

LOWER DEVONIAN CONODONTS FROM NEW SOUTH WALES

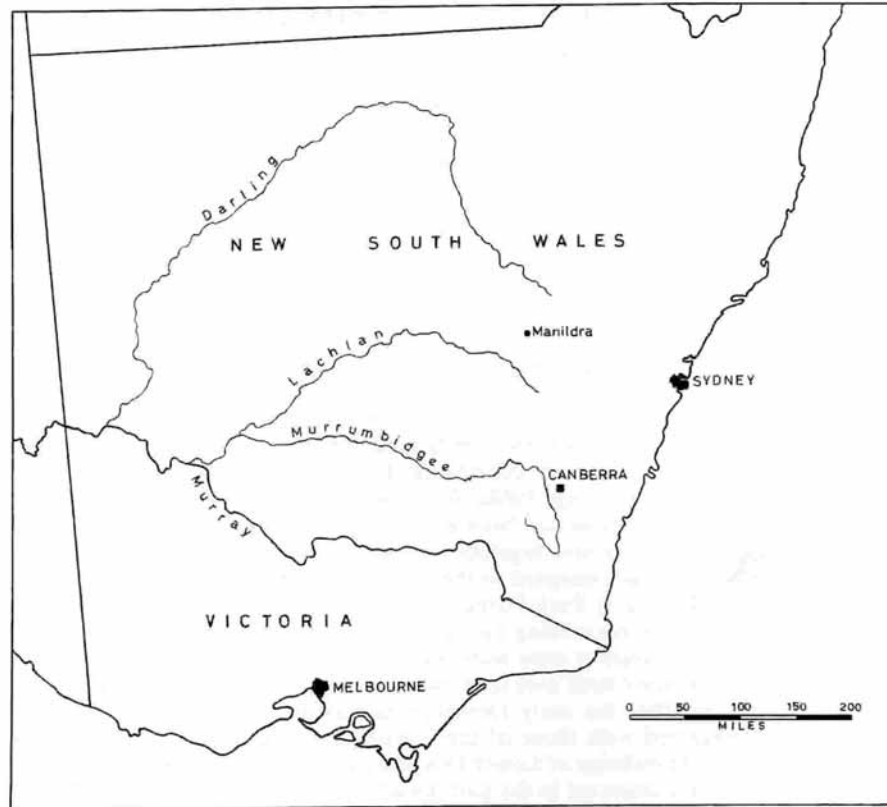
by NORMAN M. SAVAGE

ABSTRACT. Recent examination of the conodonts from the basal limestone of the Mandagery Park Formation suggests a middle to late Lochkovian (late Lower Gedinnian) age for this richly fossiliferous horizon. The fauna includes numerous early Lower Devonian conodonts but the characteristic early to late Praguian species *Spathognathodus sulcatus* and *S. optimus* are absent and this is significant in indicating a pre-Praguian upper age limit. A post-middle Lochkovian lower age limit is suggested by the presence of the conodonts *Belodella devonica*, *B. triangularis*, *S. inclinatus wurmi*, and *S. remscheidensis* in association with a brachiopod fauna which includes the genus *Quadrithyrus* and several other *Quadrithyrus* Zone brachiopods. Further, indirect, evidence of a late Lochkovian age is the association of *Quadrithyrus* Zone brachiopods with *Monograptus hercynicus* in western North America. A table of correlation is given for some important Lower Devonian sequences in eastern Australia and western North America.

THE Mandagery Park Formation, exposed in the vicinity of Manildra, New South Wales (text-fig. 1), consists largely of interbedded limestone and tuffaceous sandstone. Most of the formation is unfossiliferous but the basal limestone at Locality 1 of Savage (1968a, fig. 1) has yielded a rich fauna of brachiopods and corals with some gastropods, bryozoans, and conodonts. The brachiopod fauna has been described in several papers (Savage 1968a, b, c, 1969, 1970, 1971) in which the age of the fossiliferous basal horizon has been given as early Siegenian. The evidence of the conodonts described herein, together with new information relating to the age of brachiopod assemblages assigned to the *Quadrithyrus* Zone in northern Canada, suggests that the Mandagery Park Formation is older than Siegenian.

One of the difficulties in assessing the age of the eastern Australian deposits relative to the western European type sections is the facies difference. Traditionally, Rhenish stage names have been used for Lower Devonian deposits but it is becoming increasingly evident that the early Devonian faunas of eastern Australia can be more readily compared with those of the Bohemian facies of central and eastern Europe. The better knowledge of Lower Devonian graptolites in central and eastern Europe which has accumulated in the past decade and the growing record of Lower Devonian graptolites in eastern Australia are further factors making the Bohemian stage names more convenient. Correlation with the Rhenish stages is increasingly secondary via correlation with the Bohemian stages. Whether the base of the Mandagery Park Formation is considered to be of Gedinnian or Siegenian age will depend on where the Gedinnian-Siegenian boundary is drawn relative to the Bohemian stages. This vital correlation is still variously interpreted (Churkin and Brabb 1967; Carls 1969; Jaeger 1970; Fåhraeus 1971; Koreň 1971). In the absence of graptolites from the Rhenish area, conodont information from both the Siegenian type section and the Praguian sections would greatly aid correlation. Unfortunately conodonts are apparently absent from the Siegenian section and represented by only restricted faunas in the Praguian sections. Recent evidence from northern Canada discussed below suggests that this area might provide important mixtures of facies elements permitting more precise correlation of the Rhenish and Bohemian

stages. What is known to date indicates that the correlation of Carls (1969) was probably more accurate than most Rhenish-Bohemian correlations.



TEXT-FIG. 1. Locality map for Manildra.

Several of the species occurring in the Manildra fauna are long-ranging forms which do not at present appear to have precise stratigraphic value apart from indicating a general late Silurian or early Devonian age. Others are much more useful as age indicators and the presence of the forms *Belodella devonica*, *B. triangularis*, *Spathognathodus inclinatus wurmi*, and *S. remscheidensis* suggests a post-Pridolian age. The characteristic early to late Praguian form *S. sulcatus* and late Lochkovian to early Zlichovian form *S. optimus* are absent and this is significant in indicating a pre-Praguian age. These two species are known from several localities in eastern Australia (Philip 1965, 1966; Philip and Pedder 1967; Philip and Jackson 1970) and from Praguian age sediments in the Royal Creek and Solo Creek sections, Yukon Territory (Klapper 1969; Fåhraeus 1971). Their absence from the Manildra fauna

suggests that the base of the Mandagery Park Formation is older than the Coopers Creek Formation in Victoria and the upper part of the *Spirigerina* Unit at Royal Creek where both species occur (Philip 1965; Klapper 1969). The Mandagery Park Formation brachiopod-conodont fauna is therefore most likely of middle to late Lochkovian age, being young enough to include the four post-Pridolian conodonts mentioned above together with the brachiopod *Quadrithyrus* and other *Quadrithyrus* Zone brachiopods such as are associated with *Monograptus hercynicus* in Nevada and Yukon Territory, and old enough to pre-date the appearance of the Praguian conodonts *S. sulcatus* and *S. optimus*.

The conodont faunas of the Tyers and Buchan areas, Victoria (Philip 1965, 1966) were among the first eastern Australian conodont faunas described and these have subsequently become important reference horizons within the Lower Devonian sequences of southeast Australia. The Coopers Creek Formation at Tyers contains *S. sulcatus* and *Icriodus bilatericrescens* which indicates an age younger than the *Quadrithyrus* Zone assemblages in Nevada and Yukon Territory. Philip and Pedder (1967) consider this fauna to be of early Siegenian age and this correlation is accepted herein (text-fig. 2). The underlying Boola Beds contain a brachiopod fauna very

STAGES		GRAPTOLITE ZONES	CONODONT RANGES	MANILDRA N.S.W. AUSTRALIA	TYERS VICTORIA AUSTRALIA	BUCHAN VICTORIA AUSTRALIA	CENTRAL NEVADA U.S.A.	ROYAL CREEK YUKON CANADA
BOHEMIAN	RHENISH							
EIFELIAN								
ZLICHOVIAN	EMSIAN	M. pacificus	<i>S. exiguus</i> <i>P. loveolatus</i>			MURRINDAL LIMESTONE		
							BUCHAN CAVES LST	
PRAGUIAN	SIEGENIAN	M. yukonensis	<i>S. debilis</i> <i>S. optimus</i>				TREMATOSPIRA ZONE	GYPIDULA SRI - BICONOSTROPHIA UNIT
		M. thomasi			COOPERS CREEK FORMATION		SPINOPLASIA ZONE	
LOCHKOVIAN	GEDINNIAN	M. hercynicus	<i>I. pesavis</i> <i>I. woschmidti</i> <i>S. remscheidensis</i>	MANDAGERY PARK FORMATION			QUADRITHYRIS ZONE	SPIRIGERINA UNIT
		M. praehercynicus		MARADANA SHALE	BODLA BEDS			
PRIDOLIAN		M. uniformis					GYPIDULA PELAGICA ZONE	GYPIDULA PELAGICA UNIT
		M. transgrediens		FAIRHILL FORMATION				

TEXT-FIG. 2. Correlation chart for selected Lower Devonian sequences in south-east Australia and western North America.

close to that of the Maradana Shale at Manildra and both deposits are here assigned an early Lochkovian age. The Buchan Group limestones in Victoria are younger than the Coopers Creek Formation. The presence of *S. exiguus*, *Polygnathus foveolatus*, and *P. deshiscens* indicates a late Praguian to early Zlichovian (early to middle Emsian) age for these Buchan deposits.

