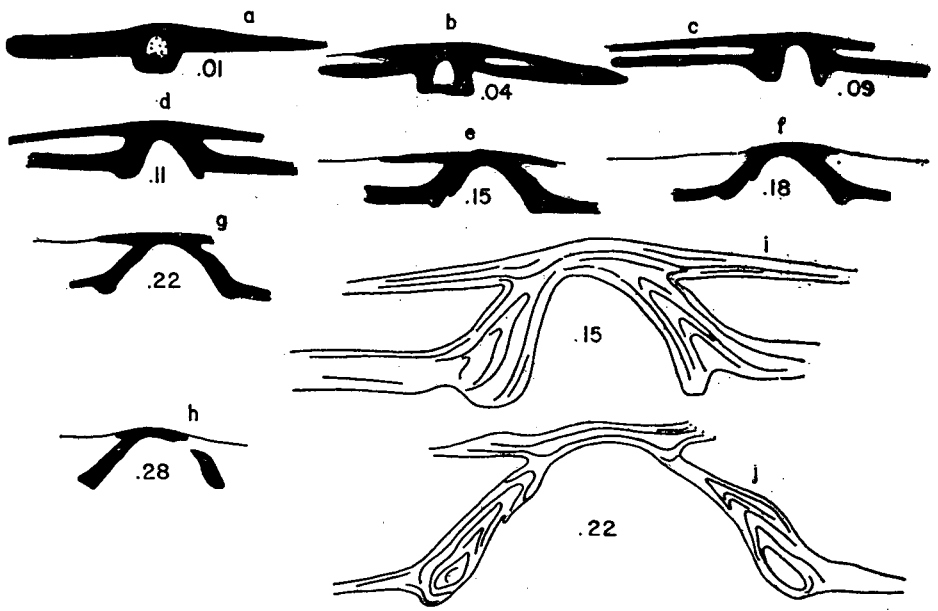

Fig. 18. *S. weaberensis*. **CPC3662. Incomplete ventral valve. Transverse section (in cm) from umbonal apex. (a)-(h), x2; (i), (j), x6.**

at Spirit Hill. They were referred to by the author in Appendix D of Traves (1955). The species is readily distinguished from the much larger and sinuate *Neochonetes pratti* (Davidson) of Permian age, which is the only previously described Carboniferous or Permian chonetid species from Western Australia.

Geological Age: Early Tournaisian.

Occurrence: CPC6128-30 and other specimens come from the isolated sandstone beds at Flapper Hills, Bonaparte Gulf Basin (locality 15 in Text-fig. 5), Burt Range Formation.

Order SPIRIFERIDA Waagen, 1883

Spiriferid Morphology and Terminology

A review of spiriferid morphology is not attempted here. The discussion is mainly introductory to the specific descriptions, with some additional observations. Terminology is for the most part as in the *Treatise on Invertebrate Paleontology* and earlier usage. Some differences are discussed.

Shell Structure

Shell structure in various spiriferids has been recently discussed by Williams (1956), Williams & Rowell (1965), Vandercammen (1956, 1959b), Dunlop (1961), Ager & Riggs (1964), and Krans (1965). The terminology used by Williams is followed here. The primary shell layer is largely eroded in most of my specimens. Some of them show the *prismatic layer* (Alexander, 1948), which Williams (1965, p. H64) considers to be only a modification of the secondary layer. Dunlop (1962) describes alterations (rarely multiple) of prismatic and ordinary fibrous shell in *Spirifer trigonalis* Martin, which she considered to mark growth halts and contraction of the mantle. The prismatic layer was noted in *Prospira laurelensis* sp. nov. Some of the Spiriferidae possess very coarse crystals (coarser than the normal prismatic layer) in the umbonal region, especially on the dental plates. These are discussed below, in the section on dental plates. They appear to be another modification of the secondary layer.

In some species, notably in *Pseudosyringothyris* and *Cyrtella,* the fibrous layer forms very distinct more or less concentric laminae (in transverse section) which are differentiated by changes in the orientation of the fibres in successive layers. Growth interruptions can also leave laminar traces.

Ivanova (1943) was able to show for *Choristites* a relationship between halts in the growth of the internal laminae and the external growth stages of the shell. Vandercammen (1956, 1959a) has distinguished layers of the shell of *Cyrtospirifer* and *Spinocyrtia* as 'fibrotest', 'prismotest', and 'callotest'.

These appear to be all modifications of the secondary shell layer and are variously distributed in different parts of the shell.

Dental Plate

Dental plate is used for each of the pair of composite plates projecting from the delthyrial edges and crossing the apex of the ventral valve to the floor in most Spiriferida. This is in accordance with the original use of the term by King (1850, p. 68). The plates are commonly divergent but may be nearly parallel in some species. In some species they are thin and delicate, but in many groups, especially the Spiriferidae, they are greatly thickened. Their size, shape, and relationship to other features are undoubtedly of some taxonomic importance. They received much attention from Fredericks (1916, 1924, 1926, 1927), Chao (1929), Semichatova (1932), and others. The discussion of these authors was largely vitiated by a failure to understand their finer structure, which was elucidated by the work of Miloradovich (1936, 1937), Ivanov & Ivanova (1937), and Ivanova (1943). Miloradovich showed that dental plates and other internal features such as median septa and delthyrial plates are laminar secretions by folds of the mantle. Ivanova (1943) showed that the most important feature of the dental plate in *Choristites* is the thin darker median part which she named the 'true dental plate'. This is called the *initial dental plate* in my descriptions. It is composed of fine fibres (generally more or less longitudinally oriented, i.e. at right angles to transverse sections). With growth of the shell in many species, the dental plate is much thickened by further deposition of either ordinary fibrous or prismatic layers. The initial dental plates may be completely obscured macroscopically, but are generally visible in transverse section. Ivanova (1943) traced the initial plates forward to their front unthickened very delicate extremities in *Choristites*. Similar thin anterior parts of the dental plates are seen in *Anthracospirifer milliganensis* sp. nov. (Text-fig. 41L). The initial dental plates appear to be ventrally in continuity with the initial floor of the valve (Pl. 27, fig. 1). In favourable sections only can the trace of the initial floor be seen (Text-figs 24, 29, 34, 35).

Thickening of the plates is commonly greater on the umbonal cavity side than on the inner (delthyrial) side. In some of the Spiriferidae the thickenings were no doubt deposited as layers but are now commonly coarsely crystalline. The crystals extend inwards only as far as the initial dental plate, which is not broken by them. Semichatova (1932) gave an elaborate description of the crystals in *Choristites* and similar forms from the Moscow basin and thought that the initial plate was merely a plane within the dental plate. She found that the crystals did not extend across it, but are oriented more or less at right angles to it. In *Choristites* (Ivanova, 1943), and in some of my species (Text-figs 34, 35), fine lines parallel to the initial dental plate can be seen in the crystals. These are no doubt the trace of the original lamination, marking interruptions in the deposition of shelly material. Ivanova considered that the crystallization occurred during the life of the animal, and pointed out that

it does not affect either the initial dental plate or the trace of the initial floor. I agree with this interpretation. It is noteworthy also that this crystallization does not affect the outer shell layers or the front parts of the shell. Diagenetic or other secondary crystallization could be expected to involve all parts indiscriminately and such recrystallization is of course found in some fossil specimens.

Dunlop (1961) did not illustrate the initial dental plate in her sections of *Spirifer trigonalis,* showing in its place a line separating two 'columnar' (i.e. prismatic) shell layers. I suspect that a thin initial dental plate is present in *Spirifer trigonalis.* Dunlop did not quote Ivanova (1943) nor list her in her bibliography. Ivanova pointed out also that the 'true' dental plate was formed of two components: one arising from the floor of the valve and the other from the delthyrial edge. Two components of the dental plate can be distinguished in sections in most of my specimens of *Spirifer, Unispirifer, Prospira,* and *Kitakamithyris,* and there is commonly a flexure at their junction. The laminar thickenings of the conjunct plates are continuous, however. Brown (1953b, p. 102) independently recognized the two components in *Martiniopsis inflata,* which has thin, unthickened, dental plates. She proposed the term *ventral adminiculum* for the delthyrial component. Dunlop (1962) independently distinguished two components in the dental plate of *Spirifer trigonalis. Dental flange* (Dunlop, 1961, p. 491) is a suitable term for the delthyrial component of the dental plate. The usage 'dorsal adminiculum' for this component in the Treatise (Part H, p. 491) is rejected because the term was proposed by Brown (1953b, p. 102) for structures in the dorsal valve.

The initial dental plate apparently corresponds to part of the prismotest of Vandercammen (1959a) and to the median structure in the dental plate described by Krans (1966) in *Euryspirifer,* and possibly to the structure in *Cyrtospirifer* Krans (1966, figs 31, 32a, b). Krans has also described a very fine median structure (a single layer of calcite prisms) in *Brachyspirifer,* which he named the *mediotest.* He postulated that this formed at the crest of the epithelial fold which secreted the dental plate. The calcite fibres on the sides of each plate were secreted simultaneously. The mediotest is said to fade out towards the floor of the valve. Similar structures were found in seven other Devonian species. Krans also distinguished a layer on the floor of the ventral muscle area as the *myotest.* This may be covered by later shell thickening. The mediotest appears to be a special structure. Further study is required to establish its relationship to the initial dental plate of *Choristites.*

Ivanova (1943) discussed the biological function of the dental plate. In *Choristites,* the delicate anterior part (unthickened initial dental plate) enters the muscle field and is very close to the spires of the brachidium. She suggested that the plate was intimately connected with the spiral lophophores, although the valves are capable of movement. As the shell grows and the muscles move forward the posterior part of the plate is thickened. It does not seem evident

to me that the dental plates are intimately related to the spiralia in mature individuals of most species of Spiriferidae; though they may well have been in the early growth stages, as suggested by Ivanova. Their significance is still in need of investigation. They are obviously subject to considerable variation of length, orientation, and thickening, even within the species, and need to be used with caution as a taxonomic criterion.

Delthyrial Plate

The delthyrial plate is the transverse apical plate in the delthyrium generally below the surface of the interarea, which is best known in cyrtospiriferids and syringothyrids but is also present in various other spiriferid species. Miloradovich (1937) considered that it was deposited by a fold of the mantle, formed like the dental plates. Williams (1956) and Williams & Rowell (1965) suggest that it is homologous with the pedicle collar and therefore deposited by pediculate epithelium. Both views imply that it is formed of the secondary or fibrous shell layer. Vandercammen (1961) considered that the delthyrial plate is formed of 'callotest' and serves as the ventral support for the pedicle capsular ring, which is homologous with the pedicle collar of the terebratuloids. He argued that the outer was the functional side of the delthyrial plate. When present it divided the 'central apical cavity' into two parts: a 'post-delthyrial cavity' behind the delthyrial plate and a 'deltidial cavity' between the delthyrial plate and deltidium. Krans (1966, figs 44a, 45a) considers that the delthyrial plate in *Cyrtospirifer* is not homologous with the pedicle collar and shows it to be formed by median apposition of thickenings on the dental plates. This mode of formation was earlier pointed out by Sokolskaya (1941, p. 12) and is exemplified in various costate spiriferids, e.g., my specimens of *Unispirifer fluctuosus* and *Prospira laurelensis* (Text-fig. 24e, f, and 29c, d respectively). Small delthyrial plates can also be found in other spiriferid species. Dunlop (1962, p. 494) has described a small convex delthyrial plate in *Spirifer trigonalis*. Near the apex this arches up dorsally above the level of the interarea, but is below this level towards the front. It is made up of fibrous shelly layer externally and of prismatic layer internally. In its early stages it appears to be formed by lateral growth from the sides of the delthyrium, but the inner layers are continuous across the delthyrium. Sokolskaya (1941) described the remnants of a small delthyrial plate in '*Spirifer tornacensis* de Kon.', from the Moscow Basin, and this appears to be continuous. The species here described as cf. *Spirifer duplicicostus* (Phillips) possesses a small convex delthyrial plate (Text-fig. 37d, e, i, j, and Pl. 29, fig. 8). The outer layers appear to be continuous with the initial dental plates, but this needs confirmation from additional sections; the inner layers are prismatic and are continuous with the laminated prismatic layer forming the thickenings of the dental plates lining the delthyrial cavity.

Pseudosyringothyris and *Cyrtella* and other syringothyridinids have larger delthyrial plates. The outer layers were at first built up independently of the initial dental plates, which are much stouter than in the Spiriferidae. The

orientation of the fibres in the outer layer of the delthyrial plate suggests that it was built up from the sides and perhaps in part from the apex. The inner thickenings are continuous with deposits on the dental plates (Text-fig. 56). In *Syringothyris,* the outer layer of the delthyrial plate appears to be built up from the apex as well as from the sides; it could not be traced to show continuity with the initial dental plate in the specimens (Text-fig. 52). It may have developed very shortly after or at the same time as the advancing syrinx which it strengthened. The syrinx is free of support at its anterior end, and probably forms the attachment site of the ventral adductor muscle. Adductor muscle scars occur on the inner side of the delthyrial plate in *Pseudosyringothyris.* The internal thickenings of the delthyrial plate and the apical part of the syrinx in *Syringothyris* are continuous with the inner thickening of the dental plate in the post-delthyrial cavity.

The presence of a delthyrial plate has been used as a taxonomic criterion in various schemes of classification, notably by Fredericks (1926, etc.). It is used by Ivanova (1959, 1960) and by Pitrat (1965) as one of the distinctions between Cyrtospiriferidae and Spiriferidae. Although the consistent possession of a sizeable delthyrial plate may be of some value as a criterion it is a feature that must be used with caution: it is variably present in the Spiriferidae.

Other delthyrial structures

The spiriferid delthyrium generally has at its margins a ridge, either at the level of the interarea or a little below. This ridge traces back posteriorly from the tooth. In favourably preserved specimens arcuate growth-lines, marking the earlier positions of the tooth, can be seen. Alexander (1948, figs 3f, 6a) used the term *dental ridge* for the analogous structure of the pentamerids. The same term is used by Dunlop (1962, p. 491), and myself. Vandercammen (1959b, p. 27) designated this ridge in *Cyrtospirifer* as the 'bourrelet deltidiale' and distinguished two marginal grooves: the 'rainure deltidiale' on the dorsal side and the 'rainure hypodeltidiale' on the ventral side of the dental ridge. He showed the deltidium fitting snugly on to these structures. The grooves, particularly the dorsal one, can usually be distinguished in my specimens.

A delthyrial covering is not commonly preserved in the spiriferids and little was ascertained from my collections. *Brachythyris* has a small convex delthyrial covering, but as the specimens are silicified they could not be usefully sectioned. A remnant of an apparently loosely attached covering was seen in sections of *Unispirifer fluctuosus* (Text-fig. 24a-c; Pl. 28, fig. 6). A *stegidium* (Cooper, 1954, p. 328), similar to the overlapping plates in front of the delthyrial plate of *Syringospira,* was observed in several specimens of *Pseudosyringothyris dickinsi* sp. nov. (Pl. 10, fig. 2a; Pl. 11, fig. 1c). Sartenaer (1955) used the same term for the overlapping plates which completely cover the delthyrium in *Cyrtinopsis* and which may be perforated by a pedicle foramen. Cowen (1968) has used the term stegidial plates for the delthyrial cover of *Mucrospirifer* and has

cogently argued that they were loose structures secreted independently from the interarea. They served to close the delthyrium, but unlike deltidial plates were not secreted integrally with the interarea and could change in shape with growth. The stegidial plates may surround the pedicle opening. Cowen considers that the stegidium was a similarly loose structure.

Hyde (1953) described a somewhat similar delthyrial cover, with the foramen developed into a pedicular tube, in the delthyrium of *Syringothyris*. This covering may also have fitted loosely in the delthyrium. Loosely secreted delthyrial coverings may not be uncommon in groups of spiriferids.

Interarea

The ventral interarea of the species of Spiriferidae described here generally display the longitudinal *denticular ridges* long known in this group and recently described in detail by Dunlop (1962) and Williams & Rowell (1965). The primary layer is eroded from most of my specimens, and the longitudinal flutings, which may deviate slightly and occasionally coalesce, are conspicuous. Denticulations on the front of the interarea are general in this family. Vandercammen (1959b, p. 28) noted that the interarea of *Cyrtospirifer* shows a differentiated micro-ornament reminiscent of the davidsoniaceans, with longitudinal and transverse lineation close to the delthyrium. Farther out the lineation is transverse only. This differentiation was not evident in the mostly somewhat worn specimens of Spiriferidae described herein. Marked differentiation is present in the Syringothyridinae. The term *perideltidium* (Dunbar & Condra, 1932) is appropriate for the inner part of the interarea in this group. The longitudinal lineations appear to be only in the outermost shell layers of *Pseudosyringothyris* and denticles were not observed. The deeper shell layers do not show flexures to correspond with the longitudinal lineations, which presumably did not have a denticular articulatory function. The perideltidium is discussed below under *Pseudosyringothyris*.

Dorsal valve

The dorsal cardinalia in the Spiriferacea are generally similar to those of *Spirifer*. A low or depressed diductor muscle area with numerous fine longitudinal platelets is present in front of the umbo. It is flanked by *socket plates* which more or less recurve to the hinge-line. Certain genera of the Spiriferidae possess longitudinal supporting plates, e.g. *Palaeochoristites* Sokolskaya, *Ectochoristites* Campbell, and *Eochoristites* Chu. Of the Reticulariacea, *Kitakamithyris* has very short plates of similar type. Well developed longitudinal plates are present in *Martiniopsis* and the Ingelarellinae in general (Campbell, 1959a). Brown (1953b, p. 102) proposed the term *dorsal adminicula* for them, but a separate term for the dorsal structures might be desirable. Waterhouse (1968, p. 6) has proposed *tabellae*. Concave hinge-plates are present in some recticulariaceans. *Torynifer? dorsiseptatus* sp. nov. possesses a hinge-plate and supporting median septum.

Pitrat (1965) uses the term 'crural plate' apparently instead of dorsal adminiculum, but this usage is not followed here. The crural base is attached to the inner side of the socket plate in the Spiriferacea and is, in some species, a wide plate or flange. The term *crural plate* is used here for this structure.

Other internal structures

An impressed vascular system was not observed in most of the spiriferid species studied. Vague grooves are present in *Pseudosyringothyris*: internal radial grooves occur in the reticulariids; and grooves opposite the costae are often present on the inside of species of the Spiriferidae. The ventral and dorsal muscles can generally be made out and are described where possible. An area of genital ('ovarian') pits flanks the ventral muscles in many of the Spiriferidae. The brachidia are described for species in which they were ascertained.

Ornament

The term *striae* is used for the fine radial longitudinal micro-ornament characteristic of most Spiriferidae and also found in other groups.

The sulcal costal arrangement of the various species of Spiriferidae is illustrated. The patterns are somewhat variable but fairly simple in the species described. The over-elaborate notational schemes of Gatinaud (1949, 1950) were not applied. The term *unicostate* is used for the pattern with a median costa originating near the sulcal apex and behind the primary costae which arise from the boundary costae. This is in place of 'uniplicate' (Grabau, 1931a). Likewise *duplicostate* is used in place of 'dupliplicate' (Grabau) for the pattern in which the pair of primary costae arise near the sulcal apex and remain nearly parallel; the median costa, if any, originates farther to the front. *Uniplicate* is now used to describe the front commissure, following Thomson (1927).

Order SPIRIFERIDA Waagen, 1883

(nom. correct. Moore, 1952)

Classification of the brachiopods with spiral appendages has recently been attempted by Ivanova (1959, 1960, 1967), Boucot et al. (1965), Pitrat (1965) and Waterhouse (1968). None of these attempts or those of earlier authors can be regarded as entirely satisfactory. It is not proposed to review the taxa and assignment of genera at this stage except to point out alternative interpretations where appropriate.

Suborder SPIRIFERIDINA Waagen, 1883

(nom. correct. Pitrat, 1965, pro suborder Spiriferacea Waagen, 1883, p. 447)

The definition of Pitrat (1965, p. H668) is accepted. The genera included broadly correspond with those of the order Spiriferida, as amended by Ivanova

(1959, 1960) but with different concept and arrangement of superfamilies. Three of Pitrat's five superfamilies are represented in the faunas described here: Spiriferacea, Reticulariacea, and Spiriferinacea.

Superfamily SPIRIFERACEA King, 1846

The definition by Pitrat (1965, p. H679) is accepted. Pitrat included 10 families; his grouping differs considerably from Ivanova's and includes genera which she placed in the Delthyriacea. The family Brachythyrididae, as erected by Pitrat, is not accepted. The described species are referred to two families: the Spiriferidae and Syringothyrididae.

Family SPIRIFERIDAE King, 1846, emend. nov.

Diagnosis: Small to large Spiriferacea; costate on fold, sulcus, and flanks; outline variable from transverse to elongate; plicate or non-plicate: sulcus and fold variably developed, may be slight; micro-ornament generally of fine radial striae crossed by fine concentric lines or lamellae; denticulate hinge-line; dental plates variable from elongate to vestigial; delthyrial plate small or lacking; socket plates generally recurved to hinge-line, rarely with dorsal adminicula; impunctate. Lower Carboniferous to Permian.

Discussion: The diagnosis is an emended expansion of the summary by Ivanova (1960). She included two subfamilies: Spiriferinae King and Brachythyridinae Fredericks. Pitrat distinguished these as two families with somewhat different definitions and generic content. In my view, on present knowledge of the genera covered by the above diagnosis, it is premature to distribute them to either of two subfamilies or to recognize two families. Ultimately it may be useful to distinguish more than two subfamilies as Waterhouse (1968) has attempted for the family Brachythyrididae, with three subfamilies, and two subfamilies in the Spiriferidae.

Most of the genera listed by Pitrat in his Spiriferidae and Brachythyrididae can be included here. The diagnosis covers a large number of genera of varied form. Costation varies from simple to fasciculate; the sulcal pattern varies from unicostate to duplicostate. Costae can be flattened or reduced in some genera, e.g. *Brachythyris*. The radial striae are not always preserved and may be lacking in some genera, e.g. *Brachythyris*.

The genera *Spirifer* Sowerby, *Unispirifer* Campbell, *Prospira* Maxwell, *Anthracospirifer* Lane, *Kinghiria* Litvinovitch, and possibly *Imbrexia* Nalivkin appear to be a closely allied Carboniferous group. The taxonomic status of some of them has been much discussed and the problems are far from settled. I have assigned Western Australian Carboniferous species to *Spirifer, Prospira, Unispirifer,*

and *Anthracospirifer*. My interpretation of each genus is outlined in the appropriate section below. I consider that each represents a fairly distinctive species group but with overlapping stratigraphic ranges. Among other recent authors, Vandercammen & Plodowski (1967) have discussed some of the group and regard *Prospira* and *Unispirifer* together with *Grandispirifer* as synonyms of *Spirifer*. However, they do not allude to the lectotype of *Spirifer striatus* in their discussion.

Maxwell (1961) suggested that *Unispirifer* might be congeneric with *Prospira*. Hill & Woods (1964, p. 20) have evidently accepted the view that *Unispirifer* is a synonym of *Prospira*, but without discussion. If this should be established, I consider a new generic name would then be required for the group of transverse early Carboniferous species which I have included under *Prospira*. Russian authors have revived the name *Fusella* M'Coy for species corresponding in part to the group included by me in *Prospira*. I have examined the monotypic specimen of *Spirifer fusiformis* Phillips, the type species of *Fusella*, in the British Museum of National History, by courtesy of Dr C. H. C. Brunton. The specimen comes from the Visean Carboniferous Limestone of Bolland, Yorkshire. It is a small, very transverse, somewhat worn specimen. The lateral costae are extremely faint; the sulcus is smooth and shallow but distinct at the commissure; two flat costae occur at the fold, which is not elevated at all. The ventral interarea is moderately high and longitudinally grooved. The internal structures are not visible. This specimen is inadequate to establish the features of the species and of *Fusella*. It is conceivable that it is a juvenile of *Spirifer convoluta* Phillips. It seems advisable not to use the generic name *Fusella* until the type species is adequately known from topotype material. However, the type locality is uncertain.

A Visean species from the Bonaparte Gulf Basin could not be satisfactorily placed in any of the established genera. It is described as Spiriferidae gen. et sp. nov. cf. *'Spirifer' duplicicostus* (Phillips). The European species has not been recently redescribed. A new generic name has not been proposed as the Bonaparte Gulf specimens are not sufficiently well preserved to serve as type species of a new genus.

The Carboniferous faunas described include two species of *Spirifer*, two of *Unispirifer*, two of *Prospira*, one of *Prospira?*, one of *Anthracospirifer*, two of *Brachythyris*, two of *Ectochoristites?*, and one of the unnamed genus. One species of *Trigonotreta* is described from the Permian, which has a rich spiriferid fauna, to be described elsewhere, of *Neospirifer*, *Spiriferella*, *Fusispirifer*, and new genera.

Genus SPIRIFER Sowerby, 1816

Type species: *Conchiliolithes Anomites striatus* Martin, 1809.

Generic features: The definition by Pitrat (1965, p. H704) is generally

acceptable. The ventral interarea is moderately high and tapering to truncated at the extremities. The maximum width can occur at the hinge-line but is commonly in front of it. The fold and sulcus are variable in intensity.

Discussion: The understanding of the classic species *Spirifer striatus* has now been clarified by the establishment of a neotype in 1956 by the International Commission of Zoological Nomenclature (Opinion 419, p. 89). As suggested by Muir-Wood, the neotype is the specimen illustrated in Sowerby (1820, p. 125, pl. 270, error as 170) and also in Sowerby (1819, Pl. 28, fig. 2). Its present number in the British Museum is 434255. So far as I know the species has not recently been described in detail. From Sowerby's figures and personal examination of the specimen, the type is a large form (about 11 cm or more wide), with width/length ratio of 1.7 and maximum width at the hinge-line, which is broken at the extremity. The ventral umbo is low and the shoulders slope gently in full dorsal view. The front margin is rounded. Early growth lines show mucronate extremities at the hinge-line. The dorsal valve shows over 32 mostly divided rounded costae on the left flank (counted at front margin) and 16 costae on the fairly wide more or less rounded fold and about the same on the incomplete sulcus. The ventral interarea is longitudinally grooved; it is comparatively low, broken at the beak, and tapers gently to the extremities. The apical origin of the sulcal costae is not preserved in the specimen. Sowerby cut one wing to expose the spiralia. His illustration (1819, Pl. 28)gives an 'X-ray' view of the same specimen as figure 2, showing the spiralia. This is presumably an imaginary reconstruction based on other specimens, since he states that figure 1 is 'little more than one inch long'. The neotype was supplied by William Martin and presumably came from Derbyshire; however, it is labelled 'Derbyshire or Cork'.

The specimen originally figured by Martin (1809, pl. 23, figs 1, 2) from Castleton, Derbyshire, seems generally to be a similar large form with a width/length ratio of 1.3. The greatest width is at or slightly in front of the hinge-line, and the front margin is rounded. However, the early growth-lines are distinctly mucronate. The left dorsal flank has about 28 partly bifurcated lateral costae. The fold is damaged or obscured but shows 7 costae near the midlength. In profile the vertical valve is a little more convex than the dorsal and the beak is upturned; the area is obscure. This specimen is apparently lost, though Brown (1953a, p. 28) noted observing a specimen at Manchester University labelled 'Types of ? Martin', which matched the illustrations. Vandercammen & Plodowski (1967, p. 2) state that they are not housed in Manchester.

Davidson (1857) characteristically had a broad interpretation of *S. striatus*. For example he included *Spirifer attenuatus* Sow., *Spirifer princeps* M'Coy, and *Spirifer clatharata* (sic) M'Coy in the synonymy of *S. striatus*. *S. clathrata* is probably best referred to *Prospira* or *Unispirifer*. *S. attenuatus* and *S. princeps* can probably be distinguished from *S. striatus* on size and proportions, but are evidently closely allied. Muir-Wood (1926) distinguished two of Davidson's illustrated specimens from 'Bolland' as *Spirifer bollandensis* Muir-Wood.

Two authors have described transverse sections of specimens ascribed to *S. striatus*. Semichatova (1941, pl. 17, figs 1a-c) illustrated a large specimen from Gateham, Derbyshire. This has maximum width at the hinge-line and the width/length ratio is 1.2; the flanks and sulcus have numerous bifurcating costae. Transverse sections near the ventral umbonal apex show the initial dental plates diverging ventrally, much like *Unispirifer fluctuosus* as illustrated in Text-figure 24e and Plate 26, figure 4. Harrington & Leanza (1952) sectioned several specimens said to be from the British Museum and labelled 'Col. Martin'; these are noted as having the characters of *S. striatus*. The specimens are figured only in transverse section. The dental plates are divergent and of moderate length; the initial dental plates (slightly flexed) are clearly shown. A small transverse apical delthyrial plate is formed by the apposition of inner thickenings of the dental plates and the prismatic shell layer is developed in the posterior parts of the valves. These specimens show internals very similar to those of *Unispirifer fluctuosus* (Glen.), Text-figure 24, and *Prospira laurelensis* sp. nov., Text-figure 29.

So far as I know, no sections of the dorsal cardinalia of *S. striatus* have been published. However, the illustrations of the dorsal structures in Davidson (1857, pl. 11, figs 19, 20) are most probably quite representative of *S. striatus* or a closely allied species. These display a low dorsal area, divergent to recurved socket plates, long descending primary crural lamellae and jugal processes. These features are similar to those seen in *S. spiritus* sp. nov. Davidson's figure 20 was reproduced by Ivanova (1960, fig. 338) to represent *S. striatus*.

The sulcal costal pattern of the neotype of *S. striatus* is incompletely shown in the specimen, but is generally similar to that of *S. spiritus* sp. nov. The micro-ornament was not discernible on the neotype; but it may be expected that it is finely striate in *S. striatus* as in related species such as *S. spiritus*.

Grandispirifer Yang, 1959, is probably a synonym of *Spirifer*, rather than of *Unispirifer*. It has for monotypic species *Grandispirifer mylkensis* Yang, a large transverse multicostellate and striate species which is said to lack dental plates. A figured internal mould (Yang, 1959), indicates that the shell is thickened with callus in the umbonal region; the dental plates were no doubt covered by this callosity. The species is recorded from the lower Visean and does not differ markedly, except in its great size, from species such as *S. attenuatus* Sow.

Spirifer is undoubtedly closely allied to *Unispirifer* and perhaps less closely to *Prospira* and *Anthracospirifer*. The species of *Spirifer* probably descend from one or more of the *Unispirifer* species: the *Unispirifer* group is mainly Tournaisian, whereas *Spirifer* is mainly Visean.

Certain Strunian and early Kinderhookian small to medium-sized striate spiriferid species have a more or less transverse form and fairly numerous lateral costae with considerable bifurcation. They include *Fusella (?) insueta*

Gretchischnikova (1966) from the Tarkansk beds (Strunian) of the Rudny Altai, *Spirifer marionensis* Shumard from the Louisiana Limestone, and the species from the Sappington Formation described by Rodriguez & Gutschick (1967) as *Spirifer* sp. and *Spirifer* cf. *greenockensis*. These species may be ancestral to *Spirifer* but are separated stratigraphically from the *S. attenuatus* group of late Tournaisian to Visean age.

In the Western Australian Carboniferous faunas two species of *Spirifer* have been distinguished. One is new, *Spirifer spiritus* sp. nov.; the other is left with open nomenclature.

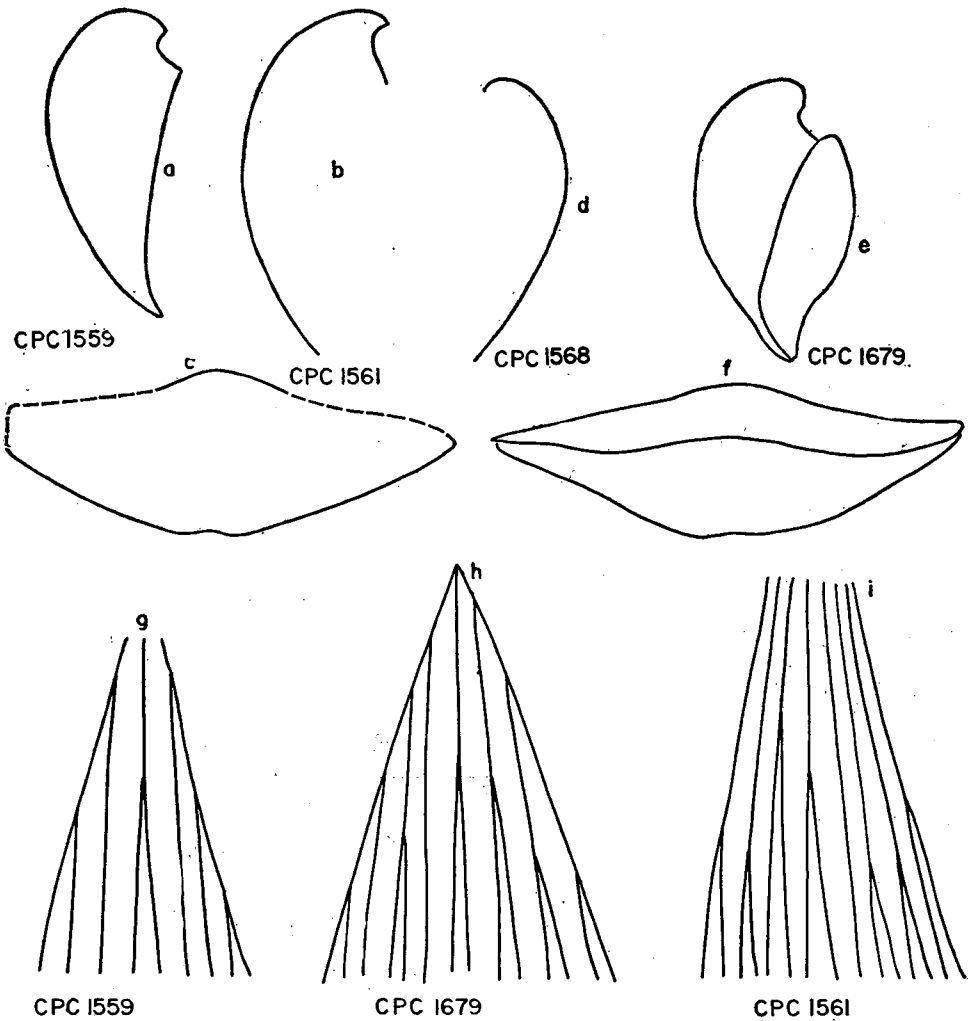

Fig. 19. *Spirifer spiritus* **sp. nov. (a)-(f) Profiles and front views of specimens illustrated in Plates 3 and 6; (g)-(i) Sulcal costae. Natural size.**

SPIRIFER SPIRITUS sp. nov.

(Pl. 3, figs 2-5; Pl. 4, figs 1, 3, 5, 6; Pl. 6, figs 1, 2; Text-figs 19, 20, 21a)

Diagnosis: Medium to large transverse species, mucronate in early stages, both valves gently convex; wide apical angle (146°-156°), shoulders concave; interarea apsacline, gently concave, moderately high (0.6 cm maximum); gentle fold and sulcus, gently uniplicate; multicostate with 9-15 costae in sinus, 25-37 bifurcating costae on each flank, radially striate; dental plates moderate and divergent; shell thin including umbonal region.

Material: Many silicified specimens are available, but most are incomplete. The greater number come from several beds in the upper part of the Septimus Limestone at Mount Septimus and a few from two other localities in isolated limestone outcrops near Spirit Hill; all localities are in the Bonaparte Gulf Basin.

Description: A small number of distinctive larger specimens has been selected as representative of the species. Many small specimens collected from the silicified beds in the Septimus Limestone may belong to the species but are generally too immature to determine whether they are the young of *Spirifer spiritus* or of the accompanying *Unispirifer septimus*. The majority of specimens are isolated valves, but a couple of more or less complete shells are available.

The following description of the ventral valve is derived from the holotype, CPC1559 (Pl. 3, figs 2a-c; Text-figs 19a, g), supplemented by comments on variations shown by other specimens. The ventral valve is wide—6.6 cm in the holotype and 6.9 cm in paratype CPC1561 (Pl. 6, fig. 1; Text-fig. 19b, c, i). The valve is mucronate in the earlier stages but not in maturity. It is gently convex in longitudinal profile, with maximum convexity near the umbo. The umbo is moderately prominent and the shoulders are gently concave in ventral and dorsal view. The sulcus is very gentle, but can be traced to the front from the umbo, where it tends to be a little more sharply defined. The flanks are gently convex. The front margin is mucronate early; later it becomes more rounded, but the greatest width is always at the hinge-line. There is very little or no development of a tongue at the sulcus. The interarea is rather low, about 5.5 mm in CPC1659, and does not exceed 6 mm. Its shape is a low triangle tapering to the sides, but it may be rounded at the ends, as in CPC1679, (Pl. 6, figs 2a, b; Text-figs 19e, f, h) and in CPC1566 (Pl. 4, figs 6a, b; Text-fig. 20). The interarea is curved and apsacline, and slightly overturned at the umbo tip. It may be serrated as a result of growth

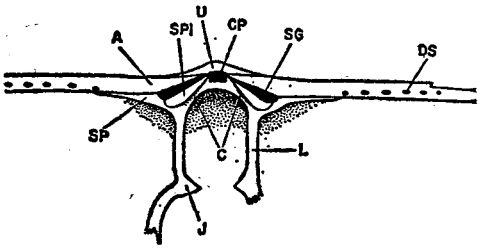

Fig. 20. *S. spiritus*. **Composite diagram of dorsal cardinalia and part of spiralia. A—dorsal interarea, DS—denticle sockets, U—dorsal umbo, CP—cardinal process, SP—socket plate, SG—socket groove, SPI—socket plate inner flange, C—crural plate, L—descending lamella, J—jugal process.**

TABLE 6: Dimensions of *Spirifer spiritus* sp. nov.

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	Ha	Dw	Da	Aa	Wef	W/L	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1559	3.75e	5.10			6.60	6.60	.55	.8	65°	155°	1.31	1.76	9			25+		
		5.00			6.60													
		3.40			5.50													
CPC1561	4.2e	5.45			6.90	6.9	.60e	—	70°	153°	1.85	1.64	15		31+	37+		
		4.50			6.90													
		3.90			6.50													
		2.60			2.90													
CPC1566				3.15	5.30	5.30	.5						11	7	22+			27
CPC1567					2.75				80°	146°					16+	16+	15+	15+
CPC1569		1.80			1.25								5	4		15+	15+	
CPC1679	4.80	5.50	3.20		6.70	6.70	.55	.70	65°	156°	1.65	1.4	14		25+	30+		
F17891			1.30	1.55	2.30	2.30					2.28			4			14	14
F17895	3.85	5.20			6.4e	6.4e						1.67	10		20+			
F17903			1.75	2.35	3.95	3.95								6				21+

interruptions on its posterior margin which is sharply defined. The interarea is marked by longitudinal flutings which can be traced into denticles on the front margin. The delthyrium is small, open, with an angle of 65° in the holotype and a range in other specimens of 63° to about 70°. The delthyrial edge is marked by a marginal groove and a dental ridge just below the interarea. The ridges can be traced into the prominent and rounded teeth.

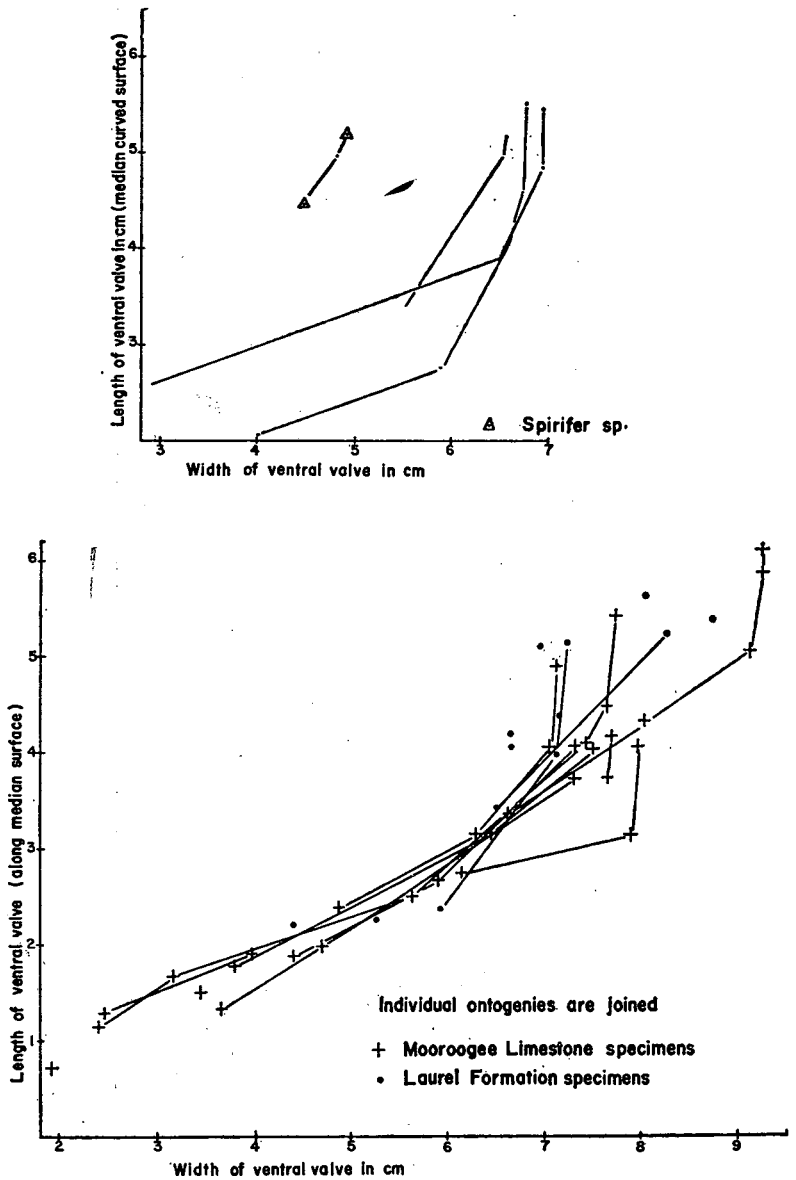

Fig. 21. Length/width ratios of (a) *S. spiritus* and (b) *U. fluctuosus*.

The dorsal valve is similarly alate and mucronate in the earlier stages. It is gently convex in longitudinal profile but more convex at the umbo. On the flanks it is very gently convex, flattening on the wings. Various examples are illustrated: CPC1560 (a very young specimen) in Plate 4, figure 1a-c; CPC1566 in Plate 4, figure 6a, b; CPC1567 and 1568 in Plate 4, figures 3a, b, and 5a, b respectively; CPC1569 in Plate 3, figure 5c; and CPC1679 in Plate 6, figure 2b. The fold is gentle though always distinguishable. The umbo is moderately prominent. The dorsal area has nearly parallel margins, is gently concave, and is anacline, and reaches 2 mm in height in the large specimen CPC1568. The posterior margin of the area in this specimen is markedly serrated by growth interruptions. It possesses a row of denticle sockets which diverges from the hinge-line, at the notothyrium, to near the middle of the area on the wings (Text-fig. 20a). The notothyrium is comparatively small with its edges diverging at about 120°.

Text-figure 21a is a scatter plot with parameters of width at hinge-line against median length on the outer surface of the ventral valve. It illustrates the few measurable specimens and shows the individual ontogenies. For comparison, the specimens referred to *Spirifer* sp. A are included.

The surface ornament is distinctive; it consists of numerous rather fine costae covering both valves. The lateral costae expand a little to the front, but the space is filled to some extent by bifurcation of the costae. Thus in the holotype, CPC1559, the 2nd to 5th costae left of the sinus split near the umbo (the third forming three branches). A second generation of bifurcation was not noticed in CPC1559 but does occur in CPC1679. In that specimen, the second to fifth costae left of the sinus bifurcate near the umbo and the first divides near the midlength. One branch of the fifth costa divides again, towards the front. CPC1561 displays bifurcation of the 2nd to 7th costae left of the sinus near the umbo and further division of some of the branches a little farther forward.

The pattern of costae in the sulcus is unicostate. Nine costae are developed in the holotype, 15 in CPC1561, 13 in CPC1679, and 9 in CPC1566. Examples are illustrated in Text-figure 19g-i. In young individuals like CPC1569, fewer costae are developed, of course.

The costae are fairly even in size, are rounded, and have rounded troughs of nearly the same dimensions. There is some flattening to the front, especially in CPC1568. Evenness varies somewhat: for instance, CPC1566 shows some variability in the size of costae and their spacing, and CPC1569 (Pl. 3, fig. 5a-c), has slightly larger and closer costae than the corresponding umbonal part of the holotype. These slight variations do not warrant separate specific recognition in such small collections. On the flanks and towards the front of CPC1559, 1561, and 1679, the costae are spaced at 4 in 5 mm.

Internal Structure: Internal features are not very well preserved in most specimens, but some observations can be made with confidence. The dental plates are rather short and not greatly thickened. In the holotype, the plates are about 1.3 cm long, roughly 7/25 of the shell length, and a smaller fraction of the curved length. In CPC1561, a larger shell, in which the plates diverge on the floor at about 55°, they measure 1.3 cm. Two young specimens are illustrated: CPC1564 in Plate 3, figure 4a, b, (x3); and CPC1562 in Plate 3, figure 3a, b, c (x2). The dental plates are short, diverging in CPC1562 at about 56°. In these small specimens, the area is nearly catacline and the front edges of the dental plates are nearly in a plane. As seen in front view in Plate 3, figure 3c, there is a small flexure in the plates. A small delthyrial plate, at the delthyrial apex, is well shown in both specimens. In larger mature individuals, this is presumably obliterated by secondary shell thickening, but the silicification in the umbonal region is generally incomplete and this detail is not preserved. The delthyrial plate is presumably similar to that of *Prospira laurelensis*. Little can be seen of the ventral muscles. The scar is small and elongate-oval in CPC1561. No scar is impressed in the young specimens CPC1562 and 1564.

The dorsal valve displays cardinalia of the usual *Spirifer* type, illustrated for CPC1560 in Plate 4, figure 1a-c (x3) and for CPC1568 in Plate 4, figure 5b (see also Text-fig. 20). CPC1560 is a very young specimen and not certainly referable to this species as its proportions do not preclude it from inclusion in *Unispirifer septimus* and the costae are simple. The dorsal adductor scar is faintly impressed and carries a faint median ridge. CPC1568 is a large mature individual and, characteristically for the species, is thin-shelled in the umbonal region. The cardinal process is not elevated and consists of about 41 tiny longitudinal platelets. The socket grooves are rather fine and their inner flange is curled up at the front. The base of the crural lamella is a wide blade, arising from the recurved socket plate. Text-figure 20a, b is a sketch incorporating features of CPC1568 and CPC1566. The descending lamellae are fine and there is a sharply pointed, ventrally directed jugal process. CPC1566 has a spiralium with 18 loops tapering towards the wings. The dorsal adductor muscles are very lightly impressed in CPC1568 and a faint median ridge is present.

All the specimens of this species, including the large ones, are thin-shelled and retain costae on the inner surface, from the front to near the umbonal region.

Discussion: The multicostate surface and general form indicate that *S. spiritus* is allied to the group of *S. striatus* (Martin). It is closest to the earliest species of the group—*S. attenuatus* Sowerby, the type of which, from Ireland, as illustrated by Davidson (1857, pl. 2, figs 12, 13), is similar in outline but only about two-thirds of the size of *S. spiritus;* it has a more pronounced fold and sinus than our species and the costae tend to be fasciculated. Douglas (1909) figured a specimen from the *Syringothyris* zone of County Clare, which is similar in size to the type and also has a slight tendency to costal fasciculation. Belgian

examples of *S. attenuatus,* as described by de Koninck (1887, pl. 25, figs 14, 15) appear to be closer in size to *S. spiritus.* Demanet (1958) lists *S. attenuatus* from the upper Tournaisian Tn 3b of the Namurian Basin and from the Waulsortien facies of late Tournaisian and Visean age. Russian examples described by Tolmatchow (1924) and Besnossova (1959) occur in the Fomin horizon of upper Tournaisian age. *S. attenuatus* also occurs in the upper Tournaisian Buktarminsk horizon of the Rudny Altai (Gretchischnikova, 1966) and the Visean C_1d horizon of Taimyr (Dedok & Chernjak, 1960). *Spirifer aschliarki* Simorin from the lower Visean of Central Kazakhstan is like *S. spiritus* in proportions but is smaller and has a lower ventral area (Monakhova, 1959). The species is also reported from Germany, Poland, Ferghana, and the Chatkal Mountains, but the specimens are not sufficiently well illustrated for comparison.

Spirifer subaequalis Hall from the Keokuk and Warsaw (Weller, 1914) appears to be the closest Mississippian species. It is smaller and has finer costae than *S. spiritus.*

S. spiritus is distinguished from *Unispirifer fluctuosus,* which is similar in shape, by its more numerous and bifurcating lateral costae and by the pattern of costae in the sulcus.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1559, 1564, 1569, F17890, F17903 from 500 to 550 feet above base of Septimus Limestone at Mount Septimus; CPC1560 from 550 to 600 feet; CPC15161-2, F17891 from 450 to 500 feet. CPC1566-8, F17895 from WAA9, and CPC1679, from locality B, Westralian Oil Ltd; both isolated outcrops of Septimus Limestone near Spirit Hill, Bonaparte Gulf Basin.

SPIRIFER sp. A

(Pl. 4, fig. 2a, b)

Material: A silicified ventral valve (figured) and a silicified shell.

Description: CPC1565 is 5.20 cm wide at the hinge-line and about 3.4 cm long, with the median curved length 4.9 cm. The greatest width is at the hinge-line. The valve is strongly convex longitudinally and transversely with greater convexity at the umbo and slight flattening on the outer posterior flanks. The umbo is prominent and erect at the tip, with an apical angle of 142°. The interarea is 0.40 cm high, concave and strongly apsacline, with rounded to truncated ends. The delthyrial angle is 68°. The valve possesses a pronounced rounded sulcus which widens to the front. The front outline is roughly semi-circular, with a small tongue at the sinus, and the anterior commissure is uniplicate. The earlier growth stages are mucronate. The ornament is much abraded and cannot be very clearly made out. It is multicostate, with at least

25 costae on each flank; some, at least, of the costae are bifurcated. The costal arrangement of the sulcus could not be determined, but there are probably at least 10 costae at the front. Internally, the valve possesses stout diverging socket plates, like those of *S. spiritus*.

A larger specimen, F21338, from a locality near Spirit Hill, can probably be associated with this specimen, though it displays some differences. It is crushed and incomplete but is about 6.6 cm wide and 5 cm long. It has a sulcus of similar type. The area is lower and tapers to one extremity; the other is rounded. The specimen is also rather more flattened on the outer posterior flanks of the ventral valve. There are about 10 costae in the broad sulcus and over 20 on the flanks. Faint fine radial and concentric striation is preserved in the sinus.

Discussion: The two specimens are not sufficiently complete to determine their affinities. The form and bifurcated lateral costae indicate inclusion in the *Spirifer striatus* group. CPC1565 was collected from the same beds as *S. spiritus*, which is wider and relatively shorter, is more numerously costate, has a slight sinus and does not have rounded or truncated ends to the interarea. *Spirifer* sp. A approaches more to the proportions of the longer forms of *Spirifer striatus* as figured by Davidson (1857), but it is not as large and has fewer costae. Better collections are required for adequate description.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1565 comes from 500-550 feet above the base of the Septimus Limestone at Mount Septimus, Bonaparte Gulf Basin; F21338 comes from WAA9 (Mines Administration Ltd), Septimus Limestone.

Genus UNISPIRIFER Campbell, 1957

Type species: *Spirifer striatoconvolutus* Benson & Dun, 1920.

Generic features: The definition by Pitrat (1965, p. H706) is satisfactory, except that moderately transverse species of similar costation should be included, width always greater than length. The ventral interarea is tapered to truncated at extremities.

Discussion: It is evident that *Spirifer* and *Unispirifer* are closely related. For example, *Unispirifer striatoconvolutus* and *Spirifer attenuatus* Sowerby are broadly similar in form and internal features. The main distinctions are the relative simplicity of the lateral costae and the fewer sulcal costae of the former. *Unispirifer* embraces a group of species, in part older than *Spirifer* and in part overlapping. Campbell (1957) stressed the simple unicostate sulcal pattern of *U. striatoconvolutus*, with relatively few costae. The median costa may divide; it is flanked by two primaries originating at the umbo without any intercalations

between it and the primaries. Similar patterns occur in other species of *Unispirifer* and also in genera such as *Prospira, Anthracospirifer,* and *Trigonotreta.* However, too much stress should not be placed on the details of sulcal costation, which can show considerable intraspecific and intrageneric variation. Therefore *Unispirifer fluctuosus* (Glenister), which has a modified unicostate pattern, with the median costa dividing at its origin, but otherwise similar to *U. striatoconvolutus,* has been included in the genus. The same pattern was noted in some specimens labelled *'Spirifer mosquensis* Fischer', in the de Koninck collection at the Harvard Museum of Comparative Zoology in Cambridge, USA. These are specimens of *S. tornacensis* and were identified by de Koninck before he proposed that name in 1883. Their provenance is given as Tournai. Other specimens have simple median costae in the sulcus.

Campbell included in *Unispirifer*: *S. tornacensis* de Koninck, *S. clathratus* M'Coy, *S. forbesi* Norwood & Pratten, *S. vernonensis* Weller, and *S. baiani* Nalivkin. Of these, *S. tornacensis* (confining the name to the large Belgian specimens described by de Koninck) is probably close to *U. striatoconvolutus.* Many specimens identified as *S. tornacensis* from other areas appear to be referable to new species of *Prospira.* However, *Spirifer tornacensis* described by Gladchenko (1960) from the Upper Tournaisian of the Prisonkulsky region of Kirgizia and the examples illustrated by Jarosz (1914) from the Tournaisian of Krakow appear to be fairly close to the type specimens. *S. clathratus* is a small form possibly better referred to *Prospira. S. vernonensis* has also been included in *Unispirifer* by Armstrong (1962). *S. forbesi* has been placed in *Imbrexia* by Besnossova (1959) and by Armstrong. *Imbrexia* Nalivkin (type species *Spirifer imbrex* Hall) is similar in all respects to *Unispirifer* Campbell except for its surface ornamentation (Armstrong, 1962, p. 52). Striae have not been observed in *I. imbrex,* but certain Russian species referred to *Imbrexia,* such as *I. topkensis* Besnossova, 1959, show both radial striae and strong concentric ornament. It is accepted provisionally that the micro-ornament of *Imbrexia* distinguishes it from *Unispirifer,* but if this is not a valid distinction *Unispirifer* is a synonym of *Imbrexia.*

The type species *Kinghiria* Litvinovitch, 1966, from the Visean of Central Kazakhstan, is rather similar in form to *U. septimus* sp. nov. but it has a mainly concentric micro-ornament. The ventral valve is much thickened at the interarea so that the dental plates are obscured.

The species which Armstrong placed in *Unispirifer, U. balki* Armstrong, *Spirifer platynotus* Weller, and *S. vernonensis* Swallow, are all rather small and variable in costation, ranging in shape from mucronate to semicircular. *S. vernonensis* has 13 sulcal costae. *S. platynotus* is better placed in *Prospira.*

Russian authors, notably Besnossova (1959) and Ivanova (1960), have applied the name *Fusella* M'Coy to species which correspond in part to *Unispirifer.* They regard *Unispirifer* as a synonym of *Fusella.* Maxwell (1961, p. 89)

discussed the present inadequate knowledge of the type species of *Fusella*. *Fusella* is best not used for other species.

Prospira Maxwell is allied to *Unispirifer*. Hill & Woods (1964) have listed *U. striatoconvolutus* as a species of *Prospira*. However, as discussed under *Prospira*, I have retained both genera, restricting *Prospira* to small species close in form and costation to the type species. If *Unispirifer* is a synonym, a new name is required for the specimens described here under *Prospira*. In Western Australia species of both *Prospira* and of *Unispirifer* occur in association in the Moogooree Limestone and the Laurel Formation. This supports the validity of separation of two generic groups. The two genera and *Spirifer*, in addition, are present in the slightly younger Septimus Limestone.

UNISPIRIFER FLUCTUOSUS (Glenister)

(Pl. 1, figs 1-6; Pl. 2, figs 1-7; Pl. 3, fig. 1a, b; Pl. 8, fig. 13; Pl. 26, fig. 4; Pl. 28, figs 1, 2, 3, 6; Text-figs 21b, 22-24)

1955 *Spirifer fluctuosus* Glenister, *J. Roy. Soc. W. Aust.* 39, 68-70, Pl. 7, figs 1-14, Pl. 8, figs 1-8c.

Diagnosis: Medium to large species, width more than twice length in adults, alate, mucronate in youth; both valves moderately convex; apical angle 150° to 156°, umbo moderate; ventral interarea apsacline, gently concave, of moderate height (0.86 cm maximum), triangular; ornament of 18 to 25 simple rounded costae on each flank, sulcus with 6 to 9 costae, median costa divides at origin, well in front of sulcal apex; radially striate; dental plates divergent and of moderate size.

Material: Glenister's specimens and others, all silicified, from the Moogooree Limestone have been re-examined, along with many unaltered shells, mostly incomplete, from the Laurel Formation.

Description: The shells are of wide transverse to mucronate shape with both valves moderately convex; the maximum convexity is near the umbo for both valves. The ventral apical angle is wide, measuring from 150°-156°. The ventral shoulders are slightly concave as seen in full ventral view. The sulcus is shallow and gently curved with broadly rounded flanks; it can be traced from umbo to front margin, where it extends forward as a slight tongue. The flanks are gently convex, flattening on the wings.

The ventral interarea is gently concave and the umbonal tip is slightly incurved. The posterior margins of the area are nearly straight, but can be convex or concave, and are often serrated by growth interruptions. The extreme lateral margins are commonly truncated. The height of the interarea is moderate,

TABLE 7: Dimensions of *Unispirifer fluctuosus* (Glenister)
(in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	T	Ha	Aa	Da	Dw	Wsf	W/L	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC430	2.80	4.10		2.35	7.3e	1.8	.45	155°			1.0	2.60	6	5	20+			
		1.90			4.40													
		2.70			5.85													
CPC446	4.2	6.15			9.20		.85	156°	58°	1.35		2.2	c9	20+				
		3.40			6.55													
		4.35			8.00													
		5.10			9.10													
		5.90			9.20													
CPC479	2.6				6.6e			154°	59°		.45	2.55	6	6			18+	
CPC1547	3.85	5.30	3.20	3.40	8.2e			153°				2.13			20+			23+
		3.45			6.50													
CPC1548	3.30	4.16	2.65	3.05	6.6+e	1.85	0.65	155°	59°		1.15	2.0	7		19+		20+	
CPC1549	3.65	5.10	3.00		7.20	2.14	0.5+	150°			1.45	1.92	8				23+	
			2.40		5.80													
			4.05		7.00													
CPC1550	3.30	5.15	2.80	3.70	6.90	2.46		150°			1.45	2.09	6					
CPC1551	4.4e				7.3e									9				
CPC1552									50°									
CPC1554							.35		80°									
CPC1675	2.90	3.80			7.25			154°				2.46	7		25			
		2.00			4.55													
		3.35			3.65													

CONTINUED from page 70

TABLE 7: Dimensions of *Unispirifer fluctuosus* (Glenister) (in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	T	Ha	Aa	Da	Dw	Wsf	W/L	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1676	3.90	5.45			7.70		.08	155°			1.68	1.97	9			24+		
		1.16			2.40													
		1.70			3.15													
		2.50			5.60													
		4.10			7.40													
		4.50			7.60													
		5.45			7.70													
F17950	3.75	4.20			7.65		.75	152°	62°	1.20		2.04	7					
					7.65													
F17951	2.80	4.10			7.45		.55		78°		1.25	2.66	7					
		1.80			3.80													
		3.15			6.40													
F17952		1.50			3.45							2.3						
F17953	2.90	4.10			7.85		.63	154°	64°			2.70	8					
		2.80			6.10													
		3.20			7.85													
F17954	3.50	4.90			7.05		.75	156°	63°			2.01	9	20+				
		2.40			4.90													
		3.10			6.30													
		4.05			7.05													
F17956		.70			1.9													
F17956		1.30			2.45													
		1.90			3.95													
F17957							.82	154°	58°									
F17883	3.85	5.70			8.0							2.06	9-10					
F17884	3.7	5.4+			8.70							2.35						
		2.25			4.40													
F17885		2.30			5.2e													
F17888	3.90	4.05			6.40							1.64						
F17887																		

not exceeding 0.86 cm, and its inclination is apsacline, as shown in Text-figure 22a-f. The delthyrial angle is rather variable; a range from 42° to 80° was recorded, the majority between 50° and 60°. A delthyrial groove lies at the edge of the delthyrium, but not at the level of the interarea as in *Prospira laurelensis;* instead it lies on the side of the dental plate and extends on to the prominent and rounded tooth. The groove probably marks the position of attachment of the deltidium, which is rarely preserved. It was seen as a remnant in the delthyrial apex of one specimen from the Moogooree Limestone (Pl. 28, fig. 6) and in the serial sections of a specimen from the Laurel Formation (Text-figs 23a-c). The interarea carries longitudinal denticular flutings.

The dorsal valve is alate and mucronate and has a gentle fold; its longitudinal convexity is more marked at the umbo; the flanks are gently convex, flattening on the wings. The dorsal area is concave and anacline, though erect at the umbo tip. Its sides are parallel, tapering at the wings, and it attains a height of about 2 mm in large specimens. The notothyrium is wide and has an angle of about 140°. The area is marked by growth-lines and by a line of small pits which diverges from a position at the front edge of the area near the notothyrium to the middle of the area on the outer edges. These sockets articulate with the denticles of the ventral valve.

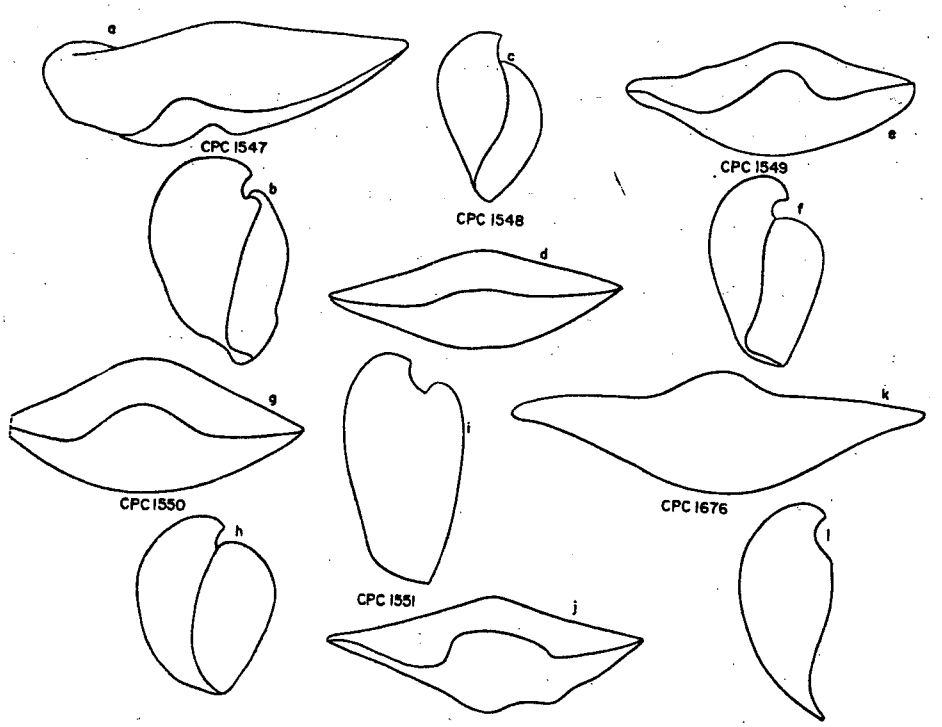

Fig. 22. *U. fluctuosus* **(Glen.). Profiles and anterior views of specimens illustrated in Plates 1 and 28. Natural size.**

The shell is wide, attaining 9.20 cm in CPC446. The front margin is mucronate, strongly so in the early growth stages. A plot of the ratio of width at hinge-line to median curved length of the ventral valve is shown in Text-figure 21b. This includes specimens from both Moogooree Limestone and Laurel Formation. Both series of specimens would fit a similar curve. The figure includes growth stages measured on individual specimens as the growth-lines are often preserved sufficiently well. Length increases much faster than width after a width of about 6 to 8 cm has been attained. In old age the length only is increased; the greatest curved length measured was 6.15 cm in CPC446. Profiles of front commissures are shown in Text-figure 22. The flexure at the sulcus of some of the specimens from the Laurel Formation is exaggerated as they have been somewhat crushed.

The shells carry rounded to slightly flattened radial costae over the whole surface. The lateral costae are almost invariably simple and widen to the front, where there are 2 in 5 mm in large specimens. Bifurcating costae were observed in only one specimen, CPC1557 (Pl. 1, fig. 2b), in which the first costa to the left of the fold is beginning to divide. The inter-troughs are rounded and slightly narrower than the costae. There are about 20 costae on each flank, but the outermost ones are faint and difficult to count.

The sulcus carries from 6 to 9 costae, counting those bounded by the two initial sinal costae which originate at the umbo. As the sinus and its margins are gently rounded it is difficult to count the sinal costae if the boundary ones cannot be traced to the umbo. The sulcal pattern is illustrated for representative specimens in Text-figure 23a, b, d. The median costa does not originate at the umbo as it does in *Prospira laurelensis* and allied species and it divides early. In some specimens another median costa is intercalated further forward. Otherwise the simple pattern resembles that of *P. laurelensis*. The fold carries from 4 to 8 costae. The surface is marked by concentric growth-lines and, in places, concentric lamellae, but the latter are commonly abraded. The growth-lines increase in density to the front. The surface is also covered by fine radiating striae on costae and troughs. The striae are rarely preserved; they are illustrated in Plate 8, figure 13.

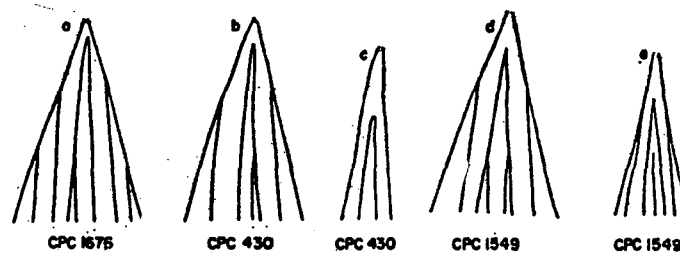

Fig. 23. *U. fluctuosus.* **(a), (b), (d) sulcal costae; (c), (e) dorsal fold costae.**

Internal features: The dental plates are prominent and divergent, extending about 3/7 of the shell length in larger specimens such as CPC446. They are greatly thickened by secondary shell in mature specimens. They diverge on the floor of the valve at angles of 45° and 60°. The apex of the delthyrium is generally occupied by a 'delthyrial plate', which is commonly thickened into a platform in mature specimens (Pl. 1, fig. 6a, b). It may have a median ridge on its outer (dorsal) surface. In young specimens the structure is a small delicate plate below the level of the interarea (Pl. 3, fig. 1a). In serial section (Text-fig. 24) the delthyrial plate is seen to have developed from the apposition of shelly laminae deposited on the inner sides of the initial dental plates. The 'post-delthyrial' cavity is subsequently, in mature specimens, infilled by shell deposit, which is generally recrystallized. A deltidium is also preserved in rare specimens; it appears to be attached along the delthyrial groove (Text-fig. 24b, e).

The ventral muscle scars lie between and in front of the dental plates. They are large and oval in mature specimens, attaining 2 cm length and 2.15 cm width in the holotype CPC446. A median narrow area of the linearly striated adductor scars is flanked by the larger diductor scars which are commonly radially crenulated and may carry only longitudinal striations. Fine details are seen only rarely in our specimens. A short posterior median ridge is commonly present. Genital pits occur on the posterior parts of the ventral interior (Pl. 2, fig. 1). The interior of the shell commonly is costate, but costae may be obliterated by shell thickening in old specimens.

The dorsal interior is illustrated in Plate 2, figures 2-5, and Plate 28, figure 1. The cardinal process is not elevated and consists of a muscle area of numerous (25-35) fine longitudinal platelets. The process is flanked by prominent diverging socket plates which recurve to the hinge-line just beyond the notothyrium; the socket grooves are rounded and widen to the front. The cardinalia are like those of *Spirifer spiritus*. Little is known of the spiralium; the descending lamellae originate from crural plates at the side of the front ends of the inner surface of the socket plates and they have fine ventrally directed jugal processes similar to those of *Unispirifer septimus*. The dorsal adductor muscles are well shown in paratype CPC444 (Pl. 28, fig. 1).

Discussion: *Unispirifer fluctuosus* resembles *Unispirifer striatoconvolutus* Campbell in its general outlines and type of lateral costation. It differs in being a little larger and in having a wider sulcus and fold and in the details of the sulcal costal pattern. The number of sulcal costae is no greater, ranging from 7 to 9, but there is no median costa originating at the apex. Instead, a pair of diverging costae originate some distance in front of the apex; in a few specimens a median costa is intercalated farther forward. This modification of the *Unispirifer* sulcal pattern has not been noted for other species in published accounts. I have included *U. fluctuosus* in the genus *Unispirifer* as the distinction is most probably only of specific importance. *U. fluctuosus* in size and general form is very like the large topotype examples of *Spirifer tornacensis* de Kon. illustrated in de

Koninck (1887, pl. 25, figs 1-10) from the 'calcschiste de Tournai'. The details of fold and sulcal costal arrangement cannot be clearly made out in the figures. Some specimens from Tournai, seen at Harvard University, have sulcal costae like *U. fluctuosus*. De Koninck (1887) noted that there are 10 to 12 costae on fold and sulcus. Demanet (1958) listed *S. tornacensis* from all substages of the Tournaisian in Belgium. Various Russian and Asian species which have been identified as *S. tornacensis* are discussed under *Prospira laurelensis*.

U. fluctuosus is distinguished from the other northwest Australian species of *Unispirifer* and *Prospira* by its greater size and peculiar sulcal costae. It has fewer costae than *Spirifer spiritus* and they are almost invariably simple on the flanks.

Geological Age: Tournaisian.

Occurrences: Holotype (CPC446), paratype (CPC444), and CPC1579, CPC1675-8, F17950-7, from locality TP42, Carnarvon Basin (2) about 440 feet above base of Moogooree Limestone. The species is also abundant elsewhere in the Moogooree Limestone at about the same level, notably locality B of Text-figure 2. CPC1547, 1548, 1550, 1555-8, F17888 from locality KC11, Fitzroy Basin, 1365-85 feet above base of composite type section of Laurel Formation, i.e. near top of higher member of formation. CPC1549, 1551, F17883-8 from NG273 (W.A. Petroleum Ltd). CPC1553-5, CPC6132-4 from KC13. Collections are available from several other localities in the Laurel Formation. All probably come from the higher beds of the upper member.

