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

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Devonian and Carboniferous Conodonts
from the
Bonaparte Gulf Basin, Northern Australia
and their use in international correlation

BY

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SUMMARY

Conodonts are represented in the Upper Devonian and Lower Carboniferous faunas of the Bonaparte Gulf Basin by 159 species referable to 35 genera, of which 1 genus, *Rhodalepis*, 17 species, and 5 subspecies are new.

The conodonts recovered from the Devonian Cockatoo Formation indicate a Frasnian age for the calcareous members. No conodonts were recovered from the sandy and conglomeratic members.

The fore, main, inter, and back-reef facies of the Ningbing Limestone have yielded conodonts indicating a Famennian age. The conodont zones erected by Ziegler in Western Europe can be recognized in general terms. The Buttons Beds are equivalent to the lower Ningbing.

A sequence of eight conodont zones has been recognized in the Burt Range Formation, Enga Sandstone, and Septimus Limestone. They can be correlated with the cuI and $cuII_{\alpha}$ zones of Germany and the 'Glen Park', Hannibal, and Chouteau Formations of the Mississippi Valley.

The upper four zones cannot be recognized in North America and Germany; they are apparently equivalent to a hiatus between the $cuII_{\alpha}$ and $cuII_{\beta}$ zones in Germany and between the Chouteau and 'Sedalia' Formations in the Mississippi Valley.

The Burt Range Formation correlates with the lower and middle *Cleistopora* (K) zone of Great Britain, the 'Glen Park', Hannibal, and Chouteau Formations of the Mississippi Valley, and the *Gattendorfia* (cuI) and lower *Pericyclus* Stufen of Germany. The Enga Sandstone correlates with all but the uppermost part of the upper *Cleistopora* (K) Zone and the Septimus Limestone correlates with the uppermost *Cleistopora* (K) Zone and the lower part of the *Zaphrentis* (Z) Zone of Great Britain. Strata of comparable age to the Enga Sandstone and Septimus Limestone appear to be absent in the Mississippi Valley and Germany.

Conodonts from the Utting Calcarenite are of lower Visean age. Visean conodonts have also been recovered from the Bonaparte Beds and rare upper Visean forms from the Burvill Beds.

Detailed study of the conodonts has shown that the Bonaparte Gulf Basin faunas are intermediate between the extreme faunal polarity exhibited by the British spathognathodid-polygnathid fauna and the German siphonodellid-*Pseudopolygnathus triangulus* fauna.

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INTRODUCTION

The Bonaparte Gulf Basin is situated in northwestern Australia, partly in the Northern Territory and partly in Western Australia. It contains Palaeozoic rocks covering about 8,000 square miles of land around the Joseph Bonaparte Gulf (Fig. 1); the larger part of the Basin lies beneath the Timor Sea.

A preliminary investigation of the geology of the Bonaparte Gulf Basin was published by Traves (1955). Previous published accounts of the geology include Matheson & Teichert (1948), Noakes et al. (1952), McWhae et al. (1958), and Thomas (1962). Noakes et al. concisely reviewed previous geological investigations and Thomas summarized the previous work on the Carboniferous sediments of the basin.

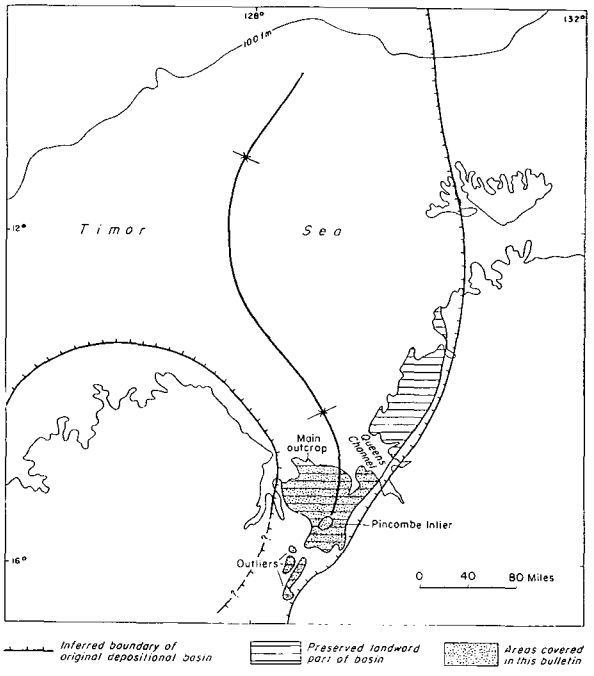

Figure 1. The Bonaparte Gulf Basin (from Veevers & Roberts, 1968)

In 1963 the Bureau of Mineral Resources, Geology & Geophysics began a more detailed study of the geology and palaeontology of the Bonaparte Gulf Basin. Initial observations on the geology were published by Veevers et al. (1964) and Playford et al. (1966). The sequence is abundantly fossiliferous and the various fossil groups are being studied.

The Cambrian-Ordovician sequence has been studied by Kaulback & Veevers (1968), the Devonian and Carboniferous by Veevers & Roberts (1967, 1968), and the Permian, Triassic, and Cretaceous sequence by Dickins, Veevers, & Roberts (in preparation). The palaeontology and correlation of the Upper Devonian strata in the basin have been discussed by Roberts, Jones, & Druce (1967) and the Carboniferous geology by Roberts & Veevers (1967).

The succession of Upper Palaeozoic conodont faunas is described in this report; initial observations have already been published by Jones & Druce (1966).

The conodonts were studied to establish a faunal sequence in the Upper Devonian and Lower Carboniferous rocks of the Bonaparte Gulf Basin and to discover whether the conodont zones based on European and North American sequences could be recognized in Australia. The European and North American zones appear to be readily recognizable in the faunal sequence of the basin; furthermore, the majority of species and subspecies identified can be referred to already described or known species present in either European or North American faunas or both.

The publication of a paper on Upper Devonian conodonts from the Canning Basin, northwest Australia (Glenister & Klapper, 1966), has enabled intercorrelation of the Devonian formations of both basins.

The present paper will serve to emphasize the importance of conodonts as biostratigraphic indices in correlation both within and between continents and the fact that the same sequence of conodont form-species can be recognized in sections tens of thousands of miles apart.

Previous Conodont Research

World

Considerable information has been published on Devonian conodonts since Hinde (1879) first described and illustrated a Devonian fauna from the Genesee Shale of New York State.

Upper Devonian conodonts in particular have been the subject of numerous detailed biostratigraphic reports; Bischoff (1956), Bischoff & Ziegler (1956), Bouckaert & Ziegler (1965), Helms (1959, 1961), and Ziegler (1956, 1957, 1958, and 1962) described the stratigraphical distribution of conodonts from classical sections in Western Europe, and Collinson, Scott, & Rexroad (1962) tabulated the conodont zones present in the Upper Mississippi Valley. Glenister & Klapper (1966) described Upper Devonian conodonts from the Canning Basin of northwestern Australia and demonstrated the application of the European zones to the Australian faunal sequences.

Recently Upper Devonian faunas have been recorded from China (Ching, 1960), Iran (Huckriede et al., 1962), Malaya (Alexander & Müller, 1963), and Queensland (Druce & Wilson, 1967; Druce, 1968a, b, c).

Considerably less work has been done on Lower Carboniferous conodonts. After the pioneer work of Branson & Mehl (1933-4, 1938), Huddle (1934), and Cooper (1939), little was published until Hass (1953, 1959), Collinson and co-authors (1959, 1961, 1962), Rexroad and co-authors (1957, 1958, 1959, 1961, 1964, 1965), and Klapper (1966) published information on North American Mississippian conodont faunas.

In Western Europe Bischoff (1957) and Voges (1959) have produced detailed biostratigraphic reports on conodont occurrences in classical German sections. British Carboniferous conodonts have been described in detail by Rhodes, Austin, & Druce (1968). Recently Lower Carboniferous conodont faunas have been recorded from Japan (Igo & Koike, 1964, 1965; Hayashi, 1963, 1964a, b), China (Ching, 1960), Italy (Manzoni, 1966), Queensland (Druce & Wilson, 1967; Druce, 1968c), and Canada (Globensky, 1967). A detailed discussion on

Lower Carboniferous conodont research is given by Rhodes, Austin, & Druce (1968)*.

Australia

Glenister & Klapper (1966, p. 780) have documented in detail Australian conodont research up to 1964. Since then papers have been published by Philip (1965) on a Lower Devonian (Upper Gedinnian-Siegenian) fauna from the Coopers Creek Formation, Victoria; by Jones & Druce (1966) on conodont zonation in the Bonaparte Gulf Basin; and further papers by Philip (1966a, b) on Ordovician (Upper Caradocian) conodonts from northern New South Wales and Lower Devonian conodonts from Buchan, Victoria.

Conodonts were first discovered in the Bonaparte Gulf Basin in 1950 by Öpik (*in* Traves, 1955), who recorded the presence of Lower Ordovician (Tremadocian) conodonts in a glauconitic sandstone exposed on Pander Ridge (which was named in honour of C. H. Pander, the author of the first paper dealing with conodonts).

Lower Carboniferous conodonts were first noted by Glenister (1960) in the Burt Range Limestone (now the Burt Range Formation) and the Septimus Limestone. The Spirit Hill Limestone at his locality (c) is considered to be the same age as the Septimus Limestone, though most of the Spirit Hill Limestone is considered to be equivalent to the Burt Range Formation (Thomas, 1962; Veevers, 1967).

Jones & Druce (1966) summarized previous conodont work in the basin and gave a brief account of the correlation of the Palaeozoic sediments, based on conodonts, in the basin; and Roberts, Jones, & Druce (1967) gave an account of the Upper Devonian correlation based on brachiopods, conodonts, and ostracods. The present Bulletin is a detailed account of the systematic palaeontology and biostratigraphy of the conodonts mentioned in these papers.

STRATIGRAPHY OF COLLECTING AREAS

The stratigraphy of the Bonaparte Gulf Basin is discussed in detail by Veevers & Roberts (1968) and Kaulback & Veevers (1968), from which the following information has been taken.

The oldest rocks found in the Bonaparte Gulf Basin are Precambrian sandstones with minor shale, acid and basic volcanics, and carbonate rocks. They are overlain unconformably by Lower Cambrian volcanics (Antrim Plateau volcanics), and Middle and Upper Cambrian and Lower Ordovician sediments. The Cambrian and Ordovician sediments are composed of quartz sandstone with minor dolomite and shale (Kaulback & Veevers, 1968).

Unconformably overlying the Precambrian and Lower Palaeozoic sequence are Upper Devonian and Carboniferous conglomerates, sandstones, shales, and limestones, which are in turn overlain by Permian glacial sediments (Keep Inlet Beds).

Devonian Sequence

The Frasnian *Cockatoo Formation* consists of about 5,000 feet of quartz sandstone, conglomerate, limestone, and dolomite, unconformably overlying the

*As a co-author of Rhodes, Austin, and Druce (1968), I was able to draw on their results when writing this Bulletin. Unfortunately their Bulletin had not been issued by the time this work went to press, and hence page numbers in the references to Rhodes, Austin, & Druce have had to be omitted.

Precambrian and Lower Palaeozoic sequences. It is conformably overlain, above transition beds, by the Ningbing Limestone or by the Buttons Beds. Eight members within the Cockatoo Formation have been mapped.

Veevers & Roberts (1968) define the *Ningbing Limestone* as the belt of limestone that crops out between the northwestern part of the Pincombe Range and a point 3 miles north-northwest of Knob Peak. It conformably overlies the Jeremiah Member of the Cockatoo Formation and is unconformably overlain by, or faulted against, the Visean Utting Calcarenite. The outcropping Ningbing Limestone consists of a reef complex containing four facies, reef, inter-reef, fore-reef, and back-reef, of which the back-reef predominates (Playford et al., 1966, p. 436-7; Veevers & Roberts, 1968).

The *Buttons Beds,* composed of sandy and silty limestone, are considered by Veevers & Roberts to be equivalent to at least part of the Ningbing Limestone. They unconformably overlie Precambrian siltstone in the Sorby Hills and the Jeremiah Formation in the Ord River Section. The top of the Buttons Beds is faulted in the Ord River area and is unconformably overlain by the Burt Range Formation in the Eight-Mile Creek area.

Carboniferous

The Tournaisian *Burt Range Formation* consists of a sequence of 150 feet of alternating hard and soft beds of thin-bedded crinoidal calcarenite with occasional sandy beds, overlain by 250 feet of finer grained crinoidal calcisiltite, then 300 feet of crinoidal calcarenite containing abundant brachiopods, and finally 250 feet of sandy skeletal calcarenite also containing brachiopods (Veevers & Roberts, p. 70). The Burt Range Formation unconformably overlies the Buttons Beds and is conformably overlain by the Enga Sandstone.

The Tournaisian *Enga Sandstone* crops out in the southeastern part of the Bonaparte Gulf Basin. It is a clean quartz sandstone with minor carbonate rocks near the base; it is estimated to be 520 feet thick (Veevers & Roberts, p. 80). In the only section where an upper contact is known, it is overlain conformably by the Septimus Limestone.

The Tournaisian *Septimus Limestone,* exposed on the lower parts of Mount Septimus, comprises 590 feet of thin-bedded sandy calcarenite, with a calcareous sandstone between 420 and 490 feet, in the type section. It is disconformably overlain by sandstone of the Border Creek Formation (Veevers & Roberts, p. 82).

The Visean *Milligans Beds* are dark shale and siltstone, known from bores, wells, and shot-holes in the region around Spirit Hill. They are poorly exposed at Spirit Hill (Veevers & Roberts, p. 101). The sequence unconformably overlies the Burt Range Formation in Spirit Hill No. 1 Well and is overlain by Burvill Beds in Milligans No. 1 Bore, where it is 364 feet thick.

The *Bonaparte Beds* are a thick basinal 'shale facies' of shale, siltstone, and sandstone extending from the Upper Devonian into the Lower Carboniferous, and are laterally equivalent to most of the sandstones and limestones deposited near the margin of the basin. The Bonaparte Beds are only known from Bonaparte No. 1 and No. 2 wells and are overlain by the Tanmurra Formation. The sequence is at least 8,900 feet thick.

The Visean *Utting Calcarenite* is a coarse to medium-grained skeletal sandy calcarenite and has an estimated thickness of more than 400 feet.

The Visean *Burvill Beds* are a sequence of sandstone, shale, and interbedded sandy limestone overlain unconformably by the Point Spring Sandstone or disconformably by the Border Creek Formation. The type section is 160 feet thick and the maximum thickness measured is 280 feet (Veevers & Roberts, p. 103).

The *'mid-Tournaisian breccia'* was described by Veevers & Roberts (1966, p. 393), who concluded from the evidence of the brachiopods and conodonts that it was of mid-Tournaisian age. They suggested that it correlated with the Pierson Limestone of Missouri, USA, the uppermost *Cleistopora* (*K*) zone of the Avonian, and the Lower *Pericyclus* Stufe (cuII$_\alpha$) of Germany.

Methods of Collection and Study

Limestones and calcareous sandstones were the only rock types systematically examined. A few samples of dolomitic limestone, sandstone, and shale were processed.

Only the four calcareous Members, the Westwood, Kununurra, Hargreaves, and Jeremiah, of the Cockatoo Formation were sampled for conodonts. The Westwood Member is fairly well exposed around the tidal flats, and one section (Section 459) of over 500 feet of limestone with sandstone interbeds was collected at 10-foot intervals. Other measured sections with minor limestone exposures were collected. Samples from the Kununurra, Hargreaves, and Jeremiah Members were isolated samples from well exposed sections with dominant sandstone lithology.

The outcropping Ningbing Limestone is a reef complex with the back-reef facies predominant in outcrop. This facies is well bedded and isolated samples from measured sections were collected (Section 443). Because the reef is massive, only isolated samples scattered throughout the reef-mass were examined; the fore-reef and inter-reef are so poorly exposed that few samples were collected, and none from measured sections.

Samples from the Buttons Beds (Section 105), Burt Range Formation (Sections 100, 101), and Enga Sandstone (Sections 103, 109), were collected from limestone beds in measured sections, and samples from the Septimus Limestone were collected at 10-foot intervals through a measured section (Section 104).

Limestone beds in two sections (107, 108) were collected from the Utting Calcarenite and samples from three thin limestone interbeds in the Burvill Beds were examined.

Shale samples from Bonaparte Nos. 1 and 2 and Spirit Hill No. 1 Wells, and a solitary outcrop of Milligans Beds, were also examined.

All limestones examined were crushed in a 3-inch jaw crusher and screened through an 8-mesh sieve, the fine fraction being retained and searched for ostracods. The remaining coarse fraction was then treated with a 15 percent monochloracetic acid solution at 60°C. The resultant residue was screened through a 100-mesh sieve, dried and separated in bromoform (S.G. 2.9); the heavy fraction was washed with methylated spirit (white spirit) and dried. This fraction was searched under a binocular microscope, and the conodonts extracted and mounted on slides. Calcareous sandstones were treated in the the same way.

All figured specimens were photographed on Ilford KB 14 film using a Leitz Orthomat microscope camera.

CONODONT FAUNAS

The present study is based on 10,000 conodonts identified at the generic level, which were recovered from 548 samples, weighing about 4,500 lb.

The distribution of conodonts was far from uniform. Some bias was introduced into the study in that nearly all the samples examined were collected from calcareous intervals: very few sandstone and shale samples were examined. The Cockatoo Formation yielded conodonts from limestone beds in the Westwood and Jeremiah Members and from calcareous sandstones in the Kununurra and Hargreaves Members. Samples from this formation yielded up to 30 identifiable specimens per kilogram; in one sample (459/150) reworked Ordovician conodonts were found. In the Ningbing Limestone conodonts were most abundant in the reef and inter-reef facies, from which 4 to 20 specimens were recovered per kilogram, whereas back-reef and fore-reef samples yielded up to 10 specimens per kilogram. The Burt Range Formation yielded up to 50 specimens per kilogram, the Septimus Limestone and Utting calcarenite 3, and the Burvill Beds 0.5. Conodonts were rare in the Enga Sandstone, the Milligan Beds, and the 'mid-Tournaisian breccia'.

In broad terms the sandy and dolomitic samples yielded fewer conodonts than the purer limestones.

The genus *Spathognathodus* was represented by 33 species, *Polygnathus* by 27, *Ozarkodina* by 13, and *Hibbardella, Hindeodella, Neoprioniodus,* and *Pseudopolygnathus* each by 7. A total of 159 species referable to 35 genera was identified. Of these one genus, nineteen species, and five subspecies are new.

Stratigraphic Distribution of Genera

The charts on pp. 9 to 13 show the stratigraphical distribution of all species described.

Ancyrognathus (1 species). An unidentified species is present in the Westwood Member of the Frasnian Cockatoo Formation.

Angulodus (4). This genus is confined to the Lower Carboniferous in the Bonaparte Gulf Basin. *A. flexus* sp. nov. and *A. minutus* sp. nov. occur in the Burt Range Formation, Enga Sandstone, and Septimus Limestone. *A.* sp. A occurs in the Utting Calcarenite and *A.* sp. B at the 7/1 locality in the Ningbing Range.

Apatognathus (5). The three species and two subspecies of *Apatognathus* occur in the Famennian Ningbing Limestone; apatognathids are not known from Carboniferous formations in the Basin.

Bryantodus (1). One species, *B. scitulus* Branson & Mehl, is known from the Tournaisian Burt Range Formation.

Cavusgnathus (2). Occurrences of this genus are confined to the Visean. *C. unicornis*? Youngquist & Peterson occurs throughout the Utting Calcarenite and *C.* sp. was recovered from the Burvill Beds.

Centrognathodus (1). An unidentified species of this genus occurs in the Famennian Ningbing Limestone.

Clydagnathus (4). This genus is confined to the Tournaisian formations. *C. gilwernensis* Rhodes, Austin, & Druce ranges from 200 feet above the base to within 250 feet of the top of the Burt Range Formation (1,510 feet thick). *C. cavusformis* Rhodes, Austin, & Druce ranges from 300 feet above the base of the Burt Range Formation into the Septimus Limestone. *C. nodosus* sp. nov. ranges

Formations and Conodont Zones where applicable / Species	Cockatoo Formation	Ningbing Limestone	Ningbing Limestone (?/1)	Burt Range Formation					Enga Sst	Septimus Limestone			Utting Calcarenite	Burvill Beds
				Spathognathodus plumulus Assemblage Zone	Siphonodella sulcata-Polygnathus parapetus Assemblage Zone	Siphonodella isosticha P. inornatus nodulatus Assemblage Zone	Siphonodella quadruplicata S. cooperi Assemblage Zone	Clydagnathus nodosus Assemblage Zone		Spathognathodus triangularis Assemblage Zone	Spathognathodus costatus Assemblage Zone	Pseudopolygnathus nodomarginatus Assemblage Zone		
Ancyrognathus sp.	*													
Angulodus flexus														
Angulodus minutus														
Angulodus sp. A													*	
Angulodus sp. B			*											
Apatognathus gemina													*	
Apatognathus varians s.s.		*												
Apatognathus varians ethingtoni		*												
Apatognathus varians klapperi		*												
Apatognathus n. sp. A		*												
Apatognathus? n.sp.		*												
Bryantodus scitulus														
Cavusgnathus unicornis?													*	
Cavusgnathus sp.														*
Centrognathodus sp.		*												
Clydagnathus cavusformis														
Clydagnathus darensis														
Clydagnathus gilwernensis														
Clydagnathus nodosus														
Dinodus fragosus			*											
Dinodus wilsoni			*											
Dinodus cf. D. wilsoni			*											
Elictognathus bialata			*											
Euprioniodina alternata														
Falcodus robertsi														
Falcodus tortus														
Falcodus variabilis		*												
Falcodus cf. F. variabilis		*												
Falcodus veeversi														
Geniculatus claviger													*	
Gnathodus burtensis														
Gnathodus cuneiformis													*	
Gnathodus girtyi simplex														*
Gnathodus texanus													*	
Hibbardella cf. H. macrodentata														

CHART 1

Species \ Formations and Conodont Zones where applicable	Cockatoo Formation	Ningbing Limestone	Ningbing Limestone (7/1)	Burt Range Formation: Spathognathodus plumulus Assemblage Zone	Burt Range Formation: Siphonodella sulcata-Polygnathus parapetus Assemblage Zone	Burt Range Formation: Siphonodella isosticha P. inornatus nodulatus Assemblage Zone	Burt Range Formation: Siphonodella quadruplicata S. cooperi Assemblage Zone	Burt Range Formation: Clydagnathus nodosus Assemblage Zone	Enga Sst	Septimus Limestone: Spathognathodus tridentatus Assemblage Zone	Septimus Limestone: Spathognathodus costatus Assemblage Zone	Septimus Limestone: Pseudopolygnathus nodomarginatus Assemblage Zone	Utting Calcarenite	Burvill Beds
Hibbardella cf. H. plana					—	—	—							
Hibbardella seperata		*			—	—	—	—						
Hibbardella telum?	*													
Hibbardella n. sp.							—							
Hibbardella sp. A							—							
Hibbardella? sp.		*												
Hindeodella brevis			*		—	—	—	—						
Hindeodella corpulenta				—	—	—	—	—		—	—	—		
Hindeodella compressa							—							
Hindeodella subtilis	*	*		—	—	—	—	—		—	—			
Hindeodella uncata			*											
Hindeodella sp.			*											
Icriodus alternatus	*	*												
Icriodus rectus		*												
Icriodus sp.			*											
Ligonodina angulata								—						
Ligonodina bicincta			*											
Ligonodina flexuosa				—										
Ligonodina sp. A		*												
Ligonodina sp. B						—								
Lonchodina furnishi													*	
?Magnilaterella sp.					—									
Mestognathus beckmanni													*	
M. neddensis													*	
Neoprioniodus barbatus						—								
Neoprioniodus confluens				—	—	—	—	—		—	—	—		
Neoprioniodus peracutus													*	
Neoprioniodus recurvus						—								
?Neoprioniodus tortus		*												
Neoprioniodus cf. N. armatus				—	—	—	—							
Neoprioniodus sp.				—										
Ozarkodina elegans		*												
Ozarkodina ethys				—	—	—	—							
Ozarkodina hindei														
Ozarkodina homoarcuata		*												

CHART 2

Species \ Formations and Conodont Zones where applicable	Cockatoo Formation	Ningbing Limestone	Ningbing Limestone (7/1)	Burt Range Formation: Spathognathodus plumulus Assemblage Zone	Burt Range Formation: Siphonodella sulcata-Polygnathus parapetus Assemblage Zone	Burt Range Formation: Siphonodella isosticha P. inornatus nodulatus Assemblage Zone	Burt Range Formation: Siphonodella quadruplicata S. cooperi Assemblage Zone	Enga Sst: Clydagnathus nodosus Assemblage Zone	Septimus Limestone: Spathognathodus sp. F (Sp. F) Assemblage Zone	Septimus Limestone: Spathognathodus costatus Assemblage Zone	Septimus Limestone: Pseudopolygnathus nodomarginatus Assemblage Zone	Utting Calcarenite	Burvill Beds
Ozarkodina huddlei			•										
Ozarkodina lacera		•											
Ozarkodina cf. O. curvata													
Ozarkodina plana													
Ozarkodina radians													
Ozarkodina regularis													
Ozarkodina rhenana													
Ozarkodina sp. A			•										
Ozarkodina sp. B													
Ozarkodina sp. C		•											
Palmatodella delicatula		•											
Palmatodella sp.		•											
Palmatolepis glabra elongata		•											
Palmatolepis glabra pectinata		•											
Palmatolepis gracilis s.s.		•											
Palmatolepis gracilis sigmoidalis		•											
Palmatolepis minuta s.s.		•											
Pelekysgnathus peejayi		•											
Polygnathus anidus													
Polygnathus bischoffi			•										
Polygnathus cf. P. brevilaminus	•												
Polygnathus collinsoni		•											
Polygnathus communis s.s.													
Polygnathus communis carinus			•										
Polygnathus communis dentatus													
Polygnathus distortus			•										
Polygnathus elongonodosus													
Polygnathus hassi		•											
Polygnathus inornatus s.s.													
Polygnathus inornatus nodulatus													
Polygnathus inornatus rostratus													
Polygnathus cf. P. longiposticus													
Polygnathus nodocostatus s.s.	•												
Polygnathus normalis	•												
Polygnathus parapetus													

CHART 3

Formations and Conodont Zones where applicable / Species	Cockatoo Formation	Ningbing Limestone	Ningbing Limestone (?/1)	Burt Range Formation				Enga Sst	Septimus Limestone			Uting Calcarenite	Burvill Beds
				Spathognathodus plumulus Assemblage Zone	Siphonodella sulcata-Polygnathus parapetus Assemblage Zone	Siphonodella isosticha P. inornatus nodulatus Assemblage Zone	Siphonodella quadruplicata S. cooperi Assemblage Zone	Clydagnathus cornutus Assemblage Zone	Spathognathodus tridentatus Assemblage Zone	Spathognathodus costatus Assemblage Zone	Pseudopolygnathus nodomarginatus Assemblage Zone		
Polygnathus siphonellus				—	—	—	—						
Polygnathus thomasi								—					
Polygnathus toxophorus					—	—	—	—					
Polygnathus cf. P. varcus	*	*											
Polygnathus znepolensis		*											
Polygnathus sp. A	*												
Polygnathus sp. B				—									
Polygnathus sp. C					—								
Polygnathus sp. D		*											
Polygnathus sp. indet.	*												
Polylophodonta confluens		*											
Polylophodonta elongata		*											
Prioniodina latericrescens						—	—	—	—				
Prioniodina? smithi		*											
Pseudopolygnathus expansus										—			
Pseudopolygnathus nodomarginatus											—		
Pseudopolygnathus triangulus s.s.			*										
Pseudopolygnathus vogesi				—	—	—	—						
Pseudopolygnathus sp. A				—									
Pseudopolygnathus sp. B							—						
Pseudopolygnathus sp. C					—								
Rhodalepis inornata		*											
Scaphignathus ziegleri		*											
Scutula bipennata		*											
Scutula cf. S. bipennata		*											
Siphonodella cooperi							—						
Siphonodella isosticha						—	—						
Siphonodella quadruplicata							—						
Siphonodella sulcata					—								
Siphonodella trirostrata			*										
Spathognathodus cf. S. aculeatus		*											
Spathognathodus anteposicornis									—	—	—		
Spathognathodus cf. S. anteposicornis									—				
Spathognathodus coalescens												*	
Spathognathodus costatus s.s.										—	—		

CHART 4

Formations and Conodont Zones where applicable / Species	Cockatoo Formation	Ningbing Limestone	Ningbing Limestone (7/1)	Burt Range Formation: Spathognathodus plumulus Assemblage Zone	Burt Range Formation: Siphonodella sulcata-Polygnathus parapetus Assemblage Zone	Burt Range Formation: Siphonodella isosticha P. inornatus nodulatus Assemblage Zone	Burt Range Formation: Siphonodella quadruplicata S. cooperi Assemblage Zone	Enga Sst: Clydagnathus nodosus Assemblage Zone	Septimus Limestone: Spathognathodus tridentatus Assemblage Zone	Septimus Limestone: Spathognathodus costatus Assemblage Zone	Septimus Limestone: Pseudopolygnathus nodomarginatus Assemblage Zone	Utting Calcarenite	Burrill Beds
Spathognathodus cf. S. costatus									—				
Spathognathodus costatus sulciferus										—	—		
Spathognathodus crassidentatus				—	—	—	—	—	—	—	—		
Spathognathodus cf. S. crassidentatus									—				
Spathognathodus cf. S. cristulus					—	—	—						
Spathognathodus cyrius s.s.						—		—	—				
Spathognathodus cyrius nodus					—								
Spathognathodus delicatulus			*										
Spathognathodus elongatus					—	—	—						
Spathognathodus plumulus nodusus				—									
Spathognathodus plumulus s.s.				—	—								
Spathognathodus cf. S. plumulus		*											
Spathognathodus plumulus shirleyae				—									
Spathognathodus quintidentatus							—						
Spathognathodus regularis					—	—	—	—					
Spathognathodus cf. S. regularis							—						
Spathognathodus cf. S. robustus										—	—		
Spathognathodus cf. S. robustus n. subsp. A				—									
Spathognathodus scitulus												*	
Spathognathodus sculderus				—	—	—	—						
Spathognathodus stabilis		*											
Spathognathodus tortus					—	—	—						
Spathognathodus tridentatus									—				
Spathognathodus n.sp. A						—	—						
Spathognathodus sp. A								—					
Spathognathodus sp. B		*											
Spathognathodus sp. C								—					
Spathognathodus? sp.										—			
Taphrognathus sp.												*	
Tripodellus robustus		*											
N. gen. et sp.		*											
gen. et sp. indet A							—						
gen. et sp. indet B		*											
gen. et sp. indet C		*											
gen. et sp. indet D							—						

CHART 5

from the upper 700 feet of the Burt Range Formation to the basal Septimus Limestone and *C. darensis* ranges from 75 feet to the top of the Septimus Limestone. *Dinodus* (3). Two species, *D. fragosus* Branson and *D. wilsoni* sp. nov., and one unidentified species of this genus occur in the Tournaisian in the Ningbing Range (7/1 locality).

Elictognathus (1). Only one species, *E. bialata* (Branson & Mehl), was found, in the Tournaisian in the Ningbing Range (7/1 locality).

Euprioniodina (1). *E. alternata* (Ulrich & Bassler) occurs throughout the Tournaisian.

Falcodus (4). One species, *F. variabilis* Sannemann, is known from the late Famennian part of the Ningbing Limestone. The remaining three species known from the basin, *F. robertsi* sp. nov., *F. veeversi* sp. nov., and *F. tortus* Huddle, occur in the Burt Range Formation.

Geniculatus (1). This genus is confined to one species, *G. claviger* (Roundy), which is restricted to the Utting Calcarenite.

Gnathodus (5). Four species and one unidentified species occur in the Tournaisian. *G. burtensis* sp. nov. ranges from the upper part of the Burt Range Formation into the Enga Sandstone. *G. cuneiformis* Mehl & Thomas and *G. texanus* Roundy both occur exclusively in the Utting Calcarenite, and *G. girtyi simplex* Dunn is known from a single specimen in the Burvill Beds.

Hibbardella (7). Species of *Hibbardella* range through the Devonian and Carboniferous in the Bonaparte Gulf Basin.

Hindeodella (7). Most species are long ranging and the genus occurs in all the Devonian and Carboniferous formations.

Icriodus (3). Two species, *I. alternatus* Branson & Mehl and *I. rectus* Youngquist & Miller, occur in the Upper Devonian; both are known from the Westwood Member, Cockatoo Formation, and the Ningbing Limestone. *Icriodus* sp. also occurs in the Ningbing Formation.

Ligonodina (5). *Ligonodina bicincta* Huddle is confined to the Tournaisian at the 7/1 locality. *Ligonodina flexuosa* Branson & Mehl occurs in the basal Tournaisian zone and *L. angulata* Branson & Mehl occurs in the *Clydagnathus nodosus* Assemblage Zone. *Ligonodina* sp. A occurs in the Ningbing Limestone and *L.* sp. B in the Burt Range Formation.

Lonchodina (1). One species, *L. furnishi* Rexroad, occurs in the Visean Utting Calcarenite.

Magnilaterella (1). A questionable magnilaterellid has been recovered from the Burt Range Formation.

Mestognathus (2). Two species, *M. beckmanni* Bischoff and *M. neddensis* Rhodes, Austin, & Druce, are known from the Visean Utting Calcarenite, and *M. beckmanni* from the Bonaparte Beds in Bonaparte No. 2 well.

Neoprioniodus (7). Apart from ?*N. tortus* sp. nov., which occurs in the back-reef facies of the Ningbing Limestone, all the neoprioniodids occur in the Lower Carboniferous.

Palmatodella (1). One identified species, *P. delicatula* Ulrich & Bassler, is known from the Famennian Ningbing Limestone.

Palmatolepis (5). All the palmatolepids, *Palmatolepis glabra elongata* Holmes, *P. glabra pectinata* Ziegler, *P. gracilis* s.s. Branson & Mehl, *P. gracilis sigmoidalis* Ziegler, and *P. minuta* s.s. Branson & Mehl, are confined to the Famennian Ningbing Formation.

Pelekysgnathus (1). One new species, *P. peejayi,* is known from the early Famennian back-reef facies of the Ningbing Limestone.

Polygnathus (27). In the Frasnian Cockatoo Formation *P. normalis* Miller & Youngquist, *P.* cf. *P. varcus* Stauffer, and *P.* cf. *P. brevilaminus* Branson & Mehl, occur commonly; *P. nodocostatus* s.s. Branson & Mehl is rare. *P.* cf. *P. varcus* also occurs in the Famennian Ningbing Limestone, as do *P. hassi* Helms, *P. znepolensis* Spasov, and *P. collinsoni* sp. nov. The latter three species occur in the late Famennian part. The Tournaisian limestone developed in the Ningbing Range (locality 7/1) has yielded *P. bischoffi* Rhodes, Austin, & Druce, *P. communis carinus* Hass, and *P. distortus* Branson & Mehl. In the Tournaisian formations polygnathids are abundant and varied. *P.* sp. B occurs in the basal 50 feet of the Burt Range Formation. *P. anidus* Cooper, *P. communis dentatus* subsp. nov., *P. inornatus nodulatus* subsp. nov., *P. inornatus rostratus* Rhodes, Austin, & Druce, *P. parapetus* sp. nov., *P. siphonellus* sp. nov., and *P. toxophorus* Cooper are all confined to the lower part of the Burt Range Formation. *P. inornatus* s.s. Branson & Mehl and *P. communis* s.s. Branson & Mehl range from the Burt Range Formation into the lower Septimus Limestone. *P. thomasi* sp. nov. and *P. elongonodosus* sp. nov. have restricted ranges in the upper part of the Burt Range Formation.

Polylophodonta (3). All three species, *P. confluens* (Ulrich & Bassler), *P. elongata* sp. nov., and *P.* sp. A, are confined to the early Famennian part of the Ningbing Limestone.

Pseudopolygnathus (7). This genus is confined to the lower Tournaisian. *P. vogesi* Rhodes, Austin, & Druce is confined to the lower Burt Range Formation, *P. triangulus* s.s. Voges to the 7/1 locality in the Ningbing Range, *P. nodomarginatus* E. R. Branson to the upper part of the Septimus Limestone, and *P. expansus* Rhodes, Austin, & Druce occurs in the Septimus Limestone.

Rhodalepis (1). This new genus is represented by one species, *R. inornata* sp. nov., in the late Famennian part of the Ningbing Limestone.

Scaphignathus (1). A new species, *S. ziegleri,* is present in the Famennian Ningbing Limestone.

Scutula (2). One species, *S. bipennata* Sannemann, and specimens compared to this species are known from the late Famennian Ningbing Limestone.

Siphonodella (5). All species of this genus are confined to the lower Tournaisian rocks. Four species, *S. cooperi* Hass, *S. isosticha* (Cooper), *S. quadruplicata* (Branson & Mehl), and *S. sulcata* (Huddle), are confined to the lower part of the Burt Range Formation. The other species, *S. trirostrata* sp. nov., is confined to the Tournaisian locality in the Ningbing Range (7/1 locality).

Spathognathodus (33). No identifiable species are known from the Frasnian Cockatoo Formation. The Famennian Ningbing Limestone has yielded the following species: *S. aculeatus* (Branson & Mehl), *S. crassidentatus* (Branson & Mehl), *S. inornatus* (Branson & Mehl), *S. stabilis* (Branson & Mehl), and *S.*

ziegleri Rhodes, Austin, & Druce. *S. crassidentatus* ranges into the Tournaisian Septimus Limestone. In the Tournaisian spathognathodids are extremely abundant. The lower part of the Burt Range Formation is characterized by subspecies of the *S. plumulus* group, whereas the middle part yields faunas containing *S.* cf. *cristulus* Youngquist & Peterson, *S. regularis* (Branson & Mehl), *S. sculderus* sp. nov., *S. tortus* (Branson & Mehl), *S. cyrius nodus* subsp. nov., *S. quintidentatus* (Thomas), and *S.* sp. nov. A. Two species, *S. cyrius* s.s. (Cooper) and *S. crassidentatus,* range into the Septimus Limestone. *S. costatus* s.s. (E. R. Branson), *S. costatus sulciferus* (Branson & Mehl), *S. anteposicornis* Scott, *S. tridentatus* (Branson & Mehl), and *S.* cf. *S. robustus* (Branson & Mehl), are all diagnostic of the Septimus Limestone. Only two species are known from the Visean: *S. scitulus* (Hinde) and *S. coalescens* (Rexroad & Collinson) occur in the Utting Calcarenite.

Taphrognathus (1). One species, also known to be present in Queensland (Druce & Wilson, 1967), is known from the Utting Calcarenite.

Tripodellus (1). Only one species, *T. robustus* Bischoff, has been recovered, from the late Famennian part of the Ningbing Limestone.

AGE, ZONATION, AND CORRELATION OF BONAPARTE GULF BASIN FORMATIONS

Devonian

Cockatoo Formation

The Cockatoo Formation was first dated as Upper Devonian on the presence of plants by Matheson & Teichert (1948, p. 82). Traves (1955) discovered pelecypods (identified by J. M. Dickins) in the formation and extended the mapping of the outcrop, although rocks now considered to belong to the Cockatoo Formation were mapped as Cambrian and Permian (Veevers & Roberts, 1968). Veevers et al. (1964) concluded that the Ragged Range Conglomerate, considered to be Cambrian by Traves (1955), is Upper Devonian on the basis of pelecypods. Jones & Druce (1966) listed conodonts from the Westwood Member which indicate a Frasnian (toI) age.

Conodonts indicating a Frasnian (toI) age are present in the middle glauconitic and carbonate members of the Cockatoo Formation. The base of the formation is undated and it may be as old as Middle Devonian (Jones & Druce, 1966, p. 358). The upper part of the formation may be as young as the toII stage of the Famennian because about 2,000 feet of sandstone, which has so far yielded no conodonts, overlies the fossiliferous limestones and is in turn overlain by the Famennian (toII$_\beta$-toVI) Ningbing Limestone (Jones & Druce, 1966, p. 358).

Westwood Member. The Westwood Member is Frasnian. Jones & Druce (1966) showed that *Ancyrognathus* sp., *Polygnathus* cf. *P. brevilaminus* Branson & Mehl, and *Polygnathus normalis* Miller & Youngquist indicate a Frasnian age. Form species of *Ancyrognathus* range throughout toI-toII, and *Polygnathus normalis* ranges from the upper Middle Devonian to the Frasnian-Famennian boundary (tmo-toI/II boundary). Later work was reported by Roberts et al. (1967), who recorded the presence of *Icriodus alternatus* Branson & Mehl, *I. rectus* Youngquist & Peterson, and *Polygnathus nodocostatus nodocostatus* Branson & Mehl.

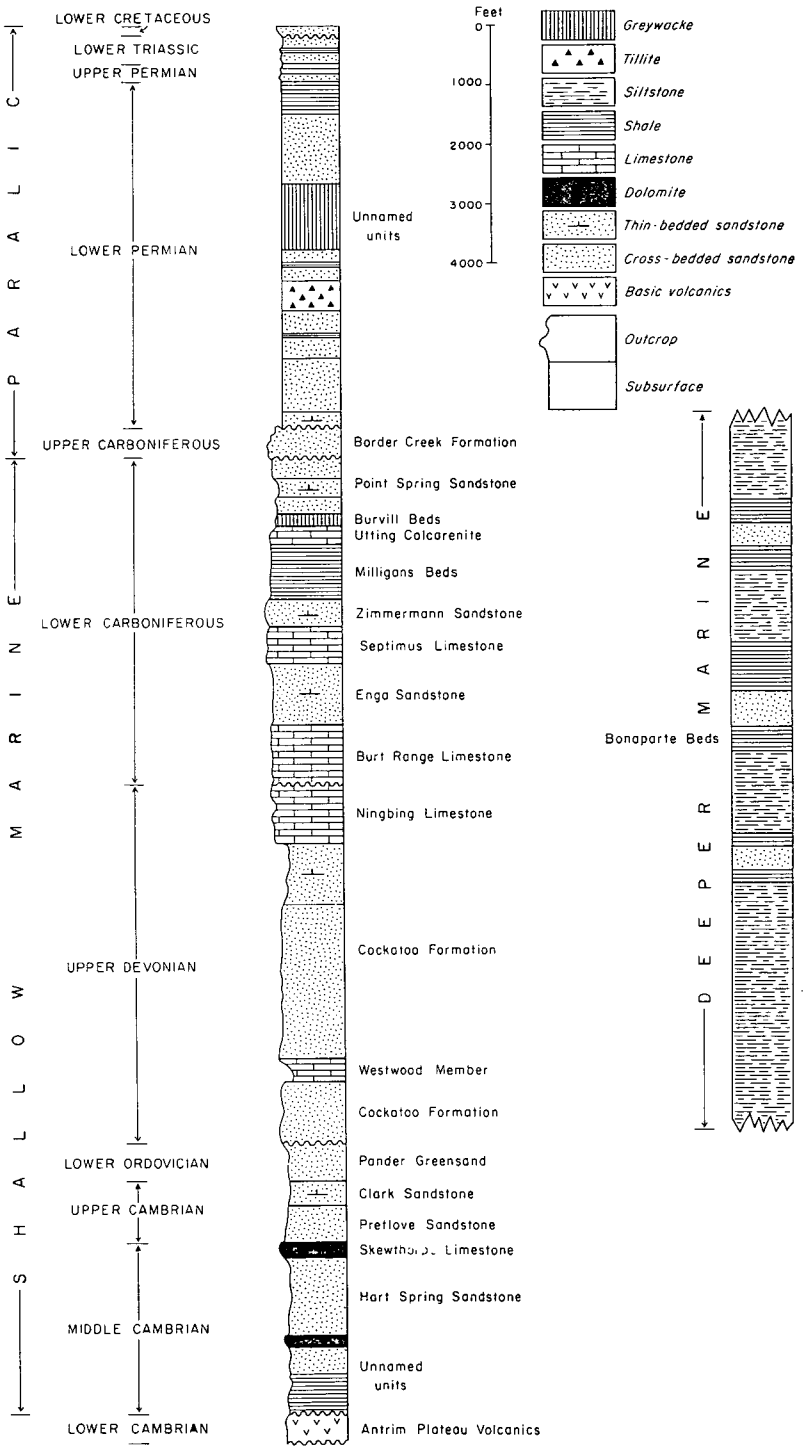

Figure 2. General stratigraphic column, Bonaparte Gulf Basin.

Icriodus alternatus first appears at the base of toIγ in Europe, but in North America it is found in the Lingle and Alto Formations of Illinois, which are correlated with the uppermost Givetian and lowermost Frasnian (Orr, 1964). *Icriodus rectus,* which Anderson (1966, p. 407) considers to be a senior synonym of *I. cornutus* Sannemann, is found in the Sheffield Formation (toIγ-toIIα) of North America; in Europe this species is referred to *I. cornutus* and ranges from the toI/II boundary to earliest toIII$_\alpha$ (Ziegler, 1962, p. 52, table 4).

Polygnathus nodocostatus s.s., represented by a single specimen, ranges from toI$_\gamma$-toIII (Helms, 1961) and perhaps as high as toV (Ziegler, 1962). The conodonts point to a Frasnian (toI$_\gamma$) age; however, the evidence is tenuous because the icriodid nomenclature is in a state of flux, and the single specimen of *Ancyrognathus* is broken. Brachiopods indicate a lower Frasnian age (Roberts et al., 1967); other faunal groups (pelecypods, algae) indicate a general Frasnian age.

Kununurra Member. The conodont fauna from the Kununurra Member is, apart from long ranging ozarkodinids, restricted to *Polygnathus normalis* Miller & Youngquist, which ranges from upper Middle Devonian to the Frasnian/Famennian boundary (Bischoff & Ziegler, 1957; Ziegler, 1962). A general Frasnian age is indicated.

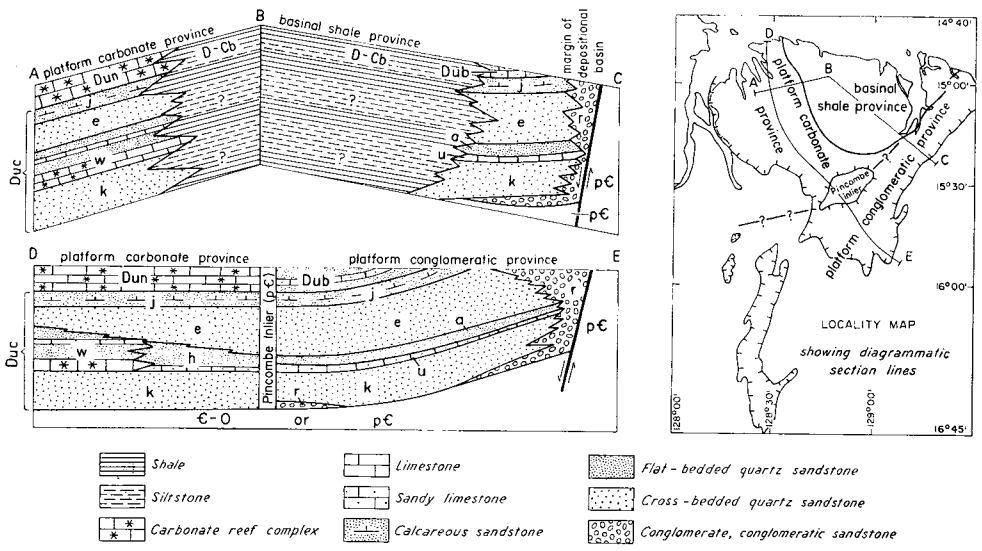

Figure 3. Generalized cross-sections, Devonian (from Veevers & Roberts, 1968)

Hargreaves Member. The conodont fauna indicates a Frasnian (toI) age. *Icriodus rectus* Youngquist & Peterson, *Polygnathus normalis* Miller & Youngquist, and *Polygnathus* cf. *P. varcus* Stauffer are all known from the Westwood Member. *Icriodus rectus* has a range of toI$_\gamma$-toII$_\alpha$ (see previously), *Polygnathus normalis* has a range of tmo-toI/toII boundary, and *P.* cf. *P. varcus* is known from the Westwood Member and the lower part of the Ningbing Limestone.

Jeremiah Member. The Jeremiah Member is older than toII$_\beta$ because it is conformably overlain by the Ningbing Limestone of toII$_\beta$-toIV age (Jones & Druce, 1966; Veevers & Roberts, 1968). Only a few conodonts are present; they include *Hindeodella subtilis* Ulrich & Bassler, *Polygnathus* sp., and *Spathognathodus* sp., and are of little stratigraphic use.

Ningbing Limestone

Conodonts recovered from the formation indicate that all the Famennian goniatite zones are represented. The greater part of the exposed Ningbing Limestone is of toII$_\beta$-toIII$_\alpha$ age (Jones & Druce, 1966), but at some localities the formation is as young as toVI and it may even range as high as the Tournaisian cuII$_\alpha$ zone (see discussion under 7/1 locality). No definite toIV faunas were recovered and the toII$_\alpha$ zone could also be missing or occupied by the upper part of the Cockatoo Formation.

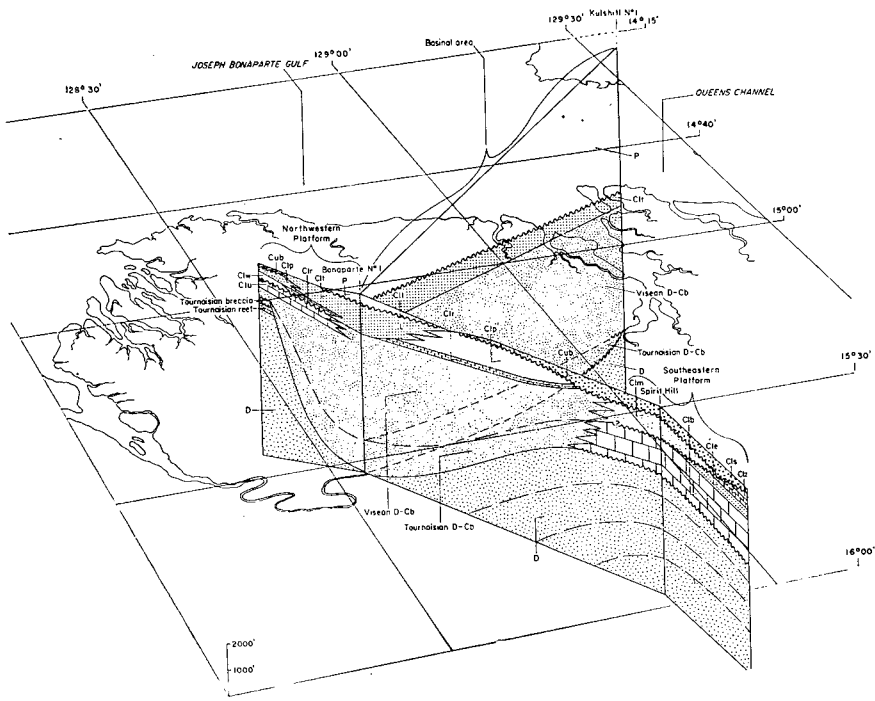

Figure 4. Distribution of Carboniferous formations (from Veevers & Roberts, 1968)

The Ningbing Limestone is developed as a reef-complex with back, fore, main, and inter-reef facies. The distribution of species between these facies and between the early Famennian (toII-toIII) and late Famennian (toIV-toVI) is shown in Table 1.

The conodonts from the Ningbing Limestone suggest that most of the Famennian is represented. Jones & Druce (1966) noted the presence of *Palmatolepis glabra elongata* Holmes and *P. glabra pectinata* Ziegler, which indicate an early

TABLE 1

DISTRIBUTION OF SPECIES IN VARIOUS FACIES OF THE NINGBING LIMESTONE

Form Species	Back Reef	Inter-Reef	Reef	Fore-Reef
Apatognathus varians varians				O
A. varians ethingtoni	+	+	♀	O
A. varians klapperi	+	+	♀	
A. sp. nov. A		+	+	
A? sp. nov.			+	
Centrognathodus sp.	O	+		
Falcodus variabilis			O	
Hibbardella sp.		+	♀	O
Hindeodella brevis			+	
H. corpulenta		+		
H. subtilis			O	
Icriodus alternatus		+		
I. rectus			+	
Neoprioniodus? tortus	+			
Ozarkodina elegans			+	
O. homoarcuata		+		
Palmatodella delicatula		+	♀	
Palmatolepis glabra elongata		+	+	
P. glabra pectinata		+	+	
P. gracilis gracilis		+	♀	O
P. gracilis sigmoidalis			O	
P. minuta minuta			+	
Pelekysgnathus peejayi	+			
Polygnathus hassi	+			
P. cf. *varcus*		+	+	
P. znepolensis				O
P. collinsoni				O
Polylophodonta confluens		+	+	
P. elongata		+		
Prioniodina latericrescens		+		
P. ?smithi		+	O	
Rhodalepis inornata	+	+	+	
Scaphignathus ziegleri		+		
Spathognathodus aculeatus	O			O
S. crassidentatus			O	
S. inornatus		+		
S. cf. *plumulus*		+	O	
S. stabilis		+		
S. ziegleri		+		O
Tripodellus robustus		+	O	

Early Famennian +
Late Famennian O

Famennian age (upper toII$_\beta$-lower toIII$_\alpha$). Further samples have yielded species indicating later Famennian zones; *Palmatolepis gracilis sigmoidalis* Ziegler is known from the upper toV-toVI zones, and *Spathognathodus aculeatus* (Branson & Mehl) has a range of toV-lower toVI (Ziegler, 1962, table 7). *Polygnathus znepolensis* Spasov has been previously described from Bulgaria in strata considered by Spasov (1965, p. 107) to be of toV-toVI age. *Polygnathus hassi* Helms is restricted to the lower toV zone (Helms, 1961, table 17).

The Ningbing Limestone is probably equivalent to the entire Famennian, although no conodont species which exclusively indicate the toII and toIV zones have been recovered (Fig. 30, p. 150).

Buttons Beds

The rocks defined as Buttons Beds by Veevers & Roberts (1968) were considered as part of the Devonian Burt Range Series by Matheson & Teichert (1948).

Öpik (*in* Traves, 1955) identified some of the fossils collected by Traves and pointed out that there was a marked similarity between them and fossils found 5 miles west of Mount Septimus (i.e. the Tournaisian Burt Range Formation). Hill (1954) described two species of Devonian corals from a locality on the Ord River. Jones & Druce (1966, p. 358) state that the conodonts from Buttons Crossing indicate an Upper Devonian age, and this is confirmed by the examination of the brachiopods (Roberts, pers. comm.) and ostracods (Jones, 1968).

Correlations

A comprehensive zonation of the Upper Devonian has been presented by Ziegler (1962). The Devonian conodonts recovered from the Bonaparte Gulf Basin can be fitted into this zonal scheme, enabling correlations to be made with European standard sections.

Cockatoo Formation. The calcareous middle members of the Cockatoo Formation can be correlated with the *Manticoceras* Stufe of Germany and possibly with the *Palmatolepis gigas* and *Palmatolepis triangularis* Zones of Ziegler (1962).

These members can also be correlated with the Sylamore Sandstone of the Mississippi Valley (Collinson, 1961), the Lime Creek Formation of Iowa (Anderson, 1966), and the Jefferson and Darby Formations of Montana, Wyoming, and South Dakota (Klapper, 1958, 1966). Conodonts recovered from the Canning Basin (Glenister & Klapper, 1966) indicate a correlation of the Cockatoo Formation with the lower part of the Virgin Hills Formation.

Ningbing Limestone. The Ningbing Limestone can be correlated with the *Cheiloceras, Platyclymenia, Clymenia,* and *Wocklumeria* Stufen of Germany (Ziegler, 1962) and with the Grassy Creek, Saverton, and Louisiana Formations of the Mississippi Valley (Collinson et al., 1962). In the Canning Basin the upper part of the Virgin Hills Formation, the Bugle Gap Limestone, and the Fairfield Formation extend over the same time interval as the Ningbing Limestone (Glenister & Klapper, 1966).

Buttons Beds. The Buttons Beds are equivalent to the lower part of the Ningbing Limestone and can be correlated with the *Cheiloceras* and *Platyclymenia* Stufen of Germany.

Carboniferous

A sequence of conodont biostratigraphic zones has been erected for the succession in the Eight Mile Creek and Burt Range areas comprising the Burt Range Formation, Enga Sandstone, and Septimus Limestone. Only a brief summary of the ages of these formations is presented here; they are discussed in more detail on pp. 27-34. The remaining Carboniferous formations either yielded sparse conodont faunas or, where the faunas were abundant, as in the Utting Calcarenite, no zonal sequence could be erected. This was due either to lack of information about stratigraphic relationships or to stratigraphically localized conodont faunas occurring within thick sequences of strata which failed to yield conodonts. The ages and correlation of these formations are fully discussed below.

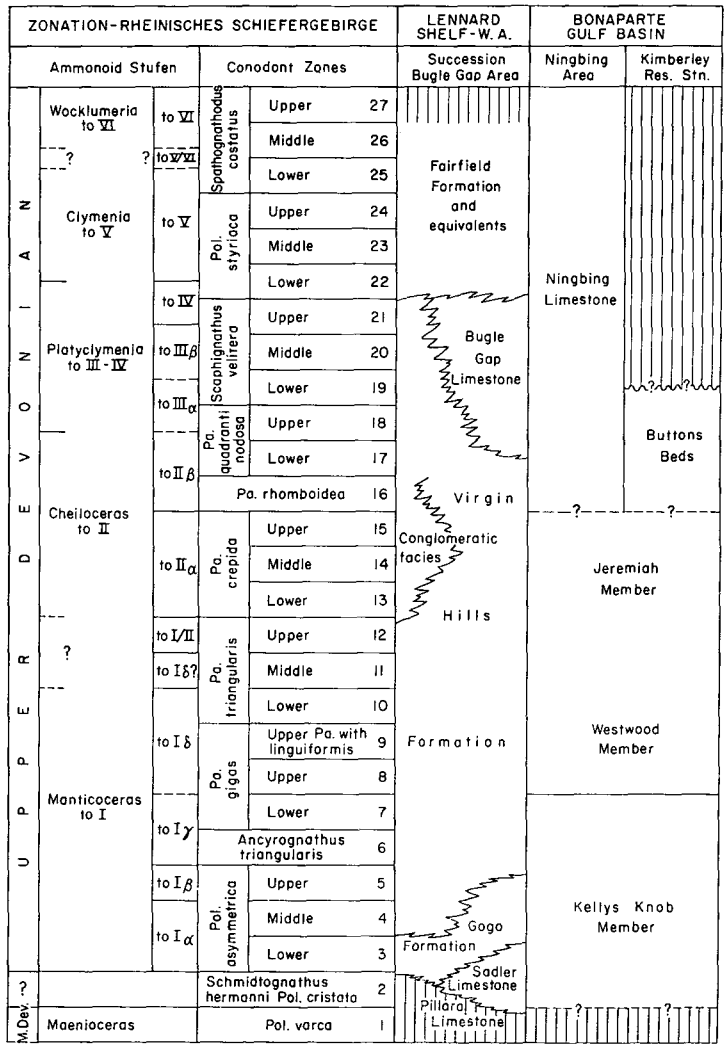

Figure 5. Correlation of Devonian formations (after Glenister & Klapper, 1967)

Burt Range Formation

The Burt Range Formation was originally dated as Upper Devonian by Matheson & Teichert (1948), who correlated the lower part of the formation with the '*Productella* limestone' in the Canning Basin. Öpik (*in* Traves, 1955) considered that the top of the formation coincided with the end of the Devonian period. Thomas (1962, p. 727) states that the Burt Range Limestone is the topmost formation in the Upper Devonian sequence, though the higher beds possibly range up into early Carboniferous. Glenister (1962, p. 214) lists conodonts from the questionably upper part of the Burt Range Limestone which indicate an early Carboniferous age.

The Burt Range Formation is of lower Tournaisian age—the basal 50 feet of the 1,510-foot section may be uppermost Devonian. It correlates with the lower and middle *Cleistopora* (K) zone of Britain, with the 'Glen Park', Hannibal, and Chouteau Formations of the Mississippi Valley, and the *Gattendorfia* Stufe (cuI) and lower *Pericyclus* Stufe (cuII$_\alpha$) of Germany.

Enga Sandstone

Matheson & Teichert (1948) included the Enga Sandstone in their Burt Range 'Series' and considered that it represented the last stage in Devonian sedimentation. Traves (1955) followed Noakes et al. (1952) in separating this formation from the Burt Range Formation and assigned it to the Lower Carboniferous, on the basis of studies by Dickins (pelecypods) and Öpik (brachiopods). Thomas (1962) suggests that the Enga Sandstone is the oldest undoubted Carboniferous formation in the basin. Jones & Druce (1966, p. 358) list conodonts which indicate a Tournaisian (cuII$_\alpha$) age for the formation.

The Enga Sandstone is of Tournaisian age. It is equivalent to the upper *Cleistopora* (K) zone of Britain. Strata of comparable age appear to be absent in both the Mississippi Valley and Germany.

Septimus Limestone

A Carboniferous age was first suggested by Matheson & Teichert (1948); Öpik (*in* Traves, 1955) lists fossils from the Septimus Limestone which indicate a Middle Mississippian age. Glenister (1962), on the basis of conodonts, considers that the upper part of the Septimus Limestone cannot be older than Middle Mississippian (late Osagian or late Tournaisian) and Thomas (1962) points out that the brachiopods indicate an equivalent age. Jones & Druce (1966) agree with these conclusions.

The Septimus Limestone is Tournaisian. It is equivalent to the uppermost *Cleistopora* (K) and lower *Zaphrentis* (Z) zones of the Avonian. Strata of equivalent age appear to be absent in the United States and Germany, although the uppermost part of the formation is possibly equivalent to the basal Sedalia Formation and the lower part of the upper *Pericyclus* Stufe (cuII$_{\beta/\gamma}$).

Limestone at 7/1 locality, Ningbing Range

At one locality on the eastern or basinward side of the Ningbing Limestone Tournaisian conodonts have been recovered from limestone indistinguishable from the Ningbing Limestone. They include:

Dinodus fragosus (Branson)
Dinodus wilsoni sp. nov.
Elictognathus bialata (Branson & Mehl)

Polygnathus bischoffi Rhodes, Austin, & Druce
Polygnathus communis carinus Hass
Polygnathus distortus Branson & Mehl
Pseudopolygnathus triangulus triangulus Voges
Siphonodella cooperi Hass
Siphonodella quadruplicata (Branson & Mehl)
Siphonodella trirostrata sp. nov.

The age of the limestone at the 7/1 locality is Tournaisian (cuI-cuII$_\alpha$). *Dinodus fragosus* ranges from upper cuI to cuII$_\alpha$ in Germany, Bulgaria, and the United States (Voges, 1959; Spasov, 1965; Klapper, 1966); *Elictognathus bialata* ranges from the *Siphonodella-Pseudopolygnathus triangulus triangulus* Zone (upper cuI) to the lower *Siphonodella crenulata* Zone (lower cuII$_\alpha$) Zone in Germany (Voges, 1959, table 1) and is known from the Bushberg Sandstone of Missouri (Branson & Mehl, 1934), and the Lodgepole Limestone and underlying strata of Montana, Wyoming, and South Dakota (Klapper, 1966). *Polygnathus bischoffi* is known from the upper *Zaphrentis* (Z) and lower *Cleistopora* (C) zones of the Avonian (Rhodes, Austin, & Druce, 1968); *Polygnathus communis carinus* occurs in the *Gnathodus punctatus* and *Bactrognathus communis* Zones of the Chappel Limestone (Hass, 1959), which Collinson et al. consider to be equivalent, in part, to the Chouteau Formation of cuII$_\alpha$ age (1962, chart 5). *Polygnathus distortus* has been described from the Bushberg Sandstone (Branson & Mehl, 1934), which, on the basis of its conodont fauna, is of cuI-cuII$_\alpha$ age. Voges (1959) gave the range of *Pseudopolygnathus triangulus* s.s. as *Siphonodella-triangulus triangulus* Zone (upper cuI)-lower *Siphonodella crenulata* Zone (lower cuII$_\alpha$), and Klapper (1966) found the same distribution in the USA, although he records only one specimen from the cuI Zone. The genus *Siphonodella* is confined to the Tournaisian in Germany (Voges, 1959). It ranges from the *Siphonodella-triangulus inaequalis* Zone (middle cuI) to the top of the *anchoralis* Zone (cuII$_\alpha$) and is confined to the Hannibal and Chouteau Formations in the standard Mississippi Valley sequence (Collinson et al., 1962). *Siphonodella cooperi* ranges from the middle Hannibal to the upper Chouteau, with its maximum development in the upper Chouteau (*ibid.*, chart 2), and *Siphonodella quadruplicata* ranges from the middle Hannibal to within the upper Chouteau, with its maximum development in the upper Hannibal and lower Chouteau (*ibid.*). In Germany it is confined to the *Siphonodella* Subzone (Bischoff, 1957).

The age of the 7/1 locality is upper cuI-lower cuII$_\alpha$; it is probably confined to the lower cuII$_\alpha$ zone. It can be correlated with the *Siphonodella quadruplicata-S. cooperi* Assemblage Zone in the Burt Range Formation in the eastern part of the basin; with the uppermost *Cleistopora* (K) Zone, the middle part of the *Siphonodella-P. inornatus* Assemblage Zone of the Avonian of Great Britain (Rhodes, Austin, & Druce, 1968), and with the uppermost lower *Pericyclus* Stufe of Germany. It is equivalent to the uppermost Hannibal and Chouteau Formations in the Mississippi Valley (*Siphonodella quadruplicata-S. crenulata* and *S. isosticha-S. cooperi* Assemblage Zones).

Milligans Beds

Conodonts are rare in the Milligans Beds; only *Ozarkodina* sp. has been recovered from cuttings in the interval 200-250 feet from Spirit Hill No. 1 Well. No age determination could be made.

Bonaparte Beds

Conodonts are rare in the Bonaparte Beds. *Mestognathus beckmanni* Bischoff has been recovered from Bonaparte No. 2 Well (4,931 feet) and unidentified gnathodids from both Bonaparte No. 1 and No. 2 Wells (see Appendix). The presence of *M. beckmanni* suggests a Visean (cuIII) age for part, at least, of the Bonaparte Beds.

'Mid-Tournaisian Breccia'

Conodonts were rare and abraded in the matrix of the breccia. They could be referred to *Clydagnathus cavusformis* Rhodes, Austin, & Druce, suggesting a lower Tournaisian (cuI-cuII$_\alpha$) age.

Utting Calcarenite

The Utting Calcarenite, the 'unnamed Visean calcarenite' of Veevers et al. (1964) and Jones & Druce (1966), was dated as early Visean by Thomas (1965) on the basis of a fauna associated with *Delepinea uttingi* Thomas. This was confirmed by Jones & Druce (1966), who considered the formation to be of cuIII age, though they suggested that it might be older.

The Utting Calcarenite is of lowermost Visean age. The fauna consists of ten species:

Cavusgnathus unicornis? Younquist & Miller
Geniculatus claviger (Roundy)
Gnathodus cuneiformis Mehl & Thomas
Gnathodus texanus Roundy
Lonchodina furnishi Rexroad
Mestognathus beckmanni Bischoff
Mestognathus neddensis Rhodes, Austin, & Druce
Spathognathodus coalescens Rexroad & Collinson
Spathognathodus scitulus (Hinde)
Taphrognathus sp.

The presence of both *Gnathodus texanus* and *G. cuneiformis* is diagnostic. Collinson et al. (1962, p. 23) note that these two species only occur together in the *Bactrognathus-Taphrognathus* Assemblage Zone of the Mississippi Valley. This zone occurs in the middle Burlington, which Collinson et al. (op. cit.) consider to be equivalent to the upper *Pericyclus Stufe* (upper cuII$_{\beta/\gamma}$). Further evidence to support this correlation is based on the fact that *Taphrognathus* sp. is the same species as is found in Queensland in association with *Staurognathus cruciformis* Branson & Mehl (Druce, 1968c), which Collinson et al. found in the underlying Zone in the Mississippi Valley.

Of the remaining species, *Mestognathus beckmanni* and *Geniculatus claviger* both range from the upper *Pericyclus* Stufe (cuII$_{\beta/\gamma}$) to the upper boundary of the *Goniatites* Stufe (cuIII$_\gamma$) in Germany (Voges, 1959, p. 268).

All the other species present suggest a slightly younger age. *Mestognathus neddensis* and *Lonchodina furnishi* both occur in the middle part of the *Dibunophyllum* (D_2) Zone in Britain (Rhodes et al., 1968), equivalent to the upper part of the *Goniatites* Stufe (cuIII) of Germany. *Lonchodina furnishi* is known from a similar horizon in the Mississippi Valley (Rexroad, 1958, p. 22). *Spathognathus scitulus* is known from the *Caninia* (C) to *Dibunophyllum* (D) Zones in Britain (Rhodes et al., 1968) and from the St. Louis Formation in Illinois (Rexroad & Collinson, 1963). *Spathognathodus coalescens* has only been

recorded from the Warsaw-Salem interval in the Mississippi Valley (Rexroad & Collinson, 1965). Although these latter species suggest that the Utting Calcarenite may be younger than stated here the absence of the *Gnathodus girtyi* and *G. commutatus* groups and *G. bilineatus* and the abundance of *G. texanus* indicate a lower Visean age, possibly $cuII_{\delta}$. If this is the case then the ranges of *Lonchodina furnishi, Mestognathus neddensis* and *Spathognathodus coalescens* should be extended downward.

Burvill Beds

Veevers & Roberts (1968, p. 103) defined the Burvill Beds as the sequence of sandstone, shale, and sandy limestone that is conformably overlain by the Point Spring Sandstone and disconformably overlain by the Border Creek Formation in the Weaber Range. The Burvill Beds contain a rich fauna of brachiopods and gastropods; Thomas (1962, p. 731) listed a fauna from Point Spring and Milligans Hills and suggested that it was Visean to Namurian.

The Burvill Beds are of uppermost Visean or possibly basal Namurian age. The fauna is sparse and the only previously known species recovered is *Gnathodus girtyi simplex* Dunn, which ranges from the *Dibunophyllum* zone (D_2) into the Namurian (E_1) in the British Isles (Rhodes et al., 1968, fig. 11). *G. girtyi simplex* is known from the late Mississippian (Chesterian) Bird Spring Formation of Nevada (Dunn, 1965, p. 1148).

The Burt Range Formation—Spirit Hill No. 1 Well

The sequence 826-2,000 feet is considered to belong to the Burt Range Formation (Veevers & Roberts, 1968). Several horizons within this interval have yielded conodonts; the highest is 1,047 feet, which has yielded a typical Burt Range fauna. The conodont-bearing horizon at 1,100 feet 6 inches to 1,102 feet 6 inches can be correlated with the *Siphonodella quadruplicata-S. cooperi* Assemblage Zone of the type section. The presence of *Siphonodella isosticha* (Cooper) and *Polygnathus communis* s.s. Branson & Mehl indicates an age younger than the *S. isosticha-Polygnathus inornatus nodulatus* Assemblage Zone and older than the *Clydagnathus nodosus* Assemblage Zone.

A fauna recovered from 1,907-1,928 feet contains *Spathognathodus plumulus plumulus* Rhodes, Austin, & Druce, suggesting the presence of the basal Tournaisian Assemblage Zone of *Spathognathodus plumulus*.

At a depth of 200-250 feet, in strata of comparable age to the Milligans Beds (Veevers & Roberts, 1968, p. 102), a single specimen of *Taphrognathus* sp. has been recovered. This species is known from the Utting Calcarenite, and also from Central Queensland (Druce, 1968c), where it is associated with *Staurognathus cruciformis* Branson & Mehl and *Pseudopolygnathus nodomarginatus* (E. R. Branson), but not with spathognathodids of the *costatus* group. This suggests that the uppermost 800 feet of strata in the Spirit Hill No. 1 Well is younger than the Septimus Limestone and could possibly be as young as the Utting Calcarenite.

Conclusions

Previous biostratigraphic information on Devonian and Carboniferous formations in the Bonaparte Gulf Basin has been published by Jones & Druce (1966). The present results modify the conclusions reached by Jones & Druce, though only in minor detail.

No change has been made in the age determination of the Cockatoo Formation. The Ningbing Limestone ('unnamed formation' of Jones & Druce) has been extended to the upper Famennian toVI Zone. The unconformity between the Devonian and Carboniferous in the Eight Mile Creek area is still considered to occupy the interval toIII-toIV.

It is now considered that the Burt Range Formation extends to the base of the Carboniferous, with a possibility that the basal 50 feet is uppermost Devonian. The conclusion that an unconformity exists between the lower *Pericyclus* Stufe ($cuII_{\alpha}$) and upper *Pericyclus* Stufe ($cuII_{\beta/\gamma}$ (p. 39) in Germany alters the Lower Carboniferous correlations. The Burt Range Formation is now considered to occupy all the *Gattendorfia* Stufe (cuI) and lower *Pericyclus* Stufe ($cuII_{\alpha}$) and extend slightly above the upper limit of $cuII_{\alpha}$.

The Enga Sandstone and Septimus Limestone occupy the interval between $cuII_{\alpha}$ and $cuII_{\beta/\gamma}$. The upper limit of the Septimus Limestone is probably equivalent to the lower limit of the $cuII_{\beta/\gamma}$ Zone in Germany.

As postulated by Jones & Druce (p. 359) the Utting Calcarenite ('unnamed Visean calcarenite' of Jones & Druce) is now thought to be of $cuII_{\delta}$ age. The conformable Burvill Beds (the lower part of the Point Spring Sandstone of Jones & Druce) are thought to be, in part, uppermost Visean, or lowermost Namurian, though the evidence is tenuous. The Burvill Beds may be equivalent to all of the *Goniatites* Stufe (cuIII).

Two species mentioned by Jones & Druce, *Siphonodella duplicata* (Branson & Mehl) and *Mestognathus bipluti* Higgins, are now considered to be wrongly identified. In the present paper *S. duplicata* is included under *Polygnathus siphonellus* sp. nov., which is considered to be a 'mirrored morphological development' of *S. duplicata* (p. 105). *M. bipluti* Higgins of Jones & Druce is now considered to be *M. neddensis* Rhodes, Austin, & Druce.

Conodont Biostratigraphic Zones and correlation

Eight Carboniferous conodont assemblage zones can be recognized in the Bonaparte Gulf Basin. They are erected on the distribution of conodonts recovered from a continuous section in the Eight Mile Creek and Burt Range areas. The sequence comprises the Burt Range Formation, the Enga Sandstone, and the Septimus Limestone. No conodonts have been recovered from the overlying Zimmermann Sandstone.

The zones erected are very similar to those erected in Great Britain by Rhodes et al. (1968) and aid in correlating British, American, and German zones. In the following discussions all correlations are with the conodont zonations erected in Britain by Rhodes et al. (1968), in the Mississippi Valley of the USA by Collinson et al. (1962), and in Germany by Voges (1959) except where stated.