Of considerable help in tying together the Bohemian and Rhenish stages is a recent discovery on Prince of Wales Island, northern Canada. R. Thorsteinsson has found a primitive pteraspid, very similar to *P. gosseleti*, associated with brachiopods which J. G. Johnson and A. J. Boucot have identified and assigned to the *Quadrithyrus* Zone (pers. comm., R. Thorsteinsson 1971). This association points to a late Lower Gedinnian ('middle' Gedinnian) age for the *Quadrithyrus* assemblage in that instance, assuming the 'Psammites de Lievin' of northern France are of late Lower Gedinnian age. As the *Quadrithyrus* assemblage has been found associated with *M. hercynicus* in Nevada and Yukon Territory, these recent developments suggest that the middle Lochkovian *M. hercynicus* Zone of the Bohemian facies may be equivalent to the early Dittonian (late Lower Gedinnian) *P. gosseleti* horizon of the Old Red Sandstone and Rhenish facies. In terms of the Rhenish stages the *Quadrithyrus* Zone of Nevada and Yukon Territory thus seems to be older than hitherto shown. The overlying *Spinoplasia* Zone is also affected by this correlation readjustment and is probably no younger than Upper Gedinnian in age. Similarly the *Gypidula pelagica* fauna in Nevada and Yukon Territory is probably of early Lower Gedinnian age rather than of late Lower Gedinnian age as commonly suggested in recent years (see Klapper 1969; Johnson 1970; Klapper *et al.* 1971).

TAXONOMIC PROCEDURES

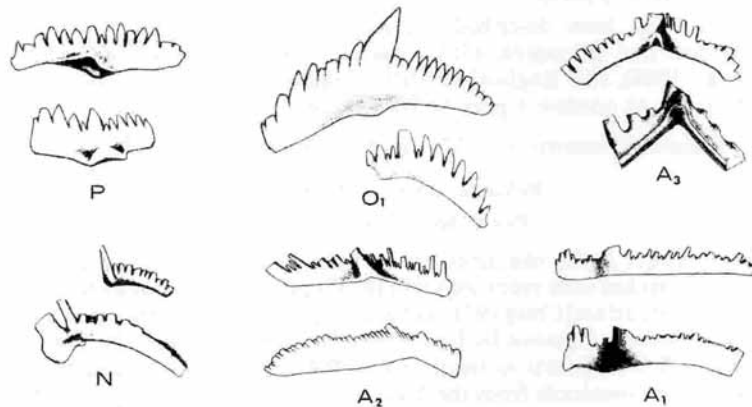
For a number of years attempts have been made to construct a biological conodont taxonomy based on actual clusters of elements (Scott 1934; Rhodes 1962) or based on logical and numerical analysis of large collections of conodont elements occurring at certain horizons (Walliser 1964; Bergström and Sweet 1966; Kohut 1969; Jeppsson 1969, 1971; Klapper and Philip 1971). From a biological point of view a multi-element classification is manifestly more satisfactory than a taxonomy based on form species, and recent progress in defining multi-element species suggests that this type of conodont taxonomy will progressively replace the single-element taxonomy during the next few years.

The conodonts recovered from the Mandagery Park Formation are few in numbers and do not lend themselves to statistical analysis nor to logical analysis at a time when very few reference multi-element species from Lower Devonian horizons are on record for comparison. Even with such meagre faunas, one might expect to be able to recognize certain recurring associations indicative of multi-element species by comparing enough assemblages of isolated elements from different localities. However, such groupings do not fall into place as smoothly as one might hope and there is evidence that the same form species may occur in more than one multi-element species (Klapper and Philip 1971). That individual elements within any apparatus have evolved independently is indicated by the great variety of ranges known for conodont elements. Branson and Mehl (1936) used the evidence of these

range differences to argue that natural assemblages do not exist, but a more acceptable explanation is that individual elements within a multi-element organism have evolved at different speeds. Thus there are problems resulting from both differential evolution of elements in a single apparatus and parallel evolution of elements in distinct apparatuses.

Klapper and Philip (1971) have described a method of reconstruction of Devonian apparatuses in which a system of symbols is used for the individual elements. Their concept of what might comprise a natural assemblage is founded on known clusters of elements. Recognition of assemblage species with elements different from those in known clusters depends on logical deduction from recurring sets of elements and numerical analysis.

The Manildra material appears to include evidence of two multi-element species of a group classified as Type 1 by Klapper and Philip (1971, pp. 431-432). Their Type 1 apparatuses comprise a platform element (P) such as *Spathognathodus* or *Polygnathus*, an ozarkodinian element (O₁) such as *Ozarkodina*, a neoprioniodontan element (N) such as *Neoprioniodus*, a hindeodellan element (A₁) such as *Hindeodella*, a plectospathodontan element (A₂) such as *Plectospathodus*, and a symmetrical element (A₃) such as *Trichonodella*; the last three elements forming a symmetry transition series. Although there are apparently two Type 1 species present in the Manildra material it is not possible at present to determine how these elements are combined. Several associations of the elements are possible to result in two apparatuses with the Type 1 diagnosis P, O₁, N, A₁, A₂, A₃ (text-fig. 3). Other elements in the Manildra material are suggestive of the Type 3 apparatus *Delotaxis* Klapper and Philip. The form species *Lonchodina walliseri* is thought by Klapper and Philip to represent the O₂ element in their *Delotaxis* apparatus. Presumably the Manildra form species *Ligonodina* aff. *salopia* and *Ligonodina* sp. also belong in this apparatus. The abundant *Belodella* and *Panderodus* elements in the Manildra fauna may be



TEXT-FIG. 3. Elements of two apparatuses of a group classified as Type 1 by Klapper and Philip (1971) with the diagnosis P, O₁, N, A₁, A₂, A₃. It is not possible at present to determine how these elements are combined. Scale of elements $\times 40$.

tentatively included in the Group 1 apparatuses of Jeppsson (1971). The work of Lange (1968) on *Belodella* clusters indicates that the total apparatus probably comprised at least six pairs of these simple elements.

Apart from the general observations above, the systematic treatment in this paper is based on the older taxonomy of isolated elements. A number of elements are described which cannot at present be even tentatively referred to multi-element apparatuses but by describing such occurrences the evidence necessary to build a more complete multi-element taxonomy will eventually become available.

In the systematic descriptions below the specimen numbers are those of the Palaeontology Collection, Department of Geology and Geophysics, University of Sydney.

SYSTEMATIC DESCRIPTIONS

Genus *BELODELLA* Ethington 1959

Type species. Belodus devonicus Stauffer 1940, by original designation of Ethington 1959, p. 272.

Belodella devonica (Stauffer 1940)

Plate 32, figs. 19, 20, 25, 26; text-fig. 4A, B, C

Differences in the cross-section of the base have been used by several workers in diagnosing various forms of *Belodella*. However, Serpagli (1967) has suggested that there is a continuous gradation between forms with a symmetrically biconvex cross-section, usually referred to *B. devonica*, and forms with a strongly triangular cross-section, usually referred to *B. triangularis*. The specimens available in the present study exhibit very different cross-sectional profiles. Three distinct types occur (text-figs. 4B, 5B, 6B) and the gradation reported by Serpagli is not evident. With so few specimens available in this Manildra fauna it is not possible to comment on the advisability of adopting Serpagli's synonymy and the division into separate forms is tentatively followed herein.