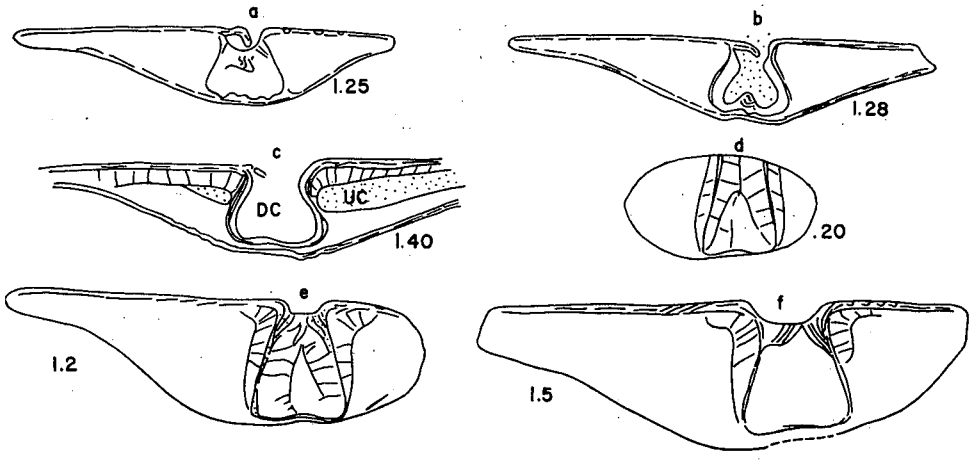

Fig. 24. *U. fluctuosus.* **Transverse sections of ventral valves. (a)-(c) CPC3770. Note small displaced deltidium; initial dental plates joining trace of initial floor of valve (probable muscle area). Low median ridge on floor in (b). Coarse calcite crystals (semidiagrammatic) in (c)-calcite fibres in blank areas are irregular, x1.4, (d)-(f) CPC3771. Delthyrial and umbonal cavities (DC and UC) infilled by shell thickening. Small 'delthyrial plate' formed early in (e) and (f) by approach of laminae from sides, and thickened to platform by infilling of delthyrial cavity, x3.5.**

TABLE 8: Dimensions of *Unispirifer septimus* sp. nov. and *U.* cf. *septimus* (in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	Ha	Aa	Da	Dw	Wsf	W/L	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
Unispirifer septimus																		
CPC1563	2.0	2.90			3.05	3.05		142°	58°		.65	1.53	8		16	14		
		2.00			2.80													
		1.35			2.15													
CPC1570	3.05	4.65			3.50	3.60	.55	135°	50°	.60	1.15	1.18	7		15+			
		3.50			3.25													
		2.15			2.55													
CPC1571			2.30	3.10	3.75	3.75					.55	1.68	6	6			20	21
CPC1572			2.50	3.25	3.9	3.9								8			14+	
F17889	1.80	2.50			3.0e	3.00	.35	146°							18	18		
		2.20			2.90e													
		1.80			2.45													
F17892	1.10	1.45			1.95	1.95	.20			.30	.35	1.77				13+		
F17894	.85	.90			1.55	1.55		146°	35°		.35	1.82	7			10+		
F17896		3.50			3.46	3.45	.55											
		1.90			2.85	2.85												
F17897					3.50	3.50	.50	131°	50°	.70						19		
F17898			2.60	3.24	4.10	4.10								8			16	
F17899	3.5+	4.95			4.4e		.60	132°	61°	.70		1.26	8				16+	
		4.46			4.4													
		3.75			4.4													
F17901		1.10			1.80	1.80	.25	130°		.15	.43		6		9+	10+		
U. cf. *U. septimus*																		
CPC1575	3.75e	4.50e	3.0e	4.0e	4.45						1.4	1.18	8			22+	23	
CPC1577	3.65	5.50			4.0	4.0	0.6	132°	50°	.60	1.48	1.09	8		15	15		
		3.00			3.95													
		2.35			3.00													
CPC1578			2.25	2.75	3.30	3.30							9	7		15	14	14

UNISPIRIFER SEPTIMUS sp. nov.

(Pl. 3, fig. 6; Pl. 5, figs 1, 2, 4, 9; Text-figs 25, 26a)

Diagnosis: Medium-sized, rather long species, 60 cm maximum width at hinge-line or slightly in front; both valves strongly convex; umbo moderately prominent, apical angle 130° to 146°; interarea gently concave, apsacline, of moderate height, maximum 0.60 cm, triangular or truncated; sulcus slight; fold stronger, rounded; 15 to 19 simple rounded costae on each flank, 6 to 8 costae in sulcus with median costa originating near apex, fine concentric ornament, radial micro-ornament not preserved; stout thickened divergent dental plates.

Material: Numerous silicified specimens, mostly incomplete and some evidently abraded before silicification.

Description: The holotype (CPC1570) and paratypes (CPC1571, 1572) come from the same bed in the Septimus Limestone. The species is medium-sized and relatively long; the holotype is 3.60 cm wide and 3.05 cm long; the largest specimen is only 4.4 cm wide and 3.5+ cm long. The ventral valve is moderately convex longitudinally and transversely with greater convexity at the umbo. The sulcus in the holotype (Pl. 5, fig. 1a-c) is very gentle; it is somewhat more pronounced though still gentle in F17899 from the same bed. The ventral shoulders are straight to slightly concave and the umbo is fairly prominent, with an apical angle of 135° in the holotype, but ranging from 130° to 146°. The higher values 142°-146° were noted in small youthful specimens. The ventral interarea is slightly concave and at a low apsacline to nearly orthocline angle. The umbo is sharply upturned at the tip. The height is moderate, 0.55 cm in CPC1570. The posterior margin of the interarea is gently convex and its lateral margins vary from being gently tapered to truncated; the two alternatives are figured on either side of the holotype. The surface of the interarea carries longitudinal flutings which terminate in front in a row of denticles. The delthyrial angle is 50° in the holotype but ranges up to 61° in the other mature specimen. A marginal delthyrial groove is present and a delthyrial ridge slightly below the level of the area connects with the rounded teeth. The delthyrium has not been preserved in any of the specimens.

The front margin of the shell in adult specimens is convexly rounded and the shell in front of the hinge-line retains nearly the same width for some distance. In the holotype the shell is slightly wider in front of the hinge-line (Pl. 5, fig. 1); in the other specimens the shell is widest at the hinge-line. The front commissure is only slightly uniplicate and there is little or no development of a tongue at the sulcus. Young specimens are more alate to slightly mucronate. Representative ratios of length to width are shown in the scatter plots of Text-figure 26a.

The dorsal valve is gently convex longitudinally and transversely, tending to flatten a little on the wings. The fold is distinct and its margins become steeper

to the front. The umbo is moderately prominent. The dorsal area has nearly parallel sides in CPC1571 (Pl. 5, fig. 2a-d), but tapers to the ends in CPC1572 (Pl. 5, fig. 4).

The surface ornament is distinctive. The costae of the flanks are nearly all simple and widen to the front. The first costa beyond the fold divides or even triplicates posteriorly in a few specimens. The costae are rounded in section, with rounded intertroughs which are nearly as wide. The number of lateral costae does not exceed 21. In the holotype there are about 15 on each flank, spaced at about 3 in 5 mm at the front near the middle. The intercostal groove flanking the fold is slightly more pronounced than the others, in many specimens. The sulcus carries from 6 to 8 costae and the pattern is of the simple unicostate type with a median costa originating near the umbo. Representative sulcal and fold patterns are shown in Text-figure 25e, f, j. Concentric growth-lines and laminae are present and increase in density to the front. Fine radial striae are not preserved and may or may not have been originally present.

Internal Structures: The mature specimens of this species have rather thickly calloused shells in the umbonal region. The dental plates are commonly greatly

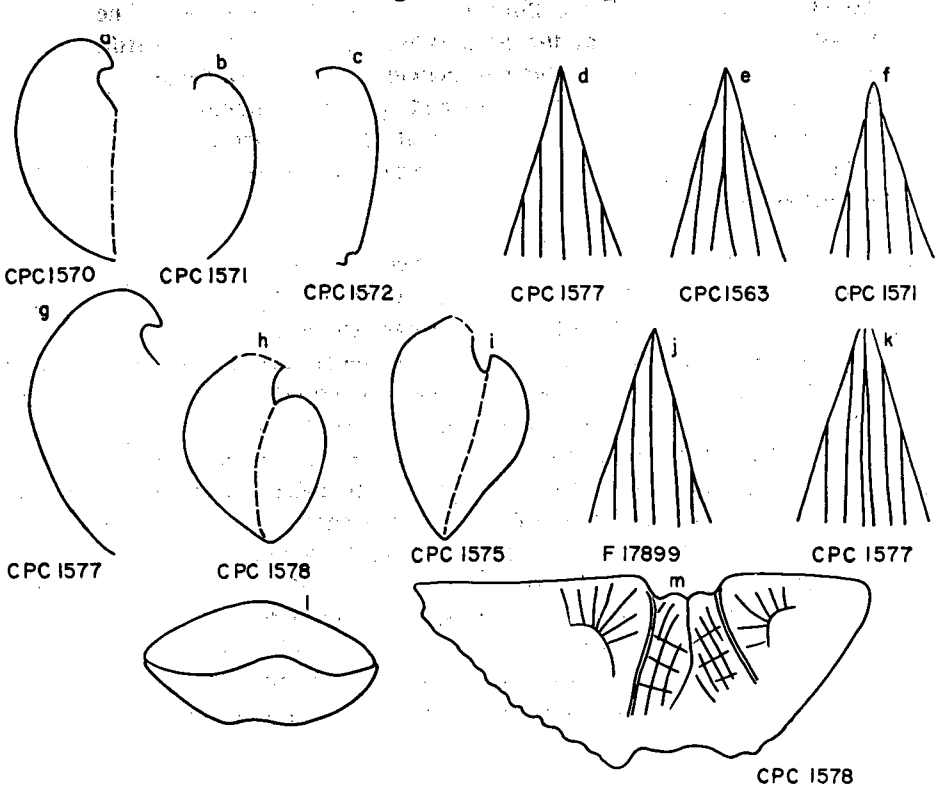

Fig. 25. (a)-(c), (e), (f), (j) *U. septimus* sp. nov.; (d), (g), (i), (k), (l), (m) *U. aff. septimus*. (a)-(c), (g)-(i) Profiles of specimens illustrated in Plate 5, x1. (d), (e), (j), (k) Sulcal costae. (f) Fold costae. (m) CPC1578, partly silicified shell. Transverse sections, x4.3.

thickened on both sides, e.g. CPC1573 (Pl. 5, fig. 9). The dental plates are fairly long: 1.2 cm in the holotype (about two-fifths of the shell length), and slightly longer in other specimens. They diverge in most specimens at an angle of about 45°; in F17897, a mature specimen, the divergence is at 37°.

The deposition of secondary shell between the plates has produced an elevated platform with a median groove. Probably a small delthyrial plate was present in the very young stages, as some of the immature specimens referred to this species because of their proportions show a very small depressed plate in the apex of the delthyrium.

The ventral muscle scars are rather deeply impressed and lie between the front ends of the thickened dental plates. They are elongate-oval in outline: 1.1 cm long and 0.85 cm wide in the holotype (Pl. 5, fig. 1b, c). The diductor scars are longitudinally striated. The median adductor scar is elongate and behind it is a low median ridge. Little can be seen of other ventral internal features. Most mature specimens are not costate on the inner surface except near the front; however, CPC1573 is costate (Pl. 5, fig. 9).

A dorsal valve (CPC1571) is illustrated in Plate 5, figure 2a-d. The cardinalia are of typical *Spirifer* pattern; the notothyrium is wide and the cardinal process consists of numerous fine longitudinal platelets. The inner flange of the socket groove is curled upwards. Neither descending crural lamellae nor spiralia are preserved in any of the specimens. The dorsal adductors are not deeply impressed and a fine median ridge is present. In contrast to the ventral valve, the dorsal interior surface is costate.

Discussion: Although *U. septimus* is relatively longer than *S. striatoconvolutus,* the type of costation indicates that it is better included in *Unispirifer* rather than in *Prospira.* The fold and sulcus costae are well defined and the lateral costae are fairly numerous (up to 21). The dental plates are well developed. The following species show broadly comparable costation but differ a little in proportions: *S. pentagonus* Sokolskaya and *S. ventricosus* Sokolskaya from the early Tournaisian of the Moscow Basin; *S. mediocris* Tolmatchow and *S. similis* Tolmatchow from the Tournaisian of the Kuznetzk Basin (these two being placed in *Fusella* by Besnossova, 1959). Also apparently broadly similar are the inadequately known *S. ventricosus* de Koninck, *S. pentagonus* de Koninck, and *S. suavis* de Koninck. *S. greenockensis* Brown, 1952, from the Banffian of Alberta is similar in costation and proportions but with less prominent umbo. The species compared by Rodriguez & Gutschick (1967) with *S. greenockensis* Brown differs by having bifurcated lateral costae. *Unispirifer? corpulentus* Carter, 1968, from the Burlington Limestone is broadly comparable but is a much more inflated species.

U. septimus is smaller and relatively narrower than *U. fluctuosus. Prospira travesi* sp. nov. has a similar outline, but has flattened fold and sulcal costae and well defined striae.

Some specimens from an outcrop of Septimus Limestone near Spirit Hill are described separately as *Unispirifer* sp. cf. *U. septimus*.

Geological Age: Late Tournaisian to early Visean.

Occurrence: All localities in Septimus Limestone on western slope of Mount Septimus, Bonaparte Gulf Basin: CPC1570-3, F17889, F17898 from 500 to 550 feet above base; CPC1563, F17892, F17897, F17900 from 450 to 500 feet; and F17894, 17901, 17902 from 550 to 600 feet.

UNISPIRIFER sp. cf. U. SEPTIMUS sp. nov.

(Pl. 5, figs 3, 5a, b, 6a, b, c, and 8a, b; Text-figs 25, 26a)

Material: Six silicified shells and some fragments.

Description: CPC1578 (Pl. 5, fig. 5a, b; Text-fig. 25h, l, m) is a fairly small shell whose outline is similar to that of the typical examples of *U. septimus*. The sulcus is only slightly developed. The ornament is similar, with 15 simple lateral costae, differing only in being slightly more rounded and in having equidimensional troughs. Striae are not preserved; fine undulating concentric growth-lamellae are present. Silicification in the umbonal region is incomplete and the shelly material is preserved. The shell is thickened in the umbonal region and the initial dental plates diverge towards the ventral surface (Text-fig.

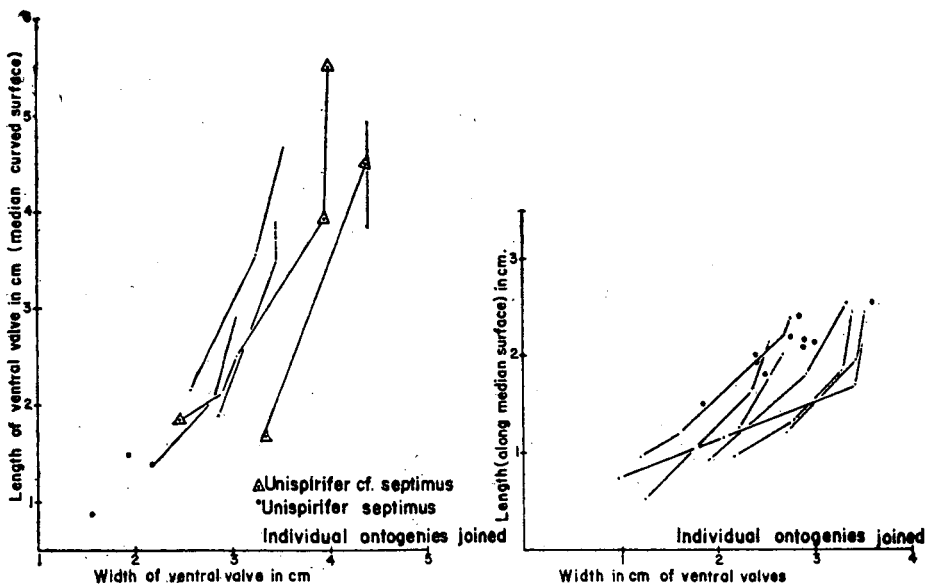

Fig. 26. Length/width ratios of (a) *U. septimus* and (b) *P. laurelensis*.

25m). CPC1577 (Pl. 5, fig. 6a, b, c; Text-fig. 25d, g) is a larger ventral valve, similar in outline to the typical *U. septimus* but with a slightly deeper sulcus. The costae of the flanks are similar to those of CPC1578 except that the fourth on the right bifurcates near the front, and some are a little uneven. The marginal sulcal costae are stronger than the remainder. Undulating concentric growth lamellae are well developed and no striae are preserved. The umbonal tip is incurved and the area is similar to that in the holotype of *S. septimus*. The shell was markedly alate and slightly mucronate in its early growth stages.

CPC1577 and 1578 may be regarded as members of *U. septimus* showing some slight varietal differences. However, CPC1575, another silicified shell, is rather distinctive. It is illustrated in Plate 5, figure 8a, b, and Text-figure 25i, k. In outline and dimensions it does not differ greatly from *U. septimus,* but is somewhat crushed on the right ventral flank, and this accentuates the asymmetric appearance of the shell. Like CPC1577 it was alate to mucronate in its early stages. It is distinctly asymmetrical; and the apsacline interarea is tapering on one side and truncated on the other. The sulcus and fold are not pronounced and the front commissure is gently uniplicate. The most distinctive features are in the ornamentation. The costae number 22 or 23 on the flanks, and a number bifurcate, some near the umbo, others to the front. The costae are thus somewhat uneven-sized and are slightly flatter than in the associated specimens. The sulcal pattern is similar to that of *U. septimus* as well as to the accompanying specimens though it is slightly more complicated with a divided middle costa. The fine ornamentation resembles that of CPC1577 and 1578; fine numerous crenulated concentric lamellae are present and there is no trace of radial striae.

The specimen illustrated in Plate 5, figure 3 (CPC7576) is of similar type with bifurcated costae. The fold is a little more accentuated than in CPC1577.

Discussion: The collection is insufficient to indicate if one or more species is included; but as the specimens were all collected together, they probably represent a population. If so, the species is variable in the development of bifurcation of the lateral costae. The presence of numerous bifurcated lateral costae suggests exclusion of the species from the genus *Unispirifer*. Even those specimens with simple lateral costae differ a little from *U. septimus* in the size and spacing of the costae. Specimens CPC1575 and 1576 possess ornament which brings them near to members of the *S. striatus* group. CPC1577 and 1578 on the other hand resemble some species of the *S. bisulcatus - S. trigonalis* group, especially Russian species described by Semichatova (1941a). The internal structure is not sufficiently well known nor are the collections sufficient to clear up the problems.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1575-8 from locality WAA9 (Mines Administration Ltd), Bonaparte Gulf Basin, isolated limestone outcrop, probably equivalent to Septimus Limestone.

Genus PROSPIRA Maxwell, 1954

Type species: *Prospira typa* Maxwell, 1954.

Generic features: Small Spiriferidae, strongly to moderately transverse; lateral costae simple, rounded; fold and sulcus gentle, usually small, with relatively few costae which are commonly flattened, rarely faint; unicostate; radial striate and concentric micro-ornament; similar to *Unispirifer,* but with fewer and simpler costae. Strunian, Lower Carboniferous.

Discussion: The summary is emended from Maxwell's, which was 'shell transverse, biconvex; sinus and fold small, smooth or weakly costate, lateral costae rounded; microscopic radial lirae over entire surface; dental plates short, thickened; dorsal medium septum small or absent'. Maxwell (1954, 1961) discussed the genus at some length, retaining the same summary in both papers. In the second (p. 89) he suggested that *Prospira* and *Unispirifer* may be congeneric, but accepted that the forms 'ascribed to *Unispirifer* are generally more costate'. He also noted that 'Campbell separated *Unispirifer* from *Prospira* by coarser costation, less numerous sinal costae, weaker dental lamellae and smaller size of *Prospira*'. These distinctions are of degree only, but a series of species between *Prospira typa* and *Unispirifer striatoconvolutus* has not been demonstrated so far. The species originally described by Maxwell are small (type species 3.4 cm wide, 2.1 cm long). Maxwell's definition of the genus would have to be broadened to cover the species now included in *Unispirifer.* I have used *Prospira* only for small forms fairly close to *Prospira typa,* not necessarily with the median costae as flat or reduced as in the type species.

The Queensland species of *Prospira* as described by Maxwell have a unicostate sulcal pattern with as many as seven or as few as three costae; these may be faint, as may the fold costae. The two new species assigned to *Prospira* commonly but not invariably show a flattening of fold and sulcal costae; this can be regarded as a tendency towards obsolescence, variably developed in different individuals and species. I have regarded as representatives of *Prospira* small overseas species which are similar to *P. typa* in other respects but without very marked flattening of the median costae. It seems possible that a tendency towards reduction of these costae might develop at more than one stratigraphical level or place in allied lineages. At the present time the stratigraphic and geographical distribution of *Prospira* is not well enough known to suggest a phylogeny of the species.

Maxwell's species were reported from the late Tournaisian and early Visean of Queensland. Elsewhere *Prospira* appears to be already present in the earliest

Tournaisian. Thus *'Spirifer tornacensis'* of H. & G. Termier (1950, pl. 114, fig. 19) from the Strunian of the Mauritanian Sahara appears to be referable to *Prospira,* and *Prospira nodai* (Tachibana, 1956) occurs in the early Tournaisian of Japan. Small related Russian forms, some incorrectly referred to *Spirifer tornacensis* de Koninck, occur in the early Tournaisian of the Moscow Basin (Sokolskaya, 1941) and the Kuznetzk Basin, e.g. *Fusella duchovae* Besnossova, *Fusella ussiensis* (Tolmatchow) (Besnossova, 1959). Other species from the Donetzk, Karagandian, and northeast Kazakhstan basins in deposits of Tournaisian age can also be referred to *Prospira. Fusella praealbanensis* Bublitschenko and its subspecies from the Strunian Tarkansk horizon of the Rudny Altai and equivalent levels in Central Kazakhstan appear to be the earliest occurrences of *Prospira* in the USSR.

It is possible that the records of *'Spirifer tornacensis'* listed by Demanet (1958), from the Strunian 'Assise d'Hastière et d'Etroeungt'—Tn 1 and also basal Tn 2a of the 'Assise de Maredsous', refer to a species of the *Prospira* group. The early Belgian forms do not seem to have been described. As reported by Vaughan (1915, p. 41, pl. 6, fig. 5a, b), the earliest Carboniferous examples of *'Spirifer tornacensis'* in Belgium are small and comparable with the small species from the Avonian Z_1 Zone of Bristol which he identified as *Spirifer clathratus* M'Coy. These appear to be referable to *Prospira.* Certain small early Mississippian species with flattened to faint median costae agree well with *Prospira typa.* They include species like *S. platynotus* Weller, *S. legrandensis* Weller, *S. louisianensis* Rowley, and *S. osagensis* Swallow; also *S. minnewankensis* Shimer (in Brown, 1952) from the upper Banffian of Alberta. Weller (1914), however, did not record striae in *S. platynotus, S. legrandensis* and *S. osagensis,* possibly because the specimens were worn.

Maxwell (1961) suggested that the Queensland species descended from *Cyrtospirifer* via *Unispirifer. Cyrtospirifer* sensu stricto can be discounted as an ancestor as it is multicostate and pustulose and has a strong delthyrial plate. Pitrat's inclusion of *Prospira* in the Cyrtospiriferidae is incorrect. The ancestors of late Tournaisian and Visean species of *Prospira* are better sought among the early Tournaisian species mentioned above than in species of *Unispirifer.* The possible synonymy of *Prospira* and *Unispirifer* is discussed on p. 70.

Internally *Prospira, Unispirifer,* and *Spirifer* are very similar. Three species are described below, of which one is doubtfully included.

PROSPIRA LAURELENSIS sp. nov.

(Pl. 2, figs 8-13; Pl. 8, fig. 14; Pl. 26, figs 1-3; Pl. 28, fig. 5a, b; Text-figs 26b, 27-30)

Diagnosis: Small, alate species, mucronate in youth, maximum width at hinge-line, width about twice length in adults; wide apical angle (126°-150°),

interarea nearly orthocline, moderately high; both valves moderately convex, fold and sulcus small; 10 to 20 simple rounded costae on flanks, 5 to 9 flatter costae on fold and sulcus; dental plates stout and divergent.

Material: 35 fairly complete specimens.

Description: The shells of this species are small; the largest specimen is about 4 cm wide and 2.2 cm long. The outline is alate, with the greatest width, in most, at the hinge-line. Width always exceeds length. Both valves are convex, with greater convexity near the umbo. The ventral valve is generally mucronate in the earlier stages and becomes less so in maturity and old age. In transverse and longitudinal profile the valve is gently to moderately convex with a distinct but gentle sulcus which deepens to the front. In rare specimens the posterior lateral flanks are slightly hollow. A projecting tongue is only slightly or not at all developed. The sulcal angle ranges from about 20 to 30°, the average nearer 20°. The umbo is not prominent and in the majority is upturned at the tip. The shoulders are straight to slightly concave and the apical angle varies from 126° to 150°. The interarea is flat to slightly concave and in most specimens is nearly orthocline to slightly apsacline. The height is variable, but in proportion to the hinge-line is usually rather high. It is marked by pronounced longitudinal flutings—denticle grooves—which commonly number about 15 in 5 mm. Less prominent transverse growth striations are also present. The area is triangular, but its posterior margins vary from gently convex to gently concave. The interareas may be truncated and some specimens are

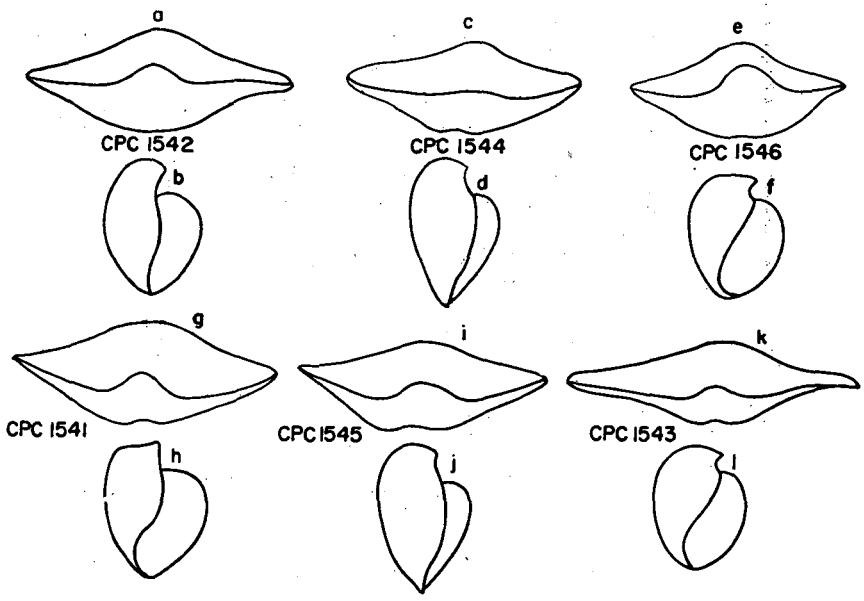

Fig. 27. *P. laurelensis* **sp. nov. Anterior and profile outlines of shells illustrated in Plate 2. Natural size.**

TABLE 9: Dimensions of *Prospira laurelensis* sp. nov. and *P.* sp. aff. *P. laurelensis* (in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	T	Ha	Dw	Da	Aa	Wsf	W/L	Sulcus	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
Prospira laurelensis																		
CPC1541	1.75	2.45	1.40	1.85	3.35	3.40	1.25		0.40	c45°	149°	0.75	1.94	6	17	17	17+	20
CPC1542	1.80	2.45	1.35	1.76	3.45	3.45	1.15	0.36	—	—	143°	0.70	1.92	5	20+	18+	19+	18+
CPC1543	1.60	2.10	1.20	1.50	3.45	3.45+	c0.97	0.40	0.30	38°	149°	0.50	2.15	—	17+	17+	18+	17+
CPC1544	1.80	2.15	1.40	1.55	2.55	2.90	1.06	0.45	0.40	43°	c140°	0.75	0.61	7	15+	14+	14+	11+
CPC1545	1.75	2.10	1.35	1.60	3.05	3.05	1.05	0.40	—	—	134°	0.65	1.74	7	14+	14+	12+	12+
CPC1546	1.50	2.20	1.20	1.45	2.75	2.75	1.05	—	—	—	—	0.65	1.83	6	14+	16+	16+	13+
F17870	1.85	2.55	1.40	1.70	3.6e	3.6e	1.13	0.35	0.40	50°	150°	0.70	1.95	7	18+	11+	14+	18+
F17871	1.50	1.8+	1.30	1.75	2.5e	2.5+	0.96	0.35	0.30	40°	143°	—	1.68	—	16+	14+	14+	15+
F17872	2.30	3.30	1.75	2.15	3.85	3.85	1.50	0.45	—	—	143°	1.0	1.67	9	17+	—	17+	20+
F17873	2.2e	—	1.75	2.0	4.1e	4.1e	1.33	—	—	—	—	—	1.87	—	15+	—	—	—
F17874	1.90	—	1.40	—	3.4e	3.4e	—	0.40	—	—	c140°	0.60	1.78	5	—	13+	—	—
F17875	1.60	2.05	—	—	2.5	2.67	—	0.30	0.25	37°	149°	0.70	1.69	5	12+	15+	—	—
F17876	1.70	2.10	1.20	1.45	2.40	2.50+	—	0.40	0.40	50°	130°	0.65	1.46	5	12+	11+	11+	12
F17877	1.85	2.40	1.35	—	2.50	2.85	—	0.50	0.40	30°	126°	0.70	1.54	7	14	13+	15+	—
F17878	1.8+e	—	1.45	1.70	3.80	3.80	—	—	—	—	—	—	2.11	—	—	—	17	17
F17879	2.15	—	1.70	2.10	3.45	3.45	1.46	0.55	—	—	—	0.85	1.60	—	—	—	—	—
F17880	1.15	1.50	1.00	1.15	1.85	1.85	0.73	0.20	—	—	133°	0.45	1.60	—	7+	7+	7+	7+
F17881	1.55	1.95	1.20	1.55	2.30	2.40	—	0.40	0.35	45°	135°	—	1.51	—	—	12+	12+	—
F17882	1.65	2.00	—	—	2.40	2.60	1.0	0.35	—	—	135°	0.65	1.57	6	9+	8+	9+	9+
F17883	1.80	2.10	1.40	—	2.70	2.90	—	0.40	—	—	135°	—	1.61	—	—	—	13+	14+
Prospira sp. aff. *P. laurelensis*																		
CPC1580	1.65	2.05	—	—	2.15	2.15	—	0.50	—	30°	144°e	—	1.24	6	10+	—	—	—
CPC1581	1.25	—	—	—	—	1.7e	—	0.40	—	33°	136°	—	1.36	5	10+	—	—	—
CPC1582	1.3+	—	1.0	—	—	2.2	.90	0.4	—	30°		—	1.69	—	—	—	—	—

asymmetrical. The delthyrium in all specimens is open; in a few a very small delthyrial plate is discernible at the apex. A dental ridge and marginal groove are present on each side of the delthyrium. The delthyrial angle ranges from about 30° to 50°. A small segment without denticle grooves, adjacent to the delthyrium, can be seen in some specimens. The dorsal valve is moderately convex in lateral and transverse profile; in a few specimens it is flattened on the lateral extremities. The fold is distinct, but in some specimens is gentle.

The surface of both valves is covered with fairly fine rounded costae (with slightly narrower rounded troughs). On each flank of the ventral and dorsal valves there are about 10 to 20 costae, usually 15-17. The lateral costae are simple and widen to the front, where they number 4-5 in 5 mm near fold and sulcus. The costae of fold and sulcus divide in characteristic fashion with a median costa originating near the umbo. The sulcus displays a simple unicostate pattern. Representative examples of fold and sulcus arrangements are illustrated in Text-figures 28a-d. The costae flanking the sulcus are slightly stronger than the rest. The costae of the sulcus and fold are usually somewhat less prominent than the remainder. The micro-ornamentation consists of fine, long radial striae crossed by concentric growth-lines and lamellae. The striated outer layer is abraded from most specimens; it is illustrated in Plate 8, figure 14. The concentric lamellae are more numerous towards the front and this indicates that the illustrated specimens are mature individuals.

Dimensions are shown in Table 9. A scatter plot of the ratios of width at hinge-line to the median curved length indicates that at a width of about 2.4 to 3.4 cm, the shell increases in length with little further increase in width.

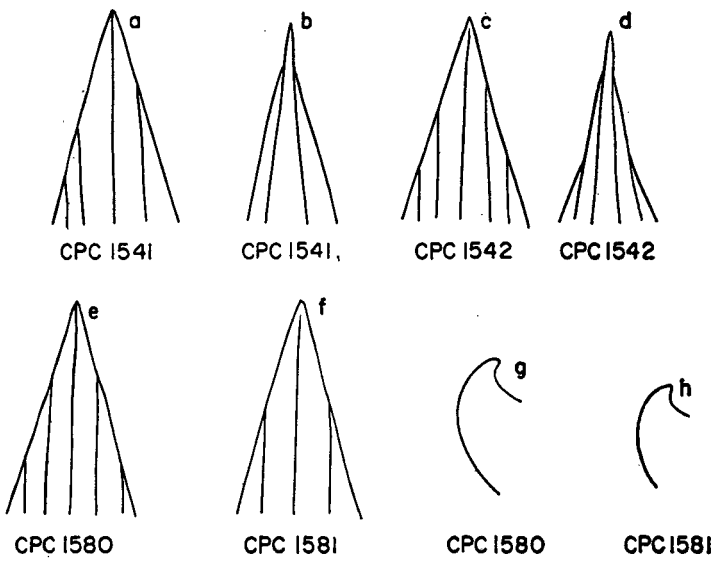

Fig. 28. (a)-(d) *P. laurelensis;* (a), (c) Sulcal costae; (b), (d) Fold costae. (e)-(h) *P. aff. laurelensis;* (e), (f) Sulcal costae; (g), (h) Outline profiles of ventral valves. Natural size.

The holotype CPC1543 and paratypes CPC1541, 2, 4, 5, 6 are all from a single locality in the Laurel Formation. Most are symmetrical, but a few are asymmetrical. Growth interruptions, shown by irregular margins and slight sinuosity in the costellae, are fairly common.

Internal structures are known only from sections and are illustrated in Plate 26, figures 1-3 and Text-figures 29 and 30. The dental plates are moderately long and divergent. The thin initial plates can be readily distinguished; the secondary thickenings are usually coarsely crystallized. In the anterior part of the dental plates, the adminicula and dental flanges can be distinguished. The denticle grooves of the interarea are marked by distinct flexures of the outer fibrous layers of the shell. The inner fibrous layers of the umbonal region tend to be coarsely crystallized. The prismatic modification of the secondary fibrous layer can be distinguished especially in sections at the level of the front of the interarea and farther forward in the shell. The outer primary or lamellar layer is nearly always worn off; the outermost layers of the secondary layer are commonly laminate, with the laminae nearly parallel to the surface of the shell. A small delthyrial plate is formed by the juxtaposition of the inner thickenings of the dental plates at the apex of the delthyrium (Text-fig. 29c, d). The ventral adductor muscles are well impressed. The spiralium is shown in Text-figure 30a-f; it has about 14 whorls. The details of the crural supporting lamellae were not determined. The dorsal cardinalia are of the general *Spirifer* type; the low cardinal process contains about 16 delicate longitudinal muscle attachment

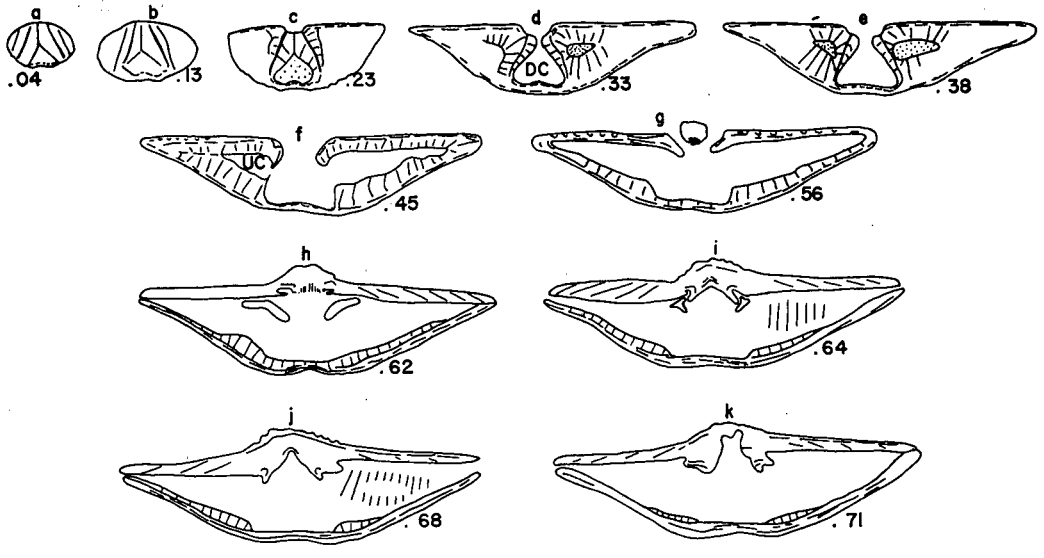

Fig. 29. *P. laurelensis.* **CPC1673. Transverse sections. (a)-(c) Show initial dental plates and initial floor of valve (probably muscle region). Coarse crystals of thickened dental plates and umbonal and delthyrial cavities shown somewhat diagrammatically in (c)-(e). Note 'delthyrial plate' in (c), (d). The final crystallized modification of the fibrous lamellae is seen on the ventral floor of the valve in (f)-(k).**

platelets and the socket plates recurve for a short distance along the margin of the dorsal area.

Discussion: *P. laurelensis* differs from *P. typa* and *P. prima* mainly in having more lateral costae and slightly more pronounced costae on the fold and sulcus. The median costae are commonly flattened but are not as faint as in some specimens of the Queensland species which may represent a somewhat specialized group of the widespread genus. *P. laurelensis* differs from *P. travesi* in being more alate, having more lateral costae and a narrower fold, and in sulcal costal pattern. It is readily distinguished from *Unispirifer striatoconvolutus* and *U. fluctuosus,* in being much smaller, with fewer lateral costae, flatter median costae and in the curves of changes of width and length with growth. It is relatively more transverse than *U. septimus.*

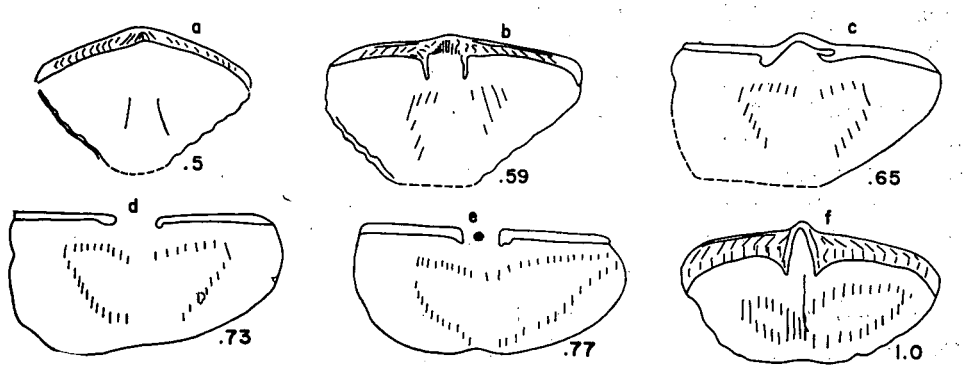

Fig. 30. *P. laurelensis.* **CPC1674. Longitudinal sections (a)-(e) in dorsal valve; (f) in ventral valve. Spiralia slightly displaced, x1.5.**

Among the numerous USSR species referable to *Prospira,* the most similar to *P. laurelensis* are *P. ussiensis* (Tolmatchow) from the upper Tournaisian Taidansk horizon of the Kuznetzk Basin and *'Spirifer tornacensis'* described by Sarytcheva & Sokolskaya (1952) from the Chernyshinsk horizon of the Moscow Basin. *P. minnewankensis* (Shimer) from the Upper Banffian of Canada is the closest of North American species. All are broadly similar in form but differ in details of costation; the sulcal costae are not markedly flattened. The Kinderhook species *S. platynotus* Weller and *S. legrandensis* Weller are also similar in form but are not definitely known to be striate.

Geological Age: Tournaisian.

Localities: The holotype, CPC1543, and paratypes CPC1541, 1542, 1544-6 and F17870-8 from locality KC18, Fitzroy Basin; CPC1670-4 and F17879-83 from SDH8, from same bed. Other isolated specimens are known from nearby localities. All localities are from beds high in the Laurel Formation.

PROSPIRA sp. aff. P. LAURELENSIS sp. nov.

(Pl. 4, figs 4a, b, c, 7a, b, c, 8a, b; Text-fig. 28e-h)

Material: Two silicified ventral valves and several incomplete moulds and impressions.

Description: The two ventral valves CPC1580 (Pl. 4, fig. 4a-c) and CPC1581 (Pl. 4, fig. 8a, b) were collected with many specimens of *Unispirifer fluctuosus*, from which they differ in size, proportions, and sulcal costal pattern. Both are smaller than the holotype of *P. laurelensis* but are comparable with some of the topotypic specimens. The sulcal pattern (Text-fig. 28e-f) is similar. The interarea is slightly more apsacline than in the topotypes and the delthyrial angle is less (30-33°). The dental plates are thin, with little thickening. CPC1581 has a tiny delthyrial plate, but CPC1580 has none. The dental plates diverge on the valve floor at 40°, with a length of 0.65 cm in CPC1580, at 50° and length 0.50 cm in CPC1581. In neither is the muscle field deeply impressed and both are costate on the internal surface. The surface ornament consists of simple rounded lateral costae, with rounded slightly narrower interspaces. There are 10 on each side, less than in the holotype, but about the same as some of the smaller topotypic specimens. The surface is finely striate.

The moulds from higher in the Moogooree Limestone appear to be similar. The most complete specimen, CPC1582, is illustrated in Plate 4, figure 7a, b, c, and agrees in outline with the topotypes. The sulcus is gentle and the fold moderate. The interarea is comparatively high, a small delthyrial plate is present, and the dental plates diverge at about 55°. The dorsal cardinalia are of the *Spirifer* type with recurved socket plates. The external mould (incomplete) of this specimen has 15 simple lateral costae and a unicostate sulcus. Another somewhat larger mould has a thicker shell with stouter dental plates and more impressed ventral adductor scars and a delthyrial platform. Ovarian pits flank the adductor scars and also are in front of the interarea. Fragmental external impressions indicate that the species is mucronate.

Discussion: This collection should probably be referred to *P. laurelensis*, but it is so imperfect that it is described separately; moreover, it is from a different basin.

Geological Age: Tournaisian.

Occurrence: CPC1580, 1581, from TP42, about 440 feet above base of Moogooree Limestone; CPC1582 and F17197 from about 220 yards west of TP42, 710 feet above base of Moogooree Limestone, Carnarvon Basin.

TABLE 10A: Dimensions of *Prospira travesi* sp. nov.
(in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	Ha	Aa	Da	Dw	W/L	Wsf	Wff	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1574			2.05	2.35	3.75	3.75							1.3		10			16	
CPC1681	2.20	2.90			2.9e	3.0	.50	142°	40°	.50	1.35	.85				15+			
F17943			1.90		2.90	2.90							.90		7			17	
F17944			1.50+		3.00	3.00							.75						14+
F17945	1.10				1.50	1.50	.25	136°	30°		1.36	.55		7			11		

PROSPIRA TRAVESI sp. nov.

(Pl. 5, fig. 7a, b; Pl. 8, fig. 12; Pl. 29, fig. 1a-c, 9; Text-fig. 31ae)

Diagnosis: Small species, maximum width in front of hinge-line; umbo moderately prominent, apical angle 136° to 140°; interarea apsacline, moderately high (0.50 cm), triangular; both valves gently convex, fold and sulcus moderately prominent, wide and rounded with acute margins; 14 to 17 simple rounded costae on each flank, flatter costae on sulcus and fold, 8 on sulcus, 10 on fold, no median sinal costae originating at apex; shell thin; dental plates delicate and divergent.

Material: Six associated silicified specimens.

Description: The specimens are isolated valves, none of which is complete. The holotype CPC1681 (Pl. 29, fig. 1a-c) is a small ventral valve. It is thin-shelled, as are all the specimens, and is finely silicified with much of the detail preserved. The shell is widest slightly in front of the hinge-line. It is

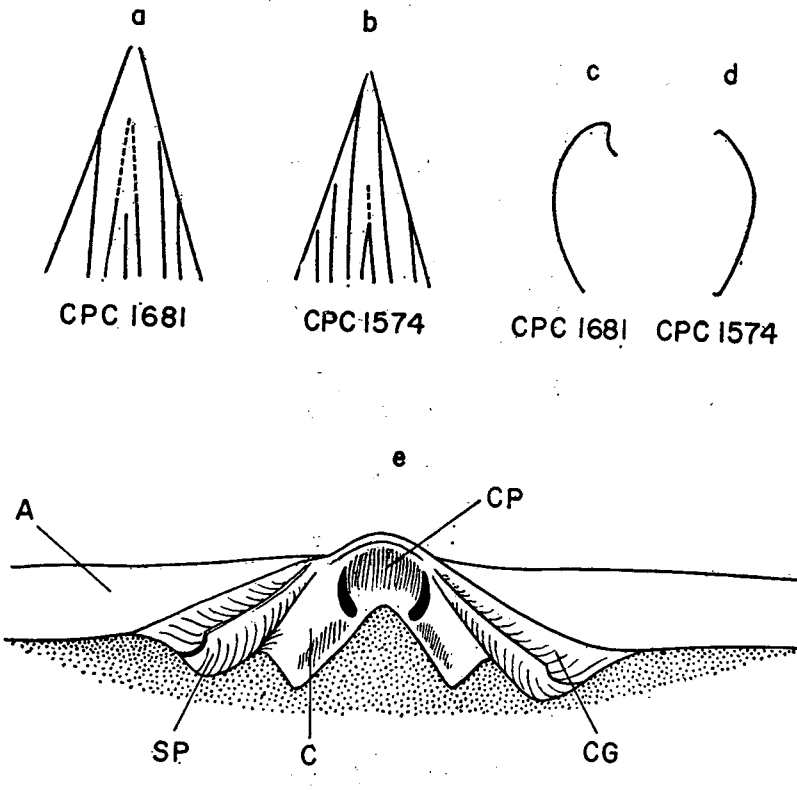

Fig. 31. *P. travesi* **sp. nov. (a), (b) Sulcal and fold costae; (c), (d), Profiles of specimens illustrated in Plates 5 and 29; (e) diagrammatic sketch of dorsal cardinalia in ventral view. CPC—cardinal process; SP—socket plate; C—crural lamella; CG—socket groove; A—dorsal interarea.**

gently convex on the flanks. The sulcus is distinct, with fairly abrupt margins and a rounded floor. The shoulders are gently concave and the umbo is fairly prominent; the apical angle is about 142°. The interarea is gently concave, apsacline, and triangular, and moderately high (0.5 cm) for the shell size. Its surface is too much worn to show whether it was fluted or not. The delthyrial angle is 40° and the delthyrium is flanked by a dental ridge and marginal groove; the ridge is at the level of the area and extends forward into prominent and obliquely disposed teeth. The front margin is rounded on the sides and in the middle, with no tongue. The greatest width was in front of the hinge-line even in the early growth stages, and ears were not developed. The anterior commissure is uniplicate.

Internally, thin blade-like plates extend from the delthyrial edge to the floor of the valve and there is no appreciable umbonal thickening. The dental plates extend forward from the umbo for about 0.8 cm and diverge at about 30°. The muscle scar cannot be distinguished; it was evidently very slightly or not at all impressed on the floor of the valve. The whole inner surface is costate.

The external ornament consists of about 15 simple lateral costae on each flank. The costae are gently convex to flattish with narrower rounded troughs; they widen to the front. The sulcus is occupied by 8 rather faint costae arranged as in Text-figure 31a; it is a little crushed and difficult to make out. The surface is marked by numerous undulating fine concentric growth lamellae which are densest in front, indicating that the shell is mature. Also clearly discernible are fine radial striae over the ventral surface.

Paratype CPC1574, a dorsal valve, is illustrated in Plate 5, figure 7a, b, and in Text-figure 31b, c, e. It is moderately convex longitudinally and transversely, with flattened flanks near the outer ends of the hinge-line. The umbo is not prominent and a broad rounded fold extends to the front. Its margins with the lateral slopes are fairly abrupt. The maximum width is at the hinge-line, but the shell is not mucronate. The lateral margin is somewhat crushed and it thus appears less convex than it was in life. Internally, the shell is costate and has a tapering dorsal orthocline area with a maximum height of 0.15 cm. The notothyrium is wide and the cardinal process and socket plates present somewhat unusual features. The cardinal process is a little more prominent than in most small spiriferids. It is roughly bilobed with about 16 fine longitudinal platelets. Extending in front of the process and flanking the socket plates are two flat flanges, which probably are the bases of the crural lamellae. A short median ridge occurs in the faintly impressed linear adductor muscle scar.

The external ornament consists of about 15 simple costae on each flank, similar to those in the holotype. The fold has 10 rather faintly expressed costae arranged as in Text-figure 31b. The surface is marked by fine radiating striae crossed by fine concentric growth-lines and lamellae (Pl. 29, fig. 9).

Discussion: *Prospira travesi* is a rather distinctive species and I could find nothing very close to it in the literature. Maxwell's three species of *Prospira* from Queensland have very faint costae on fold and sinus. In possessing less rounded costae on fold and sinus, *P. travesi* has some resemblance to them. However, the fold and sinus are moderately prominent and rather sharply defined and both fold and sinus have a considerable number of costae (8-10). The dorsal cardinalia have some peculiarites which are perhaps of minor importance.

P. travesi differs from *U. septimus* in the configuration of costae, and in possessing fine radial striae. It is also much thinner-shelled and lacks thickening in the umbonal region. The two species were collected from the same formation, though they were not found together. They are of similar proportions.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1681, 1574, F17943-5, a single slab of limestone, from BS3, on western slopes of Mount Septimus, Bonaparte Gulf Basin; Septimus Limestone, about 100 feet below top of formation.

This species is named in honour of Mr D. M. Traves, of Mines Administration Ltd, Brisbane.

PROSPIRA? INCERTA sp. nov.

(Pl. 9, figs 1-4; Text-fig. 32)

Diagnosis: Small alate Spiriferidae; both valves strongly convex; apical angle wide; ventral interarea moderately high (>.3 cm), nearly flat, orthocline; ventral sulcus very gentle with slightly developed or no costae; fold scarcely elevated; lateral costae simple and rounded, numbering up to 12 on each flank; internally with thin dental plates and low ventral median ridge.

Material: Seven incomplete specimens, coarsely silicified and ferruginized.

Description: The species is small; the holotype, CPC1600, is only about 1.45 cm long and an estimated 2.60 cm wide. The other specimens are of about the same size. CPC1600 is illustrated in Plate 9, figure 3a, b, and paratype CPC1601 in Plate 9, figure 4a, b. The shell is alate with a wide apical angle and the shoulders are slightly concave. CPC1601 has an extended hinge-line which suggests that it was probably mucronate. Both valves are strongly convex longitudinally and transversely with a tendency to flattening or concavity on the posterior lateral flanks of the ventral valve. The sulcus is very gentle, and the fold is not elevated at all, being distinguished only by a difference in the costation. The front margin is rounded in outline and the commissure is nearly rectimarginate.

TABLE 10B: Dimensions of *Prospira? incerta* sp. nov.
(in cm)

Specimen Number	L	Lb	Whl	Wm	T	Ha	Aa	Dw	W/L	Sulcus	Fold	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1600		1.20	2.60e	2.60e	1.15	0.35		.25		2+	2	9			7+
CPC1601		1.10	2.50e	2.50	1.15					4	2				12+
CPC1602	1.4+		2.85	2.85		c.3.0	152°		2.0	2		9+	8+		
CPC1605	1.05		1.60							2		6	7		

The interarea is rather high for such specimens—0.35 cm in the holotype and 0.3 cm in CPC1602. It is triangular, nearly orthocline, and almost flat, but upturned at the tip. Its posterior margin with the ventral surface is acute. The outer extremity of the area in CPC1601 is truncated and may have been mucronate. The area is fluted longitudinally, and the delthyrial angle in CPC1600 is about 35°.

Internal features are little known and satisfactory sections could not be prepared as silicification is incomplete. CPC1605, a small ventral valve, was ground at the umbo and displays two rather thin dental plates and a low median ridge (Text-fig. 32b).

The surface ornament, though the finer details are not preserved, is distinctive. The flanks carry simple gently rounded costae with narrower intertroughs. There are 12 costae on the flank of CPC1601, with the outermost ones faint; the other specimens have from 7 to 9. The sulcus is marked by two stouter costae which form its boundaries; between them is a shallow rounded groove. There are no other sulcal costae in CPC1602 (Pl. 9, fig. 1) nor in CPC1601, but there are faint traces of inner lateral branches towards the front of the sulcus in CPC1600 and possibly also a median intercalated costa. The pair of costae of the fold in both CPC1600 and CPC1601 are scarcely differentiated from

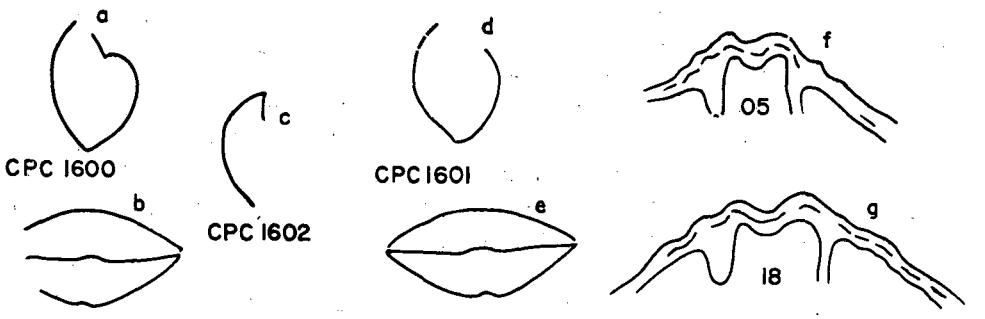

Fig. 32. *P? incerta* **sp. nov. (a)-(e) Profile and anterior outlines of specimens illustrated in Plate 9. Natural size. (f), (g) CPC1605, an incomplete and partly silicified ventral valve. Transverse sections, x3.**

the lateral ones; the marginal grooves are slightly more pronounced than the remainder. In CPC1603 (Pl. 9, fig. 2), the grooves marginal to the fold are quite pronounced and the first lateral costae are a little stouter than the remainder. Fine concentric undulating lamellae are preserved towards the front of CPC1600 and 1601. There is no trace of radial striae, but the state of preservation is inadequate to preserve such fine details.

The shell structure is unknown; no trace of punctae can be discerned, however.

Discussion: The holotype and paratype are the only specimens that can be referred with complete certainty to the new species. CPC1602 is possibly not conspecific, as it has a slightly more pronounced sulcus and the bounding costa are slightly more prominent. However, it is similar in size and proportions, though the outer flanks are very slightly more flattened. Similarly, the dorsal valve CPC1603 (Pl. 9, fig. 2) has slightly more pronounced grooves bounding the fold, compared with the holotype, and its costae are coarser. CPC1602 and CPC1603 show some resemblance in shape to species of *Strophopleura* Stainbrook and of *Voiseyella* Roberts. However they appear to lack lamellate ornament and their internal structure is not known.

Inclusion of this collection in *Prospira* can only be provisional.

Geological Age: Early Tournaisian.

Occurrence: All specimens, CPC1600-16, F17917-9, from BW5, Sandy Creek crossing on track from Carlton to Legune station homesteads, Bonaparte Gulf Basin. Isolated limestone outcrop, probably Burt Range Formation.

Genus ANTHRACOSPIRIFER Lane, 1963

Type species: *Anthracospirifer birdspringensis* Lane.

Generic features: Small to medium Spiriferidae; biconvex, wider than long but not generally strongly transverse; interarea denticulate; unicostate with undivided median sulcal costa originating at beak and two to eight undivided lateral sulcal costae originating from the sides of sulcus; six to thirteen prominent angular to rounded mostly simple costae on each lateral slope (inner ones dividing in type species); dental plates generally short, bounding the postero-lateral edge of the muscle field; dorsal cardinalia as in *Spirifer;* radially striate. Adapted from Lane (1963). Carboniferous.

Discussion: *Anthracospirifer* was erected to include a group of Pennsylvanian and late Mississippian species from North and South America. In addition to the type species, of early Pennsylvanian age, Lane included *A. matheri* (Dunbar & Condra), *A. opimus* (Hall), *A. occiduus* (Sadlick), and *A. oliveirai* (Mendes).

The type species is thin-shelled, without much umbonal thickening, and with short dental plates. The costae are prominent, with faint radial striae and concentric lamellae. Various Mississippian and Pennsylvanian species appear to be referable to *Anthracospirifer*. In many of these, all lateral costae are simple or divide only near the umbo and the shells are considerably thickened, especially in the umbonal region. The ventral muscles are commonly deeply impressed. Width and length can be nearly equal. There appears to be considerable intraspecific variation, as seen in the illustrations by Weller (1914) of species such as *S. increbescens* Hall and particularly in the biometrical study of *A. curvilateralis* (Easton) by McGugan & May (1965).

In addition to the American species certain widespread species such as *Spirifer bisulcatus* Sowerby and its numerous allies, including *A. milliganensis* sp. nov., can be placed in *Anthracospirifer*. *Spirifer trigonalis* Martin should also probably be included.

Anthracospirifer is evidently allied to *Spirifer, Unispirifer,* and *Prospira.* It is distinguished from *Spirifer* by its fewer and relatively simple costae and generally smaller size, and from *Unispirifer* by its fewer and more prominent costae and by its commonly less transverse proportions. It is less transverse than *Prospira,* and has more prominent costae, both on the flanks and on the fold and sulcus.

ANTHRACOSPIRIFER MILLIGANENSIS sp. nov.

(Pl. 8, figs 1, 2a, b, 4, 6; Pl. 27, fig. 1; Text-figs 33-35)

Diagnosis: Small species, maximum at or near hinge-line, length nearly equal to width; moderately biconvex; umbo prominent, shoulders concave; interarea triangular, moderately high (0.40 cm); sulcus narrow, fold moderate to prominent; uniplicate commissure; 7 costae in sulcus, 11 to 13 simple rounded costae on each lateral slope; dental plates stout, variable in length and inclination from nearly parallel to moderate divergence.

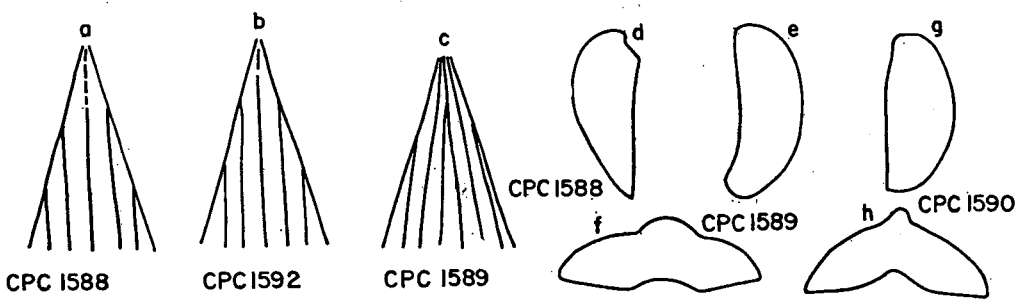

Fig. 33. *A. milliganensis* **sp. nov. (a), (b) Sulcal costae; (c) Fold costae; (d)-(h) Profiles and anterior views of specimens illustrated in Plate 8.**

Material: 10 isolated and more or less complete valves and numerous fragments, somewhat abraded, in coarse sandy limestone. Two other specimens from the same locality are described separately as *Anthracospirifer* sp. aff. *A. milliganensis*.

Description: The holotype, CPC1588 (Pl. 8, fig. 2a, b), is a small ventral valve, moderately convex both transversely and longitudinally; it has a gentle sulcus which widens but does not greatly deepen to the front. The flanks are convex and the shoulders gently concave in ventral view. The umbo is prominent and incurved at the beak. The interarea is slightly concave and apsacline. The shell is widest at the hinge-line and has a rounded front margin of roughly semicircular outline. The anterior commissure is gently uniplicate. Each lateral slope carries 12 simple rounded costae which have slightly narrower rounded inter-troughs. The sulcus has 7 costae, which are arranged in simple unicostate pattern (Text-fig. 33a), but the detail is eroded in the posterior part. The surface is decorticated but traces of a fine concentric undulating ornament are preserved. The holotype is wider than long but is probably not fully mature. CPC1592 (Pl. 8, fig. 4; Pl. 27, fig. 6; Text-figs 33, 34), is a ventral valve rather narrower but not much shorter than the holotype; its sulcus is slightly more pronounced and the apical angle more acute but the ornament is similar.

TABLE 11: Dimensions of *Anthracospirifer* species (in cm)

Specimen Number	L	Lc	Lb	Whl	Wm	Ha	Aa	Dw	Wsf	W/L	Sulcus Fold	Costae on each flank
Anthracospirifer milliganensis sp. nov.												
CPC1588	1.90	2.65		2.35	2.35	0.40	130°	.30	.65	1.23	7	12
CPS1589			2.11	2.45	2.50						6	10-11+
CPS1591	2.25	2.85		2.30e	2.30e		140°e		.90	1.02	8	11
CPC1592	1.70			1.85	1.85			.70			7	—
F17913	1.70				1.90e							12
Anthracospirifer sp. aff. *milliganensis*												
CPC1590			2.13	2.22	2.22							

The dorsal valve is represented by paratype CPC1589 (Pl. 8, figs 1, 6), which is slightly wider and longer than the holotype. The complete shell would have had length and width about equal. The valve is moderately convex longitudinally and has a fairly prominent umbo. The flanks are moderately convex with a slight concavity on the posterior lateral slopes. The fold is evenly convex and becomes higher at the front. The outline is rounded, with greatest width slightly in front of the hinge-line. The commissure is gently uniplicate. The flanks have 10 or 11 simple costae and the fold has 6 costae (Text-fig. 33c). The intercostal grooves bordering the fold are a little larger than the others. The dorsal fold can be a little more elevated: F17913 for example has 12 lateral costae.

Sections of two ventral valves are illustrated in Text-figures 34 and 35. They show a variation in the divergence and the length of the dental plates,

which are nearly parallel in Figure 34, divergent and longer in Figure 35. The core of the dental plates is the thin delicate initial dental plate, of 'prismotest', which can be traced into the outermost secondary layers of the interarea. These outer layers have denticular corrugations; the primary layer is missing as a result of erosion. In both sections the dental plates are thickened in the umbonal region by shell layers which are now coarsely crystallized but which show traces of their original lamination. The 'prismotest' also lines the delthyrial cavity (Text-figs 34h, 35h) and traces of its earlier position before shell thickenings are seen in Text-figure 34f, g. A small delthyrial plate is formed by contact of the inner thickenings of the dental plates (Text-figs 34g, 35f). The dental plates of CPC1592 are short, disappearing from the sections at 0.14 cm from the umbo. They are longer in CPC1591 (Text-fig. 35), disappearing at 0.38 cm. Comparable variability in length and divergence is displayed by a number of much abraded youthful ventral valves exposed on a slab of rock. The dental plates, as seen in dorsal view, range in divergence from 10° to 30° and in length from 0.4 to 0.8 cm.

The dorsal internal structures were not ascertained. The surface ornament is too worn to confirm the presence of striae.

Discussion: *Anthracospirifer milliganensis* sp. nov. appears to be allied to *Spirifer bisulcatus* Sowerby and related species from Britain, Belgium, and Russia. In form it agrees with the type of *S. bisulcatus* as illustrated by Davidson (1857, pl. 6, figs 6-9), but has fewer costae and is smaller. Demanet (1938, pl. 9, figs 1-3) illustrated specimens of *Spirifer bisulcatus oystermouthensis*

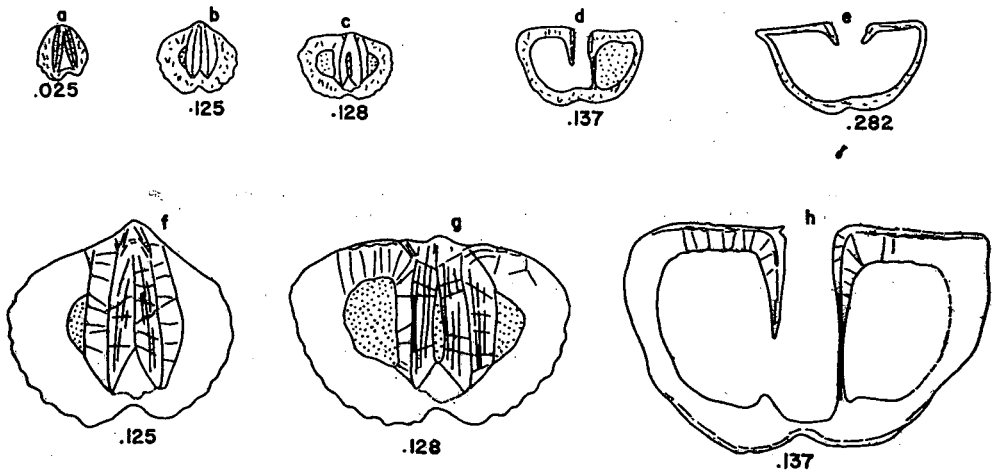

Fig. 34. *A. milliganensis*. **CPC1592, a ventral valve. Transverse sections. The sections show the subparallel dental plates, thin initial dental plates, and trace of the initial valve floor (probably muscle area). A coarse calcite crystal of the thickened dental plates and of the umbonal cavity are shown diagrammatically. Note the trace of lamination parallel to initial dental plate and simulated 'wedging in' of dental plate on floor of valve. (a)-(e), x1.5; (f)-(h), x4.5.**

Vaughan from the late Visean (V3c) of Belgium. These are very similar to *A. milliganensis* and only slightly larger. The specimens of *S. bisulcatus trigonaliformis* Demanet (1938, pl. 9, fig. 5) are quite similar to the dorsal valve described here as *A.* sp. aff. *milliganensis*. Demanet (1941) described a specimen of *S. bisulcatus* from the Upper Namurian Assise d'Andenne, which is generally similar to, though about 1½ times as large as *A. milliganensis*. In both Britain and Belgium *A. bisulcatus* is characteristically late Visean to Namurian in age. The internal structures of the British and Belgium specimens appear not to have been illustrated. However, George (1927b, p. 110) stated that the dental plates of *S. bisulcatus* were well developed, but less so than those of *S. striatus*. Reed (1948, p. 457) stated that the dental plates were like those of *Eochoristites* Chu—short and more or less parallel.

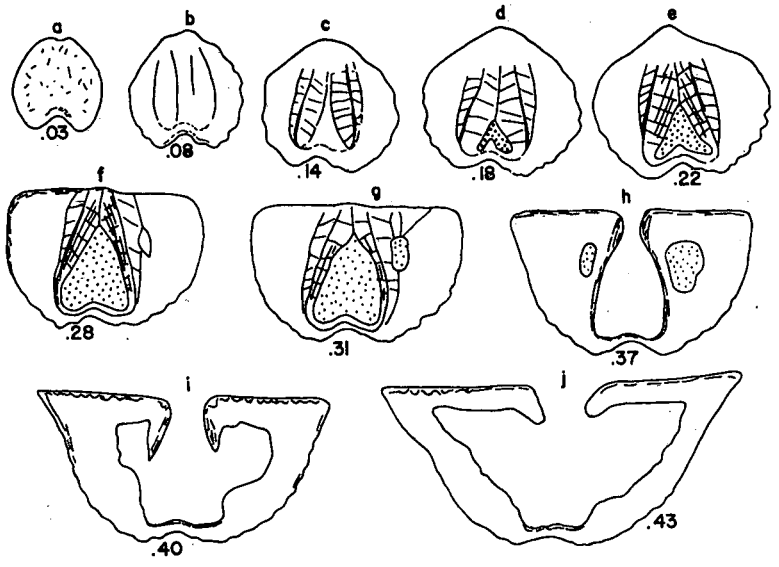

Fig. 35. *A. milliganensis.* **CPC1591, a ventral valve. Transverse sections. Sections (c)-(e) incomplete. Dental plates longer and more divergent than in Fig. 34.**

S. bisulcatus has a very lengthy bibliography of occurrences in Western Europe, Russia, and Asia. Demanet (1938, p. 88) and Muir-Wood (1948) list many of these. The great majority are too poorly illustrated to confirm the identity of the species.

Species allied to *S. bisulcatus,* from the Visean of the Moscow Basin, were well illustrated by Semichatova (1941). Of these *S. parabisulcatus* Semichatova (1941, pl. 3, pl. 10, figs 2-5 and pl. 11, figs 1-4), from the late Visean Tarus and Steshev beds, appears to be closest to *A. milliganensis,* though somewhat larger and with a tendency to mucronation. The dental plates vary from parallelism to moderate divergence, as in *A. milliganensis.*

Of North American species, *S. nox* Bell, 1929, from the Upper Windsor of Nova Scotia is similar to *A. milliganensis* but with 9-10 simple lateral costae. Mississippian species such as *A. increbescens* (Hall) and *A. curvilateralis* (Easton) tend to be larger and mucronate.

A. milliganensis is readily distinguished from the other West Australian spiriferid species by its costation, form and internal structure. The nearest is *Unispirifer septimus* sp. nov., which is larger, relatively wider, with gentle sulcus and more numerous costae and with longer, stouter, and more divergent dental plates. *Unispirifer* sp. cf. *U. septimus* is also larger, and some individuals have bifurcated lateral costae.

Geological Age: Late Visean to possibly Namurian.

Occurrence: All specimens: CPC1588-92, F17912, F21330-77 from one locality, exact position uncertain, in the Milligans Hills, about 5.5 miles bearing 10° from Mount Septimus, Bonaparte Gulf Basin. Burvill Beds.

ANTHRACOSPIRIFER sp. aff. A. MILLIGANENSIS sp. nov.

(Pl. 8, fig. 3)

The specimen CPC1590 illustrated in Plate 8, figure 3, displays features which may warrant its separation from *A. milliganensis* sp. nov. It is slightly narrower than the paratype CPC1589, measuring 2.25 cm wide and 2.15 cm long. In outline it is more triangular and the fold is elevated and is narrower. This difference in shape may result partly from some lateral compression. Five costae can be distinguished on the fold and 13 on each flank. The costae appear to be slightly more rounded than in CPC1589. The surface is rather abraded.

One other specimen, F17911, also has a keeled fold, which is however wider and less elevated than in CPC1590. It shows signs of lateral crushing and is intermediate in width and elevation of the fold between the two specimens CPC1589 and CPC1590. It appears probable that *A. milliganensis* is a somewhat variable small form with variability in both external and internal features.

The outline of CPC1589 approximates more or less to species like *Spirifer trigonalis* (Martin) and *Spirifer bisulcatus* var. *trigonaliformis* Demanet.

SPIRIFERIDAE gen. et sp. nov.

cf. 'SPIRIFER' DUPLICICOSTUS Phillips

(Pl. 8, figs 7, 9a, b, 10, 11; Pl. 29, fig. 8; Text-figs 36, 37)

Material: Five more or less complete separated valves and numerous fragments, and one internal mould of a ventral valve. All in fine to medium-grained calcareous sandstone.

Description: CPC1594 (Pl. 8, fig. 9a, b) is a small somewhat crushed ventral valve which is moderately convex and has a rather gentle sulcus. The maximum width appears to be slightly in front of the hinge-line, but as the flanks are crushed this is not certain. The outline is roughly oval. The interarea is low and apsacline with a height of about 0.35 cm, and the beak is upturned. The delthyrium is small and about 0.35 cm wide in front. The interarea is fluted longitudinally.

TABLE 12: Dimensions of Spiriferidae gen. et sp. nov. cf. *'Spirifer' duplicicostus* Phillips (in cm)

Specimen Number	L	Lc	Lb	Whl	Wm	Ha	Aa	Dw	W/L	Sulcus Fold	Costae on each flank
CPC1593	2.15	2.50		2.70					1.25	7	13+
CPC1594	2.70	3.55		2.60	2.85	.35	122°	.35	1.25	8	17
CPC1598	2.05			2.85	2.90	.25	140°		1.40	7	17
CPC1599			2.35	2.80	3.3					6	17

The ornament consists of fine slightly uneven rounded costae, separated by rounded troughs of the same width and numbering 13 in the sulcus and 17 on each flank. Although the majority are simple, the ninth costa on the right bifurcates near the midlength and the third on the left bifurcates towards the front. The sulcus is of the simple unicostate pattern and is illustrated in Text-figure 36b. The marginal costae of the sulcus are slightly wider than their neighbours. A fine undulating concentric lamellose ornament is evident, but it is not certain whether fine striae are present or not, as the matrix is too coarse to preserve the finer details sufficiently. A very fine radial lineation, which can be seen in places, may merely result from the fortuitous arrangement of the calcite fibres of the outermost secondary shell layer. CPC1594 is similar in outline to *Anthracospirifer milliganensis* but differs in having a thin shell, finer costae which tend to bifurcate, and less convexity. The marginal costae of the sulcus are not differentiated as greatly from the others as in *A. milliganensis*.

