DEVONIAN AND CARBONIFEROUS SCHIZOPHORIID BRACHIOPODS FROM WESTERN EUROPE

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Thesis submitted for Ph.D. degree,
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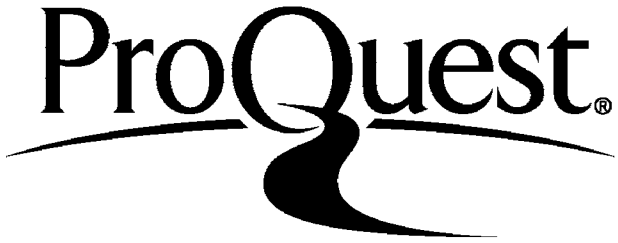

ABSTRACT

Thirteen species, one subspecies and five varieties of the brachiopod genus Schizophoria have been studied from parts of the Devonian and Carboniferous of Western Europe. One Carboniferous species and the Devonian subspecies of S. pygmaea are new, and will be formally named in due course.

All taxa are shown to be both externally and internally distinct.

In the Devonian, Schizophoria is most abundant in the Middle Devonian of the Eifel region (Germany), and in the Lower to Upper Devonian of the Dinant basin (Belgium). In the Carboniferous, Schizophoria is most abundant in the Dinantian of the Dinant basin, and in the C-D zone reef facies of the British Isles.

Species of Schizophoria from the Carboniferous are shown to be statistically distinct, when appropriate characters are selected. A detailed knowledge of morphology is necessary before accurate statistical work is undertaken. Insufficient material prevented similar work on Devonian species.

Certain Carboniferous species are apparently restricted to particular areas of reef limestone, and more than one species can in some cases be collected from the same stratigraphical and geographical position.

Most of the species are long ranging forms, except Schizophoria provulvaria (Maurer) and S. strigosa (Sowerby) of the Siegenian to Lower Emsian, S. vulvaria (Quenstedt), of the Lower Emsian to Lower Eifelian, and S. pygmaea Struve, of the Eifelian. Schizophoria pygmaea is a dwarf form occurring in two horizons within the Eifelian of the Eifel region. Schizophoria woodi Bond is restricted to the Visean.

Phylogenetically the species were probably derived from two root stocks in the Lower Devonian, S. provulvaria and S.

strigosa. An earlier ancestor is unknown. Four main lines are recognised in the Carboniferous. Lines of evolution are based externally on outline and ornament, and internally on muscle fields and the form of the brachiophore plates.

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INTRODUCTION AND ACKNOWLEDGMENTS

Many authors in Europe and Asia have contributed to previous studies of the brachiopod Schizophoria. More important work on Devonian and Carboniferous material has been completed by the following authors: Martin (1809), Schlotheim (1820-3), Sowerby (1821-3), Phillips (1836, 1841), De Buch (1840), De Koninck (1842-4, 1873), Portlock (1843), Geinitz (1853), Schnur (1853), Sandberger (1850-6), Grünewaldt (1860), Davidson (1858-63, 1864-5), Quenstedt (1867, 1868-71, 1882, 1885), Kayser (1883, 1889), Oehlert (1887), Tschernyschew (1887), Frech (1891), Maurer (1893), Drevermann (1904), Reed (1908, 1922), Gurich (1909), Yanishevsky (1918), Demanet (1921-3, 1934), Paeckelmann (1930), Maillieux (1932, 1936), Gallwitz (1932), George (1932), George and Ponsford (1938), Kelus (1939), Bond (1941), Spriesterbach (1942), Termier and Termier (1950), Sarycheva and Sokolskaja (1952), Wright (1953), Parkinson (1954), Fedorova (1955), Campbell (1957), Cvancara (1958), Biernat (1959), Veevers (1959), and Struve (1963).

These authors gave more detailed, illustrated descriptions or important synonymies. Many other authors have also contributed to the study, and these are listed in the synonymies and bibliography.

One of the most recent and detailed works on European Devonian material was completed by Biernat (1959), who gave an account of the external and internal morphology and ontogeny of Schizophoria striatula (Schlotheim).

Struve (1963) established, described, and illustrated a new species, Schizophoria pygmaea, from the Devonian of the Eifel.

Important work on Australian forms was completed by Veevers (1959), when he established, described, and illustrated three new species, Schizophoria apiculata, S. pierrensis, and

S. stainbrooki, from the upper Devonian of the Fitzroy Basin.

Most recent advances in the study of Carboniferous material from western Europe has been made by Demanet (1921-3, 1934), George (1932), George and Ponsford (1938), Bond (1941), Wright (1952), and Parkinson (1954).

In 1921-3, Demanet established two variants of Schizophoria resupinata (Martin), var. lata and var. rotundata. Var. lata differs from S. resupinata by its great shell width, relative to length, and var. rotundata differs by its rounded outline. This work was succeeded in 1934 by the establishment of four more variants, dorsosinuata, gigantea, palliata and pinguis. Var. dorsosinuata is characterised by a brachial sinus and prominent growth rugae; var. gigantea by its large size; var. palliata by its rectangular outline, dorsibiconvexity and marginal folds; and var. pinguis by its inflated outline.

In 1932 George established and described Schizophoria hudsoni from the Cayton Gill Beds of the Millstone Grit.

In 1938 George and Ponsford described the general external and internal morphology of the genus Schizophoria, established S. elboltonensis and S. nuda, and gave specific details of S. cf. dorsosinuata Demanet, S. pinguis (Demanet) and S. aff. resupinata (Martin). These descriptions were illustrated with serial sections and other text-figures.

In 1941 Bond, in his work on "Species and variation in British and Belgian Carboniferous schizophoriidae", redefined the species in terms of external and internal features. He also attempted to define the extent of variation of each species, and their stratigraphical range. His specific diagnoses were based on shape of the anterior plication and pedicle sinus when present, ornament, and the angle of divergence of the dental lamellae.

Two groups were established, one of which included Schizophoria resupinata (Martin), and the variants dorsosinuata

Demanet, elboltonensis George and Ponsford, gigantea, lata, pinguis and rotundata Demanet. These are characterised by coarse ornament, presence of spine bases, and widely divergent dental lamellae. Other species included were S. connivens (Phillips), S. hudsoni George, and S. nuda George and Ponsford. Schizophoria connivens and S. hudsoni have a biplicate or rounded to quadrate uniplicate anterior commissure. Schizophoria nuda is a species based on internal moulds.

The second group included Schizophoria gibbera (Portlock), S. palliata (Demanet) and S. woodi, a new species established by Bond. These are characterised by fine ornament and less widely divergent dental lamellae. Schizophoria gibbera and S. palliata possess a broad, deep, rounded uniplicate anterior commissure, while S. woodi possesses a broad, subangular uniplication. Schizophoria woodi also possesses a diagnostic groove-like pedicle sinus.

Outline drawings illustrated the range of variation within the species.

Wright (1952) made a statistical analysis on Avonian reef brachiopods, including Schizophoria, from Cracoe, Malham, Treak Cliff, Chrome Hill and Parkhouse Hill. By regarding the material as belonging to S. resupinata, he tried to illustrate the range of variation of the species.

Succeeding Wright in 1954, Parkinson made further quantitative studies on 2,000 specimens of Schizophoria resupinata from the Carboniferous reef facies of Withgill, Craven, Eldon Hill, and Treak Cliff. Parkinson found differences between collections within the D zone, but more significant differences between C and D zone assemblages, suggesting phylogenetic change. Length : width and thickness : width ratios tended to increase from C to D zones. There is a tendency for the brachial valve to increase in length, and the brachial umbo becomes inflated. Associated with this, is an increase in shell thickness.

Inflated forms, S. resupinata var. pinguis are characteristic of the D zone. The thinner forms, typified by the neotype of S. resupinata, although characteristic of the Tournaisian, do range into the D zone of the Visean.

Recent work on Australian forms has been completed by Campbell (1957) and Cvancara (1958). Campbell described and illustrated specimens from the Lower Carboniferous of New South Wales, ascribed to S. cf. S. resupinata. Cvancara established, described, and illustrated a new species, S. verulamensis, from the Lower Carboniferous of New South Wales.

This present work aims at completing detailed descriptions of Schizophoria from the Devonian and Carboniferous of western Europe. Devonian material has been studied from Belgium, France (Boulonnais), Germany (Eifel, Sauerland, Westerwald), and south-west England, and Carboniferous material from Belgium and the British Isles. Devonian material from south-west England is rare, consisting mainly of cleaved fragments.

Reference has been made to as many museum collections as possible (listed later), and these have been supplemented by the author's own collections from the Devonian of Germany, and from the Carboniferous reefs of Derbyshire, Isle of Man, Lancashire and Yorkshire. All available holotypes, neotypes and paratypes have been examined.

Details of internal morphology were obtained, where possible, from internal moulds, but more frequently serial sections were necessary. At least five specimens of each species were ground, unless specimens were rare, as with Schizophoria gibbera. Specimens showing external variation, and specimens from different stratigraphical levels and geographical localities were chosen. This enabled the determination of the presence and amount of internal variation correlated with external differences, stratigraphical and geographical variation. Plaster casts and photographs gave an adequate record of each specimen destroyed

by grinding. Each specimen was attached to a parallel grinder and serially ground, usually at intervals of 0.1mm. in the umbonal region, and at greater intervals, 0.5-1mm. or more, anteriorly. Drawings and 35mm. photographs recorded internal structures at each stage. The internal morphology of each specimen was later reconstructed from a series of approximately twenty photographs.