B. devonica has been described previously from Minnesota (Stauffer 1940), Nevada (Clark and Ethington 1966), Pakistan (Barnett *et al.* 1966), Turkestan (Moskolenko 1966), and England (Rhodes and Dineley 1957) in deposits of early Lower Devonian to possible Upper Devonian age.

Material. Figured specimens SU11921 and SU11922 plus one other.

Belodella resima (Philip 1965)

Plate 32, figs. 9, 10; text-fig. 5A, B, C

This form appears to be characteristic of early Devonian limestones in eastern Australia but also has been recorded from the Upper Silurian Bainbridge Limestone of Missouri (Rexroad and Craig 1971) and may be present in the early Lower Devonian fauna described from Pakistan by Barnett *et al.* (1966). Fähræus (1971) has placed *B. resima* and *B. triangularis* in synonymy with *B. devonica* in his treatment of the Lower Devonian conodonts from the Yukon Territory and it is possible that forms with a *B. resima* cross-section also occur in that fauna.

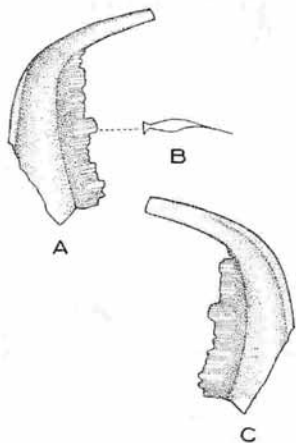
Material. Figured specimen SU11919 plus 2 others.

Belodella triangularis (Stauffer 1940)

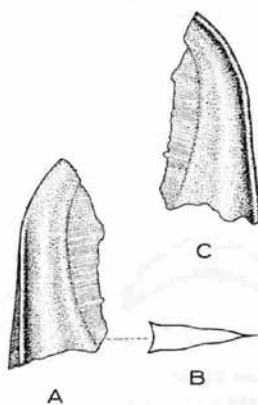
Plate 32, figs. 21, 22; text-fig. 6A, B, C

Only two specimens are available but these clearly belong to *B. triangularis*. In cross-section the cusp is strongly triangular and this is accentuated by the prominent carinae projecting from the anterior face. This element has been recorded previously in the Lower Devonian Tyers and Buchan faunas from Victoria (Philip 1965, 1966) in addition to several Devonian occurrences in America and elsewhere. It appears to range through the Devonian.

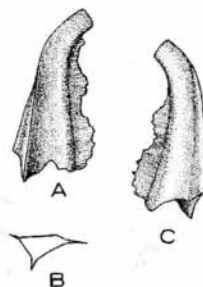
Material. Figured specimen SU11923 plus one other.



TEXT-FIG. 4. *Belodella devonica* (Stauffer 1940). A, C, Lateral views of SU11922. B, Cross-section at mid-height. $\times 60$.



TEXT-FIG. 5. *Belodella resima* (Philip 1965). A, C, Lateral views of SU11919. B, Cross-section at base. $\times 60$.



TEXT-FIG. 6. *Belodella triangularis* (Stauffer 1940). A, C, Lateral views of SU11923. B, Cross-section at base. $\times 60$.

Genus HINDEODELLA Bassler 1925

Type species. *Hindeodella subtilis* Bassler 1925, by original designation of Bassler 1925, p. 219.

Hindeodella equidentata Rhodes 1953

Plate 33, fig. 22; plate 34, figs. 4-6; text-fig. 7A, B, C

This element appears to be restricted to late Silurian and early Devonian deposits. The earliest recorded occurrence is that of the type material in the Aymestry Limestone (Rhodes 1953) of Lower Ludlow age and the latest occurrence is in the Murrindal Limestone in eastern Australia (Philip 1966) which is of late Praguian or early Zlichovian age. The element occurs in numerous faunas described from continental Europe (Ziegler 1960; Walliser 1964; Schulze 1968) and has also been recorded from Morocco (Ethington and Furnish 1962) and northern Canada (Walliser 1960).

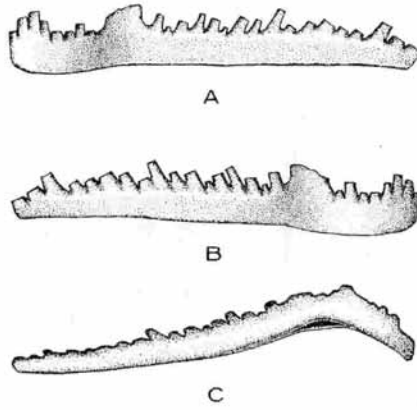
Material. Figured specimens SU11945 and SU11955 plus one other.

Hindeodella sp. A.

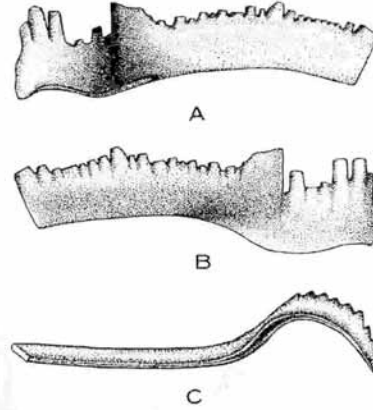
Plate 34, figs. 1-3; text-fig. 8A, B, C

Only a single specimen is available but this is very distinctive. It is characterized by the hook-like curvature of the bars, the depth of the bars, and the flattened to concave outer face of the main cusp near its base. The posterior denticles are considerably smaller than those of *H. equidentata* and *Hindeodella* sp. B.

Material. Figured specimen SU11954.



TEXT-FIG. 7. *Hindeodella equidentata* Rhodes 1953. A-C, Inner lateral, outer lateral, and aboral views of SU11955. $\times 60$.



TEXT-FIG. 8. *Hindeodella* sp. A. A-C, Inner lateral, outer lateral, and aboral views of SU11954. $\times 60$.

EXPLANATION OF PLATE 32

All figures $\times 40$.

Figs. 1, 2. *Ligonodina* aff. *salopia* Rhodes 1953. Lateral views of SU11912.

Figs. 3, 4. *Paltodus* sp. Lateral views of SU11913.

Figs. 5, 6. *Panderodus unicostatus* (Branson and Mehl 1933). Lateral views of SU11914.

Figs. 7, 8. *Panderodus simplex* (Branson and Mehl 1933). Lateral views of SU11918.

Figs. 9, 10. *Belodella resima* (Philip 1965). Lateral views of SU11919.

Figs. 11, 12. Gen. et sp. indet. Lateral views of SU11920.

Figs. 13-18. *Panderodus gracilis* (Branson and Mehl 1933). 13, 14, Lateral views of SU11915. 15, 16, Lateral views of SU11916. 17, 18, Lateral views of SU11917.