The sequence of Tournaisian zones in the Burt Range is shown in Text-figure 6. They are defined, described, and discussed below. A discussion on the international correlation of the complete zonal sequence may be found on page 34.

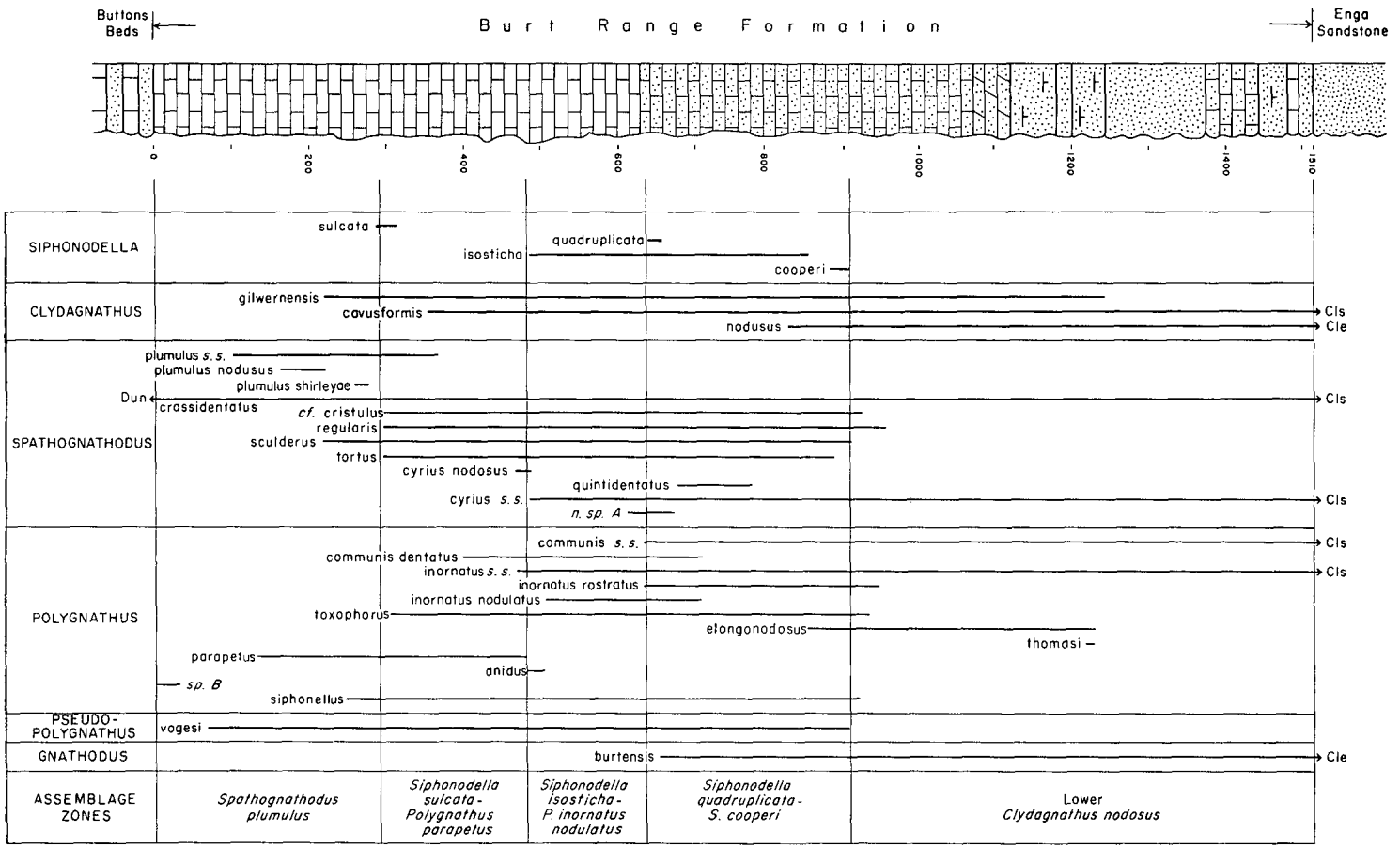

Figure 6. Ranges of important conodont species in the Burt Range Formation.

Spathognathodus plumulus Assemblage Zone

This zone is represented by the basal 300 feet of the Burt Range Formation.

Characteristic species are *Clydagnathus gilwernensis* Rhodes, Austin, & Druce, *Spathognathodus plumulus* s.s. Rhodes, Austin, & Druce, *S. plumulus nodosus* Rhodes, Austin, & Druce, *S. plumulus shirleyae* Rhodes, Austin, & Druce, *Polygnathus parapetus* sp. nov., and *Pseudopolygnathus vogesi* Rhodes, Austin, & Druce.

The base of the zone is drawn at the base of the section yielding conodonts in the Eight Mile Creek area. Strata exposed below this level have yielded Upper Devonian ostracods indicative of the toIII zone (Jones, 1968). A hiatus is present between these strata, assigned to the Buttons Beds, and the Burt Range Formation.

The upper limit of the zone and the lower limit of the overlying *Siphonodella sulcata-Polygnathus parapetus* Assemblage Zone is marked by the last occurrence of *S. plumulus shirleyae* and the first occurrence of *Spathognathodus regularis* (Branson & Mehl), *S. tortus* (Branson & Mehl), *Siphonodella sulcata* (Huddle), and *Polygnathus toxophorus* Cooper.

The basal 50 feet of this zone contain a different fauna from the remainder of the zone; it comprises only two species, *Spathognathodus* cf. *S. tridentatus* (Branson & Mehl) and *Polygnathus* sp. B. No age can be assigned to this fauna, and it is possible that this lowermost 50 feet should be referred to the uppermost Upper Devonian, because the remainder of the zone contains a fauna of basal Carboniferous aspect.

The zone correlates with the *Patrognathus variabilis-Spathognathodus plumulus* Assemblage Zone of Great Britain. Although the genus *Patrognathus* has not been recovered from the Bonaparte Gulf Basin, all the species listed above as characteristic are common to both zones, except *P. parapetus*. The presence of *S. plumulus nodosus* suggests that the zone is equivalent to the lower part of the *P. variabilis-S. plumulus* Assemblage Zone, corresponding to the *S. plumulus nodosus* subzone recognized on the North Crop of the South Wales Coalfield but not in the Avon Gorge section (Rhodes et al., 1968). This view is strengthened by the fact that Rhodes et al. draw the upper boundary of the *P. variabilis-S. plumulus* Assemblage Zone at the first occurrence of the *P. inornatus* group, which appears in the uppermost 10 feet of the overlying 175-foot *Siphonodella sulcata-Polygnathus parapetus* Assemblage Zone.

Although there are no common species, this zone correlates by interpolation with the *Gnathodus* sp. B-*G. kockeli* Assemblage Zone of the Mississippi Valley. The upper limit of both zones is drawn at the first occurrence of the genus *Siphonodella*. *Pseudopolygnathus dentilineatus* Branson & Mehl, which first occurs at the base of the *G.* sp. B-*G. kockeli* Assemblage Zone in the Mississippi Valley, could be synonymous with *P. vogesi* of the present study, which first appears 50 feet above the base of the 300-foot *S. plumulus* zone in the Bonaparte Gulf Basin.

None of the platform species in the Bonaparte Gulf Basin are represented in the zonal scheme of Voges (p. 268, 269). However, I consider that *Pseudopolygnathus dentilineatus* sensu Voges is, in part at least, synonymous with *P. vogesi* Rhodes, Austin, & Druce. *P. dentilineatus* sensu Voges ranges from the uppermost Devonian to the upper limit of the *Gattendorfia* Stufe (cuI). It is

probable that the *Spathognathodus plumulus* Assemblage Zone is equivalent to the lower part of the *Gnathodus kockeli-P. dentilineatus* Zone of Germany. This view is enhanced in later discussions on international correlation (p. 34).

Siphonodella sulcata-Polygnathus parapetus Assemblage Zone

This zone is represented by the interval 300 feet-475 feet in the Burt Range Formation.

Characteristic species are *Siphonodella sulcata* (Huddle), *Clydagnathus gilwernensis, C. cavusformis, Spathognathodus regularis, S. tortus, Polygnathus toxophorus* Cooper, *P. parapetus, P. siphonellus* sp. nov., and *Pseudopolygnathus vogesi.*

The lower limit of the zone is drawn at the first occurrence of the genus *Siphonodella* together with *Spathognathodus regularis, S. tortus,* and *Polygnathus toxophorus.* The upper limit, and the lower limit of the *Siphonodella isosticha-Polygnathus inornatus nodulatus* Assemblage Zone, is drawn at the last occurrence of *Spathognathodus cyrius nodosus* subsp. nov. and *Polygnathus parapetus* and the first occurrence of *Siphonodella isosticha, Spathognathodus cyrius* s.s. (Cooper), and *Polygnathus anidus* Cooper.

Polygnathus siphonellus first occurs 25 feet below the lower limit of the zone. *Spathognathodus plumulus* s.s. is present in the lower 75 feet of the zone and *Polygnathus communis dentatus* subsp. nov. is present in the upper 75 feet. *Polygnathus inornatus* s.s. first appears in the uppermost ten feet of the zone.

Correlation. The zone is equivalent to the upper part of the *Patrognathus variabilis-Spathognathodus plumulus* Assemblage Zone, corresponding to the *Clydagnathus* sp. A subzone of the North Crop of the South Wales Coalfield. Species common to both zones include *Clydagnathus gilwernensis, C. cavusformis, Spathognathodus plumulus* s.s., and *Pseudopolygnathus vogesi.* The upper limit of the *P. variabilis-S. plumulus* Assemblage Zone is drawn at the first occurrence of *Polygnathus inornatus inornatus,* which first occurs in the uppermost 10 feet of the 175-foot *sulcata-parapetus* zone; the first occurrence of *P. inornatus nodulatus* occurs 25 feet above the base of the overlying zone.

The zone is equivalent to the *Siphonodella sulcata* Assemblage Zone of the Mississippi Valley. The zone species, *S. sulcata* (Huddle), is found in both zones.

No direct correlation is possible with the German succession. However, Rhodes et al. (1968) note that Klapper has found *S. sulcata* in the upper part of the *Gnathodus kockeli-Pseudopolygnathus dentilineatus* Zone in Germany. In the USA Klapper & Sandberg have also found *S. sulcata* in association with *Patrognathus,* thus confirming the correlation of the *kockeli-dentilineatus* Zone (the upper part at least) with the *P. variabilis-S. plumulus* Assemblage Zone of Britain and the *S. sulcata-P. parapetus* Assemblage Zone of the Bonaparte Gulf Basin.

Siphonodella isosticha-Polygnathus inornatus nodulatus Assemblage Zone

This zone is represented by the interval 475 feet to 625 feet in the Burt Range Formation.

Characteristic species are *Siphonodella isosticha* (Cooper), *Clydagnathus cavusformis, Spathognathodus regularis, S. sculderus* sp. nov., *S. tortus, S. cyrius*

s.s., *Polygnathus communis dentatus* subsp. nov., *P. inornatus* s.s., *P. inornatus nodulatus* subsp. nov., *P. toxophorus, P. anidus, P. siphonellus, and Pseudopolygnathus vogesi.*

The boundary of this zone with the overlying *Siphonodella quadruplicata-S. cooperi* Assemblage Zone is marked by the first occurrence of *S. quadruplicata* and *Polygnathus inornatus rostratus* and also, in the Bonaparte Gulf Basin, of *P. communis* s.s. (Branson & Mehl).

Polygnathus inornatus nodulatus subsp. nov. first occurs 25 feet above the base of the zone and *P. anidus* occurs only in the basal 25 feet.

Correlation. The zone corresponds to the lower part of the *Siphonodella-Polygnathus inornatus* Assemblage Zone of Britain.

The incoming of *Siphonodella quadruplicata* marks the upper limit of the zone in Australia. This indicates a correlation with the pre-*quadruplicata Siphonodella duplicata* Assemblage Zone of middle Hannibal age in the Mississippi Valley, suggesting that *Siphonodella isosticha* occurs in slightly older strata in Australia than in North America, where its initial appearance is in the upper Hannibal.

No direct correlation is possible with the German succession. However, because it is pre-*quadruplicata* in age the *S. isosticha-P. inornatus nodulatus* Assemblage Zone is probably equivalent to the *Siphonodella-triangulus inaequalis* and *Siphonodella-triangulus* s.s. Zones of Voges (1959, p. 268).

Siphonodella quadruplicata-S. cooperi Assemblage Zone

This zone occupies an interval between 625 feet and 900 feet in the Burt Range Formation.

Characteristic species are *Siphonodella isosticha, S. quadruplicata* (Branson & Mehl), *S. cooperi* Hass, *Clydagnathus gilwernensis, C. nodosus* sp. nov., *Spathognathodus regularis, S. sculderus, S. tortus, S. quintidentatus* Thomas, *S. cyrius* s.s., *Polygnathus inornatus rostratus* Rhodes, Austin, & Druce, *P. toxophorus, P. siphonellus, Pseudopolygnathus vogesi,* and *Gnathodus burtensis* sp. nov.

The boundary with the overlying *Clydagnathus nodosus* Assemblage Zone is marked by the last occurrence of the genus *Siphonodella* and of *Spathognathodus sculderus* and *Pseudopolygnathus vogesi.*

Siphonodella quadruplicata is known from the basal 2 feet of the zone and *S. cooperi* from the upper 25 feet. *Clydagnathus nodosus* first occurs 75 feet below the top of the zone. Many species disappear immediately above the upper limit of the zone. Nearly all disappear within 25 feet of the base of the *Clydagnathus nodosus* Assemblage Zone, which is over 1,000 feet thick; they include *Spathognathodus regularis* (40 feet), *Polygnathus inornatus rostratus, P. toxophorus,* and *P. siphonellus.*

Correlation. It has already been shown that the underlying *Siphonodella isosticha-Polygnathus inornatus nodulatus* Assemblage Zone is equivalent to the lower part of the *Siphonodella-P. inornatus* Assemblage Zone of Britain. The presence of *Siphonodella isosticha, Polygnathus inornatus* s.s., *P. inornatus rostratus,* and *Pseudopolygnathus vogesi* in both the present zone and the British *Siphonodella-P. inornatus* Assemblage Zone suggests that it is probably equivalent to the middle of that zone.

The zone can be correlated with the *Siphonodella quadruplicata-S. crenulata* and *S. isosticha-S. cooperi* Assemblage Zones of the Mississippi Valley. In the Bonaparte Gulf Basin *S. quadruplicata* occurs at the base of the zone and *S. cooperi* at the top, which suggests that with more abundant faunas the two American zones could be recognized in Australia.

The presence of highly developed siphonodellids (*quadruplicata* and *cooperi*) in this zone indicates a correlation with the *Siphonodella crenulata* Zone (lower *Pericyclus* Stufe) of Germany.

Clydagnathus nodosus Assemblage Zone

This zone is represented by the uppermost 610 feet (900 feet to 1,510 feet interval) of the Burt Range Formation and the entire Enga Sandstone (529 feet).

Characteristic species are *Clydagnathus nodosus* sp. nov., *Spathognathodus cyrius* s.s., *Polygnathus inornatus rostratus, P. elongonodosus* sp. nov., and *Gnathodus burtensis*. The boundary with the *Spathognathodus tridentatus* Assemblage Zone is placed at the last occurrence of *Gnathodus burtensis* and the first appearance of *Spathognathodus tridentatus* (Branson & Mehl).

Clydagnathus nodosus is nearly confined to the zone. It first occurs 75 feet beneath the lower limit and disappears 10 feet above the base of the overlying *Spathognathodus tridentatus* Assemblage Zone. *Polygnathus thomasi* is confined to an interval at 1,225 feet in the Burt Range Formation. *P. elongonodosus* has a last occurrence at 1,225 feet.

Correlation. The zone is represented by species not represented in the Avonian of Great Britain, apart from *Spathognathodus cyrius* s.s., which is extremely rare in the *Cleistopora* and *Zaphrentis* Zones (Rhodes et al., 1968, fig. 10). Because the upper limit of the *Clydagnathus nodosus* Assemblage Zone is marked by the first occurrence of *Spathognathodus tridentatus* it is probably equivalent to the pre-*tridentatus* upper part of the *Siphonodella-P. inornatus* Assemblage Zone in Britain.

The zone appears to be absent in the Mississippi Valley. Its lower limit is marked by the disappearance of the genus *Siphonodella,* but the species of the *Gnathodus semiglaber-Pseudopolygnathus multistriatus* Assemblage Zone, which follows the disappearance in the Mississippi Valley, are not represented in the Bonaparte Gulf Basin (p. 34).

The zone is also absent in Germany. The post-*Siphonodella Scaliognathus anchoralis* fauna is not represented faunally in the 1,700 feet of conodont-bearing strata above the base of the *Clydagnathus nodosus* Assemblage Zone in the Bonaparte Gulf Basin, which all lie within zones considered to be older than the *anchoralis* Zone of Germany.

Spathognathodus tridentatus Assemblage Zone

This zone is represented by the basal 115 feet of the Septimus Limestone. Characteristic species are *Spathognathodus anteposicornis* Scott, *S. tridentatus* (Branson & Mehl), *S. cyrius* s.s., and *Polygnathus inornatus* s.s.

The boundary with the *Spathognathodus costatus* Assemblage Zone is marked by the last occurrence of *Spathognathodus cyrius* s.s. and the first occurrence of

S. costatus s.s. Many species make their final appearance within this zone, including *Clydagnathus nodosus, C. cavusformis, Polygnathus inornatus* s.s., *Angulodus flexus,* and *A. minutus.*

Correlation. The zone correlates with the *Spathognathodus* cf. *S. robustus-S. tridentatus* Assemblage Zone of Britain. The lower limits of both zones are marked by the first occurrence of *S. tridentatus* and the upper limits of both zones are drawn at the first appearance of *S. costatus* s.s. It is also interesting to note that the *Polygnathus inornatus* group makes its last appearance in this zone in Australia and in the *S.* cf. *S. robustus-S. tridentatus* Assemblage Zone in Britain.

The zone appears to be absent in both the Mississippi Valley and Germany.

Spathognathodus costatus Assemblage Zone

This zone is represented by the interval 115 feet to 450 feet in the Septimus Limestone. Characteristic species are *Spathognathodus costatus costatus* (E. R. Branson), *S. costatus sulciferus* (Branson & Mehl), *S. tridentatus, S. anteposicornis,* and *Clydagnathus darensis* Rhodes, Austin, & Druce.

The boundary with the *Pseudopolygnathus nodomarginatus* Assemblage Zone is marked by the first appearance of *P. nodomarginatus. Polygnathus communis* s.s. Branson & Mehl last occurs 50 feet below the upper limit and is extremely rare in the Septimus Limestone. *Spathognathodus tridentatus* makes its last appearance 85 feet above the base of the zone and *S. costatus sulciferus* does not occur above 135 feet above the base.

Correlation. The zone is equivalent to the lower two-thirds of the *Spathognathodus costatus-Gnathodus delicatus* Assemblage Zone in Britain. The lower limits of both zones are characterized by the first occurrence of *S. costatus* s.s. *Pseudopolygnathus nodomarginatus* marks the upper limit of the *S. costatus* zone, but first occurs in the uppermost part of the *S. costatus-G. delicatus* Assemblage Zone (equivalent to the *Clydagnathus unicornis* subzone of the North Crop of the South Wales Coalfield). The Australian zone is therefore equivalent to the *Spathognathodus costatus* s.s.-*S. costatus sulciferus* and *Gnathodus simplicatus* subzones of the *Spathognathodus costatus-Gnathodus delicatus* Assemblage Zone.

The zone appears to be absent in the United States and Germany.

Pseudopolygnathus nodomarginatus Assemblage Zone

This zone is represented by the interval 450 feet to the top of the Septimus Limestone. Characteristic species are *Pseudopolygnathus nodomarginatus* (E. R. Branson), *Spathognathodus costatus* s.s., *S. costatus sulciferus,* and *S. anteposicornis.*

The upper limit of the zone is marked by the facies change between the Septimus Limestone and the overlying Zimmermann Sandstone. No conodonts have been recovered from the Zimmermann Sandstone, so it is possible that the zone extends into it.

The zone contains an impoverished fauna in the Bonaparte Gulf Basin. Only seven species, *Spathognathodus anteposicornis, S. costatus* s.s., *S. costatus sulciferus, S. crassidentatus* (Branson & Mehl), *Clydagnathus darensis, Pseudopolygnathus nodomarginatus,* and *Neoprioniodus confluens* are present. They all range through the complete zone.

Correlation. The zone correlates with the upper part of the *S. costatus costatus-Gnathodus delicatus* Assemblage Zone, corresponding to the upper subzone (*Clydagnathus unicornis* subzone) of the North Crop section in Britain. The Australian zone and the British subzone have the following species in common: *Spathognathodus anteposicornis, S. costatus* s.s., *S. costatus sulciferus, Clydagnathus darensis,* and *Pseudopolygnathus nodomarginatus.*

The presence of the *Spathognathodus costatus* group and the absence of the *Polygnathus lacinatus* group in the *P. nodomarginatus* Assemblage Zone suggest that it is all older than the *Polygnathus lacinatus* Assemblage Zone of Britain.

The zone appears to be absent in the United States and Germany.

International Correlation and Faunal Aspect

Detailed conodont zonations of Lower Carboniferous sequences have been erected in Europe and North America. Each zonation differs to some extent, and various authors (Rhodes et al., 1968; Collinson et al., 1962, p. 12) have remarked on the difficulty of correlating certain horizons. The Australian zones appear to be intermediate between the spathognathodid-polygnathid-pseudopolygnathid zonation of Great Britain and the siphonodellid-gnathodid zones of Europe and North America. The further elucidation of the correlation between the British zones and the European and North American zones using the information obtained from Australian conodont sequences is discussed below.

Faunal Provinces

Zonal sequences of Lower Carboniferous conodonts are known from the United States (Collinson et al., 1962), Germany (Voges, 1959), and Great Britain (Rhodes et al., 1968). The present study adds a fourth detailed study of Lower Carboniferous conodont zones.

Unlike the Upper Devonian, where characteristic faunas are present in all these areas (United States, Collinson et al., 1962; Germany, Ziegler, 1962; Australia, Glenister & Klapper, 1966; Great Britain, Rhodes, pers. comm.), the Lower Carboniferous faunas exhibit considerable geographic variation.

In general the German faunas are dominated by siphonodellids and pseudopolygnathids of the *P. triangulus* group. The American faunas contain abundant siphonodellids together with polygnathids, whereas in the British faunas siphonodellids (Rhodes et al., 1968) are scarce and poygnathids and spathognathodids dominant.

Conodonts recovered from the Bonaparte Gulf Basin appear to forge a link between the Mississippi Valley faunal association and the British faunas. The Australian faunas not only contain nearly all the elements of the British faunas but are richer in siphonodellids.

The German and British sequences appear to show no variation from the faunal domination mentioned above. However, both in the United States and Australia there appears to be a variation in the faunal associations. Although spathognathodids appear to be virtually absent in the Kinderhookian in the Mississippi Valley section they are present in Missouri (Bushberg Formation, Branson & Mehl, 1934; Hannibal Formation, E. R. Branson, 1934) and Oklahoma (pre-Welden Shale, Cooper, 1939).

Klapper (1966) has described conodonts from Lower Carboniferous strata in Montana, Wyoming, and South Dakota. This fauna appears to be of the German faunal association type, comprising siphonodellids, elictognathids, dinodids, and pseudopolygnathids of the *triangulus* group. Abundant polygnathids are also present.

In the Bonaparte Gulf Basin one locality (7/1) yielded a fauna of cuII$_\alpha$ age and of German faunal aspect, including siphonodellids, dinodids, elictognathids, and pseudopolygnathids of the *P. triangulus* group, and lacking spathognathodids, clydagnathids, and polygnathids.

The extreme polarity between faunas of the same age in the Bonaparte Gulf Basin can be explained in tems of sedimentary environment. The 7/1 locality containing the fauna of German aspect is situated in an algal-brachiopod reef development in the Ningbing Range. The spathognathodid-polygnathid fauna with associated clydagnathids (British faunal aspect) occurs in a thick sequence of alternating brachiopod-bearing calcarenites and clastics.

From this it can be seen that there appears to be a certain amount of facies control in Lower Carboniferous faunas; but it appears to be exercized more through increased domination of various generic groups than through complete exclusion of certain elements.

International Correlation

Rhodes et al. (1968) admit that they had great difficulty in correlating their lower Avonian faunas with Lower Carboniferous faunas from Germany and the United States, because zonal species erected elsewhere were absent in their *Cleistopora* (K) and *Zaphrentis* (Z) zones.

The Australian faunas described here, being intermediate between those described by Rhodes et al. in Britain and those published by Collinson et al. (1962) and Klapper (1966) from the United States, aid greatly in the accurate correlating of the British and American sequences. Because the American faunas contain siphonodellids this information can also be used to tie in the German sequence.

Rhodes et al. broadly correlate their lowest zone, the *Patrognathus variabilis-Spathognathodus plumulus* Assemblage Zone, with the cuI zone of Germany and their *Siphonodella-Polygnathus inornatus* Assemblage Zone with the cuII$_\alpha$ zone. Their lowest zone is divided into two subzones in the North Crop of the South Wales Coalfield. Both these subzones can be recognized in the Bonaparte Gulf Basin; the lower, the *S. plumulus nodosus* subzone, is equivalent to the *S. plumulus* Assemblage Zone of Australia, the subzonal species being common to both. The upper, the *Clydagnathus* sp. A subzone, is equivalent to the *Siphonodella sulcata-Polygnathus parapetus* Assemblage Zone; the upper limit is marked in both cases by the incoming of *Siphonodella isosticha* and the *P. inornatus* group, although in Australia *P. inornatus* s.s. occurs 10 feet below the boundary within the 175-foot *Siphonodella sulcata-Polygnathus parapetus* Assemblage Zone. The Australian Zone also contains *Siphonodella sulcata,* the zone species of the *S. sulcata* Assemblage Zone in the Mississippi Valley (Collinson et al., 1962, p. 20).

Thus the upper part of the British *Patrognathus variabilis-Spathognathodus plumulus* Assemblage Zone (the *Clydagnathus* sp. A subzone) is equivalent to the *S. sulcata* Assemblage Zone of the Mississippi Valley and also to the upper part of the *Gnathodus kockeli-Pseudopolygnathus dentilineatus* zone of Germany, since *S. sulcata* occurs at that horizon (Rhodes et al., 1968). Because the

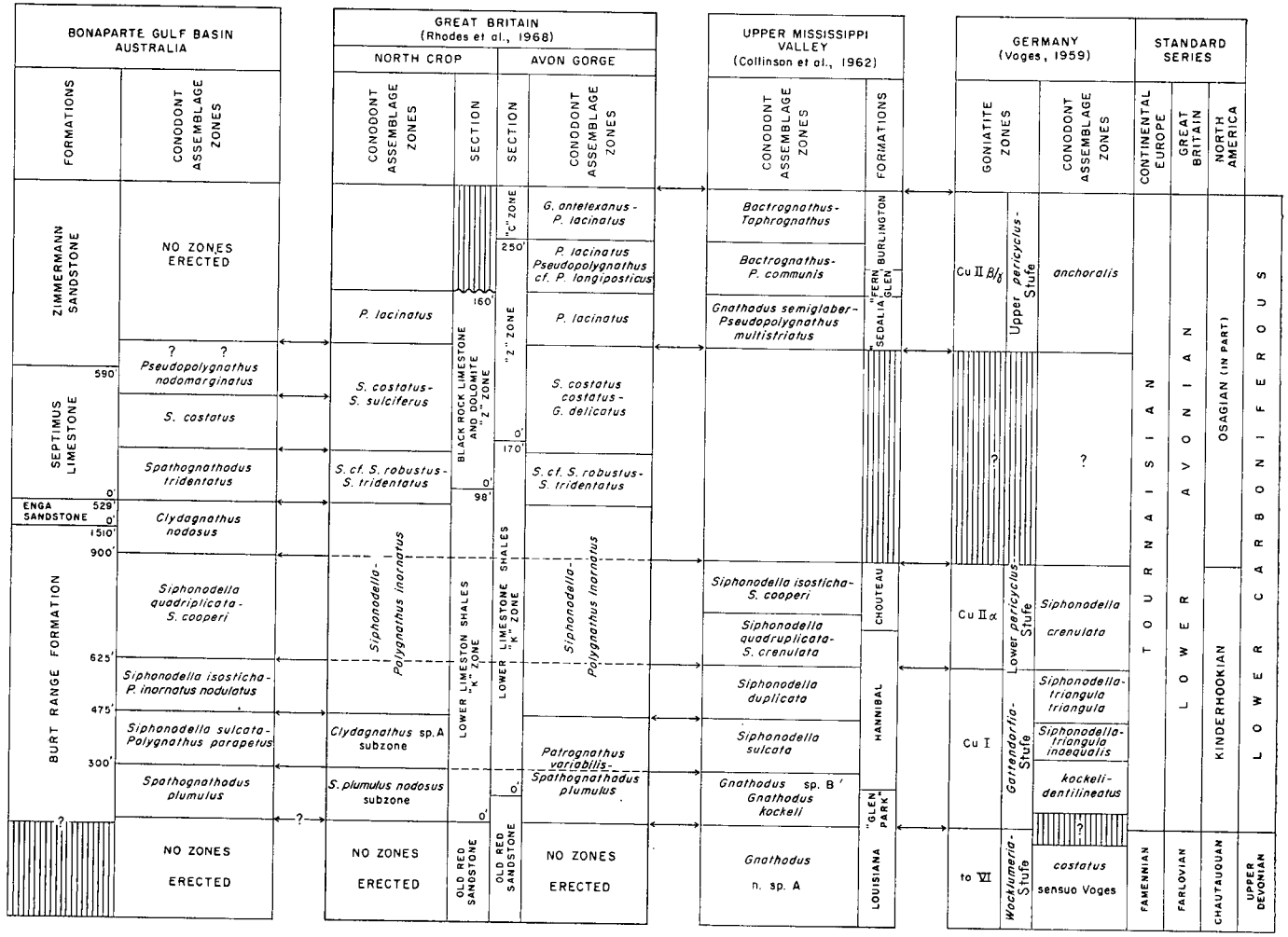

Figure 7. International correlation of Carboniferous conodont zones

lower part of the *P. variabilis-S. plumulus* Assemblage Zone (the *S. plumulus nodosus* subzone) is of pre-*sulcata* age it is equivalent, in part at least, to the *Gnathodus* sp. B-*G. kockeli* Assemblage Zone of the Mississippi Valley and the lower part of the *G. kockeli-Pseudopolygnathus dentilineatus* zone of Germany.

The *Siphonodella-Polygnathus inornatus* Assemblage Zone of Rhodes et al. is a fairly broad zone. Those authors state that, since *Siphonodella isosticha* is present, this zone cannot be older than the base of the Upper Hannibal Formation (*Siphonodella quadruplicata-S. crenulata* Assemblage Zone of Collinson et al., 1962), which is the first occurrence of *S. isosticha* in the Mississippi Valley.

Consideration of Australian faunas suggests that this is probably incorrect. The bases of the Australian *Siphonodella isosticha-P. inornatus nodulatus* Assemblage Zone and the British *Siphonodella-P. inornatus* Assemblage Zone are both drawn at the first occurrence of *S. isosticha.* Furthermore, the *P. inornatus* group occurs first at the base of the British zone: in Australia *P. inornatus* s.s. makes its first apearance only 10 feet beneath the base of the *S. isosticha-P. inornatus nodulatus* Assemblage Zone, and *P. inornatus nodulatus* occurs 25 feet above the base of the 150-foot-thick zone. The base of both zones seems to be a good time-stratigraphic horizon.

When we compare the Australian *S. isosticha-P. inornatus nodulatus* Assemblage Zone with the Mississippi Valley zones we find that this post-*sulcata* pre-*quadruplicata* zone must correlate with the post-*sulcata* pre-*quadruplicata Siphonodella duplicata* Assemblage Zone. Thus the base of the British *Siphonodella-P. inornatus* Assemblage Zone must be of a Middle Hannibal age, rather than Upper Hannibal as suggested by Rhodes et al. In Germany this interval is probably represented by the two upper cuI zones characterized by a *Siphonodella-Pseudopolygnathus triangulus* fauna.

In considering the upper limit of their *Siphonodella-P. inornatus* Assemblage Zone, Rhodes et al. (1968, fig. 16) suggest two alternate schemes for the correlation of this horizon with the Mississippi Valley sequence. In scheme A they suggest that there is only a small time break between the Mississippi Valley zone of *Siphonodella isosticha-S. cooperi* and the overlying *Gnathodus semiglaber-Pseudopolygnathus multistriatus* Assemblage Zone. In this scheme they place the upper limit of their *Siphonodella-Polygnathus inornatus* Assemblage Zone within the *Siphonodella quadruplicata-S. crenulata* Assemblage Zone of the Mississippi Valley.

In scheme B a much larger time break is suggested and a correlation between the upper limits of both the British *Siphonodella-P. inornatus* Assemblage Zone and the American *Siphonodella isosticha-S. cooperi* Assemblage Zone is inferred.

Correlation of the Australian zones suggests that scheme B is substantially correct. The British *Siphonodella-P. inornatus* Assemblage Zone appears to be broadly equivalent to three Australian zones, the *Siphonodella isosticha-P. inornatus nodulatus, S. quadruplicata-S. cooperi,* and *Clydagnathus nodosus* Assemblage Zones. The lower limits of the British zone and the Australian *S. isosticha-P. inornatus nodulatus* Assemblage Zone have been discussed above. The upper limits of both the *Siphonodella-P. inornatus* and the *Clydagnathus nodosus* Assemblage Zones are drawn at the first appearance of *Spathognathodus tridentatus* and *S. anteposicornis* and appear to be of identical age.

The Australian *Clydagnathus nodosus* Assemblage Zone, which is over 1,000 feet thick, overlies the 275-foot *Siphonodella quadruplicata-S. cooperi* Assemblage

Zone. The presence of *S. quadruplicata* in the lower part and *S. cooperi* in the upper part of the latter zone suggests a firm correlation with the American *Siphonodella quadruplicata-S. crenulata* and the overlying *S. isosticha-S. cooperi* Assemblage Zones of the Mississippi Valley. The upper limits of both the Australian *S. quadruplicata-S. cooperi* Assemblage Zone and the American *S. isosticha-S. cooperi* Assemblage Zone are drawn at the upper limit of the genus *Siphonodella.* Thus it appears that the upper third of the British *Siphonodella-P. inornatus* Assemblage Zone is younger than the American *S. isosticha-S. cooperi* Assemblage Zone but older than the overlying American zone of *Gnathodus semiglaber-Pseudopolygnathus multistriatus.* When we consider German faunas it is obvious that the cuII$_\alpha$ zone of *Siphonodella crenulata,* containing a varied siphonodellid fauna, is the same age as the *Siphonodella quadruplicata-S. cooperi* Assemblage Zone of Australia, the middle *Siphonodella-P. inornatus* Assemblage Zone of Britain, and the *S. quadruplicata-S. crenulata* and *S. isosticha-S. cooperi* Assemblage Zones of America. The *Clydagnathus nodosus* Assemblage Zone of Australia and the upper part of the British *Siphonodella-P. inornatus* Assemblage Zone do not appear to be represented in either Germany or the Mississippi Valley.

Rhodes et al. suggest that in both schemes A and B (1968, fig. 16) their *Polygnathus lacinatus* Assemblage Zone can be correlated with the *Gnathodus semiglaber-Pseudopolygnathus multistriatus* Assemblage Zone of the Mississippi Valley, which Collinson et al. (1962, chart 5) consider to be equivalent to the lower part of the cuII$_{\beta/\gamma}$ *anchoralis* Zone of Germany. In the Bonaparte Gulf Basin no conodonts are known between the *Pseudopolygnathus nodomarginatus* Assemblage Zone developed in the upper part of the Septimus Limestone and the *Gnathodus texanus* Assemblage Zone developed in the Utting Calcarenite. The *Pseudopolygnathus nodomarginatus* Assemblage Zone is considered to be older and the *Gnathodus texanus* Assemblage Zone younger than the British *Polygnathus lacinatus* Assemblage Zone. Thus the Australian faunal sequence cannot elucidate further the upper limit of the time break present in the Mississippi Valley and Germany, and the remaining zones in the Burt Range Area cannot be correlated with the standard sequences of Germany and the United States.

However, the remaining three zones in the Burt Range Area can be correlated with similar zones in Great Britain. The Australian *Spathognathodus tridentatus* Assemblage Zone can be firmly correlated with the British *Spathognathodus* cf. *S. robustus-S. tridentatus* Assemblage Zone. Both the upper and lower limits in both countries are marked by the first occurrence of the same species. The lower limits are marked by the first occurrence of S. *tridentatus* and *S. anteposicornis* and the upper limits correspond to the appearance of *S. costatus costatus.*

The remaining two zones developed in the Septimus Limestone can be correlated with the *Spathognathodus costatus* s.s.-*G. delicatus* Assemblage Zone of Britain. The Australian *costatus* Assemblage Zone is equivalent to the lower two subzones developed in the North Crop of the South Wales Coalfield (the *S. costatus* s.s.-*S. costatus sulciferus* and *Gnathodus simplicatus* subzones). The upper Septimus Limestone zone of *Pseudopolygnathus nodomarginatus* is equivalent to the upper subzone of *Clydagnathus unicornis.* The presence of *P. nodomarginatus* and *S. costatus* s.s. and *S. costatus sulciferus* in the Australian *P. nodomarginatus* Assemblage Zone indicates that it is slightly older than the British *Polygnathus lacinatus* Assemblage Zone.

Several conclusions can be drawn:

1. There is considerable geographic variation in Lower Carboniferous faunal assemblages.

2. The Bonaparte Gulf Basin and Mississippi Valley faunas are intermediate between the extreme faunal polarity exhibited by German and British faunas.

3. A stratigraphic break is present in both the Mississippi Valley and Germany. The time interval involved appears to be closely similar in both cases. It corresponds to the Enga Sandstone/Septimus Limestone interval in the Bonaparte Gulf Basin and to the upper *Cleistopora* (K) and lower *Zaphrentis* (Z) Zones in the Avonian of Britain. In the Mississippi Valley the break occurs between the Chouteau and Sedalia Formations. In Germany it occurs in the *Pericyclus* Stufe, between the $cuII_{\alpha}$ and the $cuII_{\beta/\gamma}$ zones.

4. The Hannibal Formation has a greater age range in Missouri than in the Mississippi Valley.

5. Of the two schemes put forward by Rhodes et al. (1968) for correlating British and American conodont zones, scheme B appears to be more appropriate than scheme A.

SYSTEMATIC PALAEONTOLOGY

Genus ANGULODUS Huddle, 1934

Type species: *Angulodus walrathi* (Hibbard, 1927)

ANGULODUS FLEXUS sp. nov.

(Pl. 1, figs 2, 3; Text-fig. 8)

1968 *Angulodus* sp. D, Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 29, figs 1a-2c.

Derivation of name: from the flexed anterior bar.

Material: 4 specimens, of which CPC 7801 (holotype) and 7802 are figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to *Spathognathodus tridentatus* A.Z.

Diagnosis: An elongate angulodid with a deflected anterior bar and a depressed posterior bar.

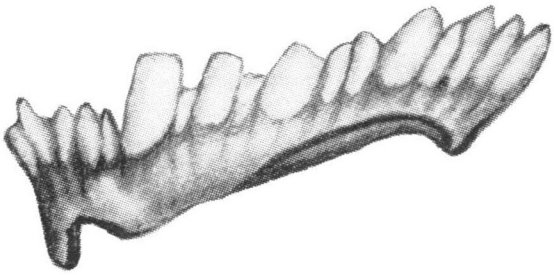

Figure 8. *Angulodus flexus* **sp. nov. Outer lateral view of holotype, CPC7801, x 60.**

Description: The unit is elongate and laterally compressed. The anterior bar is about half the length of the posterior bar, and is deflected through 70°-90°; the anterior termination is depressed through nearly 90°. The denticles number 5 or 6; they are slightly laterally compressed, posteriorly inclined and fused at their bases with free tips. The largest denticles occur at the point of maximum flexure, where the bar is both deflected and depressed. The posterior bar is depressed at the posterior termination through nearly 90°. The denticles, from 7 to 10, are laterally compressed, posteriorly inclined, fused at their bases, and free at the tips. The 2 or 3 denticles at the posterior termination are nearly horizontal and are the largest, of the same order of size as the apical denticle. The apical denticle is fairly small, subcircular in cross-section, posteriorly inclined, and lies just outside the plane of the unit on the inner side.

The basal cavity, which runs the length of the unit, is of the inverted type; the junction of the edges and the lateral face of the unit forms a chine. A keel runs along the cavity mid-length; it is narrow but deep, tending to deepen at the point of flexure of both bars.

Occurrence: *Angulodus flexus* sp. nov. is known from Britain, where it occurs in the upper part of the lower *Zaphrentis* (Z) Zone (*Spathognathodus costatus costatus-Gnathodus delicatus* Assemblage Zone) (Rhodes et al., 1968).

ANGULODUS MINUTUS sp. nov.

(Pl. 1, figs 4-8; Text-fig. 9)

1968 *Angulodus* sp. C, Rhodes, Austin, & Druce, *Bull. Brit. Mus.* (*nat. Hist.*), *Geol. Suppl.* 4, pl. 29, figs 3a-4c.

Material: 7 specimens: CPC 7799, 7800 (holotype), 7805, 7806 are figured.

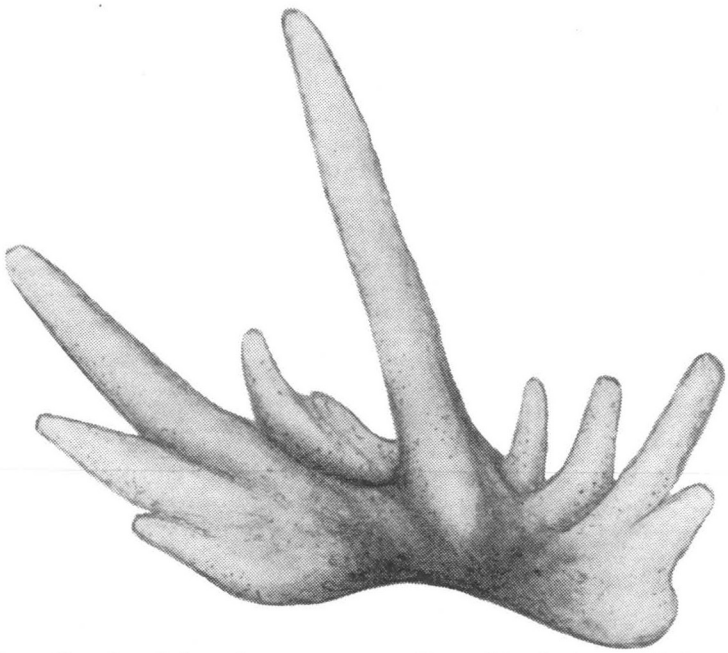

Figure 9. *Angulodus minutus* **sp. nov. Inner lateral view of holotype, CPC7800, x 100.**

Range: Upper *Siphonodella quadruplicata-S. cooperi* A.Z. to *Spathognathodus tridentatus* A.Z.

Diagnosis: An angulodid with short bars of equal length bearing from one to five denticles. Basal cavity inverted and unit keeled.

Description: Unit short, anterior and posterior bars of equal length. The anterior bar bears from 2 to 5 free-standing denticles, the largest being the penultimate; the bar is deflected through 90° and depressed through 70°-90°. The posterior bar bears 1 to 5 free-standing denticles, generally as many as are on the anterior bar. The largest, which is usually half the size of the apical denticle, is either the terminal or penultimate. The denticles of both bars are subcircular in cross-section, slightly compressed, and inclined posteriorly. The apical denticle is tall, slender, subcircular in cross-section, and laterally compressed, with anterior and posterior knife edges. It is inclined toward the inner side in a posterolateral direction, thickening in cross-section towards the base.

The base is expanded, with an inverted basal cavity and a narrow keel running down the mid-length over the whole unit. At the junction of the apical denticle and the basal lip the bar flares on the inner side.

Remarks: Specimens referred to *A. minutus* vary in some details. The deflection and depression of both bars, although present, can be very slight. The thickening of the basal part of the apical denticle can also be very slight and in some cases the inverted basal cavity is not laterally expanded. All these variations are considered to be intraspecific.

Occurrence: *A. minutus* sp. nov. is known from Britain, where it occurs in the *Cleistopora* (K) and *Zaphrentis* (Z) Zones (Rhodes et al., 1968).

ANGULODUS sp. A
(Pl. 1, fig. 9)

Material: 2 specimens; CPC 7804 is figured.

Description: Unit bowed, bars of equal length, bearing 5 or 6 denticles which are small adjacent to the apical denticle, increasing in size terminally to the point of flexure of both bars. Both bars are depressed through 90°, the depressed part of the bar bearing 1 or 2 small denticles. The apical denticle is slightly smaller than the terminal denticles and together with the bar denticles is inclined posteriorly and slightly inward.

Occurrence: The species occurs in the Utting Calcarenite.

Remarks: The specimen is not referable to any described species of *Angulodus*.

ANGULODUS sp. B
(Pl. 1, figs 1a, b)

Material: Figured specimen CPC 7803.

Description: Bars of equal length; the posterior bar bears 6 massive free-standing subcircular denticles up to the point of flexure. The posterior termination is depressed through more than 90° and bears up to 4 horizontal denticles. The anterior bar bears up to 7 tall free-standing subcircular denticles and the terminal

quarter of the bar is deflected through 90°. The apical denticle is of the same order of size as the bar denticles. The aboral surface of both bars bears a marked attachment scar and the whole unit is keeled.

Occurrence: This species occurs at the 7/1 locality in the Ningbing Range.

Genus APATOGNATHUS Branson & Mehl, 1934

Type species: *Apatognathus varians* Branson & Mehl, 1934

Much discussion has arisen over the genus *Apatognathus* owing to the sporadic occurrence of species referred to it. The type species, *A. varians,* is known from the Upper Devonian Grassy Creek Formation, Missouri, USA (Branson & Mehl, 1934). Other apatognathids occur in Visean strata of Scotland (Hinde, 1900; Clarke, 1960) and the USA (Rexroad & Collinson, 1963). The patchy distribution of species has led several authors (Clark & Ethington, 1962, p. 107; Rexroad & Collinson, 1963, p. 7; Varker, 1967, p. 128) to consider that the genus is polyphyletic. However, Varker (1967, p. 127) points out that Conil (1959) has recorded *A. varians* from the Tournaisian (Tn_2) of Belgium, which Varker equates with the Z_2 zone in England. A further occurrence of the genus is now known; Rhodes, Austin, & Druce (1968) have recorded *A. varians* and *A.* sp. nov. A from the Z zone of the North Crop of the South Wales Coalfield. As they point out, these occurrences bridge the gap in the apatognathid record, and the genus may not be polyphyletic.

Varker, in his detailed study of the genus, points out that the two Devonian species, *A. lipperti* Bischoff and *A. inversus* Sannemann, and two Triassic species, *A. longidentatus* Tatge (=*A. ziegleri* Diebel) and *A. tribulosus* Clark & Ethington, have been transferred to the genus *Gnamptognathus* by Lindstrom (1964).

APATOGNATHUS GEMINA (Hinde, 1900)
(Pl. 1, figs 10a, b)

1900 *Prioniodus geminus* Hinde, *Trans. nat. Hist. Soc. Glasgow,* 5, pl. 10, fig. 25.
1928 *Prioniodina gemina* (Hinde); Holmes, *Proc. U.S. nat. Mus.,* 72, 19, pl. 5, fig. 10.
1960 *Apatognathus geminus* (Hinde); Clarke, *Trans. Edinb. geol. Soc.,* 18, 4, pl. 1, figs 1, 2.
non 1963 *Apatognathus? gemina* (Hinde); Rexroad & Collinson, *Ill. geol. Surv. Circ.* 355, 7, pl. 1, figs 12-17 (=*A. scalena* Varker).
1967 *Apatognathus? gemina* (Hinde); Varker, *Palaeontology,* 10, 133, pl. 17, figs 9, 12, 13.
1967 *Apatognathus gemina* (Hinde); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 20, figs 3a-4b, 6a-7b.

A single specimen was recovered from the Utting Calcarenite.

APATOGNATHUS VARIANS VARIANS Branson & Mehl, 1934
(Pl. 1, figs 16a, b)

1934 *Apatognathus varians* Branson & Mehl, *Univ. Missouri Stud.,* 8, 201, pl. 17, figs 1, 2, (*non* pl. 17, fig. 3 = *A. varians klapperi*).
non 1939 *Apatognathus? varians* Branson & Mehl; Cooper, *J. Paleont.,* 13, 385, pl. 47, fig. 30.
non 1956 *Apatognathus varians* Branson & Mehl; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.,* 84, 145, pl. 14, fig. 3 (=*A. varians ethingtoni*).
1958 *Apatognathus varians* Branson & Mehl; Klapper, *J. Paleont.,* 32, 1085, pl. 141, figs 6, 8.
1961 *Apatognathus varians* Branson & Mehl; Ethington, Furnish, & Wingert, *J. Paleont.,* 35, 763, pl. 90, fig. 11.

non 1961 *Apatognathus varians* Branson & Mehl; Freyer, *Freiberger Forschr.*, C-95, 36, pl. 1, fig. 13 (=*Gnamptognathus? lipperti*).
1965 *Apatognathus varians* Branson & Mehl; Ethington, *J. Paleont.*, 39, 571.
non 1965 *Apatognathus varians* Branson & Mehl; Spasov, *Trav. géol. Bulgarie, Ser. paléont.*, 7, 84, pl. 1, fig. 3 (=*Gnamptognathus? lipperti*).
non 1966 *Apatognathus varians* Branson & Mehl; Glenister & Klapper, *J. Paleont.*, 40, 803, pl. 96, figs 14-16 (figs 14, 15 =*A. varians ethingtoni;* fig. 16 =*A.* n. sp. A).

Range: Famennian Ningbing Limestone.

Material: Figured specimen CPC 7812.

Description: An apatognathid with long slender bars, which are subparallel. Anterior and posterior bars are of equal length and bear identical dentition, which consists of small minute denticles developed en echelon in groups of three. The apical denticle is larger than the bar denticles and is curved towards the inner side and bears knife-edges on its anterior and posterior faces.

The basal cavity is small but has a large lip on the outer face which joins the two bars.

Remarks: *A. varians* is herein restricted to forms with shallow subparallel bars. *A. varians* s.s. differs from *A. varians ethingtoni* in that the bars of *A. varians ethingtoni* diverge at 20°-30° and are fairly deep and blade-like.

Occurrence: *A. varians* occurs in the Famennian Ningbing Limestone in the Bonaparte Gulf Basin.

Branson & Mehl (1934, p. 201) in their original description designated three cotypes. However, since they belong to at least two subspecies, the specimen in plate 17, figure 1 is considered the holotype, and plate 17, figure 2 is considered a paratype of *A. varians varians*. The specimen figured in plate 17, figure 3 is possibly *A. varians klapperi* subsp. nov.

APATOGNATHUS VARIANS ETHINGTONI subsp. nov.
(Pl. 1, figs 12a, b, 15; Text-fig. 10)

1956 *Apatognathus varians* Branson & Mehl; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 145, pl. 14, fig. 3.
1966 *Apatognathus varians* Branson & Mehl; Glenister & Klapper, *J. Paleont.*, 40, 803, pl. 96. figs 14, 15 only (fig. 16 =*A.* n. sp. A).

Material: 32 specimens; CPC 8339 (holotype) and CPC 8717 figured.

Derivation of name: After Dr R. L. Ethington.

Diagnosis: A subspecies of *A. varians* with fairly deep blade-like bars diverging at 20°-30°.

Description: A fragile apatognathid with blade-like bars diverging at an angle of 20°-30°. The anterior bar is extremely laterally compressed and deep, and bears 9 to 13 small, basally fused, free-tipped denticles which are subcircular in cross-section. They decrease in size toward the anterior and are inclined posteriorly. The posterior bar is the same size as the anterior bar and bears 10 to 13 small basally fused free-tipped denticles which are subcircular in cross-section. The dentition on both bars is noncyclic, but they are arranged en echelon in groups of three.

The apical denticle is laterally compressed and possesses anterior and posterior knife-edges. It is more than twice the size of the bar denticles and is inclined laterally inward.

The cavity is minute but the basal tip extends aborally on the outer lateral face to form a web joining the two limbs.

Remarks: Ethington et al. (1961) first noticed the en echelon arrangement of the denticles in *A. varians*. The present subspecies exhibits this characteristic but can be distinguished from *A. varians* s.s. by the divergence and twisting of the bars.

Occurrence: *A. varians ethingtoni* occurs in the Famennian Ningbing Limestone.

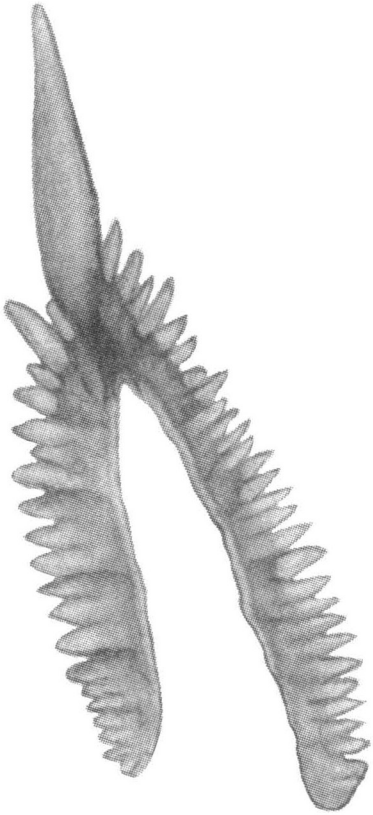

Figure 10. *Apatognathus varians ethingtoni* **subsp. nov. Inner lateral view of paratype, CPC8717, x 140.**

APATOGNATHUS VARIANS KLAPPERI subsp. nov.

(Pl. 1, figs 13a, b; 14; Text-fig. 11)

Material: 24 specimens; CPC 7808 (holotype) and CPC 7809 figured.

Derivation of name: After Dr G. Klapper.

Diagnosis: A subspecies of *A. varians* Branson & Mehl with 2 to 4 large denticles developed on the anterior part of the posterior bar.

Description: A slender unit with extremely laterally compressed bars which diverge at 20°-40°. The anterior bar bears 8 to 10 fine laterally compressed denticles with fused bases and free tips, gradually decreasing in size anteriorly. The posterior bar is slightly longer than the anterior and bears 10 to 14 fine laterally compressed denticles, with fused bases and free tips. The anteriormost 2 to 4 denticles are distinctive: they are fairly massive, and as large as the apical denticle. In some cases the largest of these bar denticles is situated at the anterior end, and in some it is the second or third denticle away from the apical denticle. The remainder of the denticles are similar to the anterior bar denticles and decrease in size uniformly towards the posterior end.

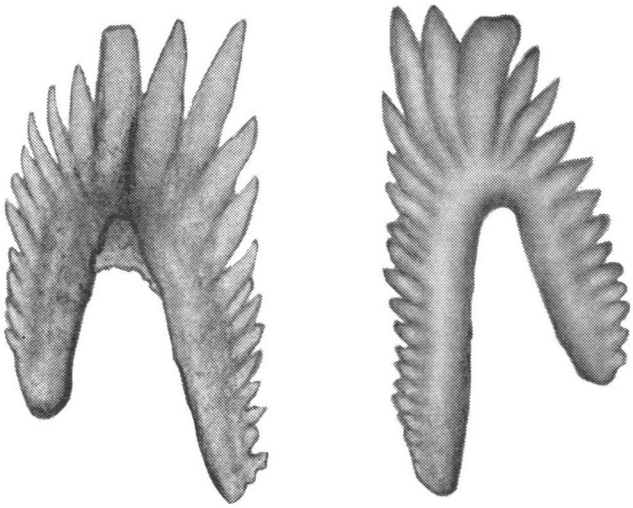

Figure 11. *Apatognathus varians klapperi* **subsp. nov. (a) Inner and (b) outer lateral views of holotype, CPC7808, x 90.**

The apical denticle is small, of the same order of size as the anteriormost posterior bar denticles; occasionally it is slightly larger. It is laterally compressed, possessing anterior and posterior knife edges, and is inclined slightly inward.

The basal cavity is minute, but the outer lateral lip is flared, forming a web between the anterior and posterior bars. The cavity extends as a very fine groove along both bars.

Remarks: *A. varians klapperi* includes the 'bicuspid' forms recognized from Wyoming and South Dakota (Ethington et al., 1961; Klapper & Furnish, 1962) and 'bicuspid' and 'tricuspid' forms from Australia (Glenister & Klapper, 1966). Since this variation appears to be constant and easily recognizable it is considered to be a valid subspecies.

Occurrence: A. varians klapperi occurs in the Famennian Ningbing Limestone.

APATOGNATHUS sp. nov. A

(Pl. 1, figs 11a, b; Text-fig. 12)

1966 *Apatognathus varians* Branson & Mehl; Glenister & Klapper, *J. Paleont.*, 40, pl. 96, fig. 16 only.

Material: 7 specimens.

Description: Unit arched, bars diverging at approximately 30°. Each bar bears cyclical dentition; large elongate subcircular denticles alternate with shorter finer ones. All denticles are free-standing and curved inwards and their tips are nearly normal to the plane of the bar.

The apical denticle is of the same type as the large denticles but is slightly larger and is curved inward through 90°.

The basal cavity is minute but is bounded on the outer side by a small lip.

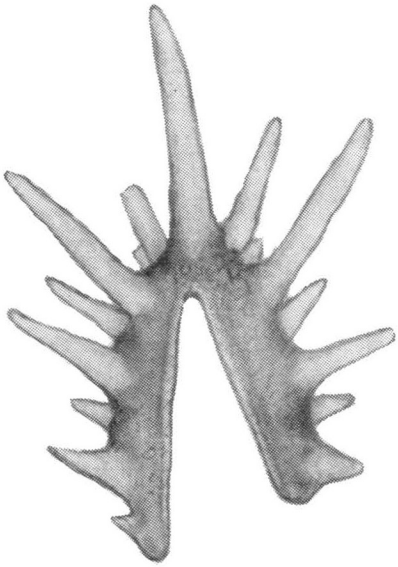

Figure 12. *Apatognathus* **sp. nov. A. Inner lateral view of specimen CPC8716, x 140.**

Remarks: The specimens cannot be placed in any described species. The extreme length and fineness of the denticles distinguish them from *A. varians*. However, one specimen (pl. 12, fig. 16) referred to *A. varians* by Glenister & Klapper (1966, p. 803) is considered to belong to this species. Glenister & Klapper suggest that this may be the forerunner of *A. varians* s.s., and I agree.

Occurrence: Early Famennian part of the Ningbing Limestone.

APATOGNATHUS? sp. nov.

(Pl. 2, figs 4a, b)

Material: 2 specimens; CPC 7807 figured.

Description: Unit massive, arched and bowed, with short bars which diverge at 45°. Anterior bar short, deep, laterally compressed, bearing 5 free-standing

laterally compressed denticles. The posteriormost denticle is minute, but the penultimate denticle is massive, half as large as the apical denticle, subcircular in cross-section and with anterior and posterior knife edges. The remaining 3 denticles are minute, decreasing in size anteriorly. The posterior bar is 1¼ times as long as the anterior and is similar in outline, bearing 6 denticles, the 2 anteriormost being minute. The third denticle is massive, and mirrors the large denticle of the anterior bar, being tall, free-standing, and knife-edged. The remaining 3 denticles are minute, decreasing in size posteriorly.

The inner oral surface of both bars bears a strong ridge, and the aboral two-thirds of the bars bear a marked attachment scar.

The apical denticle is tall, massive, and free-standing; the anterior and posterior faces are knife-edged and it is inclined slightly posteriorly and laterally toward the inner side.

The base is narrow; the bars in cross-section are v-shaped. The basal cavity is small and lies at the midpoint of the unit at the base of the apical denticle; it extends as very fine grooves along each bar.

Remarks: *Apatognathus* sp. nov. appears to be a development of *Falcodus veeversi* sp. nov., the apical denticle being enlarged and the bars shortened. It is questionable whether this species should be placed in *Apatognathus* or *Falcodus*.

Occurrence: Early Famennian part of the Ningbing Limestone.

Genus BRYANTODUS Bassler, 1925

Type species: *Bryantodus typicus* Ulrich & Bassler, 1926.

BRYANTODUS SCITULUS Branson & Mehl, 1934
(Pl. 2, figs 1a-2)

1934 *Bryantodus scitulus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 283, pl. 23, fig. 5.
1934 *Bryantodus flexus* Branson & Mehl, *ibid.*, 284, pl. 23, figs 6, 7.
1934 *Bryantodus mundus* Branson & Mehl, *ibid.*, 284, pl. 23, fig. 9.
1934 *Bryantodus gibberosus* Branson & Mehl, *ibid.*, 324, pl. 28, fig. 27.
1934 *Bryantodus rudis* Branson & Mehl, *ibid.*, 325, pl. 28, fig. 29.
1934 *Bryantodus planirostris* Branson & Mehl, *ibid.*, 326, pl. 28, fig. 31.
1934 *Bryantodus cognatus* Huddle, *Bull. Amer. Paleont.*, 21, 67, pl. 4, fig. 10.
1938 *Bryantodus mundus* Branson & Mehl; Branson & Mehl, *Univ. Missouri Stud.*, pl. 33, fig. 37.
1938 *Bryantodus scitulus* Branson & Mehl; Branson & Mehl, *ibid.*, pl. 33, fig. 36.
1939 *Bryantodus mundus* Branson & Mehl; Cooper, *J. Paleont.*, 13, 385, pl. 43, figs 25, 26.
1939 *Bryantodus planus* Branson & Mehl; Cooper, *ibid.*, 385, pl. 43, figs 29, 30.
1939 *Bryantodus curtus* Cooper, *ibid.*, 385, pl. 43, figs 16, 17.
1939 *Bryantodus tylus* Cooper, *ibid.*, 386, pl. 43, figs 45, 46.
1943 *Bryantodus mundus* Branson & Mehl; Cooper & Sloss, *J. Paleont.*, 17, 170, pl. 29, fig. 8.
1943 *Bryantodus planus* Branson & Mehl; Cooper & Sloss, *ibid.*, 170, pl. 29, fig. 3.
1944 *Bryantodus mundus* Branson & Mehl; Branson & Mehl, *in* Shimer & Shrock, *Index fossils of North America*, 243, pl. 94, fig. 21.
1944 *Bryantodus mundus* Branson & Mehl; Branson, *Univ. Missouri Stud.*, 19, 181, pl. 32, fig. 37.
1944 *Bryantodus scitulus* Branson & Mehl; Branson, *ibid.*, 181, pl. 38, fig. 36.
1949 *Bryantodus? planus* Branson & Mehl; Thomas, *Bull. geol. Soc. Amer.*, 60, 411, pl. 3, fig. 21.

Material: 4 specimens; CPC 7814, 7815 figured.

Description: In lateral view the unit is arched, the anterior bar being slightly longer than the posterior. The anterior bar bears 6 to 8 laterally compressed basally fused denticles with free posteriorly inclined tips. The posterior bar bears 6 to 9 basally fused, laterally compressed denticles which rapidly decrease in height and width posteriorly. The apical denticle is large, 3 times as wide as any other denticle and twice as high; all denticles are knife-edged on their anterior and posterior faces.

In oral view the bars are greatly expanded; they are widest at their midpoints, and narrow toward the terminations and the apical denticle.

Remarks: Branson & Mehl (1934) erected a number of new species of *Bryantodus* which differed only in the number of denticles and the thickness of the unit. I consider that these variations are intraspecific and that all should be brought to *B. scitulus* Branson & Mehl.

Occurrence: Upper *Siphonodella sulcata-Polygnathus parapetus* A.Z. to *S. quadruplicata-S. cooperi* A.Z.

Genus CAVUSGNATHUS Harris & Hollingsworth, 1933

Type species: *Cavusgnathus alta* Harris & Hollingsworth, 1933.

CAVUSGNATHUS UNICORNIS? Youngquist & Miller, 1949
(Pl. 3, figs 1a-2c)

?1949 *Cavusgnathus unicornis* Youngquist & Miller, *J. Paleont.*, 23, 619, pl. 101, figs 18-23.

Material: 17 specimens; CPC 7816, 7817 figured.

Description: An elongate, asymmetrical unit with a free blade on the outer side (left side when viewed from the anterior). In oral view the platform is elongate, 4 times as long as wide, ornamented by lateral nodes which develop into transverse ridges and then fade away toward the medial trough. The inner lateral row extends along the outer free blade for half its length and is separated from it by a shallow trough. A short posterior nodose carina is developed which dies away anteriorly and merges with the medial trough; posteriorly it is developed as a short free blade. The outer blade merges with the outer platform ornament and the whole unit is bowed, the inner side being concave. The basal cavity lip is greatly flared on the inner side but is nearly confluent with the platform on the outer side.

In lateral view the unit is arched, the maximum flexing occurring immediately posterior to the basal cavity. The blade is subtriangular, bearing 4 or 5 laterally compressed, basally fused, free chevron-tipped denticles. The largest denticle is the posteriormost; the remainder decreasing in size anteriorly to give an antero-aboral angle of approximately 70°.

The basal cavity is large, ovate, and asymmetrically flared. It occupies the mid-third of the unit and narrows toward both ends, but more abruptly towards the anterior. A medial groove extends to both the anterior and posterior terminations.

Remarks: This species is very close to *Clydagnathus cavusformis* Rhodes, Austin, & Druce, 1968, but the basal cavity is larger and extends to the posterior termination. It is questionably referred to *Cavusgnathus unicornis* because the anterior free blade lacks the prominent posteriormost denticle. Denticles increase gradually in size posteriorly, unlike *Cavusgnathus unicornis,* where the posteriormost denticle is conspicuously larger than the remaining blade denticles.

Occurrence: Throughout the Utting Calcarenite (lower Visean).

CAVUSGNATHUS sp.
(Pl. 1, figs 3a-d)

Material: Figured specimen CPC 7818.

Description: This unit is probably a pathological variant and is characterized by elongate denticles. The triangular blade bears tall discrete subcircular denticles, as does the platform, which is restricted to the median third. A long median posterior free blade which is deflected through 60° also bears tall thin discrete denticles. The basal cavity is pear-shaped and does not extend to the posterior termination.

Remarks: The form may belong to *Clydagnathus* since the basal cavities are similar. However, no clydagnathids are known from such a high stratigraphic level as the Burvill Beds of uppermost Visean or lowermost Namurian age (see p. 26).

Genus CENTROGNATHODUS Branson & Mehl, 1948

Type species: *Centrognathus sinuosa* Branson & Mehl, 1933.

CENTROGNATHODUS sp.
(Pl. 3, figs 3a, b)

Material: 7 specimens; CPC 7819 figured.

Description: Unit elongate, consisting of 3 bars designated posterior, anterolateral, and lateral; they all bear similar needle-like dentition consisting of large denticles interspersed with one or two small denticles. The posterior bar is four times as long as the lateral bars, which are of equal length.

All bars are sharply keeled and a minute pit is present at their junction.

Remarks: The specimens are similar to forms described by Sannemann (1955, p. 128) as *C. delicatus* Branson & Mehl, but possess a much longer posterior bar. *Centrognathodus* sp. of Sannemann (1955, p. 128) varies little from them, and perhaps both, together with *C. delicatus* Sannemann, 1955, should be referred to a new species. Lindstrom (1964, p. 177) suggests that *Centrognathodus* may be based on a 'pathologic' specimen.

Occurrence: Ningbing Limestone.

Genus CLYDAGNATHUS Rhodes, Austin, & Druce, 1968

Type species: *Clydagnathus cavusformis* Rhodes, Austin, & Druce, 1968.

CLYDAGNATHUS CAVUSFORMIS Rhodes, Austin, & Druce, 1968
(Pl. 4, figs 1a, b; 5-7c)

1968 *Clydagnathus cavusformis* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. His.), Geol., Suppl.* 4, pl. 1, figs 9-13d.

Material: 463 specimens; CPC 7820-7823 figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to *Spathognathodus tridentatus* A.Z.*

Description: Unit elongate, 6 times as long as wide, with an anterior blade developed on the outer side (left when viewed from the anterior).

In oral view the platform is four times as long as wide, and is ornamented with 2 rows of large lateral circular nodes. Towards the posterior termination the nodes become fused to give an irregular ridge. A posterior carina is present and is developed as a posterior medial free blade with tall, laterally compressed, fused denticles. Towards the anterior the denticles decrease in height and become low rounded nodes lower than the adjacent lateral platform nodes. The medial carina dies away at the platform mid-point. A medial trough is developed in the anterior half of the platform; it deepens anteriorly but does not flare anteriorly because the inner lateral nodes fuse with the inner face of the outer free blade. The blade is massive and the denticles are laterally compressed. The whole unit is bowed and the basal cavity lip is greatly flared on the inner side.

In lateral view the oral surface is arched; the aboral surface is irregular, the posterior two-thirds being arched and the anterior third, consisting of the blade, straight in the majority of specimens. The platform ornament consists of discrete subtriangular nodes; the posterior free blade of erect chevron-tipped denticles, 2 to 4 in number; and the anterior lateral free blade of 4 to 6 massive denticles. The posteriormost denticle of the anterior blade is the tallest, and the denticles are progressively smaller toward the anterior. These denticles are fused over most of their length but have free chevron-shaped oral terminations.

In aboral view the unit is asymmetrical, the basal cavity occupying the medial third. The cavity is pear-shaped and asymmetrical, most flared on the inner side, narrowing gradually toward the posterior but rapidly toward the anterior. A medial groove extends along the narrow keels to both terminations.

Occurrence: Lower *Cleistopora* (K) Zone in Britain (Rhodes et al., 1968).

CLYDAGNATHUS DARENSIS Rhodes, Austin, & Druce, 1968
(Pl. 4, figs 8a-9c)

1968 *Clydagnathus darensis* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.) Geol., Suppl.* 4, pl. 2, figs 6a-7d.

Material: 87 specimens; CPC 7824, 7825 figured.

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* *Range is given for stratigraphically important species and refers solely to the range in the Bonaparte Gulf Basin.*

Range: Upper *Spathognathodus tridentatus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: Unit elongate, 7 times as long as wide, with an anterior blade developed on the outer (left when viewed from the posterior) lateral face. In oral view the platform is 5 times as long as wide, and is ornamented by 2 lateral rows of low nodes which have a tendency to develop as transverse ridges which die away toward the medial trough. A short nodose carina is developed in the posterior fifth of the platform and is produced as a short posterior free blade. The anterior free blade is inset slightly from the outer platform parapet; the inner parapet runs adjacent to it and fuses with it at the blade midpoint.

In lateral view the unit is slightly arched, the platform slightly decreasing in height posteriorly. The posterior free blade is short, bearing 2 or 3 chevron-tipped laterally compressed denticles. The anterior free blade is twice the height of the platform and bears 3 to 5 chevron-tipped laterally compressed denticles. The major portion of the blade is formed by 3 massive denticles, the central one being the largest, and small blade denticles are present at the anterior termination. The antero-aboral angle is approximately 70°.

In aboral view the unit is asymmetrical, the cavity lip being flared greatly on the inner side. The inner cavity lip meets the blade keel anterior to the outer cavity lip junction. The cavity is grooved; the groove runs posteriorly along the posterior keel, and forms an extension of the posteriorly narrowing basal cavity.

Remarks: *C. darensis* differs from *C. cavusformis* Rhodes, Austin, & Druce, in the nature of the blade: in *C. cavusformis* it is taller and more plume-like.

Occurrence: *C. darensis* occurs in Britain in the uppermost *Cleistopora* (K) and lower *Zaphrentis* (Z) Zone (Rhodes et al., 1968, p.).

CLYDAGNATHUS GILWERNENSIS Rhodes, Austin, & Druce, 1968
(Pl. 4, figs 2a-4; Pl. 30, fig. 8)

1968 *Clydagnathus gilwernensis* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.) Geol., Suppl.* 4, pl. 2, figs 1a-d.

Material: 38 specimens; CPC 7828, 7829, 8059, 8340 figured.

Range: Upper *Spathognathodus plumulus* A.Z. to lower *Clydagnathus nodosus* A.Z.

Description: The unit is elongate and possesses a medial anterior blade. In oral view the unit is about 5 times as long as wide, and bears platform ornament consisting of 2 lateral rows of low isolated nodes. They are separated by a very shallow medial trough which terminates against the posterior face of the blade in the anterior and fades away toward the posterior platform termination. A short posterior carina is present in some specimens. This ornament evolved from the inner lateral ornament (right when viewed from the anterior), which in some forms is the dominant row.

In the posterior part of the platform additional nodes are added on the inner face of the inner lateral row; they appear continuous with the inner lateral row and isolate the original inner row nodes to give a short posterior carina. The carina may be developed as a short posterior free blade. The anterior free blade is medial, both rows of platform ornament terminating at its posterior face.

In lateral view the blade is plume-like; it consists of 3 to 5 fused denticles which increase in size posteriorly, the posteriormost being massive—more than twice as high as the platform and inclined slightly posteriorly. The antero-aboral angle is about 70°. The platform nodes are subtriangular and isolated.

The cavity is slightly asymmetrical and flared. A medial groove is present and runs for a short distance along the anterior and posterior keel.

Occurrence: The only previously known occurrence is in Britain, where it is confined to the lower *Cleistopora* (K) Zone (Rhodes et al., 1968).

CLYDAGNATHUS NODOSUS sp. nov.

(Pl. 5, figs 1a-2; Text-fig. 13)

Derivation of name: From the nodose cavity lip.

Material: 11 specimens; holotype, CPC 7831; paratype CPC 7830.

Range: Uppermost *Siphonodella quadruplicata-S. cooperi* A.Z. to lowermost *Spathognathodus tridentatus* A.Z.

Diagnosis: A clydagnathid with an orally nodose inner (right when viewed from the anterior) basal cavity lip.

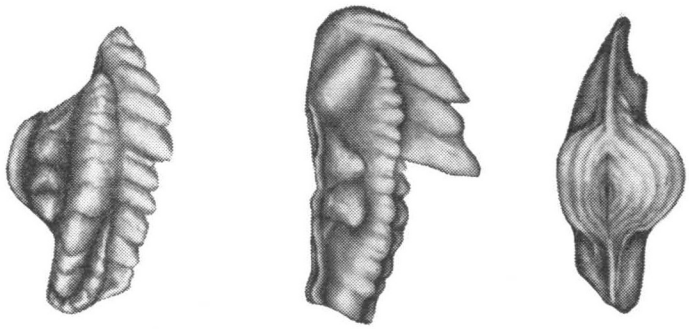

Figure 13. *Clydagnathus nodosus* **sp. nov. (a) Oral, (b) inner lateral, and (c) aboral views of holotype, CPC7831, x 30.**

Description: Unit twice as long as wide, with an outer blade developed and a nodose platform. In oral view the main platform is elongate, 3 times as long as wide, bearing 2 lateral rows of ornament. This consists of large upstanding rounded nodes on the outer platform and a fused upstanding longitudinal ridge on the inner side. Along the medial axis runs a deep trough, shallowing towards either extremity and terminated by fusion of the inner platform ornament with the outer blade at the anterior. The inner lip of the basal cavity is flared and bears one or two large rounded nodes on its upper surface. The blade is long, about two-thirds the length of the platform, and is curved inward.