Internal moulds of Schizophoria hudsoni George, S. provulvaria (Maurer) and S. vulvaria (Quenstedt) were ground following the method described by Stanley (1964, p.105). A plaster cast of the fossil internal mould was made, coated with black ink, set in a plaster block, and ground in the usual way. The ink outline represents the form of the internal mould, and the shell can then be approximately reconstructed.

Cellulose peels were also used to record structures, and thin sections allowed the study of shell structure. The shell structure of Schizophoria has previously been described, (Pocock, 1962, unpubl. M.Sc. thesis), from Devonian material of the Northwest Territories, Canada. No further details could be added from this present study.

Text-figure 1 illustrates three basic sections of Schizophoria. Reference to these will identify internal structures in succeeding text-figures of serial sections.

All previous literature has been reviewed, and complete synonymies have been assembled. Illustrated references have been re-evaluated. Many references recorded consist merely of faunal lists, short descriptions, or synonymies. Although it is not always possible to readily assess the validity of these previous identifications without illustrations or complete descriptions, they have been included under species remarks to indicate the nature of many earlier references to the genus. The content of accompanying synonymies, the stratigraphical position, and the geographical location are considered when descriptions are brief

or absent, to attempt to assess the validity of these identifications.

Previous statistical approaches by Wright (1952) and Parkinson (1954) have been criticised and re-examined and re-interpreted with the present knowledge of morphology. The importance of detailed morphological studies in the interpretation of statistical results, and the necessity of selecting appropriate characters have been shown. A simple method of plotting two characters to demonstrate specific differentiation has been applied to Carboniferous material.

The stratigraphical ranges of species have been ascertained, and their phylogeny postulated.

In completing this work the author would like to thank the North Atlantic Treaty Organisation for providing a research studentship, and Dr. C.H. Holland, of Bedford College, for his encouragement and guidance throughout and invaluable criticisms of the manuscript.

The staff of the following institutions are gratefully acknowledged for providing relevant collections of Schizophoria:

British Museum (Natural History), (specimens for sectioning) - Dr. H.M. Muir-Wood, Mr. J. Ferguson, library staff.

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Geological Survey Museum (London) - Mr. M. Mitchell.

Hunterian Museum, University of Glasgow, (specimens for sectioning) - Dr. W.I. Rolfe.

Imperial College, London, (specimens for sectioning) - Mrs. M. Muir.

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Sedgwick Museum, Cambridge - Mr. A.G. Brighton.

Senckenberg Museum, Frankfurt - Dr. W. Struve.

Trinity College, Dublin, (specimens for sectioning) - Mr. M.J. Clarke.

University of Reading - Dr. R. Goldring.

Donations of specimens for serial sectioning are noted above.

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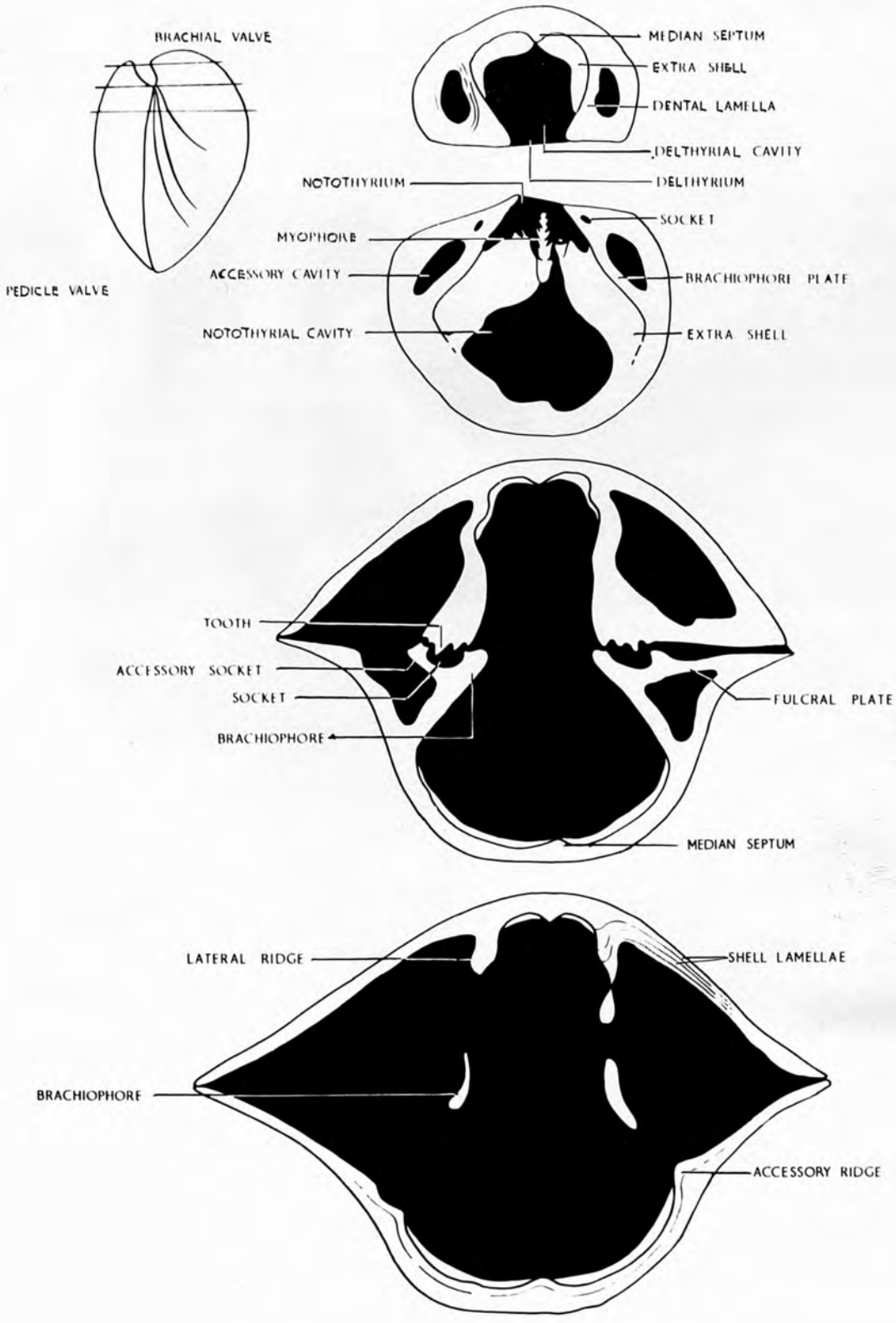


SERIAL SECTIONS

Text-fig. 1

STRATIGRAPHICAL OCCURRENCE

Specimens of Schizophoria have been examined from Devonian and Carboniferous rocks of western Europe. Devonian specimens have been examined from Belgium, France and Germany. Devonian material from south-west England is relatively rare, and, when available, is generally poorly preserved. Carboniferous specimens have been examined from Belgium and the British Isles.

Relevant stratigraphical and geographical data of specimens are presented here.

Occurrences of specimens have been copied as presented on labels. Some old collections are not always precisely localised, but where possible these specimens are omitted from the thesis, except where they illustrate important morphological features. Additional or revised stratigraphical information of museum specimens may be obtained by referring to the following sections.

DEVONIAN

A— Belgium

The detailed stratigraphical sequence and maps of localities of specimens from the Institut royal des Sciences naturelles de Belgique are shown on text-figures 2-4. The Lower Devonian specimens were collected from the southern border of the Dinant basin, and specimens from the Middle and Upper Devonian towards the basin centre.

Lithologies of the beds are given on text-figure 2.

Available data of specimens studied are as follows:

S. antiqua Solle— Frasnien, Assise de Frasnes, F 2d, Frasnes, Carrière de l'Arche, Couvin.

— same stratigraphical level, Boussu-Récif d'Hublet, Couvin.

— Frasnien, F 2h, Solre-St.-Gery,

SYSTEME DEVONIEN DE BELGIQUE

LOWER DEVONIAN CORRELATIONS WITH GERMANY

			(MAILLIEUX & DEMANET 1930) (MAILLIEUX 1941)
SUPERIEUR	ETAGE FAMENNIEN		ASSISE DES SCHISTES DE LA FAMENNE shales, sandstones
	ETAGE FRASNIEN	F 3 F 2 F 1	ASSISE DE MATAGNE shales, argillaceous limestones ASSISE DE FRASNES (a-i) shales, limestones, reefs ASSISE DE FROMELENNES shales, argillaceous limestones
MOYEN	ETAGE GIVETIEN	G	ASSISE DE GIVET argillaceous limestones, shales
	ETAGE COUVINIEN (EIFELIEN)	Co 2 Co 1	ASSISE DE COUVIN (a,b,c) argillaceous and stromatoporoid limestones, reefs ASSISE DE BURE (a,b) greywackes, shales, argillaceous limestones
INFERIEUR	ETAGE EMSIEN Koblenzstufe	Em 3 Em 2 Em 1g Em 1b Em 1a	GRAUWACKE DE HIERGES (OBERKOBLENZSCHICHTEN) ASSISE DE WINENNE (KOBLENZQUARZIT) GRES DE MORMONT GRES DE VIVREUX (UNTERKOBLENZQUARZIT) greywackes, sandstones, shales RAUWACKE DE PESCHE
	ETAGE SIEGENIEN Siegenerstufe	Sg 5 III Sg 4 Sg 3 III Sg 3b Sg 3a Sg 2 Sg 1	QUARTZOPHYLLADES DE SAINT-VITH ASSISE DE NEUFCHATEAU (HUNSRUCKSCHIEFER) GRAUWACKE INFERIEUR DE LAROCHE GRAUWACKE DE PETIGNY greywackes, sandstones, shales GRAUWACKE DE SAINT-MICHEL (HERSDORFERSCHICHTEN) GRES D'ANOR (RAUFLASERSCHICHTEN) GRES DE SAINT-HUBERT (TONSCHIEFERSCHICHTEN)
	ETAGE GEDINNIEN Gedinnestufe		ASSISE D'OIGNIES shales sandstones quartzites ASSISE DE MONDREPUITS

SIEGENIEN & EMSIEN COMPOSITE SUCCESSION FROM DINANT BASIN

Text-fig. 2

Carrière à 430m. E-S-E église, S. route de Vergnies.