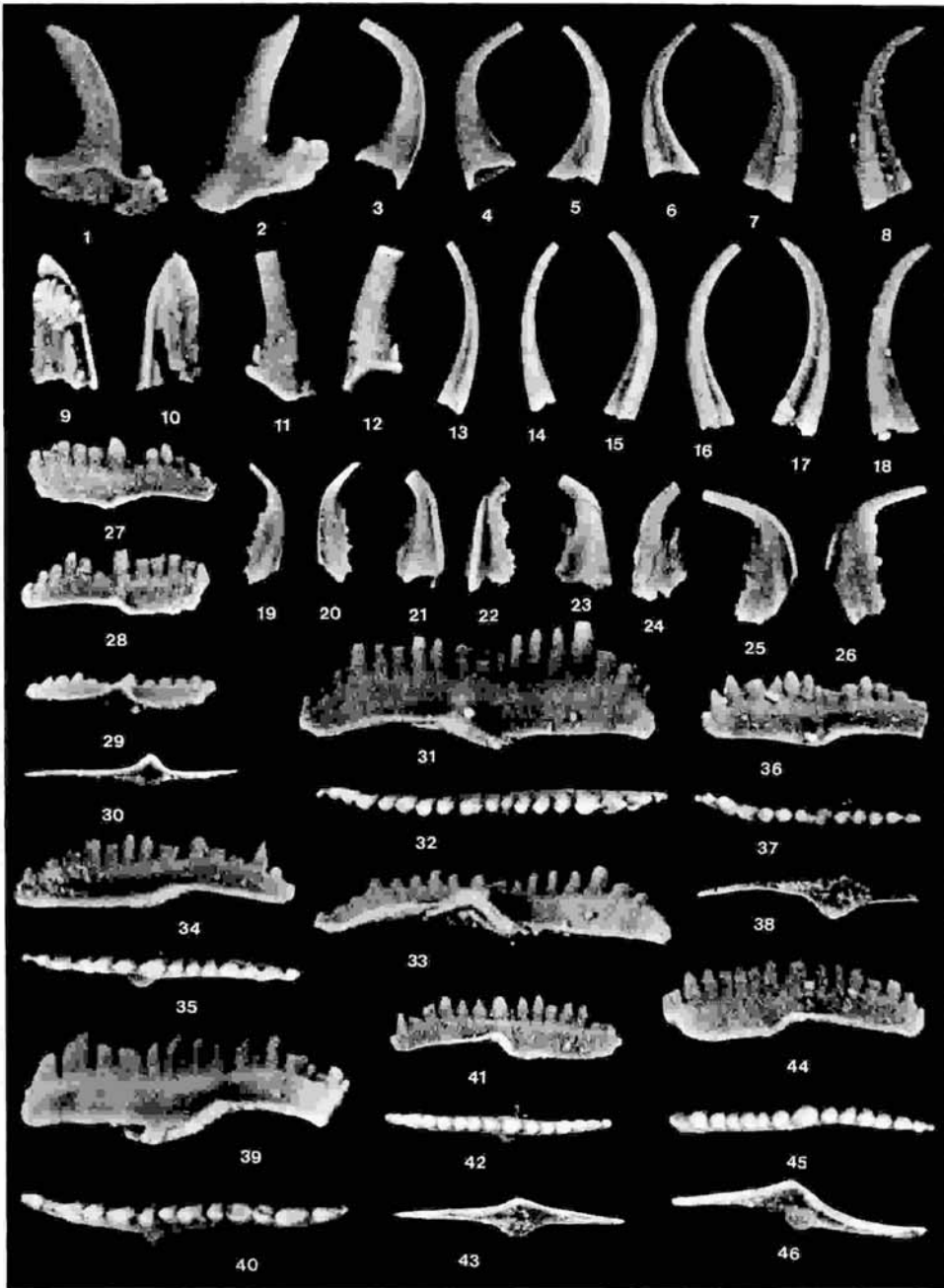
Figs. 19, 20, 25, 26. *Belodella devonica* (Stauffer 1940). 19, 20, Lateral views of SU11921. 25, 26, Lateral views of SU11922.

Figs. 21, 22. *Belodella triangularis* (Stauffer 1940). Lateral views of SU11923.

Figs. 23, 24. *Rotundacodina dubia* (Rhodes 1953). Lateral views of SU11924.

Figs. 27-46. *Spathognathodus inclinatus wurmi* Bischoff and Sannemann 1958. 27-29, Lateral and aboral views of SU11925. 30, Aboral view of SU11926. 31-33, Lateral, oral, and aboral views of SU11927.

34, 35, Lateral and oral views of SU11928. 36-38, Lateral, oral, and aboral views of SU11929. 39, 40, Lateral and oral views of SU11930. 41-43, Lateral, oral, and aboral views of SU11931. 44-46, Lateral, oral, and aboral views of SU11932.

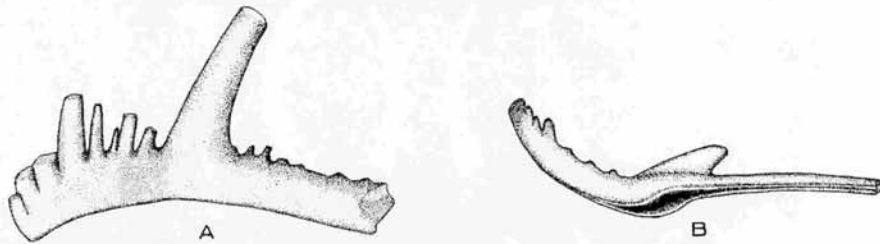


SAVAGE, Lower Devonian conodonts

Hindeodella sp. B.

Plate 33, figs. 2, 3, 11, 12; text-fig. 9A, B

This material bears some resemblance to *H. equidentata* but it is stouter than the type material of that element and has a larger, more tapering main cusp. There is also a more pronounced downward flexure of the anterior bar in the Manildra form.

TEXT-FIG. 9. *Hindeodella* sp. B. A, B, Inner lateral and aboral views of SU11934. $\times 60$.

Rexroad and Craig (1971) have restudied the type material of *H. confluens* and according to their description this Manildra material could belong to that form. Klapper (pers. comm., 1971) assures me that the denticles of *H. confluens* are characteristically fused.

Material. Figured specimens SU11934 and SU11935 plus one other.

?Hindeodella sp.

Plate 34, figs. 12, 13

Several fragments of these bars are present in the collection. They may belong to a species of *Hindeodella*.

Material. Figured specimens SU11959 and SU11960 plus four others.

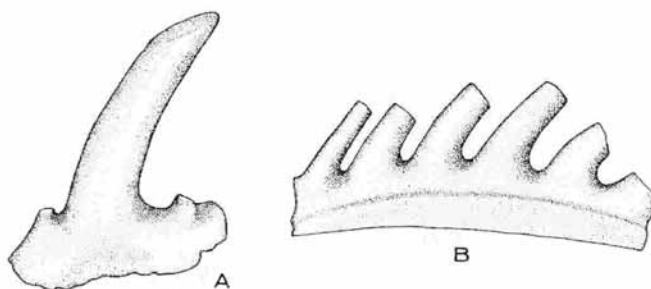
Genus LIGONODINA Bassler 1925

Type species. *Ligonodina pectinata* Bassler 1925, by original designation of Bassler 1925, p. 218.

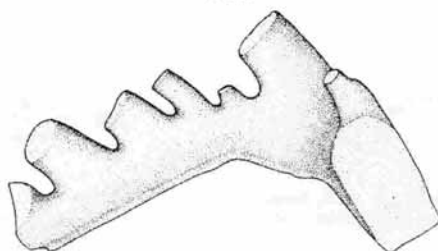
Ligonodina aff. *salopia* Rhodes 1953

Plate 32, figs. 1, 2; plate 33, fig. 36; plate 34, figs. 14, 15; text-figs. 10A, B; 11

This material resembles the type material from the Aymestry Limestone and several of the specimens from the Rheinisches Schiefergebirge described by Ziegler (1960). However, the Manildra specimens are unusually large and may be more mature than the type material. A detailed comparison is difficult with so few specimens available.



TEXT-FIG. 10. *Ligonodina* aff. *salopia* Rhodes 1953. A, Lateral view of main cusp fragment SU11912. B, Lateral view of posterior bar fragment SU11961. $\times 60$.



TEXT-FIG. 11. *Ligonodina* aff. *salopia* Rhodes 1953. Inner view of fragment SU11952. $\times 60$.

L. salopina appears to be restricted to deposits of Upper Silurian and Gedinnian age. It has been recorded mostly in continental Europe (Ziegler 1960; Walliser 1964) and England (Rhodes 1953).

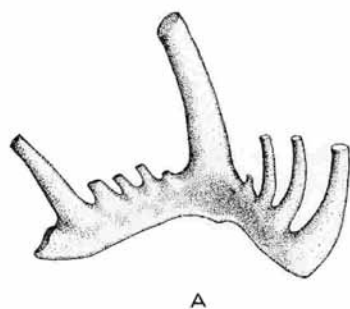
Material. Figured specimens SU11912, SU11952, and SU11961.

Ligonodina sp.

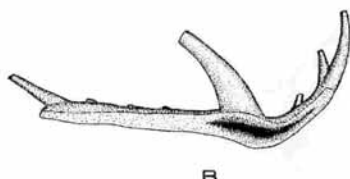
Plate 33, figs. 4-6, 37, 38; text-fig. 12A, B

This appears to be a new form of *Ligonodina* but is represented by only a single relatively complete specimen plus one fragment. It shows some resemblance to *L. silurica* Branson and Mehl but differs in possessing posterior denticles which are fewer and which become progressively larger away from the main cusp. Forms of *Ligonodina* are not prominent in the conodont literature of eastern Australia. Philip (1967) described two elements from the Middle Devonian deposits of New South Wales. The Manildra form is easily distinguished from both *Ligonodina* sp. A and *Ligonodina* sp. B of Philip (1967, pl. 3, figs. 6-8, 13, 14) in having denticles more closely set and in being less sharply geniculate. Furthermore, the processes are relatively deeper and there is no sign of the interposed denticles visible in some of the younger material.

Material. Figured specimen SU11936 and SU11948.