In lateral view the unit is deep; the platform is half the height of the blade and the cavity lip ornament is half the height of the platform. The blade consists of 5 fused denticles with chevron tips of approximately equal height.

The cavity is expanded asymmetrically, the inner side being much larger and extending further anteriorly. Either side of the cavity the unit is keeled, the posterior keel running a short distance on to the cavity.

Remarks: *C. nodosus* is similar to *C. darensis* Rhodes, Austin, & Druce, but the nodose cavity lip distinguishes it.

Genus DINODUS Cooper, 1939

Type species: *Dinodus leptus* Cooper, 1939.

DINODUS FRAGOSUS (E. R. Branson, 1934)
(Pl. 5, figs 3a-5b; Pl. 42, fig. 4)

1934 *Palmatodella fragosa* E. R. Branson, *Univ. Missouri Stud.*, 8, 333, pl. 27, fig. 5.
1934 *Palmatodella fragosa?* E. R. Branson, *ibid.*, 333, pl. 27, figs 2, 4, 6.
1934 *Falcodus? granulosus* Huddle, *Bull. Amer. Paleont.*, 21, 89, pl. 7, fig. 10.
1943 *Dinodus granulosus* (Huddle); Cooper & Sloss, *J. Paleont.*, 17, 173, pl. 29, figs 31, 35.
1959 *Dinodus fragosus* (E. R. Branson); Hass, *U.S. geol. Surv. prof. Pap.* 294-J, pl. 49, figs 16, 23.
1961 *Dinodus fragosus* (E. R. Branson); Scott & Collinson, *Kans. geol. Soc., 26th Annual Field Conf., Guidebook*, 122, pl. 2, fig. 21.
1965 *Dinodus fragosus* (E. R. Branson); Spasov, *Rev. Bulgarian geol. Soc.*, 26, 160, pl. 1, fig. 12.

Material: 5 specimens; CPC 7832-7834 figured.

Description: An extremely laterally compressed and deep bar unit. The anterior bar is depressed through 135° and deflected slightly inward. The height of the bar increases posteriorly. The denticles, about 30 in number, are fine, needle-like, posteriorly inclined, and fused over nearly their complete length, the oral terminations being free. A ledge runs along both faces close to the aboral edge and parallel with it to give the appearance of a narrow platform; they are continuous on to the posterior bar.

The posterior bar is very high, the oral and aboral edges being parallel, and bears about 50 needle-like posteriorly inclined fused denticles, the extreme tips of which are free. They are upright to posteriorly inclined and are of equal height, apart from those at the posterior termination which tend to form the posterior face of the unit. The ledge present on the anterior bar runs along the posterior bar for two-thirds its length, parallel to the aboral edge, except in the posterior part, where a deep keel is present which deepens posteriorly, disrupting the aboral margin, and forms a pseudo-aboral margin.

The unit is keeled, a minute cavity is present at the point of greatest flexure, and a faint groove runs from it along each bar.

Occurrence: *D. fragosus* is known from the Tournaisian of the United States, Germany, and Bulgaria. It ranges from upper cuI to $cuII_a$ (Voges, 1959; Spasov, 1965; Klapper, 1966). In the Bonaparte Gulf Basin it is known only from the 7/1 locality in the Ningbing Range.

DINODUS WILSONI sp. nov.
(Pl. 3, figs 5a, b)

?1956 *Dinodus leptus* Cooper; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 146, pl. 14, fig. 4.

Derivation of name: In honour of A. T. Wilson, Bureau of Mineral Resources.

Material: 4 specimens. Holotype CPC 7835.

Diagnosis: A dinodid with two bars and upright dentition.

Description: Unit arched, bars unequal in length and very deep. Anterior bar 3 times as long as posterior and bears approximately 50 fine, fused, needle-like denticles which decrease in size anteriorly. The posterior bar bears about 25 denticles of similar form to those on the anterior bar, decreasing in size posteriorly. The denticles on both bars are inclined and increase in size toward the apex, although there is no obvious apical denticle. A narrow ledge is present on both sides of both bars at the aboral edge, and this forms a pseudo-platform which increases in width slightly towards the apex.

Aborally the whole unit is grooved and a minute basal cavity is present beneath the apex.

Remarks: *D. wilsoni* differs from *D. fragosus* (E. R. Branson) and *D. leptus* Cooper in the dentition. The denticles in *D. fragosus* are all inclined posteriorly, those in *D. leptus* are inclined and recurved posteriorly. It is difficult to tell whether the form illustrated by Bischoff & Ziegler (1956, pl. 14, fig. 4) belongs to *D. leptus* or to *D. wilsoni* since their specimen appears to be broken.

There is some resemblance to *D. youngquisti* Klapper, but the three bars developed on the latter distinguish the two species.

Occurrence: In the Bonaparte Gulf Basin the species is restricted to the 7/1 locality in the Ningbing Range.

DINODUS cf. D. WILSONI sp. nov.
(Pl. 3, fig. 4)

Specimen CPC 7835 is very similar to *D. wilsoni* sp. nov., but is conspicuous by its larger denticles and obvious apical denticle. It is possible that there is a gradation from one form of dentition to the other.

Occurrence: This form is known only from the 7/1 locality in the Ningbing Range.

Genus ELICTOGNATHUS Cooper, 1939

Type species: *Solenognathus bialata* Branson & Mehl, 1934.

ELICTOGNATHUS BIALATA (Branson & Mehl, 1934)
(Pl. 6, figs 1a-2c)

1934 *Solenognathus bialata* Branson & Mehl, *Univ. Missouri Stud.*, 8, 273, pl. 22, fig. 11.
1934 *Solenognathus dicrocheila* Branson; *ibid.*, 333, pl. 27, fig. 9.
1938 *Solenognathus bialata* Branson & Mehl; Branson & Mehl, *ibid.*, 13, pl. 33, fig. 30.

1939 *Elictognathus bialata* (Branson & Mehl); Cooper, *J. Paleont.*, 13, 387, pl. 45, figs 1, 2.
1939 *Solenognathus dicrocheila* Branson; Cooper, *ibid.*, 411, pl. 45, figs 7, 8.
1944 *Solenognathus bialata* Branson & Mehl; Branson, *Univ. Missouri Stud.*, 19, 181, pl. 32, fig. 30.
1944 *Solenodella bialata* (Branson & Mehl); Branson & Mehl *in* Shimer & Shrock, *Index fossils of North America*, 244, pl. 94, fig. 6.
1949 *Solenodella* cf. *bialata* (Branson & Mehl); Thomas, *Bull. geol. Soc. Amer.*, 60, 412, pl. 3, fig. 26.
1956 *Solenodella dicrocheila* (Branson); Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 166, pl. 12, fig. 20.
1957 *Solenodella bialata* (Branson & Mehl); Bischoff, *Hess. Landesamt. Bodenf., Abh.*, 19, 55, pl. 6, figs 11, 14.
1959 *Elictognathus bialata* (Branson & Mehl); Hass., *U.S. geol. Surv. prof. Pap.* 294-J, pl. 49, fig. 21.
1959 *Elictognathus bialata* (Branson & Mehl); Voges, *Paläont. Z.*, 33, 277, pl. 33, figs 18, 19.
1966 *Elictognathus bialata* (Branson & Mehl); Klapper, *Univ. Kansas paleont. Contr. Pap.* 3, 25, pl. 5, fig. 14.

Material: 3 specimens; CPC 7837, 7838 figured.

Description: The unit is arched, with a high main blade possessing 25 to 30 laterally compressed fused denticles, free at their extreme tips. The denticles at the anterior are short and form the anterior face; they are of equal height on the anterior bar until the apical denticle is reached in the anterior third. The apical denticle is nearly twice as high as the posterior denticles and marks the apex of the oral outline. On the inner face a ledge runs parallel to the aboral edge and immediately above it. It is weakly developed in the anterior third, but becomes strongly developed in the posterior two-thirds. In this region it develops an upstanding parapet which reaches to half the height of the main blade and is composed of needle-like fused denticles which are highest at the mid-point; they decrease in height toward either end. On the outer side of the unit the ledge is weakly developed over the whole length of the unit.

In aboral view the unit is keeled and a minute elongate pit is present beneath the apical denticle.

Occurrence: *E. bialata* is known from Germany and the United States. It ranges from the upper *Gattendorfia* Stufe (upper cuI) to the lower *Pericyclus* Stufe ($cuII_{\alpha}$) in Germany (Voges, 1959). In the United States it is recorded from the Bushberg Sandstone of Missouri (Branson & Mehl, 1934) and the Lodgepole Limestone of Montana, Wyoming, and South Dakota (Klapper, 1966). In the Bonaparte Gulf Basin it is confined to the 7/1 locality in the Ningbing Range.

Genus EUPRIONIODINA Bassler, 1925

Type Species: *Euprioniodina deflecta* Ulrich & Bassler, 1926.

EUPRIONIODINA ALTERNATA (Ulrich & Bassler, 1926)
(Pl. 6, figs 4-6)

1926 *Synprioniodina alternata* Ulrich & Bassler, *Proc. U.S. nat. Mus.*, 68, 42, fig. 4, sub. fig. 4.
1928 *Synprioniodina alternata* Ulrich & Bassler; Holmes, *Proc. U.S. nat. Mus.*, 72, 30, pl. 10, figs 11, 12.
1931 *Synprioniodina alternata* Ulrich & Bassler; Cooper, *J. Paleont.*, 5, 149, pl. 29, fig. 13.
1934 *Euprioniodina regularis* E. R. Branson, *Univ. Missouri Stud.*, 8, 330, pl. 28, fig. 1.
1934 *Euprioniodina fornicata* Huddle, *Bull. Amer. Paleont.*, 31, 51, pl. 6, fig. 16.

1934 *Euprioniodina derexa* Huddle, *ibid.*, 52, pl. 11, fig. 4.
1934 *Euprioniodina debilis* Huddle, *ibid.*, 53, pl. 11, fig. 6.
1934 *Euprioniodina falx* Huddle, *ibid.*, 53, pl. 11, fig. 9.
1934 *Synprioniodina adis* Huddle, *ibid.*, 55, pl. 11, fig. 7.
1934 *Synprioniodina decurrens* Huddle, *ibid.*, 55, pl. 11, fig. 11.
1938 *Synprioniodina gracilis* Stauffer, *J. Paleont.*, 12, 441, pl. 49, fig. 12, 13.
1940 *Synprioniodina forsenta* Stauffer, *ibid.*, 14, 432, pl. 59, figs 31-33, 38-41.
1940 *Synprioniodina tropa* Stauffer, *ibid.*, 434, pl. 59, fig. 60.
1955 *Prioniodina prona* (Huddle); Sannemann, *Senck. leth.*, 36, 152, pl. 3, figs. 1, 7, 8.
1957 *Prioniodina prona* (Huddle); Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 22, 106, pl. 8, figs 12-14; pl. 9, figs 1-3; pl. 21, figs 14-16 (*non* pl. 8, fig. 15).
1957 *Prioniodina* aff. *P. prona* (Huddle); Lys & Serre, *Rev. Inst. franç. Pétrol.*, 12, 1049, pl. 6, fig. 4.
1957 *Synprioniodina forsenta* Stauffer; Lys & Serre, *ibid.*, 1051, pl. 7, fig. 6.
1959 *Prioniodina alternata* (Ulrich & Bassler); Helms, *Geologie*, 8, 652, pl. 2, fig. 15, pl. 4, fig. 29.
1961 *Prioniodina alternata* (Ulrich & Bassler); Freyer, *Freiberger Forsch.*, C-95, 78.

Material: 12 specimens; CPC 7839-7841 figured.

Description: The apical denticle is tall, erect, and laterally compressed, with posterior and anterior knife-edges. The anterior bar is short, formed as an antero-aboral projection of the apical denticle, and bears up to 3 basally fused, free-tipped, needle-like denticles. The posterior bar is 5 times as long as the anterior bar, bearing up to 14 needle-like denticles with discrete tips. The basal cavity is subapical, large with an inner flare lip. An attachment scar is sometimes present on the latero-aboral face of both bars.

Remarks: *E. alternata* is referred to *Euprioniodina* because of the presence of the denticulate anterior bar. However, the similarity between this species and *Neoprioniodus confluens* (Branson & Mehl) is striking, the denticulate antero-aboral projection being the only difference. It is probable that many species of *Neoprioniodus* developed a denticulate anterior bar and that many species of *Euprioniodina* are closely related to neoprioniodids.

Occurrence: Throughout the Tournaisian in the Bonaparte Gulf Basin.

Genus FALCODUS Huddle, 1934

Type species: *Falcodus angulatus* Huddle, 1934.

FALCODUS ROBERTSI sp. nov.

(Pl. 7, figs 4a-5b; Text-fig. 14)

Derivation of name: In honour of Dr J. Roberts, BMR.

Material: 8 specimens. Holotype CPC 7848; paratype CPC 7847.

Range: Lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Diagnosis: A falcodid with well developed symmetry and strong depression of both bars.

Description: The anterior bar is short, laterally compressed, slightly flexed, and bears 5 to 7 denticles. The 2 to 4 denticles nearest the apical denticle are small in size, the posterior 3 to 4 are minute; the two groups are separated from each

other by a massive, laterally compressed, knife-edged denticle situated at the point of flexure. The posterior bar is slightly flexed, equal in length to the anterior bar, and bears 6 to 7 denticles arranged in the same manner as the anterior bar denticles; a massive denticle is present at the point of flexure. The apical denticle is tall, massive, laterally compressed, and knife-edged. In addition it has a rounded costa on the inner face, giving it a triangular cross-section.

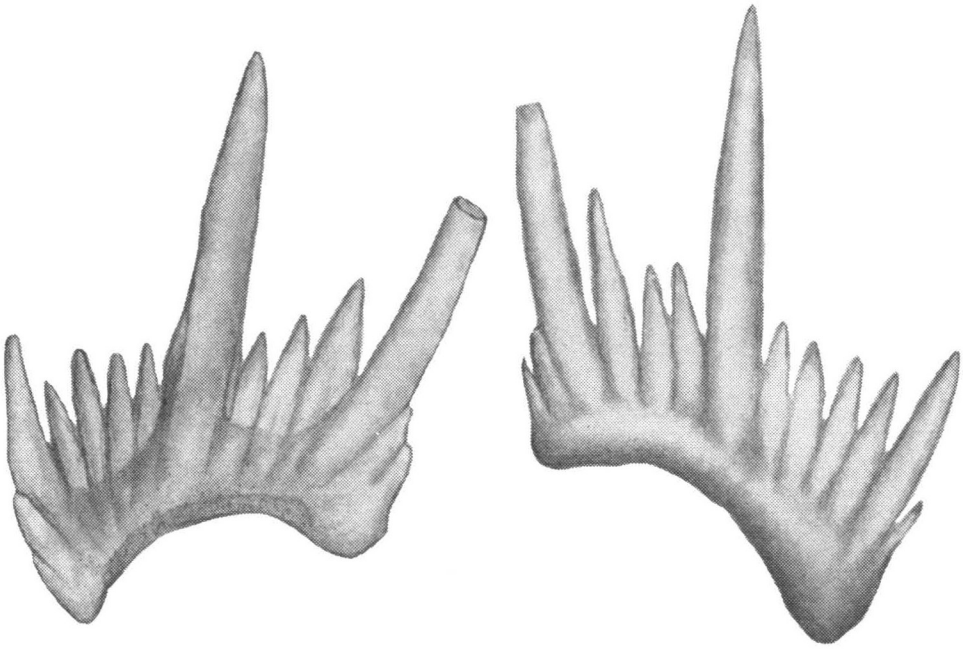

Figure 14. *Falcodus robertsi* **sp. nov. (a) Inner and (b) outer lateral views of holotype, CPC7848, x 80.**

A minute pit is developed beneath the apical denticle, and a keel is present beneath both bars.

The complete unit is nearly symmetrical, only the posterior inclination of the denticles destroying the symmetry.

Remarks: *Falcodus robertsi* sp. nov. is similar to *Falcodus tortus* Huddle, differing only in the shortening of the posterior bar to give a pseudosymmetrical outline.

FALCODUS TORTUS Huddle, 1934
(Pl. 7, figs 1-3)

1934 *Falcodus tortus* Huddle, *Bull. Amer. Paleont.*, 31, 274, pl. 7, fig. 4.
1934 *Falcodus* sp. Huddle, *ibid.*, 274, pl. 7, fig. 5.
non 1956 *Falcodus tortus* Huddle; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 146, pl. 14, fig. 7.

Material: 6 specimens; CPC 7844, 7845, 7852 figured.

Range: Middle *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Description: The anterior bar is depressed and deflected inwards; it bears up to 6 laterally compressed, isolated, inwardly inclined denticles. The anterior 3 are small and subtriangular, the next 2 are massive, laterally compressed, with anterior and posterior knife-edges; the posteriormost denticle is minute.

The posterior bar is one and a half times as long as the anterior bar and is straight for most of its length but depressed at the posterior termination. The proximal part of the bar bears seven denticles, arranged in a cyclic pattern, large denticles alternating with a single small denticle. At the point of flexure 2 massive denticles are developed, the distal one being the larger. They are laterally compressed, posteriorly inclined, and anteriorly and posteriorly knife-edged. The depressed section of the bar bears 3 small denticles, their size decreasing toward the posterior termination. The apical denticle is tall, massive, laterally compressed, knife-edged, and inclined inwardly and posteriorly.

A small cavity is developed aborally beneath the apical denticle, the lips of which form a faint ridge which extends along both bars for half their length.

Remarks: Klapper (1966, p. 27) considers *F. tortus* a junior synonym of *F. conflexus* Huddle.

There appears to be a complete gradation between 'hindeodellid' forms and 'falcodid' forms in the *F. robertsi* sp. nov.-*F. tortus* Huddle-*F. veeversi* sp. nov. group. A similar gradation from a 'hindeodellid' to a 'falcodid' morphology and a decrease in asymmetry has been noted by Rexroad & Furnish (1964, p. 671) in their *Hindeodus* series from the Upper Mississippian of south-central Iowa.

Occurrence: The only previous record of this species is from the New Albany Shale of Indiana, USA (Huddle, 1934).

FALCODUS VARIABILIS Sannemann, 1955
(Pl. 6, figs 10a, b)

1955 *Falcodus variabilis* Sannemann, *Senck. leth.*, 36, 129, pl. 4, figs 1-4.
1956 *Falcodus variabilis* Sannemann; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 123, pl. 9, figs 28-30.
1956 *Falcodus variabilis* Sannemann; Bischoff & Ziegler, *ibid.*, 147.
?1957 *Falcodus variabilis* Sannemann; Bischoff, *Hess. Landesamt. Bodenf., Abh.*, 19, 20, pl. 6, figs 29-31.
1961 *Falcodus variabilis* Sannemann; Freyer, *Friebeiger Forschr.*, C-95, 41, pl. 1, fig. 20.
1961 *Falcodus variabilis* Sannemann; Scott & Collinson, *Kansas geol. Soc., 26th Annual Field Conf. Guidebook*, 123, pl. 2, fig. 25.

Material: 8 specimens; CPC 7851 figured.

Description: The unit is deep, with equidimensional bars. The anterior bar is depressed through 90° and is deflected slightly inward. The denticles of the anterior bar decrease in height anteriorly; the posterior bar denticles, which are fine and needle-like except for the 2 posteriormost, decrease in height posteriorly. The distal 2 denticles are massive and are longer than the apical denticle.

Occurrence: *F. variabilis* is known from the the Famennian of Germany (toII-toVI) (Sannemann, 1955; Bischoff, 1957). In the Bonaparte Gulf Basin the species occurs in the late Famennian part of the Ningbing Limestone.

FALCODUS cf. F. VARIABILIS Sannemann
(Pl. 6, figs 8a-9; Pl. 38, fig. 3)

cf. 1955 *Falcodus variabilis* Sannemann, *Senck. leth.*, 36, 129.

Material: Figured specimens CPC 8027, 8028.

Description: The anterior bar is depressed through more than 90° and deflected inward; it is extremely narrow and bears about 6 needle-like free-standing denticles which may alternate in size. The apical denticle is large and posteriorly inclined, sometimes bearing small denticles on its lower anterior face. The posterior bar is nearly twice as thick as the anterior bar and bears a series of alternating denticles decreasing in height slightly towards the posterior.

Remarks: This form differs from the holotype of *F. variabilis* Sannemann in possessing a narrow, greatly deflected, and greatly depressed anterior bar. The specimens illustrated by Bischoff (1957, pl. 6, figs 29-31) as *F. variabilis* appear to be similar to the present specimens.

FALCODUS VEEVERSI sp. nov.
(Pl. 7, figs 6a-7b; Text-fig. 15)

1961 *Hindeodella* cf. *H. uncata* (Hass); Scott & Collinson (part), *Kansas geol. Soc.*, 26*th Annual Field Conf. Guidebook*, 126, pl. 2, fig. 18 only.

Derivation of name: In honour of Dr J. J. Veevers, lately of BMR, now Macquarie University.

Material: Holotype CPC 7849; paratype CPC 7850; 7 other specimens.

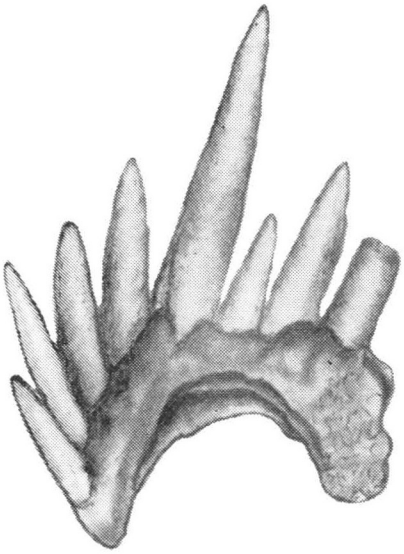

Figure 15. *Falcodus veeversi* **sp. nov. Lateral view of holotype, CPC7849, x 90.**

Range: *Siphonodella quadruplicata-S. cooperi* A.Z. to lower *Clydagnathus nodosus* A.Z.

Diagnosis: A falcodid intermediate between *Falcodus tortus* Huddle and *F. robertsi* sp. nov. The unit is only slightly asymmetrical.

Description: A slightly asymmetrical unit with depressed anterior and posterior bars. The anterior bar is depressed through 80° immediately anterior to the apical denticle and bears 6 denticles which decrease in size slightly toward the anterior termination. The posterior bar is slightly longer than the anterior and is deflected through 80° immediately anterior to its mid-point, forming a nearly asymmetrical arch with the anterior bar. It bears 6 to 8 denticles, those on the straight bar being large, laterally compressed, knife-edged, and increasing in height posteriorly; the denticles of the depressed portion of the posterior bar are minute, and subtriangular and isolated.

The apical denticle is tall, massive, laterally compressed, and knife-edged, and bears a rounded costa on the inner face, giving it a subtriangular cross-section. It is inclined inwardly and posteriorly.

The minute basal cavity is situated subapically; the base of the unit is keeled.

Remarks: *F. veeversi* is more symmetrical than *F. tortus* Huddle and appears to be intermediate between it and *F. robertsi* sp. nov.

Genus GENICULATUS Hass, 1953

Type species: *Geniculatus claviger* (Roundy, 1926).

GENICULATUS CLAVIGER (Roundy, 1926)
(Pl. 7, figs 8-10)

1926 *Polygnathus? claviger* Roundy, *U.S. geol. Surv. prof. Pap.* 146, 14, pl. 4, figs 1a-c, 2a, b.
1926 *Prioniodus healdi* Roundy, *ibid.*, 10, pl. 4, figs 5a, b.
1926 *Prioniodus* sp. D, Roundy (part), *ibid.*, 11, pl. 4, figs 13a, b only.
1941 *Euprioniodina?* sp. Branson & Mehl, *Denison Univ., Sci. Lab., Bull.*, 35, 171, pl. 5, figs 17, 18.
1941 *Metalonchodina?* sp. Branson & Mehl, *ibid.*, 172, pl. 5, fig. 15.
1941 *Bactrognathus claviger* (Roundy); Branson & Mehl, *J. Paleont.*, 15, 99.
1941 *Bactrognathus inornata* Branson & Mehl, *ibid.*, 100, pl. 19, figs 14, 15.
1953 *Geniculatus claviger* (Roundy); Hass, *U.S. geol. Surv. prof. Pap.* 243-F, 77, pl. 15, figs 10-19.
1959 *Geniculatus claviger* (Roundy); Voges, *Paläont. Z.*, 33, 279.

Material: 17 specimens; CPC 7854-7856 figured.

Description: Anterior bar long, massive, bearing 6 to 9 laterally compressed knife-edged fused denticles which increase in height anteriorly; however the 2 anteriormost denticles are small, isolated, and subtriangular. The denticles are so fused that they form an unbroken 'sail' in some specimens. The aboral half of the bar is expanded on both sides to give a pseudoplatform which can be greatly expanded.

The posterior bar is short, unexpanded, half the length of the anterior bar, is deflected inward, and bears up to 5 tall free-standing denticles which increase

in height posteriorly except for the posteriormost, which is fairly small. The apical denticle is massive and isolated, subtriangular, and inclined inwardly and posteriorly, and is ovate in cross-section.

The large ovate symmetrical cavity is situated subapically, the long axis being nearly transverse to the axis of the unit. A keel is developed along both bars and a median groove runs over its whole length.

Remarks: *G. claviger* (Roundy) is closely similar to *Lonchodina furnishi* Rexroad, which it morphologically mirrors apart from the expanded anterior bar. This bar expansion is also seen in the genus *Apatognathus*, e.g. *A. porcatus* (Hinde), and may not be of generic significance. Thus *G. claviger* may be more correctly assigned to the genus *Lonchodina*.

Occurrence: The type species occurs in the upper faunal zone of the Barnett Formation, Texas, USA (Hass, 1953). Voges (1959) records it from the upper *Pericyclus* Stufe ($cuII_{\gamma/\delta}$) and *Goniatites* Stufe (cuIII) of Germany. In the Bonaparte Gulf Basin it is found throughout the Utting Calcarenite.

Genus GNATHODUS Pander, 1856

Type species: *Gnathodus mosquensis* Pander, 1856.

GNATHODUS BURTENSIS sp. nov.

(Pl. 8, figs 4-6; Text-fig. 16)

Derivation of name: From the type locality, the Burt Range.

Material: 18 specimens; holotype CPC 7859, paratypes CPC 7857, 7858.

Range: Base of *Siphonodella quadruplicata-S. cooperi* A.Z. to upper *Clydagnathus nodosus* A.Z.

Diagnosis: A simple unornamented gnathodid with depressed platforms and a short blade.

Description: In oral view the platform is subquadrate, one diagonal axis corresponding to the plane of the carina. The inner and outer platforms are mirror images of one another and bear no ornament. The platforms slope away from the carina, the slope becoming less towards the margins. Blade short, about half the length of the platform.

In lateral view the blade is deep, composed of 7 laterally compressed fused denticles with free chevron tips. The carina is fused over the whole length and is lower than the blade; it decreases in height posteriorly. The platform is situated at the mid-height of the blade.

In aboral view the blade encroaches beyond the cavity edge then ends abruptly; a deep pit is present at this point. Running posteriorly from the pit is a keel which deepens posteriorly and forms a short posterior free blade; the posterior termination of the carina is its oral surface.

Remarks: *G. burtensis* probably developed from *P. communis* by the gradual unrolling of the upturned platform margin and eventual depression of the platforms to give a gnathodid type basal cavity. Other unornamented gnathodids have been described—*Gnathodus* n. sp. A. Collinson, *Gnathodus commutatus* (Branson &

Mehl), *Gnathodus symmutatus* Rhodes, Austin, & Druce, and *Gnathodus simplicatus* Rhodes, Austin, & Druce—all of which were probably developed from a spathognathodid ancestor. They all lack the peculiar pit and keel of *G. burtensis* sp. nov.

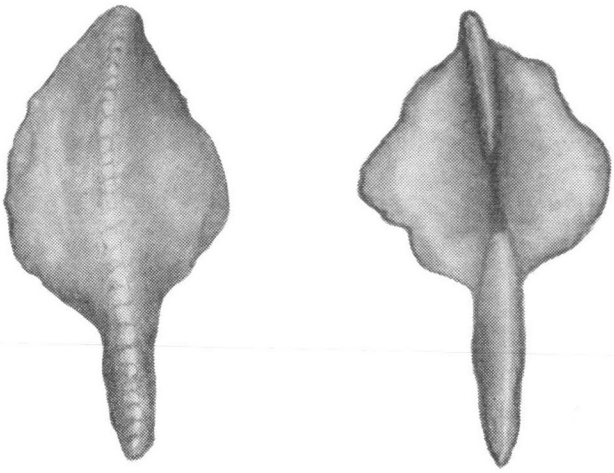

Figure 16. *Gnathodus burtensis* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC7859, x 110.**

GNATHODUS CUNEIFORMIS Mehl & Thomas, 1947
(Pl. 8, fig. 9)

1947 *Gnathodus cuneiformis* Mehl & Thomas, *J. sci. Lab. Denison Univ.*, 47, 10, pl. 1, fig. 2.
1962 *Gnathodus cuneiformis* Mehl & Thomas; Collinson, Scott, & Rexroad, *Ill. geol. Surv. Circ.* 328, chart 3.
1967 *Gnathodus cuneiformis* Mehl & Thomas; Thompson, *Rep. Inv. Mo. geol. Surv.*, 39, 39, pl. 3, fig. 13; pl. 5, fig. 17, 20.
1968 *Gnathodus cuneiformis* Mehl & Thomas; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 8, figs 6a-c.

Occurrence: The species was originally described from the Fern Glen Formation, Missouri, USA (Mehl & Thomas, 1947). Collinson, Scott, & Rexroad (1962, chart 3) give its range as Fern Glen to Middle Burlington in the Upper Mississippi Valley. Rhodes et al. (1968) record the species from a single horizon in the *Seminula* (S) Zone. In the Bonaparte Gulf Basin it occurs in the Utting Calcarenite. Thompson (1967, p. 39) has recently described it from the *Bactrognathus-Pseudopolygnathus multistriatus* and the *Bactrognathus distortus-Gnathodus cuneiformis* Assemblage Zones in southwestern Missouri.

GNATHODUS GIRTYI SIMPLEX Dunn, 1965
(Pl. 8, fig. 10)

1965 *Gnathodus girtyi simplex* Dunn, *J. Paleont.*, 39, 1148, pl. 140, figs 2, 3, 12.
1968 *Gnathodus girtyi simplex* Dunn; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.) Geol., Suppl.* 4, pl. 16, figs 1a-4d.

Figured specimen: CPC 7861.

Remarks: The single specimen recovered agrees with the description given by Dunn (1965, p. 1148) and Rhodes, Austin, & Druce(1968).

Occurrence: *G. girtyi simplex* is known from the upper *Dibunophyllum* (D_2-D_3) Zone in Britain and from the upper Lower Carboniferous (Visean) and lower Namurian of Kilnamona, Co. Clare, Eire. It was originally described from the Chesterian Bird Spring Formation of Nevada, USA (Dunn, 1965). In the Bonaparte Gulf Basin a single specimen is known from the Burvill Beds.

GNATHODUS TEXANUS Roundy, 1926
(Pl. 8, figs 1-3)

1926 *Gnathodus texanus* Roundy, *U.S. geol. Surv. prof. Pap.* 146, 12, pl. 2, figs 7a, b, 8a, b.
1926 *Gnathodus texanus* var. *bicuspidus* Roundy, *ibid.*, 12, pl. 2, figs 9a & b.
1941 *Gnathodus texanus* Roundy; Branson & Mehl, *J. sci. Lab. Denison Univ.*, 35, 173, pl. 5, figs 23-25.
1941 *Gnathodus linguiformis* Branson & Mehl, *ibid.*, 183, pl. 6, figs 18-26.
1941 *Spathognathodus deflexus* Branson & Mehl, *ibid.*, 35, 187, pl. 6, fig. 6.
1953 *Gnathodus texanus* Roundy; Hass, *U.S. geol. Surv. prof. Pap.* 243-F, 80, pl. 14, figs 15-21.
1956 *Gnathodus texanus* Roundy; Elias, *Petroleum Geology of Southern Oklahoma*, 1, 116, pl. 3, figs 32-36.
1956 *Gnathodus pretexanus* Elias, *ibid.*, 115, pl. 3, figs 9-11.
1957 *Gnathodus texanus* Roundy; Bischoff, *Hess. Landesamt. Bodenf., Abh.*, 19, 25, pl. 3, figs 24, 25 only.
1964 *Gnathodus texanus* Roundy; Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 31, pl. 2, figs 11-14.

Material: 34 specimens; CPC 7862-7864 figured.

Description: The outer platform is larger than the inner. It is formed by the flared lip of the basal cavity, which extends nearly to the posterior termination. In some specimens (Pl. 8, fig. 2) it is unornamented, but in most it bears 1 to 3 scattered nodes on the anterior portion adjacent to the carina. The inner platform is restricted to a pillar slightly anterior to the outer platform ornament. The pillar consists of 3 or 4 fused nodes, separated from the carina by a trough.

The carina is a continuation of the blade, the denticles becoming rounded and more node-like toward the posterior. A secondary row of low nodes is developed on the inner face of the carina posterior to the pillar.

In lateral view the unit is highest at the anterior, decreasing in height gradually towards the posterior. The outer platform is about 1/3 the height of the carina, but the upper surface of the pillar is on the same level as the carina.

The basal cavity is flared asymmetrically and is medially grooved; there is a small pit at the anterior end. The groove runs for a short distance along the aborally keeled anterior blade.

Occurrence: *G. texanus* was originally described from the Barnett Formation, Texas, USA (Roundy, 1926). Collinson et al. (1962) give its lowest occurrence as the Keokuk Formation, and Rexroad & Scott (1964) record it from the *Bactrognathus-Taphrognathus* Assemblage Zone of the New Providence Shale in Indiana and Kentucky. In Germany the species is recorded from the uppermost *Pericyclus* Stufe ($cuII_\gamma$) and *Goniatites* Stufe (cuIII) (Bischoff, 1957). In the Bonaparte Gulf Basin the species ranges throughout the Utting Calcarenite.

GNATHODUS sp. A
(Pl. 8, figs 7a, b)

Material: 4 specimens; CPC 7865 figured.

Description: In oral view the platform is restricted and subcircular, with a medial carina. The carina is a continuation of the blade and in its anterior portion is a low ridge. Toward the posterior it is composed of low nodes and becomes lateral, with a secondary row of nodes formed on the inner side toward the posterior end of the platform. The inner and outer platforms are both semicircular and formed of fused transverse ridges separated from the carina by a trough. The platform walls are steep and no flaring of the cavity lips is apparent.

In lateral view the blade is broken, but increases in height anteriorly and is formed of narrow, laterally compressed denticles with free chevron lips. The inner platform is almost as high as the carina, and the outer platform slightly higher.

In aboral view the cavity is asymmetrical and extremely elongate, with a medial groove which extends to the posterior termination and runs for a short distance along the keel of the anterior blade.

Remarks: The additional nodes on the inner surface of the carina and the pillar-like nature of the inner platform are reminiscent of *G. texanus* Roundy, but the well developed and characteristic outer platform serves to distinguish this species.

Occurrence: Bonaparte Beds, interval 1,564 feet 4 inches to 1,564 feet 8 inches in Bonaparte No. 1 Well.

Genus HIBBARDELLA (HIBBARDELLA) Bassler, 1925

Type species: *Prioniodus angulatus* Hinde, 1879.

HIBBARDELLA (HIBBARDELLA) cf. H. MACRODENTATA Thomas, 1949
(Pl. 9, figs 4a-6)

cf. 1949 *Hibbardella macrodentata* Thomas, *Bull. geol. Soc. Amer.* 60, 422, pl. 4, fig. 25.
1968 *Hibbardella (Hibbardella)* cf. *H. macrodentata* Thomas; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 25, figs 16a-18c.

Material: 11 specimens; CPC 7866-7868 figured.

Description: The anterior arch is symmetrical; the bars diverge at 45°; they are ovate in cross-section with a narrow keel on the aboral surface. The aboral proximal half of each bar bears an attachment scar. The oral surface of each bar bears 3 to 5 tall, isolated, slender denticles which have a subcircular cross-section and are posteriorly inclined.

The apical denticle is tall, massive, and posteriorly inclined. A small depression is present at the junction of the apical denticle with the posterior bar; orally the denticle becomes subcircular in cross-section but is twisted, bringing the aboral anterior costa into a latero-oral position. The posterior bar is massive, subcircular in cross-section, and bears isolated peg-like denticles.

A small pit is present beneath the apical denticle and narrow grooves radiate from it for a short distance along the anterior arch and posterior bar.

Remarks: Rhodes, Austin, & Druce (1968) point out that Thomas's holotype of *H. macrodentata* is broken; so, although their specimens are very similar, they only compare them with that figured by Thomas. The present specimens correspond closely to those figured by Rhodes, Austin, & Druce.

Occurrence: Thomas (1949, p. 422) records *H. macrodentata* from the Lower Mississippian English River siltstone of Iowa, USA. Rhodes et al. record it from the *Cleistopora* (K) and *Zaphrentis* (Z) Zones of the Avonian. In the Bonaparte Gulf Basin the species ranges from the upper *Spathognathodus plumulus* Assemblage Zone to the lower *Spathognathodus costatus* Assemblage Zone.

HIBBARDELLA (HIBBARDELLA) cf. H. PLANA Thomas, 1949
(Pl. 9, figs 1-3)

cf. 1949 *Hibbardella plana* Thomas, *Bull. geol. Soc. Amer.* 60, 422, pl. 2, fig. 28.

Material: 5 specimens; CPC 7870-7872 figured.

Description: The anterior arch is short and very deep, with bars diverging at 60° to 120°. The arch is symmetrical; each bar bears 5 to 7 denticles, with 3 to 4 on the proximal half and 2 to 4 on the distal half. The proximal denticles, which are basally fused, laterally compressed, and knife-edged, increase in height distally. The distal denticles are small, subcircular in cross-section, basally fused, and decrease rapidly in height distally.

The apical denticle is tall, massive, and triangular in cross-section, with 3 costae developed, 2 on the lateral faces and a single one on the posterior face. The posterior bar is extremely laterally compressed, but is broken in every recovered specimen. The aboral edge of the posterior bar merges with the anterior arch above the aboral edge of the arch. The basal cavity in some specimens is confined to the subapical area of the anterior arch; in others it occurs on the posterior face of the arch and the anterior aboral portion of the posterior bar.

In anterior view the medial part of the anterior arch is thickened immediately above the aboral edge and beneath the massive proximal denticles to give an anterior 'chine'.

Remarks: There is considerable variability in the arching of the anterior arch within the specimens studied. Some specimens appear to be identical with the holotype illustrated by Thomas (1949, pl. 2, fig. 28).

Occurrence: Thomas (p. 422) records *H.* (*H.*) *plana* from the probable Upper Devonian Maple Mill shale of Iowa, USA. In the Bonaparte Gulf Basin *H.* cf. *H. plana* ranges from the Middle *Siphonodella sulcata-Polygnathus parapetus* A.Z. to the lower *S. quadruplicata-S. cooperi* A.Z.

HIBBARDELLA (HIBBARDELLA) TELUM? Huddle, 1934
(Pl. 8, figs 8a, b)

1934 *Hibbardella? telum* Huddle, *Bull. Amer. Paleont.*, 31, 79, pl. 3, figs 10-12.

Material: 2 specimens.

Description: The anterior arch is laterally compressed, with shallow bars diverging at 60°. Each bar bears 5 to 6 laterally compressed denticles, which increase in height distally, except for the ultimate denticle, which is minute; the denticles are fused at their bases, but the tips are free.

The apical denticle is extremely tall and slender, bearing 3 costae (2 lateral and one on the posterior face), and is recurved.

The posterior bar is broken, but appears to be long and laterally compressed, bearing at least 8 needle-like, posteriorly inclined denticles.

In aboral view the 3 bars are keeled and a minute subapical basal cavity is present at the bar junction. No part of the bar is grooved.

Occurrence: This species occurs in the Westwood Member of the Cockatoo Formation.

HIBBARDELLA (HIBBARDELLA) sp. nov.
(Pl. 8, figs 12a, b)

Material: 3 specimens; CPC 7869 figured.

Description: The anterior arch is extremely laterally compressed and deep; the bars diverge at about 100° and each bears 4 to 6 denticles. They are elongate, with fused aboral halves and free tips. An attachment scar is present on the aboral quarter of both bars. The apical denticle is laterally compressed and is posteriorly inclined.

The posterior bar is long and laterally compressed, and bears a number of fine posteriorly inclined denticles.

Aborally a minute pit is situated subapically and fine grooves run for a short distance along the anterior arch and the length of the posterior bar.

Occurrence: Upper *Siphonodella quadruplicata-S. cooperi* A.Z.

HIBBARDELLA (HIBBARDELLA) sp. A
(Pl. 8, figs 11a, b)

?1959 *Ellisonia* sp. Helms, *Geologie,* 8, 641, pl. 2, figs 3a, b.

Material: 2 specimens.

Description: The unit is extremely laterally compressed. The posterior bar is slightly depressed and bears needle-like denticles which vary in size but are not arranged cyclically. The anterior arch is deflected anteriorly and each limb makes an angle of 60° aborally. They bear fine needle-like denticles. The apical denticle is laterally compressed and is twice as high as the unit and slightly inclined posteriorly. In aboral view no basal cavity could be seen.

Remarks: Helms (1959, p. 641) describes a specimen from Upper Devonian toIII-toIV strata in the Sauerlandes which is similar to *Hibbardella* sp. A. Helms refers his specimen to the genus *Ellisonia,* but both Hass (1962, p. 250) and Lindstrom (1964, p. 176) consider that *Ellisonia* is a junior synonym of *Hibbardella.*

Occurrence: *Siphonodella quadruplicata-S. cooperi* A.Z.

Genus HIBBARDELLA (HASSOGNATHUS) Rhodes, Austin, & Druce, 1968

Type species: *Trichognathus separata* Branson & Mehl, 1934.

HIBBARDELLA (HASSOGNATHUS) SEPARATA (Branson & Mehl, 1934)

1934 *Trichognathus separata* Branson & Mehl, *Univ. Missouri Stud.*, 8, 290, pl. 23, fig. 30.
1968 *Hibbardella (Hassognathus) separata* Branson & Mehl; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 25, figs 13a-14 (Synonymy).

Material: 5 specimens.

Description: The anterior arch bears 5 main denticles, separated by minor denticles, on each limb. The arch makes an angle of 90°, with a subcircular apical denticle at the apex. The posterior bar is broken. An attachment scar is present on the posterior and anterior faces of the anterior arch.

Occurrence: Rhodes et al. record the range as uppermost *Cleistopora* (K) to *Caninia* (C) Zone. In the Bonaparte Gulf Basin the species occurs from the *Siphonodella sulcata-Polygnathus parapetus* A.Z. to the *Clydagnathus nodosus* A.Z.

HIBBARDELLA? sp.
(Pl. 9, figs 7a-c)

Material: Figured specimen CPC 7874.

Description: The posterior bar is massive, bearing at least 6 massive laterally compressed free-standing posteriorly inclined denticles. The apical denticle is massive and lies in the plane of the posterior bar. The anterior arch is asymmetrical, one limb being deflected posteriorly and one anteriorly. Both bear massive free-standing posteriorly inclined denticles. The basal cavity is beneath the apical denticle; it narrows gradually posteriorly, running as a narrow groove for half the length of the unit. It curves on to the posterior limb of the anterior arch for a short distance, but is not present on the anterior limb.

Remarks: The present specimen corresponds closely to the holotype of *Roundya plana* Helms (1959, p. 654). However, the peculiar symmetry of the anterior arch and the absence of the basal cavity on one limb make it doubtful whether the form should be placed in *Hibbardella*. It could possibly be placed in the genus *Centrognathodus*. If it were placed in *Hibbardella, Roundya plana* Helms would become a homonym of *H. plana* Thomas (1949, p. 422).

Occurrence: This form occurs in the Upper Devonian Ningbing Limestone.

Genus HINDEODELLA Bassler, 1925

Type species: *Hindeodella subtilis* Ulrich & Bassler, 1926.

HINDEODELLA BREVIS Branson & Mehl, 1934
(Pl. 10, figs 1, 2)

1934 *Hindeodella brevis* Branson & Mehl, *Univ. Missouri Stud.*, 8, 195, pl. 14, figs 6, 7.
1968 *Hindeodella brevis* Branson & Mehl; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4 (Synonymy).

Material: 15 specimens; CPC 7880, 7881 figured.

Description: The anterior bar is short and deflected through 90° and is extremely laterally compressed; it bears fine, needle-like, fused denticles. The apical denticle is small, of the same order of size as the bar denticles. The posterior bar is short, laterally compressed, and bears 6 or more laterally compressed, posteriorly inclined denticles, both size and inclination increasing posteriorly. The whole unit is keeled and no basal cavity is apparent.

Occurrence: In the Bonaparte Gulf Basin *H. brevis* occurs at the 7/1 locality and ranges from the *Siphonodella sulcata-Polygnathus parapetus* A.Z. to the *Clydagnathus nodosus* A.Z.

HINDEODELLA COMPRESSA Huddle, 1934

1934 *Hindeodella compressa* Huddle, *Bull. Amer. Paleont.*, 31, 41, pl. 5, fig. 4.

Material: 6 specimens; CPC 7883, 7884 figured.

Description: The unit is bowed and arched; the posterior bar is twice as long as the anterior bar and has similar dentition. The denticles are fine, needle-like, subcircular in cross-section, cyclically developed, and increase in size and posterior inclination toward the posterior. The apical denticle is small, only fractionally larger than the adjacent bar denticles. The whole unit is keeled and lacks an obvious basal cavity.

Occurrence: In the Bonaparte Gulf Basin this species is restricted to the *Siphonodella quadruplicata-S. cooperi* A.Z.

HINDEODELLA CORPULENTA Branson & Mehl, 1934
(Pl. 10, figs 5-7)

1934 *Hindeodella corpulenta* Branson & Mehl, *Univ. Missouri Stud.*, 8, 281, pl. 22, figs 32, 33.
1968 *Hindeodella corpulenta* Branson & Mehl, Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 29, figs 16a-17c (Synonymy).

Material: 62 specimens; CPC 7877, 7891 figured. (CPC 7891 is not unequivocally placed in *corpulenta.*)

Description: The anterior bar is short and is deflected through 90° and depressed through 70°-90°. It bears 4 to 5 subcircular, isolated, posteriorly inclined denticles. The apical dentical is subcircular in cross-section, tall and posteriorly recurved. The posterior bar is straight or slightly depressed and bears 5 to 7 laterally compressed, posteriorly inclined denticles increasing in size and inclination posteriorly.

A large expanded cavity is present beneath the apical denticle and extends a short distance along the posterior bar.

Occurrence: Throughout the Tournaisian.

HINDEODELLA SUBTILIS Ulrich & Bassler, 1926
(Pl. 10, figs 3, 4)

1926 *Hindeodella subtilis* Ulrich & Bassler; *Proc. U.S. nat. Mus.* 68, 39, pl. 8, figs 17-19.
1968 *Hindeodella subtilis* Ulrich & Bassler, Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 29, figs 6a-7b; 9-10b (Synonymy).

Material: 58 specimens; CPC 7878, 7879 figured.

Description: The apical denticle is tall, slender, ovate in cross-section, and inclined posteriorly. The anterior bar is deflected through 90° immediately anterior to the apical denticle and is laterally compressed, bearing 4 to 7 needle-like denticles with fused bases and free tips. The posterior bar is slightly depressed and bears alternating denticles, 2 major denticles being separated by 1 to 3 minor denticles; there are 5 to 7 major denticles, which increase in size and inclination posteriorly.

An attachment scar is present on the aboral third of both bars in some specimens.

A minute basal cavity is developed beneath the apical denticle and a sharp keel is present on both bars.

Occurrence: In the Bonaparte Gulf Basin *H. subtilis* ranges from the base of the Tournaisian to the lower *Spathognathodus costatus* A.Z.

HINDEODELLA UNCATA (Hass, 1959)
(Pl. 10, figs 8-9b)

1959 *Hindeodina uncata* Hass, *U.S. geol. Surv. prof. Pap.* 294-J, 383, pl. 47, fig. 6.

Material: 4 specimens; CPC 7875, 7876 figured.

Description: The unit is characterized by the anterior bar, which is deflected through 90° and bears 4 to 6 circular free-standing denticles. The posterior bar is twice as long as the anterior bar and bears about 20 similar denticles which increase in size posteriorly. The apical denticle is only just longer than the adjacent bar denticles but is distinguished by being inclined inwardly.

Occurrence: The species is confined to the 7/1 locality in the Ningbing Range.

HINDEODELLA sp.
(Pl. 10, figs 10a, b)

Material: 3 specimens; CPC 7882 figured.

Description: The unit is small; the bars are of equal length and bear similar denticles. The denticles are fine and needle-like and are developed cyclically, one large denticle alternating with 2 small ones; the dentition increases in size distally. Both bars are deflected inward, the anterior one slightly more than the posterior one. The apical denticle is of the same order of size as the terminal denticles and is laterally inclined.

In aboral view the unit is knife-edged and lacks a basal cavity.

Occurrence: The species is confined to the 7/1 locality in the Ningbing Range.

Genus ICRIODUS Branson & Mehl, 1934

Type species: *Icriodus expansus* Branson & Mehl, 1938.

ICRIODUS ALTERNATUS Branson & Mehl, 1934
(Pl. 11, figs 1-2c)

1934 *Icriodus alternatus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 225, pl. 13, figs 4-6.
1968 *Icriodus alternatus* Branson & Mehl; Druce, *Bur. Miner. Resour. Aust. Bull.* 108 (Synonymy).

Material: 3 specimens; CPC 7888, 7889 figured.

Range: Cockatoo and lower part of Ningbing Formations.

Description: The platform is elongate and bears 3 rows of low erect nodes. The median row extends posteriorly, over the expanded basal cavity, beyond the lateral rows; at least 4 nodes are present on this extension. The nodes on the lateral rows are paired and the medial row nodes alternate with them. The basal cavity extends over the whole unit, it is widest at the posterior and narrows toward the anterior.

Occurrence: See Druce (1968a).

ICRIODUS RECTUS Youngquist & Peterson, 1947
(Pl. 11, figs 3-5)

1947 *Icriodus rectus* Youngquist & Peterson, *J. Paleont.* 21, pl. 37, figs 3, 4, 13, 14, 26.
1947 *Icriodus lanceolatus* Youngquist & Peterson, *ibid.*, 247, pl. 37, figs 16, 17.
1955 *Icriodus cornutus* Sannemann, *Senck. leth.*, 130, pl. 4, figs 19a-c, 20, 21.
1956 *Icriodus cornutus* Sannemann; Bischoff, *Hess. Landesamt. Bodenf. Notizbl.*, 84, 125, pl. 10, fig. 42.
1956 *Icriodus cornutus* Sannemann; Bischoff & Ziegler, *ibid.*, p. 147.
1957 *Icriodus cornutus* Sannemann; Ziegler *in* Flugel & Ziegler, *Naturw. Ver. Steiermark, Mitt.*, 87, tab. 1.
1957 *Icriodus* cf. *I. alternatus* Lys & Serre, *Inst. franç. Pétrole, Rev.*, 12, 1044, pl. 3, figs 5a, b.
1958 *Icriodus cornutus* Sannemann; Ziegler, *Hess. Landesamt Bodenf. Notizbl.*, 87, 20.
1960 *Icriodus cornutus* Sannemann; Serre & Lys, *Int. geol. Cong., 21st Sess.*, 6, 38.
1961 *Icriodus cornatus Sannemann;* Lys et al., *Rev. Inst. franç. Pétrole,* 16, 545, pl. 1, figs 8, 9.
1961 *Icriodus cornutus* Sannemann; Freyer, *Freiberger Forschr.*, C-95, 47, pl. 1, fig. 32, pl. 2, fig. 33.
1962 *Icriodus cornutus* Sannemann; Ziegler, *Hess. Landesamt. Bodenf. Abh.*, 38, 52.
1962 *Icriodus cornutus* Sannemann; Ethington & Furnish, *J. Paleont.*, 36, 1269, pl. 172, fig. 7, 8.
1965 *Icriodus cornutus* Sannemann; Ethington, *ibid.*, 39, 574.
1966 *Icriodus rectus* Youngquist & Peterson; Anderson, *J. Paleont.*, 40, 406.

Material: 9 specimens; CPC 7885-7 figured.

Range: Early Famennian part of Ningbing Limestone.

Description: The platform is small, twice as long as wide, and bears 3 rows of nodes. The median row consists of 3 or 4 small nodes, and is terminated at either end by a larger node. The posterior node is large and inclined posteriorly, and extends as a short horn. The lateral rows consist of larger discrete nodes which

alternate with the nodes of the median row. The basal cavity is widest posteriorly, where it is asymmetrical, narrows rapidly anteriorly, and continues to the anterior termination as a narrow groove.

Remarks: Anderson (1966, p. 406) discusses the synonymy of *I. rectus* and *I. cornutus* Sannemann, and suggests that *I. cornutus* is a junior synonym of *I. rectus*. From the descriptions and illustrations this view appears to be correct.

Occurrence: *I. rectus* is known from the United States, France, and Germany. In the USA it occurs in the Sheffield Formation, considered by Anderson (1966, p. 400) to be of toI_{γ}-$toII_{\alpha}$ age. In Europe it ranges from the toI-toII boundary to earliest $toIII_{\alpha}$ (Ziegler, 1962, p. 52).

ICRIODUS sp.
(Pl. 11, figs 6a-c)

Material: 1 specimen, CPC 7890.

Description: The unit is small and is almost as wide as long, bearing 3 rows of nodes on the oral surface. The median row consists of a low fused ridge which terminates in a large horn-like node. The lateral rows consist of 6 discrete nodes.

The basal cavity is greatly expanded posteriorly with a large asymmetrical flair on the inner side; it narrows rapidly toward the anterior termination.

Remarks: This specimen is similar to forms referred to *I. rectus* Youngquist & Miller, but the greatly expanded basal cavity is distinctive. Krebs & Ziegler (1966, pl. 2, figs 12-15) illustrate similar forms. They refer them to *Icriodes* (sic) n. sp., stating that they occur in toI_{γ} strata at Aachen, Germany.

Occurrence: The species occurs in the Famennian Ningbing Limestone.

Genus LIGONODINA Bassler, 1925

Type species: *Ligonodina pectinata* Ulrich & Bassler, 1926.

LIGONODINA ANGULATA Branson & Mehl, 1938
(Pl. 12, fig. 3)

1938 *Ligonodina angulata* Branson & Mehl; *Univ. Missouri Stud.* 13, 142, pl. 34, fig. 43.
1944 *Ligonodina angulata* Branson & Mehl; E. B. Branson, *ibid.*, pl. 39, fig. 43.

Material: 3 specimens; CPC 7892 figured.

Description: The apical denticle is tall, massive, ovate in cross-section and inclined posteriorly. A narrow costa runs along the anterior margin except in the aboral quarter, where it assumes an anterolateral position and extends on to the lateral bar. The lateral bar is massive, circular in cross-section, bearing low circular isolated nodes. The posterior bar is massive, circular in cross-section, deflected inward slightly and bearing massive isolated laterally compressed denticles with posterior and anterior knife-edges. The denticle next but one to the apical denticle is extremely massive and of the same order of size as the apical denticle.

A shallow pit is developed in a subapical position, but does not extend along either bar. The posterior bar has a shallow keel along its whole length.

Occurrence: *L. angulata* is confined to the *Clydagnathus nodosus* A.Z. in the Bonaparte Gulf Basin.

LIGONODINA BICINCTA Huddle, 1934
(Pl. 11, figs 4a, b)

1934 *Ligonodina bicincta* Huddle, *Bull. Paleont.*, 31, 62, pl. 12, fig. 15.
1934 *Ligonodina cryptodens* Huddle, *ibid.*, 62, pl. 12, figs 16, 17.
1947 *Ligonodina bicincta* Huddle; Youngquist, *J. Paleont.*, 21, 104, pl. 25, figs 10, 18.

Material: 2 specimens; CPC 7893 figured.

Description: The apical denticle is tall, slender, ovate in cross-section and slightly inclined posteriorly. The lateral bar joins it in an antero-aboral position and is deflected to the posterior, making an angle of 45° with the posterior bar. It is depressed through about 70° and bears 5 discrete subcircular denticles which are about a fifth the height of the apical denticle. The posterior bar is long, slender, and laterally compressed and bears 6 discrete, laterally compressed, posteriorly inclined denticles. Their size is greatest at the midpoint. The tallest denticles are about half the height of the apical denticle.

The basal cavity lies beneath the apical denticle and extends as a narrowing groove along half the length of the posterior bar.

Occurrence: *L. bicincta* is confined to the 7/1 locality in the Ningbing Range.

LIGONODINA FLEXUOSA Branson & Mehl, 1934
(Pl. 12, figs 1a-2b)

1934 *Ligonodina flexuosa* Branson & Mehl, *Univ. Missouri Stud.*, 8, 199, pl. 15, fig. 28.

Material: 2 specimens; CPC 7894, 8099 figured.

Description: The apical denticle is tall, slender, ovate in cross-section and inclined posteriorly. The lateral bar, which joins it in an antero-aboral position, is sigmoidal, being deflected anteriorly then posteriorly and finally anteriorly again, and, superimposed on this deflection, it is depressed through 90°. It is subcircular in cross-section and bears 4 or 5 short, discrete, subcircular denticles. The posterior bar is broken but is laterally compressed, and bears a number of circular, discrete, posteriorly inclined denticles.

A minute cavity occurs beneath the apical denticle and extends as a narrow medial groove along both bars.

Occurrence: *L. flexuosa* is confined to the upper part of the *Spathognathodus plumulus* A.Z.

LIGONODINA sp. A
(Pl. 11, figs 8a, b)

Material: 3 specimens; CPC 7896 figured.

Description: The apical denticle is tall, slender, and inclined posteriorly. The posterior bar is elongate and slightly depressed, and bears at least 7 discrete free-standing denticles, of which the median ones are the tallest. The anterolateral bar is short and bears 3 tall isolated denticles, and lies at right angles to the apical denticle.

The basal cavity is large, extending along both bars for some distance. The inner lip forms a web between the anterolateral and posterior bars.

Occurrence: Famennian Ningbing Limestone.

LIGONODINA sp. B

Material: 1 specimen.

Description: The apical denticle is massive and laterally compressed with slight oral twisting, the anterior knife-edge encroaching on the inner lateral face. The anterolateral bar is massive, bearing 5 denticles, of which those at either end are minute and the median 3 are massive, compressed in the plane of the bar and inclined posteriorly. The bar is only slightly depressed and lies at an angle of nearly 90° with the posterior bar, which is broken but bears massive free-standing denticles.

There is a broad attachment scar on the aboral surface and aboral halves of the lateral faces of the posterior bar.

Occurrence: Upper part of the *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z.

Genus LONCHODINA Bassler, 1925

Type species: *Lonchodina typicalis* Ulrich & Bassler, 1926.

LONCHODINA FURNISHI Rexroad, 1958
(Pl. 12, figs 4a, b)

1958 *Lonchodina furnishi* Rexroad, *Ill. geol. Surv. Rep.* 209, 22, pl. 4, figs 11-13.
1968 *Lonchodina furnishi* Rexroad; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 24, figs 20a-23c (Synonymy).

Material: 14 specimens; CPC 7897 figured.

Description: The apical denticle is laterally compressed, discrete, and inclined posteriorly and inwardly. The anterior bar is long, ovate in cross-section, bearing 7 to 9 laterally compressed denticles fused at their bases and free at their tips. Their height increases anteriorly for three quarters of the bar length, and then decreases, the anteriormost being minute. The posterior bar is short, less than half the length of the anterior bar, and bears 3 or 4 short, discrete, laterally compressed denticles. The whole bar is depressed and deflected slightly inward.

The basal cavity is subapical and is flared; the long axis of the cavity is at right angles to the long axis of the unit. A faint basal groove runs along both bars.

Remarks: The similarity between *Lonchodina furnishi* and *Geniculatus claviger* Hass is discussed under the latter species.

Occurrence: *Lonchodina furnishi* is known from the Golconda-Glen Dean Interval of the Chesterian (Collinson et al., 1962, chart 4). In Britain the species has been recorded from the uppermost *Dibunophyllum* (D_3) Zone in South Wales, and from the Gilmerton, Hosie, and Upper Long Craig Limestones of Scotland (Rhodes et al., 1968). In the Bonaparte Gulf Basin the species is found in the lower part of the Utting Calcarenite.

Genus MAGNILATERELLA Rexroad & Collinson, 1963

Type species: *Magnilaterella robusta* Rexroad & Collinson, 1963.

?MAGNILATERELLA sp.
(Pl. 13, figs 1a, b)

Material: 2 specimens; CPC 7898 figured.

Description: The bars are of equal length, both bearing similar tall isolated denticles which are circular in cross-section. The bars lie at 90° to each other and it is difficult to distinguish either as anterolateral or a posterior bar. A broad attachment scar is present at the bar junction and extends along both bars.

Occurrence: Upper *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Genus MESTOGNATHUS Bischoff, 1957

MESTOGNATHUS BECKMANNI Bischoff, 1957
(Pl. 13, figs 4a-5b)

1957 *Mestognathus beckmanni* Bischoff, *Hess. Landesamt. Bodenf., Abh.*, 37, pl. 2, figs 4a-d 5, 6, 8, 9.
1960 *Mestognathus beckmanni* Bischoff; Kronberg et al., *Fortsch. Geol. Rhein. Westf.*, 3, 14, pl. 3, figs 1a, b.
1962 *Mestognathus beckmanni* Bischoff; Meischner, *Hess. Landesamt. Bodenf., Abh.* 39, text-fig. 10.
1967 *Mestognathus beckmanni* Bischoff; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 9, figs 15-22, pl. 10, figs 11a, b, 18a, b.

Material: 14 specimens; CPC 7899, 8334 figured.

Description: The platform is lanceolate, with a blade developed on the outer side (left when viewed from the anterior). The ornament consists of two lateral rows of transverse ribs and a median carina. The carina joins with the inner platform edge at the anterior end to form the undenticulate inner free blade; it assumes a medial position in the posterior, where it is produced as a short posterior free blade. The inner platform ornament consists of low nodes on the platform edge and faint transverse ridges which fade away toward the carina. The outer platform ornament consists of transverse ridges extending laterally slightly beyond

the outer face of the outer blade. They die away toward the carina, where a faint trough is present; the trough rapidly deepens anteriorly alongside the outer blade. Both platforms rapidly narrow posteriorly.

In lateral view the outer blade forms nearly half the length of the unit and is composed of up to 10 extremely laterally compressed and fused denticles which increase in height and size posteriorly. The posteriormost denticle is discrete and in some cases lies partly outside the plane of the blade. The outer blade is twice the height of the platform. The inner blade is formed of a solitary node situated at the anterior termination of the carina and the inner platform edge.

The minute cavity is developed medially and a faint groove runs along the posterior keel. Anterior to the cavity the keel bifurcates beneath the inner and outer free blades.

Occurrence: *M. beckmanni* is known from Germany and Britain. In Germany it ranges from the upper *Pericyclus* Stufe (cuII$_{\beta/\gamma}$) to the upper part of the *Goniatites* Stufe (Voges, 1959; Meischner, 1962). In Britain the species ranges from the *Mestognathus beckmanni-Polygnathus bischoffi* Assemblage Zone to the *Gnathodus monodosus* Assemblage Zone (Rhodes et al., 1968). In the Bonaparte Gulf Basin the species occurs throughout the Utting Calcarenite, and is known from a depth of 4,931 feet in the Bonaparte No. 2 Well.

MESTOGNATHUS NEDDENSIS Rhodes, Austin, & Druce, 1968
(Pl. 13, figs 2a-c, 3)

1968 *Mestognathus neddensis* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 15, figs 4a-6c.

Material: 4 specimens; CPC 7900, 7901 figured.

Occurrence: Rhodes et al. give the range as upper *Dibunophyllum* Zone (uppermost D_2) on the North Crop of the South Wales Coalfield. In the Bonaparte Gulf Basin the species occurs in the Utting Calcarenite.

Genus NEOPRIONIODUS Rhodes & Müller, 1956

Type species: *Prioniodus conjunctus* Gunnell, 1931.

NEOPRIONIODUS BARBATUS (Branson & Mehl, 1934)
(Pl. 14, fig. 3)

1934 *Prioniodus barbatus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 288, pl. 23, figs 19, 20.
1968 *Neoprioniodus barbatus* (Branson & Mehl); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 21, figs 4-7 (Synonymy).

Material: 2 specimens; CPC 7902 figured.

Description: The apical denticle is tall, erect, and laterally compressed, with the anterior aboral portion projected aborally. The posterior bar is short; it bears 6 or 7 fused denticles which decrease in height posteriorly to give a subtriangular bar in lateral view. The basal cavity is subapical and large with flaring lips; the anterior portion of the blade is also excavated.

Occurrence: Upper part of the *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z.

NEOPRIONIODUS CONFLUENS (Branson & Mehl, 1934)
(Pl. 14, figs 11a-12)

1934 *Prioniodus confluens* Branson & Mehl (part), *Univ. Missouri Stud.*, 8, 206, pl. 15, fig. 6 (*non* pl. 15, fig. 17 = *N. alatus*).
1968 *Neoprioniodus confluens* (Branson & Mehl); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 21, figs 2a, b; 8a, b (Synonymy).

Material: 62 specimens; CPC 7903, 8335 figured.

Description: The apical denticle is tall and laterally compressed, with anterior and posterior knife-edges. The antero-aboral margin is projected aborally as a fang. The basal cavity is situated in a postero-aboral position and the inner lip is greatly flared. The posterior bar is deep, bearing at least 13 denticles which are fused except for their free chevron tips; they are laterally compressed and knife-edged. An attachment scar is present on the aboral margin of the posterior bar and the aboral projection of the apical denticle.

Remarks: One specimen (Pl. 14, figs 11a, b) shows cyclical dentition of the posterior bar; another (Pl. 14, fig. 12) shows uniform dentition. They may therefore belong to different species, though the overall morphology is so similar that I have placed both in *N. confluens*.

Occurrence: Throughout the Tournaisian.

NEOPRIONIODUS PERACUTUS (Hinde, 1900)
(Pl. 14, fig. 6)

1900 *Prioniodus peracutus* Hinde (part), *Trans. nat. Hist. Soc.*, 5, 343, pl. 10, fig. 22 only.
1968 *Neoprioniodus peracutus* (Hinde), Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 21, figs 12a-15b (Synonymy).

Material: 1 specimen, CPC 8336.

Description: The apical denticle is tall and laterally compressed, with a concave inner and a convex outer face. The anterior face is knife-edged and projected downward into an aboral fang. The cavity extends over the aboral surface of the apical denticle; the lips are thickened but not flared. The posterior bar is laterally compressed and bears a series of fused needle-like denticles decreasing in height rapidly toward the posterior.

Occurrence: The species is confined to the Visean Utting Calcarenite.

NEOPRIONIODUS RECURVUS (Branson & Mehl, 1934)
(Pl. 14, figs 5a, b)

1934 *Neoprioniodus recurvus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 288, pl. 23, figs 16, 17.
1938 *Neoprioniodus recurvus* Branson & Mehl; Branson & Mehl, *ibid.*, 13, pl. 33, fig. 39.
1944 *Neoprioniodus recurvus* Branson & Mehl; Branson, *ibid.*, 19, 181, pl. 32, fig. 39.
1953 *Neoprioniodus insolitus* Hass, *U.S. geol. Surv. Prof. Pap.* 294-J, 383, pl. 48, figs 19, 22.

Material: 2 specimens; CPC 7907 figured.

Description: Posterior bar depressed and deflected slightly, bearing at least 15 tall, erect needle-like denticles fused at their bases. The anteriormost denticle is minute, but the immediately adjacent denticles are tall and subcircular in cross-section. The remaining denticles decrease in height towards the posterior termination. The apical denticle is massive and is produced slightly antero-aborally as a blunt antecusp.

The basal cavity is situated subapically and has a flared lip on the inner lateral face.

Remarks: *N. recurvus* is similar to *N. confluens* (Ulrich & Bassler), but is distinguished from it by the short blunt antecusp and the shorter posterior bar.

Occurrence: *N. recurvus* is confined to the upper part of the *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z. It has been recovered from the Bushberg Sandstone of Missouri (Branson & Mehl, 1934, 1938).

NEOPRIONIODUS? TORTUS sp. nov.
(Pl. 14, figs 1a, b; Text-fig. 17)

Material: 16 specimens; holotype CPC 7905; paratype CPC 7904.

Diagnosis: A unit with an apical denticle, a twisted posterior bar, and no basal cavity.

Description: The apical denticle is tall, erect, and subovate in cross-section. Its anterior aboral margin is produced anteriorly into a subtriangular, anteriorly produced, undenticulate process. The posterior bar is twisted: none of the 4 to 5 denticles lies in the plane of the apical denticle. The bar and denticles are laterally compressed, the denticles are discrete and triangular, decreasing rapidly in height posteriorly. The unit is keeled; no basal cavity is apparent.

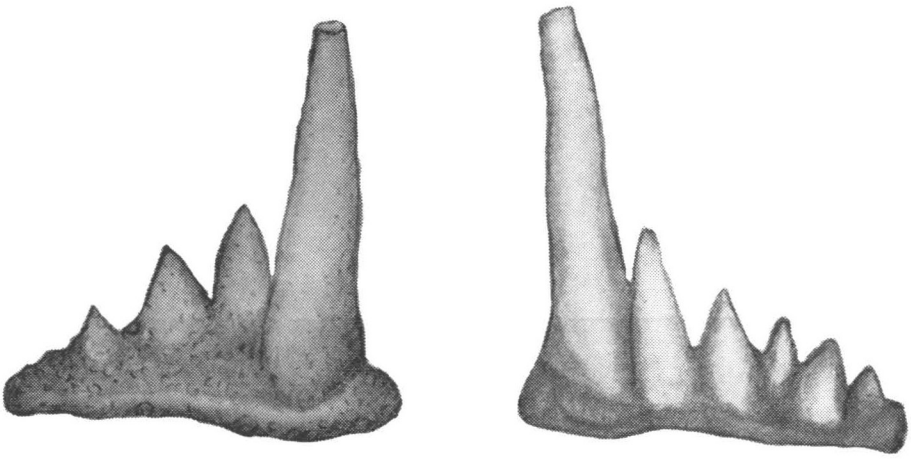

Figure 17. *Neoprioniodus? tortus* **sp. nov. (a) Inner and (b) outer lateral views of holotype, CPC7905, x 90.**

Remarks: The absence of a basal cavity is distinctive. Rhodes & Müller (1956, p. 698) in their generic description of *Neoprioniodus* state: 'The groove and basal cavity may in some cases be entirely absent'. However, this difference in a major morphological character would appear to be of generic value, and the species is only questionably referred to *Neoprioniodus*.

Occurrence: *N.? tortus* is confined to the back-reef facies of the Ningbing Limestone.

NEOPRIONIODUS cf. N. ARMATUS (Hinde, 1879)
(Pl. 14, fig. 4)

cf. 1879 *Prioniodus armata* Hinde (part), *Quart. J. geol. Soc. Lond.*, 35, 360, pl. 15, fig. 20 only.

Material: 10 specimens; CPC 8337 figured.

Description: Main cusp of medium height, erect, and laterally compressed, with anterior and posterior knife-edges. A slight antecusp may be present, and the aboro-posterior basal cavity makes an angle of 45° with the horizontal posterior bar. The cavity extends along the anterior half of the posterior bar. The posterior bar is short and bears from 5 to 7 short laterally compressed denticles which incline posteriorly.

Occurrence: *Spathognathodus plumulus* A.Z. to *Clydagnathus nodosus* A.Z. in the Bonaparte Gulf Basin.

NEOPRIONIODUS sp.
(Pl. 14, fig. 7)

Material: 2 specimens; CPC 7906 figured.

Description: The main cusp is recurved anteriorly, tall, slender, and laterally compressed. A small aborally situated basal cavity is developed, with thick unflaring lips. A shorter posterior bar bears 7 short laterally compressed posteriorly inclined denticles.

Occurrence: Uppermost *Spathognathodus plumulus* A.Z.

Genus OZARKODINA Branson & Mehl, 1933

Type species: *Ozarkodina typica* Branson & Mehl, 1933.

OZARKODINA ELEGANS (Stauffer, 1938)
(Pl. 16, figs 1a, b)

1931 *Bryantodus inequalis* Holmes; Cooper, *J. Paleont.*, 5, 147, pl. 20, fig. 5.
1938 *Ctenognathus elegans* Stauffer, *J. Paleont.*, 12, 424, pl. 48, figs 9-12.
1938 *Ctenognathus falcatus* Stauffer, *ibid.*, 425, pl. 48, figs 1, 5.
1938 *Ctenognathus falsiformis* Stauffer, *ibid.*, 425, pl. 48, figs 4, 7.
1938 *Ctenognathus firmus* Stauffer, *ibid.*, 425, pl. 48, figs 2, 6, 15.
1940 *Ctenognathus elegans* Stauffer; Stauffer, *ibid.*, 14, 422, pl. 59, figs 3-5, 8.
1945 *Ctenognathus falcatus* Stauffer; Youngquist, *J. Paleont.*, 19, 358, pl. 55, fig. 1.
1947 *Ctenognathus falciformis* Stauffer; Youngquist, *ibid.*, 21, p. 99, pl. 25, fig. 3.
1950 *Ozarkodina* sp. Youngquist & Downs, *ibid.*, 24, 670, pl. 87, figs 1, 2.

1955 *Ozarkodina elegans* (Stauffer); Sannemann, *Senck. leth.*, 36, 133, pl. 6, fig. 9.
1957 *Ozarkodina elegans* (Stauffer); Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 22, 76, pl. 20, figs 29-33.
1958 *Ozarkodina elegans* (Stauffer); Ziegler, *Hess. Landesamt. Bodenf. Notizbl.*, 87, 13.
1960 *Ozarkodina elegans* (Stauffer); Serre & Lys, *Int. geol. Cong., 21st Sess.*, 6, 38.
1961 *Ozarkodina elegans* (Stauffer); Freyer, *Freiberger Forschr.*, C-95, 57.
1962 *Ozarkodina elegans* (Stauffer); Ethington & Furnish, *J. Paleont.*, 36, 1277.
1963 *Ozarkodina elegans* (Stauffer); van den Boogaard, *Geol. Mijnb.*, 42, 253.
1964 *Ozarkodina elegans* (Stauffer); Budurov & Tschunev, *Bull. Inst. Sci. Rech. Géol.*, 1, pl. 4, fig. 13.
1965 *Ozarkodina elegans* (Stauffer); Ethington, *J. Paleont.*, 39, 577, pl. 68, fig. 15.