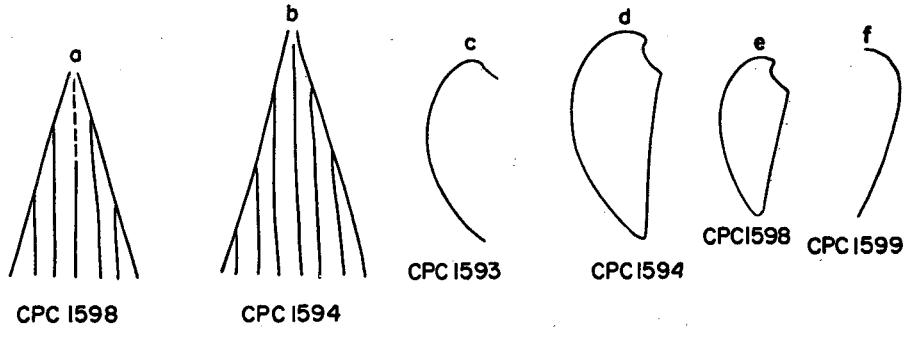

Fig. 36. cf. *S. duplicicostus*. (a), (b) sulcal costae; (c)-(f) profiles of specimens illustrated in Plate 8.

Several other incomplete ventral valves of similar size and surface features were collected with CPC1594. One of these, CPC1680, was sectioned and is illustrated in Text-figure 37a-j, and Plate 29, figure 8; the specimen is somewhat crushed. The dental plates are divergent and lie outside the sulcus; they are not greatly thickened by secondary shell deposit. An arched delthyrial plate is present at the delthyrial apex. The initial dental plates are readily distinguished and appear to be continuous with the delthyrial plate. The dental plates are still present in transverse section at 0.31 cm from the umbo. The thickenings of dental and delthyrial plates are now crystalline but preserve traces of their original lamination.

Two slightly wider specimens, a ventral and a dorsal valve from the same locality, have been included in the species. The ventral valve, CPC1598, is wider than CPC1594 and is slightly less convex in the umbonal region. Its ornamentation is similar and consists of 7 costae in the shallow sulcus and 17 on each flank; the laterals show a little bifurcation. The interarea is slightly lower than, but of similar inclination to, CPC1494; it is longitudinally fluted. The specimen is illustrated on Plate 8, figure 11. The other specimen, CPC1599, is a dorsal valve with a slightly elevated nearly flat fold, which has 6 costae. The intercostal groove marginal to the fold is wider than the others. The flanks carry about 17 occasionally bifurcating costae on each side. The maximum width appears to be slightly in front of the hinge-line. CPC1599 is illustrated in Plate 8, figure 10.

A specimen (CPC1593) from another nearby locality is also included in the species. This is an internal mould and is illustrated in Plate 8, figure 7, and

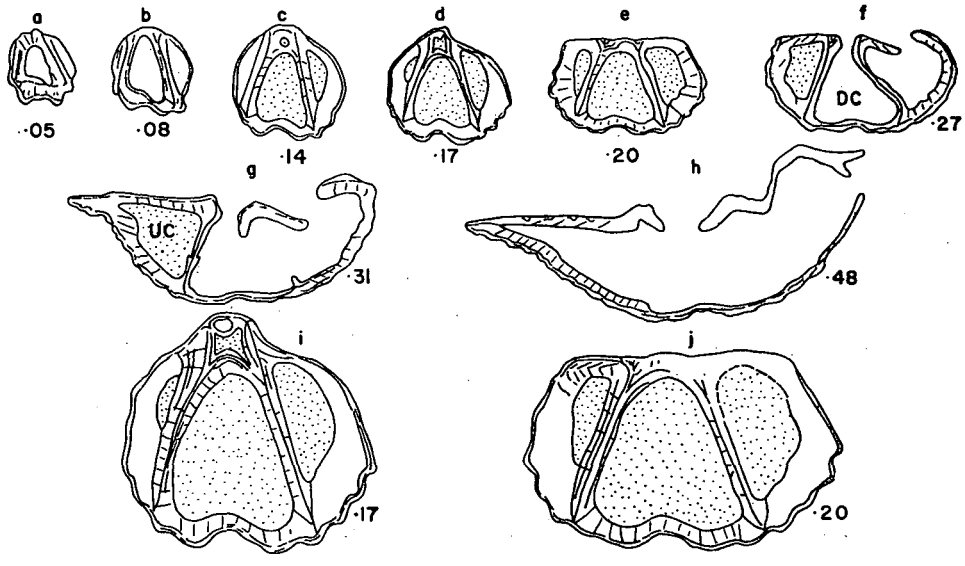

Fig. 37. cf. *S. duplicicostus*. CPC1680. Transverse sections. (a)-(h), x3.2; (i), (j), x6.2.

Text-figure 36c. Its dimensions are similar to those of CPC1594 and it was originally thin-shelled. The sulcus is rounded and deepens to the front and is moderately well pronounced. The flanks are gently convex. Thin and divergent dental plates are present. A few of the costae of the flanks bifurcate, mainly towards the front.

It is possible that more adequate collections will demonstrate that the two wider specimens should be separated specifically from the others. The common characters of similar ornament and thin shell suggest that there is only one species, which varies a little in its proportions.

Discussion: Unfortunately, the collections are insufficient to determine the range of variability of this species and I have left it unnamed. The combination of thin shell, bifurcating lateral costae, hinge-line shorter than the maximum width, and a well developed small delthyrial plate indicate an affinity with the British Visean species *Spirifer duplicicostus* Phillips and allied species. As illustrated by Davidson (1857), *S. duplicicostus* is transversely subrhomboidal when adult and almost circular when young. Phillips' type specimen (Phillips, 1836, pl. 10, fig. 1), is ovate in outline and the costae are similar to our species; the sulcus is not illustrated. Davidson did not describe the internal details, but Harrington & Leanza (1952, fig. 4) sectioned a specimen of the species from Britain, given to them by the British Museum. The illustrations display a ventral valve with diverging fairly thin dental plates and a well developed convex delthyrial plate persisting for about 5.5 mm from the apex. The dental plates and delthyrial plate are similar to those of CPC1680, illustrated in Text-figure 37. Semichatova (1942, 1943, 1948) has described species from the Visean of the Moscow Basin which she considered to be allied to *S. duplicicostus*. These include *Spirifer duplicicostus* var. *orientalis* Semichatova (equals *Spirifer orientalis* Semichatova, in Sarytcheva & Sokolskaya, 1952), from the late Visean Tarus beds of the Moscow Basin, and *Spirifer ustyensis* from the early Visean Toula beds. Both species have costation similar to our form and have thin shells and a delthyrial plate of similar type. *S. ustyensis* is about the same size as CPC1594, but the sulcus is a little more defined, a tongue is present, and the apical angle is more acute. *S. orientalis* is a smaller form than ours. Semichatova (1943) also described other small species of similar type from the same beds: *Spirifer lujkiensis* Semichatova and *Spirifer* aff. *furcatus* M'Coy. She figured (1943, fig. 3) a specimen of *S. duplicicostus* from England, which is similar in costation to CPC1594; the outline is also comparable, but it is a little wider. The specimen possessed a convex delthyrial plate. Demanet (1958, and also 1921-23) listed *Spirifer duplicicostus* from the Upper Tournaisian Tn 3a 'sous assise' and also from the early Visean, both of the 'facies waulsortien de Sosoye' in Belgium. De Koninck (1887) figured a number of rather idealized specimens of the species from near Visé, Stage III, which is equivalent to the upper Tournaisian Tn 3, according to Demanet (1958, p. 15). Our specimens resemble some of the illustrations in a general way, but the internal structures are not known.

Spirifer crassus de Koninck, a rather large species similar in outline and costation to *S. duplicicostus,* may also be allied. Harrington & Leanza (1952, fig. 3) illustrated sections of an example from England. It appears to have a delthyrial plate, but the delthyrial cavity is infilled with shelly material and the details of the structure are not clear.

It therefore appears likely that the small collection described represents a species allied to *'S.' duplicicostus* Phillips and related species. Harrington & Leanza (1952) referred *S. duplicicostus* to *Cyrtospirifer*. However, the combined features of short hinge-line, rather low interarea, thin shell, thin short dental plates, dichotomizing lateral costae, small convex delthyrial plate, and lack of pustulose micro-ornament distinguish *S. duplicicostus* from *Cyrtospirifer verneuili* (Murchison), type species of the genus. *S. duplicicostus* Phillips and our species appear to represent a new genus of the Spiriferidae, left unnamed in the absence of good comparative collections.

Geological Age: Late Visean to possibly Namurian.

Occurrence: CPC1593, locality WAA6 (Mines Administration Ltd), CPC1594, 1598, 1599, 1680, F17914, 5 locality WAA3 (Mines Administration Ltd), Milligans Hills, Bonaparte Gulf Basin. Burvill Beds.

Genus TRIGONOTRETA Koenig, 1825

Type species: *Trigonotreta stokesi* Koenig.

Generic features: Small to medium Spiriferidae; biconvex; wider than long but not strongly transverse; moderately high denticulate ventral interarea, large delthyrium; strong median fold and corresponding ventral sulcus; anterior commissure parasulcate; unicostate sulcus with three to seven costae; four to seven more or less angular plicae with six to fifteen superimposed costae on each lateral slope, lateral costae simple, bifurcated or more rarely trifurcated; dental plates with long dental flanges and short ventral adminicula; dorsal cardinalia as in *Spirifer*. Modified from Brown (1953a). Lower Permian.

Discussion: The varied history of *Trigonotreta* as a generic name was outlined by Brown (1953a, p. 57, 58). Brown described the type and other specimens of *T. stokesi* and re-established the genus. The type locality is probably on the south side of Mount Wellington, near Hobart, Tasmania, in beds of Lower Permian age. The holotype, illustrated from a plastotype by Brown (1953a, pl. 5, fig. 1), shows a trifurcating costa on the third plication left of the dorsal fold (verified by the writer in another plastotype). Such trifurcation is variably present in specimens of *T. stokesi* and also occurs in some individuals on the same or a neighbouring plication in *T. narsarhensis occidentalis* subsp. nov. Plica (plication) in the following description refers to a major lateral fold

of the shell. In enumerating both costae and plicae, I have included the fainter outer costae as plicae and also counted them as single costae (when undivided).

The micro-ornament of *T. stokesi* was not recorded by Brown; examination of possible topotypes shows them to be somewhat abraded. Other specimens from Permian limestone at Elephant Pass, near St Marys, Tasmania, are finely striate.

Brown (1953a, p. 58) discussed the distinctions of *Trigonotreta* from *Spirifer, Neospirifer,* and *Grantonia* Brown. Armstrong (1968) has cogently argued that *G. hobartensis* is synonymous with *T. stokesi,* so that *Grantonia* becomes a synonym of *Trigonotreta.* Even if the species are not identical it can be agreed that they are congeneric. *Trigonotreta* possibly descends from *Anthracospirifer.* However, no Upper Carboniferous species of *Anthracospirifer* have so far been described from Australia.

Trigonotreta is represented in Western Australia by the new subspecies *T. narsarhensis occidentalis,* described below, and by a distinctive species from the Wandagee Formation and upper Noonkanbah Formation which is to be described elsewhere. The eastern Australian species of the genus are in need of further study.

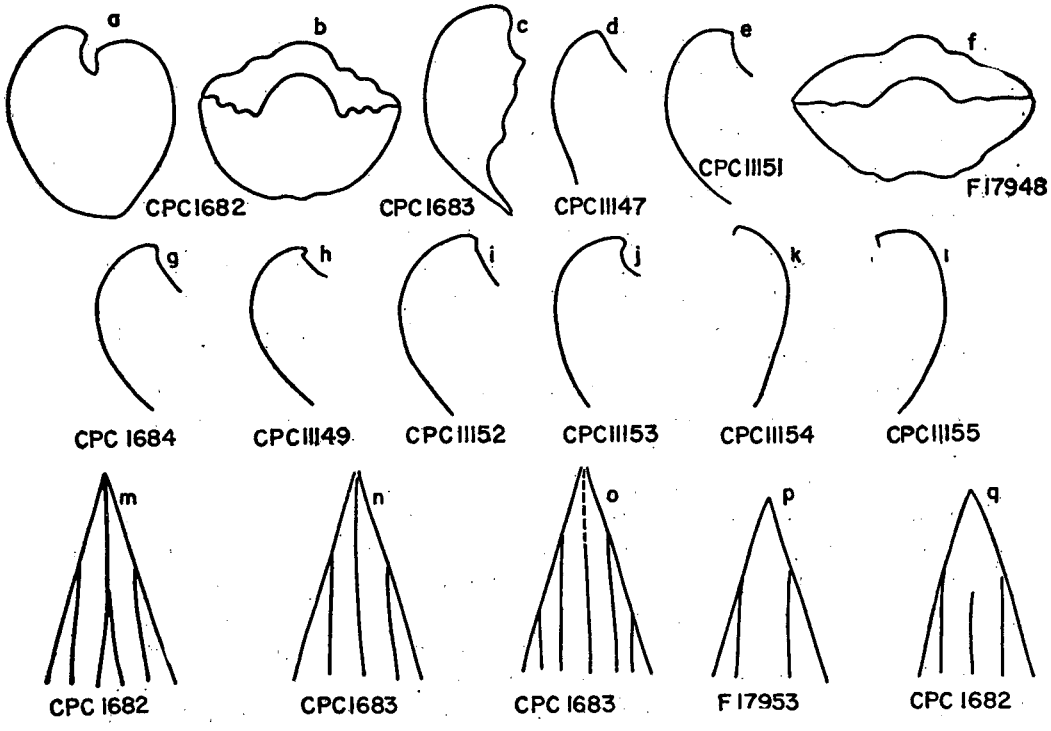

Fig. 38. *Trigonotreta narsarhensis occidentalis.* **(a)-(l) Profiles and anterior views of specimens illustrated in Plate 19 (except (f); (m)-(o) sulcal costae; (p), (q) fold costae.**

TABLE 13: Dimensions of *Trigonotreta narsarhensis* (Reed) *occidentalis* susbsp. nov. (in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	Ha	Aa	Da	Dw	Wst	W/L	T	Costae		Plications				Costae on each flank	
																Ventral		Dorsal			
														Sulcus	Fold	L.	R.	L.	R.	V	D
CPC1682	2.65	3.90	2.30	3.18	2.40	2.85	.45	115°	—	.70	1.15	1.07	2.25	6	5		6			9	9+
CPC1683	2.70	3.90			2.70	3.15	.60	117°	49°	.70	1.05	1.16		5		6	6			6	
CPC1684	2.3+				1.7e									5		6				7	
CPC11148	2.25	3.05			1.9e	2.60	.50	120°			0.85	1.15		5		6				8	
CPC11155					3.75e														6		6+
CPC11147					2.4e	3.05	.50			.70e	1.0			7		4+				7+	
CPC11152					2.25	2.85	.50	116°		.65				8		6	5			9	
CPC11149	1.95	2.55			1.90	2.5e	.35	125°	53°	.60	0.70	1.28		5		5+				5+	
CPC11153					2.95e		.45				1.0e					6-7				9	
CPC11154					2.40	3.5e									4				6		6
F17944	2.45	3.20			2.3e	2.9e	.50	123°	55°	.65		1.18		6		6				8	
F17945	3.0	3.75				2.95					1.05	.95		5	4	6				8	
F17946					2.80	3.25		117°	57°	.90	1.05			6		5				9	
F17947					2.95	3.30	.45	123°							5		6	6			10
F17948	2.40	3.0	2.20	2.7	2.55	3.00		123°			1.00	1.25	1.95	6	5	6	6	5	5	7	7
F17949	2.70	3.5	2.25	2.76	2.35	2.95		117°				1.09	1.6		4						
F17950			2.10			3.06e									5			6			8
F17951			2.25	2.93		2.95									5				6		6
F17952			2.20			4.0e									6?						
F17953			2.45	3.0		3.30									4				6		9

TRIGONOTRETA NARSARHENSIS (Reed) OCCIDENTALIS subsp. nov.

(Pl. 19, figs 1-6, 9-13; Text-figs 38-40)

1959 *Trigonotreta* sp. nov. *in* Dickins & Thomas, *Bur. Miner. Resour. Aust. Rep.* 39, 74.

Diagnosis: Medium-sized subspecies; slightiy wider than long, rarely equidimensional; maximum width at midlength; umbo prominent; 5-7 costae in sulcus; 5-7 plicae with 6-10 superimposed costae on each lateral slope. Somewhat larger and thicker shelled than *T. narsarhensis narsarhensis* (Reed).

Material: Over 100 specimens, shells and isolated valves.

Description: The subspecies is of small to moderate size; the holotype, CPC1682 (Pl. 19, fig. 1a-d), is 2.65 cm long and 2.85 wide, and the largest specimen, a dorsal valve, is about 4 cm wide. The outline is roughly oval, with the width generally greater than the length. The ventral valve is strongly convex longitudinally and transversely. It is marked by a pronounced rounded sulcus which deepens and widens to the front. Its floor and flanks are rounded. The umbo is prominent, with concave shoulders, and the apical angle varies from 115° to 125° (115° in the holotype). The interarea is apsacline to orthocline and gently concave; its contact with the ventral surface is obtuse. The height is moderate, 0.47 cm in the holotype and not exceeding 0.62 cm in other specimens. The beak is erect but not markedly incurved. The interarea is intersected by a wide delthyrium with angles ranging from 49° to 57°. It is edged by a prominent dental ridge which is at or above the level of the area, from which it is separated by a groove. The maximum width is at about the midlength and is considerably greater than the length of the hinge-line; hence, the wings and side margins are rounded. The front margin is rounded and is generally marked by a rounded tongue, considerably extended in some specimens.

The dorsal valve is strongly convex in most specimens but only moderately in others. It carries a fairly prominent rounded fold and the umbo is prominent. The area is orthocline and tapering, with a maximum height of about 2 mm. The holotype is somewhat crushed and the fold thus appears more prominent than in most specimens.

The surface ornament is distinctive. On each flank there are six (rarely seven) rounded plicae originating near the umbo; the troughs between them are narrower and more acute than the plicae themselves. In a few specimens, e.g. CPC1683 (Pl. 19, fig. 2) and CPC1684 (Pl. 19, fig. 3), the plicae are simple folds without any subordinate costae. In most specimens, however, the lateral plicae carry costae which bifurcate unevenly near the midlength of the valve. Numerous specimens have developed three costae on some of the plicae, towards the front margin. For example, CPC11152 (Pl. 19, figs 9, 10) has a trifurcated costa on the first extra-sinal plica, the second is bifurcating, and

the remainder are simple. Both flanks are not necessarily symmetrical in costal arrangement. CPC11147 (Pl. 19, fig. 4), is another individual with trifurcating costae on the first lateral plicae. The majority of individuals carry bifurcated lateral costae; roughly 10 percent have simple plicae and about the same are partly trifurcated. The costae tend to be angular in section. The number of costae is never large; the greatest number counted on a flank is ten. The sulcal costae number from 5 to 7, always with a median costa originating near the umbo; the median costa may be low and wide. Various patterns are shown in Text-figure 38m-o; the dorsal fold usually carries 4-5 costae. Fine close concentric undulating lamellae cover the surface, but are more or less abraded in nearly all the specimens. It is not clear whether the surface was radially striate, as all specimens are worn to some extent.

The interarea is marked by distinct growth-lines and less prominent longitudinal markings which are the trace of denticles; denticle flexures of the shell layers can be seen in section (Text-fig. 40i-l).

The internal features of the ventral valve are exposed in a few ventral valves. The obliquely set teeth are supported by dental flanges which are grooved on their delthyrial side. The ventral adminicula are short. Two examples are CPC11149 (Pl. 19, fig. 6a, b) and CPC11153 (Pl. 19, fig. 11). In CPC11153 the dental plate is about 0.55 cm long on the floor of the valve. The ventral muscles are elongate oval and not usually deeply impressed. In some specimens they are flanked by ridges, low extensions from the dental plates. The shell is not greatly thickened and is plicated on the inner surface. In CPC11153 it is about 0.7 mm thick at the front and not much more in the umbonal region. A few other shells are somewhat thicker.

The dorsal internals are not completely exposed. The longitudinal diductor platelets are not elevated. They are flanked by divergent recurved socket plates of the usual *Spirifer* type (Pl. 19, figs 12, 13).

Internal details are shown in a couple of serial sections (Text-figs 39, 40). In Figure 39a, b, a small delthyrial platform has developed as a result of shell thickening. The dental flanges are in contact with the short ventral adminicula only in the umbonal region. Text-figure 40 shows sections of a more complete specimen. The crural lamella is curiously enveloped by a fold of the socket plate in Figure 40m, suggesting a discrete origin. The spiralium has 13 volutions and there is no jugum. The inner secondary (prismatic) shell layers of Figure 40m and n are coarsely crystalline, and they are more irregularly crystalline umbonally. The outer secondary layers are laminate in all sections. The primary layer has not been preserved. The initial position of the 'prismotest' lining of the delthyrial cavity can be distinguished as a denser layer in Text-figure 40c-h. This denser layer marks the earlier position of muscle attachment because similar laminae are present on the floor of the valve in Text-figure 40j, k, l, m.

Discussion: The Lyons Group specimens are evidently closely allied to *T. narsarhensis* (Reed) from the Umaria beds of India. A small topotype collection made by Professor S. W. Carey and Dr F. Ahmad was available for comparison. The Indian specimens agree in form and type of costation, including the range of variability, but are smaller and more delicate. Two ventral valves, CPC11150 and CPC11151 (the largest specimen), are illustrated in Plate 19, figures 7 and 8a, b. The ventral internal structures of the Umaria and Lyons Group specimens are similar. Reed (1928) recorded the dimensions of only one shell, which was 21 mm wide and 17 cm long. He noted that the surface was finely radially striate, a feature not preserved in the new material. The greater size of the Australian specimens may be of environmental origin. Most Umaria brachiopods are thin-shelled and small. Reed distinguished some of the smaller and less plicate individuals as a variety. All the material available, however, can be regarded as one species.

On the basis of greater size, thicker shell wall, and geographic separation, the Lyons Group specimens are distinguished as a new subspecies. The Umaria topotype specimens can be distinguished as *Trigonotreta narsarhensis narsarhensis* (Reed). Another small species, *Spirifer hesdoensis* Sahni & Dutt from Manendragarh, Central India, also belongs in *Trigonotreta*. It appears to be wider and with more numerous (but simple) costae than *T. narsarhensis*. *T. stokesi* Koenig, from Tasmania, is much larger and stouter, more transverse, and generally with stronger and more numerous costae. Other Australian representatives are in need of study.

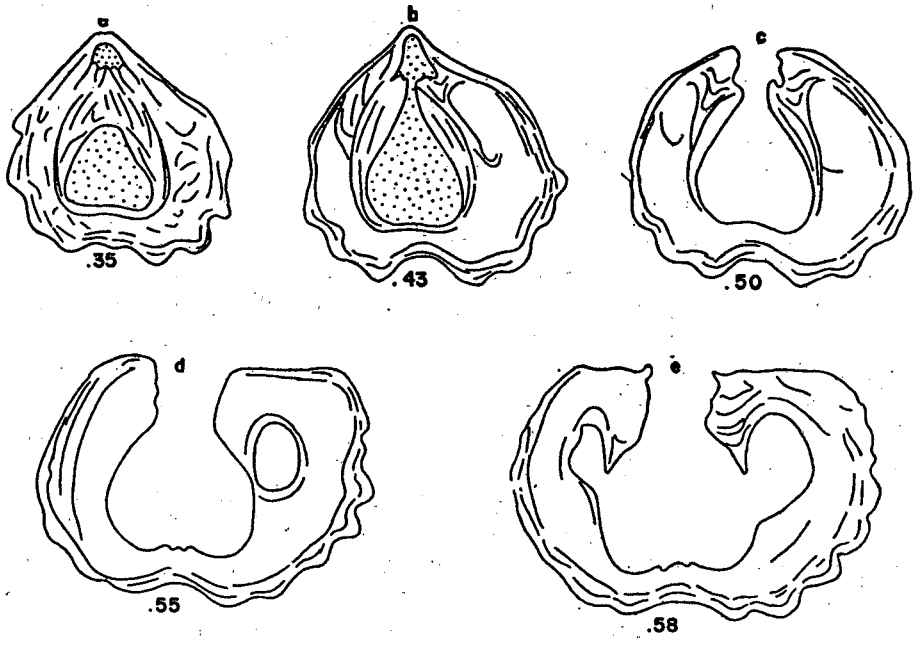

Fig. 39. *T. narsarhensis occidentalis*. **CPC6136, a ventral valve. Transverse sections, x5.3.**

Reed (1928, p. 381) commented on the resemblance of *T. narsarhensis* to *Spirifer middlemissi* Diener from the *Fenestella* Shales of Kashmir. *S. middlemissi* is inadequately known, from crushed isolated valves, but is possibly referable to *Trigonotreta,* as may be also *S. varuna* Diener and the isolated specimen which Diener (1915, p. 40) identified as *Spirifer trigonalis.* All are inadequate for comparison. The specimens from the Agglomeratic Slate referred by Bion (1928, p. 31) to *Spirifer stokesi* (Koenig) are multicostate and incorrectly identified; they are not referable to *Trigonotreta.*

Geological Age: Sakmarian.

Occurrence: All occurrences are from the upper part of the Lyons Group from a measured section. ML106 is about 3 miles bearing 45° from Round Hill Well and 1 mile west of Kialiwibri Creek crossing, Winning station, the exact stratigraphical level is uncertain. ML107 is 100 feet west of ML106, i.e. slightly higher stratigraphically. M109 is 410 feet west of ML106, higher still. T27 is the same bed as ML109 but in a slightly different position.

CPC1682, 11148-54, 6135, 36, F17944, 45, 47, 48, 53 are from ML107; CPC1683, 4, F17946, 50, 51 are from ML109; CPC11147, 11155 are from T27; F17949, 52 are from ML106.

Genus ECTOCHORISTITES Campbell, 1957

Type species: *Ectochoristites wattsi* Campbell, 1957.

Generic features: Medium-sized, subequally biconvex Spiriferidae, length generally exceeds width, maximum width about equal to or slightly greater than hinge-line; interarea truncated in maturity with denticular grooves; flanks, sulcus and fold multicostate; sulcus duplicostate and not sharply defined, commonly with linguiform extension; moderately divergent dental plates (short in type species); short dorsal adminicula. Carboniferous (Tournaisian to Namurian).

Discussion: The features listed are derived mainly from Campbell's description of the type species. He stressed the shortness of the dental plates, which show a flexure at the junction of dental flange and adminiculum; but he stated that these were not independent components. The costae of *E. wattsi* are rounded and striae were not recorded. Three other genera, *Choristites* Fischer, *Eochoristites* Chu, and *Palaeochoristites* Sokolskaya, are of similar elongate form, but differ in costation and internal structures. *Choristites,* which is mainly of Namurian to Permian age, differs from *Ectochoristites* in having long nearly parallel dental plates which are thin in front and which, in the type species, intersect the muscle field, Ivanov & Ivanova (1937) stressed this feature in *C. mosquensis* Fischer, but their figure of *C. sowerbyi* Fischer (pl. 8, fig. 3C) shows somewhat divergent dental plates flanking the muscle field. *Choristites* has striate costae

which are flatter than those of *E. wattsi*. It lacks dorsal adminicula. *Eochoristites*, of Tournaisian age, has many fewer costae than *Ectochoristites* and long dorsal adminicula. *Palaeochoristites*, also Tournaisian, has long dental plates and long dorsal adminicula. Another elongate spiriferid genus is *Globiella* Tachibana, 1963, type species *Spirifer* (*Martiniopsis?*) *nagasakaensis* Tachibana (1956) from the very Early Carboniferous of the Kitakami region of Japan. The monotypic species has obscure sulcus and slight fold, elongate slightly divergent dental plates, and short dorsal adminicula. However, it is reported to have costate dorsal valve but smooth ventral valve. The illustrations suggest that the specimens may be abraded.

Crickmay (1952) referred two species from the late Devonian to early Carboniferous of Alberta, *C. protistus* and *C. glennfoxi*, to *Choristites*. They have long and slightly divergent dental plates, but the costae are rounded and the dorsal structures were not recorded. They probably do not belong to *Choristites*, but may perhaps belong to one of the other genera named above.

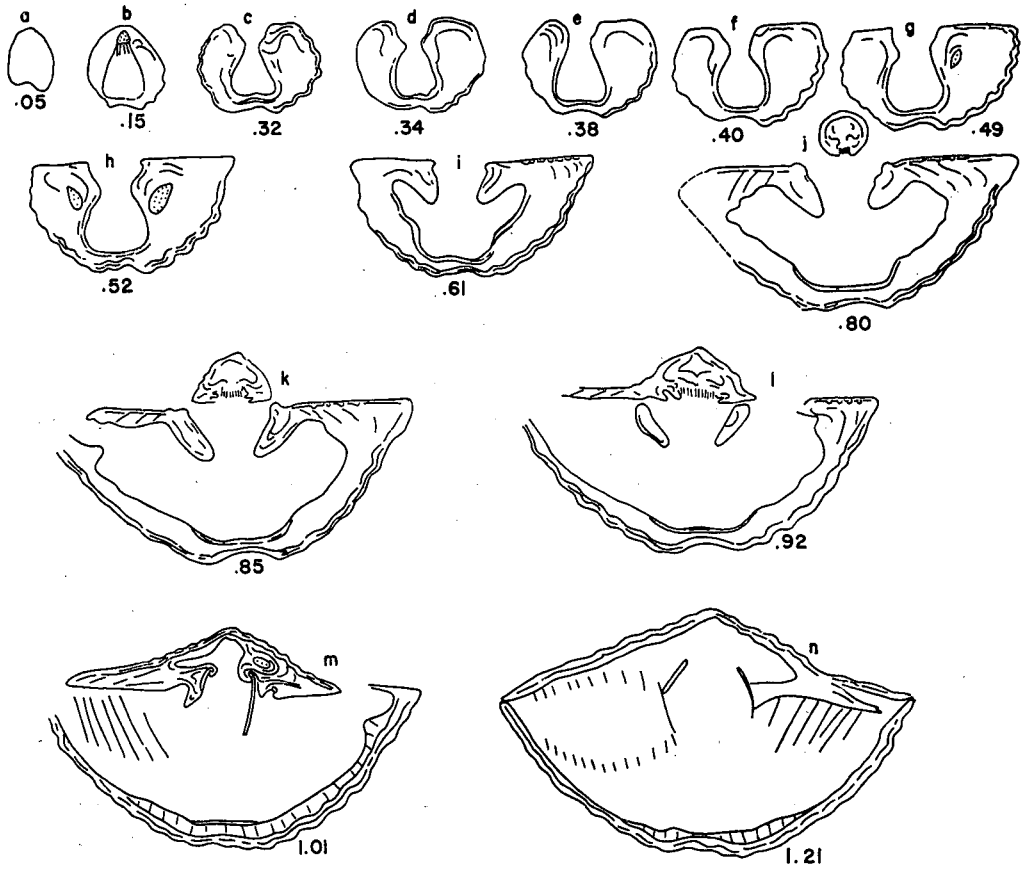

Fig. 40. *T. narsarhensis occidentalis*. **CPC6135. Slightly abraded shells. Transverse sections. Dorsal valve appears in (j)-(n), x1.5.**

Assignment of *arenatus* to *Ectochoristites* is provisional because it has rather longer dental plates and flatter costae than *E. wattsi;* also the details of the sulcal costae could not be determined. The specimens are fairly numerous but are coarsely silicified. They are varied in form, and some individuals strongly resemble species of *Choristites* but without the long parallel dental plates of that genus. For descriptive purposes, the wider specimens are described separately as *Ectochoristites? arenatus* sp. nov. *latus* var. nov.

Three incompletely preserved specimens of another species are also provisionally assigned to *Ectochoristites*. It is possible that better preserved specimens of both these species will warrant the erection of a new genus.

ECTOCHORISTITES? ARENATUS sp. nov.

(Pl. 7, figs 1-8, 10, 11; Text-figs 41, 42)

Summary of features: Medium-sized species; width equal to or more than length, rarely less; maximum width at or near hinge-line; umbo moderately prominent, ventral interarea, triangular to truncated, denticulate; sulcus gentle to slight, fold ditto; commissure gently to strongly uniplicate; costae numerous and flattened; dental plates moderately long and divergent at 19° to 37°. The wider specimens are described separately as var. *latus*.

Material: Forty specimens, all coarsely silicified and incomplete.

Description: The holotype, CPC1606 (Pl. 7, fig. 2, Text-fig. 41a, b), is relatively elongate, with the width and length both 2.85 cm. It and other shells are strongly convex transversely and longitudinally, with the greater convexity near the umbo. The sulcus is very slightly differentiated from the flanks, a little more near the umbo. The fold is very gentle but a little more accentuated than the sulcus, particular in the smaller specimens (CPC1608, Pl. 7, fig. 4, and CPC1612, Pl. 7, fig. 3a). In these and some other specimens, including the holotype, the intercostal groove bounding the sulcus is more pronounced than the others.

In ventral view, the outline is roughly ovate, with the maximum width at or slightly in front of the hinge-line. Length is about equal to or, less commonly, more than width. The umbo is prominent and rounded, with very slightly concave shoulders, and the beak is overturned. The front margin is rounded, but a few specimens display a small rounded tongue at the front of the sulcus. The dorsal valve has a prominent umbo and tends to flatten laterally on the outer flanks near the hinge-line. The front commissure is slightly to moderately uniplicate.

TABLE 14: Dimensions of species of *Ectochoristites?* (in cm)

Specimen Number	L	Lc	Lb	Whl	Wm	T	Ha	Aa	Da	Dw	Wff	W/L	Costae Fold	Costae on each flank
Ectochoristites? arenatus sp. nov.														
CPC1606	2.85		2.30	2.85	2.85	2.00	c.55	126°	58°	.52	.90	1.99		
CPC1607	2.80		2.30		2.40		c.5+	111°				.85		
CPC1608			1.75	1.85	2.05									
CPC1609			3.40	3.35	3.50						1.40			
			2.65	3.0	3.00									
CPC1610			3.00	3.50	3.50									
CPC1611	4.10				4.0+							.97		
CPC1612			1.95	2.05	2.30						.83			
CPC1613			1.8e	1.95	2.30									
CPC1614									51°					
CPC1615									50°					
F17920			2.55	2.40e	2.80e	2.10								
F17921			2.35		2.45	1.96								
F17922	2.75		2.15		2.40			110°				.87		
F17923	3.05+			3.2e	3.2e			126°e				1.04		
Ectochoristites? arenatus latus var. nov.														
CPC1616	3.25+		2.90		3.70			133°				1.13		
CPC1617			3.20		4.10	2.30					1.50			
CPC1621			2.55		3.45	1.80								
F17925			2.95	3.90	4.20									
F17926			2.50	3.50	3.65	1.65								
F17927			2.60	3.25	3.40	1.80								
F17928	3.30+				4.38e									
F17929	2.90		2.40		3.10	1.70								
F17930	4.25e				4.30									
Ectochoristites? sp. nov.														
CPC1595			3.05	3.70	3.90								9	23+
CPC1596	3.75	6.0		3.10	3.40		.44	155°		.65		.90		

The ventral interarea is apsacline to orthocline and is of moderate height (about 0.5 cm) and longitudinally fluted. The interarea of the holotype, CPC1606, is truncated but is somewhat worn; other mature specimens are truncated. The delthyrial angle varies from 50°-58° in the few measurable specimens. Some individuals were slightly mucronate.

The flanks, fold, and sulcus carry fine flat radial costae, 5-6 in 5 mm at the front of the flanks near fold and sulcus; and as far as can be seen they are simple. Details of the arrangement in fold and sulcus could not be determined, but they are of the same size as those on the flanks and are evidently numerous. The intercostal grooves are shallow and narrower than the costae; though, as noted above, the groove flanking the fold is a little more pronounced. Concentric crenulated growth-lines can be discerned in a few specimens. CPC1609 (Pl. 8, fig. 5), shows a prominent concentric step-like lamella towards the front. Preservation is too poor to show whether the surface is finely striate or not.

No shell could be satisfactorily sectioned, as silicification is incomplete. Several specimens display some of the internal features. CPC1615 (Pl. 7, fig. 8), presumably a youthful specimen, has thin blade-like dental plates which diverge at about 26° from the umbo tip. Apically they are in contact and somewhat thickened. The plates are about 1 cm long. As this specimen is only 1.4 cm

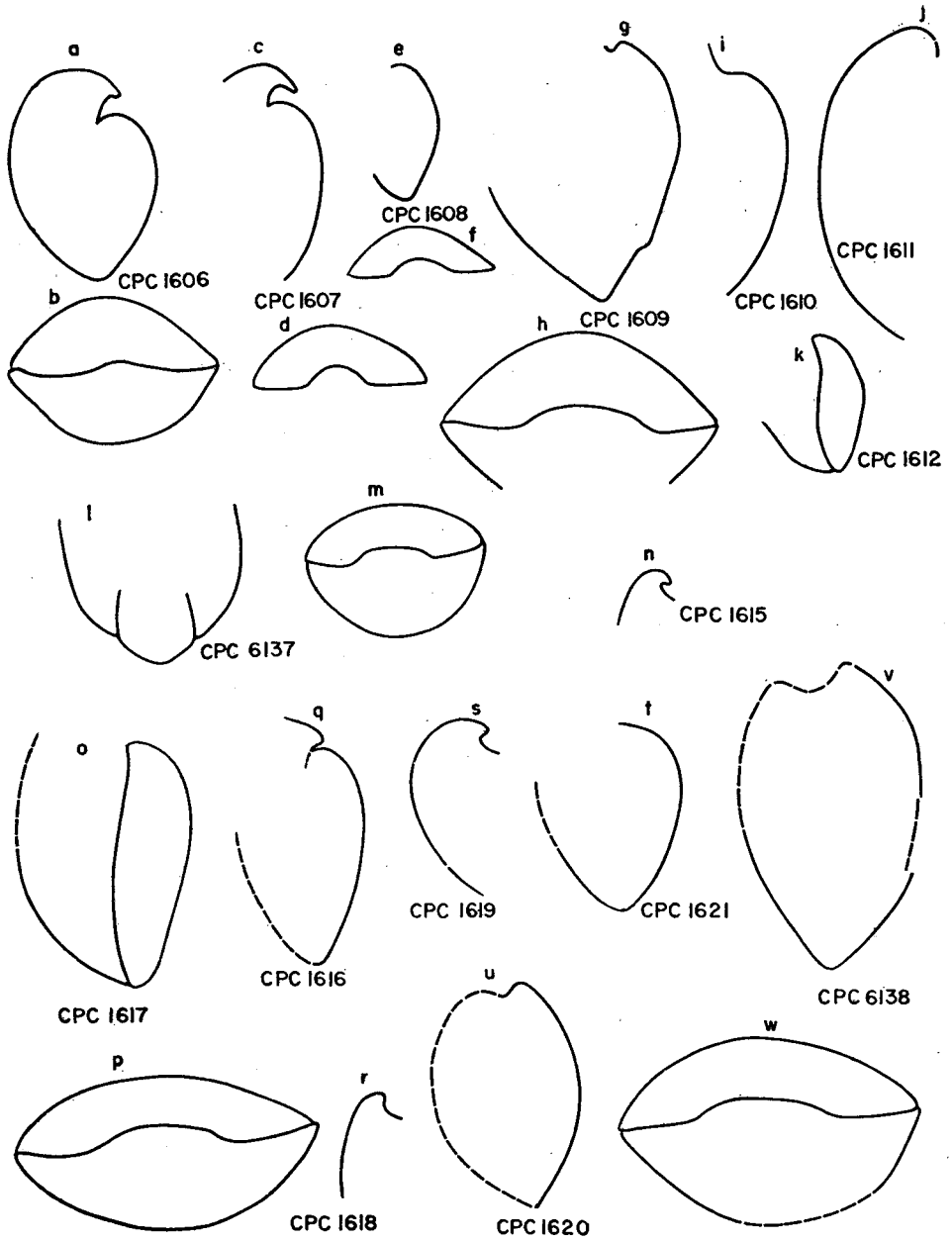

Fig. 41. *Ectochoristites? arenatus.* **Profiles of specimens illustrated in Plate 7. (o)-(w) are** *E? arenatus latus.* **Natural size.**

wide at the hinge-line, it is evidently smaller and more youthful than the holotype (which is 2.85 cm long), and is probably shorter. The plates would therefore have exceeded one third of the shell length of the specimen.

Another specimen, CPC1614 (Pl. 7, fig. 11), also youthful, has long dental plates, diverging at about 19°. The inner and outer sides of the plates have been thickened by shelly deposit and the inner thickenings have coalesced, but they leave a median groove. The plates appear to flank the well impressed muscle scar, but the median thickenings extend on to the scar. CPC1613 (Pl. 7, fig. 3b) shows the plates in transverse section just posterior to the hinge-line. The plates are not thickened and are curved, with their bases on the valve floor converging inwards and becoming parallel towards the dorsal side. An internal mould F17924 of about the same dimensions as the holotype possesses plates similar to those in CPC1615, but a little more thickened. They diverge at about 30° and flank an oval muscle scar 0.9 cm long and 0.8 cm wide. Generally dental plates are much shorter in proportion to shell length in the larger specimens.

The dorsal internal features are only partly seen in a couple of specimens. In CPC1612 (Pl. 7, fig. 10) the dorsal area is low (0.13 cm) and tapering. The notothyrium is widely divergent, the cardinal process is low, and the socket plates and groove diverge. The spiralium with 11 volutions on one side is faintly discernible in this specimen. CPC1604 (Pl. 9, fig. 5a, b) shows short dorsal adminicula supporting the socket plates. Some specimens collected by Mr E. P. Utting from Spirit Hill, probably belonging to this species, show short subparallel dorsal adminicula on each side of the cardinal process supporting the socket plates. A slight median septum is also present.

ECTOCHORISTITES? ARENATUS LATUS var. nov.

(Pl. 7, figs 9, 12-16; Text-figs 41, 42)

Summary of features: Similiar to *E? arenatus* but wider, tend to have less prominent umbones and wider apical angle; fold and sulcus scarcely differentiated from the lateral slopes; gently uniplicate commissure.

Material: Twenty specimens, topotypic with *E. arenatus,* all coarsely silicified and incomplete.

Description: No complete ventral valve is available, but the outline is rounded on sides and front. The apical angle is wide, 133° in CPC1619 (Pl. 7, fig. 9). Both valves are convex longitudinally and transversely. The ventral valve has a moderately prominent umbo and gently concave shoulders. The sulcus can scarcely be differentiated from the flanks and the fold is only slightly more distinct.

The interarea is flat, apsacline and upturned at the beak, with a height of only 0.40 cm in the one measurable specimen, CPC1618 (Pl. 7, fig. 12). The delthyrial angle in this specimen is about 52°. The dorsal umbo is moderately prominent in some specimens and only slight in others. The outer dorsal flanks in some specimens flatten slightly near the hinge-line.

As no specimens are complete, the shell outline is known only as a composite of several specimens. The width is a little more than the length and the maximum is at, or immediately in front of, the hinge-line. The front margin is smoothly rounded in outline and no tongue is developed; the commissure is gently uniplicate to nearly rectimarginate in a few specimens.

The dental plates, revealed in a few specimens, are similar to those of *E? arenatus*. They are prominent (1 cm long) and moderately divergent at about 28° in CPC1618 (Pl. 7, fig. 12). In CPC1619 (Pl. 7, fig. 9) which is a somewhat abraded ventral valve, the plates are about 1.4 cm long and diverge at about 37°, and flank the depressed oval muscle scar. The internal thickening of the plates is more developed than in CPC1618. CPC1619 is not quite as wide as CPC1616, an incomplete and somewhat crushed shell illustrated in Plate 7, figure 15, which is about 3.20 cm long. On the assumption that CPC1616 has plates at least as long as in CPC1619, the ratio of plate length to shell length is about 2:5. However, incomplete larger shells, such as CPC1617 (Pl. 7, fig. 13), suggest that the plates are relatively shorter than that. The ventral muscle scar is rather small and elongate-oval; in the largest specimen, F17930, it is about 1.4 cm long and 1 cm wide. The dorsal internal features are poorly known. Traces of the spiralium can be seen in the internal mould CPC1620. It appears to be of normal spiriferid type and occupies much of the visceral region of the animal.

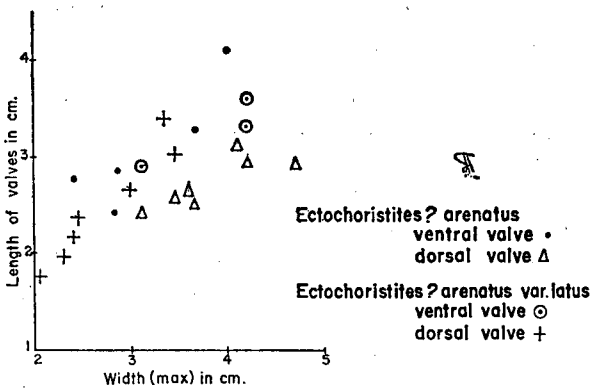

Fig. 42. Length/width ratios of *E? arenatus* **and** *E? arenatus latus.*

The surface ornament is similar to that in *E? arenatus*. In some of the larger specimens, the costae are slightly coarser, numbering from 4½ to 5 in 5 mm in the central part of the front margin. There is very little or no development of a deeper intercostal groove on the margin of the fold.

Discussion: The specimens near the type of *Ectochoristites? arenatus*, and those grouped as a variety *latus*, are here discussed together. Together they probably

represent one rather variable species. Certainly it seems unlikely that two distinct genera are represented. The difference in form may indicate dimorphism, but this can be no more than a suggestion until it is definitely established that they belong to one species. Vandercammen (1959b, p. 15) has demonstrated dimorphism (possibly sexual) in species of *Cyrtospirifer*. The specimens of var. *latus,* which are generally the larger and wider, appear to show some consistent differences from the others: they have less prominent umbones and the fold and sulcus are scarcely differentiated from the flanks.

In this latter character they differ only in degree from the specimens near the type, in which differentiation of fold and sulcus is rather slight. The internal features, as far as can be seen, are similar. Possibly in the larger specimens of var. *latus* the dental plates are not as long proportionately to length of shell as in the other group.

Ectochoristites? arenatus is distinguished from *E. wattsi* primarily on the length of its dental plates and on the flatness of the costae. The outline of *E. wattsi* and the typical *E? arenatus* are similar, and mature individuals have truncated areas. Most individuals of variety *latus* are too worn to show the shape of the area. The sulcal arrangement could not be determined in *E? arenatus,* but the costae are numerous in both species, though they appear to be more rounded in *E. wattsi,* which has a duplicostate sinal pattern.

The typical specimens of *E? arenatus* show a distinct resemblance in form and costation to *C. mosquensis* Fischer, as figured by Ivanov & Ivanova (1937, pl. 6). The umbo is not as prominent, but the main distinction lies in the dental plates, which are half or more of the shell length in *C. mosquensis,* are less divergent, and intersect the muscle field. From the illustrations, the differences appear to be of degree rather than of kind. The specimens of var. *latus* show more resemblance to *Choristites priscus* Eichwald, which is wide and has only a slight sulcus. In this species, the dental plates are long, but they appear to flank the muscle scar (Ivanov & Ivanova, 1937, pl. 4, fig. 3b). *C. mosquensis* and *C. priscus* are of Moscovian age.

The species *Globiella nagasakaensis* (Tachibana), shows some resemblance to *E? arenatus.* Tachibana (1956) illustrated internal moulds only and these resemble the elongate specimens of *E? arenatus.* Tachibana recorded that the ventral exterior was smooth, judging from external moulds: this may be an effect of poor preservation. Some of my specimens are so faintly ribbed as to be apparently smooth. The dorsal valve is said to have 4 to 7 low lateral plicae on the lateral slope and close concentric lines. Tachibana's species occurs in the lowest Carboniferous of Japan in the Kitakami Mountainland. It will be necessary to compare specimens to assess the relationship, but the two species may be congeneric.

Some Mississippian species resemble *Ectochoristites? arenatus* in general form. Thus *Spirifer maplensis* Weller, 1914, from the Kinderhook, is an elongate

multicostate form with low fold and slight sinus, but the internals are unknown. *Spirifer gregeri* Weller from the Chouteau Limestone has some similarities externally to the variety *latus*.

Geological Age: Lower Carboniferous—probably early Tournaisian.

Occurrence: All specimens, CPC1606-21, 6137, 6138; F17920-31, from locality BW5, Bonaparte Gulf Basin. Burt Range Formation.

This species is present in the limestone at Spirit Hill, and in the sandstone at Flapper Hill. It or an allied species occurs also in the Burt Range Formation in the type section area, northeast of Mount Septimus.

ECTOCHORISTITES? sp. nov.

(Pl. 8, figs 5a, b, 8; Text-figs 43, 44)

Material: An incomplete shell and a ventral valve in coarse sandy limestone and an incomplete dorsal valve in calcareous sandstone.

Description: The ventral valve, CPC1596 (Pl. 8, fig. 5a, Text-figs 43a-c, 44a), is 3.3 cm wide at its maximum width, which is both at the hinge-line and slightly in front of it. The length is 3.75 cm and the length of the median ventral curved surface is 6 cm. The valve is strongly convex in longitudinal profile and the umbo is prominent and overturned. The lateral flanks are convex and the sulcus is gentle, slightly more accentuated near the umbo, but very shallow in front. The interarea is somewhat eroded; it is apsacline and asymmetric and about 0.45 cm high. One side seems to be truncated and the other tapering. The delthyrium is about 0.65 cm wide in front. The outline is roughly elongate-ovate and the front margin is uniplicate, with a prominent tongue.

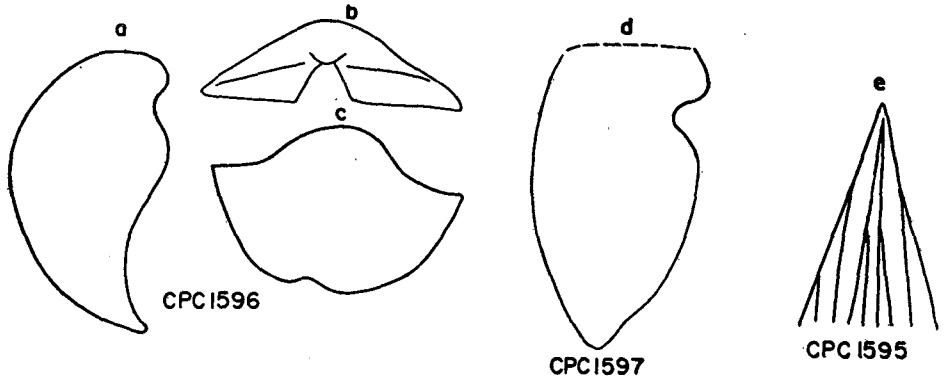

Fig. 43. *Ectochoristites?* **sp. nov. (a)-(c) profile, dorsal posterior, and front margin of ventral valve illustrated in Plate 8. (d) Profile of eroded ventral valve illustrated in Plate 8. (e) Fold costae.**

The surface is very much eroded and not much detail can be made out. It is entirely covered with rather fine costae which widen only slightly to the front and probably multiply by bifurcation; at least one of the costae on the right umbonal flank is bifurcated. At the umbo they are rounded and the troughs are of about the same width. At the front margin near the middle there are 5 costae in 0.5 cm.

Internally, CPC1596 is much thickened in the umbonal region. Polishing the umbonal surface revealed rather long dental plates, which diverge at about 20° longitudinally from the umbonal tip; a line from the tip to their front extension on the ventral floor measures about 1.4 cm.

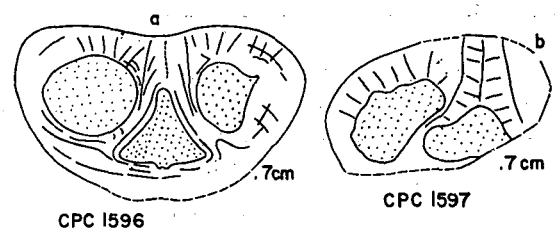

Fig. 44. *Ectochoristites?* **sp. nov. Transverse sections (a) CPC1596, an abraded ventral valve, at 0.7 cm from umbonal apex, x1.5. (b) CPC1597, a much abraded shell, at 0.7 cm from umbonal apex, x1.5.**

In a deeper transverse section (Text-fig. 43a), the dental plates are curved; and both dental lamellae and adminicula are present, fused by shell thickening.

Specimen CPC1597 (Pl. 8, fig. 5b; Text-figs 43d, 44b) was collected with CPC1596. It is an incomplete and abraded shell. The hinge-line is much worn but appears to be rather narrower than the maximum width, which is in front of it. The umbo overhangs the rather low interarea. The dorsal surface is gently convex laterally and transversely and carries a moderately prominent fold. The dorsal valve dimensions are at least 2.9 cm long and an estimated 3.8 cm wide, with the fold 1.2 cm wide in front. The surface is covered by fine costae, some of which bifurcate, and are the same size as in CPC1596.

The third specimen, CPC1595 (Pl. 8, fig. 8), was collected with the spiriferids referred to cf. *Spirifer duplicicostus* Phillips. It is associated with CPC1596 and 1597, because of its proportions and multicostation, but possibly it is not conspecific with them. It is a rather gently convex dorsal valve with the fold very low and widening to the front, where it is 1.45 cm wide. It is 3.05 cm long, 3.70 cm wide (estimated) at the hinge-line, and 3.90 cm wide at the maximum width, which is in front of the hinge-line. The left flank carries more than 23 fine costae, some of which are bifurcated. The fold carries 9 somewhat wider costae, arranged as in Text-figure 43e, and the marginal groove is wider than the intercostal grooves of the flanks.

Discussion: CPC1595 may not be conspecific with CPC1596 and 1597, but they have certain features in common and were all collected from about the same stratigraphical level. The collection is insufficient to describe the species completely. It differs from *E? arenatus* in having more rounded costae and

a more elevated fold. Both possess moderately divergent dental plates. In shape it appears to agree with the elongate individuals of *E? arenatus*. The long dental plates distinguish it from *E. wattsi* Campbell.

Geological Age: Visean to possibly Namurian.

Occurrence: CPC1595, locality WAA3 (Mines Administration Ltd), Milligans Hills, Bonaparte Gulf Basin. CPC1596, 1597, WAA4, a nearby locality. Burvill Beds.

Genus BRACHYTHYRIS M'Coy

Type species: *Spirifera ovalis* Phillips, 1836.

Generic features: The summary by Pitrat (1956, p. H707) is sufficient. Striae do not appear to have been recorded but fine concentric lines and lamellae are present.

Discussion: This widespread genus has been discussed by many authors, including George (1927), Nalivkin (1937), Sokolskaya (1941), Muir-Wood (1948), Sarytcheva & Sokolskaya (1952), Maxwell (1954), Simorin (1956), Ivanova (1959, 1960), Armstrong (1962), Roberts (1963), and Waterhouse (1968). The range according to Pitrat is 'U. Dev.? to L. Carb.'. However, Armstrong (1962) recorded that it ranges into the Morrowan in North America. Most references to Upper Carboniferous and Permian occurrences appear to be erroneous. Nevertheless Ivanova (1960) stated that it ranged into the Permian.

Two species are described below; both from the Septimus Limestone. Neither is well preserved, but *B. latecardinalis* sp. nov. shows the dorsal cardinalia, which have seldom been figured. They are similar to those of *Spirifer*. Another species of *Brachythyris* occurs at Spirit Hill.

BRACHYTHYRIS sp. cf. B. PECULIARIS (Shumard)

(Pl. 6, figs 4, 5)

Summary of features: Small species about as wide as long, maximum width at midlength; umbo prominent, with apical angle fairly high (91-107°); at least 5 flat costae on each ventral flank; very faint sulcal costae.

Material: Eight silicified ventral valves.

Description: The specimens are all small; CPC1584 (Pl. 6, fig. 4a-c), the largest, is only 1.80 cm long and about 1.75 cm wide, with a hinge-line of 1.0 cm. The valves are about as wide as long and have a short hinge-line. The

outline is rounded and the maximum width is at about the midlength. They are strongly convex, with greater convexity at the umbo, which is prominent and overturned at the beak. The apical angle varies from 91° to 107° and the shoulders are concave. A well defined rounded sulcus extends from the beak to the front margin; it broadens and deepens to the front. The interarea is small, apsacline, and triangular, only 0.15 cm high in CPC1584. It can scarcely be differentiated from the rounded lateral shoulders of the valve. It is intersected by a small delthyrium, which has an angle varying from 72° to 90°. In all the specimens, this is arched by a convex deltidium, which is evidently firmly attached to the delthyrial margin. The deltidium almost touches the overturned umbonal tip, and its front margin is concave. There was presumably an opening, in front of it, during life.

TABLE 15: Dimensions of species of *Brachythyris* (in cm)

Specimen Number	L	Lb	Whl	Wm	Ha	Aa	Da	Dw	Wsf	W/L	Costae Ventral L.	Costae Ventral R.
Brachythyris sp. cf. *B. peculiaris* (Shumard)												
CPC1583	1.20		0.80	1.15	0.15	91°	c85°			.95		5
CPC1584	1.80		1.0	1.75+	0.15	103°	c72°	c0.22		1.02	5	
F17906	1.75		1.35	1.80		103°				1.06		
F17907	1.20		0.80	1.20	0.10	107°	90°			1.00		5
F17908	0.95										5	
F17909	0.75											
Brachythyris latecardinalis sp. nov.												
CPC1585	2.55		2.65	3.0+	0.35	135°	70°		.8	1.13		8
CPC1586	2.60		2.50	3.15	0.25	120°	80°		.8	1.21	9	
	2.00		2.10	2.60							8	
CPC1587		1.6+										7 (dorsal)
CPC3869	2.40		2.65	3.15e	0.25	139°	77°		.95	1.31		7

The teeth are prominent and are strengthened inside by flanges which extend back towards the apex but do not reach the floor of the valve. They apparently converge near the apex of the delthyrium. The muscle scars are long and linear and not very deeply impressed. CPC1584 displays two linear grooves in the umbonal region and a single median groove further forward. CPC1583 (Pl. 6, figs 5a-c), a smaller valve, does not display the median anterior ridge. All the shells are thin, even in the umbonal region.

The surface ornament consists of at least five coarse lateral costae or plications on each side. Five can be detected beyond the one bounding the sulcus with a further apparently smooth outer area, but as the surface is abraded in all, there may have been more plications originally. The plications are wide and flat, broadening to the front and separated by much narrower shallow troughs. The shoulders in all specimens are apparently smooth. The plica bounding the sulcus is broader and more pronounced, and there are faint traces of sinal costae in CPC1584, but no details can be discerned.

The other six ventral valves have similar features to CPC1583, 1584. The surface is too poorly preserved to show the finer ornament in any of the specimens.

Discussion: I have assumed that the specimens available represent adequately the size range of the species. In the absence of the dorsal valve, which is necessary for adequate diagnosis, this species cannot be certainly determined. In its form and narrow hinge-line it resembles *Brachythyris ovalis* (Phillips), from the Visean of Britain, which attains a much greater size, as interpreted by Davidson. The illustrated type specimen (Phillips, 1836, pl. 10, fig. 5), is, however, only a little larger than our species.

The species is smaller and relatively shorter than *Brachythyris davidis* (Dun) from New South Wales and Queensland. A small species with similar proportions is *Brachythyris peculiaris* (Shumard), which is a characteristic species of the early Mississippian of North America. The fold is smooth or faintly furrowed, and hence the species is to be grouped with *B. ovalis*. Some individuals illustrated by Weller (1914) distinctly resemble our species; they have from 5 to 8 flat costae on each flank. Most, however, are more convex and with less prominent umbones. *S. peculiaris* is reported from the Chouteau Limestone of the Kinderhook by Weller. Branson et al. (1938) report it as very common in the Chouteau of the Lower Mississippian of Missouri. Armstrong (1962) described a small collection of the species from the Excabrosa Group of New Mexico. It is listed as a characteristic fossil of the *Spirifer missouriensis* zone of the Banffian Series of the Mississippian in Alberta by Harker & Raasch (1958). Somewhat similar small forms have been identified as *B. peculiaris* from Tournaisian deposits in USSR by various authors. Localities include the Moscow Basin (Sokolskaya, 1941), the Karagandian Basin (Simorin, 1956) and North-East Kazakhstan (Nalivkin, 1937).

Geological Age: Late Tournaisian to early Visean.

Occurrences: All specimens are from the higher beds of the Septimus Limestone, at Mount Septimus in the Bonaparte Gulf Basin. CPC1583, 1584, F17904, 5 come from 450-500 feet above base of the formation; F17906-8 from 500-550 feet and F17909 from 450 to 500 feet.

BRACHYTHYRIS LATECARDINALIS sp. nov.

(Pl. 6; figs 3, 6, 7; Pl. 28, fig. 4; Text-fig. 45)

Diagnosis: Small to medium-sized wide species, greatest width in front of but close to hinge-line, wide low interarea, 8-9 flat costae on each ventral flank, costate sulcus; dorsal valve gently convex and with broad flat undivided fold.

Material: Four silicified valves, 3 ventral and one dorsal.

Description: The shells are wider than long, with a wide hinge-line. The ventral valve is strongly convex longitudinally and transversely, with maximum convexity at the umbo, which is overturned. A rounded sulcus runs from umbo to front margin; it deepens and widens to the front. The depth is somewhat variable; in CPC1586 (Pl. 6, fig. 7a, b) it is deeper and more acute than in the holotype, CPC1585 (Pl. 6, fig. 3a, b). The umbo is prominent and rounded and the shoulders are concave. The front margin appears to be rounded and without a tongue. The maximum width is a little in front of the hinge-line.

The interarea is low and forms a tapering triangle with a height of 0.35 cm in the holotype and less in the other specimens. It is denticulated on the front margin and was probably longitudinally grooved originally, but only traces remain. The delthyrial angle ranges from 70° to 80° and a rounded arched deltidium is present in the three ventral valves. The deltidium is concave in front and nearly touches the overturned umbo. It is thin and appears to be a continuous plate firmly attached to the delthyrial edge; it effectively covers the delthyrial groove, which can be seen only at the front and near the teeth. The best example, CPC3869, is illustrated in Plate 28, figure 3.

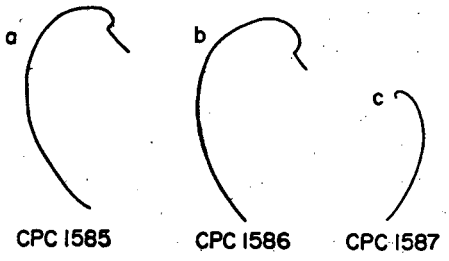

Fig. 45. *Brachythyris latecardinalis* **sp. nov. Profiles of specimens illustrated in Plate 6. (a), (b), x2; (c), x1.**

The teeth are prominent and set obliquely to the hinge-line; they are strengthened by dental flanges which extend back towards the apex but do not reach the floor of the valve. The inner details of the ventral valve cannot be discerned clearly. The shell is not greatly thickened, and the muscle scar appears to extend nearly to the front.

The ventral surface is marked by prominent wide costae flanking the sulcus. Beyond these on each side there are 8-9 wide flattened costae separated by much narrower grooves. The sulcus is faintly costate, but the details are obscured by wear. Four costae within the sulcal boundary can be discerned in CPC3869. A faint concentric growth step can be discerned in CPC1586. The dorsal valve, CPC1587, is illustrated in Plate 6, figure 6a-c. It has a moderate umbo and a wide hinge-line and is only gently convex. The fold is wide and flat and is flanked by 7 wide costae on each side. The shell is thin and the inner surface is costate. The cardinal process is depressed and the socket plates are like those of *Spirifer*, with curled inner margins to the socket grooves. A remnant of the crural lamella can be seen in Plate 6, figure 6c. The adductor scar is long and narrow.

Discussion: The combination of wide hinge-line and moderately convex dorsal valve with smooth low fold appear to separate this species from others in the literature. *B. hemispherica* M'Coy, as illustrated by Davidson (1857, pl. 9,

figs 25, 26), from the Craven District in England, also appears to belong to the *B. ovalis* group and has a wide hinge-line and rather flat dorsal valve with an undivided fold. However, the hinge-line is not relatively as wide as in *B. latecardinalis* and the maximum width is farther forward.

In outline, *B. latecardinalis* has some resemblance to *Brachythyrina pinguisiformis* Semichatova (1943, 1948), from the Protvin horizon of the Moscow Basin (late Visean to Namurian). However, *B. pinguisiformis* carries rounded costae on the whole surface, including fold and sinus. It is the earliest recorded species of *Brachythyrina* in the Moscow Basin.

Geological Age: Late Tournaisian to early Visean.

Occurrences: All specimens come from the higher beds of the Septimus Limestone at Mount Septimus in the Bonaparte Gulf Basin. The holotype CPC1585 comes from 550 to 600 feet above the base of the formation; CPC1586, 1587 and 6131 from 500 to 550 feet.

Family SYRINGOTHYRIDIDAE Fredericks, 1926

(nom. correct. Pitrat, 1965 (pro Syringothyridae Fredericks, 1926, transl. Ivanova, 1959 ex Syringothyrinae Fredericks, 1926))

The family Syringothyrididae was erected by Ivanova (1959, 1960) to include two subfamilies: the Licharewiinae Slussareva, 1958, and Syringothyridinae Fredericks, 1926. Pitrat (1965) broadly followed Ivanova's classification with amendments. Common features of the two subfamilies are the high to moderately high ventral interareas, the generally smooth fold and sulcus, and the simply costate flanks. Grigoryeva & Kotlyar (1966) somewhat drastically reallocated genera in the subfamilies, retaining only genera with a syrinx in the Syringothyridinae: *Syringothyris, Septosyringothyris,* and *Pseudosyringothyris.* The Licharewiinae in their view include *Pseudosyrinx, Asyrinxia, Orulgania* (= *Verkhotomia*), *Cyrtella, Licharewia, Permospirifer,* and *?Darvasia. Pterospirifer* and *Paeckelmannella* were excluded from the Syringothyrididae. They did not refer to the incidence of punctation in their diagnoses of the subfamilies.

In my view, more than two subfamilies can probably be usefully distinguished in this family, but some genera need more detailed study before their affinities can be adequately discussed. The Syringothyridinae as defined by Pitrat (1965) appears to be a natural grouping. It includes forms with very high interareas, perideltidia, generally smooth sulcus, and variable punctation. The syrinx may be present or absent.

The content of the Licharewiinae needs further study. *Licharewia* and its close ally *Permospirifer* and apparently *Orulgania* lack perideltidia and are impunctate. It seems reasonable to restrict the subfamily to similar forms.

Subfamily SYRINGOTHYRIDINAE Fredericks, 1926

Type genus: *Syringothyris* Winchell, 1863.

Definition: The definition by Pitrat (1965, p. H692) is suitable. Certain impunctate genera should also be included. The dorsal cardinalia, where known, are generally massive, with stout crural plates on the insides of recurving socket plates, lacking in dorsal adminicula. A median dorsal septum reaching the cardinalia may be present. Middle Devonian to Upper Permian.

Discussion: I independently defined the Syringothyridinae on similar lines to Pitrat in an unpublished thesis in 1961. Some of the genera included by Pitrat do not accord entirely with the definition and should be excluded. *Verkhotomia* Sokolskaya apparently lacks a perideltidium, and is impunctate. It is therefore not a synonym of *Pseudosyrinx*. It was equated with *Orulgania* Solomina by Grigoryeva & Kotlyar (1966). *Asyrinx* Hudson & Sudbury is inadequately known; it may lack a perideltidium and delthyrial plate. It is not synonymous with *Asyrinxia* Campbell as stated by Ivanova (1960) and Grigoryeva & Kotlyar (1966). *Plicatosyrinx* Minato is also inadequately known.

The following genera, all possessing perideltidia, can be approximately included in the subfamily: *Eosyringothyris* Stainbrook; *Syringothyris* Winchell (synonym *Prosyringothyris* Fredericks); *Syringopleura* Schuchert; *Pseudosyrinx* Weller; *Cyrtella* Fredericks; *Pseudosyringothyris* Fredericks; *Septosyringothyris* Vandercammen; and possibly *Asyrinxia* Campbell. *Subansiria* Sahni & Srivastava may belong but is inadequately known.

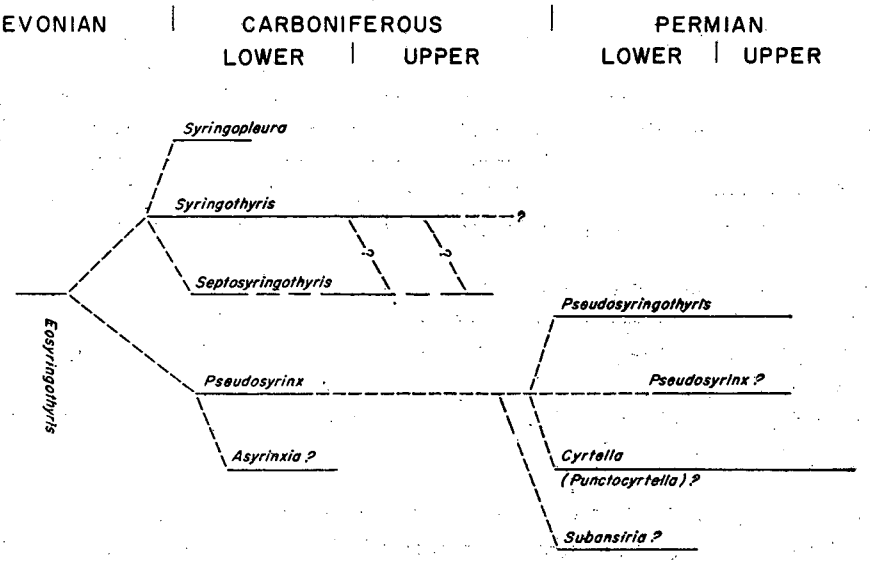

Fig. 46. Phylogeny of Syringothyridinae.

A postulated phylogeny is shown in Text-figure 46. *Eosyringothyris* is suggested as ancestral genus, following Stainbrook (1943, p. 432). Although impunctate, it possesses a perideltidium, smooth fold and sulcus, and pustulose microornament. *Septosyringothyris* may be polyphyletic. The median ventral septum could have developed independently more than once from the incipient septum common in species of *Syringothyris*. Some rare species otherwise referable to *Syringothyris* possess faint costae on fold and sulcus. These can be placed in *Syringopleura* Schuchert, which seems best regarded as a subgenus of *Syringothyris* (see p. .....). *Plicatosyrinx* may be a synonym of *Syringopleura*. *Asyrinxia* Campbell, which also has faint median costae, appears to be an aberrant member of the Syringothyridinae. Although it has a perideltidium it lacks the characteristic delthyrial plate. *Cyrtella* Fredericks was included in the Licharewiinae by Ivanova, Pitrat, and Grigoryeva & Kotlyar. However, in form it is close to *Pseudosyrinx*, possesses a perideltidium and is punctate.

The majority of genera and species in the subfamily possess fine endopunctae. These appear to be finer than those of the Spiriferinacea and most Terebratuloida; they may not be strictly homologous in all these groups. They seem to be very variable in their incidence and density in the Syringothyridinae. Punctae are commonly difficult to detect in specimens of *Syringothyris*, as indicated by the original controversy between Davidson, Carpenter, and King, and also in later descriptions such as those of Weller (1914) and Girty (1929). Vandercammen (1955) showed that impregnation in paraffin helps reveal punctae in some specimens. It seems clear, however, that certain species have very sparse or no punctae, e.g. *Syringothyris spissus*, *S.* sp. nov. B, and *S. hannibalensis* Swallow. *Pseudosyrinx*, although impunctate species are recorded, for example by Einor (1939) and Campbell (1957, p. 81), appears to be generally punctate. *Cyrtella* has been reported as impunctate but appears to me to be punctate. *Eosyringothyris* is impunctate. *Pseudosyringothyris* is finely punctate. Punctae appear to have developed early in the history of the subfamily but subsequently were lost in certain species. They are evidently not essential to the living animal.