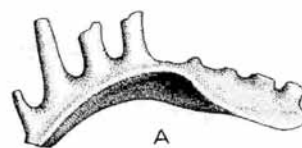


A



B

TEXT-FIG. 12. *Ligonodina* sp. A, B, Inner lateral and aboral views of SU11936. $\times 60$.



A



B

TEXT-FIG. 13. *Lonchodina walliseri* Ziegler 1960. A, B, Lateral and oral views of SU11947. $\times 60$.

Genus LONCHODINA Bassler 1925

Type species. *Lonchodina typicalis* Bassler 1925, by original designation of Bassler 1925, p. 219.

Lonchodina walliseri Ziegler 1960

Plate 33, figs. 26-28; text-fig. 13A, B

This form lies well within the variation of Ziegler's illustrated specimens (Ziegler 1960, pl. 14, figs. 2, 6, 7). An error in Walliser's 1964 synonymy (p. 44) is in need of comment as it has been followed by several later workers. Walliser refers figs. 1, 3, and 7 of Ziegler 1960, pl. 14, to *L. walliseri*, but on the preceding page he refers figs. 1 and 3 of the same plate to *Lonchodina cristagalli*. Walliser evidently intended to include Ziegler's original figures of *Lonchodina walliseri* in his 1964 synonymy, viz. Ziegler 1960, pl. 14, figs. 2, 6, and 7.

Lonchodina sp. of Rexroad (1967, p. 38, pl. 3, fig. 5) was excluded from *L. walliseri* because the basal cavity did not lie below the main cusp. However, this is not unusual in *L. walliseri* and is visible in some of the specimens figured by Walliser (1964, pl. 30, figs. 26, 30, 33) in addition to the material described herein. The basal cavity is commonly displaced posteriorly to underlie the proximal posterior denticles (text-fig. 13B).

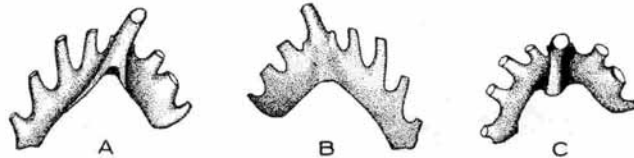
L. walliseri has previously been described from the Lower Silurian of North

America (Rexroad 1967), from the Upper Silurian of Europe (Walliser 1957, 1964), and from the Lower Devonian of eastern Australia (Philip 1965) and Europe (Ziegler 1960).

Material. Figured specimens SU11947 and SU11948 plus one other.

Lonchodina greilingi Walliser 1957

Plate 33, figs. 23, 24; text-fig. 14A, B, C



TEXT-FIG. 14. *Lonchodina greilingi* Walliser 1957. A-C, Inner lateral, outer lateral, and aboral views of SU11946. $\times 60$.

This specimen of *L. greilingi* appears to be a juvenile form. It bears some resemblance to *Trichonodella asymmetrica* Nicoll and Rexroad 1969 but differs in having more widely spaced denticles and less deep bars. *L. greilingi* is characteristically a Silurian and early Lower Devonian element. It has been described previously from Silurian beds in Morocco (Ethington and Furnish 1962), Spain (Kockel 1958), and Algeria (Müller 1962), and from Lower Devonian beds in Germany (Ziegler 1960, Walliser 1957, 1964), and eastern Australia (Philip 1965).

Material. Figured specimen SU11946.

GENUS NEOPRIONIODUS Rhodes and Müller 1956

Type species. *Prioniodus conjunctus* Gunnell 1933, by original designation of Rhodes and Müller 1956, p. 698.

Neoprioniodus excavatus (Branson and Mehl 1933)

Plate 33, figs. 18, 19, 21, 25; text-fig. 15A, B, C

The review of this element by Rexroad and Craig (1971) has helped clarify the range of variation which occurs in toptype material. They have excluded many occurrences previously assigned to the form. Their restricted diagnosis is followed here. *N. excavatus* is known previously from deposits of Upper Silurian age in North America (Branson and Mehl 1933a; Rexroad and Craig 1971) and Europe (Walliser 1964; Jeppsson 1969), and from Lower Devonian deposits in Morocco (Ethington and Furnish 1962), Europe (Bischoff and Sannemann 1958), and eastern Australia (Philip 1965).

Material. Figured specimens SU11943 and SU11944 plus one other.

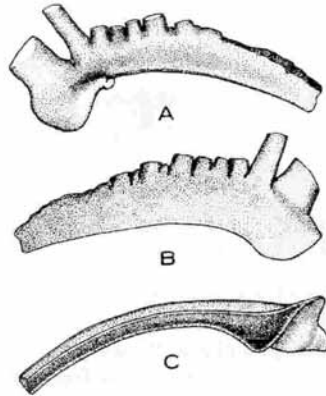
G

Neoprioniodus sp.

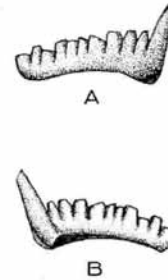
Plate 33, figs. 34, 35; text-fig. 16A, B

This form bears some resemblance to *N. planus* Walliser 1964 but differs in having a main cusp which is erect or slightly inclined anteriorly instead of being inclined posteriorly and in having a gently arched lower margin to the posterior bar.

Material. Figured specimen SU11951 plus six others.



TEXT-FIG. 15. *Neoprioniodus excavatus* (Branson and Mehl 1933). A-C, Inner lateral, outer lateral, and aboral views of SU11944. $\times 60$.



TEXT-FIG. 16. *Neoprioniodus* sp. A, B, Outer lateral and inner lateral views of SU11951. $\times 60$.

EXPLANATION OF PLATE 33

All figures $\times 40$.

- Figs. 1, 7-10. *Ozarkodina typica denckmanni* Ziegler 1956. 1, Lateral view of SU11933. 7, 9, Lateral and aboral views of SU11937. 8, 10, Lateral and oral views of SU11938.
- Figs. 2, 3, 11, 12. *Hindeodella* sp. B. 2, 3, Outer lateral and inner lateral views of SU11934. 11, 12, Outer lateral and inner lateral views of fragment SU11935.
- Figs. 4-6, 37, 38. *Ligonodina* sp. 4-6, Outer lateral, inner lateral, and oral views of SU11936. 37, 38, Aboral and oral views of fragment SU11948.
- Figs. 13-17. *Ozarkodina media* Walliser 1957. 13, Lateral view of SU11939. 14, Lateral view of SU11940. 15, Lateral view of SU11941. 16, 17, Lateral and aboral views of SU11942.
- Figs. 18, 19, 21, 25. *Neoprioniodus excavatus* (Branson and Mehl 1933). 18, 19, 21, Inner lateral and outer lateral views of SU11943. 25, Lateral view of SU11944.
- Figs. 20, 29-33. *Plectospathodus extensus* Rhodes 1953. 20, 32, 33, Aboral, inner lateral, and outer lateral views of SU11949. 29, 30, 31, Outer lateral, oral, and inner lateral views of SU11950.
- Fig. 22. *Hindeodella equidentata* Rhodes 1953. Inner lateral view of SU11945.
- Figs. 23, 24. *Lonchodina greilingi* Walliser 1957. Lateral views of SU11946.
- Figs. 26-28. *Lonchodina walliseri* Ziegler 1960. Lateral and oral views of SU11947.
- Figs. 34, 35. *Neoprioniodus* sp. Oral and outer lateral views of SU11951.
- Fig. 36. *Ligonodina* aff. *salopia* Rhodes 1953. Inner lateral view of fragment SU11952.
- Figs. 39-41. *Trichonodella inconstans* Walliser 1957. Oral, anterior, and aboral views of fragment SU11953.



SAVAGE, Lower Devonian conodonts

Genus OZARKODINA Branson and Mehl 1933

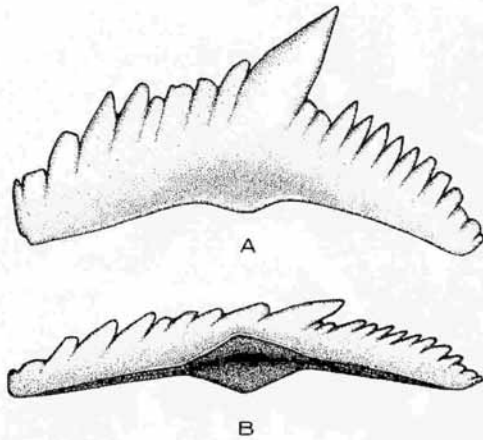
Type species. Ozarkodina typica Branson and Mehl 1933, by original designation of Branson and Mehl 1933a, p. 51.

