COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

BULLETIN No. 45.

DEVONIAN BRACHIOPODS FROM THE FITZROY BASIN, WESTERN AUSTRALIA

BY

J. J. VEEVERS.

Issued under the Authority of Senator the Hon. W. H. Spoone
Minister for National Development.
1959.

By Authority:
A. J. ARTHUR, Commonwealth Government Printer, Canberra.
(Printed in Australia.)

4328/*58*.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

BULLETIN No. 45.

DEVONIAN BRACHIOPODS FROM THE FITZROY BASIN, WESTERN AUSTRALIA

BY

J. J. VEEVERS.

Issued under the Authority of Senator the Hon. W. H. Spooner,
Minister for National Development.
1959.

By Authority:
A. J. ARTHUR, Commonwealth Government Printer, Canberra.
(Printed in Australia.)

4328/58.

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

Minister: SENATOR THE HON. W. H. SPOONER, M.M.

Secretary: H. G. RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

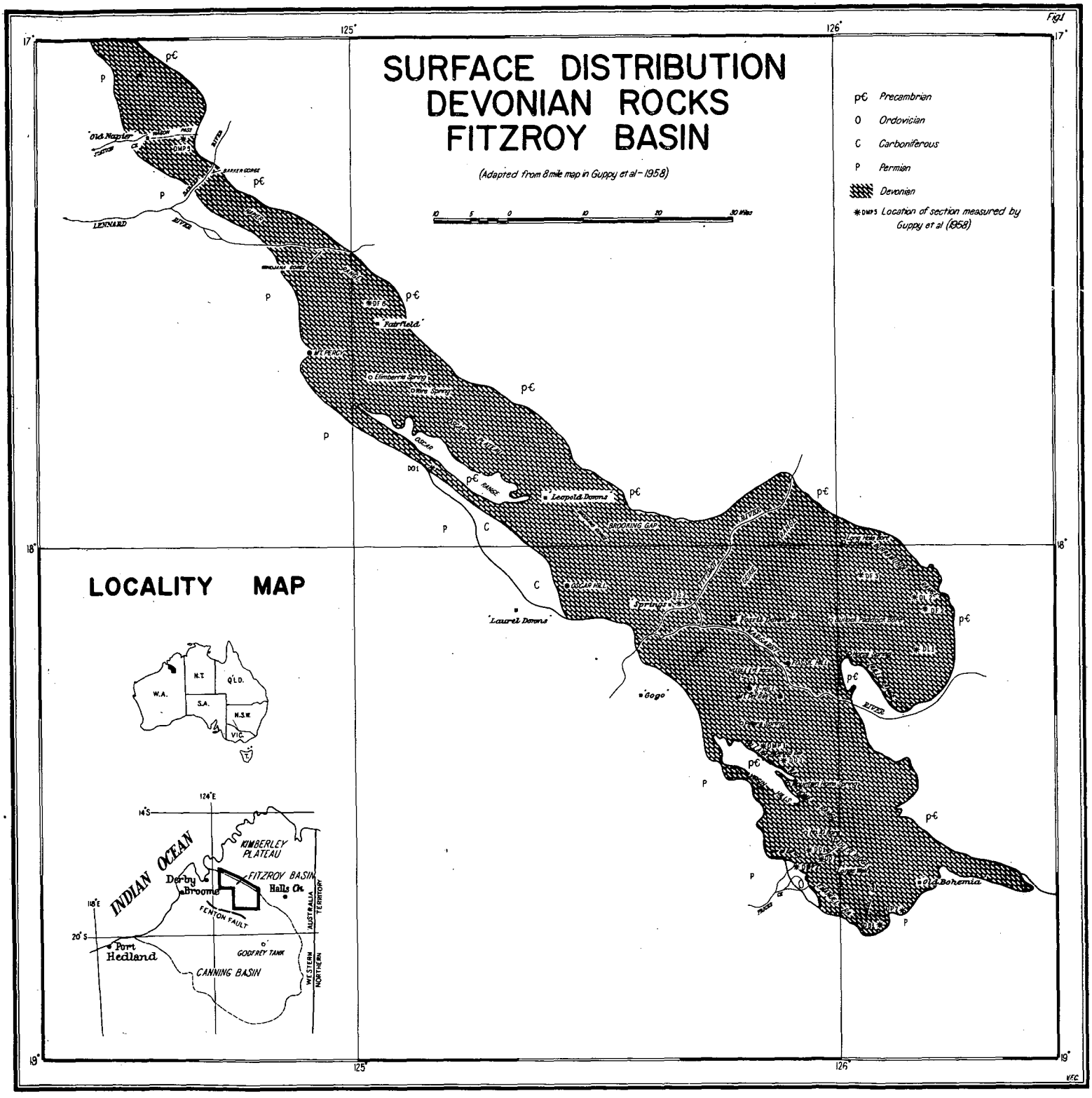
Director: J. M. RAYNER.

Deputy Director: H. TEMPLE WATTS.

This Bulletin was prepared in the Geological Section. The work on which it is based was done in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the University of London.

Chief Geologist: N. H. FISHER.

Issued 1st July, 1959.


SURFACE DISTRIBUTION
DEVONIAN ROCKS
FITZROY BASIN
(Adapted from 8 mile map in Guppy et al - 1958)
pC Precambrian
O Ordovician
C Carboniferous
P Permian
Devonian
*DMP 5 Location of section measured by Guppy et al (1958)
10 5 0 10 20 30 Miles
LOCALITY MAP
N.T.
Q'LD.
W.A.
S.A.
N.S.W.
VIC.
INDIAN OCEAN
KIMBERLEY PLATEAU
FITZROY BASIN
Derby
Broome
Halls Ck.
FENTON FAULT
Port Hedland
GODFREY TANK
CANNING BASIN
AUSTRALIA
WESTERN
NORTHERN
TERRITORY
Old Napier
BARKER GORGE
LENNARD
RIVER
Fairfield
Elimberra Spring
Mara Springs
OSCAR RANGE
Leopold Downs
BROOKING GAP
OSCAR HILLS
Laurel Downs
Gogo
Old Bohemia
125°
126°
17°
18°
19°

CONTENTS

SUMMARY

Brachiopods are represented in the Devonian fauna of the Fitzroy Basin by at least 46 species, three of which come from the upper Middle Devonian, and the rest from the Upper Devonian. These species (32 new, 11 indeterminate, 3 previously described) represent 38 genera (5 new, 7 indeterminate) which are distributed among the brachiopod superfamilies as follows:—

1 orthacean	9 dalmanellaceans	1 pentameracean
4 strophomenaceans	2 orthotetaceans	6 productaceans
1 chonetacean	9 rhynchonellaceans	4 atrypaceans
4 smooth spiriferaceans	2 rostrospiraceans	3 terebratulaceans.

The new genera are *Teichertina* (family Onniellidae), *Zophostrophia* (Stropheodontidae), *Fitzroyella* (Camarotoechiidae), *Nyege* (Coelospiridae) and *Ladjia* (Spiriferidae). The only members of the brachiopod fauna not dealt with are the inarticulates and the ribbed spiriferaceans.

A revision of Teichert's (1949) zonal scheme has led to the recognition of twelve fossil zones—five based on the stratigraphical distribution of goniatites, six on brachiopods, and one on stromatoporoids. Abundant in most of the Devonian formations and fairly restricted in stratigraphical range, the brachiopods are the most useful fossil group in local correlation in the Fitzroy Basin. Extended correlation in the upper Middle Devonian is based on the occurrence of *Stringocephalus.* The lower Upper Devonian contains most of the brachiopod species and these enable correlation to be established between rocks of the Fitzroy Basin and Frasnian deposits or equivalents in north-western France (Beaulieu), central Russia (Voroneje district), Poland (Pelcza district), Germany (Bergisch Land), and Iowa, U.S.A. The presence of five endemic forms side by side with the cosmopolitan brachiopods on which correlation is based may signify short interruptions in an almost continuous exchange of brachiopods between the Fitzroy Basin and the Northern Hemisphere during parts of Middle and Upper Devonian times. With few exceptions the upper Upper Devonian brachiopods are dependable indices in local correlation, but all are useless in extended correlation.

The only known link between the Devonian brachiopod faunas of eastern and Western Australia in *Stringocephalus,* found in the Burdekin River District, north Queensland, and in the Home Range, Fitzroy Basin. The only known link between the Devonian brachiopod faunas of the Fitzroy Basin and the Carnarvon Basin is *Spinatrypa aspera prideri* (Coleman) 1951 and possibly *Ladjia saltica* and *Productella.*

Detailed study of the brachiopods has shed light on the morphogeny of certain structures, in particular the pedicle plate, deltidial plates, dental plates, and crural plates.

ACKNOWLEDGMENTS

Most of the matter included in this bulletin appeared originally as a Ph.D. thesis submitted in the University of London. The thesis was prepared under the supervision of Professor H. H. Read in the Geology Department of Imperial College, London, during the period October, 1953, to June, 1956, while I was on leave from the Bureau of Mineral Resources.

The entire thesis has since been revised and recent discoveries in Fitzroy Basin stratigraphy and palaeontology have been dealt with. Also, as a result of helpful criticism by colleagues, several improvements in the text have been made.

It is a pleasure to record my thanks to the following for assistance in the course of this work:

To Mr. A. W. Lindner and Mr. D. J. Guppy of West Australian Petroleum Pty. Ltd., Perth, whose knowledge of the Devonian stratigraphy of the Fitzroy Basin was generously imparted; to Dr. B. F. Glenister of the University of Western Australia, who provided an unpublished list of determinations of Devonian goniatites associated with some of the brachiopods described in this bulletin; to Dr. C. Teichert of the U.S. Geological Survey, Denver, for helpful correspondence concerning fossils in the University of Western Australia Collection; to Professor R. T. Prider of the University of Western Australia, to Dr. O. P. Singleton of the University of Melbourne, to Mr. E. F. Owen of the Geology Department, British Museum (Natural History), London, to Dr. W. H. C. Ramsbottom of the Geological Survey of Great Britain, London, to Professor W. O. Dietrich of the Geologisch-Paläontologisches Institut und Museum, East Berlin, to Dr. W. Struve of the Senckenberg Museum, Frankfurt-Main, to Mr. F. S. Colliver of the University of Queensland, and to Mr. P. E. Playford of West Australian Petroleum Pty. Ltd., all of whom have kindly made specimens available from collections in their care; to Dr. H. Schmidt of Frankfurt-Main for kind advice about some of the rhynchonellids and atrypids examined; to Miss A. N. Sokolskaya of the Palaeontological Institute, Moscow, for letting me have a copy of one of her publications not otherwise available; to Professor A. Williams of the Queen's University of Belfast, for lending specimens, for help in all aspects of this thesis, and for the example of his own work in brachiopods; to Dr. H. M. Muir-Wood of the British Museum (Natural History), London, who gave valuable advice on many of the fossil groups studied, particularly on the productids; to Dr. D. V. Ager of Imperial College, for an initiation into the study of brachiopods, for much patient assistance and advice, and for reading part of the work in manuscript; to Dr. G. Thomas of Imperial College, who read the entire manuscript of the thesis and offered helpful advice.

The photographs are the work of Mr. G. T. Reid, Bureau of Mineral Resources, Canberra.

Field work in the Devonian areas of Germany, Belgium, and Devonshire was made possible by a grant from the Committee of the Central Research Fund of the University of London.

Work during 1954-56 was carried out during tenure of a Beit Scientific Research Fellowship. To the Trustees of the Fellowship, I extend my sincere thanks.

EXPLANATORY NOTES

The following abbreviations are used in the text:—

C.P.C.—Commonwealth Palaeontological Collection, kept by the Bureau of Mineral Resources, Geology and Geophysics, Canberra.

U.W.A.—University of Western Australia Collection.

B.M.(N.H.)—British Museum (Natural History), London.

G.S.G.B.—Geological Survey of Great Britain, London.

G-P.I.M.B.—Geologisch-Paläontologisches Institut und Museum, East Berlin.

Numbers preceded by the letter " F " are registration numbers in the Bureau of Mineral Resources Collection.

All references to " Teichert ", unless otherwise stated, are taken from Teichert's Report of 1949, *Stratigraphy and Palaeontology of Devonian, western portion of Kimberley Division, Western Australia* (*Bur. Min. Resour. Aust. Rep.* 2).

" Rough Range " and " S.E. Rough Range " of Teichert's Report are synonymous with the approved terms " Pillara Range " and " Virgin Hills ".

A list of the localities of brachiopods herein described is given on p. 152.

Localities of fossils collected in 1953 by West Australian Petroleum Pty. Ltd., and the Bureau of Mineral Resources are indicated by numbers preceded by the letter " K ". These localities are described by air-photograph co-ordinates or by reference to measured stratigraphical sections given in Guppy et al. (1958).

Fossils from the University of Western Australia Collection have locality numbers preceded by the letter " T ". These numbers are listed in Teichert (1949, pages 53-54 and Plate I.). Locality numbers in Teichert's manuscript (kept in the library of the Geology Department, University of Western Australia) are placed in brackets immediately after the appropriate published locality number. Localities listed in Teichert's manuscript but not mentioned in his published report are preceded by the letters " F ", " KP ", and " M ". The approximate positions of these are given by their geographical co-ordinates on the Lennard River and Noonkanbah 4-mile geological maps.

Locality numbers of fossils collected in 1956 by West Australian Petroleum Pty. Ltd. are preceded by " Ld ", " F ", " S ", or " O ". These localities are described by air-photograph co-ordinates.

HISTORICAL INTRODUCTION

The earliest investigations of the rocks in the Fitzroy Basin were carried out by E. T. Hardman. From observations made in 1883 and 1884, Hardman concluded that the exposures in the Oscar and Napier Ranges and at Mt. Pierre were Carboniferous in age. The fossils collected by Hardman were sent to the British Museum (Natural History), and Foord (1890) described and illustrated them. These descriptions led to a modification of the view that all the limestones of West Kimberley were Carboniferous, since several of the described fossils, particularly those from Mt. Pierre, indicated a Devonian age. Etheridge (1897), however, in describing a nautiloid from the Lennard River area, did not question the estimated Carboniferous age of the rocks in this area. Except for three stromatoporoids described but not illustrated by Etheridge in 1918, no descriptions or illustrations of Devonian fossils from the Fitzroy Basin appeared during the period 1897 to 1933.

In 1933 Hosking published descriptions of six species of brachiopods, three of which had not been noted by Foord. Hosking also drew up a tentative classification, based on fossils, of the Devonian rocks of the Fitzroy Basin.

Two serious misconceptions concerning the age of strata remained. The first of these, in Teichert's words, was that " the generally accepted view with regard to the limestone of the Napier and Rough Ranges was still that which had been handed on since Hardman's time, viz., that they were Carboniferous ". This opinion was strengthened by Prendergast's determinations in 1935 of fossils with marked Carboniferous aspect from the Laurel Downs Homestead area. Investigations conducted over the last few years (Thomas, 1957) have shown that a separate formation of Carboniferous age, the Laurel Beds, is present in this area. The Laurel Beds contain some of the fossils of Carboniferous aspect described by Prendergast.

The second misconception grew in connexion with the limestones in the Price's Creek area south of Gap Creek Gap. Blatchford (1927) regarded the age of the limestone as Carboniferous. He probably inspected at the same time limestones which are now recognized as separate formations, the Emanuel Formation (Ordovician) and the Pillara Formation (Devonian). The implied Upper Palaeozoic age of a new brachiopod genus described by Prendergast in 1935 from what would now be termed the Emanuel Formation went unchallenged until 1950, when Guppy and Öpik showed that the Emanuel Formation was Ordovician.

At about this time, the first attempts at determining the ages of some of the Devonian strata in greater detail were made. In 1935 Delépine described some goniatites collected by E. de C. Clarke and H. W. B. Talbot from the Mt. Pierre area, and concluded that they indicated a Famennian age. In the following year, Hill described nine coral species from the earlier collections of Hardman and others, concluding that the corals came from strata of Givetian to Frasnian age. Another important advance was made by Ripper (1937) in recognizing the stromatoporoid *Amphipora ramosa* (Phillips) from the Devonian of the Fitzroy Basin.

By this time, largely as a result of Hill's coral determinations, the assumption that the limestones of the Mt. Pierre area and the Napier and Oscar Ranges were Carboniferous in age had been abandoned. Further descriptions of corals were made by Hill in 1939 and 1954.

The pelecypod *Conocardium gogoense* was described by Fletcher in 1943.

In the decade 1939-49, Teichert contributed six papers which modified the study of the Devonian rocks of the Fitzroy Basin from an uncoordinated enterprise into the initial stages of a carefully integrated programme. His first three papers dealt with cephalopods (mainly nautiloids) and the last three with stratigraphy. The final paper (Teichert, 1949) is the main source-book for the present study.

The importance of Teichert's contribution cannot be exaggerated. In a terrain of complicated reef limestones and associated sediments, Teichert worked out the main zonal units and their relationships. Teichert's field work, like that of earlier geologists, was continuously hampered by the lack of anything but the crudest topographical base-map on the scale of 1" : 2 miles. In his review of the Devonian of Western Australia, Teichert explained that for this reason " any attempts to find ' mappable ' lithological units in the course of our brief field survey would have been doomed to failure, and would have resulted in an utterly chaotic picture of the geology of the area. Instead, the classification of rocks was made on a purely palaeontological basis . . . "

In 1947 the Fitzroy Basin was photographed from the air by the Royal Australian Air Force, and the aerial photographs at a scale of 1 : 50,000 enabled the Bureau of Mineral Resources, Geology and Geophysics to begin a comprehensive geological survey of the area, which continued from 1948 to 1952 under the leadership of D. J. Guppy. Several formations in the Devonian were not mappable at the scale available and would require maps on a scale of about 1 : 2,000 for satisfactory results. Nevertheless, among other things, the main units in the Devonian succession, together with the boundaries of the Devonian with Precambrian, Ordovician and Permian rocks, were mapped, and have been described (1958) in a Bulletin (Guppy, Lindner, Rattigan and Casey) and in maps at a scale of 4 miles to 1 inch (Noonkanbah and Lennard River Sheets).

An important contribution to the knowledge of Devonian brachiopods of the area was made by Coleman in 1951. Working on Teichert's collection of *Atrypa* he distinguished six forms, three of which had been noted by earlier workers.

In the last few years, geological activity in the area has continued to increase. Gravity, seismic, and aero-magnetic surveys have been carried out and the discovery of oil by West Australian Petroleum Pty. Ltd. near Exmouth Gulf, 1,000 miles to the south-west, has stimulated a programme of drilling. The Bureau of Mineral Resources has drilled shallow holes in key areas for stratigraphical information.

Palaeontological work carried out since the publication of Teichert's 1949 report includes Hill's (1954) description of Givetian, Frasnian and Famennian corals, Howell's descriptions (1952, 1956, 1957) of sponges, and the unpublished Ph.D. thesis of Dr. B. F. Glenister on Frasnian goniatites*. Work in hand includes the description of ribbed spiriferids by Mr. G. A. Thomas, conodonts and cephalopods by Dr. B. F. Glenister, bryozoans by Dr. J. R. Phillips, and trilobites by Dr. O. P. Singleton.

The morphology, systematics, and stratigraphical distribution of Devonian brachiopods from the Fitzroy Basin are dealt with in this bulletin.

All the groups of brachiopods so far collected have been studied, except the ribbed spiriferids, which are being examined by Mr. G. A. Thomas. The importance of brachiopods in the stratigraphy of the Fitzroy Basin lies in their occurrence, usually in considerable abundance, in most of the Devonian formations. Fossils with more

* Since published in *J. Paleont.*, 32(1), 58–96, pl. 5–15, 17 text-figs.

narrowly restricted stratigraphical ranges, such as ammonoids, are present only in a few formations of small areal extent; corals, like brachiopods, have a longer stratigraphical range, but are not so widely distributed.

For the successful study of the brachiopods from an area of roughly 3,000 square miles, large representative samples must be available. The present study is based on two large collections each of which essentially complements the other. The Bureau's collections include Devonian brachiopods collected during August-October, 1953, by a Bureau party which included G. A. Thomas, J. M. Dickins, and J. J. Veevers, and worked in close association with the West Australian Petroleum Pty. Ltd. party, led by Mr. A. W. Lindner, whose aim was to re-measure important sections of the stratigraphical units in the area. The brachiopods were thus mainly collected from re-measured type sections, and are precisely localized both areally and stratigraphically. Further samples of brachiopods were secured from isolated exposures of fossiliferous rocks.

The second collection, part of the University of Western Australia Collection, includes Devonian brachiopods collected by Dr. Curt Teichert and geologists of Caltex (Australasia) Oil Development Pty. Ltd. at various times during the years 1939 to 1941. Most brachiopods in this collection were taken from isolated exposures and unmeasured sections. Only those from topographically conspicuous localities such as Oscar Hill or Mt. Pierre are precisely localized; the remainder, and these constitute the majority, are not firmly localized either areally or stratigraphically. Nevertheless, Teichert's descriptions of the stratigraphy at each locality in his 1949 report allow considerable stratigraphical use to be made of these brachiopods. In combination the two collections form a desirably large sample in which the dominant brachiopod species are well represented.

A third suite of fossils, much smaller than either the Bureau or U.W.A. collections, was collected during 1956 by a Wapet party in the Oscar area. Most of these fossils are kept in Canberra and a small representative collection is deposited in the Geology Department, University of Western Australia.

List of Described and Illustrated Brachiopod Species from the Devonian of the Fitzroy Basin

Devonian brachiopods from the Fitzroy Basin which have been described and illustrated to date are listed below in order of publication.

Foord, A. H., 1890:

Spirifera?, p. 100, pl. 5, fig. 1.
Atrypa reticularis, Linnaeus, pp. 100-101, 2 figs. in the text.
Rhynchonella pugnus, Martin, sp., p. 101, pl. 5, figs. 2. 2a.
Rhynchonella cuboides, J. de C. Sowerby, sp., p. 102, pl. 5, fig. 3.

Hosking, Lucy F. V., 1933:

Atrypa aspera Schloth., p. 71, pl. 7, figs. 1a-c, 2.
Atrypa desquamata Sowerby, p. 72, pl. 7, figs. 3a-c, 4a-b.
Atrypa sp., p. 73, pl. 7, fig. 5.
Schizophoria striatula Schloth., pl. 73, pl. 7, fig. 6.
Pugnax pugnus Martin, p. 74, text-figure.
Spirifer sp., p. 75, pl. 7, fig. 7.

Prendergast, Kathleen L., 1935:

Camarotoechia pleurodon Phillips, pp. 19-20, text-fig. 4.

Coleman, P. J., 1951:

Atrypa reticularis teicherti Coleman 1951, p. 681, pl. 100, figs. 1-10.
Atrypa multimoda Coleman 1951, p. 682, pl. 100, figs. 11-18.
Atrypa desquamata kimberleyensis Coleman 1951, p. 683, pl. 101, figs. 7-19.
Atrypa aspera prideri Coleman 1951, p. 684, pl. 102, figs. 1-17.
Atrypa parva Coleman 1951, p. 685, pl. 102, figs. 18-29.
Atrypa n.sp., p. 687, pl. 102, figs. 30-32.

Although both Hosking and Coleman failed to list synonyms, synonymies are apparent from comparison of published illustrations.

Atrypa reticularis Linnaeus *in* Foord 1890 = *Atrypa reticularis teicherti* Coleman 1951.

Atrypa aspera Schloth. *in* Hosking 1933 = *Atrypa aspera prideri* Coleman 1951.

Atrypa desquamata Sowerby *in* Hosking 1933 = *Atrypa desquamata kimberleyensis* Coleman 1951.

Reference to the illustrations of "*Spirifera?*" in Foord (1890), *Atrypa* sp., *Pugnax pugnus* (illustrated by serial sections only), and *Spirifer* sp. in Hosking (1933), and *Camarotoechia pleurodon* (illustrated by serial sections only) in Prendergast (1935) reveals that these forms are indeterminate.

If synonymous and indeterminate species are taken into account, only nine described and illustrated valid species remain.

FOSSIL ZONES IN THE DEVONIAN ROCKS OF THE FITZROY BASIN

At least twelve fossil zones are recognizable in the Devonian rocks of the Fitzroy Basin: ten of these are in the Upper Devonian, and two in the Middle Devonian. Six zones are based on the distribution of brachiopods described and identified in this bulletin; one of the brachiopod zones, the *proteus* zone, corresponds with the "*Productella*" zone of Teichert (1943, 1949), and the *torrida* and the *saltica* zones correspond with the other brachiopod zone recognized by Teichert, the "*Atrypa*" zone. The five goniatite zones are those of Teichert (1943, 1949) as also is the *Amphipora ramosa* zone,* based on the range of the stromatoporoid *Amphipora ramosa*.

Brief descriptions of the zones and their faunas follow. The ranges of important species are given in Table 1, and the relationships between formations and fossil zones in figure 3 (p. 24). Brachiopod localities are referred to in the text by the original field locality number. Descriptions of localities are given on p. 152.

Zone of Stringocephalus fontanus.

Stringocephalus sp., *Spongophyllum?* sp., and "*Disphyllum depressum* or *Temnophyllum* sp." are recorded by Hill (1954, pp. 21, 22, 29) from near the base of the Pillara Formation about 0.8 miles north-west of Mountain Home Spring in the Home Range. Though not associated with these fossils, *Aulopora* cf. *foordi* (Hill, p. 35) occurs also in the same area at roughly the same horizon. The *Stringocephalus* is *S. fontanus* sp. nov.

* This term is synonymous with Teichert's "*Amphipora*" zone, but as in this case "*Amphipora*" is a misnomer—according to Teichert (1949), the genus *Amphipora* is also present in higher zones—the more restrictive term "*ramosa* zone" is preferable.

Table 1. Ranges of species in the Devonian rocks of the Fitzroy Basin

GIVETIAN	FRASNIAN	FAMENNIAN	CORRELATION WITH EUROPEAN DEVONIAN
			ZONES / FOSSIL SPECIES
Stringocephalus fontanus	*Amphipora ramosa*		Stringocephalus fontanus (3), Spongophyllum? sp.(2), Disphyllum depressum or Temnophyllum sp.(2)
			Aulopora cf. foordi (2)
			Amphipora ramosa (1), Hexagonaria brevilamellata (2)
			Alveolites tumidus (2)
			Disphyllum sp.(2)
			Phillipsastrea delicatula (2)
			Barrandeophyllum rubrum (2)
			Hexagonaria hullensis (2), Disphyllum depressum (2)
			Disphyllum virgatum (2)
			D.virgatum var. densum (2)
			D. curtum (2)
			Atrypa desquamata kimberleyensis (3)
			Tingella suchana (3)
			Thamnopora angusta, T. boloniensis (2)
	Crurithyris apena		Crurithyris apena (3),cf. Koenenites cooperi (1), Manticoceras cf. regulare (1)
			Hypothyridina margarita (3)
	Ladjia saltica		Ladjia saltica (3)
			Douvillina exquisita (3)
			Uncinulus wolmericus (3)
			Beloceras, etc. (1)
			Schizophoria stainbrooki (3)
			Fitzroyella primula (3)
			Nervostrophia bunapica (3)
			Devonoproductus australis (3)
			Teichertina fitzroyensis (3)
	Emanuella torrida		Emanuella torrida, Plicochonetes macropatus, Kayserella emanuelensis (3)
			Uncinulus arefactus (3)
			Wadeoceras australe (1)
			Athyris oscarensis (3)
	"Cheiloceras"		Cheiloceras, etc. (1)
			Michelinoceras cf. schlotheimi (1)
		Nyege scopimus	Nyege scopimus, Pugnax hullensis (3), Cystiphyllum kimberleyense, etc. (2)
		"Sporadoceras"	Sporadoceras cf. latilobatum (1)
			Sp. cf. posthumum(1)
			Schizophoria pierrensis & Rhipidomella incompta (3)
		Avonia proteus	Avonia proteus and other brachiopods (3), Catactotoechus tenuis (2)
			Cayutoceras inequiseptatum (1)

Notes: 1. Numbers in brackets following names of species refer to the following papers:

(1) Teichert, 1949.
(2) Hill, 1954.
(3) This bulletin.

Notes: 2. ——— accurate range.
– – – approximate range.
—?—?— probable range.

Teichert (1949, table 1) noted that *Amphipora ramosa* makes its first appearance south-east of the Margaret River 150 to 250 feet above the Precambrian in the Pillara Formation; accordingly a distinct zone beneath the *ramosa* zone, tentatively termed the *Stringocephalus fontanus* zone, may be indicated by the fossils mentioned above. At present this zone is known only from the Mountain Home Spring area.

Zone of Amphipora ramosa.

Amphipora ramosa in the Devonian rocks of the Fitzroy Basin was first identified by Ripper (1937). It is widespread in the area and is associated with the following forms:—

Corals (in Hill, 1939 and 1954):

Hexagonaria brevilamellata (Hill) 1936.
H. hullensis Hill 1954.
Disphyllum depressum (Hinde) 1890.
D. virgatum (Hinde) 1890.
D. virgatum var. *densum* Hill 1954.
D. curtum Hill 1954.
D. sp.
Temnophyllum sp.
T.? turbinatum Hill 1954.
T.? floriforme Hill 1954.
Thamnopora angusta Lecompte 1939.
T. boloniensis (Gosselet).
Alveolites tumidus (Hinde) 1890.
A. suborbicularis Lamarck.
Phillipsastrea delicatula Hill 1936.
Barrandeophyllum rubrum (Hill) 1939.
B. sp.

Brachiopods:

Tingella suchana sp. nov.
Atrypa desquamata kimberleyensis Coleman 1951.

The stratigraphical ranges of most of the corals are difficult, and in some cases impossible, to determine owing to the loss of field locality notes in the Bureau fire of 1953. Also, Hill (1954) used the stratigraphical scheme current in 1954, which has since been modified. According to this scheme, a stratigraphical division called the " Pillara Limestone " was capable of subdivision into lower and upper parts by the occurrence of the goniatite genus *Manticoceras*. The distribution of this genus shows that the Pillara Formation of Guppy et al. (1958) corresponds in general terms to the lower part of the " Pillara Limestone ". Since in most areas the Pillara Formation contains *Amphipora ramosa* throughout the greater part of its thickness, it is the coral assemblage of the lower part of the " Pillara Limestone " which is listed above.

On the evidence available at present it appears that only a few of these coral species range above the *ramosa* zone. *Thamnopora angusta* and *T. boloniensis* have been shown by a re-assessment of the stratigraphy to range into a higher zone in the Sadler Formation, *Phillipsastrea delicatula* occurs also at an unknown horizon in the type section of the Napier Formation, and *Barrandeophyllum rubrum* probably occurs also in the " *Sporadoceras* " zone.

The two occurrences of *Tingella suchana* are only 15 miles apart: Menyous Gap, 1,150 feet above the base of the type section of the Pillara Formation, and Gap Creek Gap, 130 feet above the base of a measured section (DMP 2). The considerable difference in the stratigraphical level of *T. suchana,* and the difference in the total measured thickness of the formation in both places—1,400 feet at Menyous Gap, barely 500 feet at Gap Creek Gap—suggest that the lower half or more (probably 1,000 feet) of the Pillara Formation is missing at Gap Creek Gap. *Atrypa desquamata kimberleyensis* ranges above into several zones.

Except for the long-ranging brachiopod and corals, fossils of the *ramosa* zone have been recognized only in the Pillara Formation, which everywhere rests direct on pre-Devonian rocks: on the Ordovician of the Prices Creek area, and on Precambrian

elsewhere. Its outcrop stretches with few breaks from the Old Bohemia area in the south-east to Napier Downs in the north-west, a distance of 150 miles. In most areas the lower part of the formation consists of a variable thickness of clastic material—calcarenite, calcilutite, and an occasional bed of quartz sandstone—whereas the upper part is pure biostromal limestone with initial bedding dips as high as 30°. To understand parts of Guppy et al. (1958) and Teichert (1949) it is necessary to realize that the thicknesses of the Pillara Formation given in these papers are cumulative, measured at right-angles to the initial bedding-planes, and are not necessarily the same as the stratigraphical thickness of the sedimentary pile. Thicknesses of the Pillara Formation given here in reference to fossil localities are taken from Guppy et al. and hence are cumulative. Newell et al. (1953, p. 106, fig. 53) discuss the possibility of upward, horizontal, or obliquely upward growth in organic reefs and associated deposits.

In the Pillara Formation the thickness of the basal clastic rocks ranges from 100 feet south-east of the Fitzroy River to a maximum recorded thickness of nearly 500 feet in Windjana Gorge in the Napier Range. Such differences in thickness might imply that the deposition at the base of the Pillara Formation was diachronous, but this viewpoint could only be tested by detailed systematic work on the stromatoporoids which are almost ubiquitous throughout the formation. Only *Amphipora ramosa* has been identified, and the great number of remaining undescribed stromatoporoids in the Pillara Formation remains a cardinal gap in Fitzroy Basin palaeontology. The only palaeontological evidence at present adducible for the idea of diachronous deposition is the apparently restricted geographical range of *Stringocephalus fontanus*. If this species is widespread in the Pillara Formation it is surely odd that such a conspicuously large form has been overlooked in all areas but the Home Range. The range of *Stringocephalus fontanus* will doubtless be tested by future work, but it seems reasonable at present to assume that deposition during *Stringocephalus fontanus*-zone time was confined to the Home Range area, or to the area south and east of the Fitzroy River.

The upper limit of the range of *Amphipora ramosa* and its associate *Hexagonaria brevilamellata* has so far been found always in the upper half of the Pillara Formation. Nevertheless, the upper limit of the formation is probably diachronous. In section DMP2–DD1 in the Emanuel Range the transitional contact between the Pillara Formation and the overlying Sadler Formation implies that here the deposition of the two formations was essentially continuous. Added to this physical union is the uninterrupted occurrence in both formations of the brachiopod *Ladjia saltica* gen. et sp. nov., which by virtue of its restricted range in this and other sections lends its name to the *saltica* zone, separated from the *ramosa* zone by the intervening *apena* zone. The zones do not overlap in this section, since *Amphipora ramosa* appears to have its upper limit considerably lower in DMP2 than the first appearance of *L. saltica*. Further indications of *saltica*-zone fossils in the Pillara Formation are found in the Oscar Range area (O/67, O/76) and probably in the type section in Menyous Gap at a level 1,150 feet above the base, and probably also at 300 feet above the base of a measured section (DMP5) in the Napier Range.

In another area, Bugle Gap, the Sadler Formation containing *apena*-zone fossils directly overlies the Pillara Formation, the top of which is therefore equivalent in age to the *ramosa* zone, or older. The top of the Pillara Formation may therefore be regarded as diachronous, with a probable age range equivalent to *ramosa* zone to *saltica* zone.

North-west of the Fitzroy River the Pillara Formation is overlain, in some parts unconformably, in others conformably, by various formations which contain fossils from several Upper Devonian zones, from the lowermost to the uppermost. On the one hand, at certain localities in the Napier and Oscar Ranges, the Napier Formation and the Oscar Formation (overlying the Pillara Formation) contain fossil indices of undifferentiated *apena* and *saltica* zones; in other localities the overlying Oscar Formation contains the zone fossil of the *apena* zone. These occurrences show at least that in several places the top of the Pillara Formation is older than the *saltica* zone, and at other localities is older than the *apena* zone. On the other hand, fossils secured from rocks overlying the Pillara Formation in other places may indicate zones high in the Upper Devonian. For instance *Pugnax hullensis* of the *scopimus*-zone fauna is recorded from KP150 in the overlying Brooking Formation; at this and at several other localities, the age of the top of the Pillara Formation cannot be closely estimated by superposition alone.

Zone of Crurithyris apena

In the eastern wall of Bugle Gap at localities K147 and K149 (corresponding to Teichert's loc. 61) organic reef limestone (K147), included by Guppy et al. in the Sadler Formation, is overlain unconformably by strata (K149) with fossils of Teichert's " Upper *Manticoceras* " zone. The organic reef limestone contains a small brachiopod assemblage of *Hypothyridina margarita* sp. nov., *Atrypa desquamata kimberleyensis* Coleman 1951 and *Crurithyris apena* sp. nov. According to Guppy et al. the underlying rock is part of the Pillara Formation. This brachiopod assemblage appears again in the eastern wall of Bugle Gap at K103 (corresponding to Teichert's loc. 62), and at G23, in the Long's Well area.

The stratigraphical position of the zone defined by the range of *Crurithyris apena* can be placed exactly only with respect to its upper limit, that is, beneath the " Upper *Manticoceras* " zone. The position of the brachiopodal limestone above what is presumably the Pillara Formation suggests either that the *apena* zone lies between the " Upper *Manticoceras* " zone and the *ramosa* zone, or that the *apena* zone partly coincides with the upper part of the *ramosa* zone. Since *Amphipora ramosa* is absent from the brachiopodal limestone and probably occurs in the underlying Pillara Formation, the *apena* zone more probably lies between the *ramosa* zone and the " Upper *Manticoceras* " zone.

If future work confirms this view, the *apena* zone will correspond roughly with Teichert's " Lower *Manticoceras* " zone, which is based on the occurrence of the species *Koenenites* cf. *cooperi* and *Manticoceras* cf. *regulare* in part of the Gogo Formation in the Long's Well/No. 10 Bore area (Teichert, loc. 56).

Crurithyris apena has been found in the Bugle Gap area near Long's Well, and in the Oscar Range area; so far as is known it does not extend into the adjoining zones, although its associates do. *Hypothyridina margarita* occurs also in the *saltica* zone and in the " Upper *Manticoceras* " zone in the Emanuel Range. *Atrypa desquamata kimberleyensis* ranges throughout most of the zones.

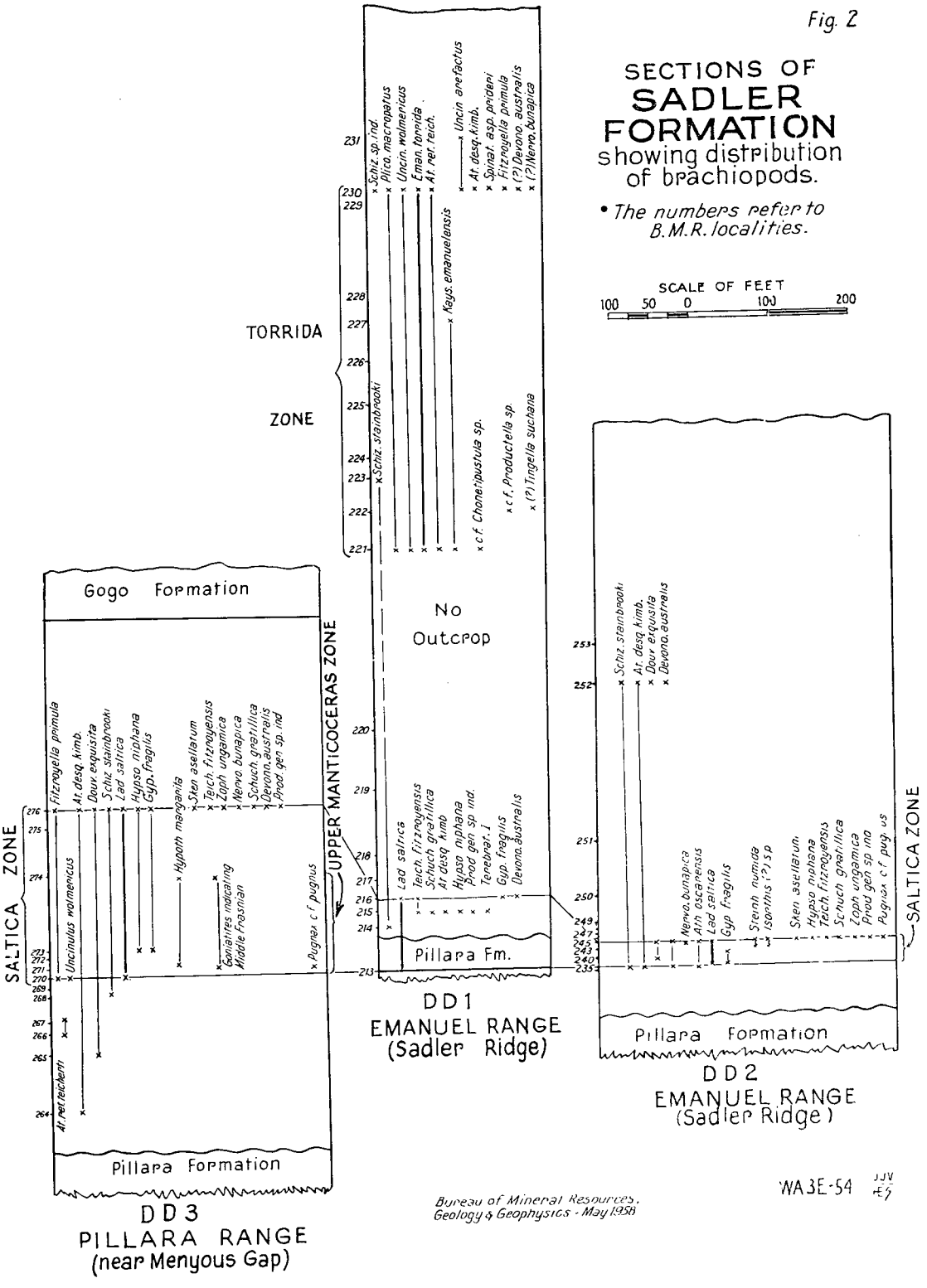
Zone of Ladjia saltica.

The *saltica* zone is based on the ranges of several species of brachiopods. Reference to table 1 and text-figure 2 reveals the profusion of species present in this zone and their close correspondence in range.

Fig. 2

SECTIONS OF SADLER FORMATION showing distribution of brachiopods.

• The numbers refer to B.M.R. localities.



DD3
PILLARA RANGE
(near Menyous Gap)

DD1
EMANUEL RANGE
(Sadler Ridge)

DD2
EMANUEL RANGE
(Sadler Ridge)

Bureau of Mineral Resources, Geology & Geophysics - May 1958

WA3E-54

The list of corals and brachiopods from this zone is as follows:—

Corals (Hill, 1954):

Disphyllum goldfussi (Geinitz).
D. sp. (*D. virgatum* (Hinde) var?).
D. intertextum Hill 1954.
Peneckiella teicherti Hill 1954.
Thamnopora boloniensis (Gosselet).
Thamnopora angusta Lecompte.
Catactotoechus obliquus Hill 1954.
Barrandeophyllum sp.
Zaphrentoides ? excavatus Hill 1954.

Brachiopods:

Skenidium asellatum sp. nov.
Teichertina fitzroyensis gen., et sp. nov.
Schizophoria stainbrooki sp. nov.
Hypsomyonia niphana sp. nov.
Douvillina exquisita sp. nov.
Zophostrophia ungamica sp. nov.
Nervostrophia bunapica sp. nov.
Fitzroyella primula gen. et sp. nov.
Hypothyridina margarita sp. nov.
Pugnax cf. *pugnus*
Ladjia saltica gen. et sp. nov.
Schuchertella gratillica sp. nov.
Gypidula fragilis sp. nov.
Devonoproductus australis sp. nov.
Steinhagella numida sp. nov.
Atrypa desquamata kimberleyensis Coleman 1951.
Uncinulus wolmericus sp. nov.
Athyris oscarensis sp. nov.
Productidae gen. et sp. ind.
Isorthis (?) sp.
Terebratulacea gen. et sp. ind. I.

Several species of ribbed spiriferids are also present; these are being described by Mr. G. A. Thomas.

As in the *ramosa* zone, stromatoporoids are numerous and fairly widely distributed, but no detail is known either of their systematics or of their stratigraphical distribution.

Presumably occurring in this zone is the pelecypod *Conocardium gogoense* Fletcher 1943, described from the "*Atrypa* limestone" on "Gogo Station, Kimberley Division, S.S.W. of No. 10 Bore, about one-third of a mile off the limestone escarpment, Western Australia" (Fletcher, 1943, p. 239). Another species possibly within the zone is the sponge *Sphaerospongia teicherti* Howell 1956, from the Napier Formation of Napier Range.

The corals *Thamnopora boloniensis, T. angusta,* and *Disphyllum goldfussi* are also found in the *ramosa* zone, and *Barrandeophyllum* sp. is found in higher zones of the Upper Devonian. Again it is difficult to determine the exact localities of the corals described by Hill (1954) and it is possible that some of the corals listed above may also occur in the overlying *torrida* zone.

The distribution of brachiopods in the *saltica* zone and in the *torrida* zone in the Emanuel Range is shown in figure 2. Although rock outcrop throughout the three sections of the Sadler Formation illustrated in figure 2 is virtually continuous, most of the brachiopods occur together in coquinoid beds and the strata between these beds are relatively or entirely barren. This somewhat discontinuous distribution of brachiopods prevents accurate delimitation of zonal boundaries. For this reason the correlation lines in figure 2 are intended as guides rather than as rigid barriers.

The partial coincidence of the lower half of the *saltica* zone and Teichert's "Upper *Manticoceras*" zone follows from the occurrence together in DD3 of a goniatite member of Teichert's zone (determined in unpublished MS by Dr. B. F. Glenister as *Ponticeras* sp.) and several *saltica*-zone fossils including *L. saltica* itself.

The lower limit in range of the goniatite is K271 and that of *L. saltica* is K270, but whereas the goniatite occurs no higher than K274, *L. saltica* ranges higher to K276, where the greatest number of brachiopod species in this section occurs. Important species such as *Skenidium asellatum* and *Teichertina fitzroyensis* occur above the goniatite and more refined work in the future may lead to the separation of a new zone roughly equivalent to the upper part of the *saltica* zone.

Atrypa desquamata kimberleyensis, Douvillina exquisita, and *Schizophoria stainbrooki* all range below the *saltica* zone in DD3 and range above it in DD2. *Fitzroyella primula, Uncinulus wolmericus, Atrypa desquamata kimberleyensis, Schizophoria stainbrooki, Devonoproductus australis* and possibly *Nervostrophia bunapica* all occur also in the *torrida* zone, and, as noted earlier, *Hypothyridina margarita* occurs also in the *apena* zone.

The fauna from T53 in the Emanuel Range, included by Teichert in the "*Atrypa*" zone, contains *Teichertina fitzroyensis* and other species characteristic of the *saltica* zone.

In the Pillara Formation *saltica*-zone fossils occur in Emanuel Range and in the Oscar Range area. These fossils are also met with in the Oscar area in the beds transitional between the Pillara and Napier Formations.

The Sadler Formation bears *saltica*-zone fossils in the Emanuel and Pillara Ranges. Part of this zone is probably represented at K126 by *Uncinulus wolmericus* in association with goniatites of the "Upper *Manticoceras*" zone (determined in MS by Dr. B. F. Glenister). This locality, in the Old Bohemia area, is included in the Gogo Formation.

Another locality of the "Upper *Manticoceras*" zone is in the Sadler Formation near Menyous Gap (DD3). This zone is also represented, as seen earlier, by the rich goniatite- and trilobite-bearing beds unconformably overlying organic reef limestone of the *apena* zone at K149 in Bugle Gap. These beds, placed by Guppy et al. in the Virgin Hills Formation, may instead belong (as the fossils suggest) to part of the Gogo Formation.

In the Burramundi Range area (T9), the *saltica* zone, probably in the Fossil Downs Formation, is represented by a fauna containing *Uncinulus wolmericus.* Further reference to T9 is given on p. 26.

Illustrations of conodonts occurring in the "*Manticoceras*" and "*Sporadoceras*" zones appear in Müller (1956, pl. 145, figures 2, 4, 14, 18).

Zone of Emanuella torrida.

A second brachiopod-rich fossil bed occurs in the upper part of the type section of the Sadler Formation. Several brachiopod species range down from this band into the *saltica* zone, but the restriction of *Emanuella torrida, Plicochonetes macropatus* and *Kayserella emanuelensis* to the upper part of the section allows the recognition of a zone tentatively termed the *torrida* zone. These three species have been recorded from only one area (on Sadler Ridge in the Emanuel Range) and their stratigraphical ranges cannot therefore be tested; hence, the validity of the zone must remain in question. *Uncinulus wolmericus,* whose range embraces the *saltica* and *torrida* zones, occurs also at Ld8 in the Oscar area.

The *torrida* zone and the *saltica* zone together almost coincide with Teichert's "*Atrypa*" zone.

The list of *torrida*-zone fossils includes only brachiopods; several coral species are also present, but although some almost certainly appear in Hill (1954), it is not possible without exact knowledge of the localities to assign coral species to the zone.

Species recorded from the *torrida* zone are—

Emanuella torrida sp. nov.
Plicochonetes macropatus sp. nov.
Kayserella emanuelensis sp. nov.
Atrypa reticularis teicherti Coleman 1951
A. desquamata kimberleyensis Coleman 1951
Uncinulus arefactus sp. nov.
Uncinulus wolmericus sp. nov.
Schizophoria stainbrooki sp. nov.
Schizophoria sp. ind.
Spinatrypa aspera prideri (Coleman) 1951
Fitzroyella primula gen. et sp. nov.
Devonoproductus australis sp. nov.
(?) *Nervostrophia bunapica* sp. nov.
cf. *Chonetipustula* sp.
cf. *Productella* sp.
cf. *Tingella suchana* sp. nov.

Of these sixteen forms, ten range into other zones. *Atrypa reticularis teicherti* is also recorded from strata just beneath the *saltica* zone near Menyous Gap and probably occurs in the *saltica* zone in the southern part of the Old Bohemia area. *A. desquamata kimberleyensis* has been found also in the *ramosa* zone in the Napier Range, in the *apena* zone of Bugle Gap, and in the *saltica* zone in the Emanuel and Pillara Ranges. *Uncinulus arefactus* occurs also in the *proteus* zone in the Napier Range, and *U. wolmericus* is also a member of the *saltica* zone in Bugle Gap, in the southern part of the Old Bohemia area, and near Menyous Gap. *Schizophoria stainbrooki* is represented by numerous individuals in the *saltica* zone in Emanuel Range and near Menyous Gap and is probably represented further in the *proteus* zone near the Burramundi Range. *Spinatrypa aspera prideri* may be also a member of a higher zone (probably the *proteus* zone) and *Fitzroyella primula, Devonoproductus australis* and *Nervostrophia bunapica* are found also in the *saltica* zone in the Emanuel Range. Finally, *Tingella suchana* is also recorded from the lower part of the *ramosa* zone in Gap Creek Gap.

Spinatrypa aspera prideri, Tingella suchana and *Nervostrophia bunapica* are poorly preserved in this zone and further collecting may show that distinct species are present. Even so, many species in the *torrida* zone have wide ranges, and the zone cannot be easily identified.

So far fossils of the *torrida* zone have been found only in the type section of the Sadler Formation.

Zone of " Cheiloceras "

The " *Cheiloceras* " zone of Teichert (1949, pp. 19, 20, 36–38) is based on a cephalopod fauna contained in rocks of the Needle-eye Rocks—Mt. Pierre area, in the Virgin Hills, and in the Old Bohemia area.

The " *Cheiloceras* " zone is almost certainly represented in some areas by the lower and middle parts of the Virgin Hills Formation. Teichert's description of the lithology and areal distribution of the *Cheiloceras*-bearing beds agrees closely with the description by Guppy et al. of the Virgin Hills Formation, and goniatities in the Virgin Hills Formation in the Old Bohemia area (at K116 in section DP2) have been determined in the field as *Cheiloceras*. Section DP2 is especially rich in goniatites, and future work directed at establishing the relationships between zones in this area should hold great promise.

Brachiopods have not yet been found in association with *Cheiloceras*.

The "Lower and Upper Sporadoceras *" zones*

Rocks of Teichert's lower and upper "*Sporadoceras*" zones are really more widespread and faunally less monotonous than those of the "*Cheiloceras*" zone. Teichert recognized fossils of these zones in the Needle-eye Rocks/Mt. Pierre area, the western part of the Pillara Range, the Virgin Hills, near Old Bohemia Homestead, and in the area south-west of Bugle Gap.

Teichert recognized 84 forms in these rocks, but only a few of these have been described. Hill's bulletin has added to the number of described corals, and although separate coral zones may be proposed when details of localities become better known, these corals are for the time being included in Teichert's "*Sporadoceras*" zone. The list of described fossils is as follows:—

Corals (*in* Hill, 1954):

"*Cystiphyllum*" (sic) *kimberleyense* Hill 1936
Barrandeophyllum cavum Hill 1954
B. rubrum Hill 1939
B. sp.
Phillipsastrea sp.
Caninia rudis Hill 1954
Aulopora recta Hill 1954

Cephalopods (*in* Delépine 1935).

Sporadoceras contiguum (Munster)
Tornoceras sp. nov
Dimeroceras clarkei Delépine 1935
Pseudoclymenia australis Delépine 1935

(*in* Teichert, 1939):

Wadeoceras australe Teichert 1939
Michelinoceras cf. *schlotheimi* (Steininger)
Galtoceras kimberleyense Teichert 1939

(*in* Teichert, 1949):

Sporadoceras spp.

Spones (*in* Howell, 1952):

Australospongia turbinata Howell 1952
A. cylindrica Howell 1952
Aulocopides patulum Howell 1952
A. teicherti Howell 1952

As may be inferred from the names of the zones, species of the goniatite *Sporadoceras* are most useful as indices: *Sporadoceras* cf. *latilobatum* is characteristic of the lower zone, *S.* cf. *posthumum* of the upper zone.

Barrandeophyllum rubrum probably occurs also in the *ramosa* zone in the Pillara Range. *Wadeoceras australe* occurs also in the "Upper *Manticoceras*" zone and in the "*Cheiloceras*" zone, and *Michelinoceras* cf. *schlotheimi* is also found in the "*Cheiloceras*" zone.

The relationship between these zones and rock formations is discussed under the next heading.

Zone of Nyege scopimus

The brachiopod *Nyege scopimus* gen. et sp. nov. occurs with *Sporadoceras* cf. *latilobatum* in the Virgin Hills Formation (T19, T39, T40, T42) in the Needle-eye Rocks area, and in the Virgin Hills; it is associated also with *Sporadoceras* cf. *posthumum* at T18 in the Virgin Hills Formation of the Needle-eye Rocks area. Although *N. scopimus* is thus associated with both upper and lower "*Sporadoceras*"-zone fossils, it remains a very important index fossil occurring throughout wide areas, commonly in limestones otherwise lacking fossils. Here *N. scopimus* usually occurs

in coquinite consisting of little else except entire shells of this species. The resulting rock-type is a remarkably pure recrystallized limestone in which each specimen of *N. scopimus* is so recrystallized that internal structures are commonly obliterated or at best barely observable. Only in one locality is *N. scopimus* known to be associated with another brachiopod: that is at T69 where it occurs with *Pugnax hullensis* sp. nov.

Rocks with fossils of the two "*Sporadoceras*" zones and the *scopimus* zone are variable in lithology, and several different formations are recognizable.

In the south-eastern wall of Bugle Gap in the type section (DB1) of the Bugle Gap Limestone, *N. scopimus* is found in the uppermost beds of the Virgin Hills Formation and in the lower half of the Bugle Gap Limestone. The Virgin Hills Formation consists here of grey to reddish-brown calcareous siltstone and sandstone in uniformly thin beds. It is overlain by the thick beds of limestone, probably recrystallized calcarenite, of the Bugle Gap Limestone. In this section the uppermost beds of the Bugle Gap Limestone contain brachiopods indicative of the *proteus* zone.

A similar set of rocks is present in section DP2 in the southern part of the Old Bohemia area. The upper part of the Virgin Hills Formation is rich in goniatites, as yet not determined, and *N. scopimus* occurs in the uppermost beds. Determinable fossils were not found in the Bugle Gap Limestone, which in this section does not extend upwards into the *proteus* zone as it does in DB1, but presumably stops in the "Upper *Sporadoceras*" zone, to be succeeded by the Fairfield Beds with *proteus*-zone fossils.

In the Mount Pierre area fossils of the "*Sporadoceras*" zones and the *scopimus* zone are contained in the Virgin Hills Formation with a lithology of red sandstone, calcarenite, and small organic reefs.

The occurrence of *Pugnax hullensis* in the Fossil Downs Formation in the Hull Range (at K356) may indicate the *scopimus* zone. North-west of the Fitzroy River at KP150 in the Brooking Gap section through the Brooking Formation, *Pugnax hullensis* again occurs and probably indicates the *scopimus* zone.

That parts of the Napier Formation are in the *scopimus* zone is shown by the occurrence of *N. scopimus* at KP72, KP141, Ld16, Ld17, Ld20, Ld27, and Ld30, and by the occurrence of *Pugnax hullensis* at KP106. The probable occurrence of *Michelinoceras* cf. *schlotheimi* in the Barker Gorge section of the Napier Formation (Teichert, 1939, p. 110) denotes either the "*Cheiloceras*" zone or the "*Sporadoceras*" zone.

Zone of Avonia proteus.

The *proteus* zone, the uppermost zone so far recognized in the Fitzroy Devonian rocks, is characterized by a fossil assemblage of brachiopods, corals, and cephalopods. The zone is named after a widespread brachiopod, Teichert's "*Productella*", identified here as *Avonia proteus* sp. nov. Accordingly, Teichert's zone, the "*Productella*" zone, is better termed the *proteus* zone.

The following forms are known from this zone:—

Corals (*in* Hill, 1954):

Catactotoechus irregularis Hill 1954
C. tenuis Hill 1954
Zaphrentis iocosa Hill 1954.

Nautiloids (*in* Teichert 1939, and Teichert & Glenister, 1952, p. 737):

Cayutoceras inequiseptatum (Teichert) 1939

(?) *Conostichoceras hardmani* (Etheridge) 1897

Brachiopods:

Avonia proteus sp. nov.
Camarotoechia lucida sp. nov.
Schuchertella dromeda sp. nov.
Leptaena sp. ind.
Schizophoria apiculata sp. nov.
S. pierrensis sp. nov.
Rhipidomella incompta sp. nov.
Athyris oscarensis sp. nov.
Meristella(?) *caprina* sp. nov.
Uncinulus arefactus sp. nov.

The several species of ribbed spiriferids in this zone are being studied by Mr. G. A. Thomas.

Some poorly preserved specimens are tentatively referred to *Schizophoria stainbrooki* and *Atrypa desquamata kimberleyensis,* both of which occur extensively in lower zones. *Athyris oscarensis* occurs also in the *saltica* zone and *Uncinulus arefactus* in the *torrida* zone. *Schizophoria pierrensis* probably ranges into the *scopimus* zone (K166).

Hill's three coral species and Teichert's nautiloid are known only from the *proteus* zone. *Conostichoceras hardmani,* determined from only a single specimen from " Lennard River ", must be collected again for its zonal position to be certain.

The characteristic lithology of strata in this zone is shown by the widespread Fairfield Beds, found in discontinuous outcrop from the Old Bohemia area in the south-eastern part of the Fitzroy Basin to Napier Downs in the north-west. Interbedded calcareous siltstone, crinoidal calcarenite, limestone breccia, and quartz sandstone contrast notably with sediments of underlying formations. The *proteus* zone is not everywhere within the Fairfield Beds, although so far the converse, that the Fairfield Beds are everywhere within the *proteus* zone, is found to be true. If further work confirms this relationship, the Fairfield Beds will be one of the few Devonian formations in the Fitzroy Basin which are not markedly diachronous.

In the south-eastern wall of Bugle Gap in the type section of the Bugle Gap Limestone, the Limestone extends without apparent break through the *scopimus* zone into the *proteus* zone. Six miles away, in a section (DP2) in the southern part of the Old Bohemia area, siltstone and calcarenite of the Fairfield Beds contain the same species of brachiopods found in the uppermost 200 feet of the Bugle Gap Limestone in DB1, signifying either that *proteus*-zone fossils range across the boundary between the Bugle Gap Limestone and the Fairfield Beds, or that this boundary is diachronous.

A second example of the variable lithology met with in the *proteus* zone is found in the Geikie Range. The highest exposed beds in a section (DS2) through the Geikie Formation are part of the *proteus* zone indicated by the zone index. Here the monotonously uniform rock in a section 700 feet thick is thickly bedded calcarenite easily distinguishable from the calcareous siltstone and crinoidal calcarenite of the partly coeval Fairfield Beds. Other fossiliferous exposures in the *proteus* zone are:

1. Top of Mt. Pierre: The lower part of the *proteus* zone is indicated in the Fairfield Beds at the top of Mt. Pierre by a brachiopod fauna including *Schizophoria pierrensis* and *Schuchertella dromeda.* The former species probably ranges through into the *proteus* zone from the underlying *scopimus* zone, but *Schuchertella dromeda* is everywhere restricted to the *proteus* zone.

2. South of the Burramundi Range: The most north-easterly outcrops of the Fairfield Beds are found in the area south of the Burramundi Range, where section DF2 was measured. Only the basal 200 feet of the 600-foot-thick section are fossiliferous. The *proteus* zone in these fossiliferous beds (K288 to K292 incl.) is represented by five forms, *Avonia proteus, Camarotoechia lucida, Athyris oscarensis,* a form similar to if not identical with *Schizophoria stainbrooki,* and doubtfully *Atrypa desquamata kimberleyensis.*

3. Fossil Hill area: Teichert's localities in the Fossil Downs Formation at the top of Fossil Hill (T12) and two miles north-north-west of Fossil Hill (T11) both contain *Avonia proteus.* At T11 the brachiopod is associated with a form identified by Teichert as *Cyrtoclymenia.*

Five miles south-west of Fossil Hill the *proteus* zone is found again at S-Hill (T27). Here Teichert collected the index fossil and *Leptaena* sp. ind. from a horizon 156 feet above the base of the Fairfield beds, and *A. proteus* alone from a horizon 187 feet above the base. From this higher horizon Teichert also collected some poorly preserved specimens of clymeniids, one of which is possibly a member of *Laevigites.*

4. Fossil Downs Homestead: The following forms are recorded from the Geikie Formation at localities K285 and T4 around the tennis court at Fossil Downs Homestead: *Schizophoria pierrensis, S.* cf. *stainbrooki, Avonia proteus, Athyris oscarensis,* and *Rhipidomella incompta.* In the same area *proteus*-zone fossils (*A. proteus, Leptaena* sp. ind., *Camarotoechia lucida, Athyris oscarensis*) are found at T5, " fossiliferous horizon north side of crest of limestone scarp north of Fossil Downs Homestead ".

5. Oscar Hill (T2, K282, K283): Oscar Hill, a flat-topped mound about 30 feet above the level of the surrounding plain and circular in plan, is situated two miles south-west of Oscar Homestead. The strata are flat-lying and display a typical Fairfield Beds lithology of interbedded calcareous siltstone and crinoidal calcarenite. An assemblage including *Schuchertella dromeda, Avonia proteus, Camarotoechia lucida,* and *Athyris oscarensis* clearly denotes the *proteus* zone. Associated with these brachiopods are the corals *Catactotoechus irregularis* and *C. tenuis* and the nautiloid *Cayutoceras inequiseptatum.* Ribbed spiriferids are particularly numerous and several forms are represented.

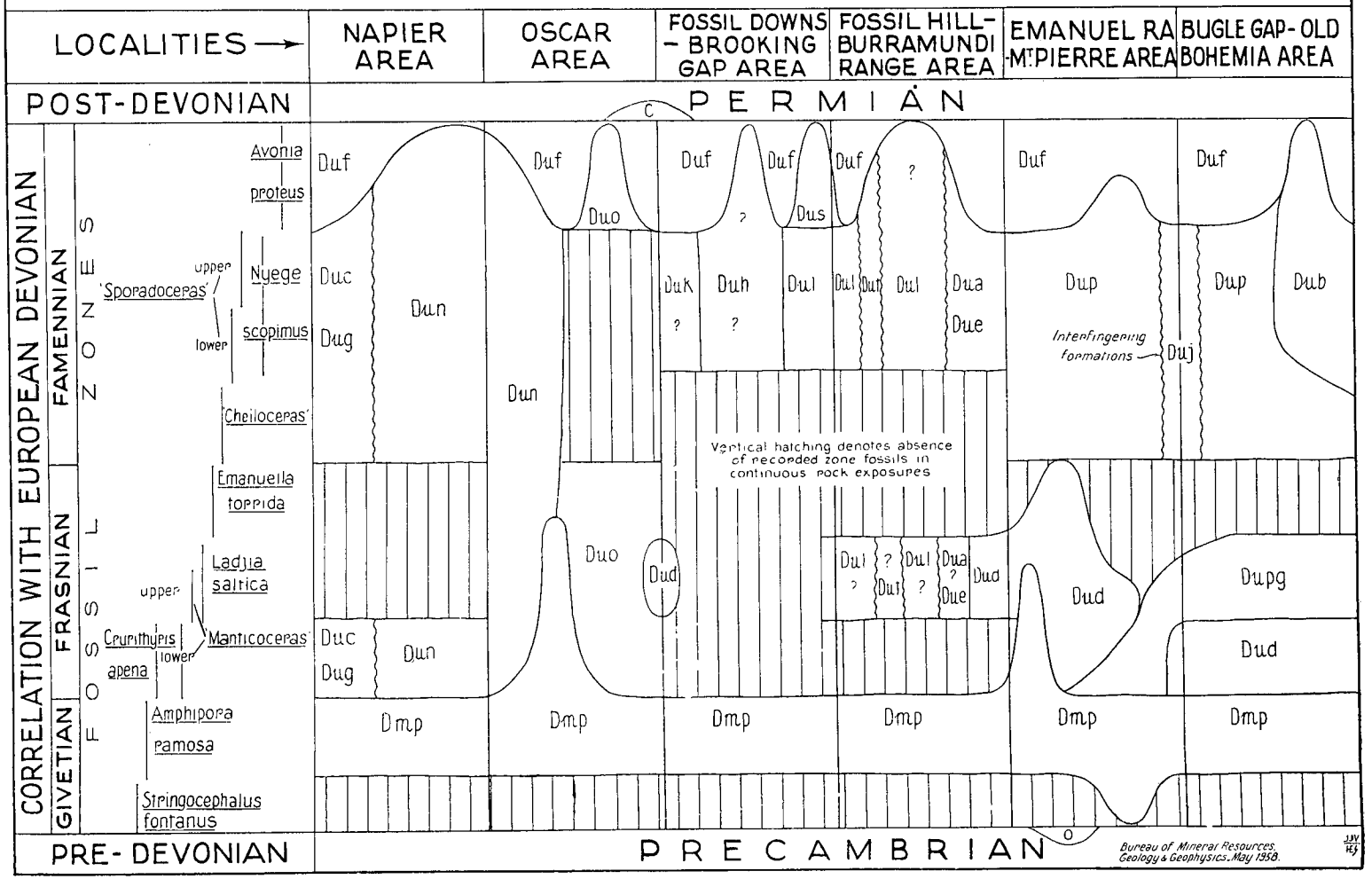
6. Fairfield Homestead: A typical *proteus*-zone assemblage comprising *Camarotoechia lucida,* (?)*Schizophoria apiculata* and (?)*Schuchertella dromeda* is found at an horizon (K551) 130 feet above the base of a section (DF8) through the Fairfield Beds one and a quarter miles north-north-east of Fairfield Homestead.

Avonia proteus, Athyris oscarensis, and *Camarotoechia lucida* are recorded from the Fairfield Beds (KP164, Ld25, Ld26) outcropping around Mt. Percy, ten miles west-south-west of Fairfield Homestead.

7. Hull Range and Burramundi Range: The *proteus* zone appears at various localities in the country between Hull Range and Burramundi Range. In the southern part of the Burramundi Range a section measured through the Fossil Downs Formation (DL2) is overlain by the Fairfield Beds (K315, K318) containing *Camarotoechia lucida.* The type section of the Fossil Downs Formation (DL1) two miles west of Mt. Elma is likewise overlain by the Fairfield Beds containing *A. proteus*

MIDDLE AND UPPER DEVONIAN FORMATIONS IN FITZROY BASIN WESTERN AUSTRALIA

Fig. 3



(K340, K341). In the thin section of the Fairfield Beds (DF3) seven miles east-north-east of Bullock Paddock Bore, Fossil Downs, the zone is represented by *Camarotoechia lucida.*

Isolated localities of the *proteus* zone in this area are K327 in the northern Hull Range, and K322, the type locality of *Schizophoria apiculata,* associated here with *Camarotoechia lucida.*

8. Station Creek, near Old Napier Downs Homestead: The most north-westerly occurrences of the zone are recorded from four of Teichert's manuscript localities, M2, M3, M8 and M9, which contain such typical forms as *A. proteus* and *Camarotoechia lucida* as well as species *Meristella*(?) *caprina,* commonly found in the Oscar Formation and Fairfield Beds in the Oscar and Napier Ranges, but apparently absent from the zone in the south-east.

9. Other localities in the Oscar and Napier Ranges: In the Oscar and Napier Ranges the *proteus* zone is recognized in the Napier Formation, in the Oscar Formation, and in the Fairfield Beds. Localities in the Napier Formation are F34, KP84, KP101, KP103, KP107, KP109, KP111, KP140, KP143 (all in Teichert MS), and W.A.Pet. numbers Ld9-11, 32, and probably Ld28; in the Fairfield Beds KP156, KP157, KP164, KP168 and KP181, and W.A.Pet. Ld25, 26; in the Oscar Formation KP149, KP167 and W.A.Pet. S4/91.

Of interest among these localities is KP103. Here *Avonia proteus* and *Camarotoechia lucida* are associated with *Uncinulus arefactus,* which is elsewhere restricted to the *torrida* zone.

Zonal equivalents of Devonian rock formations in the Fitzroy Basin (text-fig. 3)

1. Pillara Formation

At least four zones may be recognized within the Pillara Formation: the *Stringocephalus fontanus* zone; the *ramosa* zone; the *apena* zone; and the *saltica* zone. The *Stringocephalus fontanus* zone has been found only in one place, near Mountain Home Spring in the Home range, but the known areal distribution of this zone may increase when rocks beneath the *ramosa* zone are intensively sampled for fossils. The *ramosa* zone is probably present in all areas of outcropping Pillara Formation, and ranges almost throughout the greater thickness of the formation. In most areas its upper limit approaches very closely to or actually coincides with the top of the formation, but in the Emanuel and Oscar Ranges the top of the Pillara Formation grades into the *saltica* zone.

2. Sadler Formation

The *apena* zone, the *saltica* zone, the "Upper *Manticoceras*" zone, and the *torrida* zone are all present in various localities of the Sadler Formation. The *apena* zone is known from Bugle Gap and the Longs Well area; the *saltica* zone is broadly developed in the Emanuel and Pillara Ranges; the "Upper *Manticoceras*" zone has

[*Notes on text-figure* 3.—Text-figure 3, a diagram showing the relationships between zones and rock formations, was compiled from published material and from manuscripts accessible at the time of writing.

A pattern of vertical lines signifies areas in which certain zones have not yet been identified—the lines are not intended to represent a hiatus; they simply indicate that in certain areas the fossil indices of a particular zone are either absent or so far have not been discovered. For instance in the Napier area, to the writer's knowledge, fossils indicating the zones lying between the "*Cheiloceras*" zone and the *apena* zone have not been found. Accordingly this zonal gap is denoted by vertical lines.]

so far been found in this formation in one locality only, near Menyous Gap in the Pillara Range, and the *torrida* zone is restricted to Sadler Ridge. The *saltica* zone is probably present in the Sadler Formation also in the Leopold area.

3. Gogo Formation

The "Lower *Manticoceras*" zone, the "Upper *Manticoceras*" zone, and the *saltica* zone are met with in the Gogo Formation. The "Lower *Manticoceras*" zone is known from the Longs Well area (*fide* Teichert, 1949), the "Upper *Manticoceras*" zone occurs extensively in the Old Bohemia area, and the *saltica* zone is known also from this area. A remarkably strong development of the "Upper *Manticoceras*" zone takes place in what is probably a member of the Gogo Formation in Bugle Gap.

4. Virgin Hills Formation

The "*Cheiloceras*" zone, the "Upper and Lower *Sporadoceras*" zones, the *scopimus* zone and the *proteus* zone all occur within this formation.

5 Fossil Downs Formation

The only fossil recorded definitely in the Fossil Downs Formation is *Pugnax hullensis*, which on account of its association elsewhere with *Nyege scopimus* may signify the *scopimus* zone. This agrees with the estimate drawn from the order of superposition, as in many areas the Fossil Downs Formation is overlain conformably by the Fairfield Beds in the *proteus* zone. The presence of the *proteus* zone within the Fossil Downs Formation itself is suggested by some poor specimens tentatively referred to *A. proteus*, but a more definite identification is required.

The *saltica* zone is represented by a species of *Hypothyridina* (noted by Teichert, 1949, p. 29) and *Uncinulus wolmericus* in rocks exposed at T9 in the Long Hole Bore area. Guppy et al. have mapped the rocks in the Long Hole area as Fossil Downs Formation, which is characterized by limestone breccia with quartz, mica, and igneous rock fragments at the base succeeded by interbedded calcareous sandstone and siltstone, and oolitic calcarenite. Small bioherms are scattered throughout the section.

Teichert's (1949, p. 28) description of the section at T9—limestone with angular grains of feldspar succeeded by massive limestone containing small reefs—agrees closely with the Fossil Downs Formation described by Guppy et al., and since the locality is within the area of outcrop of the Fossil Downs Formation, this formation is almost certainly exposed at T9. Teichert's identification of the rocks at T9 as "*Atrypa* limestone" does not contradict the above conclusion; the stratigraphical divisions used in Teichert (1949, p. 5) "are essentially biozones comprising rocks of varying lithology. . . . Thus, *Atrypa* limestone means all the limestones of the *Atrypa* zone . . ." Confusion might arise if Teichert's special meaning of "*Atrypa* limestone" were misunderstood because, as it happens, "*Atrypa* limestone" in other areas is synonymous with Sadler Formation.

Incidentally, unless more fossils are ultimately found in the Fossil Downs Formation, its name must go down as one of the most inept in stratigraphy.

6. Bugle Gap Limestone

The lower half of the type section of the Bugle Gap Limestone corresponds to the *scopimus* zone, and the upper half to the *proteus* zone. About six miles away in the southern part of the Old Bohemia area, and connected with the type section

by an unbroken line of outcrop, the Bugle Gap Limestone—here without fossils—is overlain by the Fairfield Beds in the *proteus* zone, signifying either that *proteus*-zone fossils range across the boundary between the Bugle Gap Limestone and the Fairfield Beds, or that the boundary is diachronous.

7. Geikie Formation

The four fossil localities so far known in the Geikie Formation (K285, K506, T4, T5) contain *proteus*-zone fossils.

8. Copley Formation

Fossils are so far unknown from this formation. From field relations Guppy et al. consider that the Geikie Formation is laterally equivalent on one side to the Copley Formation and on the other to the Brooking Formation. Hence the Copley Formation is presumably equivalent in age to the *proteus* zone and possibly also to the *scopimus* zone.

9. The Brooking Formation

The only fossil recorded from the Brooking Formation is *Pugnax hullensis,* which probably indicates the *scopimus* zone.

10. Oscar Formation

The only fossil recorded in the type section of the Oscar Formation is *Pugnax* cf. *pugnus,* which ranges throughout nearly the entire Devonian section of the Fitzroy Basin.

Isolated localities in this formation have so far yielded fossils of the *proteus* zone, either the *saltica* or the *torrida* zone, or both, and the *apena* zone. Fossils representing zones lying between the *proteus* zone and the *torrida* or *saltica* zones have not yet been found.

11. Napier Formation

Various localities in the Napier Formation contain fossils of the *apena* zone, *scopimus* zone, "*Sporadoceras*" or "*Cheiloceras*" zone, and *proteus* zone. Teichert determined fossils from Barker Gorge—the type section of the Napier Formation—as probably *Michelinoceras* cf. *schlotheimi,* which ranges through the "*Cheiloceras*" and "*Sporadoceras*" zones.

12. Fairfield Beds

This formation in areas so far visited contains the *proteus*-zone assemblage only.

13. Sparke Conglomerate

According to Guppy et al. the Sparke Conglomerate is laterally equivalent to the Mt. Pierre Group. It unconformably overlies either Precambrian rocks or the Pillara Formation and in some localities either overlies or interfingers with the Virgin Hills Formation. Unless lateral equivalence between the conglomerate and the other member of the Mt. Pierre Group, the Gogo Formation, can also be demonstrated it seems best to regard the Sparke Conglomerate as roughly coeval with the Virgin Hills Formation rather than with the entire Mt. Pierre Group.

One finger of the Virgin Hills Formation extending laterally into the Sparke Conglomerate contains *Pugnax* cf. *pugnus* (K135), but this brachiopod is useless as a zonal index.

Teichert (1949, p. 38) found "*Cheiloceras*" zone goniatites in sandy beds lying between the conglomerates in the south-eastern part of the Virgin Hills.

14. Stony Creek Conglomerate, Burramundi Conglomerate, and Mt. Elma Conglomerate

These formations are interpreted by Guppy et al. as fanglomerate bodies laterally equivalent to the Fossil Downs Formation. As no fossils are known in these conglomerates, the best estimate of zonal position for these formations is the same as that for the Fossil Down Formation, that is, at least equivalent to the *scopimus* zone, and possibly also to the *saltica* zone and part of the *proteus* zone.

15. Van Emmerick Conglomerate, Behn Conglomerate

Again, fossils have not been found in these conglomerates. Guppy et al. have found that the Van Emmerick Conglomerate in part interfingers with the Napier Formation, in part is overlain by it. The Behn Conglomerate, according to the same authors, interfingers with the Napier Formation and is presumably overlain by the Fairfield Beds. Hence the age of these conglomerate formations may range from *proteus* zone to *apena* zone.