The Syringothyridinae possess high ventral interareas and usually well developed delthyrial plates. It is shown below that adductor muscle scars can be present on the delthyrial plate of *Pseudosyringothyris* which commonly has adventitious thickening (Text-fig. 47) and it is also argued that the syrinx, in part at least, serves as site of attachment for the adductor muscle (p. 138). Comparable muscle attachments may occur in the other genera but have not been described.

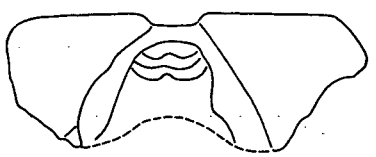

Fig. 47. *Pseudosyringothyris karpinskii* **Fredericks. Transverse section showing thickening of delthyrial plate. (Fredericks, 1916, fig. 16).**

A perideltidium is present in all the genera that have been included in the subfamily. It seems to be homologous with the perideltidium of the Davidsoniacea. In *Pseudosyrinx*, *Pseudosyringothyris*, and *Cyrtella*, as in *Syringothyris* (North,

1920, p. 172), there appears to be no change in level at the perideltidial line or margin such as is sometimes observed in davidsoniaceans. The function of the perideltidium is uncertain. The longitudinal grooves are possibly the trace of fine denticles as in the Spiriferidae; however, in sections of *P. dickinsi* sp. nov., the grooves are superficial, occurring only in the outermost shell layers. There are no flexures in deeper layers such as those marking the denticles of *Prospira laurelensis* sp. nov. Denticular sockets were not observed on the dorsal valves of *P. dickinsi* or *C. nagmargensis australis*. The longitudinal grooves may have served a similar function to that suggested by Cooper (1954, p. 332) for the grooves covering the interareas of *Syringospira* and *Sphenospira*. The grooves in those genera apparently had the role of preventing lateral shift of the animals, which lay with their high areas resting on the sandy or muddy sea floor and with the length aligned to the current direction. No direct evidence is available, however, to indicate the life habits of the Syringothyridinae.

Williams (1956, p. 248) described the interarea of the brachiopods as being covered in life by a periostracal pad of chitinous matter secreted by the mantle. Perhaps the perideltidium marks the limit of this pad, which did not extend to the edges of the interarea in this group. The pustulose and striate micro-ornament of the shell surface extends onto the outer part of the interarea in *P. dickinsi* (Pl. 13, fig. 3a, b) but not on to the perideltidium. Punctae occur over the whole interarea in *P. dickinsi*. They were also noted on the perideltidium of *Pseudosyrinx sampsoni* Weller from the Mississippian of New Mexico in a specimen presented by Dr G. A. Cooper. Weller (1914, p. 385) and North (1920, p. 172) have claimed that the perideltidium is impunctate in *Syringothyris*.

The inclination of the ventral interarea is of use in specific discrimination. However, as pointed out by Hyde, it is variable intraspecifically within limits of as much as 20° in *Syringothyris*. It is measured in the following descriptions as the angle between the plane of the area and a line joining the middle of the hinge-line and the midpoint of the front commissure.

Genus SYRINGOTHYRIS Winchell, 1863

Type species: *Syringothyris typa* Winchell, 1863.

Generic features: The features of *Syringothyris* are well known in general. The summary in Pitrat (1965, p. H692) is sufficient for the ventral valve. The genus is generally punctate, but sparsely punctate species are known.

Discussion: The function of the syrinx was early suggested as a support for the pedicle muscles, e.g. by King (1868, p. 22). He had noted the longitudinal flutings inside the slotted syrinx and deduced that they were muscle supports. A similar role is still argued by A. Williams (1965, p. H116), who compares the syrinx with the tichorhinum of *Cyrtina*. Alternative interpretations by H. S.

Williams (1913, p. 62) and by Hyde (1953, p. 266) suggest that the syrinx is the site of attachment for the ventral adductor muscle. Their views appear to have been generally overlooked. Hyde illustrated syrinxes which flare out widely at the front and are directed anterodorsally. In *Syringothyris typa* (Hyde, 1953, pl. 32, figs 5 & 7) there is a pedicle opening near the middle of the cystose deltidium. It is difficult to see how the syrinx could have functioned as pedicle muscle base in such a form. Hyde also demonstrated that a low septum commonly connects one of the syrinx walls with the thin longitudinal area of the valve floor, lying between the large diductor scars, i.e., in the position normally occupied by the adductors in spiriferids. He argued that 'the mantle tracts which had to do with margins of the usual position of the adductor muscles were intimately connected and continuous with the tracts that secreted the ridges which constitute the sides of the syrinx'. A similar low incipient septum is evident in some specimens of *S. spissus* Glenister (Pl. 30, figs 1-5) and in *S. randalli* Simpson (Sass, 1960, pl. 35, figs 2, 3, 8-11).

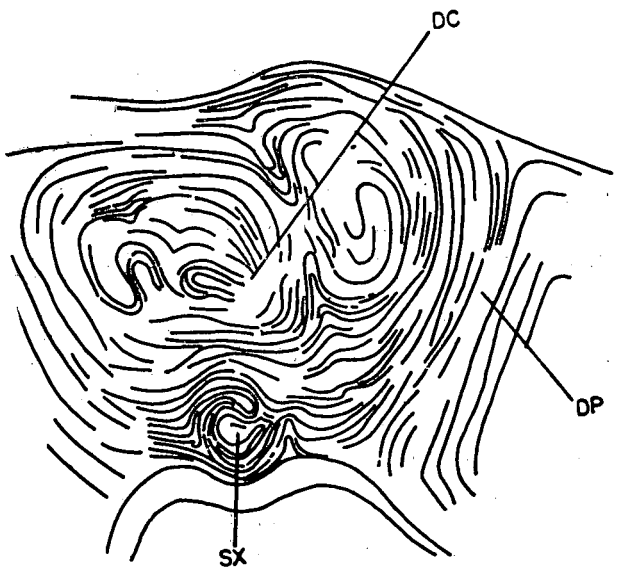

Fig. 48. *Syringothyris typica.* **Transverse section through apical part of ventral valve showing contortions of laminae infilling delthyrial cavity (after Miloradovich, 1937). DC delthyrial cavity; DP dental plate; SX syrinx.**

The syrinx of *S. spissus* (Pl. 30, figs 1-5) is oriented in the appropriate direction to serve as ventral adductor scar. Likewise in *S. australis* Maxwell (Pl. 31, fig. 1), a species with fairly low interarea, the syrinx is set deep in the valve and is directed dorsally. The suggested mode of muscle operation is similar to that indicated for *Pseudosyringothyris* (Text-fig. 54c). It seems possible that in some species the ventral adductors could be situated partly on the syrinx and partly closer to or even between the diductor muscles. Determining factors would include the height and inclination of the interarea.

Some species of *Syringothyris* become much thickened in the umbonal region. Miloradovich (1937) showed that the mantle surface which secreted this delthyrial thickening was curiously wrinkled (Text-fig. 48). Williams (1965, fig. 121) shows a somewhat similar section.

A well developed septum ('euseptoid') is a feature of *Septosyringothyris* Vandercammen, four species of which have been described from different levels of the Lower and Upper Carboniferous of Belgium, Argentina, and Russia by Vandercammen (1955), Amos (1957), Sokolskaya, in Sarytcheva et al. (1963), and Volgin (1965). The genus is possibly polyphyletic, with a ventral septum developing independently in different species of *Syringothyris*.

A delthyrial cover has been noted by various workers. Hyde (1953) has given the fullest description of the structure, which can occur as a thick cystose mass of irregular thin films. It lies above and separate from the delthyrial plate. The structure resembles the 'stegidium' of *Cyrtiopsis murchisonia* described by Sartenaer (1955).

The dorsal cardinalia (including the cardinal process) are massive and essentialiy similar to those of *Spirifer*.

Syringothyris is normally smooth on fold and sulcus; however, *S. randalli* Simpson and *S. angulata* Simpson from the early Mississippian Corry Sandstone of Pennsylvania, redescribed by Sass (1960), have faint median costae. *Syringopleura* Schuchert, 1910, which is generally regarded as a synonym of *Syringothyris,* was erected with *S. randalli* as type species. *Syringopleura* could be used (as a subgenus) for the rare forms with costae on fold and sulcus. *Plicatosyrinx* Minato may be a synonym.

Specific discrimination is not easy in *Syringothyris* because of considerable variability. Weller (1914), North (1920), and Hyde (1953) used the following criteria in distinguishing species: apical angle, height of area, delthyrial angle, curvature and inclination of the area, convexity of the lateral flanks, shape of sulcus and fold, proportions of the dorsal valve, number of costae, disposition and shape of the delthyrial plate and syrinx, and details of surface ornament. To these might be added: amount and type of umbonal shell thickening, perideltidial angle, and, perhaps, density of punctation.

Stratigraphical distribution: *Syringothyris* is well known as a late Devonian?, mainly Dinantian to Namurian genus, widely distributed in Western Europe, Russia, Asia, North Africa, North and South America, and Australia. Later occurrences have often been claimed but are less certainly established. *Syringothyris spitzbergensis* Wiman, reputedly of Permian age, from Spitzbergen is of unknown horizon and locality (Gobbett, 1963). *Syringothyris? lydekkeri* (Diener), originally collected from the *Fenestella* beds and equivalents of Kashmir, appears to be of Upper Carboniferous to possibly Lower Permian age.

Bion (1928) recorded it from the Upper Agglomeratic Slate of Kashmir (Lower Permian) but S. C. Shah (pers. comm.) thinks his specimens may be from much older beds. Waterhouse (1966, p. 61) has briefly discussed the provenance of the type specimens.

Various authors, including Muir-Wood & Oakley (1941), Merla (1934), Reed (1927), and Mansuy (1912), have reported *S. lydekkeri* from the Upper Permian of Asia, but in no case is the identity established, judging from the illustrations. This is also true of the specimens from Nepal described by Waterhouse (1966, p. 58). Campbell (1961, p. 447) made certain comparisons between *?Syringothyris bifida* Campbell from the Kuttung (Westphalian) of New South Wales and *S. lydekkeri.* It is not, however, certain from the descriptions of Diener or from his specimens that a syrinx is present in the types of *S. lydekkeri.* Bion's specimens do show a syrinx, notably the specimen illustrated in Bion (1928, pl. 3, fig. 13b).

Three species of *Syringothyris* occur in the Carboniferous of Western Australia.

SYRINGOTHYRIS SPISSUS Glenister, 1955

(Pl. 9, figs 6, 7; Pl. 30, figs 1-5; Pl. 31, fig. 3; Text-figs 49, 50)

1955 *Syringothyris spissus* Glenister, *J. Roy. Soc. W. Aust.* 39, 70-71, pl. 7, fig. 15; pl. 8, fig. 9; Text-fig. 7.

Diagnosis: Medium-sized species; both valves moderately convex; maximum width at hinge-line; ventral interarea gently concave to flat, high; apical angle wide (105° to 120°), delthyrial angle moderate (29° to 35°); wide low sulcus; dorsal fold low; 17 to 20 costae on each flank; large syrinx; incipient ventral umbonal septum; impunctate or almost so, shell thick apically.

Material: About 60, mainly silicified, specimens, mostly incomplete ventral valves.

Description: The following is supplementary to Glenister's description of the type specimens. The holotype CPC432 is the largest specimen, 5.45 cm wide, interarea 2.55 cm high. The interarea of CPC1660 (Pl. 9, fig. 6a, b; Text-fig. 49a) is 2.3 cm high, gently concave, steepening at the pointed umbo; it is less commonly flat. The inclination is at a steep apsacline angle but was not measurable. The apical angle ranges from 105° to 120°. The delthyrium, ridged and grooved at the margin, has an angle of 33° to 35° and is up to 1.45 cm wide. The perideltidial angle (one specimen) is 83°.

The ventral sulcus is wide, rather shallow, with rounded margins and a gently convex longitudinal profile. The flanks are gently convex, abruptly contacting the interarea at right angles. The dorsal valve is gently convex in both transverse and longitudinal sections. The anterior commissure is only

gently uniplicate with a slight lingual extension at the sulcus. Each flank carries from 17 to 20 simple, fairly flat costae, with narrower intertroughs. The costae widen to the front, where they are spaced at about 2½ in 5 mm.

TABLE 16: Dimensions of species of *Syringothyris* (in cm)

Specimen Number	L	Lb	Whl	Wsf	Dw	Ha	Aa	Da	Pa	Costae Ventral L.	Costae Ventral R.
Syringothyris spissus Glenister											
CPC1659				1.75				33°		17-18	
CPC1660	4.0e	2.4	4.7e		1.45	2.30	110°	33°	83°	14+	
CPC432			5.45		1.40	2.55	105°	c35°			20
Holotype											
CPC1665						2.2+	110°	30°			
CPC1666						2.0+	110°	31°			17
CPC1667							116°	29°			12
CPC1668											
CPC1669							110°	33°			
CPC1661							120°	30°			
Syringothyris sp. nov. B											
CPC1662	c3.1	1.6e	4.8	1.7	1.1	2.9	90°	c27°		21+	
CPC1663	2.75+		5.3			1.54	115°	c35°		c17-18	

The dental plates are well developed and thick. The adminicula extend for about one third of the valve length and diverge beyond the sulcus at 60° to 70°. The dental flanges are longer and the front margin of the dental plates is concave. The plates commonly bend at the junction with the delthyrial plate. The initial components of the dental plates could not be distinguished in section (Text-fig. 50), in contrast to *Syringothyris* sp. nov. B (Text-fig. 52), which is less thickened in the umbonal region. The delthyrial plate varies considerably in cross-section: commonly convex, less commonly angular and deeply grooved on the sides, more rarely irregular and nodular, rarely flat. It deepens to the front, at one third of the delthyrial length. The syrinx varies in size and extends

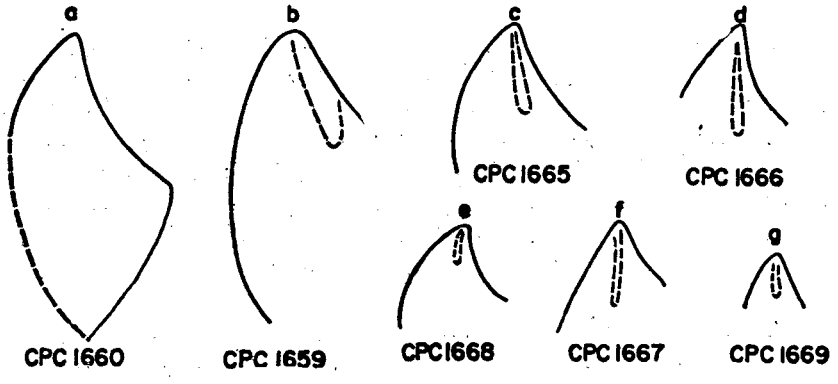

Fig. 49. *S. spissus* **Glen. Profiles of specimens illustrated in Plates 9 and 30. Position of syrinx dotted. Natural size.**

up to 7 mm beyond the delthyrial plate. It remains cylindrical to the front, commonly retaining the slit despite thickening. The longitudinal flutings are generally preserved. The ventral diductor scars lie between and in front of the dental plates e.g. CPC1659 (Pl. 9, fig. 7a, b; Text-fig. 49b). They are marked by more or less reticulate striations. In CPC1659, the pair of scars are about 1.8 cm wide and 1.4 cm long, and between them is a narrow grooved zone in the normal position of the adductor scar. This median zone can be traced as a low septum across the apex to the syrinx in some specimens (Pl. 30, figs 3, 4, 5). In others (Pl. 30, fig. 1a, b) a wide swelling lies behind the adductor scar. In general this species is considerably thickened and often irregularly pitted in the umbonal region. Generally shell thickening has obliterated the costae.

The dorsal cardinalia are seen in the holotype (Glenister, 1955, pl. 7, fig. 9) and enlarged in Plate 31, figure 3. The cardinal process consists of numerous longitudinal platelets (about 25) at the notothyrial apex. Flanking it are the crural plates, on the inside of the socket plates, which recurve to the hinge-line. The notothyrium is widely divergent and the area is low and concave. The socket groove is rounded and widens to the front. The dorsal adductor scars are long and narrow, with a slight myophragm. This specimen gapes wider than in life. Muscle contraction between syrinx and dorsal adductor scar would have effectively closed the shell.

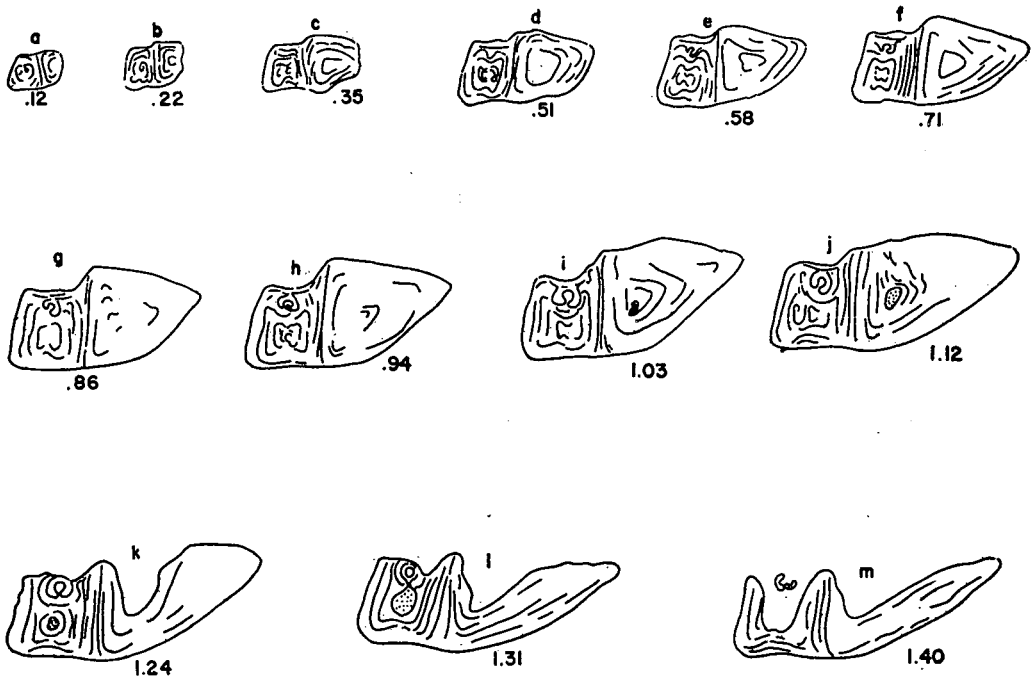

Fig. 50. *S. spissus.* **CPC1661, an abraded ventral valve. Transverse sections. Delthyrial and umbonal cavities infilled from (a)-(i). Laminae of infilled delthyrial cavity somewhat irregular, but not as contorted as in Fig. 48, x1.4.**

Glenister did not observe punctae in this species. Careful examination of the few unsilicified specimens, which are all abraded, failed to show punctae. However, in a small patch of paratype CPC448, a thin section, there are possibly three or four fine punctae near the sulcus. These are fine dark lines penetrating the outer laminae of the shell for about half the thickness; obliquity of the section could explain their absence in deeper layers.

Discussion: The internal structures in *S. spissus* are comparable with some of the features observed by Hyde in Mississippian species and support his suggestion that the syrinx was the attachment site, in part at least, for the ventral adductor muscle.

S. spissus appears to be a fairly distinctive species, but resembles some others in a general way. The closest in dimensions and number of costae is *S. hannibalensis* (Swallow) from the Louisiana Limestone of Missouri, but *hannibalensis* has a deeper sulcus and a larger syrinx which widens markedly to the front (Hyde, 1953, pl. 34, figs 9-14). It is also present in the Sappington Formation of Montana (Rodriguez & Gutschick, 1967). In addition to its early Mississippian occurrences, *S. hannibalensis* has been recognized in the upper Tournaisian of the Kuznetzk, Kazakhstan, and Moscow Basins by various authors including Nalivkin (1937), Sokolskaya (1941), and Sarytcheva et al. (1963). J. S. Williams (1943, p. 87) did not observe indubitable punctae in the Louisiana Limestone specimens, but the Sappington specimens are reported to be punctate.

Geological Age: Tournaisian.

Occurrence: The type specimens and CPC1659, 1660, 1665-9 from locality TP42, Carnarvon Basin. Moogooree Limestone, about 440 feet above base. CPC1661 and several other specimens from locality CC102, an isolated outcrop of Moogooree Limestone.

SYRINGOTHYRIS sp. nov. A

(Pl. 28, fig. 7)

Material: The figured specimen, from the Septimus Limestone, was the only one available when the plates were prepared. Others were collected in 1963.

Description: CPC6126 is a dorsal valve, about 4.6 cm wide and 2.7 cm long. It is gently convex longitudinally and transversely with a smooth low fold about 1.7 cm wide at the front. The lateral costae are nearly flat with narrow low intertroughs.

Discussion: Several other silicified specimens, with similar dimensions and costation, display the characteristic syrinx, perideltidium, and cystose deltidium of *Syringothyris*. The species will be described elsewhere.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC6126 comes from west slopes of Mount Septimus, Bonaparte Gulf Basin. Septimus Limestone, about 450 to 500 feet above the base of the formation.

SYRINGOTHYRIS sp. nov. B

(Pl. 9, figs 8, 9; Text-figs 51-52)

Material: Three incomplete specimens, all ventral valves.

Description: The two specimens illustrated on Plate 9—CPC1662 and 1663—differ considerably in proportions and may be different species. More specimens will be needed to settle this point and determine the variability of the species. The larger specimen, CPC1662 (Pl. 9, fig. 8a, b; Text-figs 51c, d), has a high gently concave interarea, much abraded at the umbo. The height is about 2.9 cm and the estimated width 4.8 cm. The apical angle is about 90°. The delthyrial angle is narrow, at about 27°. The valve is strongly convex in transverse profile; the sulcus is pronounced and deepens and widens to the front, where it attains a width of 1.7 cm. Its lateral boundaries are somewhat angular. The lateral flanks are gently convex and have a fairly abrupt contact with the interarea. The left flank carries 21 simple costae, which are abraded; they are flatter to the front and have interspaces nearly as wide. The sulcus is projected forwards as a pronounced tongue. Parallel to the front margin are two strong growth rugae, which also continue on to the interarea. The median longitudinal profile is gently convex, but its shape at the umbonal tip is not known. The interarea is nearly catacline. The dorsal valve is missing, but its dimensions can be estimated as 1.65 cm long and 4.8 cm wide at the hinge-line. The umbonal tip was cross-sectioned and showed thin dental plates, a slightly depressed concave delthyrial plate, and a small syrinx.

CPC1663 (Pl. 9, fig. 9, Text-fig. 51a, b) is somewhat crushed. Its apical angle is wider than in CPC1662 (about 115°). The umbo is pointed and upturned at the tip. The interarea is lower than in CPC1662 and measures 1.55 cm, with an estimated width of about 5.2 cm. The sulcus is a little shallower than in CPC1662 but with similarly steep sides. The costae are similar but number only 17-18 on the left flank; there are no growth rugae. The internal structure was not ascertained and hence the specimen is not necessarily a member of *Syringothyris*.

The third specimen, CPC1664, is a much abraded ventral valve embedded on its dorsal side in gritty calcareous rock. Sections are illustrated in Text-figure 52. The dental plates are moderately divergent at about 40° and are not as greatly thickened in the umbonal region as in *S. spissus*. They are built up from two initial components: adminiculum and dental flange. The delthyrial

plate is flat and not very deeply depressed below the interarea. The syrinx is comparatively small. It is internally corrugated or fluted and the posterior part has been infilled by later shelly deposit. No punctae were detected.

Both CPC1662 and 1663 are abraded but not otherwise altered, and the calcite fibres are readily distinguishable. Fine punctae were observed in a patch on the front part of the sulcus of CPC1663, where they had a diameter of about 0.01 mm and a spacing of 1 to 3 per square mm. Fine punctae were only doubtfully observed in a smaller patch on the left flank of CPC1662.

Discussion: The poverty of the collections and the wide variation of form make comparison difficult. All specimens differ from *S. spissus* by having a deeper more acute sulcus, flatter delthyrial plate, and less developed umbonal shell thickening. The closest described species appears to be *Syringothyris curzoni* (Diener, 1903) from the Lipak beds of Spiti. This is sparsely punctate and has thin divergent dental plates, a flat depressed delthyrial plate, and similar form to CPC1632. Some specimens described by Diener (1915) from the *Syringothyris* Limestone at Eishmakam in Kashmir as *Syringothyris cuspidata* also show resemblance to CPC1632. Other illustrated specimens show a range of variation comparable with the three specimens of *Syringothyris* sp. nov. B. However, neither this species nor the Himalayan species are suffiicently well known for certain identification.

Geological Age: Visean to possibly Namurian.

Occurrence: About 1 mile east of Point Spring, near foot of southern scarp of Weaber Range, Bonaparte Gulf Basin. Burvill Beds.

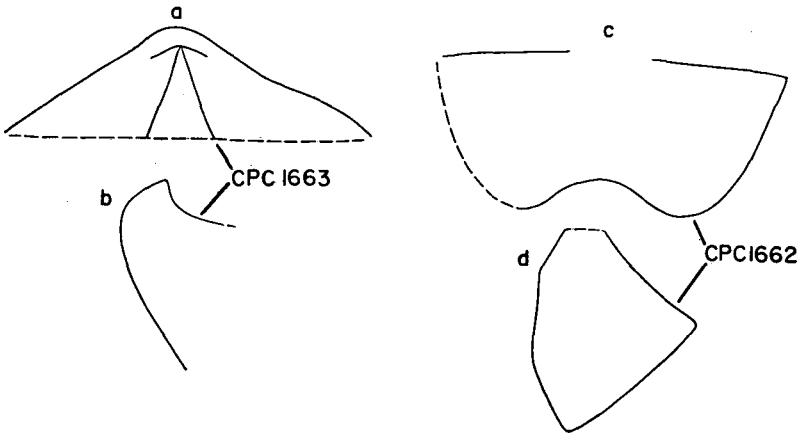

Fig. 51. *Syringothyris* **sp. nov. B. (a), (b) Outline of posterior dorsal and profile views of ventral valve illustrated in Plate 9. (c), (d) Anterior outline and profile of ventral valve illustrated in Plate 9.**

Genus PSEUDOSYRINGOTHYRIS Fredericks, 1916

Type species: *Cyrtia* (*Pseudosyringothyris*) *karpinskii* Fredericks.

Generic features: Punctate syringothyridinids, resembling *Pseudosyrinx* externally but with ventral adminicula shorter and more divergent; considerable apical thickening in ventral valve, commonly with median longitudinal callosity on inner surface of delthyrial plate which may possess a pair of adductor muscle scars. Dorsal fold smooth; cardinalia massive with recurved socket plates, and strong crural plates, no median septum.

Discussion: The type specimen of *Pseudosyringothyris* does not appear to have been redescribed. I was not able to see it in Leningrad. Fredericks gives its provenance as the Adzva River, Bolshezemelzkaya Tundra, Russia. Ivanova (1960, p. 268) records the species also from the Urals and Novaya Zemlya, all localities of Lower Permian age. The species is syringothyridinid in form, with high wide interarea, smooth sulcus, numerous simple lateral costae, divergent dental plates, and a median longitudinally divided callosity on the inner surface of the delthyrial plate (Fredericks, 1916, fig. 16; Text-fig. 47). Fredericks named

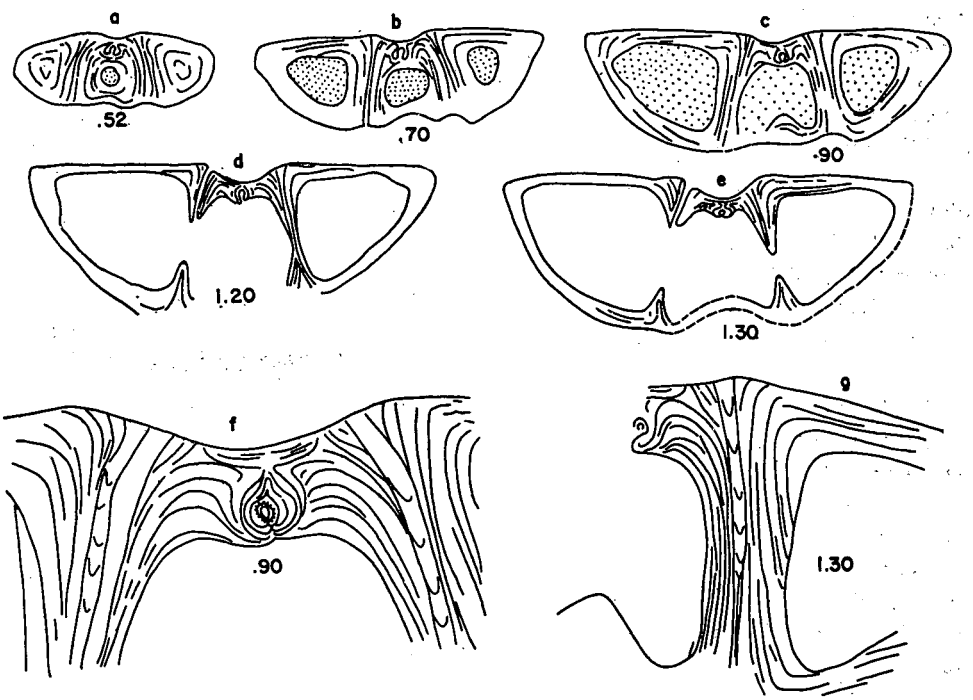

Fig. 52. *Syringothyris* **sp. nov. B. CPC1664, an incomplete ventral valve. Transverse sections. (a)-(e), 1.4; (f), (g), x3.75. (f) Shows syrinx, dental lamella, and delthyrial plate with inner thickening continuous with that of dental lamella. Outer part of delthyrial plate seems to have been initially discrete at this level. (g) Dental plate. Long initial dental lamella clearly seen; initial adminiculum not clear—seen better in anterior sections.**

this the 'pseudosyrinx' which he thought to be a stage in the development of the syrinx. The 'pseudosyrinx' appears to me to be an adventitious callosity, of variable shape, homologous with that in *P. dickinsi* sp. nov. Some specimens of *P. dickinsi* show precisely similar callosities.

The other general features of *Pseudosyringothyris* remain in doubt. Fredericks (1916, p. 52) stated that it 'strongly recalls' *Cyrtia* (now *Cyrtella*) *kulikiana* Fredericks. Ivanova (1960, p. 268) distinguishes it from *Pseudosyrinx* by the presence of the longitudinal callosity on the delthyrial plate. I have provisionally accepted the interpretation by Gobbett (1963, p. 174) that his punctate species *P. borealis* and an unnamed species, from the *Spirifer* limestone of Spitzbergen, belong in *Pseudosyringothyris*. I consider that the apical callosity shown in his plate 24, figure 3 separates a pair of muscle scars on the delthyrial plate. I have examined some of his material, including a specimen in the Riksmuseum, Stockholm, identified by him as *Pseudosyringothyris* sp., which is very similar to my specimens of *P. dickinsi* sp. nov. such as my Plate 10, figure 5.

In addition to its median callosity, other features distinguishing *Pseudosyringothyris* from *Pseudosyrinx* Weller are the shorter and more divergent ventral adminiculae. Weller (1914) did not fully describe the internal features of the type species *Pseudosyrinx missouriensis* Weller. The dental plates are said to extend more than half the distance from the beak to the front margin; the ventral muscle scars are narrow; the dorsal internal features were not described. Specimens of large internal moulds of *P. gigas* Weller from the Keokuk cherts of Missouri, kindly lent by the Yale Peabody Museum, show long thin slightly divergent dental plates, situated well within the sulcus. The inside of the delthyrial plate is smooth. The dorsal valve has a distinct median septum, extending to the cardinalia. *P. keokuk* Weller (1914, p. 409) also displays a dorsal median septum. The Mississippian species in general, e.g. *P. sampsoni* Weller, commonly have externally concave delthyrial plates which appear to be smooth internally, as seen in specimens in the Smithsonian Institution.

P. dickinsi sp. nov. was earlier referred by me to *Pseudosyrinx* sp. nov. in Dickins & Thomas (1959). However, the delthyrial plate adductor scars and short divergent adminicula warrant separation. The placement in *Pseudosyringothyris* can only be provisional. The allied genus *Cyrtella* has a grooved fold. *Subansiria* Sahni & Srivastava is not adequately known. Examination of the type specimens of *S. ranganensis*, the type species, in Calcutta, shows it to be probably punctate, but sectioning is required. The shell is largely exfoliated and the transverse irregularities on the fold are in the internal mould. The genus may be a synonym of *Cyrtella*.

The muscle scars on the delthyrial plate in *P. dickinsi* are interpreted as adductor scars (Text-fig. 54c). The myology of the ventral valve is shown in an internal mould, CPC1639 (Pl. 12, fig. 3a, b; Text-fig. 54d, e). The two large longitudinally striated diductor scars lie close together without any obvious

adductor between them. Homologous adductor scars on the delthyrial plate were noted by H. S. Williams (1913) in *'Spirifer marcyi sigma'* (*Spinocyrtia?*), a form with high area, from the Upper Devonian of New York. It is deduced that migration of the ventral adductor muscles to the delthyrial plate is an adaptation in species of *Pseudosyringothyris* with high, nearly catacline to procline, interareas. The syrinx in *Syringothyris* serves a similar role. It seems likely that in species with lower or more apsacline interareas the diductor muscles would be attached closer to the diductors and not necessarily be situated on the delthyrial plate.

Micro-ornament in *P. dickinsi* consists of fine short radial striae (grooves) interspersed with oval to pear-shaped pustules, the concentration of which varies. This micro-ornament extends onto the interarea outside the perideltidium. The Mississippian species of *Pseudosyrinx* appear to have essentially similar ornament.

A stegidium, sealing off the delthyrium, was noted in a couple of specimens of *P. dickinsi.* Preservation is poor, but the structure consists of overlapping platelets, lying in front of and attached to the delthyrial plate.

Another new species about which less is known is provisionally placed in *Pseudosyrinx?—P. ?sinuosa* sp. nov. It is not certainly punctate as the shell is not preserved. Also it may lack a perideltidium and consequently be referable to a genus of the Licharewiinae.

Stratigraphical distribution of Pseudosyrinx and Pseudosyringothyris: The North American species of *Pseudosyrinx* are of middle Mississippian age—Burlington and Keokuk. Another Lower Carboniferous species is *P. exsuperans* (de Koninck) from the middle Visean of New South Wales (Roberts, 1964a). *Pseudosyrinx* does not seem to be present in the Lower or Upper Carboniferous of USSR. Species so identified previously belong to *Verkhotomia* Sokolskaya, or *Orulgania* Solomina & Tschernyak, impunctate licharewiinid genera regarded as synonymous by Grigoryeva & Kotlyar (1966). The Chinese species from the Lower Carboniferous of Tienshan described by Yang & Chang (1960) apparently also belong to *Verkhotomia.* In general *Pseudosyrinx* has no definite Upper Carboniferous records, though it is possible that *Syringothyris? lydekkeri* Diener from Kashmir is a member.

A number of Permian species have been assigned by Branson (1948) and others to *Pseudosyrinx.* Some of these can be excluded as lacking in diagnostic features, e.g. *Spirifer subtriangularis* Schellwien, *Spirifer schellwieni* Tschernyschew, and *S. tastubensis* Tschernyschew.

Gobbett (1963) referred *P. wimani* Gobbett and *P. articus?* (Whitfield) from the *Spirifer* Limestone of Spitzbergen to *Pseudosyrinx.* However, the ventral adminicula of *P. wimani* appear to be divergent and fairly short. Campbell

(1953) and Hill & Woods (1964) have recorded a species of *Pseudosyrinx* from the Permian of Queensland.

Russian authors e.g. Licharew (1934a, 1939) have placed *C. kolymenis* (Tolmatchow) and *C. kulikianus* (Fredericks) from the Permian of the USSR in *Pseudosyrinx,* but these are now placed in *Cyrtella* (see below).

Pseudosyringothyris has so far been reported from the Lower Permian of Bolshezemelskaya Tundra, near the Urals, Northern Russia and from the *Spirifer* Limestone of Spitzbergen which Gobbett (1963) regards as Svalbardian in age, i.e. late Lower Permian to early Upper Permian. *P. dickinsi* is of early Artinskian or late Sakmarian age.

PSEUDOSYRINGOTHYRIS DICKINSI sp. nov.

(Pl. 10, figs 1-5; Pl. 11, figs 1, 2; Pl. 12, figs 1-4; Pl. 13, fig. 3; Pl. 29, fig. 7; Text-figs 53-56)

1897 *Syringothyris exsuperans* (de Koninck); Etheridge, *Rec. geol. Surv. NSW,* 5(2), 46-7, text-figs A, B, C (in part).

Diagnosis: Large species, ventral interarea high, flat to slightly concave, inclination 80° to 85°, delthyrial angle narrow (18°-22°), perideltidial angle wide (72°-82°), stegidium; sulcus deep, rounded; fold simple and prominent; lateral costae rounded, 15-18 on each flank; ornament of pustules and short radial striae; pair of prominent adductor muscle scars on inner surface of delthyrial plate; massive cardinalia; finely punctate.

Material: Numerous specimens in BMR and UWA collections, mostly incomplete; fragments of ventral interarea common.

Description: The shell is large and has the wedge-shaped form characteristic of Syringothyridinae with very high areas.

The ventral valve is an irregular half-cone, wedge-shaped in lateral profile and with a high, wide, generally flat or slightly concave interarea, which has an inclination of 80° to 85°. The umbo is pointed and only slightly, if at all, upturned. The lateral edges of the interarea are commonly rather sharp and are at an acute angle to the ventral surface. In a few specimens the interarea is asymmetrical. The lateral edges of the area are, in most, gently convex and often serrated by growth steps; the outline indicates that rate of increase in area-height exceeded increase in width, in mature to old specimens. The apical angle (measured from apex to ends of hinge-line) ranges from 82° to 100°. The delthyrium is long and rather narrow with an angle of 18°-22° and a width of 1.5 cm in the holotype, CPC1636; the width is less in the few other measurable specimens. The interarea is 6.5 cm high in the largest specimen,

TABLE 17: Dimensions of *Pseudosyringothyris dickinsi* sp. nov. (in cm)

Specimen Number	L	Lb	Whl	T	Wsf	Wff	Dw	Ha	I	Aa	Da	Pa	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1636	5.75e	3.85	8+e	3.1	c2.5	c2.5	1.5	4.85	c85°	90°			9+			10+
CPC1634		3.60	7.50			1.5	1.05	3.10		c100°	18°		17+	18+	17+	16
CPC1635	4.70	3.55	8.00	2.85	c1.5	c1.5	1.40	4.30	c80°	85°	21°			13+	16	15
CPC1639			7.65					5.30		82°						
CPC1640		3.2+	9.00			1.5+										
CPC1642			7.50				1.36	4.00				82°				
CPC1643								4.10			21°	72°			16	
CPC1644								4.20					13+			
F17247a			11.2e					6.50		84°e	22°					
F17942			11.3e					5.40		c100°	19°	80°				
F17943			10.8e					5.20								
F17944		3.25	6.5+e			1.70										
F17941			7.65				1.30	4.40		85°	20°					

with an estimated width of 11.2 cm; it is 4.8 cm high and 4.10 cm wide in the holotype. The delthyrium is flanked on each side by a dental ridge which marks the trace of the tooth. The teeth are prominent and extend for 2-3 mm in front of the area in larger specimens. They are fairly flat in section, with the long axis oblique to the hinge-line (Text-fig. 54a, b).

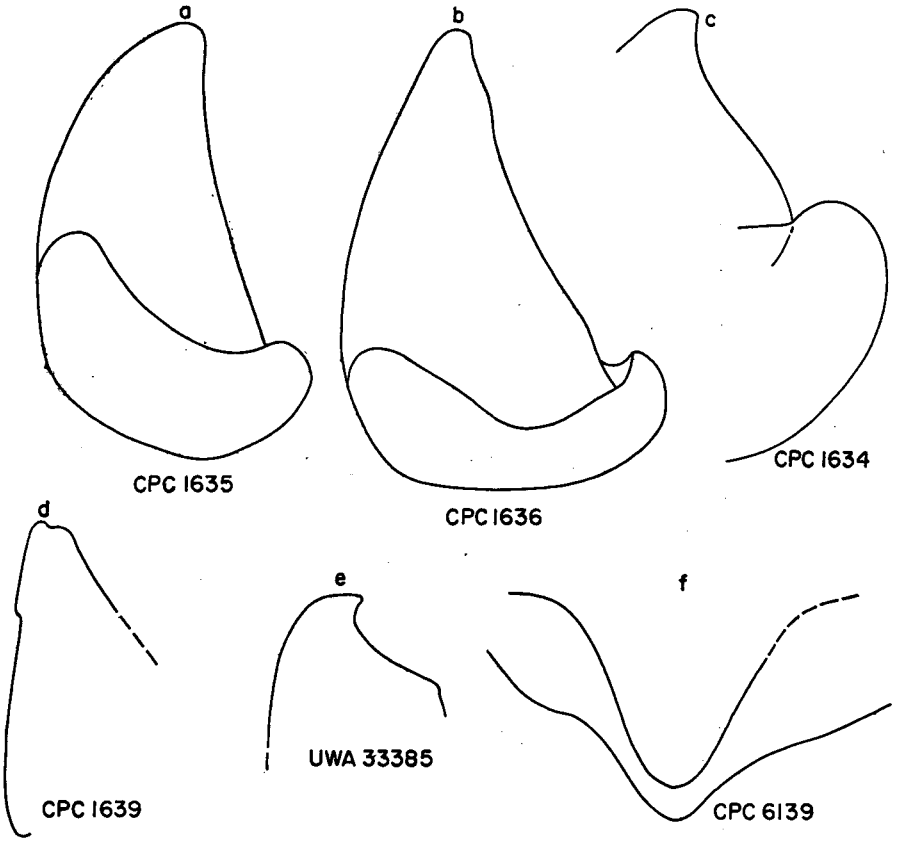

Fig. 53. *Pseudosyringothyris dickinsi* **sp. nov. Profiles of specimens illustrated on Plates 10-12. (f) Anterior view of incomplete dorsal valve. Dorsal surface below. Natural size.**

The delthyrial plate is flat to slightly concave and has a concave front margin. It extends from half to two-thirds of the delthyrial length and deepens to the front, where it can be 2 to 3 mm below the interarea in large specimens. The plate is marked by concave growth-lines parallel to its front margin. In two specimens, CPC1636 and CPC1635, there are remnants of the stegidium in front of the delthyrium. In the other specimens this is missing, presumably by detachment after death. In the holotype (Pl. 11, fig. 1c), the stegidium is somewhat abraded and consists of overlapping somewhat irregular arcuate lamellae or scale-like platelets, and apparently fits loosely on the front margin of the delthyrial plate. Four or five lamellae can be distinguished. A small

opening remains in front of the stegidium, but this may result from accidental damage to the specimen. In front, the stegidium rises to the level of the area; posteriorly it slopes back to the delthyrial plate. In CPC1635 (Pl. 20, fig. 2a) only disconnected platelet fragments remain.

The ventral surface has a pronounced and rounded sulcus which widens and deepens to the front. In median longitudinal profile, it is straight or nearly so. The boundaries of the sulcus are rounded. The flanks of the valve are flat to gently concave in transverse profile. They carry simple rounded costae which become faint towards the outer margins. The costae widen to the front, are rounded in section, but flatten somewhat to the front and have narrower rounded troughs between them. They number up to 18 on each flank but commonly are fewer. The front margin is deeply parasulcate (Pl. 10, fig. 2b; Pl. 11, fig. 1a).

The dorsal valve, which is much shorter than the ventral valve, is strongly convex in longitudinal profile, more so near the rather prominent umbo. The dorsal valve, in most, is gently convex in transverse profile and the fold is prominent and widens to the front. In the holotype and most other specimens, the fold rises rather steeply above the slopes of the flanks, but in a few, e.g. CPC6139, with a valve more convex than usual, there is a less abrupt charge of slope at the fold (Text-fig. 53f). The flanks carry simple costae like those of the ventral valve, numbering up to 17 on each side. The dorsal area is concave and apsacline to orthocline and has margins parallel to the width. It is crossed by numerous growth-lines but seemingly not by longitudinal striations. The umbo is somewhat overturned and may be fairly prominent.

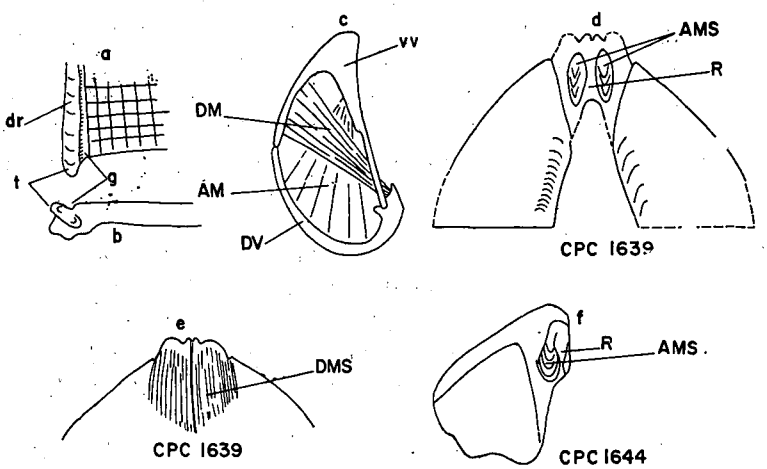

Fig. 54. *P. dickinsi.* **(a) Generalized sketch of delthyrial front edge and adjacent interarea. (b) Same in anterior view. dr—dental ridge, t—tooth, g—groove. (c) Semidiagrammatic sketch of shell in longitudinal profile section, showing muscle system. VV—ventral valve, DV—dorsal valve, AM—adductor muscles, DM—diductor muscles. (d) Dorsal view of internal mould showing adductor muscle scars (AMS) and median ridge (R) on delthyrial plate. (e) Ventral view of internal mould showing diductor muscle scars (DMS) (cf. Pl. 12, fig. 3a, b). (f) Ventral view of incomplete ventral valve (Pl. 10, fig. 5).**

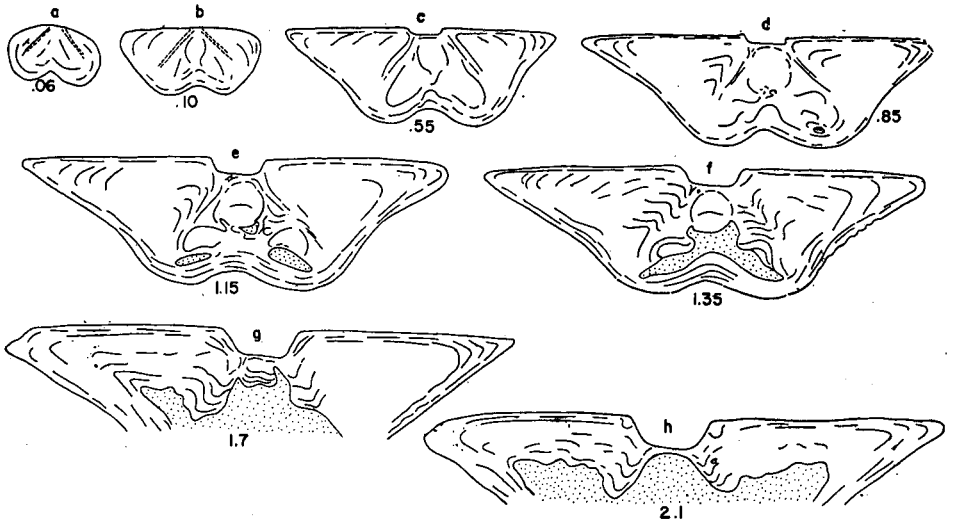

Fig. 55. *P. dickinsi.* **CPC1646, an incomplete ventral valve. Transverse sections. Delthyrial plate much thickened and apical cavities infilled. Dental flanges and adminicula are stout, x1.2.**

From 3 to 4 costae occur in 1 cm at the front of large specimens, decreasing from about 8 to 12 in 1 cm at 1 cm from the umbo. Costae appear to be flatter on the ventral valve. Both valves carry fine concentric growth-lines increasing in density towards the front, and in a few, fine lamellae are preserved.

The finer details of the ornament are rarely preserved. One specimen, CPC1641 (Pl. 12, fig. 4a, b, c), is a natural impression of the external surface of a dorsal valve. The micro-ornament consists of fine discontinuous radiating striae, interspersed with small low pustules. These are round to pear-shaped with wider end to the front. In the figures, which are enlarged eight times, the ornament is in reverse relief to the original shell surface. Pustules seem to vary in concentration over the surface.

The interarea is provided with a perideltidium. Plate 12, figure 2, and Plate 13, figure 3a, b, illustrate two examples. Figure 3a, b displays, on the lower right side, the fine bifurcating longitudinal grooves and growth-lines at right angles which mark the perideltidial surface. The area beyond this has radial striae and pustules like those on the remaining surface of the shell.

The inner surface of the valves is commonly fluted or pitted. Thus, CPC1639 (Pl. 12, fig. 3a) shows irregular longitudinal flutings which perhaps are vascular markings. Similar marks are shown on the dorsal valve of CPC1636 (Pl. 11, fig. 1b).

The shell is greatly thickened in the umbonal region and in consequence the dental plates vary in appearance. Invariably, however, their contact with

the ventral floor is shorter than their front margin at the delthyrium. Two series of sections through the umbonal region are illustrated in Text-figures 55, 56. These were drawn by tracing representative growth laminae and are therefore sketches of the successively accumulated thickness of various structures. The laminae cannot always be traced, especially, no doubt, where they are parallel to the plane of section or where the fibres are cut at right angles. The dental plates are a little different in the two sections. In CPC1646 (Text-fig. 55), they originate mainly by thickening of dental flanges arising from the delthyrial edge; they eventually reach the small adminicula on the floor of the valve. The plates diverge in both transverse and longitudinal section. The dental ridge at the side of the delthyrium is evidently a trace of the progressively developing tooth; it may show arcuate growth-lines. A small low median septum is present in the early stages of the two sections.

The section of CPC1645 (Text-fig. 56) shows that initially the dental plate was formed from a long thin dental flange and a low adminiculum. After the two

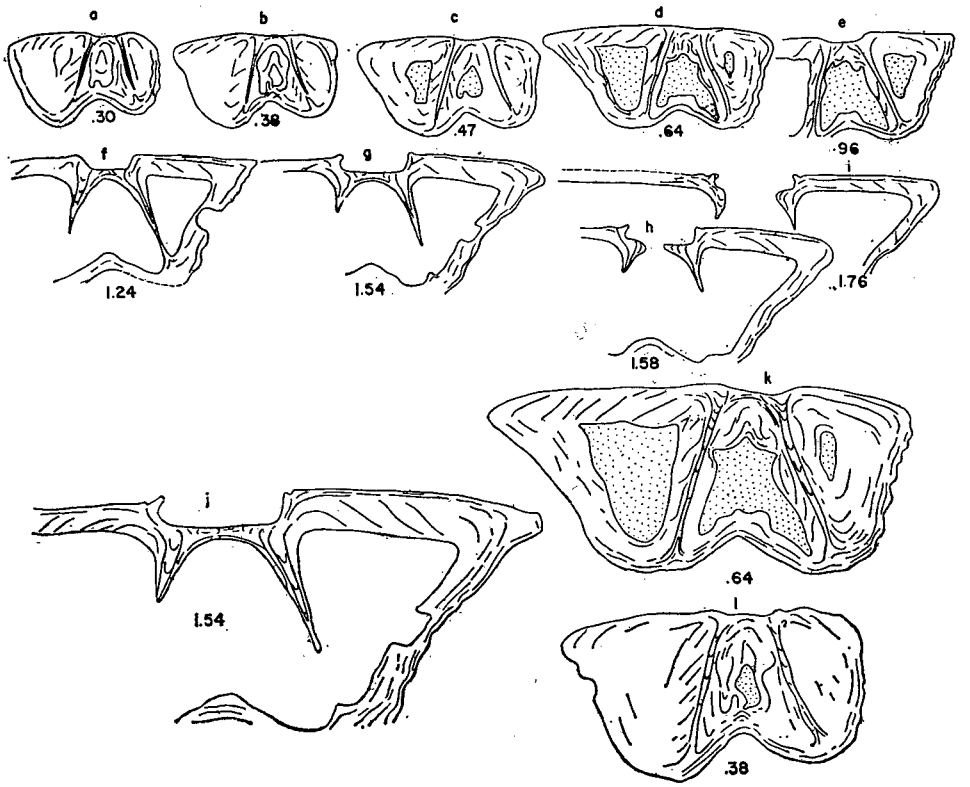

Fig. 56. *P. dickinsi.* **CPC1645, an incomplete ventral valve. Transverse sections. (a)-(i), x2; (j)-(l), x3.2. The initial dental lamella and low adminicula are fairly thin. They are unthickened in (f) and (g). (j)-(l) show the fairly thin initial dental lamella and adminicula, thickened in (k) and (l). The initial delthyrial plate in (j) seems to have been built up by growth from the sides as well as by forward growth in the middle. The dental plates and the walls in all apical cavities and delthyrial plates are thickened by more or less oblique lamellae.**

components joined, the plate was thickened by deposition of secondary shelly matter.

The delthyrial plate when initially formed is thin and flat, but internally, where the shell has been much thickened, irregular secretions are formed on its inside surface. It is generally flat and comparatively thin in front.

As will be described below, twin muscle scars separated by a median ridge can be seen on the inside of the plate. As the shell grows, these scars advance forwards and the old positions are covered by irregular deposits of callus. The ventral diductor muscle scar is large and longitudinally striated (Pl. 12, fig. 3b) and lies between and in front of the dental plates. In the illustrated specimen (CPC1639), two small projections of the muscular impression are broken from the apex on either side. These would have represented small dimples on the inside apex of the shell. The narrow median area seems to be too small to be an effective adductor scar. However, on the inner surface of the delthyrial plate of the same specimen (Pl. 12, fig. 3a), two oval striated muscle scars can be seen. Similar scars can be seen in Plate 10, figures 5 and 4b. In the latter specimen, the scars are nearer the apex than in the other. Many other specimens show such scars, commonly separated by a low median ridge. In front of the scars, the delthyrial plate is generally smooth. These scars are interpreted as the main ventral adductors, as shown in Text-figure 54c. The dorsal adductor scars extend as two rather narrow bands from in front of the cardinal process to near the front of the valve. The ventral diductors can extend forwards to a position about two-thirds of the total shell length. In the holotype they are about 1.7 cm wide and in CPC1639 they are 2.5 cm wide and 2.3 cm long.

The concave dorsal area is intersected by a widely divergent notothyrium, which is occupied by a massive cardinal process and socket plates. The cardinal process is large and oval, and made up of numerous longitudinal platelets. In CPC1638 (Pl. 11, figs 2a, b), there are 34 platelets at the posterior and dorsal side of the process. These coalesce ventrally to 19 and at the front all become fused. The very massive process of CPC1637 (Pl. 10, fig. 1) has about 25 platelets at the posterior end.

Flanking the process are strong recurved socket plates which have a pronounced rounded flange (crural plate) on their inner margins; the flange fuses with the front end of the process. In CPC1637 the process and socket plates form a kind of hinge-plate or shelf, but the more common structure is that shown by CPC1638. The socket grooves are deep and rounded and widen to the front. Their outer margin is the notothyrial edge to the dorsal area. The socket plates recurve, to the extent that they are present along the front edge of the dorsal area for some distance. CPC1640 (Pl. 12, fig. 1a, b) is a more delicate and smaller specimen, but similar to the others illustrated. The descending lamellae of the brachidia are broken from all the specimens, but originated from the front edge of the crural plate.

The dorsal adductor scars lie in front of the cardinal process and extend to near the front margin. The shape is uncertain, but the scar appears to narrow to the front and is divided by a low median ridge. Linear scars can be detected in the holotype (Pl. 11, fig. 1b). The spiralium is not adequately known. Its position can be partly seen in CPC1635 (Pl. 10, fig. 2a), where its axis is roughly parallel to the hinge-line and it tapers towards the ends. The maximum diameter is about 1.3 cm.

The shell varies considerably in thickness, especially in the umbonal region, where very thick deposits can be accumulated. In large specimens the shell wall is about 1-2 mm thick near the front margin, but is 4 mm in one specimen. The primary layer appears to be thin and is commonly missing as a result of abrasion. The inner fibrous layer forms the bulk of the shell. It is commonly laminate and the growth-layers can usually be readily traced. The lamination is partly caused by variation in the direction of the fibres of the various layers. In consequence, in a transverse section, on some layers the fibres are all at right angles to the section, and in other layers they are more or less parallel. The prismatic variant of the fibrous layer, common in *Spirifer* and allied genera, was not noted in the sections examined.

The shell is finely punctate in all the specimens examined, though the punctae cannot be seen over all the surface. The punctae penetrate the whole wall, usually at right angles, and are present on the ventral interarea. As the primary layer is usually missing, their relationships to it have not been determined. They appear to be simple fine tubes, with a diameter of about 0.01 mm. In the holotype, they have a density of about 4 per square mm in the sulcus. In CPC1634, the number varies from 1 to 2 or more per square mm in various parts of the shell. In thin section they are less readily discernible and appear to be sporadic in distribution. A somewhat exfoliated specimen is illustrated in Plate 29, figure 7. In the serial sections shown in Text-figures 55 and 56, punctae occur sporadically on the interarea including the perideltidium. The striations of the perideltidium appear to be quite superficial and are not paralleled by flexures in the secondary or fibrous layer.

Discussion: Specimens of *P. dickinsi* have been known since 1890. The specimens from the Gascoyne River named *Syringothyris exsuperans* (de Kon.) by Foord (1890, p. 149), but not figured, probably are the earliest record. Etheridge (1897, p. 46, figs A, B, C) assigned specimens from New South Wales and from the Gascoyne River to the same species. *Pseudosyrinx exsuperans* (de Koninck), as redescribed by Roberts (1964a) from the Lower Carboniferous of New South Wales, has a much lower area and is relatively wider than *P. dickinsi*. Etheridge's figure B, of the Gascoyne River specimen, is of interest as it clearly shows the muscle scars of the delthyrial plate and the median ridge between them.

P. dickinsi is similar in size to *P. borealis* Gobbett but has a relatively higher ventral area, narrower sulcus, and more numerous lateral costae (10 on each

flank in *P. borealis*). *P. karpinskii* Fredericks is insufficiently well known for comparison.

Its very high interarea, smooth fold and delthyrial plate muscle scars distinguish *P. dickinsi* from *Cyrtella nagmargensis australis* subsp. nov.

P. dickinsi is a very common species in the highly fossiliferous Callytharra Formation; it also appears to be present in the One Gum Formation of the Carnarvon Basin. It can be regarded as a useful index fossil for beds of the age of the Callytharra Formation and slightly younger. It is also common in the fossiliferous horizon at the base of the Poole Sandstone in the St George Range of the Fitzroy Basin and has been collected from near Well 27, on the Canning Stock Route, in the southern Canning Basin.

Geological Age: Lower Permian (late Sakmarian to early Artinskian).

Occurrences: CPA1634, GW75, 83 miles bearing 270° from Callytharra Springs, Carnarvon Basin, 13 feet above base of Callytharra Formation. CPC1635, Lands Dept Trig. Point K 52, Carnarvon Basin; Callytharra Formation. CPC1636, ML101, from a section in the Callytharra Formation, near Round Hill Well at lat. 23°21'S., long. 114°40'E.; 630 to 640 feet above base. CPC1637, 8, GW124, 14.8 miles bearing 59° from Towrana homestead, Carnarvon Basin; 58 to 78 feet above base of Callytharra Formation. CPC1639-42, KPA54, 16 miles bearing 120° from Mount Tuckfield, southern part of St George Range, Fitzroy Basin; base of Poole Sandstone. CPC1643, Well 27, Canning Basin, southern central part, lat. 22°49'S., 123°40'E.; Cuncudgerie Sandstone. CPC1644, G205, 2 miles east of Lyons River crossing, 1 mile south of Lyons River woolshed; Callytharra Formation. CPC1645, GW80, 2000 feet bearing 290° from Callytharra Springs; 10 feet above base of Callytharra Formation. CPC1646, GW114, 14 miles bearing 58° from Towrana homestead; 97 feet above base of Callytharra Formation. CPC1647, GW113, 14.4 miles bearing 56° from Towrana homestead, 30 to 85 feet above base of Callytharra Formation. CPC6139, GW88, 2000 feet bearing 290° from Callytharra Springs, 41 feet above base of Callytharra Formation. F17941, ML93; 0.25 miles southwest of junction of Lyndon River and Kialiwibri Creek; 320 feet above base of Callytharra Formation. F17942, 3, ML26, a section in Callytharra Formation, southeast of Donnellys well at lat. 24°6'S., 115°10'E., 155-160 feet above base of Callytharra Formation. F17944, GW86, 2000 feet bearing 29°0 from Callytharra Springs, 41 feet above base of Callytharra Formation. F17247a, b, TP78, 3.7 miles at 137° from Thambrong Pool, Williambury station; Callytharra Formation (about middle). UWA33385, from near south bank of Gascoyne River, 2.5 miles SSW of Lands Dept Trig. Station K39; Callytharra Formation.

This species is named in honour of Dr J. M. Dickins of the Bureau of Mineral Resources, Canberra.

Genus CYRTELLA Fredericks 1919 (1924)

Type species: *Cyrtia kulikiana* Fredericks, 1916.

Generic features: Punctate syringothyridinids, resembling *Pseudosyrinx* but with longitudinally grooved fold; considerable apical callosity in ventral valve. Dorsal cardinalia massive, recurved socket plates with strong crural plates on their inner sides, no supporting septum.

Discussion: The type specimens of *Cyrtella* were obtained from several localities in the Bolshezemelskaya Tundra, northern Russia, including Moy-Vadiaga, Kezhim-Terevoy River, and the Adzva River. I was unable to see Fredericks' specimens, which are said to be stored at the Academy of Science in Leningrad. However, I was kindly given a topotype specimen by Dr G. V. Kotlyar and was able to see other specimens from the Russian Far East. Fredericks described two varieties, *moy-vadiagae* and *adzvae*. The former is wider and has a lower area than the latter, but the two forms are otherwise similar. Ivanova (1960, p. 268, pl. LVIII, fig. 7a, b) figured the wider form from Kezhim-Terevoy River, to illustrate the type species. The ventral valve in the wider forms exceeds 9 cm in width and 4.5 cm in length; the ventral interarea is at least 2.2 cm high and has a perideltidium. The ventral flanks have at least 11 simple costae on each side. The sulcus is wide and apparently shallow. The dorsal fold has a distinct median furrow. The topotype specimen given to me agrees well with Fredericks' figures but has a slightly narrower sulcus. The shell is partly decorticated, revealing part of the internal mould. Scattered minute pustules occur on the surface of the mould. These are interpreted as the bases of punctae, which could also be detected as scattered slightly oblique fine perforations, infilled with dark matrix on both flanks and fold. This species has been generally assumed to be impunctate but Dr G. E. Chernyak (pers. comm.) has detected punctae on the interarea.

Grigoryeva & Kotlyar (1966, p. 49) have discussed the genus and illustrated certain features. A translation of their diagnosis is: 'Large pyramidal shell, always with high interarea. Apical apparatus: fairly long dental plates without median core; pseudodelthyrial plate. Microsculpture in the form of small papillae often arranged in concentric rows.' Their three sections (fig. 4) of the ventral umbo of *C. kulikiana* show a thickly calloused (infilled) delthyrial cavity and have not reached the lateral cavities; initial dental plates are not visible. They do not figure deeper sections. The delthyrial plate is described as formed by median contiguity of thickening from the sides of the 'pseudodelthyrial plate'. This specimen shows fine striate micro-ornament as well as pustules on parts of the surface. Some other specimens given to me by Dr M. V. Kulikov were identified as *Pseudosyrinx? kulikiana* Fredericks by Dr B. K. Licharew. They come from Artillery Springs, Barabash Region, Russian Far East. They are somewhat distorted natural internal moulds and impressions. They show fairly thin divergent dental plates with short adminicula. The dorsal cardinalia are very similar to those of

C. nagmargensis australis and *P. dickinsi* but less massive than the latter. A low median ridge occurs on the inside of the dorsal fold but this does not extend back to the cardinalia.

Grigoryeva & Kotlyar (1966, p. 49) record one other species, *C. kolymaensis* (properly *kolymensis*) (Tolmatchow) 1912 and state (p. 51) that *Cyrtella* is a Permian genus, most widespread in deposits of the upper half of the Lower Permian and the lower part of the Upper Permian. It occurs in both the Urals and northeast USSR.

Licharew (1934a) described *C. kolymensis* from Kolyma and in 1939 described *C. kulikiana* as a variety of *C. kolymensis,* referring both to the genus *Pseudosyrinx.*

It seems appropriate to include *C. nagmargensis* Bion and the new subspecies *australis* in *Cyrtella.* They are punctate syringothyridinids with a grooved fold. More detailed sectioning of *C. kulikiana* is required to see if the structure of the dental plates is significantly different to warrant generic separation. Grigoryeva & Kotlyar contrasted *Cyrtella* with *Orulgania* Solomina, which has initial dental plates.

Plodowski (1968) has erected a new syringothyridinid genus *Punctocyrtella,* type species *P. spinosa* Plodowski, from the Lower Permian of Afghanistan. Dr Plodowski kindly showed me his specimens early in 1968, at Bonn University. *P. spinosa* is evidently closely related to *C. nagmargensis* (Bion) from Kashmir. Plodowski does not record this in his account but it may be inferred from his time range for the genus—'Agglomeratic Slate Series, Upper Carboniferous to Lower Permian. Distribution: Afghanistan, Kashmir, Arabia, Australia'. *Punctocyrtella* was not expressly compared with other genera, but the diagnosis includes 'fold with median furrow'; the ventral valve has dental plates and delthyrial plate without syrinx. The dorsal valve is without apical plates. The shell is punctate. *P. spinosa* has 18-25 simple lateral costae. The sulcus is narrow, deep, subparabolic in cross section, with obsolete ribbing. The dental plates are outside the sulcus and strongly divergent. The delthyrial plate is short and thick. The ventral muscle field is very large and deeply impressed. The apical callosity is strong. The width at the hinge-line is 2.5-3.5 times the length of the shell, and the height of the concave apsacline ventral interarea is 1/6 of the width at the hinge-line. Plodowski figured the externals only of one specimen, which is about 7 cm wide. The micro-ornament is recorded as 'concentric growth lines with marginal upright spines'.

Since *Cyrtella* is most probably punctate, *Spinocyrtella* is probably a synonym. However, *C. nagmargensis* may be referable to *Spinocyrtella* should the dental plates prove to be significantly different from those of *C. kulikiana.*

Cyrtella, as interpreted here, is a Permian genus occurring in Northern Russia, near the Urals and at Kolyma and elsewhere in the Russian Far East. Outside

Russia, it occurs in Kashmir, Arabia, Afghanistan, in the Carnarvon Basin of Western Australia, and possibly in the Himalayas and the Karakorum.

CYRTELLA NAGMARGENSIS (Bion) AUSTRALIS subsp. nov.

(Pl. 11, figs 3, 4, 5, 6; Pl. 27, fig. 2; Text-figs 57, 58)

Diagnosis: Large wide subspecies attaining 10 cm in width; interarea high but lower than in *P. dickinsi,* slightly concave to flat and inclined at about 90°; apical angle 120°-130°, perideltidial angle 96° (one specimen), delthyrial angle moderately wide at 33°; wide shallow sulcus, slightly concave flanks, very sinuous front commissure with prominent tongue; dorsal valve with prominent fold with median groove of variable depth; short ventral adminicula; 14-15 round to flattened costae on each flank. Finely punctate.

Material: Two internal moulds of dorsal valves, an incomplete internal mould of a ventral valve, and a number of fragments of external impressions; two dorsal valves; two, more or less complete but crushed, shells.

TABLE 18: Dimensions of *Cyrtella nagmargensis* (Bion) *australis* subsp. nov. (in cm)

Specimen Number	L	Lb	Whl	Wsf	Wff	Ha	I	Aa	Da	Pa	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1648		3.80			1.55								13	
CPC1659	2.20		10.0e			2.60 (internal mould)								
CPC1650		3.55	9.7e		1.56									
CPC1651		3.90			1.70									
CPC1652	3.5+		10.0e		2.00	2.70		130°	33°	c96°	15	13+		14
CPC1653	3.90	3.30	8.0+	2.2	2.00	3.10	90°						15	
F17945		3.55	9.0e											

Description: The shells are large and very wide. The ventral valve is wedge-shaped in longitudinal profile, with a high, wide, and flat to slightly concave interarea. The area is 2.7 cm high and about 10 cm wide in CPC1652 and 3.1 cm high and 8 cm wide in CPC1653 (the holotype), both from the Callytharra Formation. The internal mould CPC1649 (Pl. 11, fig. 6a, b) is estimated to be 10 cm wide and the inner height of the interarea is 2.6 cm. The delthyrium of CPC1652 (Text-fig. 57a-c) is 1.4 cm wide at the hinge-line and is thus comparatively narrow, with an angle of 33°; the perideltidial angle is wide (about 96°). The umbo is slightly upturned at the tip. The apical angle in CPC1652 appears to be about 130°, but cannot be precisely measured; in CPC1653 it is about 120°. The interarea has gently convex lateral margins and its junction with the ventral surface is at an acute, nearly right angle. The area is inclined at about 90° in CPC1653. The ventral surface is moderately convex in transverse profile, but with slight concavities on the lateral slopes. The thickness of the two more or less complete valves CPC1652 and CPC1653

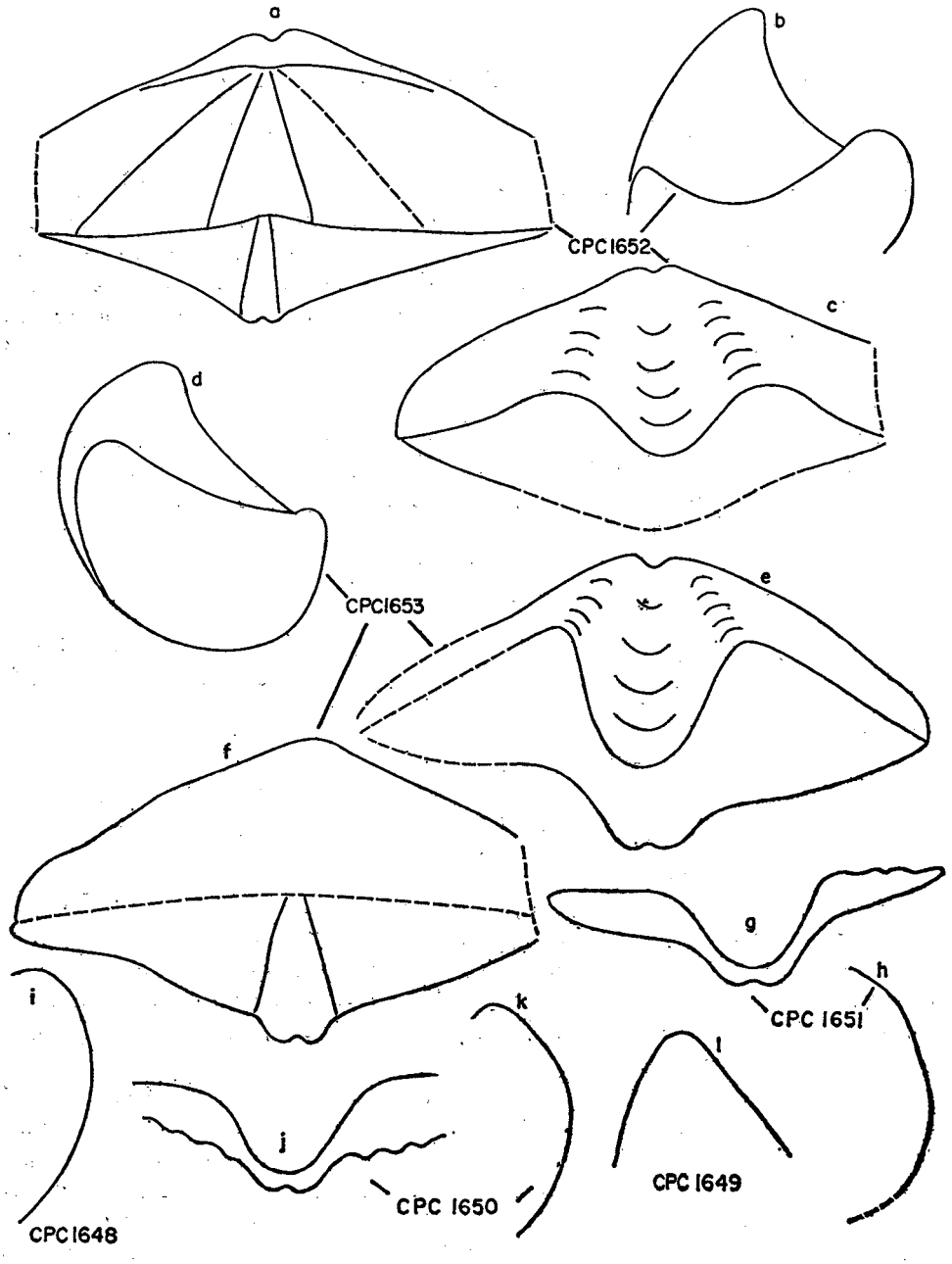

Fig. 57. *Cyrtella nagmargensis australis.* (a)-(c) Posterior dorsal, profile, and ventral views of an incomplete shell. (d)-(f) Profile, ventral, and posterior dorsal views of incomplete shell. (g)-(l) Profiles and anterior views of specimens illustrated in Plate 11. Natural size.

is 2.8 and 2.9 cm respectively. The sulcus is rounded and has rounded margins; it widens at an angle of 45° to 50° towards the front. The front margin is deeply folded and has a strongly developed ventral tongue, and in CPC1653 (Text-fig. 57) is extraordinarily sinuous. Thus, the length from umbo to front edge in the middle of the sulcus is 4 cm and at the side of the sulcus is 2.3 cm. The specimen CPC1649, although incomplete, appears to have a similar front margin (Pl. 11, fig. 6a); it is more deeply sulcate than CPC1653. The ventral costae are wide, rounded, and have narrower interspaces: in CPC1652 there are 15 on the left flank.