Ozarkodina typica denckmanni Ziegler 1956

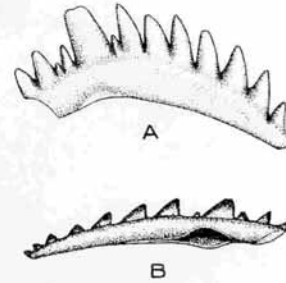
Plate 33, figs. 1, 7-10; text-fig. 17A, B

Only one mature and two immature specimens have been recovered. *O. typica denckmanni* has previously been described in eastern Australia from the Tyers, Lilydale, Buchan Caves, and Murrindal Limestones in Victoria, and from the Wee Jasper Limestone and Lick Hole Limestone in New South Wales. It is known to range from late Upper Silurian to at least Emsian age deposits in Europe (Walliser 1964).

Material. Figured specimens SU11933, SU11937, and SU11938.



TEXT-FIG. 17. *Ozarkodina typica denckmanni* Ziegler 1956.
A, B, Lateral and aboral views of SU11933. $\times 60$.



TEXT-FIG. 18. *Ozarkodina media* Walliser 1957. A, B, Lateral and aboral views of SU11941. $\times 60$.

Ozarkodina media Walliser 1957

Plate 33, figs. 13-17; text-fig. 18A, B

Ozarkodina has commonly been interpreted to include a wide range of variation. Some forms assigned to that genus could equally well be referred to *Bryodontus*. Reference to *Bryodontus* may be appropriate when the denticles are not in contact for most of their height and arise from bars with well-developed oral shoulders as in some of the Manildra material (pl. 32, figs. 15, 16). In this present study insufficient material is available for a critical review of these problems and the popular interpretation of *O. media* has been followed.

The form is common in Upper Silurian and Lower Devonian assemblages and

has been described previously from England (Rhodes 1953), North Africa (Ethington and Furnish 1962), Spain (Kockel 1958), Germany (Walliser 1957, 1964; Bischoff and Sannemann 1958), North America (Rexroad and Craig 1971; Fähræus 1971) and eastern Australia (Philip 1965, 1966). These occurrences indicate a range extending into Zlichovian age (Upper Emsian) deposits.

Material. Figured specimens SU11939, SU11940, SU11941, and SU11942 plus eight others.

Genus PALTODUS Pander 1856

Type species. *Paltodus subaequalis* Pander 1856, by subsequent designation of Ulrich and Bassler 1926, p. 7.

Paltodus sp.

Plate 32, figs. 3, 4; text-fig. 19A, B, C, D

This material is closely related to the form described by Philip (1965, p. 109, pl. 8, figs. 36, 37) from the Tyers area in Victoria but may differ in possessing a more lenticular cross-section. It appears to be close to *Paltodus* n. sp. A from the Lower Silurian Brassfield Limestone described by Nicoll and Rexroad (1969, p. 52, pl. 7, figs. 21, 22).

Material. Figured specimen SU11913 plus five others.

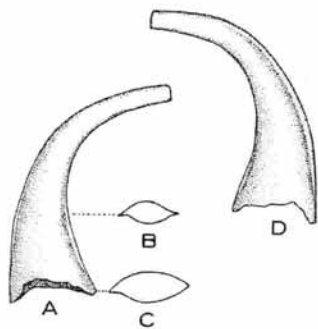
Genus PANDERODUS Ethington 1959

Type species. *Paltodus unicostatus* Branson and Mehl 1933, by original designation of Ethington 1959, p. 284.

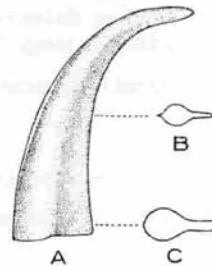
Panderodus simplex (Branson and Mehl 1933)

Plate 32, figs. 7, 8; text-fig. 20A, B, C

Rexroad and Craig have re-examined and re-figured the type material of this element and extensively revised the synonymy (Rexroad and Craig 1971, p. 697).



TEXT-FIG. 19. *Paltodus* sp. A, D, Lateral views of SU11913. B, Cross-section at mid-height. C, Cross-section at base. $\times 60$.



TEXT-FIG. 20. *Panderodus simplex* (Branson and Mehl 1933). A, Lateral view of SU11918. B, Cross-section at mid-height. C, Cross-section at base. $\times 60$.

These Manildra specimens differ from most descriptions of material referred to *P. simplex* in possessing a small carina developed along part of the anterior margin. However, such a carina is clearly visible in the re-figured type material (Rexroad and Craig 1971, pl. 81, figs. 35-40), and there seems little doubt that the Manildra specimens are the same element.

As diagnosed by Rexroad and Craig this form ranges from the Ordovician (Bergström 1961) to the late Lower Devonian (Philip 1966).

Material. Figured specimen SU11918 plus twenty-six others.

Panderodus unicostatus (Branson and Mehl 1933)

Plate 32, figs. 5, 6; text-fig. 21A, B, C

Many occurrences of *P. unicostatus* have been recorded and the diagnosis varies considerably with different authors. The problem has recently been discussed by Rexroad and Craig (1971, pp. 697, 698) who conclude that the material of many authors is not well enough figured for the precise nature of the carina or carinae to be assessed. Only a detailed examination of all material previously referred to this element would lead to a reliable synonymy.

Material. Figured specimen SU11914 plus twelve others.

Panderodus gracilis (Branson and Mehl 1933)

Plate 32, figs. 13-18; text-fig. 22A, B

There are some differences between specimens in the Manildra assemblage. All are slender and evenly recurved but the position and sharpness of the angles vary so that a considerable range of cross-section profiles results. Nevertheless, the stout opposed ridges and deep re-entrant excavations on each side are common to all specimens. Rexroad and Craig (1971, pp. 695, 696) recognize two variants in their collection but a clear distinction is not evident in the Manildra material. The records of the form indicate a range from Ordovician to Devonian.

Material. Figured specimens SU11915, SU11916, and SU11917 plus twenty-four others.

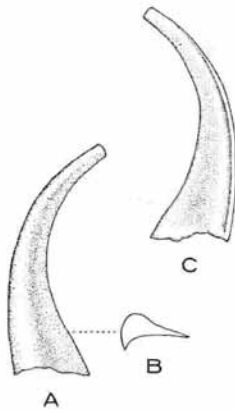
Genus PLECTOSPETHODUS Branson and Mehl 1933

Type species. *Plectospathodus flexuosus* Branson and Mehl 1933, by original designation of Branson and Mehl 1933a, p. 47.

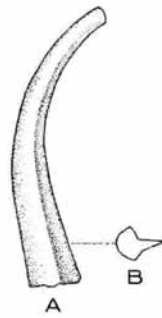
Plectospathodus extensus Rhodes 1953

Plate 33, figs. 20, 29-33; text-fig. 23A, B, C

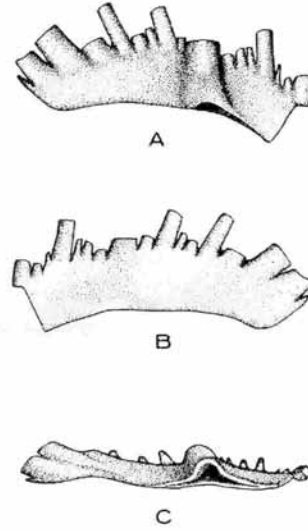
This Manildra material is less arched than the type material but falls within the range of variation of forms referred to the element elsewhere. The form has been described from widespread deposits ranging in age from Upper Silurian (Rhodes



TEXT-FIG. 21. *Panderodus unicostatus* (Branson and Mehl 1933). A, C, Lateral views of SU11914. B, Cross-section near base. $\times 60$.



TEXT-FIG. 22. *Panderodus gracilis* (Branson and Mehl 1933). A, Lateral view of SU11916. B, Cross-section near base. $\times 60$.



TEXT-FIG. 23. *Plectospathodus extensus* Rhodes 1953. A-C, Inner lateral, outer lateral, and aboral views of SU11949. $\times 60$.

1953; Jeppsson 1969; Walliser 1964; Rexroad and Craig 1971) to Lower Devonian (Philip 1965; Jentzsch 1962; Bischoff and Sannemann 1958).

Material. Figured specimens SU11949 and SU11950 plus four others.