Correlation

The only assemblages of brachiopods in the Fitzroy Basin Devonian capable of close comparison with brachiopods in other parts of the world are those in the *saltica* and *torrida* zones. By contrast, brachiopods in the *proteus* zone, though reliable locally as zonal indices, are useless in extended correlation.

Brachiopods of the saltica *and* torrida *zones*

1. Comparison with the Devonian brachiopods of Iowa

Notable similarities in faunal content exist between the *saltica* and *torrida* zones and the Independence shale, the Cedar Valley limestone, and the Lime Creek formation (or Hackberry Stage of Fenton and Fenton) of Iowa. In the following list the names of cognate species in Iowa and Western Australia are placed side by side:—

Independence shale	*Saltica* and *torrida* zones
Skenidium independense Stainbrook 1945	*S. asellatum*
Hypsomyonia stainbrooki Cooper 1955	*H. niphana*
Chonetes brandonensis Stainbrook 1945	*Plicochonetes macropatus*
Hypothyridina emmonsi Hall & Whitfield 1877	*H. margarita*

Other formations in Iowa—

Schizophoria striatula Schl. from the Cerro Gordo member of the Lime Creek formation	*Schizophoria stainbrooki*
Gypidula occidentalis Hall from Cedar Valley limestone	*Gypidula fragilis*
Devonoproductus walcotti (Fenton & Fenton) from the Lime Creek formation.	*Devonoproductus australis*

The members of each pair of species are closely related and only by reference to fine detail do specific differences become apparent. Two of the rare reported occurrences of the goniatite genus *Ponticeras* are from Iowa (in the Independence shale) and the Fitzroy Basin (in the Upper "*Manticoceras*" zone and in the *saltica* zone; identified by B. F. Glenister). In the Upper Devonian the genus *Skenidium* is found in Iowa and the Fitzroy Basin only, and the only records of the genus *Hypsomyonia* are from these areas.

Before the appearance of Stainbrook's monographs (1938a and b, 1940, 1942a, 1943a and b, 1945) on the brachiopods of the Independence shale and the overlying Cedar Valley limestone, the relative stratigraphical positions of these formations were disputed. The outcrop of the Independence shale is very poor, and apparently no exposure indisputably shows its true stratigraphical relationship to the Cedar Valley limestone. Thus the problem of the stratigraphical position of the Independence shale resolved itself into a purely palaeontological one. With the publication of Stainbrook's monographs, the problem may be considered solved. By the independent testimony of brachiopods and the goniatite *Ponticeras,* it may be concluded that the Independence shale is Lower to Middle Frasnian in age. The Cedar Valley limestone and the Lime Creek formation (including the Cerro Gordo member) are also Frasnian in age, the upper members of the Lime Creek formation being correlated with the Chemung of New York, which is equivalent to Upper Frasnian.

Two of the four Fitzroy Basin species compared with Independence shale species are restricted to the *saltica* zone; *Hypothyridina margarita* ranges from the *apena* zone to the *saltica* zone; and *Plicochonetes macropatus* is restricted to the *torrida* zone.

The other three species compared with Iowan forms range through the *saltica* zone to the *torrida* zone and so confirm the Frasnian age of these zones.

2. Comparison with Devonian brachiopods of Ferques

Closely related species are as follows:—

Frasnian of Ferques	*Saltica* and *torrida* zones
Schuchertella devonica (Keyserling)	*S. gratillica*
Chonetes douvillei } *Rigaux* *Chonetes maillieuxi* }	*Plicochonetes macropatus*
Douvillina ferguensis (Rigaux)	*D. exquisita*
Nervostrophia latissima (Rigaux)	*N. bunapica*

Rigaux (1908) divided the Frasnian of Ferques into two sub-stages, a lower part, the Beaulien, and an upper part, the Ferquien. With the exception of the two chonetids, which are restricted to the Beaulien, these brachiopods range throughout both sub-stages. Thus it is not possible by means of the correspondence of brachiopods from Western Australia and Ferques to estimate the age of the *saltica* and *torrida* zones more narrowly than undifferentiated Frasnian.

3. Comparison with Devonian brachiopods from Poland.

The following pairs of species are apparently closely related:

Poland	*Torrida* zone
Kayserella fallax (Gürich) 1896	*K. emanuelensis*
Emanuella volhynica Kelus 1939	*E. torrida*
Atrypa reticularis var. *orientalis* Kelus 1939	*Spinatrypa aspera prideri*

The stratigraphical position of *Kayserella fallax,* described from the Devonian of the Polish Mittelgebirge, is not accurately known. Both of Kelus's forms are from the Devonian of Volhynia; Kelus gives the age as Middle Devonian, at the same time referring the reader to more precise details in a paper by Samsonowicz, which unfortunately is not available to me.

In summary, three species from the *torrida* zone are found to agree closely with Polish species, one from undifferentiated Devonian, the others from undifferentiated Middle Devonian.

4. Comparison with Devonian brachiopods from the Voroneje District of Central Russia.

Less striking but nevertheless substantial similarities exist between elements of the Fitzroy Basin brachiopod fauna and species from the Devonian rocks of the Voroneje District.

Voroneje District	*Saltica* and *torrida* zones
Productus petini Nalivkin 1930	cf. *Chonetipustula* sp.
Hypothyris cuboides var. *semilukiana* Nalivkin 1930	*H. margarita*
Atrypa uralica Nalivkin 1930	*Atrypa desquamata kimberleyensis*
Stropheodonta asella Vern.	*Nervostrophia bunapica*
Streptorhynchus devonicus d'Orb.	*Schuchertella gratillica*
Atrypa tubaecostata Paeck.	*Spinatrypa aspera prideri*

Streptorhynchus devonicus d'Orb. and *Atrypa tubaecostata Paeck.* are recorded from the Voroneje beds, which Nalivkin (1930a) tentatively correlates with the Ferquien sub-stage (Upper Frasnian); the remaining species listed come from the underlying Semiluki beds, which Nalivkin refers to the upper horizons of the Beaulieu sub-stage of the Frasnian of Ferques.

5. Comparison with the brachiopods of the Dorper Kalk of Bergisch Land.

Close relationship between the *saltica* and *torrida* zones and the Dorper Kalk of Bergisch Land (Right Rhine) is shown by the two pairs of cognate species given below:

Dorper Kalk	*Saltica* and *torrida zones*
Rhynchonella (*Hypothyris*) *praeibergensis* Paeckelmann 1913	*Fitzroyella primula*
Atrypa tubaecostata Paeckelmann 1913	*Spinatrypa aspera prideri*

Paeckelmann (1913) places the Dorper Kalk at the transition between the Givetian and Frasnian.

Age of the brachiopods in the proteus *zone*

Similar pairs of brachiopods are the following:—

	Proteus zone
Schizophoria resupinata var. *pinguis* Demanet 1934 from the Visean of Belgium	*Schizophoria apiculata*
Schuchertella chemungensis Conrad 1843	*Schuchertella dromeda*
Schuchertella iowensis Stainbrook 1943 from the Cedar Valley limestone	*Schuchertella dromeda*
Avonia youngiana (Davidson)	*A. proteus*
Productus (Overtonia) celak Nalivkin 1937 from the Upper Famennian of north-eastern Kazakhstan	*A. proteus*
Camarotoechia sobrina Stainbrook 1947 from the Upper Devonian-Lower Carboniferous Percha shale of New Mexico	*Camarotoechia lucida*

The aggregate range in age of the foreign species compared with *proteus*-zone brachiopods is Frasnian to Visean.

PALAEOZOOGEOGRAPHY

Many of the Devonian brachiopods of the Fitzroy Basin are notably similar to brachiopods from the Devonian of Europe, Russia, and North America. Such similarities are to be expected, since most Middle and Upper Devonian faunas were cosmopolitan.

Endemic faunal elements, nevertheless, are present in the Devonian of the Fitzroy Basin. Two new genera, *Teichertina* and *Nyege,* are quite distinct from known brachiopods elsewhere, and two other forms, *Zophostrophia ungamica* and *Ladjia saltica,* and possibly a third, *Nervostrophia bunapica,* though related loosely to North American species, show substantial divergences from described stocks. The presence of these five endemic forms in an assemblage of forty-six described species may signify short interruptions in an almost continuous exchange of brachiopods between the Fitzroy Basin and the Northern Hemisphere during parts of Middle and Upper Devonian times.

The occurrence of *Tingella suchana* in the Middle Devonian may be evidence of an appreciable, though perhaps restricted, communication with Yunnan (China) where the only other described species of *Tingella* is found. The distinctive brachiopod genus *Stringocephalus* also occurs in the Middle Devonian of the Fitzroy Basin and Yunnan, but this is a cosmopolitan genus and is found in nearly all the major Middle Devonian provinces. *Stringocephalus* occurs also in eastern Australia and at the moment forms the only known link between the Middle Devonian brachiopod faunas of eastern and western Australia. Teichert (1943) did not find *Stringocephalus* in the Fitzroy Basin and was led to believe that it did not occur at all in this province. Teichert also mentioned the absence of the important Middle Devonian coral, *Calceola.*

There is good reason for supposing that *Calceola* is not present in Western Australia: it is not usually found in beds higher than lower Middle Devonian, and rocks of this age have not yet been found in the Fitzroy Basin.

The age of the Fitzroy Basin brachiopods can be checked by the independent evidence of the ammonoids. The presence of this group in association with brachiopods proves beyond doubt the contemporaneity of similar brachiopod faunas in the Fitzroy Basin and in other parts of the world, particularly in North America. For instance, the contemporaneity of similar brachiopod faunas in the Sadler Formation of Western Australia and the Independence shale of Iowa is confirmed by the common occurrence of the goniatite genus *Ponticeras*.

The study of the Fitzroy Basin Devonian brachiopods has thrown little light on the possible routes of migration during Devonian time. Teichert envisaged the migration of Upper Devonian goniatite faunas to Western Australia from Europe by way of the Urals and South-east Asia (Teichert, 1943, text-fig. 4). In criticism, Neaverson (1955, p. 269) rightly points out that " though Teichert holds that they (the goniatites) must have arrived in the Australian area by way of the Devonian 'Tethys' along the line of the Himalayas, there is no evidence to substantiate his claim ". The brachiopods do not necessarily contradict Teichert's views: in fact, slight support may be drawn from the similarities between Fitzroy Devonian brachiopods and contemporaneous brachiopods from the Urals.

The exact relationships between the brachiopods studied herein and those of Asia, particularly those of India, Burma and Indo-China, cannot be established until the brachiopods of these areas have been adequately described. Many similarities between Fitzroy and Asian brachiopods are noted below in the descriptions, but because the internal morphology of Asian species is rarely described, only a few comparisons can be carried to the point where either identity or dissimilarity is proved.

With the possible exception of the *Stringocephalus*-bearing limestone of the Burdekin River district south of Townsville (*see* Brown, 1944) no described Devonian brachiopod fauna in Australia is similar to that of the Fitzroy Basin. Brachiopods from the Devonian of the Carnarvon Basin, 1,000 miles south-west of the Fitzroy area, have been examined,* and the only identifiable form common to this and to the Fitzroy fauna is *Spinatrypa aspera prideri* (Coleman) 1951. *Ladjia saltica* and cf. *Productella* sp. probably occur in the Carnarvon Basin.

The relationships between the Fitzroy brachiopods and the Devonian brachiopods of eastern Australia are not known. Most eastern Australian species must be re-described before exact comparisons with the Western Australian species can be attempted. None of the Queensland Devonian brachiopods recently described by W. G. H. Maxwell (1950, 1951, 1954) are represented in Western Australia. It is possible, though as yet unproved, that the differences between the known Devonian brachiopods of eastern and western Australia are reflections of inherent differences which existed in the faunas. Teichert (1943, p. 168), after a comparison of eastern and western Australian Devonian faunas, made the same inference.

Obviously, a great deal of further work is required before any definite conclusions may be drawn. The study of the brachiopods from both regions (and particularly from Western Australia) is in its infancy, and until detailed comparative studies have been carried out, discussion of the Devonian palaeozoogeography of the eastern and western parts of Australia must remain speculative.

* Veevers, J. J. 1959 (in press)—Devonian and Carboniferous brachiopods from north-western Australia. *Bur. Min. Resour. Aust. Bull.* 55.

SYSTEMATIC DESCRIPTIONS.

TERMINOLOGY.

In anterior views of specimens, the conventional orientation has been used; that is, the dorsal valve is placed above. In posterior views the reverse applies; that is, the ventral valve is above. In the descriptions, certain terms are used with the restricted meanings given below—

shell: specimen in which both valves are united;

free shell: shell free of externally adhering sediment;

free valve: valve free of externally and internally adhering sediment;

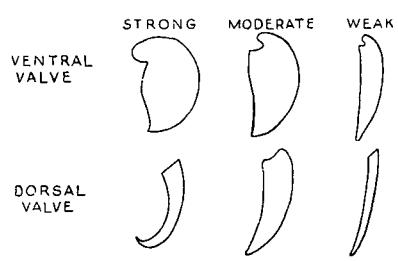
length: (adjective "longitudinal") measurement of shell or part of the shell at right angles to the hinge-line in the posterior part of the surface of commissure;

width: (adjective "transverse") measurement of shell or a part of the shell parallel to the hinge-line;

thickness: measurement of shell at right angles to the surface of commissure or, in some shells, at right angles to the posterior part of the lateral commissure;

depth: measurement of valve at right angles to the surface of commissure or, in some shells, at right angles to the posterior part of the lateral edge of the valve.

Text-fig. 4 illustrates the terms used in connexion with valve convexity.



All measurements are in millimetres.

The number placed immediately above the illustration of a serial section indicates the distance in millimetres of the section anterior to the posterior extremity of the shell.

Class ARTICULATA Huxley

Superfamily ORTHACEA Walcott & Schuchert 1908

Family SKENIDIIDAE Kozlowski 1929

Genus SKENIDIUM Hall 1860

SKENIDIUM ASELLATUM sp. nov.

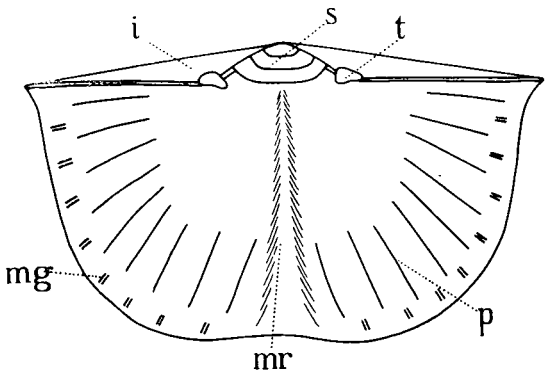
(Plate 1, figs. 1-11; Text-figs. 5, 6)

Diagnosis: Skenidium with deeply excavated inner hinge-plates, ventral valve exterior with plications dissected by shallow grooves.

4328/58.—3

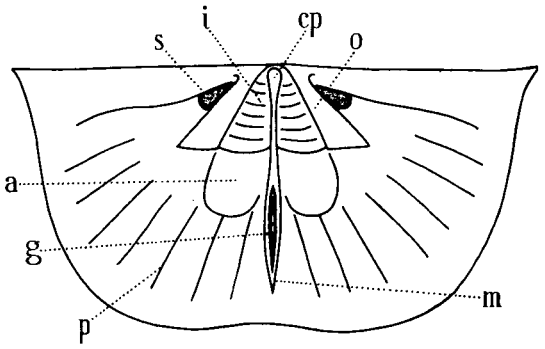
Material: Nearly one hundred well-preserved silicified free valves; no conjoined valves.

Description: Shell minute, pyramidal, plano-convex, sub-mucronate, widest at hinge-line; crenulated anterior commissure broadly sulcate to straight.



TEXT-FIGURE 5.

S. asellatum, **ventral valve interior. i: interarea, mg: marginal groove, mr: median ridge, p: plication, s. spondylium, t: tooth.**



TEXT-FIGURE 6.

S. asellatum, **dorsal valve interior. a: anterior adductor muscle-scar, cp: cardinal process, g: groove, i: inner hinge-plate, m: median septum, o: outer hinge-plate, p: plication, s: socket.**

Ventral valve pyramidal, very deep, with a slightly twisted high prominent umbo. Ventral valve interarea catacline, very long, with outline of an equilateral triangle. Delthyrium long, twice as long as wide, dorsal third open, remainder filled by a long, broad spondylium attached at its sides to the delthyrial margins, apically fused to the valve floor where further support is afforded internally by a low median ridge; the straight dorsal edge of the spondylium is unsupported, well elevated above the valve floor. Teeth small, continuing ventrally as broad low ridges which unite with the sides of the spondylium. Interior of young specimens thrown into low narrow radial plications corresponding to external grooves, but in maturer specimens plications filled in by secondarily deposited shell matter.

Dorsal valve weakly convex to nearly flat with a broad shallow median sulcus. Interarea anacline, sub-rectangular, length less than one-fifth that of ventral interarea. Notothyrium filled by the small globular cardinal process borne on posterior extremity of median septum which extends almost to the anterior margin; septum thick, with maximum height at midlength, anteriorly with a deep median groove. Broad hinge-plate composed of four parts, two long straight flat outer plates and two transversely striated, excavated inner plates; hinge-plate attached posteriorly to valve floor, above which it raises itself anteriorly to fuse with sides of median septum. Dental sockets small, bordered anteriorly by incipient fulcral plates. Anterior adductor muscle scars deeply impressed in gerontic specimens (Pl. 1, fig. 8), situated immediately anterior to the inner hinge-plates. Rest of interior smooth or with low rounded plications.

Exterior of both valves shows 15 to 20 high rounded radial plications separated by narrower grooves, crossed by evenly spaced concentric lamellar growth-lines. On ventral valves, crests of plications dissected by shallow grooves.

Measurements:

—	Length.	Width.	Depth.
Holotype (dorsal valve), C.P.C. 2912	3.1	5.9	..
Figured specimen (dorsal valve), C.P.C. 2913	3.1	5.0 (est.)	..
Figured specimen (ventral valve), C.P.C. 2914	2.4	4.2	3.2
Figured specimen (dorsal valve), C.P.C. 2916	2.0	3.7	..
Figured specimen (dorsal valve), C.P.C. 2915	2.6 (est.)	4.6	..
Figured specimen (ventral valve), C.P.C. 3020	2.6	5.0	2.8

Types: Holotype, C.P.C. 2912 (from K276). Figured specimens C.P.C. 3020, 2913, 2914, 2916 (all K276), 2915 (K245).

Horizon and localities: Sadler Formation near Sadler Ridge (K245) and near Menyous Gap (K276).

Discussion: The pyramidal shape, the spondylium, and the broad depressed hinge-plate attached anteriorly to the median septum are all characteristic of *Skenidium*.

Skenidium asellatum differs from the type species, *Orthis insignis* Hall 1859 of Helderbergian age, in its more transverse outline and the very feeble median sulcus in the dorsal valve. *Skenidium asellatum* and the basal Upper Devonian *S. independense* Stainbrook 1945 (p. 14, pl. 1, figs. 14-18) agree very closely in the shell-shape; the American species, however, lacks the grooved ventral-valve plications of the new species and in addition has less deeply excavated inner hinge-plates. The Australian species is more easily separable by notable differences in ornament from the two Russian species from the Upper Givetian described by Tscherneyschew, *S. uralicum* and *S. moelleri* (1887, pp. 106, 107, pl. 4, figs. 13-17).

Apart from the variable thickness of callus deposits in the dorsal valve, resulting in a variably smooth or plicate dorsal valve interior, variation in *S. asellatum* is unimportant.

The absence in the collection of any conjoined valves indicates the ease of disarticulation of associated valves after death. A similar condition prevails in some samples of *S. independense* in which Stainbrook (1945, p. 14) reports only one pair of united valves grouped with a number of individual valves.

Superfamily DALMANELLACEA Schuchert & Cooper

Family ONNIELLIDAE Öpik 1933 em. Bancroft 1945

Genus HYPSOMYONIA Cooper 1955

HYPSOMYONIA NIPHANA sp. nov.

(Plate 1, figs. 12-22; Text-fig. 7)

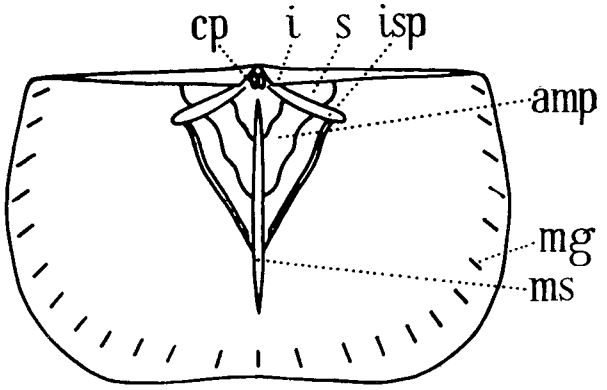
Diagnosis: Hypsomyonia with narrow costellae and a narrow dorsal adductor platform attached posteriorly to bases of socket plates.

Description: Exterior: Transversely oval in outline, profile biconvex with ventral valve the deeper. Hinge-line slightly shorter than shell width measured at midlength. Cardinal margins obtusely angular. Dorsal valve with a broad shallow median sulcus, ventral valve with a low fold. Anterior commissure broadly sulcate to nearly straight.

Ventral valve umbo swollen, interarea long, apsacline, divided by broad open delthyrium, bounded by indistinct narrow deltidial plates and a small apical plate. Notothyrium with clearly displayed chilidial plates and small bilobed cardinal process.

Both valves multicostellate in two series: about twenty larger costellae along shell margin, and four to five tiny lines between adjacent costellae.

Ventral valve interior: Teeth short, unsupported. Indistinct muscle field situated on floor of delthyrial cavity. Anterior and lateral borders of interior deeply grooved.



TEXT-FIGURE 7.

H. niphana, **dorsal valve interior. amp: adductor muscle platform, cp: cardinal process, i: interarea, isp: inner socket plate, mg: marginal groove, ms: median septum, s: socket.**

Dorsal valve interior: Bilobed cardinal process thick, squat, occupies greater part of notothyrial cavity; apparently not connected to median septum. Inner socket plates thick, moderately long, strongly divergent ventrally. Broad adductor muscle platform supported by a narrow moderately low median septum extending from a short distance anterior to the cardinal process almost to the anterior border.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2917	3.4	4.7	1.8
Figured specimen, C.P.C. 2918	1.9	2.6	1.0

Types: Holotype C.P.C. 2917 from K215; figured specimens C.P.C. 2918, 2919 (both K215), 2920, 2921 (both K273).

Horizon and localities: Sadler Formation, near Sadler Ridge (K215, K245), and near Menyous Gap (K273, K276).

Discussion: The broad dorsal adductor muscle platform supported by a narrow moderately low median septum, and the lack of dental plates, are characters of *Hypsomyonia. H. niphana* differs from the type species, *H. stainbrooki* Cooper 1955, hitherto the sole member of the genus, in its narrower brachial adductor platform and in the attachment of the posterior edge of this platform to the bases of the socket-plates. The Australian species also has narrower costellae, although the number of costellae is the same in both species. Furthermore *H. stainbrooki* has fewer lines

between costellae than *H. niphana*. The only other forms with which *H. niphana* might be confused are the members of the allied genus *Mystrophora* Kayser 1871, which are distinguishable by the distinctive pentagonal outline of the shell and by the extremely high dorsal median septum.

TEICHERTINA gen. nov.

Type species: Teichertina fitzroyensis sp. nov.

Diagnosis: Onniellidae with a spiriferoid outline, dorsal adductors extending along valve floor almost to anterior border, and costellae of two sizes, adjacent major costellae separated by one to five minor costellae.

Discussion: The primitively bilobed cardinal process, the simple inner socket plates and the presumably punctate shell of *Teichertina* place this genus in the Onniellidae.

Although *Teichertina* is quite different in shape from *Levenea* Schuchert & Cooper 1931, important internal characters such as dentition and muscle-scars have the same general plan. Thus *Teichertina* and *Levenea* both have strong teeth with vestigial dental plates in adults, a prominent cardinal process carried on a short shaft with a lobate myophore, and subequal adductor muscle-scars in the dorsal valve. Furthermore both forms seem to be characterized by " a remarkable deposition of adventitious shell, especially in the dorsal valve about the various structures of the cardinalia " (Schuchert & Cooper 1932, p. 124, referring to *Levenea*).

The most notable differences existing between *Teichertina* and *Levenea* are (1) shell-shape: whereas *Teichertina* is spiriferoid in outline with a megathyrid hinge-line and an exceptionally long ventral interarea, *Levenea* is subquadrate to subcircular in outline with a submegathyrid hinge and a short ventral interarea; (2) dorsal valve muscle field: situated in posterior half of shell in *Levenea,* extending anterior to mid-length in *Teichertina*; (3) the ribbing in *Levenea* is simple, multicostellate.

The lower Devonian *Fascicostella* Schuchert & Cooper 1931, another dalmanellacean with variably thickened costellae, is distinguishable from *Teichertina* by its circular outline, its proportionately shorter dorsal valve muscle field, and the presence of a median septum in the ventral valve.

Within the onniellids some members of the Silurian species *Parmorthis elegantula* (Dalman) (*in* Schuchert & Cooper 1932, pl. 21, fig. 13) show an anterior development of the dorsal adductors similar to that seen in *Teichertina.* But unless forms intermediate between these two genera are found in the intervening Lower and Middle Devonian rocks, this similarity in muscle pattern must be ascribed to homeomorphy.

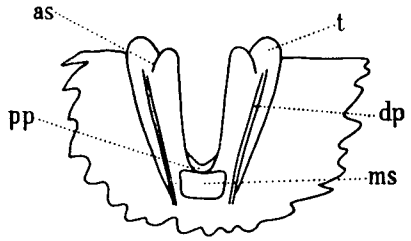
TEICHERTINA FITZROYENSIS sp. nov.

(Plate 2, figs. 1-16; Text-figs. 8, 9 (a) & (b))

Material: Eight entire free shells, eleven free valves, all silicified.

Description: Outline spiriferoid, widest at hinge-line, extremities weakly mucronate. Biconvex, ventral valve much longer and deeper than dorsal valve. Anterior commissure moderately narrowly sulcate. Specimens commonly bilaterally asymmetrical.

Ventral valve moderately convex, subpyramidal, drawn out posteriorly into a long prominent umbo with an almost straight tip. Shallow median sulcus extends from umbo to anterior margin. Interarea long, apsacline, flat, except for weak transverse concavity near tip of umbo. Delthyrium long, narrow, width equal to one-third of length; open except for apical third filled by pedicle collar barely sunk below level of interarea, and scored with faint concentric transverse growth-lines.



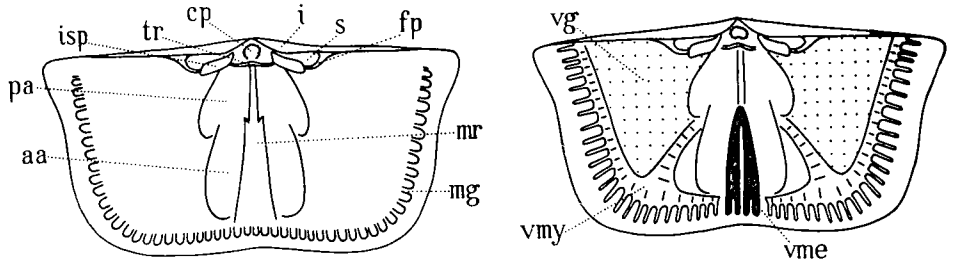
TEXT-FIGURE 8.

T. fitzroyensis, **part of ventral valve showing delthyrial structures. as: accessory socket, ms: muscle-scar, dp: dental plate, pp: pedicle plate, t: tooth.**

Dorsal valve transversely semi-elliptical in outline, weakly convex with moderately deep narrow median sulcus. Umbo small, indistinct. Interarea with one-eighth length of ventral valve counterpart, flat, anacline; outline of notothyrium triangular, equilateral, largely occupied by broad spherical primitively bilobed cardinal process.

Surface of both valves with as many as 40 unbranched strong costellae of two sizes, fairly low, narrow, rounded, separated by grooves with same size and shape; adjacent major costellae separated by one to five minor costellae; major costellae more prominent along lateral borders of dorsal valve sulcus. Anterior half of shell marked by as many as ten lamellose growth-lines.

Ventral valve interior: Teeth broad, with shallow oblique accessory sockets; dental plates vestigial, low, short, apical, reduced to ridges running along the ventral side of thick dental ridges. Muscle field apparently sub-apical, possibly confined laterally by dental plates. Rest of ventral internal surface deeply grooved, number of grooves equalling number of external costellae.



TEXT-FIGURE 9.

T. fitzroyensis, **dorsal valve interior. (a) General morphology. aa: anterior adductor, cp: cardinal process, fp: fulcral plate, i: interarea, isp: inner socket plate, mg: marginal groove, mr: median ridge, pa: posterior adductor, s: socket, tr: transverse ridge. (b) Schematic reconstruction of pallial sinuses. vme: vascula media, vmy: vascula myaria, vg: vascula genitalia.**

Dorsal valve interior: Cardinal process large, subspherical, attached to floor, posterior face divided by a shallow median fissure into two transversely striated lobes. Process separated from median septum by a low transverse ridge of unknown origin

joining bases of inner socket plates. Median septum broadens anteriorly so that at midlength it is a very broad and high rounded ridge corresponding to the external median sulcus. Sockets deep, confined medianly by strong inner socket plates produced ventrally as strong nearly parallel processes. Fulcral plates well developed on anterior side. Adductors large, deeply impressed, raised above level of surrounding valve-floor on a low broad platform divided by the median ridge. Anterior adductors long, thin, extending almost to anterior margin; posterior adductors broad.

Rest of interior radially grooved in juveniles (*see* pl. 2, fig. 15), but adults grooved only along margin with rest of interior covered by secondary deposits. (These deposits, only exceptionally found in juveniles, were very probably formed by secretion of the vascula genitalia, which would be well developed only in adults.) Marginal grooves mark positions of marginal sinuses; terminal parts of vascula myaria occupy all grooves except those near median line, which represent vascula media. An illustration of this relationship is given in text-fig. 9b. (The conventional symbols of Williams (1956) are used: vascula media in solid black, v. myaria in closely ruled lines, and v. genitalia stippled.)

The sinuses form the kind of pattern termed by Öpik (1934) oligopalmate, and by Williams (1956) saccate-inequidistributate. This is the pattern encountered in some orthaceans (e.g. in *Dolerorthis osiliensis* illustrated in Öpik, 1934, fig. 18), and in some strophomenaceans (e.g. in *Leptaena,* and in *Strophomena* illustrated in Williams, 1956, fig. 6 (5), (7)). The oligopalmate pattern is by no means typical of the dalmanellaceans. Thus with regard to the sinuses, *Teichertina,* like *Dolerorthis, Leptaena,* and *Strophomena,* is exceptional within its particular group.

Measurements:

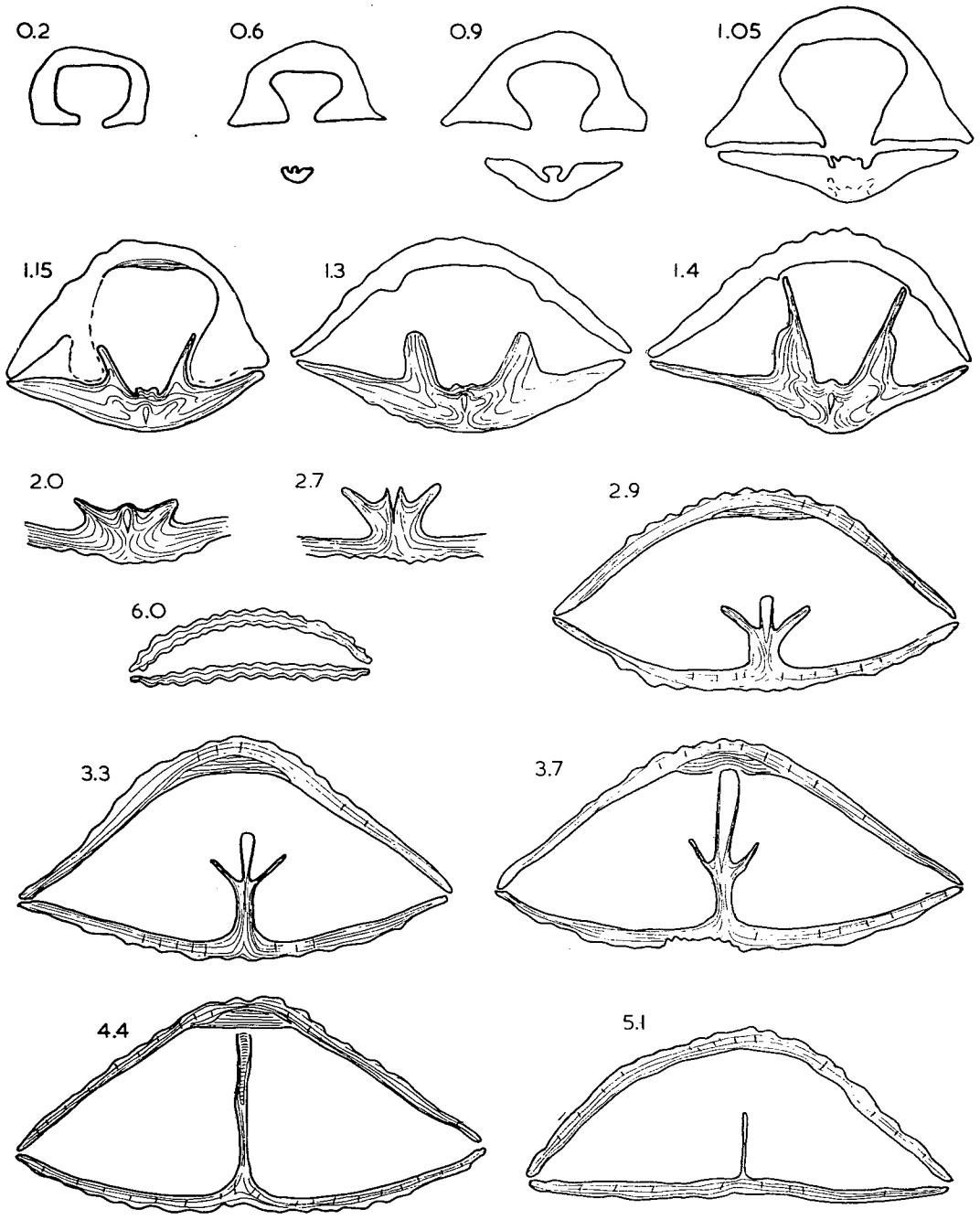
——	Length.	Width.	Thickness.
Holotype, C.P.C. 2929	4.8	7.0	2.7
Figured specimen, C.P.C. 2924	6.0	6.7	3.4

Types: Holotype C.P.C.2929 from K215. Figured specimens 2924, 2925 (both K276) 2926, 2927, 2928 (K215).

Horizon and localities: Sadler Formation near Sadler Ridge (K215, K216, K245, T53), and near Menyous Gap (K276).

Discussion: The shell structure of this species, and whether it is punctate or impunctate, are not certainly known. In many specimens the internal surface of the dorsal valve is finely pitted in a regular pattern, implying a punctate condition of the test; but as all the material is silicified this conclusion must be regarded as tentative: such fine pits could conceivably have been produced during the process of replacement and therefore might be unrelated to the structure of the living shell, which was possibly impunctate.

Williams (1956, p. 264) has observed that the paths of the adductor muscles, lying posterior to the diaphragm of the visceral cavity, must determine the antero-median limit of the diaphragm. Calcareous structures must project some distance anterior to the diaphragm if they are to afford effective support for the lophophore; so the inner socket plates of *Teichertina,* which lie behind the paths of the adductor muscles, cannot have functioned as lophophore supports.



TEXT-FIGURE 10

K. emanuelenis. **Serial sections and peels x 10 of C.P.C. 3021 from K222 with L = 6.5, W = 7.1, T = 3.5. Only median part of dorsal valve shown in sections at 2.0 mm. and 2.7 mm. anterior to umbo. Shell structure poorly expressed in first four sections, and in ventral valve of following three.**

Family MYSTROPHORIDAE Schuchert & Cooper 1931

Genus KAYSERELLA Hall & Clarke 1892, emended Cooper 1955

KAYSERELLA EMANUELENSIS sp. nov.

(Plate 1, figs. 23-33; text-figs. 10-12)

Diagnosis: Weakly sulcate *Kayserella* with a relatively long cruralium.

Material: Twenty-four entire free calcareous shells, each with the external surface well preserved.

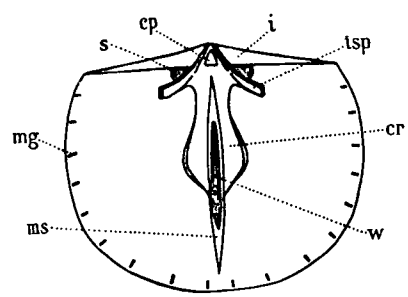
Description: Exterior: Outline subcircular, profile biconvex, ventral valve with greater depth. Convexity of both valves greatest posteriorly, least along anterior borders which are almost flat. Hinge-line two-thirds shell-width, measured at mid-length. Cardinal margins obtuse, rounded in some specimens but usually angular. Dorsal valve shallowly and broadly sulcate, anterior commissure broadly sulcate to nearly straight. Ventral valve interarea moderately long, apsacline, umbo straight to nearly erect. Dorsal valve interarea half length of ventral interarea, anacline. Delthyrium open, wide with thickened margins. Notothyrium partly closed by cardinal process and narrow chilidial plates.

Surface of both valves multicostellate in two series, increase taking place by branching (for major costellae) and intercalation (for minor costellae). Concentric growth-lines few, prominent along anterior border. Puncta characteristically in single rows between major and minor costellae (plate 1, fig. 33).

Ventral valve interior: Delthyrial cavity deep, strong blunt teeth supported by thick short dental plates. Short narrow ridges occur to side of distal extremities of inner socket plates of dorsal valve (text-fig. 10, sections 1.3, 1.4).

TEXT-FIGURE 11.

Kayserella emanuelensis **sp. nov. Two serial sections x 12 of a specimen with L = 5.7, W = 6.5, and T = 3.0. The section on the left is 0.60 mm. and that on the right 0.65 mm. anterior to the umbo. These sections are similar to Cooper's section of** *Monelasmina deshayesi* **(Rigaux) (1955, text-fig. 1, B, 10).**



TEXT-FIGURE 12.

K. emanuelensis, **interior of dorsal valve. cp: cardinal process, cr: crural plate, i: interarea, isp: inner socket plate, mg: marginal groove, ms: median septum, s: socket, w: wedge.**

Dorsal valve interior: Cardinal process thick, bilobed, low, short. Sockets bounded on their inner sides by long, slender, ventrally tapering socket-plates, which in some specimens presumably articulated with accessory sockets in ventral valve (text-fig. 11); on lateral side, sockets are barely separable from rest of valve floor. Socket-plates expanded anteriorly almost to touch floor of ventral valve. Median septum huge, maximum height at midlength where septum touches floor of ventral valve; septum medianly split posteriorly; anterior part of septum extending almost to anterior margin. Short thin cruralial plates, flaring ventro-laterally, attached to valve floor at posterior extremity of median septum, attached to sides of median septum anteriorly, and becoming highly elevated above valve floor, disappearing at a point anterior to midlength. Margins of interior of both valves finely grooved.

Shell structure: The growth laminae of the posterior part of the dorsal valve indicate, by their general parallelism with the internal surface, regular deposition of calcite in equal amounts by this part of the mantle. Examination of the structure of the median septum shows, however, that this huge plate has arisen largely by the accelerated depositional activity of specialized cells located in the part of the mantle covering the ventral keel of the septum. The absence of such specialized cells posterior to section 2.9 (in text-fig. 10) is attested by the split septum in section 2.7 and the minute median cavity found in sections 2.0, 1.4, 1.3 and 1.15. The median septum consists of the fibrous inner layer in its basal half, extending distally as a very thin sheath to a wedge-shaped plate whose terminal tip touches the ventral valve floor, thereby dividing the shell into two chambers. In most sections this plate seems to be massive, but in section 4.4 it is clear that this is a finely layered plate which must have originated in the way related above.

Puncta are seen most abundantly in the anterior half of the shell (sections 2.9 to 5.1), where they are directed at right-angles to the internal surface of the valves.

Thick callus deposits in the ventral valve, marking the positions of attachment of muscle bases, are seen in sections 2.9 to 4.4. The ventrally directed growth of the median septum apparently caused an interruption to the even flat laminar deposition of callus, because in one part of the valve (section 3.7) these deposits are undulating.

Measurements:

—	Length.	Width.	Thickness.
Holotype C.P.C. 2922	4.9	5.5	2.7
Figured specimen C.P.C. 2923	6.5	7.6	3.1

Types: Holotype C.P.C. 2922, figured specimen C.P.C. 2923 (both from K222).

Horizon and localities: Sadler Formation, Sadler Ridge: K221, K222, K224, K225, K227 and T54, T58.

Discussion: As a result of Cooper's (1955) revision, *Kayserella* has become a finely drawn genus, narrowly separable from similar orthoid genera such as *Mystrophora* Kayser 1871 and *Monelasmina* Cooper 1955. In fact, these genera, as now defined, can only be distinguished with suitable well-preserved material. Fortunately the new species is sufficiently well preserved for a detailed examination, which shows that the species, with its long high median septum dividing the shell into two halves, and inner socket plates supported by a long narrow cruralium, is a member of *Kayserella*. *K. emanuelensis* differs specifically from the type species, *K. lepida* (Schnur), in being

more weakly sulcate and in having a more highly rounded outline; furthermore, internally *K. emanuelensis* has a slightly longer cruralium. *K. emanuelensis* also differs from the basal Middle Devonian species *K. americana* Cooper 1955, with which it agrees in external shape, in having a longer cruralium. This feature suggests a closer alliance between *K. emanuelensis* and *Skenidium fallax* Gűrich 1896 (p. 236, pl. x, fig. 9) from the Devonian of Poland, now considered to be referable to *Kayserella.* Since Gűrich's description is accompanied by one figure only, it is not at present possible to judge the extent of the similarity between these two forms.

Kayserella ?koraghensis Reed 1922 (pp. 35, 36, pl. 6, figs. 14, 15) from the Upper Devonian of Koragh, near Reshun, Chitral, is very similar externally to *K. emanuelensis,* but has a deeper median sulcus in the dorsal valve. As the interior of Reed's species is unknown it is of course possible that this external similarity is not maintained internally.

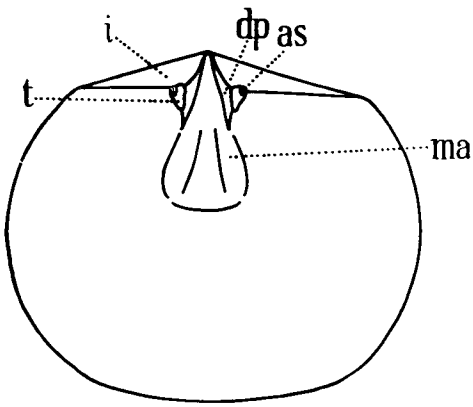
Family RHIPIDOMELLIDAE Schuchert 1913, em. Schuchert & Cooper 1932

Genus RHIPIDOMELLA Oehlert 1890

RHIPIDOMELLA INCOMPTA sp. nov.

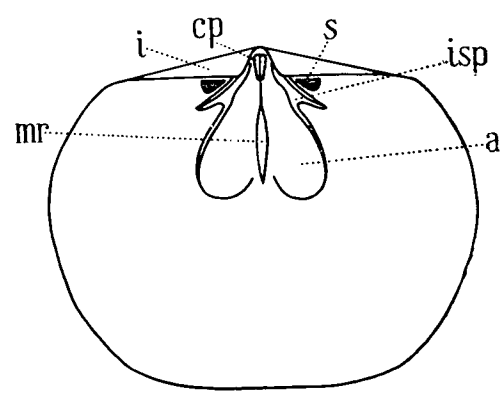
(Plate 2, figs. 22-29; Text-figures 13-16)

Diagnosis: Sulciplicate *Rhipidomella* with transverse outline and fine costellae.



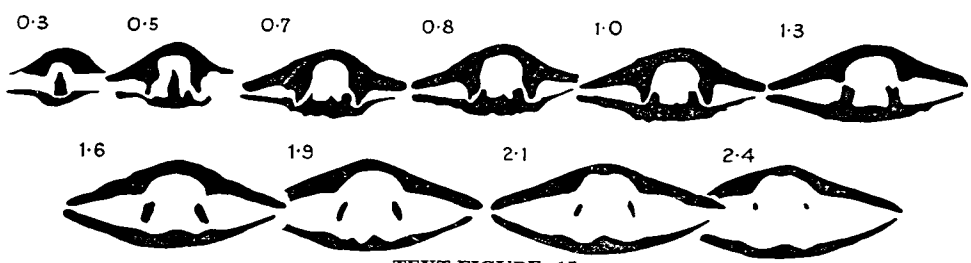
TEXT-FIGURE 13.

R. incompta, **interior of ventral valve. as: accessory socket, dp: dental plate, ma: muscle area, i: interarea, t: tooth.**



TEXT-FIGURE 14.

R. incompta, **interior of dorsal valve. a: adductor, cp: cardinal process, i: interarea, isp: inner socket plate, s: socket, mr: median ridge.**



TEXT-FIGURE 15

R. incompta. **Serial sections x 7 of U.W.A. 26016f from T25 (MS.A29) with L = 12.2, W = 14.8 and T = 5.6, showing enormous cardinal process, elevated muscle platform and simple inner socket plates in dorsal valve, and short strong teeth in ventral valve.**

Material: Twenty-seven almost entire partly recrystallized calcareous shells.

Description: Exterior: Outline subcircular to transversely rectangular. Lateral profile unequally biconvex to planoconvex, dorsal valve weakly and evenly convex, ventral valve weakly convex to flat, in many specimens concave anteriorly; anterior commissure feebly biplicate.

Ventral valve interarea short, apsacline; umbo small, swollen; dorsal valve interarea minute, anacline.

Surface multicostellate, rounded hollow costellae separated by broader, flat grooves. Holotype has twelve costellae in a width of 5 mm. along anterior median border. Concentric growth-lines few, regularly spaced.

Ventral valve interior: Delthyrial cavity deep, rectangular in section, bounded laterally by short thick vertical dental plates. Teeth long, diverging anteriorly. Muscle area wide and long, extending anteriorly almost to midlength, deeply impressed with muscles separated anteriorly by two low ridges (*see* text-fig. 16, section at 4.2 mm.).

Dorsal valve interior: Cardinal process a huge simple ridge occupying almost entire notothyrial cavity, separated from inner socket plates by two deep grooves. Sockets broad, shallow, without fulcral plates. Inner socket plates drawn out antero-ventrally into narrow tips. Muscle-scars fairly long and broad.

Shell structure: The fibrous elements of the shell are extremely minute in *Rhipidomella incompta,* so that growth laminae were traceable only in certain parts of the sectioned specimen. The puncta, however, are clearly recognizable and are circular in cross-section. Impunctate parts of the test are the cardinal process, inner socket plates, and the median posterior part of the ventral valve. The remainder of the shell is densely punctate; in section the number of puncta per square millimetre ranges from 100 to 200. Median longitudinal sections of puncta show that adjacent growth laminae are not noticeably contorted or otherwise affected by puncta.

Measurements:

—	Length.	Width.	Thickness.
Holotype U.W.A. 26016a	13.6	16.3	5.4
Figured specimen U.W.A. 26016b	11.9	13.4	6.3

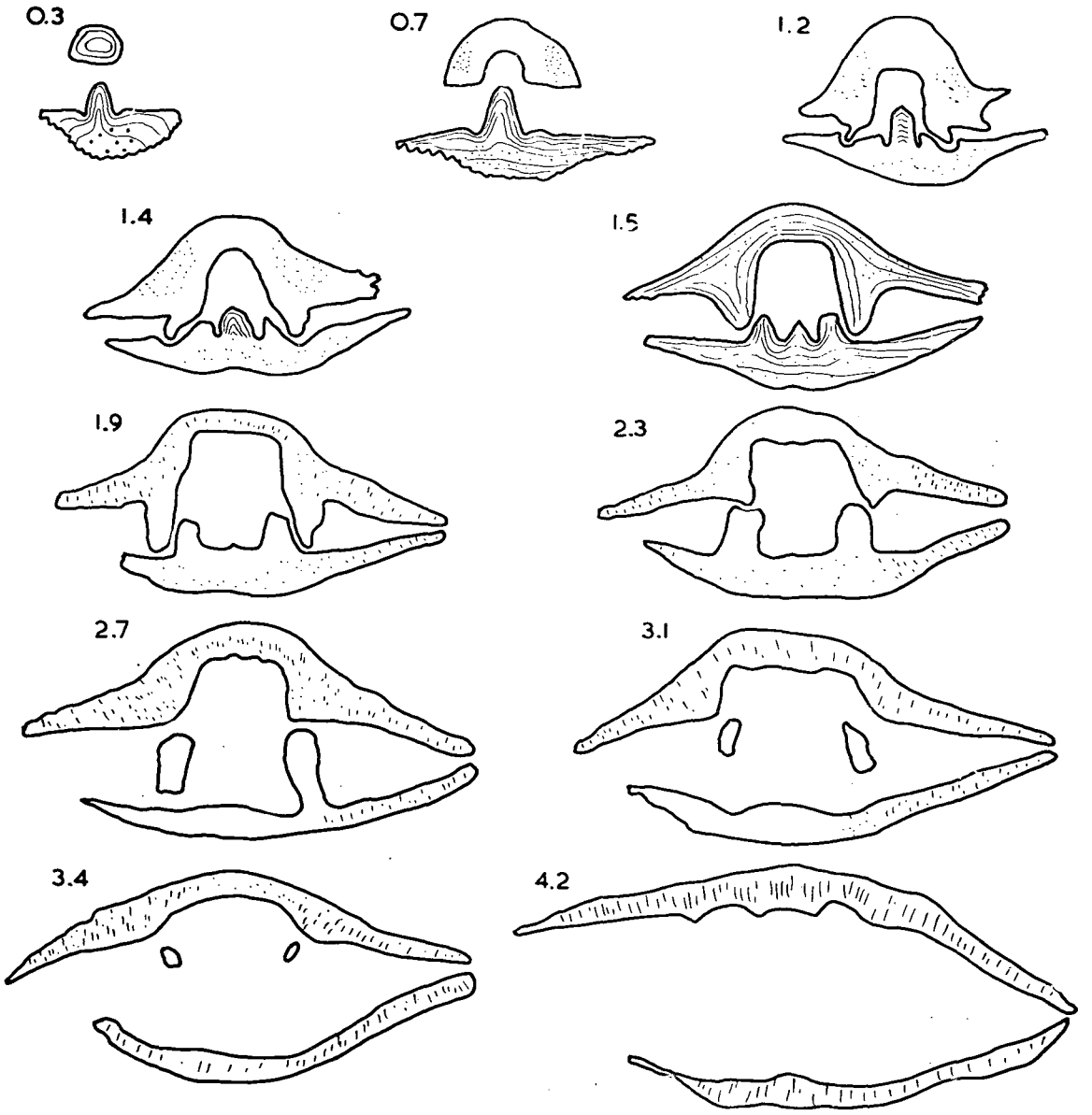
Types: The holotype, U.W.A. 26016a, comes from the eastern slope of Mt. Pierre, T 25. Figured specimen 26016b, same locality.

Horizon and localities: Virgin Hills Formation, Mt. Pierre area (T 25, T26); Geikie Formation, Fossil Homestead (T 4); Fairfield Beds, Bugle Gap (K 179).

Discussion: The general shape and costellation, the huge cardinal process, the long inner socket plates, and the broad muscle field, all denote *Rhipidomella.*

R. incompta differs from specimens B.M.(N.H.) B 13212, B 8748 of the type species, *R. michelini,* from the Lower Carboniferous of Tournai, Belgium (probably the type locality) in its persistent sulciplicate condition, and in its more transverse outline.

More similar to *R. incompta* are specimens called *Dalmanella prisca* (Schnur) (B.M.(N.H.) B 13114), *Dalmanella lunulata* (Murch.) (22716), and *Dalmanella suborbicularis* (Stein) (de Koninck Collection, 62454). The Australian species differs from all these in its finer costellae and narrower hinge.



TEXT-FIGURE 16

R. incompta. **Serial sections x 7 of U.W.A. 26016e from T25 (MS.A29) with L = 11.2, W = 12.7, T = 6.4. Shell structure well shown in all sections: puncta normal to section-plane in sections 0.3 to 1.5; some normal, others oblique in sections 1.9 and 2.3; and all oblique in remaining sections.**

Family SCHIZOPHORIIDAE Schuchert & LeVene 1929

Subfamily ISORTHINAE Schuchert & Cooper 1931

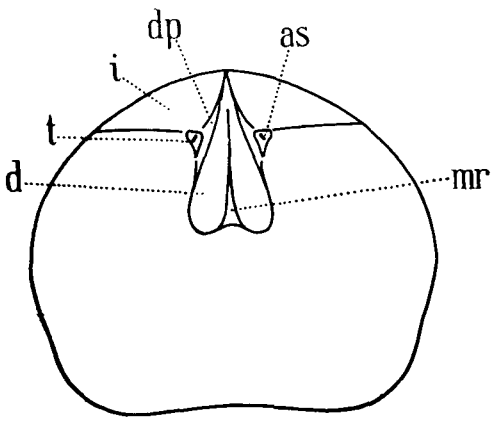
Genus ISORTHIS Kozlowski 1929

ISORTHIS(?) sp.

(Plate 2, figs. 17-21; Text-figs. 17-19)

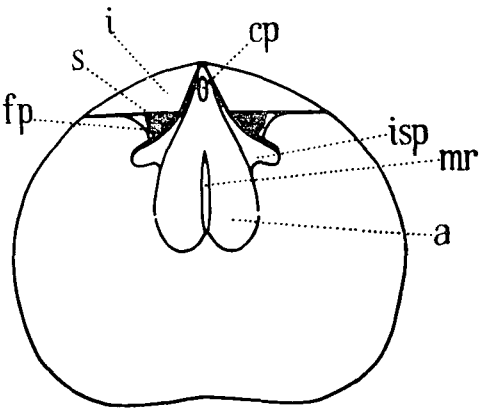
Material: Three entire silicified shells.

Description: Exterior: Rounded trigonal to rounded rectangular in outline, lateral profile equally biconvex. Ventral valve evenly convex, dorsal valve with greatest convexity at umbo. Cardinal margins broadly rounded, hinge-line narrow, less than half shell-width (which is measured anterior to midlength). Anterior commissure feebly biplicate.



TEXT-FIGURE 17.

***I.*(?) sp., ventral valve interior. as: accessory socket, d: diductor, dp: dental plate, i: interarea, mr: median ridge, t: tooth.**



TEXT-FIGURE 18.

***I.*(?) sp., dorsal valve interior. a: adductor, cp: cardinal process, fp: fulcral plate, i: interarea, isp: inner socket plate, mr: median ridge, s: socket.**

Ventral interarea flat, apsacline; umbo moderately low, tip nearly straight. Dorsal interarea flat, anacline, umbo small, tip straight.

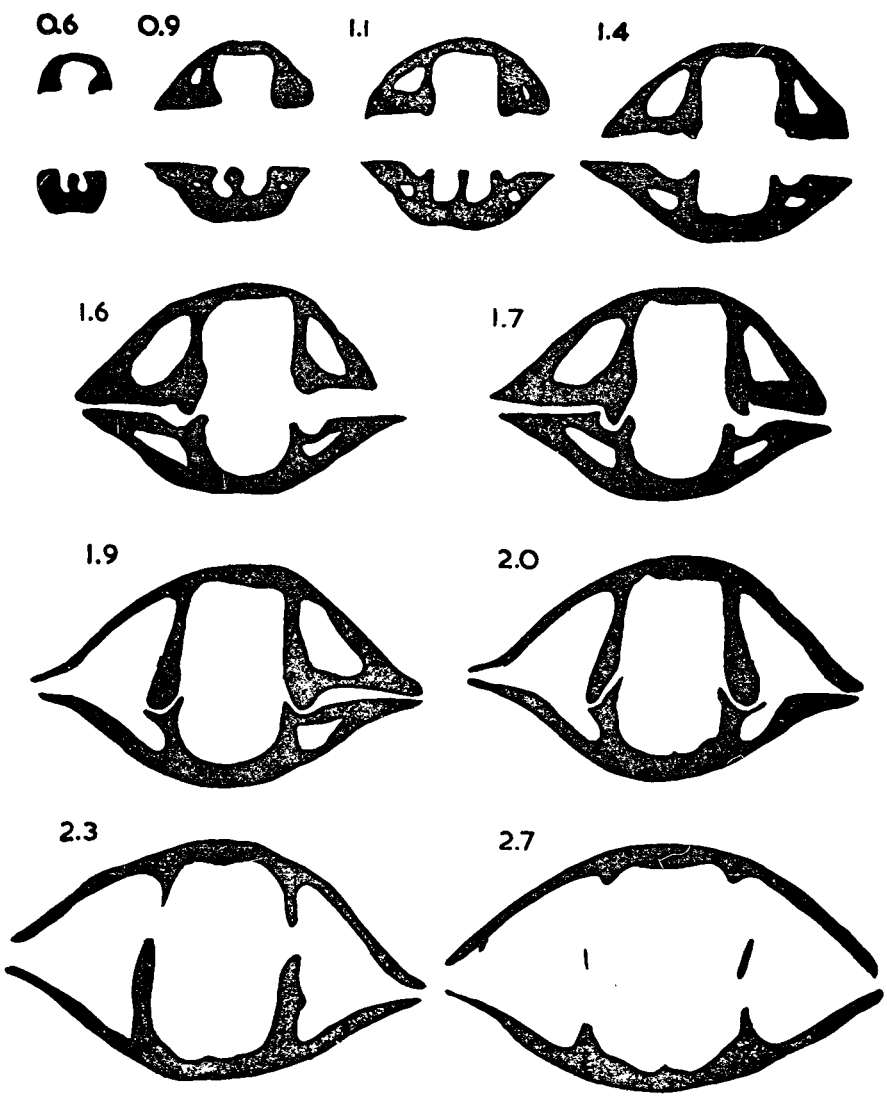
Exterior of both valves multicostellate with interspersed bases of hollow spines. Concentric growth-lines widely separated, faint.

Ventral valve interior: Teeth strong, blunt, supported by high strong dental plates. Diductor scars long and narrow, separated by broad low rounded median adductor ridge.

Dorsal valve interior: Cardinal process small, lobate, supported on low median ridge. Sockets with fulcral plates. Inner socket plates strong, high, tapering anteriorly to fine tips.

Measurements:

—	Length.	Width.	Thickness.
Figured specimen C.P.C. 2930 (from K243)	12.6	15.4	6.4
F18344 (from K246)	15.2	19.1	8.3
Sectioned specimen (from K244)	9.0	11.5	5.5



TEXT-FIGURE 19

Isorthis(?) **sp. Serial sections x 7 of a specimen from K243 with L = 9.0, W = 11.5, and T = 5.5. Notable characters are: high narrow cardinal process, sockets provided with fulcral plates, and high strong inner socket plates of dorsal valve, and strong teeth and dental plates of ventral valve.**

Horizon and localities: Sadler Formation near Sadler Ridge: K 243, K 244, K 246.

Discussion: This form looks like *Schizophoria* internally and *Rhipidomella* externally, as do members of Kozlowski's genus *Isorthis;* so these few specimens are tentatively grouped with *Isorthis.* The Kimberley species is notably thinner than the Upper Silurian type species of *Isorthis,* although its index of thickness (about 0.5) just falls within the range of variation of *I. szajnochai* (*see* Kozlowski, 1929, fig. 18).

Genus SCHIZOPHORIA King 1850

SCHIZOPHORIA STAINBROOKI sp. nov.

(Plate 3, figs. 1-13; Text-figs. 20-22)

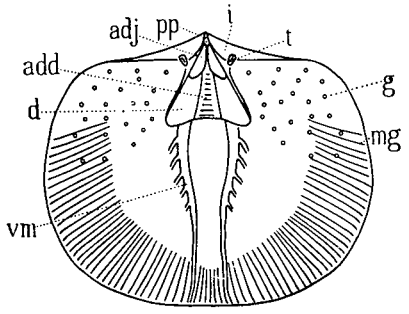
?Schizophoria striatula Schloth., Hosking, 1933, *J. Roy. Soc. W. Aust.,* 19, 73-74, pl. VIII, fig. 6.

Diagnosis: Like *Schizophoria striatula* (Schlotheim) 1813 but with rounded cardinal margins, anterior commissure with broad V-shaped sinus, and relatively coarse ribbing.

Material: 1083 free valves and shells preserved in silica.

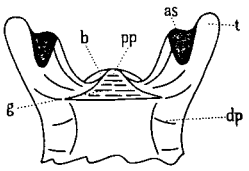
Description: Exterior: Outline subcircular to transversely ovate; profile biconvex with dorsal valve the deeper. Cardinal margins rounded or subrectangular, hinge-line narrower than shell-width, which is measured at or just anterior to midlength. Profile of ventral valve evenly and feebly convex, that of dorsal valve almost semi-circular. Anterior commissure uniplicate. Dorsal valve without fold, anterior half of ventral valve with broad shallow median sulcus. Ventral interarea long, apsacline, plane except for weak curvature dorsal to the umbo; umbo feebly convex and small tip straight; dorsal interarea half to one-third as long as ventral interarea, evenly curved, apsacline; umbo large, strongly convex. Delthyrium and notothyrium both open, wide.

Both valves multicostellate with fine rounded hollow costellae separated by angular grooves; adult shells have 10 costellae in a width of 5mm. along the median anterior border. Concentric growth-lines irregularly spaced, closely crowded along anterior and lateral margins of senile specimens. Both ventral and dorsal interarea marked by two sets of fine striae, one set normal, the other parallel, to hinge-line.



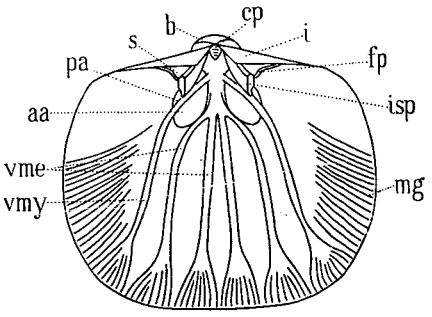
TEXT-FIGURE 20.

S. stainbrooki, **interior of ventral valve. adj: adjustor, add: adductor, d: diductor, g: genital markings, i: interarea, mg: marginal groove, pp: pedicle plate, t: tooth, vm: vascula media.**



TEXT-FIGURE 21.

S. stainbrooki, **ventral valve showing delthyrial structures. b: beak, as: accessory socket, dp: dental plate, g: groove, pp: pedicle plate, t: tooth.**



TEXT-FIGURE 22.

S. stainbrooki, **interior of dorsal valve. aa: anterior adductor, b: beak, cp: cardinal process, fp: fulcral plate, i: interarea, isp: inner socket plate, mg: marginal groove, vme: vascula media, vmy: vascula myaria, pa: posterior aductor, s: socket.**

Ventral valve interior: Delthyrial cavity deep, bounded laterally by strong vertical dental plates. Apical part in some shells occupied by a transversely striated triangular pedicle collar, anterior part of which is depressed below surface of interarea (*see* pl. 3, fig. 13, and text-fig. 21). Teeth strong with oblique crural fossettes; dental plates extend from apex to one-third of valve length, forming a low ridge bounding lateral part of muscle field. Diductor scars long, triangular, deeply impressed, separated by a transversely striated flat-crested triangular median adductor ridge, extending almost from apex to anterior extremity of diductors. Adjustor scars seen in senile specimens only (*see* pl. 3, fig. 9): they are narrowly rectangular, discrete, and occupy posterior half of muscle field. Pallial sinuses prominent but incomplete: vascula media extend from the anterior of diductors to marginal grooves; each sinus branches off five small lateral vessels, which presumably led also into marginal grooves (*see* pl. 3, fig. 7, and text-fig. 20). Senile specimens have two main trunks from which arise at midlength several smaller sinuses which cover anterior half of valve in a finely arborescent pattern (*see* pl. 3, fig. 9). Genital markings well displayed, bordering muscle field and posterior parts of pallial sinuses. Anterior and lateral borders finely grooved. This is the lemniscate pattern characteristic of *Schizophoria* (Williams, 1956, p. 278).

Dorsal valve interior: Sockets and socket plates strong, large; socket plates nearly vertical, anteriorly divergent, extend anteriorly for short distance as low ridges bordering part of muscle area. Sockets deep, provided with thick fulcral plates, inner socket plates tusk-shaped. Cardinal process small, borne on a short narrow ridge, in some specimens further supported by two short plates antero-laterally diverging, attached to base of process; attachment face of process medianly ridged, with deep transverse lateral grooves. Most valves with a simple adductor-scar, individual muscle-scars separated by flat median area divided by a low narrow median ridge (*see* pl. 3, fig. 11). Senile specimens have a quadripartite muscle-scar with circular anterior adductors surrounded by thickened ridges coalescing medianly into a broad ridge (*see* pl. 3, fig. 12). Pallial sinuses prominent; four trunks (vascula media) arise between anterior extremities of adductors (*see* pl. 3, fig. 6, and text-fig. 22); two median trunks remain parallel, lateral trunks diverge; anteriorly trunks branch into smaller vessels, which lead into marginal grooves. Furthermore, rare specimens show two lateral sinuses with posterior extremities at ridge separating anterior and posterior adductors; these trunks are subparallel to the other sinuses and similarly may divide anteriorly to run into marginal grooves. Sinus pattern pinnate, equidistributate.

Variation and measurements: An account of size and shape variation in *Schizophoria stainbrooki* is given in another paper (Veevers, 1959a).

Types: Holotype C.P.C. 2901 from K216, measurements L = 27.9 mm., W = 33.2 mm., T = 20.4 mm. Figured specimens C.P.C. 2902, 2903, 2904, 2905 (all K218), 2906 (K239), 2907 (K245), 2908 (K246).

Horizon and localities: Sadler Formation, near Sadler Ridge: K214 to K223 inclusive, K235 to K252 inclusive, T53; near Menyous Gap: K268, K273 to K276 inclusive; and Leopold Downs area: Wapet F5. Specimens from K108 are tentatively included within this species. The stratigraphical range of *S. stainbrooki* within the Sadler Formation is as follows (expressed in feet stratigraphically above the base of section):

type section (DD1)	0 to 575
measured section (DD2)	60 to 425
measured section (DD3)	190 to 430

Specimens from the stratigraphically higher Napier Formation (Ld31), Geikie Formation (K285, T5) and Fairfield Beds (K289) may be conspecific, but cannot be determined until more of this material comes to hand.

Discussion: Hosking's four specimens, recorded as *Schizophoria striatula,* are poorly preserved and illustrated. As these specimens were not available for examination their relationship to *S. stainbrooki* cannot be ascertained, but as the new species is very abundant in the Menyous Gap area from which Hosking's specimens were collected, it is almost certain that these forms are conspecific.

Schizophoria stainbrooki is indeed closely related to *S. striatula* (Schlotheim) 1813. Comparison of specimens of the Australian species and *S. striatula* (B.M.(N.H.), B13117) from what is probably the type locality (Gerolstein, Germany) reveals the following small differences: (a) the ventral valve interarea is proportionately shorter in *S. striatula;* (b) the sinus of the anterior commissure is broader and V-shaped in the new species, whereas in *S. striatula* it is deeper, narrower and rounded; (c) in *S. stainbrooki* the ribbing is coarser.

Free ventral valves labelled "*Schizophoria striatula*" (B.M.(N.H.) B41605-08) from the Hackberry Stage, Cerro Gordo substage, *Spirifer* zone, Rockford, Iowa, of uppermost Frasnian age, are distinguishable from the Australian species only by their finer ornament and the more deeply uniplicate anterior commissure. Another similar species in the American Devonian is *Schizophoria australis* Kindle (1909, p. 21, pl. 1, figs. 4-8, pl. 2, figs. 1-5, pl. 3, fig. 1), originally described as a variety of *S. striatula.* A redescription of this species is given in Stainbrook (1947, p. 303, pl. 45, figs. 1, 2, 7, 8). Specimens of this species from the Upper Famennian Percha shale of New Mexico (B.M.(N.H.) BB 11965-68) agree in most respects with the Australian species except in one important detail, their considerably shorter ventral valve interarea.

"*Orthis* (*Schizophoria*) *striatula* Schlotheim, var." (Reed, 1922, pp. 34, 35, pl. 6, figs. 12, 13) from the Upper Devonian of Koragh in the Chitrals is identical externally with *Schizophoria stainbrooki* except for the shallow low narrow median sulcus in the dorsal valve. The interior of the ventral valve of Reed's specimens is not known.

SCHIZOPHORIA PIERRENSIS sp. nov.

(Plate 3, figs. 14-22; Text-figs. 23-25.)

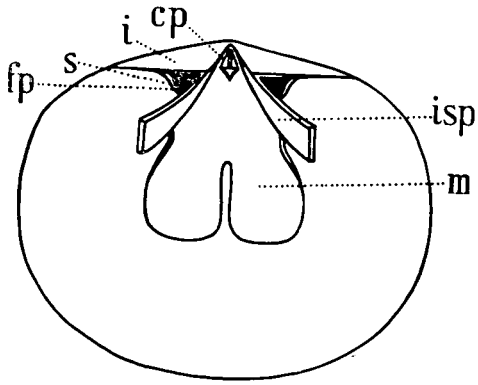
Diagnosis: Like *Schizophoria resupinata* (Martin) 1809 but with an evenly curved anterior commissure and coarser costellae.

Material: Almost one hundred partly recrystallized calcareous shells.

Description: Exterior: Transversely ovate to sub-rectangular in outline; profile biconvex, with a deep dorsal valve. Cardinal margins rounded, anterior commissure broadly and evenly uniplicate or straight. Width of hinge-line about half that of shell-width measured at or anterior to midlength. Ventral valve feebly convex in profile; umbo small, tip straight; median anterior part of valve broadly and shallowly concave. Dorsal valve moderately convex; umbo large and strongly convex with an erect tip. Both ventral and dorsal interareas apsacline, the former with length double that of the latter. Delthyrium open, notothyrium partly filled by cardinal process.

Surface of both valves multicostellate, costellae sharp, separated by rounded grooves. Adults commonly with 12 costellae in width of 5 mm. along median anterior margin. Prominent concentric growth-lines widely and regularly spaced.

Interior of ventral valve: Delthyrial cavity deep, rectangular in section. Dental plates strong, teeth with deep crural fossettes. Low sharp ridges continue forward from the dental plates, presumably functioning as muscle-enclosing ridges. Diductor-scars separated by low broad adductor ridge.

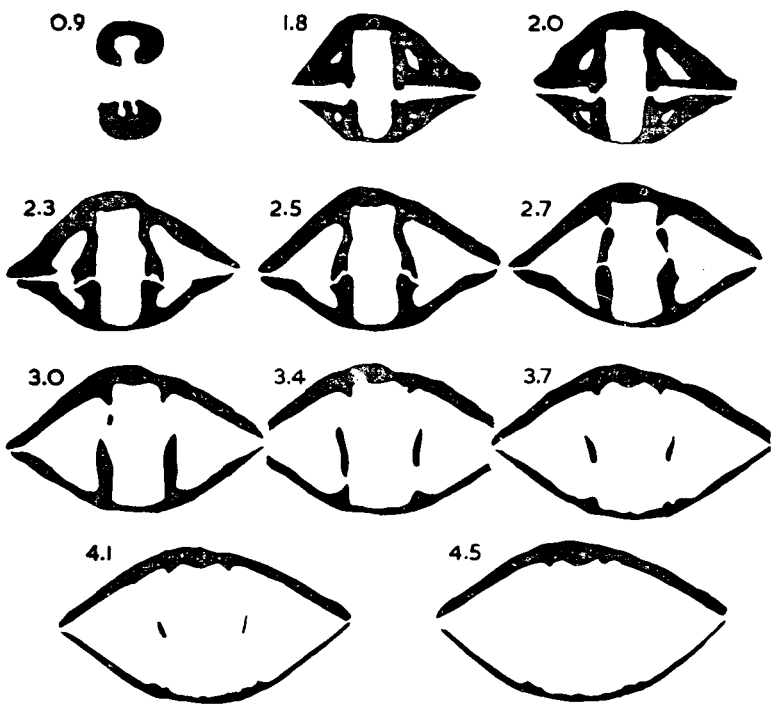


TEXT-FIGURE 23.

S. pierrensis, interior of dorsal valve. cp: cardinal process, fp: fulcral plate, i: interarea, isp: inner socket plate, m: muscle area, s: socket.

TEXT-FIGURE 24.

Schizophoria pierrensis sp. nov. Serial section x4 of a specimen from T25 illustrated in text-fig. 25; the section is 1.3 mm. anterior to the umbo. The cardinal process is expanded ventrally into a bulbous myophore supported on a high narrow median ridge.



TEXT-FIGURE 25

S. pierrensis. Serial sections x 3 of U.W.A. 26044e from T25 (MS.A29) with L = 14.2, W = 16.8, T = 8.5. Delthyrial cavity (sections 1.8, 2.0) is regularly rectangular in section, bounded by strong, long and high dental plates, which support broad teeth with crural fossettes (sections 2.3 and 2.5). Diductor-scar divided medianly by fairly broad and low adductor-ridge (sections 3.0 to 4.5). In dorsal valve sockets raised on high supports which anteriorly taper off (sections 2.3 to 4.1).

Interior of dorsal valve: Broad cardinal process carried on a long thin septum. Dental sockets wide, with fulcral plates. Sockets carried on thick vertical supports. Socket plates long, drawn out distally into pointed tips. Adductor scars bounded by low ridges carried forward from bases of socket supports.

Variation: The two figured specimens show the characteristic variation: the smaller specimen differs from the holotype in the equal convexity of the valves, in the poorly defined median ridge in the ventral valve, and in the correspondingly shallow median sulcus in the dorsal valve.

Measurements:

—	Length.	Width.	Thickness.
Holotype U.W.A. 26044c	21.8	27.0	13.1
Figured specimen U.W.A. 26044d	13.6	16.4	7.6

Types: Holotype U.W.A. 26044c; figured specimen 26044d, both from T 25 (MS A 29).

Horizon and localities: Virgin Hills Formation, Mt. Pierre area (T 25, T 26); Geikie Formation, Fossil Downs Homestead (K285); Bugle Gap Limestone, Bugle Gap (K 169); probable Fairfield Beds, Brooking area (K 503); Napier Formation, Oscar Plateau (KP 144). Tentatively determined from K 166, T 4, and Ld 9.

Discussion: Schizophoria pierrensis seems to be most closely related to specimens of the type species, *S. resupinata.* Thus the figured specimen, U.W.A. 26044d, agrees closely with "*Orthis resupinata*" from the Carboniferous Limestone of Derbyshire (B.M.(N.H.) B 23523), differing only by its slightly coarser costellae. The holotype of *S. pierrensis* is very similar to specimens of *S. resupinata* from the Carboniferous Shale of Scotland (B.M.(N.H.) B 13186), which, however, have a weak median fold in the ventral valve sulcus. From other specimens of *S. resupinata,* adults of *S. pierrensis* differ by their evenly curved anterior commissure.

Superficial similarities with *Isorthis tetragona* (de Vern.) (B.M.(N.H.) B 13118) from the Eifel, Germany, are striking, but apart from undoubted internal differences, the Australian species has a notably shallower dorsal sulcus.

A closer comparison can be made with specimens of *Orthis impressa* Hall 1843 (B.M.(N.H.) B 39825) from the Chemung of Rockford, Iowa, from which *S. pierrensis* is distinguishable by its coarser costellae.

SCHIZOPHORIA APICULATA sp. nov.

(Plate 4, figs. 1-14; Text-fig. 26.)

Diagnosis: Like *Schizophoria resupinata* var. *pinguis* Demanet 1934, but with a gently rounded posterior profile and a marked increase in shell thickness towards the posterior.

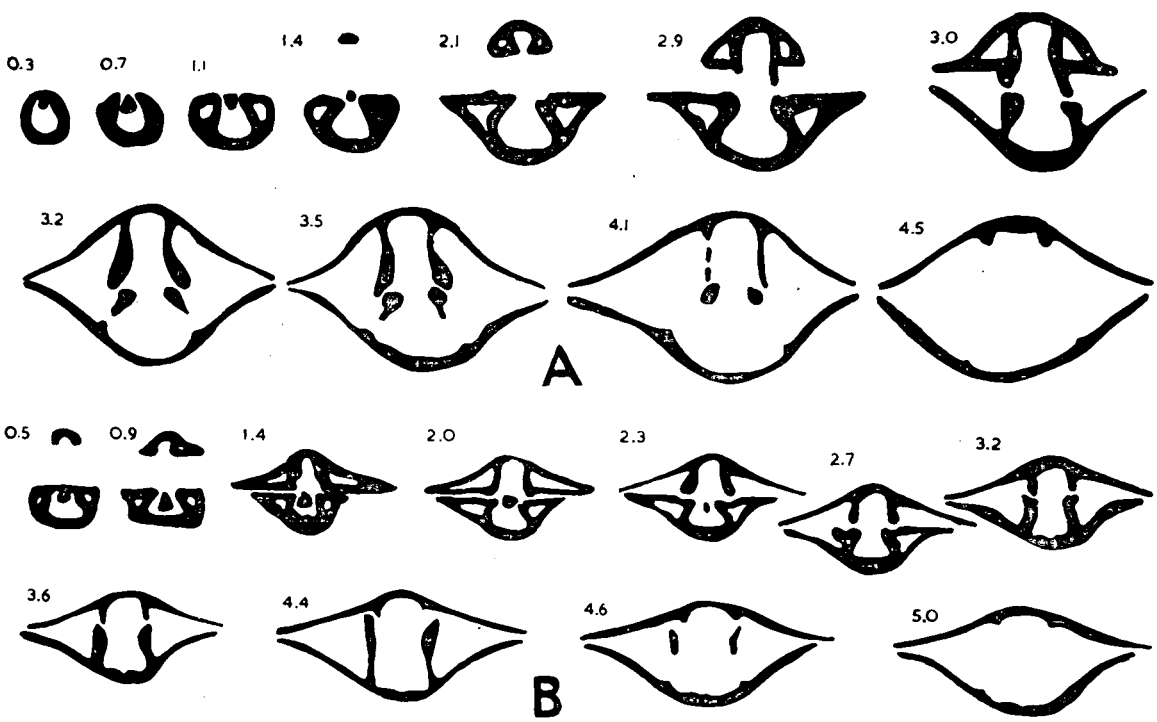
Material: 183 free entire calcareous shells, all slightly distorted and partly recrystallized.