Material: 4 specimens; CPC 7919 figured.

Description: The unit is bowed and arched; the bars are of equal length, and bear similar dentition, consisting of 8 to 10 fine needle-like, basally fused denticles with posteriorly inclined free tips on each bar. The height of the denticles gradually decreases terminally. The apical denticle is similar to the bar denticles but is longer and twice as wide. The basal cavity is small and is situated beneath the apical denticle.

Occurrence: Famennian Ningbing Limestone.

OZARKODINA ETHYS (Cooper, 1939)
(Pl. 16, fig. 3)

1939 *Subbryantodus ethys* Cooper, *J. Paleont.*, 13, 417, pl. 43, fig. 15.
1960 *Ozarkodina regularis* Branson & Mehl; Zimmermann, *Freiberger Forschr.*, C-89, 190, pl. 9, figs 10, 11.

Material: 5 specimens; CPC 7913 figured.

Description: An extremely laterally compressed and deep unit with bars of equal length. The anterior bar bears at least 7 denticles of equal size with fused bases and free chevron tips. The depth of the bar increases posteriorly although the denticles are all of the same size. The posterior bar bears at least 8 denticles similar in size and shape to those of the anterior bar; they decrease in height slightly and are inclined posteriorly. The angle between the bars is about 170°. A minute subcircular basal cavity is developed beneath the apical denticle.

Occurrence: In the Bonaparte Gulf Basin *O. ethys* ranges from the *Spathognathodus plumulus* A.Z. to the *Siphonodella quadruplicata-S. cooperi* A.Z.

OZARKODINA cf. O. HINDEI Clarke, 1960
(Pl. 16, fig. 6)

cf. 1960 *Ozarkodina hindei* Clarke, *Trans. geol. Soc. Edinb.* 18, 18, pl. 3, figs 1, 6.

Material: Figured specimen CPC 7909.

Remarks: The species is characterized by a large, slightly inclined apical denticle and discrete denticles on both bars.

Occurrence: *O. hindei* occurs in Visean limestones in Scotland (Clarke, 1960). The present specimen is from the *Spathognathodus costatus* A.Z.

OZARKODINA HOMOARCUATA Helms, 1959
(Pl. 15, figs 2, 3)

1959 *Ozarkodina homoarcuata* Helms, *Geologie,* 8, 646, pl. 2, fig. 5 (Synonymy).

Material: 14 specimens; CPC 7923, 7924 figured.

Description: A strongly arched ozarkodinid with an anterior bar twice as long as the posterior bar. The anterior bar is depressed through 70°-90° and deflected inward. It bears up to eight short, fat, fused denticles with free chevron tips; they increase in height posteriorly. The apical denticle is three times as large as the bar denticles and is inclined posteriorly.

The posterior bar is short and decreases in height rapidly towards the termination. It bears about four denticles.

The bars are expanded on the outer side. A small cavity is present beneath the apical denticle; a flange may be present on the outer side, running along both bars immediately above the aboral margin (Pl. 15, fig. 2).

Occurrence: Helms (1959, p. 647) gives the range of *O. homoarcuata* in Germany as Upper Devonian (toIII-toVI). The species was originally described from the Lower Carboniferous Bushberg Sandstone of Missouri, USA (Branson & Mehl, 1934). In the Bonaparte Gulf Basin it occurs in the Famennian Ningbing Limestone.

OZARKODINA HUDDLEI nom. nov.
(Pl. 14, fig. 8)

non 1934 *Bryantodus planus* Branson & Mehl, *Univ. Missouri Stud.,* 8, 284, pl. 23, fig. 8.
1934 *Bryantodus planus* Huddle, *Bull. Amer. Paleont.,* 21, 75, pl. 10, fig. 8.
non 1938 *Bryantodus planus* Branson & Mehl; Branson & Mehl, *Univ. Missouri Stud.,* 13, pl. 33, fig. 35.
non 1939 *Bryantodus planus* Branson & Mehl; Cooper, *J. Paleont.,* 13, 385, pl. 43, figs 29, 30.
non 1943 *Bryantodus* cf. *planus* Branson & Mehl; Cooper & Sloss, *ibid.,* 17, 170, pl. 29, fig. 3.
non 1944 *Bryantodus planus* Branson & Mehl; Branson, *Univ. Missouri Stud.,* 19, pl. 32, fig. 35.
non 1957 *Bryantodus planus* Branson & Mehl; Ziegler, *in* Flugel & Ziegler, *Mitt. naturwiss. Ver. Steiermark,* 87, 37, pl. 5, fig. 6.
1961 *Ozarkodina plana* (Huddle); Scott & Collinson, *Kansas geol. Soc.,* 26th *Ann. Field Conf. Guidebook.* 128, pl. 2, fig. 8.
1968 *Ozarkodina plana* (Huddle); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.) Geol., Suppl.* 4, pl. 27, figs 1-3.

Material: 3 specimens; CPC 7910 figured.

Description: The unit is small, laterally compressed, with subequal bars; the anterior bar bears 2 to 4 denticles which are subtriangular, laterally compressed, and discrete. The posterior bar bears 3 to 5 denticles of the same order of size and shape. The apical denticle is tall, laterally compressed, about twice the size of the bar denticles, and discrete. All denticles are posteriorly inclined and the angle between the bars is about 160°. A small elongate basal cavity is present, whose centre is beneath the posterior margin of the apical denticle. It extends as a narrowing groove along the posterior bar and as far as the anterior margin of the apical denticle.

Remarks: Huddle (1934, p. 75) erected a new species *Bryantodus planus,* unaware that it was preoccupied by *B. planus* Branson & Mehl (1934, p. 284). In fact both species belong to the genus *Ozarkodina* and because *O. plana* (Branson & Mehl) has preference the junior homonym *Bryantodus planus* Huddle is renamed *O. huddlei.*

Occurrence: This species is found at the 7/1 locality in the Ningbing Range.

OZARKODINA LACERA Helms, 1959
(Pl. 16, figs 2a, b)

1959 *Ozarkodina lacera* Helms, *Geologie,* 8, 647, pl. 2, fig. 10; pl. 5, fig. 10.
1961 *Ozarkodina lacera* Helms; Freyer, *Freiberger Forschr.,* C-95, 59, pl. 3, fig. 67.
1964 *Ozarkodina lacera* Helms; Friakova, *Vestnik UUG,* 39, 16, pl. 1, fig. 12.

Material: 4 specimens; CPC 7920, 7921 figured.

Description: The unit is bowed, the anterior bar is deep, and bears 6 laterally compressed basally fused, posteriorly inclined denticles of even height and with free tips. The apical dentition consists of 2 large denticles of identical form. The posterior bar is deflected outward from the apical dentition and then inward toward the posterior termination; the dentition consists of about 4 short laterally compressed denticles which are considerably posteriorly inclined.

The basal cavity consists of a minute pit beneath the apical dentition.

Occurrence: Famennian Ningbing Limestone.

OZARKODINA cf. O. CURVATA Rexroad, 1958
(Pl. 15, fig. 1)

cf. 1958 *Ozarkodina curvata* Rexroad, *Ill. geol. Surv. Rep.* 209, 24, pl. 4, figs 1-3.

Material: 2 specimens; CPC 7908 figured.

Description: The unit is laterally compressed, arched, and flexed. The anterior bar is deflected and depressed through 90°, bearing at least 7 denticles, the medial ones being largest. All the denticles have fixed bases and free tips. The apical denticle is massive, 3 times as high as the blade denticles, and is ovate in cross-section, with anterior and posterior knife-edges. The posterior bar is shallower than the anterior bar and bears a series of fixed posteriorly inclined denticles.

A minute pit is present at the point of greatest flexure.

Remarks: The extreme deflection of the anterior bar is distinctive. The only species exhibiting this characteristic is *O. curvata* Rexroad, but even in this species the depression and deflection is not so pronounced; so the present specimens are only compared with *O. curvata.*

Occurrence: In the Bonaparte Gulf Basin the species ranges from the *Siphonodella sulcata-Polygnathus parapetus* A.Z. to the *S. quadruplicata-S. cooperi* A.Z.

OZARKODINA PLANA (Branson & Mehl, 1934)
(Pl. 15, figs 4a, b)

1934 *Bryantodus planus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 284, pl. 23, fig. 8.
non 1934 *Bryantodus planus* Huddle. *Bull. Amer. Paleont.*, 21, 75, pl. 10, fig. 8 (=*O. huddlei* nom. nov.).
1938 *Bryantodus planus* Branson & Mehl; Branson & Mehl, *Univ. Missouri Stud.*, 13 pl. 33, fig. 35.
1939 *Bryantodus planus* Branson & Mehl; Cooper, *J. Paleont.*, 13, 385, pl. 43, figs 29, 30.
1943 *Bryantodus* cf. *planus* Branson & Mehl; Cooper & Sloss, *ibid.*, 17, 170, pl. 29, fig. 3.
1944 *Bryantodus planus* Branson & Mehl; Branson, *Univ. Missouri Stud.*, 19, 181, pl. 32. fig. 35.
1957 *Bryantodus planus* Branson & Mehl; Ziegler, *in* Flügel & Ziegler, *Mitt. naturwiss. Ver. Steiermark*, 87, 37, pl. 5, fig. 6.
non 1961 *Ozarkodina plana* (Huddle), Scott & Collinson, *Kansas geol. Soc., 26th Ann. Field Conf. Guidebook*, 128, pl. 2, fig. 8.
non 1968 *Ozarkodina plana* (Huddle); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.). Geol., Suppl.* 4, pl. 27, figs 1-3.

Material: 3 specimens; CPC 7916 figured.

Description: An elongate unit with bars of equal length. The anterior bar is deflected, bearing 7 denticles which increase in height anteriorly, apart from the 2 small distal denticles. The bar is about twice as deep as the denticles, which are short, laterally compressed, and basally fused. The apical denticle is massive, twice as wide and twice as tall as the bar denticles, laterally compressed with anterior and posterior knife edges. Because the adjacent bar denticles are minute the apical denticle is discrete. The posterior bar bears up to 7 denticles, the longest of which are medial. They are laterally compressed and discrete and are inclined posteriorly. The bar is of the same order of height as the denticles. The thickening of the oral portion on the anterior bar is most apparent near the apical denticle, where it forms a narrow shoulder. A small elongate basal cavity is present beneath the apical denticle and extends as narrowing grooves along both bars.

Occurrence: In the Bonaparte Gulf Basin *O. plana* is confined to the upper *Spathognathodus plumulus* A.Z. and the lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

OZARKODINA RADIANS (Branson & Mehl, 1938)
(Pl. 15, figs 8a, b)

1938 *Subbryantodus radians* Branson & Mehl, *Univ. Missouri Stud.*, 8, 141, pl. 34, figs 22, 23.
1944 *Subbryantodus radians* Branson & Mehl; Branson, *ibid.*, 19, pl. 39, figs 22, 23.
1947 *Subbryantodus radians* Branson & Mehl; Bond, *Ohio J. Sci.*, 47, 21. pl. 2, fig. 13.

Material: 2 specimens; CPC 7917 figured.

Description: The unit is laterally compressed and is short, with bars of unequal length. The anterior bar is short, bearing 5 irregular denticles fused for most of their length. The two denticles adjacent to the apical denticle are needle-like, but the remainder are broad with chevron tips. The apical denticle is tall, twice as large as the bar denticles. The posterior bar, which is twice the length of the

anterior bar, bears 7 denticles which increase in size posteriorly except for the proximal, which is nearly the size of the apical denticle, and the distal denticle, which is minute.

In aboral view the unit is very finely grooved, but there is no visible basal cavity.

Occurrence: In the Bonaparte Gulf Basin *O. radians* is confined to the lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

OZARKODINA REGULARIS Branson & Mehl, 1934
(Pl. 15, figs 5, 6)

1934 *Ozarkodina regularis* Branson & Mehl, *Univ. Missouri Stud.*, 8, 287, pl. 23, figs 13, 14.
1938 *Ozarkodina regularis* Branson & Mehl; Branson & Mehl, *ibid.*, 13, pl. 33, fig. 32.
1943 *Ozarkodina regularis* Branson & Mehl; Cooper & Sloss, *J. Paleont.*, 19, 170, pl. 29, fig. 12.
1944 *Ozarkodina regularis* Branson & Mehl; Branson & Mehl *in* Shimer & Shrock, *Index fossils of North America*, 244, pl. 94, fig. 17.
1944 *Ozarkodina regularis* Branson & Mehl; Branson & Mehl, *Univ. Missouri Stud.*, 19, 181, pl. 32, fig. 32.
1955 *Ozarkodina regularis* Branson & Mehl; Sannemann, *Senck. leth.*, 36, 133, pl. 6, figs 3, 5, 6, 7.
1957 *Ozarkodina regularis* Branson & Mehl; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 22, 80.
non 1960 *Ozarkodina regularis* Branson & Mehl; Zimmermann, *Freiberger Forschr.*, C-89, 190, pl. 9, figs 10, 11 (=*O. ethys*).
1961 *Ozarkodina regularis* Branson & Mehl; Freyer, *Freiberger Forschr.*, C-95, 59. pl. 3, fig. 70.
1962 *Ozarkodina regularis* Branson & Mehl; Spasov & Stefanovic, *Geol. Analu Balkan*, 29, 59, pl. 2, fig. 1.
1963 *Ozarkodina regularis* Branson & Mehl; Abdusselamoglu, *Bull. Min. Res. Explor. Inst. Turkey*, 60, 4, pl. 1, fig. 5.
1965 *Ozarkodina regularis* Branson & Mehl; Spasov, *Trav. Géol. Bulgarie, Ser. paléont.*. 7, 91, pl. 2, fig. 4.

Material: 5 specimens; CPC 7911, 7912 figured.

Description: The unit is laterally compressed; the anterior bar is the same length as the posterior bar, and each bears at least 7 laterally compressed denticles fused over most of their length but with free chevron tips. The apical denticle is massive, with anterior and posterior knife edges and twice as high and twice as broad as the bar denticles. The angle between the bars is about 150°.

A minute basal cavity is present immediately behind the apical denticle and a rapidly narrowing groove extends along the posterior bar.

Occurrence: In the Bonaparte Gulf Basin *O. regularis* ranges from the uppermost *Spathognathodus plumulus* A.Z. to the lower *Clydagnathus nodosus* A.Z.

OZARKODINA RHENANA Bischoff & Ziegler, 1956
(Pl. 16, figs 7a, b)

1956 *Ozarkodina rhenana* Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 153, pl. 14, fig. 19.
1957 *Ozarkodina rhenana* Bischoff & Ziegler; Lys, Serre, & Deroo, *Rév. Inst. franç. Pétrole*, 12, 803, pl. 11, fig. 1.

1959 *Ozarkodina* cf. *regularis* Branson & Mehl; Helms (part), *Geologie*, 8, pl. 4, fig. 13 only.
1961 *Ozarkodina rhenana* Bischoff & Ziegler; Freyer, *Freiberger Forschr.*, C-95, 60.
1965 *Ozarkodina plana* (Huddle); Ethington, *J. Paleont.*, 39, 578, pl. 68, fig. 9.

Material: 2 specimens; CPC 7925 figured.

Description: The unit is laterally compressed and the anterior bar is half the length of the posterior bar. The anterior bar bears 4 to 6 tall laterally compressed denticles with fused bases and free chevron tips. The apical denticle is twice the size of the anterior bar denticles and is free for most of its height, only its aboral third being fused. The posterior bar bears 7 to 9 denticles, about one third the size of the apical denticle and decreasing in size posteriorly. They are inclined posteriorly, and the inclination increases toward the posterior termination, though they become more erect in their oral portion, giving an upswept appearance to the posterior termination. The inter-bar angle is about 150°. The small cavity is situated immediately behind the apical denticle. It closes rapidly to the anterior but extends as a narrowing groove toward the posterior. The lips are not flared, but are slightly thickened, and run along the aboral margin of the posterior bar for one third its length.

Occurrence: *O. rhenana* is confined to the upper part of the *Spathognathodus plumulus* A.Z. in the Bonaparte Gulf Basin.

OZARKODINA sp. A
(Pl. 14, fig. 10)

Material: 4 specimens; CPC 7914 figured.

Description: An extremely deep and laterally compressed unit lacking an apical denticle, although the medial denticles tend to be largest. The dentition of the whole unit consists of about 20 rather irregular laterally compressed denticles with fused bases and free tips. The bar is about half the height of the unit and the posterior termination is flexed inward. A slight depression of the posterior portion of the bar occurs at about midpoint. A minute basal cavity is present anterior to the point of flexure.

Occurrence: 7/1 locality in the Ningbing Range.

OZARKODINA sp. B
(Pl. 16, fig. 4)

Material: 3 specimens; CPC 7915 figured.

Description: A laterally compressed unit with bars of equal length. The anterior bar is fairly deep and bears at least 9 small laterally compressed needle-like denticles with fused bases and free tips. The apical denticle is twice the width and height of the blade denticles, and like them is inclined posteriorly. The dentition of the posterior bar is distinctive, the medial denticles being much lower than the other denticles. All the denticles are needle-like and laterally

compressed, fused over most of their length, but with free tips. There is a very slight inward deflection of the posterior termination and the angle between the bars is about 150°.

A minute oval basal cavity occurs beneath the apical denticle.

Occurrence: In the Bonaparte Gulf Basin from the upper *Spathognathodus plumulus* A.Z. to the lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

OZARKODINA sp. C
(Pl. 14, fig. 9)

Material: 2 specimens; CPC 7922 figured.

Description: The unit is considerably bowed and arched and is symmetrical. The denticles of both bars decrease in height terminally and are free-standing. The apical denticle is taller and twice as wide as the bar denticles. The basal cavity is situated beneath the apical denticle and the lips are thickened to produce a 'shoulder' on the aboral edge of the unit.

Occurrence: Famennian Ningbing Limestone.

OZARKODINA ? sp.
(Pl. 16, figs 8a, b)

Material: 1 specimen, CPC 8096.

Description: The unit is palmate, arched, and deflected inward at both ends. Dentition is regular, increasing in height medially and composed of tall free-standing denticles. A small basal cavity is present beneath the median and tallest denticle.

Genus PALMATODELLA Bassler, 1925

Type species: *Palmatodella delicatula* Ulrich & Bassler, 1926.

PALMATODELLA DELICATULA Ulrich & Bassler, 1926
(Pl. 17, fig. 1)

1925 *Palmatodella delicatula* Bassler, *Bull. geol. Soc. Amer.*, 36, 219.
1926 *Palmatodella delicatula* Ulrich & Bassler, *Proc. U.S. nat. Mus.*, 68(12), 41, pl. 10. fig. 5, text-fig. 4, fig. 20.
1928 *Palmatodella delicatula* Ulrich & Bassler; Holmes, *Proc. U.S. nat. Mus.*, 72(5), 29, pl. 10, fig. 10.
1931 *Palmatodella inflexa* Cooper, *J. Paleont.*, 5, 241, pl. 28, fig. 30.
1934 *Palmatodella delicatula* Ulrich & Bassler; Huddle, *Bull. Amer. Paleont.*, 21, 56, pl. 7, fig. 1.
1935 *Palmatodella delicatula* Ulrich & Bassler; Cooper, *J. Paleont.*, 9, 312, pl. 27, fig. 33.
1935 *Palmatodella inflexa* Cooper; Cooper, *ibid.*, 312, pl. 27, fig. 34.
1955 *Palmatodella delicatula* Ulrich & Bassler; Sannemann, *Senck. leth.*, 36, 133, pl. 4, figs 12-14.
1956 *Palmatodella delicatula* Ulrich & Bassler; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 128, pl. 10, figs 10, 11.
1956 *Palmatodella delicatula* Ulrich & Bassler; Bischoff & Ziegler, *ibid.*, 154.
1957 *Palmatodella delicatula* Ulrich & Bassler; Bischoff, *ibid., Abh.*, 19, 41, pl. 6, fig. 28.
1957 *Palmatodella delicatula* Ulrich & Bassler; Bischoff & Ziegler, *ibid.*, 22, 80.

1957 *Palmatodella delicatula* Ulrich & Bassler; Lys & Serre, *Rév. Inst. franç. Pétrole,* 12, 804, pl. 11, fig. 3.
1957 *Palmatodella delicatula* Ulrich & Bassler; Ziegler *in* Flügel & Ziegler, *Mitt. naturw. Ver. Steiermark,* 87, tab. 1.
1959 *Palmatodella delicatula* Ulrich & Bassler; Helms, *Geologie,* 8, 648, pl. 1, fig. 11; pl. 2, figs 21, 22; pl. 3, figs 13, 15; pl. 5, figs 11, 12, 21.
1960 *Palmatodella delicatula* Ulrich & Bassler; Zimmermann, *Freiberger Forschr.,* C-89, pl. 1, figs 3, 4.
1961 *Palmatodella delicatula* Ulrich & Bassler; Scott & Collinson, *Kansas geol. Soc., 26th Ann. Field Conf. Guidebook,* 128, pl. 2, fig. 13.
1961 *Palmatodella delicatula* Ulrich & Bassler; Freyer, *Freiberger Forschr.,* C-95, 60, pl. 3, fig. 73; text-fig. 74.
1961 *Palmatodella delicatula* Ulrich & Bassler; Helms, *Geologie,* 8, 992, pl. 2, fig. 1.
1961 *Palmatodella delicatula* Ulrich & Bassler; Lys et al., *Rév. franç. Pétrole.* 16, 548, pl. 2, figs 9, 10.
1962 *Palmatodella delicatula* Ulrich & Bassler; Winder, *Trans. Roy. Soc. Can.,* 56, 90, figs 1-14.
1962 *Palmatodella delicatula* Ulrich & Bassler; Spasov & Stevanovic, *Geol. Analu Balkan.,* 29, 60, pl. 2, figs 10, 11.
1963 *Palmatodella* cf. *delicatula* Ulrich & Bassler; van den Boogaard, *Geol. Mijnb.,* 42, 254, pl. 1, fig. 5.
1964 *Palmatodella delicatula* Ulrich & Bassler; Mirauta & Mirauta, *Dari de Seama ale Sedintelor,* 51, 285.
1964 *Palmatodella delicatula* Ulrich & Bassler; Friakova, *Vestnik UUG,* 39, 15, pl. 1, fig. 4.
1965 *Palmatodella delicatula* Ulrich & Bassler; Spasov, *Trav. géol. Bulgarie, Ser. paléont.,* 7, 91, pl. 2, figs 6, 7.
1965 *Palmatodella delicatula* Ulrich & Bassler; Ethington, *J. Paleont.,* 39, 579, pl. 68, fig. 7.
1966 *Palmatodella delicatula* Ulrich & Bassler; Glenister & Klapper, *J. Paleont.,* 40, 806, pl. 96, figs 1, 2.

Material: 12 specimens; CPC 7926 figured.

Remarks: Van den Boogaard (1963, p. 254) has shown the intraspecific variation of the angle between the two bars of *P. delicatula* to be large and to include forms referred to both *P. delicatula* and *P. orthogonica* Ziegler. Ethington (1965, p. 579) thinks that *P. delicatula* and *P. orthogonica* are conspecific. This is probably correct, but the variation in length of the posterior bar could also be a specific characteristic; however, I follow these authors, and the present specimens, although more closely allied to *P. orthogonica* Ziegler, are placed in *P. delicatula.*

Occurrence: In the Bonaparte Gulf Basin *P. delicatula* is confined to the Famennian Ningbing Limestone.

PALMATODELLA sp.
(Pl. 16, fig. 9)

Material: Figured specimen CPC 7927.

Description: The anterior bar is depressed through about 60°; it is shallow, with well developed lateral ridges, and bears a succession of very fine fused needle-like denticles which stand erect, making an angle of nearly 60° with the bar. The posterior bar is twice as deep as the anterior bar; it bears more than 25 fine needle-like denticles which increase in size and height posteriorly and are fused to form a large 'sail'. The tall large posterior denticles are inclined posteriorly, the remainder erect. In aboral view, no basal cavity can be seen.

Occurrence: Famennian Ningbing Limestone.

Genus PALMATOLEPIS Ulrich & Bassler, 1926

Type species: *Palmatolepis perlobata* Ulrich & Bassler, 1926

PALMATOLEPIS GLABRA ELONGATA Holmes, 1928
(Pl. 17, fig. 9)

1928 *Palmatolepis elongata* Holmes, *Proc. U.S. nat. Mus.*, 72(5), 33, pl. 11, fig. 13.
1949 *Palmatolepis glabra* Ulrich & Bassler; Thomas, *Bull. geol. Soc. Amer.* 60, 434, pl. 1, fig. 19.
1956 *Palmatolepis (Palmatolepis) glabra* Ulrich & Bassler; Müller, *Abh., senck. naturf. Ges.*, 494, 25, pl. 7, fig. 15.
1959 *Palmatolepis glabra* Ulrich & Bassler δ morphotype; Scott & Collinson, *J. Paleont.*, 33, 560, pl. 75, figs 14, 15.
1959 *Palmatolepis glabra elongata* Holmes; Helms, *Geologie*, 8, (6) p. 649, pl. 2, fig. 12; pl. 5, fig. 25.
1960 *Palmatolepis glabra* Ulrich & Bassler; Zimmermann (part), *Freiberger Forschr.*, C-89, pl. 2, figs 2-4, 8-11.
1962a *Palmatolepis glabra elongata* Holmes; Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 38, 58, pl. 5, figs 6, 7.
1962b *Palmatolepis glabra elongata* Holmes; Ziegler, *Fortschr. Geol. Rhein. Westf.*, 6, 398,. pl. 1, figs 10, 14 (pre-print 1960).
1963 *Palmatolepis (Panderolepis) elongata* Holmes; Helms, *Geologie*, 12, text-fig. 2, fig. 24.
1963 *Palmatolepis glabra* Branson & Mehl (*sic*); Abdusselamoglu, *Bull. Min. Res. Explor. Inst. Turkey*, 60, 4, pl. 1, fig. 4.
1963 *Palmatolepis glabra elongata* Holmes; Forti & Nocchi, *Riv. ital. Paleont. Strat.*, 64, 323, pl. 20, figs 5a, b.
1966 *Palmatolepis glabra elongata* Holmes; Glenister & Klapper, *J. Paleont.*, 40, 813. pl. 95, fig. 1.

Material: 7 specimens; CPC 7928 figured.

Range: Lower part of the Ningbing Limestone.

Diagnosis: An extremely narrow elongate unit with a short erect subtriangular parapet and a large azygous node.

Remarks: Glenister & Klapper (1966, p. 814) discuss the distinguishing characteristics of the subspecies and its relationship to *P. helmsi* (p. 815).

PALMATOLEPIS GLABRA PECTINATA Ziegler, 1962
(Pl. 17, figs 7, 8; Pl. 18, figs 1a-3)

1941 *Palmatolepis* sp. Branson & Mehl, *Denison Univ. Bull. J. Sci. Lab.* 35, 192, pl. 7, fig. 11 only.
1955 *Palmatolepis glabra* Ulrich & Bassler; Sannemann. *Neues Jb. Geol. Paleont. Abh.*, 100, 331, pl. 24, fig. 7.
1959 *Palmatolepis glabra* Ulrich & Bassler; Scott & Collinson, *J. Paleont.*, 33, 563, pl. 76, fig. 15.
1959 *Palmatolepis glabra* Ulrich & Bassler γ morphotype; Scott & Collinson, *ibid.*, 560, pl. 75, figs 10.
1959 *Palmatolepis glabra* Ulrich & Bassler γ morphotype; Scott & Collinson, *ibid.*, 559, pl. 76, figs 1-4, 11 (*non* fig. 12 = *P. glabra acuta* Helms).
1959 *Palmatolepis glabra* Ulrich & Bassler δ morphotype; Scott & Collinson, *ibid.*, 560, pl. 75, figs 18-22 (figs 19, 22—transitional to *P. glabra acuta*); pl. 76, figs 5-9, 17.
1959 *Palmatolepis glabra* Ulrich & Bassler δ morphotype; Scott & Collinson, *ibid.*, pl. 76, figs 10, 13, 14.

1960 *Palmatolepis glabra* Ulrich & Bassler; Zimmerman (part), *Freiberger Forsch.*, C-89, pl. 2, figs 2-4, 8-11.
1961 *Palmatolepis glabra* Ulrich & Bassler; Freyer, *Freiberger Forsch.*, C-95, 62, pl. 4, figs 81, 82.
1962 *Palmatolepis glabra pectinata* Ziegler, *Hess. Landesamt Bodenf., Abh.*, 38, 59, pl. 4, fig. 16; pl. 5, figs 3-5.
1962 *Palmatolepis glabra pectinata* Ziegler; Ziegler, *Forschr. Geol. Rhein. Westf.*, 6, 398, pl. 2, figs 3-5 (preprint 1960).
1963 *Palmatolepis distorta* Branson & Mehl; Abdusselamoglu, *Bull. Min. Res. Explor. Inst. Turkey*, 60, 4, pl. 1, fig. 6.
1963 *Palmatolepis (Panderolepis) serrata* (Hinde) subsp. c, d, Helms, *Geologie*, 12, text-fig. 2, figs 21, 22.
1963 *Palmatolepis (Panderolepis) serrata pectinata* Ziegler; Helms, *ibid.*, text-fig. 2, fig. 25.
1965 *Palmatolepis glabra pectinata* Ziegler; Bouckaert & Ziegler, *Mém. Expl. Cartes Géol. Min. Belg.*, 5, pl. 3, figs 4-6.
1966 *Palmatolepis glabra pectinata* Ziegler; Glenister & Klapper, *J. Paleont.*, 40, 814, pl. 89, figs 1-3, 5, 9, 10; pl. 90, figs 4, 5; pl. 91, figs 1, 3, 5.
1966 *Palmatolepis glabra pectinata* Ziegler; Jones & Druce, *Nature*, 211, fig. 3(1).
1966 *Palmatolepis glabra pectinata* Ziegler; Winder, *J. Paleont.*, 40, pl. 156.

Material: 11 specimens; CPC 7929-7931 figured.

Range: Lower part of the Ningbing Limestone.

Remarks: Glenister & Klapper (1966, p. 814) have discussed the relationships of the morphotypes of *P. glabra* Ulrich & Bassler (Scott & Collinson, 1959).

Occurrence: In Germany the subspecies ranges from the upper *crepida crepida* (toII$_\alpha$) to the upper *quadrantinodosa* (toIII$_\alpha$) Zone (Ziegler, 1962, p. 59). The species is also known from the United States (Scott & Collinson, 1959), Turkey (Abdusselamoglu, 1963), Belgium (Bouckaert & Ziegler, 1965), and Australia (Glenister & Klapper, 1966).

PALMATOLEPIS GRACILIS GRACILIS Branson & Mehl, 1934
(Pl. 17, figs 3a-5b)

1934 *Palmatolepis gracilis* Branson & Mehl, *Univ. Missouri Stud.*, 8, 238, pl. 18, figs 2, 8 (*non* fig. 5).
1938 *Polygnathus basilicus* Stauffer, *J. Paleont.*, 12, 438, pl. 53, figs 42, 43.
1955 *Palmatolepis gracilis* Branson & Mehl; Sannemann, *Neues Jb. Geol. Paläont. Abh.*, 100(3), 331, pl. 24, fig. 15 (*non* fig. 17 = *P. minuta schleizia* (Helms)).
1956 *Palmatolepis gracilis* Branson & Mehl; Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 154, pl. 12, figs 8, 9.
1956 *Palmatolepis (Deflectolepis) deflectens* Müller, *Abh. Senck. naturf. Ges.*, 494, 32, pl. 11, figs 28-39.
1956 *Palmatolepis (Palmatolepis) gonioclymeniae* Müller, *ibid.*, 26, pl. 7, fig. 18 (*non* figs 12, 16, 17, 19 = *P. gonioclymeniae*).
1957 *Palmatolepis gracilis* Branson & Mehl; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 19, 41, pl. 6, figs 6-10.
1957 *Palmatolepis gracilis* Branson & Mehl; Ziegler *in* Flugel & Ziegler, *Mitt. naturw. Verh. Steiermark*, 87, 57, pl. 1, fig. 4.
1958 *Palmatolepis (Palmatolepis) gonioclymeniae* Müller; Klapper, *J. Paleont.*, 32, 1088, pl. 143, figs 10, 11, 13.
1959 *Palmatolepis deflectens* Müller; Helms, *Geologie*, 8, 648, pl. 6, fig. 20.
1960 *Palmatolepis gracilis* Branson & Mehl; Zimmerman, *Freiberger Forsch.*, C-89, pl. 4, figs 4-6, 8.
1961 *Palmatolepis gracilis* Branson & Mehl; Freyer, *ibid.*, C-95, 64, text-fig. 83.

1961 *Palmatolepis gracilis* Branson & Mehl; Scott & Collinson, *Kansas geol. Soc. 26th Ann. Field Conf. Guidebook,* 129, pl. 1, fig. 5.
1961 *Palmatolepis deflectens* Müller; Helms, *Geologie,* 8, 990, pl. 1, fig. 5.
1962 *Palmatolepis deflectens deflectens* Müller; Ziegler, *Hess. Landesamt. Bodenf., Abh.,* 38, 56, pl. 3, figs 17-22.
1963 *Palmatolepis (Deflectolepis) gracilis deflectens* Müller; Helms, *Geologie,* 12(4), text-figs 37, 38.
1965 *Palmatolepis (Deflectolepis) deflectens* Müller; Spasov, *Trav. géol. Bulgarie, Ser. paléont.,* 7, 93, pl. 2, fig. 9 only.
1965 *Palmatolepis (Deflectolepis) gracilis* Branson & Mehl; Spasov, *ibid.,* 94, pl. 2, figs 13, 14.
1966 *Palmatolepis deflectens deflectens* Müller; Manzoni, *G. Geol.,* 33, 478.

Material: 25 specimens; CPC 7932, 7934, 7935 figured.

Range: Famennian Ningbing Limestone.

Remarks: Glenister & Klapper (1966, p. 815) and Mehl & Ziegler (1962, p. 197) discuss in full the problems which arose from the naming of three cotypes by Branson & Mehl (1934, p. 328) and subsequent problems. They also discuss the relationships of *P. gracilis* s.s. to subspecies and to other species (p. 815).

Occurrence: Ziegler (1962, p. 56) gives the range as *rhomboidea* (toII$_\beta$) to upper *costatus* (toVI) zones. The species was originally described from the Grassy Creek Shale of Missouri, USA. It is also known from Bulgaria (Spasov, 1965) and Italy (Manzoni, 1966).

PALMATOLEPIS GRACILIS SIGMOIDALIS Zeigler, 1962
(Pl. 17, figs 2a, b)

1957 *Palmatolepis gracilis* Branson & Mehl; Cloud, Barnes, & Hass, *Bull. geol. Soc. Amer.,* 68, pl. 4, fig. 7.
1959 *Panderodella gracilis* (Branson & Mehl); Hass, *U.S. geol. Surv. prof. Pap.* 294-J, pl. 50, fig. 1.
1962 *Palmatolepis deflectens sigmoidalis* Ziegler, *Hess. Landesamt. Bodenf., Abh.,* 38, 56, pl. 3, figs 24-28.
1962 *Palmatolepis gracilis sigmoidalis* Ziegler; Mehl & Ziegler, *J. Sci. Lab., Denison Univ.,* 45, 205.

Material: 25 specimens; CPC 7932, 7934, 7935 figured.

Range: Upper part of the Ningbing Limestone.

Remarks: *P. gracilis sigmoidalis* is distinguished from the other subspecies of *P. gracilis* by the sigmoidal form of the carina.

Occurrence: The species is confined to the upper *Wocklumeria* Stufe of Germany (upper toV-VI) (Ziegler, 1962; Mehl & Ziegler, 1962).

PALMATOLEPIS MINUTA MINUTA Branson & Mehl, 1934
(Pl. 17, figs 6a, b)

1934 *Palmatolepis minuta* Branson & Mehl, *Univ. Missouri Stud.,* 8, 236, pl. 18, figs 1, 6, 7.
1955 *Palmatolepis minuta* Branson & Mehl; Sannemann, *Neues Jb. Geol. Paläont. Abh.,* 100(3), 331, pl. 24, figs 12, 16.
1955 *Palmatolepis minuta* Branson & Mehl; Sannemann, *Senck. leth.,* 36, 135, pl. 9, fig. 19.

1956 *Palmatolepis minuta* Branson & Mehl; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 129, pl. 9, figs 8, 9, 14.
1956 *Palmatolepis (Deflectolepis) minuta* Branson & Mehl; Müller, *Abh. Senck. naturf. Ges.*, 494, 31, pl. 11, figs 21-26 (*non* pl. 11, fig. 20; pl. 10, fig. 19 = *P. minuta scheizia*).
1956 *Palmatolepis (Deflectolepis) minuta* Branson & Mehl; Müller, *J. Paleont.*, 30, 1340, pl. 145, figs 3, 4.
1960 *Palmatolepis minuta* Branson & Mehl; Zimmerman, *Freiberger Forsch.*, C-89, pl. 4, figs 7, 10.
1960 *Palmatolepis (Deflectolepis) minuta* Branson & Mehl; Clark & Becker, *Bull. geol. Soc. Amer.* 71, 1673, pl. 2, fig. 1.
1961 *Palmatolepis minuta* Branson & Mehl; Freyer, *Freiberger Forsch.*, C-95, 65, pl. 4, fig. 87.
1962 *Palmatolepis minuta minuta* Branson & Mehl; Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 38, 65, pl. 3, figs 1-10.
1963 *Palmatolepis (Deflectolepis) minuta minuta* Branson & Mehl; Helms, *Geologie*, 12(4), 480, pl. 2, figs 3, 4, 8, 9; text-fig. 2, fig. 36.
1963 *Palmatolepis (Deflectolepis) minuta* Branson & Mehl subsp. a; Helms, *ibid.*, 478, pl. 1, figs 6, 8; pl. 2, figs 1, 2, 5-7; pl. 3, fig. 16, text-fig. 2, fig. 34.
1963 *Palmatolepis (Deflectolepis) schleizia* Helms (part), *ibid.*, 471, pl. 4, figs 1-5 (transitional to *P. minuta schleizia*) *non* figs 6-11 (= *P. minuta schleizia*).
1963 *Palmatolepis (Palmatolepis)* sp. A; Helms, *ibid.*, text-fig. 2, fig. 40.
1963 *Palmatolepis minuta* Branson & Mehl; Abdusselamoglu, *Bull. Min. Res. Expl. Inst. Turkey*, 60, 3, pl. 1, fig. 3.
1965 *Palmatolepis minuta minuta* Branson & Mehl; Bouckaert & Ziegler, *Mém. Expl. Cartes Géol. Min. Belg.*, 5, pl. 3, figs 1-3.
1966 *Palmatolepis minuta minuta* Branson & Mehl; Glenister & Klapper, *J. Paleont.*, 40, 817, pl. 90, figs 1, 2, 7-14 .

Material: 2 specimens; CPC 7936 figured.

Range: Lower part of the Ningbing Limestone.

Remarks: Glenister & Klapper (1966, p. 817) have discussed the general morphology of the subspecies and its relationships.

Occurrence: The species was originally described from the Grassy Creek Shale of Missouri, USA (Branson & Mehl). Ziegler (1962, p. 66) gives its range as middle *triangularis* (toI$^{\delta}$) to upper *velifera* (toIV) Zone in Germany. The species is also known from Turkey (Abdusselamoglu, 1963), Belgium (Bouckaert & Ziegler, 1965), and Australia (Glenister & Klapper, 1966).

Genus PELEKYSGNATHUS Thomas, 1949

Type species: *Pelekysgnathus inclinatus* Thomas, 1949.

PELEKYSGNATHUS PEEJAYI sp. nov.

(Pl. 18, figs 4a-7c; Text-fig. 18)

Derivation of name: In honour of P. J. Jones, BMR.

Material: 20 specimens; holotype CPC 7939; paratypes CPC 7937, 7938, 8332.

Diagnosis: A species of *Pelekysgnathus* which is laterally compressed, fairly short, and bears a short erect main denticle.

Description: A simple blade unit bearing 6 to 8 erect denticles which increase in size and height posteriorly, terminating in a larger main cusp. The denticles have fused bases and free chevron tips.

A basal cavity is developed beneath the main cusp at the posterior extremity and extends to the anterior termination as a narrowing groove with slightly flaring lips.

Remarks: Thomas (1949, p. 424) erected four species of *Pelekysgnathus*. Anderson (1966, p. 409) places three of them, *P. inclinatus, P. communis,* and *P. nodosus,* in synonymy, and the fourth, *P. costatus,* in the genus *Icriodus* (p. 410). Sannemann (1955, p. 149) erected a further new species, *P. planus,* and Bischoff & Ziegler (1957, p. 83) questionably referred a new species, *P.? primitiva,* to

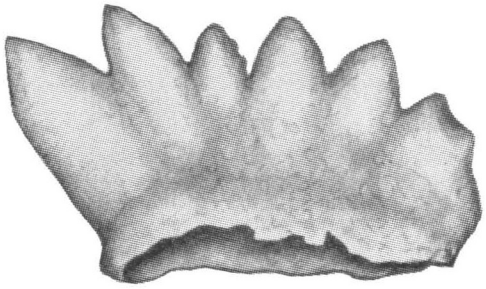

Figure 18. *Pelekysgnathus peejayi* **sp. nov. Lateral view of holotype, CPC7939, x 120.**

Pelekysgnathus; but Glenister & Klapper (1966, p. 827) placed it in their new genus *Playfordia. P. peejayi* differs from from *P. inclinatus* in having an erect main denticle and being very short. It differs from *P. planus* in being shorter and taller with a less flaring basal cavity. One of Sannemann's figured specimens (1955, pl. 4, fig. 23) may possibly belong to this new species.

Occurrence: *P. peejayi* is restricted to the early Famennian back-reef facies of the Ningbing Limestone.

Genus POLYGNATHUS Hinde, 1879

Type species: *Polygnathus dubia* Hinde, 1879.

POLYGNATHUS ANIDUS Cooper, 1939
(Pl. 22, figs 1a-4c)

1939 *Polygnathus anida* Cooper, *J. Paleont.*, 13, 399, pl. 39, figs 39, 40.
?1939 *Polygnathus symmetrica* Cooper, *ibid.*, 404, pl. 41, figs 50, 51.

Material: 11 specimens; CPC 7988-91 figured.

Range: Lower *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z.

Description: The blade is subtriangular, less than half the length of the platform, composed of up to 6 laterally compressed fused denticles with free chevron tips. The platform is nearly symmetrical, with varying ornament. In some specimens it consists of upturned platform edges with deep troughs either side of the carina, and in others there are faint transverse ridges and medial nodes. In yet others, strong short transverse ridges are developed.

In aboral view the unit is distinctive, the basal cavity being large and elongate with a large attachment area surrounding it.

Remarks: Rexroad & Scott (1964, p. 36) placed *P. anidus* in synonymy with *P. longiposticus* Branson & Mehl, but the characteristically large basal cavity serves to distinguish it. *P. symmetricus* Cooper is probably synonymous with *P. anidus,* but Cooper (1939, p. 404) emphasizes the straight carina in *P. symmetricus,* so it is only questionably placed in synonymy. *P. lacinatus* Huddle (1934, p. 95) is possibly a senior synonym of *P. anidus;* it was redescribed and illustrated by Rhodes, Austin, & Druce (1968). The present specimens are certainly not referable to *P. lacinatus* sensu Rhodes, Austin, & Druce, which may possibly be a new species.

The development of a large symmetrical basal cavity is seen in several species during the Carboniferous period. It is difficult to place them in either *Polygnathus* or *Pseudopolygnathus,* and they may constitute a new generic group.

Occurrence: *P. anidus* also occurs in the pre-Welden Shale of Oklahoma (Cooper, 1939).

POLYGNATHUS BISCHOFFI Rhodes, Austin, & Druce, 1968
(Pl. 23, figs 1a-2c)

1957 *Polygnathus inornata* E. R. Branson; Bischoff, *Hess. Landesamt. Bodenf. Abh.,* 19, 42, pl. 2, figs 17, 18, 20, 21.
1959 *Polygnathus* cf. *flabella* Branson & Mehl; Voges (part), *Paläont. Z.,* 33, pl. 34, fig. 11 only.
1963 *Polygnathus inornata* E. R. Branson; Higgins et al., *Bull. Soc. belge Géol. Paléont. Hydrol.,* 72, 225, fig. 5, pl. 5, fig. 29.
1968 *Polygnathus bischoffi* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.) Geol., Suppl.* 4, pl. 13, figs 8a-11c.

Material: 6 specimens; CPC 7983, 7984 figured.

Remarks: In the United Kingdom *P. bischoffi* is restricted to lower *Caninia* (C) Zone strata (Rhodes et al., 1968) but in the Bonaparte Gulf Basin it occurs with siphonodellids of the *S. quadruplicata-S. cooperi* Assemblage Zone, equivalent to the upper *Cleistopora* (K) zone in Britain. It is possible either that *P. bischoffi* has a greater range than it has in Britain, or that the sequence is condensed at the 7/1 locality; this is the only locality from which it is known in the Bonaparte Gulf Basin.

POLYGNATHUS cf. P. BREVILAMINA Branson & Mehl, 1934
(Pl. 19, figs 1-4)

1934 *Polygnathus brevilamina* Branson & Mehl, *Univ. Missouri Stud.,* 8, 246, pl. 21, figs 3-6.
non 1941 *Polygnathus brevilamina* Branson & Mehl; Ellison & Graves, *Bull. Missouri Univ. School Min. Metall., tech. Ser.,* 14, 4, pl. 2, figs 7, 22.

Material: 39 specimens; CPC 7940-43 figured.

Range: Middle calcareous members of Cockatoo Formation.

Description: The platform is elongate, three times as long as wide, with anterior and posterior free blades developed. The carina consists of a low ridge of fused nodes, which merges with the denticulate anterior blade and nodose posterior blade. The inner platform is narrow, consisting of a ridge of fused nodes, which form the platform edge and a narrow trough which separates the nodes from the carina. The trough deepens anteriorly and the platform edge parallels the carina. The inner platform wall slopes outward slightly. The inner platform is slightly wider and widens toward the posterior extremity, where it narrows rapidly. The ornament consists of a row of fused nodes forming the platform edge and separated from the carina by a trough which deepens anteriorly. The posterior blade is short and thick, the anterior blade three times as long and laterally compressed; both are medial. In lateral view the anterior free blade is half as high again as the platform and consists of at least 8 fused needle-like denticles with free chevron tips. These denticles are recurved posteriorly. The anterior-aboral angle is about 70°. The inner platform wall and the carina are of the same height, but the outer platform wall is higher—slightly higher than the nodose posterior blade, which stands up from the carina and then decreases in height to the posterior termination. The aboral marginal outline is characteristic; the posterior portion of the platform is horizontal, but the anterior portion of the platform and the anterior free blade are convex; a sharp 'knick-point' in the outline separates them at the platform midpoint. In aboral view the unit is sharply keeled; the keel is sinuous in the posterior portion of the platform. A faint groove in the keel is present along the anterior blade and anterior portion of the platform. It terminates immediately anterior to the 'knick-point' where it widens very slightly into a basal cavity.

POLYGNATHUS COLLINSONI sp. nov.

(Pl. 23, figs 3, 4; Text-fig. 19)

1961 *Polygnathus communis* Branson & Mehl; Scott & Collinson, *Kansas geol. Soc., 26th Annual Field Conf. Guidebook,* 130, pl. 1, figs 8, 10 only.

Derivation of name: After Dr C. W. Collinson.

Material: 12 specimens; holotype CPC 7982 and paratype CPC 7981 figured.

Range: Late Famennian Ningbing Limestone.

Diagnosis: A smooth platformed polygnathid with a longitudinal row of nodes, or a ridge developed on either side of the free blade at the anterior end of the platform.

Description: The blade is shorter than the platform, and is composed of some 10 laterally compressed denticles of equal height with fused bases and free chevron tips. The blade continues on to the platform as a carina composed of low nodes, and an extremely short posterior free blade may continue beyond. The platform is symmetrical and is completely smooth except at the anterior end, where a longitudinal row of nodes flanks the carina, being separated from it by a trough which shallows, but flanks the carina over its whole length. There is a small round basal cavity in the anterior third of the platform, and immediately posterior to it a marked inversion of the aboral surface; erupting from this is a strong keel which deepens towards the posterior platform termination.

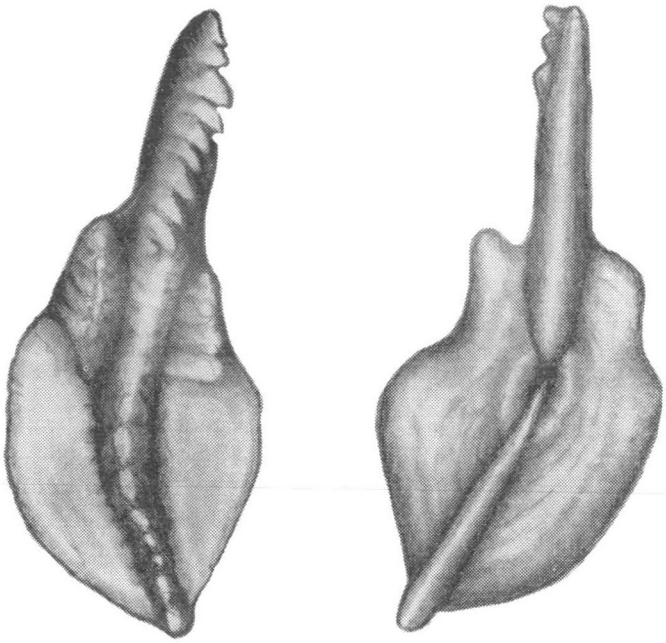

Figure 19. *Polygnathus collinsoni* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC7982, x 65.**

Remarks: In describing the conodont fauna of the Louisiana Limestone Scott & Collinson (1961, p. 130) referred some specimens to *P. communis* Branson & Mehl, noting however that they represented at least three morphological variants. In our faunas one of these variants is present to the exclusion of the others and is erected as a new species. *P. collinsoni* differs from *P. communis* s.s. in lacking the strong upturning of the platform edges. Specimens with denticulate anterior platforms such as *P. communis dentatus* subsp. nov. still show the strong upturning of the platform edges. In *P. collinsoni* the basal cavity is posterior to the blade-platform junction, whereas in the *P. communis* group it is at the junction.

POLYGNATHUS COMMUNIS COMMUNIS Branson & Mehl, 1934
(Pl. 18, figs 8a-11)

1934 *Polygnathus communis* Branson & Mehl, *Univ. Missouri Stud.*, 8, 293, pl. 24, figs 1-4.
1966 *Polygnathus communis* Branson & Mehl; Manzoni, *G. Geol.*, 33, 478.
1968 *Polygnathus communis communis* Branson & Mehl; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 12, figs 2a-5c (Synonymy).

Material: 72 specimens; CPC 7944-46 figured.

Range: *Siphonodella quadruplicata-S. cooperi* A.Z. to the top of the *Spathognathodus tridentatus* A.Z.

Remarks: The specimens are all small and do not exhibit the swelling of the upturned platform edges of more mature specimens in other faunas. The transition from *P. communis communis* to *Gnathodus burtensis* sp. nov. is discussed under the later species.

POLYGNATHUS COMMUNIS CARINUS Hass, 1959

(Pl. 18, figs 12a-c)

1959 *Polygnathus communis* Branson & Mehl var. *carina* Hass, *U.S. geol. Surv. prof. Pap.* 294-J, 391, pl. 47, figs 8, 9.

1959 *Polygnathus* cf. *styriaca* (Ziegler); Voges (part), *Paläont. Z.*, 33, 294, pl. 34, figs 36-39 only.

1964 *Polygnathus communis carina* Hass; Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 34, pl. 2, figs 24, 25.

1967 *Polygnathus communis carina* Hass; Thompson, *Rep. Inv. Missouri geol. Surv.*, 39, 45, pl. 2, figs 7, 10; pl. 4, figs 6, 9.

Material: 3 specimens; CPC 7957 figured.

Description: The blade is as long as the platform, and is composed of at least 9 laterally compressed denticles with free chevron tips. It is highest at the mid-point, but all the denticles are the same order of size. The blade continues on to the platform as a median carina composed of low circular nodes with sharp tips. The platform is symmetrical and narrows posteriorly; the surface is smooth except at the anterior end, where low nodes form a posteriorly inclined transverse ridge. In aboral view there is a small basal cavity at the junction of the free blade and the platform, and there is some inversion of the aboral surface adjacent to the cavity. A strong grooved keel runs to the posterior termination.

Remarks: There is some resemblance between this subspecies and *P. purus* s.s. Voges. However, the anterior platform ornament serves to distinguish them.

Occurrence: *P. communis carinus* was originally discovered in the Chappel Limestone of Texas (Hass, 1959). Rexroad & Scott (1964, p. 15) record it from the *Gnathodus semiglaber-Pseudopolygnathus multistriatus* Assemblage Zone of the Rockford Limestone, Indiana, USA. Thompson (1967, p. 46) records it in the lower part of the same zone in Missouri. In the Bonaparte Gulf Basin it occurs at the 7/1 locality in the Ningbing Range.

POLYGNATHUS COMMUNIS DENTATUS subsp. nov.

(Pl. 18, figs 13a-14)

Derivation of name: From the denticulate anterior platform margins.

Material: 90 specimens; holotype CPC 7948, paratype CPC 8333.

Range: Middle *Siphonodella sulcata-Polygnathus parapetus* A.Z. to lower *Siphonodella quadruplicata-S. cooperi* A.Z.

Diagnosis: A subspecies of *P. communis* having denticulate platform edges at the extreme anterior of the platform.

Description: In oral view, the platform is short, twice as long as wide. It is symmetrically divided by a carina which is a fused ridge of denticles, none of which are discrete. Both platforms are ornamented by a thickened platform edge produced as an oral 'roll'. There is no indication of denticles or nodes except on the extreme anterior of both edges, where up to 4 fused denticles with free chevron tips occur. In some specimens these are only developed on the outer side. A very deep trough is present either side of the carina, separating it from the thickened platform edge. In lateral view the anterior free blade is the same height as the

carina and the inner platform edge but lower than the outer platform edge. The aboral edge of the blade is considerably lower than the aboral edge of the platform. The blade is composed of 10 short, fused, needle-like denticles of equal height with free needle tips. The platform edge is smooth, and the platform merges with the blade anterior to its face. A continuation of the platform edge merges with a fine horizontal ridge in the aboral third of the blade. In aboral view the platform is convex except for the anterior third, which is concave. Immediately anterior to this and situated on the posteriormost portion of the blade is a medium-sized circular basal cavity with slightly flared lips. The aboral surface of the platform has a medial keel which deepens posteriorly. The aboral surface of the free blade is knife-edged and possesses a fine medial groove.

Remarks: The inversion of the aboral surface adjacent to the basal cavity is not so conspicuous as in other subspecies of *P. communis*.

POLYGNATHUS DISTORTUS Branson & Mehl, 1934
(Pl. 24, figs 1a-c)

1934 *Polygnathus distorta* Branson & Mehl, *Univ. Missouri Stud.*, 8, 294, pl. 24, fig. 12.
1966 *Polygnathus inornata* Branson; Klapper (part), *Univ. Kansas paleont. Contr., Pap.* 3, pl. 1, figs 11-14 only; pl. 4, fig. 3 only.

Material: 2 specimens; CPC 7985 figured.

Description: The blade is one third the length of the platform, composed of laterally compressed basally fused denticles with free chevron tips which are largest medially. The platform is asymmetrical, the inner platform being smaller; the inner platform is ornamented with faint transverse ridges which disintegrate to nodes and which are in turn separated from the carina by a trough. The outer platform has a secondary platform developed outside the upturned platform edge. The main platform contains a few transverse ridges posteriorly and a deep trough anteriorly. The secondary platform is smooth except for a nodose posterior margin. In aboral view, a small round basal cavity is developed. The thickened lips run to both terminations as a raised keel with a medial groove.

Remarks: The Bonaparte Gulf specimens differ from Branson & Mehl's type (Pl. 24, fig. 5) in having a secondary platform on one side only; but they are so alike in platform morphology and ornament that they are placed in the same species. *P. distortus* belongs to the *P. inornatus* group.

Occurrence: *P. distortus* has been described from the Bushberg Sandstone of Missouri, USA (Branson & Mehl) and illustrated from lower Mississippian sections in Montana, Wyoming, and South Dakota by Klapper (1966), who included them in *Polygnathus inornatus*. In the Bonaparte Gulf Basin the species is known as the 7/1 locality in the Ningbing Range.

POLYGNATHUS ELONGONODOSUS sp. nov.
(Pl. 24, figs 2a-4c; Text-fig. 20)

Derivation of name: From the elongate nodose platform.

Material: 12 specimens; holotype CPC 7970; paratypes CPC 7971, 7972.

Range: Restricted to the uppermost *Siphonodella quadruplicata-S. cooperi* A.Z. and the lower *Clydagnathus nodosus* A.Z.

Diagnosis: A polygnathid with nodose ornament on the posterior half which disrupts and masks the carina. The anterior ornament consists of transverse ridges obsolescent toward the carina, which is flanked by deep troughs.

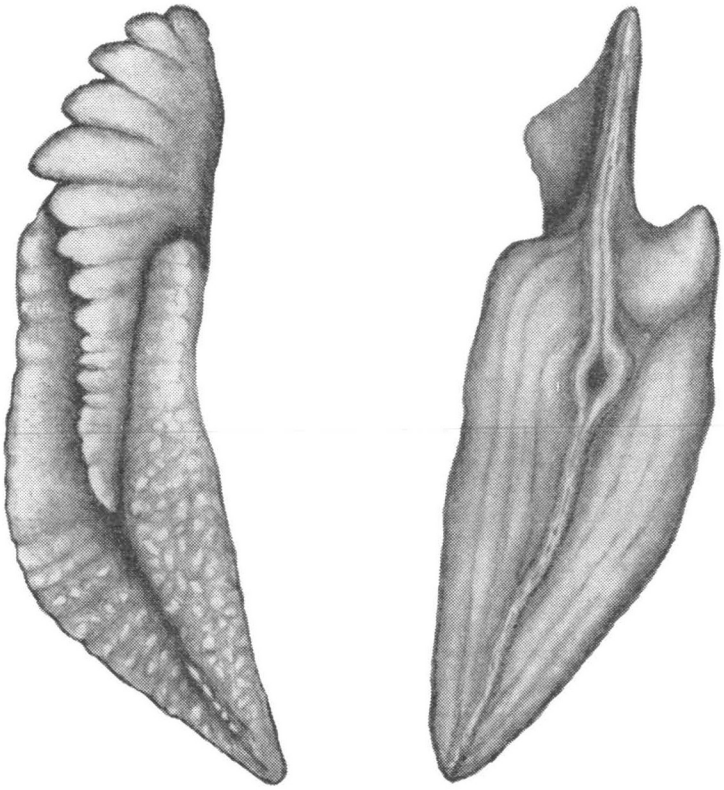

Figure 20. *Polygnathus elongonodosus* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC7970, x 60.**

Description: The unit is elongate, 4 times as long as wide. The platform is symmetrical, divided by a low carina formed of fused nodes. The carina merges with the blade in the anterior and becomes obsolescent in the posterior third of the platform. The inner platform ornament consists of faint transverse ridges which disintegrate into low nodes towards the carina before disappearing. The platform surface is often convex upwards in the medial third. The outer platform bears faint transverse ridges diminishing toward the carina and erupting on the platform edge as low nodes. The posterior half of the platform is ornamented by nodes arranged haphazardly and sometimes fusing into irregular ridges, which disrupt and mask the carina. The outer platform wall is, in most specimens, expanded to give a secondary outer platform outside the platform edge.

In lateral view the blade is only just higher than the platform and is about a quarter of its length; it is composed of about 6 short laterally compressed fused denticles with free chevron tips. The aboral outline is depressed posterior to the basal cavity.

The basal cavity is ovate and situated in the anterior third of the platform. The anterior keel beneath the free blade is grooved, but the platform keel, which is deflected inwards, is not. The aboral surface bears concentric growth-lines, which appear as faint ridges and grooves.

Remarks: *P. elongonodosus* is characterized by the development of low nodes on the posterior half of the platform. The anterior half of the platform and the blade are similar to the *P. inornatus* group, from which the species may have developed. Rhodes, Austin, & Druce (1968) noted that some specimens of *P. inornatus* possess posterior transverse ridges disintegrating into nodes.

POLYGNATHUS INORNATUS INORNATUS Branson & Mehl, 1934
(Pl. 20, figs 1a-3c)

1934 *Polygnathus inornata* Branson & Mehl, *Univ. Missouri Stud.*, 8, 293, pl. 24, figs 5-7.
1968 *Polygnathus inornata inornata* Branson & Mehl; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 10, figs 4a-6c (Synonymy).

Material: 82 specimens; CPC 7949, 7951, 7952 figured.

Range: Uppermost *Siphonodella sulcata-Polygnathus parapetus* A.Z. to lower *Spathognathodus tridentatus* A.Z.

Description: The blade is subtriangular, composed of about 8 laterally compressed denticles increasing in height and width medially. The platform is lanceolate, nearly symmetrical, ornamented by strong transverse ridges diminishing towards the medial carina, which is flanked by anteriorly deepening troughs.

The basal cavity lies at the anterior end of the platform at the junction with the free blade. It is subovate and extends along the aboral edge of the blade and the platform keel as a fine groove. A 'chine' is present at the junction of the aboral surface and the lateral faces.

Remarks: Some specimens show characters transitional to *P. inornatus rostratus* Rhodes, Austin, & Druce (1968).

Occurrence: Rhodes, Austin, & Druce (1968) record *P. inornatus inornatus* from the upper part of the *Cleistopora* (K) Zone. It was originally described from the Bushberg Sandstone of Missouri, USA (Branson & Mehl, 1934).

POLYGNATHUS INORNATUS NODULATUS subsp. nov.
(Pl. 21, figs 2a, b; Text-fig. 21)

Derivation of name: From the nodose ornament.

Material: 56 specimens; holotype CPC 7986.

Range: *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z. to lower *Siphonodella quadruplicata-S. cooperi* A.Z.

Diagnosis: A subspecies of *P. inornatus* with a rostral ridge on the inner platform; the platform is ornamented with irregular nodes.

Description: The blade is short, one third the length of the platform, and is composed of up to 6 laterally compressed basally fused denticles with free chevron tips which are largest medially. The blade continues on to the platform as a low nodose carina.

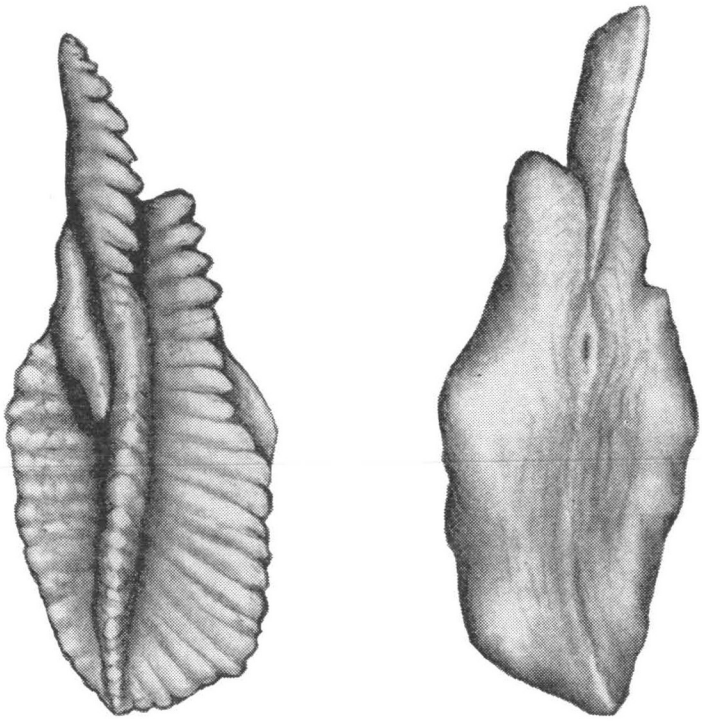

Figure 21. *Polygnathus inornatus nodulatus* **subsp. nov. (a) Oral and (b) aboral views of holotype, CPC7987, x 70.**

The platform is asymmetrical; the outer platform is expanded and bears strong transverse ridges which disappear towards the carina. An anteriorly deepening trough separates the outer platform ornament from the carina. The inner platform bears an anterior rostral ridge. The remainder of the platform is covered with irregular nodes which reach nearly to the carina but are separated from it by a narrow shallow trough.

The basal cavity is small, round, and situated in the anterior third. A keel runs to the posterior termination; a faint trough may be present.

Remarks: *P. inornatus nodulatus* is a variant of *P. inornatus rostratus* Rhodes, Austin, & Druce (1968). It bears a similar rostral ridge, but differs in having nodose ornament instead of transverse ridges. It differs from *P. elongonodosus* sp. nov. in that the nodose ornament is confined to the inner platform and a rostral ridge is developed. Like *P. inornatus rostratus,* it shows a homoeomorphic tendency toward the genus *Siphonodella,* especially *S. duplicata* (Branson & Mehl).

POLYGNATHUS INORNATUS ROSTRATUS Rhodes, Austin, & Druce, 1968
(Pl. 20, figs 4a-c; Pl. 21, figs 1a-c)

?1939 *Polygnathus irregularis* Cooper, *J. Paleont.*, 13, 400, pl. 39, figs 57, 58.
1962 *Pseudopolygnathus?* cf. *Pseudopolygnathus triangula* Voges; Müller, *J. Paleont.*, 36, 1388, text-figs 9a-c.
1968 *Polygnathus inornata rostrata* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 10, figs 7a-9c.

Material: 18 specimens; CPC 7950, 7958 figured.

Range: *Siphonodella quadruplicata-S. cooperi* A.Z. to lowermost *Clydagnathus nodosus* A.Z.

Description: The platform is lanceolate, more than twice as long as wide, and asymmetrical. A low nodose carina is developed as a continuation of the anterior free blade. The posterior termination of the platform and the carina are blunt. The inner platform is narrow, ornamented with 2 rows of low nodes. In the anterior portion the platform edge develops posteriorly into a platform ridge; this breaks up into a row of low nodes which parallel the secondary platform edge in the posterior. An anteriorly deepening trough is present between the anterior inner platform edge and the anterior free blade. The outer platform is the larger and the platform edge is very high. The ornament consists of very low transverse ridges which disappear toward the carina and give way to an anteriorly deepening trough adjacent to the carina. In lateral view the blade is half as high as the platform and is composed of laterally compressed, completely fused denticles with free chevron tips, which are tallest in the middle of the blade. The outer platform rim is nearly as high as the blade in its posteromedial part. The inner platform and the carina are the same height.

A basal cavity can be seen in the anterior third of the platform; on either side is a keel which extends to both extremities. Only the anterior keel is grooved. A 'chine' is present on the platform on both sides of the posteriorly deepening keel; it marks the junction of the lateral and aboral platform faces and is concave to the keel.

Occurrence: *P. inornatus rostratus* is otherwise known only from Britain, where it occurs in the upper *Cleistopora* (K) Zone and the basal bed of the *Zaphrentis* (Z) Zone on the North Crop of the South Wales Coalfield (Rhodes et al., 1968). It is probably present in the Banff Formation of Alberta (Müller, 1962) and the pre-Welden shale of Oklahoma (Cooper, 1939).

POLYGNATHUS cf. P. LONGIPOSTICUS Branson & Mehl, 1934
(Pl. 21, figs 4a-5)

cf. 1934 *Polygnathus longipostica* Branson & Mehl, *Univ. Missouri Stud.*, 8, 294, pl. 24, figs 8-11.

Material: 6 specimens; CPC 7966, 7967 figured.

Description: The platform is lanceolate and irregular. It is divided by a carina formed of low fused nodes arranged in an irregular linear fashion, which merges with the free blade in the anterior and terminates at the posterior extremity of

the platform. The platform ornament consists of nodes and transverse ridges arranged irregularly to form a highly irregular platform edge. On either side of the carina there is a shallow trough which tends to deepen anteriorly.

The blade is more than twice as high and half as long as the platform and consists of about 4 broad, laterally compressed, wholly fused denticles. A small pear-shaped basal cavity is present in the anterior third of the platform; it narrows rapidly anteriorly but slowly posteriorly and the low thickened lips run on to form the anterior and posterior keel. The keel is finely grooved over its whole length.

Occurrence: In the Bonaparte Gulf Basin *P.* cf. *P. longiposticus* is confined to the upper *Spathognathodus plumulus* A.Z.

POLYGNATHUS NODOCOSTATUS NODOCOSTATUS Branson & Mehl, 1934
(Pl. 19, fig. 6)

1934 *Polygnathus nodocostata* Branson & Mehl, *Univ. Missouri Stud.*, 8(3), 246, pl. 20, figs 9-13; pl. 21, fig. 15 (pl. 20, fig. 12 is lectotype selected by Helms, 1961, p. 686).
1934 *Polygnathus varinodosa* Branson & Mehl, *ibid.*, 249, pl. 20, fig. 15 (*non* pl. 21, figs 9, 11, 12 = *P. pennatuloidea: non* pl. 21, fig. 18).
1934 *Polygnathus rhomboidea* Ulrich & Bassler; Branson & Mehl, *ibid.*, 245, pl. 21, fig. 8 (*non* fig. 13 = *P. rhomboidea*).
1958 *Polygnathus nodocostata* Branson & Mehl; Klapper, *J. Paleont.*, 32, 1089, pl. 142, fig. 4.
1961 *Polygnathus nodocostata* Branson & Mehl; Helms, *Geologie*, 10, 686.
1961 *Polygnathus nodocostata nodocostata* Branson & Mehl; Helms, *ibid.*, 687, pl. 1, figs 17, 21, 23; pl. 2, figs 16-20, 22, text-fig. 6.
1961 *Polygnathus nodocostata incurva* Helms, *ibid.*, 686, pl. 1, figs 14-16, text-fig. 5.
1961 *Polygnathus nodocostata* cf. *ovata* Helms, *ibid.*, 703, pl. 1, figs 13, 24.
1961 *Polygnathus nodocostata nodocostata* Branson & Mehl; Helms, *ibid.*, 994, pl. 3, fig. 11.
1961 *Polygnathus nodocostata* Branson & Mehl; Freyer, *Freiberger Forsch.* C-95, 72.
1962 *Polygnathus nodocostata* Branson & Mehl s.l.; Ziegler, *Hess. Landesamt. Bodenf. Abh.*, 38, 90, pl. 10, figs 2, 9-15.
1965 *Polygnathus nodocostata nodocostata* Branson & Mehl; Bouckaert & Ziegler, *Mém. Expl. Cartes Géol. Min. Belg.*, 5, pl. 4, figs 3, 4.
1966 *Polygnathus nodocostata* Branson & Mehl; Anderson, *J. Paleont.*, 40, 412, pl. 51, figs 8, 12, 13.
1966 *Polygnathus nodocostata nodocostata* Branson & Mehl; Glenister & Klapper, *J. Paleont.*, 40, 829, pl. 94, figs 8, 9, 14, 15.

Material: 1 specimen, CPC 7997.

Range: Westwood Member of Cockatoo Formation.

Remarks: Glenister & Klapper (1966, p. 829) have discussed the relationships of subspecies of *P. nodocostatus*. The present specimen is very similar to Branson & Mehl's specimen (1934, p. 20, fig. 13) except that there appears to be some breakdown of the ornament linearity; ridges, as opposed to lines of nodes, are developed.

Occurrence: *P. nodocostatus nodocostatus* is recorded from the United States, Germany, Belgium, and Australia. It ranges from the upper Frasnian (toI$_\gamma$) to the lower Famennian (toIII) (Helms, 1961) and perhaps as high as the upper Famennian (toV) (Ziegler, 1962).

POLYGNATHUS NORMALIS Miller & Youngquist, 1947
(Pl. 19, figs 7a-10b)

1938 *Polygnathus webbi* Stauffer (part), *J. Paleont.*, 12, 439, pl. 53, figs 25, 28, 29 (*non* fig. 26 = *P. webbi*).
1947 *Polygnathus webbi* Stauffer; Miller & Youngquist, *J. Paleont.*, 21, 515, pl. 74, figs 1, 2.
1947 *Polygnathus normalis* Miller & Youngquist, *ibid.*, 21, 515, pl. 74, fig. 4 only (*non* fig. 5 = *P. decorosa*).
1947 *Polygnathus? rugicosta* Miller & Youngquist, *ibid.*, 515, pl. 74, fig. 15.
1948 *Polygnathus normalis* Youngquist & Miller, *ibid.*, 22, 448, pl. 68, fig. 11.
1948 *Polygnathus longipostica* Branson & Mehl; Youngquist & Miller, *ibid.*, 448, pl. 68, fig. 12.
1956 *Polygnathus normalis* Miller & Youngquist; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 133, pl. 9, fig. 18.
1957 *Polygnathus normalis* Miller & Youngquist; Bischoff & Ziegler, *ibid., Abh.*, 22, 93.
1957 *Polygnathus normalis* Miller & Youngquist; Ziegler *in* Flügel & Ziegler, *Mitt. naturw. Verh. Steiermark*, 87, 29.
1957 *Polygnathus normalis* Miller & Youngquist; Lys & Serre, *Rév. Inst. franç. Pétrole*, 12, 805, pl. 11, fig. 7.
1957 *Polygnathus normalis* Miller & Youngquist; Lys & Serre, *ibid.*, 1049, pl. 6, figs 1a, b.
1957 *Polygnathus normalis* Miller & Youngquist; Müller & Müller, *J. Paleont.*, 31, 1089, pl. 135, fig. 9; pl. 141, fig. 3.
1957 *Polygnathus amana* Müller & Müller, *ibid.*, 1085, pl. 135, fig. 4.
1957 *Polygnathus granulosa* Branson & Mehl; Müller & Müller, *ibid.*, 1088, pl. 135, fig. 2, 8; pl. 141, fig. 1.
1958 *Polygnathus normalis* Miller & Youngquist; Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 87, 13.
1959 *Polignathus (sic)* aff. *P. normalis;* Panseri & Barsotti, *Inst. Geol. Espana, Notas Comun.*, 55, 163, pl. 1, figs 7, 7a.
1960 *Polygnathus normalis* Miller & Youngquist; Lys & Serre, *Int. geol. Cong., 21st Sess. Rep.*, 6, 38.
1961 *Polygnathus normalis* Miller & Youngquist; Helms, *Geologie*, 8, pl. 2, fig. 4.
1961 *Polygnathus normalis* Miller & Youngquist; Freyer, *Freiberger Forschr.*, C-95, 72, pl. 4, figs 103, 104.
1961 *Polygnathus normalis* Miller & Youngquist; Beach, *Brigham Young Univ. geol. Stud.*, 8, 49, pl. 6, fig. 6.
1962 *Polygnathus normalis* Miller & Youngquist; Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 38, 91.
1964 *Polygnathus normalis* Miller & Youngquist; Budurov & Tschunev, *Bull. Inst. sci. Rech. Géol.*, 1, 256, 257, pl. 4, figs 6a, b.
1965 *Polygnathus normalis* Miller & Youngquist; Ethington, *J. Paleont.*, 39, 582.
non 1965 *Polygnathus normalis* Miller & Youngquist s.l.; Krebs & Ziegler, *Fortsch. Geol. Rhein. Westf.*, 9, pl. 2, fig. 1 (= ?*P.* sp. nov.).
1966 *Polygnathus normalis* Miller & Youngquist; Anderson, *J. Paleont.*, 40, 412.