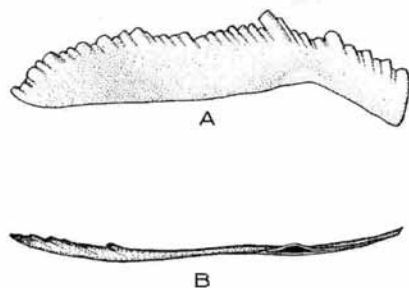
Plectospathodus aff. *alternatus* Walliser 1964

Plate 34, figs. 16-18; text-fig. 24A, a

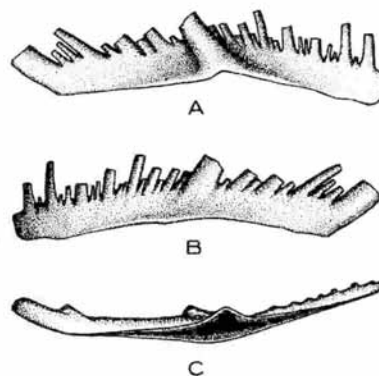
This is a *Hindeodella*-like form with finer denticles and deeper bars than in the type material of *P. alternatus*. It is close to material described as *P. alternatus* by Philip (1965, 1966) from the Tyers and Buchan Caves Limestones in Victoria. The variation noted by Philip suggests that a similar variation could occur in the Manildra material if more specimens were available.

P. alternatus appears to range from the very latest Silurian (Walliser 1964) to the late Lower Devonian (Philip and Jackson 1970). It is known from several localities in Europe (Ziegler 1960; Walliser 1964), eastern Australia (Philip 1965, 1966; Philip and Jackson 1970) and northern Canada (Walliser 1960).

Material. Figured specimens SU11962 and SU11963.



TEXT-FIG. 24. *Plectospathodus* aff. *alternatus* Walliser 1964. A, B, Inner lateral and aboral views of SU11963. $\times 60$.



TEXT-FIG. 25. *Plectospathodus* sp. A-C, Inner lateral, outer lateral, and aboral views of SU11955. $\times 60$.

Plectospathodus sp.

Plate 34, figs. 7, 8; text-fig. 25A, B, C

This form resembles *P. extensus* in lateral view but lacks the upcurved extension of the basal cavity which characterizes that element. Furthermore, there is a prominent basal groove present for much of the length of the unit. Thus it is very different from *P. extensus* aborally. It is probably conspecific with material illustrated by Walliser as *Plectospathodus* sp. (Walliser 1964, pl. 30, figs. 18, 20, 22). There is evidently some gradation from *Plectospathodus* sp. to *P. alternatus* and then through to deep, finely denticulate forms of the latter element such as illustrated herein.

Material. Figured specimen SU11955 plus one other.

EXPLANATION OF PLATE 34

All figures $\times 40$.

Figs. 1-3. *Hindeodella* sp. A. Inner lateral, outer lateral, and oral views of SU11954.

Figs. 4-6. *Hindeodella equidentata* Rhodes 1953. Inner lateral, outer lateral, and oral views of SU11955.

Figs. 7, 8. *Plectospathodus* sp. Inner lateral and outer lateral views of SU11955.

Fig. 9. *Trichonodella excavata* (Branson and Mehl 1933). Posterior view of SU11956.

Figs. 10, 11, 30-32. *Spathognathodus inclinatus wurmi* Bischoff and Sannemann 1958. 10, 11, Oral and lateral views of SU11957. 30, 31, Lateral and aboral views of SU11958.

Figs. 12, 13. ?*Hindeodella* sp. 12, Lateral view of fragment SU11959. 13, Lateral view of fragment SU11960.

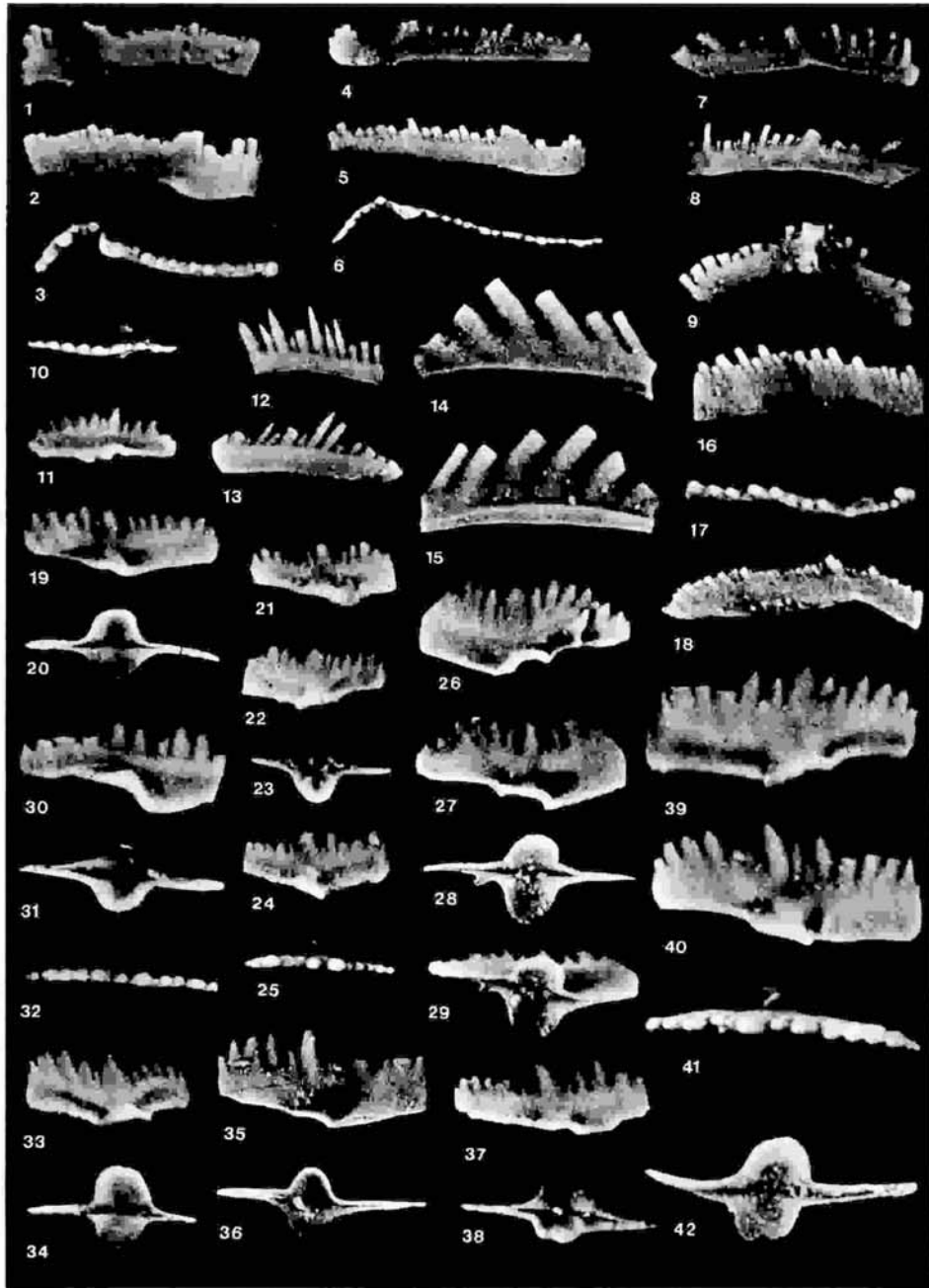
Figs. 14, 15. *Ligonodina* aff. *salopina* Rhodes 1953. Lateral views of posterior bar fragment SU11961.

Figs. 16-18. *Plectospathodus* aff. *alternatus* Walliser 1964. 16, 17, Lateral and oral views of SU11962.

18, Lateral view of SU11963.

Figs. 19-29, 33-42. *Spathognathodus remscheidensis* Ziegler 1960. 19, 20, Lateral and aboral views of SU11964. 21-23, Lateral and aboral views of SU11965. 24, 25, Lateral and oral views of SU11966.

26-29, Lateral and aboral views of SU11967. 33, 34, Lateral and aboral views of SU11968. 35, 36, Lateral and aboral views of SU11969. 37, 38, Lateral and aboral views of SU11970. 39-42, Lateral, oral, and aboral views of SU11971.



SAVAGE, Lower Devonian conodonts

Genus ROTUNDACODINA Carls and Gandl 1969

Type species. *Rotundacodina noguerensis* Carls and Gandl 1969, by original designation of Carls and Gandl 1969, p. 206.

Rotundacodina dubia (Rhodes 1953)

Plate 32, figs. 23, 24; text-fig. 26A, B, C

Rhodes (1953) clearly had doubts about referring his material to *Cordylodus*, particularly as there was no evidence of a posterior bar. The genus *Rotundacodina*, recently proposed by Carls and Gandl (1969), encompasses Rhodes's species although the type species lacks the posterior denticle.