Description: Exterior: Outline transversely ovate to rounded quadrate, profile biconvex, gibbous dorsal valve longer and much deeper than moderately convex

ventral valve. Both valves characteristically deepest posteriorly. Cardinal margins rounded, hinge-line a little shorter than shell width measured at or anterior to midlength. Anterior commissure with a uniformly arched low fold extending across its entire width. No fold in dorsal valve; only rare ventral valves have an anterior median concavity; generally anterior part of ventral valve is feebly convex to flat. Ventral interarea weakly curved, apsacline, with twice length of strongly curved, overhanging, apsacline dorsal interarea. Ventral umbo small and weakly convex with nearly erect tip. Dorsal umbo strongly convex, large, with inturned tip. Delthyrium and notothyrium both open, wide.

Shell multicostellate with rounded costellae separated by rounded striae. Terminations of hollow costellae characteristically displayed over anterior half of shell. Adults commonly with 15 costellae in width of 5 mm. along median anterior margin. Concentric growth-lines faintly impressed, with variable height and at irregular intervals.

Ventral valve interior: Teeth thick, dorsally swollen, supported by high vertical dental plates, which extend anteriorly a short distance along valve floor as low ridges, presumably limiting muscle field. Median adductor ridge poorly developed or absent.



TEXT-FIGURE 26

S. apiculata. **A. Serial sections and peels x 1¼ of C.P.C. 3022 from K322 with L = 29.2, W = 37.5 and T = 18.5, showing globular cardinal process and comparatively low inner socket plates. B. Serial sections x 1 of another specimen from K322 with L = 33.0, W = 43.2 and T = 15.2; shell thinner than C.P.C. 3022; also inner socket plates higher and crural plates stronger.**

Dorsal valve interior: Cardinal process small, globular, anchored apically to notothyrial cavity, extending without support a short distance anteriorly. Sockets strong, with fulcral plates; socket plates high, tusk-shaped, converging ventrally or becoming parallel and vertical anteriorly where they almost touch floor of ventral valve.

Shell structure: Fibrous, finely punctate. Puncta appear on unworn surfaces to be concentrated linearly along crests of costellae in rows of three to five puncta; but on slightly worn shells, they are seen to be distributed evenly over the shell surface.

Variation: In the sample of 183 shells, the range in shell width is 16.4 mm. to 46.5 mm. (*see* Veevers 1959a). Probably only adults are represented; within this group, variation in shape is negligible, restricted to trivial differences in relative convexity of the shell and the development of a flat or faintly concave surface in the anterior half of the ventral valve.

Measurements:

—	Length.	Width.	Thickness.
Holotype C.P.C. 2909	26.4	34.2	20.6
Figured specimen C.P.C. 2910	28.3	39.1	21.1
Figured specimen C.P.C. 2911	30.8	40.1	22.5
F18337/144	22.8	29.6	14.4

Types: The holotype C.P.C. 2909, from Hull Range, locality K322, is a comparatively well-preserved specimen with a broadly uniplicate anterior commissure. Figured specimens are C.P.C. 2910 and 2911, also from K322.

Horizon and locality: Fairfield Beds, near Hull Range, K322. Poorly preserved specimens from K551 (Fairfield Homestead) resemble this species, but this determination must remain speculative until better preserved material is collected.

Discussion: Schizophoria apiculata agrees in many characters with *S. resupinata* var. *pinguis* Demanet 1934 (pp. 59, 60, pl. 4, figs. 9-11) from the Limestone of Visé, Belgium. The distinguishing feature is the shape of the posterior half of the dorsal valve. In *S. resupinata* var. *pinguis* the dorsal valve is deeply inflated and in posterior view has straight steep lateral flanks descending from an almost flat dorsal surface. The same profile in *S. apiculata* is gently rounded and much less inflated. These differences hold in comparison between specimens of the Australian species and specimens of *S. resupinata* var. *pinguis* from the British Carboniferous (B.M. (N.H.) B2480, B54136-8, B54146), which furthermore do not increase in depth towards the posterior to the same degree as the new species.

SCHIZOPHORIA sp. ind.

(Plate 2, figs. 30-38; Text-fig. 27)

Material: Twenty-five partly recrystallized calcareous shells, poorly preserved, distorted and worn.

Description: Exterior: Outline transversely ovate to sub-rectangular, profile equally biconvex; most specimens have been squashed anteriorly to give a Y-shaped profile. Hinge-line comparatively long, less than shell-width measured at midlength. Cardinal margins rounded. Ventral valve interarea long, apsacline to catacline, umbo moderately convex, tip straight. Dorsal valve interarea short, apsacline, umbo small, weakly convex. Delthyrium and notothyrium open.

Surface of both valves poorly preserved; multicostellate, 12 to 14 costellae in width of 5 mm. along median anterior margin. Growth-lines few or absent. Surface finely punctate.

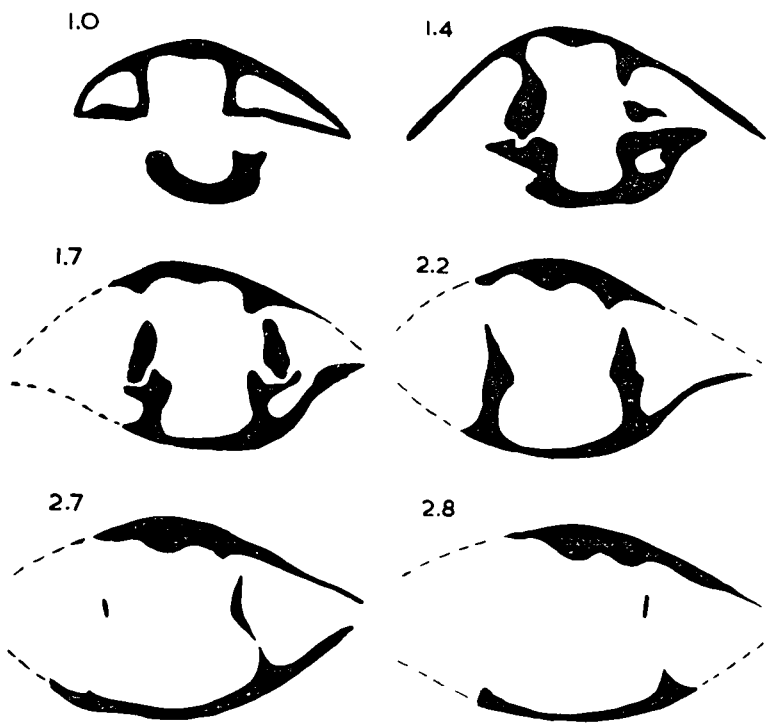
Interior: Teeth thick, supported by high vertical dental plates. Diductors separated by broad low median adductor ridge. Sockets with broad fulcral plates, supported on thick vertical socket plates, high anteriorly, tapering distally.

Measurements:

—	Length.	Width.	Thickness.
Figured specimen C.P.C. 2931 (K230)	14.0	19.6 (est.)	7.5
Figured specimen C.P.C. 2932 (K230)	10.9	15.5	5.8

Horizon and locality: Sadler Formation, Sadler Ridge, K230.

Discussion: If the specimens studied are typical mature shells, they may possibly represent the genus *Isorthis* Kozlowski 1929. The poor development of growth-lines, however, is an indication that these specimens are immature; accordingly the determination as *Schizophoria* agrees with observations concerning the earlier stages of members of this genus.



TEXT-FIGURE 27

Schizophoria **sp. ind. Serial sections x 6 of a specimen from K230 measuring L = 10.4, W = 13.3, T = 4.8. Characteristic of *Schizophoria* are strong dental plates (section 1.4), median adductor-ridge (sections 1.4 to 2.8), strongly supported sockets provided with fulcral plates, and long high tapering inner socket plates.**

Superfamily PENTAMERACEA Schuchert 1896

Family PENTAMERIDAE McCoy 1844

Subfamily GYPIDULINAE Schuchert & LeVene 1929

Genus GYPIDULA Hall 1867

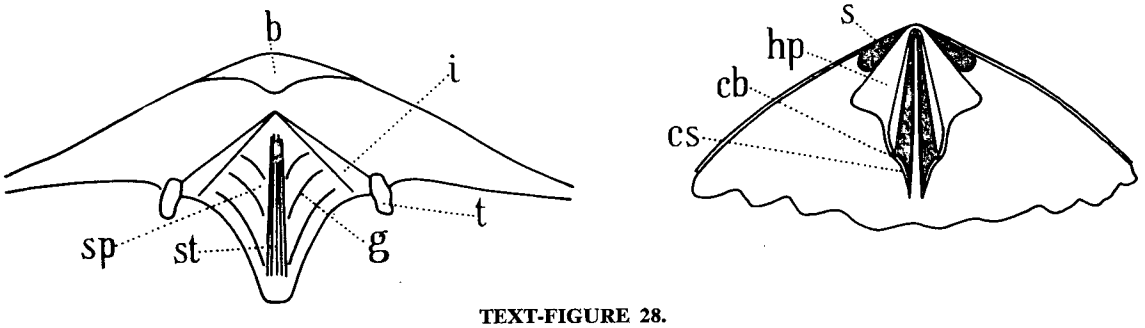
GYPIDULA FRAGILIS sp. nov.

(Plate 4, figs. 13-19; Text-fig. 28)

Diagnosis: Transverse *Gypidula* with a broad and deep dorsal valve sulcus and a low ventral valve fold, with four plications; rest of shell exterior smooth.

Material: Thirty-nine more or less fragmentary silicified shells and valves.

Description: Exterior: Outline transversely elliptical, profile biconvex with ventral valve the deeper. Hinge-line straight, short, width equal to one-quarter to one-third that of shell-width measured at midlength. Cardinal margins rounded. Anterior commissure sulcate, sinus angular in outline with steep lateral borders and a multiplicate median part. Dorsal valve sulcus developed over anterior half of valve, well set off from nearly flat lateral flanks, with five deep rounded grooves and four rounded plications. Low ventral valve fold developed anteriorly, with four rounded plications separated by rounded grooves. Rest of shell smooth. Ventral valve umbo broad, strongly convex, tip inturned; interarea long, very narrow, gently curved, apsacline, poorly delimited by low beak-ridges; divided by a wide, open delthyrium occupying almost entire interarea. Some specimens with thickenings along delthyrial margins, but generally margins are flush with interarea. Dorsal valve umbo prominent, strongly convex, tip erect. Interarea apsacline, with half length of ventral counterpart, gently curved, perforated by wide open notothyrium.



TEXT-FIGURE 28.

G. fragilis **(a) ventral valve showing delthyrial structures. b: beak, g: growth-line, i: interarea, sp: spondylium, st: striae, t: tooth. (b) dorsal valve showing cardinalia. cb: crural base, cs: crural septum, hp: hinge-plate, s: socket.**

Anterior and lateral parts of shell exterior crossed by numerous concentric growth-lines which continue into the interareas. Rest of shell exterior, except for the multiplicate fold and sulcus, smooth.

Ventral valve interior: Teeth short, strong, blunt, divergent dorsally; dental lamellae united into a spondylium supported apically by a very short, stout median septum; narrow ventro-median part of spondylium flat, dorsal surface marked by 15 longitudinal striae, rest of dorsal surface of spondylium crossed by numerous growth-lines (*see* pl. 4, fig. 20).

Dorsal valve interior (*see* pl. 4, fig. 19a, b): Moderately deep notothyrial cavity bordered by crural apparatus composed of three pairs of plates fused together; long

wide divided hinge-plate formed by two flat plates joined posteriorly to valve wall to form sockets. A second pair of plates unites with dorsal edges of the hinge-plate, each line of junction being marked by a longitudinal ridge; these plates are vertical except at their dorsal extremities, which are gently curved medianly. Slender crural bases lie along junction between these plates and the third pair of plates, the thin crural septa which converge dorsally to lie a short distance apart in parallel lines along valve floor. Anterior edges of septa extend almost to midlength; inner surface of septa marked by faint growth-lines.

Measurements:

——	Length.	Width.	Thickness.
Holotype C.P.C. 2935	18.2	24.2	14.4
Almost entire shell, F18414a	19.7	22.8	15.6

Types: Holotype C.P.C. 2935, an almost entire, partly silicified shell from K237; figured specimens C.P.C. 2933 (K239), part of a dorsal valve showing crural apparatus; 2934 (K237), a ventral valve.

Horizon and localities: Sadler Formation, near Sadler Ridge (K216, K236, K237, K238, K239, T53), and near Menyous Gap (K273, K276).

Discussion: The sulcate shell-shape, the ventral spondylium, and the crural apparatus in the dorsal valve indicate *Gypidula.*

Gypidula fragilis differs from the type species, *Pentamerus occidentalis* Hall 1858, in its more transverse outline, small ventral umbo, and broader and deeper dorsal sulcus. From *Pentamerus biplicatus* Schnur (B.M. (N.H.) B39529) from the Middle Devonian of Gerolstein, the Fitzroy species differs in its more transverse outline and its smooth lateral flanks. Its shape agrees more closely with specimens of *Pentamerus striatus* F. Roemer from the same locality (B39534), which, however, have strong lateral plications.

Gypidula romingeri var. *indianensis* Kindle 1901 (pp. 653, 654, pl. 6, figs. 12, 12a), from the Upper Coblenzian Jeffersonville limestone of Falls of Ohio, is similar in shape to *G. fragilis,* but has longer plications in both valves and a broader umbo.

Specimens identified as *Gypidula occidentalis* Hall from the Cedar Valley limestone of Iowa (Stainbrook, 1938b, pl. 1, figs. 1-4) have anterior commissures and lateral profiles identical with that of the holotype of *G. fragilis* but are more elongate and have deeper plications.

Superfamily STROPHOMENACEA Schuchert 1896

Family STROPHOMENIDAE King 1846

Subfamily STROPHOMENINAE Williams 1953

Genus LEPTAENA Dalman 1828

LEPTAENA sp. ind.

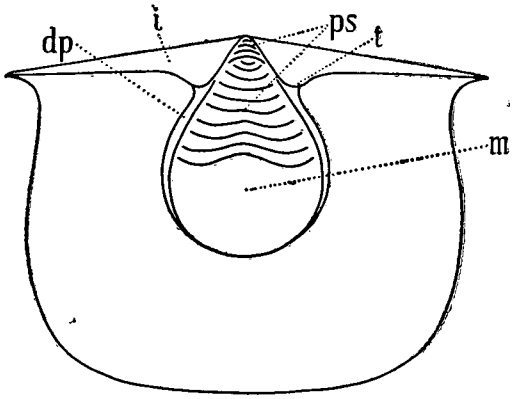
(Plate 5, figs. 22-28, Text-figs. 29-31)

Material: Eight almost entire free calcareous shells, several specimens embedded in limestone showing exterior of one valve only.

Description: Exterior: Outline semi-oval, widest at or a short distance anterior to hinge-line, cardinal marginal angular, subtending angles of 90° to 100°. Profile plano-convex, geniculate. Dorsal valve flat, shallowly and narrowly depressed immediately posterior to line of geniculation; ventral valve gently convex to almost flat, similarly depressed immediately posterior to line of geniculation, with a very shallow broad sulcus along the 'trail'. Length of ventral trail equal to half length of rugose disc; angle of geniculation 80° to 90°.

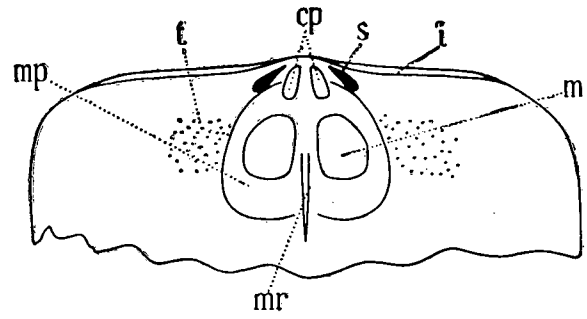
Ventral umbo minute, interarea linear. Dorsal umbo not developed, interarea linear.

Exterior of both valves multicostellate, costellae faint, closely spaced (20 to 30 in width of 5mm at the line of geniculation). Ventral valve costellae may be grouped into two series, larger costellae (at intervals of 1mm along line of geniculation) separated by several finer costellae. Disc crossed by as many as 12 narrow low rugae and trail crossed by numerous faint growth-lines. Whole surface finely pitted (pseudopunctate) as the result of solution of taleolae.



TEXT-FIGURE 29.

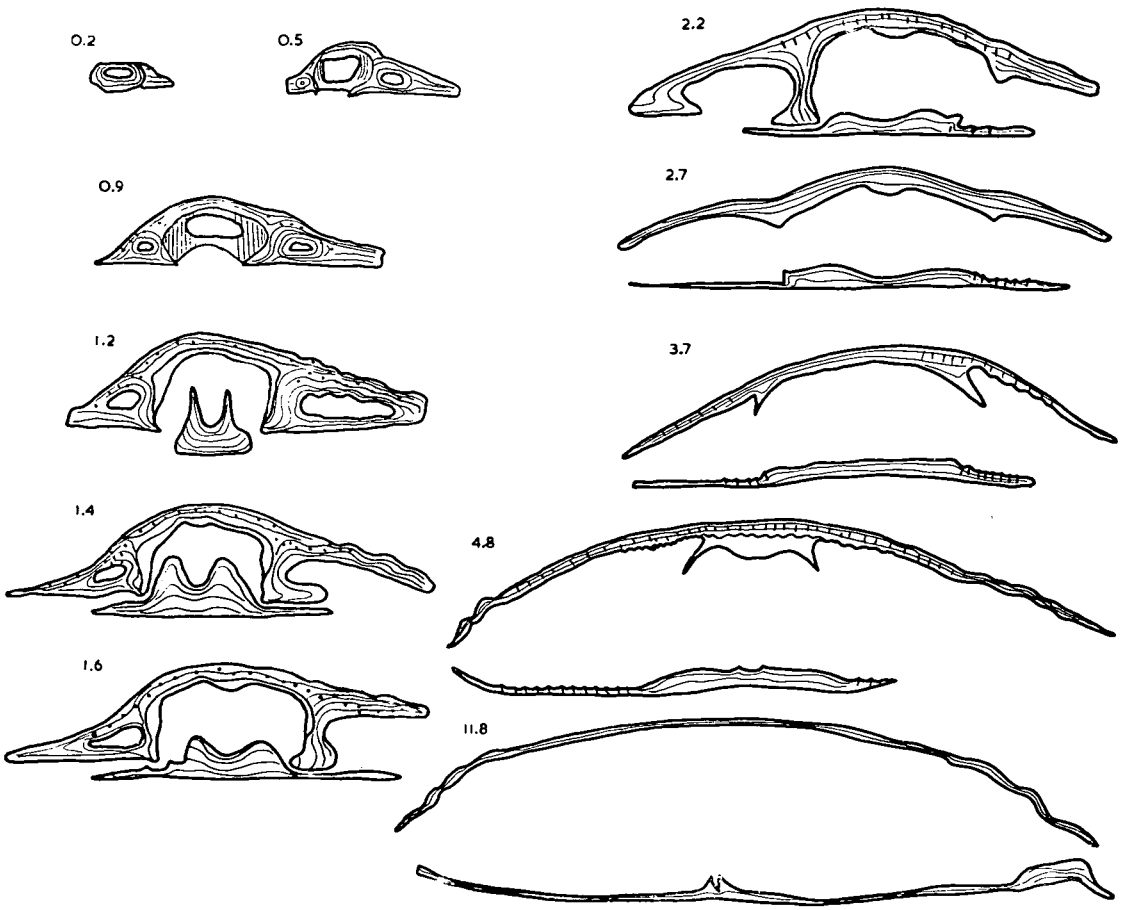
L. **sp. ind., ventral valve interior. dp: dental plate, i: interarea, m: muscle area, ps: pedicle sheath, t: tooth.**



TEXT-FIGURE 30.

L. **sp. ind., dorsal valve interior. cp: cardinal process, i: interarea, m: muscle area, mp: muscle platform, s: socket, t: taleolae.**

Ventral valve interior: Sections 0.2, 0.5 and 0.9 (text-figure 31) show a short tubular structure composed of very thin lamellae, the pedicle sheath, on the ventral and lateral sides of delthyrial cavity. Sheath opens on its dorsal side a short distance anterior to umbo, but ventral and lateral sides continue as a sheet of lamellar tissue along valve floor and inner sides of teeth and dental plates, terminating at anterior edge of latter. Although outer (lamellar) shell layer has been worn off external surface of shell, and therefore cannot be compared in structure with pedicle sheath, sheath with its anterior extension is undoubtedly part of outer layer. The extremely faint growth laminae of the pedicle sheath are concentric in section 0.1, virtually parallel in section 0.5, and aligned ventro-dorsally further anteriorly in section 0.9, implying a change in direction of deposition: from an even deposition around the posterior periphery of the pedicle to deposition concentrated at the sides of the anterior part of the pedicle. The well-developed pedicle sheath indicates the persistence in the living adult shell of a functional pedicle which was able to resorb parts of the delthyrial wall and the entire pseudodeltidium, as Arber (1939, pp. 82-90) and Williams (1953a, p. 2) also deduced.



TEXT-FIGURE 31

Leptaena **sp. ind. Serial sections and peels x 5 of U.W.A. 26095d from T27, with lateral parts of hinge broken off. L = 20.3, W = 23.1, T = 4.8. Taleolae (pseudopuncta) normal to section-plane in first six sections, oblique in remaining sections.**

Teeth broad with flat expanded dorsal faces, supported by short, strong, vertical dental plates. Muscle field broad, anteriorly elevated on a platform of callus material, enclosed by sharp-crested flanges (text-fig. 31, sections 3.7, 4.8).

Dorsal valve interior: Cardinal process large, bilobed, extending deeply into delthyrial cavity; sides of cardinal process form inner parts of dental sockets which are simple broad shallow depressions on valve floor. Base of cardinal process broadens anteriorly into a low longitudinally-grooved muscle platform which terminates anteriorly in a low narrow ridge (section 11.8).

Shell structure: Three different kinds of shell matter were found in the specimen sectioned: (1) the pedicle sheath, consisting of very thin lamellae; (2) the seats of muscle attachment composed in the dorsal valve of coarse wavy laminae, in the ventral valve apparently of amorphous callus material; (3) the remainder of the shell, composed of finely fibrous material locally enclosing taleolae. The taleolae are concentrated

in the ventral valve, but do not occur in the teeth or dental plates. In the dorsal valve the only taleolae seen are concentrated around the muscle platform to form the centres of tiny papillae along the floor of the interior (*see* sections 3.7, 4.8 and 11.8).

Measurements:

—	Length.	Width.	Thickness.	Length of trail.
Figured specimen U.W.A. 26095a (T27) ..	19.0	30.5	11.1	10.8
Figured specimen U.W.A. 26095b (T27) ..	20.6	24.3	..	..
Figured specimen U.W.A. 26095c (T27) ..	17.6	21.5 (est.)	7.4	9.2

Horizon and localities: Fairfield Beds, S-Hill (T27) and Fossil Hill (T12); Geikie Formation, Fossil Downs Homestead (T5); Bugle Gap Limestone, Bugle Gap (K170); Napier Formation, near Fairfield Homestead (KP101); Oscar Formation, near Brooking Gorge (KP149).

Discussion: The Fitzroy *Leptaena* is apparently identical externally with specimens labelled "*Leptaena analoga* (Phillips)" from the Lower Carboniferous of the British Isles (B.M.(N.H.) B91399, B91400, 26232, B8946), "*Leptaena rugosa*" from the Devonian of the Eifel (B.M.(N.H.) B83799-801), and "*Leptaena analoga*" from Gerolstein (B.M.(N.H.) B39637). Until further collections become available, and hence until the range of variation can be determined, it is best to leave this species unnamed.

Family STROPHEODONTIDAE Caster 1939, em. Williams 1953

Subfamily STROPHEODONTINAE Caster 1939

Genus DOUVILLINA Oehlert 1887, em. Williams 1953

Subgenus DOUVILLINA (DOUVILLINA) Oehlert 1887, em. Williams 1953

DOUVILLINA (DOUVILLINA) EXQUISITA sp. nov.

(Plate 6, figs. 1-5; Text-fig. 32)

Diagnosis: Moderately small, weakly concavo-convex *Douvillina* with 20 to 30 costellae in two series; interspaces between adjacent costellae crowded with four to six radial lines.

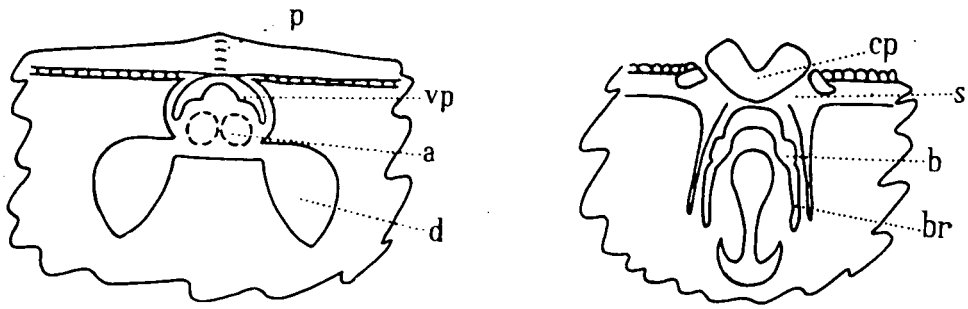
Material: Nearly fifty free silicified shells and valves.

Description: Exterior: Outline semicircular to sub-triangular, mucronate; profile biplanate to weakly concavo-convex, anterior commissure straight to weakly sulcate.

Ventral valve weakly convex, deepest at mid-point; umbonal region moderately convex; median fold absent or weakly developed, strongest at umbo. Tip of umbo nearly straight, perforated by tiny pedicle foramen. Interarea fairly long, weakly concave, almost overhung by beak-ridges, apsacline to nearly orthocline, marked longitudinally by closely crowded lines, the external traces of denticles. Pseudodeltidium with a sharp narrow median fold.

Dorsal valve nearly flat except for broad shallow median depression. Interarea slightly overhanging posterior margin of valve, flat, hypercline; chilidium vestigial.

Shell exterior with prominent primary costellae (total of 10 to 15 in adults), between which are inserted an equal number of secondary costellae mainly developed anteriorly. Interspaces between adjacent costellae crowded with four to six minute radial lines. Minute growth wrinkles (with average interval of 1.5 mm.) cross costellae producing a finely rugose surface; between successive growth wrinkles there are up to ten extremely fine growth-lines.



TEXT-FIGURE 32.

D. exquisita **(a) part of the ventral valve interior. a: adductor, d: diductor, p: pseudodeltidium, vp: ventral process. (b) part of the dorsal valve interior. b: boss, br: brace-plate, cp: cardinal process, s: socket.**

Ventral valve interior: Hinge minutely denticulate for half distance between pseudodeltidium and mucronate extremities; denticles narrow, separated by narrower grooves. Posterior part of delthyrial cavity occupied by ventral process which is divided anteriorly into two lobes separated by a shallow delthyrial pit. Broad low median ridge immediately anterior to ventral process divides muscle field. Adductors on either side of median ridge small, circular to longitudinally elliptical. Diductors large, elongate, divergent anteriorly, bounded laterally by high overhanging walls whose inner parts almost unite with the anteriorly swollen median ridge to form an arch. Rest of interior coarsely to finely papillate, with faint radial lines corresponding to external costellae grooved along anterior and lateral margins.

Dorsal valve interior: Cardinal process with flat, widely separated prongs at right angles to each other, attachment faces directed posteriorly, disjunct; process bounded laterally by shallow dental sockets. Muscle field narrow, elongate, elevated above valve floor, circumscribed by high thick overhanging braceplates each with a prominent rounded posterior boss. Muscle field divided by strong median septum expanding anteriorly into a thick high protuberance, posteriorly giving way to spoon-shaped depression, presumed to be the posterior adductor scar. Muscle platform bounded laterally by narrow low tuberculate ridges. Rest of interior closely papillate with faint radial lines on anterior and lateral margins.

Measurements:

—	Length.	Width.	Depth of ventral valve.
Holotype C.P.C. 2938 (K244)	10.6	12.7	3.4
Figured specimen C.P.C. 2937 (K244)	9.8	12.8	2.8
Larger specimens F18305/1 (K242)	14.7	19.8	4.1
Smaller specimen F18300/1 (K245)	3.9	6.8	1.1
Mucronate specimen F18300/2 (K245)	9.2	15.5	2.7

Of these specimens, the last, F18300/2, is the only one in which the mucronate extremities of the hinge remain intact.

Types: Holotype C.P.C. 2938, figured specimens C.P.C. 2937 (ventral valve), 2936 (dorsal valve), all from K244.

Horizon and localities: Sadler Formation, near Sadler Ridge (K236, K242, K244, K245, K252, T53, T58), and near Menyous Gap (K265, K266, K276). Tentatively determined from Horse Spring (K480).

Discussion: In the opposed valves of the living shell the high rounded bosses situated in the dorsal valve at the posterior ends of the braceplates must have lain close to the incipient arches of the muscle-enclosing ridges in the ventral valve. Although the functions of the bosses and the incipient arches are not understood, the growth of these structures towards one another, reducing the volume of the visceral cavity, and probably making the valves difficult to close tightly, was probably an important contributory factor in the extinction of the *Douvillina* stock in Upper Devonian times.

The medianly folded pseudodeltidium, vestigial chilidium, disjunct cardinal process lobes, obsolescent socket plates, deeply impressed muscle scars, and well-formed braceplates in the dorsal valve are diagnostic of *Douvillina* (*Douvillina*).

Douvillina exquisita differs from the type species, *Orthis dutertrei* Murchison 1840, in being much smaller and less strongly concavo-convex, and in having fewer, more widely spaced primary costellae. Externally, *D. exquisita* agrees closely with *D. bellistriata* Cooper & Cloud (1938, pp. 446, 447, pl. 54, figs. 52, 58, 59) which, however, may be distinguished by its strongly concavo-convex profile. Comparison of shell interiors is not possible as *D. bellistriata* is apparently unknown internally. *D. bellistriata* was described from Devonian exposures in Calhoun County, Illinois, which are correlated with the upper part of the Tully formation of New York, of lowermost Frasnian age.

More closely comparable in shape to the Fitzroy species is *Douvillina ferquensis* (Rigaux) 1873 (B.M.(N.H.) B39367); but the costellae of *D. ferquensis* are finer and more numerous.

D. exquisita is superficially similar to *Orthis interstrialis* Phillips 1841, but *O. interstrialis* has a wider outline, more primary costellae, and no secondary costellae. Certain variations of the British species, such as G.S.G.B. 50839 from the Middle Devonian of Plymouth, are more difficult to distinguish from *D. exquisita,* although reference to the minute details of the costellation, especially the presence or absence of secondary costellae, provides a certain test of specific difference.

Specimens of *Douvillina interstrialis* (Phillips) in Mansuy (1912, p. 72, pl. 13, figs. 4a-c) and also in Grabau (1931, pp. 16-18, pl. 1, fig. 1) are very close externally to *D. exquisita:* details of shell shape, size and external ornament agree very closely in so far as these details can be seen from the illustrations. No internal details are given by either author. Mansuy's specimens are from Ta-Hi-Ti (Upper Devonian of Yunnan). Grabau's specimens are from "Devonian of southern Kansu". Both Mansuy's and Grabau's specimens differ from typical *D. interstrialis* in being weakly convex.

ZOPHOSTROPHIA gen. nov.

Type species: Zophostrophia ungamica sp. nov.

Diagnosis: Stropheodontids in which the divergent ventral diductors are enclosed by overhanging bounding ridges which stop short of uniting dorsally into the kind of arch diagnostic of *Hercostrophia* Williams 1950.

Discussion: Zophostrophia is included in the Stropheodontidae because of its denticulate hinge and its well-developed ventral process.

Z. ungamica resembles in general characters members of *Hercostrophia* Williams 1950. Similarities are mainly found in the interior of the ventral valve; the divergence of the diductors, associated with the dorsally-directed growth of the muscle-enclosing ridges; the excavate process pits; and the strong ventral process. Important differences are found in detailed comparisons of shell shape, the muscle scars and ridges of the dorsal valve, and the external ornament: *Hercostrophia* is not geniculate; the muscle-enclosing ridges in the dorsal valve of *Hercostrophia* are narrowly separated in comparison with homologous structures in *Zophostrophia*; externally, *Zophostrophia* lacks the accentuated primary costellae and fairly prominent growth-lines characteristic of *Hercostrophia.* Nevertheless, like *Hercostrophia, Zophostrophia* is clearly a member of a " divergent line of shalerid stock in which the main trend was towards an encirclement of the diductor muscles by inward growth of the apices of the bounding ridges " (Williams, 1953b, p. 47). This trend in *Zophostrophia* did not develop as far as in *Hercostrophia,* in which the apices of the obtusely triangular bounding ridges meet postero-centrally to form a narrow ring of shell deposit around each scar.

ZOPHOSTROPHIA UNGAMICA sp. nov.

(Plate 6, figs. 6-12; Text-figs. 33-35)

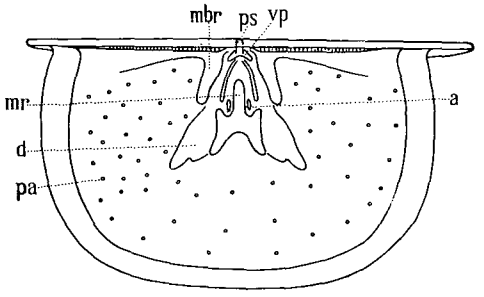
Material: Four almost entire free shells, an incomplete free dorsal valve, and an almost free ventral valve, all silicified.

Description: Exterior: Outline semicircular to transversely semi-oval, profile geniculate, disc biplanate to plano-convex. Hinge-line mucronate, cardinal margins rectangular, anterior commissure undulating.

Ventral valve flat to very weakly convex, deepest immediately anterior to beak; geniculated sharply through 80° to 100° anteriorly, less acutely along lateral parts of shell. Length of trail equal to three-fifths length of disc. Umbo barely discernible, interarea moderately long, flat or gently concave, some specimens with transverse groove dividing interarea into two planes of equal length inclined at 150°. More commonly surface of interarea marked by as many as three faint transverse striae which, becoming prominent laterally, form one or more slender spines inclined at low angles to the hinge-line. Hinge denticulated over greater part of width, four denticles in width of 1 mm. Pseudodeltidium flush with interarea, flat.

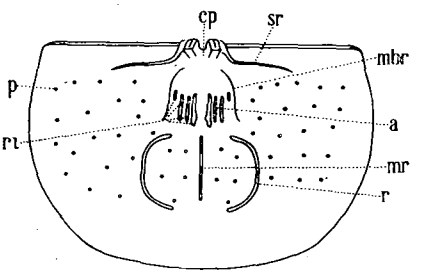
Dorsal valve flat except for geniculated marginal extremities. Without umbo; interarea linear, notothyrium closed.

Shell exterior covered by closely crowded minute radial costellae of uniform size (8 costellae in 1 mm. at line of geniculation) increasing by intercalation. Both valves with weak concentric rugae immediately posterior to line of geniculation.



TEXT-FIGURE 33.

Z. ungamica, **ventral interior. The pallial sinuses are shown in Text-fig. 35. a: adductor, d: diductor, mbr: muscle-bounding ridge, mr: median ridge, pa: papilla, ps: pseudodeltidium, vp: ventral process.**



TEXT-FIGURE 34.

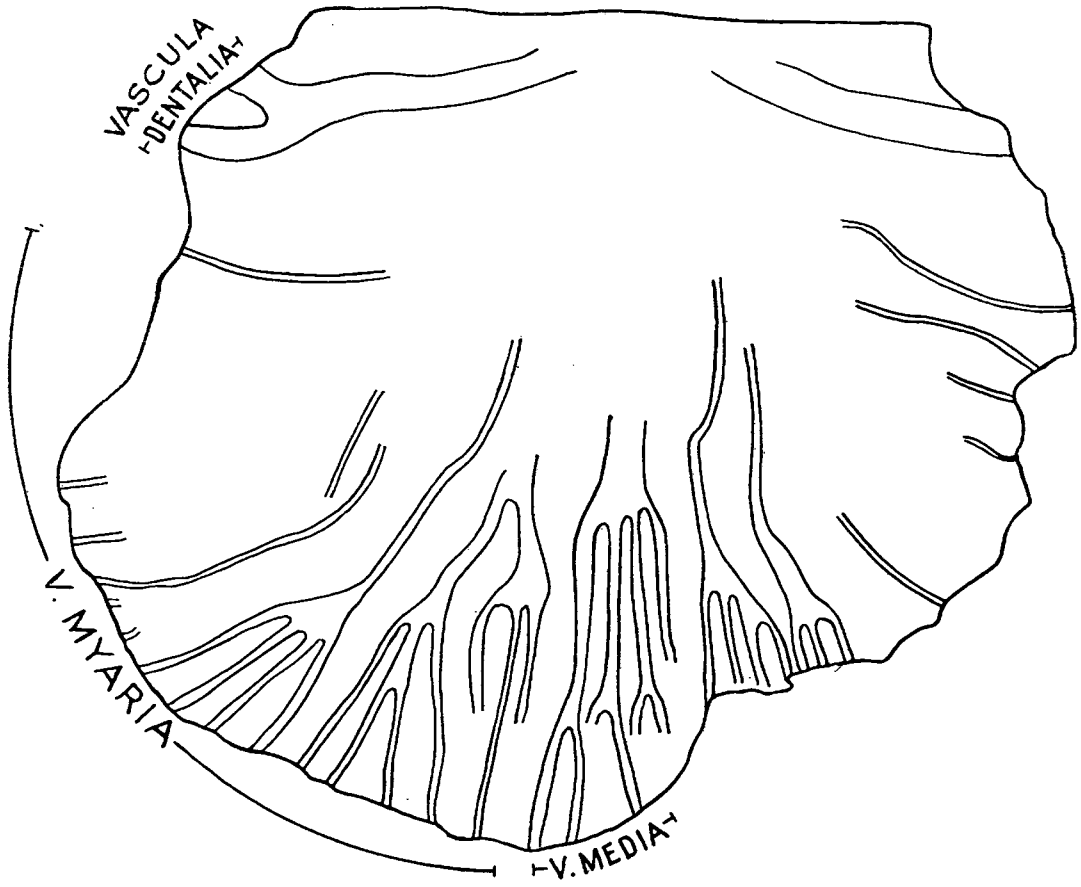
Z. ungamica, **dorsal valve interior. a: adductor, cp: cardinal process, mbr: muscle-bounding ridge, mr: median ridge, r: ridge, p: papilla, ri: muscle ridges, sr: socket ridge.**

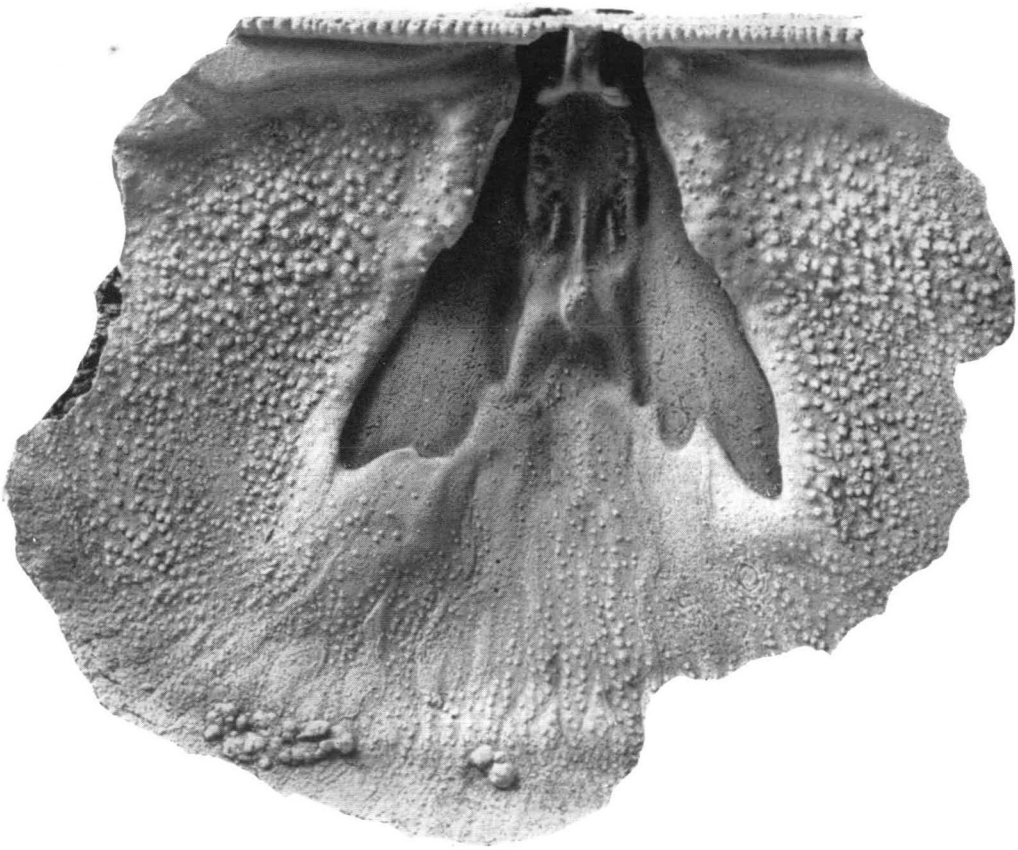
Ventral valve interior: Pseudodeltidium supported by strong ventral process which arises from posterior floor of delthyrial cavity as a thick septum, supported anteriorly by two laterally directed ridges in turn supported by thickened bases. Lateral to ventral process are deep bulbous cavities in which prongs of cardinal process articulate. Diductors elongate, divergent, bounded laterally and anteriorly by high overhanging rounded ridges, deeply grooved posteriorly on their inner side Adductors lightly impressed, surrounded posteriorly by low rounded lateral ridges, and anteriorly by a low ridge contiguous with high prominent median mound; each scar further divided by a short low longitudinal ridge.

Except for pallial sinuses and muscle field, entire surface of ventral valve papillate, papillae coarse posteriorly and fine anteriorly. Pallial sinuses particularly well preserved in ventral valve C.P.C. 2941; vascula media, v. myaria, and v. dentalia are all clearly shown (fig. 35). The v. dentalia are broad deep channels which split laterally; the posterior branch presumably leads to an extended " ear " or " wing " and the anterior branch leads to the anterior margin of the valve. Paired v. media issue as a fairly narrow single trunk immediately anterior to the high median mound between the inner muscle-enclosing ridges. On each side of the inner part of the valve are three v. myaria which branch repeatedly towards the margin to form shallow but prominent marginal grooves. Less regularly disposed sinuses on the sides of the valve probably lead back into the muscle field and hence may also be grouped as v. myaria.

Together, these sinuses form a polypalmate (or pinnate) pattern most closely reminiscent of *Clitambonites schmidti epigonus* Öpik (1934, fig. 8). The three types of sinus, v. media, myaria and dentalia, are similarly developed and distributed in *Zophostrophia ungamica* and *Clitambonites.*

The only other strophеodontid with well-preserved sinuses appears to be *Strophonelloides* Caster 1939, a genus coeval with *Zophostrophia.* Although in his strophеodontid memoir Williams (1953b) makes no mention of the vascular system, he presents a figure of the ventral valve of *Strophonelloides* sp. (pl. 8, fig. 1) which leaves no doubt that the pattern here is polypalmate. Although in respect of sinus pattern *Strophonelloides* is less similar to *Zophostrophia* than say *Clitambonites*


VASCULA
DENTALIA
V. MYARIA
V. MEDIA



TEXT-FIGURE 35.
Nervostrophia bunapica, **pallial sinuses.**

schmidti epigonus, the same three groups of sinuses, the reduced v. media, the broadly spread v. myaria, and the v. dentalia lying parallel to the hinge-line, are all distinguishable in the American genus.

Thus, although several different sinus patterns exist among strophomenoids, the polypalmate type of pattern in *Zophostrophia* must enhance Williams' idea (1956, p. 278) that the polypalmate (or pinnate) pattern is the most commonly developed pattern in the ventral valve of strophomenoids. In this regard, the strophomenoids closely resemble the other group of polypalmate shells, the clitambonoids.

Dorsal valve interior: Bifid cardinal process strong, moderately small, disjunct; deeply notched, each prong moderately short, postero-ventrally directed attachment surface with shallow longitudinal groove. Vestigial socket ridge unattached posteriorly, embedded in valve floor anteriorly. Muscle field limited laterally by broad high ridges. Adductors longitudinally oval, separated by a narrow median depression. Anterior half of each scar marked by three narrow low longitudinal ridges. Outer ridge continues anteriorly into a conical mound. In anterior of muscle field are two narrow arcuate ridges and a median ridge. Internal surface, except muscle field, finely papillate.

Measurements:

—	Length.	Width.	Thickness of Disc.	Length of Trail.
Holotype C.P.C. 2942	24.7	40 (est.)	4.1	10.0
Figured specimen C.P.C. 2939	21 (est.)	38.2	4.0	..

Types: Holotype C.P.C. 2942; figured specimens C.P.C. 2939, 2940 (dorsal valve), 2941 (ventral valve). All from K245.

Horizon and localities: Sadler Formation; holotype and figured specimens from Sadler Ridge area (K245), one specimen from near Menyous Gap (K276).

Discussion: The internal structures of the shell indicate that the lophophore had the form of a thin disc closely adpressed to the dorsal valve. The low ridges anterior to the muscle field of the dorsal valve, therefore, very probably functioned as weak supports to a spirolophous lophophore, divided by the median ridge into two equal parts. According to this reconstruction, one similar to that already proposed for other strophomenoids (*see* Williams, 1956, pp. 256, 266), the mouth would lie between the two small ridges bounding the adductors on their inner sides.

Genus NERVOSTROPHIA Caster 1939, em. Williams 1953

NERVOSTROPHIA BUNAPICA sp. nov.

(Plate 7, figs. 1-8; Text-figs. 36, 37)

Diagnosis: Like *Nervostrophia nervosa* (Hall) 1843 but with fewer primary costellae and more secondary costellae. Probably also with ventral valve adductors circumscribed by low ridges.

Material: Four almost entire free silicified valves, twelve fragmentary silicified valves.

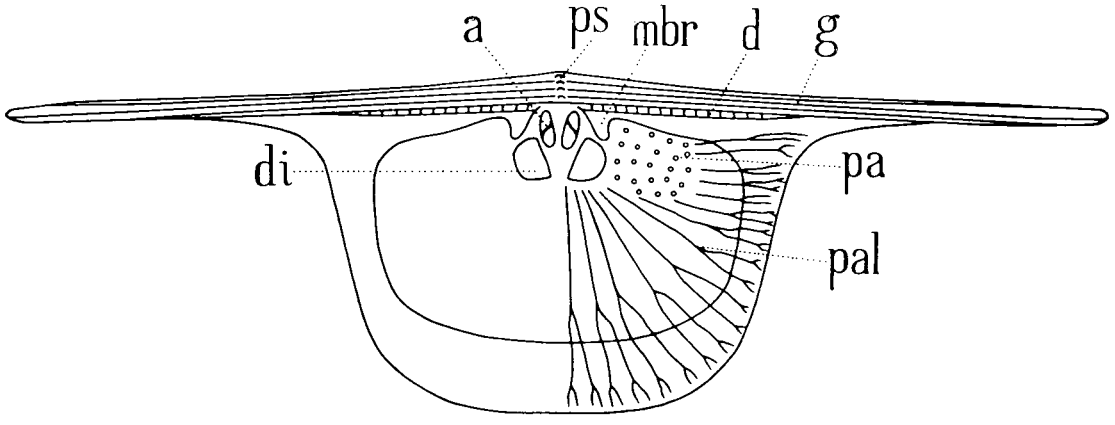
Description: Exterior: Outline longitudinally semi-oval, mucronate; profile weakly plano-convex to biplanate, anterior commissure straight.

Ventral valve weakly convex to flat, umbo minute. Interarea moderately short, flat, apsacline, surface marked transversely by several faint ridges; growth-lines on external surface continuous with anterior edges of spines along hinge, which therefore mark former position of successive extremities of hinge-lines. Pseudodeltidium medianly folded.

Dorsal valve shallowly concave to flat. Interarea linear, anacline, chilidium apparently vestigial.

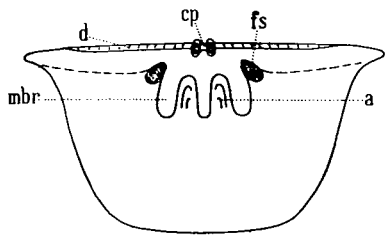
Both valves parvicostellate with up to 30 nervate primary radial costellae separated by as many as 12 minute radial lines; increase by intercalation. Concentric growth-lines faint centrally, becoming prominently lamellar on the margins.

Ventral valve interior: Denticles numerous, flat-sided, narrow, spaced 4 in 1 mm., hinge denticulate over half its width. Visceral area gently concave, margins concentric with valve periphery; rest of interior flat or weakly concave. Pseudodeltidium supported by thin ventral process prolonged anteriorly as a low ridge expanding into a broad low conical mound which bisects muscle field. Tiny longitudinally elliptical adductors further divided by oblique narrow strips of non-impressed shell-matter into anterior and posterior pairs. Broader strip of non-impressed shell-matter separates adductors from small lightly impressed longitudinally oval diductors. Muscle field contained postero-laterally by slightly overhanging moderately high tuberculate ridges. Between these ridges and the hinge-shelf, surface crowded with coarse papillae; rest of interior very finely papillate; faint lines of papillae divide marginally into two branches, which correspond with external costellae. These lines probably correspond to pallial sinuses.



TEXT-FIGURE 36.

N. bunapica, **ventral valve interior. a: adductor, d: denticle, di: diductor, g: growth-line, mbr: muscle-bounding ridge, pa: papilla, pal: pallial sinus, ps: pseudodeltidium.**



TEXT-FIGURE 37.

N. bunapica, **dorsal valve interior. a: adductor, cp: cardinal process, d: denticular socket, fs: false socket, mbr: muscle-bounding ridge.**

Dorsal valve interior: Bifid cardinal process short and stout, narrowly cleft. Each lobe longitudinally grooved, attachment surface facing posteriorly. Vestigial socket-plates fused to sides of cardinal process, whence they descend to valve floor, continue parallel to hinge-line, and terminate marginally. Base of cardinal process prolonged anteriorly as broad low median ridge terminating at anterior edge of muscle field. From sides of cardinal process issue two very stout flat-topped muscle-enclosing ridges, likewise terminating at anterior edge of muscle field. Elliptical adductors moderately deeply impressed, longitudinally striated. Rest of interior with coarse to fine papillae.

Measurements:

	Length.	Width.		Depth of Ventral Valve.
		At Hinge.	At Midlength.	
Holotype C.P.C. 2943	26.5	60 (est.)	33.1	2.5
Figured specimen C.P.C. 2944	12.1	30 (est.)	16.3	1.4
Figured specimen U.W.A. 26271a	21.0	..	27.5	2.8

Types: Holotype C.P.C. 2943 from K 245, a nearly entire free silicified ventral valve. Figured specimens C.P.C. 2944 (K 245), U.W.A. 26271a and 26271b (both from T 53).

Horizon and localities: Sadler Formation, near Sadler Ridge (K 245, T 53), and near Menyous Gap (K 276). Poor specimens from Sadler Ridge (K 230) are doubtfully referred to this species. Oscar Formation, Oscar Range (O/73); transition between Pillara Formation and Napier Formation on Oscar Plateau (O/67).

Discussion: The Fitzroy species agrees generically in all respects except one with members of *Nervostrophia:* whereas in the type species of *Nervostrophia, Strophomena nervosa* Hall 1843, the adductors of the ventral valve are comparatively long, divergent, and splayed out anteriorly, in *N. bunapica* the ventral valve adductors are fairly short, parallel, and enclosed by low ridges. As only two ventral valve interiors have been seen, and as only one of these is well preserved, the small discrete muscle field may not be typical of all members of this species. If it is, a new genus is probably represented, homeomorphic with *Nervostrophia;* on the other hand, if the muscle-enclosing ridges are found to be abnormal deposits in shells which ordinarily

have long, divergent ventral valve diductors, it is clear that the Fitzroy form is a valid member of *Nervostrophia*. *N. bunapica* differs further from the type species in having fewer primary costellae and more secondary costellae.

Apart from the differences in the pattern of the ventral valve muscle-field, *N. bunapica* is similar to two American species, *N. rockfordensis* (Fenton & Fenton) 1924 (pp. 93-95, pl. 21, figs. 3-7) from the Hackberry Stage, and *N. tulliensis* H. S. Williams, the latter illustrated in Cooper & Williams (1935, pl. 57, fig. 4). *N. vestita* Crickmay 1952 (pp. 608, 609, pl. 78, figs. 1-6) of Hackberry age is very similar to *N. bunapica,* differing only in having double the number of costellae found in the Australian species.

Members of *Nervostrophia* have been reported so far from North America only; but even if *N. bunapica* is not an acceptable member of this genus, *Leptaena latissima* Rigaux 1873 (p. 53, figs. 7a-d), which is indisputably a valid *Nervostrophia,* does extend the geographical range of the genus. *N. latissima* occurs in the Ferques Limestone and Beaulieu Shales of north-western France and is also recorded from Belgium (Maillieux, 1910, p. 140) in the Zone à *Sp. orbelianus,* the Schistes à *Receptaculites* and the Récif de l'Arche, on the southern border of the Dinant Synclinorium. Rigaux's figures illustrate the nervose costellae, the long radially striated muscle scars of the ventral valve interior extending anterior to midlength and enclosed laterally and medianly by fairly high ridges, the flat pseudodeltidium, and a dorsal valve interior indistinguishable from that of other species of *Nervostrophia.* The posterior part of a ventral valve from Ferques (B.M.(N.H.) B 19189) is figured by Arber (1942, p. 183, text-fig. 2E). This species is also discussed and illustrated by Quenstedt (1871, p. 598, pl. 57, figs. 59-61). Kayser found a similar if not identical form in the upper Couvinian Crinoiden-Schichten of Sötenich (1871, p. 629). *N. latissima* differs from *N. bunapica* in its greater size and coarser nervose costellae, and in having the ventral valve muscle field not enclosed anteriorly.

Nervostrophia is possibly further represented by *Strophomena nodulosa* Phillips in Torley (1908, pp. 35, 36, pl. 9, fig. 1), which has nervose primary costellae with fine interposed radial lines. There are no details of the interior.

Mansuy (1912, pp. 66, 67, pl. 12, figs. 3a, b) described the exterior of a ventral valve which he assigned to *Orthotetes crenistria* Phillips. It comes from the Devonian of Siao-Long-Tan, eastern Yunnan. In ornamentation and shape this form agrees with *N. bunapica:* valve outline is transversely semi-elliptical, radial costellae number 50 at the margin, and there are three to five fine lines between adjacent costellae, which are nervose. No internals are shown.

From the original description of *Leptaena asella* Verneuil 1845 (pp. 224, 225, pl. 14, figs. 3a-c) it may be inferred that this species also belongs to *Nervostrophia:*

> Les stries de la surface sont plus tortueuses, plus irrégulières et sujettes à des renflements subitement interrompus. . . . A l'intérieur, la valve dorsale [ventral valve of present-day usage] est pourvue de deux arêtes qui divergent à partir des bords de l'ouverture, et d'une arête médiane qui sépare deux petites cavités oblongues, situées au dessous du crochet.

Plate 14, fig. 3b of Verneuil's work shows the muscle-enclosing ridges and the short median ridge separating the posterior half of two short narrowly elliptical

impressions. These impressions are probably those of the adductors, and the diductors probably spread anteriorly; but the impressions may possibly be the diductors, and in that case, *L. asella* would be strictly congeneric with *N. bunapica.*

Verneuil's species is recorded by Nalivkin (1930a) from the Devonian of the Voroneje District.

Superfamily ORTHOTETACEA Williams 1953

Family SCHUCHERTELLIDAE Stehli 1954

Subfamily SCHUCHERTELLINAE Williams 1953 em. Stehli 1954

Genus SCHUCHERTELLA Girty 1904

SCHUCHERTELLA DROMEDA sp. nov.

(Plate 5, figs. 11-21; Text-figs. 38, 39)

Diagnosis: Large relatively thin resupinate *Schuchertella* with 10 to 12 costellae in a width of 5 mm. at anterior border of adults.

Material: Nearly 50 entire calcareous shells; no free valves.

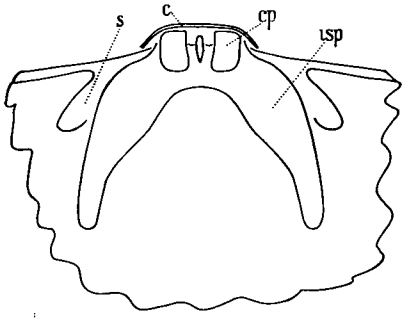
Description: Exterior: Outline semicircular to semi-oval, profile convexo-planar to resupinate; hinge-line equal to or slightly shorter than shell-width, measured at or just anterior to hinge-line. Cardinal margins acutely angular or rounded. Anterior commissure variable, straight to broadly and gently sulcate.

Ventral valve resupinate, less commonly nearly flat except in convex umbonal region. Resupination takes place in a mature specimen at midlength. Rare specimens have a low narrow median fold which arises from umbo, and is prolonged to anterior border. Umbo small, weakly convex, tip straight. Interarea moderately long, flat, apsacline, marked transversely with as many as six narrow rounded grooves. Pseudodeltidium narrow, strongly arched, with a straight dorsal edge. Perideltidium poorly expressed, delimited from rest of interarea by two faint straight lines running from the umbo on either side to a point on the hinge-line a little less than half-way from the pseudodeltidium to the lateral extremity of the hinge-line.

Dorsal valve weakly convex with a broad fold including the entire valve except for the flat postero-lateral flanks. Narrow shallow median sulcus arises from point just anterior to umbo; sulcus absent in some specimens. Umbo tiny, inconspicuous; interarea linear, smooth, anacline; notothyrium filled by posterior edge of cardinal process, chilidium not developed.

Exterior of both valves multicostellate, costellae low and narrow, rounded in profile, separated by slightly wider shallow rounded grooves; costellae spaced 10 to 12 in a width of 5 mm. at anterior border of adults; increase by intercalation. As many as six faint, widely spaced concentric growth-lines; a local dictylate pattern is induced by development of numerous tiny growth wrinkles crossing costellae.

Ventral valve interior: Pedicle foramen not seen. Pseudodeltidium well depicted in sections 0.3, 0.7, 0.9 and 1.3 (text-fig. 39); it is strongly arched, set off from rest of interarea by fairly deep rounded grooves. Teeth short, weak, dorsally grooved, without dental plates. Muscle field shallowly impressed, striated, sub-circular, length equal to one-third valve length.



TEXT-FIGURE 38.

S. dromeda, **part of dorsal valve interior. c: chilidium, cp: cardinal process, isp: inner socket plate, s: socket.**

Dorsal valve interior: Cardinal process large, fairly strong, filling posterior part of notothyrial cavity. Attachment face trilobed, broad, facing posteriorly. Cardinal process base expanded antero-laterally into thick squat overhanging socket plates which extend a short distance anterior to teeth.

Shell structure: Sections 0.3, 0.7, 0.9 and 1.3 (text-fig. 39) show a continuity of growth laminae through the pseudodeltidium, palintrope and valve wall. Most authors maintain (Beecher, 1901, p. 260) that the strophomenoid pseudodeltidium is composed principally of the outer (lamellar) shell layer; but the pseudodeltidium of *Schuchertella dromeda,* though probably covered by a very thin sheet of the outer shell layer not seen in the sections, is otherwise composed entirely of the inner (fibrous) layer. The pseudodeltidium is thus an undifferentiated deposit by that part of the mantle responsible for the simultaneous formation of the umbo and palintrope.

The cardinal process and dental sockets are simple deposits of the fibrous layer in which the growth laminae lie parallel to the internal surface.

The only bodies which might be confused with normal strophomenoid taleolae (pseudopuncta) are very rare irregularly shaped short non-fibrous rods embedded in the fibrous shell layer. Williams (1956, p. 256) has observed that taleolae are lacking in *Schuchertella* and *Fardenia.*

Measurements:

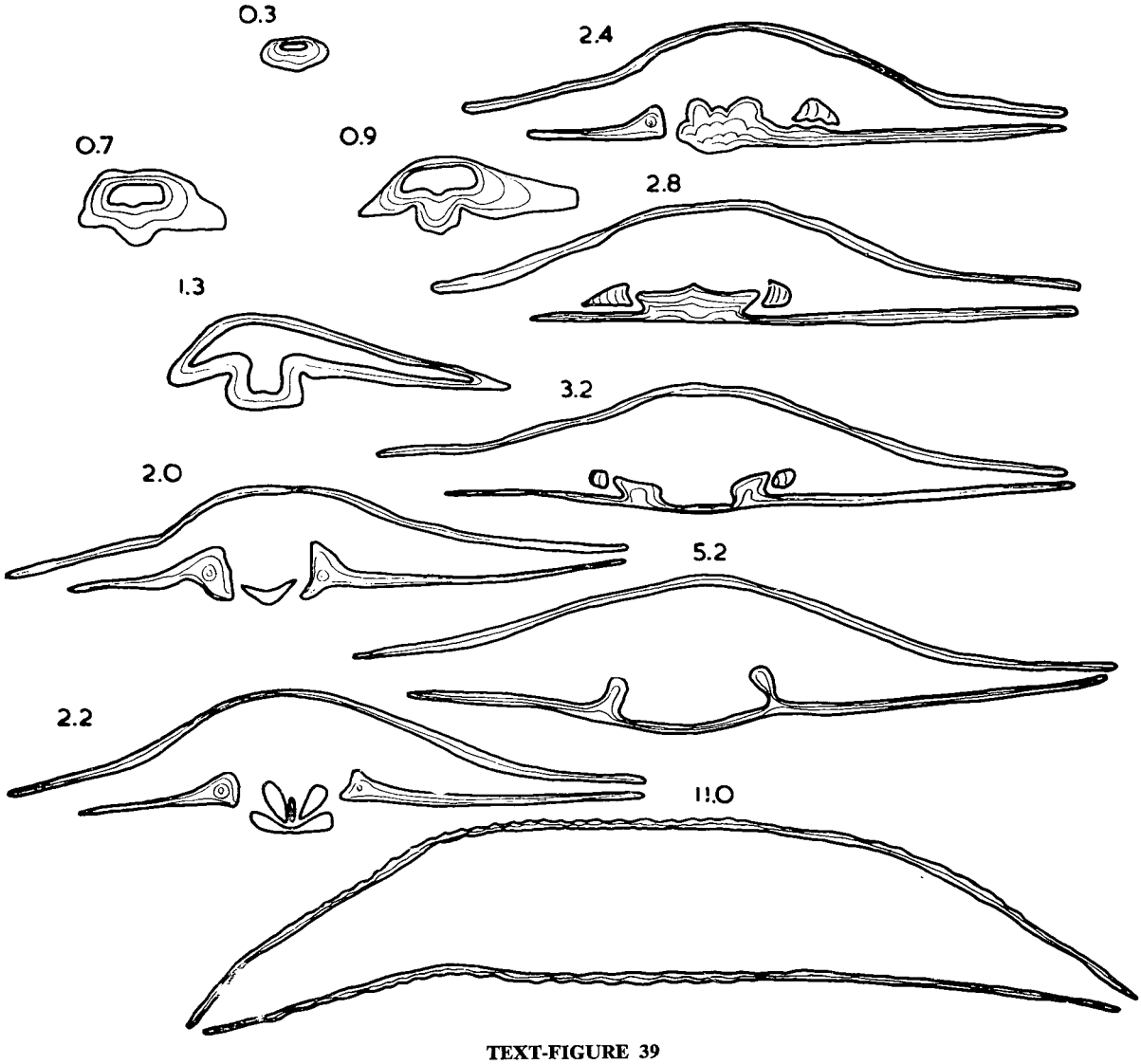
—	Length.	Width.	Thickness.
Holotype C.P.C. 2945	26.0	40.0	9.8
Figured specimen C.P.C. 2946	27.8	33.9	10.0
Figured specimen C.P.C. 2947	19.3	27.2	6.1
Large specimen F18285/2	34.9	45.5	7.9

Types: Holotype C.P.C. 2945, figured specimens 2946, 2947, 3038; all, except 3038, a ventral valve, are entire calcareous shells; all from K283 (Oscar Hill).

Variation: The only small shell collected from K283, C.P.C. 2947 (pl. 5, figs. 19, 20), differs notably in shape and ornament from adults of the same locality. First, this shell is strongly biconvex; secondly, radial costellae are more widely spaced; and thirdly, concentric growth-lines are very prominent.

Horizon and localities: Fairfield Beds, Oscar Hill (K283, T2), Burramundi Range (K291, K292), Mt. Pierre (T25), Old Bohemia area (K179), north of Mt. Percy (KP157). Tentatively identified from Fairfield Beds on Fossil Downs (K320), and near Fairfield Homestead.

Discussion: The fusion of the cardinal process lobes with the inner socket plates, and the lack of dental plates, are the diagnostic features of *Schuchertella*. *S. dromeda* differs from the type species, *Streptorhynchus lens* White 1862, in its larger, proportionately thinner, resupinate shell.



TEXT-FIGURE 39

S. dromeda. **Serial sections and peels x 5 of C.P.C. 3023 from Oscar Hill with L = 20.3, W = 26.8, depth of dorsal valve 4.3. Taleolae conspicuously absent.**

S. dromeda is similar in shape to *Streptorhynchus chemungensis* (Conrad) 1843 from the Chemung of New York, figured in Hall (1867, pl. 10, figs. 1-26), but has much stronger costellae. *Schuchertella iowensis* Stainbrook 1943a from the Upper Devonian Cedar Valley limestone of Iowa (pl. 6. figs. 8-10, 12-18, pp. 42, 43) is also similar in size and shape to *S. dromeda,* but has much coarser costellae.

Orthotetes umbraculum Schl. sp. from the Devonian of Santa Lucia, Spain, figured by Oehlert (1897, pl. 27, figs. 9-11) is externally identical with *Schuchertella dromeda.* It has the same resupinate shell shape and the costellae are of identical size and shape. Internal characters are not given.

SCHUCHERTELLA GRATILLICA sp. nov.

(Plate 5, figs. 1-10; Text-figure 40)

Diagnosis: Biconvex *Schuchertella* with a variably developed interarea, usually very long and twisted; 12 to 14 costellae in width of 5 mm. along anterior margin of adults.

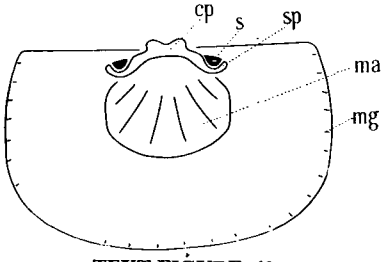
Material: Fourteen almost entire free silicified shells; one specimen shows part of a dorsal valve interior.

Description: Exterior: Outline variable, subcircular to longitudinally oval, profile equally biconvex; shell widest at midlength; hinge-line straight, wide, with obtusely angular margins, anterior commissure straight, deepest at midlength.

Ventral valve uniformly weakly convex, deepest at midlength. Umbo extremely variable in shape: small and inconspicuous to large, strongly convex, and twisted. Interarea accordingly variable in length, plane, transversely striated, apsacline. Perideltidium delimited clearly by oblique straight lines. Pseudodeltidium broad, uniformly arched or with a median fold, crossed by growth striae continuous with those over interarea. Dorsal valve weakly convex except on flat postero-lateral flanks. Umbo barely developed, interarea linear, transversely striated, anacline to nearly hypercline, notothyrium plugged by cardinal process.

Exterior of both valves has numerous narrow comparatively high radial costellae of uniform size (12 to 14 in a width of 5 mm. along anterior border of adults), rounded in profile, separated by wider furrows, increase by intercalation. Adults have poorly expressed concentric growth-lines, widely spaced, senile specimens have growth-lines closely crowded along margins.

Ventral valve interior: There are no dental plates.



TEXT-FIGURE 40.

S. gratillica, **dorsal valve interior. cp: cardinal process, ma: muscle area, mg: marginal groove, s: socket, sp: socket plate.**

Dorsal valve interior: Cardinal process bilobed, each lobe deeply striated; cardinal process supported on a vertical socket plate enclosing between itself and valve wall a deep dental socket. Muscle field moderately deeply impressed, large, subcircular,

divided medianly by low narrow ridge, rest of field crossed by tiny attachment ridges. Marginal borders of interior finely grooved.

Variation: The shape of the holotype is typical of most specimens. The tendency of the ventral umbo to become drawn out posteriorly is illustrated by the other figured shell. Such wide shape-variation is characteristic of members of the Orthotetacea, which, lacking a functional pedicle, were cemented by the umbo to the substratum.

Measurements:

——	Length.	Width.	Thickness.
Holotype C.P.C. 2948	31.9	36.0	12.4
Figured specimen C.P.C. 2950	30.0	29.4	12.7

Types: The holotype C.P.C. 2948 from K246 and figured specimen 2950 (K245) are almost entire silicified shells; the third figured specimen, 2949 (K243), is part of a free dorsal valve.

Horizon and localities: Sadler Formation, near Sadler Ridge (K215, K245, K246), and near Menyous Gap (K276).

Discussion: Schuchertella gratillica differs from the type species by its larger size and much longer ventral valve interarea.

The Australian species is closely related to specimens of *S. devonica* (Keyserling) 1846 from Ferques. Serial sections of specimens from the Devonian of Ferques show that Keyserling's species, successively included by authors in *Orthis, Leptaena,* and *Streptorhynchus,* is a member of *Schuchertella.* Davidson (1864, p. 80) describes *S. devonica* as

> those bi-convex specimens, which are . . . very inconstant in their external form, both valves being convex, their striae smooth and not strongly marked, while the area assumes every kind of shape, both in height and width, being often irregularly twisted, and wider than long on one side than on the other; the beak curved backwards or inclined to one or to the other side, while nothing appears regular in the shell.

Davidson and other earlier workers were inclined to include *S. devonica* as a variety of "*Orthis crenistria*" or "*Orthis umbraculum*". The exteriors of these three forms are not dissimilar, but later work has shown that the last two species, now members of *Schellwienella* Thomas 1910, have strong dental plates. As dental plates are not found in *Schuchertella devonica,* the earlier determinations, based on the external characters of homoeomorphic species, must be rejected.

S. devonica and *S. gratillica* are remarkably similar in all features except that of costellation. Whereas adults of *S. gratillica* have 12 to 14 costellae in 5 mm. along the anterior margin, in the corresponding part of adults of *S. devonica* there are only 8 or 9 costellae. Furthermore the costellae of *gratillica,* though more closely crowded than those in *devonica,* are notably higher.

Superfamily PRODUCTACEA Waagen 1883

Family PRODUCTIDAE Gray 1840

Subfamily PRODUCTELLINAE Schuchert & LeVene 1929

Genus DEVONOPRODUCTUS Stainbrook 1943

DEVONOPRODUCTUS AUSTRALIS sp. nov.

(Plate 8, figs. 16-21; Text-figs. 41, 42)

Diagnosis: Like *Devonoproductus walcotti,* but with the posterior margin of ventral valve smooth, and rest of ventral valve exterior with 5 to 10 spines or spine-bases.

Material: Fifty free silicified shells and valves from many localities; six calcareous shells.

Description: Exterior: Longitudinally semi-oval to subcircular in outline, hinge wide, shell widest at midlength. Profile concavo-convex, ears small; anterior commissure straight.

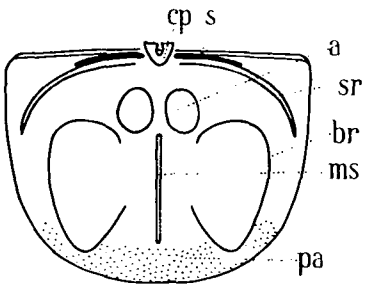
Ventral valve moderately to strongly convex, with small well-defined flat ears separated from the umbonal slope by shallow sinuses. Umbo high, prominent, umbonal angle 90°. In profile, valve curvature decreases anteriorly, in anterior view lateral slopes are straight, venter weakly convex. Some specimens have umbonal tip with a narrow median groove on the dorsal side representing a cicatrix of attachment; the position of the cicatrix implies that the living shell lay with the plane of commissure parallel to the surface of the object to which it was attached. Interarea linear, flat, anacline; delthyrium narrow, its anterior half occupied by the cardinal process.

Dorsal valve evenly and weakly concave except for flat postero-lateral ears. No interarea.

Surface of ventral valve finely costellate, with concentric growth-lines, and 5 to 10 widely spaced spine-bases. Costellae spaced 3 in 1 mm. along anterior border, very low, rounded in profile, separated by shallow rounded grooves. Concentric growth-lines, numbering 6 to 10 in adults, are less regularly concentric, not all continuous from one side of valve to the other. Spine-bases without any preferred distribution, slightly elongated longitudinally.

Surface of dorsal valve covered solely by regularly concentric and generally evenly spaced lamellose growth-lines; lamellae overlap one another anteriorly, inclined at 10° to plane of commissure. Usually there are two growth-lines in 1 mm. in the median line, except in postero-median part of valve, where there may be as many as 8 lines in 1 mm.

Ventral valve interior: Broad sinuses separating ears from umbonal slopes are represented internally by high sharp-crested ridges running antero-laterally from delthyrial angles; these ridges function with primitive sockets of dorsal valve in a rudimentary form of articulation. Sections 1.5, 1.7, and 2.4 (text-figure 42) show ventral ridge and dorsal groove opposed in closed shell. Dorsal side of umbonal cavity provided with a broad low rounded ridge which fits tightly between cardinal process lobes in closed shell. Rest of interior smooth and featureless.

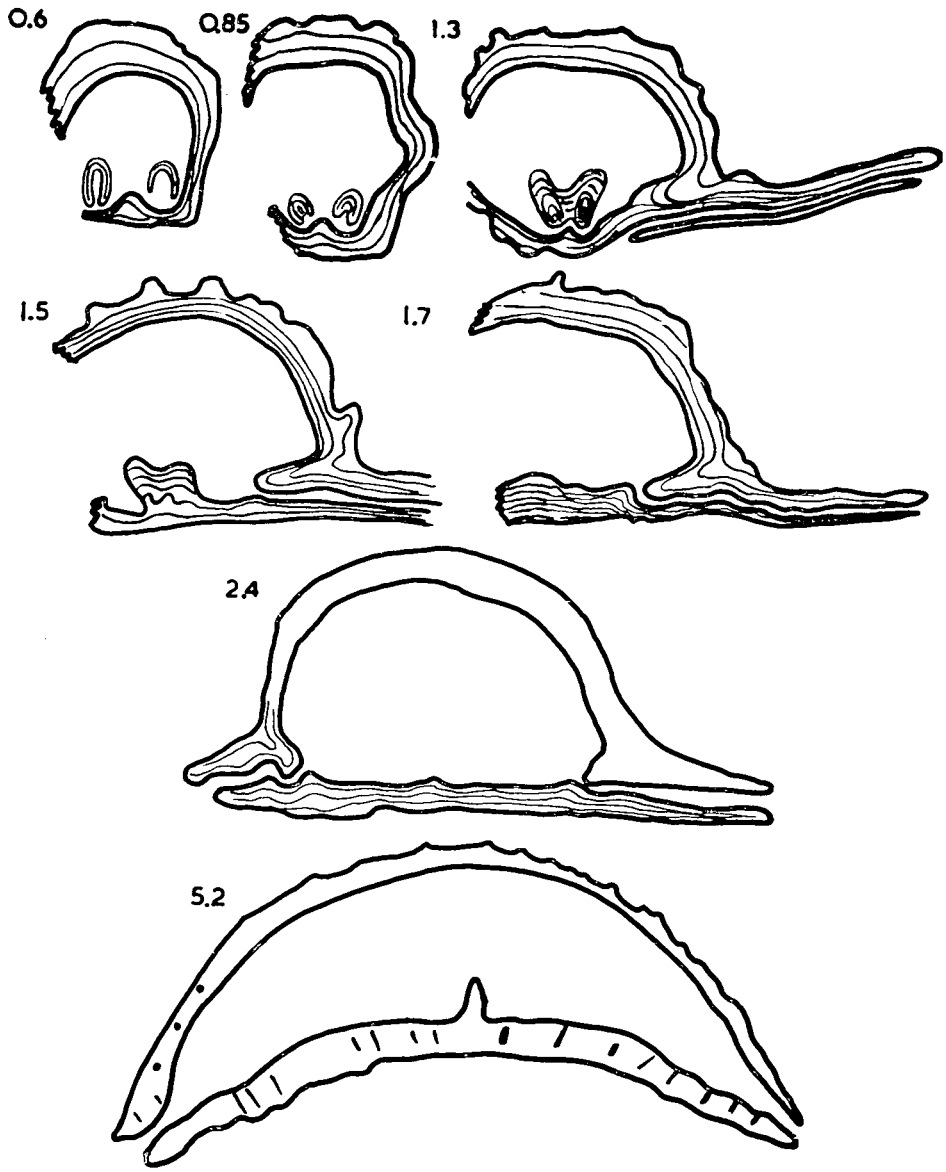


TEXT-FIGURE 41.