Material: 52 specimens; CPC 7953-56 figured.

Range: Throughout the Westwood Member, Cockatoo Formation.

Diagnosis: A simple polygnathid with an incurved posterior termination, constricted anterior platform edges, and low nodes developed on the platform perimeter.

Remarks: Anderson (1966, p. 413) discusses the position of gerontic forms of *P. normalis,* described as *P.? rugicostus* by Miller & Youngquist (1947, p. 515) and *P. granulosus* Branson & Mehl by Müller & Müller (1957, p. 1088).

Occurrence: *P. normalis* is known from the United States, Germany, France, Italy, and Bulgaria. It ranges from the Upper Middle Devonian to the Frasnian-Famennian boundary (tmo-to1/11 boundary).

POLYGNATHUS PARAPETUS sp. nov.

(Pl. 43, figs 6a-9b)

Derivation of name: From the blade-like development of the outer parapet.

Material: 81 specimens; holotype CPC 7977, paratypes CPC 7974-7976.

Range: Middle *Spathognathodus plumulus* A.Z. to upper limit of *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Diagnosis: A polygnathid characterized by a blade-like development of the outer platform parapet and a funnel-shaped attachment scar adjacent to the basal cavity.

Description: The platform is elongate, over three times as long as wide, and is divided symmetrically by a medial carina. The carina is formed of low fused nodes which merge with the anterior free blade in the anterior, and is projected beyond the posterior termination of the platform to form a short posterior free blade. Both platforms are narrow; their surface is gently concave in the posterior half, where they are ornamented by short transverse ridges which fade toward the carina and erupt on the platform edge, serrating it slightly. The carina is flanked on either side by a shallow trough in this part of the platform; anteriorly the troughs deepen and the platform edges become upturned until they are vertical. The platform edges bear laterally compressed fused chevron-tipped denticles. The anterior free blade is less than half the length of the platform. It is composed of about 6 denticles, of which the medial two are tallest, and the remainder shorten both anteriorly and posteriorly. The denticles are laterally compressed, fused, with free chevron tips. The anterior outer platform edge is extremely tall, as high as the anterior free blade. It is composed of fused denticles with free chevron tips, with a medial costa on each. The posterior outer platform edge is as high as the inner platform edge and a little over half the height of the anterior free blade. The anterior inner lateral face of the platform is vertical or overturned, producing a flat face in lateral view. The posterior free blade is very short and bears two short triangular denticles.

A small circular basal cavity is visible in the anterior third of the platform. A medial keel runs anteriorly along the free blade and posteriorly along the platform from the basal cavity. A fine medial groove is present over the whole distance. Symmetrically arranged around the basal cavity and extending and narrowing to the posterior termination is a flat attachment scar. At the junction of this area and the platform walls a 'chine' is present.

Remarks: In overall morphology *P. parapetus* is similar to *P. brevilaminus* Branson & Mehl. The differing basal cavity and aboral structure, and the very high anterior outer platform, serve to distinguish it. The high platform edge is also seen in *P. communis dentatus* subsp. nov. *Polygnathus permarginatus* E. R. Branson is very similar to *P. parapetus* in oral ornament and morphology, but the aboral surface is not illustrated and Branson makes no mention of any attachment scar round the basal cavity; if further work on Missouri Bushberg faunas shows it to be present *P. parapetus* sp. nov. would fall in synonymy with *P. permarginatus* Branson. For the present it is considered that the attachment scar on the aboral surface of *P. parapetus* is sufficient criterion to erect a new species.

POLYGNATHUS SIPHONELLUS sp. nov.
(Pl. 25, figs 1-2b; Text-fig. 22)

Derivation of name: From the siphonodellid character of the oral surface.

Material: 144 specimens; holotype CPC8033, paratype CPC 8034.

Range: Uppermost *Spathognathodus plumulus* A.Z. to upper limit of *Siphonodella quadruplicata-S. cooperi* A.Z.

Diagnosis: A polygnathid with a well developed rostral ridge and denticulate platform developed on the outer side of the ridge.

Description: The platform is ovate, just over twice as long as wide, and divided unequally by a low carina formed of fused rounded nodes merging with the anterior free blade and becoming obsolete posteriorly after being deflected slightly toward the inner side. The inner platform ornament consists of low nodes arranged transversely or transverse ridges which diminish toward the carina. In the anterior, part of the platform margin may be upturned and inset close to the carina, from which it is separated by a deep trough. The outer platform is wide and semicircular; it is ornamented by faint transverse ridges. The posterior termination is spatulate, lacks a carina, and is generally smooth. At the anterior end a longitudinal ridge parallels the carina, its most anterior part being the platform edge. Posterior to this, it encroaches on the outer platform. This ridge is separated from the carina by a deep trough.

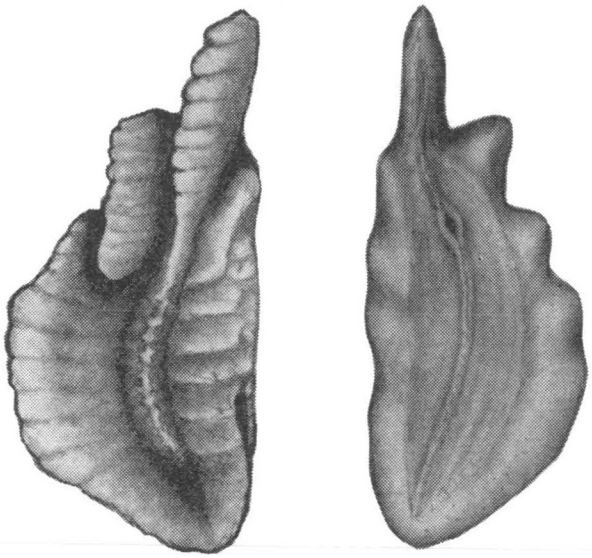

Figure 22. *Polygnathus siphonellus* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC8033, x 60.**

In lateral view the anterior free blade is the same height as the platform, in some specimens slightly higher, and about a quarter the length. It is composed of 5 to 7 laterally compressed fused denticles with free chevron tips, the oral

margin being convex and the tallest denticle situated medially. The platform edges are higher than the carina, the general height decreasing toward the posterior termination.

A minute elongate basal cavity is visible in the anterior half. A faint groove runs anteriorly along the free blade and a low keel is developed along the platform. Concentric growth-lines are present on the extremely flat aboral surface and a 'chine' is well developed at the junction of the lateral and aboral surfaces.

Remarks: *P. siphonellus* seems to continue the trend seen in *P. inornatus rostratus* Rhodes, Austin, & Druce, 1968, for polygnathids to mirror the development of siphonodellids. Orally it closely resembles *S. duplicata* and *S. crenulata,* but the aboral surface, particularly the basal cavity, is distinctive and places the species in *Polygnathus*.

POLYGNATHUS THOMASI sp. nov.
(Pl. 25, figs 5a, b)

1949 *Polygnathus* sp. B. Thomas, *Bull. geol. Soc. Amer.*, 60, 419, pl. 3, fig. 33.

Derivation of name: In honour of Dr L. A. Thomas.

Material: 6 specimens; holotype CPC 7973.

Diagnosis: A small polygnathid with an inner platform which does not reach as far posteriorly as the outer platform.

Description: The platform is short, twice as long as wide, and asymmetrically divided by a carina formed of low fused denticles, which merges with the blade anteriorly, and in the posterior can extend beyond the platform to form a very short posterior free blade. The inner platform is much narrower and does not extend as far posteriorly as the outer platform. Both platforms have serrated edges and very faint transverse ridges which fade away towards the carina, on either side of which there is a shallow trough. In lateral view the blade is low, only just higher than the platform, and about half its length. It is composed of about 4 laterally compressed fused denticles of equal height.

A large circular basal cavity is visible at the junction of the blade and the platform. The cavity lips are slightly flared. The deep medial keel runs along the aboral surface of the platform and is not grooved.

Occurrence: Thomas (1949, p. 419) records the species from the lower Carboniferous English River and Prospect Hill siltstone of Iowa, USA. In the Bonaparte Gulf Basin it has an isolated occurrence in the *Clydagnathus nodosus* A.Z.

POLYGNATHUS TOXOPHORUS Cooper, 1939
(Pl. 25, figs 4a, b; 7a-9c)

1939 *Polygnathus toxophora* Cooper, *J. Paleont.*, 13, 404, pl. 39, figs 69, 70.

Material: 6 specimens; CPC 7959, 7960, 7968, 7969 figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to lowermost *Clydagnathus nodosus* A.Z.

Description: The platform is lanceolate and asymmetrical. A medial nodose carina is continuous with the denticulate anterior and posterior free blades. The inner platform is the same width as the outer platform; although their anterior margins

are confluent its posterior termination is anterior to that of the outer plaform. The ornament is similar on both platforms, consisting of coarse transverse ridges which erupt from the platform margin as chevron-shaped denticles.

The anterior free blade is the same length as the platform and is twice the height. It consists of at least 5 laterally compressed, basally fused, free-tipped, fused denticles which increase in height anteriorly. The posterior free blade is half the length of the platform and bears 4 or 5 short anteriorly inclined denticles. The platform edges are the same height as the carina.

The large basal cavity is pear-shaped—widest near the anterior platform extremity, and narrowing rapidly toward the anterior free blade and very slowly towards the posterior extremity.

Occurrence: *P. toxophorus* is known from the pre-Welden shale of Oklahoma, USA (Cooper, 1939).

POLYGNATHUS cf. P. VARCUS Stauffer, 1940
(Pl. 19, figs 11, 12)

cf. 1940 *Polygnathus varcus* Stauffer, *J. Paleont.*, 14, 430, pl. 60, figs 49, 53, 55 (fig. 49 = lectotype selected by Bischoff & Ziegler, 1957, p. 98).

Material: 58 specimens; CPC 7964, 7965 figured.

Range: Cockatoo Formation and lower part of Ningbing Formation.

Description: The unit is curved, but the platforms are of equal size. Both platforms consist of shallow unornamented troughs with upturned edges either side of the carina. The platform edges are greatly thickened but lack ornament. The medial carina is a ridge of low fused nodes which terminates at the posterior with the thickened platform edges and anteriorly merges with the free blade.

The blade is twice as deep as the platform, extending both above and below it. It is the same length as the platform and consists of at least 12 laterally compressed fused denticles of approximately equal height but tending to be higher in the medial portion. A small elongate basal cavity is visible at the junction of the anterior free blade and the platform. The remainder of the platform and the blade bear a sharp keel.

Remarks: The present specimens have similar morphological features to *P. varcus* Stauffer but have blades and platforms of approximately the same length. *P. varcus* has a restricted platform and a very long anterior free blade.

POLYGNATHUS ZNEPOLENSIS Spasov, 1965
(Pl. 26, figs 1a-3c)

1965 *Polygnathus znepolensis* Spasov, *Trav. géol. Bulgarie, Sér. paléont.*, 7, 96, pl. 3, figs 1, 2.
?1966 *Polygnathus* cf. *P. obliquicostata* Ziegler; Glenister & Klapper, *J. Paleont.*, 40, 830.

Material: 18 specimens; CPC 7978-80 figured.

Range: Upper part of Ningbing Limestone.

Description: The blade is less than half the length of the platform, and is composed of laterally compressed needle-like denticles of approximately the same size. The blade continues on to the platform as a median carina composed of a large number of small nodes. Height decreases abruptly at the junction of the blade with the carina. The platform is asymmetrical; the posterior portion of the expanded outer platform is lobate and lacks any ornament except faint nodes on the platform edge. The inner platform is narrow and is ornamented by about 14 low fine diagonal ridges which run anteriorly from the carina. In the anterior half the inner platform is constricted, the platform edge being upturned and composed of low nodes. A similar development is seen on the anterior portion of the outer platform, the two edges being separated from the median blade by deep troughs. Aborally, the basal cavity is minute and elongate, situated at the junction of the free blade and the platform. A keel runs from the basal cavity to the posterior termination.

Remarks: Spasov (1965, pp. 96, 107) erected a new species *Polygnathus znepolensis* to include forms with a smooth outer platform and a diagonally ornamented inner platform. Spasov's figured specimens differ from the Bonaparte Gulf Basin specimens in that the outer platform is larger and the anterior platform edges less upturned; but this may be due to the fact that Spasov's specimen is massive. Glenister & Klapper (1966, p. 830) described some species from the Canning Basin, Western Australia, as *Polygnathus* cf. *P. obliquicostatus* Ziegler, noting that their specimens lacked the ornament on the outer platform which is present in that species. These unfigured specimens also probably belong to *P. znepolensis* Spasov.

Occurrence: This species has previously been recorded from Bulgaria in strata of toV-toVI age (Spasov, 1965) and possibly from the Canning Basin, Western Australia.

POLYGNATHUS sp. A
(Pl. 21, fig. 3)

Material: 2 specimens; CPC 8330 figured.

Description: The blade is very short and deep, composed of fine laterally compressed denticles fused over most of their length. It continues on to the platform as a low carina. The platform is considerably arched and bowed; its surface slopes towards both ends. The ornament consists of transverse ridges faint in the anterior half but transgressing and masking the carina in the posterior half.

The basal cavity is in the anterior third and is small and round. A keel runs from the cavity to the posterior termination.

Remarks: Three species of *Polygnathus* exhibit strong cross ridges in the posterior half of the platform; but all three, *P. linguiformis* Hinde, *P. semicostatus* Branson & Mehl, and *P. obliquicostatus* Ziegler, are considerably longer and do not exhibit the anterior sloping of the platform.

Occurrence: Frasnian Cockatoo Formation.

POLYGNATHUS sp. B
(Pl. 26, figs 5a-7c)

Material: 10 specimens; CPC 7994-6 figured.

Range: Lowermost *Spathognathodus plumulus* A.Z.

Description: The blade is about the same length as the platform, composed of laterally compressed denticles with free chevron tips, the height increasing toward the anterior. The free blade continues on to the platform as a low carina.

The platform is nearly symmetrical; it is constricted anteriorly, gently expands posteriorly, and has a rounded blunt end. The ornament consists of nodes developed on the platform edges and running towards the carina as transverse ridges, but separated from it by a trough on either side of the carina.

In aboral view the unit is distinctive; the whole aboral surface is a broad inverted basal cavity with a median trough.

Remarks: Orally *P.* sp. B resembles *Pseudopolygnathus radinus* (Cooper), classed as a junior synonym of *Pseudopolygnathus ithus* (Cooper) by Rexroad & Scott (1964, p. 39-40), but the aboral surface is completely different—*P. radinus* (Cooper) possesses a normal basal cavity. The species also resembles *P. scaphus* (Cooper) (sic) of Thomas (1949, pl. 3, fig. 22); but Thomas' specimen is neither described nor illustrated in aboral view, so no firm comparison can be made. *P. scaphus* (Huddle) differs both orally and aborally from the Bonaparte Gulf specimens.

POLYGNATHUS sp. C
(Pl. 26, figs 4a, b)

Material: 7 specimens; CPC 8000 figured.

Description: The platform is elongate, three times as long as wide, and is divided by a medial carina formed of low fused nodes merging anteriorly with the free blade and terminating at the blunt posterior platform extremity. The inner platform is narrow, ornamented with irregular transverse nodes that become fainter toward the carina. The platform edge is upturned to give a deep trough between it and the carina. The inner platform is medially expanded. The platform edge ornament, which consists of low fused nodes, does not follow the edge in this medial part but moves close to the carina, leaving a secondary platform outside the platform edge. The carina and the platform edge ornament are separated by a deep narrow trough. The secondary platform is ornamented by low irregular nodes.

The blade is twice as high and a third as long as the platform. It is composed of 7 laterally compressed fused denticles with free chevron tips. Apart from the two anterior denticles, which are small, it is highest at the anterior, decreasing in height uniformly toward the posterior.

Aborally there is a shallow, very narrow, elongate basal cavity in the middle of the platform. The remainder of the unit is keeled; the keel has a fine medial groove, and its posterior portion is twisted and has a blunt termination.

Occurrence: Upper *Siphonodella sulcata-Polygnathus parapetus* A.Z.

POLYGNATHUS sp. D
(Pl. 23, fig. 5)

Material: 1 specimen, CPC 7998.

Description: Platform ovate, asymmetrical, bearing a carina which is a low fused ridge. The platform ornament consists of 4 parallel fused ridges on either platform, which parallel the carina. They are the same height over the whole unit.

Aborally there is an ovate basal cavity at the anterior end of the platform; a keel runs from the cavity to the posterior termination.

Remarks: The species obviously belongs to the *P. nodocostatus* group. No named species possesses low ridges over its whole length; but a form figured by Branson & Mehl (1934, pl. 20, fig. 16) as *P.* sp. appears to be similar to the present specimen. *P.* cf. *pennatuloideus* Holmes, as illustrated by Helms (1961, p. 2, fig. 15), is also similar, and the present specimen could be an adaptation of this species.

Occurrence: Famennian Ningbing Limestone.

Genus POLYLOPHODONTA Branson & Mehl, 1934

Type species: *Polygnathus gyratilineatus* Ulrich & Bassler, 1926.

POLYLOPHODONTA CONFLUENS (Ulrich & Bassler, 1926)
(Pl. 34, figs 3a, b)

1926 *Polygnathus confluens* Ulrich & Bassler, *Proc. U.S. nat. Mus.*, 68(12), 46; pl. 7, figs 14, 15.

1934 *Polylophodonta linguiformis* Branson & Mehl, *Univ. Missouri Stud.*, 8(3), 244, pl. 20, figs 6, 7 (*non* fig. 1 = *P. pergyrata*).

1956 *Polylophodonta confluens* (Ulrich & Bassler); Hass, *U.S. geol. Surv. prof. Pap.* 286, 8, pl. 3, fig. 10.

1959 *Polylophodonta confluens* (Ulrich & Bassler); Hass, *U.S. geol. Surv. prof. Pap.* 294-J, pl. 50, fig. 18.

1961 *Polylophodonta confluens* (Ulrich & Bassler); Helms, *Geologie*, 10, 698, pl. 3, figs 13, 14, 18; text-fig. 14.

1962 *Polylophodonta gyratilineata* (Holmes); Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 38, 96, pl. 9, figs 19, 20 (*non* fig. 17 = *P. pergyrata?*).

non 1962 *Polylophodonta confluens* (Ulrich & Bassler); Hass, in *Treatise on Invertebrate Paleontology*, Pt W., *Miscellanea*, W61, text-fig. 36, fig. 9 (= *P. pergyrata*).

1964 *Polylophodonta aff. confluens* Ulrich & Bassler; Lindström, *Conodonts, Elsevier, London*, fig. 61b.

Material: 2 specimens; CPC 8001 figured.

Range: Lower part of Ningbing Limestone.

Diagnosis: A polylophodontid with platform consisting of ridges paralleling the carina in the anterior half and becoming transverse in the posterior half to give a semiconcentric pattern.

Remarks: Glenister & Klapper (1966, p. 331) discuss the relationship of the various species of *Polylophodonta* and the interspecific variability of *Polylophodonta confluens*.

Occurrence: The original occurrence was in the Hardin Sandstone, Tennessee, USA (Ulrich & Bassler, 1926). Ziegler (1962, p. 96) records the range of the species as *rhomboidea* (lower toII_β) to lower *quadrantinodosa* (upper toII_β) zone in Germany.

POLYLOPHODONTA ELONGATA sp. nov.
(Pl. 34, figs 1a-2c; Text-fig. 23)

Derivation of name: After the elongate platform.

Material: 8 specimens; holotype CPC 8002, paratype CPC 8003.

Range: Lower part of Ningbing Limestone.

Diagnosis: An elongate polylophodontid with coarse diagonal ribbing.

Description: The blade is shorter than the platform; it is composed of 8 low denticles which are laterally compressed and basally fused, with free chevron tips. The blade continues on to the platform as a carina, which runs diagonally across the platform to the outer edge.

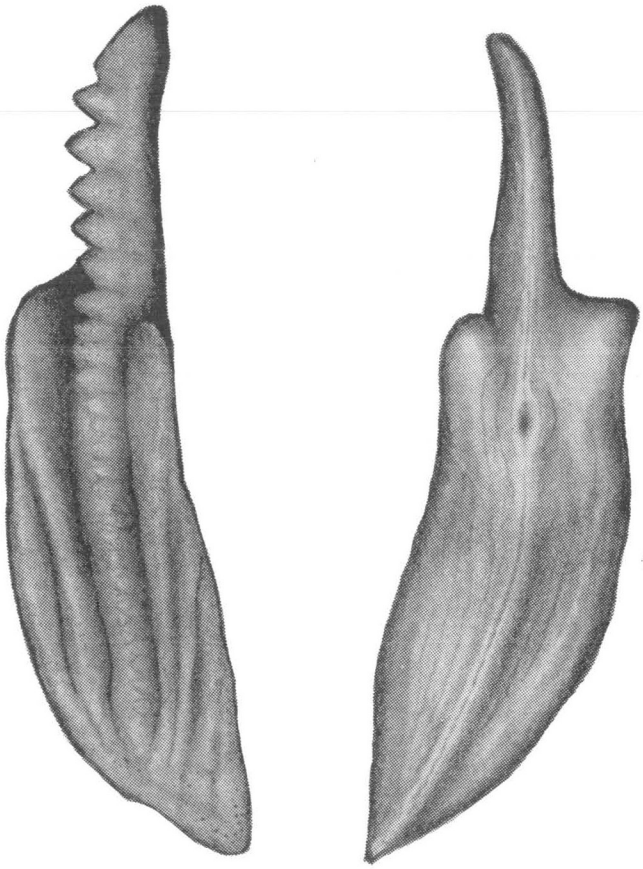

Figure 23. *Polylophodonta elongata* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC8002, x 90.**

The platform is lanceolate; on the outer side of the carina it is restricted and bears one longitudinal ridge. The inner platform ornament consists of up to 6 fused ridges which run diagonally across the posterior half of the platform, paralleling the carina. In aboral view the unit is elongate with a small elongate basal cavity in the anterior quarter. A keel runs to the posterior termination.

Remarks: *P. elongata* can be distinguished from other species of *Polylophodonta* by the marked elongation of the platform and by the diagonal rather than concentric ornament on the platform.

POLYLOPHODONTA sp. A
(Pl. 34, figs 4a, b)

Material: 1 specimen, CPC 8006.

Description: The unit is pear-shaped, twice as long as wide and lacking a carina except at the extreme anterior, at the junction of the platform and the blade. The platform ornament consists of low ridges composed of fused nodes arranged in a longitudinal fashion. Some rows are irregular and in the anterior they tend to have a semicircular pattern.

In lateral view the blade is about one third the length of the platform, but is 3 times as deep, extending both orally and aborally with reference to the platform. It is composed of about 4 laterally compressed fused denticles with free chevron tips, the tallest situated medially. The platform is depressed immediately posterior to the basal cavity. In aboral view, the small elongate basal cavity is visible in the anterior third of the unit. The remainder is keeled; a fine groove originating at the basal cavity runs for a short distance along it in either direction.

Remarks: The species is characterized by the linearity of the ornament: most polylophodontids show concentric or pseudoconcentric ornament.

Occurrence: One specimen has been found in the Buttons Beds (see Appendix).

Genus PRIONIODINA Bassler, 1925

Type species: *Prioniodina subcurvata* Ulrich & Bassler, 1926.

PRIONIODINA LATERICRESCENS (Branson & Mehl, 1934)
(Pl. 34, figs 5, 6)

1934 *Lonchodina latericrescens* Branson & Mehl, *Univ. Missouri Stud.*, 8, 212, pl. 14, fig. 20.
1968 *Prioniodina latericrescens* Branson & Mehl; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 24, fig. 19.

Material: 14 specimens; CPC 8007, 8331 figured.

Description: Unit elongate, arched, and bowed, with bars of equal length. Anterior and posterior bars are similar, expanded and circular in cross-section, becoming more laterally compressed towards their distal ends. They both bear from 5 to 6 medium-sized, blunt-tipped, basally fused denticles which are ovate in cross-section with anterior and posterior knife edges. The apical denticle is twice the size of the bar denticles and of the same general shape; it is composed of 3 wholly fused denticles which are seen as germ denticles within the bar.

Aborally there is a small basal pit beneath the apical denticle; surrounding it is an inverted basal cavity which inflates the aboro-lateral margins of the apical denticle and extends along both bars for approximately half their length.

Occurrence: In the Bonaparte Gulf Basin *P. latericrescens* ranges from the *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z. to the *Spathognathodus tridentatus* A.Z.

PRIONIODINA? SMITHI (Stauffer, 1935)
(Pl. 34, fig. 7; Pl. 38, figs 7a, b)

1938 *Prioniodus smithi* Stauffer, *J. Paleont.*, 12, 441, pl. 50, fig. 26.

1947 *Euprioniodina parvula* Miller & Youngquist, *J. Paleont.*, 21, 507, pl. 73, fig. 16.

1955 *Prioniodina smithi* (Stauffer); Sannemann, *Senck. leth.*, 36, 152, pl. 3, figs 15, 17.

1956 *Prioniodina smithi* (Stauffer); Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 135, pl. 10, figs 18, 19.

1959 *Prioniodina smithi* (Stauffer); Helms, *Geologie*, 9, 653, pl. 2, fig. 8; pl. 4, fig. 17.

1959 *Prioniodina* cf. *smithi* (Stauffer); Helms, *ibid.*, 666, pl. 1, fig. 15.

1960 *Prioniodina smithi* (Stauffer); Zimmermann, *Freiberger Forsch.*, C-89, pl. 8, figs 9, 10.

1961 *Prioniodina smithi* (Stauffer); Freyer, *Freiberger Forsch.*, C-95, 79, pl. 5, figs 118-120.

1962 *Prioniodina powellensis* (Stauffer); Ethington & Furnish, *J. Paleont.*, 36, 1284.

1962 *Prioniodina smithi* (Stauffer); Spasov & Stevanovic, *Geol. Analu Balkan.*, 29, 62, pl. 2, fig. 12.

1963 *Prioniodina smithi* (Stauffer); (Stanffer in text), Abdusselamoglu, *Bull. Min. Res. Expl. Inst. Turkey*, 60, 4, pl. 1, fig. 10.

1964 *Prioniodina smithi* (Stauffer); Friakova, *Vestnik UUG*, 39, 14, pl. 1, fig. 10.

1965 *Prioniodina smithi* (Stauffer); Spasov, *Trav. géol. Bulgarie, Sér. paléont.*, 7, 98, pl. 3, fig. 7.

1966 *Prioniodina? smithi* (Stauffer); Glenister & Klapper, *J. Paleont.*, 40, 833, pl. 96, figs 7-9. (Synonymy).

Material: 6 specimens; CPC 8008 figured.

Remarks: As was pointed out by Glenister & Klapper (1966, p. 833) the generic designation of *Prioniodina? smithi* is questionable. It definitely does not belong in *Prioniodina* since this genus is an arched blade with both bars in the same plane and with a large basal cavity (Rhodes & Müller, 1956, p. 697; Sweet et al., 1959, p. 1060; Glenister & Klapper, 1966, p. 833; Rhodes, Austin, & Druce, 1968).

Glenister & Klapper (p. 833) also point out that it is not possible to refer *P.? smithi* to *Neoprioniodus*. However, the presence in transmitted light of denticles on the anterolateral bar suggests that *P.? smithi* might be referred to *Palmatodella*.

Occurrence: *P.? smithi* is present throughout the Ningbing Limestone in the inter-reef and main-reef facies.

Genus PSEUDOPOLYGNATHUS Branson & Mehl, 1934

Type species: *Pseudopolygnathus primus* Branson & Mehl, 1934.

PSEUDOPOLYGNATHUS EXPANSUS Rhodes, Austin, & Druce, 1968
(Pl. 35, figs 5a-c)

1968 *Pseudopolygnathus expansa* Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 5, figs 2a-c, 4a-c.

Material: 3 specimens; CPC 8021 figured.

Description: The platform is elongate, three times as long as wide, and is divided symmetrically by a low medial carina formed of fused nodes. The inner platform is larger and bears coarse nodes on the platform edge with ridges connecting them to the carina. One prominent ridge in the anterior half bifurcates and erupts as two nodes on the platform margin. The outer platform is lower than the inner and is separated from the carina by an anteriorly deepening trough. The platform edge is crenulate.

Aborally, the unit has a large asymmetrical basal cavity which occupies nearly the whole platform area.

Occurrence: This species is recorded by Rhodes et al. (1968) from the middle of the *Cleistopora* (K) Zone of the Avon Gorge. In the Bonaparte Gulf Basin it occurs in the middle of the *Spathognathodus costatus* A.Z.

PSEUDOPOLYGNATHUS NODOMARGINATUS (E. R. Branson, 1934)

(Pl. 35, figs 1a-3b)

1934 *Polygnathus nodomarginata* E. R. Branson, *Univ. Missouri Stud.*, 8, 310, pl. 25, fig. 10.
1968 *Pseudopolygnathus nodomarginata* (E. R. Branson); Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 12, figs 6a-8c, 10a-c; pl. 9, figs 1a-4c

Material: 21 specimens; CPC 8010, 8011, 8100 figured.

Range: Throughout the *Pseudopolygnathus nodomarginatus* A.Z.

Description: The unit is lanceolate in juveniles and subovate in adults, being just over twice as long as wide. The platform is divided unequally by a medial carina formed of low fused nodes which merge with the free blade at the anterior and form a sharp posterior termination with the platform at the distal end. The outer platform extends farther anteriorly than the inner platform and is usually slightly narrower and is ornamented with transverse ribs; these are weakly developed in the juveniles but very strong in the adults, reaching to the carina in some cases. The inner platform bears similar ornament, though it tends to be weaker. The platform height decreases anteriorly and an anteriorly deepening trough is formed between the platform edge and the carina in the anterior half. The complete platform edge is serrated. In lateral view the anterior free blade is twice as high as the platform, which is arched, and about one third the length. It is formed of extremely laterally compressed denticles with fused bases and free chevron tips, height decreasing from the tall median denticles.

An extremely large, symmetrical, ovate basal cavity is developed in the anterior half. It extends half way along the blade and to the posterior termination as a narrowing groove within a sharp keel. The basal cavity is also deeply grooved, the low thickened lips of the cavity closing on either side to form the keel.

Occurrence: *P. nodomarginatus* was originally described from the Hannibal Formation, Missouri, USA (Branson, 1934). In Britain Rhodes et al. (1968) give the range of the species as upper *Zaphrentis* (Z) Zone.

PSEUDOPOLYGNATHUS TRIANGULUS TRIANGULUS Voges, 1959
(Pl. 37, figs 1a-3c)

1959 *Pseudopolygnathus triangula triangula* Voges, *Paläont. Z.*, 33, 304, pl. 35, figs 7-13, text-fig. 5.
1961 *Pseudopolygnathus triangula triangula* Voges; Dvorak & Freyer, *Geologie*, 8, 13, pl. 1, figs 15-22.
non 1964 *Pseudopolygnathus triangula* Voges; Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 42, pl. 2, fig. 28 (= *P. triangula pinnata*).
1966 *Pseudopolygnathus triangula triangula* Voges; Klapper, *Kansas Univ. paleont. Contr. Pap.* 3, 13, pl. 1, figs 15-22.
1966 *Pseudopolygnathus triangula triangula* Voges; Manzoni, *G. Geol.*, 33, 482, pl. 60, fig. 9.

Material: 3 specimens; CPC 7961-3 figured.

Description: The blade is half the length of the platform, and bears a series of low laterally compressed denticles, with fused bases and free chevron tips. The height and width gradually increase anteriorly. The blade continues on to the platform as a median carina composed of low circular nodes with sharp tips.

The platform is asymmetrical: the inner anterior part is slightly wider than the outer anterior part. The ornament consists of strong transverse ridges which become faint towards the carina.

The basal cavity is large and shallow, but nearly symmetrical.

Remarks: Some specimens (Pl. 37, figs 3a-c) show transitional characteristics toward *P. triangulus pinnatus* Voges.

Occurrence: *P. triangulus triangulus* occurs in Germany and the United States. Voges (1959) gave the German range as upper *Gattendorfia* Stufe (upper cuI) to lower *Pericyclus* Stufe (lower $CuII_{\alpha}$). Klapper (1966) records the species from the Lodgepole Limestone of lower $cuII_{\alpha}$ age and a single specimen from a dark shale unit of cuI age (p. 9). The Bonaparte Gulf specimens are from the 7/1 locality in the Ningbing Range.

PSEUDOPOLYGNATHUS VOGESI Rhodes, Austin, & Druce, 1968
(Pl. 36, figs 1a-7b)

1956 *Pseudopolygnathus striata* Mehl & Thomas; Bischoff & Ziegler, *Hess. Landesamt. Bodenf. Notizbl.*, 84, 164, pl. 11, fig. 20.
1957 *Pseudopolygnathus dentilineata* E. R. Branson; Bischoff, *ibid., Abh.*, 19, 50, pl. 4, figs 30-32 only.
1959 *Pseudopolygnathus dentilineata* E. R. Branson; Voges, *Paläont. Z.*, 33, 297, pl. 34, figs 49, 50; text-fig. 5, fig. 2.
1968 *Pseudopolygnathus vogesi* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 5, figs 1a-c, 3a-c, 5-8.

Material: 152 specimens; CPC 8012-18 figured.

Range: *Spathognathodus plumulus* A.Z. to uppermost *Siphonodella quadruplicata*-*S. cooperi* A.Z.

Description: The platform is subtriangular, varying from twice as long as wide to equidimensional. It is divided unequally by a medial carina which merges with the free blade in the anterior and can be produced in the posterior to form a short

free blade. In some specimens the platform ornament disrupts the carina. The outer platform is broadest in its medial portion. The ornament consists of very coarse transverse ridges separated by deep transverse troughs. The ridges extend outward to differing degrees, producing a highly irregular platform edge. The inner platform broadens gently anteriorly from the pointed posterior termination in the posterior half, but in the anterior half it expands greatly. The ornament differs on the two halves; in the posterior it consists of transverse ridges and troughs mirroring the outer platform, but the anterior part possesses low irregular nodes separated from the carina by a deep wide trough. The nodose ornament is considerably lower than the remainder of the platform ornament; some of the transverse ridges, where present, extend to the carina, fusing with it and destroying its linearity.

In lateral view the anterior free blade is twice the height and half the length of the platform. It is composed of laterally compressed fused denticles with free chevron tips. It is highest at the anterior end, apart from the anteriormost denticle, which may be shorter. The height decreases rapidly posteriorly, the blade merging with the carina. The carina is the same height as the outer platform and posterior inner platform. The anterior inner platform is about half the height of the rest of the platform and nodes may be developed on the inner lateral face.

The basal cavity is greatly expanded laterally, its long axis being at about 70° to that of the unit, and is the same width as the platform length. The remainder of the unit is keeled, with a narrow inverted basal cavity extending to the posterior termination. A faint groove runs along the whole length of the unit.

Remarks: Rhodes, Austin, & Druce (1968) erected a new species *P. vogesi,* because they could show that the genus *Pseudopolygnathus* was polyphyletic. The marked homoeomorphy in the group makes it extremely difficult to distinguish the species, and, until the original faunas of Branson & Mehl and E. R. Branson from the Bushberg and Hannibal Formations of Missouri are scrutinized in detail the nomenclature of the genus will remain conjectural. Until the phylogeny of E. R. Branson's species is elucidated, it seems preferable to retain the name *P. vogesi,* even though it markedly resembles *P. dentilineatus* Branson.

PSEUDOPOLYGNATHUS sp. A

(Pl. 37, figs 4a, b; Pl. 42, figs 2a-d)

Material: 4 specimens; CPC 8019, 8020 figured.

Description: The blade is high, composed of 3 massive fused denticles which increase in height posteriorly. The platform is symmetrical, bisected by a median carina and ornamented by strong transverse ridges which run to the carina and give the appearance of transverse ridges across the whole platform.

The basal cavity is large and symmetrical. The posterior termination of the unit is missing.

Occurrence: Middle *Spathognathodus plumulus* A.Z.

PSEUDOPOLYGNATHUS sp. B
(Pl. 35, figs 4a-d)

Material: 2 specimens; CPC 8022 figured.

Description: The blade is triangular, formed by fusion of at least 4 denticles. The platform is elongate, four times as long as wide, and caused by growth of lateral denticles on a median bar which erupts on the platform surface as a carina. The lateral denticles on both sides are fused, and are lower than the carina. The carina extends as a short posterior free blade. The basal cavity is large and asymmetrical with a fine median keel.

Remarks: This pseudopolygnathid appears to have developed from a spathognathodid ancestor similar to *S. regularis* (Branson & Mehl).

Occurrence: Middle *Siphonodella quadruplicata-S. cooperi* A.Z.

PSEUDOPOLYGNATHUS sp. C
(Pl. 37, figs 5a-6b)

Material: 3 specimens; CPC 7992, 7993 figured.

Description: The blade is high, composed of 3 denticles which are laterally compressed and fused, with free chevron tips. It runs into the carina, which is a fused ridge running into the inner lateral margin, not following the line of the aboral keel. On both inner and outer platforms tall lateral denticles are developed, and a short posterior free blade is en echelon to the carina. The cavity is large and situated medially, narrowing rapidly anteriorly and slowly posteriorly.

Remarks: The divergence of the carina from the line of the keel is the diagnostic feature.

Occurrence: Lowermost *Siphonodella isosticha-Polygnathus parapetus* A.Z.

Genus RHODALEPIS nov.

Type species: *Rhodalepis inornata* sp. nov.

Derivation of name: After Professor F. H. T. Rhodes.

Diagnosis: A platform conodont lacking platform dentition and a carina. The oral surface is smooth except for minute pitting. The aboral surface, instead of possessing a basal cavity, has a broad attachment scar.

Remarks: The surface pitting is similar to the structure seen in *Playfordia* Glenister & Klapper and *Dinodus* Cooper. The characteristic appearance of the aboral surface is similar to the aboral surface of the Lower Carboniferous genus *Siphonodella* Branson & Mehl. The abnormal surface structure of certain conodonts has been noted in a fauna from the Middle/Upper Devonian boundary in Germany (Lindström & Ziegler, 1965). They consider that the four form-genera *Falcodus, Angulodus, Oulodus,* and *Roundya* which exhibit this ornament in their fauna belong to one natural species, *Elsonella rhenana* Lindström & Ziegler.

RHODALEPIS INORNATA gen. nov. et sp. nov.
(Pl. 38, figs 1a-2c; Text-fig. 24)

Material: 12 specimens; holotype CPC 8005, paratype CPC 8004.

Range: Lower part of the Ningbing Limestone.

Derivation of name: From the unornamented platform.

Diagnosis: A species of *Rhodalepis* with an ovate platform outline and lacking any dentition on the oral surface. The aboral surface bears no basal cavity but a broad attachment scar is present.

Description: The blade is just shorter than the platform, and is composed of about 12 laterally compressed basally fused denticles with free chevron tips and of equal height. The height decreases slightly at the junction with the platform. The blade does not continue on to the platform as a carina, but ceases just posterior to the anterior margin of the platform. The platform is ovate and symmetrical; the surface bears no ornament except faint pitting. In lateral view the platform is arched with respect to the blade and is quite thin; the oral surface is slightly convex.

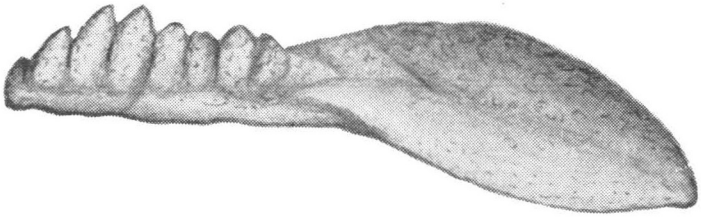

Figure 24. *Rhodalepis inornata* **sp. nov. Oral view of holotype, CPC8005, x 100.**

There is no basal cavity, but a large attachment scar or inverted basal cavity is present. It reaches over the whole length of the platform and occupies about half the width, the edges paralleling the edges of the platform.

Remarks: Some specimens have narrower platforms than others, but this is considered to be within the range of variability of the species. The aboral characteristics of this species are similar to those of the genus *Siphonodella*. The lack of ornament is peculiar to *Rhodalepis*.

Genus SCAPHIGNATHUS Ziegler, 1960

Type species: *Scaphignathus velifera* Ziegler, 1960.

SCAPHIGNATHUS ZIEGLERI sp. nov.
(Pl. 38, figs 4a-6; Text-fig. 25)

1966 *Scaphignathus velifera* Helms; Glenister & Klapper (part), *J. Paleont.*, 40, fig. 4 only (figs 1, 2 = *S. velifera*).

Derivation of name: After Dr W. Ziegler.

Material: 26 specimens; holotype CPC 8024, paratypes CPC 8023, 8025.

Diagnosis: A species of *Scaphignathus* lacking a carina.

Description: The blade is short and high, composed of 3 medium-sized fused denticles with free tips, increasing in size posteriorly, terminating in a massive tall laterally compressed posteriorly inclined denticle. The blade is situated laterally, on the right side when viewed from the posterior.

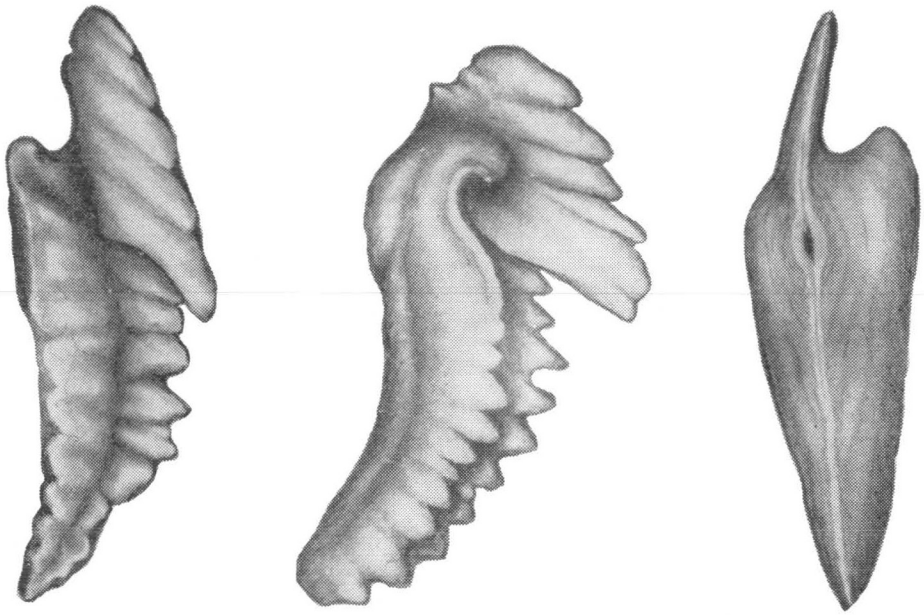

Figure 25. *Scaphignathus ziegleri* **sp. nov. (a) Oral, (b) inner lateral, and (c) aboral views of holotype, CPC8024, x 65.**

The platform is elongate and is divided by an anteriorly deepening trough. The edges bear low round nodes which may develop into short transverse ridges. The posterior termination is sharp and a short posterior free blade formed by the junction of the two platform margins may be developed.

The basal cavity is small and elongate, and a narrow keeled trough runs to the posterior termination.

Remarks: *S. ziegleri* differs from *S. velifera* Helms in lacking any form of carina.

Occurrence: *S. ziegleri* is confined to the early Famennian part of the Ningbing Limestone.

Genus SCUTULA Sannemann, 1955

Type species: *Scutula venusta* Sannemann, 1955.

SCUTULA BIPENNATA Sannemann, 1955

(Pl. 38, figs 8a, b)

1955 *Scutula bipennata* Sannemann, *Senck. leth.*, 36, 154, pl. 4, figs 5, 8, 9.
1956 *Scutula bipennata* Sannemann; Bischoff, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 136, pl. 10, fig. 20.

1958 *Scutula bipennata Sannemann;* Ziegler, *Hess. Landesamt. Bodenf., Notizbl.* 87, pl. 12, figs 24, 27, 30, 31.
1959 *Scutula bipennata* Sannemann; Helms, *Geologie,* 8, 656.
1961 *Scutula bipennata* Sannemann; Scott & Collinson, *Kansas geol. Soc. 26th Ann. Field Conf. Guidebook,* 139, pl. 2, fig. 4.
1961 *Scutula bipennata* Sannemann; Freyer, *Freiberger Forsch.,* C-95, 83, pl. 5, figs 133, 134.
1964 *Scutula bipennata* Sannemann; Lindström, *Conodonts,* 155, fig. 53c.
1965 *Scutula bipennata* Sannemann; Spasov, *Trav. géol. Bulgarie, Sér. paléont.,* 7, 100, pl. 3, fig. 19.
1966 *Scutula bipennata* Sannemann; Glenister & Klapper, *J. Paleont.,* 40, 834, pl. 96, figs 3, 4, 17.

Material: 4 specimens; CPC 8026 figured.

Remarks: The Bonaparte Gulf specimens are very similar to those described by Sannemann.

Occurrence: Upper part of Ningbing Limestone.

SCUTULA cf. S. BIPENNATA Sannemann, 1955

Material: 2 specimens.

Remarks: This form lacks one of the latero-posterior bars of *S. bipennata* Sannemann, since it consists of 2 anterior bars and one latero-posterior bar only. It is possibly an intermediary form between *S. bipennata* and *S. venusta* Sannemann.

Occurrence: Upper part of Ningbing Limestone.

Genus SIPHONODELLA Branson & Mehl, 1944

Type species: *Siphonognathus duplicata* Branson & Mehl, 1934.

SIPHONODELLA COOPERI Hass, 1959
(Pl. 39, figs 2a-4b, 6)

1934 *Siphonognathus quadruplicata* Branson & Mehl (part), *Univ. Missouri Stud.,* 8, 295, pl. 24, fig. 21.
1934 *Siphonognathus duplicata* Branson & Mehl; Branson (part), *ibid.,* 315, pl. 25, fig. 1 only.
1938 *Siphonognathus duplicata* Branson & Mehl; Branson & Mehl (part), *ibid.,* 13, 148, pl. 34, fig. 34 only.
1939 *Siphonognathus quadruplicata* Branson & Mehl; Cooper, *J. Paleont.,* 13, 409, pl. 41, figs 44, 45.
1949 *Siphonodella duplicata* (Branson & Mehl); Youngquist & Patterson (part), *ibid.,* 23, 69, pl. 16, fig. 7 only.
1951 *Siphonodella duplicata* (Branson & Mehl); Youngquist & Downs, *ibid.,* 25, 789, pl. 111, fig. 21.
1951 *Siphonodella duplicata* (Branson & Mehl), var. B; Hass, *Bull. Amer. Ass. Petrol. Geol.,* 68, pl. 5, fig. 8.
1956 *Siphonodella duplicata* (Branson & Mehl); Bischoff & Ziegler (part), *Hess Landesamt. Bodenf., Notizbl.,* 84, 165, pl. 12, fig. 13 only.
1956 *Siphonodella duplicata* (Branson & Mehl); Hass, *U.S. geol. Surv. prof. Pap.* 286, 25, pl. 2, fig. 7.
1957 *Siphonodella duplicata* (Branson & Mehl); Bischoff, *Hess. Landesamt. Bodenf., Abh.,* 19, 55, pl. 6, figs 1, 2.

1957 *Siphonodella duplicata* (Branson & Mehl) var. A; Cloud, Barnes, & Hass, *Bull. geol. Soc. Amer.*, 68, pl. 5, fig. 8.
1959 *Siphonodella cooperi* Hass, *U.S. geol. Surv. prof. Pap.* 294-J, 392, pl. 48, figs 35, 36.
1960 *Siphonodella duplicata* (Branson & Mehl); Copeland (part), *Trans. Roy. Soc. Canada*, ser. 3, 41, pl. 1, fig. 21 only.
1961 *Siphonodella cooperi* Hass; Beach, *Brigham Young Univ. geol. Stud.* 8, 46, pl. 6, figs 8, 10, 11.
1961 *Siphonodella cooperi* Hass; Scott & Collinson, *Kansas geol. Soc. 26th Ann. Field Conf. Guidebook*, 131, pl. 2, figs 31, 33, 35.
1961 *Siphonodella duplicata* (Branson & Mehl); Freyer *in* Dvorak & Freyer, (part), *Geologie*, 8, 894, pl. 2, fig. 13 only.
1964 *Siphonodella cooperi* Hass; Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 43, pl. 3, figs 27-29.
1966 *Siphonodella cooperi* Hass; Klapper, *Kansas Univ. paleont. Contr., Pap.* 3, 16, pl. 2, figs 10, 11; pl. 3, figs 1-4.

Material: 15 specimens; CPC 8029, 8031, 8032, 8039 figured.

Range: Uppermost part of *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: In oral view the platform is lanceolate; it is three times as long as wide and is flexed and arched near its midpoint. It is divided unequally by a median carina formed of low round fused nodes which merge anteriorly with the free blade and extend to the posterior platform termination. The inner platform is narrow and ornamented by a longitudinal ridge of fused nodes which is narrow and upright in the anterior half, then broadens and becomes fainter in the posterior half. The extreme posterior part lacks ornament. The outer platform is slightly wider, expanding suddenly immediately anterior to the point of flexure. A longitudinal ridge of upright fused nodes parallels the carina in the anterior half. At the point of expansion an azygous node occurs and the ridge then parallels the platform outline before fading away. Ornament is lacking on the posterior half. Troughs, which deepen anteriorly, separate the longitudinal ridges from the carina on both sides. The longitudinal ridges form the platform edge in the extreme anterior, but are situated on the platform posteriorly.

In lateral view the anterior free blade is low, the same height as the longitudinal ridges. It is short, less than one quarter the length of the unit, and is composed of 5 or 6 short laterally compressed fused denticles with free blunt tips. The longitudinal ridges and platform edges are of the same height and are higher than the carina. The posterior part of the platform is depressed through about 30°; the remainder of the aboral outline is straight.

In aboral view, no basal cavity can be seen; the anterior free blade is keeled, as is the anterior half of the platform. A median groove is present on the platform keel; both keel and groove cease at the point of flexure. The aboral surface is flat. Concentric growth-lines, and a strong 'chine' at the junction of the lateral and aboral surfaces, are present.

Occurrence: Collinson et al. (1962, chart 2) give a range for the species of *Siphonodella duplicata* s.s. Assemblage Zone (Middle Hannibal Formation) to *Siphonodella isosticha-S. cooperi* Assemblage Zone (Upper Chouteau Formation). The species is known from Germany (Bischoff & Ziegler, 1956; Bischoff, 1957; Freyer, 1961), Canada (Copeland, 1961), and Britain (Rhodes et al., 1968).

SIPHONODELLA ISOSTICHA (Cooper, 1939)
(Pl. 39, figs 5a, b; 7a-9b)

1939 *Siphonognathus isosticha* Cooper, *J. Paleont.*, 13, 409, figs 9, 10.
1962 *Siphonodella* n. sp. A; Collinson, Scott, & Rexroad, *Illinois geol. Surv. Circ.* 328, 7, chart 2.
1962 *Siphonodella obsoleta* Hass; Müller, *J. Paleont.*, 36, 1388, figs 4a, b.
1964 *Siphonodella isosticha* (Cooper); Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 44, pl. 3, figs 21-23.
1965 *Siphonodella isosticha* (Cooper); Ethington, *J. Paleont.*, 39, 587, pl. 67, figs 15, 17.
1968 *Siphonodella isosticha* (Cooper); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 12, figs 9a, b; 11a, b.

Material: 29 specimens; CPC 8035, 8038 figured.

Range: *Siphonodella isosticha-Polygnathus parapetus* A.Z. to *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: In oral view the platform is elongate, lanceolate, and bowed, divided unequally by a median carina. The carina is formed of low, rounded, fused nodes which merge with the anterior blade and extend to the blunt platform termination. The outer platform is ornamented with faint transverse ridges; in the anterior half a strong longitudinal ridge formed of fused nodes parallels the free blade. It is developed near the platform edge but does not form it. The inner platform is narrower than the outer and is ornamented by faint nodes, often aligned in transverse rows. In the anterior half a longitudinal ridge formed of fused nodes lies parallel to the outer platform ridge. It forms the platform edge only in the extreme anterior; posteriorly it encroaches on the platform, approaching the carina, which is laterally flexed, but terminating before reaching it. Deep troughs separate both longitudinal ridges from the carina, and the oral surface of the trough extends further anteriorly along the free blade than does the remainder of the platform.

In lateral view the blade is as high as or just higher than the platform and about one quarter its length. It is composed of about 7 laterally compressed denticles with free chevron tips. The denticle width and height increase slightly anteriorly. The longitudinal ridges and outer platform edge stand above the remainder of the platform and the carina.

The aboral surface is flat; there is a minute elongate central basal cavity, and a grooved keel runs along the aboral edge of the free blade. The platform is flexed and arched immediately behind the basal cavity.

Occurrence: Rexroad & Scott (1964, p. 15) record the species in the *Siphonodella isosticha-S. cooperi* Assemblage Zone of the Rockford Limestone of Indiana, USA. In Britain the species is present in the upper *Cleistopora* (K) Zone (Rhodes et al., 1968).

SIPHONODELLA QUADRUPLICATA (Branson & Mehl, 1934)
(Pl. 40, figs 1a-3b)

1934 *Siphonognathus quadruplicata* Branson & Mehl, *Univ. Missouri Stud.*, 8, 295, pl. 24, figs 18-21.
1966 *Siphonodella quadruplicata* (Branson & Mehl), Klapper, *Kansas Univ. paleont. Contr. Pap.* 3, 17, pl. 2, figs 5-8; pl. 3, figs 9-12; pl. 4, figs 16, 20 (synonymy).

Material: 3 specimens; CPC 8040-42 figured.

Range: Lowermost *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: The blade is short and low, highest anteriorly, and is composed of about 6 laterally compressed fused denticles with free chevron tips. It merges with the carina, which is composed of low nodes fused into a ridge.

The platform bears 2 rostral ridges on both inner and outer sides. The rostral ridges on the inner platform tend to join at their posterior extremities. The inner platform bears a series of nodes which can fuse to form ridges; they are, in some cases, developed as concentric rings concave to the carina. The outer platform bears fine widely spaced transverse ridges.

Aborally, the basal cavity is minute and elongate, situated at the point of flexure of the unit. Fine concentric growth-lines are present on the aboral surface.

Occurrence: Collinson et al. (1962, chart 2) give the range of *S. quadruplicata* as middle Hannibal Formation to the middle part of the upper Chouteau Formation. Rexroad & Scott (1964) record the species in the *Siphonodella isosticha-S. cooperi* Assemblage Zone of the Rockford Limestone in Indiana, Klapper (1966, p. 9) records the species from a dark shale unit (cuI) and the Lodgepole Limestone ($cuII_{\alpha}$) of Montana, Wyoming, and South Dakota.

SIPHONODELLA SULCATA (Huddle, 1934)
(Pl. 39, figs 1a, b)

1934 *Polygnathus sulcata* Huddle, *Bull. Amer. Paleont.*, 21, 95, pl. 8, figs 1-3.
1962 *Siphonodella sulcata* (Huddle); Collinson, Scott, & Rexroad, *Ill. geol. Surv. Circ.* 328, 6, chart 2.

Material: 2 specimens; CPC 8043 figured.

Range: Lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Description: The platform is elongate, three times as long as wide, and is divided unequally by a median carina. The carina is formed of low round fused nodes which merge with the anterior free blade and proceed to the posterior platform termination. The outer platform is somewhat wider than the inner, but both are upturned at about 45° to the horizontal and bear faint transverse ridges. The anterior platform edges are upturned vertically and are inset slightly. Deep troughs separate the carina from the anterior platform edges.

In lateral view the anterior free blade is low, the same height as the platform. It is short, one third the length of the unit, and is composed of 6 short, laterally compressed, fused denticles with free chevron tips. The denticle height increases slightly anteriorly except for the ultimate denticle, which is small. The platform edges are higher than the carina.

Aborally, the basal cavity occurs in the anterior third of the platform, and is minute and elongate. The free blade bears a grooved keel, the remainder of the unit a low grooveless keel. The area around the keel is flat and bears concentric growth-lines.

Remarks: This species, although polygnathid in its oral ornament, is clearly referable to the genus *Siphonodella* (see Collinson et al., 1962, p. 6 and chart 2).

Occurrence: Collinson et al. (1962, chart 2) give the range of the species as lower and middle Hannibal Formation. In Germany the species has been found in the upper part of the *Gnathodus kockeli-Pseudopolygnathus dentilineatus* Zone (upper cuI).

SIPHONODELLA TRIROSTRATA sp. nov.
(Pl. 41, figs 7a-8b; Text-fig. 26)

Derivation of name: From the three rostral ridges developed.

Material: 7 specimens; holotype CPC 8030, paratype CPC 8044.

Diagnosis: A siphonodellid with 3 rostral ridges, 1 on the inner side and 2 on the outer. Ornament consists of nodes on the inner and either faint transverse ridges or a smooth surface on the outer platform.

Description: The blade is about half the length of the platform, highest anteriorly and consisting of up to 20 laterally compressed, basally fused denticles with free tips. It continues on to the platform as a low nodose carina which is fused into a ridge.

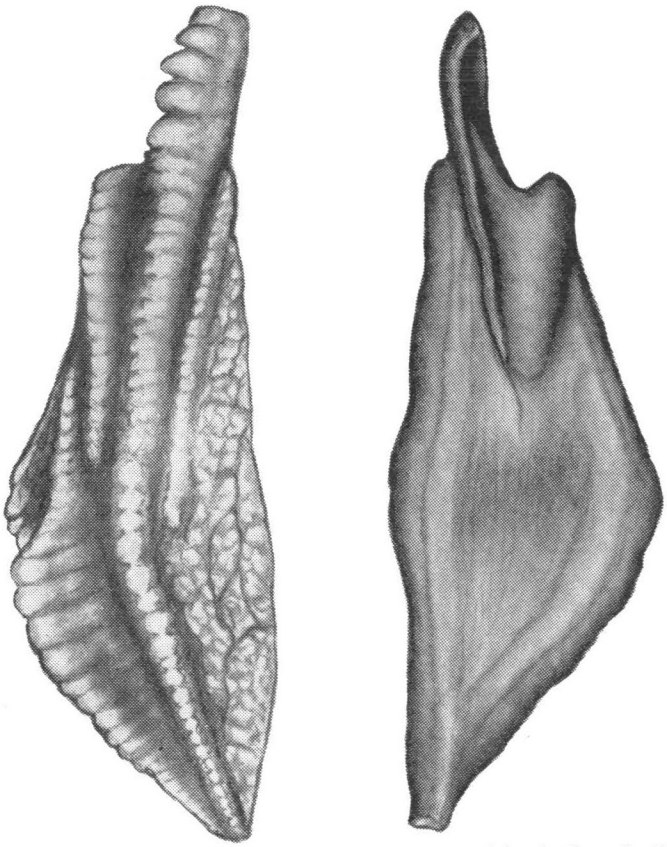

Figure 26. *Siphonodella trirostrata* **sp. nov. (a) Oral and (b) aboral views of holotype, CPC8030, x 50.**

The inner platform bears one rostral ridge in the anterior half which may be paralleled by a line of low nodes; the posterior half bears a large number of irregular low round nodes. The outer platform bears 2 rostral ridges in the anterior half. The inner ridge is separated from the carina by a deep trough, and terminates about halfway along the platform. The outer ridge begins about the midpoint of the inner ridge, from which it is separated by a trough, and runs out to the platform edge, with which it merges. The flange of platform outside the outer ridge bears a few nodes paralleling the platform margin.

The basal cavity is minute and elongate, situated at the platform midpoint at the point of flexure.

Remarks: The specimen illustrated by Lindström (1964, p. 170, fig. 61d) and referred to *S. quadruplicata* Branson & Mehl appears to belong to *S. trirostrata*. This presence of only one rostral ridge on the inner side together with the lack of ornament on the posterior half of the outer platform separates it from *S. quadruplicata*.

The ornament is very similar to *S. obsoleta* Hass, but the two rostral ridges on the outer platform set it apart from that species.

Occurrence: *S. trirostrata* is known from the 7/1 locality in the Ningbing Range.

Genus SPATHOGNATHODUS Branson & Mehl, 1941

Type species: *Ctenognathus murchisoni* Pander, 1856.

SPATHOGNATHODUS cf. S. ACULEATUS (Branson & Mehl, 1934)
(Pl. 27, figs 5a-c)

cf. 1934 *Spathodus aculeatus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 186, pl. 17, figs 11, 14.

Material: 7 specimens; CPC 8082 figured.

Remarks: One specimen of *Spathognathodus* resembles *S. aculeatus* both in blade development and in the basal cavity, which is subcircular and medial. However, the lateral dentition is slightly different; the denticles are fused into a pseudo-platform rather than being peg-like. The Bonaparte Gulf specimens closely resemble, in part, *S. aculeatus* sensu Ziegler (1962, pl. 13, figs 31, 32).

Occurrence: Famennian Ningbing Limestone.

SPATHOGNATHODUS ANTEPOSICORNIS Scott, 1961
(Pl. 29, fig. 1a, b)

1961 *Spathognathodus* n. sp. A. Scott & Collinson, *Kansas geol. Soc. 26th Ann. Field Conf. Guidebook*, 132, pl. 1, figs 12-15.
1961 *Spathognathodus anteposicornis* Scott, *J. Paleont.*, 35, 1224, text-fig. 2H-K.
1968 *Spathognathodus anteposicornis* Scott; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 3, figs 5a-8b.

Material: 13 specimens; CPC 8045 figured.

Range: *Spathognathodus tridentatus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: In lateral view the unit is elongate; the oral outline is generally convex upward over the posterior three-quarters, the high anterior blade disrupting the outline. The blade is about twice the height of the bar and is composed of 2 to 3 massive laterally compressed fused denticles with free chevron tips. The bar bears 14 or 15 denticles which are broadest and tallest in the anterior third and are laterally compressed and fused with free chevron tips. A single denticle is developed laterally, anterior to the midpoint of the basal cavity. It is the same height as the bar denticles and may diverge from them by as much as 45° The aboral outline is straight over the anterior half and the basal cavity region, but the posterior half is depressed through as much as 20°.

The basal cavity is large, pear-shaped, medial, and symmetrical. It narrows rapidly anteriorly, the lips fusing to form the keel on the aboral edge of the blade. Posteriorly it narrows slowly to form a narrow groove which runs to the posterior termination.

Occurrence: *S. anteposicornis* was originally described from the Louisiana Limestone of Illinois (Scott, 1961). In Britain it ranges from the upper *Cleistopora* (K) Zone to the lower *Zaphrentis* (Z) Zone (Rhodes et al., 1968).

SPATHOGNATHODUS cf. S. ANTEPOSICORNIS Scott, 1961
(Pl. 29, figs 2a, b)

cf. 1961 *Spathognathodus anteposicornis* Scott, *J. Paleont.*, 35, 1224, text-figs. 2H-K.

Material: 2 specimens; CPC 8072 figured.

Description: The form is very similar to *S. tridentatus* Branson & Mehl and *S. anteposicornis* Scott, differing only in the nature of the lateral dentition. In this form the lateral denticle is represented by a bifurcating denticle diverging from the unit at an angle of 45°. It does not fuse either by transverse ridges or swelling of the bar to give a narrow platform.

Remarks: The bifurcation of lateral ornament is seen in other forms, e.g. *Pseudopolygnathus expansus* Rhodes, Austin, & Druce, 1968.

Occurrence: Uppermost *Spathognathodus tridentatus* A.Z.

SPATHOGNATHODUS COALESCENS Rexroad & Collinson, 1965
(Pl. 27, fig. 1)

1965 *Spathognathodus coalescens* Rexroad & Collinson, *Illinois geol. Surv. Circ.* 388, 13, pl. 1, figs 20-22.

Material: Figured specimen CPC 8046.

Description: The unit is elongate and laterally compressed; the oral outline is straight except at the anterior end, where a massive denticle is developed. The aboral outline is stepped, the posterior aboral surface being higher than the anterior. The dentition consists of a massive anterior denticle, about three times as wide as the remaining 11 denticles, which are of equal height and width, laterally compressed and fused with free blunt tips. The cavity lips are slightly flared.

The basal cavity is elongate and symmetrical, broadest at its anterior end, which is just posterior to the large anterior denticle. It narrows gradually posteriorly, extending to the posterior termination. A median groove is present.

Occurrence: The only other known occurrence of *S. coalescens* is in the Warsaw and Salem Formations (Valmeyeran) of Illinois, USA (Rexroad & Collinson, 1965). In the Bonaparte Gulf Basin it is confined to the Utting Calcarenite.

SPATHOGNATHODUS COSTATUS COSTATUS (E. R. Branson, 1934)
(Pl. 29, figs 3a-4b)

1934 *Spathodus costatus* E. R. Branson, *Univ. Missouri Stud.* 8, 303, pl. 27, fig. 13.

For complete synonymy and discussion on phylogeny see:

1968 *Spathognathodus costatus costatus* (E. R. Branson); Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 3, figs 13a-15b.

Material: 8 specimens; CPC 8047, 8048 figured.

Range: *Spathognathodus costatus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: In oral view the unit is laterally compressed, straight, and elongate. It is composed of an anterior blade and a denticulate bar with a series of lateral denticles on the left side when viewed from the anterior. These lateral denticles number from 5 to 7 and in some cases are joined by low parapets to the main bar.

In lateral view the blade is about one fifth the length of the unit and twice as high. It is composed of 3 laterally compressed fused denticles with free chevron tips. The oral outline is convex upward, the median denticle being the tallest. The lateral denticles are slightly higher than the bar denticles, which number about 20; the oral outline is straight except in the posteriormost portion, where it slopes downward. The aboral outline is also straight apart from a slight depression of the posteriormost portion.

The basal cavity forms the medial third of the unit and is elongate and symmetrical, narrowing both anteriorly and posteriorly. The lips fuse to form an aboral keel at the anterior, while at the posterior the cavity extends as a narrow groove within a shallow keel.

Occurrence: Rhodes et al. (1968) record *S. costatus costatus* from the uppermost *Cleistopora* (K) Zone and lower *Zaphrentis* (Z) Zone in the Avon Gorge. It was originally described from the Hannibal Formation of Missouri, USA (Branson, 1934).

SPATHOGNATHODUS cf. S. COSTATUS COSTATUS (E. R. Branson, 1934)
(Pl. 29, figs 5a-c)

Material: 2 specimens; CPC 8088 figured.

Remarks: This form is probably a gerontic form of *S. costatus* s.s. It is characterized by an additional node on the outer anterolateral face immediately posterior to the blade.

Occurrence: Uppermost *Spathognathodus tridentatus* A.Z.

SPATHOGNATHODUS COSTATUS SULCIFERUS (Branson & Mehl, 1934)
(Pl. 29, figs 6-8)

1934 *Spathodus sulciferus* Branson & Mehl, *Univ. Missouri Stud.* 8, 274, pl. 22, figs 12, 13.

For complete synonymy and discussion on phylogeny see:

1968 *Spathognathodus costatus sulciferus* (Branson & Mehl); Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 3, figs 16a-18b.

Material: 14 specimens; CPC 8049-51 figured.

Range: *Spathognathodus costatus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: In oral view the unit is elongate, five times as long as wide. It is composed of a high anterior blade and a bar with lateral denticles on either side. The left side (when viewed from the anterior) bears up to 11 lateral denticles which protrude at up to 45° from the plane of the unit and are connected to the main bar by narrow parapets. The right side bears similar denticles in the posterior part, but toward the anterior they move on to the outer side of the oral surface of the cavity, and are separated from the main bar, which is carina-like, by a wide trough. Anterior to the basal cavity no denticulation is developed on the right side.

The blade is twice as high as the platform and about a third of the length of the unit. It is composed of 6 laterally compressed fused denticles with free chevron tips which increase in height anteriorly except for the ultimate denticle, which is small. The denticles of the bar number up to 20; they are short, laterally compressed, and wholly fused apart from the most posterior two or three which have free chevron tips.

The basal cavity occupies the medial third. It is large, pear-shaped, and slightly asymmetrical, and narows rapidly anteriorly and slowly posteriorly. In the anterior the lips merge to form an aboral keel on the free blade; posteriorly the cavity extends as a narrowing groove to the posterior termination. The cavity itself is grooved; there is a minute pit at its anterior end.

Occurrence: Rhodes et al. (1968) record *S. costatus sulciferus* from the uppermost *Cleistopora* (K) and lower *Zaphrentis* (Z) Zones in the Avon Gorge, Britain. The species was originally described from the Bushberg Sandstone of Missouri, USA (Branson & Mehl, 1934, p. 274).

SPATHOGNATHODUS CRASSIDENTATUS (Branson & Mehl, 1934)
(Pl. 27, figs 2a-3b)

1934 *Spathodus crassidentatus* Branson & Mehl, *Univ. Missouri Stud.* 8, 276, pl. 22, figs 17, 18.
1968 *Spathognathodus crassidentatus* (Branson & Mehl), Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 3, figs 1a-4b (Synonymy).

Material: 62 specimens; CPC 8053, 8054 figured.

Range: Upper *Spathognathodus plumulus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: The unit is extremely laterally compressed with no lateral appendages. In lateral view it is seen to be made up of 15 to 20 laterally compressed fused denticles with free chevron tips. The tallest 3 or 4 denticles are situated anteriorly;

they are about twice the height of the remainder of the unit. The heights of the remaining denticles vary only slightly, though enough to give a convex outline: those at the rear tend to be smallest and the median denticle largest.

The basal cavity occupies the whole of the median third and is pear-shaped, narrowing rapidly anteriorly and slowly posteriorly. It extends as a narrowing groove along the keels developed on the aboral surface of the anterior and posterior thirds. The cavity itself has a median groove which bisects it, and a minute pit is developed at the anterior extremity.

SPATHOGNATHODUS cf. S. CRASSIDENTATUS (Branson & Mehl, 1934)
(Pl. 27, figs 4a-6c)

Material: Figured specimens CPC 8085, 8087.

Remarks: Some specimens, although broadly falling into the concept of *S. crassidentatus,* have minor but important differences. One specimen has three larger denticles on the posterior end of the unit, resembling in some ways *S.* cf. *S. robustus*. Others possess even dentition which slopes rapidly from the anterior to the posterior end.

Occurrence: Uppermost *Spathognathodus tridentatus* A.Z.

SPATHOGNATHODUS cf. S. CRISTULUS Youngquist & Miller, 1949
(Pl. 28, figs 1-3)

cf. 1949 *Spathognathodus cristula* Youngquist & Miller, *J. Paleont.*, 23, 621, pl. 101, figs 1-3.
1938 *Spathognathodus regularis* Branson & Mehl (part), *Univ. Missouri Stud.* 13, 137, pl. 34, fig. 2 only.
1968 *Spathognathodus* cf. *S. cristula* Youngquist & Miller; Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 8, figs 14a-18d.

Material: 39 specimens; CPC 8055, 8328, 8329 figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to uppermost *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: The unit is laterally compressed, bearing 8 to 10 denticles. The anteriormost denticle is massive, twice as wide and nearly twice as tall as the other denticles. The remaining denticles are of approximately equal height in the median third, the oral outline being slightly convex upward; in the posterior third denticle height decreases rapidly. All the denticles are laterally compressed and fused with free blunt tips.

The basal cavity is situated in the medial third; it is pear-shaped, narrowing rapidly anteriorly and slowly posteriorly. The anterior and posterior thirds of the unit are keeled.

Occurrence: Apart from the specimen illustrated by Branson & Mehl (1938, pl. 34, fig. 2) from the Bushberg of Missouri, USA, this form has only been recorded from Britain. Rhodes et al. (1968) record it as low as the lower *Zaphrentis* (Z) Zone. The present specimens are even older, occurring in strata equivalent to the *Cleistopora* (K) Zone.

SPATHOGNATHODUS CYRIUS CYRIUS (Cooper, 1939)
(Pl. 28, figs 4a-5c)

1939 *Spathodus sulciferus* Branson & Mehl; Cooper (part), *J. Paleont.*, 13, pl. 45, fig. 17 only.
1939 *Spathodus cyrius* Cooper, *J. Paleont.*, 13, 413, pl. 45, fig. 25.
non 1943 *Spathodus cyrius* Cooper; Cooper & Sloss, *ibid.*, 17, 175, pl. 28, figs 3, 4, 10, 12 (= *S. crassidentatus*).
1951 *Spathognathodus macer* Branson & Mehl; Youngquist & Downs, *J. Paleont.*, 25, 791, pl. 11, figs 1, 2.
1968 *Spathognathodus* cf. *S. cyrius* (Cooper); Rhodes, Austin & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 7, figs 12a-14c.

Material: 5 specimens; CPC 8056, 8057 figured.

Range: *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z. to upper limit of *Spathognathodus tridentatus* A.Z.

Description: The unit is elongate and laterally compressed, bearing about 35 fine needle-like denticles. The anterior part is composed of 4 massive denticles. The remainder of the denticles are of approximately equal height, though they decrease in height gradually toward the posterior, in the posterior third.

The cavity is situated medially, and is subcircular; it is narrower at the posterior than the anterior and has thickened lips. The remainder of the unit is keeled.

Remarks: Rhodes *et al.* (1968) noted that the holotype of *S. cyrius* bears only 20 denticles, whereas their specimens averaged 30 denticles.

Occurrence: *S. cyrius cyrius* is known from the pre-Welden shale of Oklahoma (Cooper, 1939) and the Wassonville dolomite of Iowa (Youngquist & Downs, 1951). In Britain it has been recorded from the *Cleistopora* (K) and *Zaphrentis* (Z) Zones of the Avonian (Rhodes et al., 1968).

SPATHOGNATHODUS CYRIUS NODUS subsp. nov.
(Pl. 28, figs 6a-c; Text-fig. 27)

Derivation of name: From the extra nodes developed on the lateral faces.

Material: 8 specimens; holotype CPC 8079.

Range: Upper *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Diagnosis: A subspecies of *S. cyrius* with strongly developed lateral ornament on the left side as viewed from the anterior.