The Manildra occurrence in beds of late Lochkovian age (middle Gedinnian) extends the known range of the element. The type material is from the Upper Silurian of England (Rhodes 1953) and the Spanish material is of early Gedinnian age (Carls and Gandl 1969).

Material. Figured specimen SU11924.

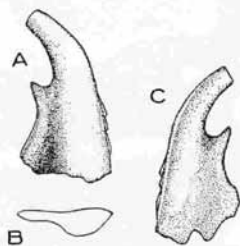
Genus SPATHOGNATHODUS Branson and Mehl 1941

Type species. *Spathodus primus* Branson and Mehl 1933, by original designation of Branson and Mehl 1941, p. 98.

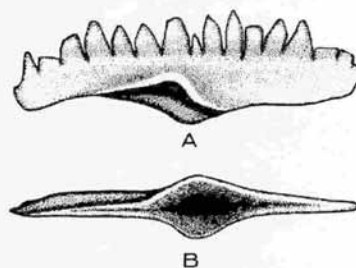
Spathognathodus inclinatus wurmi Bischoff and Sannemann 1958

Plate 32, figs. 27-46; plate 34, figs. 10, 11, 30-32; text-fig. 27A, B

In placing *S. wurmi* in synonymy with *S. inclinatus*, Walliser (1964, p. 76) reasoned that a continuous gradation was evident between these forms. A comparison of the illustrations of the type specimens shows that, at the very least, there are extreme end members which are easily distinguishable. It may be argued that Rhodes's specimens, which are relatively short and have denticles which are backwardly inclined, are immature forms of *S. inclinatus*, and that the specimens described by Bischoff and Sannemann, which are long and have upright denticles, particularly large at the anterior end of the specimens, are mature or even gerontic forms of



TEXT-FIG. 26. *Rotundacodina dubia* (Rhodes 1953). A, C, Lateral views of SU11924. B, Cross-section of base. $\times 60$.



TEXT-FIG. 27. *Spathognathodus inclinatus wurmi* Bischoff and Sannemann 1958. A, B, Lateral and aboral views of SU11931. $\times 60$.

S. inclinatus. However, if this is the case there is a surprising tendency for the different growth stages to occur in distinct faunas and even to assume some stratigraphic significance, with the larger, upright forms having larger anterior denticles occurring most commonly in Lower Devonian deposits. For these reasons the latter are herein treated as the distinct subspecies *S. inclinatus wurmi*.

This *Manildra* material is close to the type material of Bischoff and Sannemann (1958, pl. 14, figs. 4-9) but is conspicuously less elongate with proportionally fewer denticles. The Frankenwald material generally grew to a larger size and several of the illustrated specimens are almost twice the length of the larger *Manildra* specimens. Nevertheless, if specimens of the same size are compared there is very little difference in the blade proportions and the number of denticles developed (cf. Bischoff and Sannemann, pl. 14, fig. 4 and pl. 31, fig. 41 herein). An important feature of the subspecies is the development of distinct shoulders along the upper surfaces of the bars below the denticle bases. One specimen figured herein (pl. 33, figs. 10, 11) is probably a juvenile form of *S. inclinatus wurmi* but could be interpreted as *S. inclinatus inclinatus*.

S. inclinatus wurmi has been described from Europe (Bischoff and Sannemann 1958; Ziegler 1960; Walliser 1964; Spasov and Veselinović 1963), eastern Australia (Philip 1965; Philip and Jackson 1970) and North America (Klapper 1969; Fähræus 1971) in beds of Upper Silurian to late Lower Devonian age.

Material. Figured specimens SU11925-SU11932.

Spathognathodus remscheidensis Ziegler 1960

Plate 34, figs. 19-29, 33-42; text-fig. 28A, B

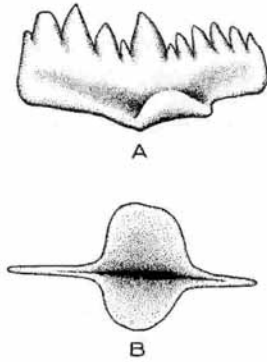
There is a close resemblance between this *Manildra* form and the material described as *S. canadensis* from the Upper Silurian (?) of Arctic Canada (Walliser 1960). Walliser (1964, p. 87) placed *S. canadensis* in synonymy with *S. remscheidensis*, together with the material described as *Spathognathodus* cf. *canadensis* by Ziegler from the Rheinisches Schiefergebirge. The recent work of Barnett (1971) suggests that much of the variation previously recorded for this element may be ecological.

S. remscheidensis is known from Europe (Ziegler 1960; Walliser 1964; Mashkova 1967; Fähræus 1969), eastern Australia (herein), North America (Walliser 1960; Klapper 1969; Barnett 1971) and Pakistan (Barnett *et al.* 1966). All these occurrences are in Gedinnian age deposits. However, it may be reasoned that the forms described as *S. steinhornensis buchansensis* from the Buchan Caves Limestone by Philip (1966) should be referred to *S. remscheidensis*, in which case the range of the element would extend to the late Siegenian.

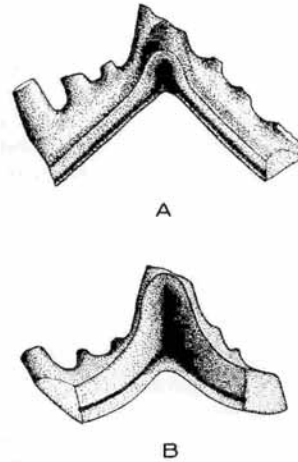
Material. Figured specimens SU11964-SU11971 plus five others.

Genus TRICHONODELLA Branson and Mehl 1948

Type species. *Trichognathus prima* Branson and Mehl 1933, by original designation of Branson and Mehl 1948, p. 527.



TEXT-FIG. 28. *Spathognathodus remscheidensis* Ziegler 1960. A, B, Lateral and aboral views of SU11968. $\times 60$.



TEXT-FIG. 29. *Trichonodella inconstans* Walliser 1957. A, B, Posterior and aboral views of SU11953. $\times 60$.

Trichonodella inconstans Walliser 1957

Plate 33, figs. 39-41; text-fig. 29A, B

Only two fragmentary specimens are available but they undoubtedly fall within the range of variation of *T. inconstans* as defined by Walliser (1964). This element is of widespread distribution and its recorded range extends from the Upper Silurian (Rexroad and Craig 1971; Walliser 1964) to the late Lower Devonian (Philip 1966).

Material. Figured specimen SU11953 plus one other.

Trichonodella excavata (Branson and Mehl 1933)

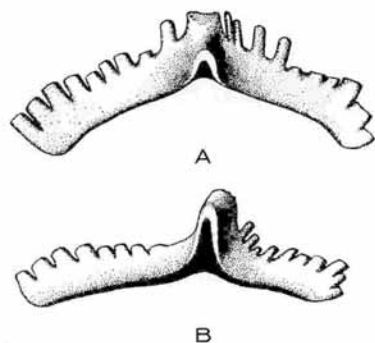
Plate 34, fig. 9; text-fig. 30A, B

This Manildra material agrees closely with the lectotype and topotype material recently figured by Rexroad and Craig (1971, pl. 79, figs. 43-46). The basal cavity of the Bainbridge material is more strongly flexed upwards but this may be a function of growth. The specimens described by Philip (1966) are only doubtfully included in this form. They are characterized by ridges running from the basal cavity along the posterior sides of the lateral bars, a feature not apparent in the illustrations of the topotype material.

T. excavata is a common element in assemblages ranging in age from Upper Silurian (Rhodes 1953; Rexroad and Craig 1971; Walliser 1964) to Gedinian (Bischoff and Sannemann 1958; Schulze 1968; Ethington and Furnish 1962). The

inclusion of the Buchan material (Philip 1966) would extend this range to the late Siegenian or early Emsian.

Material. Figured specimen SU11956 plus one other.



TEXT-FIG. 30. *Trichonodella excavata* (Branson and Mehl 1933). A, B, Posterior and aboral views of SU11956. $\times 60$.

Acknowledgements. I wish to thank Dr. F. H. T. Rhodes and Dr. G. Klapper for reading an early draft of the manuscript and making several helpful suggestions. Dr. R. Thorsteinsson and Dr. J. G. Johnson provided valuable information concerning unpublished faunal occurrences in northern Canada and central Nevada, respectively.

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