D. australis, **dorsal valve interior. a: adductor, br: brachial ridge, cp: cardinal process, ms: median septum, pa: papilla, sr: socket ridge.**

Dorsal valve interior: Cardinal process stout, bilobed, each lobe deeply notched, facing posteriorly. Low narrow median septum extends from midlength almost to anterior border, where septum is highest. Each low brachial ridge forms part of a

longitudinal ellipse on either side of the median ridge. Muscle field not sensibly impressed. Anterior and antero-lateral parts of interior covered by closely crowded fairly coarse papillae.



TEXT-FIGURE 42

D. australis. **Serial sections and peels x 8 of C.P.C. 3024 from K230. L = 11.1, W = 13 (estimated), T = 4.5. Part of ventral valve umbo broken off in first five sections. Taleolae (pseudopuncta) seen only in last section.**

Shell structure: The growth laminae of the fibrous shell layer imply that the ventral articulatory ridge, cardinal process, dorsal articulatory socket, and dorsal median septum all originate by uniform deposition of calcite from a simple fold in the mantle. Growth laminae are strictly parallel with the internal surfaces, and resorption does not seem to have occurred.

Taleolae are clearly distinguishable only in the more anterior sections of the dorsal valve (section 5.2, text-figure 42); they are wide, apparently massive, fairly widely spaced with long axes approximately normal to the internal surface on which the taleolae appear as papillae. In other sections of the dorsal valve, and in all sections of the ventral valve, taleolae are infrequent.

Variation: For the part of the ontogeny represented by available specimens (with width range 3 mm. to 20 mm.) shape variation is almost negligible.

Measurements:

—	Length.	Width.	Depth of Ventral Valve.
Holotype C.P.C. 2951	17.4	19.2	7.6
Figured specimen C.P.C. 2953	14.3	16.7	7.6
Small specimen	7.3	8.0	2.6

Types: Holotype C.P.C. 2951, figured specimens C.P.C. 2952 (dorsal valve), 2953 (ventral valve), all from K245.

Horizon and localities: Sadler Formation, near Sadler Ridge (K216, K239, K244—K246, K252), and near Menyous Gap (K276). Tentatively determined from K112, K144 and K230.

Discussion: This is the third species of *Devonoproductus* to be described; but it is understood that the genus is represented, though at present unrecorded, from many other localities outside U.S.A. and Australia.

The specimens described as *Productus sericeus* v. Buch by Kayser (1872, pp. 694, 695, pl. 27, figs. 9 a, b) agree externally with *Devonoproductus*. These specimens come from the Cuboides Schichten of the Eifel and Ober Kunzendorf.

The American species are *D. walcotti* (Fenton & Fenton) 1924, from the Cerro Gordo member of the Lime Creek Stage of Iowa (Upper Frasnian), the type species, and *D. vulgaris* Stainbrook 1945, from the Independence shale of Iowa. The Australian species is very similar to the type species; the only constant difference is that *D. walcotti* has more, and more prominent, spines than *D. australis*. In specimens of similar size, no more than about ten spines or spine bases are found in *D. australis*, whereas 30 to 40 prominent spines in *D. walcotti* do not seem to be exceptional. Furthermore the posterior margins of the ventral valve of the type species are rather densely spinose, those of *D. australis* practically smooth.

The Australian *Devonoproductus*, like *D. walcotti*, differs from *D. vulgaris* in its larger size and the smaller number of spines.

Genus STEINHAGELLA Goldring 1957

STEINHAGELLA NUMIDA sp. nov.

(Plate 9, figs. 11-20; Text-figure 43)

Diagnosis: Like *Steinhagella membranacea* (Phillips) 1841 but with coarse growth rugae.

Material: Ten nearly entire shells, one entire ventral valve, two entire dorsal valves, several fragmental valves, all silicified.

Description: Exterior: Transversely oval to subquadrate in outline, hinge-line slightly less than width at or posterior to midlength; profile weakly concavo-convex, almost plano-convex.

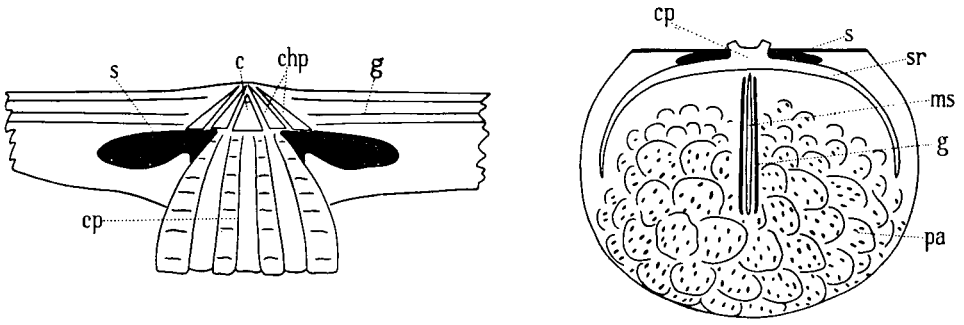
Ventral valve deepest slightly posterior to midlength; profile almost uniformly curved, slightly more convex posteriorly. Anterior profile with straight lateral flanks, venter weakly convex. Umbo ranges from strongly convex to barely discernible, umbonal tip erect, posterior face flat, cicatrix with three tiny shallow pits. Ears poorly demarcated from umbo, weakly convex. Interarea well developed, short, flat, orthocline; pseudodeltidium apical, very short, flat, comparatively wide; short delthyrium plugged by cardinal process.

Dorsal valve shallowly concave, almost plane in some specimens, with wide flat ears, deepest at mid-point. Umbo a minute elevation immediately anterior to cardinal process. Short anacline interarea developed over half width of hinge-line, flat, length less than half of ventral valve interarea. Narrow chilidial plates set off from rest of interarea by deep sutures.

Surface of ventral valve covered by numerous uniformly spaced hollow spines which arise vertically from small circular mounds arranged loosely into quincunxes; most spines, except ones along posterior margin, which point posteriorly, change direction a short distance above their base to lie almost parallel to valve surface in a radial pattern; spines up to 5 mm. long. Surface also marked by small concentric rugae which weave among spine-bases. At central part of valve there are 10 rugae in a length of 5 mm.

Similarly the dorsal valve exterior is covered by wavy concentric rugae which, however, may coalesce to form regularly spaced tiny pustules which are the bases of broken off spines; these spine-bases are arranged in quincunxes, and the spines themselves are directed radially as in the other valve.

Interior: Ventral valve of adults has greater part of delthyrial cavity filled with callus deposits. The low narrow median ridge in the posterior part of the valve is flanked on either side by a shallow depression which allows movement of the cardinal process. Slightly anterior to this point are two very lightly impressed tiny narrow elongate muscle-scars. Overhanging the delthyrial cavity on either side is a strong sharply crested ridge which presumably functioned as a tooth. Dentition is best seen in smaller specimens in which secondary deposits are not important. The specimen illustrated in plate 9, figures 17 and 18, has small but well-developed teeth found at the delthyrial angles, divergent anteriorly.



TEXT-FIGURE 43.

S. numida **(a) posterior view of cardinal process. c: chilidium, chp: chilidial plates, cp: cardinal process, g: growth-line, s: socket. (b) dorsal valve interior. cp: cardinal process, g: groove, ms: median septum, pa: papilla, s: socket, sr: socket ridge.**

Cardinal process strong, squat, with two short thick lobes, each deeply grooved. Dorsal part of cardinal process covered by three discrete plates: a flat median triangular plate with apex at umbo, separated on either side by a suture from a short triangular plate. These lateral plates are in turn divided by sutures from the narrow chilidial plates. Base of cardinal process bordered by short moderately deep ventrally divergent dental sockets. Very low narrow marginal ridges arise lateral to the sockets, remain parallel to hinge-line, and terminate laterally. Low median septum extends from midlength almost to cardinal process. Muscle field not impressed. Marginal parts covered with numerous fine papillae.

Variation: One important feature displayed in the small sample studied is the marked difference in shape and comparative thickness of the cardinal process shown by specimens of different sizes. The small specimen (pl. 9, fig. 20) has narrow widely separated cardinal process lobes supported by strong ridges; the larger specimen (pl. 9, figs. 14, 15) has a thick compact cardinal process in which the lobes are narrowly separated, supported by very short low ridges.

Measurements (disregarding spines):

	Length.	Width.	Depth of Ventral Valve.
Holotype C.P.C. 2954	23.3	30.7	6.7
F18492/1 (K244)	27.8	36 (est.)	10.5
F18492/2 (K244)	17.7	20.2	6.6
Figured specimen C.P.C. 2956	12.7	16.1	2.3

Types: Holotype C.P.C. 2954 from K245; figured specimens 2955 (posterior part of a dorsal valve), 2956 (ventral valve), 2957 (dorsal valve with spines preserved), all from K245.

Horizon and localities: Sadler Formation, near Sadler Ridge (K244-K246).

Discussion: Steinhagella numida seems to be most clearly related to the type species, *Leptaena membranacea* Phillips 1841 (p. 60, pl. 25, fig. 101) from the Upper Devonian of Devon and Cornwall. Phillip's species has been assigned by authors to

several different genera. After its original place in *Leptaena,* it remained for eighty years in *Productella.* Reed's division of *Productella* in 1943 led to *membranacea* being placed tentatively in his sub-genus *Whidbornella;* and finally, Goldring (1957) has chosen *membranacea* as the type of *Steinhagella.*

Steinhagella includes subquadrate shells with short ventral and dorsal interareas, ornament of stout recumbent spines and concentric rugae on both valves, small teeth in the ventral valve, and a fairly long posteriorly directed cardinal process and a thin median septum in the dorsal valve.

Similarities and differences between *S. membranacea* and *S. numida* are difficult to judge owing to the profound differences in mode of preservation: the British species occurs as impressions in slate, whereas specimens of the Australian species are replaced by fine-grained silica. Nevertheless the similarities between these species remain striking; shape and size compare closely, and, insofar as can be judged, the ornament of fine zig-zagging growth rugae and recumbent radially directed spines is common to both. The cardinal process and other features of the dorsal interior also agree. The main difference is found in the width of the growth rugae: those in *S. membranacea* are very fine, those in *S. numida* are comparatively coarse.

A still more notable similarity in external appearance exists between the holotype of *S. numida* and the specimen of *Strophalosia productoides* Davidson illustrated by Mansuy (1912, pl. 8, figs. 5a–d, pp. 52, 53) from the Middle Devonian limestone of eastern Yunnan. Minute details of ornament are given in Mansuy's figures. The shape and general pattern of the closely crowded spines with interweaving minute rugae on both valves show that Mansuy's specimens and specimens of *S. numida* are externally similar. Details of the interior are not given.

Other possibly related forms are—

(a) *Strophalosia?* sp. in Reed (1912, p. 103, pl. 8, fig. 6) from the Mashhad District, Khorasan, Persia, associated with a variety of *Spirifer verneuili,* indicating Upper Devonian age. Only the exterior of a dorsal valve is available and this shows similar ornament to *Steinhagella numida;*

(b) *Productella membranacea* (Phillips) in Reed (1922, p. 88, pl. 13, figs. 22, 22a) from the Upper Devonian of the Pamirs, which seems to be externally identical with *S. numida;*

(c) *Productus membranaceus,* Phill. (Verneuil, 1845, p. 285, pl. 15, figs. 11a, b) from the Devonian limestone " des rives du Volkof et d'Octrada ";

(d) *Productella productoides* var. *sinensis* Grabau 1931 (pp. 43-47, pl. 2, fig. 5, pl. 3, figs. 28-30, pl. 4, fig. 19, pl. 5, figs. 2, 3, 7-11), which has the same kind of spines and shape as *S. numida.* A distinguishing feature, however, is that the wavy concentric rugae so characteristic of the Australian species are not so well developed in the Chinese variety;

(e) *Productella membranacea* (Phillips) in Borghi (1939, pp. 141, 142, pl. 1, fig. 16) from the Devonian of Maharuga, Fezzan, is similar to *S. numida* but has a more transverse outline. Borghi's specimens are poorly preserved and these similarities could easily be superficial.

cf. PRODUCTELLA sp.

(Plate 8, figs. 24, 25)

Material: An almost entire calcareous shell, free of externally adhering sediment: C.P.C. 2958, from K222, Sadler Formation, Sadler Ridge; length 11.8 mm., width 14.6 mm., depth of ventral valve 5.5 mm.

Description: Exterior: Outline semi-elliptical, strongly concavo-convex, concavity of dorsal valve corresponding closely to convexity of ventral valve so that the internal volume of shell is small. Hinge-line wide, shell widest at or posterior to midlength.

Ventral valve strongly convex, anterior profile showing moderately steep lateral flanks and a weakly arched venter. In lateral profile convexity increases towards the posterior. Umbo broad, fairly low, tip of umbo weakly inturned, with an indistinct supra-apical cicatrix. Postero-lateral ears very small, poorly defined. Interarea extends across entire hinge-line, proportionately long, anacline. Delthyrium narrow, anterior part filled by cardinal process, posterior half covered by flat pseudodeltidium.

Dorsal valve strongly concave with raised, almost flat ears. Umbo tiny, being a simple median rise. Interarea well developed, length equal to half that of ventral valve interarea, orthocline. Posterior face of apparently bilobed cardinal process and two chilidial plates flush with interarea.

Ventral valve exterior crossed by small broad flat concentric rugae separated by shallow rounded grooves, most prominent posteriorly. Most rugae are continuous from one side of the valve to the other, and some join laterally with adjacent rugae. Thirty spine-bases evenly distributed over ventral valve exterior, each drawn out a short distance longitudinally. Spines not preserved.

Surface of dorsal valve crossed by concentric rugae, narrower and lower than those of other valve. No spine-bases.

Shell structure: The shell matter of the lateral parts of the dorsal valve is translucent and it is possible to see the outlines of the embedded taleolae; these are fairly long strong rods arranged radially, making an acute angle with the anterior surface of the valve.

Discussion: On external details this form could be placed in either *Productella* Hall 1867 or *Heteralosia* King 1938. As these genera are distinguishable only by the characters of the spines, long and nearly erect in *Productella,* short and oblique in *Heteralosia,* suitably preserved specimens will be required for a valid determination of the Fitzroy form. The form is externally identical with a new species of *Productella* from the Carnarvon Basin (Veevers, *B.M.R. Bull.* 55).

Subfamily PRODUCTINAE Waagen 1884

Genus AVONIA Thomas 1914, em. Muir-Wood 1928

AVONIA PROTEUS sp. nov.

(Plate 8, figs. 1-15; Text-figs. 44, 45)

Diagnosis: Like *Avonia youngiana* but with discontinuous costae, weaker growth-lines, and a broader umbo.

Material: (a) Sixty immature free almost entire calcareous shells with a calcitic matrix; (b) fifty mature free calcareous specimens with margins broken off, some with the exterior partly replaced by silica; (c) several recrystallized calcareous specimens embedded in limestone.

Description: Exterior: Outline subquadrate to longitudinally oval, length equal to or greater than width, widest at rounded antero-lateral margins. Profile strongly concavo-convex.

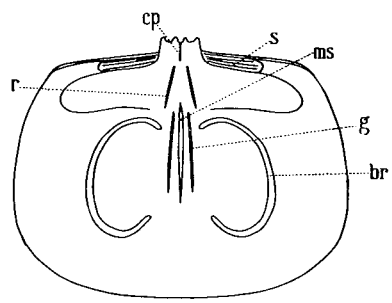
Ventral valve deepest at mid-point, lateral profile almost semi-circular but with convexity increasing towards umbo. Anterior profile quadrate, lateral flanks nearly vertical, venter flat to weakly convex. Umbo strongly convex, moderately broad, tip inturned, projecting a very short distance dorsal to hinge-line, without cicatrix of attachment. Interarea linear, developed only along median part of hinge-line, width equal to half hinge-line width, twisted so that it is anacline medianly, orthocline laterally. Ears small, poorly defined.

Dorsal valve moderately to deeply concave, internal cavity of shell accordingly small. Ears tiny, interarea and umbo not developed.

Ventral valve exterior covered with short evenly spaced spine-bases situated on low discontinuous radial ridges giving a pseudo-costate appearance. Only basal parts of the erect spines preserved. Rare valves have fine concentric rugae.

Dorsal valve without spines; instead exterior marked by large shallow circular pits, most numerous anteriorly. Posterior part of valve, most notably the ears, covered by concentric rugae of small uneven size.

Interior: Ventral valve featureless except for short lateral ridges (text-figure 45, section 4.4), which presumably articulated in a rudimentary fashion with the adjacent lateral grooves of the dorsal valve; otherwise ventral valve edentulous.

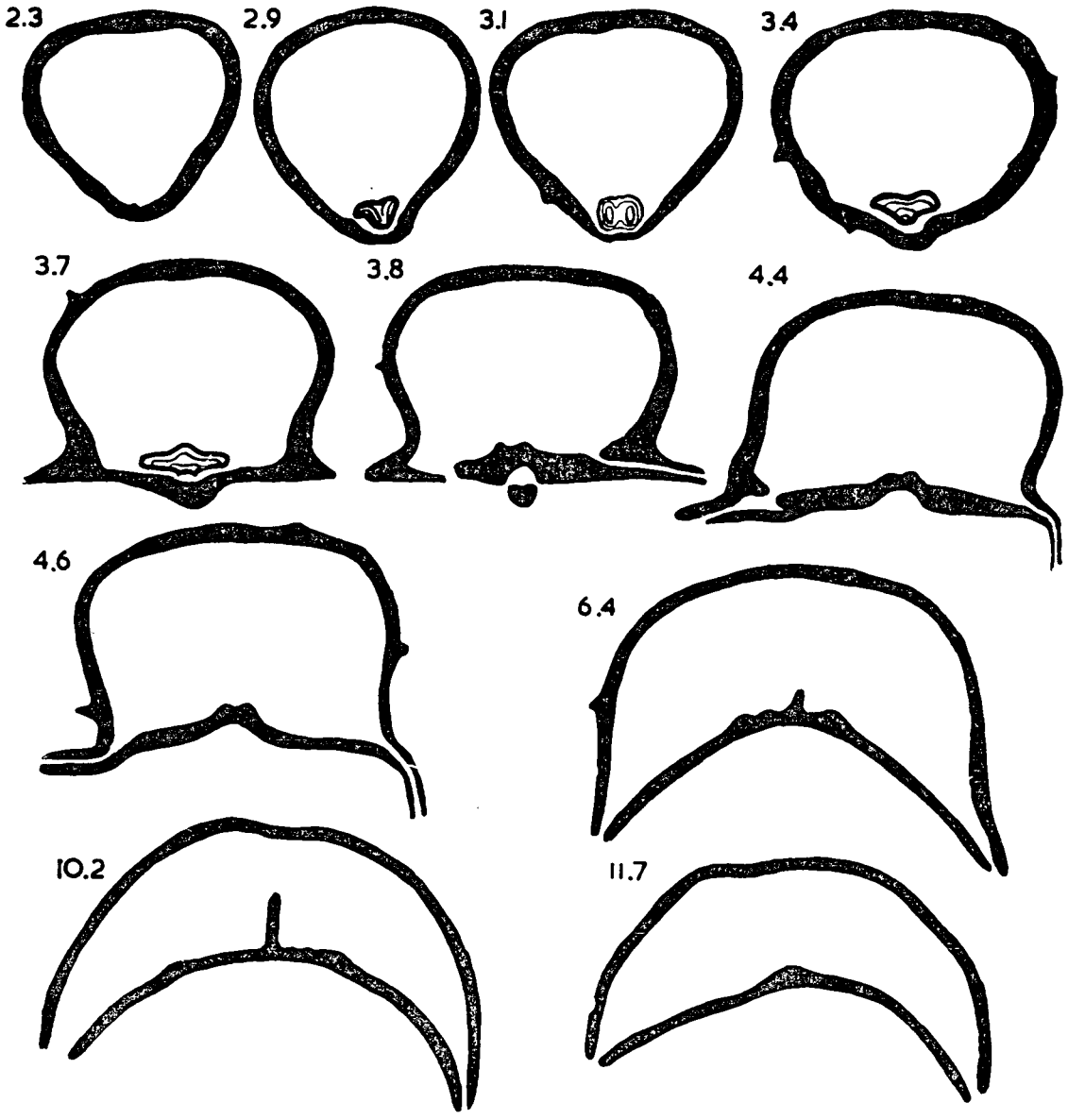


TEXT-FIGURE 44.

A. proteus, **interior of dorsal valve. cp: cardinal process, br: brachial ridge, g: groove, ms: median septum, r: ridge, s: socket.**

Cardinal process strong, bilobed, attachment face of each lobe deeply grooved, directed posteriorly. Broad base of cardinal process prolonged anteriorly into two low narrow parallel ridges between which, a short distance posterior to midlength, is developed a high narrow ventrally swollen median septum which continues anteriorly to midlength. Sections (text-figure 45, sections 10.2, 11.7) show fairly small internal cavity of shell.

Shell structure: Both the outer (lamellar) and inner (fibrous) shell layers are preserved in the ventral valve. Spine-bases have the same structures as those in *Productella subaculeata* (*see* Veevers, 1959b).



TEXT-FIGURE 45

A. proteus. **Serial sections and peels x 4 of C.P.C. 3025 from Oscar Hill. L = 15.5, W = 17.8, T = 8.0. Sections show that species edentulous except for lateral ridge (seen in section 4.4), which presumably articulated with adjacent groove in dorsal valve.**

The cardinal process has a simple shell structure (text-fig. 45, sections 2.9 to 3.7). The disposition of the growth laminae indicates that each cardinal process lobe was deposited by a cylindrical sheath of the mantle and that the part of the process immediately anterior to the lobes was deposited locally by the ventral side of the mantle.

The median septum, found from a separate study (Veevers, 1959b) to be similar to that of *Productella subaculeata,* contains a central core of cryptocrystalline material enclosed in a thin layer of fine fibres continuous dorsally with the elements of the inner layer. The structure of this high median septum recalls in intimate detail the structure of the homologous structure in *Kayserella emanuelensis,* and a similar means of formation is proposed for both structures: the dorsal valve mantle was folded medianly; on its inner side the mantle fold deposited fibres homologous to those of the inner shell layer; at the ventral crest of the mantle fold specialized cells deposited concordantly but at a comparatively accelerated rate the central wedge of cryptocrystalline material.

Measurements:

—	Length.	Width.	Depth of ventral valve.
Holotype, C.P.C. 2959	23 (est.)	26 (est.)	12 (est.)
Figured specimen C.P.C. 2960	21.5	19.6	13.7
Figured specimen C.P.C. 2961	22.7	17.1	13.1
Figured specimen C.P.C. 2962	15.1	17.2	11.7
Figured specimen C.P.C. 2963	15.0	13.3	9.4
Figured specimen U.W.A. 2583	27.9	34.2	21.8

Variations: A. proteus is a broadly conceived species and later work might show that several different forms have been united under one name. It is conceivable, of course, that intra-specific variation alone is responsible for the variety of shape shown.

Immature specimens from K283 are known to be conspecific with adult specimens from K290 because of the similarity of the external markings and similar internal structure. The main difference lies in the shell shape, which is more compact with a relatively broader umbo in the younger shells, and more elongate and relatively shallower in the adult shells. Further evidence of affinity is given by specimens intermediate in shape between these two extremes. Studied in closer detail, adult shells are seen to differ from younger shells in having spine-bases drawn out longitudinally into nearly continuous costae.

Among adult specimens the most notable variation is the tendency towards the formation of a narrow shallow median sulcus in the anterior half of the ventral valve.

Although the specimen selected as holotype is fragmentary, it contains the greatest number of features common to immature and mature shells, and so forms a link between specimens of different ontogenetic stage.

Types: Holotype C.P.C. 2959 from K290: figured specimens C.P.C. 2960, 2961, also from K290; 2962, 2963 from K283, U.W.A. 25838a from T4.

Horizons and localities: The localities of this species are numerous and widespread, extending from Bugle Gap to the Napier Range: Fairfield Beds (K180, K282, K283, K288, K290, K292, K340, K341, K551, T11, T12, T27, KP156, KP168, M2, M8, M9, Ld26); Bugle Gap Limestone (K169, K170); Geikie Formation (K285, K506, T4, T5); Napier Formation (KP103, KP107, KP109, KP140, Ld11); Oscar Formation (KP149, KP167). Specimens from K355 (Fossil Downs Formation); KP111, Ld9, Ld28 (Napier Fomation); M3 (Fairfield Beds); and S4/91 (Oscar Formation) are tentatively determined as *A. proteus.*

Discussion: A. proteus is similar to specimens of the type species, *Productus youngianus* Davidson 1860, from the Lower Carboniferous (D1) of Narrowdale, Staffordshire (B.M.(N.H.) B48674, B48675, B48667, B48677). These shells differ from more typical *A. youngiana* in their less prominent growth-lines. In turn *A. proteus* differs from the Staffordshire specimens in having still weaker growth lines, and a relatively broader umbo.

Other specimens labelled *Avonia youngiana* in the collections of the B.M.(N.H.) are very like the Fitzroy species. Specimens from the Lower Carboniferous of Little Island, Cork (B.M.(N.H.) B44005) differ from *A. proteus* only by their uninterrupted costae. One specimen (B.M.(N.H.) B34499) from the Carboniferous limestone of Richmond, Yorkshire, shows the ventral valve exterior only, and is indistinguishable from specimens of *A. proteus*.

The surface markings of "*Avonia davidsoni* (Jarosz)" from the Carboniferous of Plas Gwyn, Llanfair, Anglesey (B.M.(N.H.) B20557) are very similar to those of *A. proteus*, and these two species are distinguishable only by the deeper dorsal valve of the latter.

Productus (*Overtonia*) *celak* Nalivkin 1937 (p. 144, pl. 6, figs. 30a, b), from the Upper Famennian Sulcifer beds of north-eastern Kazakhstan, is very similar in shape and ornamentation to *A. proteus* but has "indistinct, concentric wrinkles . . . developed in apical part".

Teichert (1949) noted the widespread distribution of *A. proteus*, which he tentatively determined as *Productella* cf. *productoides* (Murchison) and *Productella* cf. *spinulicosta* Hall, the latter from one locality only, T2 (K283), where only immature specimens of *A. proteus* occur. The rocks in which these fossils occur were referred to by Teichert as the *Productella* limestone.

Reference to Murchison's (1840) original description of *Productella productoides* show that *A. proteus* differs from this species in the following characters: shorter hinge; elongate outline; pitted dorsal valve; no interarea in dorsal valve (the dorsal valve of *P. productoides* has a well-developed interarea); and spine-bases on ventral valve pseudo-costate.

A. proteus differs from *Productella spinulicosta* (Hall) 1857, now the type of *Spinulicosta* Nalivkin 1937, in the following characters: the umbo of *P. spinulicosta* is not so prominently broad as it is in *A. proteus;* and the spine-bases in *P. spinulicosta* are much shorter than those in *A. proteus*.

cf. CHONETIPUSTULA sp.

(Plate 8, figs. 22, 23)

Material: One specimen, a nearly entire calcareous shell, well preserved and almost free of externally adhering sediment: C.P.C. 2965 from Sadler Formation near Sadler Ridge (K221); length 7.9 mm., width 9.3 mm., depth of ventral valve 2.5 mm.

Description: Exterior: Outline transversely quadrangular, widest at midlength; lateral profile weakly concavo-convex. Hinge wide and straight, anterior commissure straight.

Ventral valve uniformly weakly convex, umbo conspicuous, tiny dimple on posterior part of the umbo possibly a cicatrix of attachment. Interarea orthocline, flat, comparatively long; pseudodeltidium very short and narrow, weakly arched.

Dorsal valve weakly concave except for small weakly convex umbo. Interarea hypercline, a little shorter than ventral valve interarea, flat, with the notothyrium completely filled by posterior part of the cardinal process, which is probably tri-lobed.

Twenty-four broad-based hollow spines on external surface of ventral valve; those on posterior margin erect, directed posteriorly, those on rest of valve bent over sharply at the base so that distal part of spine lies almost on valve surface, directed radially. Rest of ventral valve surface and all dorsal valve surface marked with concentric undulations, irregular in height and concentricity. Smaller undulations, as many as 10 in length of 1 mm., are developed on and between larger undulations which are up to 1 mm. across. Dorsal valve without spines.

Interior not known.

Discussion: This specimen agrees externally with the genus *Chonetipustula* Paeckelmann 1931, type species *Productus plicatus* Sarres, em. Kayser 1881. The Australian form is unlike the Carboniferous species of *Chonetipustula* which Paeckelmann described from Germany, but agrees with the middle Famennian "*C. membranacea* (Phill.)" recorded from the Moscow Basin (Sarycheva & Sokolskaya, 1952, tab. 13, fig. 78). The dorsal valve exteriors of both forms are identical, but there are fewer spines on the ventral valve of "*C. membranacea*".

PRODUCTIDAE gen. et sp. ind.

(Plate 9, figs. 1-3)

Material: Three free, silicified, entire ventral valves.

Description: Exterior: Ventral valve strongly convex, outline subcircular; anterior profile strongly arched, lateral flanks and venter both nearly straight. Lateral profile becoming increasingly more convex posteriorly. Umbo large, prominent, tip inturned. Hinge-line wide, straight, valve widest at midlength. Ears small, barely distinguishable from umbonal slopes. Interarea extends across less than half of hinge-line, linear, anacline. Surface covered uniformly with moderately stout spines, generally erect, hollow, arranged irregularly along growth-lines, which are faint and well-spaced anteriorly, closely crowded and well-defined posteriorly. Low spine-bases radially elongate, giving a faint pseudocostation to the external surface, and extending through valve wall to appear as shallow elongate depressions internally.

Interior: Delthyrium narrow, dorso-lateral parts thickened into transversely elongate teeth. Muscle field not impressed. Internal surface punctured by internal part of hollow spines; lateral parts of internal surface covered by tiny evenly spaced papillae.

Measurements (disregarding spines):

—	Length.	Width.	Depth of ventral valve.
Figured specimen, C.P.C. 2966, from K245	19.6	21.0	12.4
F18484 (K215)	8.2	10 (est.)	3.6

Horizon and localities: Sadler Formation, near Sadler Ridge (K215, K245), and near Menyous Gap (K276).

Discussion: The linear interarea, tiny teeth and general shape of this form are somewhat similar to members of *Productella* Hall, to which it is possibly related.

Superfamily CHONETACEA Shrock & Twenhofel 1953

Family CHONETIDAE Hall & Clarke 1895

Genus PLICOCHONETES Paeckelmann 1903, em. Sokolskaya, 1950

PLICOCHONETES MACROPATUS sp. nov.

(Plate 9, figs. 4-10; Text-figs. 46-48.)

Diagnosis: Transversely semi-oval *Plicochonetes* with eight growth-lines in length of 1 mm., a total number of 30 to 45 costae, and as many as eight spines on posterior margin of ventral valve.

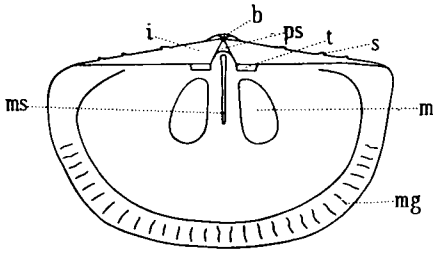
Material: Sixty-nine free almost entire calcareous shells and one free ventral valve.

Description: Exterior: Outline transversely semi-oval, widest at or slightly anterior to hinge-line; profile moderately strongly concavo-convex; anterior commissure straight or weakly sulcate.

Ventral valve moderately convex, deepest at mid-point. Some specimens with a very broad low median fold, postero-lateral parts nearly flat. Umbo small, interarea moderately long, apsacline, weakly concave medianly, flat laterally, with faint transverse striae. Pseudodeltidium short, smooth, gently arched, outline of anterior edge concave.

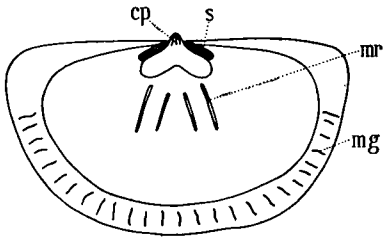
Dorsal valve weakly to strongly concave, some specimens with a broad median depression. Umbo not developed, interarea hypercline, in the same plane as ventral valve interarea but with half its length; maximum of four faint transverse striae visible on surface of interarea. Posterior part of cardinal process fills notothyrium and median part of delthyrium so that only the dorso-lateral angles of the delthyrium remain open.

Surfaces of both valves have numerous radial costae, well-rounded, increasing postero-medianly by intercalation, anteriorly and laterally by branching, ranging in number from 30 to 45. Lamellose concentric growth-lines closely spaced, 6 to 8 in 1 mm, laterally becoming discontinuous, some overlapping, forming with costae a characteristic reticulate pattern. Maximum of eight short broad laterally-directed spines on posterior margin of ventral valve.



TEXT-FIGURE 46.

P. macropatus, **ventral valve interior. b: beak, i: interarea, m: muscle area, mg: marginal groove, ms: median septum, ps: pseudodeltidium, s: spine, t: tooth.**



TEXT-FIGURE 47.

P. macropatus, **dorsal valve interior. cp: cardinal process, mg: marginal groove, mr: muscle ridge, s: socket.**

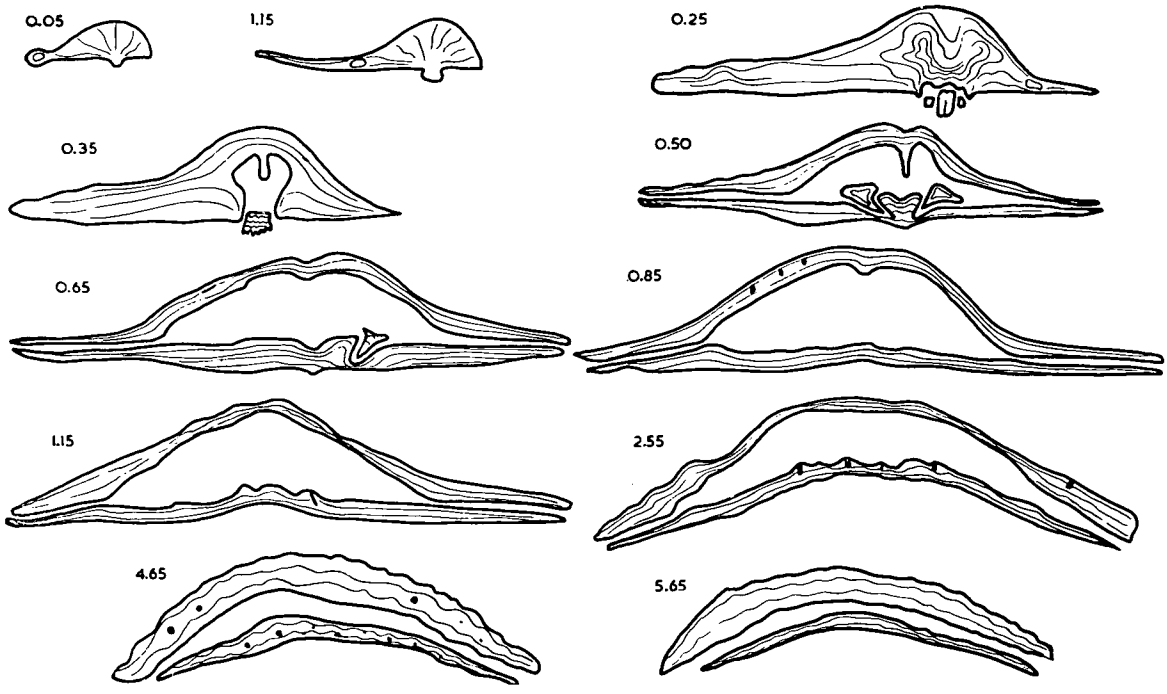
Ventral valve interior: Teeth small, without dental plates. Delthyrial cavity with high strong median septum prolonged anteriorly as low narrow ridge dividing lightly impressed circular muscle field. Margins of valve flat, radially grooved.

Dorsal valve interior: Cardinal process squat, wide, resting direct on valve floor, with 4 to 6 posterior lobes. Dental sockets deeply incised, undercutting sides of anterior part of cardinal process. Muscle field medianly elevated, enclosed by short low ridges.

Shell structure: The spines along the posterior margin of the ventral valve are hollow structures infilled with mineral matter. Taleolae are numerous only in the anterior half of shell; section 2.55 (text-figure 48) shows taleolae forming the cores of the muscle-enclosing ridges.

Measurements:

—	Length.	Width.	Depth of ventral valve.
Holotype, C.P.C. 2967	6.6	10 (est.)	2.3
Figured specimen C.P.C. 2968	5.5	8.0	2.1



TEXT-FIGURE 48

P. macropatus. **Serial sections and peels x 12 of C.P.C. 3026 from K221 with L = 5.1, W = 6.8 and T = 2.4. Two spine-bases along posterior margin of ventral valve: one on left-hand side of sections 0.05 and 0.15, the other on right-hand side of section 0.25. Internally these spines are simply cylindrical cavities in the fibrous shell infilled with mineral matter. Cardinal process seen in sections 0.25 and 0.35, teeth and sockets in sections 0.50 and 0.65, and taleolae in sections 0.85 to 4.65.**

Types. Holotype C.P.C. 2967 from K227; figured specimens 2968, 2969 (ventral valve), both from K221.

Horizon and localities: Sadler Formation, near Sadler Ridge: K221, K222, K223, K224, K226, K227, K230.

Discussion: Sokolskaya's (1950) emendation of *Plicochonetes* appears in Russian. The following selections are taken from a translation in the British Museum (Natural History) (p. 69):—

In form, the shell is like that of *Chonetes*—concavo-convex, small, with well-developed areas on both valves. The ornament is represented by fine costae considerably broader than the sulci separating them. The Devonian and Tournaisian species have ribs ornamented with fine transverse striate fissures [illustrated in Sokolskaya's figure 21]. In the Viséan form these transverse striations on the costae are lacking. The sulci between the costae have no transverse striations.

In *Plicochonetes* spines occur along the hinge margin as in all *Chonetes,* and they connect with the inner cavity of the shell through the oblique passages passing through the area of the ventral valve.

Small teeth are arranged on both sides of the delthyrium in the ventral valve. There are a median septum, indistinct muscle impressions and numerous rounded tubercles that are most protuberant on the ears. The absence of the median septa from the few available dorsal valves of *Pl. nanus* is explained by the early age of the shells in question in which the septa have not yet developed and not by their being entirely absent in *Plicochonetes.* The median septum is plainly visible in representatives of the internal structure of the dorsal valve of the type species of the genus, *Pl. buchianus.*

Comparisons.—*Plicochonetes* differs from the genus *Chonetes* by its very distinctive radial ornament. The shell is ornamented with ribs instead of fine costae . . .

The majority of species of the genus *Plicochonetes* exist in the Devonian and Lower Carboniferous, at the end of which, in the Viséan, they attained their greatest development, whereafter they die out.

In only one detail does Sokolskaya's description differ from that of *P. macropatus*: *P. macropatus* lacks a median septum in the dorsal valve. According to Sokolskaya this difference also exists between typical *Plicochonetes* and the Devonian *P. nanus* (Verneuil) 1845, but " is explained by the early age of the shells in question ".

Similar North American species are *Chonetes scitulus, C. scitulites* and *C. brandonensis. Chonetes scitulus* Hall 1857 from the Hamilton Formation of Hamburg, New York (B.M.(N.H.) B39784, B75908-15) is similar in shape and size to *P. macropatus* but differs in its coarser radial ribs and lack of finer concentric ornament. *C. scitulites* Cooper 1945 (p. 480, pl. 63, figs. 35–38), from the lower Givetian of Illinois, is costate and is similar in shape to *P. macropatus;* distinguishing features of *C. scitulites* are its finer costae and proportionately longer shell. *C. brandonensis* Stainbrook 1945 from the Independence shale is almost certainly a *Plicochonetes.* Both valves are marked externally " by about 50 fine costae, closely aggregated, broadly convex, and increasing by division. They are crossed by numerous concentric growth lines which give them a slightly rugose appearance " (Stainbrook, 1945, p. 41). The distinguishing feature of *C. brandonensis* is its subquadrate outline with width only slightly greater than length.

Chonetes plebeja Schnur from the Cuboides Schichten of Serginsk, recorded by Tscherneyschew (1887, pl. 14, figs. 22–24), is indistinguishable externally from *Plicochonetes macropatus. P. macropatus* is not so closely related to the originals of *Chonetes plebeja* Schnur 1854 (pp. 226, 227, pl. 42, figs. 6a–d), which have length equal to width.

Chonetes douvillei Rigaux 1894 (p. 104, pl. 1, fig. 1) is similar in many respects to *Plicochonetes macropatus.* It has the same size and shape, and more importantly the type of ornamentation is the same: radial costae crossed by fine yet conspicuous growth-lines. The costae, however, are more numerous in *C. douvillei*—about 50 at the anterior and lateral margins. Rigaux's species comes from Blacourt near Ferques and occurs in the shales underneath the Dolomite.

According to the illustrations, another of Rigaux's species, *Chonetes maillieuxi* Rigaux 1908 (p. 31, pl. 2, fig. 15), is similar in size, shape and ornament to *Plicochonetes macropatus.* Internal details are unknown.

Superfamily RHYNCHONELLACEA Schuchert 1896

Family CAMAROTOECHIIDAE Schuchert & LeVene 1929

Subfamily CAMAROTOECHIINAE Schuchert & LeVene 1929

Genus CAMAROTOECHIA Hall & Clarke 1893

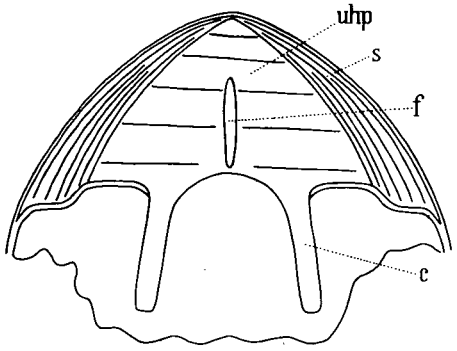
CAMAROTOECHIA LUCIDA sp. nov.

(Plate 10, figs. 1–11; Text-figs. 49–54)

1935 *Camarotoechia pleurodon* (Phillips), Prendergast, K. L., Some Western Australian Upper Palaeozoic Fossils: *J. Roy. Soc. W. Aust.,* 21, 19-20, text-fig. 4.

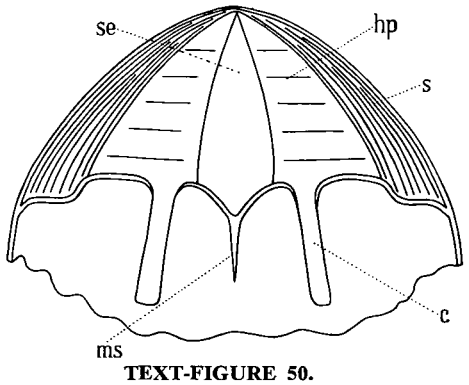
Diagnosis: Transversely ovate *Camarotoechia,* commonly with three, rarely with four or five angular plications on ventral valve sulcus and five to eight plications on each lateral slope. In the dorsal valve the septalium and median septum range from incipient structures confined within the notothyrial cavity to short but well-developed structures. Hinge-plate divided or undivided.

Material: Over 100 free silicified shells and valves, several free calcareous shells.



TEXT-FIGURE 49.

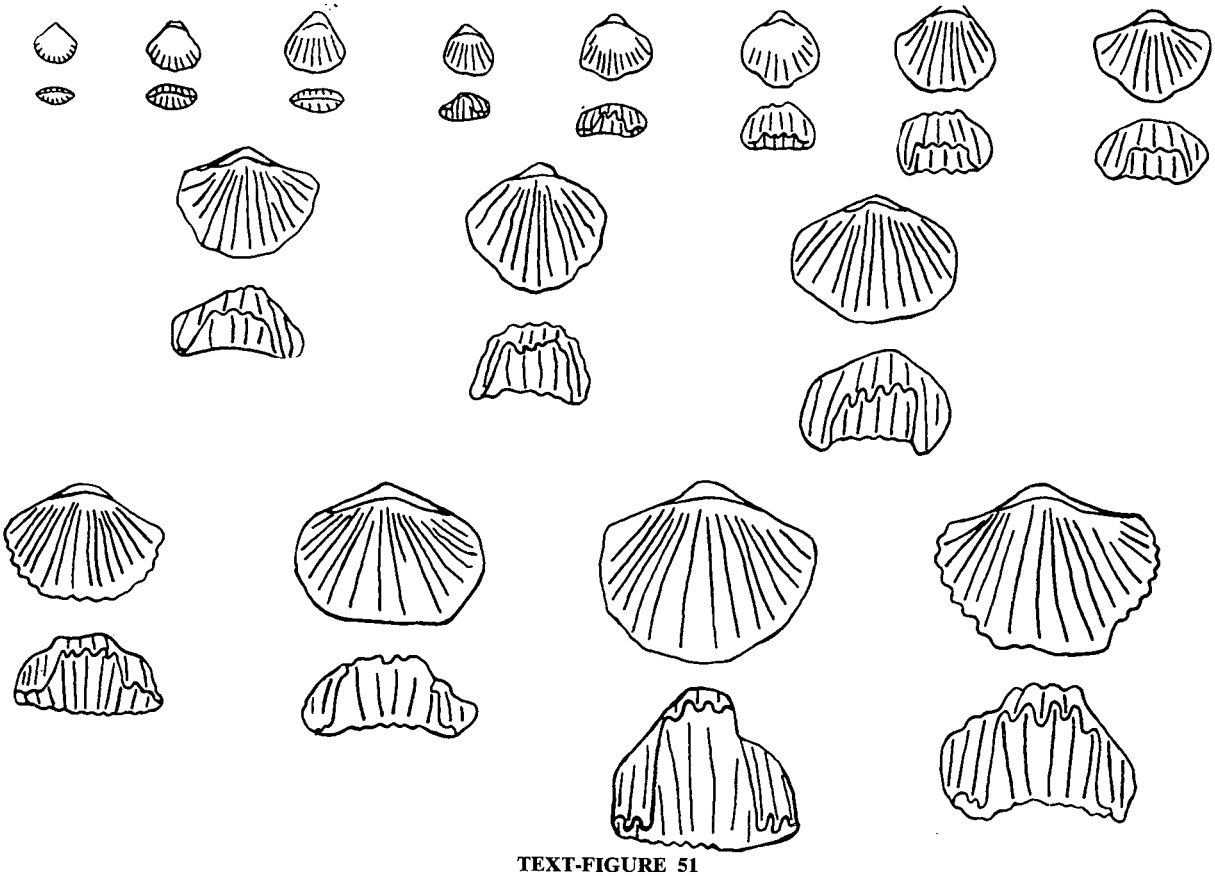
C. lucida, **without septalium.. c: crus, f: foramen, s: socket, uhp: unsplit hinge-plate.**



TEXT-FIGURE 50.

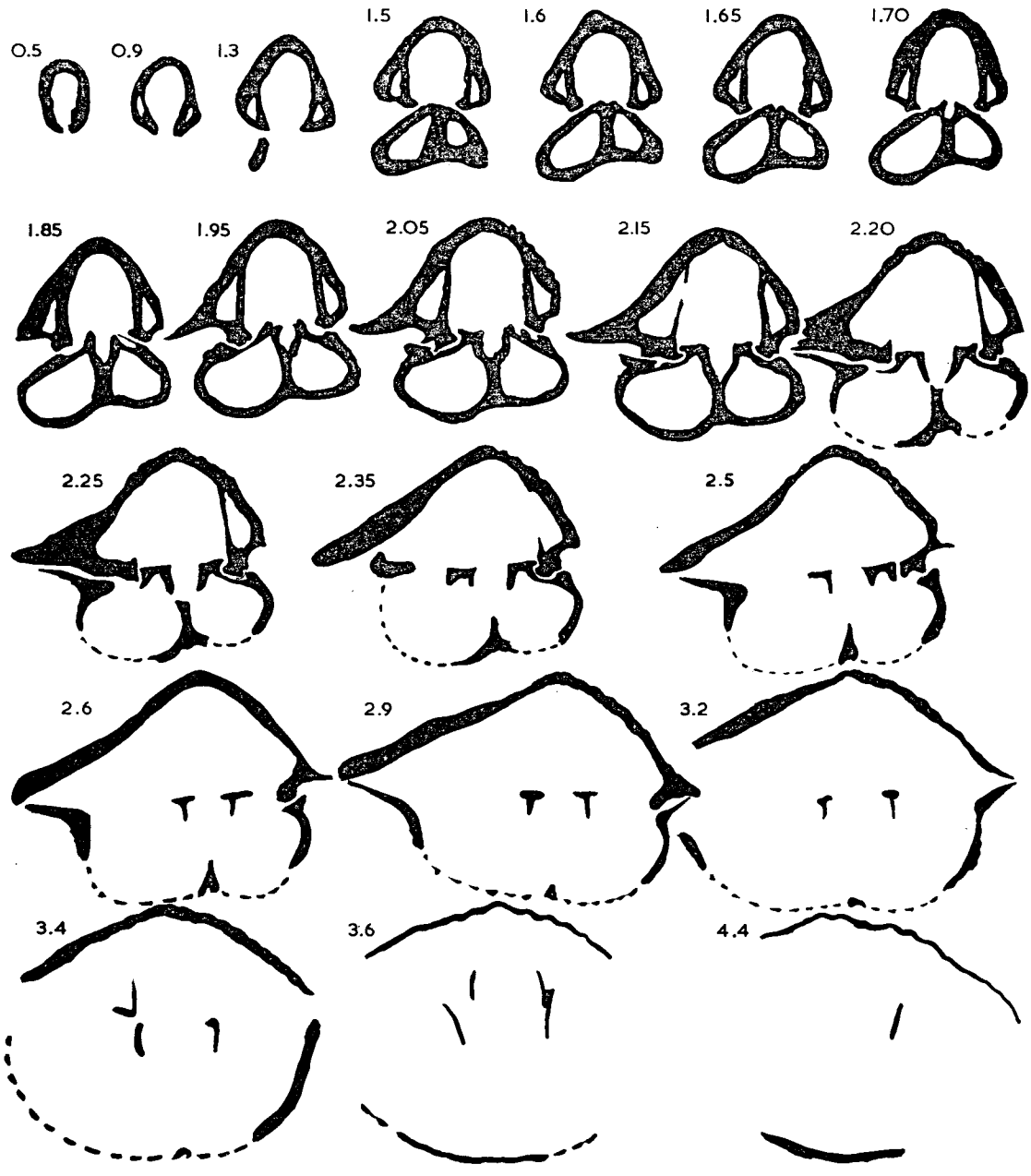
C. lucida, **with septalium. c: crus, hp: hinge-plate, ms: median septum, s. socket, se: septalium**

Description: Exterior: Outline trigonal, length and width sub-equal in minute specimens (less than 6 mm. in width), transversely ovate in larger specimens. Degree of biconvexity increasing from weak in minute specimens to very strong, gibbous in largest specimen. Lateral profile ranges with increasing size from trihedral to sub-elliptical to rhomboidal. Similarly the apical angle ranges from 90° to 140°. Shell widest and thickest near hinge-line. Anterior commissure straight to gently sulcate in smaller specimens, rectangularly uniplicate in larger specimens.



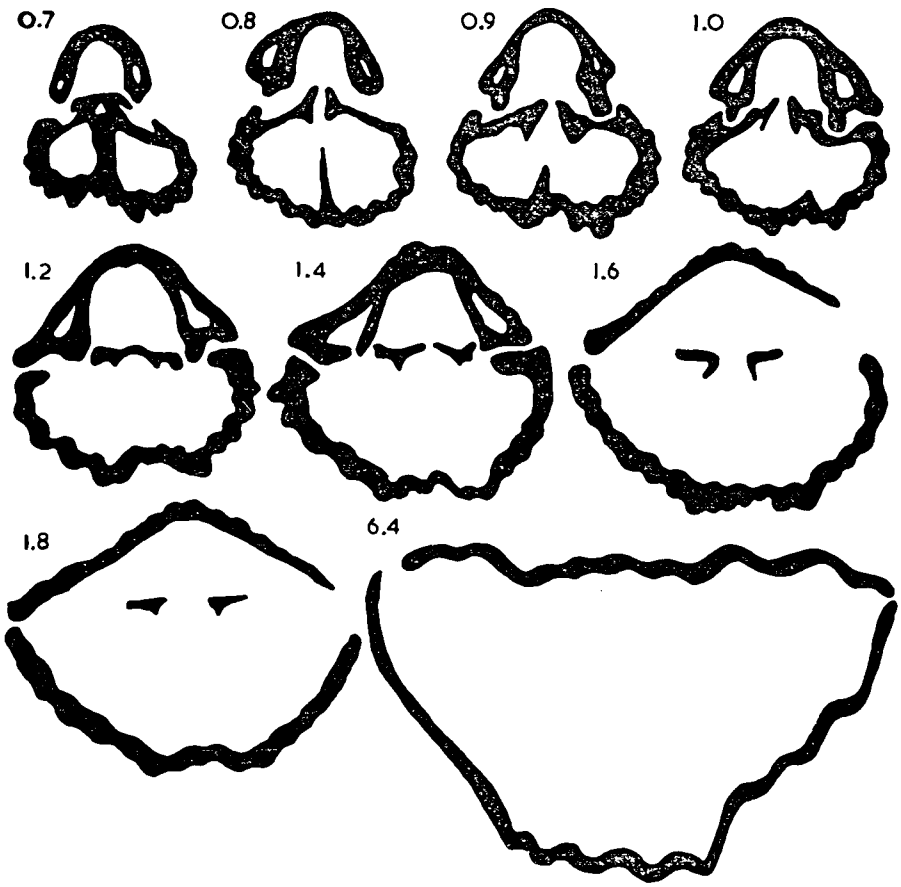
TEXT-FIGURE 51

C. lucida. **Anterior and dorsal views of fifteen specimens x1. Specimens chosen from Oscar Hill and K322.**



TEXT-FIGURE 52

C. lucida. **Serial sections x 3 of a specimen from Oscar Hill. L = 13.6, W = 17.4, T = 10.1. Septalium supported by median septum (sections 1.50 to 2.15) and split hinge-plate.**



TEXT-FIGURE 53

C. lucida. **Serial sections and peels x 6 of C.P.C. 3027 from Oscar Hill, with L = 10.3, W = 15.1, T = 9.4. Features differing from those of typical specimens are united hinge-plate (in section 1.2), incipient septalium, and very poor development of median septum.**

Ventral valve flat to weakly convex in lateral profile, with a broad median sulcus radiating from a short distance anterior to umbo, progressively deepening anteriorly, limited by nearly vertical straight lateral walls. At the anterior commissure the sulcus projects as a long tongue into the dorsal valve fold. Umbo acute in lateral profile, erect to weakly incurved, in latter instance overhanging broad convex dorsal valve umbo, the tip of which projects into anterior half of delthyrium. Deltidial plates small, roofing over tip of dorsal valve umbo in shells with an erect ventral valve umbo, divided, leaving an elliptical posterior foramen, which extends posteriorly to tip of umbo. Interarea short, narrow (width equal to half shell-width), gently concave, overhung by beak-ridges.

Dorsal valve weakly to strongly arched, median fold arising a short distance anterior to umbo, increasing in height and width anteriorly.

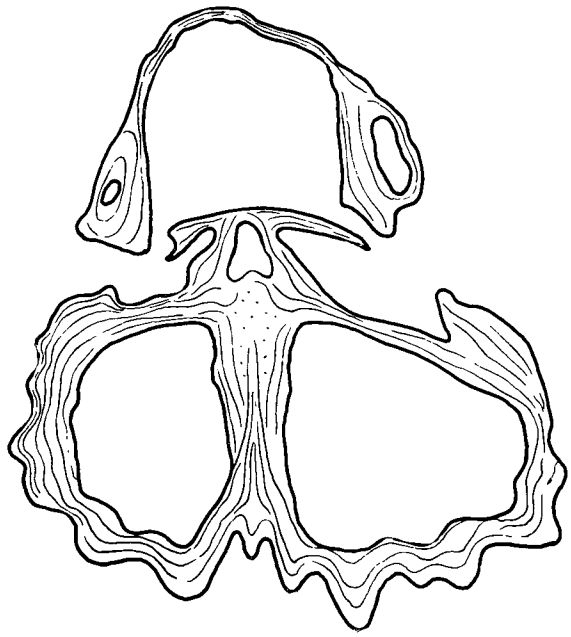
Both valves strongly plicated, commissure deeply serrated. Plications acutely angular, increase in width proportional to radial distance from umbo; three plications

on ventral valve sulcus, four on dorsal valve fold, five to eight on each lateral slope. Plications crossed by extremely faint concentric growth-lines seen only on very favourably preserved surfaces, two to three in a length of 1 mm.

Interior: Internal features seen directly in free silicified valves from K289, indirectly by serial sections of larger specimens from K283 and K322. In all specimens examined a wide range of variation in the minute details of the interior is superimposed over a general similarity of design.

Teeth strong and broad, divergent anteriorly, supported by long vertical slender dental plates; well-developed lateral denticula are separated from the teeth by narrow grooves in which the tips of the lateral borders of the dental sockets articulate.

Most specimens have a strong but short dorsal-valve median septum; e.g. in a shell 13.6 mm. long, the length of the median septum is 1.0 mm.; septum supports a short but well developed septalium. Hinge-plate tiny, divided, flat. Dental sockets deeply excavated, broad, crura straight, T-shaped in cross-section, diverge anteriorly at a very low angle.



TEXT-FIGURE 54

C. lucida. **Enlargement (x15) of section 0.7 of text-figure 53. Shape of growth laminae indicates that median septum formed in two stages: (a) initially, dorsal mantle folded on dorsal side into sharp high median fold which deposited a high median ridge; (b) after second stage of deposition by mantle along median ventral and lateral sides of notothyrial cavity, median ridge joined by newly deposited matter to ventral wall of valve, entire structure forming an incipient septalium.**

Another group of shells has an incipient septalium and an extremely short posterior median septum (0.2 mm. long in a specimen with length 10.3 mm.), more accurately termed a posterior ridge in the notothyrial cavity; hinge-plate united anteriorly, divided posteriorly, with the median sides of the divided hinge-plate swollen into narrowly separated flat parallel surfaces; dental sockets broad and shallow, excavated posteriorly under umbonal tip; crura short and thick.

Shell structure fibrous, impunctate.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2970	6.1	6.8	3.5
Figured specimen C.P.C. 2972	7.6	10.0	4.6
Figured specimen C.P.C. 2971	12.0	19.8	14.5

Types: Holotype C.P.C. 2970, an entire silicified shell from K289; figured specimen C.P.C. 2972 from the same locality; figured specimen C.P.C. 2971 from Oscar Hill.

Horizon and localities: Fairfield Beds: Old Bohemia area (K179), Burramundi Range (K288, K289, K292, K315, K318, K322, K327), Oscar Hill (K283), Brooking Gap (T1), Fossil Downs (K319), Fairfield Homestead (K551), Mt. Percy (KP164, Ld25), Station Creek (M3, M8, M9); Napier Formation: near Fairfield Homestead (KP84), near Dingo Gap (KP103), near Wire Spring (KP143, Ld32), and near Elimberrie Spring (Ld10). Bugle Gap Limestone: Bugle Gap (K169). Geikie Formation: Fossil Downs Homestead (T5).

Discussion: Schmidt (1941) originally diagnosed *Tetratomia* as follows (in translation): "A genus of *Camarotoechia*-like appearance but without septalium. Dorsal septum weak or failing. Hinge-plate united."

This diagnosis is obviously applicable also to those members of *Camarotoechia lucida* in which the dorsal valve has an incipient septalium. In the field these shells occur side by side with other specimens identical except for a more strongly developed septalium and dorsal median septum, and a divided hinge-plate. The degree of development of the septalium and dorsal median septum varies continuously throughout the population (cf. text-figs. 54 and 52, section 1.70) and it could not be maintained that two species are present. The variation in the shape of the hinge-plate, united in specimens with an incipient septalium, divided in those with a split hinge-plate, is also continuous, and is likewise indicative of normal variation within a camarotoechiid population. Indeed there is abundant evidence that a variably divided or undivided hinge-plate is a very common feature in several, if not all, species of camarotoechiids. Schmidt in her discussion of *Tetratomia* notes this kind of variation in the species of the *Camarotoechia daleidensis* group and attributes it to the frequent non-preservation of the joining-piece between the separate halves of the divided hinge-plate. Evidence given immediately below suggests that the deposition by the mantle of such a joining-piece is more likely than poor preservation to be responsible for this kind of variation. An allied form, *Machaeraria* Cooper 1955, varies similarly though apparently not so widely: in this genus, the hinge-plate is divided but the inner hinge-plates almost meet in some specimens. Topotypical specimens of the type species of *Camarotoechia, C. congregata,* in the collections of the British Museum (Natural History), have either a divided or an undivided hinge-plate: of an assemblage of shells, B9564, B96425, B96427, B96429 and B96510 have divided hinge-plates and B96426 has an undivided plate. Cooper acknowledges this kind of variation in his diagnosis of *Camarotoechia* (1944, p. 311): ". . . dorsal interior with divided hinge-plates; . . . segments of hinge-plate attached to median septum by supporting plates making a short, small cruralium often covered with growth of inner hinge plates."

This demonstration of fairly wide internal variation within a camarotoechiid species casts serious doubt on the validity of the genus *Tetratomia,* so far represented only by the type species, *T. tetratoma.* Owing to lack of material this species is

known internally by only a few rather poor sets of serial sections. Perhaps an examination favoured by abundant well-preserved material would show that *T. tetratoma* includes groups of specimens which at one extreme of variation may agree with *Camarotoechia* and at the other agree with a different genus. If, as is likely, according to the above discussion of camarotoechiid variation, the variation between such two extreme groups can be proved to be continuous, then *Tetratomia* must be placed in synonymy with *Camarotoechia.*

Relationships: Externally, *C. lucida* differs markedly from *Tetratomia tetratoma* in its more transverse, almost elliptical outline and its gibbous dorsal valve.

Camarotoechia ferquensis (Gosselet) 1887 from the Frasnian of France and Belgium has the same shape as *C. lucida,* but the plications are different: rounded in *C. ferquensis,* angular in the Australian species.

Camarotoechia sobrina Stainbrook 1947 (pl. 47, figs. 19-22) from the Upper Famennian-Lower Tournaisian Percha shale of New Mexico is very similar to *C. lucida,* but has a higher fold. Another externally similar species is *Rhynchopora pustulosa* White from the Burlington limestone of Iowa (of Mississippian age) figured in Hall (1867, pl. 58, figs. 1-4). Except for its surface pores, White's species is externally indistinguishable from *C. lucida.*

Another species similar to *Camarotoechia lucida* is *C. billingsi* Hall 1867 (pl. 54, figs. 9-13) from the Corniferous Limestone of Western New York. The Australian species, however, has distinctly stronger and sharper plications. Other species of *Camarotoechia* close to *C. lucida* are *C. upensis* Sokolskaya 1952 and *C. acutirugata* (de Koninck), both from the Lower Carboniferous of the Moscow Basin (*see* Sarycheva & Sokolskaya, 1952, pl. 46, figs. 250, 252).

The species from Fossil Downs Station, recorded as *Camarotoechia pleurodon* (Phillips) by Prendergast (1935), is *C. lucida.*

In the same paper Prendergast (p. 20, pl. 2, figs. 1-6) describes a new variety, *Camarotoechia pleurodon* Phillips var. *tripla,* from a locality 12 miles south-west of Oscar Range Homestead. Specimens of brachiopods from the newly recognized Carboniferous rocks of the same locality are identical with Prendergast's variety, which is restricted to the Carboniferous. *C. pleurodon* var. *tripla* is well characterized by its subspherical shape and the almost constant number of three plications on the dorsal valve fold.

A redescription of this form will appear separately.

CAMAROTOECHIA sp. ind.

(Plate 10, figs. 12-21; Text-fig. 55)

Material: More than 50 poorly preserved free calcareous shells, partly recrystallized.

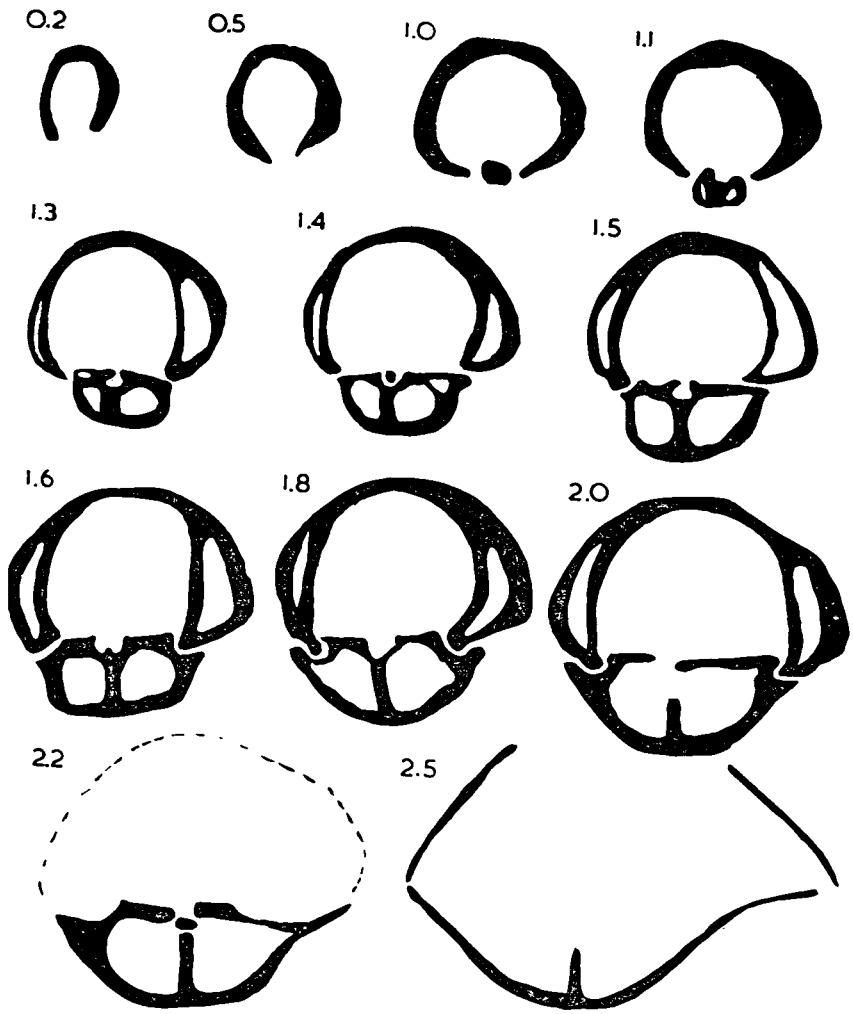
Description: Exterior: Variation in shell-shape is like that of *Camarotoechia lucida* (*see* text-figure 51). Biconvex, dorsal valve more highly convex than ventral valve. Width measured at two-thirds of shell-length from umbo in juveniles, at midlength in adults; for juveniles, width and length are equal, for adults, width is greater than length. All specimens thickest at midlength.

Ventral valve gently convex posteriorly, broad triangular sulcus arising a third of shell length from umbo, poorly delimited from lateral slopes, produced anteriorly into a moderately long tongue trapezoid to triangular in outline. Apical angle ranges from 80° (in juveniles) to 120° (in adults), tip of umbo suberect. Narrow delthyrium open, without deltidial plates. Interarea short and narrow, gently concave.

Dorsal valve with high median fold arising immediately anterior to umbo; tip of umbo obtruded into delthyrium.

Plications few in adults, one or two on sulcus, two or three on fold and two (rarely three or four) on each lateral slope. Anterior commissure accordingly episulcate to multiplicate. Plications sharp-backed, triangular in outline, separated by grooves of similar shape. Concentric markings not present.

Interior: Ventral valve has short high vertical dental plates supporting moderately small parallel teeth. Dorsal valve interior has a well-developed median septum supporting a small short septalium. Hinge-plate divided. Dental sockets moderately deep and narrow.



TEXT-FIGURE 55.

Camarotoechia **sp. ind. Serial sections x 6 of specimen from F33 with L = 8.2, W = 12.3, T = 7.3.**

Characteristic features of *Camarotoechia* **are: small teeth supported by high curved dental plates (sections 1.3 to 2.0), and flat hinge-plate with narrow cruralium supported by strong median septum (sections 1.1 to 2.5).**

Measurements:

	Length.	Width.	Thickness.
Figured specimen 26712a	10.9	13.5	8.1
Figured specimen 26712b	10.9	13.7 (est.)	5.8

Figured specimens: U.W.A. 26712a and 26712b from F33.

Localities: Napier Formation (F32, F33), south of Van Emmerick Range.

Discussion: Externally this form differs notably from *Camarotoechia lucida* in its less convex dorsal valve, four-sided outline and the fewer, more prominent marginal plications.

Genus UNCINULUS Bayle 1878

UNCINULUS WOLMERICUS sp. nov.

(Plate 10, figs. 36-50; pl. 15, figs. 14-17; Text-figs. 56-58)

Diagnosis: Uncinulus with nine to twelve plications on anterior and lateral parts of exterior, postero-median parts smooth. Ventral valve without a median ridge between muscles.

Material: Over 100 free calcareous shells, partly to totally recrystallized; several steinkerns.

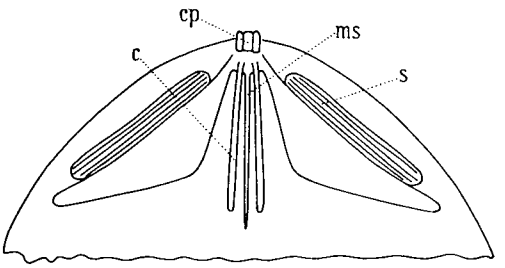
Description: Exterior: Outline transversely subelliptical to subcircular, rarely longitudinally elongate. Profile biconvex, dorsal valve deeper than ventral. Shell widest at or just behind midlength. Anterior commissure narrowly and angularly uniplicate.

Ventral valve evenly and moderately convex except antero-medianly, where the shallow sulcus is drawn out into a flat narrow quadrangular tongue. Apical angle ranges from 110° to 140°; umbo low, erect to suberect; delthyrium narrow, without deltidial plates, filled by the dorsal valve beak. Planareas poorly defined, wide, short and fairly flat.

Dorsal valve moderately to strongly convex, rarely globose, greatest convexity posteriorly. Narrow median fold developed at anterior border, steeply set off from lateral slopes.

Plications well developed along anterior and lateral borders of both valves; broad, lowly arched or flat, separated by narrow grooves. Most specimens have 3 to 5 plications on the dorsal valve fold, 6 to 8 on each lateral slope. Concentric lines extremely fine, 8 to 10 in 1 mm., seen only on favourably preserved surfaces.

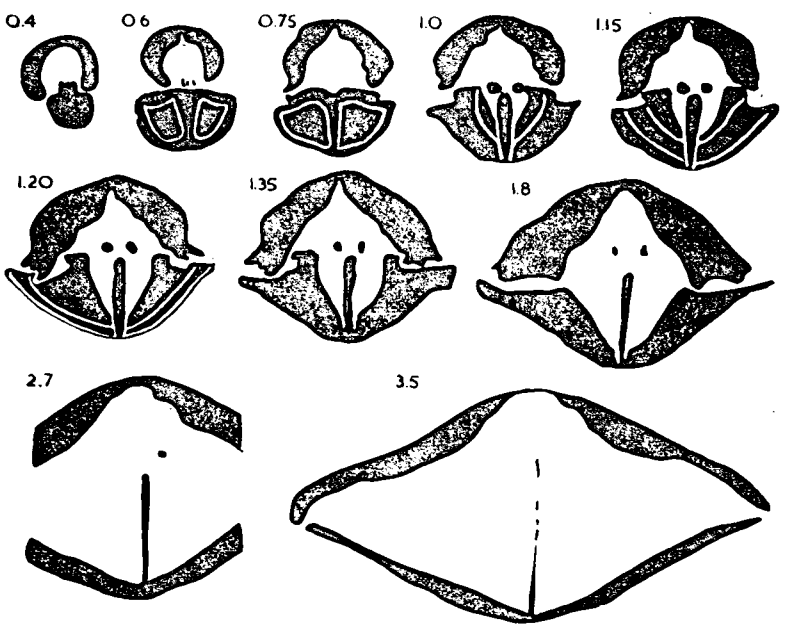
Interior: Ventral valve muscle field almost circular, deeply impressed. Teeth are simple lateral apophyses of valve wall, dorso-lateral faces deeply serrated, divergent or convergent anteriorly.



TEXT-FIGURE 56.

U. wolmericus, **part of dorsal valve showing cardinalia. c: crus, cp: cardinal process, ms: median septum, s: socket.**

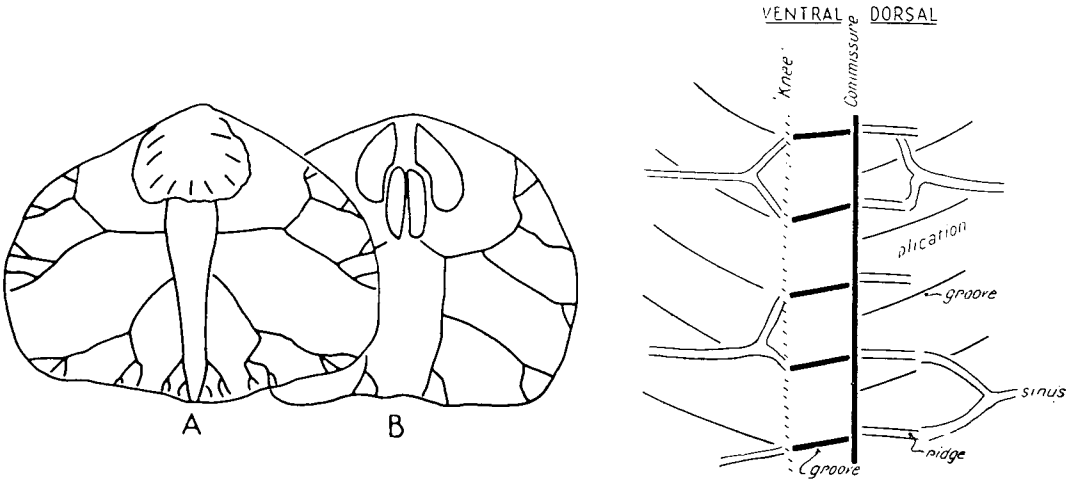
Dorsal valve provided with a short, longitudinally furrowed cardinal process, raised a short distance above valve floor. Median septum thick posteriorly, supporting a short united hinge-plate. Further anteriorly median septum becomes thinner and higher, bisecting broad pitted posterior adductors and elongate-oval anterior adductors. Crura short, cylindrical, thick and parallel, gently curving antero-ventrally. Dental sockets fairly simple shallow broad depressions, provided in some specimens with short sharp ridges which articulate with grooves in teeth.



TEXT-FIGURE 57.

U. wolmericus. **Serial sections x 5 of specimen from K221. L = 17.1, W = 12.5, T = 7.3. Gross division of shell matter into different layers shown by white lines in sections 0.6 to 1.2. Cardinal process (section 0.6), crura (sections 1.0 to 2.7), and prominent median septum (sections 1.0 to 3.5) are important features of dorsal valve, as the primitive lateral teeth (sections 1.20, 1.35) are of ventral valve.**

The shell wall is exceptionally thick compared with other brachiopods, though normal for *Uncinulus* (*see* Schmidt, 1941, taf. 6, figs. 17, 18, and Hall & Clarke 1894, p. 200).



TEXT-FIGURE 58.

U. wolmericus **(a) A, dorsal valve interior; B, ventral valve interior, both showing muscle-scars and pallial sinus pattern. (b) enlarged lateral view of part of steinkern, showing connexion of sinuses with grooves and ridges.**

Sinuses: C.P.C. 3040, a steinkern from K270 (pl. 15, figs. 14-17, text-fig. 58a and b), shows the saccate (apocopate)-saccate sinus pattern characteristic of many living and fossil rhynchonelloids (*see* Williams, 1956, pp. 279-280). The marginal parts of the dorsal sinuses occupy deep narrow grooves which continue back into the broader, steep-sided grooves of the rest of the sinus system. The very end of each marginal sinus leads into an internal groove, corresponding with an external plication. On the ventral valve, each sinus terminates lateral and anterior to the " knee ", or " Schwelle " of Öpik (1934, p. 42, text-fig. 9), in a high narrow ridge which lies along an internal plication, corresponding to an external groove. Since the plications in *wolmericus* are alternate, the marginal sinuses of the dorsal valve oppose those of the ventral valve. These relations, shown in text-fig. 58b, corroborate Öpik's idea that the ribbing of the brachiopod shell is merely the expression of the marginal sinuses.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2973	13.9	15.6	9.2
Figured specimen C.P.C. 2974	14.3	19.2	7.6
Figured specimen U.W.A. 26275	11.4	15.5	11.7

Types: Holotype C.P.C. 2973 (K221), figured specimens C.P.C. 2974 (K221), C.P.C. 3040 (K270), U.W.A. 26275 (T54).