The dorsal valve (Pl. 11, figs 3, 4, 5) is distinctive. In tranverse profile, it is gently convex, but with a steep fold, furrowed by a median groove or sinus which deepens and widens to the front. The depth of the groove varies from specimen to specimen but is distinct in all. The dorsal umbo is prominent and slightly overturned. The longitudinal profile is strongly convex. The front margin is plicate but not apparently sulciplicate. The more or less orthocline dorsal area is about 2.5 mm high near the middle and gently tapers to the ends of the hinge-line. The cardinalia resemble those of *P. dickinsi,* but are less massive, the socket and crural plates being similar in shape and inclination. The dorsal surface carries 13-15 costae, rounded like those of the ventral valve; the troughs are of nearly the same width as the costae, which number 4-5 in 5 mm at the front near the fold. The surface ornament, as seen in a small portion of F17946, is similar to that of *P. dickinsi,* i.e., it has pustules interspersed with short striae. Fine concentric growth lines can also be discerned.

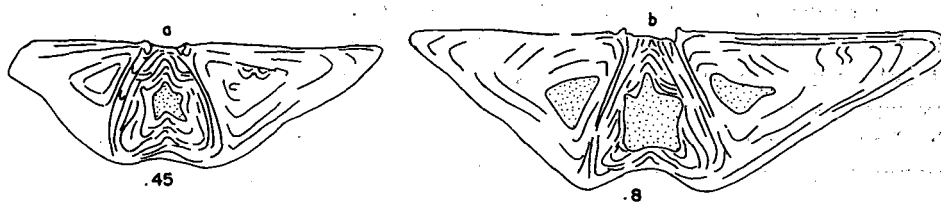

Fig. 58. *C. nagmargensis australis.* **CPC1653, an incomplete shell. Transverse sections, x2. (b) is shown enlarged in Plate 27, figure 2.**

Internal features are not well displayed. The incomplete internal mould (CPC1649) possesses dental plates apparently like those of *P. dickinsi;* their contact with the floor is short and they diverge beyond the sulcus. The diductor muscle scar is longitudinally striate and extends well in front of the dental plate. A delthyrial plate could be seen in CPC1652, but its internal surface is unknown. Sections were made near the umbo of CPC1653 (Pl. 27, fig. 2; Text-fig. 58a, b). The inner surface of the delthyrial plate and the nearby parts of the dental plates are greatly thickened by secondary shelly deposit. The dental plates were initially formed from long dental flanges and short adminicula. There is no syrinx. The shell is punctate, with fine punctae like those of *P. dickinsi* in all shells.

Discussion: The Western Australian specimens appear to be close to *P. nagmargensis* (Bion, 1928) from the Agglomeratic Slate of Kimsar and Nagmarg in Kashmir. Bion's specimens possess a prominent deeply furrowed fold on the dorsal valve, and three specimens are 9.6, 11.8, and 12.6 cm in width. His one figured ventral valve, an internal mould (Bion, 1928, pl. 11, fig. 3) has dental plates, widely divergent as in CPC1649 but extending much farther along the floor of the valve to about half the shell length. Reed (1932) described and figured several more examples. The fold is distinctly furrowed, but not necessarily at the front margin. The lateral costae are from 10-15 in number and are described as 'sharply rounded'. The area is high, although Reed does not record dimensions, but his figure (pl. VI, fig. 2c) shows the palintrope of a mould to be about 1.7 cm in height. The area is inclined at 90° to the 'plane of the valve'. Reed claimed that there is a syrinx, but his figures and examination of the specimens show that the inside of the delthyrial plate is fairly smooth (pl. VI, figs 3, 3a) and that the supposed syrinx is a dimple (a small apical callosity) at the umbonal tip of the internal mould. Bion sectioned two specimens and saw no syrinx, and stated that the internal moulds showed no syrinx. Read observed that the shell was punctate and transferred the species from *Spirifer* to *Syringothyris*. This is not acceptable, in view of the absence of a syrinx, and the species can be included in *Cyrtella.*

The new subspecies is distinguished from the Kashmir forms by the sinuosity of the front commissure, by the projecting tongue at the sulcus of some specimens and by shorter ventral adminicula.

C. nagmargensis has been recorded from the Lower Permian of the Karacorum Range by Renz (1940) and from the Anthracolithic (probably Lower Permian) of Subansiri in the Eastern Himalayas by Sahni & Srivastava (1956), but the specimen is inadequate for certain identification. It was also described from the Lower Permian of southeast Arabia by Hudson & Sudbury (1959). Their specimens are like the types in most details but are smaller.

C. nagmargensis australis is larger, and has a more sinuous commissure and more lateral costae, than *C. kulikiana* (Fredericks). It seems to have fewer lateral costae than *C. spinosa* (Plodowski), which is also smaller and less sinuous at the commissure and apparently has more pronounced spines.

C. nagmargensis australis stratigraphically overlaps *P. dickinsi,* from which it differs by its lower ventral interarea and grooved fold as well as structures of delthyrial plate. It is moderately abundant in the Lyons Group, but rare in the Callytharra Formation, in which *P. dickinsi* is common.

Geological Age: Lower Permian (Sakmarian to early Artinskian).

Occurrence: All localities are in the Carnarvon Basin. CPC1648, 1649, F17945-8, 1.8 miles northwest of Coyango Well, Williambury station; Lyons

Group, about 1750 feet below top. CPC1650, MG158, 360 feet west of a point on the rabbit-proof fence, 3.4 miles south of Coyango Well; 1090 feet below top of Lyons Group. CPC1561, TP78, 3.7 miles bearing 137° from Thambrong Pool, Williambury station, about middle of Callytharra Formation. CPC1652, GW88, 2000 feet, bearing 290° from Callytharra Springs; 57-58 feet above base of Callytharra Formation. CPC1653, GW75, 4400 feet, bearing 270° from Callytharra Springs, 13 feet above base of Callytharra Formation.

Genus PSEUDOSYRINX Weller, 1914

Type species: *Pseudosyrinx missouriensis* Weller.

Generic features: See discussion on p. 138.

PSEUDOSYRINX? SINUOSA sp. nov.

(Pl. 13, figs 1, 2; Pl. 30, figs 6, 7, 8; Text-fig. 59)

Diagnosis: Large wide species, apical angle about 130°, interarea high (but lower than in *P. dickinsi* and *C. nagmargensis australis*), delthyrial angle wide (43-50°); sulcus shallow, wide and rounded; very sinuous front commissure; dorsal fold simple and moderate, lateral swelling on each dorsal flank; about 12 rounded costae on each side; micro-ornament of fine short striae.

Material: Two more or less complete internal moulds, an incomplete dorsal internal mould, an incomplete ventral impression and fragments.

Description: The holotype, CPC1654 (Pl. 13, fig. 1a-e: 1d, e are latex impressions), is an internal mould. A latex cast of paratype CPC1656 (Pl. 30, fig. 6a, b) shows the general form of the ventral valve. The shell is wide, with a high gently concave interarea, upturned a little at the beak. The apical angle in CPC1656 is about 130°, but is not accurately measurable. The interarea is obscured and it is not certain that it possesses a perideltidium. Its junction with the ventral surface is abrupt at about a right angle or more acutely. The ventral surface is moderately convex but with a concavity on the outer flanks. The sulcus is wide and shallow, with rounded floor and rounded prominent margins. The front margin is sinuous, with a prominent tongue at the sulcus. The delthyrial plate in CPC1656 is depressed about 2 mm below the interarea in front, where its margin is concave; it extends about half the length of the delthyrium.

The dorsal valve, as shown by the internal moulds and by CPC1657, an external impression (Pl. 30, fig. 8), is gently convex in longitudinal profile, and has a prominent rounded fold. There is a gentle swelling on each flank and a slight

depression bordering the fold. The valve is moderately convex in longitudinal profile.

TABLE 19: Dimensions of *Pseudosyrinx? sinuosa* sp. nov. (in cm)

Specimen Number	L	Lb	Whl	Wsf	Dw	Ha	I	Aa	Da	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
CPC1654	3.00	2.76	9.14e	c2.0	1.10	1.95			43°			10+	
CPC1655	2.45	2.45	7.0e	c1.5	1.3	1.70			c50°	12+			
CPC1656	3.50		8.0e		1.35	1.90	c90°	c130					
CPC1657	2.8e		6.0e						10°+				

Internally the dental plates are strongly divergent and lie well beyond the sulcus. In CPC1656 they extend about half the shell length, but in the internal moulds the adminicula are shorter. The shells are evidently much thickened in the umbonal region. Internally the delthyrial plate is thick and fairly smooth. In Plate 13, figure 1e, the delthyrial plate has a pair of depressions with a median swelling, near the apex. These may be similar to the paired muscle scars found on the delthyrial plate of *P. dickinsi.* The small dimple at the front of the delthyrial plate in figure 1e is an artefact formed by a bubble in the latex cast. The diductor muscle scars on the ventral floor extend well in front of the dental plates. In CPC1654 they appear to be transversely oval with a width of 2.10 cm and length of 4.05 cm. There are traces of crossed lineation on them and some indication of a differentiated part near the middle at the posterior end. This portion may be part of the adductor scar as it is in contact with the pair of depressions on the inside of the delthyrial plate.

Internally, the dorsal valve is similar to that of *P. dickinsi* and the cardinalia are of much the same shape, though less massive. The dorsal area in CPC1658 (Pl. 30, fig. 7) is about 3 mm high and gently concave. The dorsal adductor scar extends from a depression in front of the cardinal process to near the front of the valve. In CPC1654, it is about 2 cm or more long and about 1.1 cm wide. A low median ridge is present on the scar.

Reconstruction of the muscular system of CPC1654 suggests that the ventral adductor muscle was attached in part to the posterior end of the delthyrial plate and partly to the posterior end of the ventral floor. Possibly the attachment position migrated during growth of the shell.

The external surface is illustrated in Plate 30, figure 8. The costae cannot be numbered accurately in any of the specimens, but there are at least twelve on each flank. They vary in size in a somewhat unusual way: in addition to widening to the front, those on the dorsal lateral swelling are wider than those on either side of it. They are gently and somewhat flatly rounded and have narrower interspaces. The surface is marked by concentric growth-lines. The micro-ornament consists of fine short striae, as in *P. dickinsi,* but pustules

appear to be rare. In their place are numerous fine pits which perhaps mark the position of the punctae. In the absence of shelly material punctae cannot be confirmed.

Discussion: *P? sinuosa* is included only provisionally in *Pseudosyrinx* as it is not certain that it possesses a perideltidium or punctae. It is possibly referable to a genus of the Licharewiinae, but none of the described species appears to be close. In shape it partakes to some degree of the characters of both *P. dickinsi* and *C. nagmargensis australis,* but has a lower interarea than the former and lacks the grooved fold of the latter. It is not closely comparable with other described species.

It is so far known only from the lower part of the Permian Madeline Formation in the Wooramel River area and from correlated beds south of the Gascoyne River. It may prove to be useful as an index fossil.

Occurrence: CPC1654-8, F17949, from WB66, 3.4 miles, bearing 212° from Keogh Hill, Carnarvon Basin; lower part of Madeline Formation. F17950, from GW50, 10 miles bearing 308° from Windarie homestead, Carnarvon Basin; near base of Coyrie Formation.

Superfamily RETICULARIACEA Waagen, 1883

(nom. transl. Pitrat, 1965, ex Reticulariinae Waagen, 1883, p. 538)

The definition and content of the superfamily are in need of further study. Pitrat (1965) included the families Reticulariidae Waagen, 1883, Elythidae

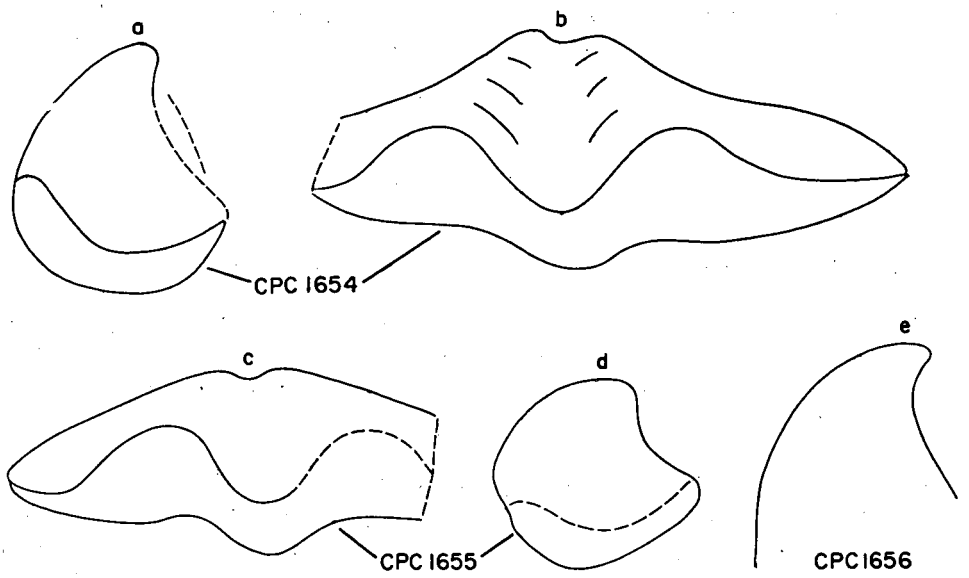

Fig. 59. *Pseudosyrinx? sinuosa.* **(a)-(d) Profiles and anterior views of internal moulds illustrated in Plate 13. (e) Profile of specimens illustrated in Plate 30.**

Fredericks, 1919 (1924), and Martiniidae Waagen, 1883. The Martiniidae lack spinose ornament and should not be included. Ivanova (1959, 1960) grouped the Reticulariidae (with subfamilies Reticulariinae and Elythinae) together with Delthyridae, Ambocoeliidae, and Martiniidae in the superfamily Delthyriacea. The Reticulariidae and Elythidae are distinctive in their ornamentation and Ivanova's classification is not adopted here. Pavlova (1967) has recently discussed the group. It is arguable whether or not the group of reticulariaceans with biramous spines should be grouped as a family or subfamily, but Pitrat's arrangement is provisionally accepted.

Family ELYTHIDAE Fredericks, 1919 (1924)

(nom. transl. Pitrat, 1965, ex Elythinae Fredericks, 1919 (1924), p. 304)

= Phricodothyrinae Caster, 1939.

Diagnosis: Smooth to gently plicate biconvex Spiriferida, rounded cardinal extremities; ventral interarea small, may be ill defined, fold and sulcus slight or absent, flanks smooth or slightly plicate; anterior commissure rectimarginate to weakly uniplicate; micro-ornament of concentric growth lamellae, each with row of fine biramous spines, and in some interspinous pustules; internal apical structures variable, generally with fine, internal radial ribs. Middle Devonian to Permian.

Discussion: The diagnosis is modified from Pitrat (1965) and Ivanova (1960). The internal structures are very variable in this group, as indicated by the discussions of George (1932), Minato (1953), Campbell (1955, 1961), Maxwell (1954, 1961), Minato & Kato (1963), Roberts (1965a), and others.

Genus KITAKAMITHYRIS Minato, 1951

Type species: *Torynifer* (*Kitakamithyris*) *tyoanjiensis* Minato, 1951.

Generic features: Elythids with biramous spines, generally in radial rows, lacking interspinous pustules; ventral interior with dental plates and median septum; dorsal valve lacking concave hinge-plate and strong supporting septum; interior finely radially ribbed.

Discussion: *Kitakamithyris* was discussed by Minato (1953), Maxwell (1961), Campbell (1955, 1961), Roberts (1965a), and Pavlova (1967). The Carboniferous elythid species so far described from eastern Australia all possess dental plates and median ventral septa and were referred to *Kitakamithyris* by Maxwell (1961, 1964) and Roberts (1964a, 1965a).

The species *K. moogooriensis* sp. nov. possesses small dorsal adminicula in addition to the ventral structures of *Kitakamithyris*. Small dorsal adminicula are found also in the type specimen of *Martinothyris* Minato, which, as pointed out by Maxwell (1961, p. 98), is either an invalid genus or synonymous with *Phricodothyris* George. Minato (1953, p. 70) named as type specimen of *Martinothyris* the specimen figured by George (1932, p. 545) of *Phricodothyris lineata* (Martin). In Opinion 420 of the International Commission of Zoological Nomenclature, p. 132, 1956, it was ruled that the type specimen of *Terebratula? lineata* Sowerby, 1822, is the lectotype selected and figured by Muir-Wood (1951, pl. 5, fig. 4a-c). This specimen is stated by Muir-Wood to lack dental plates and is thus probably similar to *P. lucerna* George, type species of *Phricodothyris*. Martin's species, including *Conchyliolithus anomites* (*lineatus*) Martin, 1809, had earlier been invalidated by the ICZN in 1948. The type specimen of *Martinothyris* shows small dental plates and dorsal adminicula and was one of the topotypes of the neotype of *Phricodothyris lineata* (Martin) selected by George. The type specimen of *Martinothyris,* if it is specifically distinct from *P. lineata* (Sowerby), is therefore unnamed. Consequently *Martinothyris* is either synonymous with *Phricodothyris* or invalid. Minato (1953) did not refer any other specimens or species to *Martinothyris*. Minato & Kato (1963) validated another of Minato's genera, *Nebenothyris,* but so far as I know *Martinothyris* has not been validly established. Pitrat (1965, p. H723, fig. 588, 1) incorrectly shows *Martinothyris* as a valid genus. He cites the ICZN Opinion 420, establishing *Terebratula? lineata* Sowerby as a valid species, but his illustrations are reproductions of George's invalid neotype of *'P. lineatus* (Martin)' and George's figure 6.

From the description by George (1932, p. 543-546, figs 6, 7, pl. 35, figs 1a-d), *'Phricodothyris lineata* (Martin)', from D Zone, Castleton, Derbyshire, is very variable internally. Topotypes can possess small dental plates and dorsal adminicula or lack them completely. The value for generic distinction of such impersistent characters is very doubtful.

K. moogooriensis sp. nov. is included in *Kitakamithyris* Minato because of its strong dental plates and low ventral median septum and its resemblance to *K. tyoanjiensis* Minato and some of the eastern Australian species. The small adminicula are regarded as variable features of no more than specific significance.

KITAKAMITHYRIS MOOGOORIENSIS sp. nov.

(Pl. 20, figs 10, 11; Text-figs 60, 61)

Diagnosis: Medium-sized species, width exceeds length; prominent umbo, apical angle 113°-118°; strongly biconvex, nearly rectimarginate; ventral interior with strong dental plates diverging at 36°, long low median ridge; dorsal interior with small divergent socket and crural plates, small dorsal adminicula, and low median ridge.

Material: Seven poorly preserved isolated valves and one internal mould of a ventral valve. The larger valves are partly embedded in tough calcareous matrix.

TABLE 20: Dimensions of *Kitakamithyris moogooriensis* sp. nov. (in cm)

Specimen Number	L	Lb	Whl	Wm	Ha	Aa	Da	Dpa	Ldp	W/L
CPC1630	2.25			c2.6e		118°e	55°	36°	1.2+	1.15
CPC1632				2.6e						
CPC1684		2.4e		3.30						
F17940	c2.40		2.05	c3.2e	.60	c113°				1.34

Description: The species is medium-sized for the genus; one ventral valve is about 3.2 cm wide and at least 2.4 cm long. Both valves are strongly convex, and the outline is transversely elliptical, with a prominent rounded umbo. There is very little or no sulcus on the ventral valve and no fold on the dorsal valve; hence the front margin is probably rectimarginate. The umbo is overturned at the beak and has apical angles of 113° and 118° in two measurable specimens. In specimen F17940, the shoulders are slightly concave and the interarea is 0.6 cm high, apsacline, and gently concave. The hinge-line is 2.0 cm long, roughly two thirds of the maximum width.

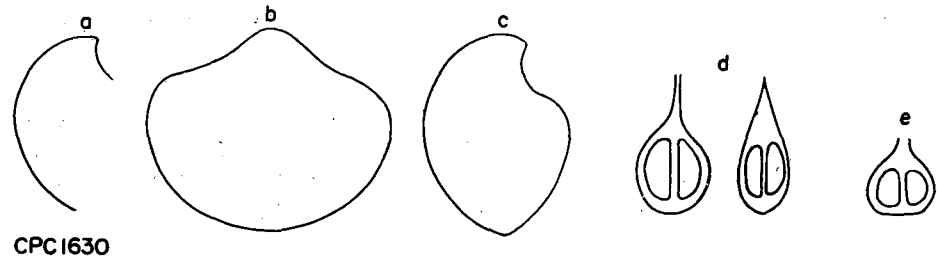

Fig. 60. *Kitakamithyris moogooriensis.* **(a) Profile of ventral valve illustrated in Plate 20. (b), (c) Composite ventral view and profile. Natural size. (d), (e) Arrangements of spine bases on different parts of surface of CPC1684, x20.**

The surface is ornamented with concentric bands carrying rows of radially aligned biramous spine bases. The spinose bands are lamellate in front and their density increases to the front. Thus in CPC1684 (Pl. 20, fig. 11), a dorsal valve, the bands are spaced at 8 in 5 mm of length near the middle and at 14 in 5 mm of length near the front of the shell. The spine bases also vary in size; near the middle of CPC1684 there are 18 for 5 mm distance, in a concentric row. The spine bases extended across each band with their front close to the edge of each lamella (Text-fig. 60d, e).

The interior of the ventral valve is well shown in a ventral mould, CPC1630, the holotype (Pl. 20, fig. 10a, b). The valve was thin-shelled and the dental plates are thin and long (over 1.2 cm), diverging at about 36° on the floor of

the valve. The front extension of the plates is slightly more divergent. A fairly low median ridge extends for nearly 2 cm from the tip of the umbo. The muscles are lightly impressed, but linear grooves can be distinguished between the dental plates and close to the median ridge. The whole inner surface is faintly radially ribbed with some concentric banding. Two specimens were sectioned. One of these, a rather crushed shell, CPC1631, confirms the presence of long thin dental plates and a median ridge (Text-fig. 61a-1). There is a slight median ridge at the umbo of the dorsal valve, but no hinge-plate and supporting septum such as occurs in *Torynifer dorsiseptatus* sp. nov. Sections in the umbonal region of a dorsal valve, CPC1684, confirm the absence of a concave hinge-plate and dorsal septum (Text-fig. 61m-p). The socket and crural plates are similar to those illustrated by George (1932) in sections of *Phricodothyris* and *Reticularia.* They are not supported on the floor of the valve, but come from the area; near the umbonal tip of CPC1631 the shell is strengthened by a pair of very short adminicula similar to those of *Phricodothyris lineata* (George, 1932, fig. 6). These were not seen in CPC1684, which is abraded in this region. Other specimens possess a low median ridge in the dorsal umbonal region, but it is not known how far this extends to the front. The cardinal process is presumably at the thickened region seen in Text-figure 61d, e, and m. Text-figure 61 suggests that the muscle platelets extend a little in front of the thickened portion. The brachidium was not preserved in the sections.

Discussion: *K. moogooriensis* sp. nov. is represented by a rather sparse collection but is a distinctive species. It appears to be fairly close in shape to *K. tyoanjiensis* Minato, which is somewhat larger. Minato (1952) described it as lacking a

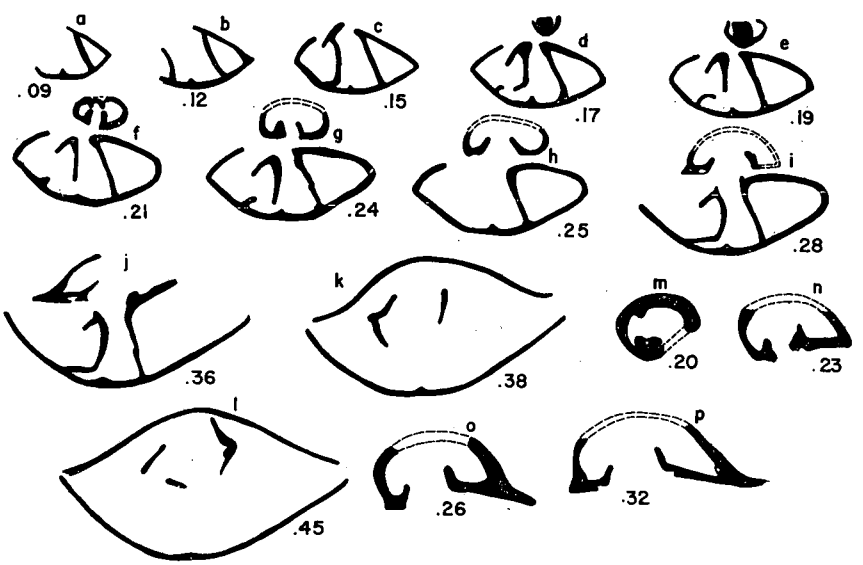

Fig. 61. *K. moogooriensis.* **Transverse sections. (a)-(l) CPC1631, an incomplete crushed shell, x2.5. (m)-(p) CPC1684, an incomplete dorsal valve, x2.**

dorsal septum, but one of his figures (pl. 9, fig. 4a) suggests a slight median dorsal ridge. The species occurs in the Tournaisian Hikoroiti and Arisu formations of Japan. The specimens which Maxwell (1954) described as *Phricodothyris lineata,* from the late Tournaisian to early Visean of the Mount Morgan district, Queensland, are apparently similar in form and with comparable ventral internal structure. *K. globosa* Maxwell, 1961, from the Visean of Old Cannindah, Queensland, agrees in being only slightly sulcate but is much more convex. The other east Australian species described by Campbell (1955, 1961), Cvancara (1958), and Roberts (1964a, 1965a) are uniplicate and have stronger median ventral septa.

Reticularia cooperensis (Swallow) as described by Sanders (1958) from the early Mississippian of Sonora, Mexico, has certain resemblances. The outline is similar to *K. moogooriensis* but the species is smaller and the ventral median septum more pronounced. Sanders' specimens lack the hinge-plate of *Torynifer,* to which the species has been referred by Shaw (1962).

Geological Age: Tournaisian.

Occurrence: All specimens CPC1630-2, CPC1684, F17937-40, from CC120, Carnarvon Basin. Moogooree Limestone, about 478-88 feet above base.

Genus TORYNIFER Hall & Clarke, 1894

Type species: *T. criticus* Hall & Clarke 1894 = *Spirifer pseudolineata* Hall, 1858.

Generic features: Smooth elythids, width generally exceeds length, outline subelliptical, biconvex longitudinally, generally uniplicate; surface ornament of concentric lamellae bearing biramous spines, without interspinous pustules; dental plates strong, median ventral septum usually fairly well developed; dorsal interior with long concave hinge-plate supported by a low median septum; interior finely radially ribbed.

Discussion: Cooper (1942, p. 229) pointed out that the specimen on which Hall & Clarke had founded *Torynifer* was a member of the species *'Reticularia' pseudolineata* (Hall). It was part of a dorsal valve showing the concave hinge-plate and septum, and Hall & Clarke (1894, pl. 84, figs 34, 35) had mistaken it for a ventral valve with a spondylium. The above summary is modified from Cooper (1944, p. 327). The range of the genus in North America is from the late Devonian Percha Shale (Stainbrook, 1947, referred by Cooper (1954, p. 325) to the Upper Devonian) to the late Mississippian Chester Group. Shaw (1962) listed eight species from the Mississippian as belonging to *Torynifer.* These are *T. cooperensis* (Swallow), *T. tenuispinatus* (Herrick), *T. temerarius* (Miller), *T. pseudolineatus* (Hall), *T. salamensis* (Weller), *T? glaber* (Branson),

and *T. montanus* Shaw. Of these, he regards *T. glaber* as synonymous with *T. pseudolineatus*. Shaw did not illustrate or discuss the internal details of *T. montanus* or of the other species. The internal structure of the type specimens of *T. cooperensis* (Swallow) has not been described. Some specimens described by Sanders (1958) from Sonora, Mexico, as *Reticularia cooperensis* (Swallow) appear to belong to *Kitakamithyris* (see p. 162). As far as I know, only in *T. pseudolineatus, T. setigerus,* and *T. spinosus* have a concave hinge-plate and septum been definitely recorded.

Reticularia pseudolineata (Hall) has been reported by Nalivkin (1937) from northeast Kazakhstan and by Simorin (1956) from the Karagandian basin. As the internal structures are not described, reference to the species is unsubstantiated. Ivanova (1960) recorded *Torynifer pseudolineatus* from the Lower Carboniferous of the Kuznetzk Basin. She illustrated a transverse section (fig. 394), which shows a concave hinge-plate and supporting septum in the dorsal valve, thus confirming the identification of the genus. The section also shows a small delthyrial plate as well as dental plates and low septum in the ventral valve. Besnossova in Besnossova et al. (1962) and Sarytcheva et al. (1963) also illustrated sections and described a new subspecies *T. pseudolineatus asiaticus* ranging from the Tournaisian (Taidonsk horizon) to the Namurian, and two other new species, from the Kuznetzk Basin.

The new species *Torynifer? dorsiseptatus* is provisionally included in *Torynifer*. Its internal structures are very like those of *T. pseudolineatus;* however, all specimens are silicified and exfoliated so that it is not certain that biramous spines were present on the surface. No other reticulariacean genus has so far been described with the internal structures of *T. pseudolineatus* but lacking biramous spines.

TORYNIFER? DORSISEPTATUS sp. nov.

(Pl. 20, figs 1-5, 7-9, 13; Text-fig. 62a-f)

Diagnosis: Medium-sized species, width exceeds length; outline subelliptical with prominent umbo; small longitudinally striated interarea; slight sulcus and fold; internally with well developed dental plates diverging at 33° to 47°, low ventral median ridge; dorsal valve with low area and concave hinge-plate with supporting septum; ornament unknown, probably spinose.

Material: Forty silicified isolated valves, mostly incomplete.

Description: The species is above medium size for *Torynifer;* the largest ventral valve, CPC1624 (Pl. 20, fig. 7a, b), is over 3.6 cm wide and about 3 cm long. The ventral valve is roughly elliptical in outline and has a prominent umbo. The length is about five-sixths of the maximum width in larger specimens. The hinge-line is shorter than the maximum width, from three-fifths to three-

TABLE 21: Dimensions of *Torynifer? dorsiseptatus* sp. nov. (in cm)

Specimen Number	L	Lc	Lb	Lbc	Whl	Wm	Ha	Aa	Da	Dw	DPa	Ldp	W/L
CPC1622	1.90	2.66			1.35	2.25	.25	121°	56°	.45	44°	.75	1.18
CPC1623					1.40		.35	116°	59°	.60	36°		
CPC1624	c3.00				2.75	3.60+	.55	113°	59°	.72	43°	1.0	1.20
CPC1626					1.8e	2.8e							
CPC1627			2.20	2.95	1.70	2.85							
CPC1628						2.6e					33°	1.25	
CPC1629								112°			36°	1.2	
F17932	2.10	2.95			1.25	2.3e	.25	119°	72°	.45	37°	.85	1.1
F17933	1.50	2.0				1.65	.45	119°	67°		43°	.70	1.1
F17934			1.65	1.80	1.0e	2.15e							
F17935	1.15	1.6			.80	1.45	.15	119°	72°	.29	37°	.55	1.26
F17936	1.35	1.75			.90	1.45	.25	122°	59°	.32	47°	.55	1.07

quarters in larger specimens. The greatest width occurs at about the midlength. The pedicle valve is convex longitudinally and transversely, being much more strongly convex in the umbonal region. The umbo is prominent, more or less obtusely pointed and overturned at the beak. The shoulders are gently concave. the apical angle ranges from 112° to 122°. The interarea is small and triangular, gently concave and strongly apsacline, and merges imperceptibly into the shoulders. It is marked by fine longitudinal striations; those towards the middle are intersected by the delthyrial edge. Fine growth-lines are also present. The delthyrium is wide, with angles of 56° to 72°. Many specimens possess the remnants of a deltidial plate extending as a fine lamella outwards from the delthyrial edge. The teeth are prominent and are set obliquely to the hinge-line. A very gentle sulcus could be discerned on the ventral surface, and the front commissure appears to be gently uniplicate.

The dorsal valves are transversely elliptical, with their greatest width at about one third of their length from the umbo. The valves are convex transversely and longitudinally (though less than the ventral valve) and are only slightly folded. The front margin appears to be nearly rectimarginate to gently uniplicate. The umbo is prominent and pointed.

The internal features are distinctive. The teeth are supported by thin dental flanges which join long thin adminicula bending slightly at the contact. The

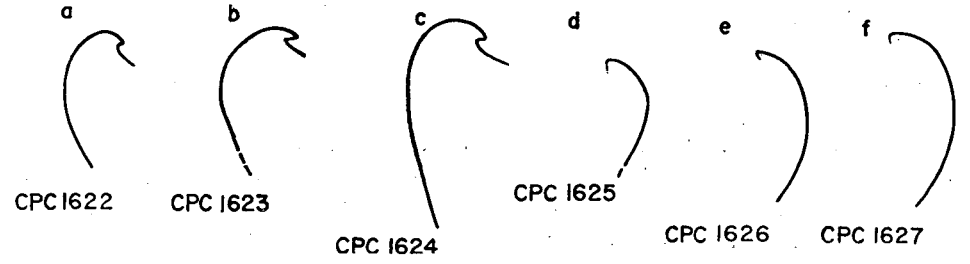

Fig. 62. *Torynifer? dorsiseptatus.* **Profiles of specimens illustrated in Plate 20.**

adminicula are up to 1.25 cm long on the floor of the valve in larger specimens. They diverge without flexure at angles of 33° to 47°. The dental flanges in some specimens carry a ridge on their delthyrial sides, e.g. paratype CPC1622 (Pl. 20, fig. 1a, b, c).

A low ventral septum or ridge is present in most specimens, extending from the apex for as much as 1.7 cm in large specimens. The ventral muscles are very slightly or not at all impressed. They are elongate and lie between the dental plates, and are flanked by faint extensions of the plates (Pl. 20, fig. 4b). The shell in the umbonal region is thin, with very little development of secondary thickening.

The dorsal valve has a low tapering area, intersected by a notothyrium of somewhat varied divergence (Pl. 20, figs 8, 9). All dorsal valves possess a concave hinge-plate which is supported by a prominent septum. The septum is wider where it supports the hinge-line and narrows to the front. Its length is 0.75 cm in CPC1626, the holotype (Pl. 20, fig. 9). The socket grooves widen to the front and the inner flange is curved round at its outer extremity. The cardinal process is small and provided with numerous longitudinal platelets. The brachial apparatus is unknown; the crural plate forms the front outer edge of the hinge plate. The adductor muscle scar was not impressed and cannot be distinguished. The internal surface of the valve is faintly radially ribbed.

In none of the specimens is the surface ornament adequately known. It appears that the specimens were probably abraded before silicification, and in most the silicification is too coarse to preserve the finest details. Most specimens reveal a reticulate pattern (Pl. 20, figs 4a, 13): the surface of this shell is partly exfoliated; the overlying concentric laminae, as exposed, are directed backwards. In CPC1627, the surface is marked by concentric laminate undulations spaced at 8 in 5 mm near the umbo and 11 in 5 mm near the front margin. The radial pattern consists of fine scale-like thin laminae overlapping sideways in each concentric band. Occasionally there is a trace of spinose fringe to the concentric laminae. Presumably the unexfoliated surface carried spines; but whether these were biramous or uniramous cannot be determined. It is possible that the peculiar exfoliated surface indicates a unique type of surface ornament, but unaltered specimens are needed to determine this.

Discussion: *Torynifer? dorsiseptatus* sp. nov. does not differ greatly in shape from *T. pseudolineatus*. It has a slighter sulcus and less strongly elevated ventral septum. An illustration in Hall & Clarke (1894, p. 36, fig. 30) shows a partly exfoliated surface on a specimen of *T. pseudolineatus,* which, though diagrammatic, appears to be comparable with the surface of the Moogooree species. Other Mississippian species are not as close.

Of the Russian species *T. pseudolineatus asiaticus* Besnossova from the Kuznetzk Basin is larger and more sulcate. The other Kuznetzk species appear

to be wider. Besnossova *in* Sarytcheva et al. (1963, pl. 18, fig. 3a, text-fig. 134) also illustrated exfoliated surfaces which resemble the worn surfaces of my specimens. Comparable surfaces are also seen in Permian specimens of cf. *Kitakamithyris* sp. from Western Australia, which has indubitable biramous spines.

Geological Age: Late Tournaisian to early Visean.

Occurrence: All specimens from the western slope of Mount Septimus. CPC1622-5, 1628, 1629, F17933, 17935 from 500 to 550 feet above the base of the Septimus Limestone; CPC1626, 1627, F17932, F17934 from 550 to 600 feet; and F17934 from 450 to 500 feet.

Superfamily SPIRIFERINACEA Davidson, 1884

(nom. transl. Ivanova, 1959, ex subfam. Spiriferinidae Davidson, 1884)

Family SPIRIFERINIDAE Davidson, 1884

(nom. transl. Ivanova, 1959, ex subfam. Spiriferinidae Davidson, 1884)

The definition and generic assignments of Pitrat (1965, p. H711) are provisionally accepted here.

Genus PUNCTOSPIRIFER North, 1920

Type species: *Punctospirifer sabricostus* North.

Generic features: Small mostly transverse spiriferinids, generally widest at hinge-line and with plicate flanks; fold and sulcus wider than any of lateral plicae, sulcus smooth or with median costa, fold smooth or may have slight median sinus; interarea moderately high and with fairly acute posterior margins; ornament of close concentric imbricating lamellae which may be striate, but lack erect spine-bases; internally with prominent median septum and divergent dental plates; callosity generally not greatly developed in umbonal region but may be present; low median ridge in dorsal adductor muscle scar; strongly and coarsely punctate. Carboniferous to Permian.

Discussion: The summary is based on the account of the type species of *Punctospirifer*, described from topotypes by Campbell (1959b), and also discussed by Sanders (1958). There is a discrepancy in their account of the fine surface ornament. According to Campbell: 'crossing the lamellae there is a series of very fine radial threads which are often in line on adjacent lamellae, so that they could well be called radial lirae'. Campbell also notes that 'on the posterior portions of some specimens they seem to be slightly raised into extremely minute projections causing an almost imperceptible serration of the lamellar edge'.

Sanders states that the lamellae carry 'fine hair-like spines which lie flat in the plane of the lamellae'. Presumably both authors are describing the same features. It is evident that coarse spine-bases, such as are present in *Spiriferellina, Spinuliplica,* and *Reticulariina,* are missing in *Punctospirifer.* However, fine hollow spines appear to extend from the edges of the lamellae in *Punctospirifer amblys* Cvancara, from the Tournaisian of New South Wales.

North described the type species as possessing a posteriorly and ventrally directed V-shaped jugum. Campbell failed to detect a jugum in five sectioned specimens in which the spires had twelve volutions. Stehli (1954) has commented that the jugum is probably anteriorly directed.

I have provisionally included species with a median plication or costa in the sulcus and a groove on the fold within the diagnosis of the genus. Campbell (1959b) noted that some of the topotypes of *P. scabricostus* (North) possess a 'weak median furrow' in the sulcus, which presumably refers to a median costa. However, I have not observed this feature in other topotype collections. Species possessing a median costa and grooved fold have been placed in *Punctospirifer* by various authors, e.g. Muir-Wood (1948), but it is possible that they should be separated generically.

Campbell (1961) erected two monospecific genera, *Spinuliplica* and *Liriplica,* for species with low median plicae in the sulcus and slight median grooves in the dorsal folds. These forms occur in the Upper Carboniferous Kuttung rocks of New South Wales. They have the rounded wings commonly found in *Spiriferellina,* that is, with greatest width in front of the hinge-line. Campbell distinguished *Spinuliplica* from *Punctospirifer* on a combination of characters, notably the less extended hinge-line, less high interarea, spinose surface ornament instead of lirate, and presence of plications on fold and sulcus. *Liriplica,* in contrast to *Punctospirifer,* has less sharp beak ridges, fine regular growth-lines in addition to the growth lamellae, very strongly thickened calluses in delthyrial and umbonal cavities, and less protruding cardinal process as well as plicae on fold and sulcus.

Whatever the value of the other features mentioned for generic discrimination, it seems evident that plicate fold and sulcus do occur in species referable on other grounds to *Punctospirifer. Spiriferellina* Fredericks, type species *S. cristata* (Schlotheim) of Permian age, can also show a faint median plication on the sulcus and a sinus on the dorsal fold. This species has rounded wings and is spinose over the whole surface of the valves. Dunbar (1955) referred *S. cristata* to *Punctospirifer,* but this seems to be too wide an interpretation of the genus.

Punctospirifer is common in Lower Carboniferous deposits in Western Europe, USSR, and North America. It is also reported from Upper Carboniferous and Permian deposits. It has been described from the Lower Carboniferous of New South Wales by Cvancara (1958) and Middle Carboniferous of Queensland

by Maxwell (1964) and McKellar (1965). There is a need for reappraisal of the generic assignment of some of the younger species, as many of them do not appear to be particularly close to *P. scabricostus* North.

The Western Australian Carboniferous faunas include four species of *Punctospirifer*. They are distinguished mainly on the criteria of relative width, number of lateral costae, height of area, and inclination of the dental plates, They can be fairly closely compared with species from the Lower Carboniferous of USSR and perhaps Central Asia and also with certain species from the Mississippian of North America. They have less resemblance to species which authors have referred to *Punctospirifer* from the Pennsylvanian and Permian of North America and to Upper Carboniferous and Permian species from Brazil, Peru, and Spitsbergen.

The brachidia are not preserved in any of the available specimens.

PUNCTOSPIRIFER PLICATOSULCATUS Glenister

(Pl. 25, figs 3-7; Text-figs 63, 64)

1955 *Punctospirifer plicatosulcatus* Glenister, *J. Roy. Soc. W. Aust*, 39, 69, pl. 6, figs 26-29, pl. 8, figs 10-12.

Diagnosis: Average-sized species, width 1.3 times length in adults, greatest at hinge-line in majority; area high (0.6 mm); median sulcal costa, and 9-10 rounded plicae or costae on each ventral flank; groove on fold and 8-9 costae on each dorsal flank; dental plates widely divergent, septum strong, half to two-thirds of shell length; minor thickening in apical region; spines not known.

Material: About 90 specimens, 70 silicified (mainly youthful) and 17 unaltered shells from Moogooree Limestone, several specimens from Laurel Formation.

Description: Glenister (1955, p. 69) has described the holotype (a ventral valve) and a paratype (dorsal valve). The following observations supplement Glenister's description of the Moogooree specimens. The ventral apical angle varies from 116° to 124° with umbo pointed but not overturned; back ridges are sharp and straight. The mature ventral valve is strongly convex transversely and longitudinally. Most specimens are widest at the hinge-line, a few slightly in front. The interarea is nearly catacline in maturity, apsacline in young specimens. The delthyrial angle varies from 23° to 30°. The median costa may be more pronounced than in the holotype. The dorsal valve is gently convex longitudinally and transversely, with a tendency to flattening or concavity on the outer flanks. The fold is invariably grooved and is variable in elevation. The anterior commissure is gently sulciplicate. Asymmetry of the interarea, and irregular growth, in general, are common. The surface of all specimens is worn and no spines are preserved. Erosion of the numerous coarse punctae has roughened the surfaces.

TABLE 22: Dimensions of species of *Punctospirifer* (in cm)

Specimen Number	L	Lc	Lb	Whl	Wm	T	Ha	Aa	Da	Dw	Wsf	W/L	Sulcus	Costae Ventral L.	Costae Ventral R.	Costae Dorsal L.	Costae Dorsal R.
Punctospirifer uttingi sp. nov.																	
CPC1690	1.65	2.30	1.10	2.30	2.30		.50e	120°	c25°e	.18	c.8	1.40	1	8	8	7	7
CPC1691	1.00	1.20	.80	1.90	1.90	.75	.35	127°	23°	.23	.44	1.90	1	7	7	6	6
CPC1692	1.25	1.65	1.00	1.80	1.80	.85	.35	128°	27°	.22	.52	1.44	1	8			7
CPC1693	1.30	1.85		2.10	2.10		.45	129°	23°	.28	.67	1.58	1		8		
CPC1694	0.50	.50	.45	1.60	1.60	.45	.25	137°	25°	.11	.18	3.2	1	6	6	5	5
P. plicatosulcatus Glenister																	
CPC431	1.40	1.95			1.80		.6	118°	30°	.35	.55	1.28	1	9	9		
F17957	1.3+	1.70		1.65	1.75		.40	124°	30°		.50				10		
F17958	1.1+	1.25		1.80	1.80		.55	116°	23°		.45			9	9		
F17959	0.90	1.00		1.70	1.70		.45	119°	28°	.25	.35	1.80	1	9	8		
F17960	1.10	1.20		1.90	1.90						.40	1.72		9	9	8	8
F17961	1.20	1.55		1.80	1.80		.60			.25	.45	1.50		10			
F17962	1.40	1.70		2.40	2.40		.50					1.71			9	8	
F17963				1.90	1.90										9		
F17964			1.05+	2.15												10	10
F17965	1.40	2.05		1.40	1.40		.52	110°			.45	1.0	1		10		
P. mucronatus sp. nov.																	
CPC1685	1.30+			3.35	3.35e		.40	136°	35°	.40	.7+	2.57	1	13	12		12
CPC1686	1.55			4.50	4.50		.50	154°	46°	.50	.75	2.90	1	17+	14+		
CPC1687	1.20	1.75		3.40	3.40		.40	147°e	42°	.35	.55	2.82	1	13+	16		
CPC1688	1.65	2.20					.65		35°	.55	.75						
CPC1689				1.5e	1.5e		.30	143°		.20	.35				9		
CPC1697		2.05					.50		42°	.40							
F17955	1.5+			3.10	3.10		.45	149°	37°	.45	.55e	2.06	1	15	15		
F17956	1.15+			2.60	2.60		.30	145°	54°	.45		2.25	1	14	14		

The dental plates are strong and diverge at about 45° on the valve floor, with bases lying on the internal ridge corresponding to the trough between second and third lateral costae in nearly all specimens. The ventral adminicula are low and thin, and shorter than the interarea. The dental flanges are slightly thickened, particularly near the umbo, and may be ridged on the inner side. They taper back from the hinge-line to meet the adminiculum at a distance of about one-third of the height of the interarea. The septum is thin and prominent, and extends from half to two-thirds of shell length. The dorsal cardinalia are similar to those in *Punctospirifer uttingi*. The spiralia are unknown.

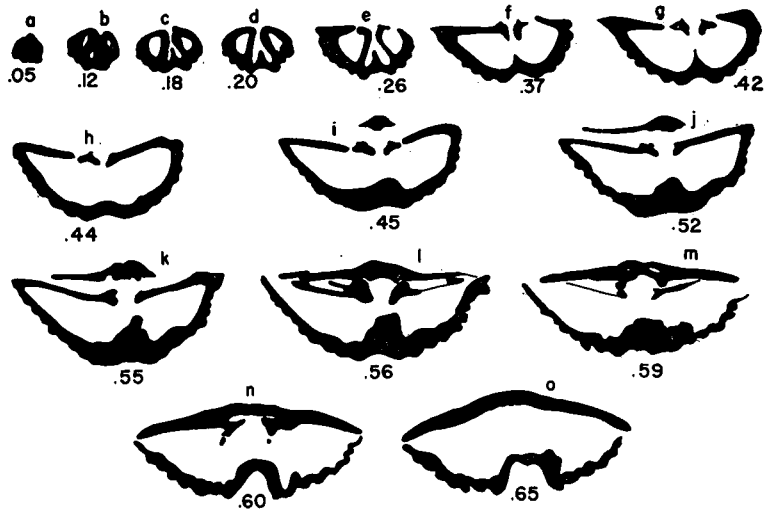

Fig. 63. *Punctospirifer plicatosulcatus*. **CPC1697, a somewhat crushed shell. Transverse sections, x1.5.**

Sections of an unaltered specimen, CPC1697, are shown in Text-figures 63 and 64. The punctae are not illustrated. They cover the entire top section; in later sections they are sparse on dental plates and upper part of the septum and socket plates; they are absent from the cardinal process. The dental flanges are secondarily thickened near the apex and join the septum at one stage. Their main core is made up of longitudinally directed fine fibres which are cut transversely in sections; they are built up from the delthyrial edge by accretion. The shell wall is crushed and folded in the more anterior sections which makes it appear to be thickened. Punctae are dense and coarse on the shell wall, about 0.04-0.05 mm in diameter and with a density of 44 to 70 per mm. They are illustrated in Plate 25, figures 3 and 7.

A number of incomplete specimens from the Laurel Formation are similar in size, proportions, and costation, and are included in the species.

Discussion: *P. plicatosulcatus* is not unique among species of *Punctospirifer* in its possession of a costa in the sulcus, as suggested by Glenister (1955). The type species *P. scabricostus* apparently may rarely possess one. It is similar in form and has 8-9 lateral costae, but lacks a sinus on the fold. Species with median dorsal sinus and costate sulcus are known from the Moscow Basin (Sokolskaya, 1941), the Kuznetzk Basin (Tolmatchow, 1931), the Visean of Taimyr (Dedok & Tschernjak, 1960), and the Visean of Tien Shan (Grober, 1909). Of these, the species called *P. partitus* (Portlock) by Sokolskaya is similar in shape but somewhat smaller, and has 5-7 lateral costae on each ventral flank. It is from the Chernyshinsk horizon (Upper Tournaisian). *P. orlawi* Tschernjak, from the Visean C_1d of Taimyr, is also smaller but has 7-9 lateral costae.

Comparable species are known in North America. *P. solidirostris* White from the Kinderhook is similar in form also but is smaller, and has 6-8 lateral costae

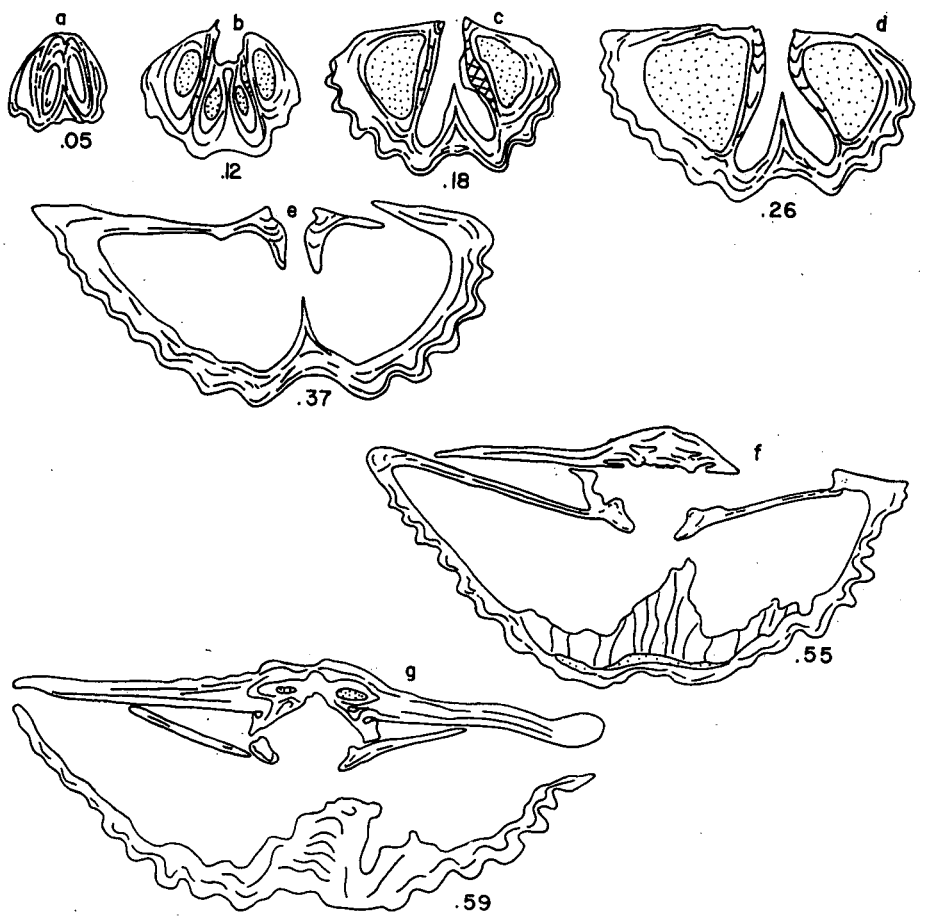

Fig. 64. Same specimen as in Fig. 63. Apparent thickening in (f), (g) caused by shell being crushed, x2.

and a thickened apical region. It is also listed in the upper Banffian of Alberta by Brown (1952) and the lower Rundlean by Harker & Raasch (1958).

P. plicatosulcatus is evidently closely allied to *P. uttingi* sp. nov., but is smaller, has more costae (9-10 instead of 6-8) on each ventral flank, and more divergent ventral adminicula. The median costa is less strongly developed.

Geological Age: Tournaisian.

Occurrences: CPC431, 447 (holotype and paratype), and F17957-9 and many other specimens from TP42, about 460 feet above the base of Moogooree Limestone. CPC1697, 1698, F17960, 17961 from CC120 about 478 to 488 feet above base of Moogooree Limestone. F17962, F17965 from KC13, and F17963, F17964, from Ng247 (W.A. Petroleum Ltd), both localities in upper member, Laurel Formation.

PUNCTOSPIRIFER UTTINGI sp. nov.

(Pl. 14, figs 5-9, 10b, 11-13; Text-fig. 65)

Diagnosis: Moderately large species; width 1.4 times length in adults, greatest at hinge-line; area moderately high (0.5 cm); median sulcal costa, and 7-8 angular costae on each ventral flank; sinus on fold and 6-7 costae on each dorsal flank; dental plates moderately divergent (25°-35°); septum long (2/3 shell length); secondary thickening in apical region generally slight; no spines seen.

Material: 36 silicified specimens, mostly immature.

Description: The species is of medium size for the genus. The holotype, CPC1690 (Pl. 14, fig. 12a, b) is a mature shell; the other illustrated specimens, excepting CPC1693 (Pl. 14, figs 9a, b, 10b), are more youthful. The outline is semi-elliptical, with the length about $\frac{3}{4}$ of the width. Both valves are strongly and fairly evenly convex, longitudinally and transversely. The umbo is prominent and the shoulders are concave, with fairly acute beak ridges. The apical angle ranges from 120° to 129° in larger specimens; in one very youthful specimen, CPC1694 (Pl. 14, fig. 8a-c), it is 137°. The sulcus is prominent and deep, with a strong plication at its lateral margin. It originates at the umbo and deepens and widens to the front. Its floor is fairly acutely angled and is marked by a distinct plica or costa in all specimens.

The interarea is triangular and fairly high, about 0.5 cm in the holotype; it is gently concave at the umbo, flatter in front, and is apsacline to nearly orthocline. The front edge of the area appears to be denticulate, but longitudinal grooves are not visible. The delthyrium is rather narrow, but somewhat variable, with angles of 23° to 28°. Dental ridges occur on the margins. These pass into strong teeth and are at the level of the area.

The dorsal valve tends to flatten on the extreme flanks and carries a prominent grooved fold. The greatest width is at the hinge-line. Youthful specimens are alate to mucronate. In mature specimens, the front margins are rounded, with a small tongue at the sulcus. The margin is sulciplicate. Many specimens, including the holotype, are somewhat asymmetrical and grew irregularly.

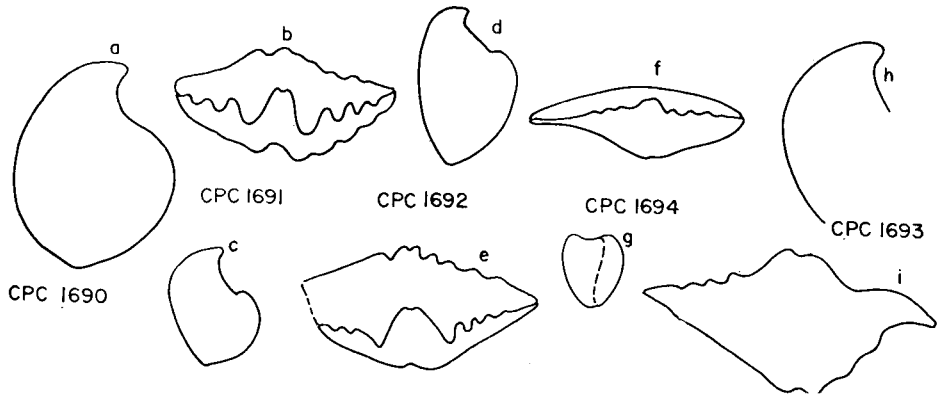

Fig. 65. *P. uttingi.* **Specimens illustrated in Plate 14. (a) Profile of shell, x2. (b), (c) Anterior view and profile, x1.5. (d), (e) Profile and anterior view, x1.5. (f), (g) Anterior view and profile, x2. (h), (i) Profile and anterior view of ventral valve, x2.**

The flanks carry prominent acute plications or large costae which number from 6 to 8 on each side of the ventral valve and 5 to 7 on the dorsal valve. The outer ones are much fainter than the inner. The costae are crossed by numerous close imbricating, undulating lamellae. In no specimens are striae visible, but they may have been present, as all specimens were worn slightly before silicification. The silicification is generally rather coarse and finer details are obliterated. No spines or spine-bases were seen.

Internally, the ventral valve has prominent dental plates. The adminiculum is usually thin and lies along the groove corresponding to the first trough beyond the marginal costa of the sinus. The angle of divergence in CPC1693 is about 25° and in CPC1696 (Pl. 14, fig. 5), about 35°. The adminicula are variable in length but are shorter than the area; their front extension may be very thin and delicate. The dental flanges are rather thicker than the adminicula and may be ridged on the inside near the flexured junction of the two components. The median septum is prominent and long (about two-thirds of the shell length); it is thin and more elevated in front. At the back it is thicker but callus is not greatly developed at the apex of the delthyrium. Little can be made of the ventral musculature or other internal features.

The dorsal valve has a low tapering area, 1.8 mm high in the largest specimen. The cardinal process is a small, elevated, roughly bilobed structure with longitudinal platelets on its posterior part; it is flanked by divergent socket and crural

plates. The process and flanking plates may be sufficiently elevated to form tiny hinge plates. The socket-grooves are wide and rounded. The crural plate is a concave flange on the front inside edge of the socket-plates, and the descending lamella originated from its front outer extremity. A median fine low septum is present on the floor of the valve. Along the posterior part of the internal ridge, corresponding to the grooves flanking the fold, are two low ridges. These probably mark the boundaries of the dorsal adductor muscle scars. The outer edges of the socket plates recurve to the hinge-line. The dorsal cardinalia of CPC1695 (a fairly youthful specimen) are illustrated in Plate 14, figure 13. In larger specimens, the fold is more pronounced and the muscles are more deeply impressed.

The shell is rather coarsely and uniformly punctate.

Observations: *P. uttingi* is closely allied to *P. plicatosulcatus* and was at first identified with it. However, it has consistent differences: the lateral costae are fewer, the ventral adminicula are less divergent, the costae are more angular, and the interarea lower; the median costa is stronger and the shoulders more concave. Some of the species discussed under *P. plicatosulcatus* are broadly similar but smaller, e.g. *P. solidirostris* (White). The species figured by Vaughan (1915, pl. 7, fig. 5a, b) from the Petit Granit, Avesnes, Belgium (upper Tournaisian Tn 3b of Demanet, 1958) and identified as *Spiriferina mőlleri* de Koninck resembles *P. uttingi* in form and costation. It differs considerably from de Koninck's original figures.

P. uttingi is much less transverse and has fewer costae than *P. mucronatus* sp. nov., which first accompanies and later replaces it in the Septimus Limestone.

Geological Age: Late Tournaisian to early Visean.

Occurrence: All specimens are from the upper beds of the Septimus Limestone on the western slope of Mount Septimus. CPC1691-3, 1695 are from 550 to 600 feet and CPC1690, 1694, 1696 are from 500 to 550 feet above the base of the formation.

The species is named in honour of Mr E. P. Utting, formerly Chief Geologist of Westralian Oil Ltd, who presented many of the specimens described from the Bonaparte Gulf Basin; they were collected by him and geologists of the company.

PUNCTOSPIRIFER MUCRONATUS sp. nov.

(Pl. 14, figs 1, 2, 3, 4, 10a; Text-fig. 66)

Diagnosis: Large species; greatest width at hinge-line and ranging from 2 to 3 times the shell length; area high, delthyrial angle wide (35°-54°); median

sulcal costa; 13-17 lateral rounded costae on each ventral flank; sinus on dorsal fold; dental plates widely divergent at 44° to 53°; secondary thickening in umbonal region; no spines seen.

Material: Eight silicified specimens.

Description: The outline is very transverse with mucronate extremities. Both valves are strongly convex longitudinally but tend to have an irregular gentle convexity transversely and a flattening on the outer flanks. The umbo is prominent and pointed and the apical angle varies from 136° to 154°. The shoulders are slightly concave, but in some are asymmetrical. The interarea is moderately high (0.5 cm in the holotype). The beak ridges are sharp and in CPC1687 are irregular and strongly serrated by growth interruptions. The interarea is concave, with the beak erect but not overturned. The inclination is nearly catacline for the front of the interarea, which carries transverse growth-lines but no longitudinal grooves, though it appears to be denticulate on the front margin. The delthyrium is wide, with angles of 35° to 46°. The teeth are prominent, set obliquely to the hinge-line, and their growth-trace forms a pronounced rounded marginal ridge to the delthyrium, at the level of the area. The ventral sulcus is a broad and fairly shallow rounded depression which carries a low plication on the floor. The front margin is broadly convex, with a very pronounced tongue at the sulcus; the commissure is distinctly sulciplicate.

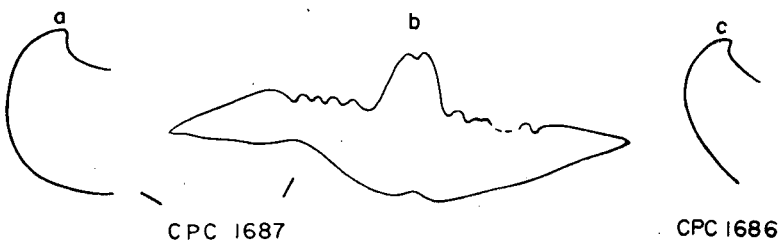

Fig. 66. *P. mucronatus.* **Outline of specimens illustrated in Plate 14. (a), (b) Profile and anterior outline of ventral valve, x2. (c) Profile of ventral valve, x1.**

The holotype, CPC1655 (Pl. 14, fig. 1a-f), has the only available dorsal valve, which is incomplete: it has a prominent fold with a median groove.

The surface ornament of the flanks consists of rounded costae or plicae which become less prominent at the outer edges. The holotype has 13 on one side of the ventral, and 12 on one dorsal, flank. The number ranges up to 17 in other specimens. The costae and troughs are nearly equidimensional, with the costae slightly larger in some specimens. Traces of fine close imbricating lamellae can be seen towards the front of some specimens. Most, however, are too coarsely silicified to preserve much of the fine ornament. Striae, if present originally, are not now visible. No spines or spine-bases have been discerned.

The ventral interior displays a prominent median septum which extends for nearly two thirds of the shell length. It is thin in front but much thickened in the delthyrial region, even in youthful specimens, e.g. CPC1689 (Pl. 14, fig. 10a). The dental plates are long and divergent. The adminicula diverge at angles of 47° in the holotype, 49° in CPC1687, 50° in CPC1686, 44° in CPC1688, and 53° in the very youthful CPC1689. The bases are beyond the sulcal floor, lying along the inside of the second plica. The dental flanges tend to be thickened; the septum and dental lamellae tend to fuse in the delthyrial region and form a ridged platform below the level of the interarea. The ventral muscles are not deeply impressed and apparently extend as far forwards as the end of the septum.

The dorsal cardinalia are known only from the holotype. The dorsal area is about 0.16 mm high and has parallel sides: the notothyrium is widely divergent. The cardinal process is a small triangle of longitudinal platelets on a raised platform, formed by median junction of the socket and crural plates. The socket grooves originate at the sides of the process and are wide and rounded; they recurve to the hinge-line. The crural plates are fused with the outer front edges of the socket-plates (Pl. 14, fig. 1a-c). A low median septum extends forward in front of the socket-plates on the floor of the valve.

Two ventral valves, collected with the topotypes of *P. plicatosulcatus* from the Moogooree Limestone, have been included in this species. Both are very transverse and carry 14 and 15 lateral costae respectively. They are similar in internal details to the topotypes of *P. mucronatus*.

Discussion: *P. mucronatus* does not very closely resemble any species in the literature. Apparently the nearest is *P. transversus* (McChesney), which has a median sulcal costa and grooved fold. As described by Weller (1914), this is a wide but smaller species. There are 10-12 lateral costellae, which are fewer than the maximum in *P. mucronatus*. *P. transversus* is known from the upper Mississippian (Chester Series) of the midcontinent of North America. Elias (1957) also records its occurrence in the late Mississippian of Oklahoma (Redoak Hollow Formation) and refers to its occurrence in the Morrow (Lower Pennsylvanian) of Arkansas. *P. transversus* was described from the Itaituba Formation of Brazil by Dresser (1954); Mendes (1956b) has erected the Itaituba specimens into a new species, *P. leinzi* Mendes, and states that the fusulinid fauna indicates that the Itaituba fauna is of Middle Pennsylvanian age. Easton (1962) described *P. transversa* from Chesterian beds in Central Montana. *P. hirsutus* McKellar, 1965, from the Westphalian of Queensland, is of similar outline but lacks the median ventral costa and is smaller.

Punctospirifer sp., described by Gaetani (1965) from the Gerud Formation—Member A, North Iran, of early Tournaisian age, appears to be somewhat similar. It is incompletely known but is a wide form with similar median ornamentation and about 11 rounded costae on each side.

P. mucronatus differs from the other Western Australian species in its much greater width and more numerous costae.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC1685-9 from the western slopes of Mount Septimus, Bonaparte Gulf Basin. Septimus Limestone, from 550 to 600 feet above the base. F17955, 17956 from TP42, Carnarvon Basin. Moogooree Limestone, 460 feet above the base.

PUNCTOSPIRIFER? sp. nov.

(Pl. 20, fig. 12a-c; Text-fig. 67)

Material: One nearly complete specimen and six incomplete shells.

Description: The nearly complete specimen, CPC1682 (Pl. 20, fig. 12a-c) is the largest; it is 1.0 cm long, 1.2 cm wide, 0.9 cm thick, and the dorsal valve is 0.90 cm long. The interarea is 0.35 cm high and is apsacline and slightly concave. The umbo is pointed and prominent but not upturned. Both valves are strongly convex. The ventral valve carries a fairly narrow deep rounded sulcus. The dorsal fold is narrow and possibly has a slight median groove. A distinct slight groove is present on the fold of one of the other specimens. The right flank of the ventral valve carries six distinct deep rounded plicae and a very faint seventh one at the outer edge. There are six plicae on the left dorsal flank. The entire surface, including that of the interarea, is abraded, but there are faint traces of imbricating concentric lamellae. Punctae cannot be discerned in this shell, but are present in a couple of the others. The apparent absence of punctae was probably caused by alteration of the shell. This is unusual in the Western Australian spiriferinids, which are generally clearly punctate even in silicified specimens.

One specimen, CPC1683, was sectioned and is illustrated in Text-figure 67. The dental plates are moderately divergent with their adminicular bases lying beyond the sulcus. The plates and septum are thickened in the delthyrial region to form a platform. The initial dental plate is clearly visible.

The other specimens are fragmentary, but of similar proportions. A very faint median ridge in the sulcus is discernible in one of them.

Discussion: The apparent absence of punctae in CPC1682 suggested that this small form was a representative of *Tylothyris*. However, as some of the other specimens are undoubtedly punctate it has been assigned to *Punctospirifer*, CPC1682 can be distinguished from other Western Australian species of the genus, but a more adequate collection is needed to describe the species fully. It does not appear to be close to any other species of *Punctospirifer* and may be referable to some other punctate genus.

Geological Age: Tournaisian.

Occurrence: CPC1682, 1683, F17966-9, from CC102, Carnarvon Basin. Isolated outcrop of the Moogooree Limestone.

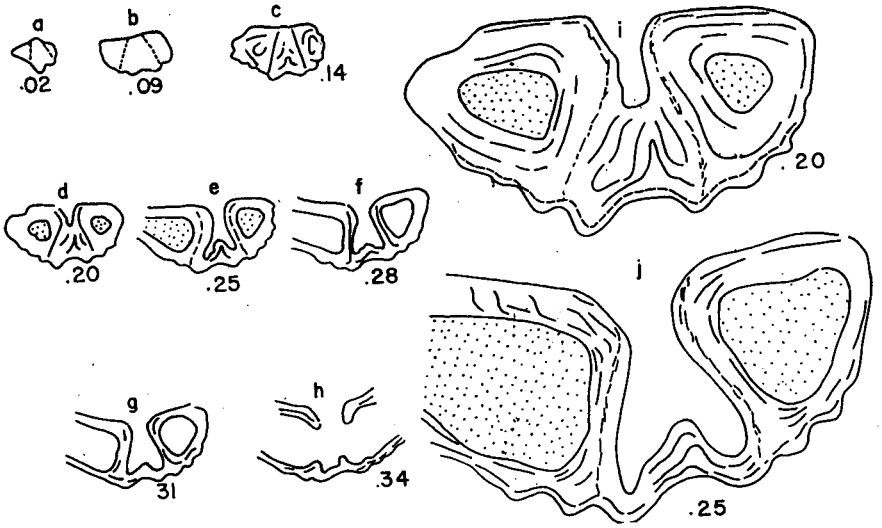

Fig. 67. *Punctospirifer?* **sp. nov. CPC1682, an incomplete ventral valve. Transverse sections. (a)-(h), x2; (i), (j), x6.8.**

SPIRIFERIDINA gen. et sp. indet.