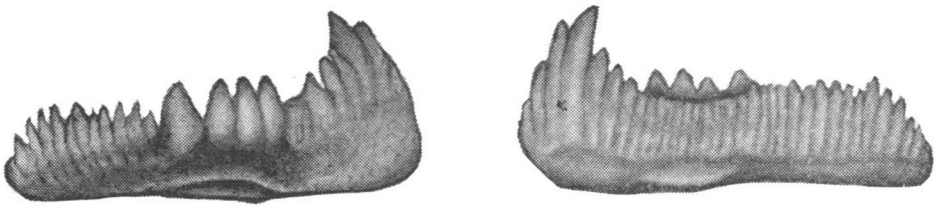

Figure 27. *Spathognathodus cyrius nodus* **subsp. nov. (a) Inner and (b) outer lateral views of holotype, CPC8079.**

Description: The unit agrees with *S. cyrius* in all details except that lateral ornament is present. It consists of large lateral nodes whose tips are above the top of the main blade; in the figured specimen they number 4, but in others range from 2 to 5.

Remarks: *S. cyrius nodus* is distinguished by the large number of fine needle-like denticles on the main bar and the development of lateral dentition. The large number of needle-like denticles distinguishes the subspecies from other laterally ornamented spathognathodids.

SPATHOGNATHODUS DELICATULUS (E. R. Branson, 1934)
(Pl. 31, fig. 7)

1934 *Spathodus delicatulus* E. R. Branson, *Univ. Missouri Stud.*, 8, 304, pl. 27, fig. 14.
1939 *Spathodus delicatulus* E. R. Branson; Cooper, *J. Paleont.*, 13, 413. pl. 41, figs 17, 18.
1949 *Spathognathodus delicatulus* (E. R. Branson); Thomas, *Bull. geol. Soc. Amer.*, 60, 412, pl. 4, fig. 13.

Material: 2 specimens; CPC 8081 figured.

Description: The unit is elongate, three times as long as high, bearing about 18 denticles of about equal height, and is slightly higher anteriorly than posteriorly. At the midpoint a wider and larger denticle is present. The basal cavity is situated in the posterior half; it is widest anteriorly and narrows slowly posteriorly, closing before the posterior termination.

Remarks: The regular dentition and the large denticles at the midpoint serve to distinguish the species.

Occurrence: *S. delicatulus* was originally described from the Hannibal Formation of Missouri, USA. In the Bonaparte Gulf Basin it occurs at the 7/1 locality in the Ningbing Range.

SPATHOGNATHODUS PLUMULUS PLUMULUS Rhodes, Austin, & Druce, 1968
(Pl. 30, figs 6, 7)

1968 *Spathognathodus plumulus plumulus* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 1, figs 1a-2c, 5, 6.

Material: 244 specimens; CPC 8058, 8060 figured.

Range: *Spathognathodus plumulus* A.Z. to lower *Siphonodella sulcata-Polygnathus parapetus* A.Z.

Description: The unit is elongate, with lateral denticles on the left side as viewed from the anterior. The anterior blade is twice as tall as the remainder of the unit. It is composed of 3 to 6 laterally compressed fused denticles with free needle tips; the tallest is the posteriormost, and the height decreases regularly toward the anterior. The median third of the unit is of constant height; the posterior third shallows, the blade denticles decreasing in height posteriorly. The 10 to 16 denticles of the posterior blade are all laterally compressed and fused with free tips.

Three to seven denticles are developed on the left face of the unit as viewed from the anterior. They tend to fuse to form a parapet, and a trough develops between them and the blade. In some cases the anterior blade is more medial than lateral.

The cavity occupies the median third and is pear-shaped, narrowing rapidly anteriorly, slowly posteriorly, and extending as a narrowing groove along the keel to the posterior termination. The cavity lips flare slightly.

Occurrence: The only previous record of *S. plumulus plumulus* is from all but the uppermost *Cleistopora* (K) Zone in the Avonian of Britain (Rhodes et al., 1968).

SPATHOGNATHODUS cf. S. PLUMULUS Rhodes, Austin, & Druce, 1968
(Pl. 30, figs 1a-c)

cf. 1968 *Spathognathodus plumulus plumulus* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 1, figs 1a-2c, 5, 6.

Material: 12 specimens; CPC 7826, 7827 figured.

Description: The Bonaparte Gulf specimens differ from *S. plumulus* s.s. only in the position of the blade, which tends to be medial as opposed to lateral. Rhodes, Austin, & Druce (1968) describe a transition from *S. plumulus* to *Clydagnathus* including specimens with a medial blade but having a clydagnathid platform development. It may be that *Clydagnathus* developed both from forms of *S. plumulus* with lateral blades and forms with medial blades, the development of a clydagnathid platform in some cases being primary, in others secondary.

Occurrence: Famennian Ningbing Limestone.

SPATHOGNATHODUS PLUMULUS NODOSUS Rhodes, Austin, & Druce, 1968
(Pl. 30, figs 3a-4)

1968 *Spathognathodus plumulus nodosus* Rhodes, Austin, & Druce, 1968 *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 1, figs 3a-4c.

Material: 4 specimens; CPC 8062, 8063 figured.

Range: Middle *Spathognathodus plumulus* A.Z.

Description: The unit is similar to *S. plumulus* s.s. in all respects except the development of a large single node on the anterior face of what is normally the undenticulate side.

Remarks: *S. plumulus nodosus* appears to mirror the development seen in *Clydagnathus,* a genus derived from it (Rhodes, Austin, & Druce, 1968). *Clydagnathus nodosus,* which shows this type of dentition, may thus have developed from this subspecies, rather than *Clydagnathus cavusformis,* by lateral movement of the free blade.

Occurrence: *S. plumulus nodosus* is restricted to the lower *Cleistopora* (K) Zone of the Avonian in Britain (Rhodes et al., 1968).

SPATHOGNATHODUS PLUMULUS SHIRLEYAE Rhodes, Austin, & Druce, 1968
(Pl. 30, fig. 5)

1968 *Spathognathodus plumulus shirleyae* Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 1, figs 7a-8c.

Material: 5 specimens; CPC 8061 figured.

Range: Uppermost *Spathognathodus plumulus* A.Z.

Description: *S. plumulus shirleyae* resembles *S. plumulus* s.s. in every detail apart from the lateral denticles: only one lateral denticle is developed, immediately anterior to the midpoint of the basal cavity.

Remarks: The only specimen found is broken, but it is very similar to those figured by Rhodes, Austin, & Druce (1968).

Occurrence: In Britain the species is present in the basal part of the *Cleistopora* (K) Zone (Rhodes et al., 1968).

SPATHOGNATHODUS QUINTIDENTATUS Thomas, 1949
(Pl. 31, figs 2a, b)

1938 *Spathodus elongatus* Branson & Mehl (part), *Univ. Missouri Stud.*, 13, pl. 34, fig. 9 only, (pl. 34, fig. 6 = *S. elongatus*).
1949 *Spathognathodus quintidentatus* Thomas, *Bull. geol. Soc. Amer.*, 60, 429, pl. 4, figs 8, 9.

Material: 5 specimens; CPC 8080 figured.

Range: Lower *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: The oral surface is irregular. The unit can be divided into two, an anterior blade with 4 or 5 denticles of equal height and a posterior part which is lower and is regularly depressed, with even dentition.

Remarks: Rexroad & Scott (1964, p. 48-49) classed *S. quintidentatus* as a junior synonym of *S. crassidentatus* (Branson & Mehl); but the arching of the posterior termination and the high blade composed of 4 or 5 denticles of equal height appear to be diagnostic, and *S. quintidentatus* Thomas is considered to be a valid species.

Occurrence: The species was originally described from the Prospect Hill siltstone (Lower Carboniferous) of Iowa, USA (Thomas, 1949, p. 429).

SPATHOGNATHODUS REGULARIS (Branson & Mehl, 1938)
(Pl. 31, figs 3a-5b, 8)

1938 *Spathodus regularis* Branson & Mehl, *Univ. Missouri Stud.*, 13, 137, pl. 34, figs 1, 3, 10 (fig. 2 = *S.* cf. *S. cristula*).
1944 *Spathodus regularis* Branson & Mehl; Branson & Mehl *in* Shimer & Shrock, *Index fossils of North America*, 244, pl. 94, fig. 1.
1964 *Spathognathodus regularis* (Branson & Mehl); Rexroad & Scott, *Indiana geol. Surv. Bull.* 30, 49, pl. 3. figs 1, 2.

Material: 42 specimens; CPC 8064-67 figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to lowermost *Clydagnathus nodosus* A.Z.

Description: Unit laterally compressed. The anterior blade is one and a half times as high as the remainder of the unit and is composed of two laterally compressed denticles of equal height with free chevron tips. The remainder of the unit decreases in height posteriorly, but the denticles in the median third are twice as wide as the anterior denticles, and although the width decreases posteriorly the posteriormost denticles are wider than those of the anterior third of the bar. These denticles have free chevron tips. The anterior blade denticles number 2, the anterior needle-tipped denticles 4, and there are 8 posterior chevron-tipped denticles.

The basal cavity is situated in the posterior half. It is pear-shaped, narrowing rapidly anteriorly but slowly to the posterior, where it reaches the termination.

Occurrence: Branson & Mehl (1938) originally recorded *S. regularis* from the Bushberg of Missouri. Rexroad & Scott (1964, p. 15) record it from the *Siphonodella isosticha-S. cooperi* Assemblage Zone of the Rockford Limestone in Indiana, USA.

SPATHOGNATHODUS cf. S. REGULARIS (Branson & Mehl, 1935)
(Pl. 31, fig. 1)

cf. 1938 *Spathodus regularis* Branson & Mehl, *Univ. Missouri Stud.* 13, 137, pl. 34, figs 1, 3, 10.

Material: 6 specimens; CPC 8078 figured.

Description: The unit is extremely laterally compressed and bears no lateral ornament. The anterior blade is composed of 3 denticles, the posteriormost two being massive, three times as wide and half as high again as the bar denticles. They are laterally compressed and fused, but have free chevron tips. The bar denticles are uniform and decrease in height regularly towards the posterior. They are needle-like, laterally compressed, fused, with blunt face tips, and are inclined posteriorly, the inclination increasing toward the posterior.

The basal cavity is elongate and extremely narrow and is situated at the centre of the unit. It has slightly thickened lips. The remainder of the unit is keeled.

Remarks: The unit resembles *S. regularis* (Branson & Mehl), but has 20 massive denticles instead of 1 or 2 on the anterior face.

Occurrence: In the middle part of the *Siphonodella quadruplicata-S. cooperi* A.Z.

SPATHOGNATHODUS cf. S. ROBUSTUS (Branson & Mehl, 1934)
(Pl. 28, figs 7a-c; pl. 32, figs 2a-c)

cf. 1934 *Spathodus robustus* Branson & Mehl, *Univ. Missouri Stud.*, 8, 189, pl. 17, fig. 21.
1968 *Spathognathodus* cf. *S. robustus* (Branson & Mehl), Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 7, figs 6a-7c.

Material: 8 specimens; CPC 8068 figured.

Range: *Spathognathodus costatus* A.Z. to *Pseudopolygnathus nodomarginatus* A.Z.

Description: The unit is elongate, laterally compressed, and bears a series of irregular denticles which tend to decrease in height and increase in width posteriorly. The antero-aboral angle is about 70° and the anterior end is twice as high as the posterior end. The posterior third is slightly twisted and depressed. The basal cavity is developed in the median third and is large, symmetrical, and pear-shaped, narrowing rapidly anteriorly. The thickened lips are slightly flared.

Occurrence: In Britain this form is known from the uppermost *Cleistopora* (K) and lower *Zaphrentis* (Z) Zones of the Avonian (Rhodes et al., 1968).

SPATHOGNATHODUS cf. S. ROBUSTUS subsp. nov. A
(Pl. 32, figs 6a, b)

Material: 4 specimens; CPC 8070 figured.

Description: The anterior blade is composed of 2 large subtriangular denticles fused in their aboral half, but free over their oral half. The remainder of the unit is composed of fine fused needle-like denticles with free tips, but in the posterior part the denticles are wider, discrete, slope posteriorly and are deflected inward.

Two or three lateral denticles are developed on either side of the unit above the basal cavity, forming a platform-like thickening in the median third. The basal cavity is developed medially and is subcircular, narrowing more slowly posteriorly. The remainder of the unit is keeled.

Remarks: Further addition of denticles and a thickening of the median third of the unit to form a platform results in forms described as *Pseudopolygnathus* (see Pl. 6, figs 2, 10). The Bonaparte Gulf specimens are very similar to *Spathognathodus* sp. B of Rhodes, Austin, & Druce (1968, pl. 7, figs 8a-c), except for the rounded anterior edge. *S.* sp. B may be a pathological variant of *S.* cf. *S. robustus* subsp. nov. A.

Occurrence: In the middle part of the *Spathognathodus plumulus* A.Z.

SPATHOGNATHODUS SCITULUS (Hinde, 1900)

1900 *Polygnathus scitulus* Hinde, *Trans. nat. Hist. Soc. Glasgow*, 5, 343, pl. 9, figs 9-11 only.
1928 *Penderodella scitula* (Hinde); Holmes, *Proc. U.S. nat. Mus.*, 16, pl. 6, figs 26, 28 only.
1960 *Spathognathodus scitulus* (Hinde); Clarke, *Trans. geol. Soc. Edinb.*, 18, 21, pl. 3, figs 12, 13.
1963 *Spathognathodus scitulus* (Hinde); Rexroad & Collinson, *Ill. geol. Surv. Circ.* 355, 20, pl. 2, figs 14, 19, 29-31.
1968 *Spathognathodus scitulus* (Hinde); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 8, figs 9a-11d.

Description: The unit is short and laterally compressed; it is composed of 8 or 9 fused denticles. The anteriormost denticle is massive, 3 times as wide as the other denticles and half as tall again. The median 3 denticles are upright and of

equal height; the posterior 4 or 5 are inclined and decrease in height rapidly to the posterior. The aboral outline is concave and the anterior-aboral angle is about 70°.

An asymmetrical basal cavity is developed. It is ovate, the long axis being normal to the long axis of the unit, and is flared laterally. The flaring on the inner side is nearly twice that of the outer.

Occurrence: *S. scitulus* is known from Britain, where it ranges from the *Caninia* (C) Zone to the upper *Dibunophyllum* (D) Zone (Rhodes et al., 1968). It has been recorded from the St Louis Formation of Illinois (Rexroad & Collinson, 1963). In the Bonaparte Gulf Basin it occurs in the Utting Calcarenite.

SPATHOGNATHODUS SCULDERUS sp. nov.
(Pl. 43, figs 1a-5)

?1966 *Spathognathodus aculeatus* (Branson & Mehl); Glenister & Klapper, *J. Paleont.*, 40, pl. 95, fig. 11.

Derivation of name: From old English sculder = shoulder.

Material: 91 specimens; holotype CPC 8075, paratypes CPC 8073, 8074, 8076, 8077.

Range: Middle *Spathognathodus plumulus* A.Z. to upper limit of *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: The unit is laterally compressed and elongate, with a series of nodes along the left hand side when viewed from the anterior. The anterior blade is twice as high as the remainder of the unit and is composed of 2 fused denticles which are recurved posteriorly. The posteriormost denticle is usually the larger of the two and is thickened, the thickening running on to the blade and curving through more than 90° to form a thickened shoulder at the base of the bar denticles. The antero-aboral angle is 90°-100°.

The bar denticles are small and fused, and have blunt tips which just protrude from the thickened 'shoulder'. They number about 14 and are of the same height except in the posterior third, where they decrease in height. Some of them may be present on the posterior face of the anterior blade. A series of 3 to 5 denticles is developed on the left lateral face as viewed from the anterior, but some specimens lacking any lateral dentition were found. The lateral denticles are peg-like and in some cases are connected to the main bar by low transverse ridges. These denticles tend to be higher than the bar denticles.

A large pear-shaped symmetrical cavity is developed. It narrows rapidly anteriorly and slowly posteriorly, but in both directions extends as a narrow groove along the keels.

Remarks: The addition of further denticles on both sides of the bar gives rise to forms similar to *Pseudopolygnathus vogesi* Rhodes, Austin, & Druce, 1968, which has a similar blade and 'shoulder' developed. The ranges of both species are nearly identical (Text-fig. 6).

SPATHOGNATHODUS STABILIS (Branson & Mehl, 1934)
(Pl. 31, figs 6a, b)

1934 *Spathodus stabilis* Branson & Mehl, *Univ. Missouri Stud.*, 8, 188, pl. 17, fig. 20.
1956 *Spathognathodus stabilis* (Branson & Mehl); Bischoff & Ziegler, *Hess. Landesamt. Bodenf., Notizbl.*, 84, 167, pl. 13, fig. 11.
1959 *Spathognathodus stabilis* (Branson & Mehl); Helms, *Geologie*, 8, 658, pl. 3, figs 1, 5; pl. 6, fig. 18, 23.
1961 *Spathognathodus stabilis* (Branson & Mehl); Freyer, *Freiberger Forschr.*, C-95, 88.
1962 *Spathognathodus stabilis* (Branson & Mehl); Ziegler, *Hess. Landesamt. Bodenf., Abh.*, 38, 112, pl. 13, figs 1-10.
non 1966 *Spathognathodus stabilis* (Branson & Mehl); Klapper, *Univ. Kansas paleont. Contr. Pap.* 3, 23, pl. 5, figs 6, 7.

Material: 8 specimens; CPC 8071 figured.

Remarks: *S. stabilis* can be distinguished from other simple spathognathodids by the relatively even oral outline sloping from the anterior to the posterior end. The basal cavity occupies the posterior half of the unit, and the flared lips narrow slowly toward the posterior termination and rapidly, at about the midpoint, in an anterior direction.

Occurrence: Famennian Ningbing Limestone.

SPATHOGNATHODUS TORTUS (Branson & Mehl, 1934)
(Pl. 33, figs 2a, b)

1934 *Prioniodella*(?) *torta* Branson & Mehl, *Univ. Missouri Stud.*, 8, 216, pl. 16, fig. 1.

Material: 5 specimens; CPC 8325 figured.

Range: *Siphonodella sulcata-Polygnathus parapetus* A.Z. to *Siphonodella quadruplicata-S. cooperi* A.Z.

Description: The unit is elongate and very shallow. The blade anterior to the basal cavity is composed of 7 tall denticles subovate in cross-section; they are of equal height except for 2 small ones at the anterior termination. The denticles are fused at their bases, but their oral halves are free. The blade is laterally compressed. Posterior to the cavity the unit becomes barlike; it is subcircular in cross-section, is twisted, and depressed. It bears about 9 discrete denticles, ovate in cross-section, and massive in the central portion; they decrease in height in both directions.

The basal cavity extends over the complete length of the posterior half of the bar and is inverted; in the median third a minute elongate pit is developed.

Remarks: Branson & Mehl (1934, p. 216) noted the similarities of *P. tortus* specimens to species of *Spathognathodus*, but excluded it from that genus on account of the basal cavity. However, the basal cavity is similar to that of spathognathodids except that it is inverted over most of its length.

Occurrence: The only previous record of *S. tortus* is from the Grassy Creek shale of Missouri, USA (Branson & Mehl, 1934).

SPATHOGNATHODUS TRIDENTATUS (E. R. Branson, 1934)

1934 *Spathodus tridentatus* E. R. Branson, *Univ. Missouri Stud.*, 8, 307, pl. 27, fig. 25.
1968 *Spathognathodus tridentatus* (E. R. Branson); Rhodes, Austin, & Druce, *Bull. Brit. Mus. (nat. Hist.), Geol., Suppl.* 4, pl. 3, figs 9a-12b (Synonymy).

Material: 34 specimens.

Range: *Spathognathodus tridentatus* A.Z.

Remarks: Rhodes, Austin, & Druce (1968) give a full description of *S. tridentatus*. They point out that it differs from *S. aculeatus* (Branson & Mehl) in having a narrow elongate basal cavity. Both species are represented in the Bonaparte Gulf collection, although always in a broken state; however, the nearly circular basal cavity of *S. aculeatus* and the elongate basal cavity of *S. tridentatus* were sufficiently diagnostic to distinguish the two species, which in the Bonaparte Gulf Basin are separated by over 2,000 feet of strata.

SPATHOGNATHODUS sp. nov. A
(Pl. 33, figs 19, b, c, d)

1968 *Spathognathodus* cf. *S. robustus* Branson & Mehl; Rhodes, Austin, & Druce (part) *Bull. Brit. Mus. (nat. Hist.), Geol.*, pl. 7, figs 7a, b, & c only (pl. 7, fig. 6a, b, c = *S.* cf. *S. robustus*).

Material: 8 specimens; CPC 8326 figured.

Range: Upper part of *Siphonodella isosticha-Polygnathus inornatus nodulatus* A.Z. to lower part of *S. quadruplicata-S. cooperi* A.Z.

Description: The unit is deep and elongate, and bears a series of fused denticles, the extreme aboral tips of which are free. In the anterior half a blade is developed, formed of about 3 denticles, the posteriormost of which is massive; it is higher than the remainder of the unit. In the posterior part of the unit the denticles are shorter but broader, and decrease in height rapidly towards the posterior termination. A suggestion of lateral dentition can be seen on some specimens.

In aboral view the unit is distinctive: there are lateral flanges on the lips of the elongate basal cavity.

Remarks: The unit is similar to *S. crassidentatus* (Branson & Mehl), but its massiveness and the nature of the blade distinguish it.

SPATHOGNATHODUS sp. A
(Pl. 32, fig. 1)

Material: 2 specimens; CPC 8069 figured.

Description: The unit is laterally compressed and composed of irregular fused denticles, which except for the slightly smaller anteriormost decrease in height posteriorly. The antero-aboral angle is about 60°, and the anterior face slopes posteriorly as an undenticulate shoulder. The anteriormost denticle is slightly

wider than the others. In the median third of the unit the denticles are fused and needle-like and of approximately the same height. In the posterior third, which is slightly deflected and depressed through 45°, the denticles become short and discrete.

A narrow elongate basal cavity is developed; the remainder of the unit is keeled.

Occurrence: Middle part of the *Clydagnathus nodosus* A.Z.

SPATHOGNATHODUS sp. B
(Pl. 33, fig. 3)

Material: 2 specimens; CPC 8327 figured.

Description: The unit is elongate and highest anteriorly, where a subtriangular blade is developed; it is composed of 3 broad denticles decreasing in height anteriorly. There is a gap of about one denticle width between the blade and the remainder of the unit. The remaining 12 or so denticles are tall, discrete, and subcircular in cross-section. An ovate basal cavity is situated in the anterior third of the unit and a broad attachment scar occupies the lower third of both lateral faces.

Remarks: The form is very similar to *S.* cf. *S. robustus* of Rhodes, Austin, & Druce (1968), but the nature of the blade and the position of the basal cavity distinguish it.

Occurrence: Famennian Ningbing Limestone.

SPATHOGNATHODUS sp. C
(Pl. 32, figs 4a, b)

Material: Figured specimen CPC 8084.

Description: The unit is arched and bowed, with a markedly convex oral surface. Denticles tend to be large in the anterior half and decrease in height towards both ends. A single lateral node is developed on both sides at the midpoint of the unit and half-way up the lateral face. The basal cavity occupies nearly the whole aboral surface, being widest at the midpoint and narrowing progressively towards both ends.

Occurrence: Middle part of the *Clydagnathus nodosus* A.Z.

SPATHOGNATHODUS ? sp.
(Pl. 32, figs 3a, b)

Material: Figured specimen CPC 8092.

Description: The unit is elongate and bar-like. The anterior blade is offset laterally from the remainder of the unit; it is composed of 3 tall, laterally compressed, knife-edged denticles which are discrete over most of their length. The remainder of the unit bears irregular denticles, low and fused in the median third, and extremely tall, erect, and discrete in the posterior third.

A basal cavity is developed in the anterior half, posterior to the anterior blade. It is elongate and symmetrical. The remainder of the unit is keeled.

Remarks: This form is questionably referred to *Spathognathodus* because of the offset anterior blade.

Occurrence: Lower part of the *Spathognathodus costatus* A.Z.

Genus TAPHROGNATHUS Branson & Mehl, 1941

Type species: *Taphrognathus varians* Branson & Mehl, 1941.

TAPHROGNATHUS sp.
(Pl. 41, figs 1a, b)

Material: 3 specimens; CPC 8089 figured.

Description: The platform is elongate, 5 times as long as wide; the ornament consists of 2 nodose platform rims separated by a deep medial trough. A medial carina is present in the extreme posterior and this extends as a very short posterior free blade. The anterior free blade is medial in its aboral portion, though its oral portion tends toward the left side as viewed from the anterior.

The anterior free blade is composed of at least 4 massive laterally compressed fused denticles with free chevron tips. Their height decreases anteriorly, the posteriormost denticle being exceptionally massive and over twice as high as the platform. The platform is depressed through 45° at its midpoint.

The basal cavity is lanceolate and developed over the whole aboral platform surface, narrowing to a fine groove at the posterior termination. The anterior free blade is keeled.

Remarks: The specimen differs from *T. varians* Branson & Mehl in having a massive denticle at the posterior termination of the free blade.

Occurrence: The species occurs in the Utting Calcarenite and in the Spirit Hill No. 1 Bore in the interval 200-250 feet.

Genus TRIPODELLUS Sannemann, 1955

Type species: *Tripodellus flexuosus* Sannemann, 1955.

TRIPODELLUS ROBUSTUS Bischoff, 1957
(Pl. 41, figs 2a-3)

1957 *Tripodellus robustus* Bischoff, *Hess. Landesamt. Bodenf., Abh.*, 19, 58, pl. 6, fig. 40.
1959 *Tripodellus robustus* Bischoff; Helms, *Geologie*, 8, 659, pl. 2, figs 7, 17, 20.
1961 *Tripodellus robustus* Bischoff; Freyer, *Freiberger Forsch.*, C-95, 89, pl. 6, fig. 152.
1964 *Tripodellus robustus* Bischoff; Lindström, *Conodonts*, fig. 55d.
1965 *Tripodellus robustus* Bischoff; Spasov, *Trav. géol. Bulgarie., Sér. paléont.*, 7, 103.
1966 *Tripodellus robustus* Bischoff; Glenister & Klapper, *J. Paleont.*, 40, 836, pl. 96. fig. 6.

Material: 4 specimens; CPC 8090, 8091 figured.

Occurrence: Upper part of Ningbing Limestone.

gen. nov. et sp. nov.
(Pl. 41, figs 4a, b)

Material: Figured specimen CPC 8098.

Description: The unit is palmate, the apical denticle being small, with one bar on either side. Both are flexed inward and then outward and bear denticles which are tall, needle-like and free-standing; they are alternately inwardly and outwardly inclined. An inverted basal cavity is present beneath the apical denticle and a fine trough runs through the centre of it.

Remarks: The form differs from *Curtognathus* Branson & Mehl in being palmate and from *Rhipidognathus* Branson, Mehl, & Branson in lacking an obvious basal cavity.

Occurrence: Famennian Ningbing Limestone.

gen. et sp. indet. A
(Pl. 42, figs 3a, b)

Material: Figured specimen CPC 8093.

Description: An elongate unit composed of tall fused denticles. The anterior half is composed of tall laterally compressed denticles fused at their bases but otherwise separate, with needle tips. The denticles decrease in height and are inclined posteriorly, apart from the anteriormost which is small. They are also laterally curved, giving a concave face on the left side as viewed from the anterior. The posterior half is composed of about 8 low, laterally compressed broad denticles with free chevron tips. They are inclined posteriorly and laterally, giving a convex face of the left side as viewed from the anterior.

A small elongate symmetrical basal cavity is developed in the anterior half, anterior to the junction of the differing denticles. The remainder of the unit is keeled.

Remarks: This form is closest to the genus *Spathognathodus* (Branson & Mehl).

Occurrence: Lower part of the *Siphonodella quadruplicata-S. cooperi* A.Z.

gen. et sp. indet. B
(Pl. 41, fig. 5)

Material: Figured specimen CPC 8094.

Description: An arched unit composed of a large apical denticle inclined posteriorly with its aboral anterior and posterior faces produced into bars. The anterior bar is denticulate, but both bars are broken. A deep basal cavity occupies the whole unit.

Occurrence: Famennian Ningbing Limestone.

gen. et sp. indet. C
(Pl. 41, fig. 6)

Material: Figured specimen CPC 8095.

Description: An elongate unit with a broken but stout denticulate anterior bar with a posteriorly inclined apical denticle. The posterior bar is inflated and undenticulate and terminates in a point.

Occurrence: Famennian Ningbing Limestone.

gen. et sp. indet. D
(Pl. 42, figs 1a, b)

Material: 2 specimens; CPC 8097 figured.

Description: The unit consists of a simple bar with the anterior portion deflected through 90°. It bears tall free-standing denticles, the posterior portion 7 and the anterior at least 5; in both specimens the anterior is broken.

The basal cavity is elongate and situated immediately posterior to the flexure.

Occurrence: Lower part of the *Siphonodella quadruplicata-S. cooperi* A.Z.

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APPENDIX

Devonian conodonts from samples collected from the Cockatoo and Ningbing Formations.

Cockatoo Formation

Westwood Member

Section 12 Westwood Creek (Veevers & Roberts, 1968, fig. 27)

Ancyrognathus sp.
Apatognathus? sp. nov.
Euprioniodina sp.
Hindeodella sp.
Ozarkodina sp.
Polygnathus cf. *P. brevilaminus* Branson & Mehl
Polygnathus normalis Miller & Youngquist
Polygnathus cf. *P. varcus* Stauffer

Section 13 Westwood Creek (Veevers & Roberts, 1968, fig. 27)

Hindeodella sp.
Icriodus rectus Youngquist & Peterson
Ozarkodina sp.

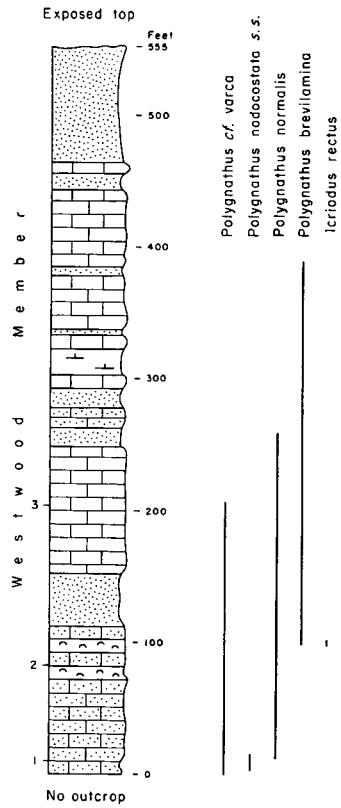

Figure 28. Ranges of conodont species in Section 459, Westwood Member, Cockatoo Formation.

Section 459 Westwood Creek, latitude 14°52′S, longitude 128°30′E (Veevers & Roberts, 1968, fig. 27)
Hindeodella sp.
Icriodus rectus Youngquist & Peterson
Ozarkodina sp.
Polygnathus cf. *P. brevilaminus* Branson & Mehl
Polygnathus nodocostatus nodocostatus Branson & Mehl
Polygnathus normalis Miller & Youngquist
Polygnathus cf. *P. varcus* Stauffer

Section 460 Westwood Creek (Veevers & Roberts, 1968, fig. 27)
Polygnathus brevilaminus Branson & Mehl

Section 461 Westwood Creek (Veevers & Roberts, 1968, fig. 27)
Hibbardella sp.
Hindeodella sp.
Icriodus alternatus Branson & Mehl
Neoprioniodus sp.
Ozarkodina sp.
Polygnathus cf. *P. brevilaminus* Branson & Mehl

Kununurra Member

Section 406 Abney Hill, near Kununurra (Veevers & Roberts, fig. 11)
Polygnathus normalis Miller & Youngquist

Section 424 Dillon Spring Area (Veevers & Roberts, 1968, Map 1)
Ozarkodina sp.
Polygnathus normalis Miller & Youngquist

Hargreaves Member

Section 427 Hargreaves Hills (Veevers & Roberts, 1968, fig. 19)
Hindeodella sp.
Icriodus rectus Youngquist & Peterson
Neoprioniodus sp.
Ozarkodina sp.
Polygnathus normalis Miller & Youngquist
Polygnathus cf. *P. varcus* Stauffer

Jeremiah Member

Sections 443 & 444 Jeremiah Hills (Veevers & Roberts, 1968, fig. 26)
Spathognathodus cf. *plumulus* Rhodes, Austin, & Druce

Ningbing Limestone

Section 8 Surprise Creek (Veevers & Roberts, 1968, fig. 31)
Sample 7 *Hibbardella* sp.
Hindeodella sp.

Section 11 Knob Peak
Sample 3 *Apatognathus varians ethingtoni* subsp. nov.
Hindeodella sp.
Rhodalepis inornata gen. nov. et sp. nov.

Section 15 South of Knob Peak (Veevers & Roberts, 1968, Map 1)
Sample 2 *Palmatolepis glabra elongata* Holmes
Palmatolepis glabra pectinata Ziegler
Polygnathus sp.

Section 17 Tanmurra Creek (Veevers & Roberts, 1968, fig. 33)
Sample 4 *Spathognathodus aculeatus* Branson & Mehl
Spathognathodus ziegleri Rhodes, Austin & Druce

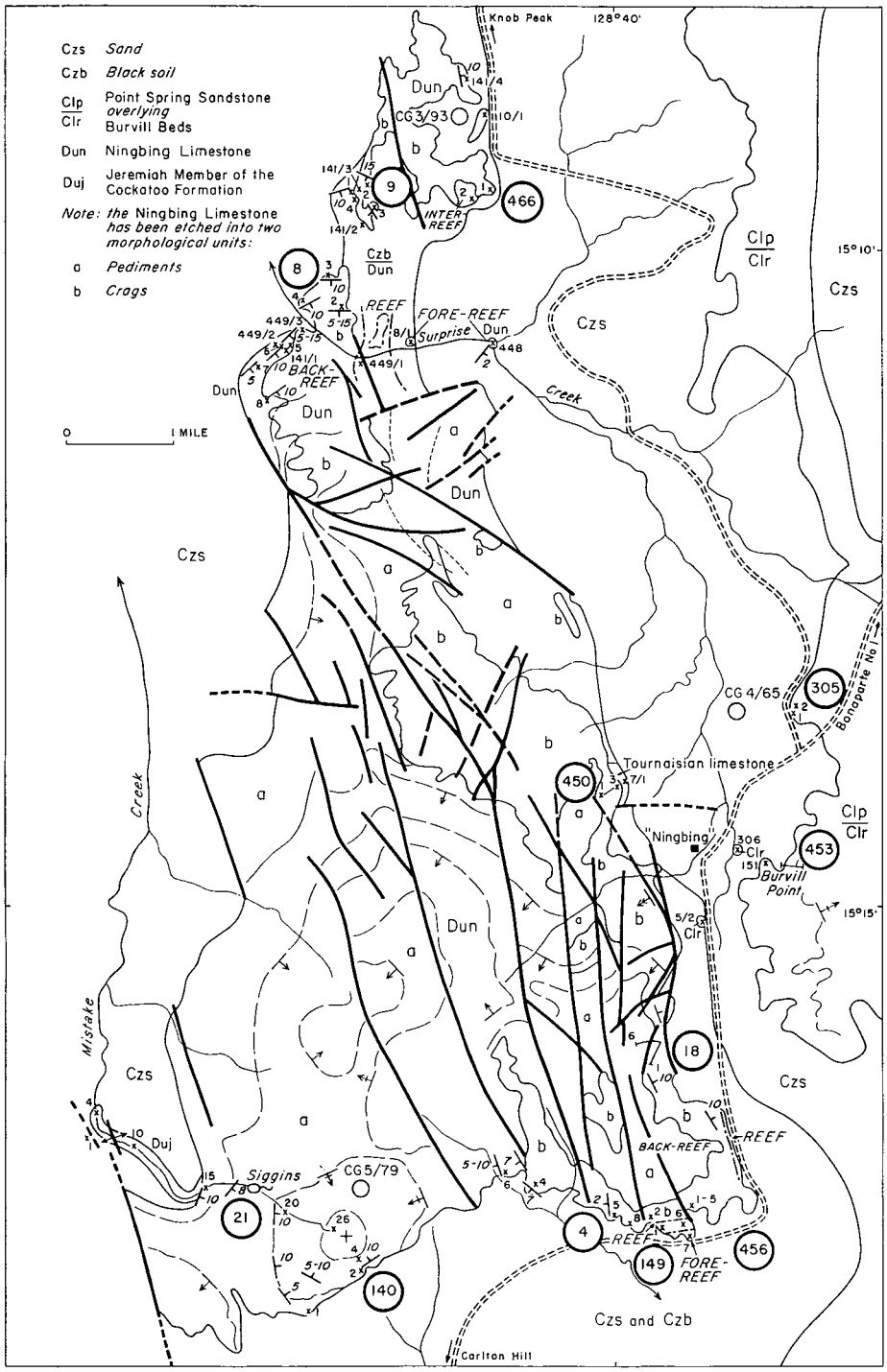

Figure 29. Collecting localities, southern half of outcrop of Ningbing Limestone. (from Veevers & Roberts, 1968)

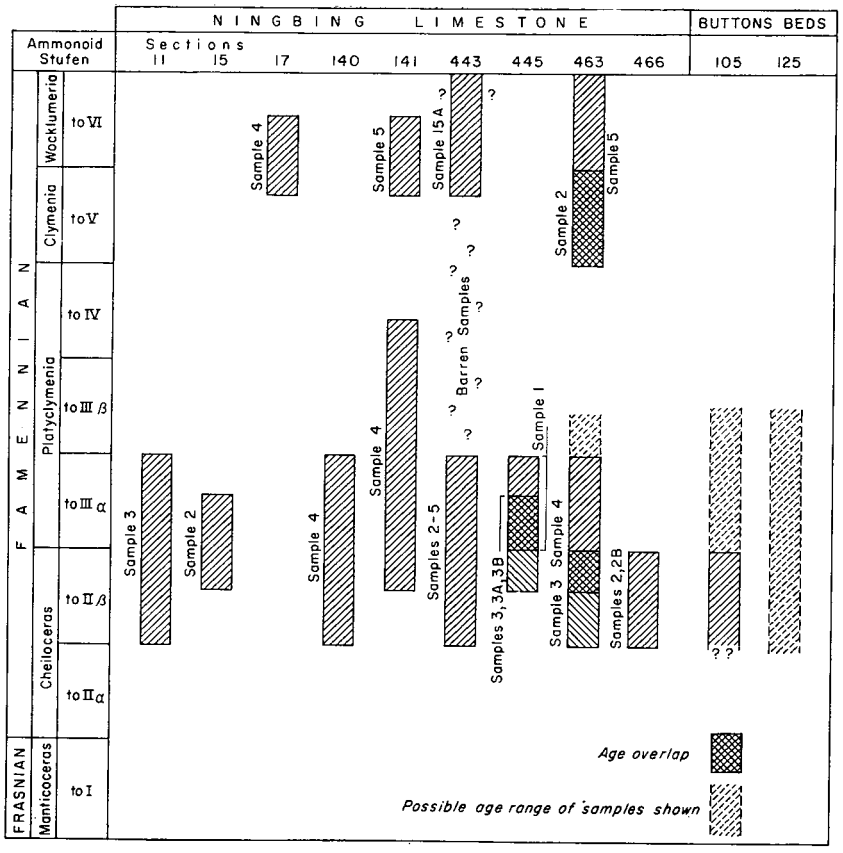

Figure 30. Ranges of samples in the Ningbing Limestone and Buttons Beds.

Section 140 Southern Ningbing Range (Veevers & Roberts, 1968, fig. 31)
Sample 4 *Rhodalepis inornata* gen. nov. et. sp. nov.

Section 141 Surprise Creek area (Veevers & Roberts, 1968, fig. 31)
Sample 4 *Palmatolepis glabra elongata* Holmes
Hindeodella brevis Branson & Mehl
Sample 5 *Apatognathus varians ethingtoni* subsp. nov.
Apatognathus varians klapperi subsp. nov.
Hibbardella sp.
Hindeodella subtilis Ulrich & Bassler
Neoprioniodus sp.
Ozarkodina homoarcuata Helms
Palmatodella delicatula Ulrich & Bassler
Palmatolepis gracilis gracilis Branson & Mehl
Palmatolepis gracilis sigmoidalis Ziegler
Prioniodina? smithi (Stauffer)
Scutula bipennata Sannemann
Spathognathodus cf. *plumulus* Rhodes, Austin & Druce
Spathognathodus crassidentatus Branson & Mehl
Tripodellus robustus Bischoff

Section 280 Jeremiah Hills (Veevers & Roberts, 1968 Map 1)
Sample 4 *Polygnathus* sp.

Section 443 Jeremiah Hills (Veevers & Roberts, 1968, fig. 26)

Sample 2	*Apatognathus varians klapperi* subsp. nov. *Ozarkodina* sp. *Polygnathus* sp. *Spathognathodus* sp.
Sample 4	*Apatognathus varians klapperi* subsp. nov. *Apatognathus varians ethingtoni* subsp. nov. *Hindeodella* sp. *?Neoprioniodus tortus* sp. nov. *Ozarkodina* sp. *Pelekysgnathus peejayi* sp. nov. *Rhodalepis inornata* gen. nov. et sp. nov. *Spathognathodus* sp.
Sample 5	*Apatognathus varians ethingtoni* subsp. nov.
Sample 13	*Apatognathus varians klapperi* subsp. nov. *Spathognathodus* sp.
Sample 14	*Hindeodella* sp. *Neoprioniodus* sp. *Ozarkodina* sp. *Spathognathodus* sp.
Sample 15	*Palmatodella delicatula* Ulrich & Bassler *Spathognathodus* sp.
Sample 15A	*Spathognathodus aculeatus* Branson & Mehl *Spathognathodus* sp.
Sample 22	*Hindeodella corpulenta* Branson & Mehl *Polygnathus* sp. *Spathognathodus* sp.

Section 450 Near Ningbing homestead (Veevers & Roberts, 1968, fig. 31)

Sample 1	*Icriodus rectus* Youngquist & Petersen

Section 455 Öpik Hill area (Veevers & Roberts, 1968, fig. 33)

Sample 1	*Apatognathus varians ethingtoni* subsp. nov. *Apatognathus varians klapperi* subsp. nov. *Centrognathodus* sp. *Hibbardella* sp. *Hindeodella* sp. *Icriodus alternatus* Branson & Mehl *Neoprioniodus* sp. *Ozarkodina homoarcuata* Helms *Palmatodella delicatula* Ulrich & Bassler *Palmatolepis gracilis gracilis* Branson & Mehl *Prioniodina? smithi* (Stauffer) *Spathognathodus inornatus* (Branson & Mehl) *Spathognathodus stabilis* (Branson & Mehl) *Tripodellus robustus* Bischoff
Sample 3	*Hindeodella corpulenta* Branson & Mehl *Palmatolepis glabra pectinata* Ziegler *Scaphignathus ziegleri* sp. nov.
Sample 3A	*Apatognathus?* sp. nov. *Hibbardella* sp. *Icriodus alternatus* Branson & Mehl *Palmatolepis glabra pectinata* Ziegler *Palmatolepis gracilis gracilis* Branson & Mehl *Rhodalepis inornata* gen. nov. et sp. nov.

Sample 3B *Apatognathus varians ethingtoni* subsp. nov.
Hindeodella sp.
Neoprioniodus sp.
Ozarkodina sp.
Palmatolepis glabra pectinata Ziegler
Palmatolepis gracilis gracilis Branson & Mehl
Scaphignathus ziegleri sp. nov.
Spathognathodus cf. *S. plumulus* Rhodes, Austin & Druce

Section 463 Utting Gap (Veevers & Roberts, 1968, Map 1)

Sample 2 *Centrognathodus* sp.
Spathognathodus sp.
Polygnathus hassi Helms

Sample 3 *Apatognathus* sp.
Falcodus variabilis Sannemann
Hibbardella sp.
Hindeodella sp.
Neoprioniodus sp.
Ozarkodina elegans (Stauffer)
Palmatolepis glabra pectinata Ziegler
Palmatolepis gracilis gracilis Branson & Mehl
Palmatolepis minuta minuta Branson & Mehl
Palmatodella delicatula Ulrich & Bassler
Polygnathus varcus Stauffer
Polylophodonta confluens Ulrich & Bassler
Polylophodonta elongata sp. nov.
Scaphignathus ziegleri sp. nov.

Sample 4 *Apatognathus?* sp. nov.
Apatognathus varians klapperi subsp. nov.
Apatognathus sp. nov. B
Scaphignathus ziegleri sp. nov.

Sample 5 *Apatognathus varians ethingtoni* subsp. nov.
Apatognathus varians varians Branson & Mehl
Hibbardella sp.
Hindeodella sp.
Neoprioniodus sp.
Ozarkodina homoarcuata Helms
Palmatolepis gracilis gracilis Branson & Mehl
Polygnathus collinsoni sp. nov.
Polygnathus znepolensis Spasov
Scutula bipennata Sannemann

Section 466 Surprise Creek area (Veevers & Roberts, 1962, fig. 31)

Sample 2 *Palmatolepis gracilis gracilis* Branson & Mehl
Polygnathus sp.
Polylophodonta elongata sp. nov.
Prioniodina latericrescens
Scaphignathus ziegleri sp. nov.

Sample 2B *Hibbardella* sp.
Hindeodella sp.
Icriodus alternatus Branson & Mehl
Ozarkodina sp.
Palmatodella delicatula Ulrich & Bassler
Palmatolepis glabra pectinata Ziegler
Palmatolepis gracilis gracilis Branson & Mehl
Polygnathus varcus Stauffer
Polylophodonta confluens (Ulrich & Bassler)
Scaphignathus ziegleri sp. nov.

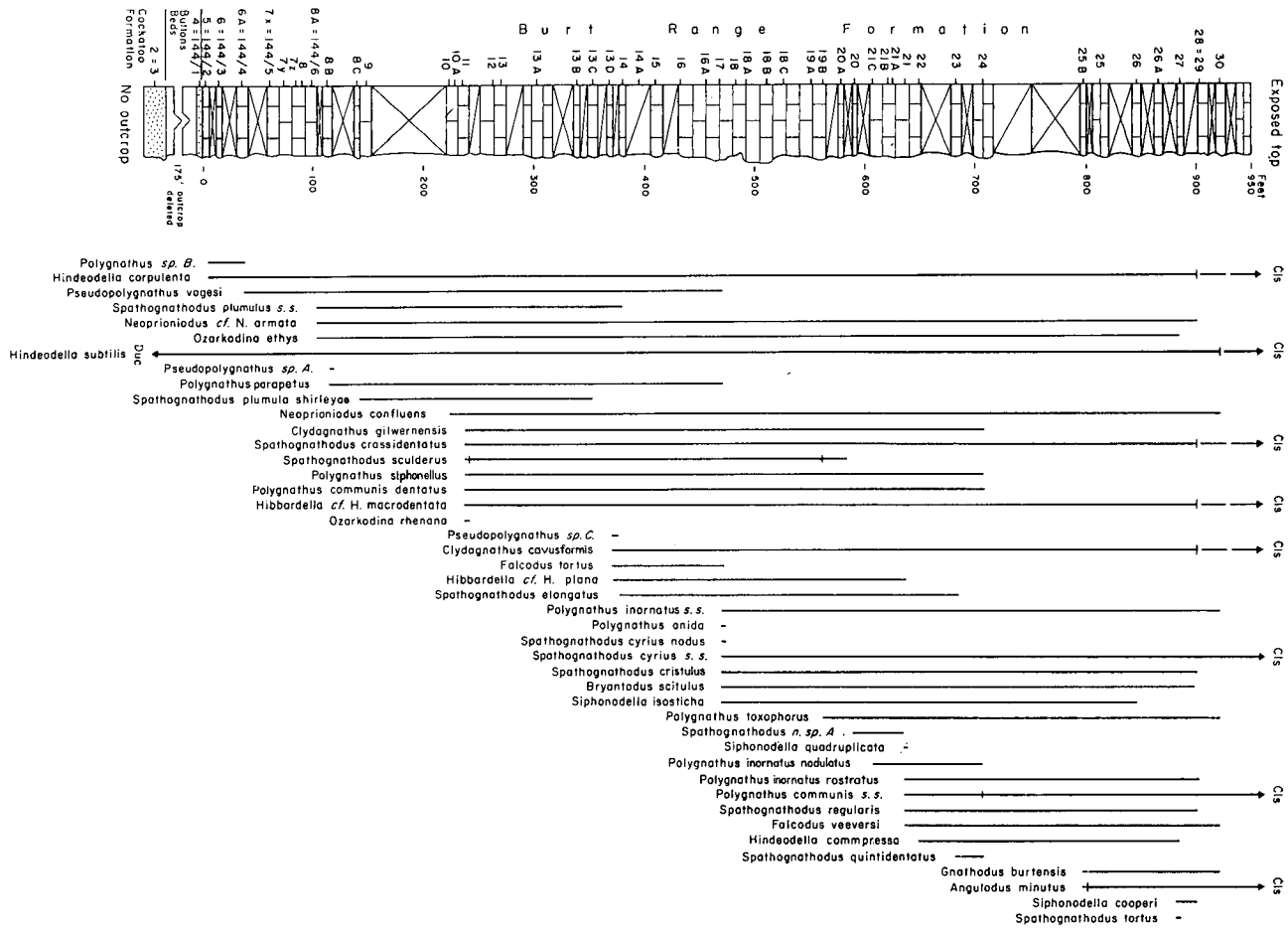

Figure 31. Ranges of conodont species, Section 100, Burt Range Formation

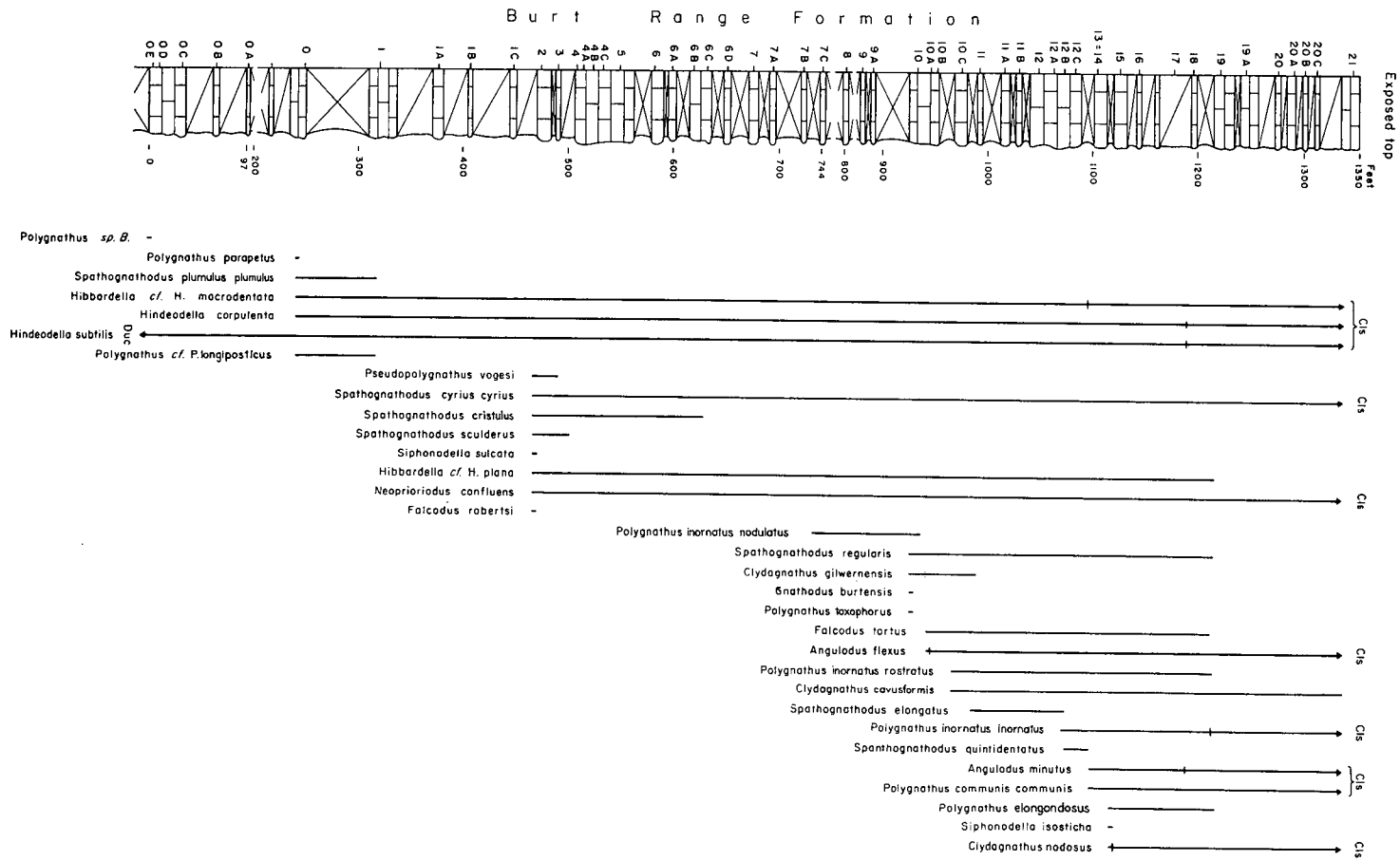

Figure 32. Ranges of conodont species, Section 101, Burt Range Formation

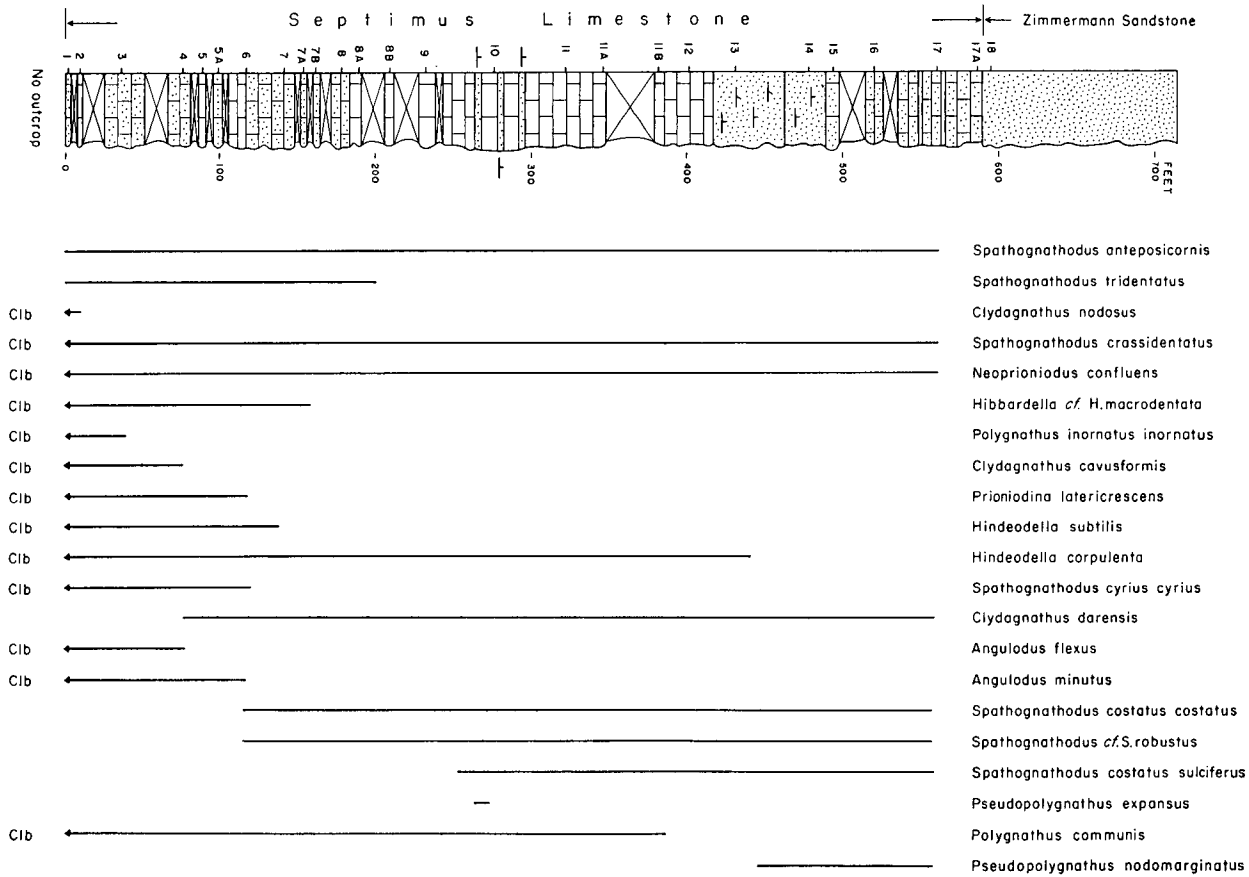

Figure 33. Ranges of conodont species, Section 104, Septimus Limestone

Buttons Beds

Section 105 Buttons Crossing (see Veevers & Roberts, 1968, fig. 35). Sample numbers are stratigraphic height, in feet, above base of section.

Sample 170	*Ligonodina* sp.
Sample 320	*Spathognathodus* aff. *S. robustus* (Branson & Mehl)
Sample 370	*Hindeodella corpulenta* Branson & Mehl
Sample 440	*Hibbardella* sp. *Hindeodella* sp. *Neoprioniodus* sp.
Sample 735	*Hindeodella* sp. *Spathognathodus* sp.
Sample 820	*Polylophodonta* sp. A

Section 125 Sorby Hills (Veevers & Roberts, 1968, fig. 37)

Sample 4	*Polygnathus* sp.

FAUNAS FROM THE UTTING CALCARENITE

Section 107 Utting Gap (Veevers & Roberts, 1968, fig. 63)

Sample 1	*Geniculatus claviger* (Roundy) *Gnathodus texanus* Roundy
Sample 2	*Cavusgnathus unicornis?* Youngquist & Miller
Sample 3	*Gnathodus texanus* Roundy *Taphrognathus* sp.
Sample 4	Barren
Sample 5	Barren
Sample 6	Barren
Sample 6A	*Cavusgnathus unicornis?* Youngquist *Geniculatus claviger* (Roundy) *Gnathodus cuneiformis* Mehl & Thomas *Lonchodina furnishi* Rexroad *Mestognathus beckmanni* Bischoff *Mestognathus neddensis* Rhodes, Austin & Druce *Spathognathodus coalescens* Rexroad & Collinson
Sample 7	*Cavusgnathus unicornis?* Youngquist & Miller *Geniculatus claviger* (Roundy) *Gnathodus texanus* Roundy *Mestognathus beckmanni* Bischoff *Spathognathodus scitulus* (Hinde)

Section 108 Utting Gap (Veevers & Roberts, 1968, fig. 63). Latitude 14° 58′S, Longitude, 128°56′E.

Sample 0	*Cavusgnathus unicornis?* Youngquist & Miller *Gnathodus texanus* Roundy *Lonchodina furnishi* Rexroad *Mestognathus beckmanni* Bischoff
Sample 1	*Cavusgnathus unicornis?* Youngquist & Miller *Geniculatus claviger* (Roundy) *Gnathodus texanus* Roundy *Lonchodina furnishi* Rexroad *Mestognathus beckmanni* Bischoff *Neoprioniodus peracutus* (Hinde)
Sample 2	*Gnathodus texanus* Roundy
Sample 3	*Geniculatus claviger* (Roundy) *Gnathodus texanus* Roundy *Mestognathus beckmanni* Bischoff

Sample 3A	*Cavusgnathus unicornis?* Youngquist & Miller
Sample 4	*Cavusgnathus unicornis?* Youngquist & Miller
	Gnathodus texanus Roundy
Sample 4B	*Cavusgnathus unicornis?* Youngquist & Miller
	Geniculatus claviger (Roundy)
Sample 5	*Cavusgnathus unicornis?* Youngquist & Miller
	Gnathodus texanus Roundy
	Mestognathus beckmanni Bischoff
	Apatognathus gemina (Hinde)

FAUNA FROM THE BURVILL BEDS

Section 435 Weaber Range (Veevers & Roberts, 1968, fig. 60, 61)

Sample B	*Gnathodus girtyi simplex* Dunn
	Cavusgnathus sp.

FAUNAS FROM SPIRIT HILL No. 1 WELL

	Taphrognathus sp.
200′-250′	*Ozarkodina* sp.
1,047′	*Clydagnathus cavusformis* Rhodes, Austin & Druce
	Clydagnathus darensis Rhodes, Austin & Druce
	Euprioniodina alternata Ulrich & Bassler
	Hibbardella macrodentata Thomas
	Hindeodella sp.
	Ozarkodina sp.
	Polygnathus communis communis Branson & Mehl
	Polygnathus sp.
	Spathognathodus sp.
1,100′ 6″ to 1,102′ 6″	*Clydagnathus cavusformis* Rhodes, Austin & Druce
	Euprioniodina alternata Branson & Mehl
	Hindeodella corpulenta Branson & Mehl
	Ozarkodina sp.
	Polygnathus communis communis Branson & Mehl
	Siphonodella isosticha (Cooper)
	Spathognathodus regularis Branson & Mehl
	Spathognathodus sp.
1,412′ to 1,415′	*Hindeodella corpulenta* Branson & Mehl
	Hindeodella subtilis Ulrich & Bassler
	Polygnathus communis communis Branson & Mehl
	Prioniodina sp.
	Siphonodella isosticha (Cooper)
	Spathognathodus regularis Branson & Mehl
1,624′-1,628′	fragments
1,900′-1,907′	*Prioniodina* sp.
1,907′-1,928′	*Ozarkodina* sp.
	Spathognathodus plumulus plumulus Rhodes, Austin & Druce

FAUNAS FROM THE BONAPARTE WELLS

BONAPARTE No. 1	
1,564′ 4″ to 1,564′ 8″	*Gnathodus* sp. A
	Ozarkodina sp.
3,486′ 8″ to 3,488′ 8″ and 3,492′ 8″ to 3,494′	*Gnathodus* sp.
BONAPARTE No. 2	
2,171′ 4″ to 2,173′ 4″	*Gnathodus* sp.
4,931′	*Hindeodella* sp.
	Mestognathus beckmanni Bischoff

PLATE 1

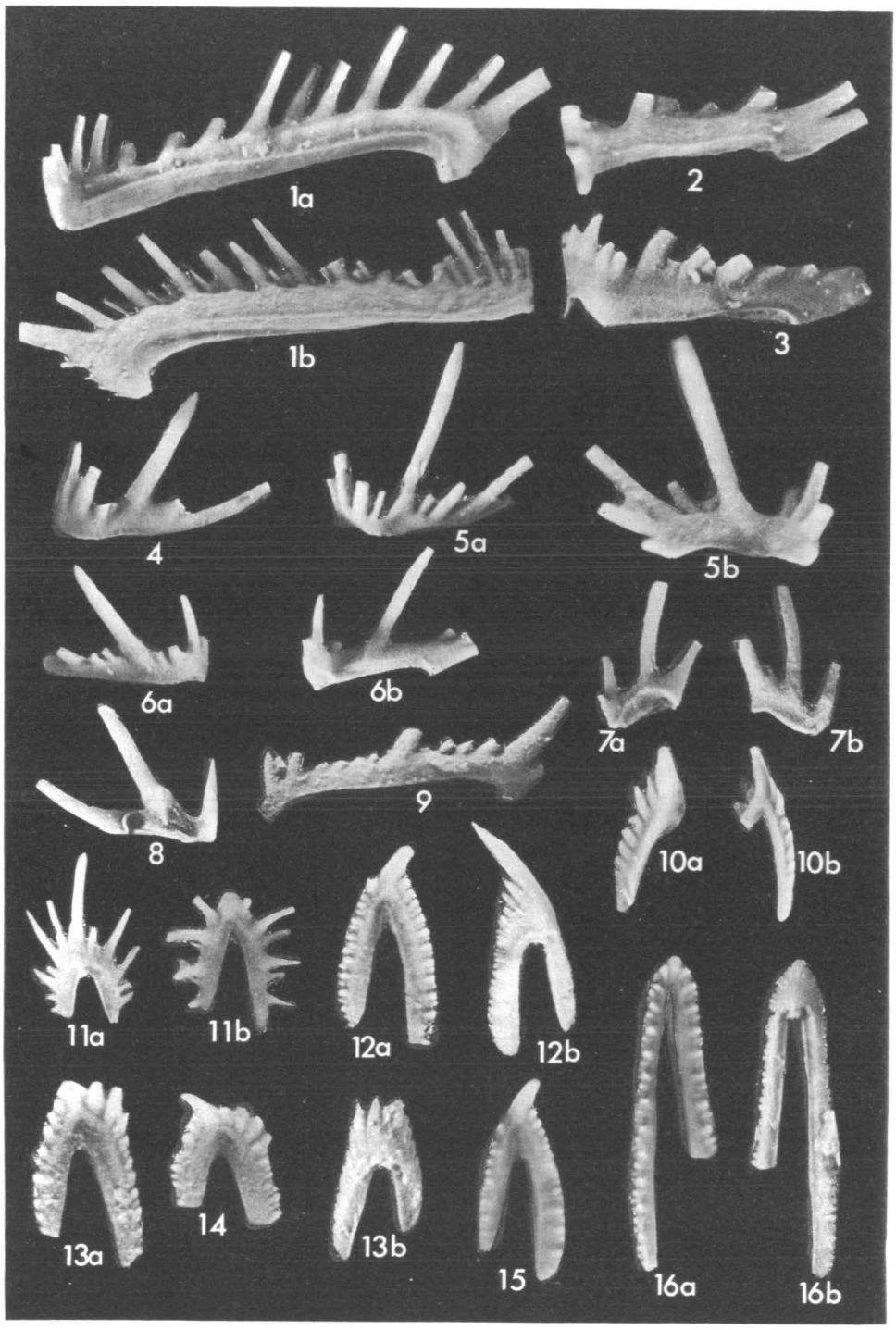
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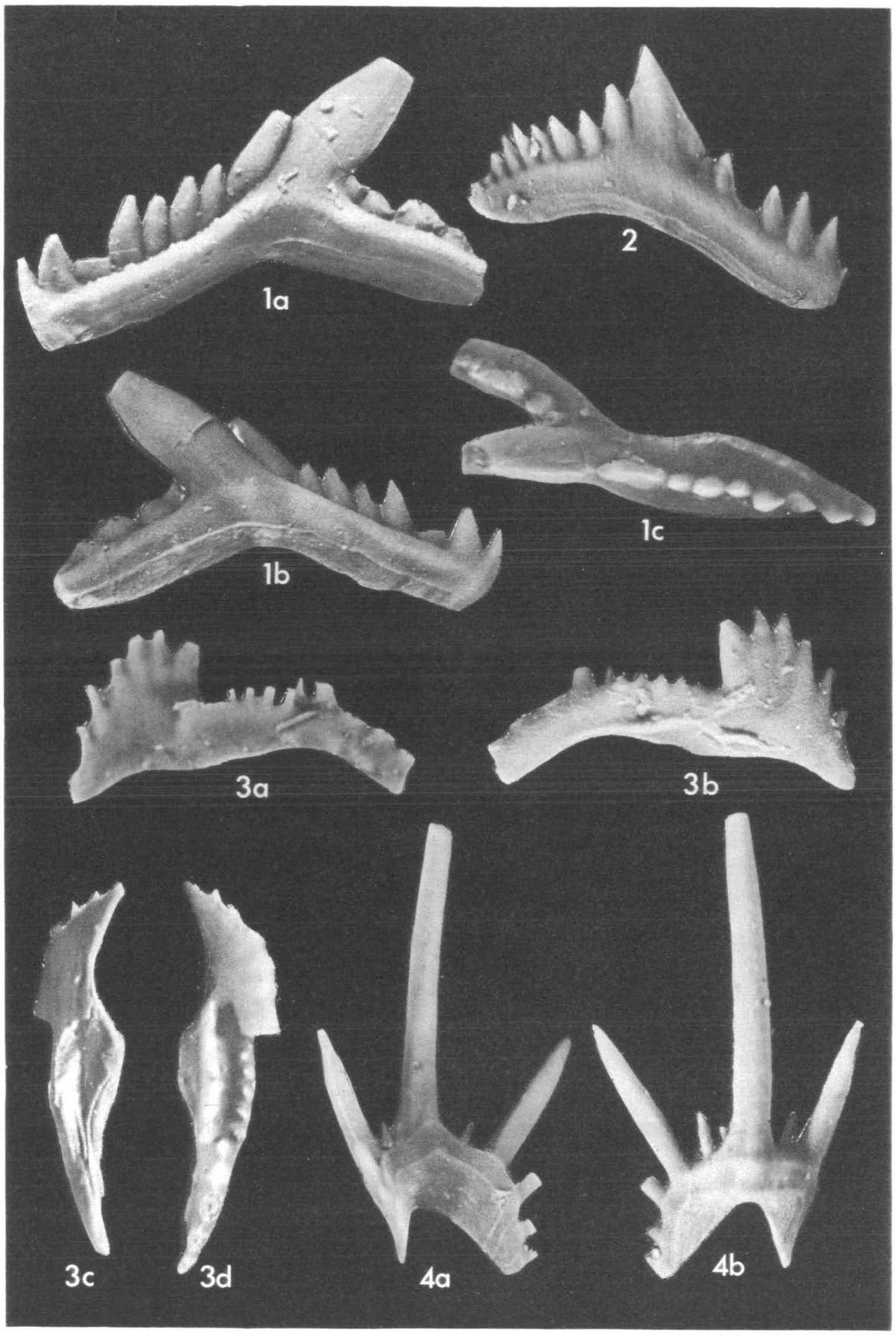
PLATE 2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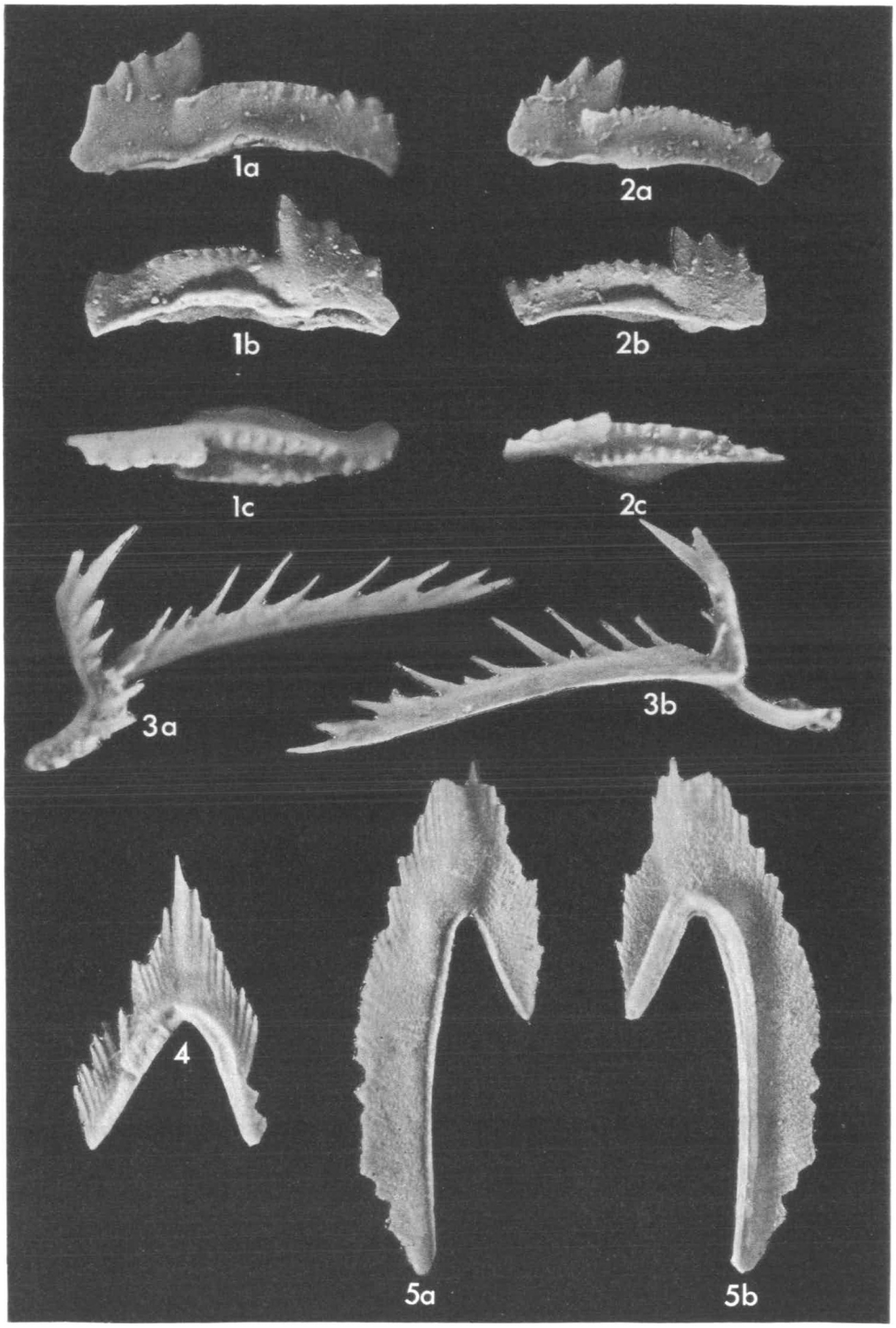
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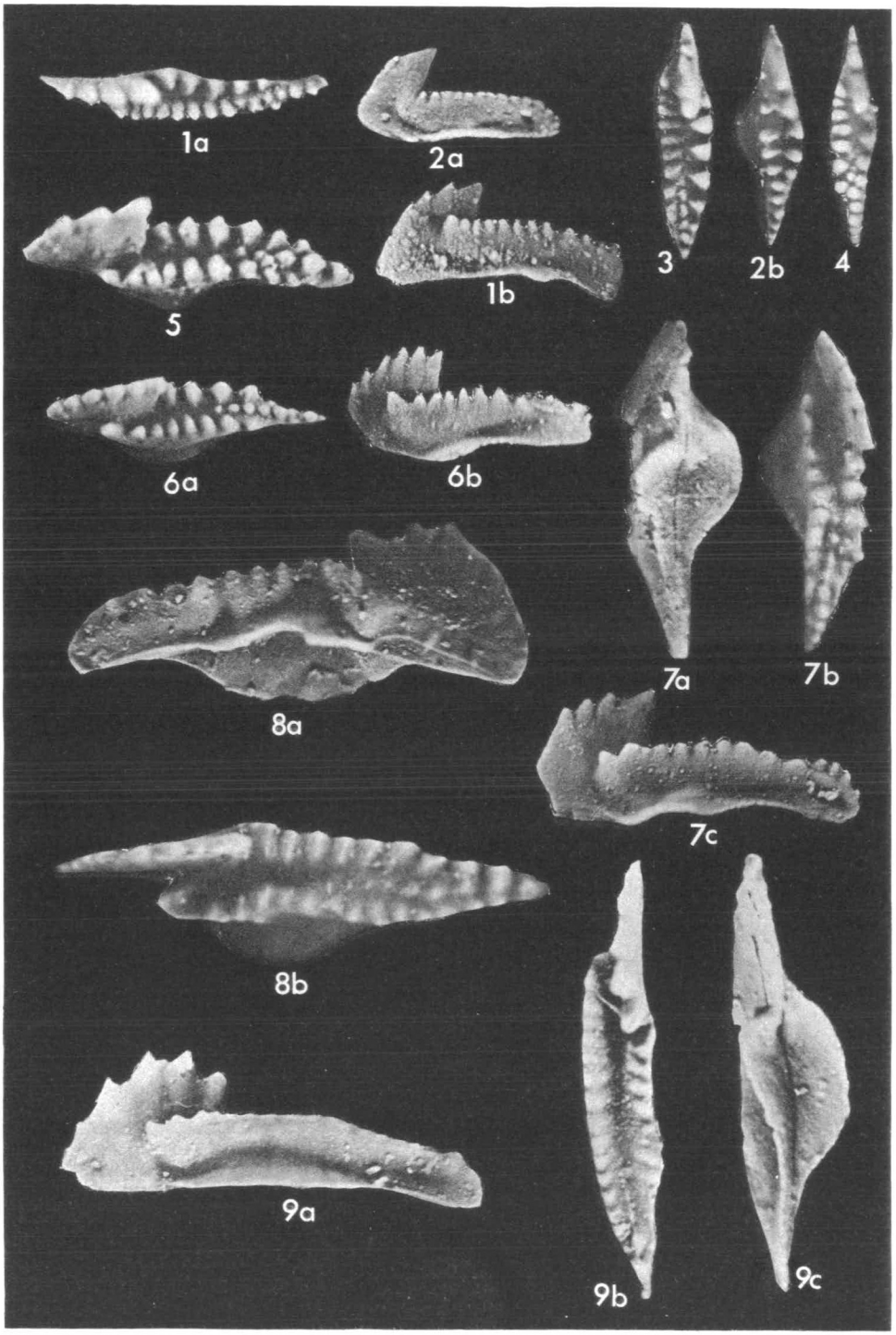
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PLATE 5