Horizon and localities: Sadler Formation near Sadler Ridge (K221, K224, K225, K228, K230, T54), near Menyous Gap (K270); Gogo Formation, Old Bohemia area (K126), and undifferentiated Mt. Pierre Group, Bugle Gap (K98) and Old Bohemia area (K121, K172-K174); Oscar Formation, Oscar Range (Ld8); probable Fossil Downs Formation near Long Hole Bore (T9). Poor specimens from Sadler Formation at K144, K274 and K480 are tentatively referred to *U. wolmericus.*

Discussion: By virtue of its strong dorsal septum and the united hinge-plate, which bears at its posterior a primitive cardinal process, *wolmericus* is included in *Uncinulus.* It differs from the type species, *Terebratula subwilsoni* d'Orbigny 1850, in having the postero-median part of the exterior smooth and ventral valve interior without a ridge dividing the muscle-field.

U. wolmericus is practically identical internally with *U. coronatus* (Kayser) 1871 from the Upper Couvinian of the Eifel (Schmidt, 1941, pl. 6, fig. 18). Externally these species are easily separable as the German species is strongly plicate.

Camarophoria (sic) (*Liorhynchus?*) *medioplicata* Nalivkin 1930b (pl. 4, figs. 1-6) is externally similar to *Uncinulus wolmericus* but with a deeper sulcus. This species comes from the Givetian of West Ferghana.

Rhynconella Le Meslii (sic) Rigaux 1894 (p. 103, pl. 2, fig. 2) from the Frasnian (horizon of "*Strophomena Gosseletii*") of Beaulieu is similar in shape to *Uncinulus wolmericus* but has deeper marginal plications.

UNCINULUS AREFACTUS sp. nov.

(Plate 11, figs. 8-13; Text-figs. 59, 60)

Diagnosis: Transverse *Uncinulus* with a broad sulcus, marginal plications, and crura which arise posterior to the sockets.

Material: Over 100 free calcareous shells most of which are crushed and recrystallized.

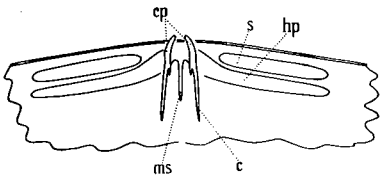
Description: Exterior: Outline transversely elliptical to quadrate, width greatest at midlength. Profile biconvex, both valves moderately convex, dorsal valve slightly deeper. Hinge-line short and straight, cardinal margins broadly curved; anterior commissure broadly uniplicate.

Ventral valve umbo low, apical angle 130° to 150°; tip of umbo erect occupying most of delthyrium. Interarea or planareas not developed. Triangular shallow median sulcus, anterior to midlength, forming a short broad flat tongue; sulcus set off from lateral flanks by rounded or flat surfaces inclined at 45° to surface of tongue.

Dorsal valve umbo strongly convex. A low and broad median fold developed along anterior border.

Marginal surfaces of both valves with broad flat low plications separated by narrow grooves; sulcus with 8 to 10 plications with about the same number on each lateral flank. Very faint concentric lines cross marginal plications.

Interior: Teeth simple, attached direct to valve wall half-way between median point and lateral extremities of hinge-line; teeth converge anteriorly and dorsally and are not grooved.



TEXT-FIGURE 59.

***U. arefactus*, part of dorsal valve interior. c. crus, cp: cardinal process, hp: hinge-plate, ms: median septum, s: socket.**

Cardinal process deeply grooved, low, continuing anteriorly with narrow crural supports and crura, both of which are delicate structures. The crura are freed from the crural bases posterior to the dental sockets and they diverge anteriorly and ventrally. Dental sockets simple lateral excavations into rudimentary hinge-plate. Median septum very thick posteriorly, tapering and increasing in height anteriorly.

Measurements:

	Length.	Width.	Thickness.
Holotype, C.P.C. 2975	23.6	34.0	11.6
Figured specimen, C.P.C. 2976	20.8	34.1	14.0
Small specimen from K231	14.6	26.6	13.2

Types: Holotype C.P.C. 2975; figured specimen 2976; both from K231.

Horizon and localities: Sadler Formation, Sadler Ridge: K231, K230, T57, T58; Napier Formation, S.E. Napier Range (KP103).

Discussion: The shell wall is very thick and seems to be composed of two layers in the dorsal valve; thus the median septum is traceable embedded in shell matter some distance behind its emergence above the surface. A curious feature of the dorsal interior is the detachment of the crura from the crural bases at a position posterior to the teeth and sockets.

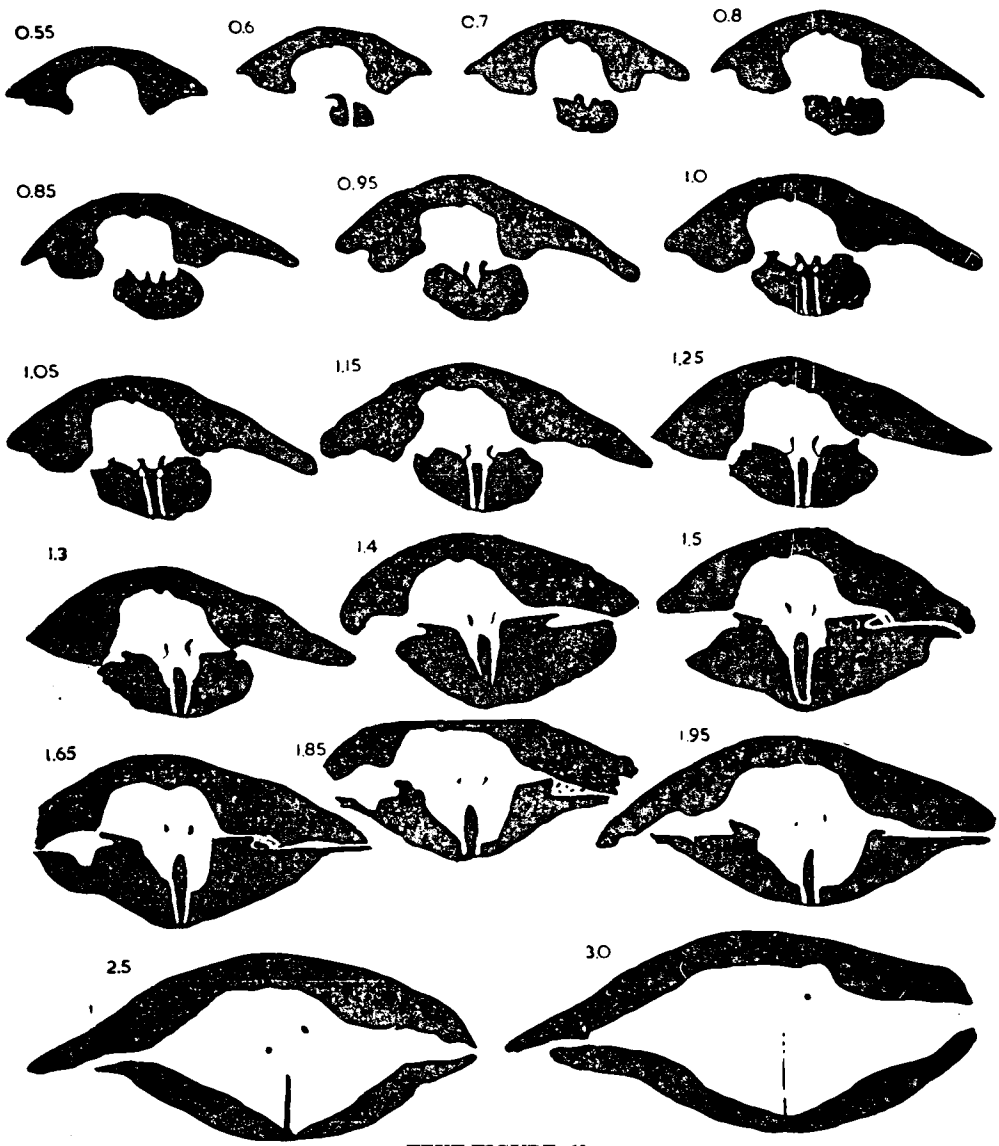
As in *wolmericus*, the generic characters of *arefactus* (strong dorsal septum, united hinge-plate, and primitive cardinal process) are found in the dorsal valve. *U. arefactus* is distinguished from *U. wolmericus* by its transverse outline and its broad sulcus. The more transverse specimens of *U. wolmericus* are very similar in shape to *U. arefactus*, but internal differences such as the relative positions of teeth and sockets, crura, and the deep median posterior groove in the ventral valve of *U. wolmericus* allow a clear separation of any externally similar specimens.

Genus HYPOTHYRIDINA Buckman 1906

HYPOTHYRIDINA MARGARITA sp. nov.

(Plate 10, figs. 22-35; Text-figs. 61, 62)

1890 *Rhynchonella cuboides*, J. de C. Sowerby, sp. Foord, A. H., Description of fossils from the Kimberley District, Western Australia: *Geol. Mag.*, Dec. III, vol. 7, p. 102, pl. 5, fig. 3.



TEXT-FIGURE 60.

U. arefactus. **Serial sections x 2 of specimen from K230, Sadler Ridge. L = 18.5, W = 28 (est.), T = 7.5. Note delicate crura, freed from their attachment with valve-wall posterior to hinge-line (section 1.3), and considerable thickness of shell-wall.**

Diagnosis: Like *Hypothyridina cuboides* and *H. venustula* but with broader costae, more transverse outline, and smaller size.

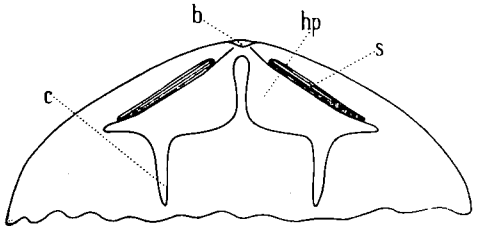
Material: About 120 free calcareous shells, partly to totally recrystallized; there are 100 juveniles and 20 adults.

Description: Exterior: Outline transversely oval to quadrangular, widest at mid-length; profile dorsi-biconvex, dorsal valve strongly and evenly convex, posterior of ventral valve weakly convex; lateral profile of ventral valve with its long tongue is semi-circular. Anterior commissure strongly uniplicate, quadrangular.

Ventral valve convex at umbo, flat on postero-lateral flanks; antero-median part produced dorsally into a long, curved tongue. Umbo small, erect, narrow delthyrium open, probably without deltidial plates; interarea small, gently concave.

Profile of dorsal valve with greatest curvature posteriorly. Median fold developed anterior to midlength, low but prominent, descending by short vertical limbs to lateral flanks. Umbo gently arched, umbonal tip covered over by part of ventral valve umbo.

Surface with narrow low flat plications running along entire length of shell, separated by very narrow furrows. Adults with 8 to 10 plications on tongue, 14 or more on each dorsal valve lateral flank. Growth-lines minute, on tongue commonly 5 to 8 in 1 mm.



TEXT-FIGURE 61.

H. margarita, **part of dorsal valve interior showing cardinalia. b: beak, c: crus, hp: hinge-plate, s: socket.**

Interior: Delthyrial cavity deep and broad, walled by long high nearly vertical dental plates. Teeth small, pointed, converging anteriorly and dorsally. No median septum. Hinge-plate divided, very thin, flat; its anterior edge provided with delicate curved processes diverging anteriorly and dorsally. Crura thin, emerging from outer part of hinge-plate so that posterior ends of crura lie close to walls of valve. Dental sockets small, shallowly excavated into outer hinge plates.

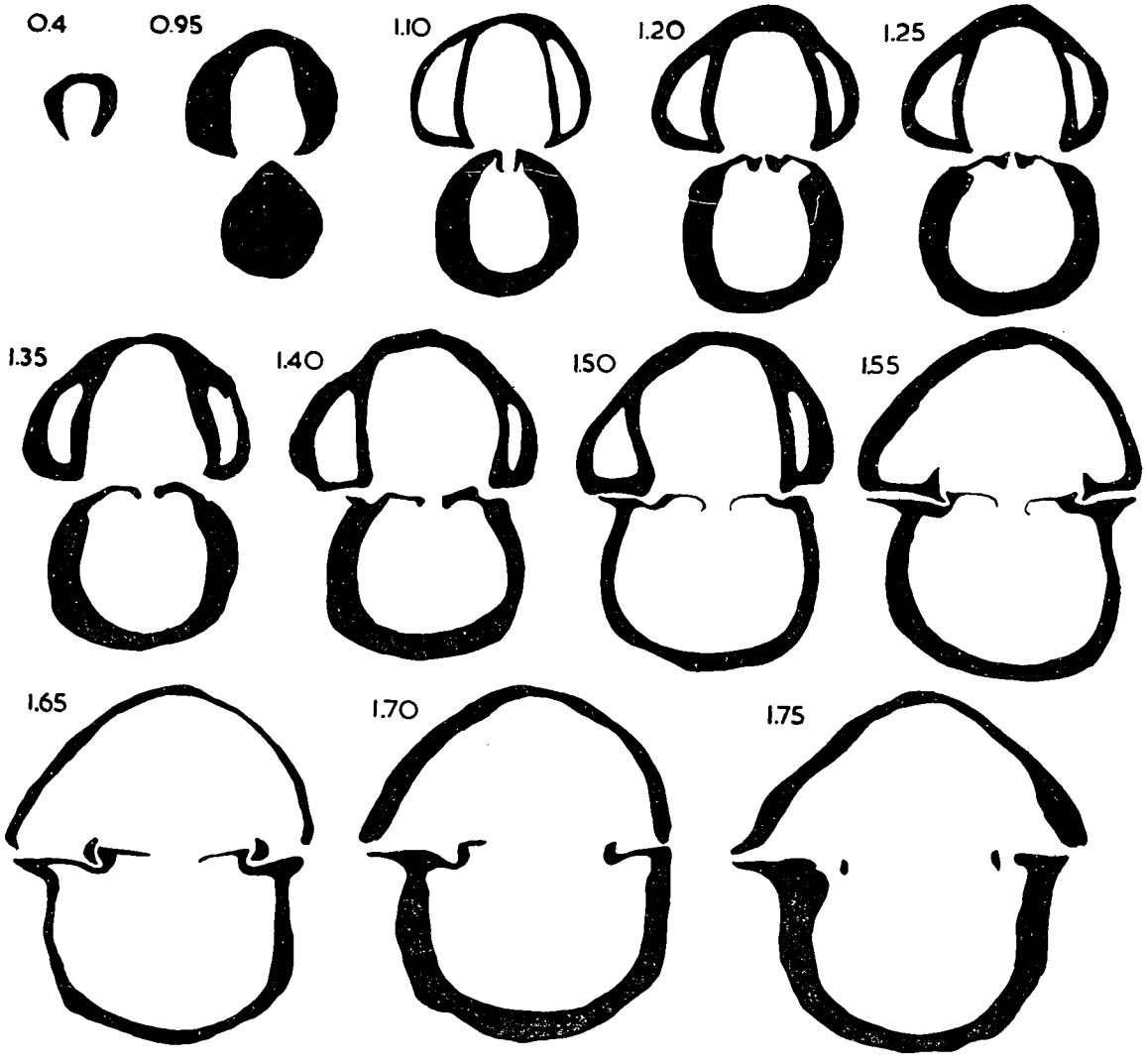
Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2977	22.3	27.1	24.7
Figured specimen, C.P.C. 2978	12.0	15.5	13.2
Small specimen from K150	6.3	7.1	3.3
Large specimen from K150	16.8	18.3	12.3

Types: Holotype C.P.C. 2977 from Ld31, Oscar Range. Figured specimens C.P.C. 2978 from K150, and U.W.A. 26712c from F33.

Horizon and localities: Sadler Formation, Bugle Gap (K103, K144, K147, K148, K150, K153, K154, T61), near Menyous Gap (K271, K274), near Long's Well (G23); Oscar Formation, near Palm Spring (Ld33, 0/73); Napier Formation, south-west of Van Emmerick Range (F33), near Elimberrie Spring (Ld31), and doubtfully from the beds transitional between the Pillara Formation and the Napier Formation near Elimberrie Spring (0/67).

Discussion: The new species has the diagnostic properties of *Hypothyridina:* flat plications separated by narrow grooves, a divided hinge-plate, and no dorsal septum. Foord (1890, p. 102, pl. 5, fig. 3) recorded and illustrated *Hypothyridina cuboides*



TEXT-FIGURE 62.

H. margarita. **Serial sections x 4 of juvenile specimen from K150, with L = 15.0, W = 15.3, T = 10.2.**

Note narrowly split hinge-plate, the crura situated close to shell-wall (section 1.75), and tiny sharp teeth (sections 1.55, 1.65) supported by high dental plates.

from Rough Range. Although the specimen illustrated is immature and has a lower apical angle than that of typical specimens of *H. margarita,* it can nevertheless be matched with other small specimens of *H. margarita.*

H. margarita comes closest to a specimen of *H. cuboides* figured by Whidborne (1893, pp. 134, 135, pl. 15, figs. 6, 6a) from the Devonian of south Devonshire. This specimen and the Fitzroy specimens have a prominent fold in the dorsal valve which distinguishes them from other *Hypothyridinae.* Whidborne's expression for the figured shell, " a very deep specimen ", may imply that this specimen is exceptionally globose.

Davidson's description (1864) of *H. cuboides* (Sowerby) 1840, almost certainly based on topotypical material, is probably the best available, and compared with the specimen figured by Davidson, Whidborne's figured specimen is indeed exceptional. This specimen may nevertheless be a valid member of *H. cuboides*, occurring side by side with more typical specimens. Even so, *H. margarita* may be readily separated from *cuboides* by the number of plications on the tongue, 8 to 10 in adults of *margarita*, 12 to 20 in adults of *cuboides*.

H. venustula robusta Cooper & Williams 1935 is also similar to *H. margarita*. Its tongue with 3 to 6 plications is longer than wide but the shell is nearly as wide as long, and the dorsal valve fold is not developed. *H. venustula* s.s., though similar to *H. margarita* in the number of plications on the tongue (6 to 8), differs from the Fitzroy species to a greater degree than its variety *robusta:* as well as lacking a dorsal valve fold, *venustula* has a tongue with length and width nearly equal.

Another North American species, *H. emmonsi* (Hall & Whitfield) 1877, seems to lie between *H. margarita* and *H. venustula* s.s. Like *venustula, emmonsi* has a tongue with an almost square outline, and like *margarita,* it has, though poorly developed, a fold on the dorsal valve; but unlike both *venustula* s.s. and *margarita, emmonsi* has 13 or more plications on the tongue.

FITZROYELLA gen. nov.

Type species: Fitzroyella primula sp. nov.

Diagnosis: Small strongly plicated shells with an interior like *Hypothyridina* Buckman 1906.

Discussion: The following species are included in *Fitzroyella*:—

F. primula sp. nov.

Terebratula angularis Phillips 1841.

Rhynchonella ibergensis Kayser 1881.

Rhynchonella (Hypothyris) praeibergensis Paeckelmann 1913.

Leidhold (1928) discussed the three European species and included them in what he termed the *Ibergensis* group of the genus *Uncinulus*.

Probably the oldest species is *F. angularis* from undifferentiated Givetian-Frasnian of Devonshire and the Givetian of Germany. *F. praeibergensis* comes from the Givetian-Frasnian boundary, and *F. ibergensis* and *F. primula* are both Frasnian. Consequently the age of *Fitzroyella* is Frasnian and probably also Givetian.

Although the interiors of *F. angularis* and *F. ibergensis* are unknown, their external similarity with *F. primula* and *F. praeibergensis* leaves little doubt that these four species are congeneric. The type species and *F. praeibergensis* both have interiors similar to those of *Hypothyridina:* ventral valve with long dental plates, dorsal valve with a flat divided hinge-plate, short strong crura, and a short median septum supporting an incipient septalium. *Fitzroyella* differs markedly, however, from *Hypothyridina* in its less globular shape and, more significantly, in its strongly plicated shell.

Diagnosis of the species:

1. *F. primula:* Maximum width 10 mm., 12 to 18 strong plications, sulcus in ventral valve, very weak fold in dorsal valve, moderately high ventral valve beak. Anterior commissure deeply serrated, anterior and lateral margins bent over perpendicularly.

2. *F. ibergensis:* Maximum width 15 mm., barely developed sulcus in ventral valve, fold absent in dorsal valve; 24 strong plications but anterior commissure not deeply serrated. Anterior and lateral margins bent over perpendicularly.

3. *F. praeibergensis:* Maximum width 11 mm., 13 plications, shallow sulcus in ventral valve, low fold in dorsal valve. Anterior commissure weakly serrated. Anterior and lateral margins bent over perpendicularly.

4. *F. angularis:* Maximum width 10 mm., well-developed ventral valve sulcus and dorsal valve fold, 10 to 15 plications, deeply serrated anterior commissure, but anterior and lateral borders not bent over.

Notes on some of the species:

(a) *Fitzroyella angularis* (Phillips) 1841.

1841 *Terebratula angularis* Phillips, p. 89, pl. 35, figs. 162a, b, c.

1864 *Rhynchonella angularis,* Davidson, p. 68, pl. 14, figs. 11, 11a, 12, 12a, 12b, 13, 13a.

1885 *Rhynchonella angularis,* Maurer, p. 198, pl. 8, figs. 21, 22.

1893 *Rhynchonella angularis,* Whidborne, p. 132.

1928 *Uncinulus angularis,* Leidhold, pp. 33, 34.

The original figures of Phillips are inadequate for the purpose of establishing correspondence between figures and specimens. He named Barton (Devonshire) as locality. The first reviser was Davidson (1864), whose figures, though improving on those of Phillips, still lack required detail. On p. 69 Davidson noted: " Phillips' original term being preserved in the collection of Mr. Lee ". Davidson figured two specimens in the Lee Collection and for both of these Barton is indicated as locality. The third specimen figured by Davidson, and indicated as being in the collection of the Geological Survey, has the locality of Woolborough. Whidborne (1893, p. 132) listed the whereabouts of nineteen specimens of what he considered to be *angularis,* including " From Wolborough [sic] . . . one of Phillips' figured specimens in the Museum of Practical Geology ". In agreement with this, the specimen (6891) kept in the Geological Survey Museum (formerly known as the Museum of Practical Geology) is found to correspond as far as one can judge with figures of Phillips (pl. 35, fig. 162b) and of Davidson (pl. 14, fig. 12, 12a, 12b), and the measurements of length and width of this specimen agree with Davidson's pl. 14, fig. 12, a cross therein indicating these measurements. In contradiction to this line of evidence, the label belonging to G.S.G.B. 6891 gives Newton Bushel (the former name of Newton Abbot, Devonshire) as the locality.

The two specimens of *angularis* in the British Museum (Natural History) (BB16302, 16303) are very poorly preserved but the possibility of one or both of them having been figured by Phillips stems from their indicated locality of Barton.

Poorly preserved as they are, these three specimens, G.S.G.B.6891, B.M.(N.H.) BB16302, and 16303, may be accepted as being conspecific and the need for selection of a lectotype is accordingly not pressing. In any case this task would best be carried out by one familiar with the Devonian rocks and fossils of Devonshire.

Until details of the Barton locality become better known, the age of *angularis* cannot be judged more definitely than undifferentiated Givetian-Frasnian, the general age assigned to the fossiliferous limestones in the Torquay area.

If, however, the specimens from the Kalk of Waldgirm were correctly determined by Maurer (1885) as *angularis,* and Leidhold suggests that this is so, at least the Givetian age of this species will have been established.

(b) *Fitzroyella ibergensis* (Kayser) 1881.

1843 *Terebratula primiparilis* Schlotheim *in* F. A. Roemer (p. 18, pl. 5, fig. 10a-c).

1881 *Rhynochonella ibergensis* Kayser (pp. 332, 333, pl. 19, figs. 2, 2a-c, 3, 3a).

1928 *Uncinulus ibergensis,* in Leidhold (pp. 33, 34, pl. 2, fig. 7).

Roemer's specimens from the Frasnian limestone of Grund in the Harz Mountains were placed by Whidborne (1893, p. 132) in synonymy with *angularis.* Earlier, however, Clarke (1884), in revising the fauna of the Frasnian limestone at Iberg, near Grund, included Roemer's form in *ibergensis;* Clarke probably handled Roemer's material and consequently would have been in a stronger position to make a definite determination.

The synonymy of *ibergensis* turned full circle when Whidborne (1893, p. 131) included this name within *Rhynchonella implexa* Sowerby 1840, a form considered by Davidson merely as a variant of *Terebratula primiparilis* Buch 1834. Finally, in Schmidt (1941, pp. 22, 23), the individuality of *implexa* is upheld.

All these allegedly synonymous species are easily separated from the strongly plicated *ibergensis* by means of their numerous low costellae.

FITZROYELLA PRIMULA sp. nov.

(Plates 16, figs. 1-10; Text-figs. 63-65)

Diagnosis: Maximum width 10 mm., twelve to eighteen strong plications, weak sulcus in ventral valve, very weak fold in dorsal valve, moderately high ventral valve beak. Anterior commissure deeply serrated, anterior and lateral margins bent over perpendicularly.

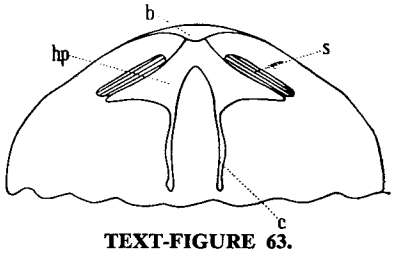
Material: Nineteen entire free calcareous shells, nine free silicified shells, three steinkerns.

Description: Exterior: Pentagonal in outline, profile equally biconvex. Hinge-line short, curved in small shells, larger shells with a proportionately longer, nearly straight hinge-line. Larger specimens widest at hinge-line, smaller specimens widest a short distance anterior to hinge-line. Lateral and anterior commissures extremely deeply serrated, lateral and anterior margins bent at right-angles to rest of shell exterior.

Ventral valve weakly convex to flat. Umbo high, tip perforated by small circular foramen; rest of delthyrium closed by medianly-fused deltidial plates. Planareas wide, moderately long, weakly concave. Median anterior part of valve flat or with a shallow broad sulcus.

Dorsal valve with a low convex umbo, tip protruded into anterior part of delthyrium. Weak median fold. No interarea or planareas.

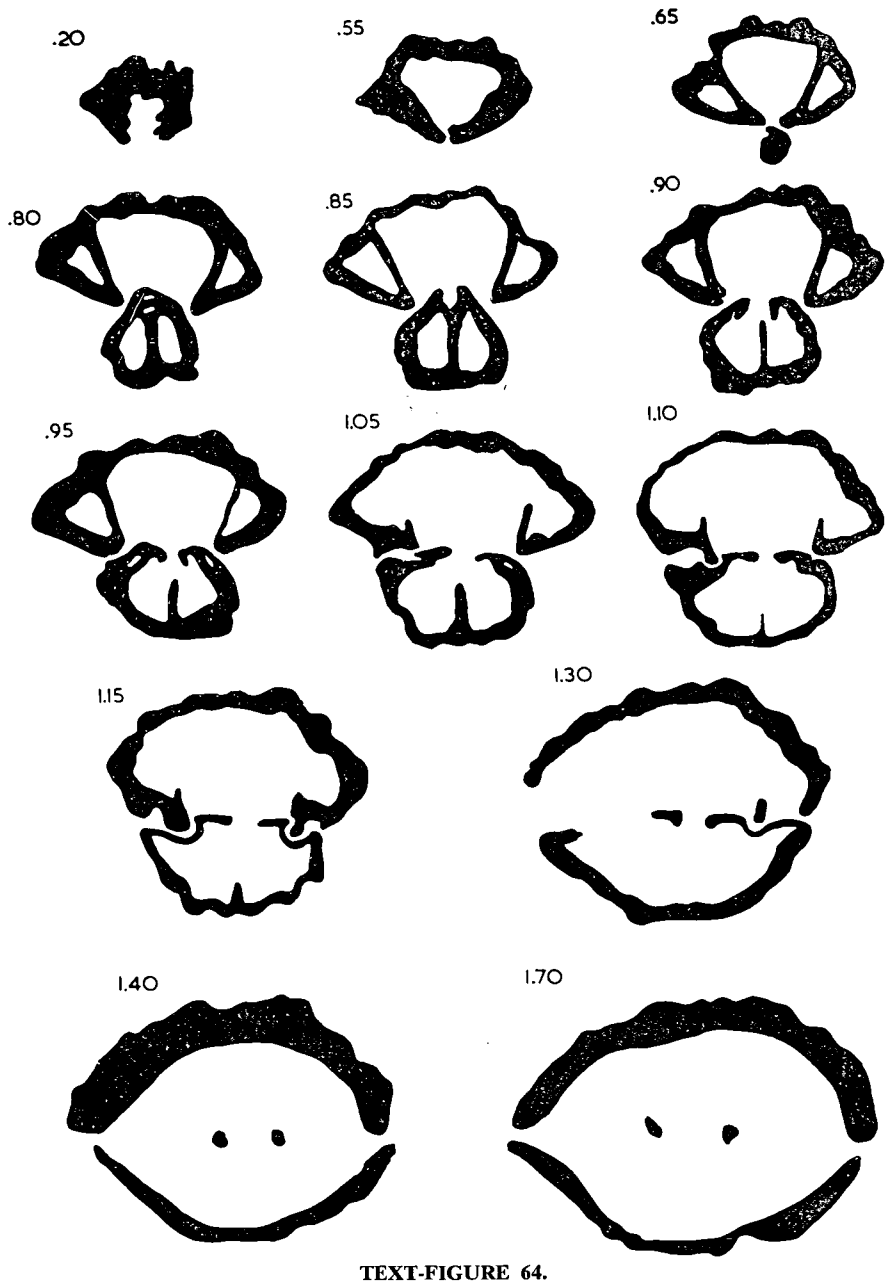
Both valves strongly plicated; plications broad, high and rounded, separated by grooves of similar size and outline. Each valve has twelve to eighteen plications, which increase by branching and intercalation.



TEXT-FIGURE 63.

F. primula, **cardinalia of dorsal valve. b: beak, c: crus, hp: hinge-plate, s: socket.**

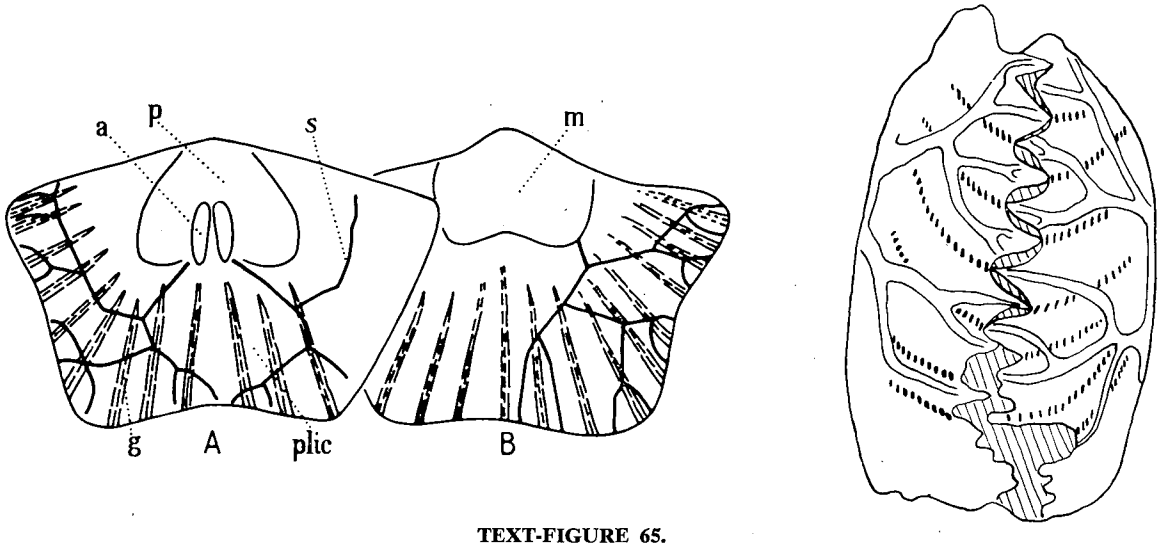
Interior: Teeth small, parallel, supported by very short slender dental plates. Adductor-scars located within and anterior to delthyrial cavity; they are longitudinally oval, separated by a low median ridge. Diductor-scars are broad and circular, situated anterior to teeth.



TEXT-FIGURE 64.

F. primula. **Serial sections and peels x 10 of C.P.C. 3028 from K230. L = 6.0, W = 6.7, T = 5.0.**

Notothyrial cavity with short median septum supporting posterior part of flat split hinge-plate. Dental sockets moderately deep, excavated into sides of hinge-plates. Crura simple, straight, divergent anteriorly. Lanceolate median adductors separated by low narrow median ridge surrounded by semi-circular outer adductor-scars.



TEXT-FIGURE 65.

F. primula, **pallial sinus pattern and muscles in C.P.C. 2983 (diagrammatic). (a) A, dorsal valve; B, ventral valve. a: anterior adductor, g: groove, m: muscle field, p: posterior adductor, plic: plication, s: pallial sinus. (b) lateral view, showing connexion between terminal sinuses and internal plications.**

Sinuses: The pallial sinuses of *F. primula,* though different in pattern from homologous vessels in the orthaceans and clitambonaceans illustrated by Öpik (1934), nevertheless show the same marginal features. The rare preservation of the marginal sinuses in a steinkern, C.P.C. 2983, shows the relation between the terminations of the sinuses and the internal plications. On the internal surface of the shell the sinuses of the adult are impressed in a pattern which at first sight seems to be totally independent of the plications (*see* pl. 16, figs. 8 and 9). At the very margins of the valves, however, the terminal sinuses lie along the backs of the internal plications (*see* pl. 16, fig. 10, and text-fig. 65b) like the homologous features in *Cyrtonella kukersiana* illustrated by Öpik (1934, pl. 45, fig. 2, text-fig. 54). In either valve of C.P.C. 2983, an alternate pair of terminal sinuses bifurcate just before the margin, thus indicating the gerontic condition of this specimen.

The sinus pattern is saccate(apocopate)-saccate. Leidhold (1928, pl. 2, fig. 7) illustrates the sinuses of the ventral valve of *F. ibergensis,* which correspond generally with those of *F. primula.*

Measurements:

——	Length.	Width.	Thickness.
Holotype, C.P.C. 2979..	6.6	6.3	4.6
Figured specimen, C.P.C. 2980	5.6	5.9	3.6

Types: Holotype C.P.C. 2979 from K230; figured specimen C.P.C. 2980 from K276.

Horizon and localities: Sadler Formation, near Sadler Ridge (K230, K243, K246, T53), near Menyous Gap (K270, K274, K276).

Genus PUGNAX Hall & Clarke 1894

PUGNAX HULLENSIS sp. nov.

(Plate 11, figs. 14-19; Text-figs. 66, 67)

1890 *Rhynchonella pugnus,* Martin, sp. Foord, A. H., Description of Fossils from the Kimberley District, Western Australia: *Geol. Mag.,* Dec. III, vol. 7, p. 101, pl. 5, figs. 2, 2a.

Diagnosis: Like *Pugnax pugnus* (Martin) but with a shorter tongue and fewer plications.

Material: Several free calcareous shells, partly recrystallized.

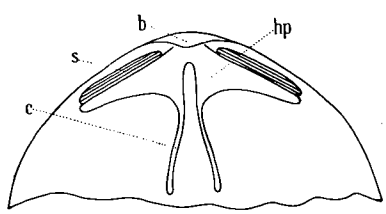
Description: Exterior: Outline transversely subelliptical to subcircular, widest at midlength. Lateral profile trihedral, dorsi-biconvex, dorsal valve globose, ventral valve weakly convex posteriorly. Hinge-line very short, gently curved, cardinal margins broadly rounded. Anterior commissure generally sulciplicate, sulcus broad and deep. Lateral commissure broadly serrated.

Ventral valve weakly convex posteriorly, anterior half depressed in a broad sulcus, which is prolonged dorsally as a long broad flat tongue. Apical angle 120° to 130°, umbo broad and low, umbonal tip erect. No interarea.

Dorsal valve globose with a broad median fold developed near anterior border. Tip of umbo obtruded into delthyrium.

Anterior and lateral margins with short strong plications, 2 or 3 on fold, 4 on each lateral flank, sharply angular, separated by grooves of similar shape. Entire external surface covered by numerous faint concentric growth-lines, evenly spaced, 3 or 4 lines in 5 mm., most prominently expressed on lateral margins. Antero-median part of dorsal valve in favourably preserved specimens (such as the holotype) marked by very fine radial striae, 20 in 5 mm.

Interior: Dental plates high, vertical, slightly divergent anteriorly, supporting small rounded anteriorly divergent teeth. Denticula delicate, separated from teeth by sharp grooves, diverging anteriorly and dorsally.



TEXT-FIGURE 66.

P. hullensis, **cardinalia of dorsal valve. b: beak, c: crus, hp: hinge-plate, s: socket.**

Dorsal valve without median septum. Dental sockets deeply incised into umbo, moderately broad and shallow in section. Hinge-plate divided, flat, outer hinge-plate shallowly excavated. Crura slender, straight and parallel.

Variation: The specimen figured in plate 11, figure 19, though of equal width to the holotype, nevertheless has a weakly convex dorsal valve, an incipient tongue and a smooth anterior commissure. Generally shells of this size have a crenulated anterior commissure.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2984..	29.3	39.5	28.9
Figured specimen, C.P.C. 2985	26.2	38.3	17.8

Types: Holotype C.P.C. 2984; figured specimen C.P.C. 2985, both from K356.

Horizon and localities: Fossil Downs Formation, eastern Hull Range (K356); Mt. Pierre Group, near Old Bohemia Homestead (T69); Brooking Formation, Brooking Gap (KP150); Napier Formation, near Elimberrie Spring (O/77), and near Dingo Gap (KP106, Ld29).

Discussion: In *hullensis* the general shell-shape, divided hinge-plate, and lack of a median septum signify the genus *Pugnax*.

P. hullensis closely resembles specimens labelled *P. pugnus* from the Carboniferous Limestone of Yorkshire (B.M. (N.H.) B340). Distinguishing features are the shorter tongue and the fewer plications in the Australian species. The Yorkshire specimens commonly have as many as six or seven plications.

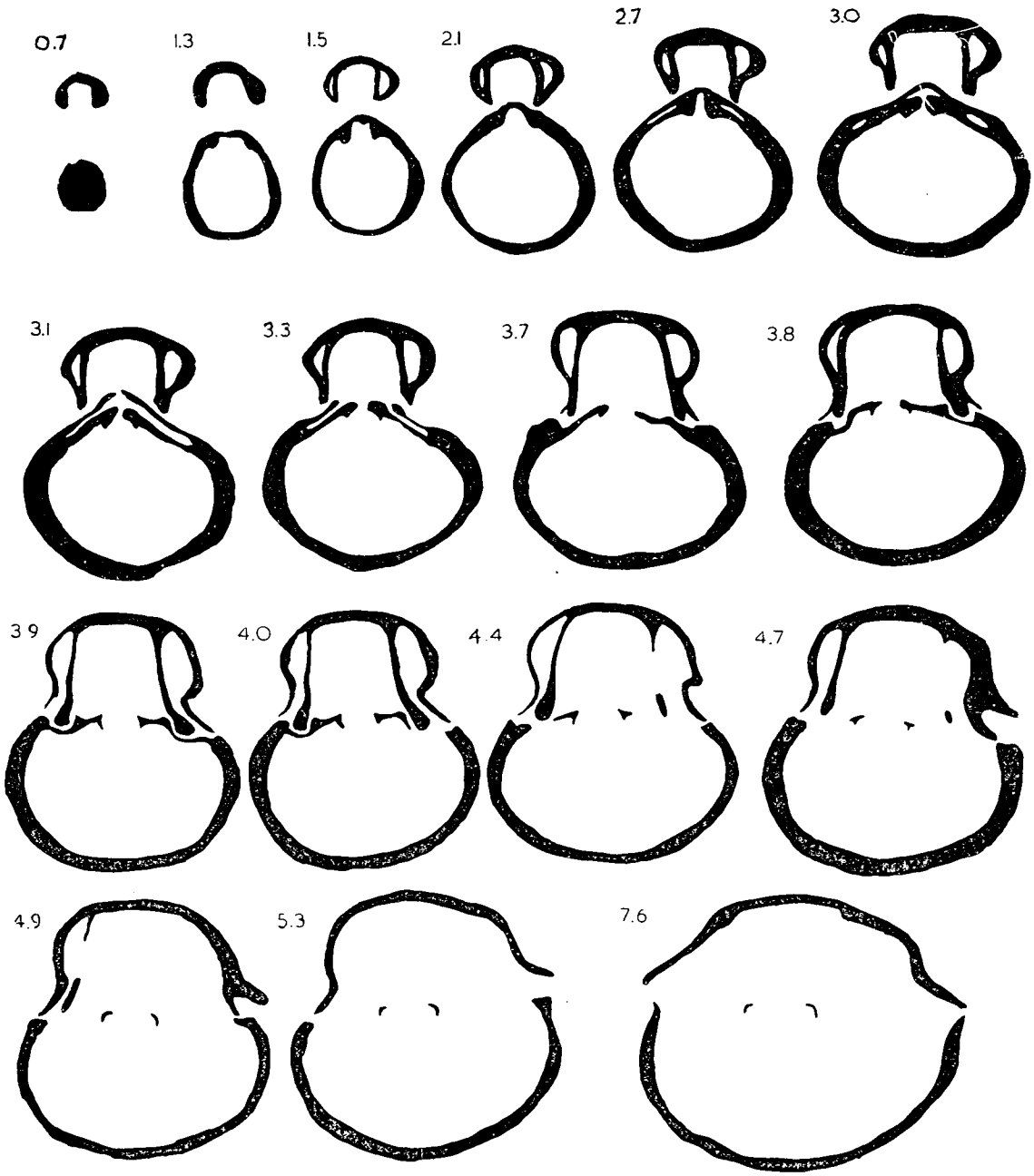
Specimens of *Rhynchonella pugnus* from Mt. Pierre, illustrated in Foord (1890), are in all probability members of *Pugnax hullensis*. They are more transverse in outline than the holotype but agree closely with the specimen figured in plate 11, fig. 19.

PUGNAX sp. cf. PUGNAX PUGNUS (Martin) 1809

(Plate 11, figures 22-25; Text-fig. 68)

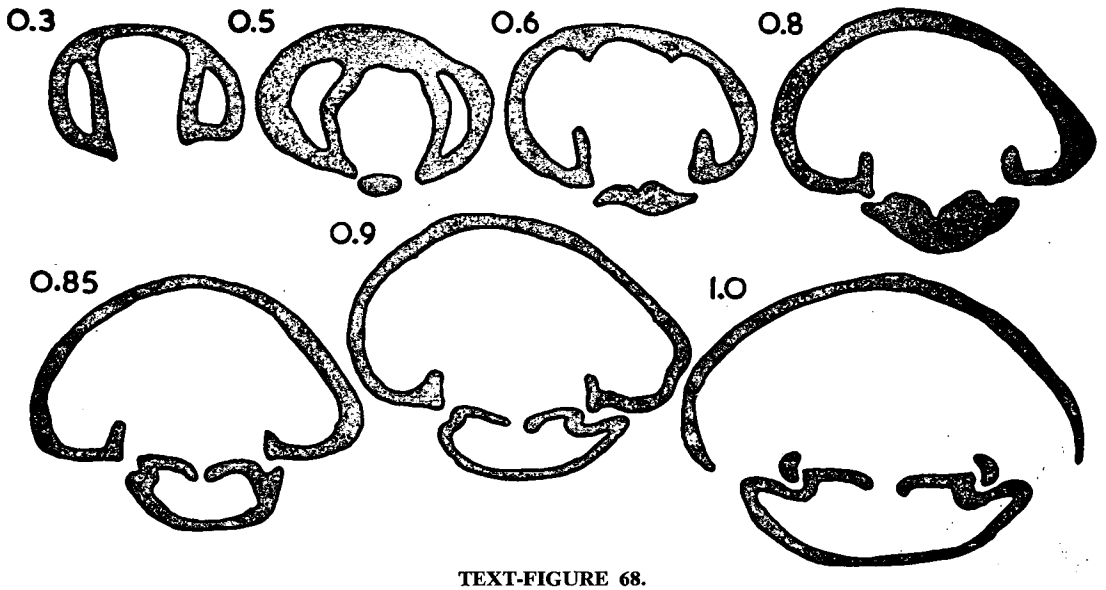
Material: Thirty adult shells.

Comparison with P. hullensis: Exterior: *Pugnax* cf. *pugnus* differs essentially from *P. hullensis* in the greater number of plications on the dorsal valve fold and on the ventral valve sulcus. Adult specimens of the main sample (from K144) have 5 or 6 plications on the dorsal valve fold compared with 2 or 3 in *P. hullensis*. In species of *Pugnax*, all of which have a wide range of variation in the number of plications, these dissimilarities cannot alone be attributed to specific differences. But coupled with the further difference in the plications, angular in *P. hullensis*, rounded in *P.* cf. *pugnus*, the difference in the number of plications may indicate separate forms.



TEXT-FIGURE 67.

P. hullensis. **Serial sections x 1.5 of specimen from K356 with L = 25.7, W = 32.3, T = 27.0. Note flat divided hinge-plate (sections 3.8 to 4.0), delicate crura, and strong blunt teeth supported by long high dental plates.**



TEXT-FIGURE 68.

P. sp. cf. *P. pugnus.* **Serial sections x 6 of specimen from K150; L = 9.0, W = 11.0, T = 5.5. Features denoting *Pugnax* are high dental plates, divided hinge-plate, and small sockets excavated in sides of hinge-plate. Immaturity of shell indicated by relatively short dental plates.**

Interior: There are no essential differences in internal features between this group of shells and *P. hullensis.*

Measurements:

—	Length.	Width.	Thickness.
Figured specimen, C.P.C. 2986 (K144)	18.8	27.1	18.6
Figured specimen, C.P.C. 3039 (K245)	15.7	19.4	14.2

Horizon and localities: Sadler Formation, Old Bohemia area (K103), Bugle Gap (K144, K148), Sadler Ridge (K244, K245), near Menyous Gap (K271); Virgin Hills Formation, Mt. Pierre (T25), and undifferentiated Mt. Pierre Group, Old Bohemia area (K135, K177); Bugle Gap Limestone, Bugle Gap (K169); Geikie Formation, near Springs Homestead (K506); Oscar Formation, Linesmans Creek (K539), near Palm Spring (KP167, O/73); Napier Formation, near Elimberrie Spring (Ld19, Ld31), near Dingo Gap (KP144); and the transition between Pillara Formation and Napier Formation near Elimberrie Spring (KP134, O/66).

Discussion: P. cf. *pugnus* is externally indistinguishable from specimens of *Pugnax* from the Devonian of Néhou, Normandy (B.M. (N.H.) Tesson Collection 65645). The figured specimen, C.P.C. 2986, differs from specimens of *Pugnax* from the Devonian of Iberg, Hanover (B19024), in having shorter and lower plications. C.P.C. 2986 is also indistinguishable externally from specimens labelled *Pugnax acuminatus* from the Middle Devonian of Lummaton, Devon (B15308).

Specimens of *Pugnax* cf. *pugnus* from K144 are externally similar to Mansuy's *Rhynchonella* (*Pugnax*) *pugnus* Martin (1912, p. 81, pl. 15, figs. 5a–i) from the *Spirifer verneuili* beds of Sin-Tsouen.

As the Fitzroy form is indistinguishable from some of the specimens of *Pugnax pugnus* illustrated by Parkinson (1954a, pl. 58, figs. 1-15) from the Lower Carboniferous of England, it is judged wisest to give these specimens a tentative name until larger collections permit exact measurement of the range of variation and hence valid comparisons with other species of *Pugnax*.

PUGNAX sp. cf. P. ACUMINATUS (J. Sowerby) 1882

(Plate 11, figs. 20, 21)

Material: Twelve nearly entire free calcareous recrystallized shells.

Description: Outline triangular, profile dorsi-biconvex, dorsal valve with steeply arched fold, ventral valve with long flat sulcus tapering into a long triangular dorsal tongue. Anterior commissure acuminate. Surface of both valves smooth or with two or three short low rounded costae on each lateral flank, one or two on dorsal fold. Interior not known.

Measurements:

	Length.	Width.	Thickness.
U.W.A. 26540 (KP84)	11.3	15.3	13.8
26878a (KP152)	15.8	18.8	20.7
26878b (KP152)	14.4	18.2	10.5
26878c (KP152)	15.7	17.8	10.7
26708a (F29)	12.0	16.3	18.2
26708b (F29)	11.7	17.5	15.0

Horizon and localities: Napier Formation, west of Van Emmerick Range (F29), near Fairfield Homestead (KP84), and near Leopold Downs Homestead (KP152); Oscar Formation near Palm Spring (0/73); Pillara Formation, four miles north of Wire Spring (0/76).

Discussion: Even in this small sample of six shells several of the characteristic features of the shape variation in *Pugnax acuminatus* recorded by Parkinson (1954b) may be seen. Four shells agree closely with fig. 2 (1) of Parkinson (1954b), all having a high acuminate anterior commissure; the other two, being less sharply acuminate, agree with fig. 2 (5).

Superfamily ATRYPACEA Schuchert & LeVene 1929

Family COELOSPIRIDAE Hall & Clarke 1894

NYEGE gen. nov.

Type species: Nyege scopimus sp. nov.

Diagnosis: Small broadly sulcate shells with strong plications. Teeth supported by short high dental plates. Hinge-plates divided.

NYEGE SCOPIMUS sp. nov.

(Plate 11, figs. 1-7; Text-fig. 69)

Material: Several hundred entire free calcareous shells, almost all of which are totally recrystallized.

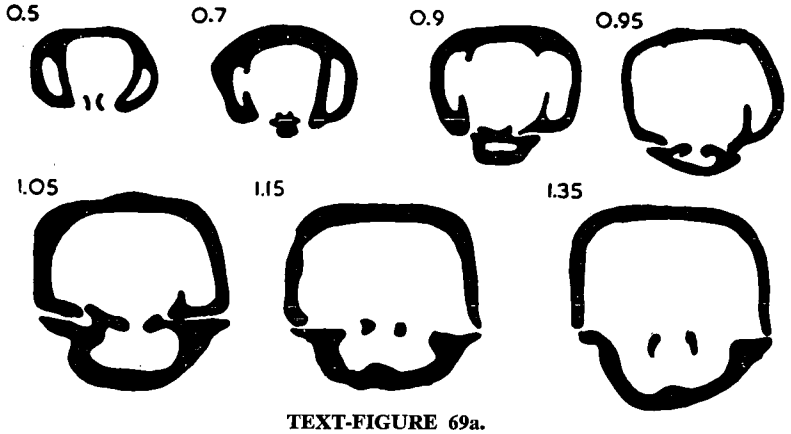
Description: Exterior: Outline fan-shaped in smaller specimens, pentagonal in larger specimens; in profile both valves have the same degree of convexity. Width and length subequal, width measured a short distance anterior to midlength. Lateral commissure uniformly weakly curved, anterior commissure broadly and strongly sulcate, intraplicate or multiplicate.

4328/58.—8

Ventral valve evenly convex in profile. Umbo narrow, tip suberect, apical angle slightly less than 90°, delthyrium open, without interarea or planareas. A high broad median fold arises just anterior to umbo, and descends by nearly vertical sides to narrow lateral slopes. Anterior part of the fold becomes medianly depressed at anterior commissure so that part of fold is prolonged dorsally as short triangular tongue.

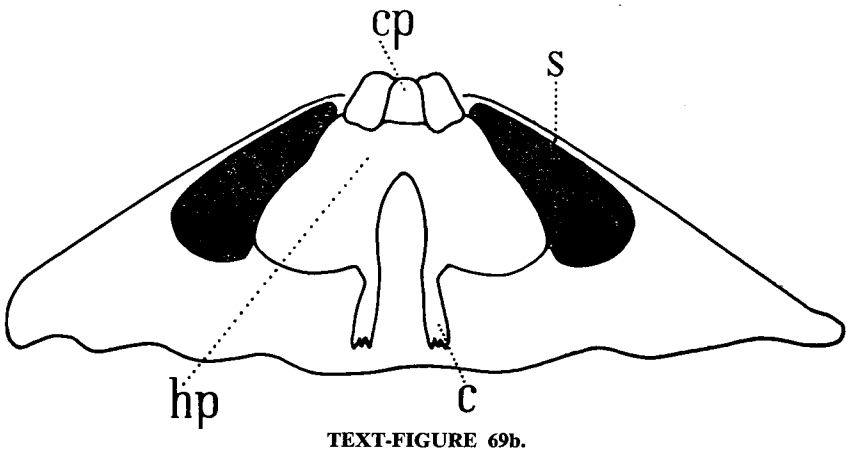
Dorsal valve umbo inconspicuous, tip protruded into open delthyrium. Anterior half of valve depressed into a broad and deep sulcus whose width may exceed half shell width. Anterior part of sulcus medianly folded so that along anterior margin sides of sulcus project ventrally a short distance as complements to triangular tongue of ventral valve.

Both valves covered by low rounded radial plications separated by grooves of similar size and shape; increase is by intercalation and branching. Ventral valve sulcus commonly has 5 to 7 plications, lateral slopes 4 to 6 plications; also very fine concentric lines, 7 to 10 in 1 mm.



TEXT-FIGURE 69a.

N. scopimus. **Serial sections x 9 of specimen from K159 measuring L = 11.0, W = 12.2, T = 7.5. Note, in dorsal valve, probable cardinal process (sections 0.5, 0.7), dental sockets excavated in sides of split hinge-plate (section 0.9), and strong crura (sections 1.15 and 1.35). In ventral valve, teeth directed medianly and supported posteriorly by high dental plates.**



TEXT-FIGURE 69b.

N. scopimus, **dorsal valve cardinalia. c: crus, cp: cardinal process, hp: hinge-plate, s: socket.**

Interior: Teeth short, parallel, supported by short high dental plates. Sections indicate that what is probably the cardinal process is well developed, bilobed. Hinge-plate split, sockets shallowly excavated. Crura straight and parallel. Broad low median ridge arises along floor of dorsal valve immediately anterior to hinge-line. No median septum.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2987	10.7	9.6	6 4
Figured specimen, C.P.C. 2988	13.7	13.0	8.4

Variation: Larger specimens from K168 (such as that illustrated in plate 11, figures 6 and 7) differ from the holotype mainly in their rounded pentagonal outline and an apical angle greater than 90°. Less prominent differences are their weaker plications and more prominent concentric growth-lines. In many samples specimens of this aspect are associated with other specimens indistinguishable from the holotype and it may be inferred confidently that the larger pentagonal shells are merely the adult form of less mature shells like the holotype. Owing to the vagaries of preservation external shape and internal structure can be correlated only in smaller shells. Accordingly one of these has been selected as holotype.

Types: Holotype C.P.C. 2987 from K159; figured specimen C.P.C. 2988 from K168.

Horizon and localities: Bugle Gap Limestone, Bugle Gap (K145, K166-K168); Virgin Hills Formation, Old Bohemia area (K181), Needle-eye Rocks (T18, T19), Virgin Hills (T39, T40, T42), and undifferentiated Mt. Pierre Group, Bugle Gap (K159, K160), and near Old Bohemia Homestead (T69); Napier Formation near Elimberrie Spring (Ld16, Ld17, Ld20, Ld30), near Dingo Gap (KP141), and Windjana Gorge (KP72).

Discussion: The main question at present is not the validity of *Nyege* as a genus but its familial relationships. As families in the Atrypacea are distinguished mainly by the form of the spiralium, the systematic place of *Nyege* can only be determined when details of the interior become fully known. A more detailed examination of the interior of *Nyege,* however, will not be profitable until material in a more suitable form of preservation comes to hand. Altogether 24 specimens were sectioned to provide the meagre information concerning the interior shown in text-fig. 69 (a).

Nyege scopimus seems most closely related to the genus *Coelospira* Hall 1863, which ranges from Lower Silurian to Middle Devonian. The type species is *Leptocoelia concava* Hall 1857 from the Lower Helderberg of New York. The specimen of "*Coelospira concava* Hall" figured in Roger (1952, fig. 97, p. 99) compares closely with the large specimen of *Nyege* figured in plate 11. This form, which comes from the Lower Devonian Haragan shale of White Mound, Oklahoma, is described by Amsden (1958).

Three specimens of *Coelospira concava* (Hall), two from the Lower Helderberg of Hudson, New York (B.M.(N.H.) B9319), the third from the Shaly Limestone of Clarksville, New York (B16420), were available for comparative study with specimens of *Nyege.* This comparison showed that in addition to an important internal difference,

namely the lack of dental plates in *Coelospira,* these genera are dissimilar in the following: (1) the plications in *Nyege* are usually sharp and high; those in *Coelospira* are low and rounded. (2) The dorsal valve of *Nyege* is medianly sulcate, sides of sulcus steep; the dorsal valve of *Coelospira* is shallowly and broadly depressed.

If, in spite of these differences, *Nyege* is held to be a member of the Coelospiridae, the uppermost limit of the stratigraphical range of the family must be extended to the *Sporadoceras* zone of the Upper Devonian.

Nyege is distinguished from recorded Palaeozoic Rhynchonellacea simply by its sulcate dorsal valve.

Nyege scopimus differs from *Australocoelia polyspera* (Gill) 1950 (pp. 245, 246, pl. 1, figs. 25-28) from the Lower Devonian of the Zeehan area, Tasmania, by its sharper plications and deeper median sulcus.

Atrypa svinordi Wenjukoff 1886, recorded by Nalivkin (1930a, pl. 6, figs. 11a-d), is sulcate with fairly long costellae. It is not plicate like *Nyege,* but the peculiar sulcate shape suggests that these two forms are related. *Atrypa svinordi* is found in the Lower Frasnian Semiluki beds of the Voroneje district, Russia.

Family ATRYPIDAE Gill 1871

Subfamily ATRYPINAE Waagen 1883, em.Poulsen 1943

The Atrypidae of Western Australia were described by Coleman in 1951. At this time the only extensive collection available was that of Teichert, consisting "of about 250 specimens, most of them in a poor state of preservation. . . . As a result the surface features of most specimens are worn or partially absent. . . ." (Coleman, 1951, p. 677). In this collection Coleman found two new species and three new subspecies.

The present revision of Fitzroy Atrypidae is favoured with a much larger collection of better preserved fossils. In the Bureau collection there must be well over 1,000 well-preserved specimens, many silicified; hence the relationships between species are more apparent here than in the collection available to Coleman.

Of Coleman's five forms, three are recognized and two are rejected as synonyms.

Genus ATRYPA Dalman 1828

ATRYPA RETICULARIS TEICHERTI Coleman 1951

(Text-figs. 70-72)

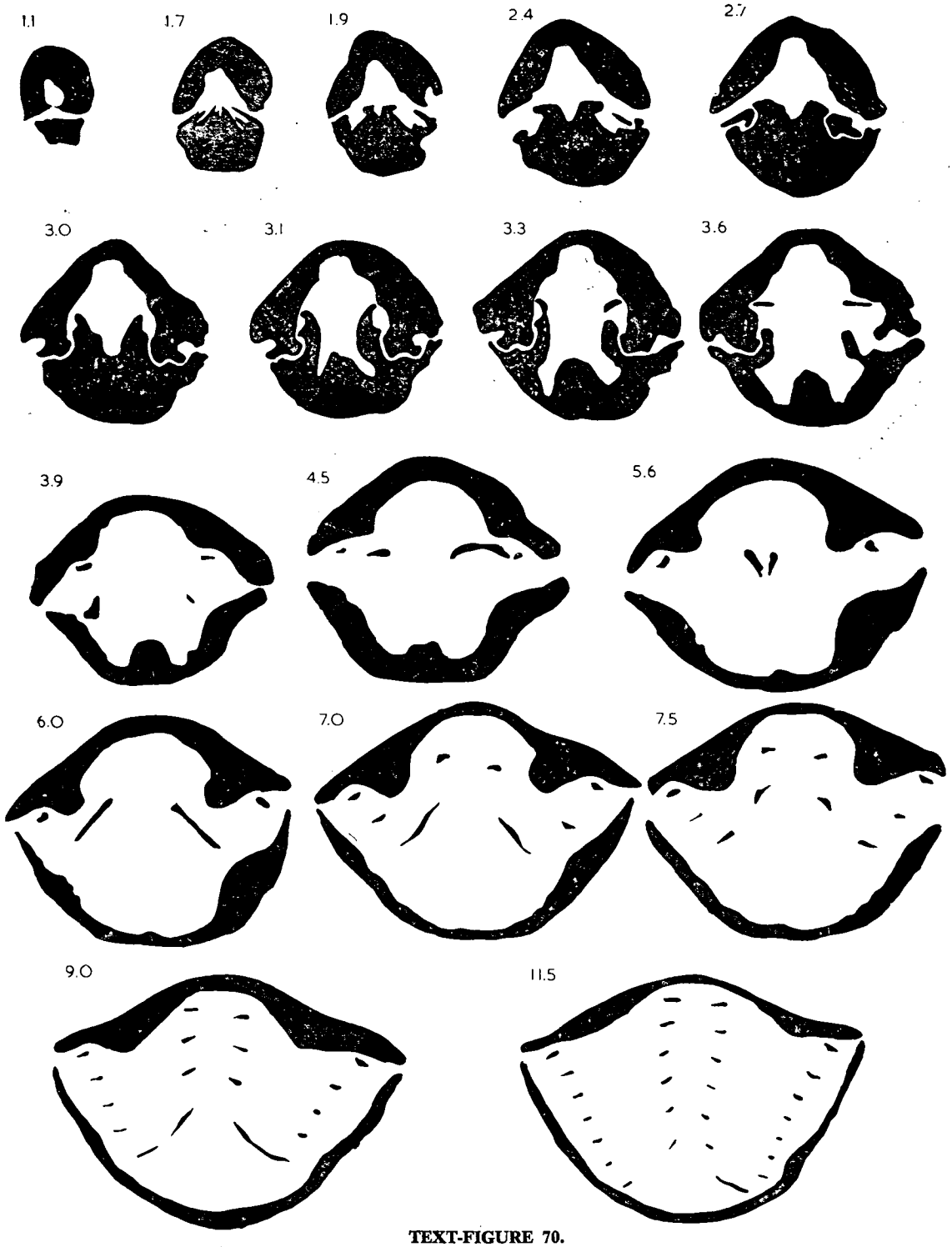
1890 *Atrypa reticularis* Linnaeus, Foord, *Geol. Mag.,* Dec. 3, vol. 7, pp. 100, 101 (figs. a and b).

1951 *Atrypa reticularis teicherti* Coleman, *J. Paleont.,* 25 (5), pp. 681, 682, pl. 100, figs. 1-10.

Diagnosis: Globose, dorsi-biconvex *Atrypa* with short, broad, dorsally-directed tongue in anterior of ventral valve. Ventral valve beak suberect, shell length greater than or equal to shell width, costellae increase by dichotomy, growth-lines weakly shown.

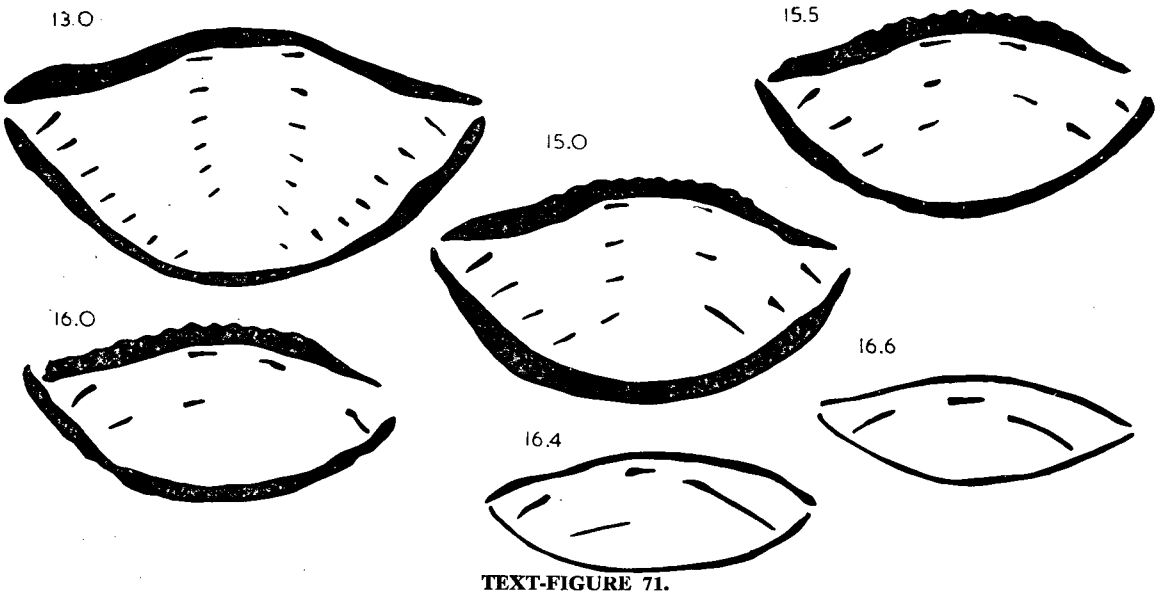
Material: Over 100 free entire calcareous shells.

Description: Nothing can be added to Coleman's original description of the exterior. The conspicuous feature of the interior is the very high and broad median boss dividing the narrow adductor-scars on the posterior part of the dorsal valve. The stratigraphical significance of this feature is discussed below. Each brachial coil has six to eight turns. The jugum is united.



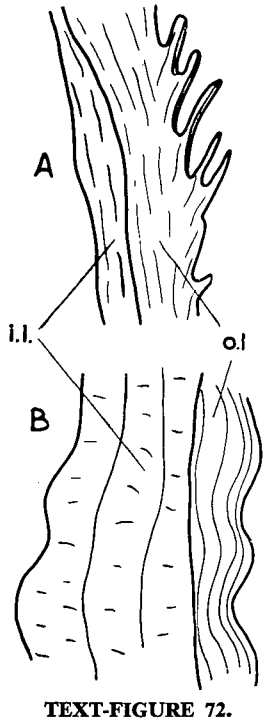
TEXT-FIGURE 70.

A. reticularis teicherti. **Serial sections and peels x 3 of C.P.C. 3030 from K225. L = 18.4, W = 21.2, T = 13.1. Note divided hinge-plate (sections 1.9 and 2.4), broad and high median ridge (sections 3.1 to 6.0), and ribbon-like crura and spiralia (sections 3.3 to 11.5) of dorsal valve. Section 5.6 is immediately posterior to anterior extremity of jugum. Teeth primitive grooved marginal structures articulating with broad shallow sockets bounded on median side by very high crural plates.**



TEXT-FIGURE 71.

A. reticularis teicherti. **Serial sections x 3 of shell from K225. L = 20.3, W =21.0, T = 10.9. Apices of conical spires, consisting of seven turns, are directed dorsally.**



TEXT-FIGURE 72.

A. reticularis teicherti. **Sections and peels x 15 of C.P.C. 3031 from K223. L = 25.5, W = 24.5, and T = 15.2. Both sections 6.1 mm. anterior to umbo. A: section at lateral edge of ventral valve showing thick outer layer (o.l.) drawn out into delicate lamellae, and thin inner layer (i.l.). B: section at median part of ventral valve showing thin costate outer layer and thick coarse-layered inner layer.**

Shell structure: Impunctate, two-layered. Thick inner layer cryptocrystalline except for two or three growth surfaces denoting temporary cessations in what was otherwise a continuous process of growth. Outer layer moderately thick medianly, becoming thicker than inner layer on lateral margins; it is finely fibrous, folded into low costae and grooves, drawn out laterally into short oblique lamellae. Folds in outer layer are in no way reflected in the inner layer so that the inner and outer layers are unconformable.

Horizon and localities: Sadler Formation near Sadler Ridge, at or near the type locality, T58 (K221, K223, K224, K225, K230), and near Menyous Gap (K266). Probably also at K126.

Discussion: The brief review of *Atrypa reticularis* which follows aims at finding the significance, if any, of the median boss in the posterior part of the dorsal valve.

A well-developed boss (though less conspicuous than that in the Fitzroy form) is characteristic of the varieties of *A. reticularis* from the Devonian of Poland described by von Kelus (1939): *ventricosa, regularis, parazonata,* and *orientalis.* Poulsen (1943) found a well-developed though short median septum in the posterior part of the dorsal valve of *A. reticularis* from the Silurian of Gotland, but this structure is very short and thin, and cannot be considered homologous with the broad median ridge of the Fitzroy and Polish forms. The specimens of *A. reticularis* from the Lower Ludlow shales of Herefordshire sectioned by Stainbrook (1945, figure 1 (2), p. 48) also lack a broad median ridge in the dorsal valve. It is regrettable that sections of the Devonian *A. reticularis* from Oklahoma and New York in the same work (Stainbrook 1945, figure 1 (3), (12), p. 48) are inadequately figured and that the presence or absence of a median ridge cannot therefore be determined.

It might be concluded, though very speculatively on the basis of such scanty evidence, that the broad median ridge of the dorsal valve is found only in forms of *A. reticularis.* In Alexander's (1949) revision of *A. reticularis* from the Silurian of Europe there is no mention of a broad median ridge; the adductor impression "is divided longitudinally by a low pseudo-septum" but this is apparently a thin structure not homologous with a broad high median ridge.

According to the section of *Spinatrypa trulla* (Stainbrook) 1945 and *Spinatrypa spinosa* (Hall) 1843 given in Stainbrook (1945, figure 1, (4), (8), p. 48) it would seem that the Devonian genus *Spinatrypa* Stainbrook 1951 also is characterized by a dorsal median ridge.

ATRYPA DESQUAMATA KIMBERLEYENSIS Coleman 1951

(Plate 15, figure 13; text-fig. 73)

1933 *Atrypa desquamata* Sowerby, Hosking, *J. Roy. Soc. W. Aust.,* 19, p. 72, pl. 7, figs. 3a-c, 4a-b.

1951 *Atrypa desquamata kimberleyensis* Coleman, *J. Paleont.,* 25 (5), 683-684, pl. 101, figs. 7-19.

1951 *Atrypa multimoda* Coleman, *ibid.,* pp. 682, 683, pl. 100, figs. 11-18, pl. 101, figs. 1-6.

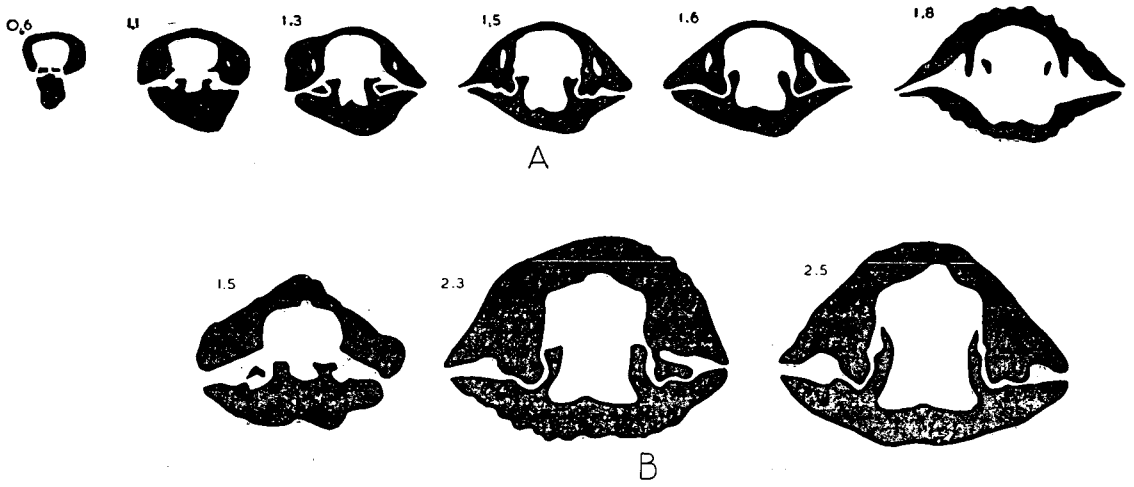
1951 *Atrypa parva* Coleman, *ibid.,* p. 685, pl. 102, figs. 18-22, 25-29, *non* pl. 102, figs. 23, 24.

Diagnosis: Weakly to moderately biconvex *Atrypa* without tongue, but with a gently uniplicate anterior commissure in adults. Ventral valve beak generally straight,

less commonly suberect, shell width greater than or equal to shell length. Costellae increase by intercalation and dichotomy, growth lamellae prominent, forming semi-tubular spines along the backs of costellae.

Description: From the study of a large sample of this subspecies the following additional morphological details are known:—

1. Delthyrium closed anteriorly by two broad triangular plates medianly fused; sub-apical part of delthyrium open, circular in outline.



TEXT-FIGURE 73.

A. desquamata kimberleyensis. **Serial sections x 3 of two specimens from K246. A: six serial sections of specimen with L = 17.5, W = 21.7, T = 18.3, showing deltidial plates (section 0.6), tiny umbonal cavities, blunt teeth (1.3 to 1.6), and crura (1.8). B: three serial sections of specimen with L = 26.6, W = 27.4 and T = 24.4, showing broad strong teeth attached direct to valve-wall, not supported by dental plates.**

2. Radial costellae and grooves semicircular in sectional outline; increase by dichotomy and intercalation. In the posterior half of adult shells the intersection of costellae and growth lamellae is marked by semi-tubular spines lying obliquely or vertically to the shell surface. The spines, extensions of the growth lamellae, have a maximum length of 4 mm. The tapering distal part of the spine is parallel to the valve surface and is almost completely tubular owing to the inrolling of the lateral edges; the basal part is semi-tubular.

There are 8 to 10 very fine lines placed between adjacent growth lamellae.

3. A feature of the ventral interior of juvenile shells is the presence of dental plates. In adults the umbonal cavities are filled by thick deposits of the inner shell layer so that dental plates are indistinguishable. In the dorsal valve the median ridge separating the adductor-scars is low and broad. The brachidium is essentially the same as that in *A. reticularis teicherti.*

Figured specimen: C.P.C. 2989 from K245.

Discussion: The loss of identity of dental plates in adults of this form is the reason for its not being included in Kozlowski's (1929) subfamily Septatrypinae (according to Muir-Wood 1955, p. 81, probably synonymous with Karpinskiinae Poulsen 1943), typified by shells with long thin vertical dental lamellae and small teeth.

Atrypa multimoda was the name given by Coleman to transverse bulbous specimens with small ears and with interarea narrow or not formed at all. Coleman held also that these specimens were constantly larger at maturity than adults of either *A. desquamata kimberleyensis* or *A. reticularis teicherti.* Coupled with the fact that all but one of the localities of *A. multimoda* yield also *A. desquamata kimberleyensis,* this alleged size difference leaves little doubt that *A. multimoda* refers not to a separate form but to the larger more variable specimens called *A. desquamata kimberleyensis.* Such specimens tend to develop a swollen shape, incipient ears and an incipient interarea, all characters of ontogenic and not specific significance.

Similar remarks apply to *Atrypa parva.* Inspection of large collections of *A. desquamata kimberleyensis* leaves no doubt that *A. parva* is representative merely of the smaller size-groups of *kimberleyensis.*

Horizons and localities: Sadler Formation, Old Bohemia area (K103, K112), Bugle Gap (K142, K144, K148, K150), Sadler Ridge (K215, K229, K235-K237, K239, K241-K246, K248, K250, K252, K253), Longs Well area (G23, T53), near Menyous Gap (K264, K265, K267, K269-K274, K276, K463), Pillara Spring (K300, K301), Horse Spring (K480); Pillara Formation, Old Wagon Track, Napier Downs (K571-K573); Mt. Pierre Group, Old Bohemia area (K121, K172-K174); Oscar Formation, Morown Yard (Ld8), Palm Spring (O/73); Napier Formation, Wire Spring (Ld29) and probably from Elimberrie Spring (Ld31); Fairfield Beds, Burramundi Range (K289).

Genus SPINATRYPA Stainbrook 1951

(=*Hystricina* Stainbrook 1945, non *Hystricina* Mallock 1932)

SPINATRYPA ASPERA PRIDERI (Coleman) 1951

(Text-figs. 74, 75)

1933 *Atrypa aspera* Schloth., Hosking, *J. Roy. Soc. W. Aust.,* 19, p. 71, pl. 7, figs. 1a–c, 2.

1951 *Atrypa aspera prideri* Coleman, *J. Paleont.,* 25 (5), 684-685, pl. 102, figs. 1-17.

(?)1951 *Atrypa parva* Coleman, *ibid.,* pl. 102, figs. 23, 24, *non* pl. 102, figs. 18-22, 25-29.

Diagnosis: Atrypa aspera with weakly biconvex shell, and a straight to suberect beak.

Material: Over 100 free calcareous shells.