(Pl. 20, fig. 6)

A single decorticated ventral valve, possessing long subparallel dental plates, is illustrated in Plate 20, figure 6. This specimen, CPC1633, was collected from the Laurel Formation of the Fitzroy Basin and is the only one of its kind so far collected in the Carboniferous of Western Australia. It is about 2.2 cm wide and over 1.8 cm long and is moderately convex longitudinally and transversely. The thin dental plates are about 1.3 cm long. As the surface is decorticated, nothing is known of the ornamentation, and hence its generic identity cannot be determined. The long subparallel dental plates distinguish it from other Carboniferous species from Western Australia. The dental plates are suggestive of *Martiniopsis* and the genera of the Ingelarellinae Campbell, 1959, most of the members of which are Permian. A Lower Carboniferous genus, *Eomartiniopsis* Sokolskaya, with long subparallel dental plates, is represented by several species from the Tournaisian of the Moscow Basin. Sokolskaya (1959, and in Sarytcheva et al., 1963) has described another Lower Carboniferous genus, *Tomiopsis,* from the Kuznetzk Basin, which displays the characteristic ingelarellinid ornament of fine short grooves.

Geological Age: Lower Carboniferous (Tournaisian).

Occurrence: CPC1633 comes from locality KC11, Springs station, Fitzroy Basin; from about 1365 to 1385 feet above the base of the composite type section of the Laurel Formation.

Suborder ATHYRIDIDINA Boucot, Johnson, & Staton, 1964

(nom. correct. Boucot, Johnson, & Staton, 1965, pro suborder Athyridoidea Boucot et al. 1964 = suborder Rostrospiracea Moore, 1952).

Family ATHYRIDIDAE M'Coy, 1844

(nom. correct. Boucot et al. 1964, pro Athyridae M'Coy, 1844, emend. Davidson, 1881).

Subfamily ATHYRIDINAE M'Coy, 1844

(nom. correct. Boucot et al., 1964, pro Athyrinae M'Coy, 1884, nom. transl. Waagen, 1883, ex Athyridae M'Coy, 1844).

The definitions and generic groupings of Boucot et al. (1965) are accepted.

Genus CLEIOTHYRIDINA Buckman, 1906

Type species: *Athyris royssii* Davidson, 1860 (non Léveillé, 1835).

Generic features: See Boucot et al. (1965, p. H662).

Discussion: Various spinose Athyridinae from the Carboniferous and Permian have been generally referred to *Cleiothyridina* since Buckman (1906) proposed the name for the species group earlier referred to *Cleiothyris* by King (1850). Buckman (p. 324) named as type species, '*Athyris royssii,* Davidson, Mon. Carb. Brach. pl. XVIII, figure 8'. This figure is in Davidson (1860, issued for 1858) and comes from Ulverstone*. Boucot et al. (1965, p. H662) and earlier authors including Davidson (1860, p. 84) equate *Athyris royssii* Dav. with *Spirifer deroissyi* Léveillé. However, it has not been established that Davidson's specimens, from Ulverstone, and those of Léveillé are conspecific. De Koninck (1887, p. 85), discussing *S. deroissyi,* stated that the lamellose specimens usually referred to it are not properly members of the species as described by Léveillé, in which neither spines nor longitudinal striae were recorded. Sanders (1958, p. 62) noted that his unpublished studies of British and Belgian brachiopods indicate that the taxonomic status of *Cleiothyridina* is in doubt.

* Waterhouse (1968, p. 11) is incorrect in stating that a specimen from the Permian of the Salt Range was designated by Buckman as the type of *Cleiothyridina.*

Licharew et al. (1960, p. 284) incorrectly name *Atrypa pectinifera* Sowerby, 1840, as the type species. This was the type species designated for *Cleiothyris* by King (1850). *Cleiothyris* King, however, was rejected by Buckman (1906) as a homonym of *Cleiothyris* Phillips, 1841. No recent description of the type specimen of *C. royssii* has been made as far as I know. Davidson's illustration (pl. 18, fig. 8) appears to show the spinose lamellae, regarded as characteristic of the genus, and his figure 10, an enlarged sketch of another specimen from Ulverstone, shows the concentric rows of long spines very clearly. Pending a restudy of the type species, the interpretation of Boucot et al. (1965) and earlier authors, e.g. Cooper (1944) and Dunbar & Condra (1932), is followed here.

The Carboniferous rocks of northwestern Australia contain at least four species of *Cleiothyridina,* one of which is doubtfully included. Numerous undescribed species are present in the Permian of the same region. Some attain very large dimensions.

CLEIOTHYRIDINA MINILYA sp. nov.

(Pl. 23, figs 6-11, 13; Pl. 22, fig. 15; Text-figs 68, 69a, 70)

Diagnosis: Medium-sized species, width exceeds length, with maximum ratio about 1.4; umbo prominent with concave shoulders; apical angle 115°-127°; gentle sulcus on ventral valve and low fold on dorsal; outline transversely ovate, maximum width near midlength; close fine concentric spinose lamellae, commonly with a concave flexure on the fold.

Material: 36 silicified shells, mostly somewhat crushed, from Moogooree Limestone; numerous silicified shells from Septimus Limestone. An exfoliated specimen from the Laurel Formation is also doubtfully included.

TABLE 23: Dimensions of *Cleiothyridina minilya* sp. nov. (in cm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
CPC3733	3.0+	4.1+	1.85		118°	1.33
CPC3736	2.85	3.50	1.75	2.60	116°	1.23
CPC6111	2.10	2.90	1.20	1.80	120°	1.4
CPC6112	1.80	2.45	1.10	1.70	127°	1.36
CPC6113	2.5+	3.50			c.119°	1.4
CPC6115	2.40	3.00				1.25
F21425	2.7e	3.20	1.90	2.40		1.18
F21426	2.4+	3.10			121°	1.3
F21427	2.80	3.4e	2.55		116°	1.2
F21428	2.90	3.5+	1.75	2.70		1.2
F21429	3.50				115°	
F21430				3.20		
F21431	1.85	2.00				1.1
F21432	2.0+	2.40	1.20			1.2
F21455	2.95	3.55				1.2

Description: The holotype, CPC3733, is illustrated in Plate 23, figure 6a, b, and Text-figure 68a, b. The species is of medium size for the genus. Both valves are moderately convex. The ventral umbo is prominent, with concave lateral shoulders which enclose apical angles of 115° to 127°. The pedicle foramen is somewhat damaged in most, but appears to be open, though probably partly encroached by the dorsal umbo. The outline is laterally ovate; the lateral and front margins are rounded. Width always exceeds length, with ratios ranging up to 1.4. The maximum width is near the midlength.

The ventral valve is moderately convex longitudinally and transversely. It carries a broad gentle sulcus which begins about 1.3 cm from the umbo and widens and deepens to the front.

The dorsal valve has a moderately prominent umbo and is moderately convex longitudinally and transversely, with a broad fold which becomes a little steeper to the front. The anterior commissure is moderately uniplicate to parasulcate.

The surface is ornamented with numerous fine fringed concentric lamellae which, where favourably preserved, are extended into long flat separated spines which lie nearly parallel to the surface (Pl. 23, fig. 10). In CPC3734, there are 10 lamellae in 5 mm at the front 0.85 to 1.35 cm from the umbo. The lamellae show a flattening in their outline in the vicinity of the centre of the fold in many specimens and may even be slightly concave.

The internal structure is known mainly from sections. The structures are typically athyridinid; there are thin curved dental lamellae enclosing the pedicle cavity. The ventral adductor and diductor musculature appears not to be deeply impressed. The dorsal valve has a perforate subquadrate cardinal plate which is concave on the ventral side. Its outline appears to be more nearly triangular

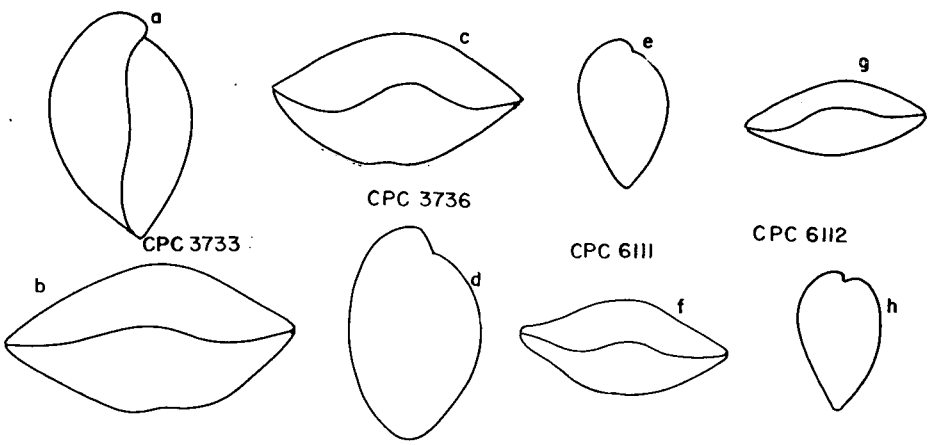

Fig. 68. *Cleiothyridina minilya.* **Profiles and anterior views of specimens illustrated on Plate 23. Natural size.**

than those in the species of *Composita*. With its prominent anterior projections, the shape approximates to a triangle with the apex removed. The cardinal plate, somewhat eroded, is seen also in CPC6114 (Pl. 22, fig. 15a, b). The shell wall is quite thick in the umbonal region, giving the appearance of a dorsal area. The dorsal valve has a low median septum (myophragm) in the umbonal region.

The details of the spiralia were not satisfactorily determined in any of the sections prepared.

The shell is fibrous and impunctate.

Discussion: *C. minilya* sp. nov. appears to be present in both the Moogooree Limestone and the Septimus Limestone. Three of the Septimus Limestone specimens, CPC6111-3, are illustrated in Plate 23, figures 8, 9, 11. Many specimens (some larger) have been collected since the plates were prepared, one measuring 3.5 cm long and 4.3 cm wide. A single much-worn specimen from the Laurel Formation, CPC3856 (Pl. 22, fig. 13a, b), is doubtfully referred to the species.

C. minilya seems to be fairly close to *C. obmaxima* (McChesney) as described by Weller (1914) from the upper Kinderhook, Burlington, and Keokuk of the Mississippian. It is not as large nor as strongly sulcate, but is similar in proportions, and the slight flexure of the growth lamellae at the fold is present in both. *C. obmaxima* has been identified elsewhere, e.g. in the Rundlean of

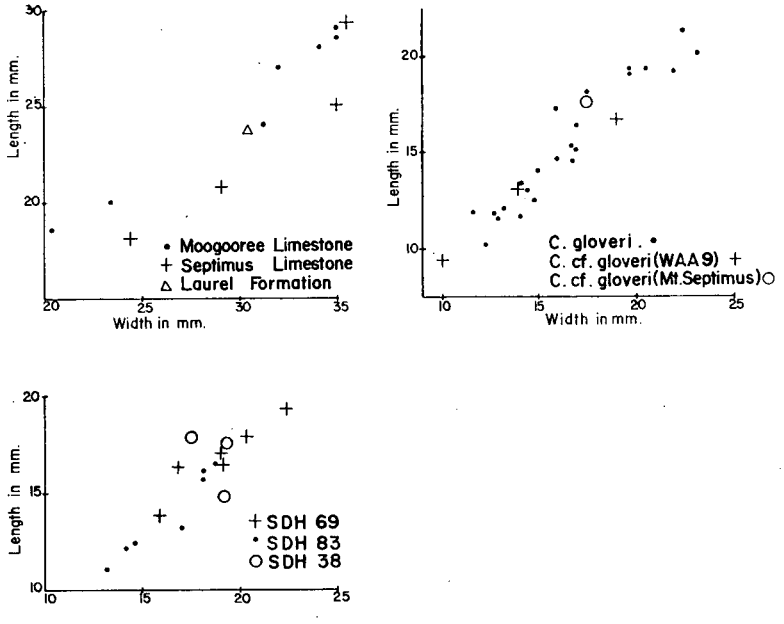

Fig. 69. Length/width ratios of species of *Cleiothyridina*. **(a)** *C. minilya*, **(b)** *C. gloveri*, **(c)** *C? fitzroyensis*.

Alberta. It was reported from the Tournaisian of Kweichow, by Yang (1964), from the Karagandian Basin by Nalivkin (1937), and from northeast Kazakhstan by Simorin (1956). Some west European species are similar in proportions to *C. minilya* but are in need of revision. The type specimen of *C. glabristria* (Phillips), from Bolland in Yorkshire, is similar in outline but larger. It has been reported from various Tournaisian and Visean levels in Britain and Ireland. Demanet (1958) listed it from Tournaisian Tnlb, 'Assise de Hastière', Belgium.

C. minilya is readily distinguished from the other Carboniferous species of *Cleiothyridina* in Western Australia by its greater size and its moderate fairly narrow sulcus. It does not appear to be close to any of the species described from New South Wales or Queensland.

Geological Age: Tournaisian to early Visean.

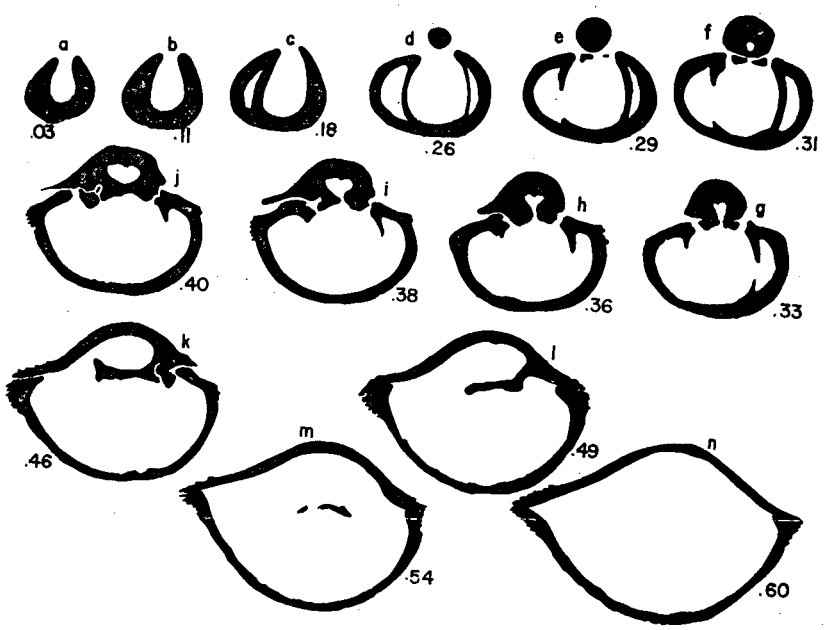

Fig. 70. *C. minilya.* **CPC3735. Transverse sections. Perforate hinge-plate of dorsal valve appears in (g)-(l). Spiralium missing.**

Occurrence: CPC3733-5, F21425-31, from CC120, Carnarvon Basin; 478-88 feet above base of Moogooree Limestone. CPC3736, F21432 from CC102, isolated outcrop of Moogooree Limestone. CPC6111-4, F21455 from western slope of Mount Septimus, Bonaparte Gulf Basin, from 500-50 feet above base of Septimus Limestone, F21452 from 550 to 600 feet of same section. CPC6115, SDH38, Fitzroy Basin, Laurel Formation, type section about 1420 feet above base.

CLEIOTHYRIDINA GLOVERI sp. nov.

(Pl. 24, figs 1-10, 14; Text-figs 71, 72)

Diagnosis: Small to medium-sized species; slightly wider than long; umbo prominent, with slightly concave shoulders, apical angle 100-130°; dorsal valve more inflated than ventral, but no fold; broad anterior ventral sulcus; outline round to transversely ovate, maximum width near midlength.

Material: 56 coarsely silicified and ferruginized shells.

Description: The species is small to medium for the genus. The holotype, CPC3737 (Pl. 24, fig. 5a, b; Text-fig. 71a, b), of average size, measures 1.89 cm long, 1.97 cm wide and 1.2 cm thick. One doubtfully included specimen, much larger than the others, is 3.2 cm long and 3.9 cm wide. The outline is variable; in most it is laterally ovate (the width exceeding the length), but in a few they are equal. The maximum width is near the midlength. The umbo is prominent, with slightly concave shoulders which enclose apical angles ranging from 100° to 130°; most are from 113° to 125°. The pedicle foramen is rounded and well exposed. A narrow area appears to be developed. The ventral valve is gently to moderately convex longitudinally and in the majority of specimens develops a wide sulcus in front which involves the whole anterior margin of

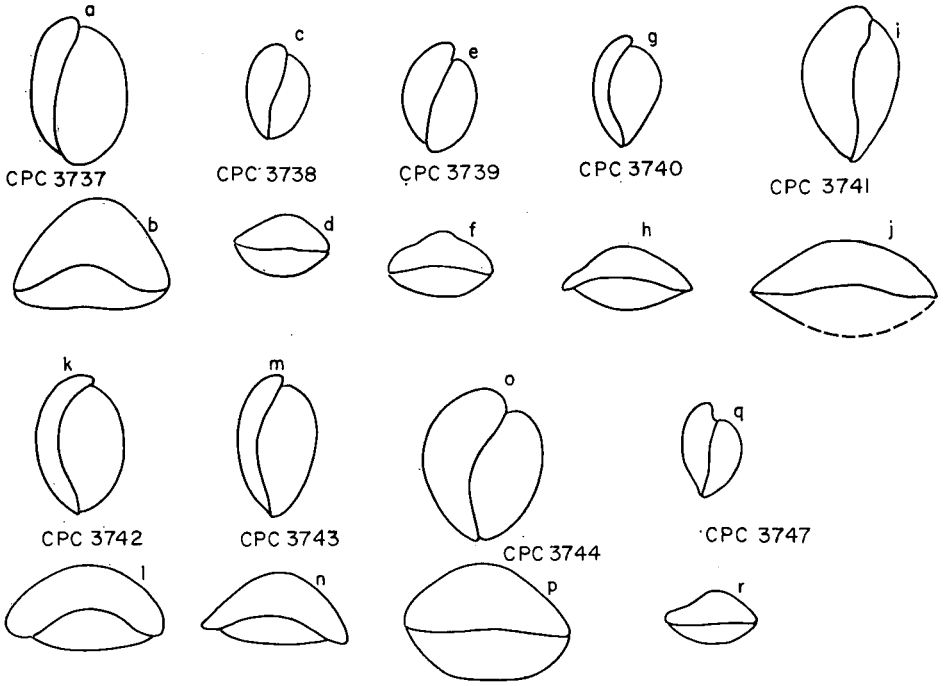

Fig. 71. *C. gloveri*. **Profile and anterior outlines of specimens illustrated in Plate 24. Natural size.**

the valve. The dorsal valve is the more convex, strongly and evenly so longitudinally and very strongly convex transversely, but only rarely is a fold differentiated. The umbo is prominent and infills the dethyrium. The front commissure is usually widely uniplicate but in a few specimens is nearly rectimarginate.

TABLE 24: Dimensions of *Cleiothyridina gloveri* sp. nov. (in mm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
Cleiothyridina gloveri						
CPC3737	18.9	19.7	12	17.8	117°	1.04
CPC3738	11.8	11.6	7.4	11.1	118°	0.98
CPC3739	13.3	14.2	8.1	12.4	113°	1.07
CPC3740	14.5	16.9	7.7	13.3	130°	1.16
CPC3741	19.1	22.1	11.5	18	125°	1.16
CPC3742	19.1	19.8	11.6	16.7	114°	1.04
CPC3743	18.0	17.7	9.2	16.9	100°	0.98
CPC3744	19.2	20.7	13.4	18.0	121°	1.08
CPC3747	11.5	13.0	16.4	10.7	122°	1.13
F21433	16.3	17.1	9.3	15.2	112°	1.05
F21434	12.1	13.3	7.5	11.0		1.1
F21435	15.2	16.9	9.3	14.0	111°	1.04
F21436	15.0	17.0	9.5	13.6	125°	1.13
F21437	14.0	15.1	8.8	—	—	1.07
F21438	17.1	16.2	11.2	13.6		.95
F21439	14.5	16.0	7.8	14.0	124°	1.15
F21440	11.6	14.1	8.0			1.15
F21441	19.8	23.4				
F21442	13.1	14.5	8.2	12.8	125°	1.11
F21443	10.2	12.4	5.9	10.1		1.21
F21444	11.9	12.7	7.2	11.1		1.07
F21445	32.0	39.0				1.21
C. sp. cf. *C. gloveri*						
CPC3748	16.5	19.0e	10.1	15.8		1.15
CPC6116	13.1	14.0	8.4	12.3		1.08
CPC6117	9.4+	10.0	5.5			1.08
F21450	21.0	22.6				1.07
CPC6118	26.0	28.0				1.07
F21453	17.5	17.5				1.0

The surface details are not very well preserved; nevertheless, most specimens possess some traces of concentric fringed lamellae. In several these show fine long flat separated spines, e.g. CPC3745 (Pl. 24, fig. 10). The lamellae are best preserved near the front margins and are close and overlapping. In the strongly sulcate specimens, the concavity formed by the sulcus is accentuated by the curvature of the marginal lamellae.

The internal structures are not very well known as the specimens could not be sectioned satisfactorily. Incomplete sections reveal dental plates and cardinal plates of athyridinid type (Text-fig. 72a, b). The spiralia are partly exposed in a few specimens, e.g. CPC3741 (Pl. 24, fig. 6b). One specimen, CPC3746 (Pl. 24, fig. 14a, b), shows the triangular to quadrate cardinal plate, perforated near the umbo.

Discussion: The specimens of *C. gloveri* sp. nov. are coarsely silicified; the finer details and the internal structures are poorly preserved. It is a variable form but seems to be fairly distinctive in shape. Various Mississippian species appear to have somewhat similar outlines, but not with the wide sulcus and absence of fold. *C. sublamellosa* (Hall) from the Chesterian appears to come closest. *C. gloveri* is distinct in proportions and sulcation from the other Western Australian species.

Geological Age: Early Tournaisian.

Occurrence: All specimens, CPC3737-47, F21433-45 from BW5, Bonaparte Gulf Basin. Burt Range Formation; isolated outcrop of partly silicified and ferruginized limestone.

This species is named in honour of Dr J. E. Glover of the Geology Department, University of Western Australia and formerly of Mines Administration Ltd, Brisbane.

CLEIOTHYRIDINA sp. nov. cf. C. GLOVERI sp. nov.

(Pl. 24, figs 11-13; Pl. 22, fig. 18; Text-figs 69b, 73)

Material: 17 complete and incomplete silicified shells.

Description: The specimens of this species resemble *C. gloveri* in outline and proportions. However, only in one, CPC6118 (Pl. 22, fig. 18) from Mount Septimus, is there any development of sulcus, and this is slight. This specimen has numerous fine concentric fringed lamellae spaced at 11 in 5 mm near the front. The other illustrated specimens, from locality WAA9, CPC3748, 6116-7 (Pl. 24, figs 11-13), are rectimarginate but otherwise comparable in outline with examples of *C. gloveri*. They carry fine fringed lamellae, too much abraded to show whether long spines were originally present. The umbones tend to be prominent and the pedicle foramina are exposed. The convexity of ventral and of dorsal valves is more nearly equal than in *C. gloveri*. CPC-3748 displays the opposed spiralia with a jugum and jugal bifurcations, but these unfortunately could not be illustrated. F21451, from Mount Septimus, a gently convex dorsal valve, has a subquadrate to triangular cardinal plate.

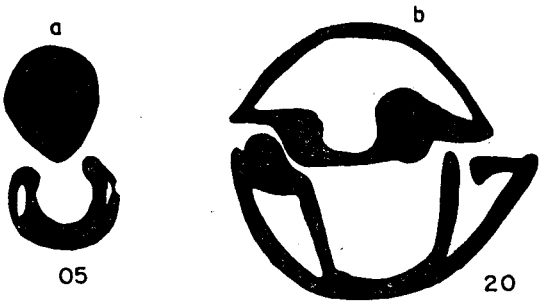

Fig. 72. *C. gloveri.* **Transverse sections of incompletely and irregularly silicified shell, x5.**

Discussion: More complete collections are needed to determine all the characters of this species, and whether the collections from the two localities should be associated. The specimens from WAA9, which are non-sulcate, may possibly be more closely allied to *Composita hendersoni* sp. nov. than to *C. gloveri*. They have some resemblance to small rectimarginate Mississippian species such as *C. hirsuta* (Hall) from the Salem Limestone.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC3748, 6116, 6117, F21446-50 from WAA9 (Mines Administration Ltd); Bonaparte Gulf Basin, isolated outcrop probably equivalent to Septimus Limestone. CPC6118, F21453, 21454, from western slope of Mount Septimus, about 500 feet above base of Septimus Limestone.

CLEIOTHYRIDINA? FITZROYENSIS sp. nov.

(Pl. 24, figs 19, 20; Text-figs 69c, 74, 75)

Diagnosis: Small species, width generally exceeds length; umbo moderately prominent with concave shoulders, apical angle 122°-133°; valves nearly equally biconvex without sulcus or fold; commissure rectimarginate; outline rounded to transversely ovate with maximum width in posterior half; fringed lamellae, apparently spinose.

TABLE 25: Dimensions of *Cleiothyridina? fitzroyensis* sp. nov. (in mm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
CPC6119	17.8	17.3	12.5	16.4	122°	.97
CPC6120	19.3	22.2	13.4	18.4	129°	1.15
F21456	17.8	20.2	8.3	11.2	132°	1.13
F21457	18.8	15.8	8.3	13.0	119°	1.14
F21458	16.4	16.6	9.5	14.7	114°	1.01
F21459	17.1	18.8	8.9	16.2	122°	1.08
F21460	16.5	19.2	9.2	15.7	128°	1.16
F21461	16.1	17.9	8.8	14.6		1.11
F21462	17.9	20.5	10.1	16.7	133°	1.14
F21463	16.5	18.0	10.1	16.3	127°	1.09
F21464	18.8	21.6	12.3	17.6	123°	1.15
F21465	13.0	17.0	8.5	12.0	133°	1.30
F21466	15 6	18.0	9.4	14.5		1.2
F21467	12.1	14.0	7.9	11.3		1.16
F21468	11.0	13.0	5.8	10.3		1.19
F21469	13.2	14.5	7.7	11.8	122°	1.18
F21470	14.8	19.0	9.0			1.27
F21471	16.3	19.0		15.9	129°	1.16
F21472	8.4	11.0	5.0	8.6		1.3

Material: 32 more or less complete shells, all somewhat abraded.

Description: The species is small; the holotype, CPC6120 (Pl. 24, fig. 19), a mature specimen, is 1.93 cm long, 2.22 cm wide and 1.34 cm thick. The

outline is rounded to transversely subelliptical and in all specimens except one (CPC6119, Pl. 24, fig. 20, which is somewhat distorted) the width exceeds the length. The umbo is generally not very prominent and the lateral slopes are distinctly concave. They enclose apical angles ranging from 114° to 133°, with the majority over 122°. The pedicle foramen is generally obscured by the dorsal umbo, but this may in part result from displacement of the valves. The greatest width is between one-third and half the length from the umbo.

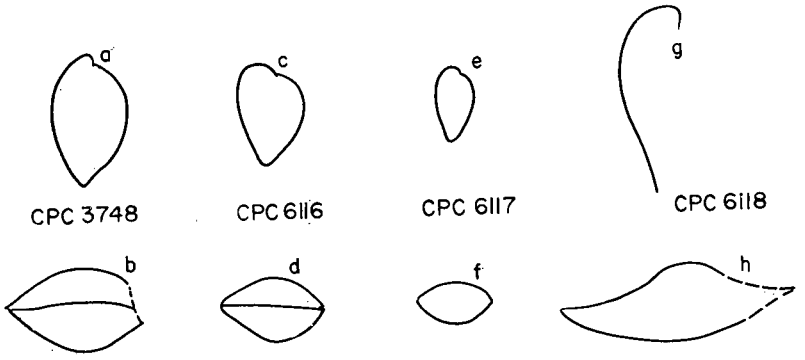

Fig. 73. *C.* **aff.** *gloveri.* **(a)-(f) Profiles and anterior outlines of specimens illustrated in Plate 24. (g), (h) Profile and anterior outline of ventral valve illustrated in Plate 24. Natural size.**

Both valves are moderately to fairly strongly and evenly convex, longitudinally and transversely; neither fold nor sulcus is developed and the anterior commissure is rectimarginate. Many valves are crushed, thus reducing their apparent convexity.

The surface in all shows some traces of close concentric overlapping fringed lamellae and in a few, notably the two illustrated specimens, there are traces of flat spines. The spines are not sufficiently well preserved for certain determination of their discrete character and thus they may merely mark indentations in the lamella, as in *Athyris.*

The internal structure is known only from sections (Text-fig. 75a-k). The dental plates and subtriangular perforate cardinal plate are quite typically athyridinid. A low median ridge is present in the dorsal umbonal region. The spiralia have about 10-11 whorls on each side. The details of jugum and secondary lamellae were not elucidated.

Discussion: *C? fitzroyensis* sp. nov. appears to be fairly distinctive. Several small species from the Mississippian, e.g. *C. tenuilineata* (Rowley), *C. hirsuta* (Hall), and *C. parvirostris* (Meek & Worthen) lack sulcus and fold. In this they resemble *C? fitzroyensis* but differ in outline and are less convex. Similar small species are recorded from the USSR, e.g. *C. hirsuta* in the Tournaisian of the Moscow Basin (Sarytcheva & Sokolskaya, 1952) and in northeast Kazakhstan (Nalivkin, 1937). *C. kusbassica* Besnossova, 1963, from the Tournaisian

(Taidonsk horizon) of the Kuznetzk Basin and *C. asinuata* (Lisitzin) (Rotai, 1931) are likewise similar in lacking sulcus and fold but are rather more rounded in outline than *C? fitzroyensis*. *C. squamosa* Roberts, 1963, from the Tournaisian of Lewinsbrook, New South Wales, is also more rounded in outline. *C? transversa* from the late Devonian Percha Shale is similar in outline but is a little wider and slightly sulcate.

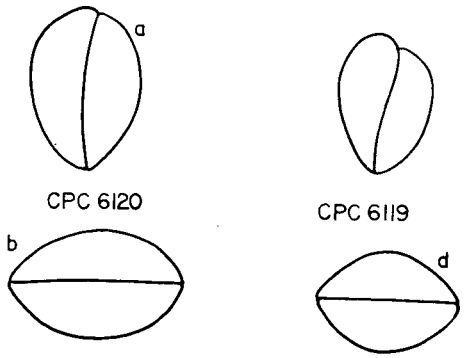

Fig. 74. *C? fitzroyensis.* **Profile and anterior outlines of specimens illustrated in Plate 24. Natural size.**

C? fitzroyensis differs from the other species described here in lacking fold and sulcus and in its outline, with the maximum width nearer the umbo.

Geological Age: Tournaisian.

Occurrence: All specimens are from the Laurel Formation, Fitzroy Basin. CPC6119, F21470-2, from locality SDH38, about 1420 feet above base of formation. CPC6120, 6121, F21456-60, from SDH69, CPC6122, F21461-9, from SDH83, both localities high in formation.

CLEIOTHYRIDINA? sp. nov.

(Pl. 23, fig. 12a, b; Text-fig. 76)

Material: One incomplete exfoliated shell and its external impression and one incomplete shell.

Description: The ventral valve is moderately convex longitudinally and transversely with a broad rounded sulcus which begins near the umbo. The

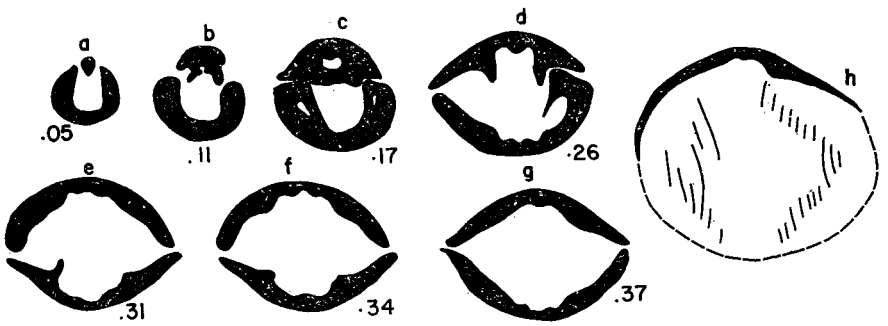

Fig. 75. *C? fitzroyensis.* **(a)-(g) CPC3759, a ventral valve. Transverse sections. Spiralium missing. (h) CPC3760, an abraded shell, at 0.24 cm from middle of dorsal surface, x2.1.**

width (5.1 cm) exceeds the length (3.8 cm) in the illustrated specimen CPC6123. The other measurable specimen is only slightly wider than long. The maximum width is about one third of the length from the front. The anterior commissure is broadly parasulcate.

TABLE 26: Dimensions of *Cleiothyridina?* sp. nov. (in cm)

Specimen Number	L	Wm	T	Aa	W/L
CPC6123	c4.0	5.1e	1.30	110°	1.28
CPC6124	3.80	4.0+	1.10	c 115°	1.06

The umbonal region and the dorsal valve are abraded in CPC6123, but the lateral umbonal slopes enclose an apical angle of 110°. The other specimen, CPC6124, is much abraded and somewhat distorted; its anterior commissure is more deeply sulcate, and the dorsal valve has a narrower fold. The brachidia are partly exposed and are large opposed spires with 14-15 whorls on each side.

The surface impression of CPC6123 preserves traces of the numerous overlapping concentric lamellae. Eleven were counted in 5 mm at about 1 cm from the front margin, but farther forward they are much more numerous. It is not quite clear whether discrete spines are present or not. If present, they are not nearly as well developed as in *C. minilya* and it is possible that the lamellae are like those described for *Actinoconchus*. However, our species is larger and more sulcate than any of the figured specimens of *A. planosulcatus* (Phill.) or *A. paradoxus* M'Coy, which are said to possess continuous fringed lamellae.

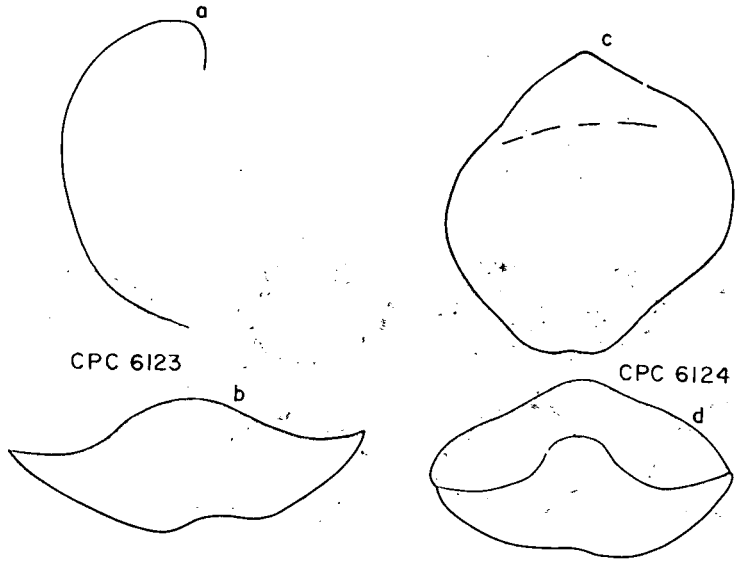

Fig. 76. *Cleiothyridina?* **sp. nov. (a), (b) Profile and anterior outline of ventral valve illustrated on Plate 23. (c), (d) Dorsal and anterior outline of much abraded shell.**

Discussion: The species differs from *C. minilya* in having a more pronounced fold, and in its dimensions. The ornament does not display discrete spines, but this may result from the state of preservation. It does not differ greatly in general outline and the two forms may be allied. Better specimens are needed for adequate description. Its general resemblance to *C. obmaxima* Weller and to *C. glabristria* (Phillips) may be noted.

Geological Age: Visean to possibly Namurian.

Occurrence: CPC6123, 6124, 6162, F21473, come from BW7, Bonaparte Gulf Basin. Burvill Beds.

Genus COMPOSITA Brown, 1849

Type species: *Spirifer ambiguus* Sowerby, 1823.

Generic features: See Boucot et al. (1965, p. H662).

Discussion: The type species, *C. ambigua* (Sowerby) from the Visean of Britain, has not been recently redescribed. Davidson's account seems reasonably clear. The species is of medium size, variable in outline, often wider than long, with variably developed trilobation and a groove on the fold. The internal structures, as illustrated by Davidson (1860, pl. 17, figs 12-14), are typically athyridinid. Internal structures have been mainly interpreted from North American species, notably of *Composita subtilita* (Hall) by Hall & Clarke (1894) and Dunbar & Condra (1932). *Composita* has been widely recognized in Carboniferous rocks from Western Europe, various basins in USSR, and North America. It is less conspicuous in Asian faunas, which include those of China, Yunnan, and Kashmir. It is also known from Algeria. In eastern Australia it has been reported from the Upper Carboniferous Booral Formation of New South Wales by Campbell (1961) and from the Yarrol Basin of Queensland by Maxwell (1964) and Hill & Woods (1964). *Composita* is not a conspicuous part of the eastern Australian faunas and seems not to be known from the Lower Carboniferous. The genus is also reported widely from the Permian, but many of the Permian species listed in Branson (1948) are in need of study. Western Australian Permian occurrences are so far unsubstantiated.

Besnossova (1963) erected two genera, *Iniathyris* and *Pseudopentagonia,* for early Tournaisian (Strunian) species from the Kuznetzk Basin. These were placed in the Nucleospiridae Davidson. Externally they resemble species of *Composita.* From her descriptions they seem to have less complex jugal bifurcations than *Composita* but are otherwise similar. The status of these genera is doubtful; Boucot et al. (1965) placed them in doubtful synonymy with *Composita.*

Four species are described from the Lower Carboniferous of Western Australia, where they are common. The species are very variable in shape, a well known

feature of this genus (see, for instance, the studies of Grinnell & Andrews, 1964, on the North American species). The new species are widely separated geographically and most individuals can be fairly readily distinguished. The structures of the brachidia were determined, by sectioning, only for *C. hendersoni* sp. nov. and *C. variabilis* sp. nov. They possess the characteristic jugum but the details of the jugal processes could not be elucidated. Otherwise the internal structures of the four species appear to agree well with *Composita*.

COMPOSITA CARNARVONENSIS sp. nov.

(Pl. 22, figs 1-4, 7-10; Text-figs 77, 78a)

Diagnosis: Medium-sized species, length equals or is slightly greater than width in maturity; umbo prominent, with flat to rounded shoulders, apical angle 95° to 105°; broad shallow ventral sulcus and low dorsal fold in front; round to ovate outline with maximum width slightly in front of midlength; front commissure uniplicate; muscle impressions variable, small paired median swellings behind ventral diductor muscles.

Material: 22 silicified valves and incomplete shells; 21 somewhat crushed and mostly incomplete shells and several moulds.

TABLE 27: Dimensions of *Composita carnarvonensis* sp. nov. (in cm)

Specimen Number	L	Wm	Lb	Aa	W/L	T
CPC3707	2.70	2.70	2.20	c105°	1.0	
CPC3708	2.90	2.65		105°	.91	
CPC3709	1.90	1.90e	1.70		1.0	
CPC3712	1.15	1.10	.95		.95	
F21331	2.35	2.30		c95°	.98	
F21332	3.25	3.00	2.80		.92	
F21333	2.00	2.20		c106°	1.1	
F21334	3.50	3.30	3.05	c100°	.94	2.25
F21335	2.00	1.75	1.80		.87	
F21336	2.15	2.10+	1.95	c100°	.97	
F21337	1.80	1.60	1.60	c100°	.89	

Description: The holotype is a silicified incomplete shell, CPC3707 (Pl. 22, figs 2 and 10). The species is medium-sized for the genus; the largest specimen, a silicified shell, F21334, is 3.50 cm long, 3.30 cm wide, and 3.05 cm thick. Most specimens are considerably smaller. The length is generally greater than the width but may be equal to it or slightly less. The shell is more or less equally biconvex, oval, with the greatest width near or slightly in front of the midlength. The umbo is rounded, with apical angle of 95 to 105°. The ventral valve is moderately convex, with a greater convexity at the umbo. In all specimens, it carries a gentle sulcus towards the front. The sulcus generally develops near or in front of the midlength and may be extended forward as a slight tongue.

The pedicle foramen is large and rounded and the delthyrium is short and widely divergent, being occupied by the umbo of the dorsal valve, e.g. CPC3709 (Pl. 22, fig. 3). The dorsal valve is gently and fairly evenly convex, commonly with a slight wide median fold, but is quite smooth in some specimens. The dorsal umbo is moderately prominent.

The surface ornament consists only of concentric growth-lines and step-like lamellae which are fairly numerous in many mature specimens, especially in front. The growth-lines extend round to the delthyrial margin.

The silicified valves have rather thin shells, and the finer details of internal features are not well preserved in most. The teeth, which are set obliquely on the front margin of the delthyrium, are prominent and pointed, and are supported by short curved dental plates, which lie fairly close to the walls of the valve but are quite distinct in front. The dental plates do not extend as far forward, on the floor, as the front of the delthyrium. Their position is shown in the two moulds illustrated in Plate 22, figures 4, 7, 8. Between them is a concave depression, which has faint transverse striations and marks the place of the pedicle muscle impression. In the internal moulds and one of the silicified valves the dental plates extend forward as low ridges flanking the oval diductor scars. The median adductor scar is small and heart shaped. Behind the depressed adductor muscles and in front of the pedicle muscle impression are a pair of small rounded to oval swellings, of uncertain significance (Pl. 22, fig. 7).

The dorsal cardinalia are characteristic of *Composita*. A large subquadrate cardinal plate extends anteroventrally (Pl. 22, figs 9,10). The socket grooves are flanked on the inside by socket plates which fuse with the crural plates and the median concave hinge-plate, which has a flat median anterior extension, faintly ridged in some specimens. The outer part of the median hinge-plate is faintly longitudinally striated on the ventral side; the various markings may

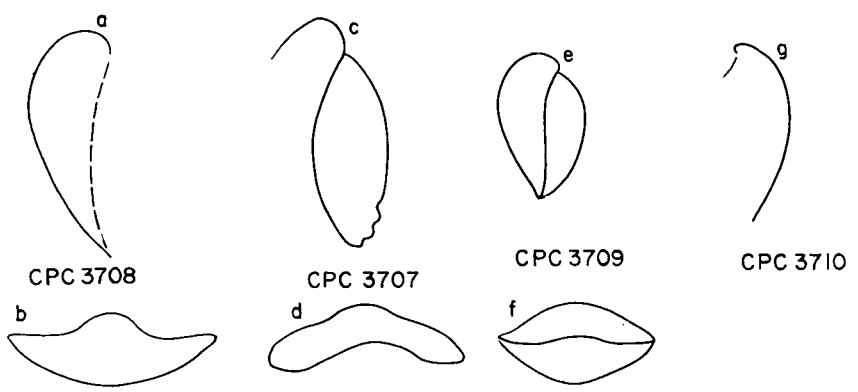

Fig. 77. *Composita carnarvonensis*. **Profile and anterior outlines of specimens illustrated in Plate 22. Natural size.**

indicate pedicle adjustor attachments. The cardinal plate is perforated apically (Pl. 22, figs 4, 10). The posterior extensions of the cardinal plate in *Composita,* not strongly developed in the illustrated specimens, may be the cardinal process. In front of the cardinal plate lies the fairly well impressed elongate adductor muscle scar, divided by a distinct low myophragm. Genital pits flank the posterior part of the dorsal adductor scar and the vascular vessels radiate from it to the margins (Pl. 22, fig. 4). The brachidia have not been observed; presumably the primary lamellae originate from the anterior extensions of the crural plates.

Discussion: *C. carnarvonensis* seems to be fairly distinctive. It resembles to some extent the figures of *C. ficoidea* Vaughan of the *Seminula* zone near Bristol; however, George (1927) stated that *ficoidea* is quite variable and can approach *C. ambigua* in form. Some of the Kuznetzk Basin species are gently sulcate

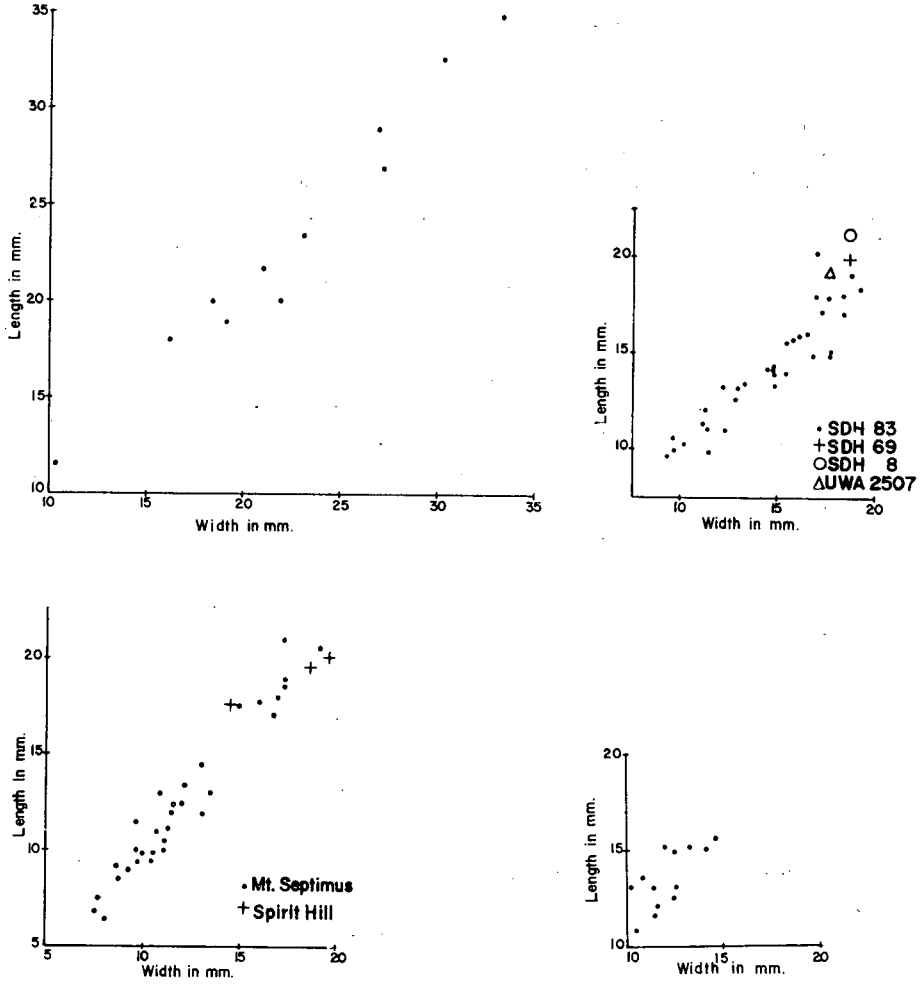

Fig. 78. Length/width ratios of species of *Composita.* **(a)** *C. carnarvonensis;* **(b)** *C. hendersoni;* **(c)** *C. bonapartensis;* **(d)** *C. variabilis.*

(Besnossova, 1963). Of these *C. megala* Tolmatchow from the Tournaisian (Taidonsk horizon) to the early Visean is larger and wider, *C. oblonga* Tolmatchow is smaller, both are more sulcate. The lower Banffian species *C. athabascensis* Warren (Brown, 1952) and the similar species from the Sappington Formation of Montana (Rodriguez & Gutschick, 1967) are broadly comparable but smaller. Sulcal development is variable in the Banffian species. *C. rotunda* Snider from the Chesterian of Oklahoma is similarly gently sulcate but tends to be shorter.

C. carnarvonensis is larger and more sulcate than *C. bonapartensis*. It is not trilobate like *C. variabilis*. It is less variable and is larger than *C. hendersoni* and lacks the tendency to a sulciplicate margin.

Geological Age: Tournaisian.

Occurrence: All specimens are from the Moogooree Limestone, Carnarvon Basin. CPC3707-10, F21331-3, from TP42, about 460 feet above base. CPC3711, 3712, F21334-7, from CC120, 478 to 488 feet above base.

COMPOSITA HENDERSONI sp. nov.

(Pl. 23, figs 1-5; Text-figs 78b, 79-82)

1935 *Composita subtilita* Hall; Prendergast, *J. Roy. Soc. W. Aust.*, 21, 18, pl. 3, figs 4, 5.

Diagnosis: Small species; longer than wide in maturity; umbo prominent, shoulders straight, apical angle 85°-108°; strongly biconvex; generally with long sulcus and fold and commonly with small sinus on fold; outline elongate ovate with maximum width near midlength; muscles well impressed, small paired median swellings behind ventral diductor muscles; strong growth lamellae.

Material: Several hundred isolated shells, of which 150 are sufficiently complete for measurement.

Description: The holotype, CPC3720 (Pl. 23, fig. 2a, b), is a mature specimen. It is 2.02 cm long, 1.69 cm wide and 1.45 cm thick. The outline is variable; in mature specimens it is elongate-oval; in younger specimens it may be rounded with width more than length. Both valves are strongly convex in maturity, the ventral the more so. The umbo is fairly prominent, with slightly concave shoulders and apical angle of 85° to 108°, and rounded pedicle foramen. Nearly all specimens show a distinct ventral sulcus which in some originates at the umbo but commonly at about the midlength. Rare adult specimens have neither fold nor sulcus. Most dorsal valves have a gentle fold which in about half is flattened or has a slight sinus. The commissure, in consequence, varies from uniplicate to slightly sulciplicate. The maximum width in maturity is near the midlength, in youth more anterior.

TABLE 28: Dimensions of *Composita hendersoni* sp. nov. (in mm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
CPC3720	20.2	16.9	14.5	17.4	87°	.83
CPC3721	18.3	19.1	11.9	16.0	105°	1.04
CPC3722	16.7	17.1	11.0	14.9	90°	1.03
CPC3723	17.2	17.1	10.6	15.3	108°	1.0
CPC3724	15.8	16.0	10.7	14.1	99°	1.01
F21381	15.9	16.4	11.1	c14.5		
F21382	15.5	15.4	10.5	c13.7		
F21383	17.8	17.5	10.0	16.5		
F21384	13.2	12.1	7.6	11.5		
F21385	13.2	12.9	9.8	12.0		
F21386	14.8	16.7	9.3	13.3		
F21387	17.9	16.8	11.4	15.2		
F21388	18.0	18.2	12.0	15.8		
F21398	14.1	14.6	9.0	12.2		
F21390	16.0	17.5	10.1	15.1		
F21391	15.6	15.6	8.6	12.5		
F21392	19.1	18.6	12.0	16.1		
F21393	14.3	14.7	8.9	13.1		
F21394	10.9	12 2	6.3	9.5		
F21395	17.1	18.2	11.9	15.8		
F21396	16.2+	17.9	10.1	c14.6		
F21397	13.4	13.1	8.2	11.7		
F21398	12.6	12.7	8.3	11.0		
F21399	17.8	18.6	8.4	14.9		
F21400	14.1	14.4	9.5	13.2		
F21401	13.4	14.7	8.7	12.4		
F21402	11.1	11.2	7.2	10.0		
F21403	12.2	11.1	7.4	11.0		
F21404	11.4	11.0	7.7	10.4		
F21405	14.0	15.2	8.7	12.4		
F21406	9.9	11.3	6.5	9.1		
F21407	12.2	10.9	7.1	10.7		
F21408	19.8	18.6	12.3	16.3	93°	0.94
F21409	19.8	18.5	12.9	18.0	95°	0.93
F21410	21.2	18.7	14.6	18.5	90°	0.88
UWA2507	19.2	17.6	12.3	17.1	85°	0.92
F21363	18.0	16.8		16.4	97°	0.93
F21364	17.7	15.9	11.9	15.3	90°	0.93
F21365	15.0	14.6			90°	0.97
F21366	8.4	8.4				
F21367	11.5	9.5				
F21368	6.8	7.4				
F21369	9.7	9.7				
Dorsal Valves						
F21370		10.6		10.4		
F21371		10.9		10.5		
F21372		14.9		14.5		
F21373		11.6		11.8		
F21374		9.9		9.5		
F21375		7.0		6.9		
F21376		11.4		10.6		
F21377		13.4		13.9		
F21378		14.5		13.7		
F21379		9.5		8.6		
F21380		7.4		6.6		

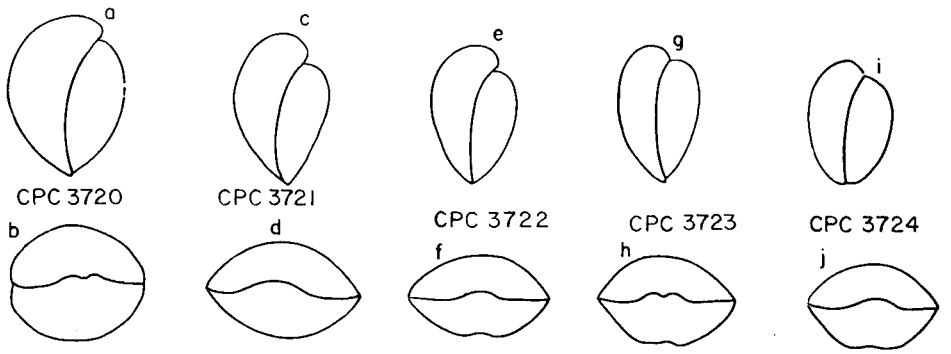

Fig. 79. *C. hendersoni.* **Profile and anterior outlines of specimens illustrated in Plate 23. Natural size.**

Internal structures are known only from sections, illustrated in Text-figures 80-82. These show curved dental plates and perforate quadrate cardinal plate, similar to those of *C. carnarvonensis* and *C. bonapartensis*. A pair of small swellings behind the ventral diductor muscles are like those of *C. carnarvonensis* and *C. variabilis*. The spiralia occupy much of the shell and have 10 to 12 whorls on each side. A small jugum is present, but the jugal bifurcations could not be clearly made out.

The surface is marked by concentric growth-lines, and step-like lamellae, six of which are present on the holotype.

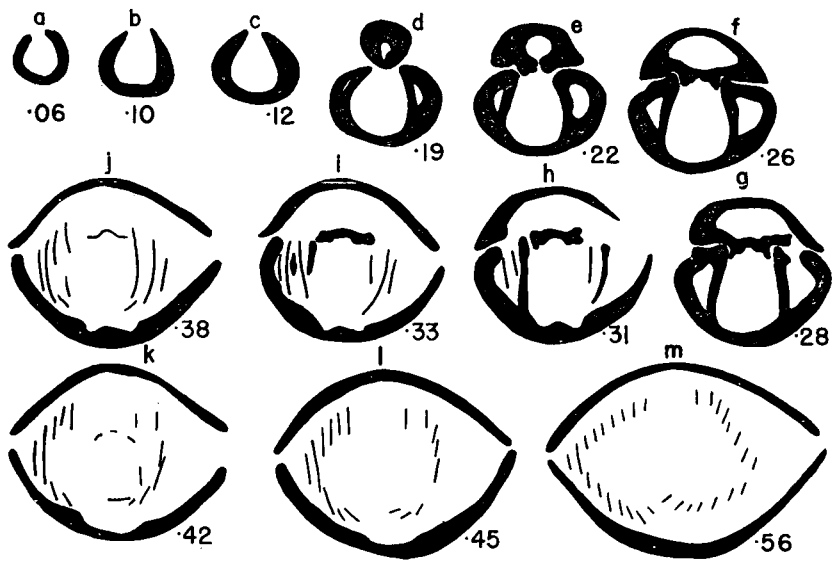

Fig. 80. *C. hendersoni.* **CPC3725. Transverse sections. Spiralium slightly displaced, x2.4.**

Discussion: *C. hendersoni* was first recognized by Prendergast (1935), who referred it to *Composita subtilita* (Hall). There is a resemblance between certain individuals of both species, but the range of variability of *C. subtilita* as described by Dunbar & Condra (1932) and Grinnell & Andrews (1964) differs from that of *C. hendersoni*. *C. subtilita,* a very variable Pennsylvanian species, is not sulciplicate and is larger. *C. ambigua* is commonly sulciplicate, but is a much wider and more deeply plicate form than *C. hendersoni,* which appears to be a distinctive species. A specimen from the *Syringothyris* Limestone of Eishmakam in Kashmir, which was named *Spirigera subtilita* Hall by Diener (1915, pl. 1, fig. 9a, b, c), resembles the mature specimens of *C. hendersoni* in outline and in having a sinus on the fold. They are possibly conspecific.

The possession of long narrow proportions, sulcus, and sinus on fold distinguishes *C. hendersoni* from the other species described herein.

Geological Age: Tournaisian.

Occurrence: All localities are in the higher beds of the Laurel Formation, Fitzroy Basin. CPC3720-6, F21381-1407, from locality SDH83; F21408, 9 from SDH69; F21410 from SDH8; UWA2507 probably came from nearby, being reported by Prendergast as 12 miles west of Oscar Range homestead. Numerous other specimens have been collected from many localities in the Laurel Formation, including the type section.

The species was named in honour of Mr S. D. Henderson, who collected many of the specimens described from the Laurel Formation.

COMPOSITA BONAPARTENSIS sp. nov.

(Pl. 22, figs 5, 6, 11-14, 16, 17; Text-figs 78c, 83)

Diagnosis: Small species, length exceeds width in mature specimens, umbo rounded and prominent with convex shoulders, apical angle 90°-112°; both valves

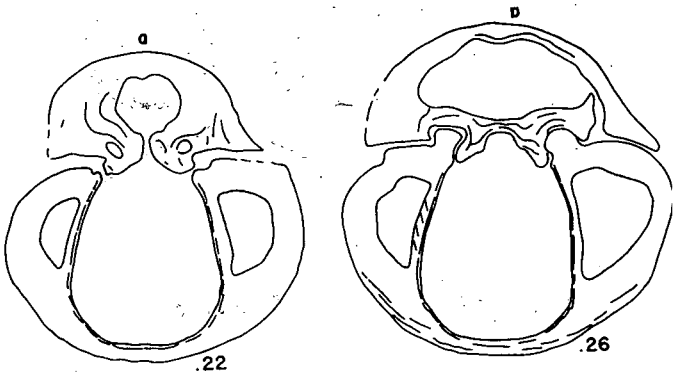

Fig. 81. *C. hendersoni.* **CPC3725. Transverse sections; show dental plates and perforate hinge-plate (cf. Fig. 80), x5.2.**

strongly and evenly convex, no sulcus or fold, front commissure rectimarginate; outline rounded to elongate ovate; muscles well impressed.

Material: Several hundred silicified shells and isolated valves.

TABLE 29: Dimensions of *Composita bonapartensis* sp. nov. (in mm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
Shells and Ventral Valves						
CPC3713	21.0	17.1			104°	0.82
CPC3715	18.6	17.2	13.0	16.1	90°	0.93
CPC3718		17.2		16.1	102°	0.93
CPC6125	17.4	14.6		14.8	94°	0.84
F21338	20.0	19.6			100°	0.98
F21339	19.5	18.6			99°	0.95
F21340	11.1	11.2				
F21341	9.8	10.8				
F21342	9.6	9.4				
F21343	8.9	9.1				
F21344	11.9	12.9				
F21345	11.8	11.3				
F21346	12.3	11.4				
F21347	10.4	10.8	7.2	9.1		
F21348	11.0	10.5				
F21349	7.5	7.5				
F21350	6.6	7.9				
F21351	8.6	8.4				
F21352	13.1	13.3	9.2			
F21353	10.0	9.5				
F21354	9.0	10.3				
F21355	17.0	16.6			112°	0.98
F21356	13.3	12.0				
F21357	12.1	10.7				
F21358	14.3	13.4			100°	0.93
F21359	12.4	11.8				
F21360	20.5	18.7			93°	0.92
F21361	11.1	11.3	7.3	10.0		
F21362	9.4	10.2				

Description: The species is rounded to oval in outline; the maximum width is at, or slightly in front of, the midlength. In the majority of specimens the length exceeds the width, but may be equal or rarely less. Both valves are strongly convex, the dorsal often slightly more so. The great majority of specimens lack fold and sulcus, and the front commissure is rectimarginate. The umbo is rounded and moderately prominent, and its lateral slopes are gently convex with apical angles of 90° to 112°. The pedicle foramen is rounded, and a divergent delthyrium extends in front of it (Pl. 22, fig. 12a, b). This is flanked by slightly depressed flanged dental ridges. The teeth are prominent and set obliquely. The delthyrium is normally covered by the moderately prominent dorsal umbo.

The surface ornament consists of fine concentric growth-lines and step-like lamellae. Eight of the latter are seen in the holotype, CPC3715 (Pl. 22, fig. 13a, b); the growth-lines are more numerous.

Internally, the structures are similar to those of *C. carnarvonensis,* except that the muscles are commonly more deeply impressed than in most of the silicified shells of that species. The dental plates are prominent and support the teeth, and are not completely fused to the shell wall. The pair of small swellings or bosses in front of the pedicle impression of *C. carnarvonensis* are absent in this species. In fact, one specimen, CPC3719, shows two small depressions in the corresponding position (Pl. 22, fig. 16b). The dorsal valve interior is quite similar to that of *C. carnarvonensis.* The quadrate cardinal plate (Pl. 22, figs 5, 6, 16a) is perforate near the umbo. The dorsal adductor scars are elongate and commonly well impressed and have a distinct thin myophragm. They are flanked by ovarian pits and faint radial vascular striations.

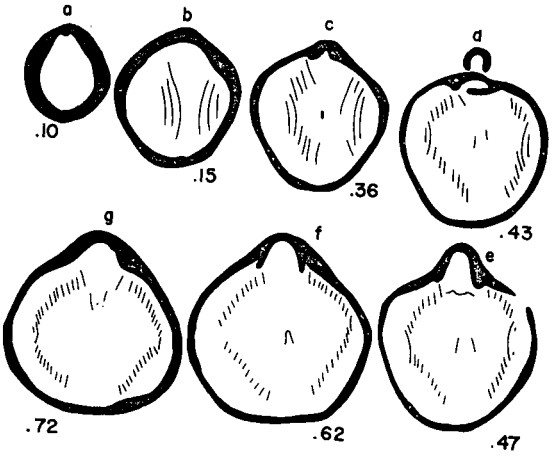

Fig. 82. *C. hendersoni.* **CPC3726. Longitudinal section, x1.6.**

Discussion: The great majority of the specimens described came from the Septimus Limestone at Mount Septimus. In addition is a group of somewhat crushed, but also silicified specimens from locality WAA9, which are similar in all respects to the other specimens. *C. bonapartensis* seems to be very distinctive in almost invariably lacking sulcus and fold. Certain species appear to have individuals which are smooth but others which are sulcate e.g. *C. ficoidea* Vaughan and *C. carnarvonensis.* In respect to size and proportions, *C. magnicarina* Campbell from the Kuttung (Booral Formation) of New South Wales is similar but possesses a variable ventral sulcus and a more pronounced dorsal septum. The smooth rectimarginate and oval shape distinguishes *C. bonapartensis* from the other Western Australian species.

Geological Age: Late Tournaisian to early Visean.

Occurrence: CPC3713-9, F21340-80, from western slopes of Mount Septimus, Bonaparte Gulf Basin. Septimus Limestone, about 550 to 600 feet above the base. CPC6125, F21338, 21339, from WAA9 (Mines Administration Ltd), isolated outcrop, probably equivalent to Septimus Limestone.

COMPOSITA VARIABILIS sp. nov.

(Pl. 24, figs 15-18; Text-figs 78d, 84-86)

Diagnosis: Small species, generally longer than wide, some very narrow; umbo prominent, apical angle 90° to 100°; outline variable but maximum width in anterior half; a few specimens smooth but majority with anterior ventral sulcus and dorsal fold with lateral depressions, producing trilobation; muscles well impressed.

Material: 70 shells, mostly abraded and some incomplete.

Description. The specimens are all small but mostly adult, with both valves moderately convex. The holotype, CPC-3727 (Pl. 24, fig. 17a, b), of average dimensions, is 1.2 cm long, 1.15 cm wide, and 0.70 cm thick. The outline varies from rounded to elongate-oval to distinctly trilobate in front. Length exceeds width in most, but they are equal in a few, specimens. The umbo is moderately prominent, apical angle 90° to 100°. The ventral valve generally has a gentle fold but also can be smooth. Commonly the fold is produced forward and flanked by grooves, giving distinctly trilobate appearance. The front commissure varies from rectimarginate through uniplicate to parasulcate. The maximum width is at half to two thirds of the shell length from the umbo.

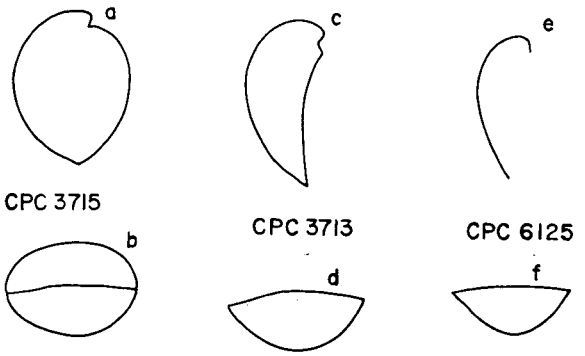

Fig. 83. *C. bonapartensis.* **Profile and anterior outlines of specimens illustrated in Plate 22. Natural size.**

TABLE 30: Dimensions of *Composita variabilis* sp. nov. (in mm)

Specimen Number	L	Wm	T	Lb	Aa	W/L
CPC3727	12.0	11.6	6.9	10.5	90°	.97
CPC3728	13.0	12.6	7.0	11.3	98°	.97
CPC3729	15.0	14.2	—	—	99°	.94
CPC3730					90°	
F21411	13+	13.5+			100°	
F21412	11.7	11.7				1.0
F21413	13.0	11.5	7.4	11.3	93°	.88
F21414	15.5	14.7	8.5	13.7		.95
F21415	12.5	12.5	8.2	10.2		1.0
F21416	10.9	10.4	5.9	9 2	98°	.96
F21417	14.8	12.5	7.5	13.8		.95
F21418	13.4	10.8	8.5	11.4		.75
F21419	12.9	10.3	7.5	11.2		.80
F21421	15.2	12.0e		12.2		.78
F21422	15.0	13.3		13.8		.87

The surface ornament is generally somewhat abraded; but only concentric growth lamellae have been detected.

Internally the structure resembles that of *C. carnarvonensis*. A few internal moulds, prepared from the specimens, display similar features, including the small swellings noted in front of the pedicle cavity. Serial sections of specimens CPC3731 and 3732 are illustrated in Text-figures 85, 86. They reveal the dental plates and quadrate perforated hinge-plate characteristic of *Composita*. The spiralia have 11 whorls on each side. A jugum is present, but the details of the secondary jugal lamellae, if any, could not be determined.

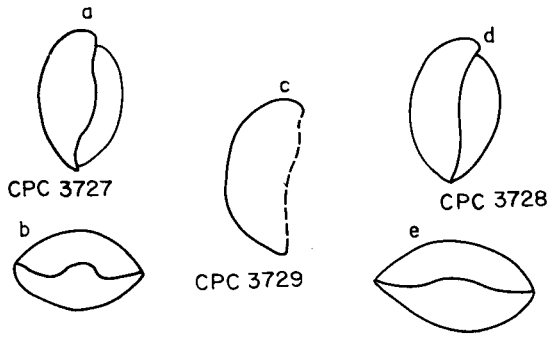

Fig. 84. *C. variabilis*. **Profile and anterior outlines of specimens illustrated in Plate 24. Natural size.**

Discussion: This small species is very variable in form. Some individuals appear to be nearly smooth and in this respect resemble *C. bonapartensis*. The majority, however, tend towards a trilobate development in the front with a dorsal fold flanked by low depressions. These individuals resemble in this respect such species as *Composita trinuclea* (Hall), which is widely distributed through the Meramecian and Chesterian series of North America. The Mississippian forms may develop a small dorsal sinus on the fold. *C. trinuclea* was also identified from the Ruzakov beds of northeast Kazakhstan of late Tournaisian to Visean age (Nalivkin, 1937). Monakhova (1959) recorded it from central Kazakhstan. Simorin (1956) identified it from beds of similar age in the Karagandian basin of Russia. Another species with comparable trilobation is *C. hunanensis* Wang from the Tournaisian of Kweichow. *Pseudopentagonia injensis* Besnossova from the Tournaisian of the Kuznetzk Basin has a somewhat similar trilobate shape.

C. variabilis is possibly present in the Bonaparte Gulf Basin. A single trilobate specimen was collected by Mr E. P. Utting, from locality 'S' in 1959, northeast of Ningbing homestead, in beds which are probably part of the Burvill Beds or Point Spring Sandstone sequence.

Geological Age: Probably Visean.

Occurrence: Specimens CPC3727-32, F21411-24 from one general locality, 1.7 miles bearing 351° from Moogooree homestead, Carnarvon Basin, Yindagindy Formation.

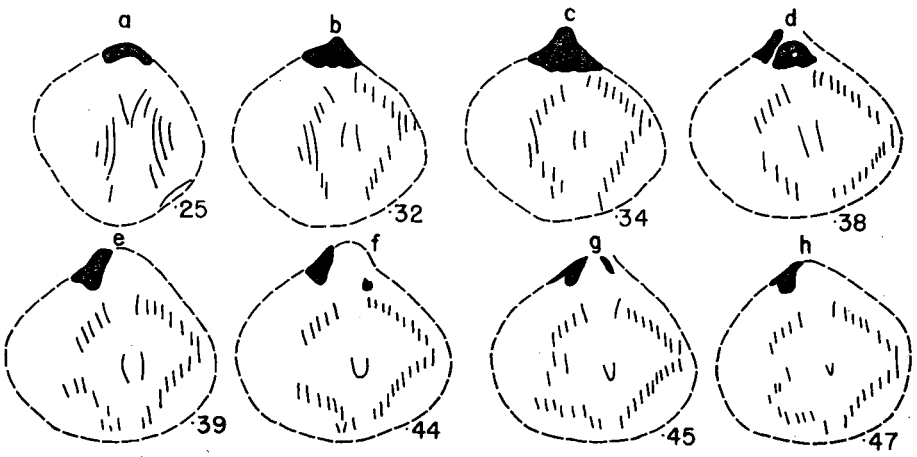

Fig. 85. *C. variabilis*. **CPC3731, an abraded shell. Longitudinal sections, x2.5.**

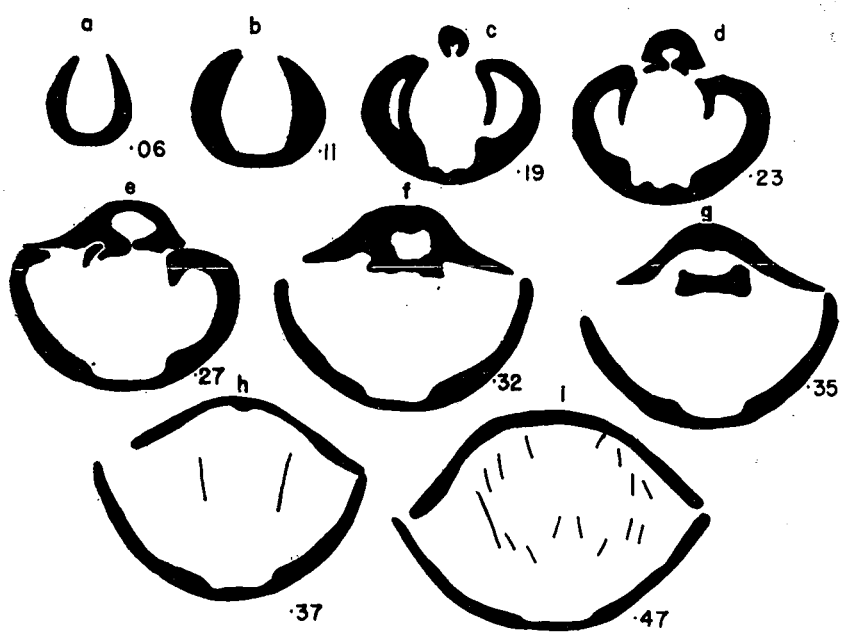

Fig. 86. *C. variabilis*. **CPC3732. Tranverse sections. Spiralium somewhat displaced, x4.7.**

CARBONIFEROUS LOCALITIES

Carnarvon Basin

Moogooree Limestone: TP42, about 3.5 miles bearing 135° from Williambury homestead (1 of Text-fig. 2).

CC120, north bank of Minilya River, 2.5 miles bearing 75° from Williambury homestead (2 of Text-fig. 2).

CC102, 0.85 miles bearing 185° from Williambury homestead (3 of Text-fig. 2).

Yindagindy Formation: TP....., 1.7 miles bearing 351° from Moogooree homestead (5 of Text-fig. 2).