— Frasnien, F 2i, Boussu-en-Fagne, Carrière du cimetière, Couvin.

S. provulvaria (Maurer)— Dévonien Inférieur, Siegenien, Grès d'Anor, Sg 2, Petigny, Couvin.

— Dévonien Inférieur, Siegenien, Grauwacke de Saint-Michel, Sg 3, Saint Hubert; Bois de Saint Michel, Thiers des Grippes, Saint Hubert; Grupont; tranchée chemin de fer, Mirwart, Grupont.

— Dévonien Inférieur, Siegenien, Grauwacke Inférieur de Laroche, Sg 3III.

— Dévonien Inférieur, Siegenien, Quartzophyllades de Saint-Vith, Sg 5III, tranchée chemin de fer, 650m. s-o-de Breitfeld, Saint Vith.

— Dévonien Inférieur, Emsien Inférieur, Grauwacke de Pesche, Em 1a, tranchée chemin de fer de Gedinne, Pondrome.

— Dévonien Inférieur, Emsien Inférieur, Grès de Mormont, Em 1g, Erezée.

S. striatula (Schlotheim)— Couvinien Supérieur, Assise de Couvin, CO 2a, 600m. N. Tellin, Grupont; Jemelle, Rochefort.

— Couvin Supérieur, Assise de Couvin, CO 2c, Fond des Valaines, Rochefort; Jemelle, Rochefort; N. de la Haie d'Oppagne, Durbuy; Route de Champlon-Famenne, Marche.

— Frasnien Moyen, F 2a, Boussu, Couvin; Nismes, Olloy; Petigny, Couvin.

— Frasnien Moyen, F 2b, Chimay au S. de la Maladrie, Seloignes.

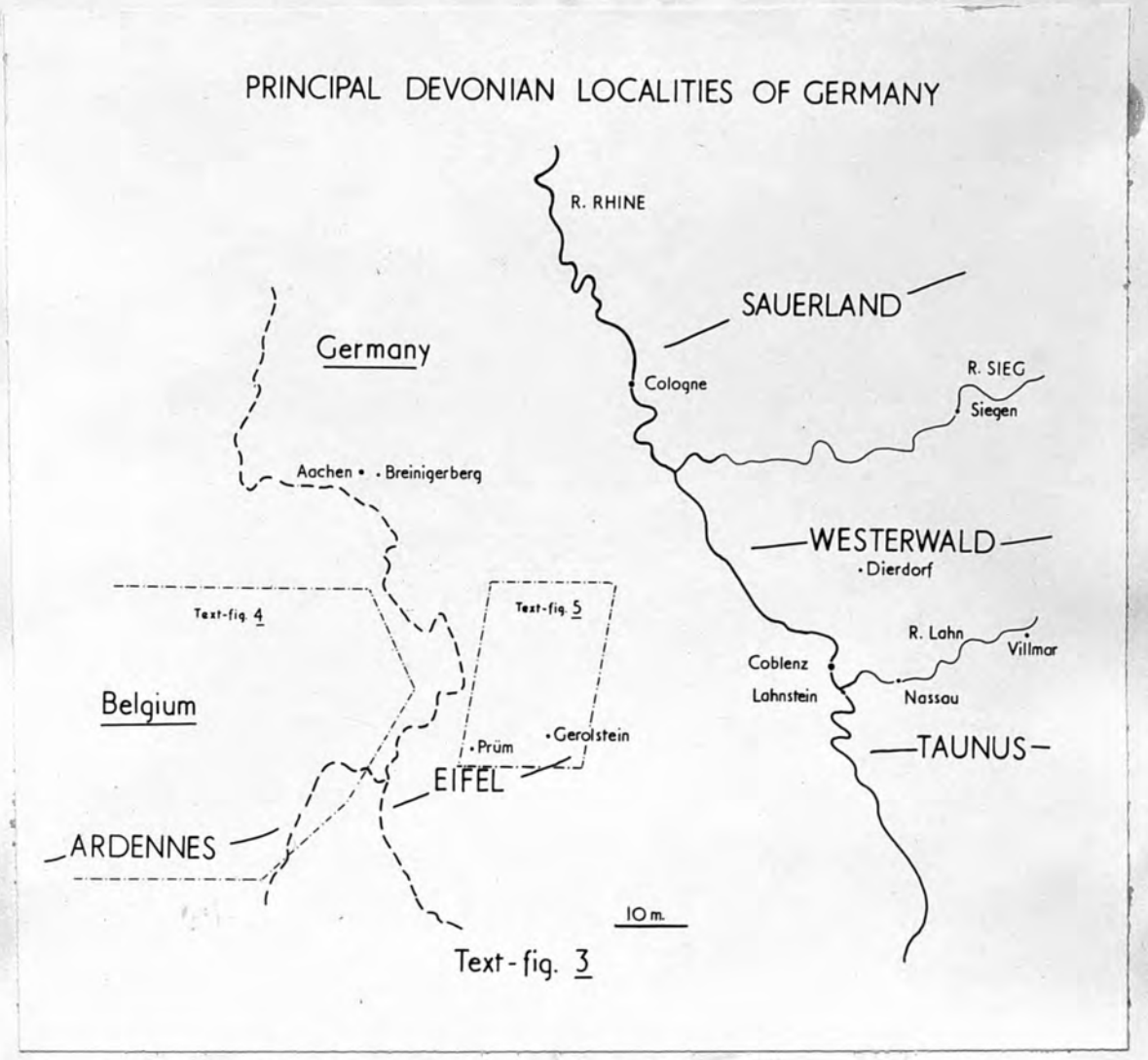
— Frasnien Moyen, F 2e, tranchée chemin de fer, 600m. N. station Marloie, Aye.

S. strigosa (Sowerby)— Dévonien Inférieur, Siegenien, Grauwacke de Saint-Michel, Sg 3, tranchée chemin de fer, Mirwart, Grupont.

— Dévonien Inférieur, Siegenien, Grauwacke

de Petigny, Sg 3b, Couvin.

— Dévonien Inférieur, Emsien Inférieur, Grauwacke de Pesche, Em 1a, tranchée chemin de fer de Gedinne, Pondrome.



Text-fig. 3

S. vulvaria (Quenstedt)— Dévonien Inférieur, Emsien Supérieur, Grauwacke de Hierges, Em 3, 2,200m. N.O. d'Ambly, Rochefort; chemin de fer Belair, 600m. S. de la station de Grupont; 400m. S.O. de Masbourg, Rochefort; route de Saint Hubert, 1,400m. N.O. de Masbourg, Rochefort; 750m. S. de Petigny, Couvin; tranchée chemin de fer Vicinal, Olloy; 150m. N. de Grimbiémont, Marche; 1,400m. SE. de Couvin, N. du Bois Hestren; tranchée chemin de fer Jemelle, Rochefort.

— Dévonien Moyen, Couvinien Inférieur, Assise de Bure, CO 1a, 200m. S. station

PRINCIPAL DEVONIAN LOCALITIES OF THE DINANT BASIN

Text - fig. 4

de Jemelle, tranchée route de Jemelle a Forrières, Rochefort; tranchée Vicinal Olloy-Oignies.

— Dévonien Moyen, Couvinien, Assise de Bure, CO 1b, Chemin de Lesterny à la halte du chemin de fer, Rochefort.

B— France (Boulonnais)

The Boulonnais is an eroded anticline east of Boulogne and south-west of Calais. Deep erosion has exposed Palaeozoic rocks in the north-east, in the region of Ferques (Pruvost, 1924, p.29).