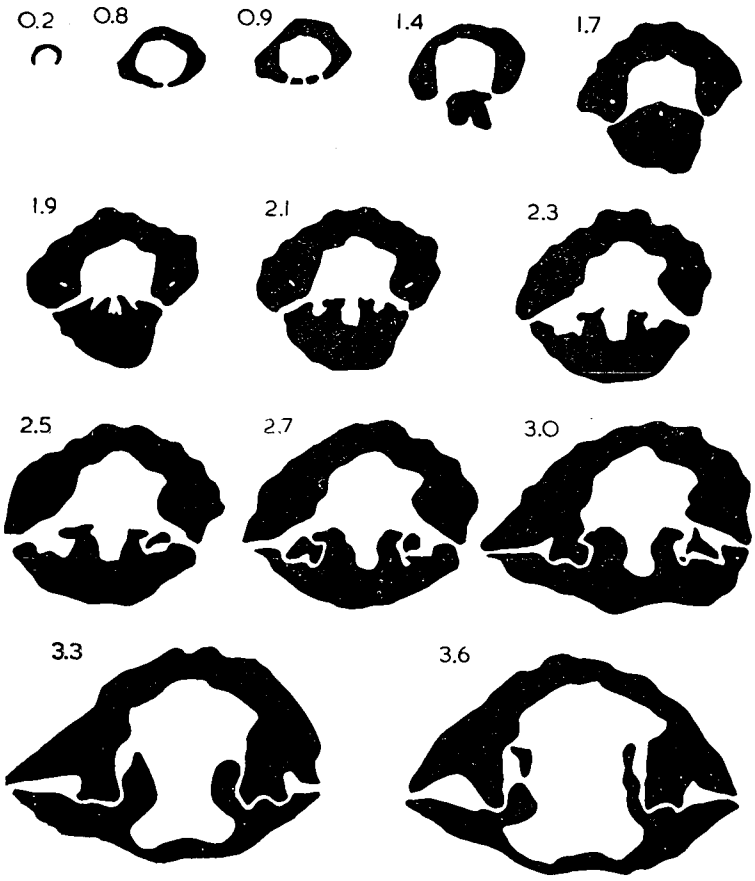
Description: This subspecies is much less variable than other Atrypidae from the Fitzroy Basin. Its diagnostic characters are as follows:—

(1) shell always weakly biconvex;

(2) length and width of shell subequal;

(3) ventral valve interarea long, width less than half shell width, orthocline to apsacline, beak straight to suberect;

(4) surface of both valves with strong wide rounded costae (3 to 4 costae in width of 5 mm. at anterior margin of adults). Growth-lines very regular in spacing, lamellar.

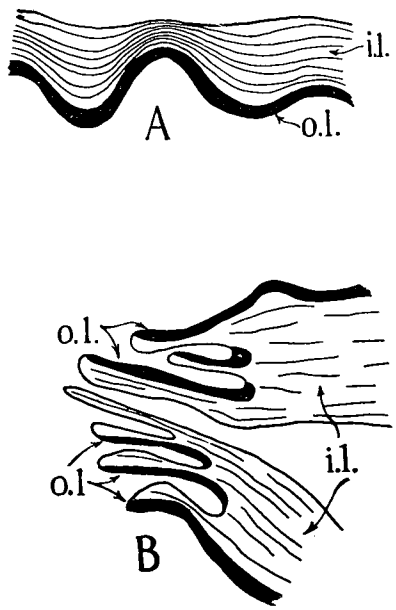


TEXT-FIGURE 74.

S. aspera prideri. **Serial sections x 3 of specimen from K230. L = 16.4, W = 16.5, T = 9.6. Section 0.9 shows deltidial plates; 2.1 to 2.5 show flat, divided hinge-plate; 2.5 to 3.6 strong grooved teeth; and 3.3 and 3.6 strong high crural plates.**

Internal structures are shown by the set of serial sections illustrated in text-figure 74; teeth strong, simple, without dental plates; high crural plates, and a broad low median ridge in the posterior of the dorsal valve.

Shell wall two-layered, outer layer very thin and apparently massive, appearing most prominently in lateral lamellose extensions (text-figure 75). Inner layer finely fibrous, moderately thick, with growth laminae parallel to inner surface of outer layer.



TEXT-FIGURE 75.

S. aspera prideri. **Two sections and peels of C.P.C. 3029 from K230. L = 13.3, W = 13.1 and T = 6.5. Sections both 3.0 mm. posterior to anterior margin. A: section x 15 through median part of ventral valve showing thin cryptocrystalline outer layer (o.l) and thick fibrous inner layer (i.l). B: section x 15 through lateral part of shell showing both outer and inner layers drawn out into delicate lamellae.**

Horizon and localities: Sadler Formation, Sadler Ridge: K230; tentatively determined from K503, probably in the Fairfield Beds. These are not topotypical specimens (the type locality is T31, Menyous Gap).

Discussion: Although the sectioned specimens are not topotypical, their similarity to Coleman's types affirms that they are *S. aspera prideri.* Specimens from K503 (?Fairfield Beds) are probably members of another form. They have broader costae and so resemble *Spinatrypa trulla* (Stainbrook) 1945 and *S. elongata* (Webster) 1888. It is possible, however, that they are simply the larger, more strongly costate variations of *S. aspera prideri.*

The specimen figured in Coleman (1951, pl. 102, figs. 23, 24) and included in *Atrypa parva* has the coarse costae and the shape of *prideri*; accordingly this specimen is considered best grouped with *prideri.*

Superfamily SPIRIFERACEA Waagen 1883

Family SPIRIFERIDAE King 1846

Subfamily AMBOCOELIINAE George 1931

Genera, by original designation: *Ambocoelia* Hall 1860, *Ambothyris* George 1931, *Crurithyris* George 1931; by subsequent designation: *Echinocoelia* Cooper & Williams 1935, *Ilmenia* Nalivkin 1941, *Thomasaria* Steinbrook 1945, Emanuella Grabau 1925, and *Ladjia* gen. nov. The salient features and the stratigraphical ranges of these genera are shown in Table 2, opposite.

All genera possess a small (less than 20 mm. wide) shell, short parallel discrete or united crural plates, jugum reduced or absent; and an ornament of spines, and radial and concentric lines.

In no other group of brachiopods is an estimate of the range of variation in internal characters so necessary for valid classification as in the Ambocoeliinae. The small size of the shell, coupled with the common obliteration of internal characters by recrystallization, has militated against detailed studies of the interior. In overcoming these difficulties, von Kelus (1939) and Vandercammen (1956) have set the standard for future work on this group. Vandercammen's collections of Belgian Ambocoeliinae, well preserved for the most part, were nevertheless inadequate to show the full range of variation, so that several shortcomings appear in his tentative grouping of genera. Incidentally, he overlooked Nalivkin's genus *Ilmenia*.

Vandercammen tentatively proposed one main criterion for grouping the genera: dental plates developed (*Thomasaria, Echinocoelia*), and dental plates not developed (*Ambocoelia, Ambothyris, Crurithyris, Emanuella*). A second criterion, the combination of cruralium, tooth ridges, and pedicle collar or apical callosity (plaque delthyriale), was used to distinguish *Emanuella* from other genera lacking dental plates. Within the Ambocoeliinae taxonomic value neither at the generic nor probably at the specific level can be placed on the presence or absence of a pedicle collar because all members of this group possess this character. Vandercammen's belief that *Echinocoelia* lacks a pedicle plate is controverted by the original description of *Echinocoelia* (Cooper & Williams, 1935, p. 844, " delthyrium narrow, closed at the apex by a thick callosity ") and by the figures of *E. incurva* (Cooper & Williams, pl. 59, fig. 25), which, the authors note, " shows the apical callosity very well ". Nor is the presence of a pedicle plate of specific significance as Vandercammen (p. 44) suggests for *Crurithyris inflata* (Schnur) 1853. The type species of *Crurithyris, C. urii,* is almost certainly provided with a pedicle collar (*see* Veevers, 1959b), and other species of *Crurithyris,* such as *C. apena* sp. nov., also possess this feature.

A comprehensive study of variation in the internals of *Ladjia saltica,* based on a collection of more than a hundred silicified dorsal and ventral valves from one locality, shows that three ventral valves possess dental plates, the remainder lack them (*see* pl. 12, figs. 23-28); they are well developed in C.P.C. 2996 (pl. 12, fig. 28), weakly developed in C.P.C. 2997 (pl. 12, fig. 26), and moderately developed in C.P.C. 2999, (pl. 12, fig. 25). It cannot be argued that a separate species characterized by dental plates is represented by these specimens, for the development of dental plates is transitional. Nor can it be argued that the three valves are " sports " or " monsters ", for in every other character but that of dental plates they agree with other valves in the collection. Whether or not dental plates are variably developed in other ambocoeliinid species which at present are thought to lack them can be established only by more extensive examination of the interior. But until this work has been done, the strict use of dental plates as diagnostic characters is questionable. From his study of *Ilmenia*, Nalivkin (1941, p. 217) recognized the low value of dental plates as criteria for dividing the Spiriferidae, and accordingly emended George's diagnosis of the Ambocoeliinae as follows:—" Dental plates absent or faintly developed ", adding that " apparently the absence or presence of dental plates is not a very important feature ". Incidentally, Nalivkin's reference to " faintly developed " dental plates is inexplicable since in his description of *Ilmenia* (pp. 216-217) he says the genus has " divergent dental plates well developed ". The " vestigial dental plates " of *Echinocoelia,* noted by Cooper & Williams (1935), and also by Vandercammen (1956, p. 43), are better

termed tooth ridges (carènes delthyriales), simple thickenings along the delthyrial margins. No doubt they are closely related to dental plates; in specimens C.P.C. 2999 and 2997 of *Ladjia saltica* (pl. 12, figs. 25, 26), the tooth ridges are contiguous with the dental plates, forming a single structure. To be consistent in thinking of tooth ridges as shortened dental plates, Vandercammen would be required to transfer *Emanuella* to his subdivision of Ambocoeliinae with dental plates.

Another aspect of Ambocoeliinid variation is the range from discrete crural plates to their union in a cruralium. Specimens of *L. saltica* have a cruralium (C.P.C. 2995, pl. 12, fig. 21) or discrete plates (C.P.C. 3043, 3042, pl. 12, figs 22, 29). Admittedly, C.P.C. 2995 is the only valve in the collection with a cruralium but, like the development of dental plates in the same species, this development is transitional, several specimens having an incipient cruralium. Variation from discrete crural plates to a cruralium is characteristic also of *Emanuella volhynica* Kelus 1939 (figs. 2 and 3 therein), and, outside the Ambocoeliinae, of *Tingella suchana* sp. nov. (text-figs. 91 and 92). Thus the criteria used by Vandercammen in diagnosing *Emanuella,* viz., tooth ridges, cruralium, and pedicle plate, must be rejected.

Generic diagnoses:

Ambocoelia: megathyrid plano- or concavo-convex Ambocoeliinae with dorsal adductors situated anteriorly.

Ambothyris: submegathyrid shells with fine radiating lines. (This genus is inadequately known.)

Crurithyris: brachythyrid shells with narrow ventral and dorsal sulci opposed, with minute spines and radiating striae.

Echinocoelia: submegathyrid shells with a high ventral interarea, and concentric rows of spines.

Emanuella: brachythyrid shells without fold or sulcus, with concentric rows of minute spines.

Ilmenia: like *Ambothyris* but with well-developed dental plates.

Ladjia: Ambocoeliinae with radiating costellae, ventral sulcus and dorsal fold alternate.

Thomasaria: well-developed dental plates, fold and sulcus alternate.

LADJIA *gen. nov.**

Type species: Ladjia saltica sp. nov.

Diagnosis: Like *Echinocoelia* Cooper & Williams 1935 but with surface ornament of numerous radiating costellae and concentric growth-lines: rare specimens with dental plates and cruralium.

Discussion: Ladjia, known only by the type species, *L. saltica,* is closely related to *Echinocoelia incurva* Cooper & Williams 1935 from the (uppermost Couvinian) Mottsville Formation of New York State. Comparison of pl. 12, figs. 1 to 5 with pl. 59, figs. 25, 20 of Cooper & Williams (1935) and pl. 22, figs. 17-19 of Willard (1939) reveals a striking similarity in shell-shape and especially in the development of delthyrial structures. The genera, however, are clearly differentiated by surface markings: *Echinocoelia* has concentric undulations each bearing a single row of fine short simple spines, *Ladjia* has numerous radial costellae crossed by fine concentric lines of growth.

* While this work was in the press, Volume 38 (1/2) of *Senckenbergiana Lethaea* (1957) was received; it contains (pp. 49–72, pls. 1–3) a description by B. Paulus of a new genus of smooth spirifers, called *Rhynchospirifer*, from the Middle Devonian rocks of the Eifel, Germany. The type of *Rhynchospirifer, R.halleri* Paulus 1957, closely resembles *Ladjia saltica*, but *Rhynchospirifer* and *Ladjia* are not synonyms because *Rhynchospirifer* has well-developed dental plates. and a cruralium supported by a median septum; rare specimens of *Ladjia saltica* have dental plates and a cruralium, but most do not.

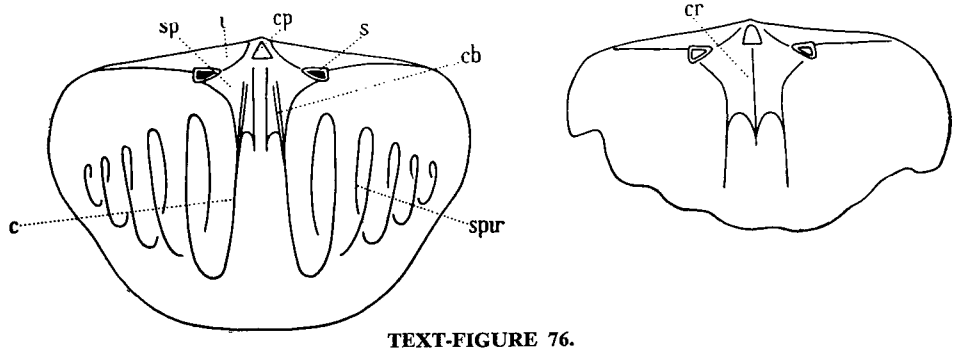
LADJIA SALTICA sp. nov.

(Plate 12, figs. 1-29; Text-figs. 76-78)

Material: Several hundred well-preserved silicified shells and single valves, and nine steinkerns.

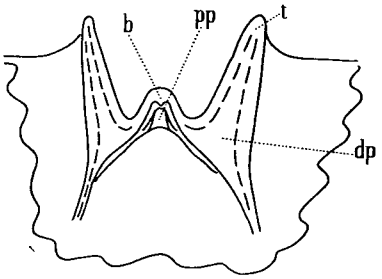
Description: Shell-shape: Biconvex, ventral valve strongly, dorsal valve weakly convex. Shell widest at midlength, slightly anterior to the submegathyrid to brachythyrid hinge-line which subtends angles of 80° to 100° with lateral margins. Ventral beak erect to slightly inturned, carried on a prominent high umbo. Dorsal beak erect, umbo small but prominent. Ventral interarea long, apsacline, flat over most of its length, curved immediately anterior to beak; beak-ridge well to poorly expressed. Dorsal interarea short, anacline, flat near hinge-line, slightly curved anterior to beak. Ventral median sulcus and dorsal median fold variably developed in anterior part of shell so that anterior commissure varies from straight to broadly uniplicate.

Hinge-structures: Tooth ridges, marking earlier positions of the teeth and therefore forming the outline of the delthyrium, are sharply demarcated from the ventral interarea by their lack of growth-lines and their height above or below the level of the interarea; on account of these features, tooth ridges may simulate deltidial plates. The corresponding dorsal socket ridges, which are simple semi-tubular structures deeply furrowed along their posterior surface, because they lie flush with the dorsal interarea may similarly simulate chilidial plates. Deltidial plates in the form of very narrow ridges lie along the entire length of the delthyrium slightly raised above the level of the interarea or above the external surface of the tooth ridge.



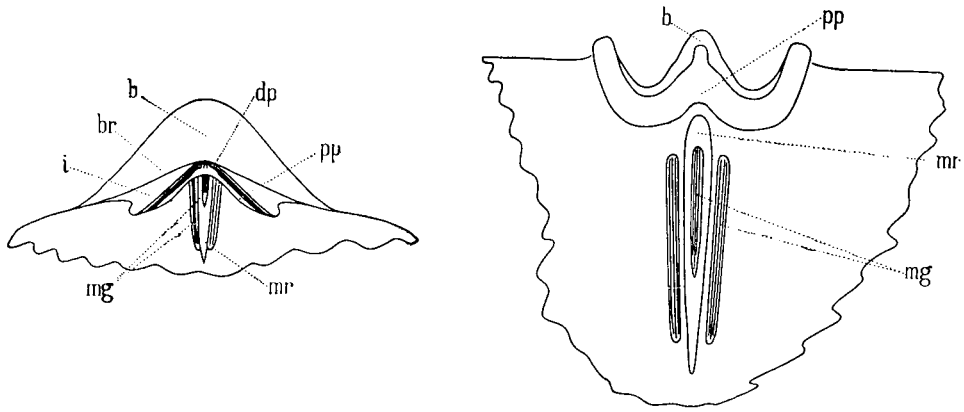
TEXT-FIGURE 76.

L. saltica, **dorsal valve interior. (a) without cruralium, (b) with cruralium. c: crus, cp: cardinal process, cb: crural base, cr: cruralium, i: interarea, s: socket, sp: socket plate, spir: spiralium.**



TEXT-FIGURE 77.

L. saltica, **part of ventral valve showing delthyrial structures. This is a rare specimen with dental plates. b: beak, dp: dental plate, pp: pedicle plate, t: tooth.**



TEXT-FIGURE 78.

L. saltica, **two views of the delthyrial part of a ventral valve. (a) dorsal view, (b) anterior view. b: beak, br: beak-ridge, dp: deltidial plate, i: interarea, mg: muscle grooves, mr: muscle-ridge, pp: pedicle-plate.**

Pedicle plate a strong, medianly furrowed, transversely striated, tongue-shaped structure located within beak-cavity; it has arms which lie on ventral side of tooth ridges and taper off a short distance behind teeth. Cardinalia and spiralia: Triangular cardinal processes fused to valve-floor immediately anterior to dorsal beak; anterior edge of process elevated above valve-floor, supported on either side by a short anteriorly directed ridge; muscle attachment face longtitudinally striated. Crural bases arise anterior to cardinal process and for a distance equal to one-third valve length crura are contained within crural plates extending from valve-floor (along which they are parallel and narrowly separated) to anterior side of socket-ridges. Anterior to these plates crura are parallel and without jugum or jugal processes. Spiralia are simple open structures with three to five turns, apices directed laterally. Muscle areas: Along floor of ventral valve a low median ridge extends anteriorly from delthyrial cavity for one-third of valve-length (pl. 12, figs. 23, 24); over its posterior half the ridge itself bears a median furrow, presumably the attachment area of the adductors. On either side of the median ridge is an elongate quadrate shallow depression, the attachment area of the diductors. Surface markings: Fifty to sixty radial costellae which increase by intercalation are crossed by fine concentric lines of growth spaced 4 to 6 in a length of 1 mm. The interareas are scored by a reticulate pattern of prominent growth-lines parallel to, and striations normal to the hinge-line.

Variations: Width-range of specimens in the sample is 2 mm. to 13 mm. Variation in shell-shape is illustrated by the four shells figured (pl. 12, figs. 1-20). The hinge-line tends to range from submegathyrid in larger specimens to brachythyrid in the smaller, almost pentagonal specimens. Most large specimens have a moderately broad shallow sulcus in the ventral valve with a corresponding low fold in the dorsal valve, together forming a uniplicate anterior commissure, whereas smaller specimens are without both sulcus and fold, and the anterior commissure is straight.

A sample of more than 100 well-preserved free ventral valves (from locality K213) contains only three specimens (illustrated in pl. 12, figs. 25, 26, 28) with dental plates. Each plate is very short and thin, apparently fused dorsally with the

pedicle collar and the ventral face of the tooth ridge, anchored ventrally to the valve-floor, along which the plates are slightly divergent anteriorly. The dorsal surface of the pedicle collar is medianly grooved (seen in pl. 12, figs. 23, 24), medianly ridged (fig. 27), or smooth. In the rare specimens provided with dental plates, the pedicle collar has its lateral extremities directed ventro-laterally to fuse with the median side of the dental plate, whereas in specimens without dental plates, the lateral parts are directed dorsally along the anterior edge of the tooth ridge.

The crural plates of most specimens are fused separately with the valve-floor, but some rare specimens (pl. 12, fig. 21) show crural plates uniting above the valve floor into a median septum, the entire structure forming a cruralium.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 2990	9.9	11.8	6.9
Figured specimen, C.P.C. 2992	7.7	7.5	5.1
Figured specimen, C.P.C. 2993	8.9	10.0	6.1
Figured specimen, C.P.C. 2991	13.3	13.0	8.7

Types: Holotype C.P.C. 2990 from K215. Figured specimens C.P.C. 2992, 2993, 2991, 2994, 2995, 2996, 2997, 2998, 2999, 3042, 3043, all except C.P.C. 2991 (K215) from K213.

Horizon and localities: Pillara Formation, Gap Creek Gap (K213), Oscar Range (0/78), tentatively from Old Wagon Track, Napier Downs (K573); Sadler Formation near Sadler Ridge (K214-K216, K237, K239, K242, K245) and near Menyous Gap (K270, K272-K274, K276).

Discussion: Observations of the rarely developed cruralium and dental plates imply a large variability for *Ladjia saltica*. In many groups of brachiopods the presence or absence of such features as dental plates and a cruralium may constitute a generic or a higher taxonomic distinction, but in this species such differences are found within members of an apparently contemporaneous living community.

Concerning the possible function of dental plates in this species, two suggestions may be offered: (a) dental plates functioned as dental supports during the juvenile stage, since in the adult it is unlikely that any support to the teeth was afforded by such weak structures. In later stages the reduction of dental plate growth led to their incorporation into later deposits of the umbo so that only in the rare cases where early dental plate growth was exceptionally large would the plates be visibly differentiated from the umbonal shell matter; or (b) dental plates are abnormally strong developments of the lateral parts of the pedicle plate.

Genus EMANUELLA Grabau 1925

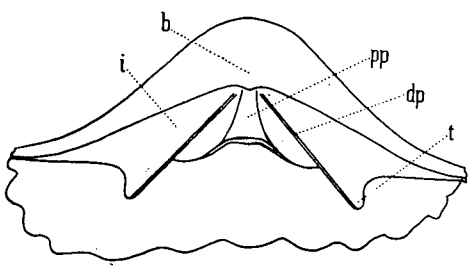
EMANUELLA TORRIDA sp. nov.

(Plate 13, figs. 1-9; Text-figs. 79-83)

Diagnosis: Like *E. volhynica* Kelus 1939 but with a smaller shell, a straight beak, and proportionately larger spine-bases arranged in quincunxes.

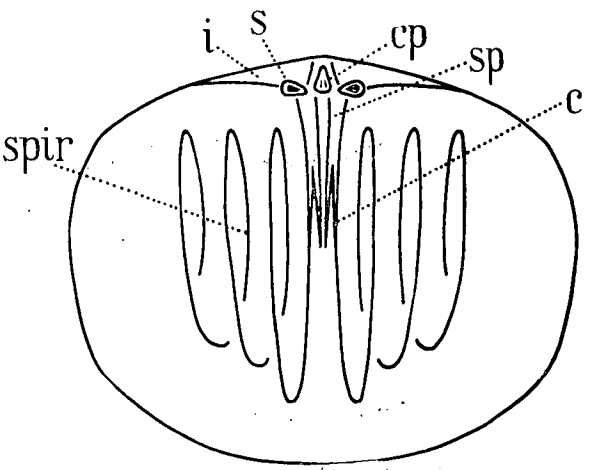
Material: 107 almost entire calcareous shells, external surface slightly worn, free of adhering sediment.

Description: Shell-shape: Subcircular, length and width subequal, width measured at midlength. Biconvex, ventral valve nearly semicircular in lateral profile, that of dorsal valve only weakly convex. Hinge-line brachythyrid with rounded cardinal margins. Ventral beak moderately inturned, carried on a small umbo. Dorsal umbo likewise small, beak straight to erect. Ventral interarea long, apsacline, nearly orthocline, gently curved along its length, beak-ridges well to poorly expressed. Dorsal interarea one-third as long as ventral counterpart, anacline, nearly flat. Anterior commissure straight, valves without sulcus or fold. Hinge structures: Postero-lateral parts of delthyrium plugged by tongue-shaped pedicle collar. Inner side of delthyrium occupied by narrow deltidial plates, outer side by narrow tooth ridges. These structures, pedicle collar, tooth ridge, and deltidial plate (described in detail under the heading shell structure) are closely comparable with the same structures found in *Ladjia saltica* gen. et sp. nov., and other Spiriferidae, particularly *Emanuella takwanensis* (Kayser) (*see* Veevers, 1959b) and *Tingella suchana* sp. nov.



TEXT-FIGURE 79.

E. torrida, **delthyrial part of ventral valve. b: beak, dp: deltidial plate, i: interarea, pp: pedicle plate, t: tooth.**

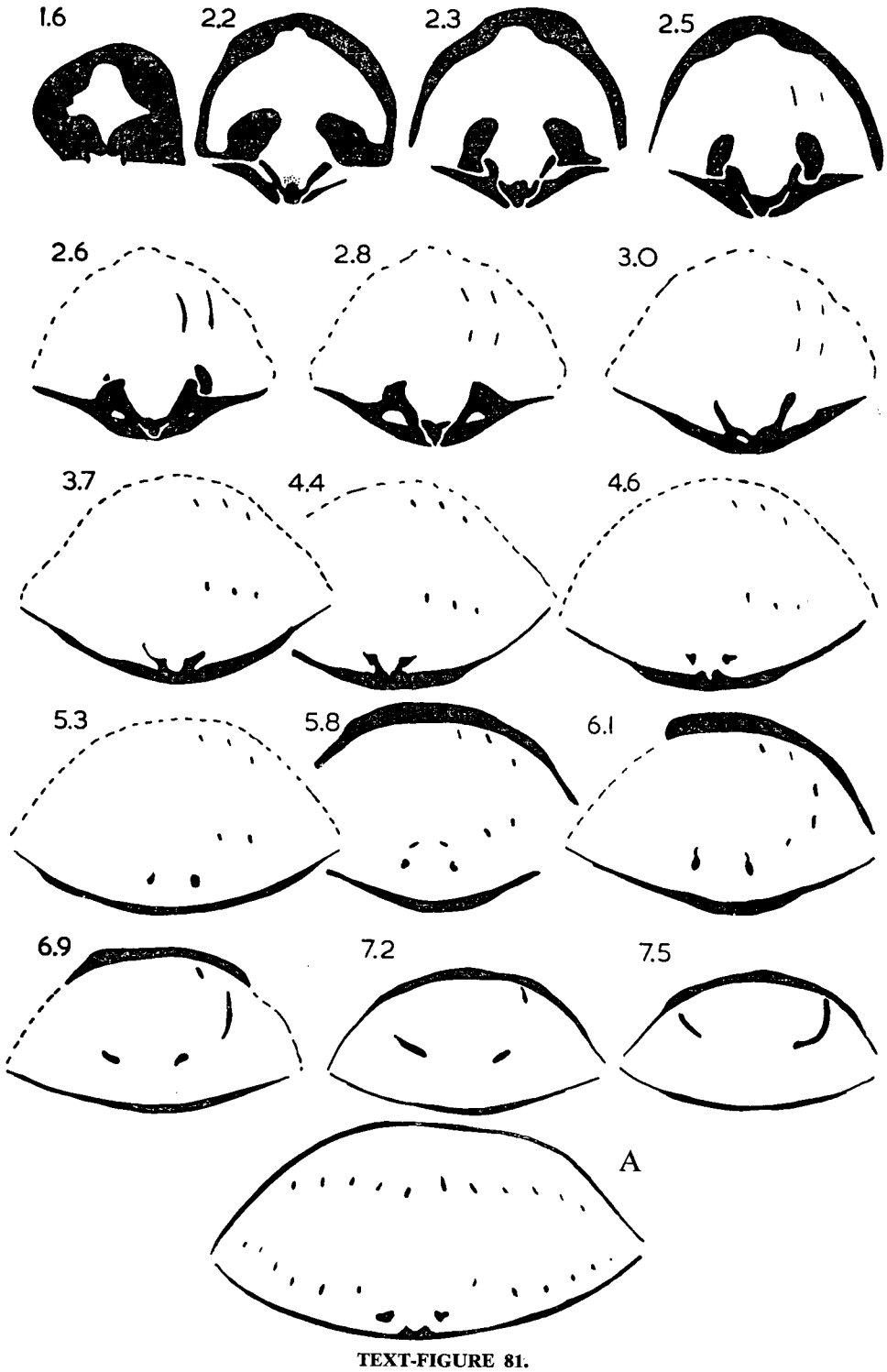


TEXT-FIGURE 80.

E. torrida, **dorsal valve interior. c: crus, cp: cardinal process, i: interarea, s: socket, sp: socket-plate, spir: spiralium.**

Cardinalia and spiralia: Cardinal process small, short, squat, fused to floor of notothyrial cavity; muscle-attachment surface finely tuberculate (text-fig. 82D). Each side of notothyrium formed by a short, thin, inner socket plate continuing dorsally into the socket which is supported anteriorly by the crural plate. Crural plates set closely together, short, strong, and parallel. Crural base continues in front of its supporting plate as a strong cylindrical crus. Each spiralium has three to six turns, with apex directed laterally.

Muscle scar: The only clear indication of a muscle attachment surface (apart from that of the cardinal process) is the narrow flat median depression in the extreme posterior part of the ventral valve (text-fig. 82 A-C). This depression is interpreted



TEXT-FIGURE 81.

E. torrida. **Serial sections x 6 of specimen from K226. L = 9.6, W = 8.5, T = 6.0. (Section x 5 marked "A" at bottom of figure is of another specimen from K226 with L = 9.7, W = 10.0, T = 5.4, taken 4.4 mm. anterior to the umbo, and shows entire spiralia, each with six turns.) Sections show deltidial plates (1.6), enormously thick teeth (2.2 to 2.6), tuberculate cardinal process and sessile sockets (2.2 to 2.6), crural bases supported on short crural plates (4.4), and continuation of crura into primary lamellae (5.8 and 6.1).**

as the position of attachment of the pedicle muscle, probably the only muscle capable of functioning from such a posterior position. From an analysis of shell structure it is inferred that in some specimens the posterior dorsal adductors were attached to the ventral surfaces of the crural plates.

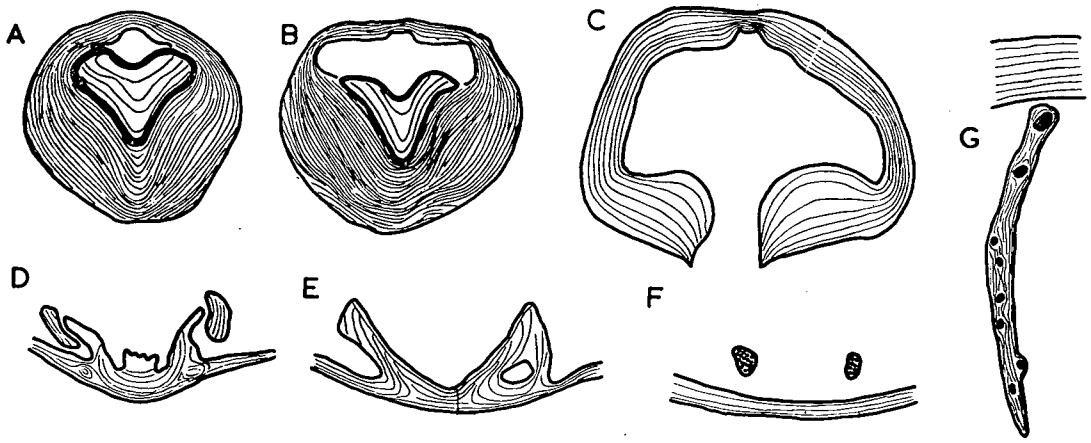
Surface markings: The exterior of most shells is deceptively smooth and only on dorsal valves from which adhering protective sediment has been recently removed can the well-developed spine-bases be seen (pl. 13, figs. 6, 7). The ornament is preserved on dorsal valves only. The spine-bases are comparatively large for *Emanuella,* slightly elongated longitudinally, radially and concentrically arranged to form a pattern of quincunxes. The surface density along the dorsal anterior border is 12 per sq. mm., 3 in 1 mm. measured transversely, 4 in 1 mm. measured longitudinally.

Shell structure: Only the fibrous (inner) layer of the shell is preserved in the specimens sectioned; this layer is impunctate.

The ventral umbo (text-fig. 82 A, B, text-fig. 83 A-D) has two well-differentiated structural parts: an outer part (the valve wall, including the deltidial plates), composed of fine continuous fibres disposed in concentric laminae, and an inner part (the pedicle collar) made of coarser layers which at their sides lie at right-angles to, and are truncated by, the fibrous elements of the valve wall. Repeated deposition by the umbonal part of the mantle, which decreased the volume of the apical cavity, has been responsible for forcing part of the mantle out of the delthyrial cavity past the delthyrial edges, where shell deposition in continuity with the rest of the shell has formed deltidial plates. This mode of formation of deltidial plates in spiriferids was first demonstrated by means of the evidence of shell structure studies made by Miloradovich (1937, p. 528). The lamination of the shell matter shows that after this early regularly concentric deposition of the valve wall the thick-layered pedicle collar arose through deposition by the dorsal side only of the umbonal part of the mantle. Williams (1956, pp. 255-257) considers that this second stage of deposition is caused by the anterior retreat of the pediculate-outer epithelial junction during the early maturity of the organism. Certainly the shell structure of the umbo confirms this interpretation for the origin of the pedicle collar in *E. torrida.*

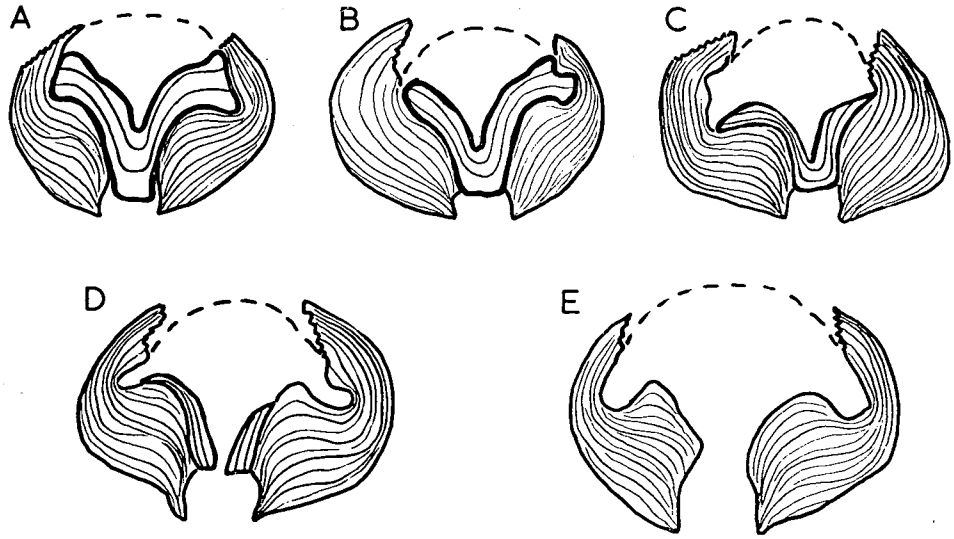
There is no clear evidence that the crural plate has been formed, as might be expected, by a primary fold in the mantle. On the contrary, each crural plate (text-fig. 82 D, E) has apparently grown by shell accretion along the ventro-lateral side followed by later deposition of a very thin continuous shell layer along the ventral surface of both plates (text-fig. 82 E), interpreted as a deposit over the attachment surface of the posterior adductor muscles.

Immediately anterior to the crural plate the crus is composed of a bundle of fibres with long axes directed anteriorly (text-fig. 82 F). The primary lamella, sectioned tangentially at its anterior extremity (82G), is composed of numerous fine long fibres in which are embedded apparently massive bodies with an elliptical sectional outline. Other sections of the spiralia show a simple fibrous structure but do not contain massive structures. The rods perhaps were formed by differentially accelerated deposition by the lophophore epithelium and functioned in providing the lophophore with additional support.



TEXT-FIGURE 82.

E. torrida. **Serial sections and peels of C.P.C. 3033 from K226 with L = 10.3, W = 9.5, T = 5.7. All x 10 except G, x 25. A, B: sections through umbo of ventral valve, 0.60 mm. and 0.80 mm. anterior to posterior extremity. Show pedicle collar and small delthyrial cavity with narrow median muscular impression on ventral side. C: 1.55 mm. anterior to umbo, showing larger delthyrial cavity, open delthyrium with tiny deltidial plates, incipient tooth ridges and the median muscle-scar. D: 3.7 mm. anterior to the umbo, showing dorsal valve with tuberculate cardinal process and teeth engaged with sessile sockets. E: 4.4 mm. anterior to umbo, dorsal valve showing crural plates with thin callus deposit over ventral surface. F: 5.9 mm. anterior to umbo, part of dorsal valve with cross-sections of crura in which calcite fibres orientated at right-angles to plane of section. G: 7.8 mm. anterior to umbo, part of ventral valve (above) and primary lamella showing growth laminae pushed aside by structureless bodies, presumably bases of spines.**



TEXT-FIGURE 83.

E. torrida. **Serial sections and peels x 14 through ventral valve umbo of C.P.C. 3032 from K226, with L = 8.7 mm. Numbers in brackets refer to distance anterior to posterior extremity of shell. A (0.75): showing structural continuity of valve wall and deltidial plates, and truncated lateral parts of pedicle collar. B (0.90), and C (1.05) show reduced size of anterior part of pedicle collar. D (1.10): showing anterior extremities of pedicle collar and delthyrium opening into delthyrial cavity. E (1.25), just anterior to pedicle collar, showing posterior parts of tooth ridges.**

Spined spiralia are not unknown among the Spiriferidae. Oehlert (1887, p. 67, pl. 5, fig. 16) records specimens of *Ambocoelia umbonata* Conrad from the Devonian of France in which the spiralia bear short spines situated with their long axes normal to the surface of the spiralia. Without further knowledge of the shell structure of these spiralia it is unfortunately not possible to determine whether or not these spines are homologous to the massive bodies found in *E. torrida.*

Variation: The material studied ranges in shell width from 5 mm. to 12 mm. Shell-shape is very uniform, shape variation being restricted to a tendency to transverse elongation accompanied by the development of a narrow dorsal median sulcus. The size and shape of the pedicle collar is variable; in most specimens it is a small obscured structure behind the beak, but in others (pl. 13, fig. 8) it is prominently exposed owing to a considerable development in a dorsal direction.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 3000	9.8	10.3	6.3
Figured specimen, C.P.C. 3001	9.8	10.8	5.3
Figured specimen, C.P.C. 3002	10.5	11.4 est.	7.0

Types: Holotype C.P.C. 3000 from K221; figured specimens C.P.C. 3001, 3002 (both K226).

Horizon and localities: Sadler Formation near Sadler Ridge: K221, K223, K226, K227, K230, T54.

Discussion: Emanuella torrida differs from the type species, *Nucleospira takwanensis* Kayser, in its smaller size, straight anterior commissure and relatively coarser spinules on the external surface. Also the sockets in *E. torrida* are sessile, in *E. takwanensis* elevated in a cruralium. This is not an important difference, however, as the position of the sockets, whether sessile or elevated, is unimportant in many related forms such as *Tingella, Ladjia* and *E. volhynica* Kelus 1939 (pp. 3-7, text-figs. 1-6, 14-16, pl. 2, figs. 7-13). Kelus's species from the Middle Devonian of Poland is closely related to *E. torrida.* There are, however, critical differences: the beak of *E. volhynica* is strongly inturned, that of *E. torrida* is straight; the surface spinules of *E. volhynica* are arranged strictly into concentric rows with smooth areas between rows. The size of individuals also differs considerably; specimens of *E. volhynica* have a maximum width of 27.6 mm. whereas this measurement for largest *E. torrida* is 12 mm. The specimens of *E. torrida* may possibly, of course, be all immature and consequently correspond to smaller specimens of *E. volhynica,* which have sessile sockets (cf. Kelus, 1939, fig. 3 with text-fig. 82 E).

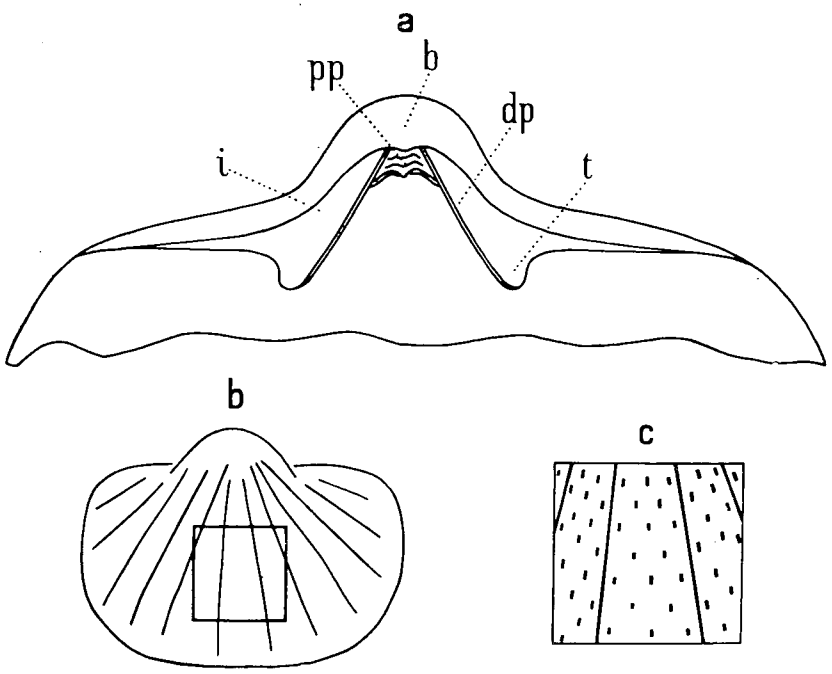
Genus Crurithyris George 1931

Crurithyris apena sp. nov.

(Plate 13, figs. 10-19; Text-figs. 84-87)

Diagnosis: Like *Crurithyris urii* but with a smaller ventral umbo, and surface markings of closely crowded radial and concentric lines set over a shagreen pattern of more widely spaced shallow circular pits.

Material: Eighty free, partly recrystallized calcareous shells; several shells embedded in calcarenite. No shell interiors available.

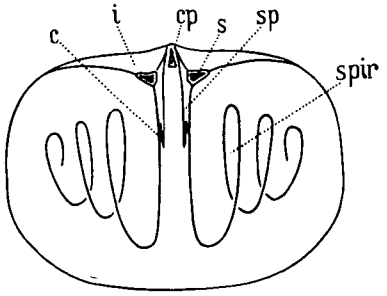


TEXT-FIGURE 84.

C. apena, **(a) posterior part of ventral valve, (b) exterior of ventral valve, and (c) enlargement of part of ventral valve exterior showing radial lines and tiny pits. b: beak, dp: deltidial plate, i: interarea, pp: pedicle plate, t: tooth.**

Description: Shell-shape: Subcircular to pentagonal in outline, width slightly greater than length, shallow median sulci in both valves, ventral sulcus extending throughout the valve-length, dorsal sulcus broad, only found anteriorly. Ventral umbo not prominent, beak moderately inturned, interarea apsacline.

Ventral hinge and delthyrial structures: The pedicle collar (text-fig. 86 A, B) fills the posterior part of the delthyrium between the tooth ridges. Narrow deltidial plates (text-fig. 86 C-E) are developed along the delthyrial edges.

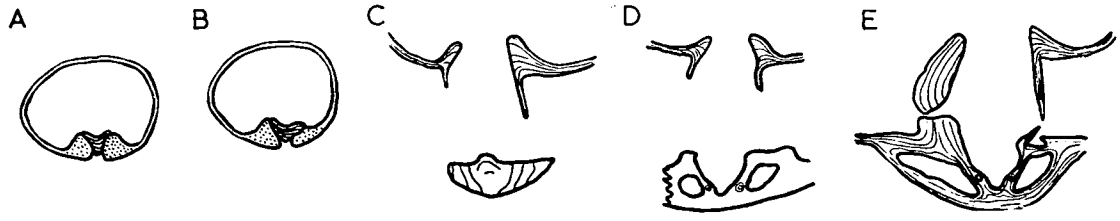


TEXT-FIGURE 85.

C. apena, **dorsal valve, interior. c: crus, cp: cardinal process, i: interarea, s: socket, sp: socket plate, spir: spiralium.**

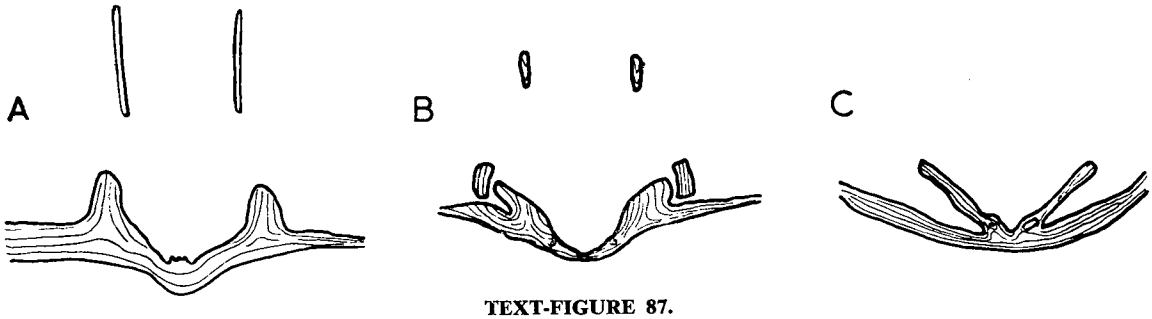
Dorsal structures: Cardinal process apparently tuberculate (text-fig. 87A); it rests only a short distance above the valve floor. Dental socket strong, modified by a chilidial plate (or inner socket plate) (text-fig. 86E, right side of drawing). Crural plates set closely together, short, parallel, may or may not unite at the valve floor

to form a sessile cruralium (text-fig. 86E, 87C). Crural bases extend well posteriorly. The shell structure of the crural plates (text-fig. 86 E, 87C) implies an origin by equal ventral and dorsal deposition by a primary fold in the mantle, a result contrasting with the corresponding conclusion reached for *Emanuella torrida.* This difference, however, might be explained by assuming that the adductors in *C. apena* were situated anterior to the crural plates so that they did not influence the morphogeny of these structures, as perhaps the adductors did in *Emanuella torrida.*



TEXT-FIGURE 86.

C. apena. **Serial sections x 10 of C.P.C. 3034 from K150, 7.9 mm. long. A (0.35) and B (0.45): ventral valve showing pedicle collar and incipient tooth ridges. C (0.75): ventral valve with well-developed tooth ridges and deltidial plates, dorsal valve with low cardinal process. D (1.05): ventral valve as in C, dorsal valve showing posterior part of sockets supported by crural plates containing crural bases near valve floor. E (1.25): Ventral valve with large blunt teeth (left), deltidial plate and dental ridge (right); dorsal valve with elevated sockets on narrow crural plates.**



TEXT-FIGURE 87.

C. apena. **Serial sections x 12 of C.P.C. 3035 from K150 with length 7.2 mm. A (1.10): dorsal valve with socket plates, tuberculate cardinal process and primary lamellae; B (1.20): sessile sockets engaged with teeth; C (1.40): crural plates with crural bases embedded near valve-floor.**

Surface markings: Surface of both valves covered with a radial and concentric mesh of fine closely crowded indistinct lines set over a quincunxial pattern of more widely spaced shallow circular to elongate pits. The pits do not appear to be the hollow bases of spines but the poor preservation does not allow a definite conclusion to be drawn.

Variation: Range of shell width is 2 mm. to 10 mm. The main shape variation occurs in the convexity of the dorsal valve, ranging from moderately convex, as in the holotype, to weakly convex or nearly flat as in figured specimen C.P.C. 3004.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 3003	6.0	6.8	4.1
Figured specimen, C.P.C. 3004	7.7	9.0	5.0

Types: Holotype C.P.C. 3003 from K150; figured specimens 3004 (K150), 3005, 3006 (both K103).

Horizon and localities: Tentatively from Pillara Formation, Oscar Range (Ld21); Sadler Formation, Old Bohemia Area (K103, T61), Bugle Gap (K147, K148, K150, K153, K154), Longs Well area (G23); Napier formation, Elimberrie Spring (Ld31); tentatively from Oscar Formation, Palm Spring (0/73).

Discussion: Crurithyris apena is very similar to the type species, *C. urii* (Fleming) 1828, differing only in surface markings and the shape of the ventral umbo. Thus apart from these differences—pits instead of spinules over their surface, and smaller umbones—specimens of *C. apena* are identical with specimens B83457-66 in the British Museum (Natural History) labelled "*Ambocoelia urii* (Dav.) Carboniferous Shale, Tournay" and B18238, "*Spirifer Urii* de K. (Goldfussianus) Carboniferous Belgium M.P.G. Coll." These specimens are probably conspecific with the specimens recorded as "*Crurithyris urii*" by Demanet (1941, pp. 222, 223, pl. 13, figs. 6, 7). Demanet's specimens range through the Assise d'Ardenne (Upper Namurian) and include specimens from Tournai.

Nalivkin (1937, pl. 17, figs. 14a-d) illustrates *Ambocoelia umbonata* Hall from the Lower Famennian Meister Beds of the Djezkazgan district. This form is identical in size and shape to *Crurithyris apena* but has a stronger dorsal valve sulcus.

Nalivkin's *Ambocoelia unionensis* Weller from the Lower Tournaisian Kassin beds of the Koktas-djartas district (1937, pl. 28, figs. 2a-d), similar in many respects to *Crurithyris apena,* is shorter and more transverse in outline.

From comparison of illustrations of exteriors, *C. apena* is indistinguishable in general shape from *Spirifer inflatus* (Schnur) and *Spirifer decipiens* Torley 1934, both in Torley (1934, pp. 114, 115, pl. 8, figs. 38-40, and p. 115, pl. 8, fig. 41 respectively). Both species occur in the Upper Givetian of Bilveringsen, Germany.

Ambocoelia gregaria Hall, var. *asiatica* Reed 1922 (pp. 112, 113, pl. 16, figs. 15-20) from the Upper Devonian of Ak Baital, Pamirs, is compared by Reed to "the Upper Devonian *Sp. urii* Flem." It is submegathyrid, and both valves are narrowly medianly sulcate. Again no details of the interior are given. Externally Reed's variety is almost identical with *Crurithyris apena* even in details of the fine ornament: "epidermal layer finely punctate, with traces ? of delicate radial striae".

Subfamily Martiniinae Waagen 1883

Genus Tingella Grabau 1931

Tingella suchana sp. nov.

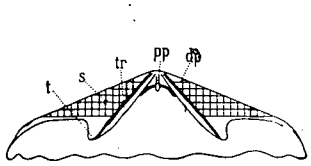
(Plate 15, figs. 1-9; Text-figs. 88-94)

Diagnosis: Transversely quadrate *Tingella* with a small weakly inturned umbo and a broad, almost flat sulcus in the ventral valve, lacking a corresponding fold in the dorsal valve.

Material: Nearly fifty calcareous shells with external surface poorly preserved.

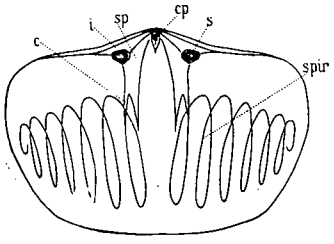
Description: Exterior: Outline subquadrangular, width greater than length, shell widest slightly anterior to wide hinge-line. Cardinal margins rounded, hinge-line and straight lateral margins subtending angles of 70° to 90°. Profile biconvex to nearly planoconvex, ventral valve strongly convex in posterior half, anterior median part

depressed in a broad sulcus. Dorsal valve moderately convex to nearly flat with an incipient median anterior fold. Anterior commissure weakly uniplicate.



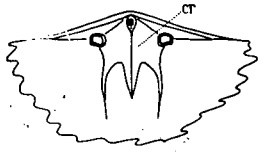
TEXT-FIGURE 88.

T. suchana, **interior of posterior part of ventral valve. dp. deltidial plate, s: striae, pp: pedicle plate, t: tooth, tr: tooth-ridge.**



TEXT-FIGURE 89.

T. suchana, **dorsal valve interior. c: crus, cp: cardinal process, i: interarea, s: socket, sp: socket-plate, spir: spiralium.**

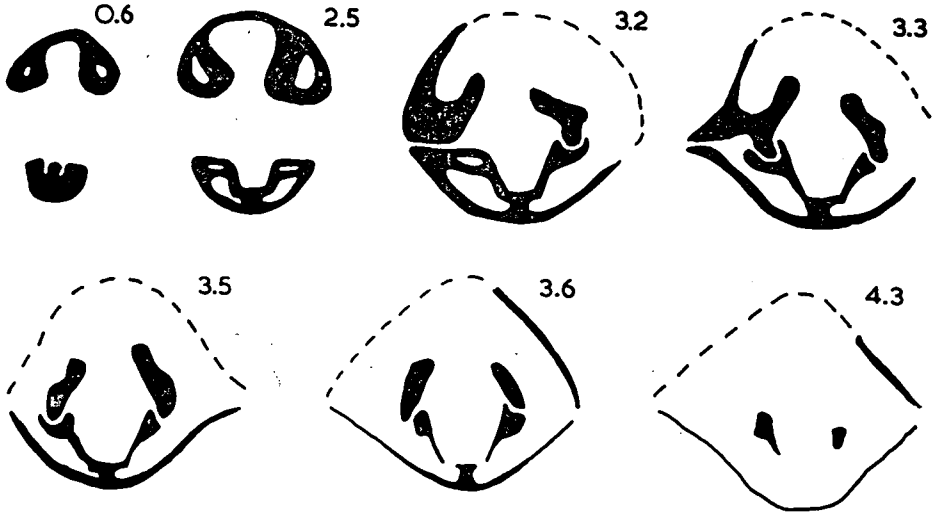


TEXT-FIGURE 90.

T. suchana, **part of a dorsal valve with a cruralium. cr: cruralium.**

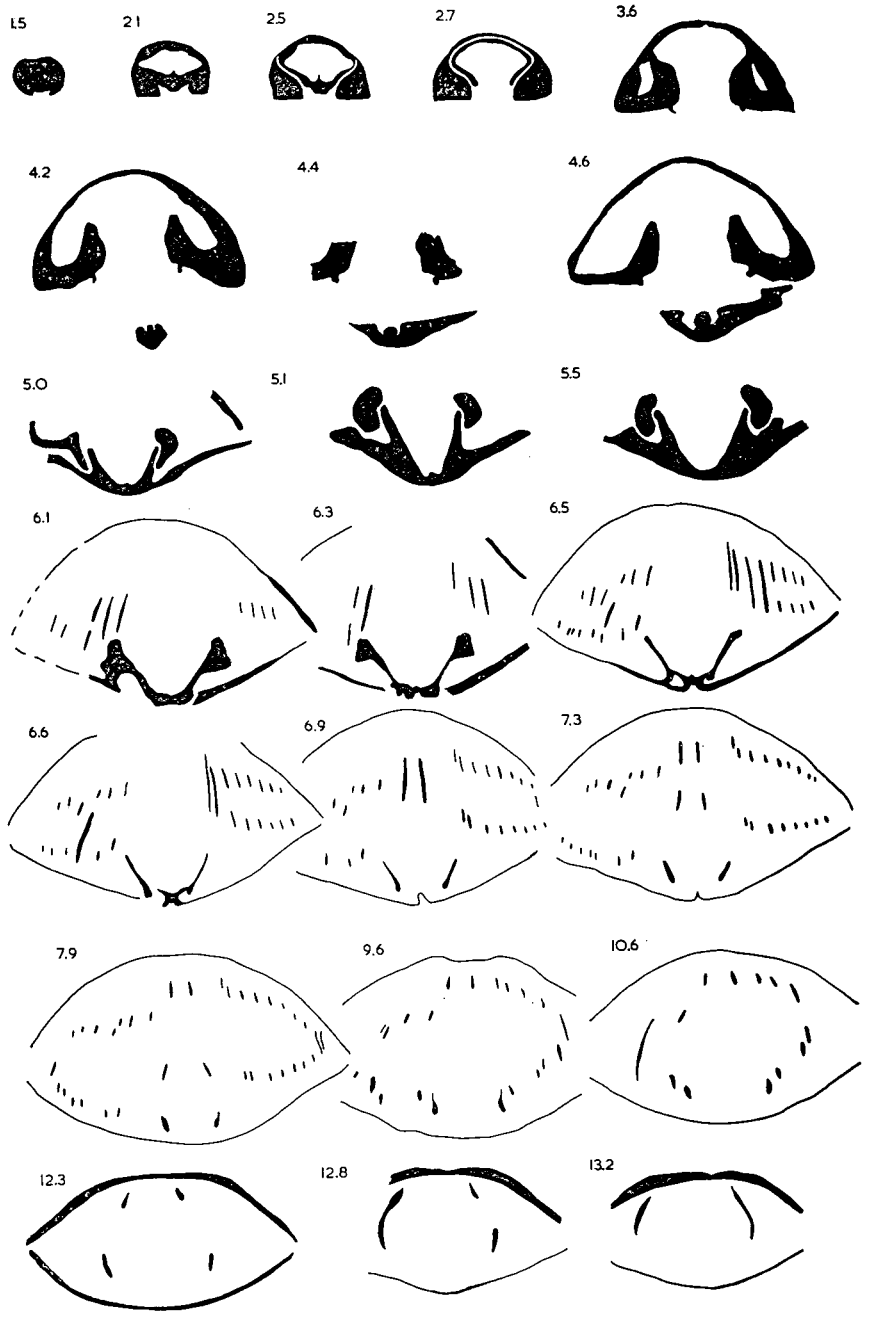
Ventral valve umbo moderately low with an erect tip, apical angle exceeding 90°. Apsacline interarea well defined by straight beak-ridges which continue to the cardinal margins. Dorsal valve umbo small but prominent, interarea anacline.

Ventral valve interior: The pedicle collar has the same general shape and relative position as the collar in *Emanuella torrida* (cf. text-fig. 83 and text-fig. 93); that is, the collar is located within the ventral valve umbo and it consists of a dorso-median part blocking the posterior extremity of the delthyrium and two lateral arms which lie along the sides but not along the ventral wall of the delthyrial cavity. Dental plates very thick, short, convergent dorsally; teeth large, club-shaped in section, divergent dorsally. Deltidial plates are poorly developed narrow linear structures situated at the delthyrial edges.



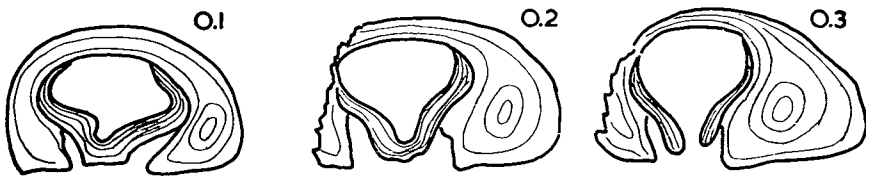
TEXT-FIGURE 91.

T. suchana. **Serial sections x 2½ of C.P.C. 3036 from K209. L = 17.5, W = 20.3, T = 11 8. Whereas sections in text-fig. 92 show that sockets are sessile, sections above show sockets raised above valve-floor on a very short, thick, median ridge, sockets and supporting ridge forming together a cruralium-like structure.**



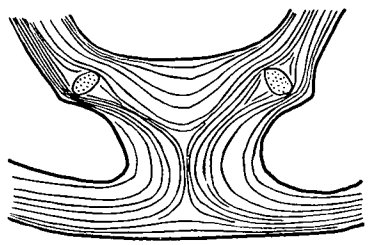
TEXT-FIGURE 92.

T. suchana. **Serial sections x 4 of a specimen from K209 with L = 14.3, W = 14.8, and T = 8.6. First five sections through umbo show pedicle collar, deltidial plates and short dental plates. Sections 4.2, 4.4 and 4.6 show globular cardinal process with striated attachment face. Dorsal and median parts only of ventral valve are given in section 4.4, and parts of shell left out of sections 5.0, 5.1 and 5.5. Strong teeth supported by tooth ridges seen in sections 5.0, 5.1 and 5.5. They articulate with sockets formed by valve-wall and posterior parts of crural plates. Spiralia have eleven turns and are directed laterally. No jugum; the primary lamellae simply continue as first turns of spiralia. Shell-wall worn in sections 6.1 to 10.6.**



TEXT-FIGURE 93.

T. suchana. **Serial sections x 5 of umbo of ventral valve of C.P.C. 3037 from K209, in which pedicle collar well developed.**



TEXT-FIGURE 94.

T. suchana. **Serial section x 12 of median dorsal part of specimen figured in text-figure 91. Section 2.5 mm. anterior to umbo. Shows crural bases lodged in bases of crural plates just ventral of union of plates to form short thick median ridge (*cf.* Kelus, 1939, fig. 2, showing a section through the homologous part of *Emanuella volhynica* Kelus 1939). Growth laminae parallel outlines of inner sides of valve and imply that cruralium originated through regular deposition of calcite fibres by two simple folds in mantle. Sections in text-figures 91 and 94 show that process continued until median part of mantle retreated ventrally to form cruralium. In specimen figured in text-figure 92 mantle did not retreat, and sockets consequently remain sessile.**

Dorsal valve interior: Cardinal process low, sessile, spherical, with a tuberculate attachment surface. Dental sockets very thick, deeply excavated, sessile or supported by thick crural plates which unite above the floor into a cruralium supported by a thick squat median ridge. Crural plates diverge anteriorly and continue as crura which lack either a jugum or jugal processes. Spiralia are simple laterally-directed spires, each with 10 or 11 turns.

Surface markings: The specimen figured in plate 15, figure 6, shows over the ventral valve interarea a reticulate pattern of narrow deep striae normal to, and fine growth-lines parallel to, the hinge-line. The apparently unworn posterior ventral surface of the same specimen shows two widely-spaced low radial costellae. From this meagre evidence, available from one specimen only of the collection, it is inferred that the exterior is crossed by widely-spaced low radial costellae and concentric growth-lines.

Shell structure: Only the inner layer was seen. This is fibrous, impunctate.

Variations: Notable variation in the form of the dental sockets and their supports is seen from comparison of text-figures 91 and 92. This kind of variation, from sessile sockets to a well-developed cruralium, is found also in *Ladjia saltica* (*see* pl. 12, figs. 21, 22 and 29) and *Emanuella volhynica* Kelus 1939 (*see* Kelus, 1939, figs. 2 and 3). In all three species the cruralium seems to have been formed by the same process. Continued deposition by the two mantle folds responsible for the formation of the juvenile sessile sockets leads to the ventral retreat of the mantle with the resulting union of the inner sides of the socket plates to form a median ridge.

Measurements:

—	Length.	Width.	Thickness.
Holotype, C.P.C. 3007	13.2	15.0	10.2
Figured specimen, C.P.C. 3008	13.8	16.8	10.7
Figured specimen, C.P.C. 3044	17.2	20.0	13.8

Types: Holotype C.P.C. 3007; figured specimen 3008; both from K209; figured specimen 3044 from K463.

Horizon and localities: Pillara Formation, Gap Creek Gap (K209, K210), Menyous Gap (K463); tentatively from Sadler Formation, Sadler Ridge (K222).

Discussion: Tingella suchana and the type species are the only described members of *Tingella.* The type species *T. reticularioides* Grabau 1931 from Middle Devonian beds of Yunnan, China, was described on the basis of two specimens, one showing external, the other internal characters. *T. suchana* differs from *T. reticularioides* mainly in shell-shape: *T. suchana* is transversely quadrate in outline, it has a small weakly inturned umbo and a broad almost flat sulcus in the ventral valve, and it lacks a corresponding median fold in the dorsal valve; the type species is less transverse in outline, has a more strongly inturned umbo and a more prominent median sulcus in the ventral valve, and a median fold in the dorsal valve.

A revision of the Chinese species will be required to elucidate its relationships with species of allied genera such as *Martiniopsis* and *Reticularia.*

Comparison of text-figures 91 and 92 with figures 4, 4a, 4b of Kelus (1939) reveals that *T. suchana* is internally very similar to, if not identical with *Emanuella volhynica* Kelus 1939. But the shape and ornament of the exterior show that they differ generically: the outline of *Emanuella volhynica* Kelus is nearly circular, with ornament of very fine spines; that of *Tingella suchana* is transversely elliptical, with ornament presumably of fine growth-lines and radial costellae.

A single specimen from the Sadler Formation resembles *T. suchana,* but is too poorly preserved to be positively identified.

Superfamily ROSTROSPIRACEA Schuchert & LeVene 1929

Family ATHYRIDAE Davidson 1884

Genus ATHYRIS McCoy 1844

ATHYRIS OSCARENSIS sp. nov.

(Plate 14, figs 1-13; Text-figs. 95-98)

Diagnosis: Like *A. fultonensis* (Swallow) 1860 but with a circular or rounded outline and fewer concentric lines and radial striae.

Material: The description is based upon a collection of more than a hundred specimens. The main sample, K283, from which the holotype was chosen, contains free partly recrystallized calcareous shells with worn external surfaces. Specimens

from K235, K236, K237, K244, K246, K285 and T4 have been replaced by coarse-grained silica in beekite rings; specimens from K288, K289, have been more favourably replaced in finer-grained silica.

Width-range: Specimens in samples containing more than ten shells have the following width-ranges:—

K244: 9.1 mm. to 18.2 mm. (43 specimens).

K283: 5.8 mm. to 26.3 mm. (several hundred).

K285: 17.5 mm. to 28.5 mm. (24).

K288: 1.5 mm. to 11 mm. (47).

K289: 1.2 mm. to 10 mm. (approx. 100 shells and valves).

K292: 10 mm. to 19 mm. (21).

Since each of these width-ranges is encompassed by that of K283, it is possible to conclude, by a comparison of shells of the same size from different samples, that the collection contains one species only.

Description: Shell-shape: Shell-shape is best described separately for specimens of four sizes:

Width 1 *mm. to* 4 *mm.,* terebratuloid, length greater than width, widest a short distance anterior to midlength, profile equally biconvex. Ventral valve weakly sulcate anteriorly, anterior commissure weakly uniplicate.

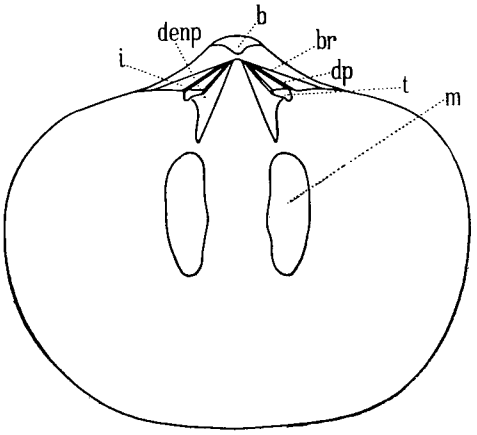
Width 4 *mm. to* 7 *mm.,* length and width subequal, widest a short distance posterior to midlength; profile equally biconvex. Ventral valve with shallow median sulcus, dorsal valve broad, low median fold, anterior commissure broadly uniplicate.

Width 7 *mm. to* 10 *mm.,* width greater than length, widest at midlength; profile equally biconvex. Ventral valve with moderately deep median sulcus, dorsal valve with prominent median fold, anterior commissure narrowly uniplicate.

Width 10 *mm. to* 27 *mm.* Variation within this group is considerable. Outline pentagonal to trapezoidal, apical angle 90° or less. Length is greater or less than width which is generally measured at midlength; shell from very strongly to weakly biconvex. The ventral valve sulcus varies from deep to shallow, the dorsal fold from low to high, and the anterior commissure from broadly and weakly uniplicate to narrowly and strongly uniplicate. In strongly uniplicate specimens the anterior median part of the ventral valve projects as a narrow tongue.

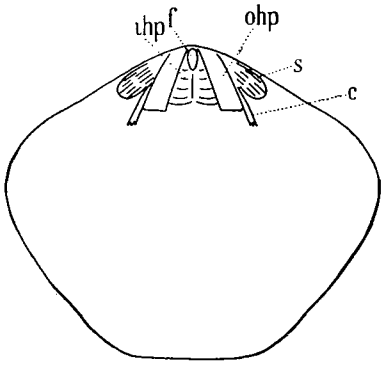
The characteristics of the ventral umbo are fairly constant for all but the smallest specimens; umbo low with beak inturned, overhanging the dorsal umbo, foramen circular. In smaller specimens the ventral umbo extends only a short distance posterior to the dorsal umbo, and the wide foramen opens posteriorly.

Ventral valve interior: Teeth small, supported by short thin parallel dental plates not extending anterior to the teeth; diductor muscle-scars situated posterior to mid-length, elongate-oval in shape, widely separated.



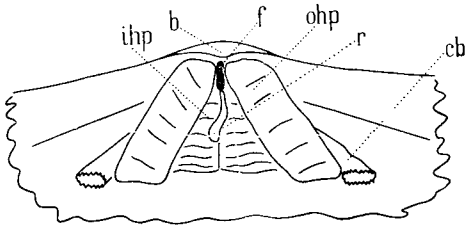
TEXT-FIGURE 95.

A. oscarensis, **ventral valve interior. b: beak, br: beak-ridge, denp: dental plate, dp: deltidial plate, i: interarea, m: muscle area, t: tooth.**



TEXT-FIGURE 96.

A. oscarensis, **interior of dorsal valve. c: crus, f: foramen, ihp: inner hinge-plate, ohp: outer hinge-plate, s: socket.**

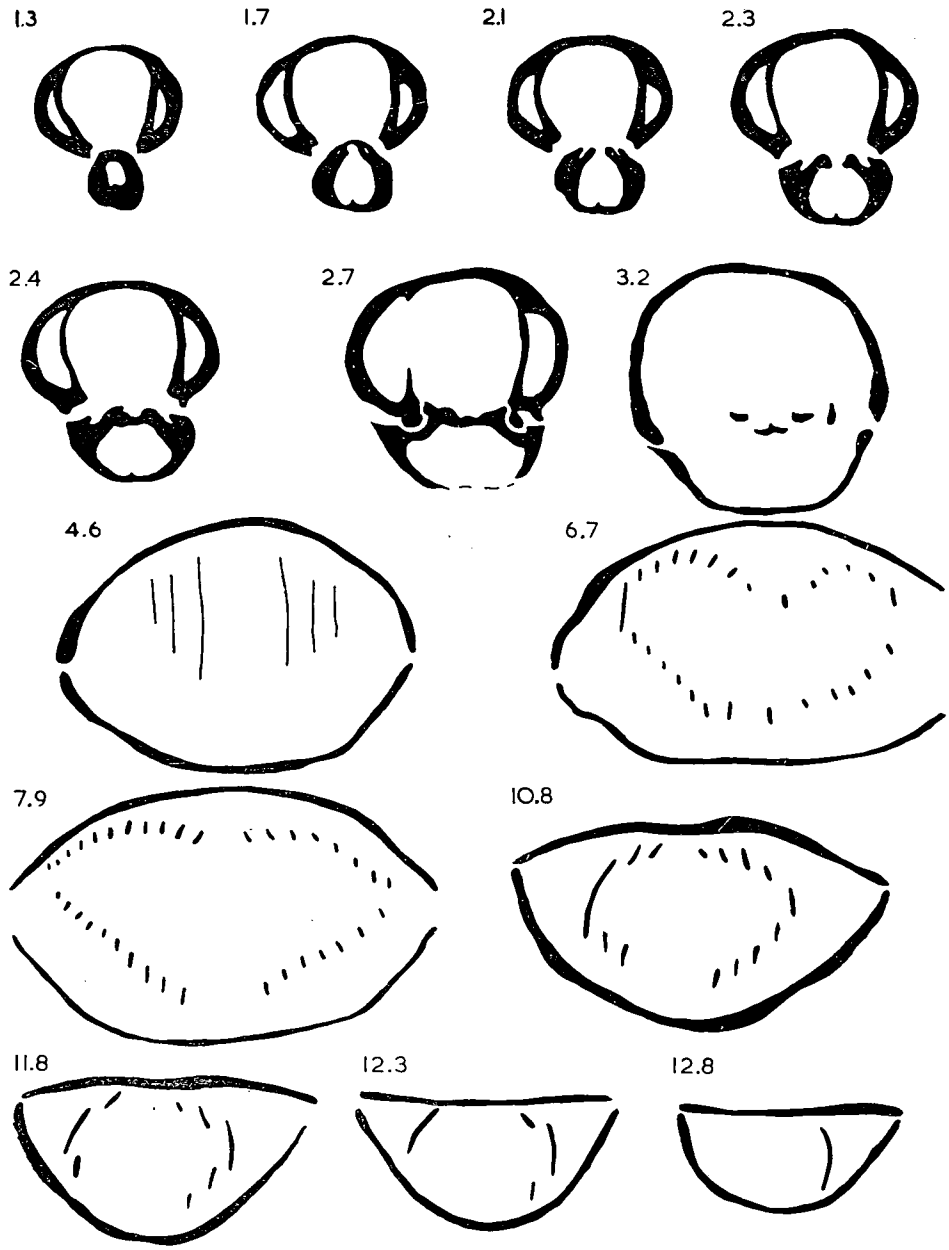


TEXT-FIGURE 97.

A. oscarensis, **dorsal valve cardinalia. b: beak, cb: crural base, f: foramen, ihp: inner hinge-plate, ohp: outer hinge-plate, r: structure of uncertain origin.**

Dorsal valve interior: Hinge-plate composed of two flat, blade-like anteriorly diverging outer plates (crural bases) separated by a striated, medianly ridged, depressed median plate. The posterior third of the median plate is longitudinally perforate; in one silicified specimen (pl. 14, fig. 13) a worm-shaped structure, of uncertain origin, lies along the ventral surface of the median hinge-plate and overhangs the anterior edge of the perforation. Short stout crural plates support the hinge-plate. The dental sockets are bounded by part of the valve wall and the lateral parts of the outer hinge-plate. The spiralium consists of eight to twelve turns, apices are directed laterally, and the spiralium occupies nearly the entire shell cavity anterior to midlength.

Surface markings: The external surface is best preserved in specimens from K288 and K289. Concentric lines and lamellae cover the entire external surface of both valves; the lines are closely spaced, with five lines in a length of 1 mm. Three to five lines separate adjacent lamellae, which subtend angles of 15° to 20° with the anterior part of the valve surface. The free edges of the lamellae are indented to form short flat spines joining laterally at their bases. Commonly there are four spines in a width of 1 mm.



TEXT-FIGURE 98.

A. oscarensis. **Serial sections x 4 of specimen from Oscar Hill with L = 13.8, W = 14.5, T = 7.4, showing long curved dental plates, short relatively small teeth, posteriorly perforated united hinge-plate, and simple laterally-directed spiralia with eleven turns.**

Measurements:

	Length.	Width.	Thickness.
Holotype, C.P.C. 3015	16.0	17.8	10.5
Figured specimen, C.P.C. 3014	8.6	10.9	4.7
Figured specimen, C.P.C. 3013	18.8	21.5	..
Figured specimen, C.P.C. 3039	16.9	21.6	..
Figured specimen, C.P.C. 3012	6.4	7.2	3.4
Figured specimen, C.P.C. 3010	5.4	5.5	..
Figured specimen, C.P.C. 3011	5.4	5.5	..

Types: Holotype C.P.C. 3015, an entire calcareous shell from Oscar Hill (K283); figured specimens 3014 (K283), 3013, 3009 (both K285), 3012 (K289), 3010, 3011 (both K288).

Horizon and localities: Fairfield Beds, Oscar Hill (K283, T2), south of Burramundi Range (K287-K289, K291, K292), east of Mt. Percy (Ld25); Sadler Formation near Sadler Ridge (K235-K237, K244, K246); Geikie Formation, Fossil Downs Homestead (K285, T4); Napier Formation, Elimberrie Spring area (Ld10). More favourably preserved material from the Sadler Formation, at present represented by coarsely crystalline silicified specimens, may show that a second species of *Athyris* is present.

Discussion: The dental plates and the apically perforate hingeplate betoken *Athyris*. *A. oscarensis* is clearly distinguished from topotypical specimens of the type species, *A. concentrica* (von Buch), from the Middle Devonian of Gerolstein, Germany (B.M.(N.H.) B903, B2707, B2709, B39523). The main difference is one of shape: adults of *A. concentrica* are generally circular or rounded in outline, adults of *A. oscarensis* are pentagonal or trapezoidal. Surface markings differ to a lesser extent: *A. concentrica* has concentric lines of greater height and wider spacing than those of *A. oscarensis*.

Of other specimens of *Athyris* from Europe, Britain, Russia and North America seen in the collection of the B.M.(N.H.), specimens of only one species were found to compare closely with those of *A. oscarensis*. These are specimens of *A. fultonensis* (Swallow) 1860 from Clarke County, Indiana (B.M.(N.H.) B1187). The main difference between the species is found in surface details: *A. fultonensis* has a greater number of closely crowded fine concentric lines and fine radial striae.