Canning (Fitzroy) Basin

Laurel Formation: KC11, 2.4 miles bearing 180° from 12 Mile Bore, Springs station (Section II of Text-fig. 4).

KC13, 4.0 miles bearing 289° from Egans Bore (near locality V of Text-fig. 4).

KC18, in creek, 1.9 miles bearing 330° from Egans Bore.

Ng273 (W.A. Petroleum Ltd), 2.4 miles bearing 40° from Laurel Downs homestead.

Ng247 (W.A. Petroleum Ltd), 4.0 miles bearing 290° from Egans Bore (same bed as KC11).

Ng51 (W.A. Petroleum Ltd), 2.8 miles bearing 98° from Egans Bore.

SDH8, 1.35 miles bearing 320° from Egans Bore (same bed as IV in Text-fig. 4).

SDH38, 5.5 miles bearing 310° from Egans Bore (near section II in Text-fig. 4).

DH69, 0.5 miles bearing 213° from Egans Bore.

SDH83, 1.5 miles bearing 158° from Egans Bore.

Bonaparte Gulf Basin

Burt Range Formation: BW5, 'Sandy Creek beds', crossing on Sandy Creek on track from Carlton to Legune homesteads, 24.8 miles bearing 33° from Mount Septimus (2 in Text-fig. 5).

BW1, 'Flapper Hill beds', Flapper Hill (3 in Text-fig. 5).

Enga Sandstone: Locality E (Westralian Oil Ltd), 6 miles bearing 24° from Mount Septimus (1 in Text-fig. 5).

Septimus Limestone: Mount Septimus, western slope (4 in Text-fig. 5); WAA9 (Mines Administration Ltd = locality B, Westralian Oil Ltd), 16.8 miles bearing 34° from Mount Septimus (5 in Text-fig. 5); locality A (Westralian Oil Ltd), about 13.5 miles bearing 36° from Mount Septimus (6 in Text-fig. 5).

Burvill Beds: BW7, about 1 mile east of Point Spring, lower scarp of Weaber Range (7 in Text-fig. 5).

WAA3 (Mines Administration Ltd), Milligans Hills, 5.5 miles bearing 10° from Mount Septimus (8 in Text-fig. 5).

WAA4 (Mines Administration Ltd), Milligans Hills, nearby locality.

WAA6 Mines Administration Ltd), Milligans Hills, 2 miles bearing 327° from WAA3.

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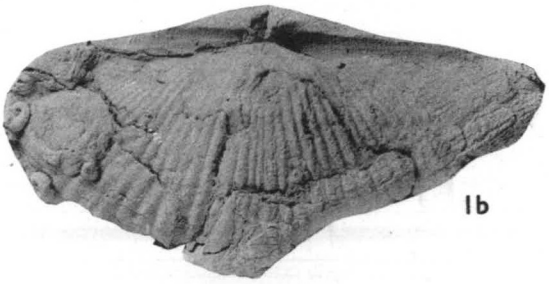
PLATE 1

Unispirifer fluctuosus (Glenister) .... **Page 70**

1a, b. CPC1547. Shell, ventral and dorsal views, x1.
2a, b. CPC1551. Shell in ventral and dorsal views, x1.
3a, b. CPC1548. Shell in ventral and dorsal views, x1.
4a, b. CPC1550. Shell in ventral and dorsal views, x1.
5 CPC1552. Part of ventral valve, in dorsal and anterior dorsal views showing dental plates and delthyrial plate, x1.

All specimens are from the Laurel Formation, Fitzroy Basin.

1a



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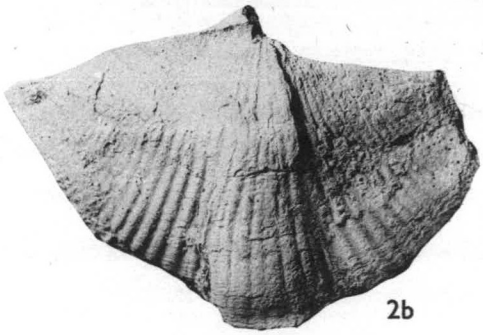

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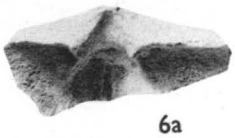

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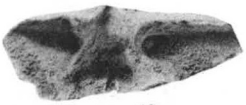

6b

PLATE 2

1-7 *Unispirifer fluctuosus* (Glenister) .... Page 70

1 CPC1554. Interior of ventral valve in anterior view, x2.
2 CPC1553. Interior of dorsal valve in ventral view, showing cardinalia, x2.
3 CPC1555. Part of interior of dorsal valve, showing socket plate, x2.
4 CPC1556. Part of interior of dorsal valve, showing cardinal process, x2.
5 CPC1557. Part of interior of dorsal valve, showing socket plate, x2.
6 CPC1558. Part of interior of ventral valve, showing dental plate, anterior view, x1.
7 CPC1558. Part of ventral valve in dorsal view, showing interarea and dental plate, x1.

8-13 *Prospira laurelensis* sp. nov. .... Page 84

8a, b. CPC1541, paratype. Shell in ventral and dorsal views, x1.
9a, b. CPC1542, paratype. Shell in ventral and dorsal views, x1.
10a, b. CPC1546, paratype. Shell in ventral and dorsal views, x1.
11a, b. CPC1543, **holotype.** Shell in ventral and dorsal views, x1.
12a, b. CPC1544, paratype. Shell in ventral and dorsal views, x1.
13a, b. CPC1545, paratype. Shell in ventral and dorsal views, x1.

All specimens from Laurel Formation, Fitzroy Basin.

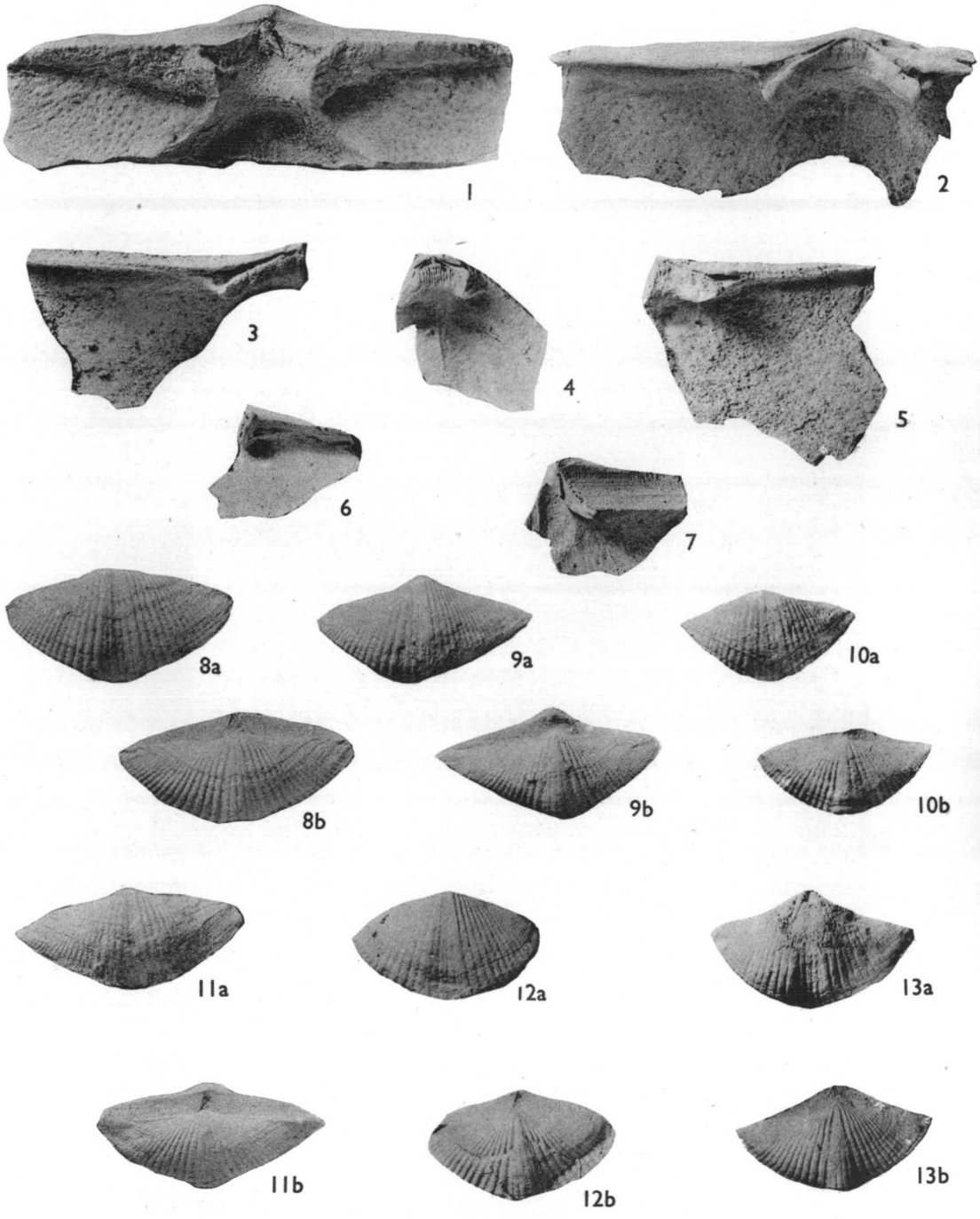
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PLATE 3

1a, b. *Unispirifer fluctuosus* (Glenister), CPC1579 .... Page 70

Interior of ventral valve, anterior and dorsal view, x3.

2-4 *Spirifer spiritus* sp. nov. .... Page 62

2a, b, c. CPC1559, **holotype.**
Ventral valve in ventral, posterior ventral and posterior dorsal views, x1.
3a, b, c. CPC1562.
Interior of ventral valve in dorsal and two anterior views, x2.
4a, b. CPC1564.
Interior of ventral valve in anterior and dorsal views, x3.

5a, b, c. *Spirifer spiritus?* CPC1569 .... Page 65

Shell in ventral and two dorsal views, x1½.

6a, b. *Unispirifer septimus* sp. nov. CPC1563 .... Page 78

Ventral valve in ventral and dorsal views, x1.

Figure 1 from Moogooree Limestone. Other specimens from Septimus Limestone.

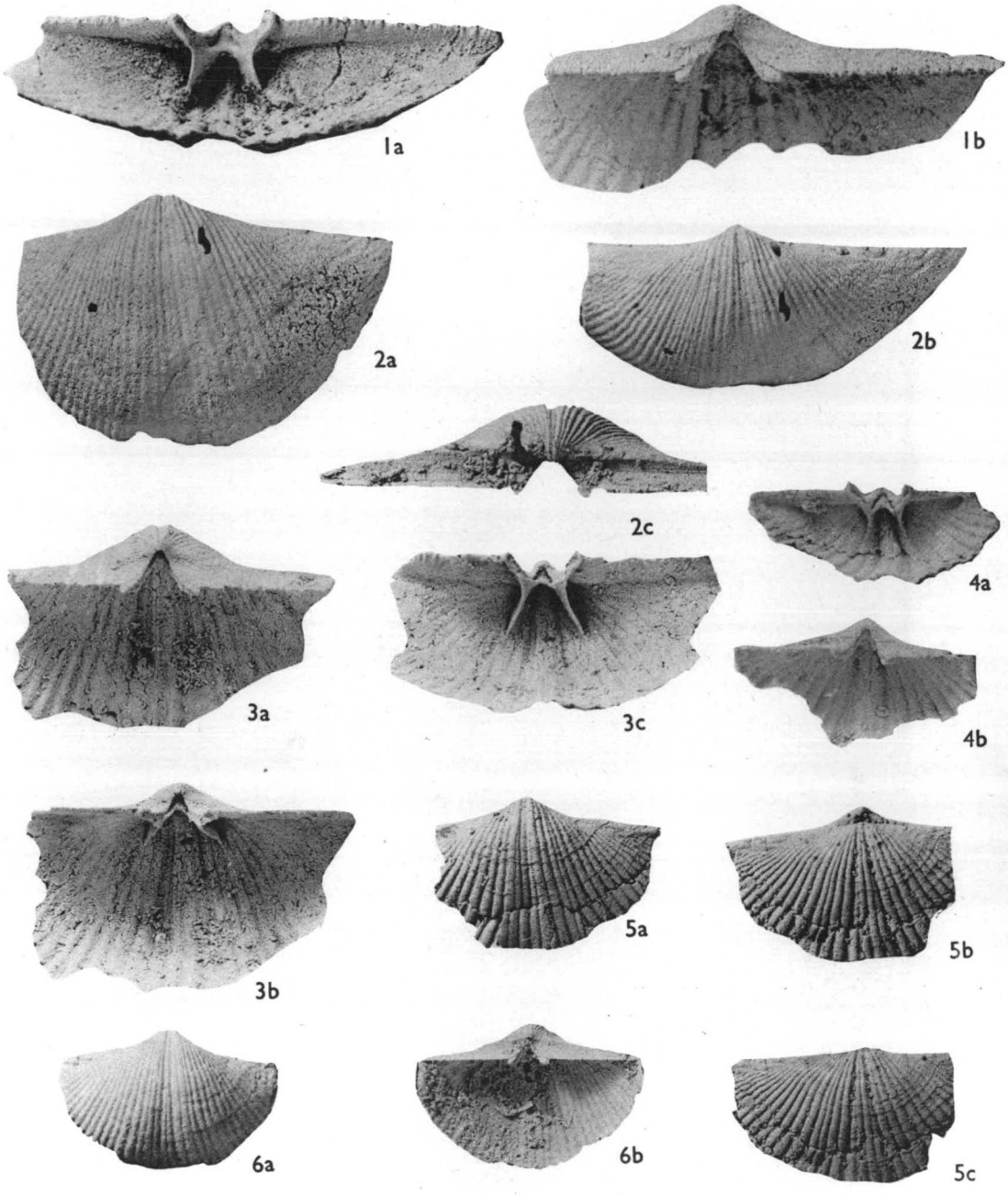
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PLATE 4

1a, b, c. *Spirifer spiritus* sp. nov. CPC1560 .... Page 62
Dorsal valve in ventral, anterior ventral and dorsal views, x3. Septimus Limestone.

2a, b. *Spirifer* sp. CPC1565 .... Page 67
Ventral valve in ventral and dorsal views, x1. Septimus Limestone.

3a, b. *Spirifer spiritus.* CPC1567 .... Page 62
In complete shell in ventral and dorsal view, x1. Septimus Limestone (north of Spirit Hill).

4a, b, c. *Prospira* aff. *laurelensis* sp. nov. CPC1580 .... Page 90
Ventral valve in ventral, dorsal and anterior dorsal views, x1½. Moogooree Limestone.

5a, b. *Spirifer spiritus.* CPC1568 .... Page 62
Dorsal valve in dorsal and ventral view, x1. Septimus Limestone (north of Spirit Hill).

6a, b. *Spirifer spiritus.* CPC1566 .... Page 62
Shell in ventral and dorsal view, x1. Septimus Limestone (north of Spirit Hill).

7a, b, c. *Prospira* aff. *laurelensis.* CPC1582 .... Page 90
Internal mould in dorsal, ventral and posterior dorsal views, x1½. Moogooree Limestone.

8a, b. *Prospira* aff. *laurelensis.* CPC1581 .... Page 90
Ventral valve in posterior valve and ventral views, x1½. Moogooree Limestone.

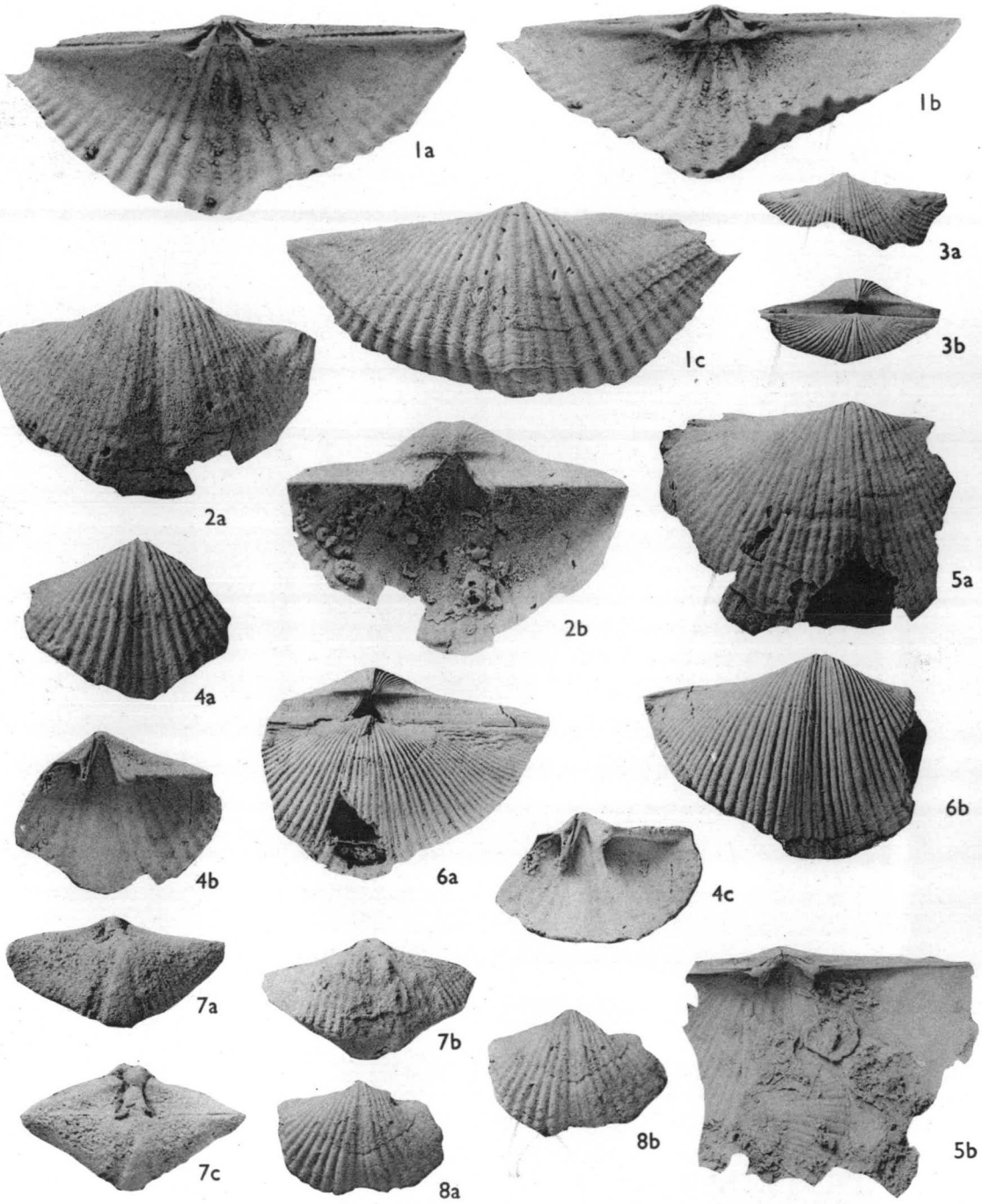
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PLATE 5

1, 2, 4, 9. *Unispirifer septimus* sp. nov. .... Page 78

1a, b, c. CPC1570, **holotype.**
Ventral valve in ventral, dorsal and anterior dorsal views, x1.
2a, b, c, d. CPC1571, paratype.
Dorsal valve in dorsal and ventral views, x1, and in anterior ventral and ventral views, x2.
4 CPC1572, paratype.
Dorsal valve in dorsal view, x1.
9 CPC1573.
Incomplete ventral valve in anterior dorsal view, x1.

3, 5, 6, 7. *U.* cf. *septimus* .... Page 81

3 CPC1576. Incomplete shell in dorsal view, x1.
5a, b. CPC1578. Shell in ventral and dorsal view, x1.
6a, b, c. CPC1577. Ventral valve in ventral, posterior ventral and dorsal views, x1.
8a, b. CPC1575. Incomplete shell in dorsal and ventral views, x1.

7a, b. *Prospira travesi* sp. nov. CPC1574, paratype .... Page 92

Dorsal valve in ventral valve, x1½, and dorsal view, x1.
Figures 1, 2, 4, 7, 9 from Septimus Limestone, at Mount Septimus.
Figures 3, 5, 6, 8 from Septimus Limestone, north of Spirit Hill.

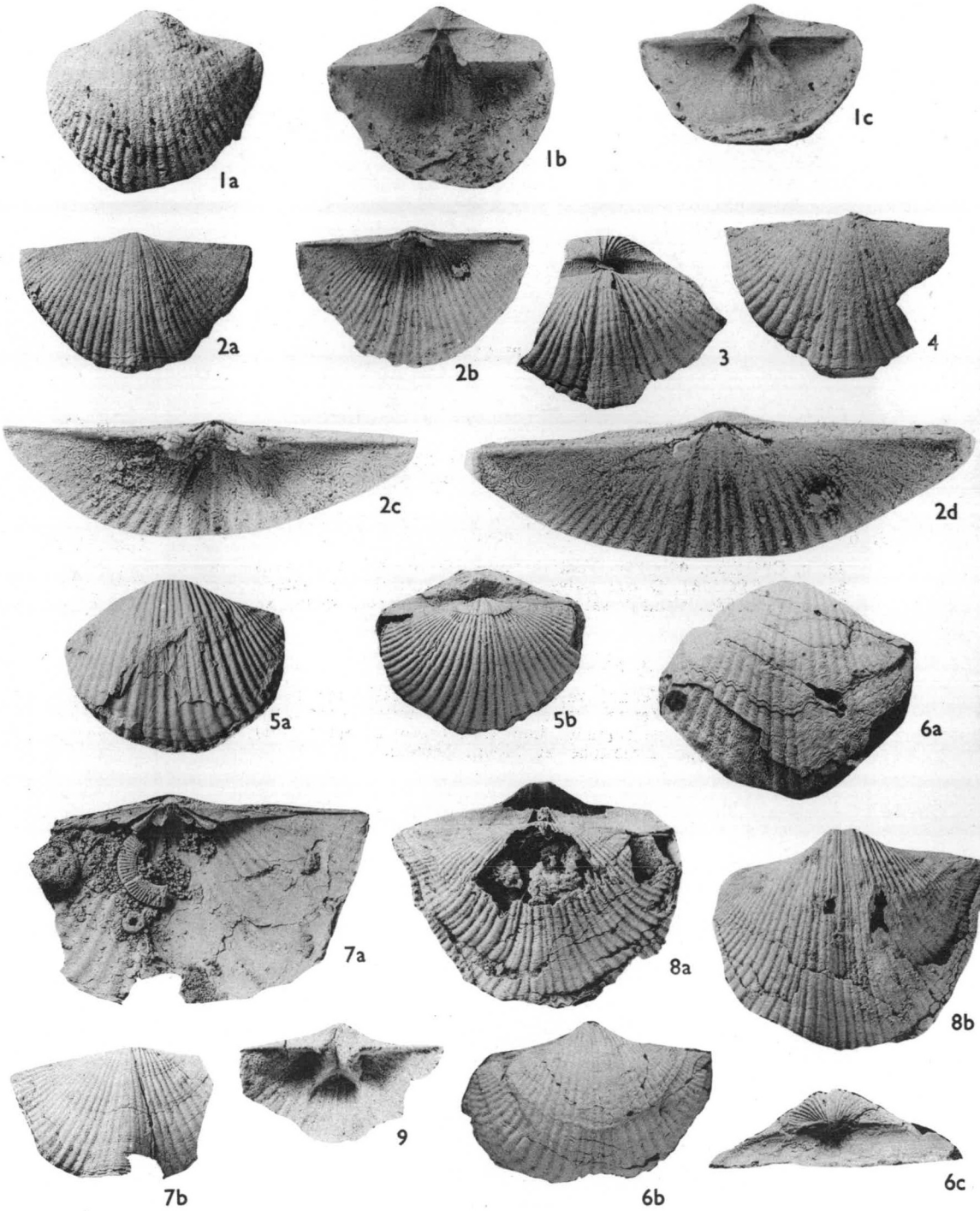
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PLATE 6

1, 2. *Spirifer spiritus* sp. nov. .... Plate 62

1 CPC1561, paratype. Ventral valve in ventral view, x1.
2a, b. CPC1679. Ventral view in ventral and dorsal views, x1.

3, 6, 7. *Brachythyris latecardinalis* sp. nov. .... Page 123

3a, b, CPC1585, **holotype.** Ventral valve, in ventral and dorsal views, x1½.
6a, b, c. CPC1587. Dorsal valve in dorsal, ventral, and anterior ventral views, x2.
7a, b. CPC1586. Ventral valve in ventral and dorsal views, x1.

4, 5. *Brachythyris* sp. cf. *B. peculiaris* (Shumard). .... Page 121

4a, b, c. CPC1584. Ventral valve in ventral, dorsal, and anterior dorsal views, x2.
5a, b, c. CPC1583. Ventral valve in ventral, dorsal, and anterior dorsal views, x2.
Figure 2a, b from the Septimus Limestone (north of Spirit Hill); all other specimens from the Septimus Limestone at Mount Septimus.

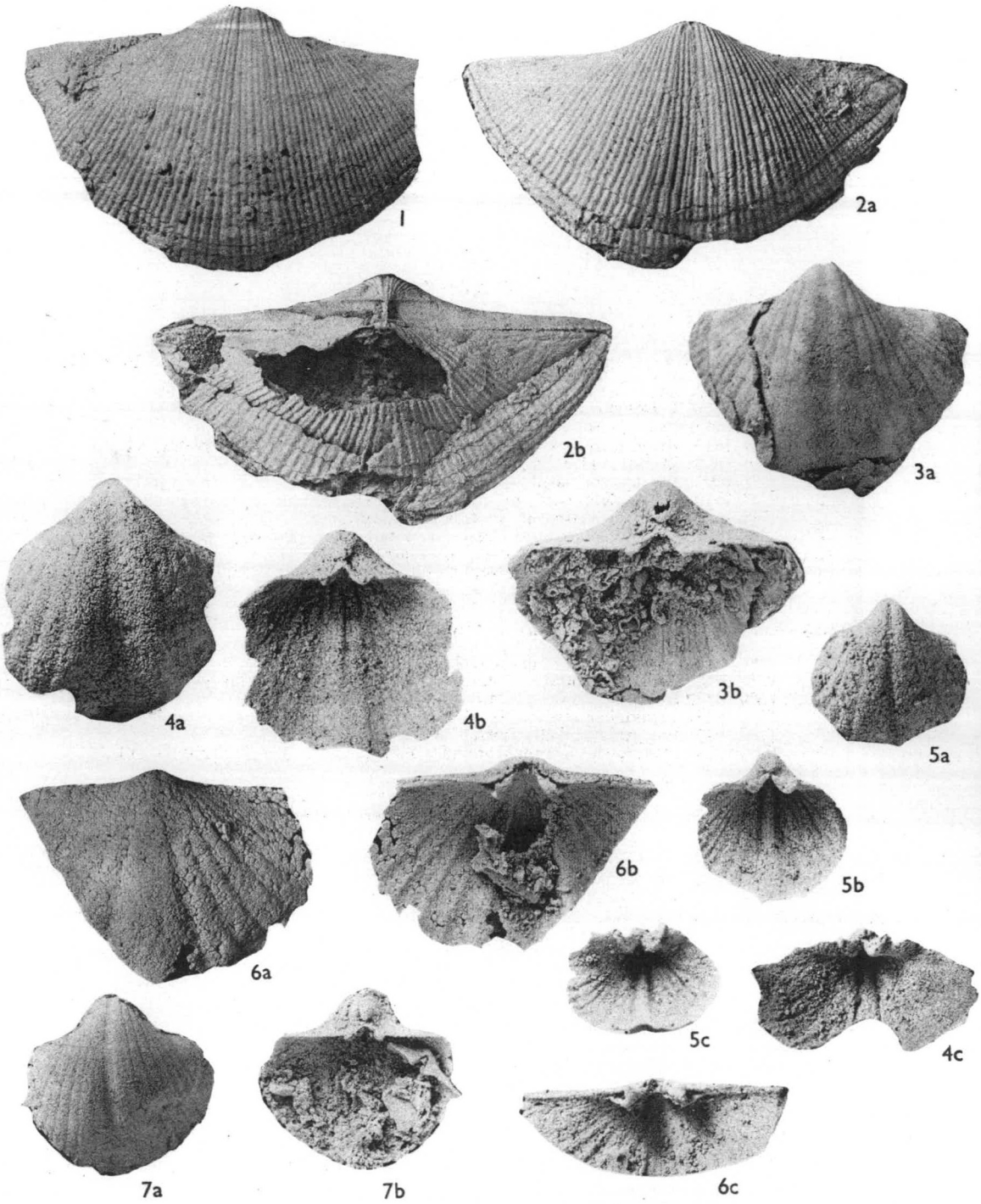
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PLATE 7

1-8, 10, 11. *Etochoristites? arenatus* sp. nov. .... Page 113

1 CPC1607. Shell in dorsal view, x1.
2 CPC1606, **holotype.** Shell in dorsal view, x1.
3a CPC1612. Dorsal valve in dorsal view.
3b CPC1613. Incomplete shell in posterior view, showing dental plates, x1.
4 CPC1608. Dorsal valve in dorsal view, x1.
5 CPC1609. Incomplete shell in dorsal view, x1.
6 CPC1610. Incomplete shell in dorsal view, x1.
7 CPC1611. Ventral valve in ventral view, x1.
8 CPC1615. Incomplete ventral valve in dorsal view, showing dental plates, x2.
10 CPC1612. Dorsal valve in posterior ventral view, x2.
11 CPC1614. Part of ventral valve, dorsal view showing dental plates, x2.

9, 12-16. *Ectochoristites? arenatus latus* var. nov. .... Page 116

9 CPC1619. Ventral valve in dorsal view, abraded, x1.
12 CPC1618. Part of ventral valve, dorsal view showing dental plates, x2.
13 CPC1617. Incomplete shell, ventral view, x1.
14 CPC1621. Incomplete shell, dorsal view, x1.
15 CPC1616. Incomplete shell, dorsal view, x1.
16 CPC1620. Incomplete internal mould, ventral view showing spiralia, x1.

All specimens from Burt Range Formation at Sandy Creek, Bonaparte Gulf Basin.

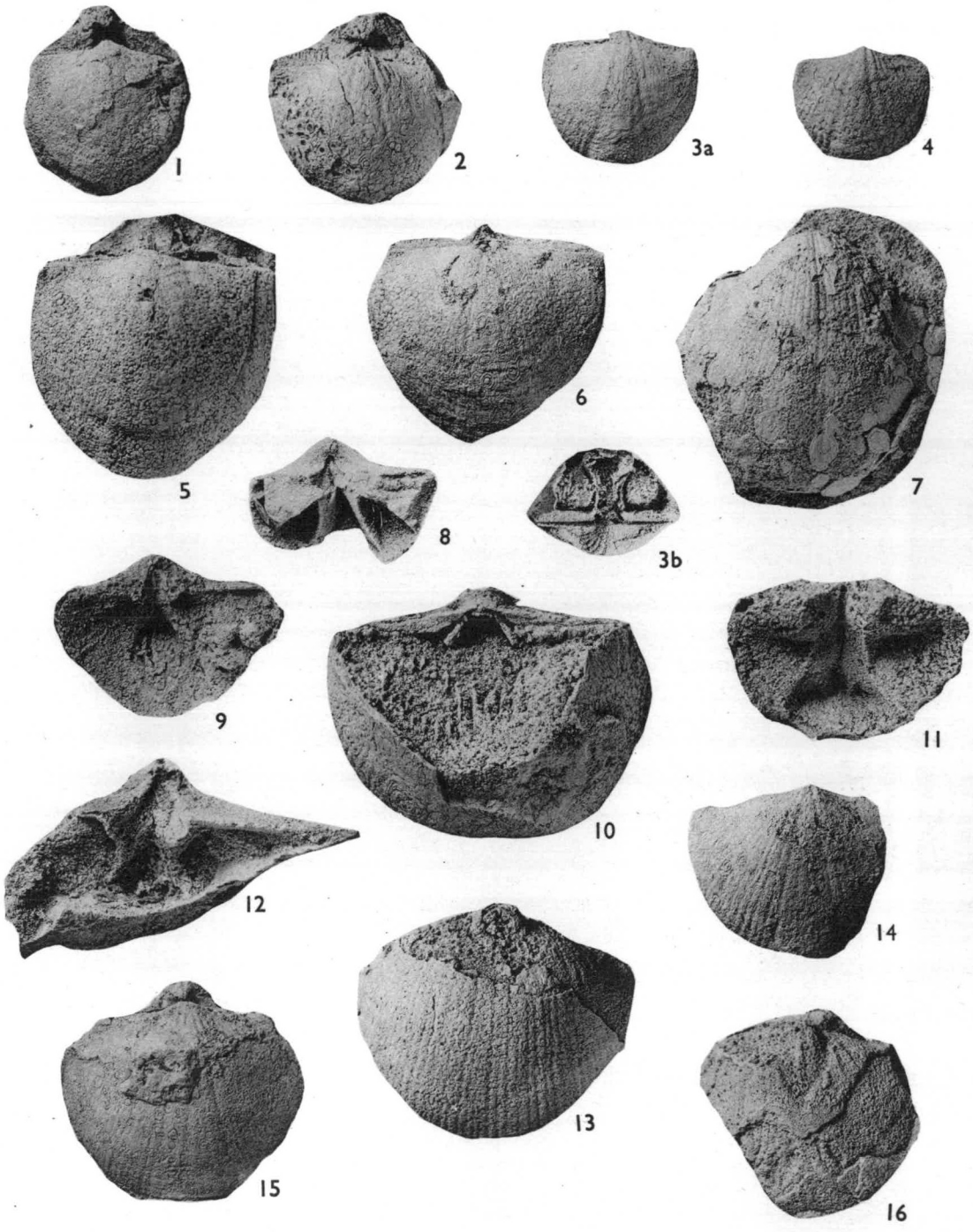
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PLATE 8

1, 2, 4, 6. *Anthracospirifer milliganensis* sp. nov. .... Page 97

1. CPC1589, paratype. Dorsal valve in dorsal view, x1½.
2a, b. CPC1588, **holotype.** Ventral valve in ventral and posterior dorsal view, x1½.
4. CPC1592, paratype. Ventral valve in posterior ventral view, x1½.
6. CPC1589. Part of external impression, x1.

3. *Anthracospirifer* aff. *milliganensis.* CPC1590 .... Page 101

Dorsal valve in dorsal view, x1½.

5, 8. *Ectochoristites?* sp. nov. .... Page 119

5(a) CPC1596. Ventral valve in ventral view.
(b) CPC1597. Incomplete shell in dorsal view, both x1.
8. CPC1595. Incomplete dorsal valve in dorsal view, x1.

7, 9-11. Spiriferidae gen. et sp. nov. (cf. *Spirifer duplicicostus* Phillips) .... Page 101

7. CPC1593. Internal mould of ventral valve in ventral view, x1½.
9a, b. CPC1594. Ventral valve in ventral and dorsal views, x1.
10. CPC1599. Dorsal valve in dorsal view, x1.
11. CPC1598. Ventral valve in ventral view, x1.

12. *Prospira travesi* sp. nov. CPC1574. Portion of surface, x8 .... Page 92

13. *Unispirifer fluctuosus.* Portion of surface (silicified), x8 .... Page 70

14. *Prospira laurelensis* sp. nov. CPC1543. Portion of surface, x8 .... Page 84

Figs 1-11 from Burvill Beds, Bonaparte Gulf Basin.
Fig. 12 from Septimus Limestone, Bonaparte Gulf Basin.
Fig. 13 from Moogooree Limestone, Carnarvon Basin.
Fig. 14 from Laurel Formation, Fitzroy Basin.


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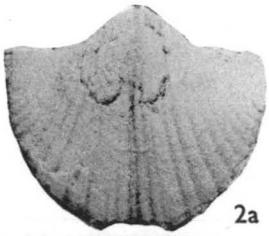
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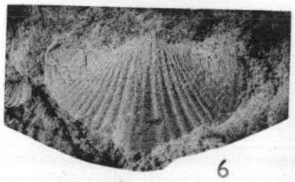
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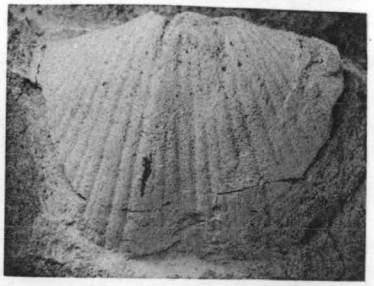
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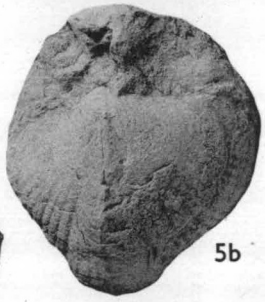
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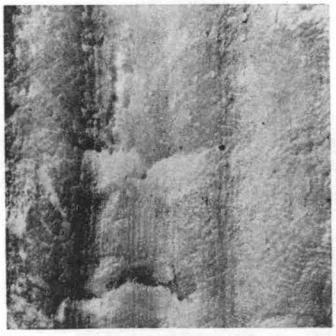
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PLATE 9

1-4. *Prospira? incerta* sp. nov. .... Page 94

1. CPC1602. Ventral valve, ventral view, x2.
2. CPC1603. Incomplete dorsal valve, dorsal view, x2.
3a, b. CPC1600, **holotype.** Incomplete shell, ventral and dorsal views, x2.
4a, b. CPC1601, paratype. Incomplete shell, ventral and dorsal views, x2.

5a, b. *Ectochoristites? arenatus* (*?*) CPC1604 .... Page 116

Portions of dorsal valve, showing cardinalia in ventral and posterior ventral view ,x3.

6, 7. *Syringothyris spissus* Glenister .... Page 131

6a, b. CPC1560. Shell, somewhat worn, in ventral and dorsal views.
7a, b, c. CPC1659. Ventral valve, in dorsal, anterior dorsal, and ventral views, x1. Moogooree Limestone.

8, 9. *Syringothyris* sp. nov. B .... Page 135

8a, b. CPC1662. Ventral valve in ventral and posterior dorsal views, x1.
9. CPC1663. Ventral valve in ventral view, x1.
Figures 1-5 Burt Range Formation, at Sandy Creek, Bonaparte Gulf Basin.
Figures 6-7 Moogooree Limestone, Carnarvon Basin.
Figures 8-9 Burvill Beds, Bonaparte Gulf Basin.

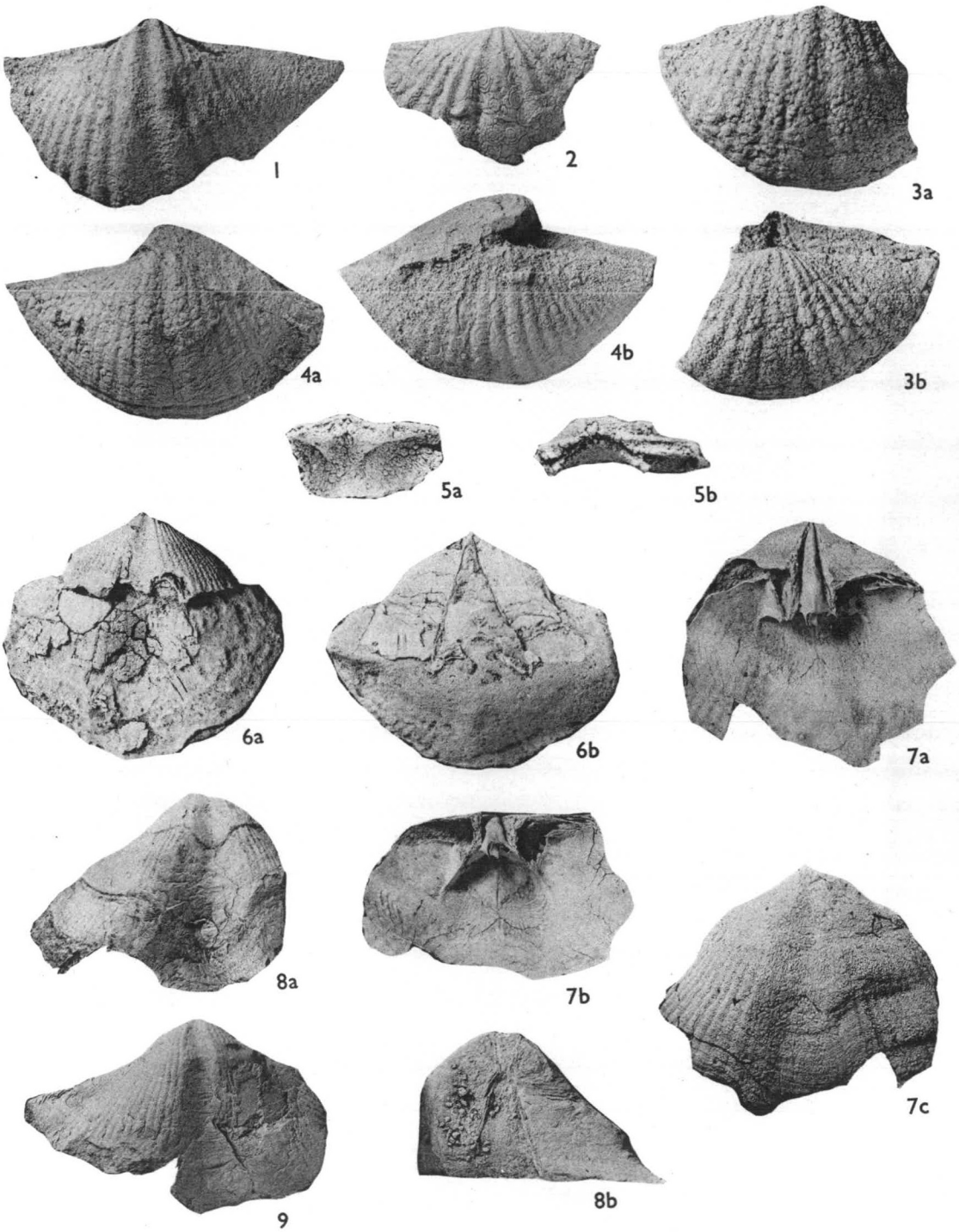
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PLATE 10

Pseudosyringothyris dickinsi sp. nov. .... Page 140

1. CPC1637. Incomplete dorsal valve, in posterior ventral view showing the cardinalia, x1½.

2a, b, c. CPC1635. Shell in posterior dorsal, ventral and dorsal views, x1.

3a, b. CPC1634. Shell in posterior dorsal and dorsal views, x1.

4a, b. CPC1635. Portion of ventral valve, in posterior dorsal view showing delthyrial plate, and in anterior dorsal view showing dental plate and inside of delthyrial plate with part of the adductor muscle scar near the internal apex, x1.

5. CPC1644. Portion of a ventral valve, showing inside of one side of the interarea and part of the delthyrial plate. Note dental plate and pair of adductor muscle scars (only one complete) separated by a median ridge, x1.

All specimens from the Callytharra Formation, Carnarvon Basin.

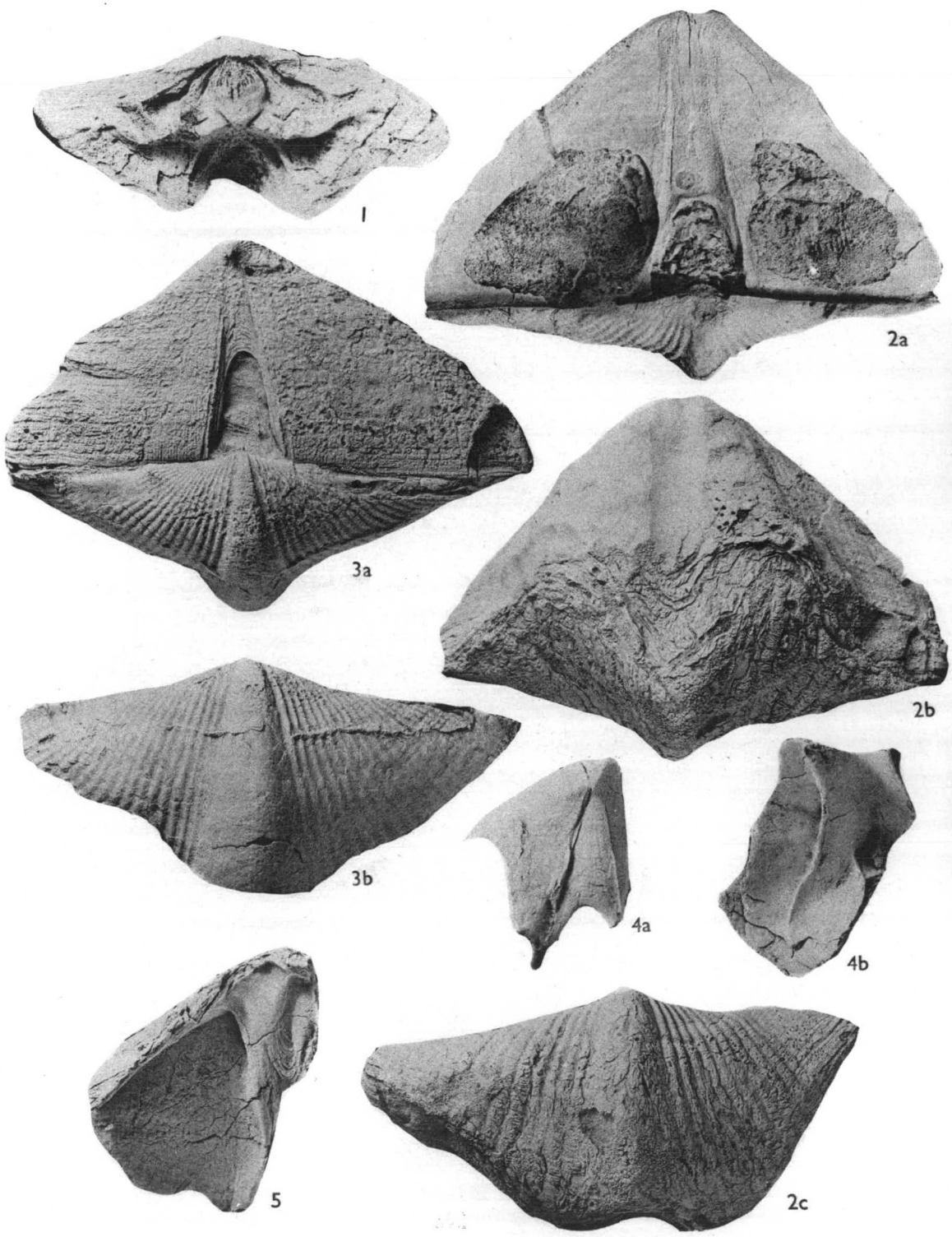
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PLATE 11

1, 2. *Pseudosyringothyris dickinsi* sp. nov. .... Page 140

1a, b, c. CPC1636, **holotype.** Abraded shell in ventral, dorsal and posterior dorsal views, x1.

2a, b. CPC1638. Portion of dorsal valve showing cardinalia in posterior and anterior ventral views, x1½.

3-6. *Cyrtella nagmargensis* (Bion) *australis* subsp. nov. .... Page 151

3. CPC1648. Internal mould of dorsal valve, x1.

4. CPC1651. Incomplete dorsal valve in dorsal view, x1.

5. CPC1650. Incomplete dorsal valve in dorsal view, x1.

6a, b. CPC1649. Incomplete internal mould of ventral valve, ventral view, and posterior dorsal view showing inside of interarea, x1.

Figures 1, 2 Callytharra Formation.

Figures 3-6 Lyons Group.

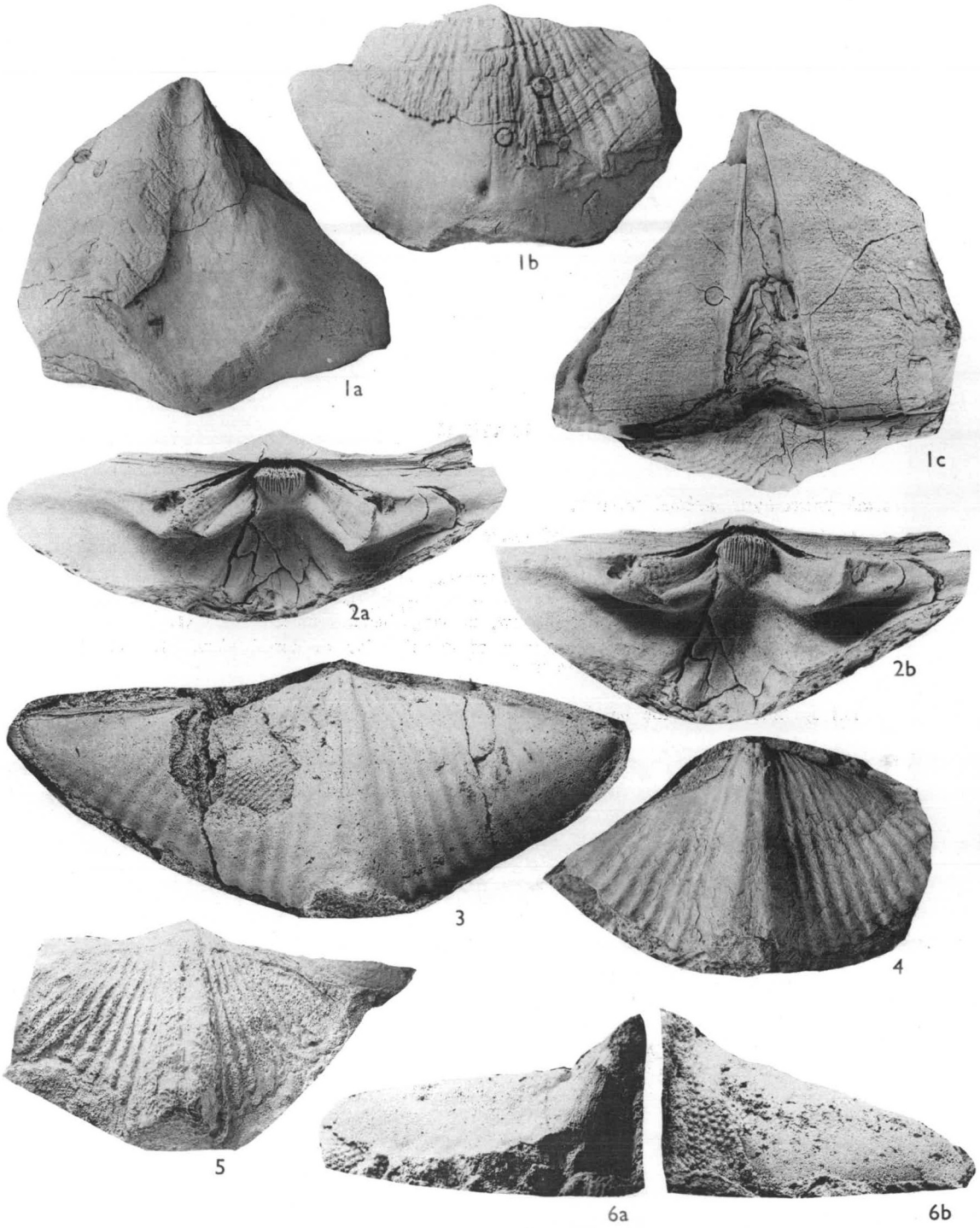
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PLATE 12

Pseudosyringothyris dickinsi sp. nov. .... Page 140

1a, b. CPC1640. Rubber mould of inside of dorsal valve, dorsal and anterior dorsal views, x1½.

2. CPC1642. External impression of interarea, x1.

3a, b. CPC1639. Internal mould of ventral valve, in posterior dorsal view showing inside of interarea and in ventral view, showing diductor muscle scar, x1.

4a, b, c. CPC1641. External impression of dorsal valve in dorsal view, x1, and of two parts showing micro-ornament, x8.

All specimens from the basal Poole Sandstone, Fitzroy Basin.

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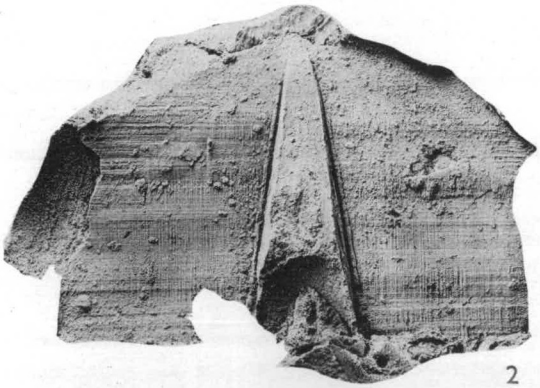
1b



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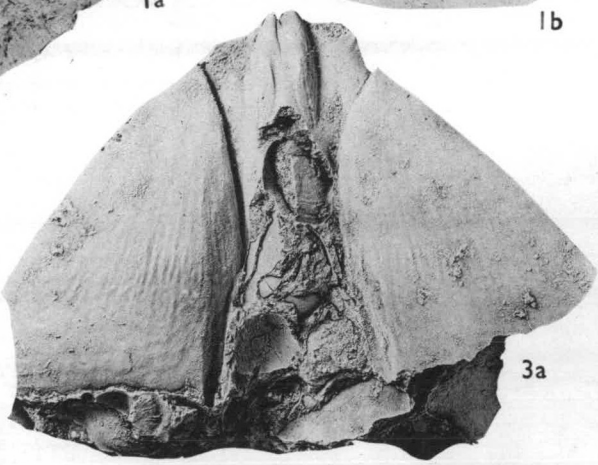

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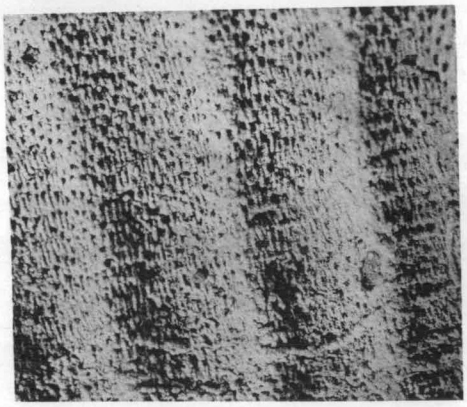

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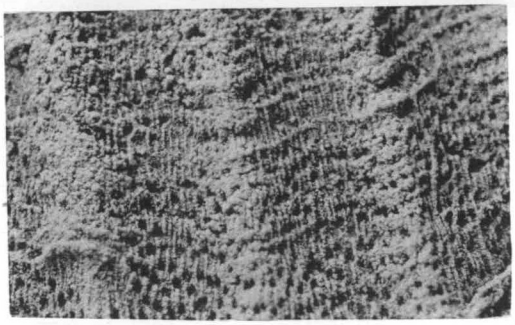

4c

PLATE 13

1, 2. *Pseudosyrinx? sinuosa* sp. nov. .... Page 155

1a, b, c, d, e. CPC1654 **holotype.** Internal mould in dorsal, posterior dorsal, and ventral views, and rubber moulds of inside of interarea, and cardinalia, x1.

2a, b, c. CPC1655. Internal mould in posterior dorsal, dorsal, and ventral views, x1

3a, b. *Pseudosyringothyris dickinsi* sp. nov. CPC1643 .... Page 140

External impression of interarea, x1, and enlarged, x8.

Figures 1, 2 Madeline Formation, Carnarvon Basin.

Figure 3 Cuncudgerie Formation, Canning Basin.

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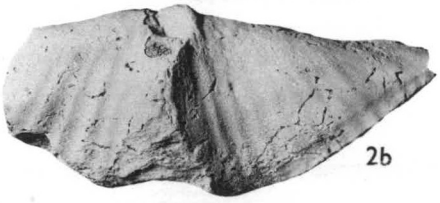
2a



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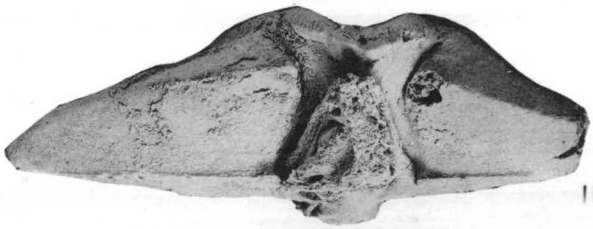

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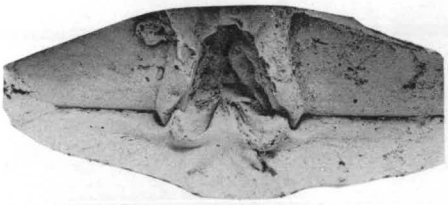

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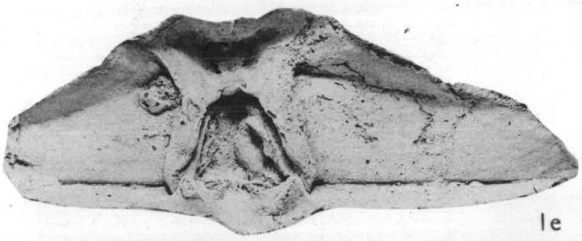

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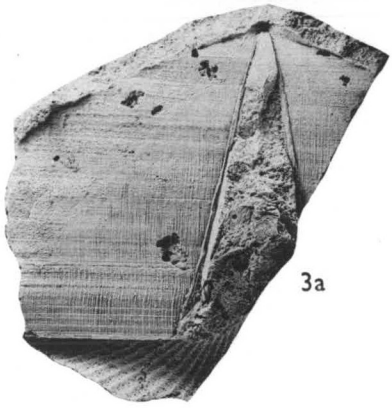

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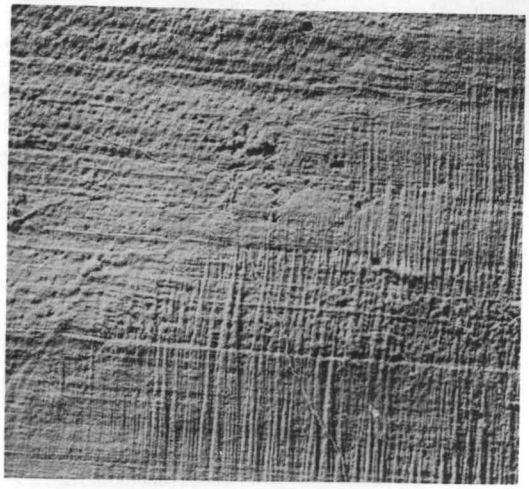

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PLATE 14

1-4, 10a. *Punctospirifer mucronatus* sp. nov. .... Page 174

1a, b, c, d, e, f. CPC1685, **holotype.** Disarticulated shell showing dorsal valve in posterior ventral, dorsal and ventral views, and ventral valve in posterior dorsal, ventral and dorsal views, x2.

2a, b. CPC1686. Ventral valve in ventral and dorsal views, x1.

3. CPC1688. Incomplete ventral valve in posterior dorsal view, x1½.

4a, b. CPC1687. Ventral valve in ventral and dorsal views, x1½.

10a. CPC1689. Ventral valve, anterior dorsal view, x3.

5-9, 10b, 11-13. *Punctospirifer uttingi* sp. nov. .... Page 172

5. CPC1696. Ventral valve in dorsal view, x2.

6a, b, c. CPC1692. Shell in ventral, dorsal, and posterior dorsal views, x1½.

8a, b, c. CPC1694. Shell in dorsal, posterior dorsal and ventral views, x2.

9a, b. CPC1693. Ventral valve in dorsal and ventral views, x1½.

10b. CPC1693. Ventral valve, dorsal anterior view, x2.

11. CPC1697. Ventral valve, dorsal anterior view, x1½.

12a, b. CPC1690, **holotype.** Shell in ventral and dorsal views, x1½.

13. CPC1695. Dorsal valve, ventral view showing cardinalia, x3.

All specimens from Septimus Limestone, Bonaparte Gulf Basin.

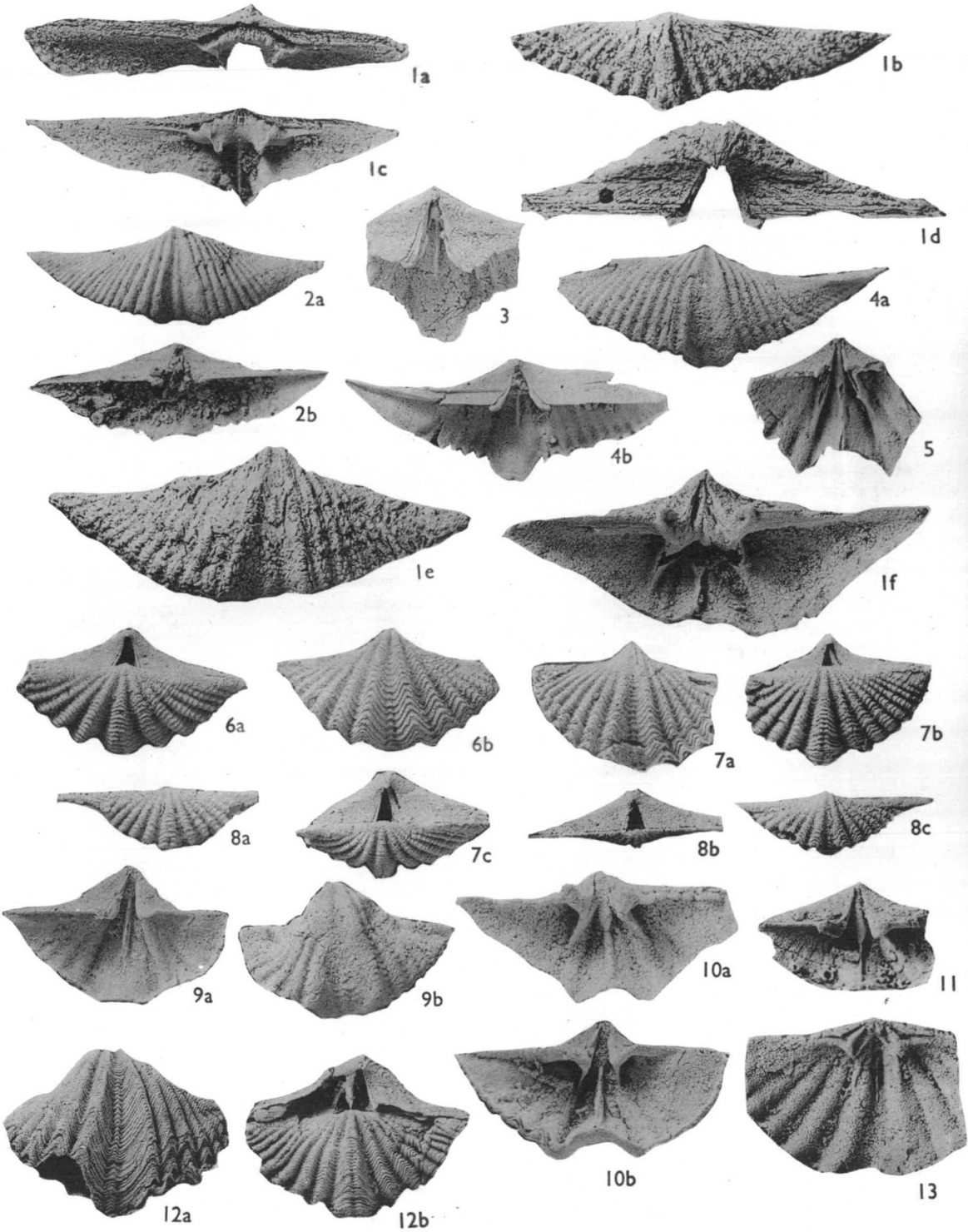
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PLATE 15

1-5, 8. *Schellwienella* aff. *S. australis* sp. nov. .... Page 43

1. CPC3675. Ventral valve in ventral view, x2.
2a, b. CPC3674. Ventral valve in ventral and dorsal views, x3.
3a, b. CPC3676. Dorsal valve in dorsal and ventral views, x3.
4a, b. CPC3677. Ventral valve in anterior ventral and ventral views, x3.
5a, b. CPC3678. Dorsal valve in dorsal and ventral views, x3.

6, 7, 9. *Schellwienella australis* sp. nov. .... Page 41

6a, b. CPC3649, **holotype.** Dorsal valve showing ventral and posterior views of cardinalia, x2.
7. CPC1699. Ventral valve, embedded in limestone, dorsal view, x1.
8a, b. CPC3679. Portion of dorsal valve showing cardinal process in dorsal and ventral views, x3.
9a, b. CPC3649, **holotype.** Dorsal valve in dorsal and ventral views, x1.

All specimens from Septimus Limestone, Bonaparte Gulf Basin.

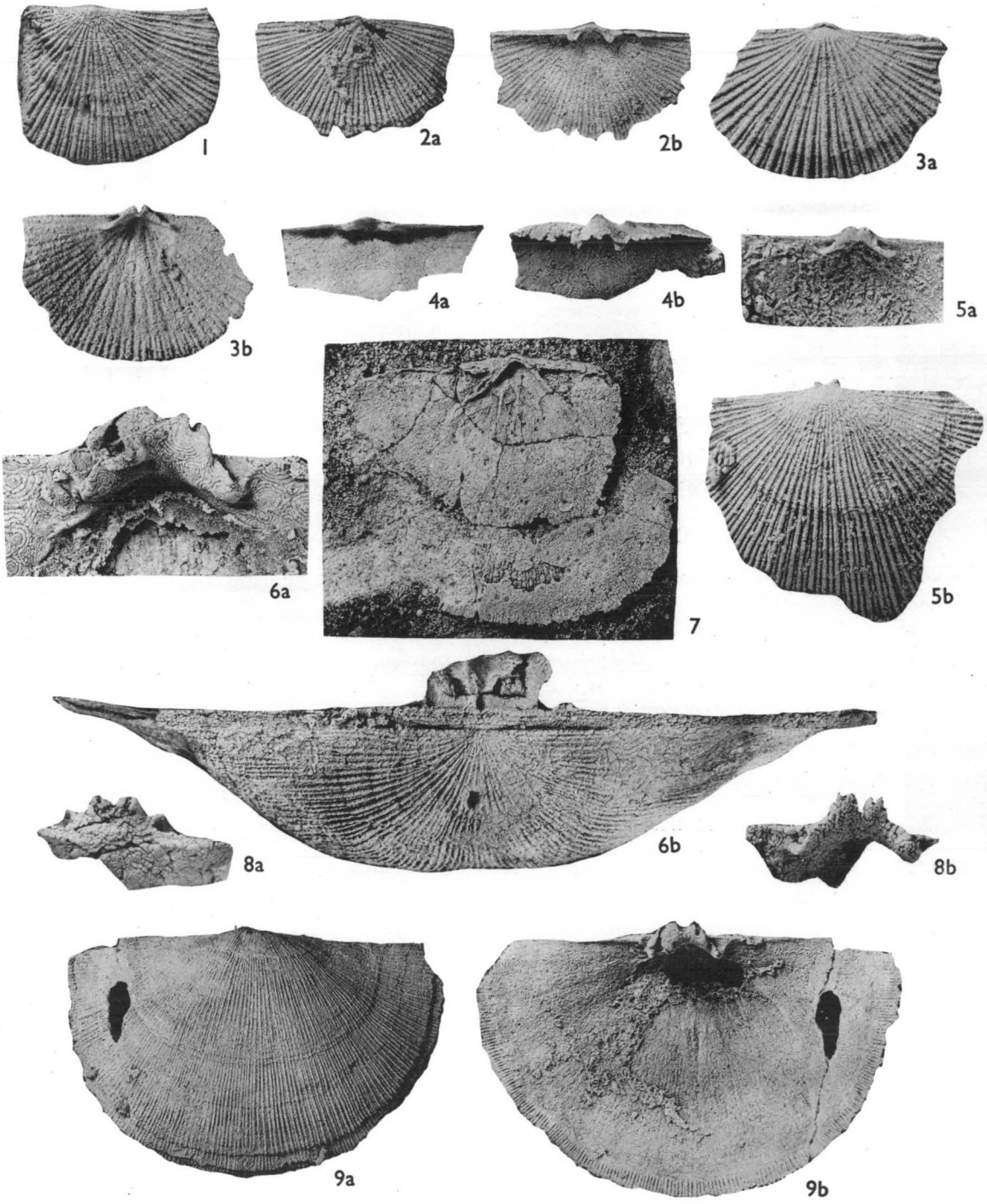
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PLATE 16

1-5, 10. *Schellwienella weaberensis* sp. nov. .... Page 44

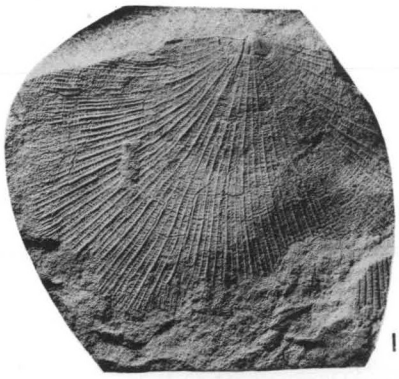
1. CPC3657, **holotype.** Ventral valve in ventral view, x1.
2. CPC3662. Ventral valve in ventral view, x1.
3. CPC3658, paratype. Dorsal valve in dorsal view, x1.
4. CPC3661. External impression of ventral valve, x1.
5. CPC3659. Incomplete dorsal valves, x1.
10. CPC3658. Part of eroded surface enlarged, x8.

6. *Schellwienella* cf. *minilyensis* sp. nov. CPC3666 .... Page 40

Ventral valve embedded in limestone, ventral view, x1.

7-9. *Schuchertella? dorsiplana* sp. nov. .... Page 35

7. CPC3669. Incomplete shell, dorsal view, x2.
8a, b. CPC3670. Incomplete shell in ventral and dorsal views, x2.
9. CPC3668. Incomplete dorsal valve embedded in limestone, x1.
Figures 1-5, 10 from Burvill Beds, Bonaparte Gulf Basin.
Figures 6-9 from Laurel Formation, Fitzroy Basin.



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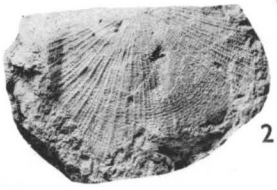

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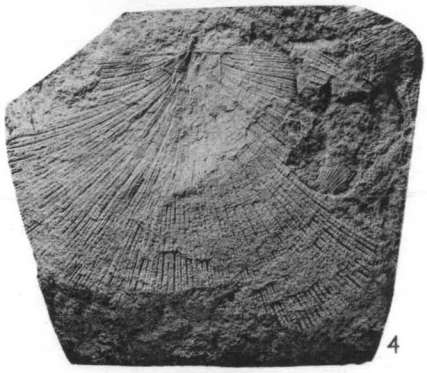

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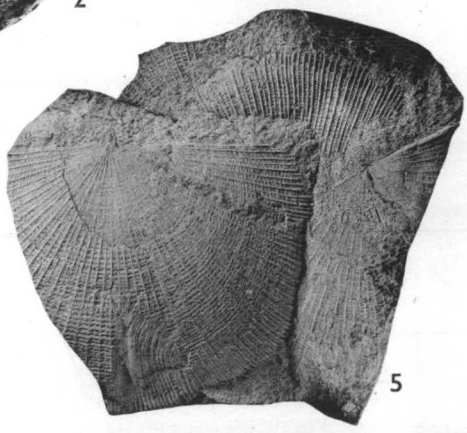

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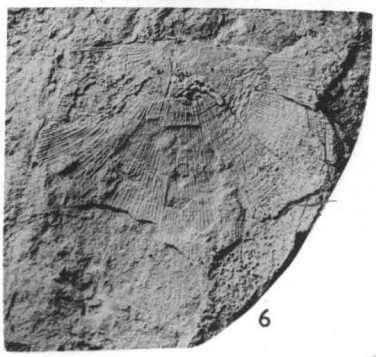

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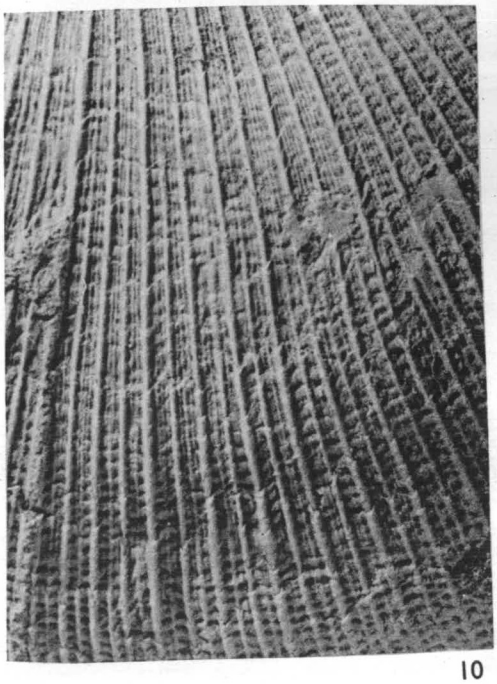

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PLATE 17

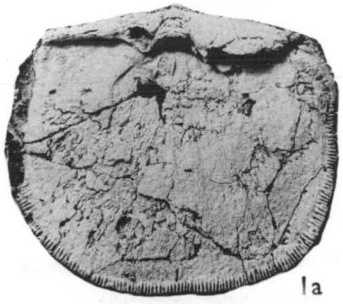
1-6. *Schellwienella minilyensis* sp. nov. .... Page 37

1a, b. CPC3651, **holotype.** Ventral valve, in dorsal and dorsal anterior views, x1.
2a, b, c. CPC3652. Dorsal valve in ventral, dorsal and posterior views, x1.
3. CPC3656. Ventral valve, ventral view, x1.
4a, b. CPC3654. Ventral valve in dorsal and ventral views, x1.
5. CPC3655. Ventral valve, ventral view, x1.
6a, b. CPC3653. Incomplete dorsal valve in dorsal posterior and ventral views, x2.