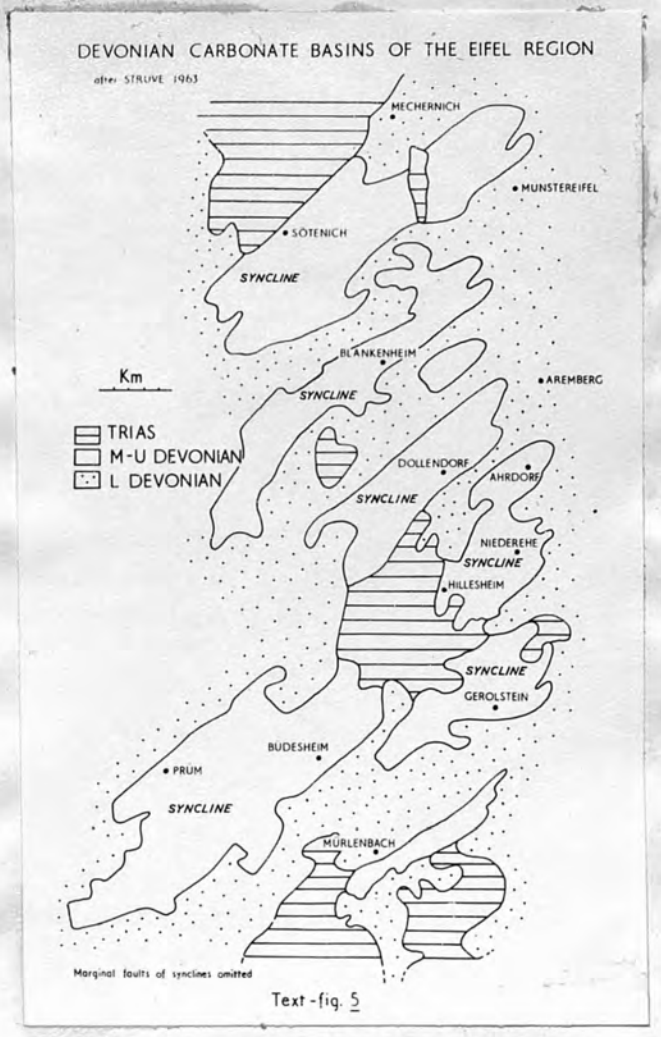
A few specimens of Schizophoria striatula (Schlotheim) have been examined from Frasnian dolomitic shales of the Carrière (Quarry) Parisienne. Additional specimens of this species have been studied from the Devonian of Ferques.

C— Germany

Most of the German material examined was collected from the Eifel region by Mr. P. Copper and the author. A map of the synclines of the Eifel is given on text-figure 5. The Hillesheimer syncline provided much of the material, the succession and lithologies of which are shown on text-figure 6. The stratigraphy and lithologies of other Eifel synclines can be referred to this succession. Middle Devonian rocks, bordered by Lower Devonian rocks, outcrop in the synclines, while Upper Devonian rocks occur only in the Prüm syncline.

Specimens from Upper Devonian, Frasnian shales, have been collected by Mr. P. Copper from near Aachen and at Paffrath, near Cologne.

Lower Devonian material has been studied from old museum collections. Geographical localities are shown on text-figure 3, although detailed stratigraphical and geographical data are generally lacking.



Text-fig. 5

Available data of specimens studied is as follows:

S. antiqua Solle— Upper-Middle Devonian, Villmar, Brücham Bahnhof.

— Lower Frasnian, Paffrath, Paffrather Syncline near Cologne, MTB Mulheim-Rhein.

S. provulvaria (Maurer)— Lower Devonian, Seifen.

— Lower Devonian, Seifener Schichten, Seifen.

— Lower Devonian, Siegener Schichten, Seifen.

S. pygmaea Struve— Eifelian, Nohn/Ahrdorf Beds, Hundsdell/ Bildstock Horizon, Sotenicher Syncline, MTB Mechernich, r 37560 : h 97080, Eifel.

— Eifelian, Ahrdorf Beds, Bildstock Horizon, MTB Dollendorf, r 5452 : h 8064; r 5537 : h 7536, Eifel.

— Eifelian, Ahrdorf Beds, Flesten Horizon, MTB Dollendorf, r 5621 : h 8211; r 5580 : h 8149; r 5595 : h 8214; MTB Mechernich, Eifel.

— Eifelian, Schwirzheim Horizon, Gerolstein, Eifel.

S. pygmaea subspecies A— Eifelian, Lauch Beds, Wolfenbach Horizon, MTB Dollendorf, r 5248 : h 8038, Eifel.

— Eifelian, Junkerberg Beds, Blankenheim Railway Cutting, Blankenheim Syncline, Eifel.

— Middle Devonian, Gerolstein, Eifel.

S. striatula (Schlotheim)— Eifelian, Lower Nohn Beds, Weilersbach Horizon, Hillesheimer Syncline, MTB Dollendorf, r 5698 : h 7835.

— Eifelian, Junkerberg Beds, Geisdorf Horizon, MTB Gerolstein, r 3668 : h 6569, r 3688, h 6591; MTB Mechernich, r 4095, h 9701, Eifel.

— same stratigraphical level, Prüm Syncline, Eifel.

— Eifelian, Freilingen Beds, Eilenberg Horizon, MTB Dollendorf, r 5434 : h 7532, Eifel.

— Eifelian, Lower Freilingen Beds, MTB Munstereifel, r 4736 : h 0180; MTB Mechernich, r 4650 : h 0149, Eifel.

S. strigosa (Sowerby)— Lower Devonian, Unter Coblenzian.

S. vulvaria (Quenstedt)— Lower Devonian, Eifel, Coblenz, Lahnstein.

— Lower Devonian, Ober Coblenzian, Daleiden.

— Lower Devonian, Coblenzian, Grimbach.

— Lower Devonian, Ober Ems, Niederprüm, Prüm.

MTB - Messtischblatt or topographical map
r - latitude
h - longitude.

MIDDLE DEVONIAN OF THE HILLESHEIMER SYNCLINE (EIFEL)

MIDDLE DEVONIAN

STAGES	BEDS		SERIES	HORIZONS
GIVETIAN	DREIMÜHLEN			Binz sh., nod. lms.
	CÜRTEN			Meerbüsch strom. lms. Forstberg sh., argill. lms. Marmorwand bitum. lms. Felschbach sandy sh.
	LOOGH			Rech lms., sh. Wotan lms.
EIFELIAN	AHBACH			Müllert sh., argill. lms. Lahr lms., sh. Hallert argill. lms.
	FREILINGEN			Nollenbach crin. lms., sh. Eilenberg sh., nod. lms.
	JUNKERBERG		"RUDERSBACH"	Geisdorf nod. lms., sh. Rassenriff ostiolatus horizon Nims lms., sh.
			HEINZELT	Rechert argill. lms., lms. Hönselberg sh., argill. lms. Mussel sh., lms. Klausbach argill. sst., sh.
	AHRDORF		NIEDEREHE	sh., lms.
			BETTERBERG	Wasen nod. lms., sh. Flesten sandy sh, nod. lms. Köll sh., bitum. lms. Bildstock sh, sandy sh., lms.
	NOHN	Ob.		Hundsdell lms., sst. Dankerath sandy sh.
		Unt.	AHÜTTE	Hunnertsberg sandy sh. Erdel lms. Markstein sh. Schmitzbach sh.
			KIRBERG	Schleit sh., argill. lms Weilersbach sh., lms.
	LAUCH			Dorsel sh., sst, lms. lenses Wolfenbach lms., sh.

KEY

argill	argillaceous	nod.	nodular
bitum	bituminous	sh.	shale
crin.	crinoidal	sst.	sandstone
lms.	limestone		

Text-fig. 6

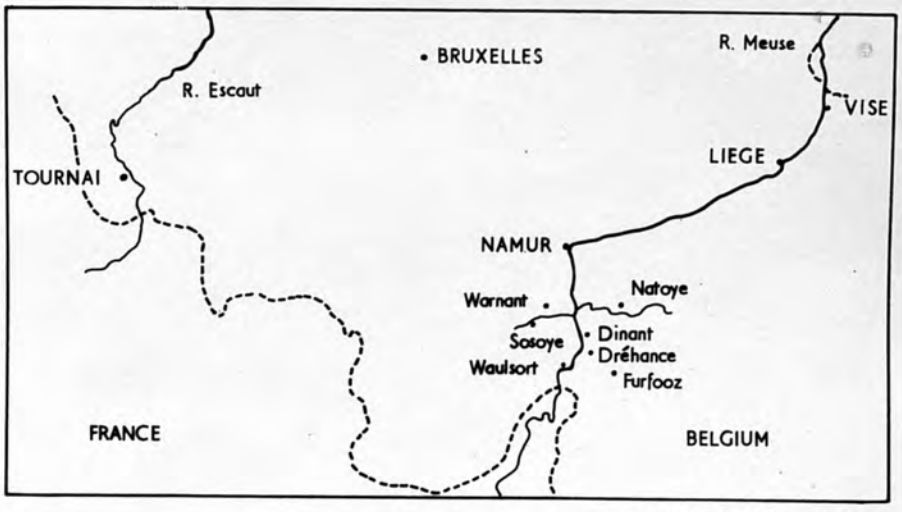
CARBONIFEROUS

A— Belgium

The map of localities and detailed stratigraphical sequence of specimens studied from the Institut royal des Sciences naturelles de Belgique are shown on text-figures 7 and 8.

The main Dinantian outcrops occur in the Dinant and Namur basins. The Waulsortian reef facies is developed at two

PRINCIPALES LOCALITES DU DINANTIEN DE LA BELGIQUE



AFTER DEMANET 1958

TEXT-FIG. 7

horizons, development in the Viséan greatly exceeding that of the Tournaisian. The Petit granit (text-figure 8) is replaced by Waulsortian limestones south of Dinant, and the Marbre noir is replaced by such limestones in the region of Sosoye. The Waulsortian limestones are a blue-veined, fenestellid, richly fossiliferous rock.