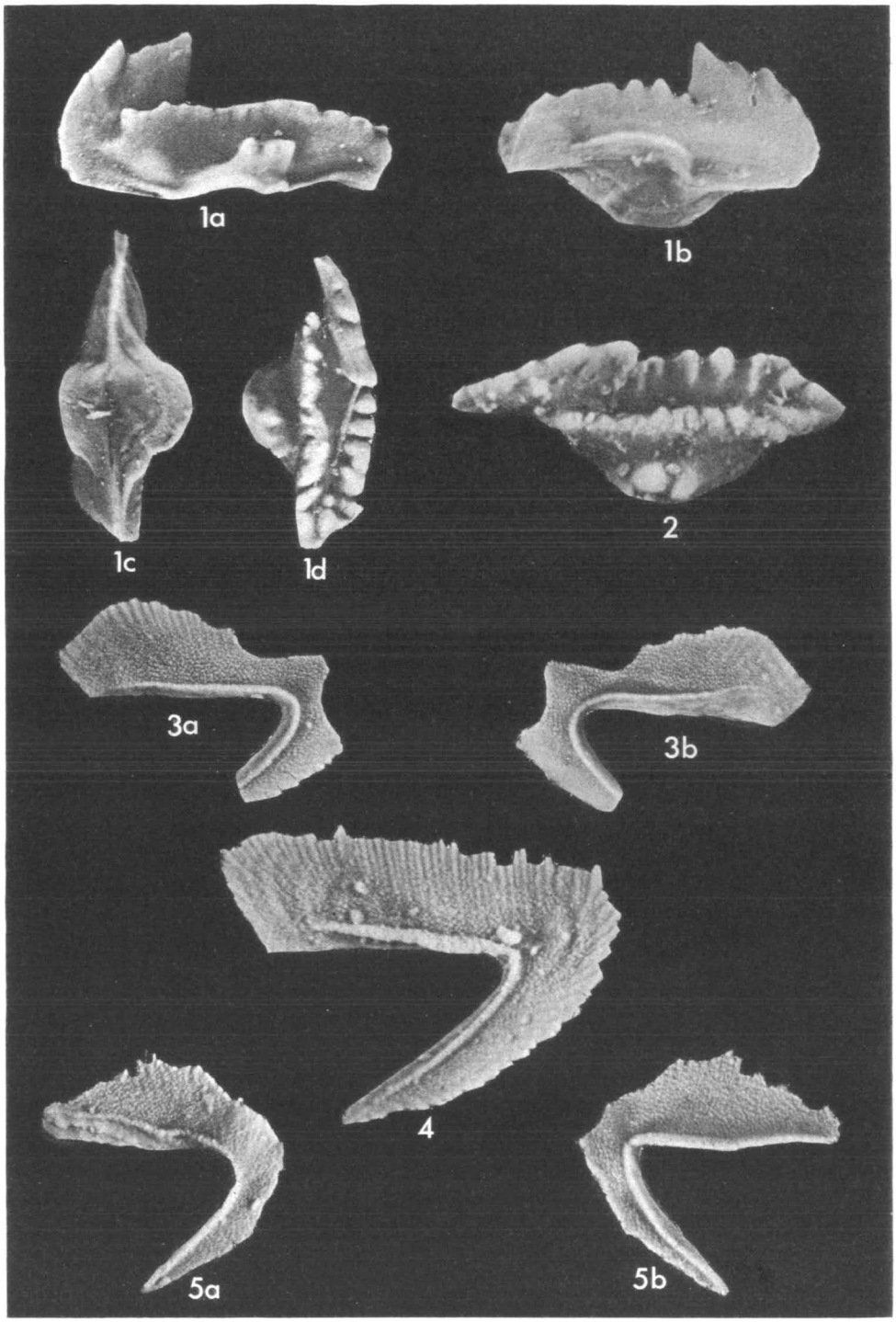
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PLATE 6

		page
Elictognathus bialata (Branson & Mehl, 1934)		54
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b	Inner lateral view of specimen CPC 7837	
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Euprioniodina sp.		—
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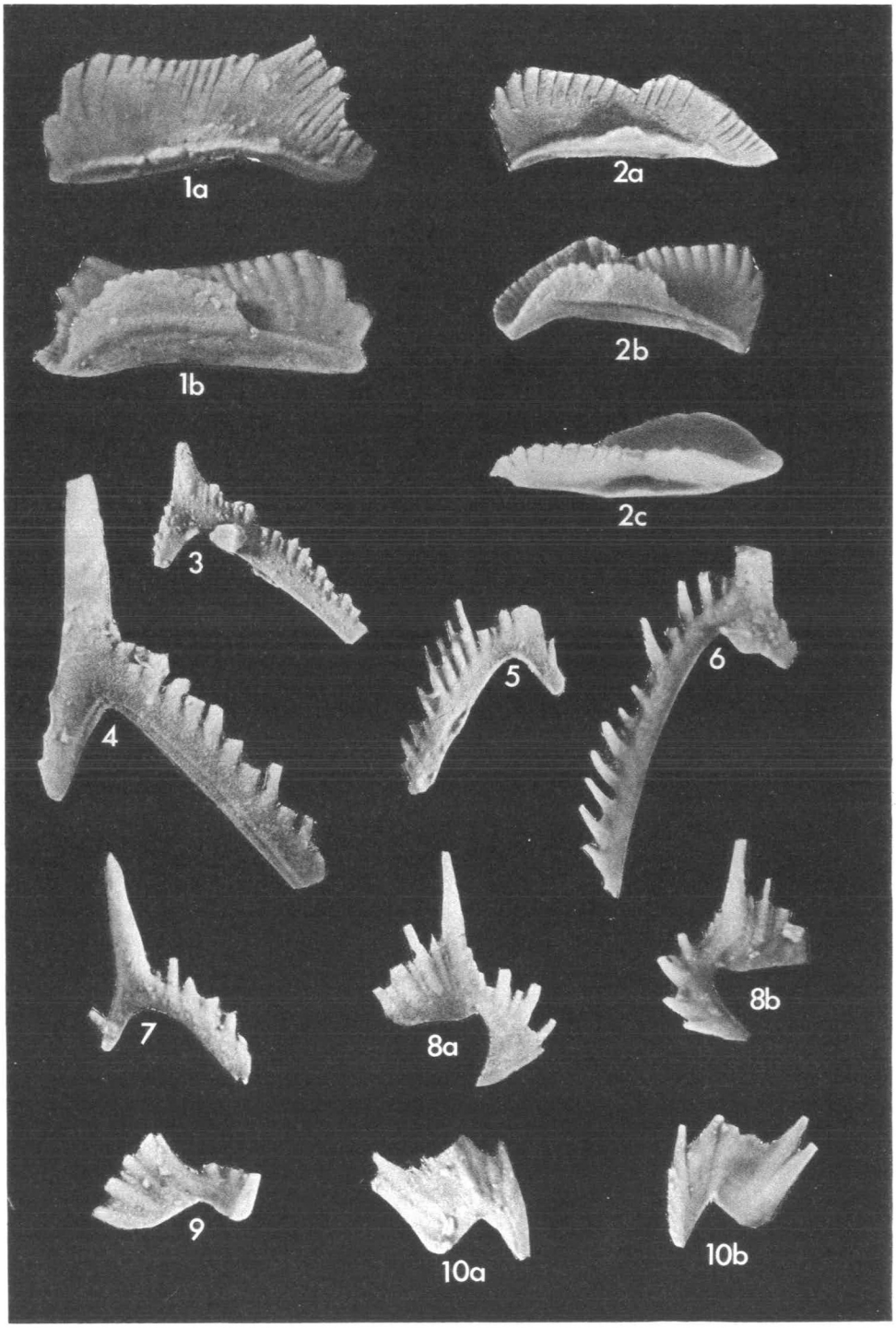
b	Inner lateral view of specimen CPC 7851	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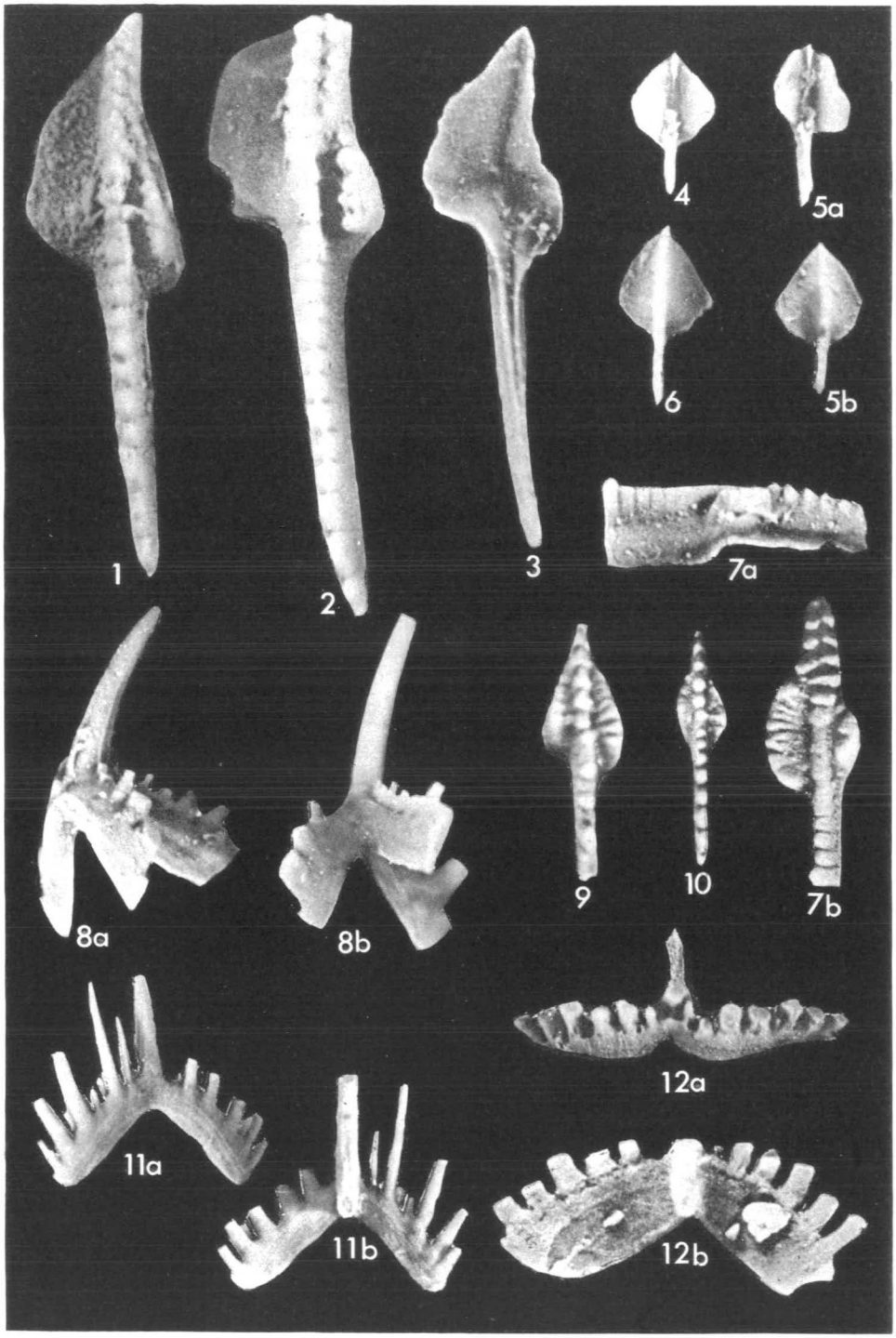
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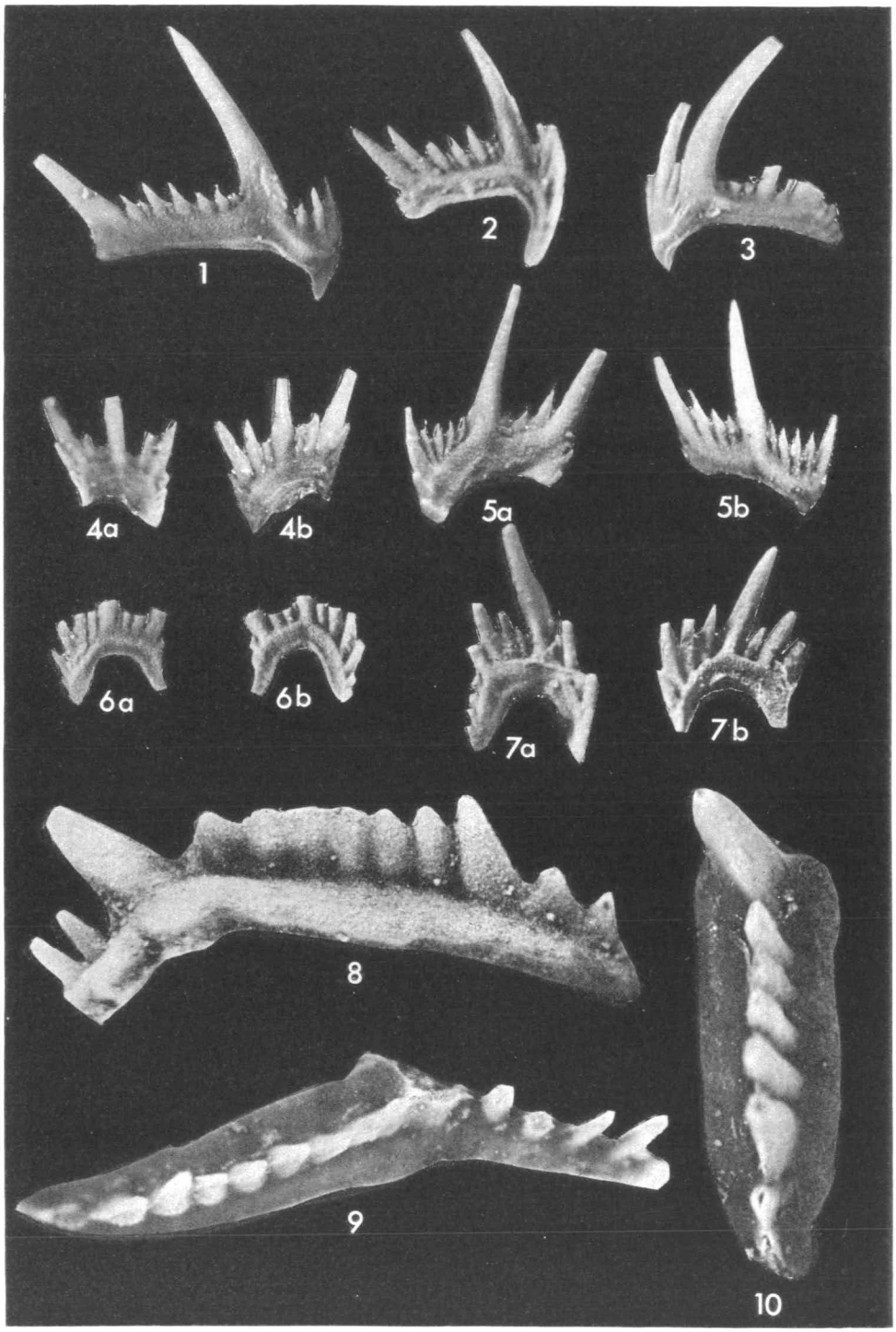
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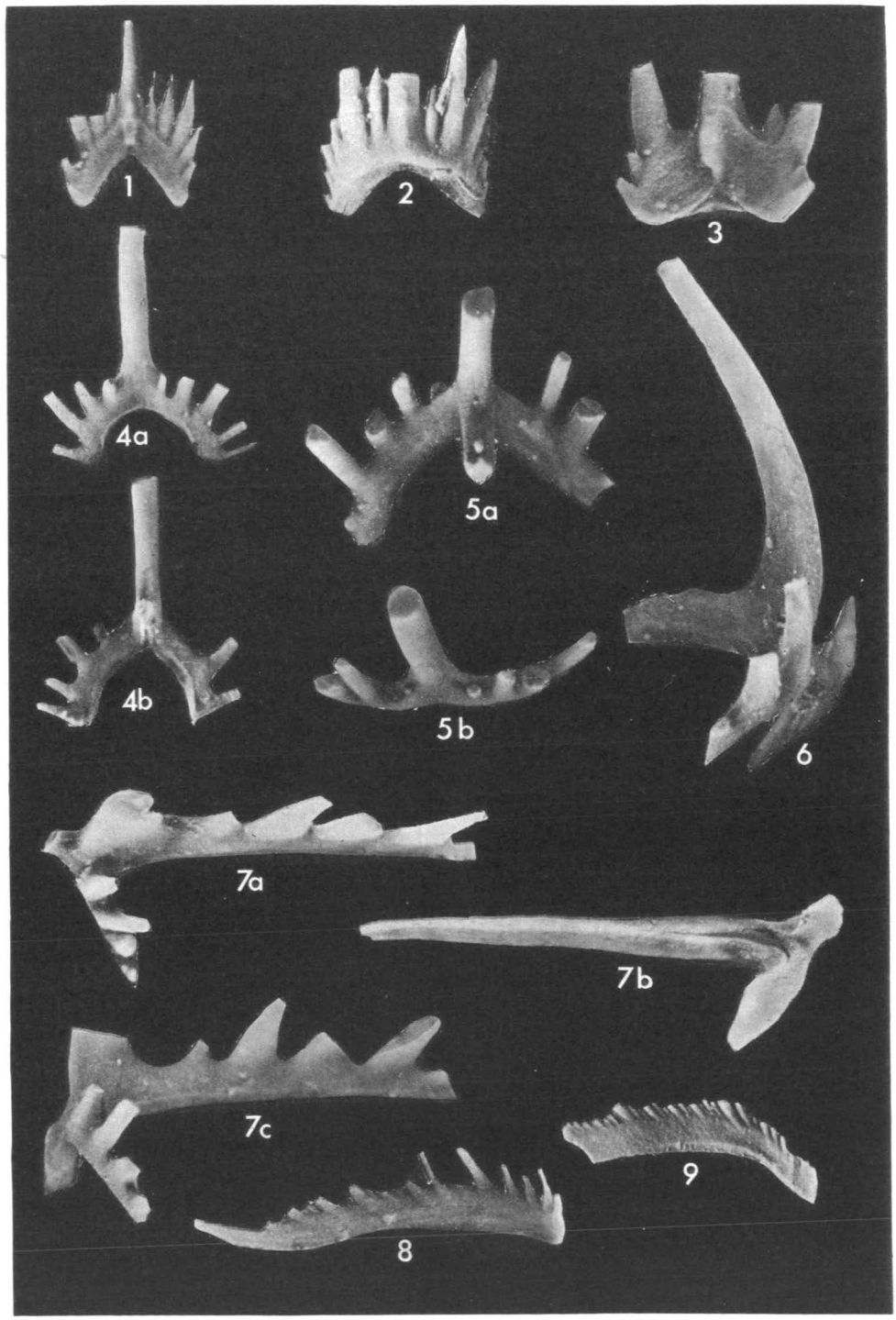
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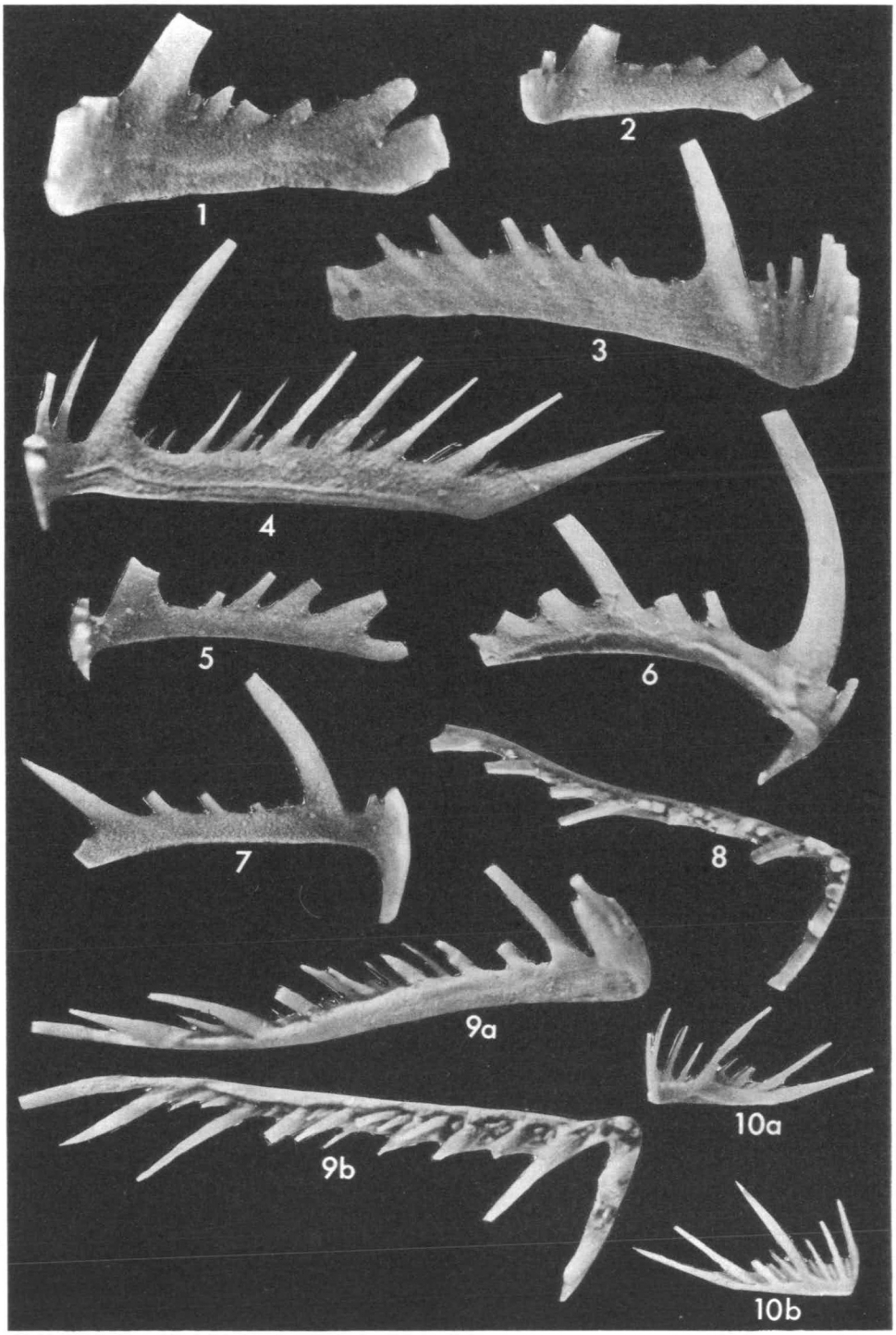
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PLATE 11

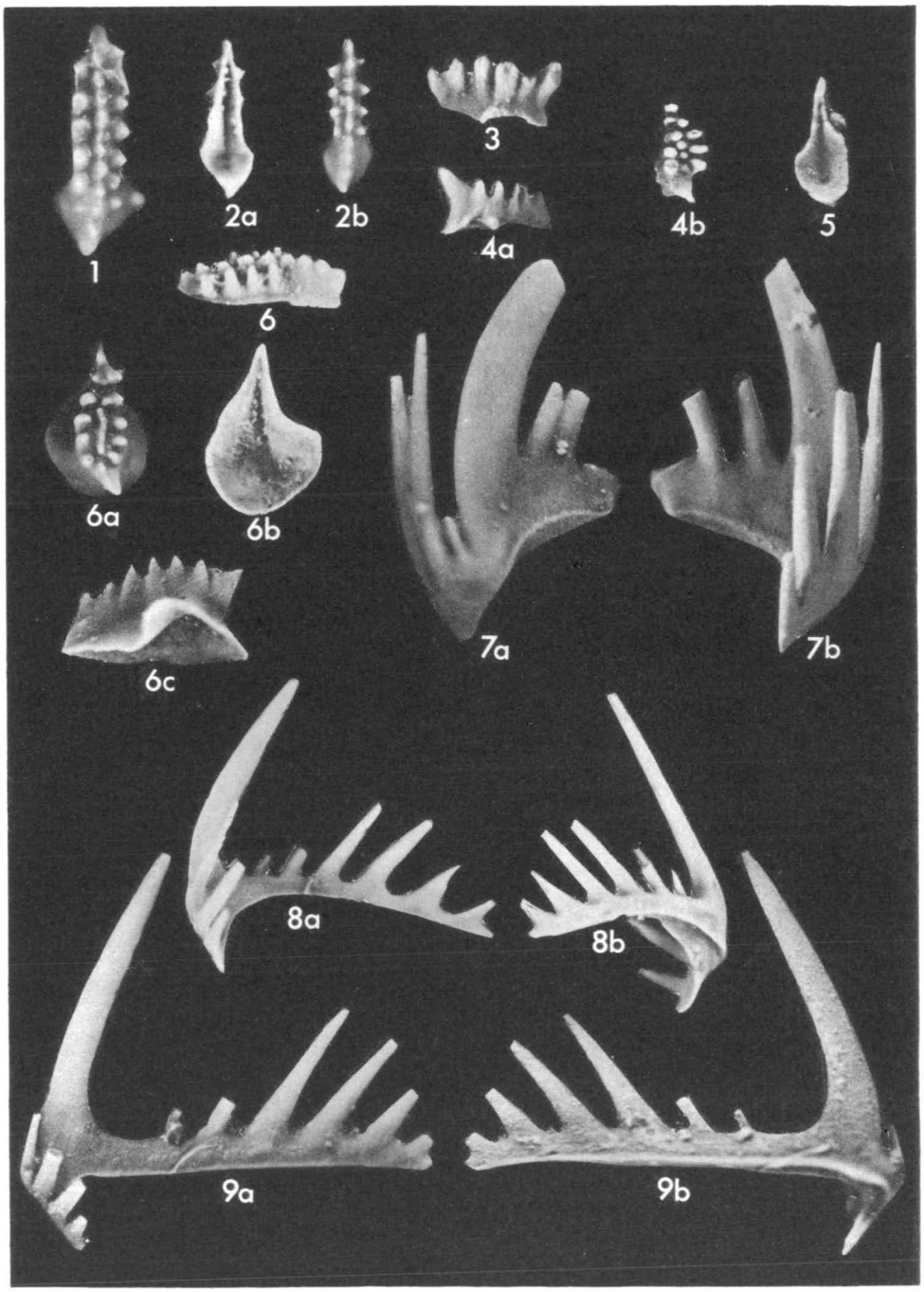
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PLATE 12

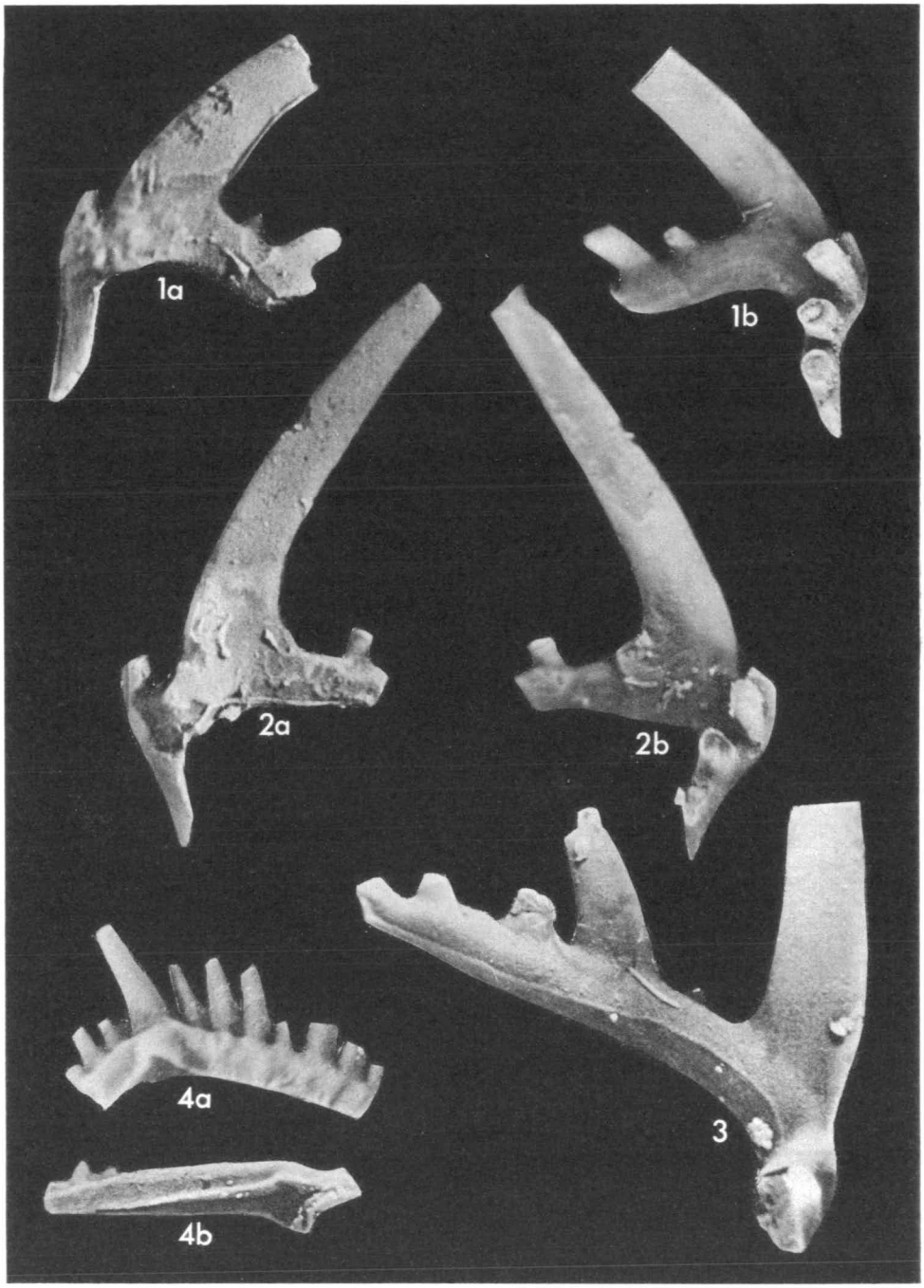
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PLATE 13

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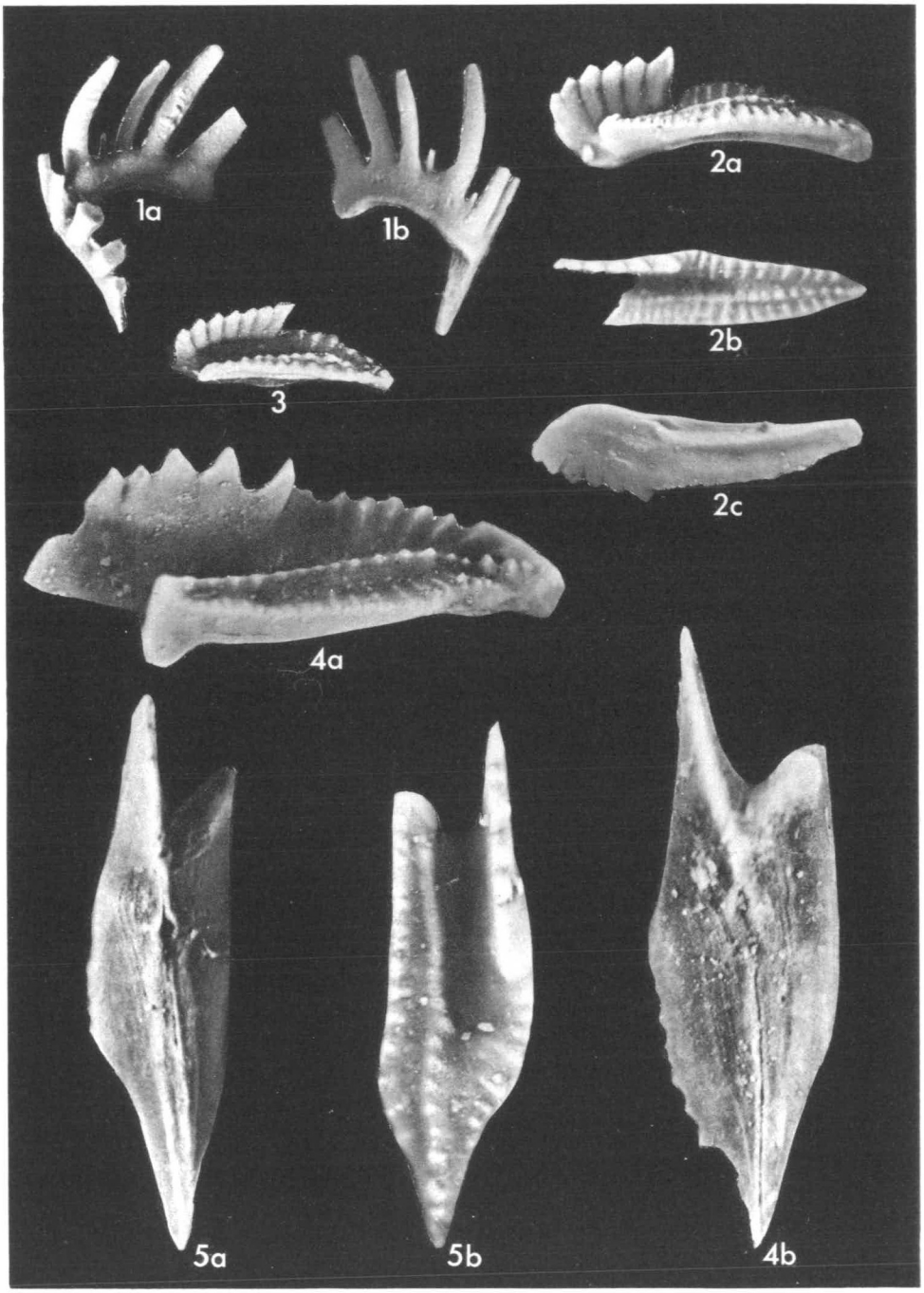
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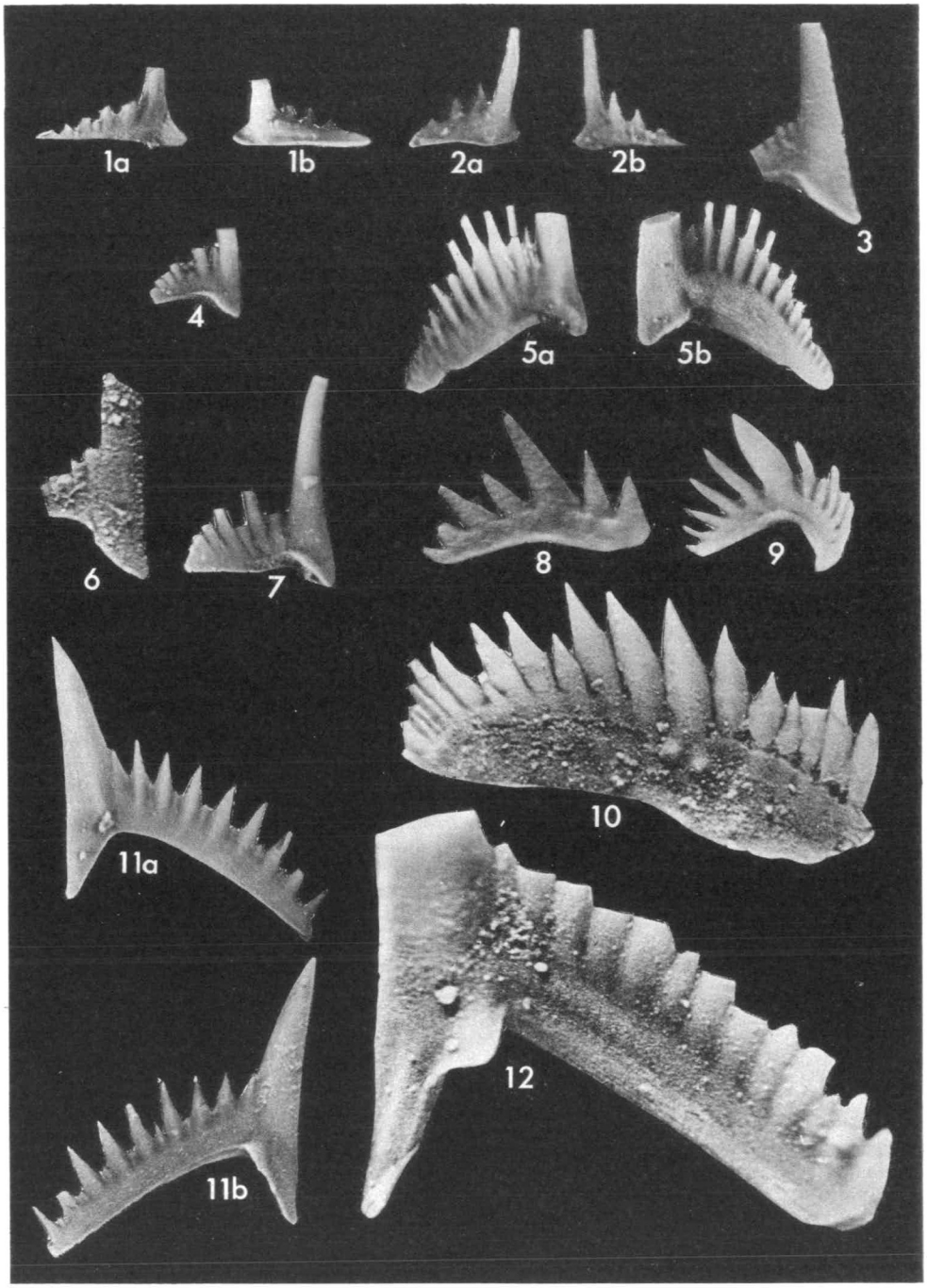
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PLATE 15

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Ozarkodina radians (Branson & Mehl, 1938)		82
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b	Inner lateral view of specimen CPC 7917	

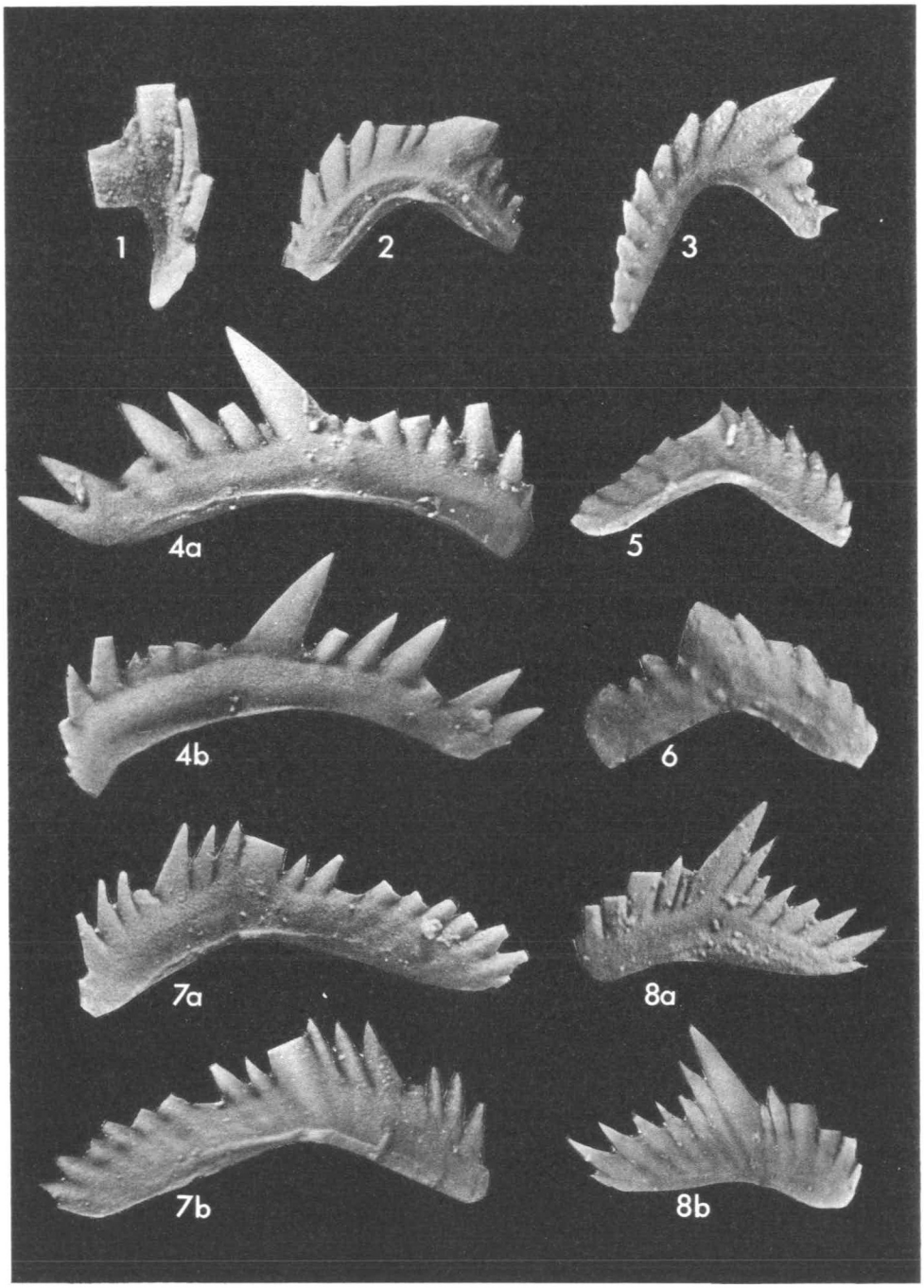
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PLATE 16

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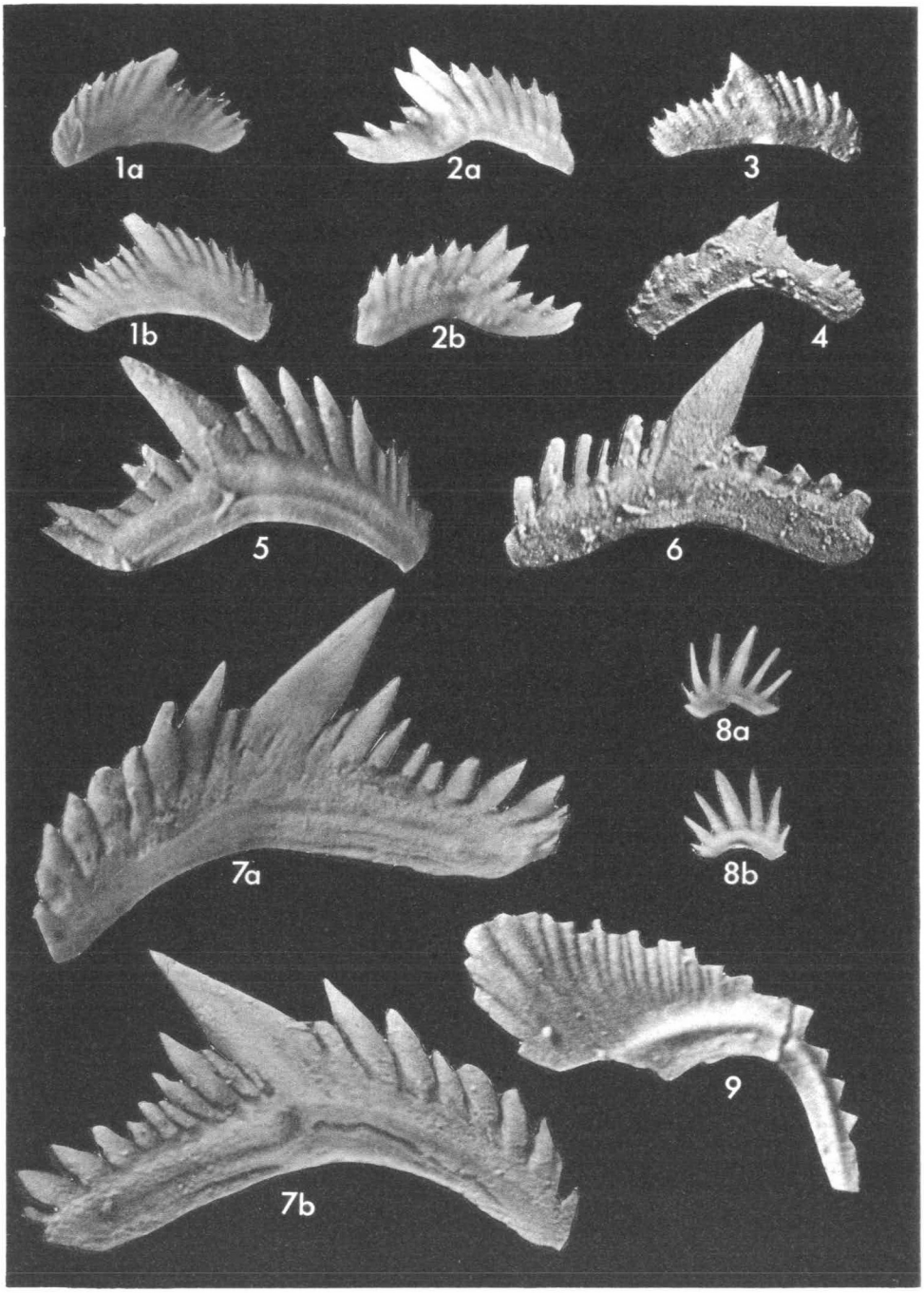
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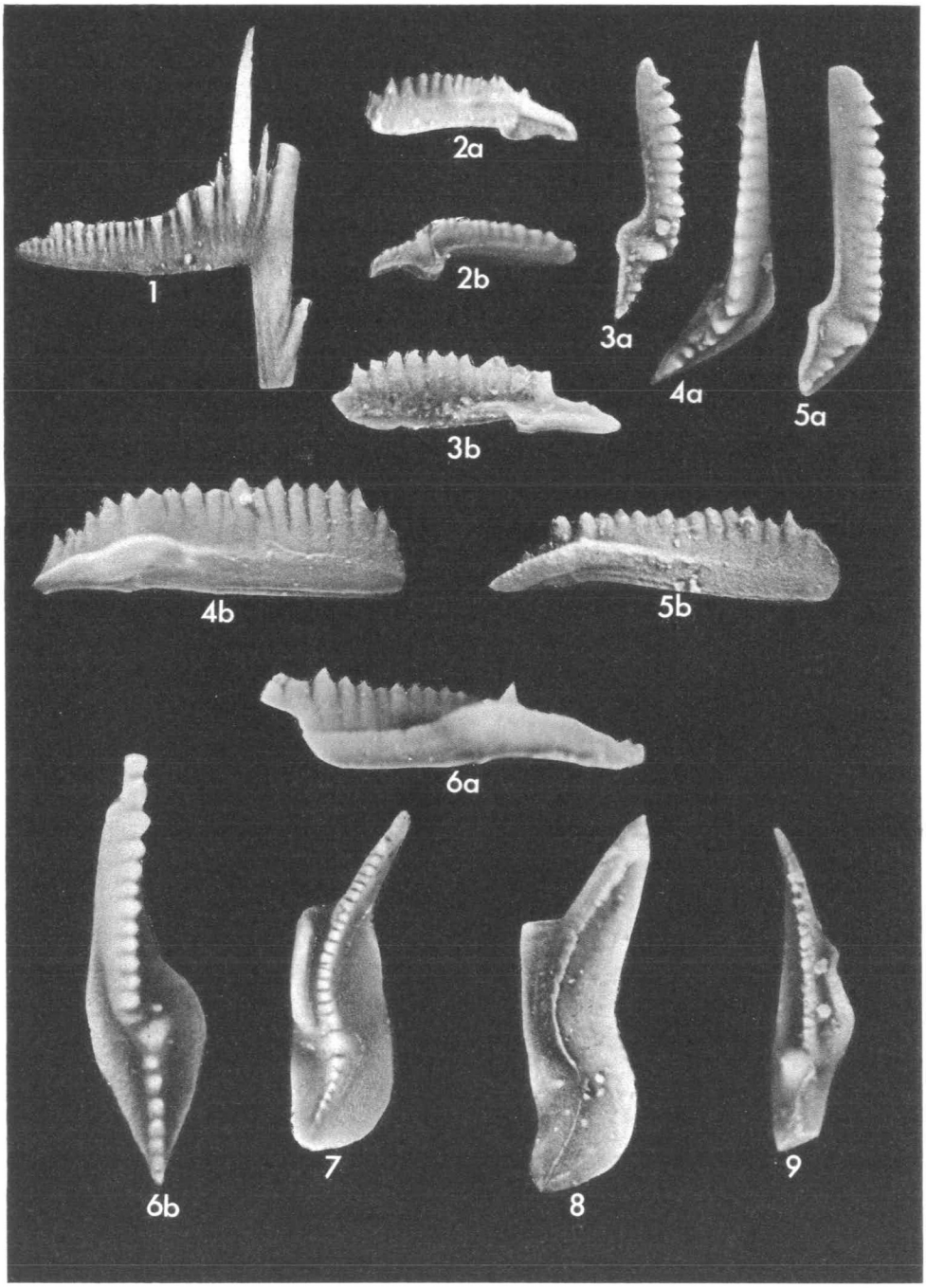
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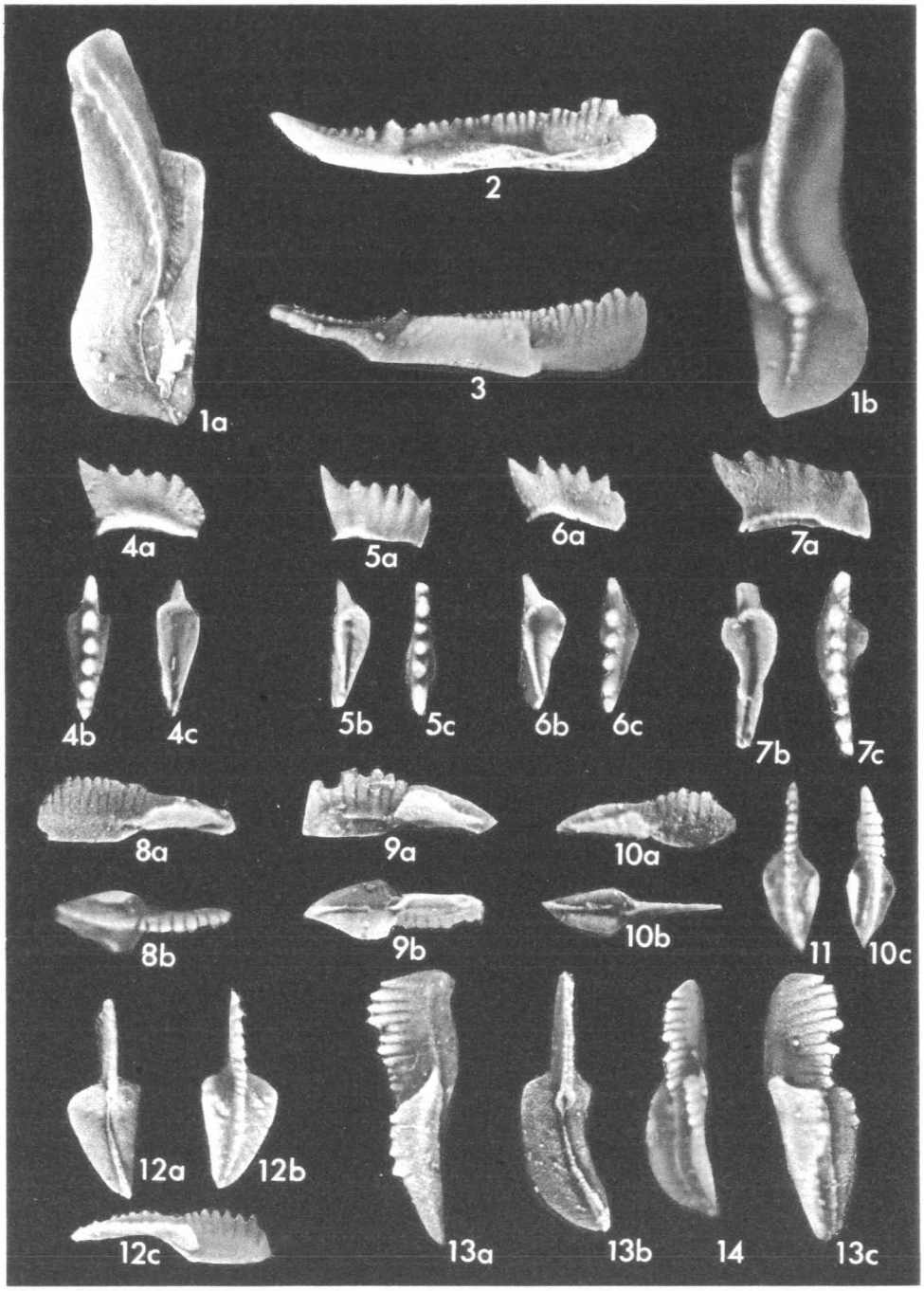
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PLATE 19

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Polygnathus brevilaminus Branson & Mehl, 1934 ....

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Fig. 2	Latero-oral view of specimen CPC 7942
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b	Oral view of specimen CPC 7943
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Polygnathus cf. *P. brevilaminus* Branson & Mehl, 1934 ....

Fig. 5a	Lateral view of specimen CPC 7999
b	Oral view of specimen CPC 7999

Polygnathus nodocostatus nodocostatus Branson & Mehl, 1934 ....

Fig. 6	Oral view of specimen CPC 7997

Polygnathus normalis Miller & Youngquist, 1947 ....

Fig. 7a	Aboral view of specimen CPC 7956
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Fig. 8a	Oral view of specimen CPC 7954
b	Aboral view of specimen CPC 7954
Fig. 9a	Oral view of specimen CPC 7953
b	Aboral view of specimen CPC 7953
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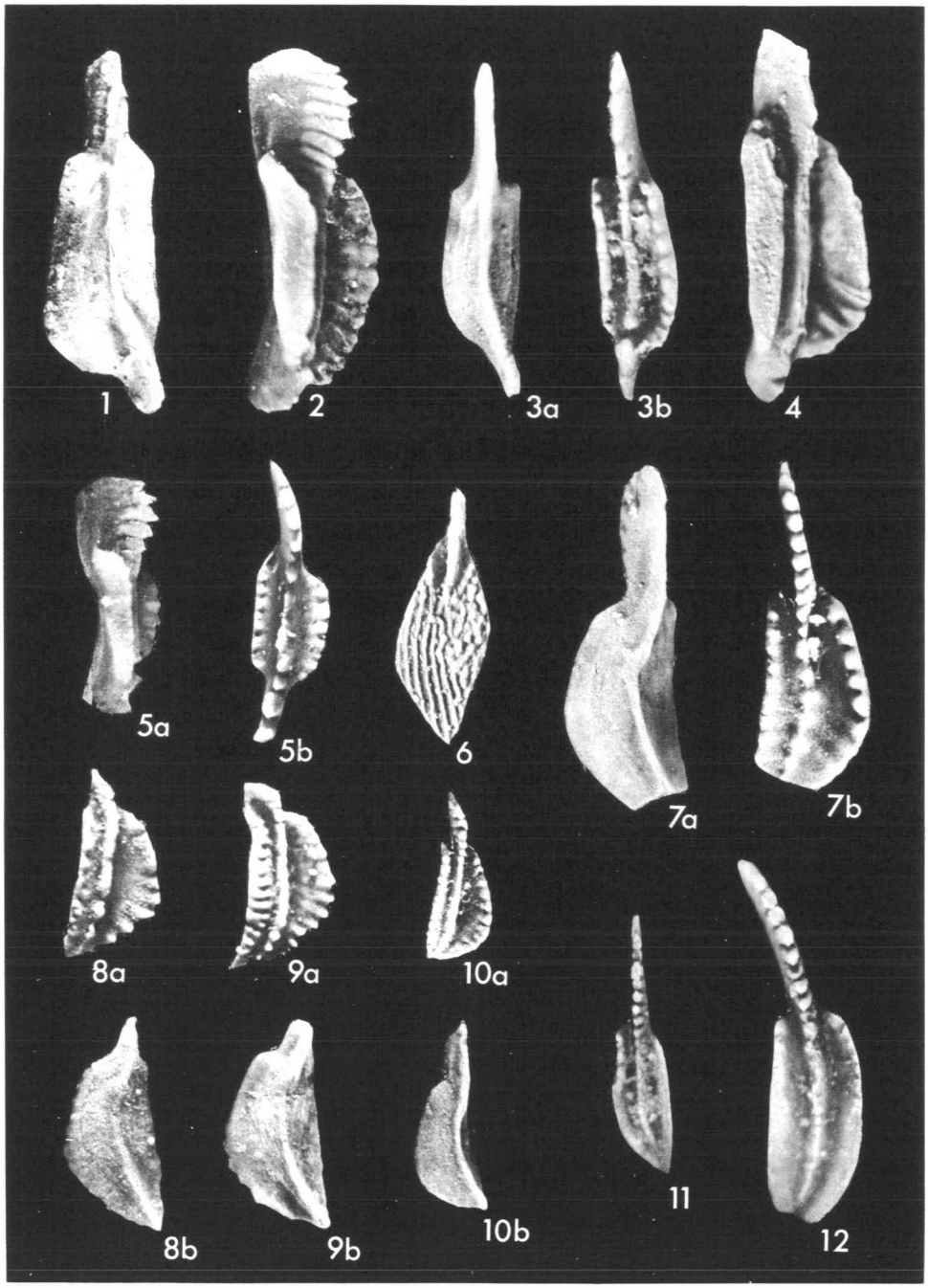
b	Aboral view of specimen CPC 7955

Polygnathus cf. *P. varcus* Stauffer, 1940 ....

Fig. 11	Oral view of specimen CPC 7965
Fig. 12	Oral view of specimen CPC 7964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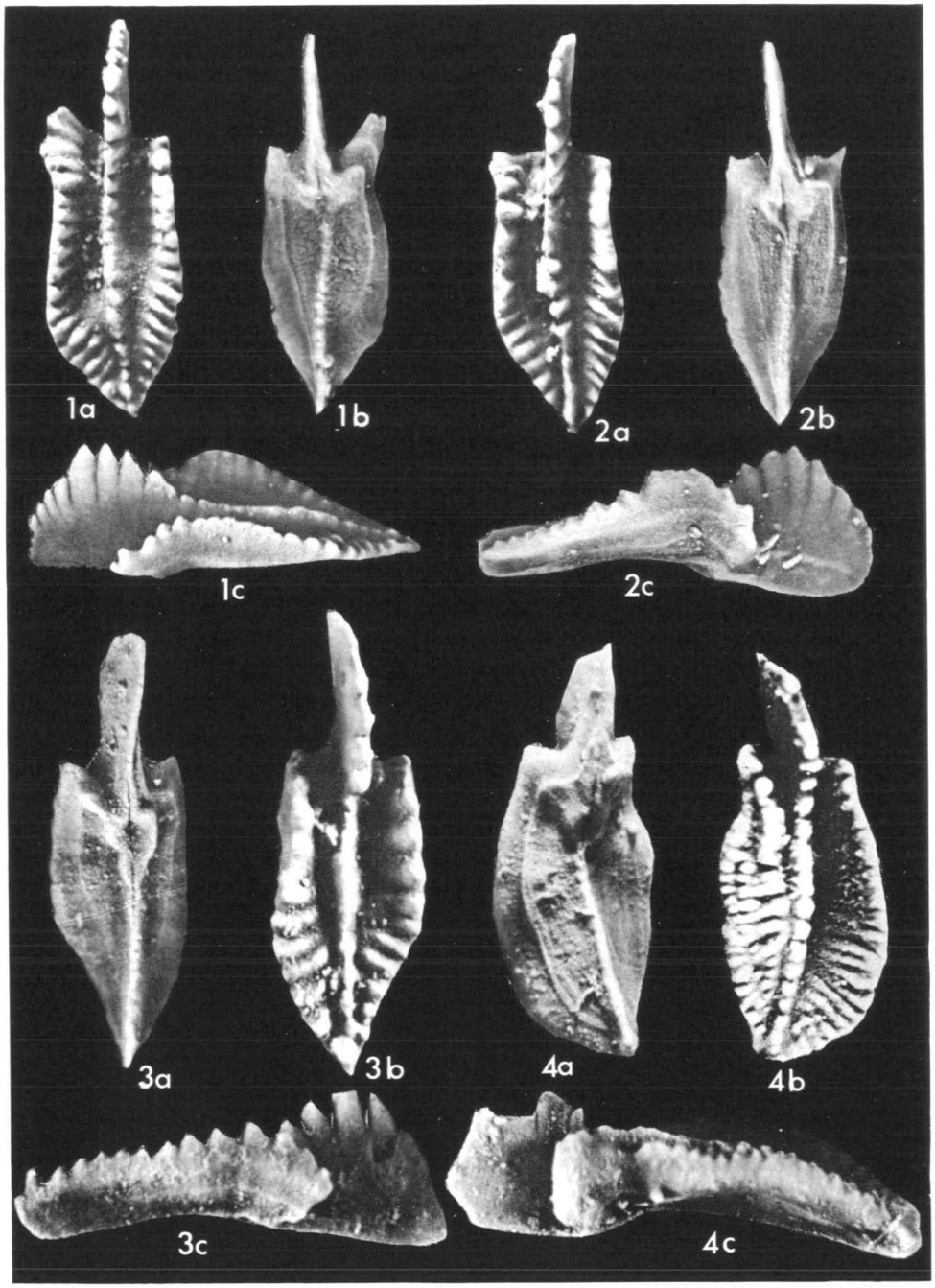
c	Inner lateral view of specimen CPC 7950	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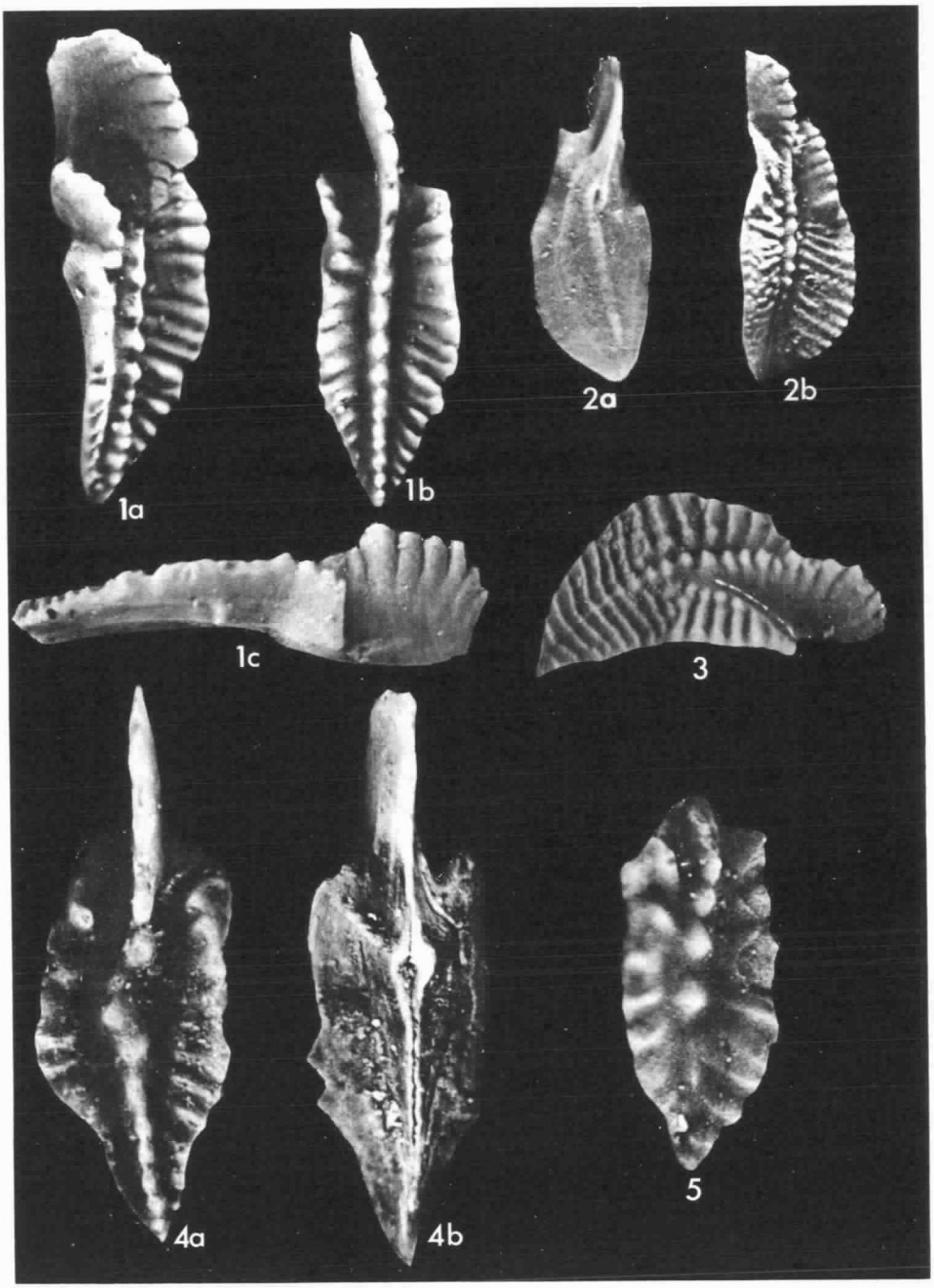
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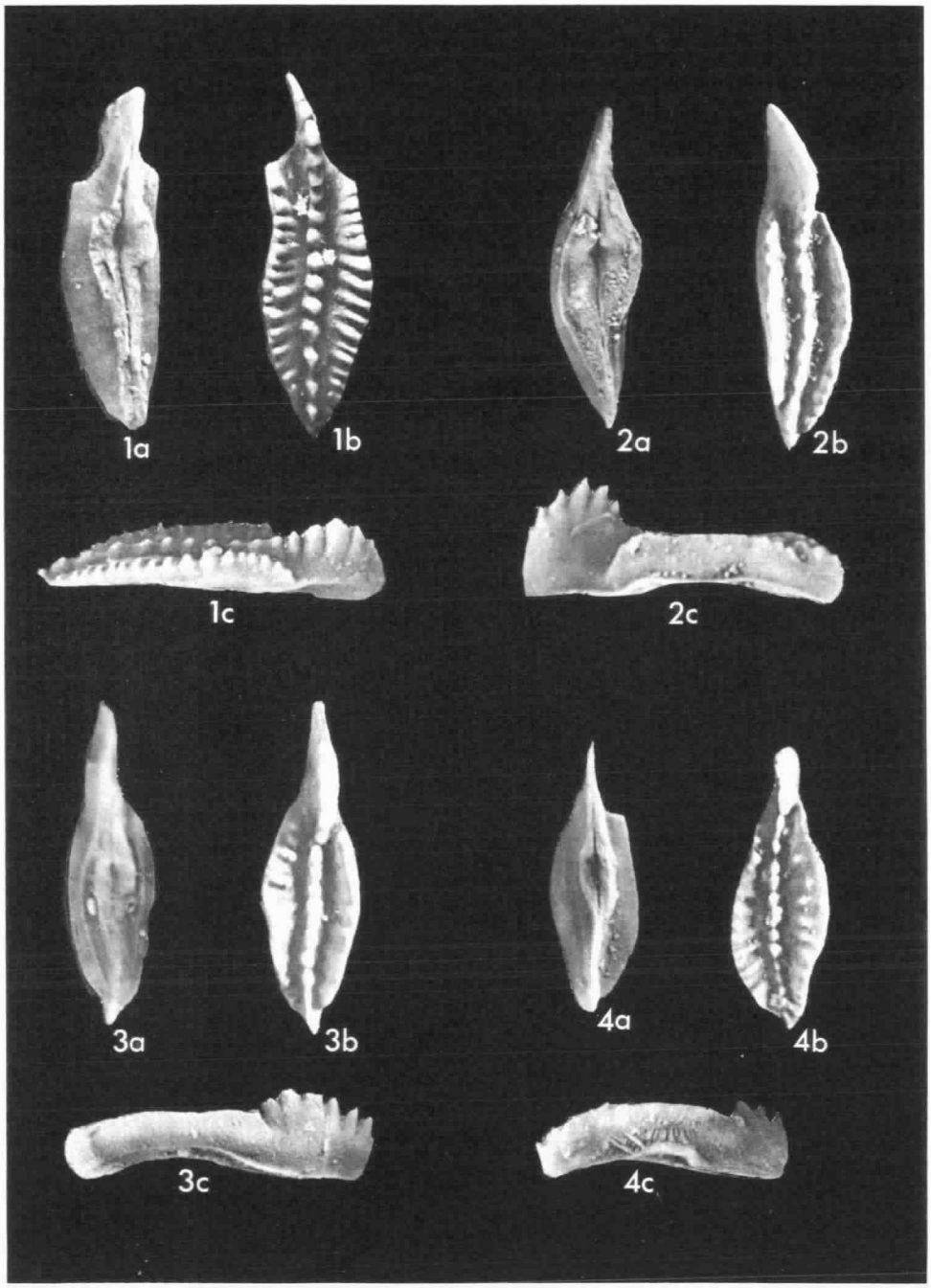
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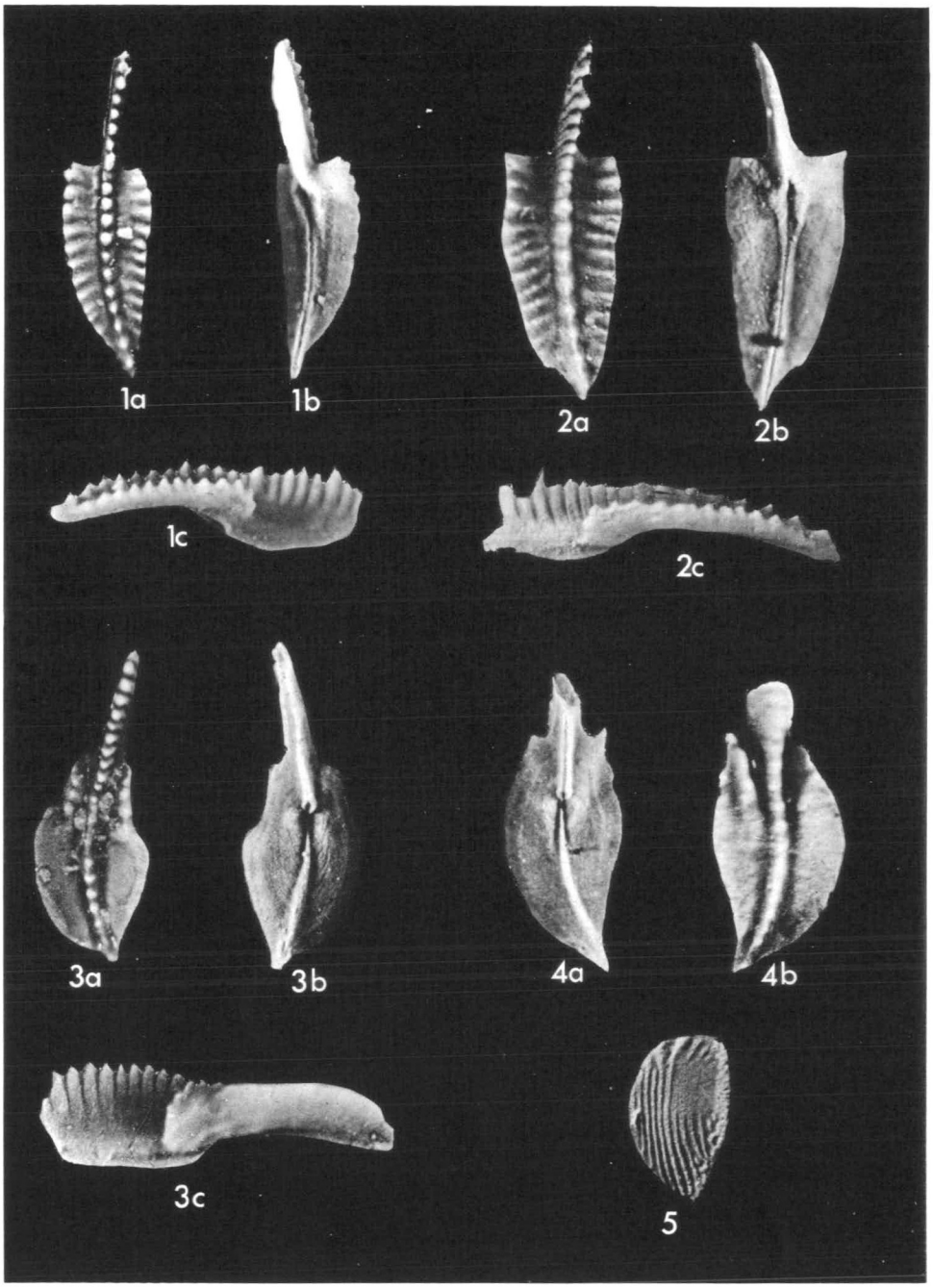
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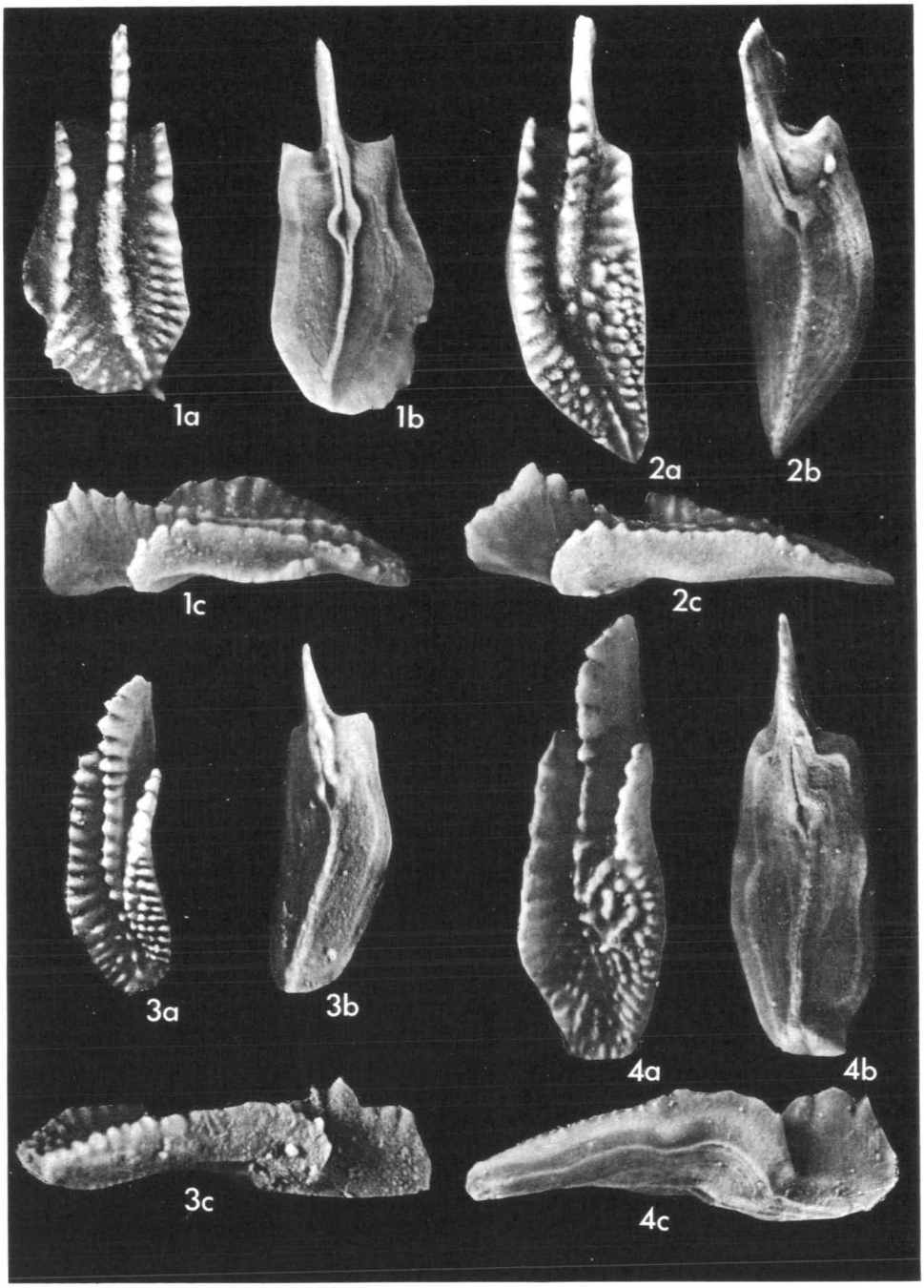
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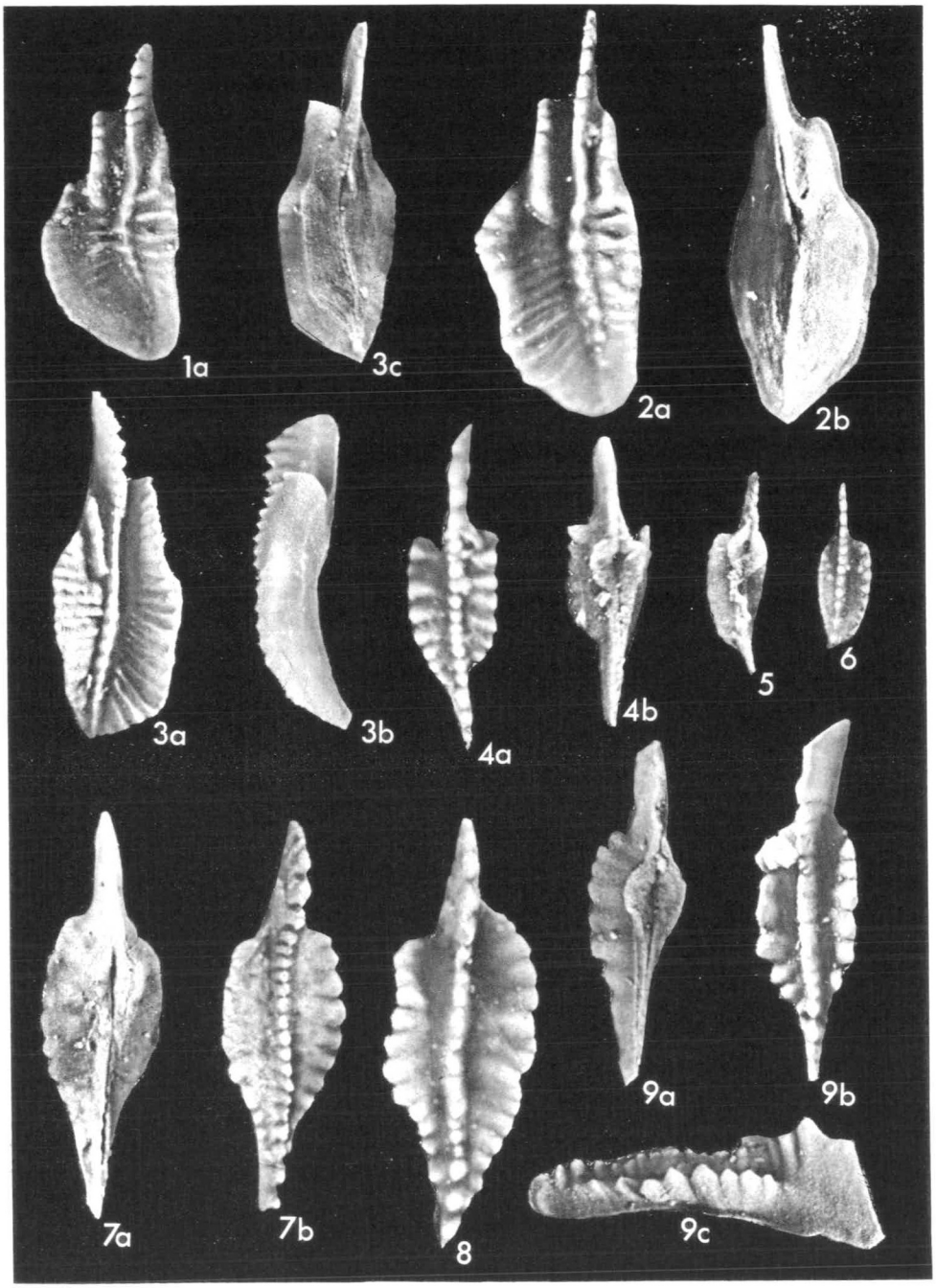
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PLATE 26