7-9. *Schellwienella weaberensis* sp. nov. .... Page 45

7. CPC3663. Dorsal valve, internal mould, x2.
8. CPC3664. Dorsal valve, internal mould, x1.
9. CPC3665. Dorsal valve, external impression, x2.

Specimens 1-6 from Moogooree Limestone, Carnarvon Basin.
Specimens 7-9 from Burvill Beds, Bonaparte Gulf Basin.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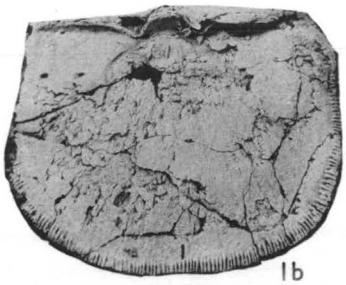
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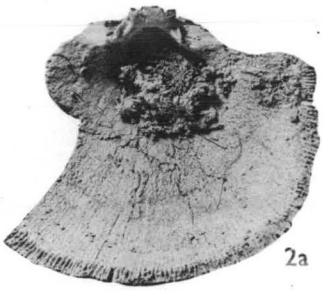
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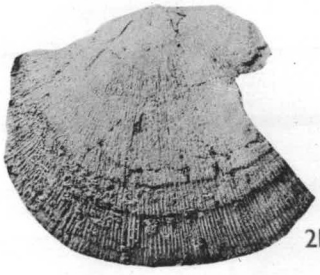
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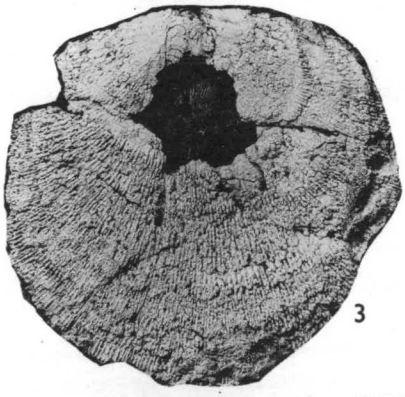
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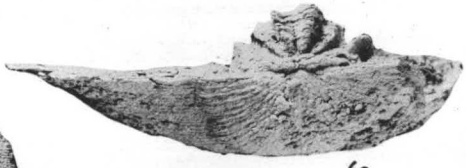
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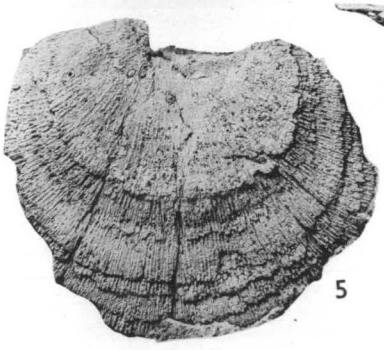
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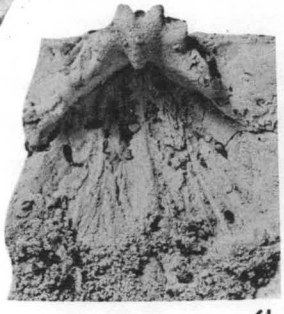
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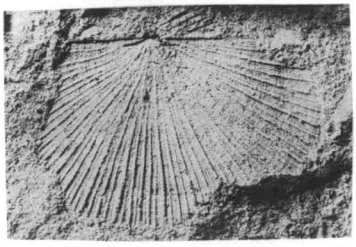
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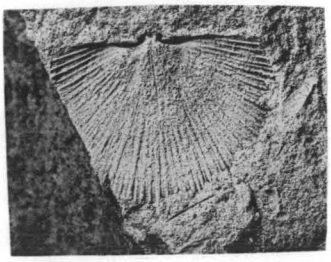
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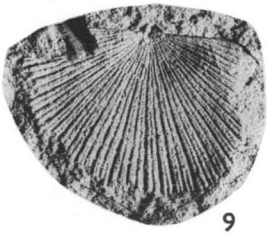
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PLATE 18

Leptagonia analoga (Phillips) .... Page 39

1a, b. CPC3699. Shell in dorsal and ventral views, x1.

2a, b. CPC3706. Shell in ventral and dorsal views, x1½.

3. CPC3703. Incomplete ventral valve, in dorsal view, x2.

4a, b. CPC3702. Incomplete dorsal valve in ventral and dorsal views, x2.

5. CPC3705. Incomplete ventral valve in dorsal view, x2.

6a, b. CPC3701. Incomplete shell, in ventral and dorsal views, x2.

7a, b. CPC3700. Dorsal valve in ventral and dorsal views, x1.

8. CPC3704. Dorsal valve in dorsal view, x2.

Figures 2a, b from Enga Sandstone, Bonaparte Gulf Basin; remainder from Septimus Limestone.

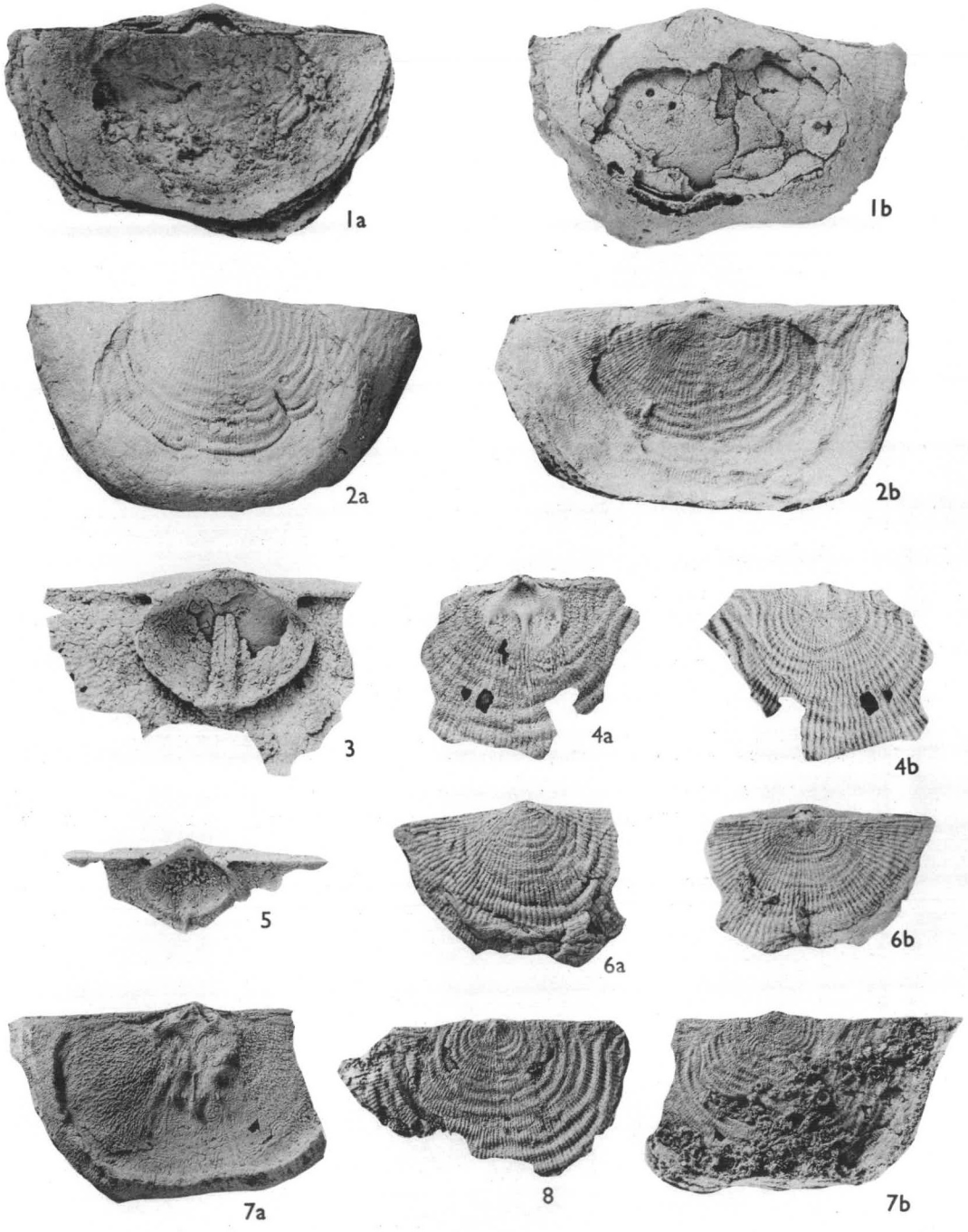
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PLATE 19

1-6, 9-13. *Trigonotreta narsarhensis* (Reed) *occidentalis* subsp. nov. .... Page 108

1a, b, c, d. **holotype.** CPC1682. Shell in dorsal posterior, ventral, dorsal, and lateral views, x1.

2. CPC1683. Ventral valve, ventral view, x1.

3. CPC1684. Incomplete ventral valve, ventral view, x1.

4. CPC11147. Ventral valve, ventral view, x1.

5. CPC11148. Ventral valve, ventral view, x1.

6a, b. CPC11149. Ventral valve, interior in dorsal and anterior dorsal views, x2.

9. CPC11152. Ventral valve in ventral view, x1.

10. Same specimen in ventral view, x1½.

11. CPC11153. Incomplete ventral valve showing dental flange in oblique dorsal view, x2.

12. CPC11154. Dorsal valve, in ventral view showing cardinalia, x2.

13. CPC11155. Incomplete dorsal valve, in ventral view, showing cardinalia, x2.

7, 8. *Trigonotreta narsarhensis narsarhensis* (Reed) .... Page 110

7. CPC11150. Ventral valve, ventral view, x2.

8a, b. CPC11151. Ventral valve (somewhat crushed) in ventral and anterior dorsal views, x2.

Figures 7, 8 from Umaria beds, railway cutting, Umaria, India.
Remainder are from Lyons Group, Carnarvon Basin.

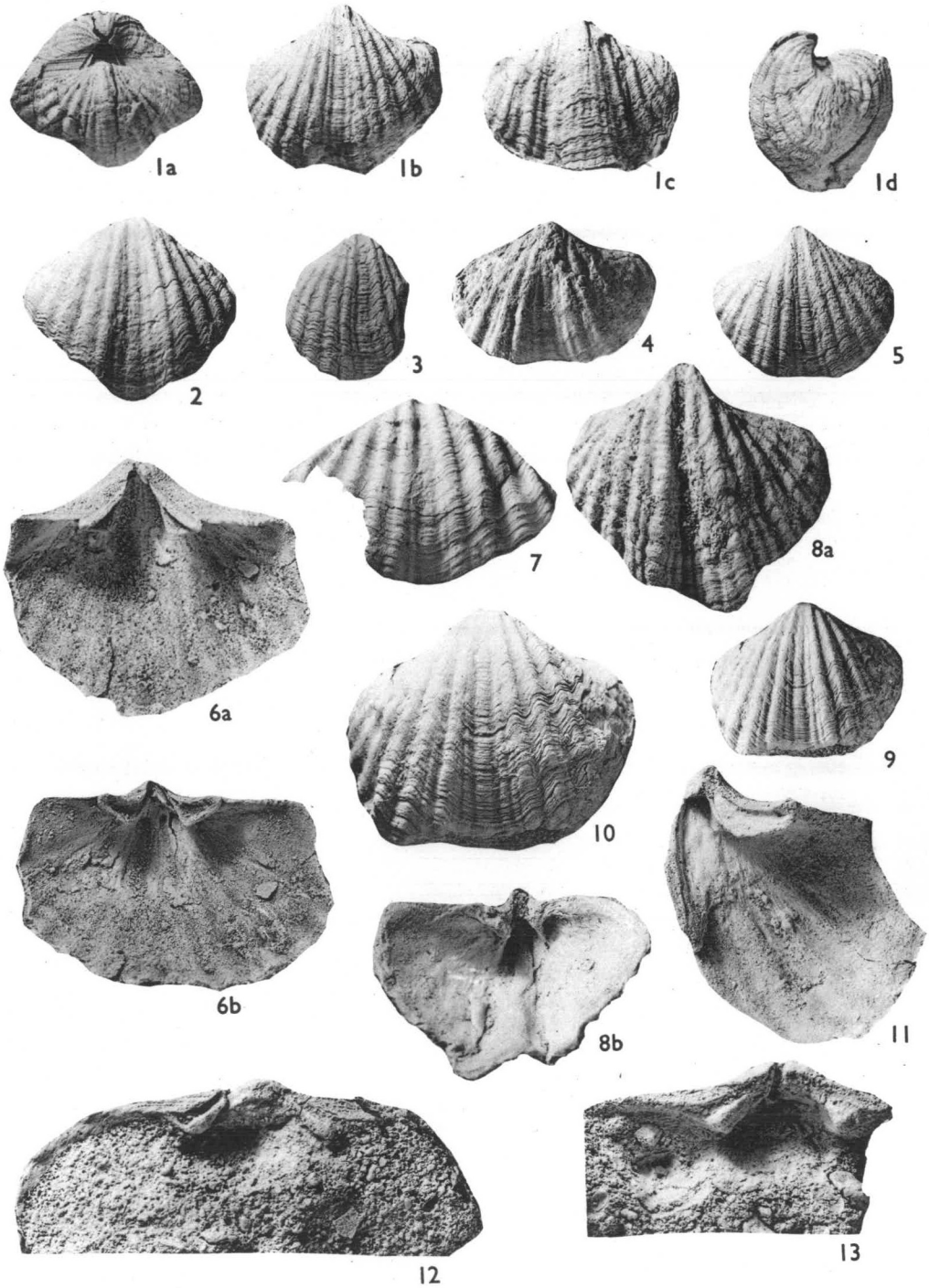
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PLATE 20

1-5, 7-9, 13. *Torynifer? dorsiseptatus* sp. nov. .... Page 163

1a, b, c. CPC1622, paratype. Ventral valve, in dorsal and two anterior dorsal views, x2.
2a, b. CPC1623. Incomplete ventral valve, in anterior dorsal and dorsal views, x1.
3. CPC1627. Dorsal valve in dorsal view, x1½.
4a, b. CPC1628. Incomplete ventral valve, in ventral and anterior dorsal views, x1.
5a, b. CPC1929. Incomplete ventral valve, in ventral and dorsal views, x1.
7a, b. CPC1624. Ventral valve in dorsal and ventral views, x1.
8. CPC1628. Incomplete dorsal valve, interior showing hinge plate and septum, x2.
9. CPC1626, **holotype.** Dorsal valve, interior in dorsal view, x2.
13. CPC1628. Portion of surface, enlarged, x8.

6. *Spiriferidina?* gen. et sp. ind. CPC1633 .... Page 178

Ventral internal mould, ventral view, x2.

10, 11. *Kitakamithyris moogooriensis* sp. nov. .... Page 159

10a, b. CPC1630, **holotype.** Ventral internal mould, in ventral and dorsal views, x1.
11. CPC1632. Portion of surface enlarged, somewhat worn, x10.

12a, b, c. *Punctospirifer?* sp. nov. CPC1682 .... Page 177

Shell in dorsal, ventral and lateral views, x2.
Figures 1-5, 7-9, 13, Septimus Limestone, Bonaparte Gulf Basin.
Figure 6, Laurel Formation, Fitzroy Basin.
Figures 10, 11, 12 Moogooree Limestone, Carnarvon Basin.

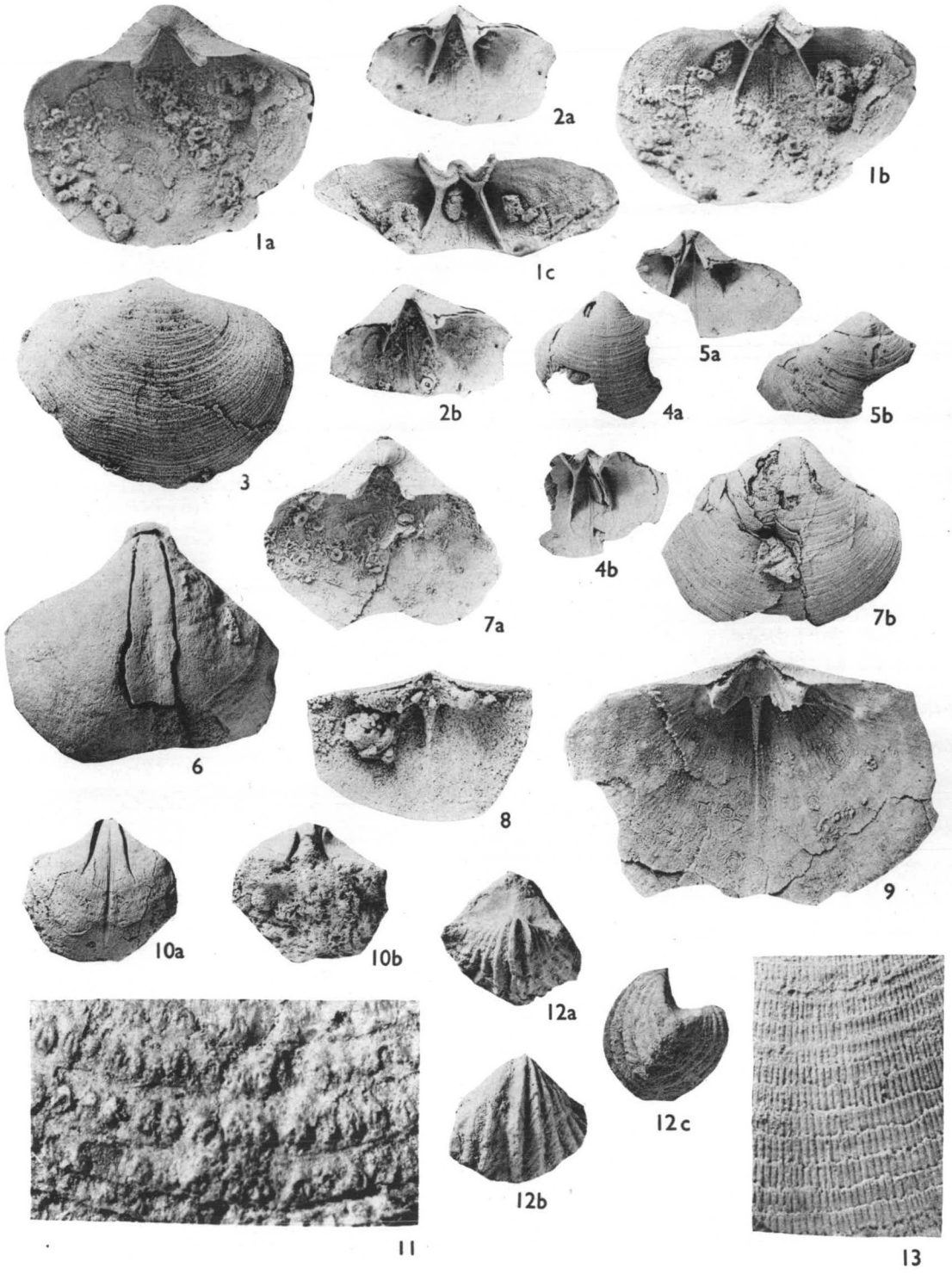
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PLATE 21

Rhipidomella michelina? (Léveillé) .... Page 25

1. CPC3680. Shell, in ventral and lateral views, x1.
2. CPC3685. Incomplete dorsal valve, in ventral view, x2.
3. CPC3686. Incomplete dorsal valve, in dorsal view, x2.
4a, b. CPC3681. Ventral valve in ventral and dorsal views, x1.
5a, b. CPC3684. Ventral valve in dorsal and ventral views, x1.
6. CPC3682. Ventral valve in dorsal view, x2.
7. CPC3687. Incomplete dorsal valve in ventral view, x2.
8. CPC3692. Ventral valve, dorsal view, x1.
9a, b. CPC3688. Shell, in ventral and dorsal view, x1½.
10. CPC3690. Dorsal valve in ventral view, x1½.
11. CPC3693. Ventral valve, ventral view, x1.
12a, b. CPC3691. Ventral valve, ventral and dorsal views, x1.
13. CPC3694. Ventral valve, dorsal view, x1.
14. CPC3689. Ventral valve, dorsal view, x1½.
15a, b. CPC3696. Ventral valve in ventral and dorsal views, x1.
16a, b. CPC3695. Shell in ventral and dorsal views, x1.

Figures 1-7 Moogooree Limestone.
Figures 8-12, 14 Septimus Limestone.
Figures 13, 15, 16 Laurel Formation.

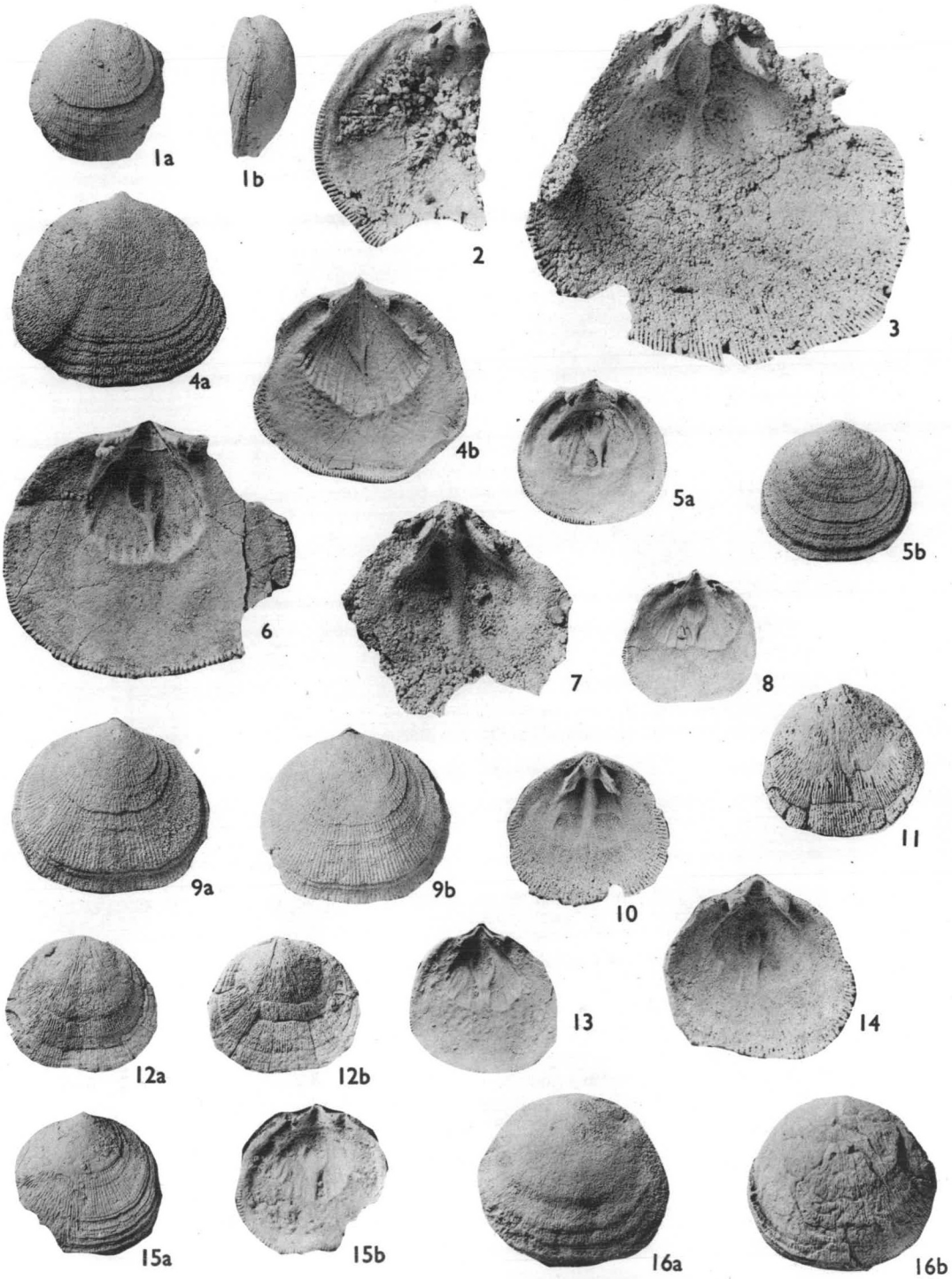
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PLATE 22

1-4, 7-10. *Composita carnarvonensis* sp. nov. .... Page 192

1. CPC3708, paratype. Ventral valve, ventral view, x1.
2. CPC3707, **holotype.** Incomplete shell showing dorsal valve in dorsal view, x1.
3. CPC3709, paratype. Incomplete shell in dorsal view, x1.
4. CPC3711. Incomplete internal mould in posterior dorsal view, x2.
7. CPC3712. Internal mould, in ventral view, x2.
8. Same specimen in dorsal view, x2.
9. CPC3710, paratype. Incomplete dorsal valve in dorsal view, x2.
10. CPC3707, **holotype.** Incomplete shell in anterior view, x2.

5, 6, 11-14, 16, 17. *Composita bonapartensis* sp. nov. .... Page 198

5. CPC3714. Incomplete shell in ventral view, x2.
6. sp. nov. Same specimen, in oblique anterior ventral view, x2.
11a, b. CPC6125. Shell, crushed, in ventral and dorsal views, x1.
12a, b. CPC3713. Ventral valve in ventral and dorsal views, x1½.
13a, b. CPC3715, **holotype.** Shell in ventral and dorsal views, x1½.
14. CPC3716. Incomplete ventral valve in dorsal view, x2.
16a. CPC3717. Incomplete dorsal valve, in ventral view, x2.
16b. CPC3719. Incomplete ventral valve, in dorsal view, x2.
17. CPC3718. Crushed ventral valve in ventral view, x1.

15a, b. *Cleiothyridina minilya.* CPC6114 .... Page 180

Incomplete dorsal valve, showing hinge plate in ventral and anterior views, x1½.

18. *Cleiothyridina* sp. nov. cf. *C. gloveri.* CPC6118 .... Page 186

Ventral valve in ventral view, x1.

Figures 1-4, 7-10 Moogooree Limestone.
Figures 5-6, 12-18 Septimus Limestone, Mount Septimus.
Figure 11 Septimus Limestone, north of Spirit Hill.

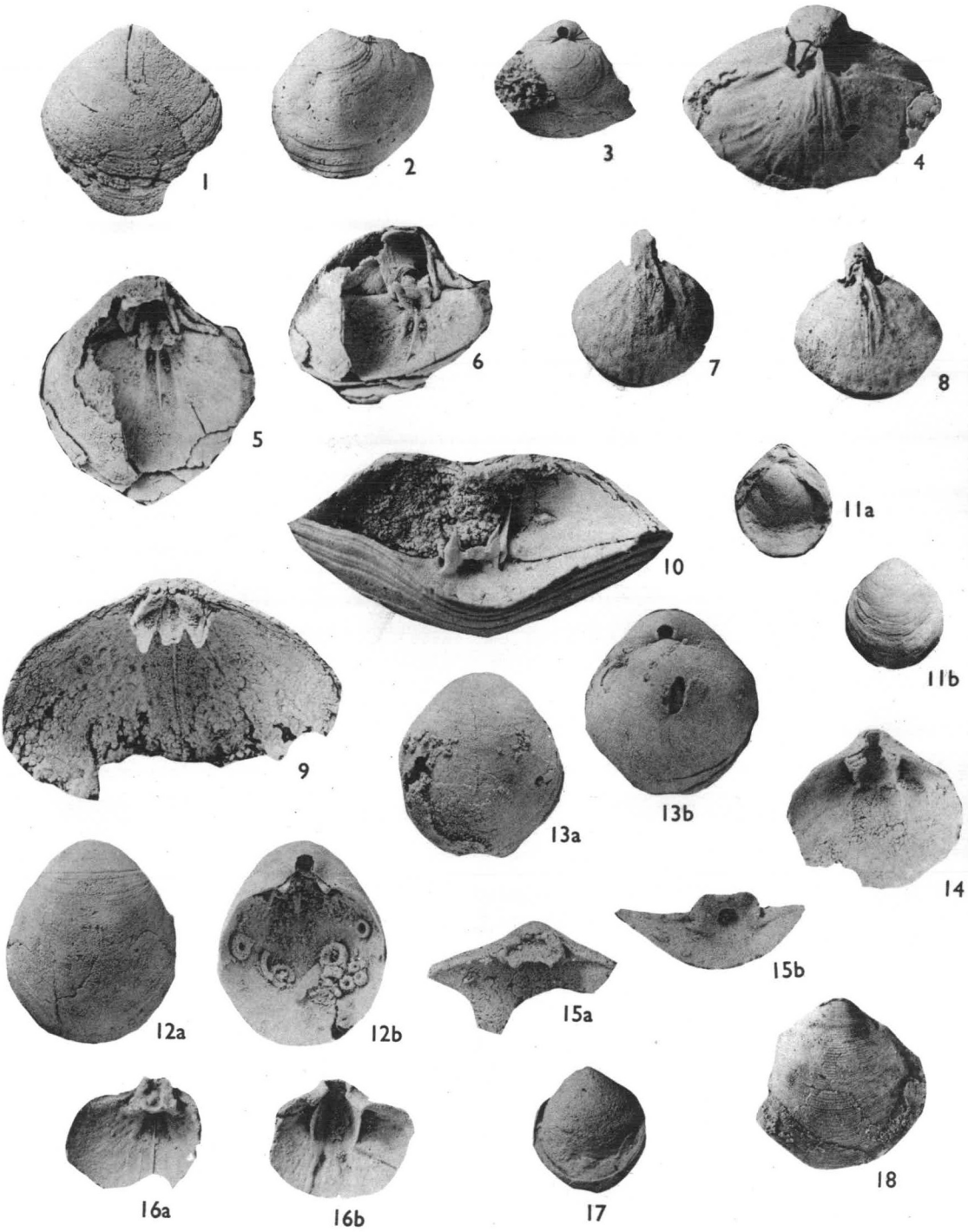
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PLATE 23

1-5. *Composita hendersoni* sp. nov. .... Page 195

1a, b. CPC3721, paratype. Shell in ventral and dorsal views, x1.
2a, b. CPC3720, **holotype.** Shell in ventral and dorsal views, x1.
3a, b. CPC3722, paratype. Shell in ventral and dorsal views, x1.
4a, b. CPC3723, paratype. Shell in ventral and dorsal views, x1.
5a, b. CPC3724, paratype. Shell in ventral and dorsal views, x1.

6-11, 13. *Cleiothyridina minilya* sp. nov. .... Page 180

6a, b. CPC3733, **holotype.** Shell in ventral and dorsal views, x1.
7. CPC3736, paratype. Shell in dorsal view, x1.
8a, b. CPC6111. Shell in dorsal and ventral views, x1.
9a, b. CPC6112. Shell in dorsal and ventral views, x1.
10. CPC3734. Portion of surface enlarged, x8.
11a, b. CPC6113. Crushed shell, in ventral and dorsal views, x1.
13a, b. CPC6115. Worn shell in ventral and dorsal views, x1.

12a, b. *Cleiothyridina?* sp. nov. CPC6123 .... Page 189

Incomplete shell showing internal mould with attached shelly material, and decorticated external surface, x1.

Figures 1-5, 13 Laurel Formation.
Figures 6-7, 10 Moogooree Limestone.
Figures 8, 9, 11 Septimus Limestone.
Figures 12a, b Burvill Beds.


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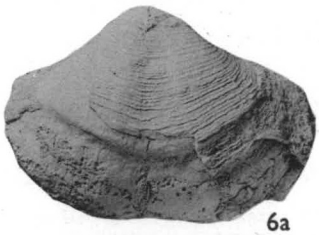
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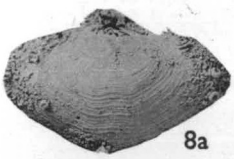
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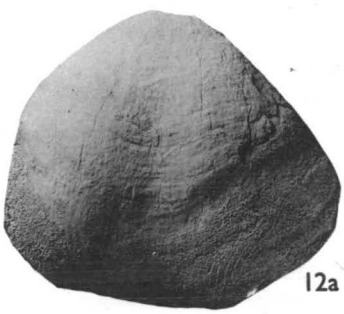
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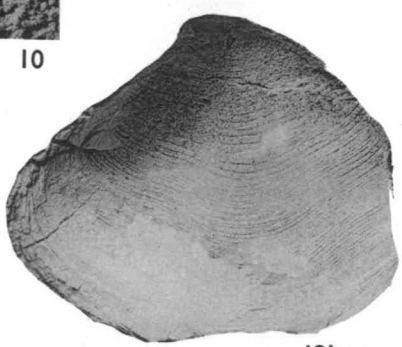
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13b

PLATE 24

1-10, 14. *Cleiothyridina gloveri* sp. nov. .... Page 184

1a, b. CPC3728. Shell in dorsal and ventral views, x1.
2a, b. CPC3747. Shell in dorsal and ventral views, x1.
3a, b. CPC3739. Shell in dorsal and ventral views, x1.
4a, b. CPC3740. Shell in dorsal and ventral views, x1.
5a, b. CPC3737, **holotype**. Shell in dorsal and ventral views, x1.
6a, b. CPC3741. Shell in dorsal and ventral views, x1.
7a, b. CPC3742. Shell in dorsal and ventral views, x1.
8a, b. CPC3743. Shell in dorsal and ventral views, x1.
9. CPC3744. Shell in dorsal view, x1.
10. CPC3745. Dorsal valve, x2.
14a, b. CPC3746. Incomplete dorsal valve in posterior ventral, and ventral views, x1.

11-13. *Cleiothyridina* sp. nov. cf. *C. gloveri* .... Page 186

11a, b. CPC3748. Shell in dorsal and ventral views, x1.
12a, b. CPC6116. Shell in dorsal and ventral views, x1.
13a, b. CPC6117. Shell in dorsal and ventral views, x1.

15-18. *Composita variabilis* sp. nov. .... Page 201

15. CPC3729. Shell in dorsal view, x1½.
16a, b. CPC3728. Shell in dorsal and ventral views, x1½.
17a, b. CPC3727, **holotype**. Shell in dorsal and ventral views, x1½.
18. CPC3730. Ventral view of ventral valve embedded in limestone, x1½.

19, 20. *Cleiothyridina? fitzroyensis* sp. nov. .... Page 187

19a, b. CPC6120, **holotype**. Shell in dorsal and ventral views, x1.
20a, b. CPC6119. Shell in dorsal and ventral view, somewhat distorted, x1.

Figures 1-10, 14, Burt Range Formation.
Figures 11-13, Septimus Limestone, north of Spirit Hill.
Figures 15-18, Yindagindy Limestone.
Figures 19-20, Laurel Formation.

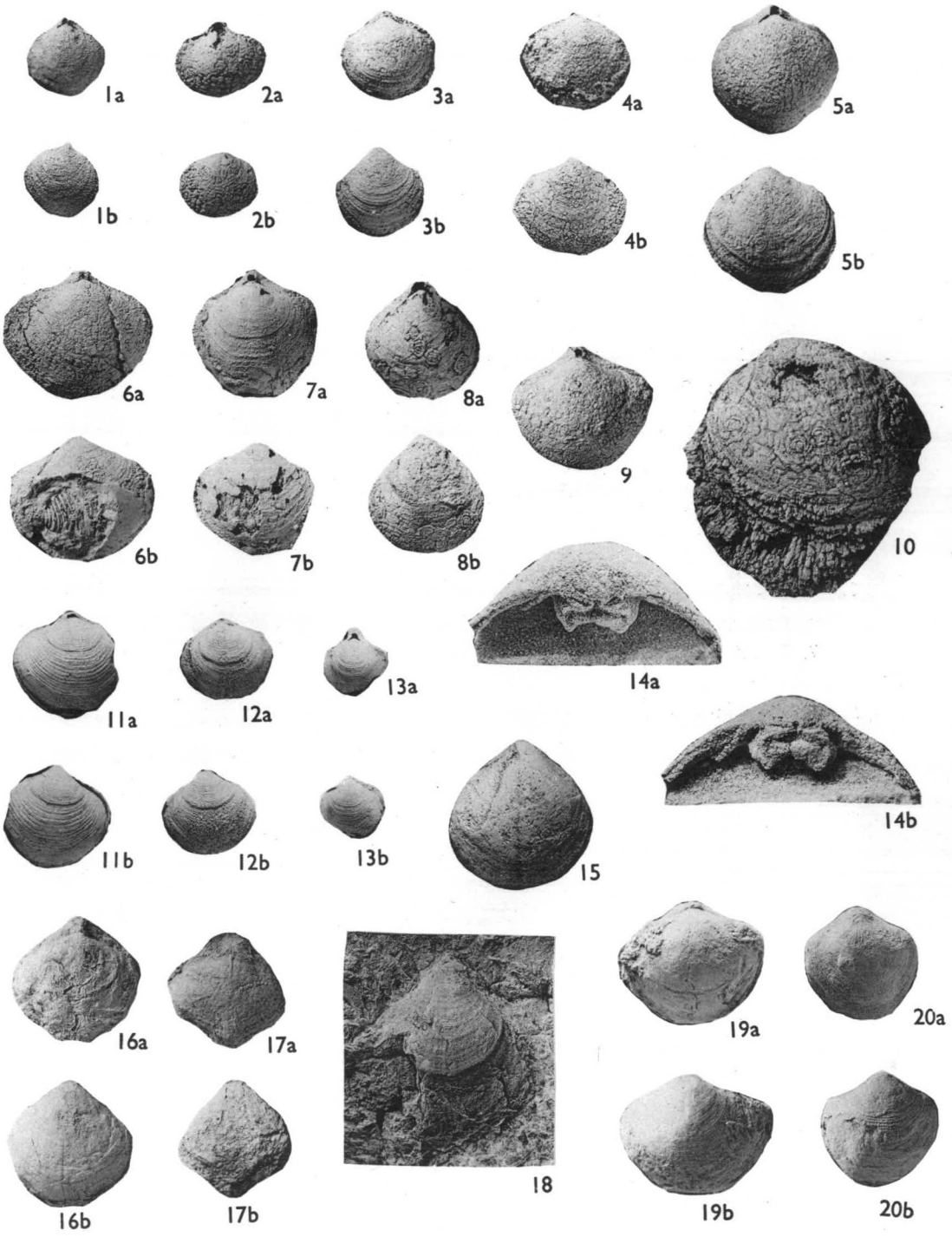
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PLATE 25

1, 4. *Schuchertella? dorsiplana* sp. nov. .... Page 36

1. CPC3673. Transverse section of shell wall, showing pseudopunctae, x50.
4. CPC3671. Transverse section of shell wall, showing pseudopunctae, outer surface exfoliated, x50.

2. *Rhipidomella michelini?* (Léveillé) .... Page 25

CPC3697b. Tangential section of shell wall, showing endopunctae, x30.

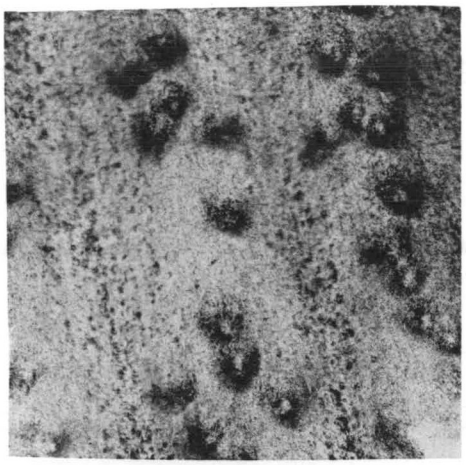
3, 7. *Punctospirifer plicatosulcatus* Glenister .... Page 168

3. CPC1698. Tangential section of shell wall, showing endopunctae, x50.
7. CPC1698. Transverse section of same shell, outer surface exfoliated, x50.

5, 6. *Rhipidomella michelini?* (Léveillé) .... Page 25

5. CPC3697a. Transverse section of a shell, both valves touching, showing endopunctae, x30.
6. Same, x50.

Figures 1, 2, 4, 5, 6 from Laurel Formation.
Figures 3, 7 from Moogooree Limestone.



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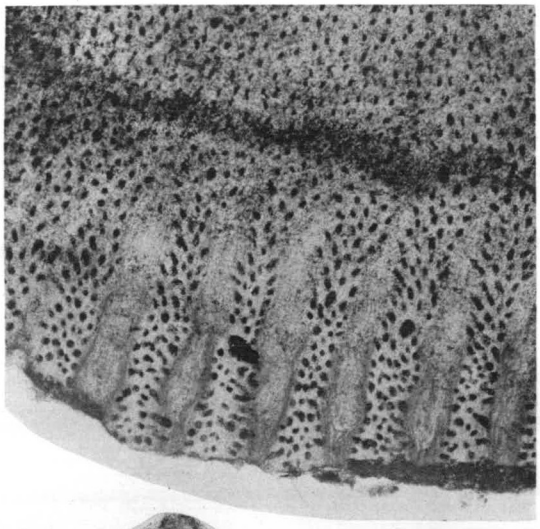

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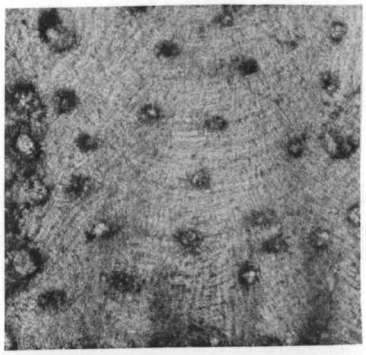

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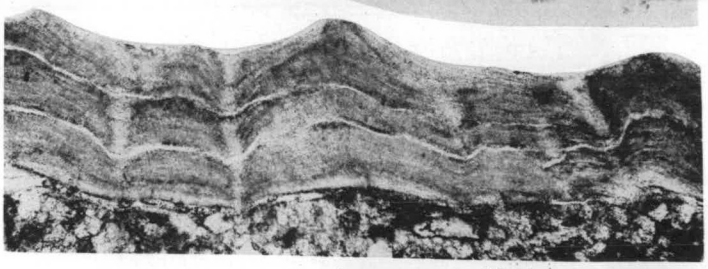

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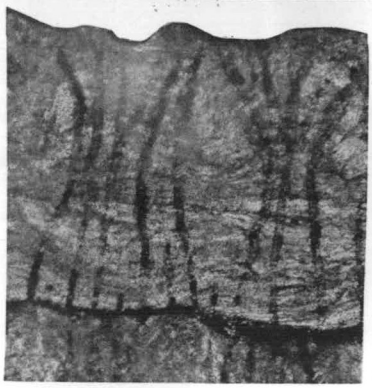

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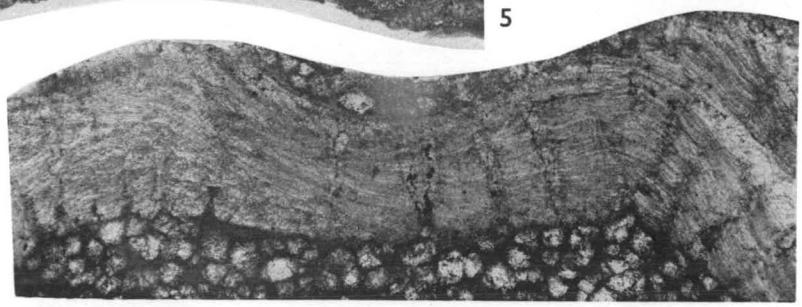

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PLATE 26

1, 2, 3. *Prospira laurelensis* sp. nov. .... Page 84

1. CPC1670. Transverse section through shell near umbo, showing interarea and initial dental plates, x8.
2. CPC1671. Transverse section through shell, anterior to Figure 1, showing delthyrial cavity lined by delthyrial thickening of the dental plates. Note denticle flexures along interarea, x8.
3. CPC1672. Transverse section through shell anterior to Figure 2, showing delthyrial and umbonal cavities and dental plates, and dorsal cardinalia, x8.

4. *Unispirifer fluctuosus* (Glenister), CPC6134 .... Page 70

Transverse section through ventral valve near umbonal apex, showing divergent initial dental plates, x5.7.

The ventral surface is on the right for each figure.

All specimens from the Laurel Formation, Fitzroy Basin.

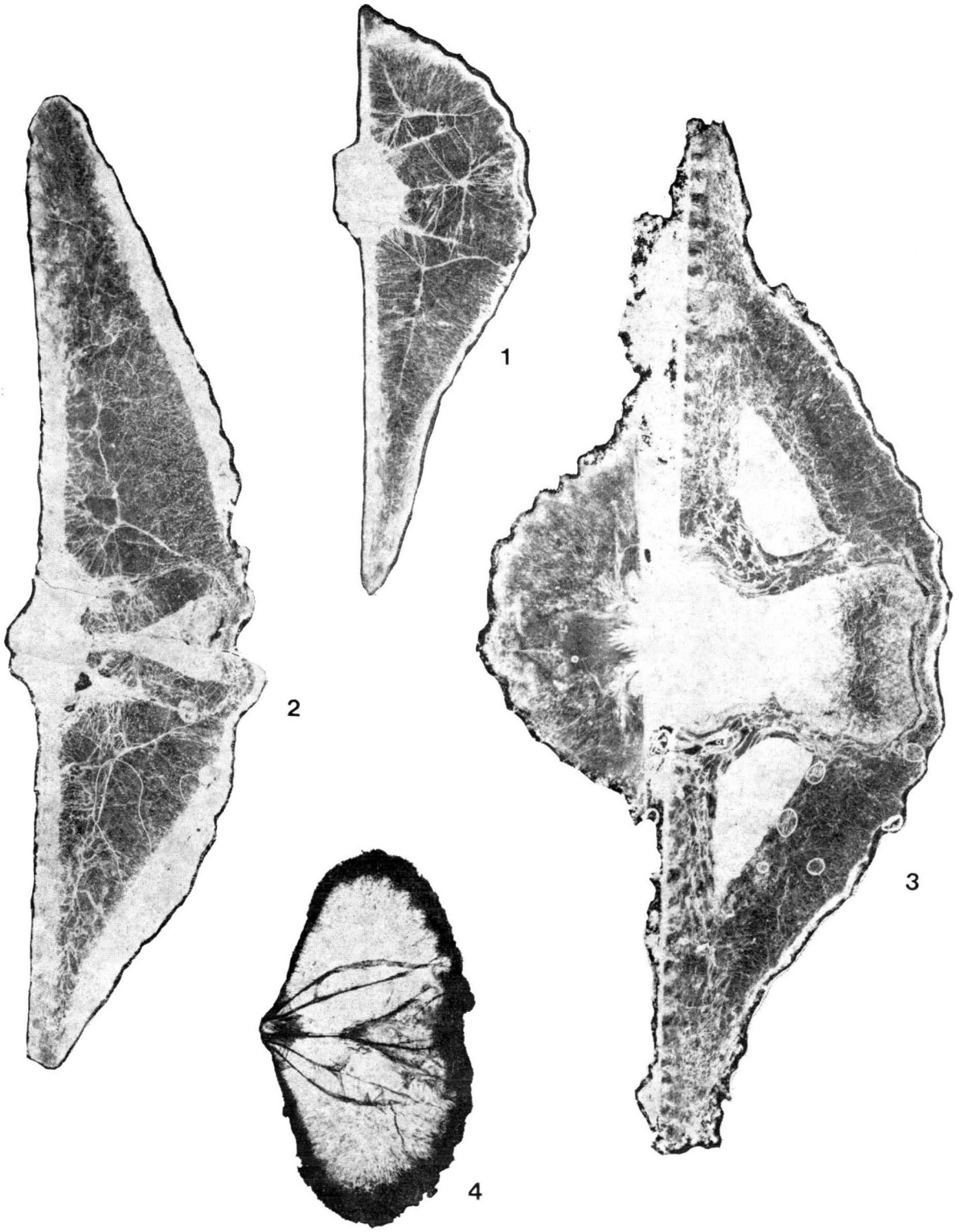
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PLATE 27

1. *Anthracospirifer milliganensis* sp. nov. CPC1592 .... Page 97

   Projection of celluloid peel of an etched transverse section at .128 cm from umbonal apex, x6. The section shows subparallel dental plates; the thin median initial dental plates are readily distinguished; they pass ventrally into a thin band marking the initial floor of the valve. The thickenings of the dental plates are coarsely crystalline, but faint laminations parallel to the initial dental plate can be made out (they are not clear in the figure).

2. *Cyrtella nagmargensis* (Bion) *australis* subsp. nov. CPC1653, **holotype.** .... Page 151

   Projection of celluloid peel of etched transverse section at 0.8 cm from umbonal apex. The figure shows the initial dental plates and the laminate thickening of the delthyrial and umbonal cavities and the delthyrial plate. The low adminiculum is also discernible.

Figure 1, Burvill Beds.

Figure 2, Callytharra Formation.

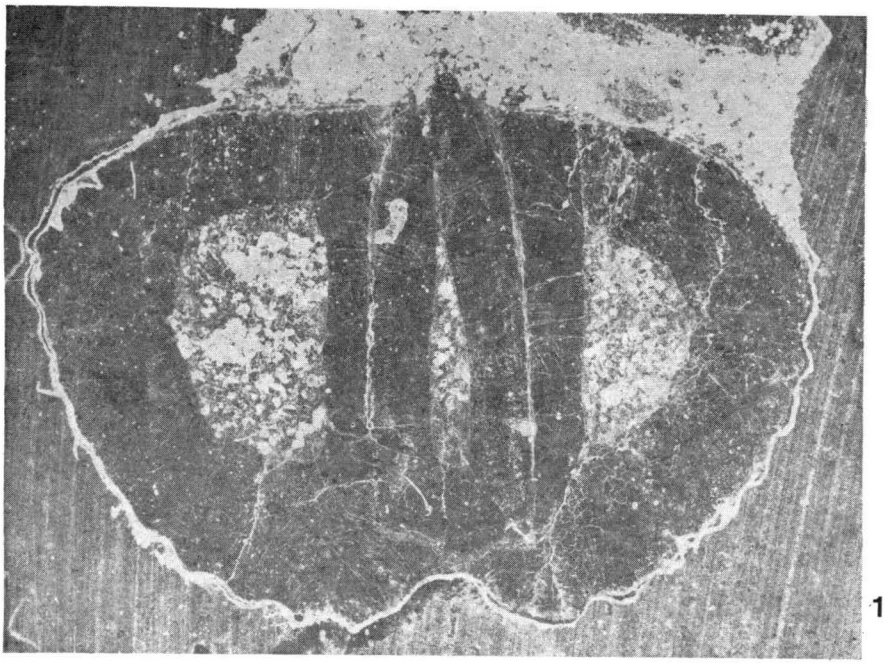

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PLATE 28

1, 2, 3, 6. *Unispirifer fluctuosus* (Glenister) .... Page 70

1. CPC444, paratype. Dorsal valve in dorsal view, x1½.
2. CPC1676. Ventral valve in ventral view, x1.
3. CPC1678. Ventral valve in dorsal view, x1.
6. CPC1677. Ventral valve in dorsal view, x1½.

4. *Brachythyris latecardinalis* sp. nov. CPC6131 .... Page 123

Ventral valve, dorsal view showing interarea and deltidium, x3.

5a, b. *Prospira laurelensis*. CPC1541, paratype .... Page 84

Shell in dorsal and ventral views, x2.

7. *Syringothyris* sp. nov. A CPC6126 .... Page 134
Dorsal valve in dorsal view, x1.

8. *Schellwienella australis* sp. nov. CPC 3650 .... Page 41

Ventral valve in ventral view, x1.

9. *Schellwienella* aff. *australis*. CPC3674 .... Page 44

Incomplete ventral valve, in anterior dorsal view, showing dental plates, x3.

Figures 1, 2, 3, 6, Moogooree Limestone.
Figures 4, 7, 8, 9, Septimus Limestone.
Figures 5a, b, Laurel Formation.

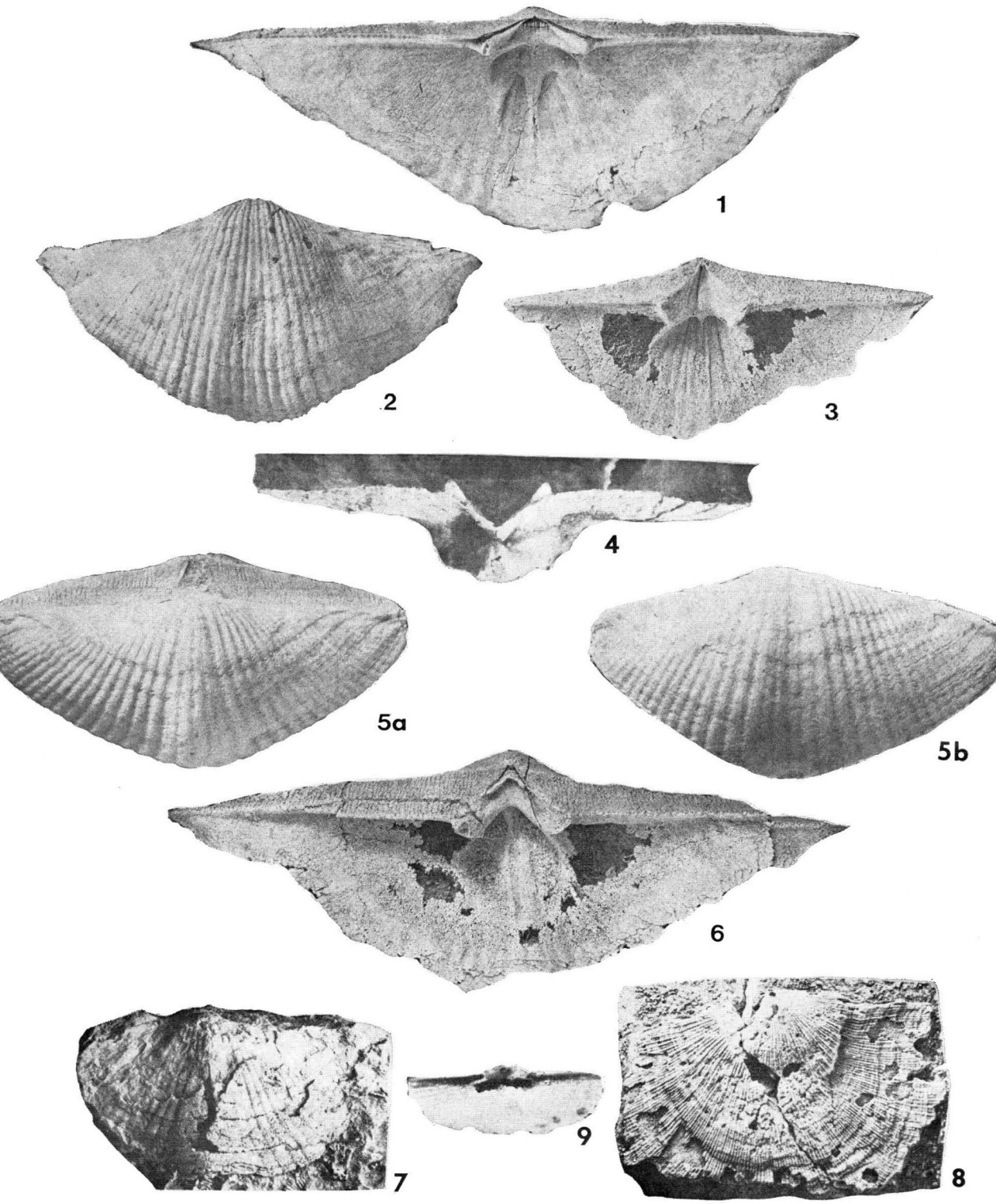
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PLATE 29

1, 9. *Prospira travesi* sp. nov. .... Page 92

1a, b, c. CPC1681, **holotype.** Ventral valve in dorsal, anterior dorsal, and ventral views, x1½.

9. CPC1574. Part of dorsal surface, enlarged, showing costae and radial striae, x10.

2-4. *Rugosochonetes?* sp. B .... Page 48

2. CPC6129. Internal mould of ventral valve, x2.

3. CPC6130. Internal mould of ventral valve, x2.

4. CPC6128. Internal mould of dorsal valve, x2.

5. *Rugosochonetes?* sp. A .... Page 47

5a, b. CPC6127. Incomplete shell in ventral and dorsal views, x2.

6. *Schuchertella? dorsiplana* sp. nov. CPC3667, **holotype.** .... Page 34

Incomplete ventral valve in ventral view, x1.

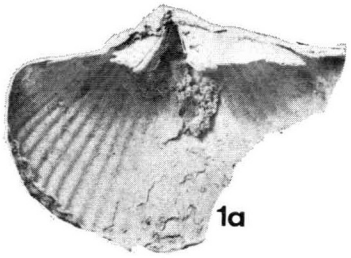
7. *Pseudosyringothyris dickinsi* sp. nov. CPC1647 .... Page 140

Transverse section through shell wall, anterior part of dorsal valve, outer surface (on top) exfoliated, x12.

8. Spiriferidae gen. et. sp. nov. (cf. *Spirifer duplicicostus* Phill.). CPC1680 .... Page 101

Celluloid peel of transverse section at 0.17 cm from posterior end, x13.

Figures 1, 9, from Septimus Limestone.
Figure 8, Burvill Beds.
Figures 2, 3, 4, Burt Range Formation.
Figures 5a, b, 6, Laurel Formation.
Figure 7, Callytharra Formation.



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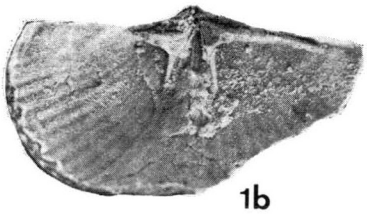

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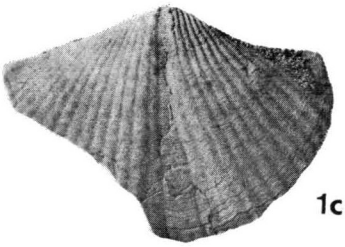

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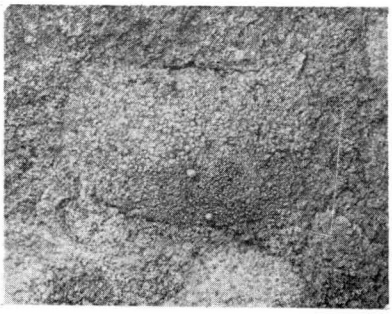

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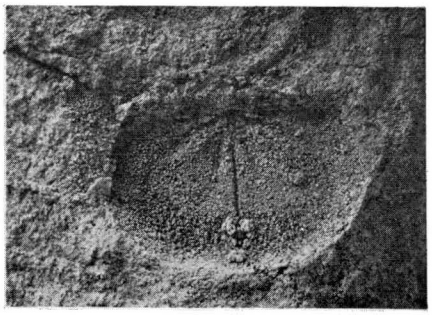

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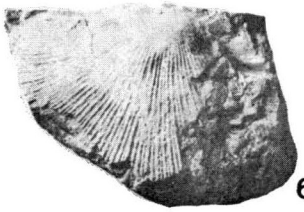

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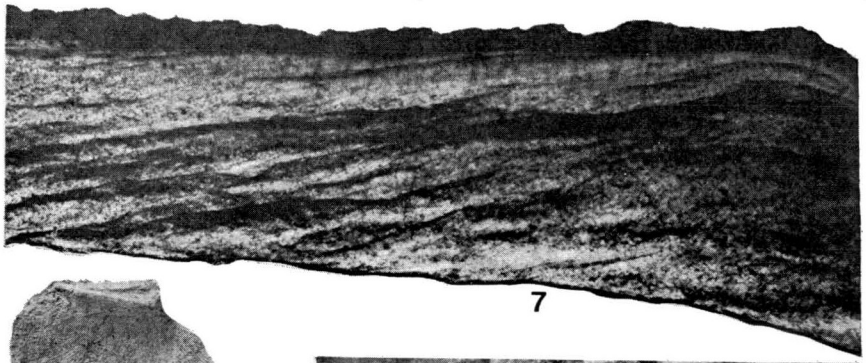

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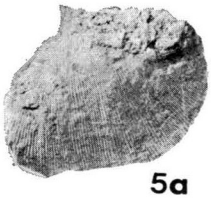

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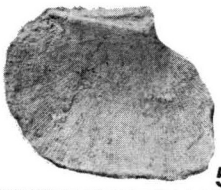

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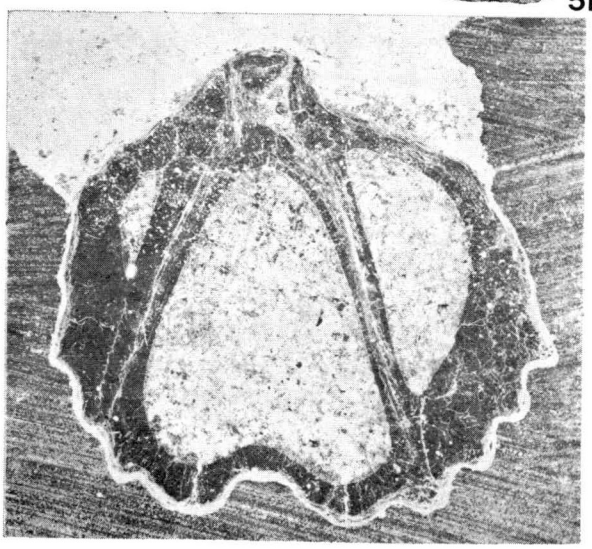

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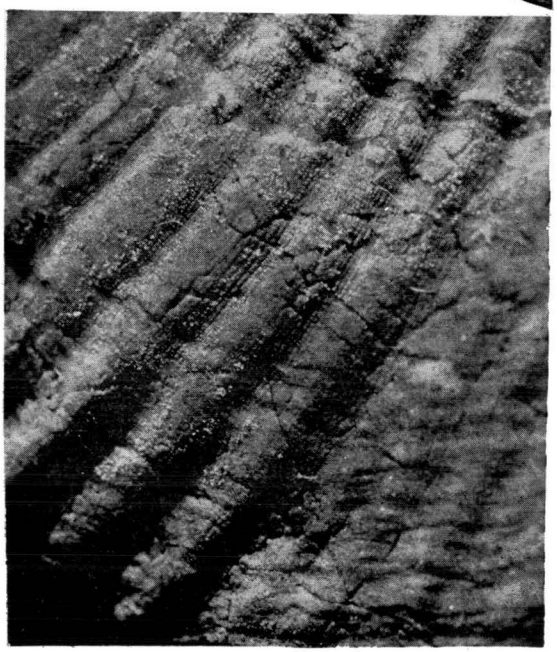

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PLATE 30

1-5. *Syringothyris spissus* Glenister .... Page 131

1a, b. CPC1666. Part of ventral valve in posterior dorsal and anterior dorsal views, showing interarea, syrinx, dental plates and callus below syrinx, x2.

2. CPC1668. Part of ventral valve in anterior dorsal view, showing syrinx and dental plates, x2.

3. CPC1660. Part of ventral valve in anterior dorsal view, showing syrinx, dental plates and thick low septum below syrinx, x2.

4. CPC1665. Part of ventral valve in anterior dorsal view, showing syrinx and dental plates.

5. CPC1667. Part of ventral valve in oblique anterior dorsal view showing dental plates, syrinx and thin septum below syrinx, x2.

6-8. *Pseudosyrinx? sinuosa* sp. nov. .... Page 155

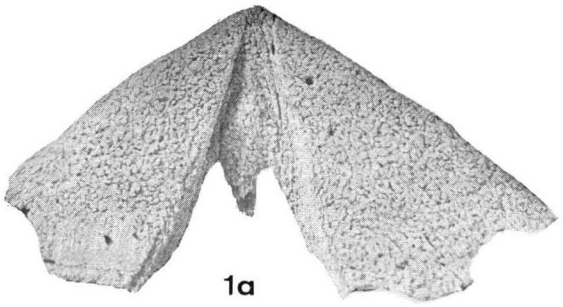
6a, b. CPC1656. Rubber mould of incomplete ventral valve, in dorsal posterior and anterior views showing interarea, dental plates, and delthyrial plate, x1.

7. CPC1658. Rubber mould of part of dorsal valve, in ventral view, showing cardinalia, x1½.

8. CPC1657. Rubber mould of external impression of dorsal valve, in dorsal view, x1.

Figures 1-5, Moogooree Limestone.

Figures 6-8, Madeline Formation, Carnarvon Basin.



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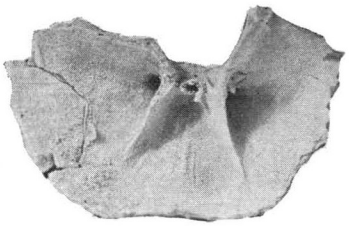

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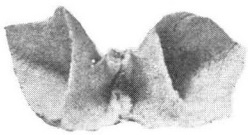

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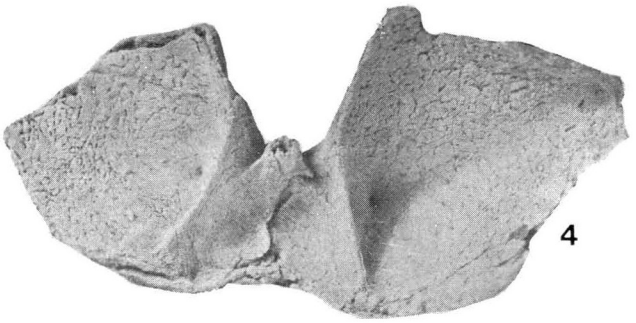

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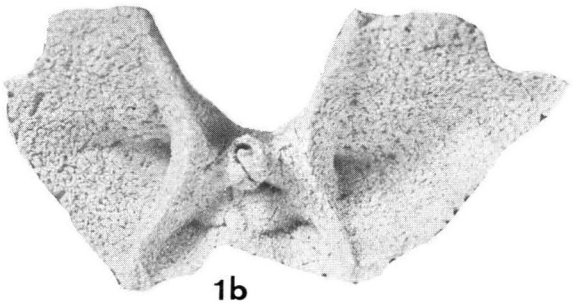

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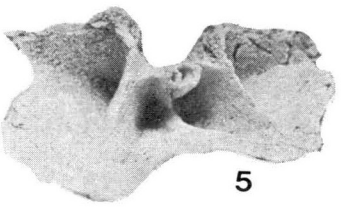

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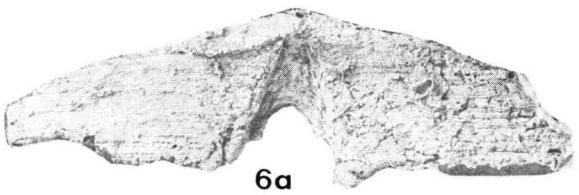

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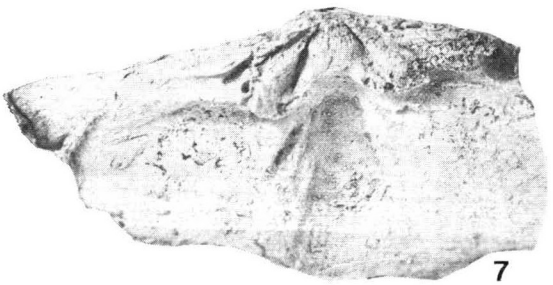

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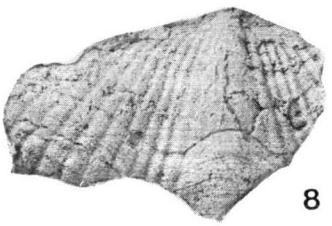

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PLATE 31

1, 2. *Syringothyris australis* Maxwell .... Page 129

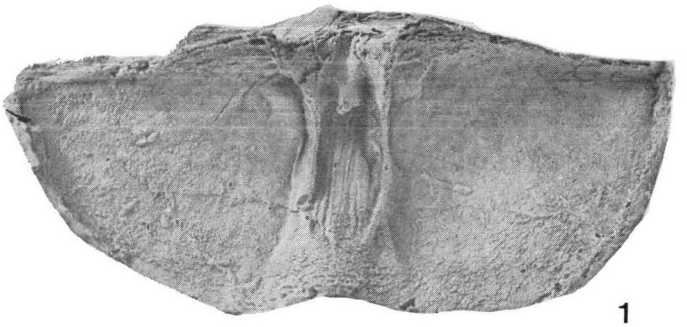
1. UQ F15268. Rubber impression of internal mould of ventral valve, showing syrinx and dental plates, in anterior dorsal view, x2.

2a, b. UQ F19167. Rubber impression of internal mould of dorsal valve, in anterior ventral and ventral view, showing cardinal process, socket plates and dorsal area (the rubber is distorted slightly), x2.

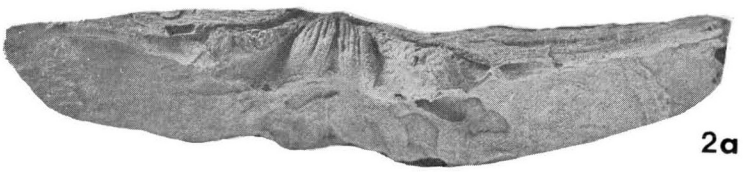
3. *Syringothyris spissus* Glenister. CPC432, **holotype.** .... Page 131

Incomplete shell, showing internal view of interarea, syrinx and dorsal cardinalia, x2.

Figures 1, 2, from Mount Morgan district, Queensland.
Figure 3, from Moogooree Limestone.



1



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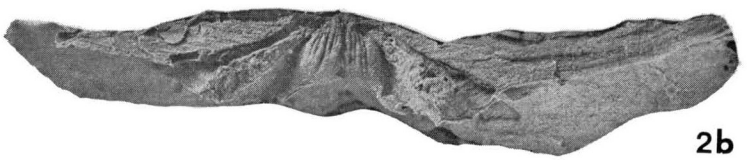

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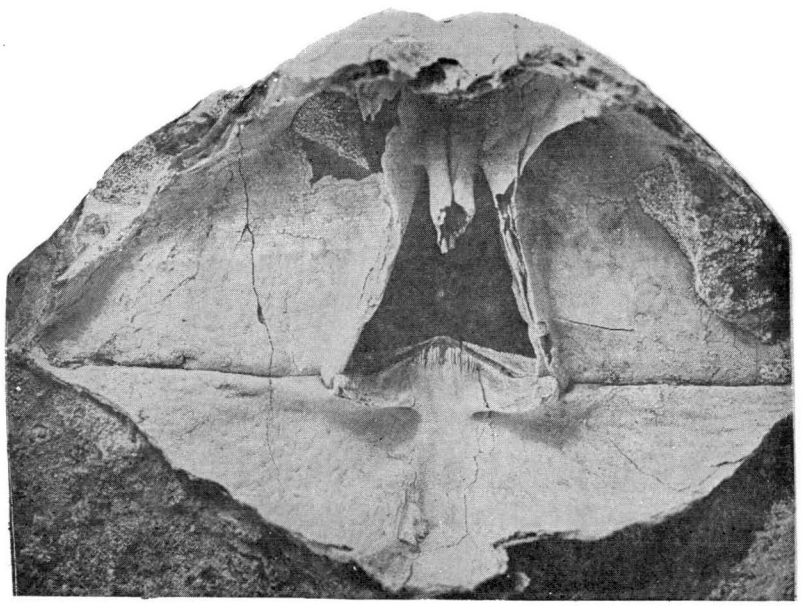

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