Available data of specimens studied is as follows:

S. connivens (Phillips)— Viséan, Visé.

S. linguata (Quenstedt)— Tournaisian, Tn 3b, Dréhance.

S. resupinata (Martin)— Waulsortian, Wève, Dinant.

DINANTIEN DE LA BELGIQUE

ETAGES	ASSISES	SOUS-ASSISES	NOTATIONS EMPLOYEES A L' I. R. SC. N. B.
VISEEN	III. DE WARNANT V_3	Couches de passage	V_{3c} sup.
		Calcaires et schistes (Calcaire de Visé (Namur) bassin)	V_{3c} inf.
		Bleu belge	V_{3b}
		Grande Crèche et oolithe supérieure	V_{3a}
	II. DE NAMECHE V_2	Calcaire inférieur d'Anhée et Petite brèche	V_{2b}
		Calcaire de Neffe et oolithe moyenne	V_{2a}
	I. DE DINANT V_1 (faciès waulsortiens exceptionnels)	Calcaire et dolomie de Sovet	V_{1b}
		Marbre noir et oolithe inférieure	V_{1a}
TOURNAISIEN	III. DE CELLES (faciès waulsortiens ordinaires) Tn_3	Calcaire de Leffe	Tn_{3c}
		Petit granite	Tn_{3b}
		Calcaire d'Yvoir	Tn_{3a}
	II. DE MAREDSOUS Tn_2	Calcschistes de Maredsous	Tn_{2c}
		Calcaire de Landelies	Tn_{2b}
		Schistes à Spiriferellina	Tn_{2a}
	I. D' HASTIERE ET D' ETROEUNGT Tn_1	Calcaire et schiste d' Hastiere	Tn_{1b}
		Schistes, macignos et calcaires d' Etroeungt	Tn_{1a}

AFTER DEMANET 1958

Text-fig. 8

— Viséan, Furfooz, Dinant.

var. dorsosinuata Demanet

— Tournaisian, Tn 3bR, Wève, Dinant.

— Tournaisian, Tn 3, Tournai.

— same horizon, Trouder Frontal, Furfooz, Dinant.

var. lata Demanet

— Assise de Celles, Waulsortian, Tn 3bR, Drehance.

— same horizon, Lez-Fontain, Natoye.

var. pinguis Demanet

— Tournaisian, Waulsortian, Furfooz, Dinant.

— Tournaisian, Tn 3bR, Vère Chateau, Dinant.

S. woodi Bond— Calcaire de Visé, V 3b-V 3c, Visé.

B— British Isles

The stratigraphical positions of areas of Carboniferous rocks from which specimens of Schizophoria have been collected, or studied from museum collections, are given on text-figure 9.

Most species of Schizophoria are confined to the Lower Carboniferous, although S. connivens extends into the Namurian (E2) of Scotland (Gair), and S. hudsoni occurs in the Namurian (R1) of Yorkshire. Rare specimens have been recorded from the marine bands of the Coal Measures (eg. Edwards and Stubblefield, 1947, p.229, Schizophoria sp.).

Specimens examined are essentially from the reef facies, since the fauna is so abundant and easily extracted. In most cases the fauna is sporadically distributed, occurring in pockets or shell banks. Schizophoria does occur in the more massif facies, but is less abundant and difficult to extract. Caldbeck, Cayton Gill, Gair, Corrie Burn, Avon Gorge and the Mendips are included in this study, although not belonging to the reef facies, since they illustrate the extended range of the genus. There is

a concentration of areas studied in the C2-C2 S1 and D zones, since reef limestones are most abundant at these levels. The massif facies is developed in the K and Z zones, where specimens are more scarce. Specimens from the Namurian are restricted to marine bands, the Calmy Limestone of Gair, and the marine Cayton Gill siltstone of Yorkshire.

Only relevant sections of the Dinantian or Namurian sequences have been described, and further details may be acquired from cited references. Areas have been described under geographical regions 1-10, and some areas are further subdivided.

Text-figures 10-15 illustrate areas where specimens have been collected by the author, and localities for each area are marked.

1. Avon Gorge

Vaughan's succession (1905) ranges from the K1 to D2 subzones. Massive limestones of the Z1 subzone are exposed in quarry one (Vaughan, ibid), and the lowest part of quarry two, and the Z2 subzone is exposed in the upper part of quarry two.

Specimens of Schizophoria resupinata (Martin) have been examined from the Z zone.

2. Caldbeck, Cumberland

Lower Carboniferous rocks at Falls Brew Caldbeck span the S2 to D3 subzones (Eastwood, 1946).

Specimens of Schizophoria linguata (Quenstedt) have been studied from this area.

3. Derbyshire

a. Castleton -- The stratigraphical succession as presented by Parkinson (1953) is as follows:

Edale Shales
— unconformity —
P1

STRATIGRAPHICAL POSITION OF AREAS OF CARBONIFEROUS STUDIED IN THE BRITISH ISLES

	STAGES	SUB-STAGES	"ZONES"	AREAS STUDIED
UPPER CARBONIFEROUS	NAMURIAN		R_3 R_2 R_1 H E_2 E_1	Cayton Gill Darley Markington Pateley Bridge (non reef) Fewston Gair (non reef)
LOWER CARBONIFEROUS	DINANTIAN	VISEAN	D_3 P_2 D_2 P_1 D_1 B_2 S_2 B_1 C_2 S_1	Corrie Burn (non reef) Castletown (B-P_1) Parkhouse Hill Castleton Cracoe Curkeen Hill Malham Narrowdale Co. Meath Scaleber Caldbeck (S_2-D_1),(non reef) Clitheroe Carrick on Shannon (C_2S_1-P_2) Little Island Tyrone (C_2S_1-D_2)
		TOURNAISIAN	C_2 C_1 Z_2 Z_1 K_2 K_1	Bolland Buttevant Co. Kerry Co. Kildare Thorpe Cloud Co. Limerick (C_1-C_2S_1) Mendips (K_1-D_2) Avon Gorge (K_1-D_2),(non reef)

Areas marked belong to reef facies except where otherwise indicated

Equivalency of brachiopod-coral and goniatite-lamellibranchs zones after WELLS and KIRKALDY 1956

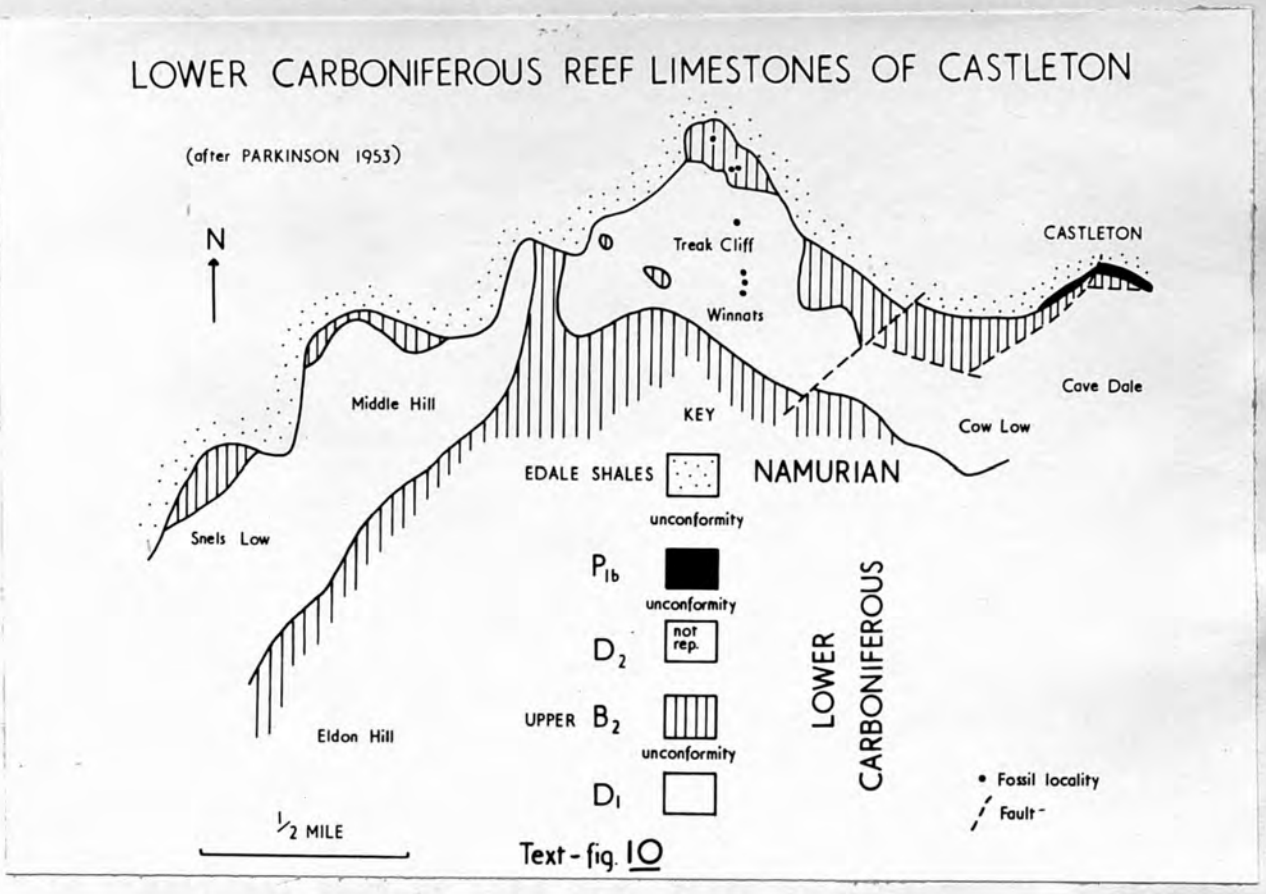
Text-fig. 9

— unconformity —
D2
Upper B2
— unconformity —
D1

(text-fig. 10)

Cow Low, Middle Hill, Snels Low, Treak Cliff and Winnats form part of a reef complex situated on the northern edge of the Carboniferous Limestone plateau of north Derbyshire.