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b	Aboral view of specimen CPC 7978	
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b	Lateral view of specimen CPC 7995	
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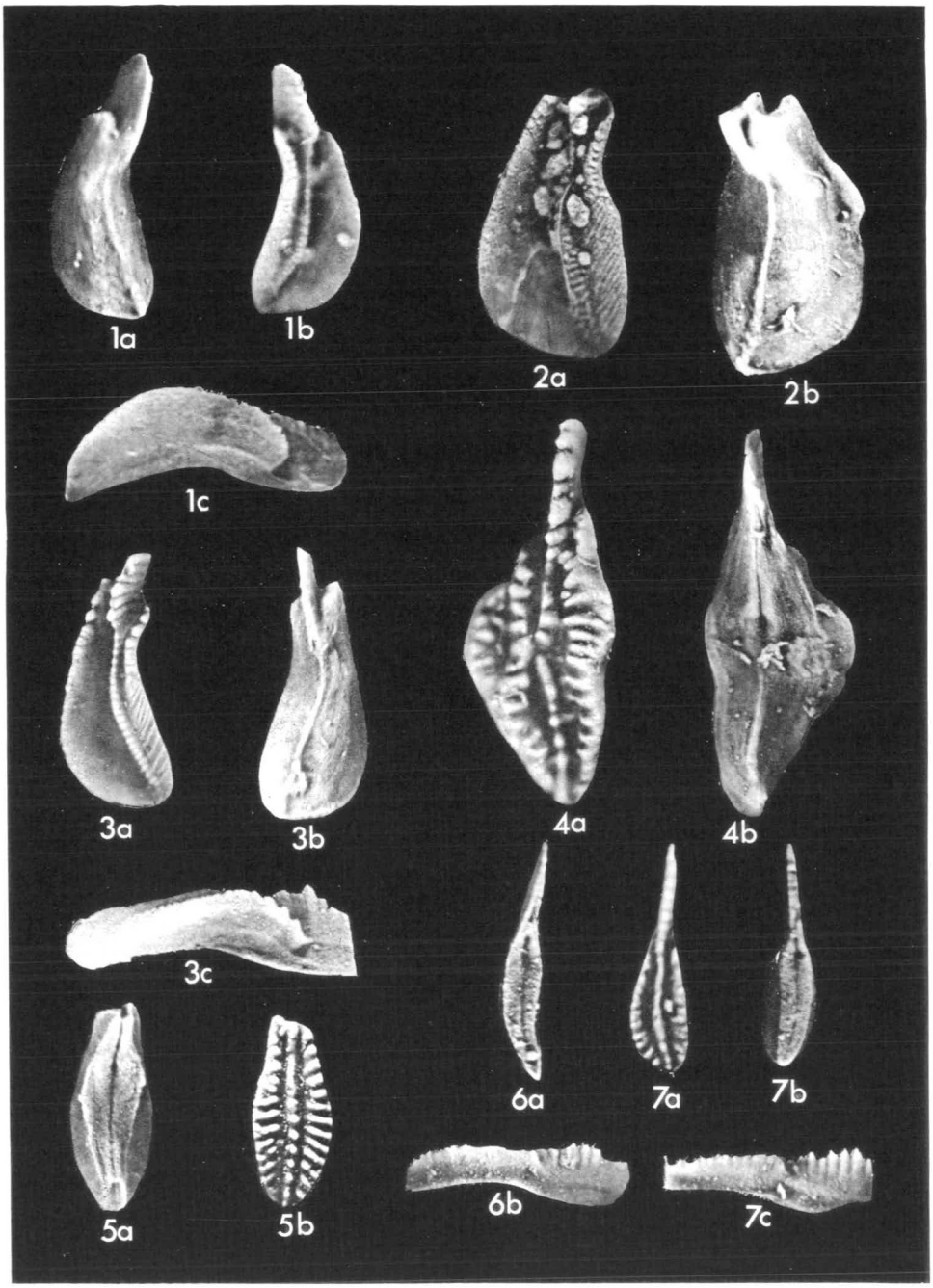
b	Aboral view of specimen CPC 7996	
c	Lateral view of specimen CPC 7996	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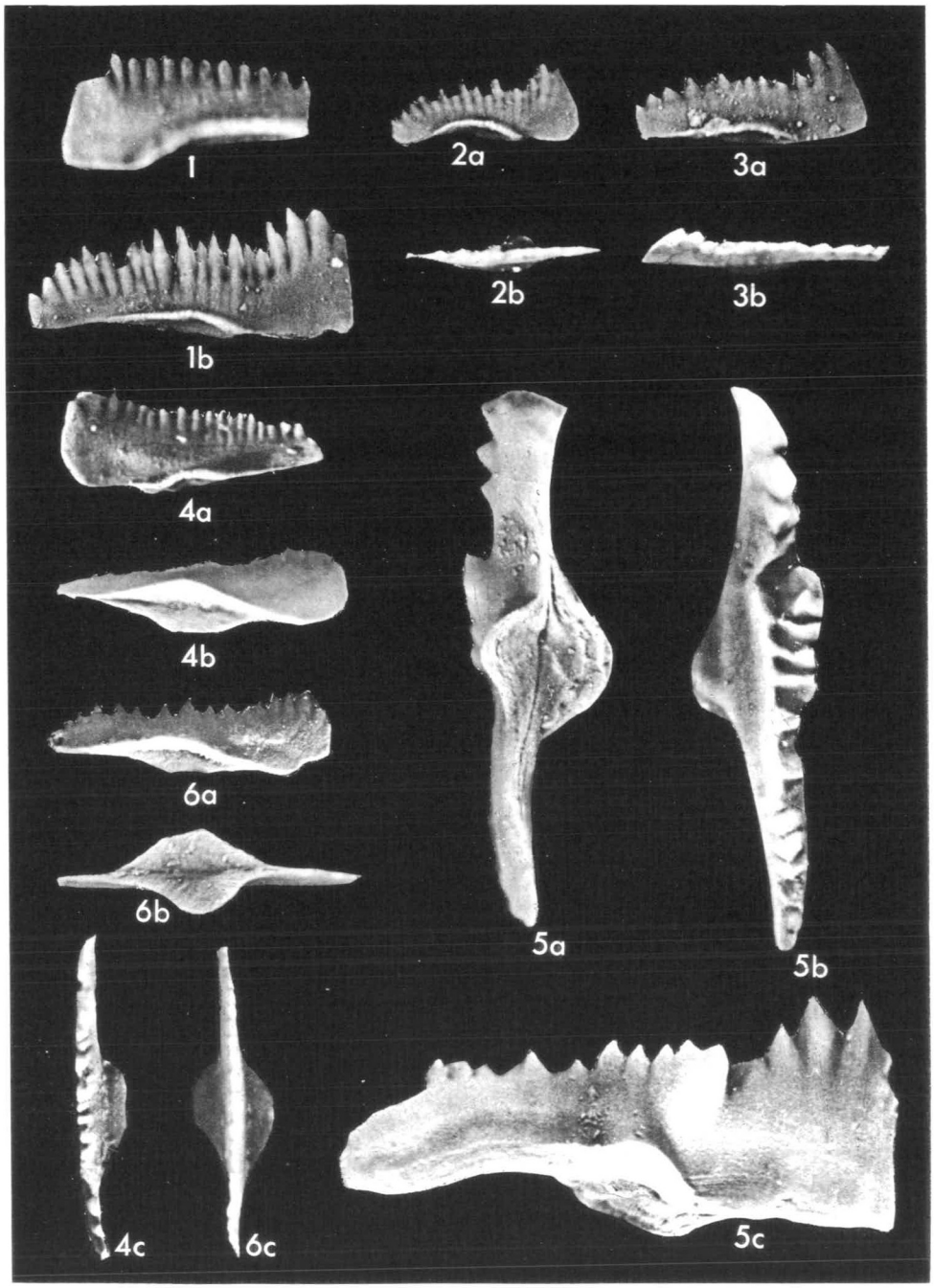
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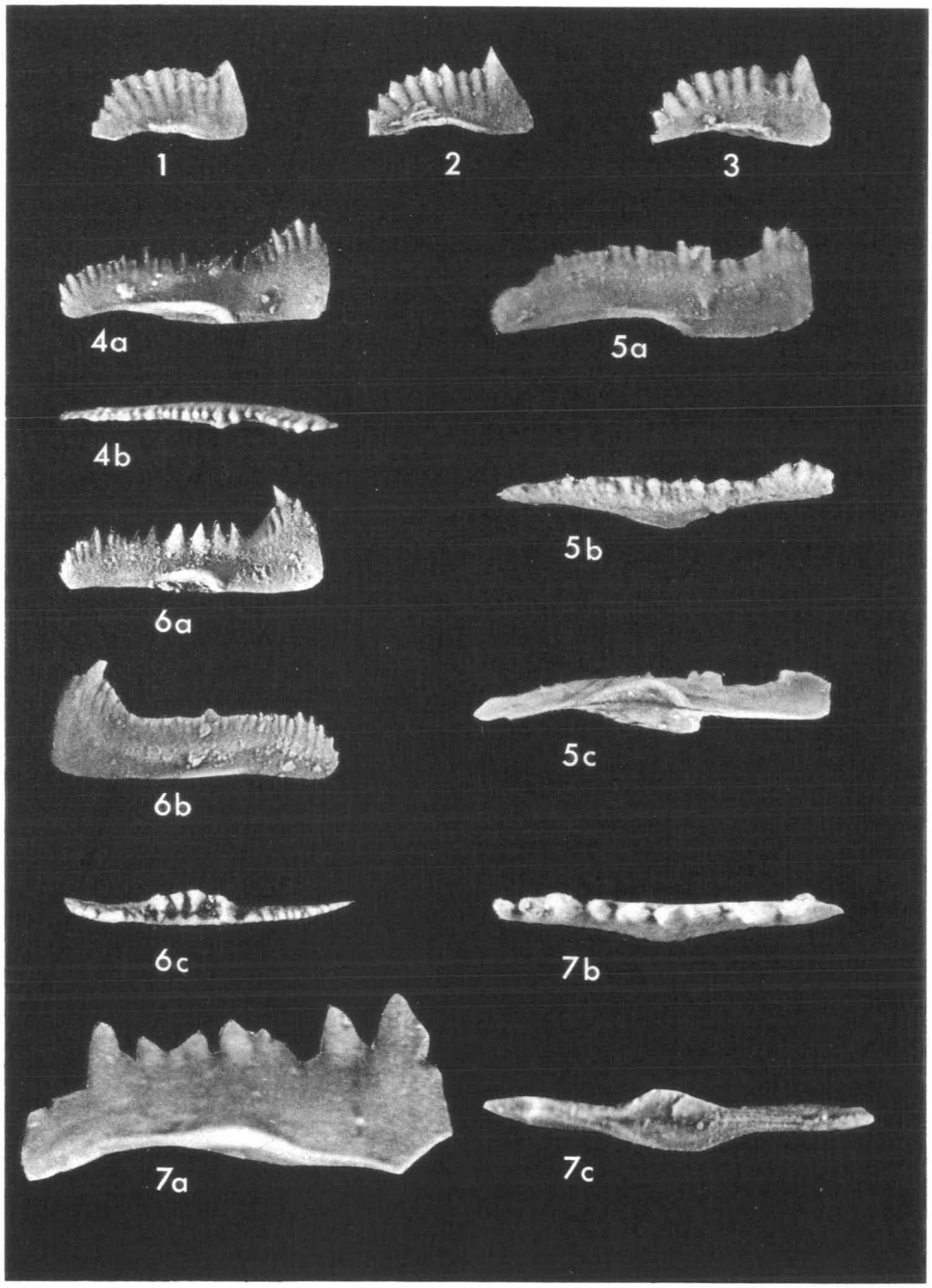
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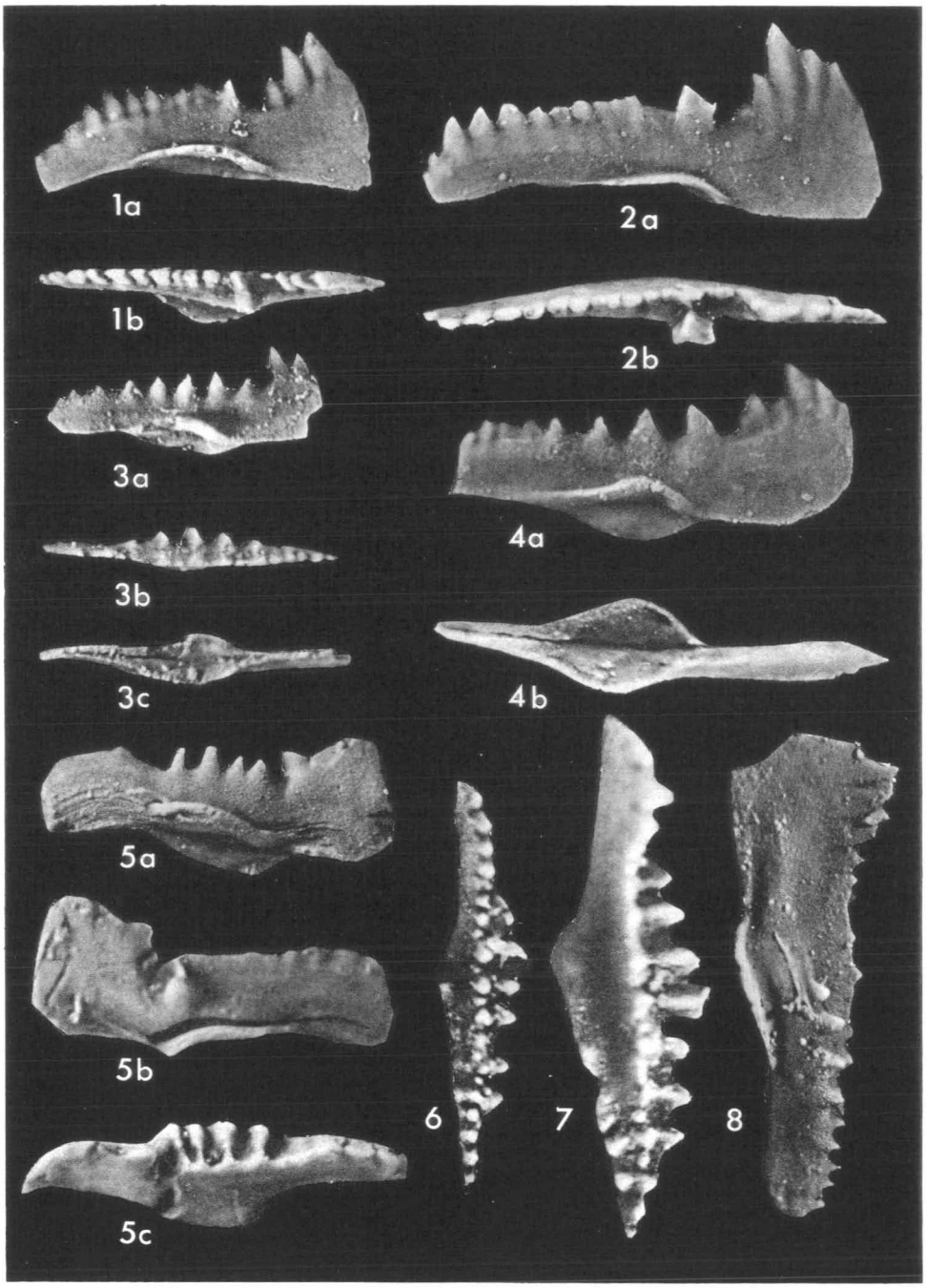
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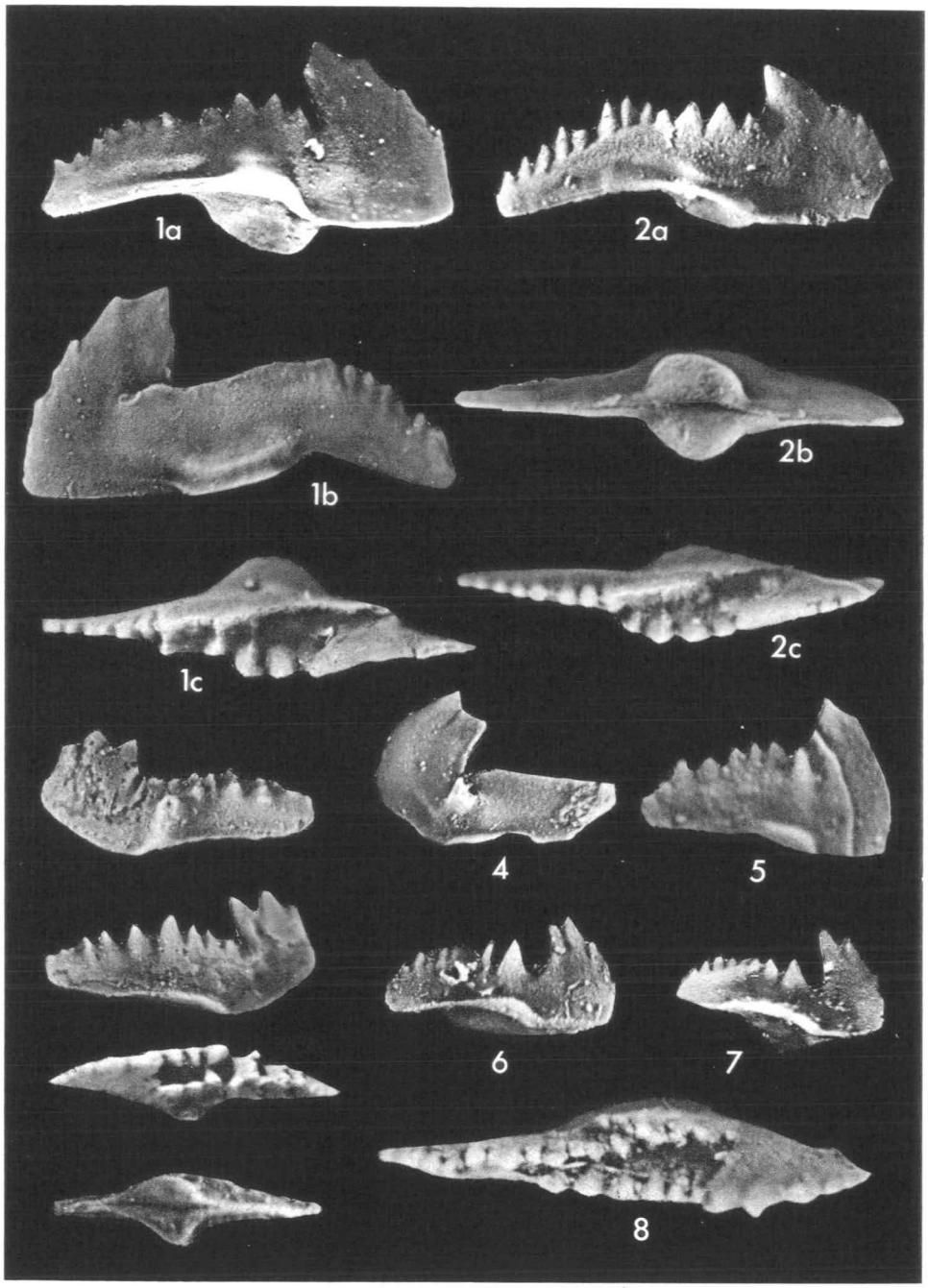
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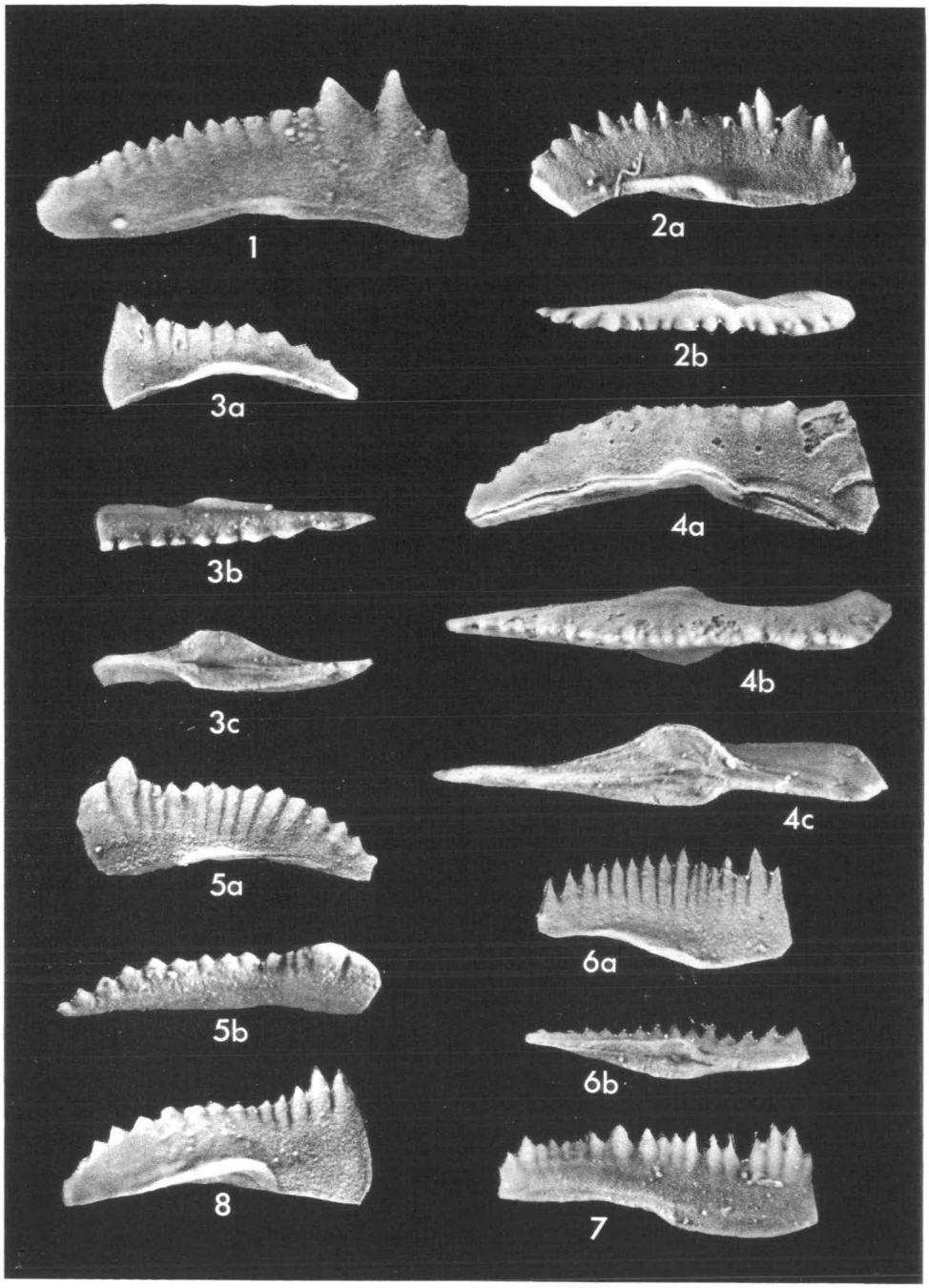
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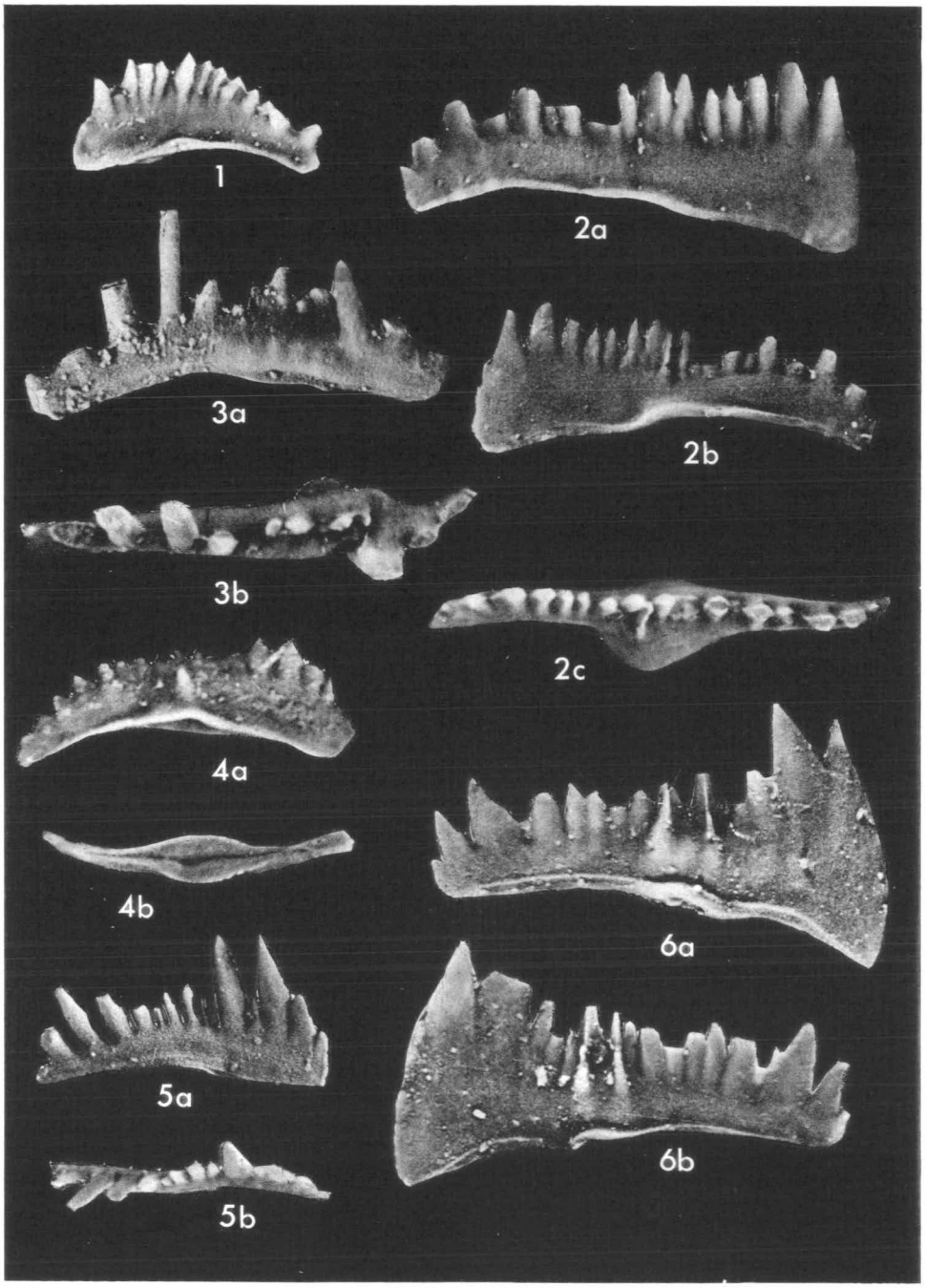
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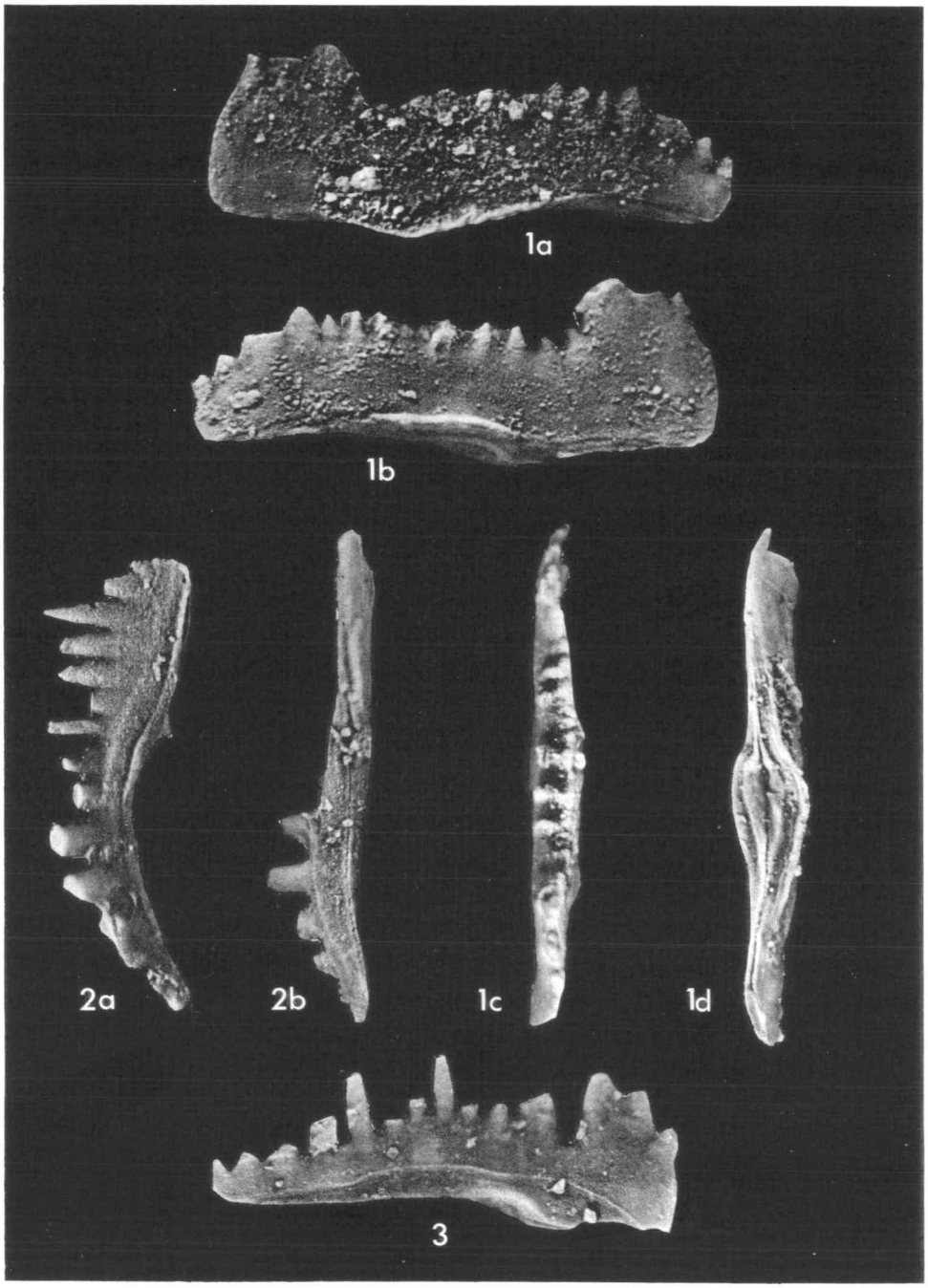
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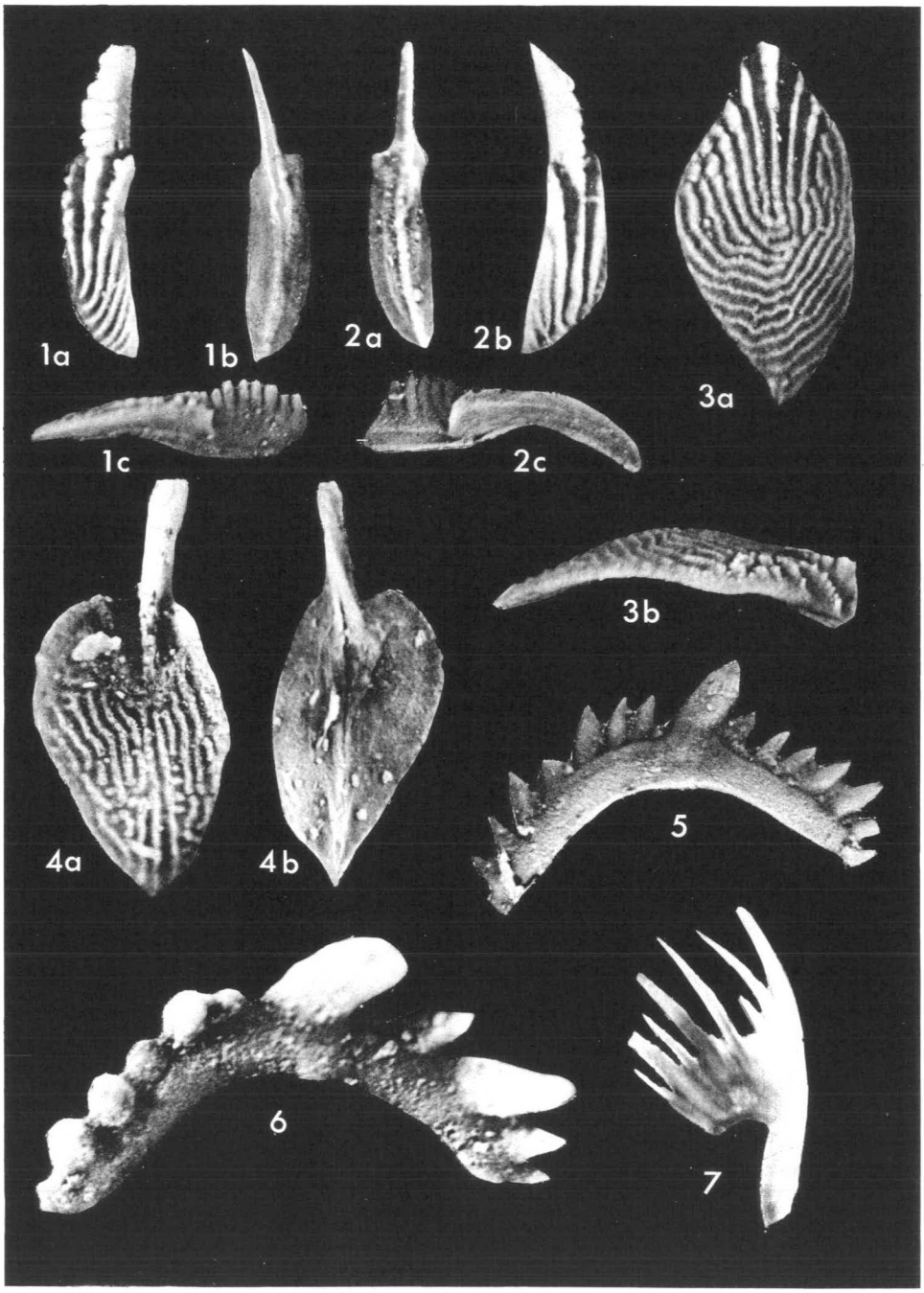
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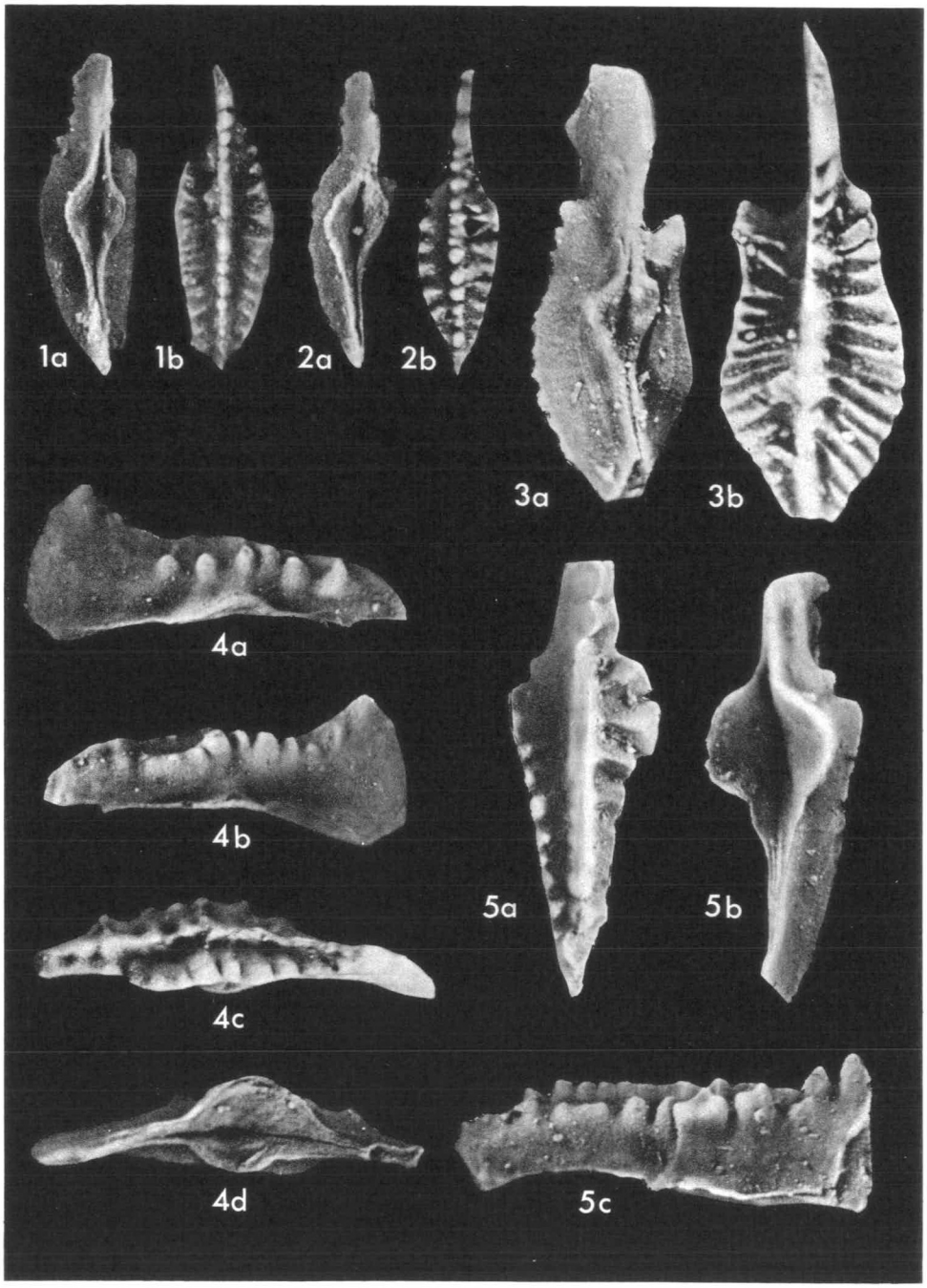
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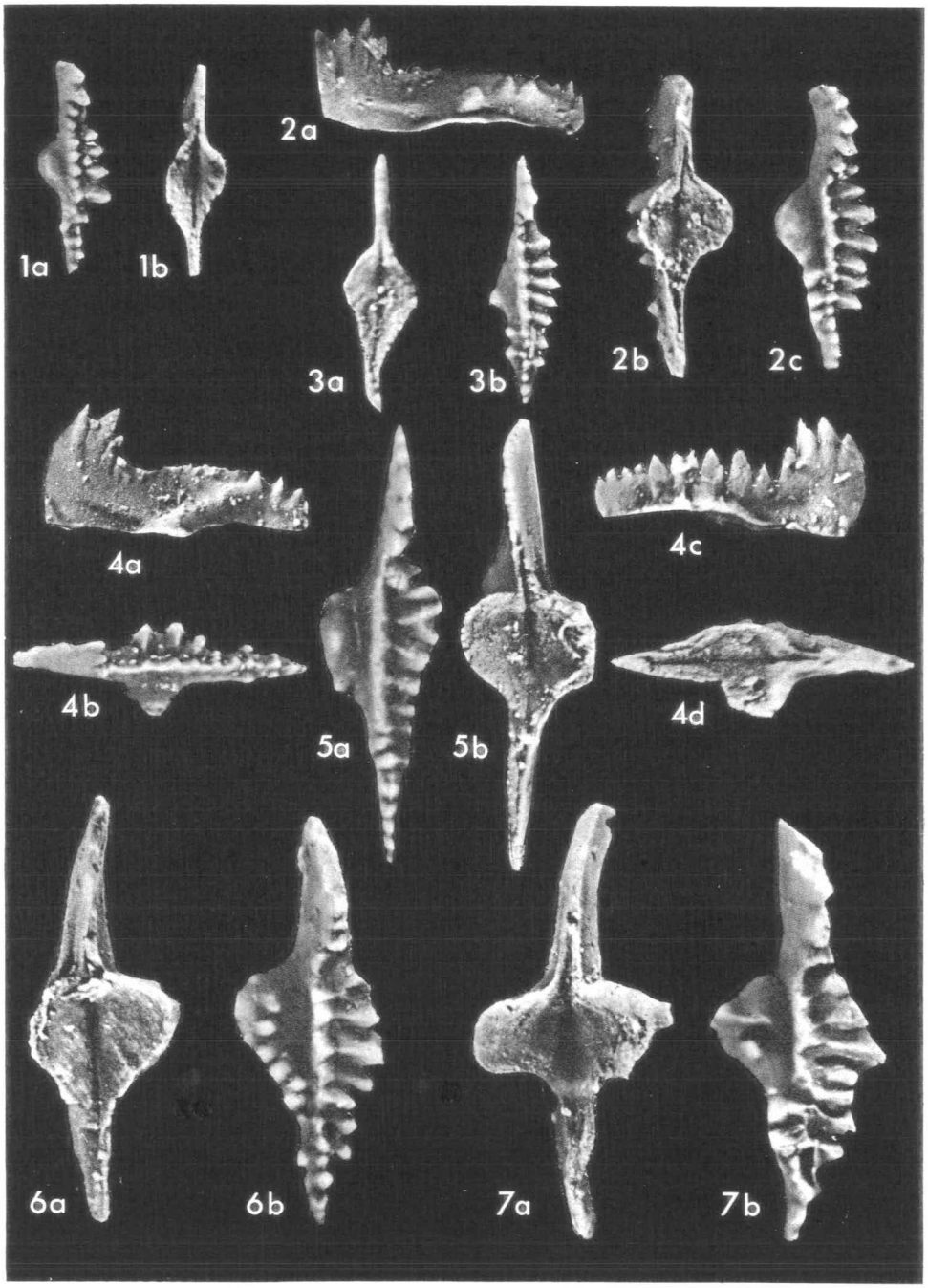
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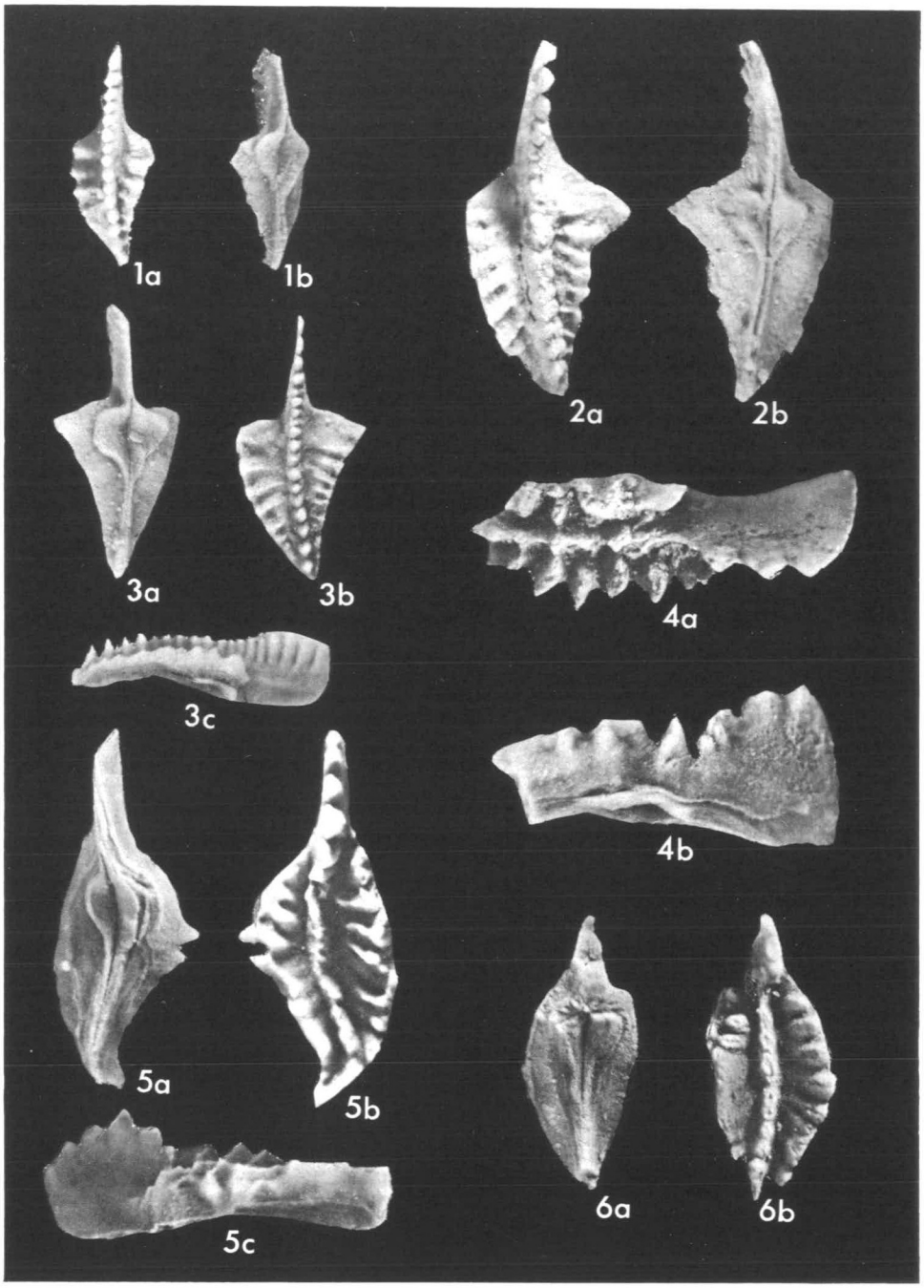
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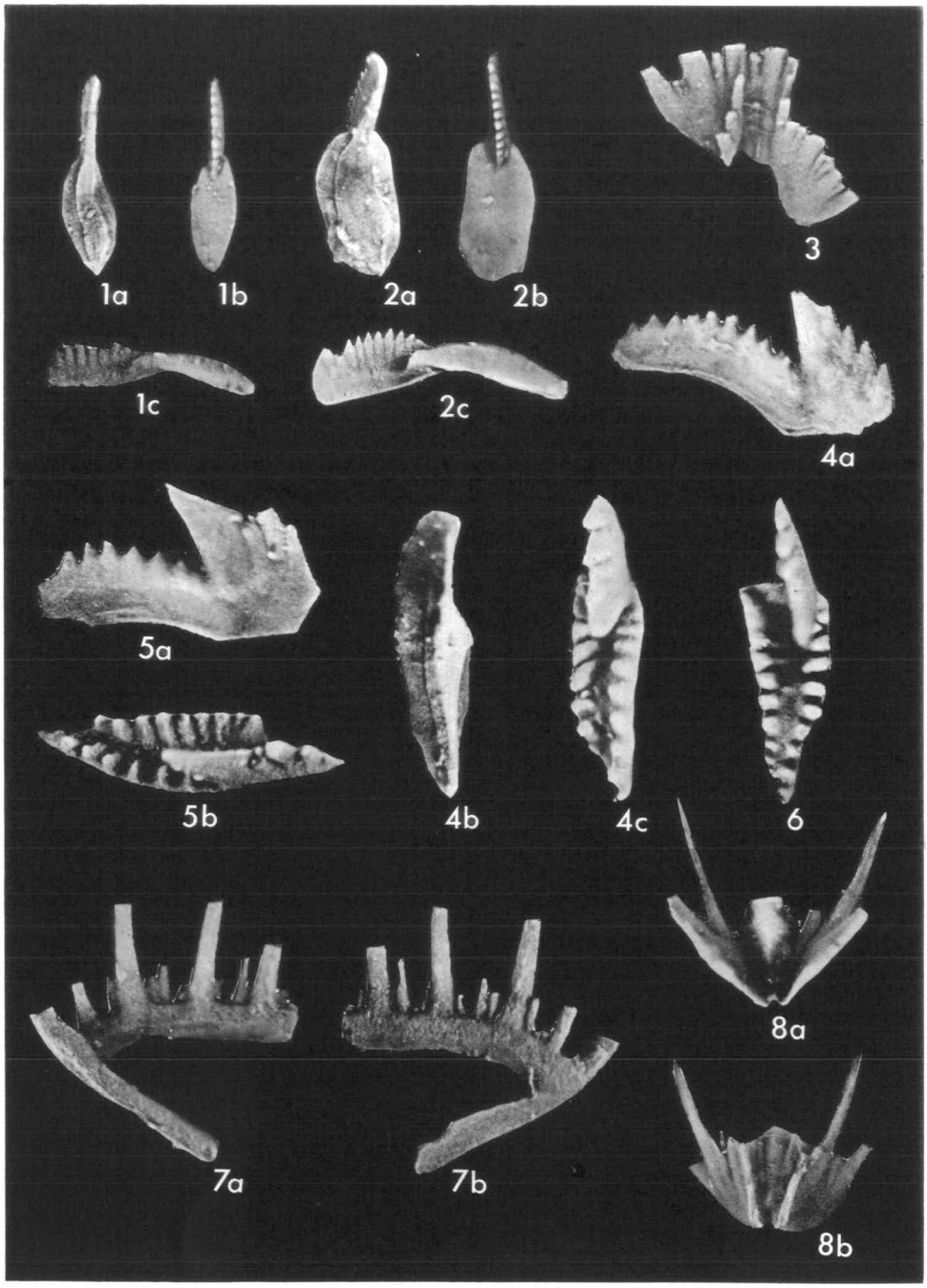
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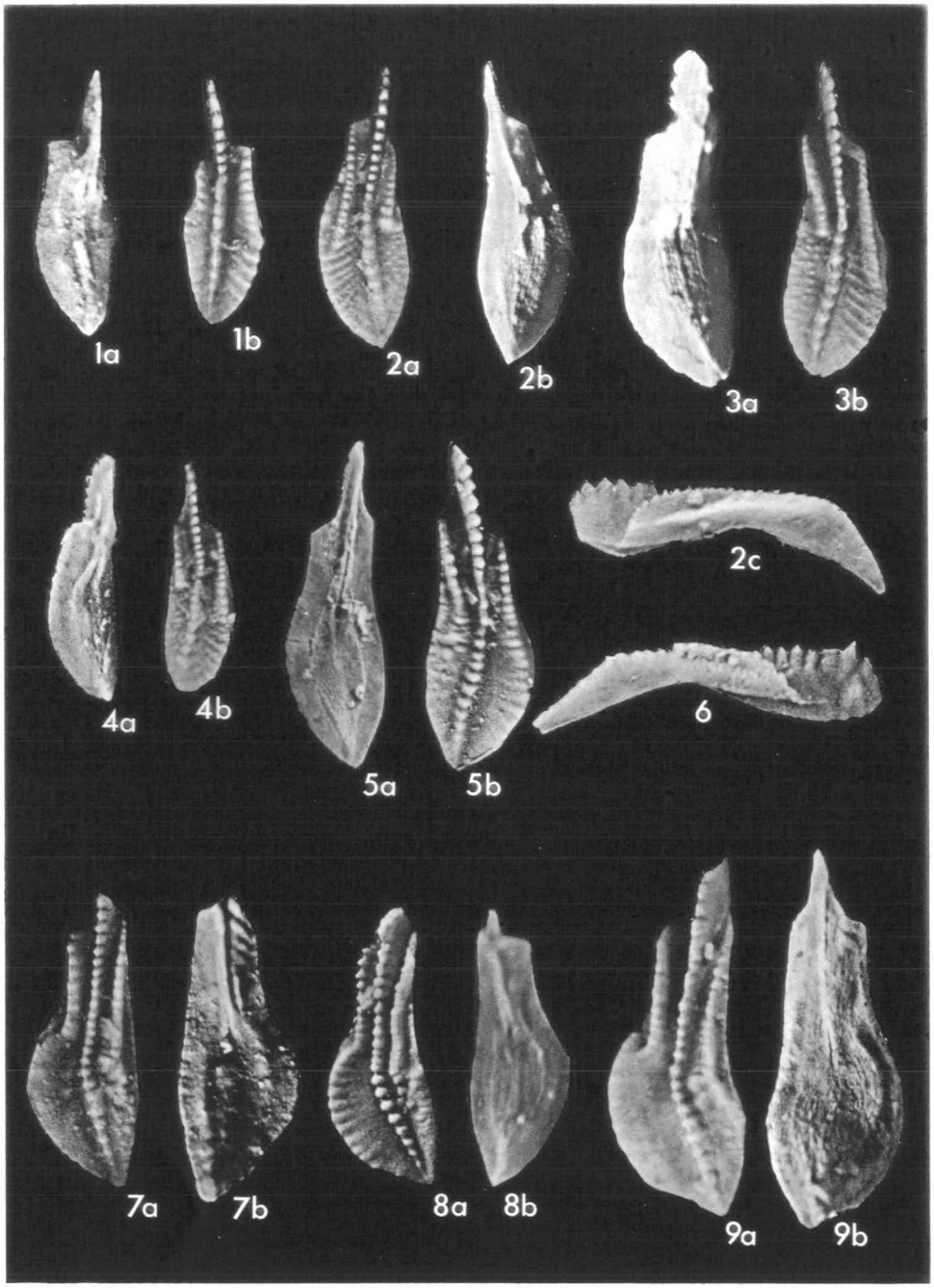
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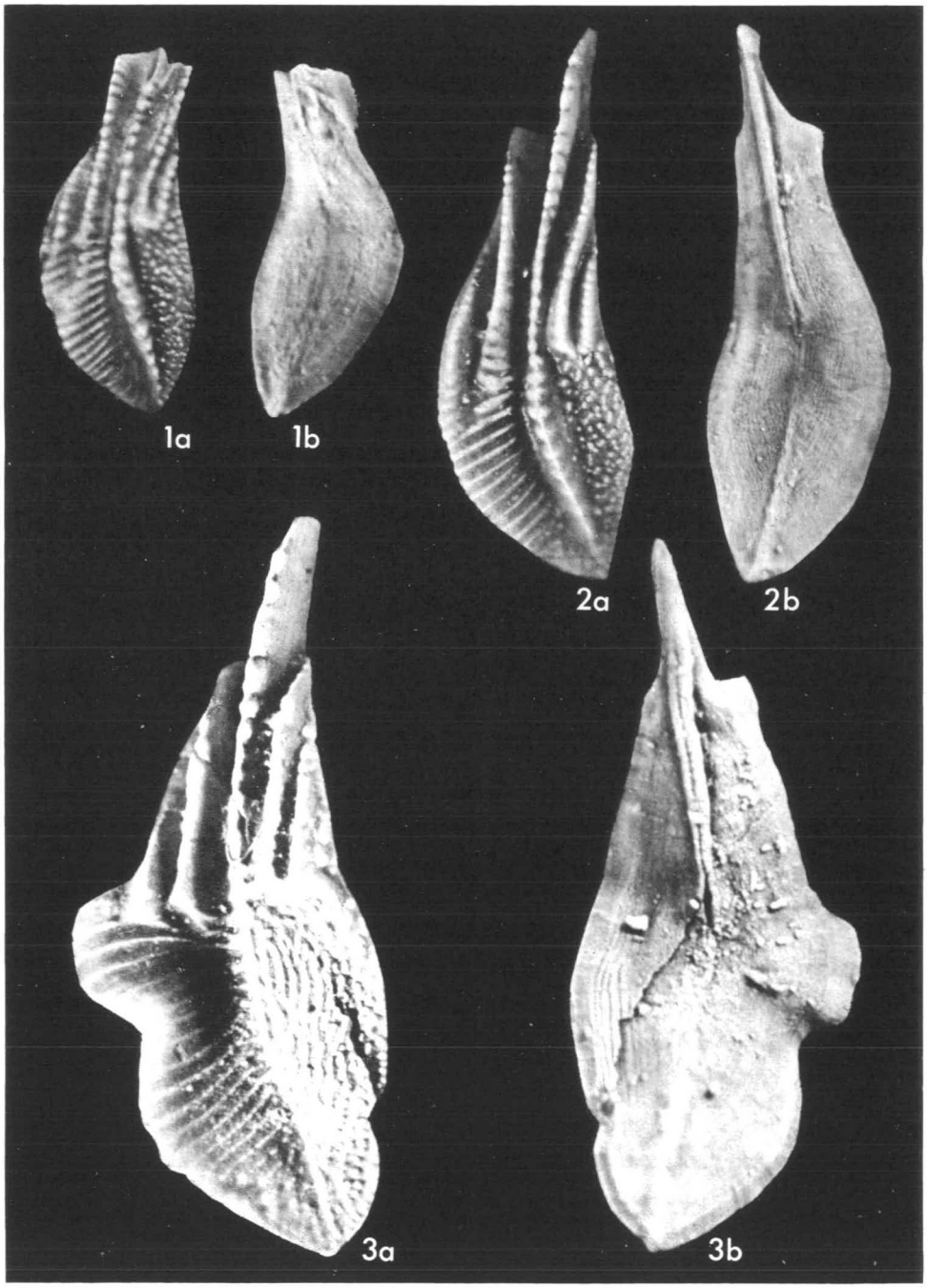
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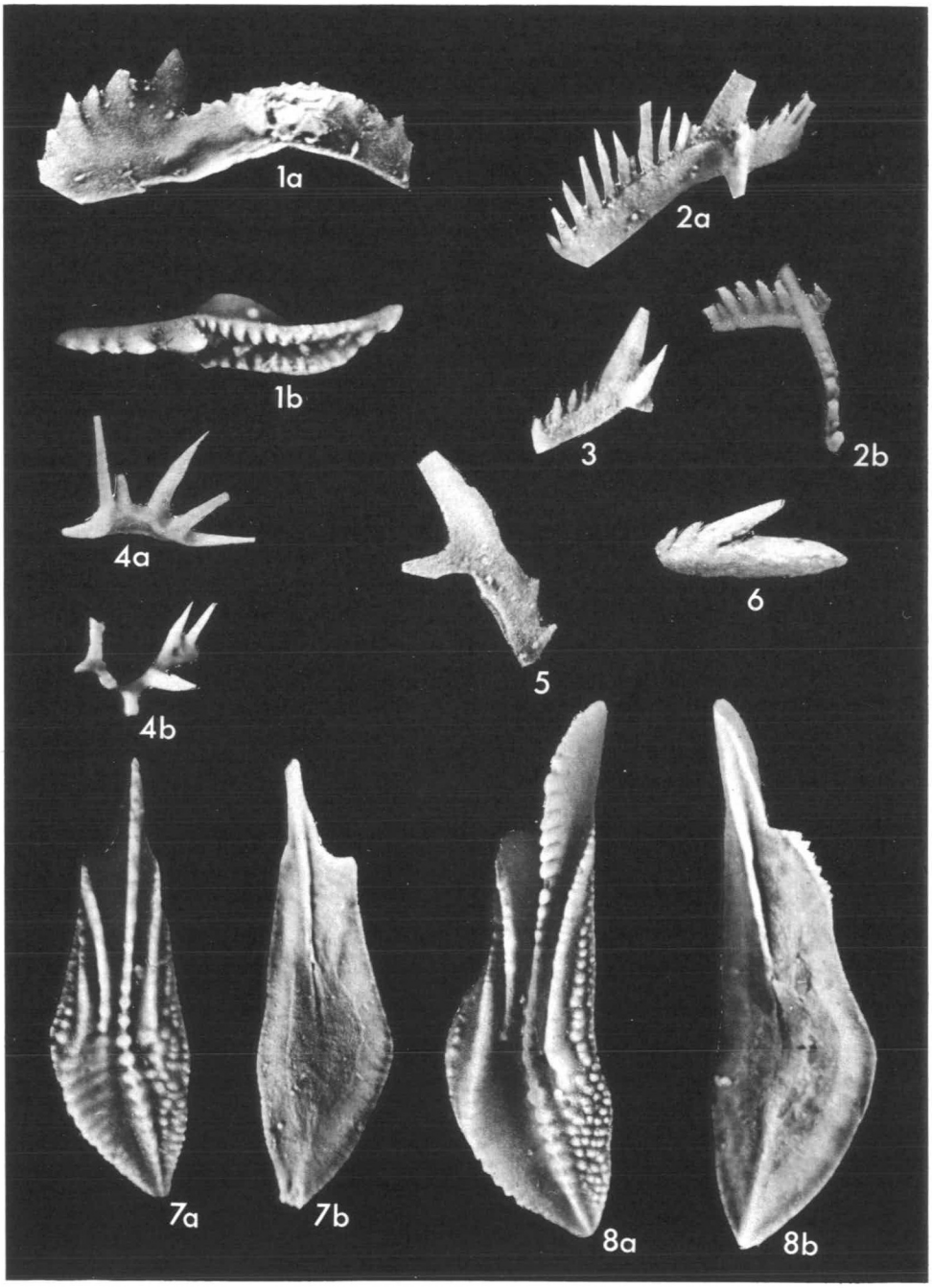
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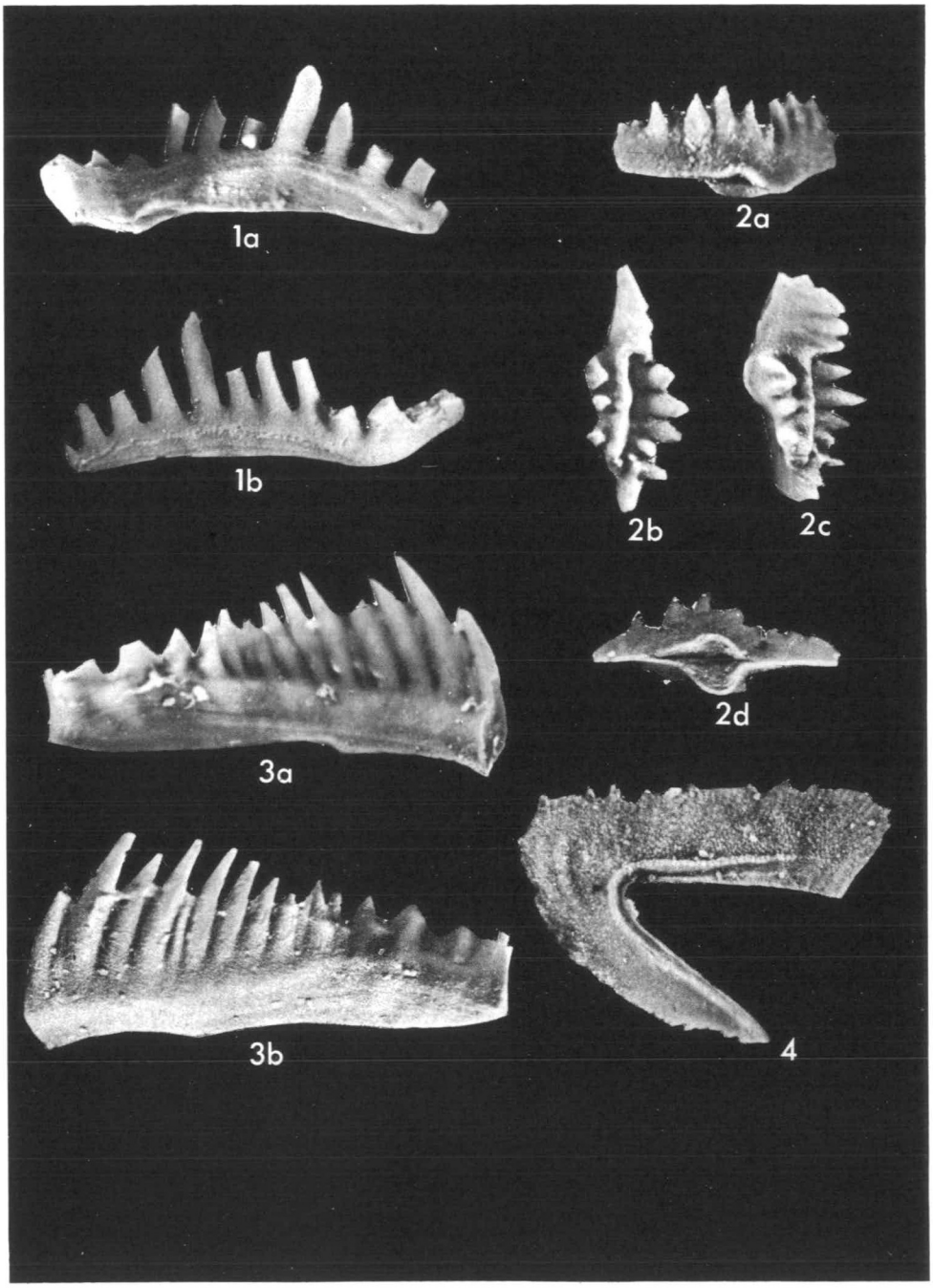
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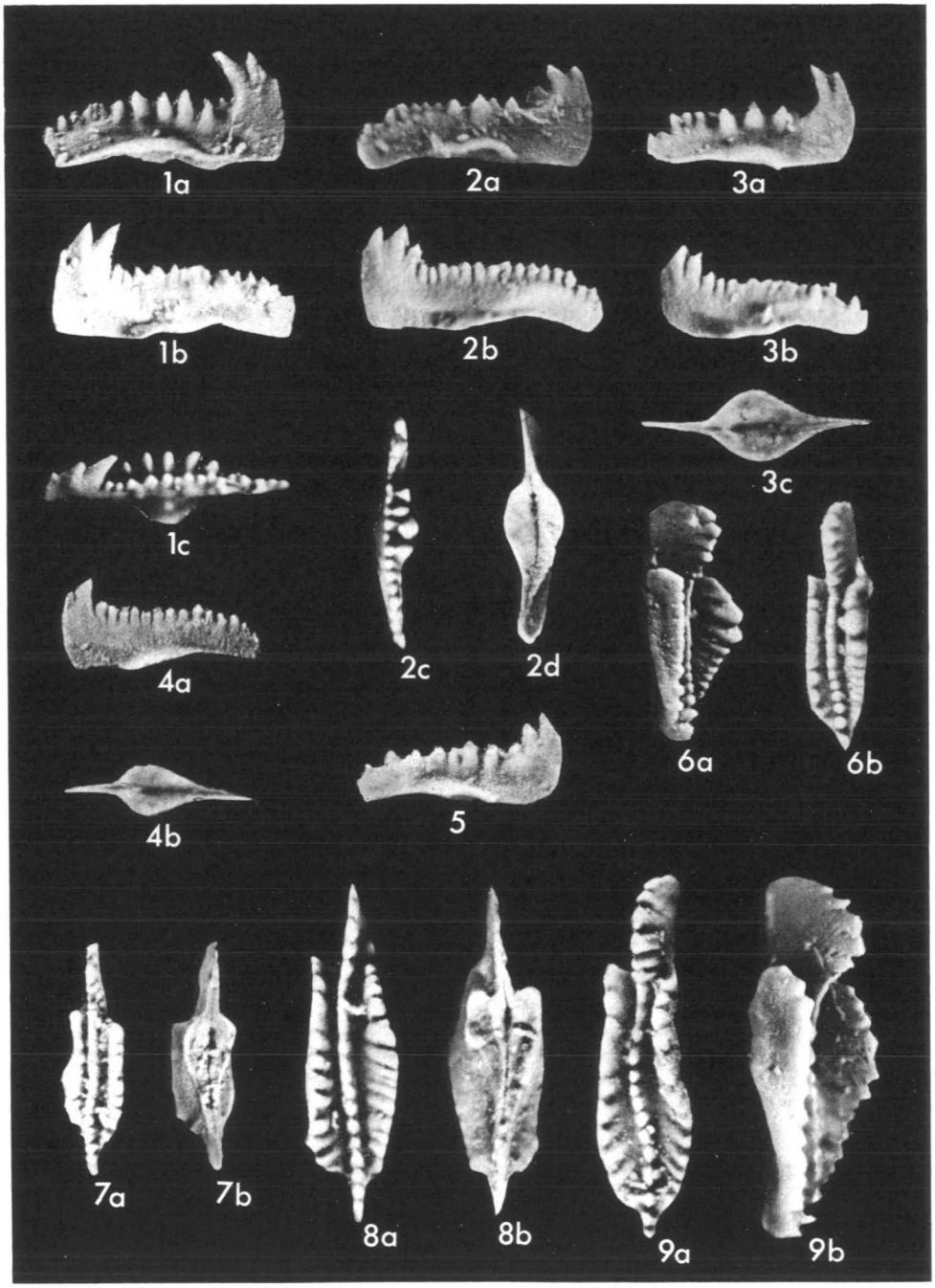
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