The Fitzroy species is less closely comparable with topotype specimens BB(6642-8) of *A. vittata* (Hall) 1860, which have more acute apical angles and more globose shells. Most authors have considered Hall's species as a junior synonym of *A. fultonensis;* it is therefore of particular interest as a study of variation in *Athyris* that Branson (1922, pp. 109, 110) gives evidence from collections numbering several hundred specimens that *A. fultonensis* and *A. vittata* are separate species and that moreover, by tracing the continuous gradation existing between specimens of *A. fultonensis* and *A. minima* (Swallow) 1860 from the same topotype locality, Branson demonstrates that these names are synonymous.

Athyris sinerizi Almela & Revilla 1950 (pl. 1, figs. 1a-e, pl. 2, figs. 1a-e, 2, pp. 8-11) from Eifelian of León, Spain, is similar to *Athyris oscarensis* except that *A. sinerizi* has a sharper median sulcus in the ventral valve.

Family MERISTELLIDAE Hall & Clarke 1894

Subfamily MERISTELLINAE Waagen 1883

Genus MERISTELLA Hall 1860

MERISTELLA (?) CAPRINA sp. nov.

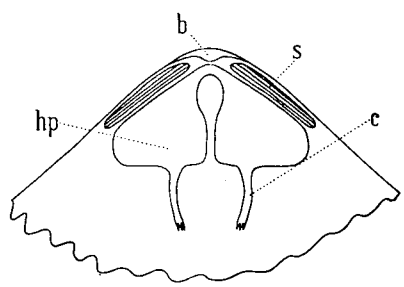
(Plate 14, figs. 14-21; Text-figs. 99, 100)

Diagnosis: Nearly cylindrical *Meristella* with a surface of widely spaced concentric lines crossed by closely crowded radial lines spaced 2 in a width of 1 mm. along the anterior border; dorsal valve with a poorly developed median septum.

Material: 17 partly recrystallized calcareous specimens.

Description: Exterior: Outline longitudinally ovate, nearly cylindrical, length greater than width, width measured at or anterior to midlength. Valves equally convex, profile almost elliptical. Apical angle acute, lateral slopes of the umbo remain straight almost to the midlength. In most specimens the lateral margins are straight and parallel. Ventral valve with a shallow broad median sulcus. Anterior commissure broadly uniplicate. Ventral valve umbo low and broad with an apparently erect tip. Dorsal valve umbo comparatively high with the tip protruded into the delthyrium.

Ventral valve interior: Teeth large, supported posteriorly by strong dental plates. At the lateral borders of the hinge the ventral wall is expanded into a strong rudimentary denticulum (text-fig. 100, section 2.8).



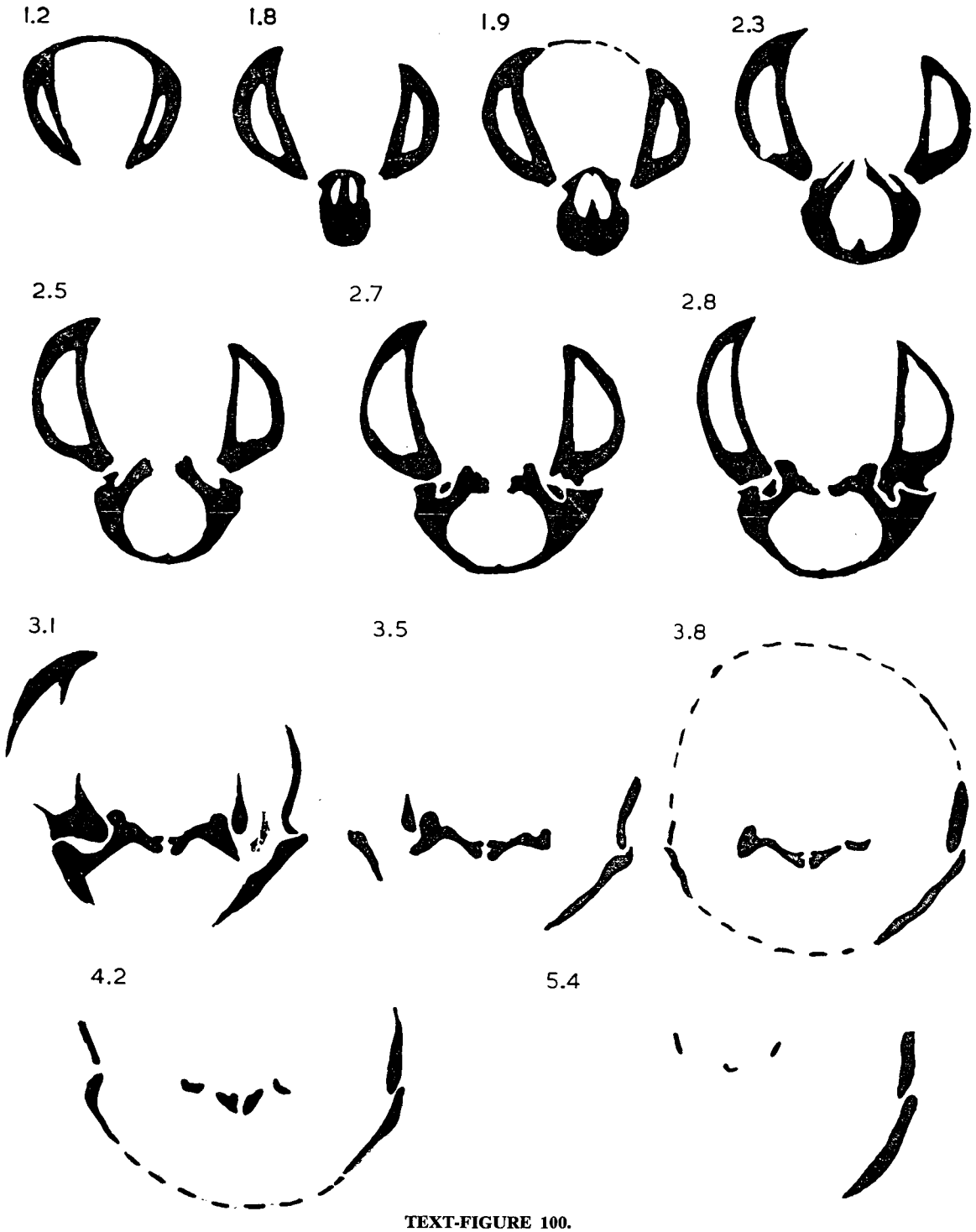
TEXT-FIGURE 99.

M.(?) caprina, **cardinalia of dorsal valve. b: beak, c: crus, hp: hinge-plate, s: socket.**

Dorsal valve interior: Posterior part of notothyrial cavity occupied by very short stout median septum carried forward as a low median ridge. Hinge-plate widely divided posteriorly, narrowly at its interior edge. Median edges of divided hinge-plate are bilobed in section (*see* text-fig. 100, sections 3.1-3.8). Crural plates strong, divergent along the valve floor, forming with the inner valve wall and the outer part of the hinge plate a very strong dental socket. Spiralia not seen.

Surface markings: Coarse, widely spaced concentric lines are crossed by closely crowded radial lines, 2 lines in a width of 1 mm. along the anterior border.

4328/58.—10



TEXT-FIGURE 100.

M. (?) *caprina.* **Serial sections x 5 of specimen from KP181 with L = 18.0, W = 15.7 and T = 12.5. This species has high curving dental plates and moderately small teeth like those in *Athyris*, but in dorsal valve hinge-plate is divided. Inner parts of hinge-plate lobed, possibly to allow increase in area of attachment of diductor muscles.**

Measurements:

——	Length.	Width.	Thickness.
Holotype U.W.A. 26779a	18.9	15.4	11.8
Figured specimen, 26779b	14.5	12.8	9.6

Types: Holotype U.W.A. 26779a; figured specimen 26779b, both from a Teichert manuscript locality, KP181, three miles north of Mt. Percy.

Horizon and Localities: Fairfield Beds, Mt. Percy area (KP181), Station Creek (M2, M9) and east of Old Napier Homestead (F34); Oscar Formation, Brooking Gorge (KP149).

Discussion: Atrypa laevis Vanuxem 1842, the type species of *Meristella,* has a strong dorsal median septum which extends almost to midlength. As the dorsal median septum in *caprina* is barely developed, it is doubtful whether this species is indeed a *Meristella.* Nevertheless without the help of the taxonomically important spiralia, not preserved in specimens so far collected, it is not at the moment possible to find a better place for *caprina* than in *Meristella.*

M. plebeja (J. de C. Sowerby) has a similar elongate shape but its lateral margins are not parallel. *Meristella hunanensis* Tien 1938 from the Middle Devonian of Hunan, China is almost identical externally with *M.* (?) *caprina.* Unfortunately the interior of the Chinese shell is unknown.

Some of the variations of *Meristella nasuta* (Conrad) figured in Cooper (1944, pl. 127, figs. 26, 27) but not those in Hall (1867, pl. 48) from the Onondaga of North America, have similar shape to *M.* (?) *caprina* except that the ventral valve umbo in the former is rostrate, overlying the dorsal valve umbo. Also the interior of *nasuta,* furnished presumably with a strong dorsal median septum, differs from that of *caprina.*

Superfamily TEREBRATULACEA Waagen 1883

Family STRINGOCEPHALIDAE King 1850

Genus STRINGOCEPHALUS Defrance 1825

Stringocephalus Defrance 1825, *in* Cloud (1942, pp. 104-107, pl. 17, figs. 1-6, pl. 18, figs. 1-7).

Diagnosis (emended Cloud, 1942): Large, longitudinally to transversely lenticular, punctate brachiopods, with a prominent median septum in each valve, and a long rod-like terminally bifid cardinal process.

Diagnosis of species (the species of *Stringocephalus,* with an indication of their validity, are listed in Cloud, 1942, pp. 106, 107):

S. burtini Defrance 1825, the type species: adults 80 mm. wide, length exceeds width, ventral beak erect to incurved, ratio of hinge width to valve width 0.3-0.6.

S. cf. *burtini* (*in* Brown, 1944): same size as *burtini,* length equals width, beak suberect to erect, hinge proportionately narrow (hinge ratio 0.35-0.45).

S. dorsalis Goldfuss 1842: both valves medianly sulcate.

S. giganteus (Sowerby) 1840: large, adults 170 mm. wide, width exceeds length, beak inconspicuous.

S. obesus Grabau 1931: small, adults 45 mm. wide, length exceeds width, ventral beak incurved.

S. obesus grandis Grabau 1931: large, adults 115 mm. wide, but not as large as *giganteus,* length equals width, ventral beak erect to incurved.

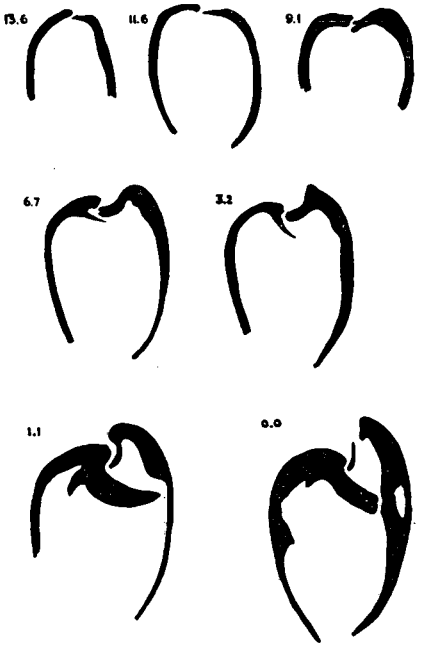
S. fontanus sp. nov.: slightly larger than *burtini,* width exceeds length, beak suberect to erect, hinge proportionately wide (ratio 0.60-0.85).

STRINGOCEPHALUS FONTANUS sp. nov.

(Pl. 17, figs. 1-3, 4a, 4-6; Pl. 18, figs. 1a-d, 2-4; text-figs. 101, 102)

Material: Seventeen calcareous specimens including seven nearly entire shells and one dorsal valve. The matrix is calcilutite.

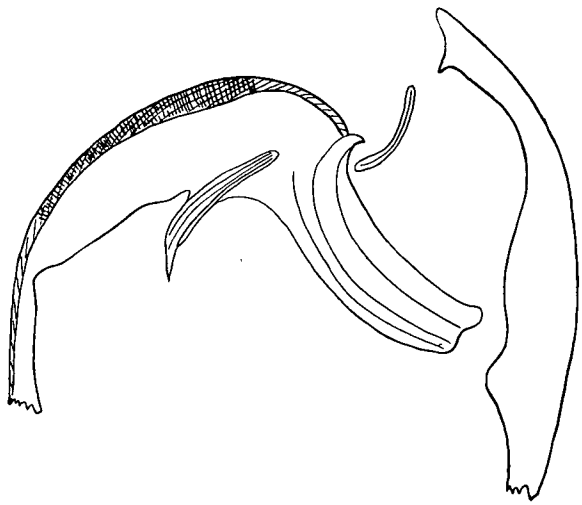
Description: Exterior: Specimens agree with the description of the exterior of *S. burtini* given on page 107 of Cloud (1942) except, as is pointed out in the diagnosis, that average shell of *S. fontanus* is larger and transverse, rare dorsal valves sulcate, beak suberect to erect, and hinge-line almost megathyrid. Exterior crossed by as many as 5 faint growth lines in 5 mm.



TEXT-FIGURE 101.

S. fontanus; **seven serial *longitudinal* sections x ½ of a specimen from K438. Numbers refer to distance in mm. of section from plane of symmetry.**

Interior: Large tooth (text-fig. 101, sections 9.1, 6.7) supported by slender tooth-ridge; dorsal socket expanded medianly and anteriorly as a hinge-plate (sections 6.7, 3.2) which fuses on one side with base of cardinal process, on other with slender crural base. Crura not preserved. Cardinal process divided distally into two prongs which overhang high slender median septum of ventral valve (sections 1.1, 0.0). Other structures seen in section are the low slender dorsal median septum, and open foramen and thin pseudodeltidium (" henidium " of Cloud) in the ventral valve (0.0).



TEXT-FIGURE 102.

S. fontanus; **part of section 0.1 mm. from plane of symmetry x 2, showing shell structure.**

Shell structure: Outer layer not preserved. Shell matter weakly recrystallized, puncta visible only in thin section (pl. 18, fig. 4, text-fig. 102); puncta normal to outer surface of shell, do not divide, crowded 5 in 1 mm. Of the preserved shell layers, only fibrous inner layer is punctate. Shell matter of ventral and dorsal median septa cryptocrystalline. Growth laminae in inner layer (pl. 18, fig. 4, text-figure 102) dip at low angle towards anterior from outside to inside of shell, in same way that Cloud (1942, p. 25) and Williams (1956, fig. 2) have observed in living terebratuloids. Growth laminae of cardinal process and pseudodeltidium, shown diagrammatically in text-fig. 102, parallel sectional outline of these structures, so indicating regular secretion of shell matter on outer and inner sides; crural base has similar origin except that its proximal half has been incorporated in the dorsal median septum.

Measurements:

Specimen No.	U.W.A. 39403	C.P.C. 3017	U.W.A. 38895a	C.P.C. 3019	U.W.A. 39405	U.W.A. 38895b	U.W.A. 38895c
Length ventral valve ..	95 est.	80 est.	73.5	71	85 est.	79	32
Length dorsal valve ..	80 est.	65 est.	57.0	60.5	70 est.	64	29
Width	100 est.	90 est.	80 est.	75 est.	88	85	39
Thickness	70.5	57.5	49	42	46	45	18
Umbonal angle ventral valve(°)	90	90	90	90	80	80	120
Umbonal angle dorsal valve	150	160	155	160	160	130	140
Width hinge	80 est.	55 est.	60 est.	55 est.	62	73	32

Variations: All but one of the specimens are adults. The juvenile specimen is weakly biconvex and its beak, compared with the beak of adults, is proportionately inconspicuous. The adults have more or less the same shape except two specimens, one with a weakly convex, nearly flat dorsal valve (U.W.A. 38895b), the other (U.W.A. 39405) with a broad shallow sulcus in the dorsal valve. Of the beaks of the seven well-preserved shells, four are erect, one suberect, one slightly incurved, and one strongly incurved (terms used in sense of Thomson, 1927, text-fig. 23, p. 80).

Types: Holotype U.W.A. 39403, figured specimens U.W.A. 39404, 39405, C.P.C. 3017, 3018 (dorsal valve), 3019 (sectioned specimen). All from K438.

Horizon and locality: K438, base of Pillara Formation, 1 mile south-east of Mountain Home Spring, where a north-running fence crosses the Home Range. From another locality, 1.8 miles, north-west of K438, Hill (1954, pp. 21, 29) records the association of *Stringocephalus* with *Disphyllum depressum* (Hinde) or *Temnophyllum* sp., and *Spongophyllum* ? sp.

Superfamily TEREBRATULACEA Waagen 1883

Gen. et sp. ind. I

(Plate 15, fig. 10)

Material: Three entire free silicified shells; one fragment each of a dorsal valve and a ventral valve.

Description: Subcircular to longitudinally oval in outline, weakly biconvex in profile. Anterior commissure straight. External surface smooth with very faint radial lines. Deltidial plates discrete, foramen subapical. Hinge-plate probably unsupported. Crura not seen.

Measurements:

—	Length.	Width.	Thickness.
Figured specimen, C.P.C. 3016	7.7	5.5	2.6
Shell, F.18539	4.6	4.7	1.6
Shell U.W.A. 26271/4	2.2	2.0	0.9
Fragment of ventral valve, 26271/5	2.3	2.3	..
Fragment of dorsal valve, 26271/6	2.0	1.8	..

Horizon and localities: Sadler Formation near Sadler Ridge (K215, T53).

Discussion: These specimens are probably juveniles. Critical details of morphology, such as presence or absence of crura and, if present, their shape, are not available.

Gen. et sp. ind. II

(Plate 15, figs. 11, 12)

Material: Two entire free calcareous shells, one fragmentary shell, all recrystallized.

Description: Specimens small (the figured specimen, U.W.A. 25978a, has L = 6.6, W = 6.7, T = 4.2). Outline triangular, profile weakly biconvex; anterior commissure broadly and shallowly uniplicate. External surface smooth.

Horizon and locality: Virgin Hills Formation, Needle-eye Rocks (T18).

GLOSSARY OF NEW NAMES

apena (*Crurithyris*) (Gr. *apenes*), rough, referring to the pitted external surface.
apiculata (*Schizophoria*) (L), small-pointed, referring to the tips of the socket plates.
arefactus (*Uncinulus*) (L.), dried up, referring to condition of specimens at type locality.
asellatum (*Skenidium*) (L.), belonging to the little donkey.
australis (*Devonoproductus*) (L.), southern.
bunapica (*Nervostrophia*) (Aust. aboriginal "*Bunapo*"), derived from the name of a Kimberley tribe of aborigines.
caprina (*Meristella*) (L.), of the goat.
dromeda (*Schuchertella*) (L.), referring to the camel.
emanuelensis (*Kayserella*), from the Emanuel Range; refers also to Kayser's Christian name.
exquisita (*Douvillina*) (L.), excellent, fine.

FITZROYELLA (fem. gender), from the Fitzroy Basin.
fontanus (*Stringocephalus*) (L.), of the spring, referring to the Mountain Home Spring area.
fragilis (*Gypidula*) (L.), easily broken, brittle.
gratillica (*Schuchertella*) (L.), referring to a cake similar in shape to this species.
fitzroyensis (*Teichertina*), from the Fitzroy Basin.
hullensis (*Pugnax*), from Hull Range.
incompta (*Rhipidomella*) (L.), unadorned, simple.

LADJIA (fem. gender, Aust. abor. myth), the Great Spirit of the Yam.
lucida (*Camarotoechia*) (L.), clear.
macropatus (*Plicochonetes*) (NL.), referring to the kangaroo.
margarita (*Hypothyridina*) (L.), pearl.
niphana (*Hypsomyonia*) (Gr. *nipha*, snow) referring to weather when description was written; also to appearance of the silicified shell.
numida (*Whidbornella*) (NL.), named after the brush-turkey.

NYEGE (masc. gender, Aust. abor. myth), a Supreme Being.
oscarensis (*Athyris*), from Oscar Hill.
pierrensis (*Schizophoria*), from Mt. Pierre.
primula (*Fitzroyella*) (L.), first, referring to its position within the genus.
proteus (*Avonia*) (L.), a Greek God.
saltica (*Ladjia*) (L. *saltus*, a gap), from Gap Creek.
scopimus (*Nyege*) (Gr. *skopimos*), suitable for a purpose, referring to the stratigraphical application of this species.
stainbrooki (*Schizophoria*), named after the late Dr. M. A. Stainbrook, of Brandon, Iowa.
suchana (*Tingella*) (Gr. *souchos*), of the crocodile.

TEICHERTINA, after Dr. C. Teichert, formerly of the University of Western Australia.
torrida (*Emanuella*) (L.), parched, scorched.
ungamica (*Zophostrophia*) (Aust. abor. *Ungami*), belonging to a tribe of Australian aborigines.
wolmericus (*Uncinulus*) (Aust. abor. *Wolmeri*), belonging to another tribe.

ZOPHOSTROPHIA (fem. gender, Gr. *zophos* west, *strophia* as in *Nervostrophia*), the western stropheodontid.

LIST OF LOCALITIES WITH DETERMINATIONS OF BRACHIOPODS

1. Bureau of Mineral Resources Localities

These localities, indicated by numbers preceded by the letter "K", are described by air-photograph co-ordinates (Table 3) or by reference to stratigraphical sections detailed in Guppy et al. (1958). The system of air-photograph reference (Resolution 70(10)) adopted by the National Mapping Council of Australia has been used.

An expression such as DP3 D1 following the locality number indicates the position of the locality within a measured section. Localities of measured sections are shown in text-figure 1. For example, in the above expression, DP3 indicates the measured section and D1 indicates the position of the locality within the section; this position is also given with respect to the height above base of section.

K98 Bugle Gap (Mt. Pierre Group)—*saltica* or *torrida* zone
Uncinulus wolmericus

K103 (= T62) "Gap in reef limestone on old road from Mt. Pierre Well to Old Bohemia" (Sadler Formation)—*apena* zone
Hypothyridina margarita
Crurithyris apena
Pugnax sp. cf. *P. pugnus*
Atrypa desquamata kimberleyensis

K108 Old Bohemia area (Sadler Formation)—? zone
(?) *Schizophoria stainbrooki*

K112 Old Bohemia area (Sadler Formation)—*saltica* or *torrida* zone
(?) *Devonoproductus australis*
Atrypa desquamata kimberleyensis

K121 Old Bohemia area (Mt. Pierre Group)—*saltica* or *torrida* zone
Uncinulus wolmericus
Atrypa desquamata kimberleyensis

K126 DP3 D1 Southern part, Old Bohemia area (Gogo Formation)—*saltica* or *torrida* zone
Uncinulus wolmericus
(?) *Atrypa reticularis teicherti*

K135 Old Bohemia area (Mt. Pierre Group)—? zone
Pugnax sp. cf. *P. pugnus*

K142 Eastern side of Bugle Gap (Sadler Formation)—? zone
Atrypa desquamata kimberleyensis

K144 Eastern side of Bugle Gap (Sadler Formation)—*saltica* zone
Hypothyridina margarita
Pugnax sp. cf. *P. pugnus*
(?) *Uncinulus wolmericus*
Atrypa desquamata kimberleyensis
(?) *Devonoproductus australis*

K145 Eastern side of Bugle Gap (Bugle Gap Limestone)—*scopimus* zone
Nyege scopimus

K147 (= T61, in part) -154 "Reef and brachiopod limestone overlain by red beds at foot of main reef limestone, 6.6 miles from Mt. Pierre Well on old road to Old Bohemia." (Sadler Formation)—*apena* zone

K147 *Crurithyris apena*
Hypothyridina margarita

K148 *Crurithyris apena*
Pugnax sp. cf. *P. pugnus*
Hypothyridina margarita
Atrypa desquamata kimberleyensis

K150 *Crurithyris apena*
Hypothyridina margarita
Atrypa desquamata kimberleyensis

K153 *Crurithyris apena*
Hypothyridina margarita

K154 *Crurithyris apena*
Hypothyridina margarita

K159-K170—type section of Bugle Gap Limestone—South-eastern wall of Bugle Gap.

K159 DB1 B1 (Mt. Pierre Group) (75′ below base of type section: *see* Guppy et al., 1958)—*scopimus* zone
Nyege scopimus

K160 DB1 B1 (Mt. Pierre Group) (60′ below base of type section)—*scopimus* zone
Nyege scopimus

K166 DB1 F1 (380′ above base of type section)—*scopimus* zone
Nyege scopimus
(?) *Schizophoria pierrensis*

K167 DB1 F1 (= K166)—*scopimus* zone
Nyege scopimus

K168 DB1 G1 (700′ above base of type section)—*scopimus* zone
Nyege scopimus

K169 DB1 K1 (1,120′ above base of type section)—*proteus* zone
Avonia proteus
Pugnax sp. cf. *P. pugnus*
Schizophoria pierrensis
Camarotoechia lucida

K170 DB1 K1 (1,100′ above base of type section)—*proteus* zone
Leptaena sp. ind.
Avonia proteus

K172 Southern part of Old Bohemia area (Mt. Pierre Group)—*saltica* or *torrida* zone
Atrypa desquamata kimberleyensis
Uncinulus wolmericus

K173 DP2 A Southern part of Old Bohemia area (Mt. Pierre Group)—*saltica* or *torrida* zone
Atrypa desquamata kimberleyensis
Uncinulus wolmericus

K174 Southern part of Old Bohemia area (Mt. Pierre Group)—*saltica* or *torrida* zone
Atrypa desquamata kimberleyensis
Uncinulus wolmericus

K177 Southern part of Old Bohemia area (Mt. Pierre Group)—? zone
Pugnax sp. cf. *P. pugnus*

K179 DP2 H to J Southern part of Old Bohemia area (Fairfield Beds)—*proteus* zone
Schuchertella dromeda
Rhipidomella incompta
Camarotoechia lucida

K180 (=K179) DP2 H to J Southern part of Old Bohemia area (Fairfield Beds)
Avonia proteus

K181 DP2 E1 Southern part of Old Bohemia area (top of Virgin Hills Formation)—*scopimus* zone
Nyege scopimus

K209 DMP2 C2 Gap Creek Gap (Pillara Formation) (135′ above base of DMP2)—*ramosa* zone
Tingella suchana

K210 DMP2 C3 Gap Creek Gap (Pillara Formation) (190′ above base of DMP2)—*ramosa* zone
Tingella suchana

K213 DMP2 E2 (Pillara Formation) For location of this and following localities to K276, *see* text-fig. 2.—*saltica* zone
Ladjia saltica

K214 DD1 A1 (This locality and the following to K276 are in the Sadler Formation)—*saltica* zone
Schizophoria stainbrooki
Ladjia saltica

K215 DD1 A2—*saltica* zone
Hypsomyonia niphana
Teichertina fitzroyensis
Schizophoria stainbrooki
Schuchertella gratillica
Productidae gen. et sp. ind.
Terebratulacea gen. et sp. ind. I
Ladjia saltica
Atrypa desquamata kimberleyensis

K216 DD1 A3—*saltica* zone
Teichertina fitzroyensis
Schizophoria stainbrooki
Gypidula fragilis
Devonoproductus australis
Ladjia saltica

K217 DD1 A4
K218 DD1 A5
K219 DD1 B2
K220 DD1 C1
} *Schizophoria stainbrooki*—? zone

K221 DD1 D1—*torrida* zone
Schizophoria stainbrooki
Kayserella emanuelensis
cf. *Chonetipustula* sp.
Plicochonetes macropatus
Uncinulus wolmericus
Emanuella torrida
Atrypa reticularis teicherti

K222 DD1 D2—*torrida* zone
Schizophoria stainbrooki
Kayserella emanuelensis
Plicochonetes macropatus
cf. *Productella* sp.
cf. *Tingella suchana*

K223 DD1 D3—*torrida* zone
Schizophoria stainbrooki
Plicochonetes macropatus
Emanuella torrida
Atrypa reticularis teicherti

K224 DD1 D4—*torrida* zone
Kayserella emanuelensis
Plicochonetes macropatus
Uncinulus wolmericus
Atrypa reticularis teicherti

K225 DD1 D5—*torrida* zone
Kayserella emanuelensis
Atrypa reticularis teicherti
Uncinulus wolmericus

K226 DD1 D6—*torrida* zone
Plicochonetes macropatus
Emanuella torrida

K227 DD1 D7—*torrida* zone
Kayserella emanuelensis
Plicochonetes macropatus
Emanuella torrida

K228 DD1 E1—*torrida* zone
Uncinulus wolmericus
Atrypa reticularis teicherti

K229 DD1 E2—*torrida* zone
Atrypa desquamata kimberleyensis

K230 DD1 E3—*torrida* zone
Schizophoria sp. ind.
(?) *Nervostrophia bunapica*
(?) *Devonoproductus australis*
Plicochonetes macropatus
Uncinulus wolmericus
Uncinulus arefactus
Atrypa reticularis teicherti

Spinatrypa aspera prideri
Emanuella torrida
Fitzroyella primula

K231 DD1 E5—? zone
Uncinulus arefactus

K235 DD2 B2—*saltica* zone
Schizophoria stainbrooki
Atrypa desquamata kimberleyensis
Athyris oscarensis

K236 DD2 C1—*saltica* zone
Schizophoria stainbrooki
Douvillina exquisita
Gypidula fragilis
Atrypa desquamata kimberleyensis
Athyris oscarensis

K237 DD2 C2—*saltica* zone
Schizophoria stainbrooki
Gypidula fragilis
Ladjia saltica
Atrypa desquamata kimberleyensis
Athyris oscarensis

K238 DD2 C3—*saltica* zone
Schizophoria stainbrooki
Gypidula fragilis

K239 DD2 C4—*saltica* zone
Schizophoria stainbrooki
Gypidula fragilis
Devonoproductus australis
Ladjia saltica
Atrypa desquamata kimberleyensis

K240 DD2 C5—*saltica* zone
Schizophoria stainbrooki

K241 DD2 C6—*saltica* zone
Schizophoria stainbrooki
Atrypa desquamata kimberleyensis

K242 DD2 C7—*saltica* zone
Schizophoria stainbrooki
Douvillina exquisita
Ladjia saltica
Atrypa desquamata kimberleyensis

K243 DD2 C8—*saltica* zone
Isorthis(?) sp.
Schizophoria stainbrooki
Atrypa desquamata kimberleyensis
Fitzroyella primula

K244 DD2 C9—*saltica* zone
Isorthis(?) sp.
Schizophoria stainbrooki

Douvillina exquisita
Devonoproductus australis
Steinhagella numida
Atrypa desquamata kimberleyensis
Athyris oscarensis
Pugnax sp. cf. *P. pugnus.*

K245 DD2 C10—*saltica* zone
Skenidium asellatum
Hypsomyonia niphana
Teichertina fitzroyensis
Schizophoria stainbrooki
Schuchertella gratillica
Douvillina exquisita
Zophostrophia ungamica
Nervostrophia bunapica
Devonoproductus australis
Steinhagella numida
Productidae gen. et sp. ind.
Ladjia saltica
Atrypa desquamata kimberleyensis
Pugnax sp. cf. *P.pugnus*

K246 DD2 C11—? zone
Isorthis (?) sp.
Schizophoria stainbrooki
Schuchertella gratillica
Devonoproductus australis
Steinhagella numida
Atrypa desquamata kimberleyensis
Athyris oscarensis
Fitzroyella primula

K247 DD2 D2—? zone
Schizophoria stainbrooki

K248 DD2 D3—? zone
Schizophoria stainbrooki
Atrypa desquamata kimberleyensis

K249 DD2 D4—? zone
Schizophoria stainbrooki

K250 DD2 D5—? zone
Schizophoria stainbrooki
Atrypa desquamata kimberleyensis

K251 DD2 D7—? zone
Schizophoria stainbrooki

K252 DD2 D8—? zone
Schizophoria stainbrooki
Douvillina exquisita
Devonoproductus australis
Atrypa desquamata kimberleyensis

K253 DD2 D9—? zone
Atrypa desquamata kimberleyensis

K264 DD3 B1—? zone
Atrypa desquamata kimberleyensis

K265 DD3 C1—? zone
Douvillina exquisita
Atrypa desquamata kimberleyensis

K266 DD3 C2—? zone
Douvillina exquisita
Atrypa reticularis teicherti

K267 DD3 C3—? zone
Atrypa desquamata kimberleyensis

K268 DD3 C4—? zone
Schizophoria stainbrooki

K269 DD3 C5—? zone
Atrypa desquamata kimberleyensis

K270 DD3 C6—*saltica* zone
Uncinulus wolmericus
Fitzroyella primula
Atrypa desquamata kimberleyensis
Ladjia saltica

K271 DD3 C7—*saltica* zone
Atrypa desquamata kimberleyensis
Hypothyridina margarita
Pugnax sp. cf. *P. pugnus*

K272 DD3 C8—*saltica* zone
Ladjia saltica
Atrypa desquamata kimberleyensis

K273 DD3 D2—*saltica* zone
Hypsomyonia niphana
Schizophoria stainbrooki
Gypidula fragilis
Ladjia saltica
Atrypa desquamata kimberleyensis

K274 DD3 D3—*saltica* zone
(?) *Uncinulus wolmericus*
Schizophoria stainbrooki
Hypothyridina margarita
Ladjia saltica
Atrypa desquamata kimberleyensis
Fitzroyella primula

K275 DD3 E2—*saltica* zone
Schizophoria stainbrooki

K276 DD3 E4—*saltica* zone
Skenidium asellatum
Hypsomyonia niphana
Teichertina fitzroyensis
Schizophoria stainbrooki
Douvillina exquisita

Zophostrophia ungamica
Nervostrophia bunapica
Schuchertella gratillica
Devonoproductus australis
Productidae gen. et sp. ind.
Gypidula fragilis
Ladjia saltica
Atrypa desquamata kimberleyensis

K282 Oscar Hill (Fairfield Beds)—*proteus* zone
Avonia proteus

K283 Oscar Hill (Fairfield Beds)—*proteus* zone
Schuchertella dromeda
Avonia proteus
Camarotoechia lucida
Athyris oscarensis

K285 (=T4)
Fossil Downs Homestead, near tennis courts (Geikie Formation)—*proteus* zone
Schizophoria pierrensis
Schizophoria sp. cf. *S. stainbrooki*
Avonia proteus
Athyris oscarensis

K287 South of Burramundi Range (Fairfield Beds)—*proteus* zone
Athyris oscarensis

K288 (= K287) South of Burramundi Range (Fairfield Beds)—*proteus* zone
Avonia proteus
Camarotoechia lucida
Athyris oscarensis

K289 DF2 A1 South of Burramundi Range (Base of Fairfield Beds in section DF2)—*proteus* zone
Camarotoechia lucida
Atrypa desquamata kimberleyensis
Athyris oscarensis
Schizophoria sp. cf. *S. stainbrooki*

K290 DF2 A2 South of Burramundi Range (100′ above base of Fairfield Beds in section DF2)—*proteus* zone
Avonia proteus

K291 DF2 A3 South of Burramundi Range (180′ above base of Fairfield Beds in section DF2)—*proteus* zone
Schuchertella dromeda
Athyris oscarensis

K292 DF2 A4 South of Burramundi Range (190′ above base of Fairfield Beds in section DF2)—*proteus* zone
Schuchertella dromeda
Avonia proteus
Camarotoechia lucida
Athyris oscarensis

K300 Pillara Spring area (Sadler Formation)—? zone
Atrypa desquamata kimberleyensis

K301—Pillara Spring area (Sadler Formation)—? zone
Atrypa desquamata kimberleyensis

K315 DL2 E1 South of Burramundi Range (100′ above base of Fairfield Beds in section DL2)—*proteus* zone
Camarotoechia lucida

K318 DL2 E3 South of Burramundi Range (315′ above base of Fairfield Beds in section DL2)—*proteus* zone
Camarotoechia lucida

K319 DF3 A1 7 miles ENE of Bullock Paddock Bore, Fossil Downs (15′ above base of Fairfield Beds in section DF3)—*proteus* zone
Camarotoechia lucida

K320 DF3 A2 (35′ above base of Fairfield Beds in section DF3)—*proteus* zone
(?) *Schuchertella dromeda*

K322 Southern Burramundi Range (Fairfield Beds)—*proteus* zone
Schizophoria apiculata
Camarotoechia lucida

K327 Northern Hull Range (Fairfield Beds)—*proteus* zone
Camarotoechia lucida

K340 DL1 E3 (200′ above base of Fairfield Beds in section DL1)—*proteus* zone
Avonia proteus

K341 DL1 E4 (220′ above base of Fairfield Beds in section DL1)—*proteus* zone
Avonia proteus

K355 Eastern Hull Range (Fossil Downs Formation)—? *proteus* zone
(?) *Avonia proteus*

K356 Eastern Hull Range (Fossil Downs Formation)—? *scopimus* zone
Pugnax hullensis

K463 Dmp1 A11 Menyous Gap (1,150′ above base of type section of Pillara Formation) (*See* Guppy et al., 1958)—*ramosa* zone
Atrypa desquamata kimberleyensis
Tingella suchana

K480 Horse Spring area (Sadler Formation)—*saltica* or *torrida* zone
Atrypa desquamata kimberleyensis
(?) *Uncinulus wolmericus*
(?) *Douvillina exquisita*

K503 Geikie Gap area (?Fairfield Beds)—*proteus* zone
(?) *Spinatrypa aspera prideri*
Schizophoria pierrensis

K506 DS2 A3 3.5 miles east of Springs Homestead (Geikie Formation)—*proteus* zone
(750′ above base of section)
Avonia proteus
Pugnax sp. cf. *P. pugnus*

K539 DO1 A1 Linesmans Creek (110′ above base of type section of Oscar Formation)—? zone
Pugnax sp. cf. *P. pugnus*

K551 DF8 A1 1¼ miles bearing 037°T from Fairfield Homestead (Fairfield Beds) (120′ above base of section DF8)—*proteus* zone
(?) *Schizophoria apiculata*
(?) *Schuchertella dromeda*
Avonia proteus
Camarotoechia lucida

K571 and K572 Dmp5 C2, Eastern entrance of Old Wagon Track, Napier Downs (Pillara Formation) (280′ above base of section Dmp5)—? *saltica* zone
Atrypa desquamata kimberleyensis

K573 = K571 and K572 Dmp5 C3 (Pillara Formation)—? *saltica* zone
Atrypa desquamata kimberleyensis
(?) *Ladjia saltica*

G23 Longs Well area (Sadler Formation)—*apena* zone
Crurithyris apena
Atrypa desquamata kimberleyensis
Hypothyridina margarita

2. List of Localities of Devonian Brachiopods Collected by Dr. Curt Teichert, West Kimberley, 1940-41

These brachiopods form part of the University of Western Australia Collection. Numbers preceded by "T" denote localities listed on pages 53 and 54 and plotted on plate 1 of Teichert's report (1949). The numbers of localities in Teichert's manuscript (kept in the library of the Geology Department, University of Western Australia) are placed in brackets immediately after the appropriate published locality number.

T1 (A1) "Highest brachiopod horizon Brooking Gap Section" (Fairfield Beds)—*proteus* zone
Camarotoechia lucida

T2 (B6-10) (= K283) Oscar Hill (Fairfield Beds)—*proteus* zone
Schuchertella dromeda
Athyris oscarensis

T4 (A21) (= K285) "Fossil Downs Homestead—around Tennis Court" (Geikie Formation)—*proteus* zone
Athyris oscarensis
Avonia proteus
Rhipidomella incompta
(?) *Schizophoria pierrensis*

T5 (A22) "Fossiliferous horizon just behind crest of scarp behind Fossil Downs Homestead" (Geikie Formation)—*proteus* zone
Leptaena sp. ind.
Avonia proteus
Camarotoechia lucida
(?) *Schizophoria stainbrooki*
Athyris oscarensis

T9 (H11) "Limestone above Long Hole Conglomerate" (Fossil Downs Formation)—*saltica* or *torrida* zone
Uncinulus wolmericus

T11 (A17-A20) "'Clymenia' beds N. of Margaret River, W. of Fossil Hill, 1.2 miles from Fossil Hill Camp" (Fairfield Beds)—*proteus* zone
Avonia proteus

T12 (A15) "Top of Fossil Hill" (Fairfield Beds)—*proteus* zone
Avonia proteus
Leptaena sp. ind.

T 18 (A57) "S.E. corner of Needleeye Rocks" (Virgin Hills Formation)—*scopimus* zone
Terebratulacea gen. et sp. ind. II
Nyege scopimus

T18 (A60) "10-21 ft. below base of LS conglomerate, S.E. corner Needleeye Rocks" (Virgin Hills Formation)—*scopimus* zone
Nyege scopimus

T19 "1.55 miles N. of Mt. Pierre Camp" (Virgin Hills Formation)—*scopimus* zone
Nyege scopimus

T25 (A24-25) "Mt. Pierre" (Virgin Hills Formation)—? zone
Pugnax sp. cf. *P. pugnus*

T25 (A26) "Mt. Pierre" (Virgin Hills Formation)—*proteus* zone
Rhipidomella incompta
Schizophoria pierrensis

T25 (A28) "Top of Mt. Pierre" (Fairfield Beds)—*proteus* zone
Schizophoria pierrensis
Schuchertella dromeda

T25 (A29) "Eastern slope of Mt. Pierre, strata above A26" (Virgin Hills Formation)—*proteus* zone
Rhipidomella incompta
Pugnax sp. cf. *P. pugnus*
Schizophoria pierrensis

T25 (A30) "E. slope of Mt. Pierre 6 feet below horizon A26" (Virgin Hills Formation)—? zone
Pugnax sp. cf. *P. pugnus*

T26 (A87) "Just below LS conglomerate, second hill east of Mt. Pierre Trig." (Virgin Hills Formation)—*proteus* zone
Rhipidomella incompta
Schizophoria pierrensis

T27 (A83) "156 ft. above red beds, S.E. part of S.-Hill"—*proteus* zone
Avonia proteus
Leptaena sp. ind.

T27 (A84) "187 ft. above red beds, S.E. part of S.-Hill" (Fairfield Beds)—*proteus* zone
Avonia proteus

T39 (B19-B21) "Little hill in N.W. extension of northernmost of the limestone ridges of the S.E. Rough Range, N.E. of No. 3 Bore" (Virgin Hills Formation)—*scopimus* zone
Nyege scopimus

T40 (B31-B33) " Section through N.W. part of northernmost of the limestone ridges of the S.E. Rough Range, N.E. of No. 3 Bore ", " 31 ft. below top of lower LS series " (Virgin Hills Formation)—*scopimus* zone

Nyege scopimus

T42 (C34-C35) " About 1 mile E. of . . . little hill (with reef on top) 5.6 miles S.E. of No. 3 Bore near road to Salty Bore " (Virgin Hills Formation)—*scopimus* zone

Nyege scopimus

T53 (D10) " Between small hills near Long's Well and reef limestone approximately south of Long's Well " (Sadler Formation)—*saltica* zone

Teichertina fitzroyensis
Schizophoria stainbrooki
Douvillina exquisita
Gypidula fragilis
Terebratulacea gen. et sp. ind. I
Atrypa desquamata kimberleyensis
Fitzroyella primula

T54 (C44) " Low hill of yellow limestone, north of reef limestone, approximately 1.5 miles south-west of Long's Well and ½ miles north-west of Locality 44." The reference to locality 44 is a mistake as this locality is at least 8 miles distant from T54. (Sadler Formation)—*torrida* zone

Kayserella emanuelensis
Emanuella torrida
Uncinulus wolmericus

T57 (D13) " Goniatite and *Atrypa* beds in fault zone 3 miles N.W. of Long's Well on flat " (Sadler Formation or Gogo Formation)—*torrida* zone

Uncinulus arefactus

T58 (C57-59) " About ⅓ mile north of main reef limestone, east of Gap Creek Gap " (Sadler Formation)—*torrida* zone

Kayserella emanuelensis
Douvillina exquisita
Uncinulus arefactus

T61 (B83) (= K147) " Reef and brachiopod limestone overlain by red beds at foot of main reef limestone, 6.6 miles from Mt. Pierre Well on old road to Old Bohemia " (Sadler Formation)—*apena* zone

Hypothyridina margarita
Crurithyris apena

T69 (H13) " ¼ to ½ mile east of Old Bohemia " (Mt. Pierre Group)—*scopimus* zone

Pugnax hullensis
Nyege scopimus

Localities listed in Teichert's manuscript but not included in his published report, with determinations of brachiopods.

Published reference maps are the 4-mile Sheets Noonkanbah and Lennard River, and the 8-mile map of the Fitzroy Basin, in Guppy et al. (1958).

F29 17° 05.2′ S, 124° 37.0′ E. (Napier Formation) —? zone

Pugnax sp. cf. *P. acuminatus*

F32 17° 04.8′, 124° 37.2′ (Napier Formation)—? zone
Camarotoechia sp. ind.

F33 17° 04.7′, 124° 36.0′ (Napier Formation)—*apena* or *saltica* zone
Camarotoechia sp. ind.
Hypothyridina margarita

F34 17° 13.4′, 124° 37.1′ (Napier Formation)—*proteus* zone
Meristella(?) *caprina*

KP72 17° 26.0′, 124° 59.7′ (Napier Formation)—*scopimus* zone
Nyege scopimus

KP84 17° 32.5′ 125° 05.0′ (Napier Formation)—*proteus* zone
Pugnax sp. cf. *P. acuminatus*
Camarotoechia lucida

KP101 17° 34.2′, 125° 06.1′ (Napier Formation)—*proteus* zone
Leptaena sp. ind.

KP103 17° 40.5′, 125° 11.2′ (Napier Formation)—*proteus* zone
Avonia proteus
Uncinulus arefactus
Camarotoechia lucida

KP106 17° 42.3′, 125° 13.9′ (Napier Formation)—? *scopimus* zone
Pugnax hullensis

KP107 17° 41.7′, 125° 09.1′ (Napier Formation)—*proteus* zone
Avonia proteus

KP109 17° 41.7′, 125° 09.1′ (Napier Formation)—*proteus* zone
Avonia proteus

KP111 17° 40.5′, 125° 05.2′: 2 miles west of Wire Spring, 4 miles from Elimberrie —? *proteus* zone
(?)*Avonia proteus*

KP134 17° 39.7′, 125° 01.5′ (Napier Formation *or* Pillara Formation)—? zone
Pugnax sp. cf. *P. pugnus*

KP140 17° 43.0′, 125° 14.0′ (Napier Formation)—*proteus* zone
Avonia proteus

KP141 17° 43.5′, 125° 13.2′ (Napier Formation)—*scopimus* zone
Nyege scopimus

KP143 17° 42.5′, 125° 11.2′ (Napier Formation)—*proteus* zone
Camarotoechia lucida

KP144 17° 42.2′, 125° 11.7′ (Napier Formation)—*proteus* zone
Schizophoria pierrensis
Pugnax sp. cf. *P. pugnus*

KP149 18° 03.3′, 125° 29.9′ "SE end of Oscar Ra. halfway between Station and Brooking Gorge" (Oscar Formation)—*proteus* zone
Leptaena sp. ind.
Meristella(?) *caprina*
Avonia proteus

KP150 17° 59.2′, 125° 34.0′ "just W. of S. entrance to Brooking Gap from reef series" (Brooking Formation)—? *scopimus* zone
Pugnax hullensis

KP152 17° 49.7′, 125° 23.9′ "On plain 4 miles NW of Leopold Downs Station from rock debris on plain surface" (Napier Formation)—? zone
Pugnax sp. cf. *P. acuminatus*

KP156 17° 32.0′, 124° 55.5′ (Fairfield Beds)—*proteus* zone
Avonia proteus

KP157 17° 32.7′, 124° 55.0′ (Fairfield Beds)—*proteus* zone
Schuchertella dromeda

KP164 17° 34.8′, 124° 56.7′ (Fairfield Beds)—*proteus* zone
Camarotoechia lucida

KP167 17° 40.8′, 124° 57.0′ (Oscar Formation)—*proteus* zone
Avonia proteus
Pugnax sp. cf. *P. pugnus*

KP168 17° 29.5′, 124° 52.8′ (Fairfield Beds)—*proteus* zone
Avonia proteus

KP181 17° 35.3′, 124° 56.5′ (Fairfield Beds)—*proteus* zone
Meristella(?) *caprina*

M2 17° 10.2′, 124° 34.8′ "Station Creek, (Old) Napier Downs Homestead" (Fairfield Beds)—*proteus* zone
Avonia proteus
Meristella(?) *caprina*

M3 17° 10.3′, 124° 34.2′ "Station Creek, (Old) Napier Downs Homestead" (Fairfield Beds)—*proteus* zone
(?)*Avonia proteus*
Camarotoechia lucida

M8 17° 11.8′, 124° 32.0′ "Station Creek about 5 miles from (Old) Napier Downs Homestead" (Fairfield Beds)—*proteus* zone
Avonia proteus
Camarotoechia lucida

M9 17° 12.0′, 124° 31.8′ "Station Creek about 5 miles from (Old) Napier Downs Homestead" (Fairfield Beds)—*proteus* zone
Avonia proteus
Camarotoechia lucida
Meristella(?) *caprina*

3. List of Localities of Devonian brachiopods collected by WAPET during 1956 in the Oscar Area.

These brachiopods are kept by the Bureau of Mineral Resources in Canberra, except for a small representative collection deposited in the University of Western Australia.

Ld8 (Oscar Formation)—*saltica* or *torrida* zone
Atrypa desquamata kimberleyensis
Uncinulus wolmericus

Ld9 (Napier Formation)—*proteus* zone
Schizophoria pierrensis
(?) *Avonia proteus*

Ld10 (Napier Formation)—*proteus* zone
Camarotoechia lucida
Athyris oscarensis

Ld11 (Napier Formation)—*proteus* zone
Avonia proteus

Ld16 (Napier Formation)—*scopimus* zone
Nyege scopimus

Ld17 (Napier Formation)—*scopimus* zone
Nyege scopimus

Ld19 (Napier Formation)—? zone
Pugnax sp. cf. *P. pugnus*

Ld20 (Napier Formation)—*scopimus* zone
Nyege scopimus

Ld21 (Pillara Formation)—? *apena* zone
(?) *Crurithyris apena*

Ld25 ½ mile east of Mt. Percy (Fairfield Beds)—*proteus* zone
Athyris oscarensis
Camarotoechia lucida

Ld26 1 mile E.S.E. of Mt. Percy (Fairfield Beds)—*proteus* zone
Avonia proteus

Ld28 (Napier Formation)—? *proteus* zone
(?) *Avonia proteus*

Ld29 (Napier Formation)—? *scopimus* zone
Pugnax hullensis
Atrypa desquamata kimberleyensis

Ld30 (Napier Formation)—*scopimus* zone
Nyege scopimus

Ld31 (Napier Formation)—*apena* zone
Crurithyris apena
Hypothyridina margarita
Pugnax sp. cf. *P. pugnus*
(?) *Atrypa desquamata kimberleyensis*
cf. *Schizophoria stainbrooki*

Ld32 (Napier Formation)—*proteus* zone
Camarotoechia lucida

Ld33 (Oscar Formation)—*apena* or *saltica* zone
Hypothyridina margarita

F5 (Sadler Formation)—? zone
Schizophoria stainbrooki

S4/91 (Oscar Formation)—? *proteus* zone
(?) *Avonia proteus*

O/66 (Napier Formation/Pillara Formation)—? zone
Pugnax sp. cf. *P. pugnus*

O/67 (Napier Formation/Pillara Formation)—? *saltica* zone
Nervostrophia bunapica
(?) *Hypothyridina margarita*

O/73 (Oscar Formation)—*apena* or *saltica* zone
Hypothyridina margarita
Nervostrophia bunapica
Pugnax sp. cf. *P. pugnus*
P. sp. cf. *P. acuminatus*
Atrypa desquamata kimberleyensis
(?) *Crurithyris apena*

O/76 (Pillara Formation)—*saltica* zone
Ladjia saltica
Pugnax sp. cf. *P. acuminatus*

O/77 (Napier Formation)—? *scopimus* zone
Pugnax hullensis

TABLE 3.—AIR-PHOTOGRAPH CO-ORDINATES OF LOCALITIES.

Locality.	4-mile Map Area.	Run No.	Photo No.	Quadrant.	Co-ordinates.		
					x	y	Diagonal.
A. Bureau of Mineral Resources Localities.							
K98	Mount Ramsay	10	D 5372	A	0.70	2.94	3.02
K103	Mount Ramsay	10	D 5372	D	2.44	0.44	2.48
K108	Mount Ramsay	10	D 5371	B	3.56	0.60	3.60
K112	Mount Ramsay	10	D 5371	A	1.57	1.12	1.94
K121 (approx. position)	Mount Ramsay	10	D 5371	A	2.24	0.80	2.38
K126 (165ft. above base of DP3: co-ordinates of base of DP3)	Mount Ramsay	10	D 5371	A	2.30	0.80	2.44
K135	Mount Ramsay	10	D5371	D	2.54	0.90	2.70
K142, 144	Mount Ramsay	11	D5267	B	1.76	1.74	2.48
K145	Mount Ramsay	11	D5267	B	0.92	1.04	1.39
K147	Mount Ramsay	11	D5266	D	1.87	0.36	1.90
K148	Mount Ramsay	11	D5266	D	1.83	0.46	1.88
K150	Mount Ramsay	11	D5266	D	1.73	1.10	2.03
K153	Mount Ramsay	11	D5266	D	1.62	1.12	2.02
K154	Mount Ramsay	11	D5266	D	1.68	1.08	2.00
K159 to K170 are referred to base of DB1, whose co-ordinates are	Mount Ramsay	11	D5266	D	0.52	0.52	0.73
Top of DB1	Mount Ramsay	11	D5266	C	0.04	1.16	1.17
K172	Mount Ramsay	10	D5370	A	2.07	3.60	4.18
K173	Mount Ramsay	10	D5370	A	1.84	3.56	3.85
K174	Mount Ramsay	10	D5370	A	1.96	3.42	3.95
K177	Mount Ramsay	10	D5371	A	2.86	1.30	3.14
K179 (co-ordinates of DP2 H)	Mount Ramsay	11	D5265	D	3.50	0.76	3.60
K181	Mount Ramsay	11	D5265	D	4.02	0.90	4.12
K209, K213 referred to base of section Dmp2, whose co-ordinates are	Noonkanbah ..	8A	E5335	D	2.48	0.24	2.50
K214 (base of DD1) ..	Noonkanbah ..	8A	E5335	B	3.20	1.40	3.48
K215 to K231 referred to K214	..	..	..	..	..	..	..
K221	Noonkanbah ..	8A	E5335	B	2.60	2.06	3.32
K228	Noonkanbah ..	8A	E5335	B	2.36	2.38	3.36
K235 to K253 referred to base of DD2, whose co-ordinates are ..	Noonkanbah ..	9A	C5175	A	0.00	1.16	1.16

TABLE 3.—AIR-PHOTOGRAPH CO-ORDINATES OF LOCALITIES—*continued.*

Locality.	4-mile map area.	Run No.	Photo No.	Quadrant.	Co-ordinates.		
					x	y	Diagonal.
A. BUREAU OF MINERAL RESOURCES LOCALITIES—*continued.*							
K264 to K276 referred to base of DD3, whose co-ordinates are ..	Noonkanbah	6	5766	A	0.19	1.92	1.94
K282	Noonkanbah	1A	D5062	C	0.94	1.64	1.90
K287	Mount Ramsay	2	A5571	A	0.98	1.80	2.06
K289	Mount Ramsay	2	A5571	A	1.09	2.64	2.88
K290 to K292 referred to K289	..	..	..	..	..	...	..
K300	Noonkanbah	6	5766	B	0.28	2.06	2.08
K301	Noonkanbah	6	5766	B	0.19	2.12	2.14
K315, K318 referred to base of DL2; co-ordinates of base of Fairfield Beds in DL2	Mount Ramsay	2	A5572	C	0.07	0.48	0.49
K318	Mount Ramsay	2	A5571	A	1.02	2.17	2.40
K319	Mount Ramsay	2	A5574	B	2.34	1.60	2.84
K320 referred to K219 ..	..	..	..	..	..	..	..
K322	Mount Ramsay	2A	D5306	A	1.76	2.65	3.18
K327	Mount Ramsay	3	A5584	A	0.58	1.28	1.40
K341	Mount Ramsay	3	A5587	D	0.15	0.96	0.98
K355	Mount Ramsay	3	A5585	D	1.36	0.36	1.40
K356	Mount Ramsay	3	A5585	D	1.42	0.46	1.50
K438	Noonkanbah	7	5759	C	3.32	0.08	3.33
K463	Noonkanbah	6	5766	B	1.24	3.30	3.52
K480	Mount Ramsay	3	A5583	C	0.44	2.84	2.88
K503	Lennard River	15	5136	D	1.82	2.08	2.76
K506	Noonkanbah	2	A5024	D	1.68	0.15	1.70
K539	Lennard River	15	5150	B	2.54	2.19	3.36
K551	Lennard River	9	5072	A	0.05	2.08	2.10
K571, K572, K573 referred to base of Dmp5, whose co-ordinates are ..	Lennard River	3	5089	B	0.72	1.04	1.26
G23	Noonkanbah ..	9A	C5174	D	0.14	1.78	1.80
B. WEST AUSTRALIAN PETROLEUM PTY. LTD. LOCALITIES.							
Ld8	Lennard River	11	5074	B	1.15	0.05	—
Ld9	Lennard River	11	5075	D	0.13	0.23	—
Ld10	Lennard River	11	5073	D	2.45	0.08	—
Ld11	Lennard River	11	5073	D	1.54	0.08	—
Ld16	Lennard River	11	5072	D	0.31	0.06	—
Ld17	Lennard River	11	5072	A	0.08	0.10	—
Ld19	Lennard River	11	5072	C	0.97	1.60	—
Ld20	Lennard River	11	5072	C	1.31	1.14	—
Ld21	Lennard River	12	5015	A	1.43	1.04	—
Ld25	Lennard River	10	5012	A	0.94	0.90	—
Ld26	Lennard River	10	5012	A	1.31	0.39	—
Ld30	Lennard River	11	5072	B	0.17	0.19	—
*Ld28							
*Ld29							
Ld31	Lennard River	11	5072	C	0.94	1.13	—
*Ld32							
Ld33	Lennard River	11	5073	A	1.21	3.39	—
S 4/91	Lennard River	13	5066	A	0.77	1.10	—
0/66	Lennard River	11	5072	B	0.98	2.50	—
0/67	Lennard River	11	5072	B	1.06	2.59	—
0/73	Lennard River	11	5074	C	2.34	1.13	—
0/76	Lennard River	11	5072	B	0.26	0.31	—
0/77	Lennard River	11	5072	B	0.26	0.29	—

* Data not supplied.

BIBLIOGRAPHY

ALEXANDER, FRANCES E. S., 1949.—A revision of the brachiopod species *Anomia reticularis* Linnaeus, genolectotype of *Atrypa* Dalman. *Quart. J. geol. Soc. Lond.*, 207-220, pls. 9, 10, 2 text-figures.

ALMELA, A., and REVILLA, J., 1950.—Especies fósiles neuvas del devoniana de León. *Not. Comun. Inst. Geol. Min. España*, 20, 45-60, pls. 1-3.

AMSDEN, T. W., 1958.—Haragan articulate brachiopods, *in* Stratigraphy and paleontology of the Hunton Group in the Arbuckle Mountain region, by T. W. Amsden and A. J. Boucot. *Okla. geol. Surv. Bull.* 78.

ARBER, MURIEL A., 1939.—The nature and significance of the pedicle foramen of *Leptaena* Dalman. *Geol. Mag.*, 76, 82-92, 3 text-figures.

ARBER, MURIEL A., 1940.—The relation of the valves to the pedicle in the Strophomenid brachiopods. *Ibid.*, 77, 161-174, 3 text-figures.

ARBER, MURIEL A., 1942.—The pseudodeltidium of the Strophomenid brachiopods. *Ibid.*, 79, 179-187, 3 text-figures.

BEECHER, C. E., 1901.—STUDIES IN EVOLUTION. N.Y. & London. Yale Bicentennial Publications.

BELANSKI, C. H., 1928.—Pentameracea of the Devonian of Northern Iowa. *Univ. Iowa Stud.*, n.s. 12, (7), 3-34, 4 pls., 15 text-figures.

BENSON, W. N., 1922.—Materials for the study of the Devonian palaeontology of Australia. *Rec. geol. Surv. N.S.W.*, 10 (2), 83-204, pls. 13, 14.

BLATCHFORD, T., 1927.—Geology of portions of the Kimberley Division, with special reference to the Fitzroy Basin and the possibilities of the occurrence of mineral oil. *Bull. geol. Surv. W.Aust.*, 93, 56 pp.

BORGHI, P., 1939.—Fossili Devonici del Fezzan. *Publ. Inst. Geol. Palaeont. Geogr. fis. Univ. Milano*, Ser. P, 15, 115-183, pls. i-v.

BRANSON, E. B., 1922.—The Devonian of Missouri. *Missouri Bur. Geol. Mines*, 17, (2nd ser.), 279 pp., 71 pls.

BROWN, IDA A., 1944.—Stringocephalid Brachiopoda in eastern Australia. *J. Roy. Soc. N.S.W.*, 77 (1), 119-129.

BROWN, R. W., 1954.—THE COMPOSITION OF SCIENTIFIC WORDS. Published by the author, Washington, pp. 1-882.

CLARKE, J. M., 1884.—Die Fauna des Iberger Kalkes. *Neues Jb. Miner. Beil. Bd*, 3, 385.

CLOUD, Jr. P. E., 1942.—Terebratuloid Brachiopoda of the Silurian and Devonian. *Geol. Soc. Amer. Spec. Pap.* 38, 182 pp., 26 pls., 17 text-figs.

COLEMAN, P. J., 1951.—*Atrypa* in Western Australia. *J. Paleont.*, 25, 677-690, pls. 100-102, text-figs. 1-3; Addendum. *Ibid.*, 26 (5), 861 (1952).

COOPER, G. A., 1944.—Phylum Brachiopoda, *in* INDEX FOSSILS OF NORTH AMERICA, by H. W. Shimer & R. S. Shrock. The Technology Press, Massachusetts Inst. Tech., pp. 277-365, pls. 105-143.

COOPER, G. A., 1945.—New species of brachiopods from the Devonian of Illinois and Missouri. *J. Paleont.*, 19 (5), 479-489, pls. 63, 64.

COOPER, G. A., 1955.—New genera of Middle Paleozoic brachiopods. *Ibid.*, 29, 45-63, pls. 11-14, 1 text-fig.

COOPER, G. A., and CLOUD, Jr., P. E., 1938.—New Devonian fossils from Calhoun County, Illinois. *Ibid.*, 12, 444-460, pls. 54, 55.

COOPER, G. A., and WILLIAMS, J. S., 1935.—Tully Formation of New York. *Bull. geol. Soc. Amer.*, 46, 781-868, pls. 54-60, 7 text-figs.

CRICKMAY, C H., 1952.—Discrimination of the late Upper Devonian. *J. Paleont.*, 26 (4), 585-609, pls. 70-78.

DAVIDSON, T., 1864.—A monograph of British Brachiopoda, III, Pt. VI. The Devonian Brachiopoda. *Monogr. Palaeontogr. Soc.*, 17, 1-131, 20 pls.

DELÉPINE, G., 1935.—Upper Devonian goniatites from Mt. Pierre, Kimberley District, Western Australia. *Quart. J. geol. Soc. Lond.*, 91, 208-15, pls. 12, 13.

DEMANET, F., 1934.—Les Brachiopodes du Dinantien de la Belgique. *Mém. Mus. Hist. nat. Belg.*, 61, 1-114, 10 pls.

DEMANET, F., 1941.—Faune et stratigraphie de l'étage Namurien de la Belgique. *Ibid.*, 97, 327 pp., 18 pls.

ETHERIDGE, Jr., R., 1897.—An *Actinoceras* from north-west Australia. *Rec. Aust. Mus.*, 3, 7-9, pl. 3.

ETHERIDGE, Jr., R., 1918.—Observations on Carboniferous and other fossils . . . *Proc. S.Aust. Br. Roy. geogr. Soc. Aust.*, 18 (1916-17), 250-262, pls. 39, 40.

FENTON, C. L., and FENTON, M. A., 1924.—The stratigraphy and fauna of the Hackberry Stage of the Upper Devonian. *Contr. Mus. Geol. Univ. Mich.*, 1, 260 pp., 45 pls.

FERGUSON, A. R., 1951.—Cellulose peels as a technical aid in geology and metallurgy. *Sci. Technol. Assoc. Bull. Lond.*, 1-3.

FLETCHER, H. O., 1943.—The genus *Conocardium* from Australian Palaeozoic rocks. *Aust. Mus. Rec.*, 21, 231-242.

FOORD, A. H., 1890.—Description of fossils from the Kimberley District, Western Australia. *Geol. Mag.*, n.s., dec. 3, 7, 98-106, pls. 4 & 5.

GEORGE, T. N., 1931.—*Ambocoelia* Hall and certain similar British Spiriferidae. *Quart. J. geol. Soc. Lond.*, 87, 30-61, pls. 3-5.

GILL, E. D., 1950.—Preliminary account of the palaeontology and palaeoecology of the Eldon Group formations of the Zeehan Area, Tasmania. *Pap. Roy. Soc. Tas.*, 231-258, 1 pl.

GOLDRING, R., 1957.—The last toothed Productellinae in Europe. *Paläont. Z.*, 31 (3/4), 207-228, pl. 24.

GRABAU, A. W., 1931.—Devonian Brachiopoda of China: I: Devonian Brachiopoda from Yunnan and other Districts in South China. *Palaeont. sinica*, ser. B, 3 (3), 545 pp., 67 text-figs., 54 pls. (plates published 1933).

GUPPY, D. J., and ÖPIK, A. A., 1950.—Discovery of Ordovician rocks, Kimberley Division, Western Australia. *Aust. J. Sci.*, 12 (6), 205.

GUPPY, D. J., LINDNER, A. W., RATTIGAN, J. H., and CASEY, J. N., 1958.—Geology of the Fitzroy Basin, Western Australia. *Bur. Min. Resour. Aust. Bull.* 36.

GÜRICH, G., 1896.—Das Palaeozoicum im Polnischen Mittelgebirge. *Verh. russ.-kais. min. Ges. St. Petersb.*, 2nd ser., 32, 1-539, pls. 1-15.

HALL, J., 1852.—Palaeontology of New York, II: containing descriptions of the organic remains of the lower middle division of the New York System. *Nat. Hist. N.Y.*, Albany, 362 pp., 85 pls.

HALL, J., 1867.—Idem, 4, (1): containing descriptions and figures of the fossil brachiopods of the Upper Helderberg, Hamilton, Portage and Chemung Groups. *Ibid.*, 428 pp., 63 pls.

HALL, J., and CLARKE, J. M., 1892, 1894.—Idem, 8: an introduction to the study of the genera of Palaeozoic Brachiopoda. *Ibid.*, pt 1, 1892, 367 pp., 20 pls., 37 text-figures; pt 2, 1894, 394 pp., 84 pls., 271 text-figures.

HALL, J., and WHITFIELD, R. P., 1877.—Palaeontology, *in U.S. geol. Expl. 40th Parallel*, 4 (2). *Prof. Pap. engng Dep. U.S. Army*, 18, 199-302, pls. 1-7.

HARDMAN, E. T., 1884.—Report on the geology of the Kimberley District, Western Australia. *W.Aust. parl. Pap.* 31.

HARDMAN, E. T., 1885.—Idem. *Ibid.*, 34.

HILL, DOROTHY, 1936.—Upper Devonian corals from Western Australia. *J. Roy. Soc. W.Aust.*, 22, 25-29.

HILL, DOROTHY, 1939.—Western Australian Devonian corals in the Wade Collection. *J. Roy. Soc. W.Aust.*, 25, 141-151, 1 pl.

HILL, DOROTHY, 1954.—Coral faunas from the Silurian of New South Wales and the Devonian of Western Australia. *Bur. Min. Resour. Aust. Bull.* 23, 51 pp., 4 pls.

HOSKING, LUCY F. V., 1933.—Distribution of Devonian rocks in the Kimberley Division; and description of a recent collection of Devonian fossils from the Kimberley Division. *J. Roy. Soc. W.Aust.*, 19, 67-76, pl. 7, 1 text-fig.

HOWELL, B. F., 1952.—Four new Devonian sponges from Western Australia. *Bull. Wagner Inst. Sci.*, 27 (1).

HOWELL, B. F., 1956.—A new Devonian *Sphaerospongia* from Western Australia. *Ibid.*, 31 (1).

HOWELL, B. F., 1957.—A new Devonian Sponge, *Striatospongia cylindrica* from Western Australia. *Ibid.*, 32 (1).

KAYSER, E., 1871.—Die Brachiopoden des Mittel-und Ober-Devon der Eifel. *Z. dtsch. geol. Ges.*, 23, 491-647, pls. 9-14.

KAYSER, E., 1872.—Neue Fossilien aus dem rheinischen Devon. *Ibid.*, 24, 691-700, pls. 27, 28.

KAYSER, E., 1881.—Ueber einige neue devonische Brachiopoden. *Ibid.*, 33 (2), 331-337, pl. 19.

VON KELUS, A., 1939.—Devonische Brachiopoden und Korallen der Umgebung von Pelcza, in Volhynien. *Bull. Serv. géol. Pol.*, 8, 1-51, 3 pls., 41 text-figs.

KEYSERLING, A. GRAF., 1846.—WISSENSCHAFTLICHE BEOBACHTUNGEN AUF EINER REISE IN DAS PETSCHORA-LAND, IM JAHRE 1843. St. Petersburg, Carl Kray, 1-465, 22 pls., 2 maps.

KINDLE, E. M., 1901.—The Devonian fossils and stratigraphy of Indiana. *Ann. Rep. Ind. Dep. Geol. nat. Resour.*, 25 (1900), 529-758, pls. 1-31.

KINDLE, E. M., 1909.—The Devonian fauna of the Ouray limestone. *U.S. geol. Surv. Bull.*, 391, 1-60, 10 pls.

KOZLOWSKI, R., 1929.—Les Brachiopodes Gothlandiens de la Podolie Polonaise. *Palaeont. polon.*, 1, 254 pp., 45 figs., 1 map, 12 pls.

LEIDHOLD, C., 1928.—Beitrag zur Kenntis der Fauna des rheinischen Stringocephalenkalkes, in besondere seiner Brachiopodenfauna, Teil I. *Abh. preuss. geol. Landesanst.*, n.f., 109.

MAILLIEUX, E., 1910.—Étude comparative de la repartition des espèces fossiles dans le Frasnien inférieur du bord meridional du bassin dinantais et dans les niveaux synchroniques du Boulonnais. *Bull. Soc. belge Géol.*, 23, 115-151, 3 figs.

MANSUY, H., 1912.—Étude géologique du Yun-nan Oriental: Pt. 2, Paléontologie. *Mém. Serv. géol. Indoch.*, 1 (2), 1-147, pls. 1-XXV.

MAURER, F., 1885.—DIE FAUNA DER KALKE VON WALDGIRMES BEI GIESSEN.

MAXWELL, W. G. H., 1950.—An Upper Devonian brachiopod (*Cyrtospirifer reidi* sp. nov.) from the Mt. Morgan District. *Publ. Univ. Qld Dep. Geol.*, 3 (12), 8 pp., 1 pl.

MAXWELL, W. G. H., 1951.—Upper Devonian and Middle Carboniferous brachiopods of Queensland. *Ibid.*, 3 (14), 27 pp., 4 pls.

MAXWELL, W. G. H., 1954.—Upper Palaeozoic formations in the Mt. Morgan District—Faunas. *Ibid.*, 4 (5), 58 pp., 6 pls.

MILORADOVICH, B. V., 1937.—Morphogensis of the ventral valve in Spiriferidae. *Probl. Palaeont. Publ. palaeont. Lab. Univ. Mosc.*, 2-3, 501-535, 32 text-figs.

MUIR-WOOD, HELEN M., 1934.—On the internal structure of some Mesozoic Brachiopoda. *Phil. Trans.*, ser. B, 223, 511-567, pls. 62, 63.

MUIR-WOOD, HELEN M., 1951.—The Brachiopoda of Martin's "Petrificata Derbiensia". *Ann. Mag. nat. Hist.*, ser. 12 (4), 97-118, pls 3-6.

MUIR-WOOD, HELEN M., 1953.—Techniques employed in grinding and illustrating serial transverse sections of fossil Brachiopoda: *Ibid.*, 12 (6), 919-922, 1 diagram.

MUIR-WOOD, HELEN M., 1955.—A HISTORY OF THE CLASSIFICATION OF THE PHYLUM BRACHIOPODA. Lond., Brit. Mus. (nat. Hist.), 124 pp., 12 text-figs.

MUIR-WOOD, HELEN M., and OWEN, E. F., 1952.—The use of acetic acid in developing brachiopod shells. *Proc. Geol. Ass., Lond.*, 63, 313-315.

MÜLLER, K. J., 1956.—Taxonomy, nomenclature, orientation, and stratigraphic evaluation of conodonts. *J. Paleont.*, 30 (6), 1324-40.

MURCHISON, R. I., 1840.—Sur les roches dévoniennes que se trouvent dans le Boulonnais. *Bull. Soc. géol. Fr.*, 11, 229-256.

NALIVKIN, D., 1930a.—The Semiluki and the Voroneje beds of the Upper Devonian of Voroneje region. *Bull. geol.-prosp. Serv. U.S.S.R.*, 49 (1), 53-93, pls. 6-8.

NALIVKIN, D., 1930b.—Brachiopods from the Upper and Middle Devonian of the Turkestan: *Mém. Comm. géol. U.R.S.S.*, n.s., 180, 1-221, pls. 1-10.

NALIVKIN, D, 1937.—Brachiopods of the Upper and Middle Devonian and Lower Carboniferous of North-eastern Kazakhstan: *Trans. cent. geol.-prosp. Inst.*, 99, 1-200, pls. 1-39, (Eng. summ. pp. 134-162).

NALIVKIN, D., 1941.—Brachiopods of the Main Devonian Field *in* Fauna of the Main Devonian Field. *Palaeont. Inst. Acad. Sci. U.S.S.R.* 139-226, 8 pls.

NEAVERSON, E., 1955.—STRATIGRAPHICAL PALAEONTOLOGY, A STUDY OF ANCIENT LIFE-PROVINCES, 2nd Ed. Oxford, Clarendon, viii + 806, 18 pls.

NEWELL, N. D., RIGBY, J. K., FISCHER, A. G., WHITEMAN, A. J., HICKS, J. E., and BRADLEY, J. S., 1953.—PERMIAN REEF COMPLEX OF THE GUADELUPE MOUNTAINS REGION, TEXAS AND NEW MEXICO. San Francisco, Freeman, 236 pp., 32 pls.

OEHLERT, D.-P., 1887.—Brachiopodes du Dévonien de l'ouest de la France. *Bull. Soc. Ét. sci. d'Angers*, 8 pp., 1 pl.

OEHLERT, D.-P., 1897.—Fossiles dévoniens de Santa Lucia (Espagne) I. *Bull. Soc. géol. Fr.* Ser. 3, 24, 814-875, pls. 26-28.

ÖPIK, A., 1934.—Über Klitamboniten. *Publ. geol. Instn Univ. Tartu*, 39, 239 pp., 48 pls.

PAECKELMANN, W., 1913.—Das Oberdevon des bergischen Landes. *Abh. preuss. geol. Landesanst.*, n.f., 70, 1-356, pls. 1-6.

PARKINSON, D., 1954a.—Quantitative studies of brachiopods from the Lower Carboniferous reef limestones of England. II: *Pugnax pugnus* (Martin) and *P. pseudopugnus* n.sp. *J. Paleont*, 28, 563-573, pl. 58, 18 text-figs.

PARKINSON, D., 1954b.—Idem, III: *Pugnax acuminatus* (J. Sowerby) and *P. mesogonus* (Phillips). *Ibid.*, 28, 668-676, 12 text-figs.

PHILLIPS, J., 1841.—FIGURES AND DESCRIPTIONS OF THE PALAEOZOIC FOSSILS OF CORNWALL, DEVON AND WEST SOMERSET. London, Longmans, Brown, Green, & Longmans, 231 pp., 60 pls.

POULSEN, C., 1943.—The Silurian faunas of North Greenland. *Medd. Grønld*, 72 (3), 1-60, 6 pls., 22 text-figs.

PRENDERGAST, KATHLEEN L., 1935.—Some Western Australian Upper Palaeozoic fossils. *J. Roy. Soc. W. Aust.*, 21, 9-35, pls. 2-4, 6 text-figs.

QUENSTEDT, F. A., 1871.—PETREFACTENKUNDE DEUTSCHLANDS. Abt. 1 (2), Brachiopoden, 748 pp., 25 pls.

REED, F. R. C., 1912.—Devonian fossils from Chitral, Persia, Afghanistan, and the Himalayas. *Rec. geol. Surv. India*, 41 (2), 86-100, pls. 7, 8.

REED, F. R. C., 1922.—Devonian fossils from Chitral and the Pamirs. *Palaeont. Indica*, n.s., 6 (2), 133 pp., 16 pls.

REED, F. R. C., 1943.—Notes on certain Upper Devonian brachiopods figured by Whidborne. *Geol. Mag.*, 80, 68-78, 95-106, 132-138.

RIGAUX, E., 1873.—Notes pour servir à la Géologie du Boulonnais. 1: Description de quelques Brachiopodes du terrain Dévonien de Ferques. *Mém. Soc. Acad. Boulogne-sur-Mer*, 5 (1873-1876), 47-60, 1 pl.