Reef limestones of Middle D1 age form the summit ridge



of Treak Cliff and part of the flat to the west. The rocks are generally sparsely fossiliferous, except for shell pockets. The limestones are overlain unconformably on the north and north-east by white or light-grey, shelly and crinoidal limestones of Upper B2 age.

Reef limestones of Eldon Hill, D1 in age, are confined to the north-west slopes, the facies changing to the east and south-east (Parkinson, 1943, p.124).

The following species and variant have been examined:

S. connivens (Phillips)— D1 limestones, Treak Cliff.

S. linguata (Quenstedt)— D1 limestones, Treak Cliff.

S. resupinata (Martin)— D1 limestones, Eldon Hill, Middle Hill, Treak Cliff.

— Upper B2 limestones, Treak Cliff.

var. pinguis Demanet
— D1 limestones, Eldon Hill, Treak Cliff.

S. woodi Bond— D1 limestones, Eldon Hill, Treak Cliff.

— Upper B2 limestones, Treak Cliff.

4. Dovedale, Derbyshire - Staffordshire

The stratigraphical sequence for the reef facies as presented by Parkinson (1949) is as follows:

Gateham shales - probably Namurian
— unconformity —
Narrowdale Limestone D1(B2)
— unconformity —
Alstonfield Limestone S
— unconformity in Thorpe Cloud area —
Dovedale Limestone C1-2.

Dovedale presents a transitional area between the Carboniferous Limestone massif and basin facies. Areas of reef limestone do not generally produce topographical features except Narrowdale, Thorpe Cloud and Wetton Hills, which are typical knolls.

The Dovedale Limestone (C1-2) is an obscurely bedded, pale limestone, varying from grey-white to blue-white, fine to coarse-grained and crinoidal, with tufa layers, breccias and boulder beds. Fossils are scarce, except for a brachiopod bed at the summit of Thorpe Cloud.

The succeeding Alstonfield Limestone (S2) is only locally developed.

The Narrowdale Limestone (D1) resembles the Dovedale Limestone in lithology. The reef knolls of Narrowdale and Wetton contain a local abundance of fossils.

The following species and variant have been examined:

S. connivens (Phillips)— D1 subzone, Narrowdale.

S. linguata (Quenstedt)— C1-2 subzones, Thorpe Cloud.

— D1 subzone, Narrowdale, Wetton.

S. resupinata (Martin)— D1 subzone, Narrowdale, Wetton.

var. pinguis Demanet

— C1-2 subzones, Thorpe Cloud.

5. Glasgow District

The stratigraphical succession as presented by Currie (1953) and Bassett (1958) is as follows:

CARBONIFEROUS LIMESTONE SERIES	Upper Limestone Group	Castlecary Lst.	E2
		Calmy Lst.	
		Orchard Lst.	
		Index Lst.	
	Limestone Coal Group		E1
		Top Hosie Lst.	
	Lower Limestone Group	Hurlet (Corrie Burn) Lst.	P2
CALCIFEROUS SANDSTONE SERIES			P1

The Lower Limestone Group, P2 in age, consists of limestone bands separated by shales, thin clay-band ironstones, sandstones and coal bands. The Upper Limestone Group, E2 in age, is composed of sandstones separated by limestone bands.

Schizophoria connivens (Phillips) has been examined from the Hurlet Limestone (P2), at Corrie Burn), and from the Calmy Limestone (E2), at Gair, Carluke.

6. Ireland

a. Carrick-on-Shannon — The stratigraphical succession as given

by Caldwell (1959) is as follows:

Roscunnish Shales P1-2
Cavetown Limestone Group D1
Croghan Limestone Group D1
Ballymore Beds S2-D1
Oakport Limestone Group S2
Kilbryan Limestone Group C2 S1
Boyle Sandstone Group C2 S1

The Kilbryan Limestone Group consists of dark, irregularly bedded, fine-grained bioclastic limestones with interbedded shales. The Ballymore Beds are dark-grey, crinoidal and shelly limestones, with some shales and reef limestones. The Cavetown Limestone Group is composed of crinoidal calcarenites and fine-grained, dark limestones, chert, and unbedded sheet reefs.

Schizophoria resupinata (Martin) has been examined from these three groups.

b. County Cork — Schizophoria gibbera (Portlock) has been examined from the C1-2 subzones at Buttevant.

Poorly bedded, pale-grey coloured, compact, highly fossiliferous Waulsortian reef limestones of C2-S1 age (Turner, 1952) also outcrop on Little Island. Schizophoria gibbera (Portlock), S. sp. nov. and S. resupinata (Martin) have been studied from Little Island.

c. County Dublin — Schizophoria connivens (Phillips) and S. resupinata (Martin) have been studied from the Curkeen Hill Limestone, a grey to light-grey coloured, poorly bedded rock, from near Loughshinny. Matley and Vaughan (1906) assigned the limestone to the D2 subzone, but Smyth (1949) included the Curkeen Hill Knoll in the Grey Limestones of the D1 subzone.

d. Counties Kerry and Kildare — Schizophoria sp. nov. occurs in pale grey, poorly-bedded or unbedded limestones of the C2 subzone of the Maine Valley, Kerry, and S. connivens (Phillips) in the C1-2 subzones at Millicent, Kildare, parts of the Waulsortian reef belt.

e. County Limerick — Waulsortian reef limestones span the C1-2 and possibly C2 S1 subzones of the Carboniferous succession of north-west County Limerick (Shephard-Thorn, 1963). The bioclastic limestones range from poorly bedded, coarsely crinoidal types to fine-grained calcite mudstones.

The following species and variant have been studied:

S. connivens (Phillips)

S. resupinata (Martin)

var. dorsosinuata Demanet.

f. County Meath — Schizophoria connivens (Phillips) has been examined in the D1 subzone of County Meath.

g. County Tyrone — Carboniferous rocks range in age from the C2 S1-D zones (Padget, 1952). Many brachiopods described by Portlock in 1843 were collected from beds at Kildress, which range from the S2 subzone to the S2 D1 subzone or early D2 subzone (Padget, 1952a).

Portlock's holotype of Schizophoria gibbera is localised as Carboniferous Limestone, Tyrone, and could possibly have been collected at Kildress.

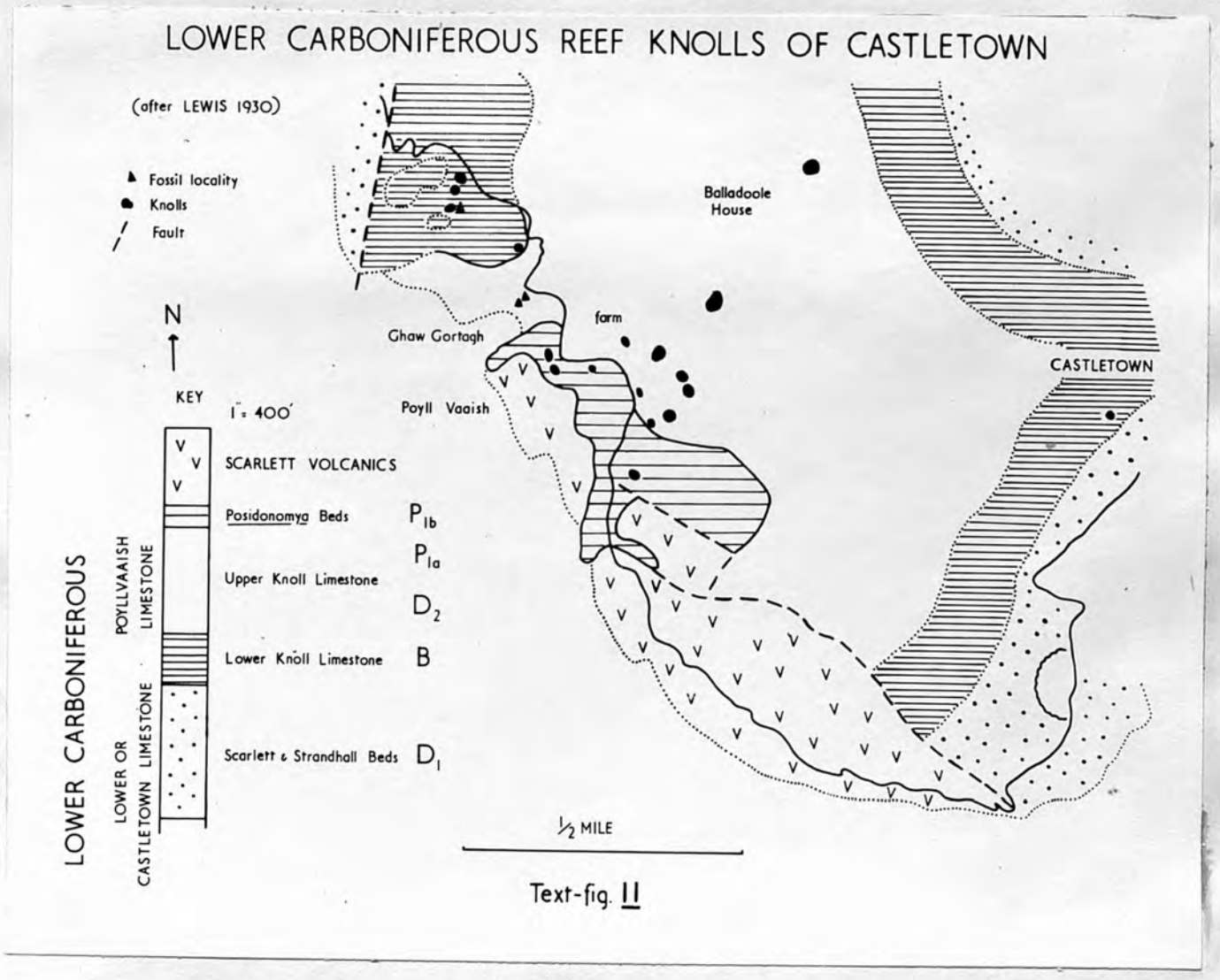
7. Isle of Man

The stratigraphical succession of the Castletown area as presented by Lewis (1930) is as follows:

POYLLVAAISH LIMESTONE	Posidonomya Beds	P1 b
	Upper Knoll Limestone	P1 a
	Coral Band	D2
	Lower Knoll Limestone	B
LOWER OR CASTLETOWN LIMESTONE	Scarlett and Strandhall Beds	D1

(text-fig. 11)

The Lower Knoll Limestone of B age is a coarse-grained buff-sandy coloured, well jointed, soft, dolomitized rock. The overlying Upper Knoll Limestone of P1 a age is a fine to coarse-grained, light to dark-grey coloured, jointed, unbedded or poorly bedded rock.



Text-fig. 11

Although specimens are more easily extracted from the friable lower limestone, preservation is better in the upper limestone.

The following species and variants have been examined:

S. connivens (Phillips)— Lower Knoll Limestone

S. resupinata (Martin)— Lower and Upper Knoll Limestones

var. pinguis Demanet— Lower Knoll Limestone

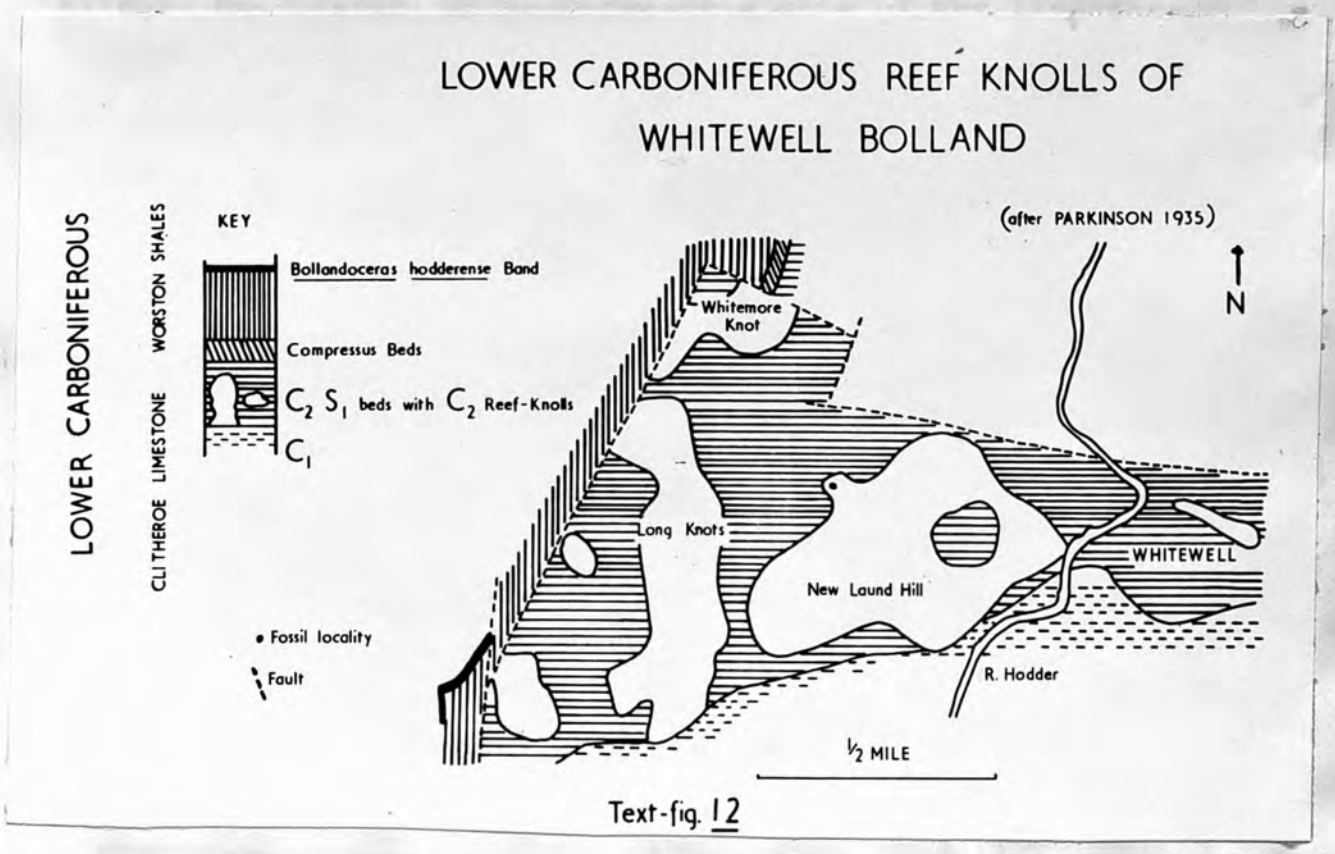
var. lata Demanet— Upper Knoll Limestone

S. woodi Bond— Upper Knoll Limestone.

8. Lancashire

a. Bolland (Lancashire-Yorkshire) — The Clitheroe Limestone of

C2 S1 age contains reef knolls of C2 age (Parkinson, 1935), (text-fig. 12). Long Knots, New Laund Hill and Whitemore Knot are knolls lying on the north-west limb of the Slaidburn anticline, composed of a fine-grained, light-grey or buff-coloured, unbedded, jointed, crinoidal reef limestone.



Text-fig. 12

The following species and variant have been examined:

S. connivens (Phillips)— Bolland

S. gibbera (Portlock)— Bolland

S. linguata (Quenstedt)— Bolland

S. resupinata (Martin)— Bolland, New Laund Hill

var. pinguis Demanet— Bolland.

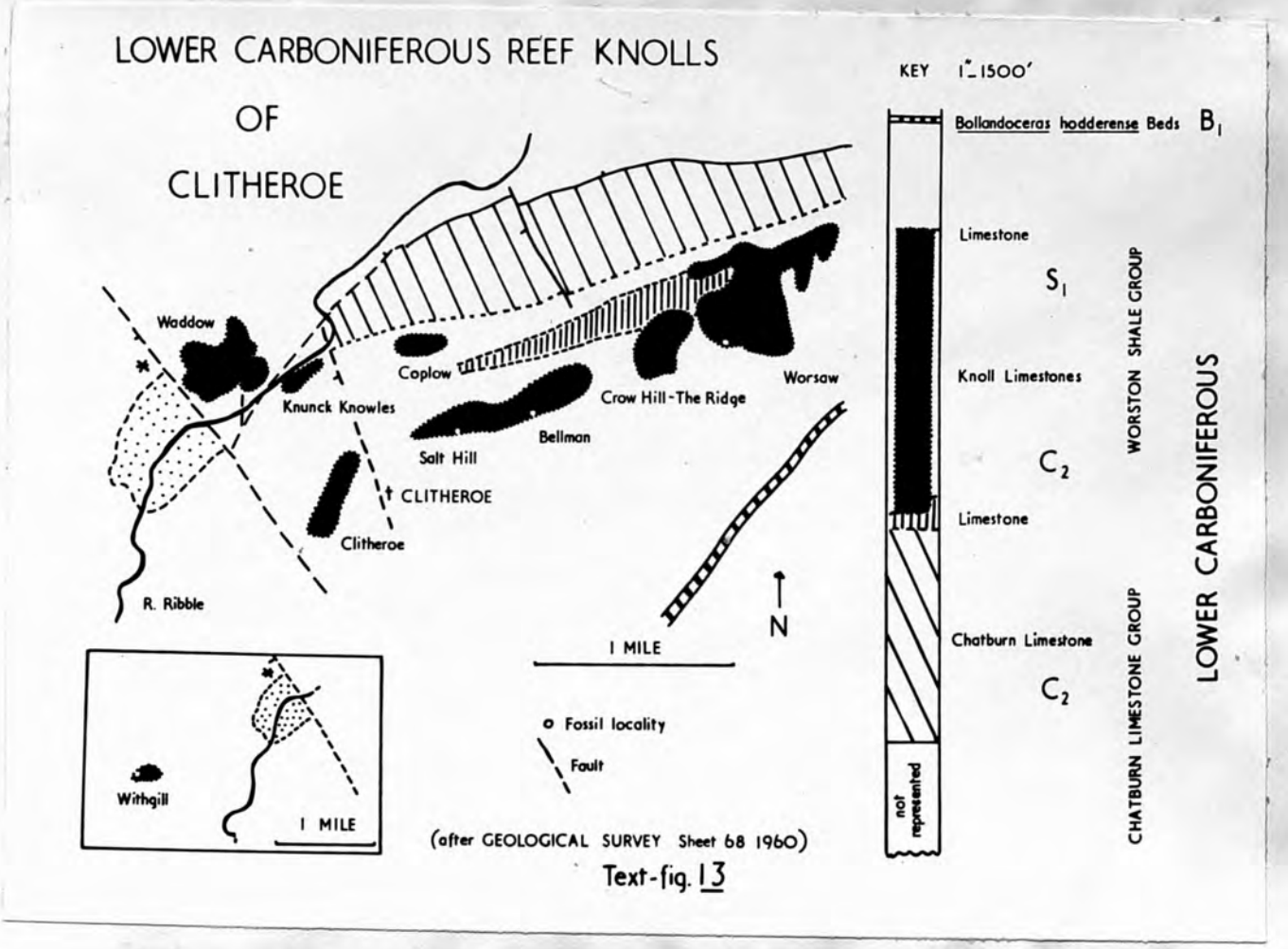
b. Clitheroe — The stratigraphical succession as presented by the Geological Survey (1961, Memoir 68) is as follows:

Worston Shale Group
- B1-2
- Limestones S2
- Knoll Limestones C2 S1
- Limestones C2

Chatburn Limestone Group | Chatburn Limestone C2
Calcareous Shales C1

(text-fig. 13).