RIGAUX, E., 1894.—Notice géologique sur le Bas Boulonnais. *Ibid.*, 19 (1891-1894), 5-108, pls. 1, 2, 2 tables.

RIGAUX, E., 1908.—LE DÉVONIEN DE FERQUES ET SES BRACHIOPODES. Boulogne-Sur-Mer, Chez Mlle Deligny.

RIPPER, ELIZABETH A., 1937.—A note on the occurrence of *Amphipora ramosa* (Phillips) in Western Australia. *J. Roy. Soc. W. Aust.*, 23, 37-41.

ROEMER, F. A., 1843.—DIE VERSTEINERUNGEN DES HARZGEBIRGES. 40 pp., 12 pls., Hannover.

ROGER, J., 1952.—Classe des Brachiopodes, *in* TRAITÉ DE PALÉONTOLOGIE, directed by Jean Piveteau. Paris, Masson et Cie, 2, 3-160, pls. 1-12, 121 text-figs.

SARYCHEVA, T. G., and SOKOLSKAYA, A. N., 1952.—Key to the Palaeozoic Brachiopoda of the Moscow Basin. *Trans. palaeont. Inst. Mosc.*, 38, 1-307, 71 pls., 231 figs. (in Russian).

SCHMIDT, HERTA, 1941.—Die mitteldevonischen Rhynchonelliden der Eifel. *Abh. senck. natur. Ges.*, 459, 1-79, pls. 1-7, 1 text-fig.

SCHNUR, J., 1854.—Zusammenstellung und Beschriebung sammtlicher in Uebergangsgebirge der Eifel vorkommenden Brachiopoden nebst Abbildung derselben. *Palaeontographica*, 3, 169-254, pls. 22-45.

SCHUCHERT, C. A., and COOPER, G. A., 1932.—Brachiopod genera of the suborders Orthoidea and Pentameroidea. *Peabody Mus. nat. Hist., Mem.* 4 (1), 1-270, 29 pls., 36 text-figs.

SIMPSON, B., 1933.—A Study in variation, *Pugnax pugnus* Martin and *Pugnax* cf. *sulcatus* J. de C. Sow. *Naturalist, Lond.*, 914, 57-77, 7 text-figs.

SOKOLSKAYA, A. N., 1950.—Chonetidae of the Russian Platform. *Trud. palaeont. Inst. Akad. Nauk, S.S.S.R.*, 27, 1-107, 13 pls.

STAINBROOK, M. A., 1938a.—*Atrypa* and *Stropheodonta* from the Cedar Valley Beds of Iowa. *J. Paleont.*, 12, 229-256, pls. 30-35.

STAINBROOK, M. A., 1938b.—Pentameridae of the Cedar Valley Beds of Iowa. *Amer. Midl. Nat.*, 19, 723-739, pls. 1-2, 8 text-figs.

STAINBROOK, M. A., 1940.—Orthoid brachiopods of the Cedar Valley limestone of Iowa. *Ibid.*, 23, 482-492, pls. 1, 2.

STAINBROOK, M. A., 1942a.—Brachiopoda of the Cedar Valley Beds of Iowa—Inarticulata, Rhynchonellacea and Rostrospiracea. *J. Paleont.*, 16, 604-619, pls. 88, 89, 6 text-figs.

STAINBROOK, M. A., 1942b.—Brachiopoda of the High Point Sandstone of New York. *Amer. J. Sci.*, 240, 879-890, pls. i, ii.

STAINBROOK, M. A., 1943a.—Strophomenacea of the Cedar Valley limestone of Iowa. *J. Paleont.*, 17, 39-57, pls., 6, 7.

STAINBROOK, M. A., 1943b.—Spiriferacea of the Cedar Valley limestone of Iowa. *Ibid.*, 17, 417-450, pls. 65-70, 14 text-figs.

STAINBROOK, M. A., 1945.—Brachiopoda of the Independence shale, Iowa. *Mem. geol. Soc. Amer.* 14, 1-74, pls. 1-6, 2 text-figs.

STAINBROOK, M. A., 1947.—Brachiopods of the Percha shale of New Mexico and Arizona. *J. Paleont.*, 21, 297-328, pls. 44-47.

STAINBROOK, M. A., 1948.—Age and correlation of the Devonian Sly Gap Beds near Alamogordo, New Mexico. *Amer. J. Sci.*, 246 (12), 765-790, 2 pls.

STAINBROOK, M. A., 1950.—Brachiopoda and stratigraphy of the Aplington formation of northern Iowa. *J. Paleont.*, 24, 365-385.

TEICHERT, C., 1939.—Nautiloid cephalopods from the Devonian of Western Australia. *J. Roy. Soc. W. Aust.*, 25, 103-121, 2 pls., 2 text-figs.

TEICHERT, C., 1940.—Actinosiphonate cephalopods (Cyrtoceroida) from the Devonian of Australia. *Ibid.*, 26, 59-75, 4 pls., 2 text-figs.

TEICHERT, C., 1941.—Upper Devonian goniatite succession of Western Australia. *Amer. J. Sci.*, 239, 148-153.

TEICHERT, C., 1943.—The Devonian of Western Australia: a preliminary review. *Amer. J. Sci.*, 241, 69-94 and 167-184.

TEICHERT, C., 1947.—Stratigraphy of Western Australia. *J. Roy. Soc. N.S.W.*, 80, 81-142, pls. 4-7, 10 text-figs.

TEICHERT, C., 1948.—A simple device for coating fossils with ammonium chloride. *J. Paleont.*, 22, 102-104, 1 text-fig.

TEICHERT, C., 1949.—Observations on stratigraphy and palaeontology of Devonian, western portion of Kimberley Division, Western Australia. *Bur. Min. Resour. Aust. Rep.* 2, 1-55, pls. 1-6, 2 tables, 1 text-fig.

TEICHERT, C., and GLENISTER, B. F., 1952.—Fossil nautiloid faunas from Australia. *J. Paleont.*, 26 (5), 730-752, pls. 104-108.

THOMAS, G. A., 1957.—Lower Carboniferous deposits in the Fitzroy Basin, Western Australia. *Aust. J. Sci.*, 19 (4), 160-161, 1 fig.

THOMSON, J. A., 1927.—Brachiopod morphology and genera (Recent and Tertiary). *Manual N.Z. Board Sci. Art*, 7, 338 pp., 2 pls. 103 text-figs.

TORLEY, K., 1908.—Die Fauna des Schleddenhofes bei Iserholm. *Abh. preuss. geol. Landesanst.*, n.f., 53, 1-56, pls. 1-10.

TORLEY, K., 1934.—Die Brachiopoden des Massenkalkes der Oberen Givet-Stufe von Bilveringsen bei Iserholm. *Abh. senck. natur. Ges.*, 43 (3), 67-148, 9 pls.

TSCHERNEYSCHEW, T., 1887.—Die Fauna des mittleren und oberen Devon am West-Abhange des Urals. *Mém. Comm. géol. St Petersb.*, 3 (3), 1-208, pls. 1-14.

ULRICH, E. O., and COOPER, G A., 1938.—Ozarkian and Canadian Brachiopoda. *Geol. Soc. Amer., Spec. Pap.* 13, 323 pp., 57 pls., 14 text-figs.
VANDERCAMMEN, A., 1956.—Revision des Ambocoeliinae de la Belgique. *Bull. Inst. roy. Sci. nat. Belg.* 32 (43), 51 pp., 2 pls., 36 text-figs.
VANUXEM, L., 1842.—Geology of New York: Pt. 3, comprising the survey of the Third geological district. *Nat. Hist. N.Y., Albany,* 306 pp., 80 text-figs.
VEEVERS, J. J., 1959a.—Size and shape variation in the brachiopod *Schizophoria* from the Devonian of Western Australia. *J. Paleont.*, 33. (in press)
VEEVERS, J. J., 1959b.—The type species of *Productella, Emanuella, Crurithyris* and *Ambocoelia* (Brachiopoda). *J. Paleont.*, 33. (in press)
VERNEUIL, E. de, 1845.—Paléontologie: part 3, vol. 2, *of* GÉOLOGIE DE LA RUSSIE D'EUROPE ET DES MONTAGNES DE L'OURAL *by* R. I. Murchison, E. de Verneuil and A. de Keyserling. London, John Murray, 512 pp., 43 pls.
WHIDBORNE, G. F., 1893.—Devonian fauna of the south of England, 2 (3). *Palaeontogr. Soc. Monogr.*, 47, 91-160, pls. 11-18.
WILLARD, B., 1939.—The Devonian of Pennsylvania: Middle and Upper Devonian. *Pa geol. Surv., 4th. ser., Bull.* G. 19.
WILLIAMS, A., 1950.—New Stropheodontid brachiopods. *J. Wash. Acad. Sci.*, 40 (9), 277-282, 17 text-figs.
WILLIAMS, A., 1953a.—The classification of the Strophomenoid brachiopods. *Ibid.*, 43 (1), 1-13, 13 text-figs.
WILLIAMS, A., 1953b.—North American and European Stropheodontids: their morphology and systematics. *Mem. geol. Soc. Amer.*, 56, 67 pp., 13 pls., 5 text-figs.
WILLIAMS, A., 1956.—The calcareous shell of the Brachiopoda and its importance to their classification. *Biol. Rev.*, 31, 243-287.

PLATE 1.

Skenidium asellatum sp. nov. .. .. .. Page 33

Figs. 1-11, all x 4

1-3. External, internal and tilted back internal views of the holotype, C.P.C. 2912.
4-7. Posterior, interior, external and lateral views of ventral valve, C.P.C. 2914.
8. Internal view of C.P.C. 2913, a dorsal valve showing deeply impressed anterior adductor scars.
9. Internal view of a dorsal valve, C.P.C. 2915, showing long flat outer hinge-plate.
10. Internal view of C.P.C. 3020, a ventral valve, showing low median ridge.
11. Internal view of C.P.C. 2916, a dorsal valve showing internal ribbing.

Sadler Formation, Sadler Ridge and Menyous Gap areas.

Hypsomyonia niphana sp. nov. .. .. .. Page 35

Figs. 12-22, all x 4

12-16. Dorsal, ventral, posterior, lateral and anterior views of holotype, C.P.C. 2917.
17. Internal view of ventral valve, C.P.C. 2921, showing marginal grooves.
18-20. Dorsal, ventral and anterior views of C.P.C. 2918.
21-22. Internal views of dorsal valves, C.P.C. 2919 and 2920, showing bilobed cardinal process, long divergent inner socket plates, adductor platform, and long median septum.

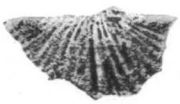
Sadler Formation, Sadler Ridge and Menyous Gap areas.

Kayserella emanuelensis sp. nov. .. .. .. Page 41

Figs. 23-32, all x 4; fig. 33, x 25

23-27. Dorsal, ventral, posterior, lateral and anterior views of the holotype, C.P.C. 2922.
28-32. Dorsal, ventral, anterior, posterior and lateral views of C.P.C. 2923.
33. Median part of dorsal valve of C.P.C. 2923 enlarged (x 25) to show major costellae separated by linear minor costellae, and grooves crowded with puncta in single or double rows.

Sadler Formation, Sadler Ridge area.


1


2


3


4


5


6


7


8


9


10


11


12


13


14


15


16


17


18


19


20


21


22


23


24


25


26


27


28


29


30


31?


33


32

PLATE 2.

Teichertina fitzroyensis gen. et sp. nov. .. .. .. Page 37

Figs. 1-16, all x 3½

1-5. Dorsal, ventral, posterior, lateral and anterior views of holotype, C.P.C. 2929.
6-10. Dorsal, ventral, posterior, lateral and anterior views of C.P.C. 2924.
11. Anterior view of ventral valve, C.P.C. 2926, showing the teeth with crural fossettes and the vestigial dental plates.
12. Posterior view of the preceding specimen showing the pedicle collar.
13. Anterior view of ventral valve, C.P.C. 2925, showing vestigial dental plates and the depressed sub-apical muscle field.
14. Posterior view of preceding specimen, showing pedicle collar.
15. Internal view of dorsal valve, C.P.C. 2928 (with anterior part of ventral valve still attached), showing deep sockets confined by strong fulcral plates, and the grooved internal surface.
16. Internal view of dorsal valve, C.P.C. 2927, showing elevated muscle field and the broad median ridge; most of the interior is thickened by callus deposits.

Sadler Formation, Sadler Ridge and Menyous Gap areas.

Isorthis (*?*) sp. .. .. Page 46

Figs. 17-21, all x 1

Dorsal, ventral, lateral, anterior and posterior views of C.P.C. 2930.

Sadler Formation, Sadler Ridge area.

Rhipidomella incompta sp. nov. .. .. .. Page 43

Figs. 22-29, all x 1.

22-25. Dorsal, ventral, lateral and anterior views of the holotype U.W.A. 26016a.
26-29. Dorsal, ventral, lateral and anterior views of U.W.A. 26016b.

Virgin Hills Formation, eastern slope of Mt. Pierre.

Schizophoria sp. ind. .. .. Page 54

Figs. 30-38, all x 1

30-34. Dorsal, ventral, lateral, posterior and anterior views of C.P.C. 2932, an almost entire shell compressed anteriorly.
35-38. Dorsal, ventral, lateral and anterior views of C.P.C. 2931, an almost entire shell compressed anteriorly.

Sadler Formation, Sadler Ridge.

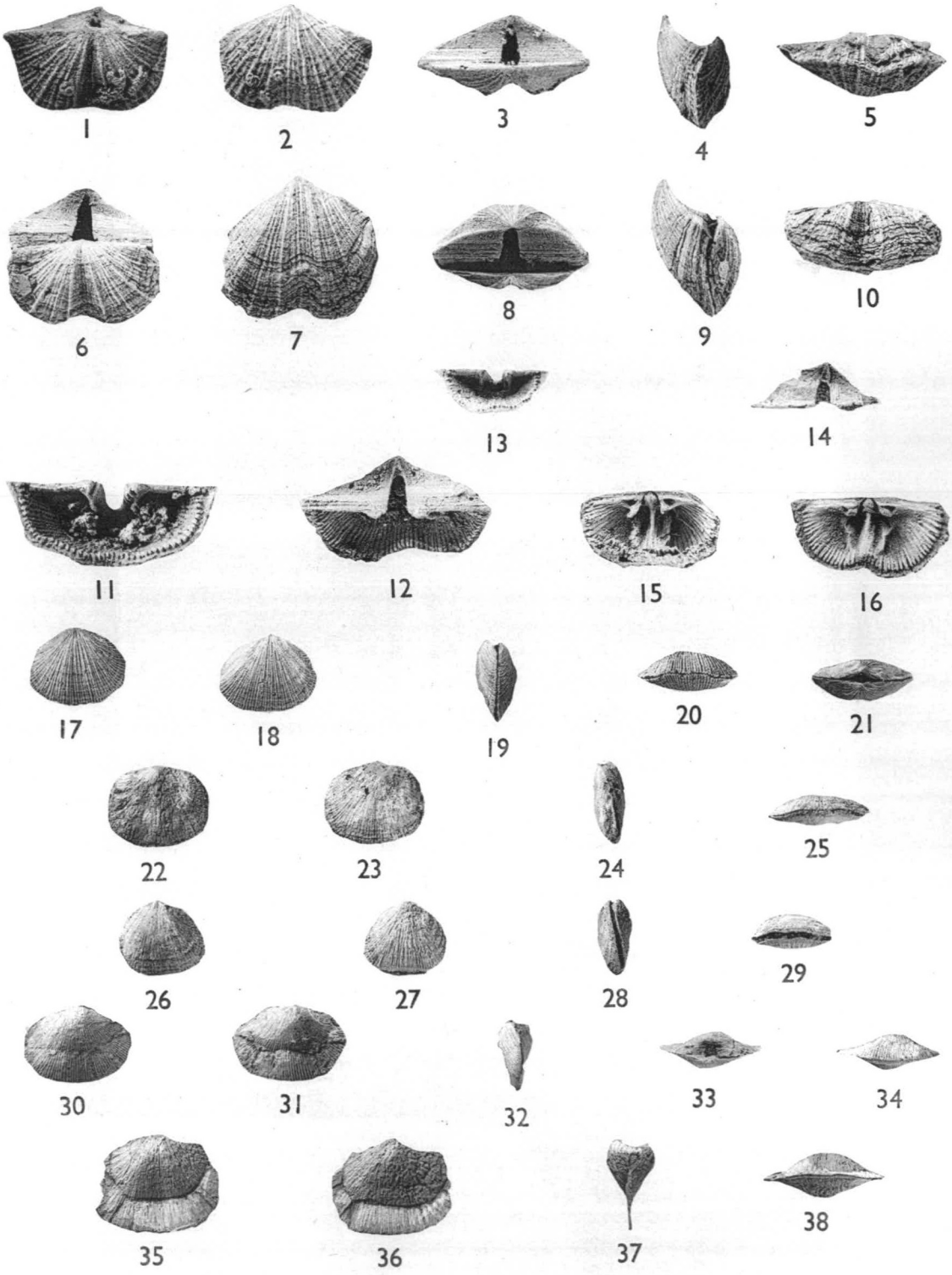

1
2
3
4
5
6
7
8
9
10
13
14
11
12
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

PLATE 3.

Schizophoria stainbrooki sp. nov. .. .. .. Page 48

Figs. 1-13, all x 1 except fig. 11 (x 2) and fig. 13 (x 10)

1-5. Dorsal, ventral, anterior, lateral and posterior views of holotype, C.P.C. 2901. The small coiled tube attached to the dorsal valve is *Spirorbis*.

6. Internal view of dorsal valve, C.P.C. 2902, showing inner socket plates and tiny cardinal process.

7. Internal view of ventral valve, C.P.C. 2903, showing obcordate muscle field, pallial sinuses, and genital markings.

8. Ventral view of broken shell, C.P.C. 2908, showing external surface with numerous thin hollow costellae and faint concentric growth-lines.

9. Internal view of a senile ventral valve, C.P.C. 2904, showing long adjustor deposits, coarse genital markings, and arborescent pallial sinuses.

10. External view of dorsal valve, C.P.C. 2907, showing a long narrow median sulcus.

11. Internal view (x 2) of dorsal valve C.P.C. 2905, showing simple oval adductors separated by a smooth surface divided by a low narrow median ridge.

12. Internal view (x 1) of fragment of a senile dorsal valve, C.P.C. 2906, showing anterior adductors encompassed by broad low ridges.

13. Internal view (x 10) of the apex of ventral valve C.P.C. 2903, figured above (fig 7), showing transversely striated apical plate.

Sadler Formation, Sadler Ridge.

Schizophoria pierrensis sp. nov. .. .. .. Page 50

Figs. 14-22, all x 1

14-17. Dorsal, ventral, anterior and lateral views of holotype, U.W.A. 26044c.

18-22. Dorsal, ventral, anterior, lateral and posterior views of a juvenile specimen, U.W.A. 26044d.

Virgin Hills Formation, eastern slope of Mt. Pierre.

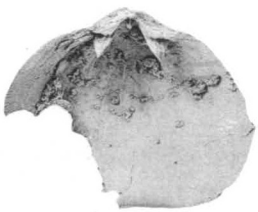
1

2

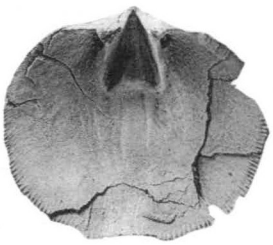
3

4

5



6



7

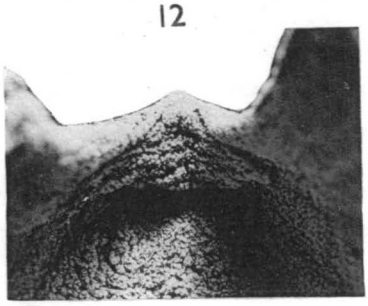
8

10

12

9

11



13

14

15

16

17

18

19

20

21

22

PLATE 4.

Schizophoria apiculata sp. nov. .. .. .. Page 52

Figs. 1-14, all x 1

1-5. Dorsal, ventral, lateral, anterior and posterior views of holotype, C.P.C. 2909.
6-9. Dorsal, ventral, lateral and posterior views of C.P.C. 2910.
10-14. Dorsal, ventral, lateral, posterior and anterior views of C.P.C. 2911. Attached to the exterior of the ventral valve are numerous shells of *Spirorbis*.

Fairfield Beds, southern part of Hull Range.

Gypidula fragilis sp. nov. .. .. .. Page 56

Figs 15-20, all x 1 except fig. 19b (x 2½) and fig. 20 (x 4)

15-18. Dorsal, ventral, anterior and lateral views of the holotype, C.P.C. 2935.
19a, 19b. Internal views x 1 and x 2.5 of broken dorsal valve, C.P.C. 2933, showing crural apparatus.
20. Internal view x 4 of posterior of ventral valve, C.P.C. 2934, showing large spondylium with minute median longitudinal grooves and coarser but still faint transverse lines.

Sadler Formation, Sadler Ridge area.


1


2


3


4


5


6


7


8


9


13


14


10


11


12


19a


15


16


17


18


19b

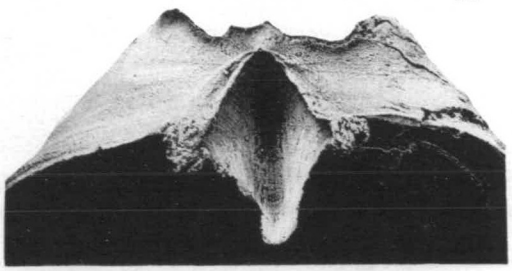

20

PLATE 5.

Schuchertella gratillica sp. nov. .. .. .. Page 72

Figs. 1-10, all x 1

1-4. Dorsal, ventral, lateral and anterior views of C.P.C. 2950 showing the long ventral umbo.
5-8. Dorsal, ventral, lateral and anterior views of the holotype, C.P.C. 2948.
9, 10. External and internal views of a broken dorsal valve, C.P.C. 2949, showing cardinal process, socket plates and muscle field.

Sadler Formation, Sadler Ridge area.

Schuchertella dromeda sp. nov. .. .. .. Page 69

Figs. 11-21, all x 1

11-14. Dorsal, ventral, lateral and anterior views of the holotype, C.P.C. 2945.
15-18. Dorsal, ventral, lateral and anterior views of C.P.C. 2946.
19, 20. Dorsal and anterior views of a small biconvex specimen, C.P.C. 2947, tentatively included within this species.
21. Interior of ventral valve, C.P.C. 3038, showing muscle field.

Fairfield Beds, Oscar Hill.

Leptaena sp. ind. .. .. Page 57

Figs. 22-28, all x 1

22-24. Dorsal, ventral and lateral views of U.W.A. 26095c.
25. Dorsal view of U.W.A. 26095b, showing concentric rugae and fine costellae.
26-28. Dorsal, ventral and lateral views of U.W.A. 26095a.

Fairfield Beds, S-Hill.

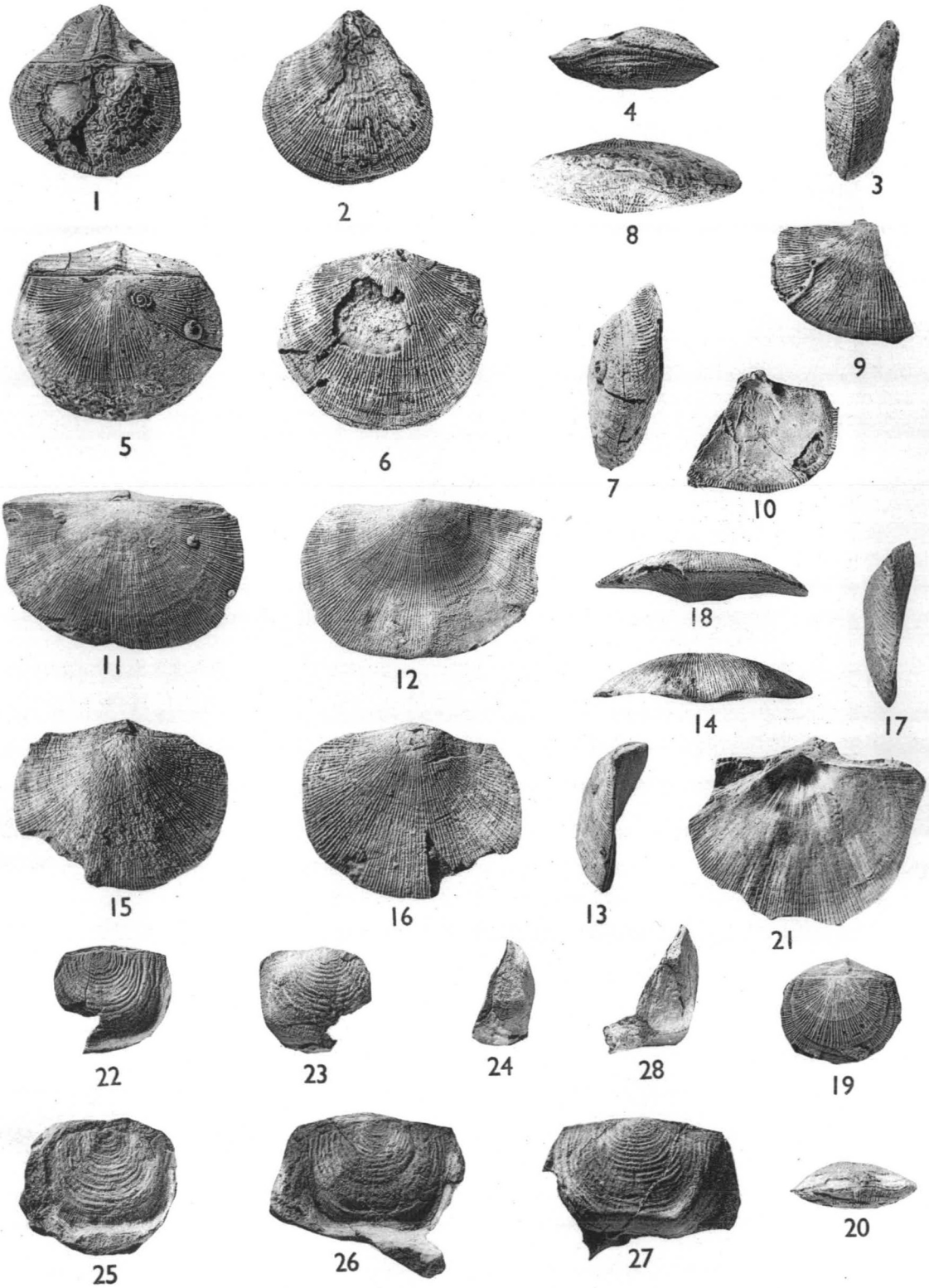

1
2
4
8
3
5
6
7
9
10
11
12
18
14
17
15
16
13
21
22
23
24
28
19
25
26
27
20

PLATE 6.

Douvillina exquisita sp. nov. .. .. .. Page 60

Figs. 1-5, all x 3

1, 2. Dorsal and ventral views of the holotype C.P.C. 2938.

3. Internal view of dorsal valve, C.P.C. 2936, showing cardinal process and thick brace-plates with posterior bosses.

4. External view of the same valve.

5. Internal view of ventral valve C.P.C. 2937 showing muscle field bounded by high overhanging ridges.

Sadler Formation, Sadler Ridge area.

Zophostrophia ungamica gen. et sp. nov. .. .. Page 63

Figs. 6a, 7-10, x 1; figs. 6b, 11 and 12, x 3½

6a, 6b, 7, 8. Dorsal (x 1, x 3½), ventral (x 1) and lateral views (x 1) of the holotype, C.P.C. 2942.

9, 10. Dorsal and ventral views of C.P.C. 2939 showing the mucronate hinge-line.

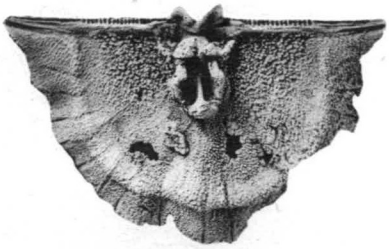
11. Internal view (x 3½) of dorsal valve C.P.C. 2940, showing cardinal process and striated muscle field.

12. Internal view (x 3½) of ventral valve C.P.C. 2941, showing elongate divergent diductor scars, and pallial sinuses.

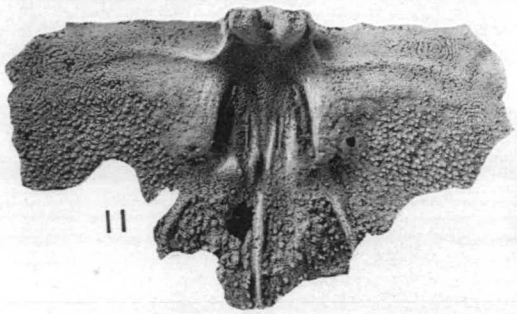
Sadler Formation, Sadler Ridge area.

1

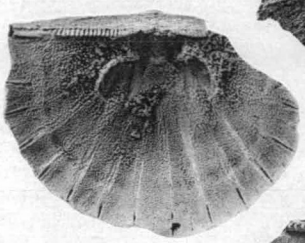
2



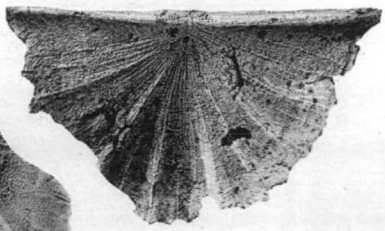
3



11

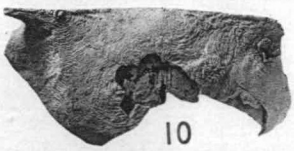


5

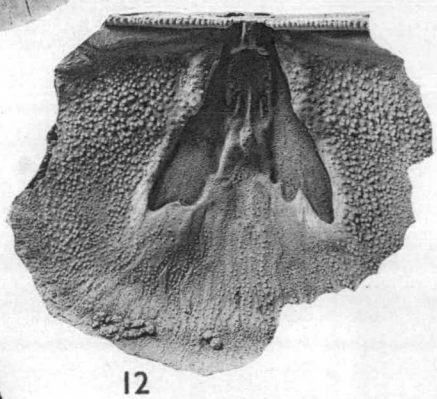


4

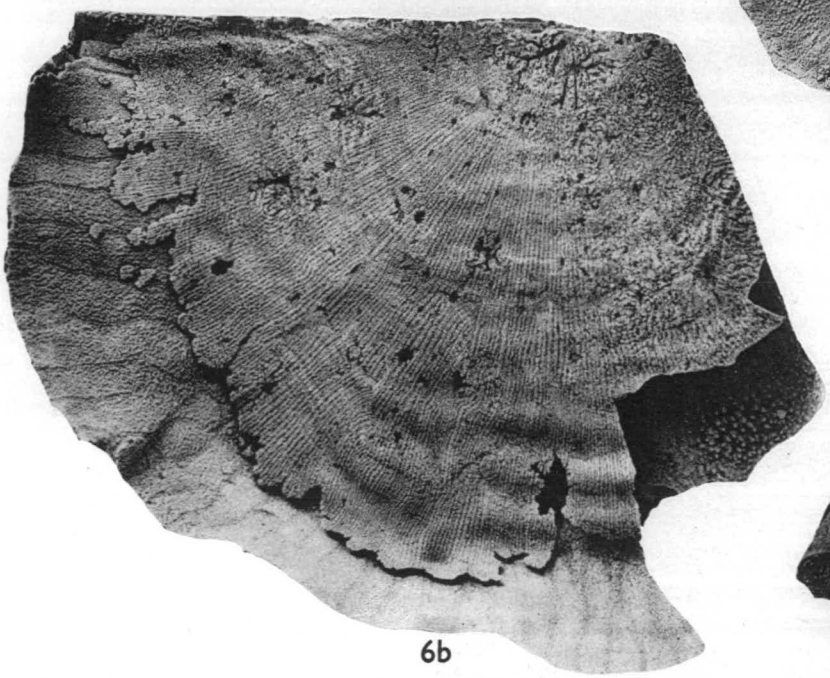
9



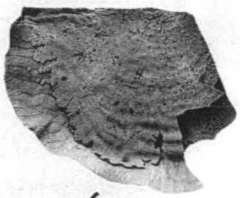
10



12



6b



6a

7

8

Plate 7.

Nervostrophia bunapica sp. nov. .. .. .. Page 65

Figs. 1a, 2a, 3-5, 6a, 7, 8 are x 1; figs. 1b, 2b, and 6b are x 3

1a, 1b. External views (x 1 and x 3) of a ventral valve (U.W.A. 26271a) showing the well-developed nervose costellae.

2a, 2b. Internal views (x 1 and x 3) of a dorsal valve (U.W.A. 26271b) showing denticular sockets, cardinal process, deeply impressed muscle field, and numerous tiny papillae.

3, 4. External and internal views of a ventral valve, C.P.C. 2944, showing the delicate hinge.

5. External view of a calcareous ventral valve, C.P.C. 2964, from K230 (all other valves are silicified).

6a, 6b, 7. Internal (x 1 and x 3) and external (x 1) views of the holotype, C.P.C. 2943, a free ventral valve. Part of the exterior is covered with cemented detrital matter. The internal views show the small well impressed muscle field confined to the posterior part of the valve, and the well-developed pallial sinuses.

8. Internal view of a ventral valve (U.W.A. 26271a, shown in figs. 1a, 1b) with a longer muscle field.

Sadler Formation, Sadler Ridge.

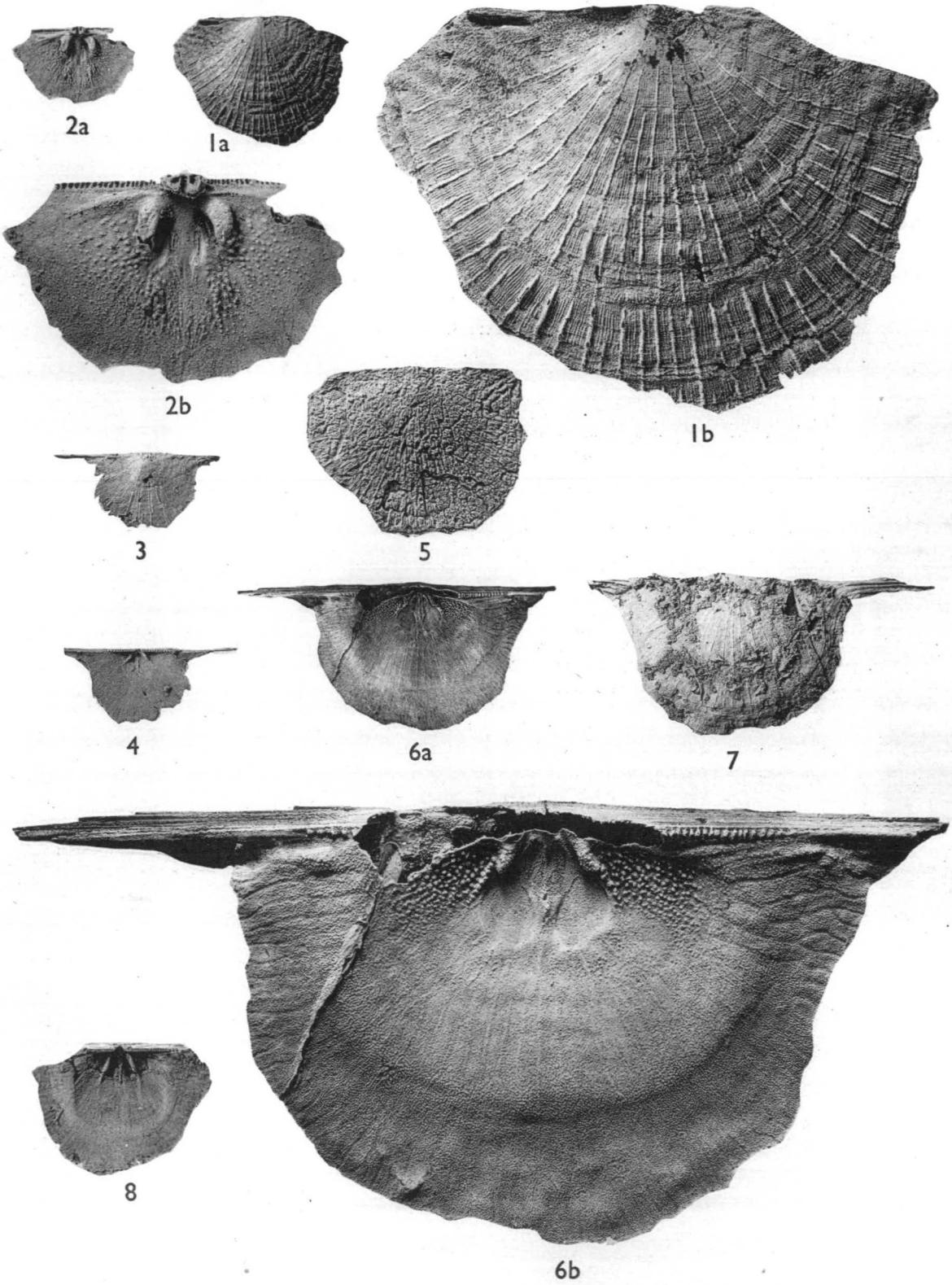

2a
1a
1b
2b
3
5
4
6a
7
8
6b

PLATE 8.

Avonia proteus sp. nov. .. .. .. Page 80

Figs. 1-15, all x 1

1-4. Dorsal, ventral, lateral and posterior views of the holotype, C.P.C. 2959.
5, 6. Lateral and ventral views of C.P.C. 2961, an elongate shell.
7. Ventral view of another elongate shell, C.P.C. 2960.
8-11. Dorsal, ventral, lateral and posterior views of a juvenile specimen, C.P.C. 2962, from Oscar Hill.
12-15. Dorsal, ventral, lateral and posterior views of another juvenile specimen, C.P.C. 2963, also from Oscar Hill.

Fairfield Beds, Oscar Hill and south of Burramundi Range.

Devonoproductus australis sp. nov. .. .. .. Page 73

Figs. 16-21, all x 1

16-18. Dorsal, ventral and posterior views of the holotype, C.P.C. 2951.
19, 20. External and internal views of a ventral valve, C.P.C. 2953.
21. Internal view of dorsal valve (with part of ventral valve attached), C.P.C. 2952, showing cardinal process, median ridge and brachial ridges.

Sadler Formation, Sadler Ridge area.

cf. *Chonetipustula* sp. .. .. Page 84

Figs. 22, 23. Dorsal and ventral views x 3 of C.P.C. 2965.

Sadler Formation, Sadler Ridge area.

cf. *Productella* sp. .. .. Page 80

Figs. 24, 25. Dorsal and ventral views (x 3) of C.P.C. 2958.

Sadler Formation, Sadler Ridge area.

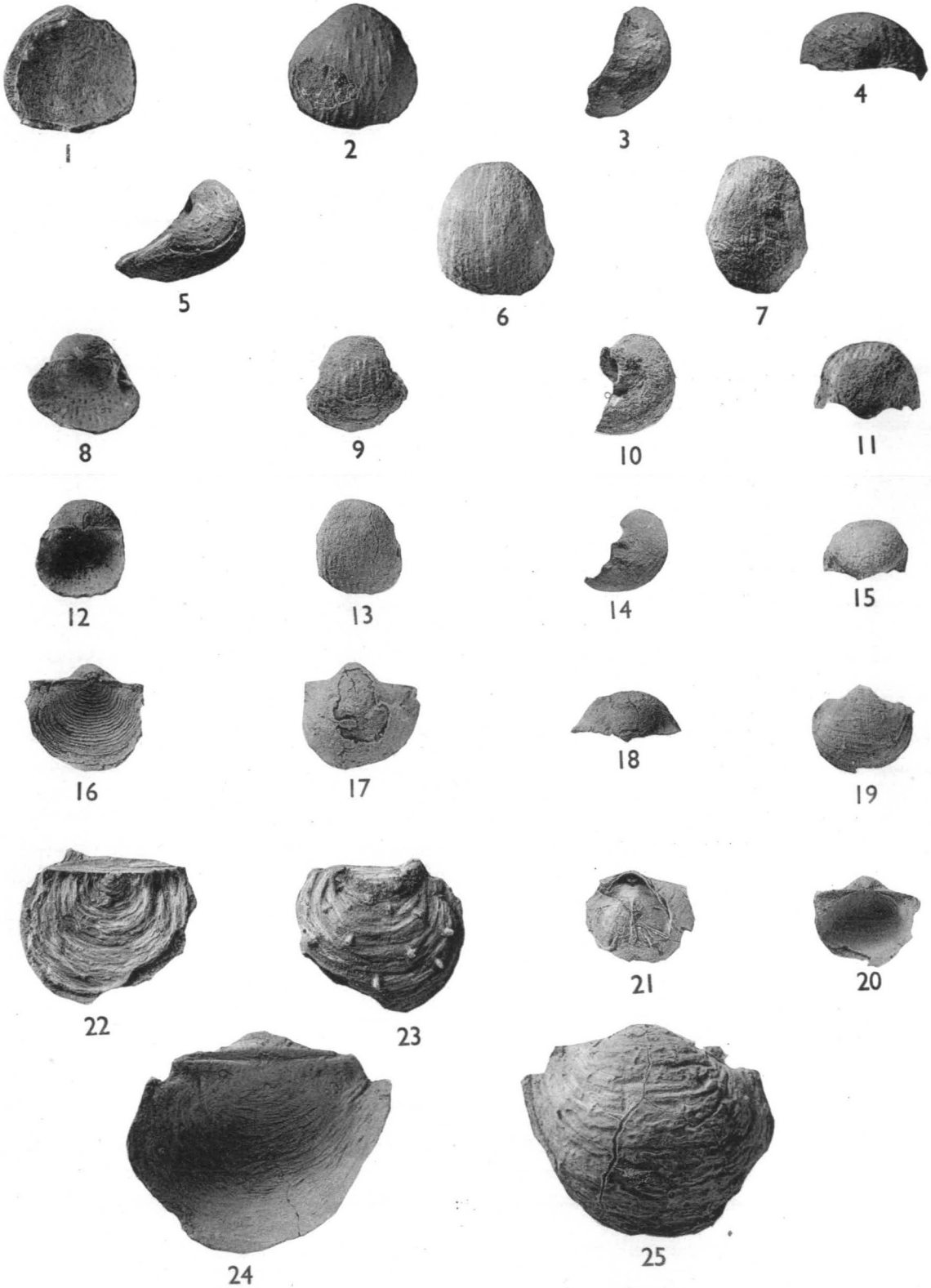

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
22
23
21
20
24
25

PLATE 9.

Productidae gen. et sp. ind. .. .. .. Page 85

Figs. 1-3

External, internal and lateral views (x 1) of C.P.C. 2966.

Sadler Formation, Sadler Ridge area.

Plicochonetes macropatus sp. nov. .. .. .. Page 85

All x 4½, except fig. 10, x 20.

4, 5. Dorsal and ventral views of the holotype, C.P.C. 2967, showing short spines along cardinal margin.

6, 7. Dorsal and ventral views of C.P.C. 2968.

8, 9a, 9b. External, internal and posteriorly tilted internal views of ventral valve, C.P.C. 2969, showing teeth, median septum and muscle field.

10. External view (x 20) of median part of holotype, C.P.C. 2967, showing radial ribs crossed by numerous prominent concentric growth-lines.

Sadler Formation, Sadler Ridge area.

Steinhagella numida sp. nov. .. .. .. Page 77

All x 1, except figs. 15, 18, 19b and 20, x 3

11-13. Dorsal, ventral and lateral views of the holotype, C.P.C. 2954, showing characteristic surface ornament of fine concentric rugae weaving between spine-bases.

14, 15. Internal (x 1) and posterior (x3) views of part of a dorsal valve, C.P.C. 2955, showing the cardinal process, dental sockets and chilidial plates.

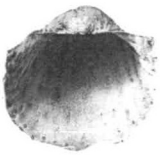
16, 17. External and internal views (x 1) of a small ventral valve, C.P.C. 2956, showing numerous thin spines.

18. Enlargement (x 3) of fig. 17 to show teeth and hollow interior of spines.

19a, 19b, 20. External views (x 1, x 3) and internal view (x 3) of a small dorsal valve, C.P.C. 2957, showing tiny spines, cardinal process and median septum.

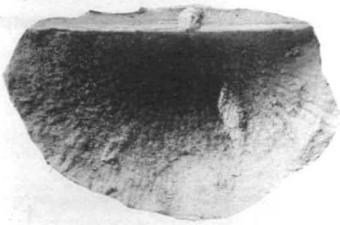
Sadler Formation, Sadler Ridge area.

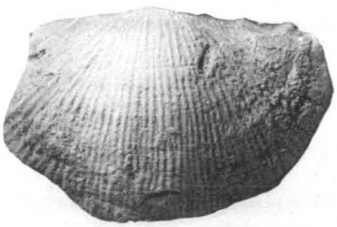

1


2


3

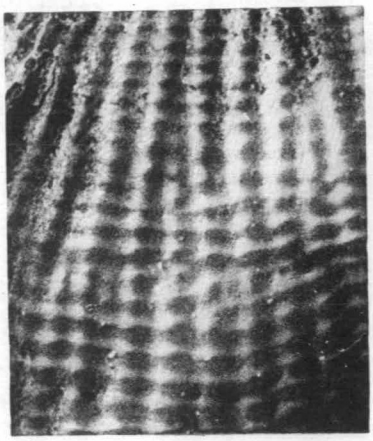

8

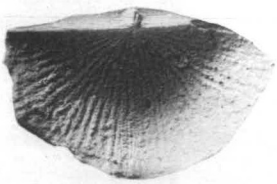

4


5


9a

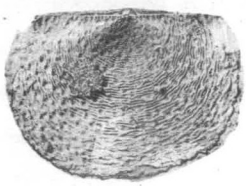

9b

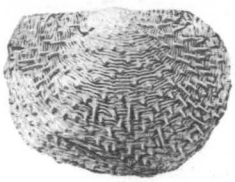

10


6


7


13


11


12


16

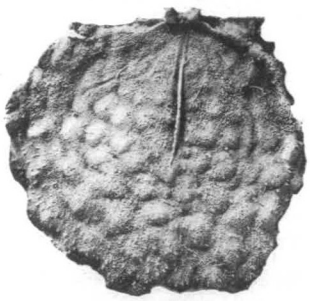

14


19a


15


17


19b


20


18

PLATE 10.

Camarotoechia lucida sp. nov. .. .. .. Page 88

Figs. 1-5, all x 1. Dorsal, ventral, posterior, lateral and anterior views of C.P.C. 2971, a calcareous shell from Oscar Hill.

6-10. Dorsal, ventral, lateral, posterior and anterior views (x 3) of the holotype, C.P.C. 2970, a silicified shell.

11. Anterior view (x 5½) of an open silicified shell, C.P.C. 2972, showing dental plates, short median septum supporting septalium, and blunt crura.

Fairfield Beds, Burramundi Range area and Oscar Hill.

Camarotoechia sp. ind. .. .. .. Page 94

Figs. 12-21, all x 1

12-16. Dorsal, ventral, posterior, lateral and anterior views of U.W.A. 26712a.

17-21. Dorsal, ventral, posterior, lateral and anterior views of a juvenile specimen, 26712b, without plicae.

Napier Formation, south of Van Emmerick Range.

Hypothyridina margarita sp. nov. .. .. .. Page 100

Figs. 22-35, all x 1

22-26. Dorsal, ventral, posterior, lateral and anterior views of a small specimen, C.P.C. 2978.

27-30. Dorsal, ventral, anterior and lateral views of U.W.A. 26712c.

31-35. Dorsal, ventral, posterior, anterior and lateral views of the holotype C.P.C. 2977.

Napier Formation, Elimberrie Spring and Van Emmerick Range areas, and Sadler Formation, Bugle Gap.

Uncinulus wolmericus sp. nov. .. .. .. Page 96

Figs. 36-50, all x 1

Dorsal, ventral, lateral, posterior and anterior views of the holotype, C.P.C. 2973, and two other specimens, C.P.C. 2974, and U.W.A. 26275.

Sadler Formation, Sadler Ridge area.

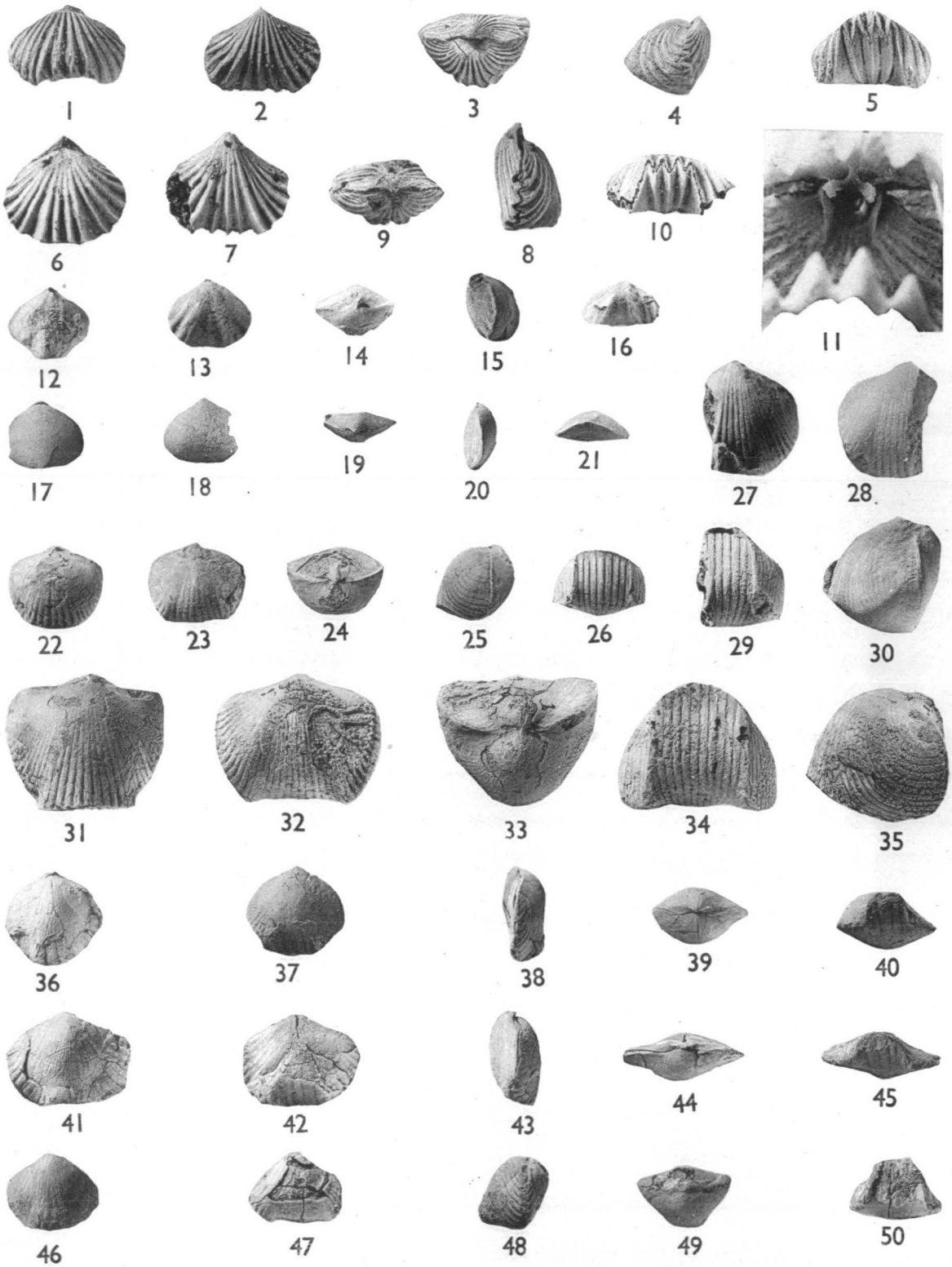

1
2
3
4
5
6
7
9
8
10
11
12
13
14
15
16
17
18
19
20
21
27
28
22
23
24
25
26
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50

PLATE 11.

Nvege scopimus gen. et sp. nov. .. .. .. Page 113

Figs. 1-7, all x 1.5

1 5. Dorsal, ventral, posterior, lateral and anterior views of the holotype, C.P.C. 2987.
6, 7. Dorsal and anterior views of C.P.C. 2988, a maturer specimen.

Bugle Gap Limestone, east wall of Bugle Gap.

Uncinulus arefactus sp. nov. .. .. .. Page 99

Figs. 8-13, all x 1

8, 9. Dorsal and ventral views of C.P.C. 2976.
10-13. Dorsal, ventral, anterior and lateral views of the holotype, C.P.C. 2975.

Sadler Formation, Sadler Ridge

Pugnax hullensis sp. nov. .. .. .. Page 109

Figs. 14-19, all x 1

14-18. Dorsal, ventral, lateral, posterior and anterior views of the holotype, C.P.C. 2984.
19. Anterior view of a juvenile specimen, C.P.C. 2985, which has a non-plicate anterior commissure.

Fossil Downs Formation, Hull Range.

Pugnax sp. cf. *P. acuminatus* (J. Sowerby) 1822 .. .. Page 113

Figs. 20, 21, both x 1

Dorsal and anterior views of U.W.A. 26878a. Napier Formation near Leopold Downs Homestead.

Pugnax sp. cf. *P. pugnus* (Martin) 1809 .. .. .. Page 110

Figs. 22-25, approximately x 1

22-23. Dorsal and anterior views of C.P.C. 2986.
24, 25. Dorsal and anterior views of C.P.C. 3039.

Sadler Formation, Bugle Gap and Sadler Ridge.


1


2


3


4


5


8


9


6


7


12


13

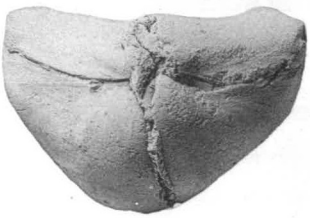

10


11


19


14


15


17


16


18


20


21


22


23


24


25

PLATE 12.

Ladjia saltica gen. et sp. nov. .. .. .. Page 126

Figs. 1-28, all approximately x 3

1-5, 6-10, 11-15, 16-20. Dorsal, ventral, lateral, posterior and anterior views of C.P.C. 2991, 2990 (the holotype), 2993 and 2992.

21. Interior of dorsal valve, C.P.C. 2995, showing the cruralium and narrow median septum.

22, 29. Interior of dorsal valves, C.P.C. 3043 and 3042 showing cardinal process, dental sockets and discrete crural plates bearing the crural bases.

23. Interior of ventral valve, C.P.C. 2994, showing teeth, dental ridges, pedicle plate, median ridge and diductor muscle scars.

24. Anterior view of the interior of the preceding specimen showing dental ridges, pedicle plate, median ridge (grooved posteriorly) and the elongate diductor muscle scars.

25, 26, 28. Anterior views of the interiors of three ventral valves, C.P.C. 2999, 2997 and 2996, showing dental ridges, pedicle plate and small dental plates.

27. Anterior view of the interior of ventral valve, C.P.C. 2998, showing dental ridges, pedicle plate, median ridge and elongate diductor muscle scars.

Pillara and Sadler Formations, Gap Creek Gap.

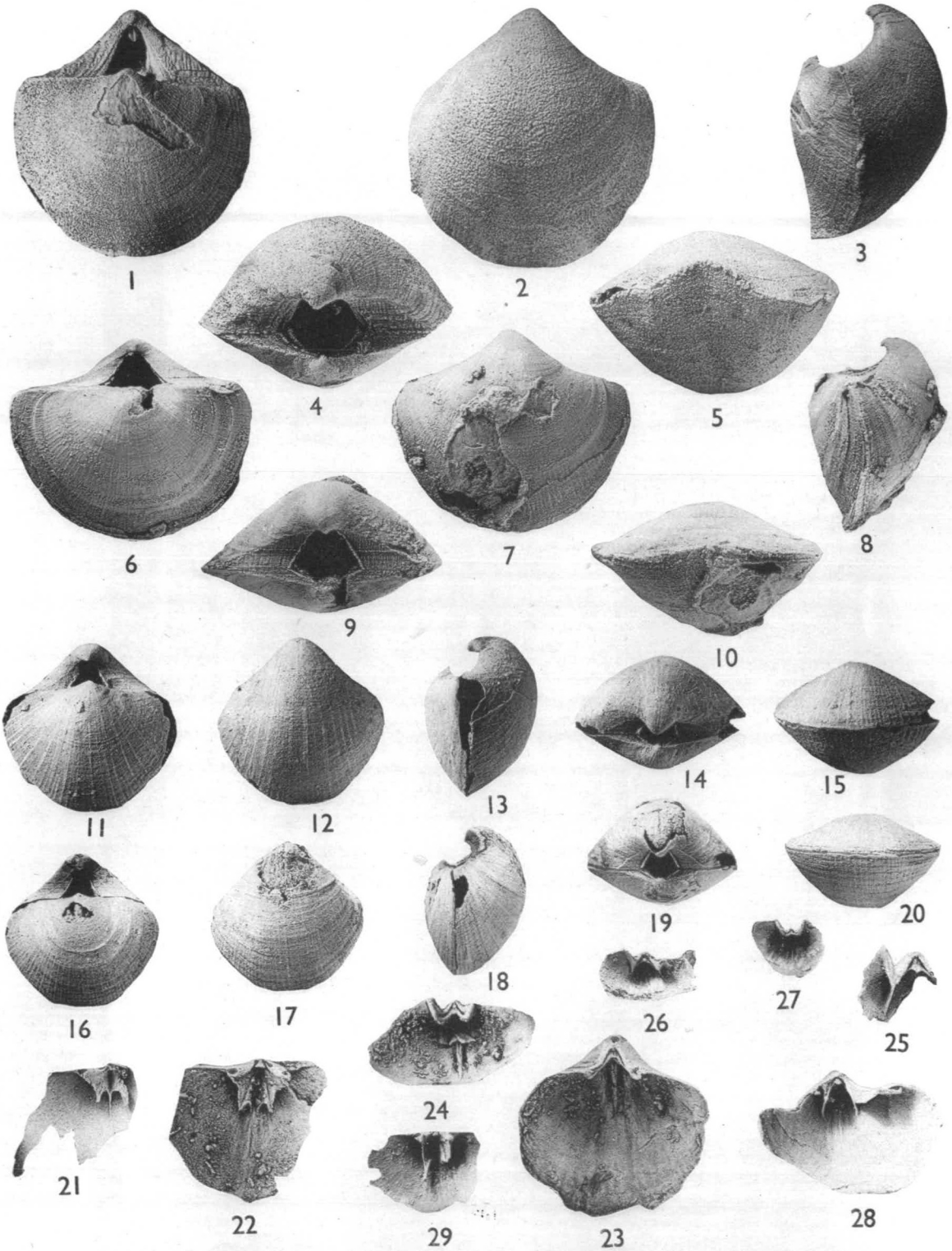

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

PLATE 13.

Emanuella torrida sp. nov. .. .. .. Page 128

Figs. 1-5, 8, 9 are x 3; fig. 6 is x 8; fig. 7 is x 32

1-5. Dorsal, ventral, lateral, anterior and posterior views of the holotype, C.P.C. 3000.

6, 7. Part of the surface of the dorsal valve of the holotype enlarged (x 8, x 32) to show the minute spine-bases.

8. Dorsal view of C.P.C. 3002 showing the large dorsally directed pedicle plate and well-defined beak-ridges.

9. Ventral view of a worn specimen, C.P.C. 3001, showing traces of the spiralia.

Sadler Formation, Sadler Ridge area.

Crurithyris apena sp. nov. .. .. .. Page 133

Figs. 10-19 x 3, except figs. 18 and 19, x 6

10-13. Dorsal, ventral, lateral and anterior views of the holotype, C.P.C. 3003.

14-17. Dorsal, ventral, anterior and lateral views of C.P.C. 3004, a larger specimen with a proportionately wider hinge.

18. Dorsal view (x 6) of a broken shell, C.P.C. 3001, showing widely spaced radial lines, and concentric growth-lines with numerous tiny circular pits.

19. Ventral view of C.P.C. 3006, showing a faint radial and concentric pattern of narrow lines with numerous tiny pits.

Sadler Formation, Bugle Gap.

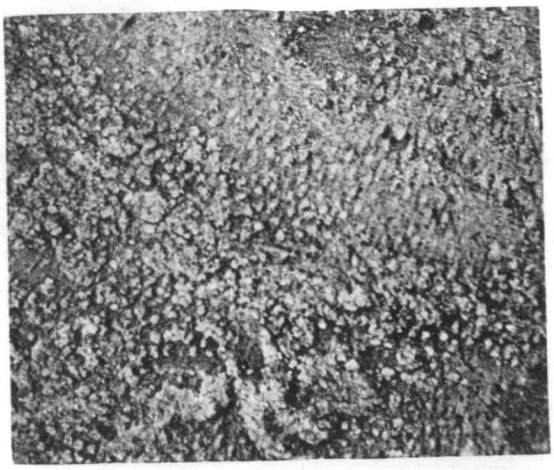

1


2


4


3


5


7


6


9

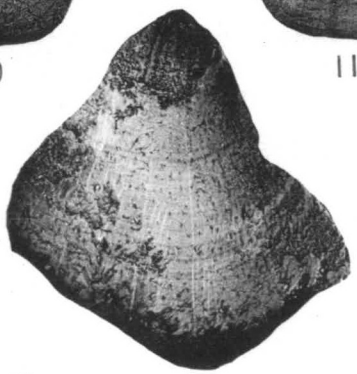

8


10


11


12


13


18


19


14


15


16


17

PLATE 14.

Athyris oscarensis sp. nov. .. .. .. Page 140

Figs. 1-7, 12 are x 2; figs. 8, 9, x 3; figs. 10, 11 x 4; and fig. 13 x 5

1-5. Dorsal, ventral, lateral, posterior and anterior views (x 2) of the holotype, C.P.C. 3015.

6, 7. Dorsal and anterior views respectively (x 2) of C.P.C. 3014, a smaller specimen with well-preserved spines.

8, 9. Dorsal and ventral views (x 3) of C.P.C. 3012, a silicified shell showing lamellose growth-lines and flat spines.

10. Internal view (x 4) of dorsal valve C.P.C. 3011 showing the perforated hinge-plate.

11. Antero-dorsal view (x 4) of C.P.C. 3010 showing teeth, dental sockets and (?) muscle field.

12. Interior (x 2) of ventral valve C.P.C. 3013 showing teeth, dental plates and faint elongate diductors.

13. Internal view (x 5) of posterior part of C.P.C. 3009 showing perforate hinge-plate and worm-shaped structure of uncertain origin.

Fairfield Beds, Oscar Hill, Fossil Downs Homestead and near Burramundi Range.

Meristella (?) caprina sp. nov. .. .. .. Page 145

Figs. 14-21, all x 2 approximately

14-17. Dorsal, ventral, lateral and anterior views of U.W.A. 26779b.

18-21. Dorsal, ventral, anterior and lateral views of the holotype, U.W.A. 26779a.


1


2

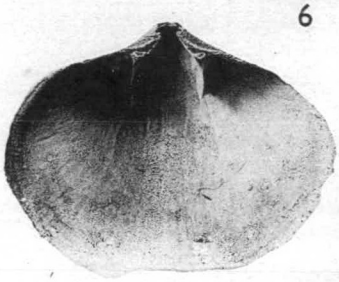

3


7


6


4


5


12


8


9


13


11


10

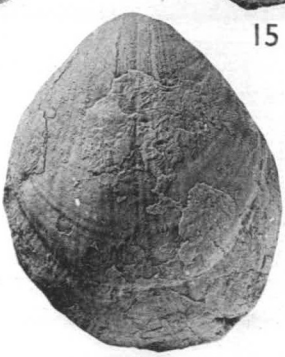

14


15


16


17


18


19


20


21

PLATE 15.

Tingella suchana sp. nov. .. .. .. Page 136

Figs. 1-9, x 2

1-5. Dorsal, ventral, anterior, posterior and lateral views of the holotype, C.P.C. 3007.

6. Posterior view (dorsal valve uppermost) of C.P.C. 3008 to show the reticulate pattern of striae and growth lines on the ventral interarea.

7, 9. Dorsal, lateral and anterior views of C.P.C. 3044 showing faint radial striae and concentric growth lines.

Pillara Formation, Gap Creek Gap and Menyous Gap.

Terebratulacea gen. et sp. ind. I .. .. .. Page 150

Fig. 10.

Dorsal view (x 3½) of a silicified shell, C.P.C. 3016.

Sadler Formation, Sadler Ridge area.

Terebratulacea gen. et sp. ind. II .. .. .. Page 150

Figs. 11, 12.

Dorsal and ventral views (x 3½) of U.W.A. 25978a.

Needle-eye Rocks, Virgin Hills Formation.

Atrypa desquamata kimberleyensis Coleman 1951 .. .. Page 119

Fig. 13.

Lateral view (x 4) of a silicified valve, C.P.C. 2989, showing growth laminae drawn out into spines.

Sadler Formation, near Sadler Ridge.

Uncinulus wolmericus sp. nov. .. .. .. Page 96

Figs. 14 and 16 x 3; 15 and 17 x 4; all of the one specimen, a steinkern, C.P.C. 3040.

14. Dorsal view showing pallial sinuses, and narrow median septum bisecting broad posterior and elongate anterior adductors.

15. View similar to fig. 14, but a little to one side to show the pallial sinuses terminating as deep grooves along the backs of the internal grooves.

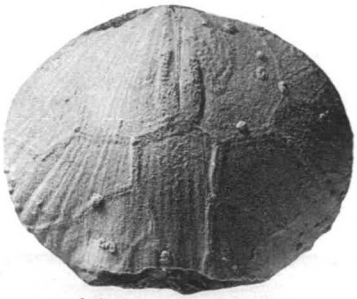
16. Ventral view showing pallial sinuses and circular muscle field.

17. View similar to fig. 16, but a little to one side to show the pallial sinuses terminating along the backs of internal plications. The photograph does not show the marginal features illustrated in text fig. 58b.

Sadler Formation, Menyous Gap area.

1

2

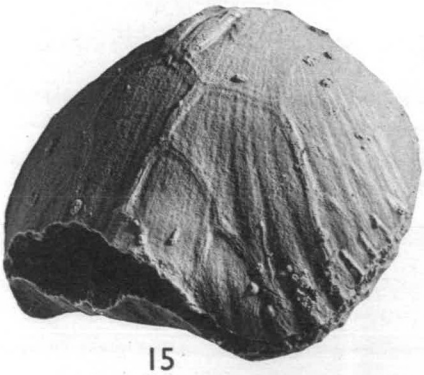


14

3

4

5

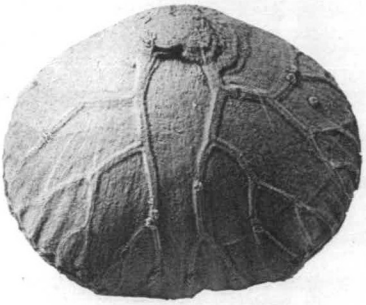


15

6

7

8



16

9

17

10

11

12

13

PLATE 16.

Fitzroyella primula gen. et sp. nov. .. .. .. Page 106

Figs. 1-10, all x 6 except fig. 10, x 2

1-4. Dorsal, ventral, anterior and lateral views of the holotype, C.P.C. 2979.

5. Interior of silicified ventral valve C.P.C. 2982, showing deeply impressed muscle scars, and the depressions along the line of geniculation.

6. Interior of silicified dorsal valve C.P.C. 2981, showing part of the hinge-plate, and the depressions along the line of geniculation.

7. Dorsal view of silicified shell C.P.C. 2980 showing foramen, fused deltidial plates, and long and wide planareas. The tubular structure adhering to the shell is probably *Cornulites*.

8-10. Dorsal (x 6), ventral (x 6) and lateral (x 12) views of steinkern C.P.C. 2983 showing muscle scars and well-developed pallial sinuses. Fig. 10 shows the terminations of the sinuses lying along the backs of the internal plications.

Sadler Formation, Sadler Ridge and Menyous Gap areas.

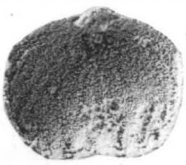
1

2

3

4

5



6

7

10

8

9

PLATE 17.

Stringocephalus fontanus sp. nov. .. .. .. Page 148

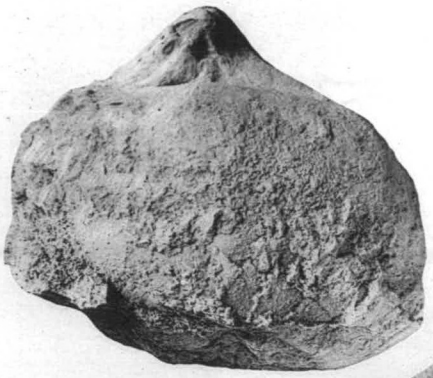
Figs. 1-7, x 2/3 except fig. 4a, x 1¾

1-3. Dorsal, posterior and lateral views of C.P.C. 3017.

4-7. Dorsal, ventral, posterior and lateral views of the holotype, U.W.A. 39403, an almost entire shell.

4a. Dorsal view of delthyrium and ventral interarea of U.W.A. 39403 (x 1¾) showing circular foramen, conjunct deltidial plates, and pseudodeltidium (or 'henidium' of Cloud, 1942).

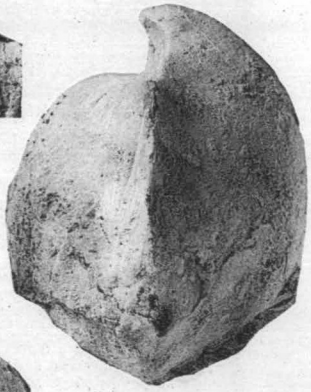
Base of Pillara Formation, Home Range.



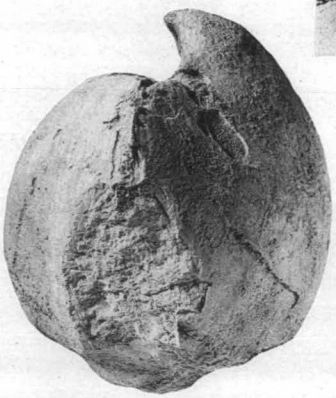
1

2

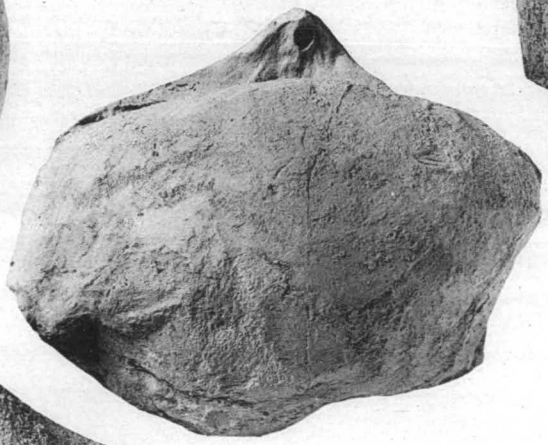
4a



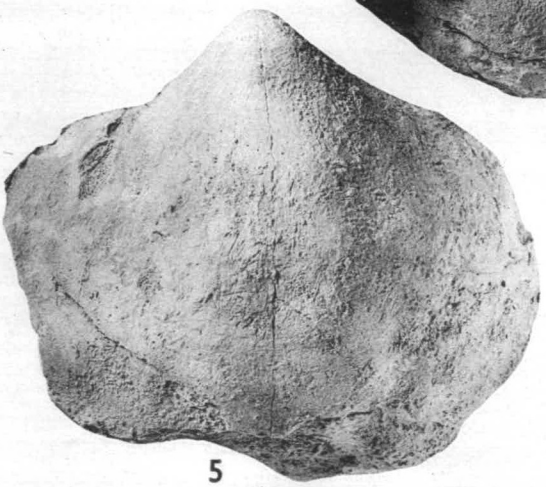
3



7



4



5

6

PLATE 18.

Stringocephalus fontanus sp. nov. .. .. .. Page 148

Figs. 1 a-d, 2, 3 x 2/3; fig. 4 x 30

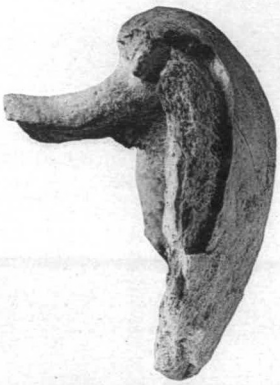
1a-d. Lateral, posterior, antero-ventral and ventral views of C.P.C. 3018, an almost completely excavated dorsal valve. The cardinal process, broken at the tip, is supported by a long high slender median septum. The sockets are attached to the sides of the cardinal process to form a hinge plate.

2. Dorsal view of U.W.A. 39405, a specimen with a broken shallow sulcus in the dorsal valve.

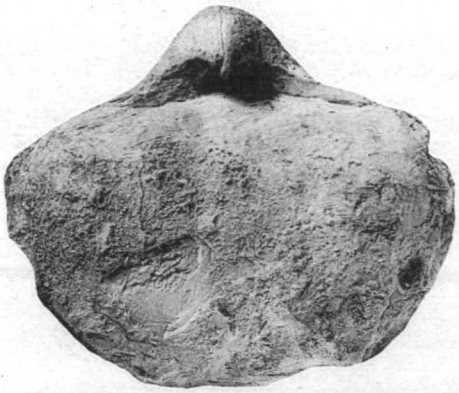
3. Dorsal view of U.W.A. 39404 showing faint concentric growth lines along the margin of the dorsal valve.

4. Section (x 30) of C.P.C. 3019; the section lies in the plane of symmetry through the dorsal valve. The secondary (fibrous) shell layer (between the broken lines) shows faint traces of puncta and growth laminae inclined towards the anterior. The clear material below the secondary layer is the cryptocrystalline calcite of the dorsal median septum.

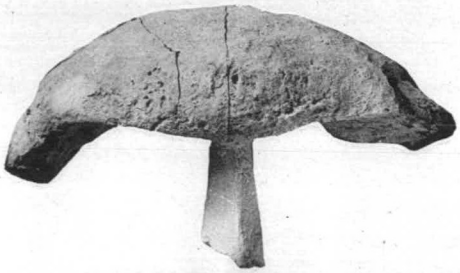
Base of Pillara Formation, Home Range.



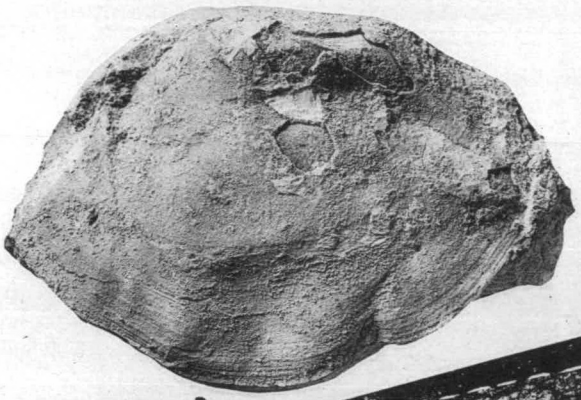
1a



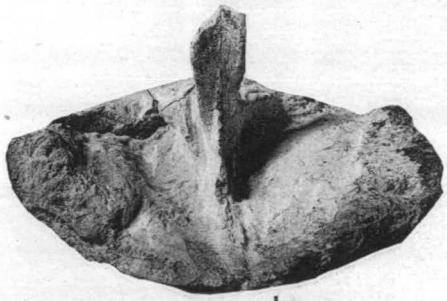
2



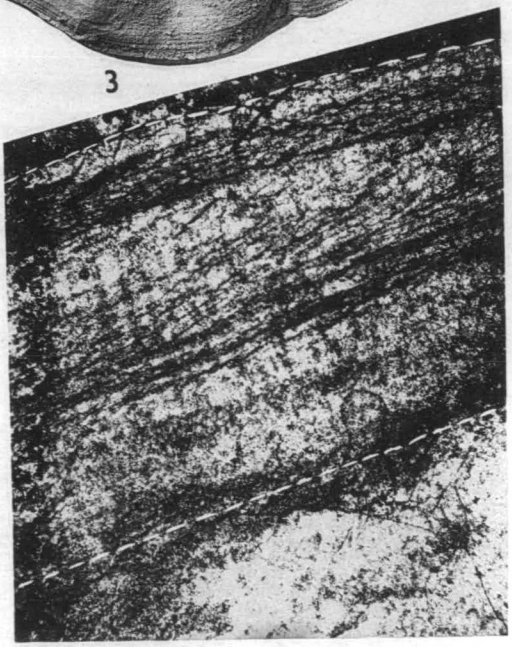
1b



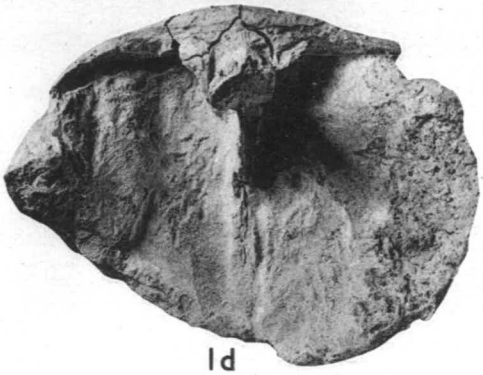
3



1c



4



1d

INDEX.

Reference to systematic descriptions in bold face; to illustrations, in italics.

Asterisks indicate species and formations outside the Fitzroy Basin.

This index includes all known recorded fossils from the Devonian rocks of the Fitzroy Basin.

By Authority: A. J. ARTHUR, Commonwealth Government Printer, Canberra.