Bellman, Clitheroe, Coplow, Crow Hill-The Ridge, Knunck Knowles, Salthill, Waddow, Withgill and Worsaw are a series of aligned bank deposits, away from the site of any limestone massif. They occur at many stratigraphical levels, yet appear to belong to the C2 S1 zone.



Text-fig. 13

The reef limestones are composed of three lithological types, knoll limestone proper, coarsely crinoidal knoll talus, and clastic limestones, generally of the normal bedded type. The knoll limestone is a fine to coarse-grained, light-grey or buff-coloured, unbedded or obscurely bedded rock. The rich fauna is sporadically distributed in pockets.

The Worston Shale Group of the Geological Survey includes the Pendleside Limestone, Worston Shale Series and Coplow and Salthill Knoll Series of Parkinson (1926). The survey found the separation of the knoll series to be impracticable. Where knolls are present, the line joining their tops is not a stratigraphical boundary, and where knoll-bearing strata gives place to equivalent beds without knolls, the latter are inseparable from the rest of the Worston Shale Group.

A re-survey of the knoll limestone has shown the absence of faunal and lithological facies as in true reefs, so that it is concluded that the reefs are really bank deposits.

The following species have been examined:

S. connivens (Phillips)— Clitheroe

S. aff. gibbera (Portlock)— Worston Shale Group, Bellman Knoll

S. resupinata (Martin)— Worston Shale Group, Bellman, Salthill, Withgill, Worsaw Knolls.

9. Mendips

The Dinantian sequence at Burrington Combe ranges from the K1 to D2 subzones (Sibly, 1905, 1906). The K zone is composed of a thick series of shales with subsidiary limestones. Limestones are important higher in the zone. Schizophoria resupinata (Martin), and possibly S. connivens (Phillips) have been studied from the K2 subzone.

10. Yorkshire

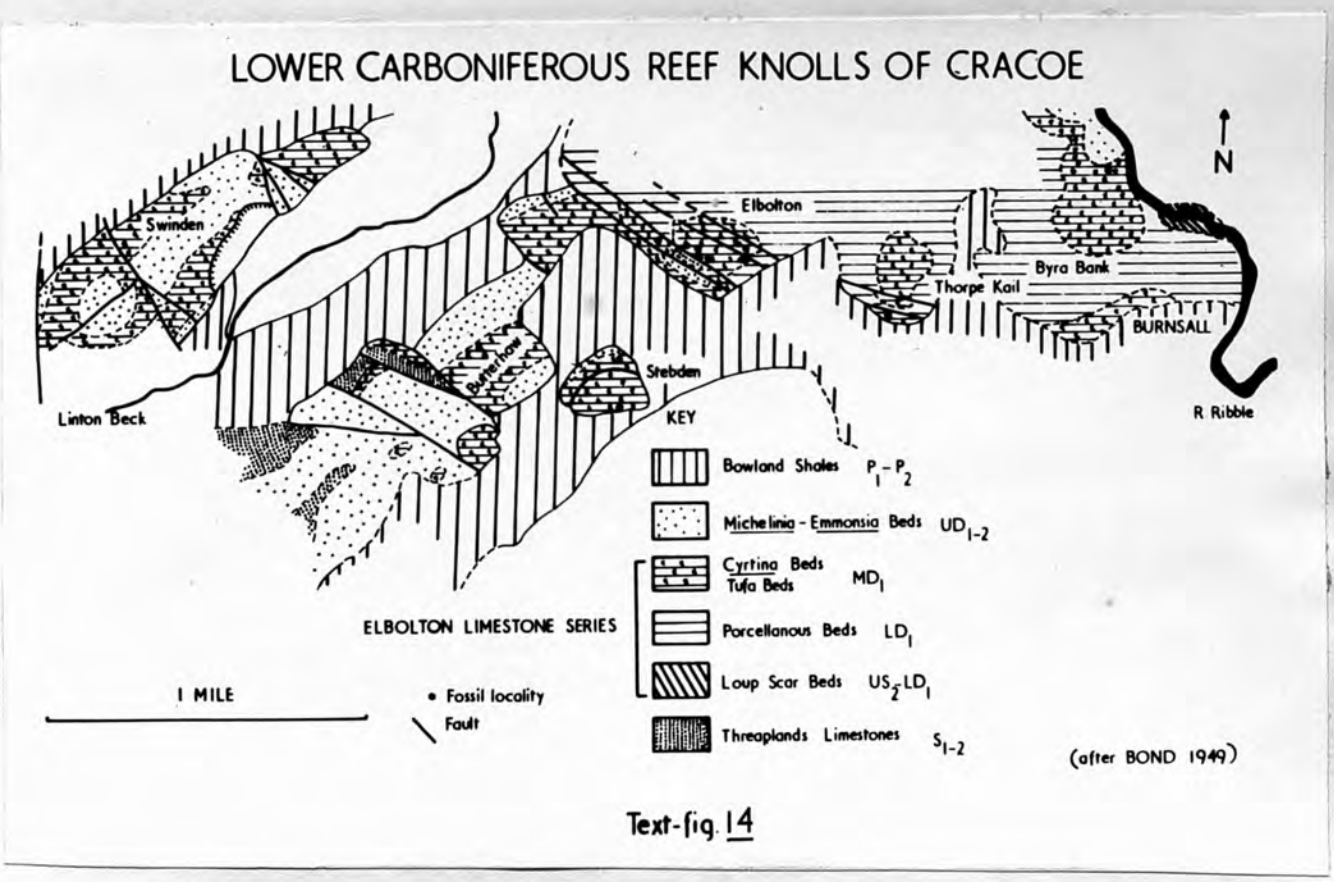
a. Cayton Gill, Darley, Fewston, Markington, Pateley Bridge — The Cayton Gill Beds, R1 in age, are a development of marine shelly siltstone towards the lower part of the Kinderscout Grit Group. Schizophoria hudsoni George is present in these beds.

b. Cracoe — The stratigraphical succession as given by Bond (1949) is as follows:

P1	Lower Bowland Shales	
Upper Lower	— unconformity —	
D1 - D2	Michelinia-Emmonsia Beds	
Upper Middle S2 - D1	Elbolton Limestone Series	(iv) Davidsonina (Cyrtina) septosa Beds Middle D1
		(iii) Tufa Beds Middle D1
		(ii) Porcellanous Beds Lower D1
		(i) Loup Scar Beds Upper S2 or Lower D1
S1-2	Threaplands Limestone Series	

(text-fig. 14).

Butterhaw, Byra Bank, Elbolton, Stebden, Swinden and Thorpe Kail Knolls form part of a line of reef knolls on the



Text-fig. 14

southern edge of the Carboniferous Limestone plateau of Yorkshire. They are mainly composed of Elbolton Limestone Series (Upper S2-Middle D1), the subdivision of which is shown above. The Loup Scar Beds, dark crinoidal limestones, are exposed along the River Wharfe. The succeeding Porcellanous Beds consist of fine-

grained, buff-coloured limestones.

The Tufa Beds are fine-grained, dark or medium-grey coloured rocks, with irregular layers of tufa. These are succeeded by beds of similar lithology, the Davidsonina septosa Beds. The two latter groups of beds are very fossiliferous, but preservation of fauna is less perfect in the higher bed.

The following species and variants have been examined:

S. connivens (Phillips)— Butterhaw, Elbolton, Byra Bank, Stebden, Swinden, Thorpe Kail

S. resupinata (Martin)— Butterhaw, Byra Bank, Elbolton, Stebden, Swinden, Thorpe Kail

var. lata Demanet— Elbolton

var. pinguis Demanet— Elbolton

S. woodi Bond— Swinden.

All specimens occur in the Elbolton Limestone Series.

c. Malham — Reef limestones of Upper D1 age are exposed on Burn's Hill and Cawden and Wedber Knolls, just south of the mid Craven Fault (Hudson, 1949). These buff to light-grey coloured, poorly bedded shelf reef limestones were deposited on and against bedded limestones of S2 and Lower D1 age. Schizophoria connivens (Phillips) has been studied from Malham, and S. resupinata (Martin) and S. woodi Bond from Wedber Knoll.

d. Scaleber Bridge, Settle — The stratigraphical succession as presented by Hudson (1930) is as follows:

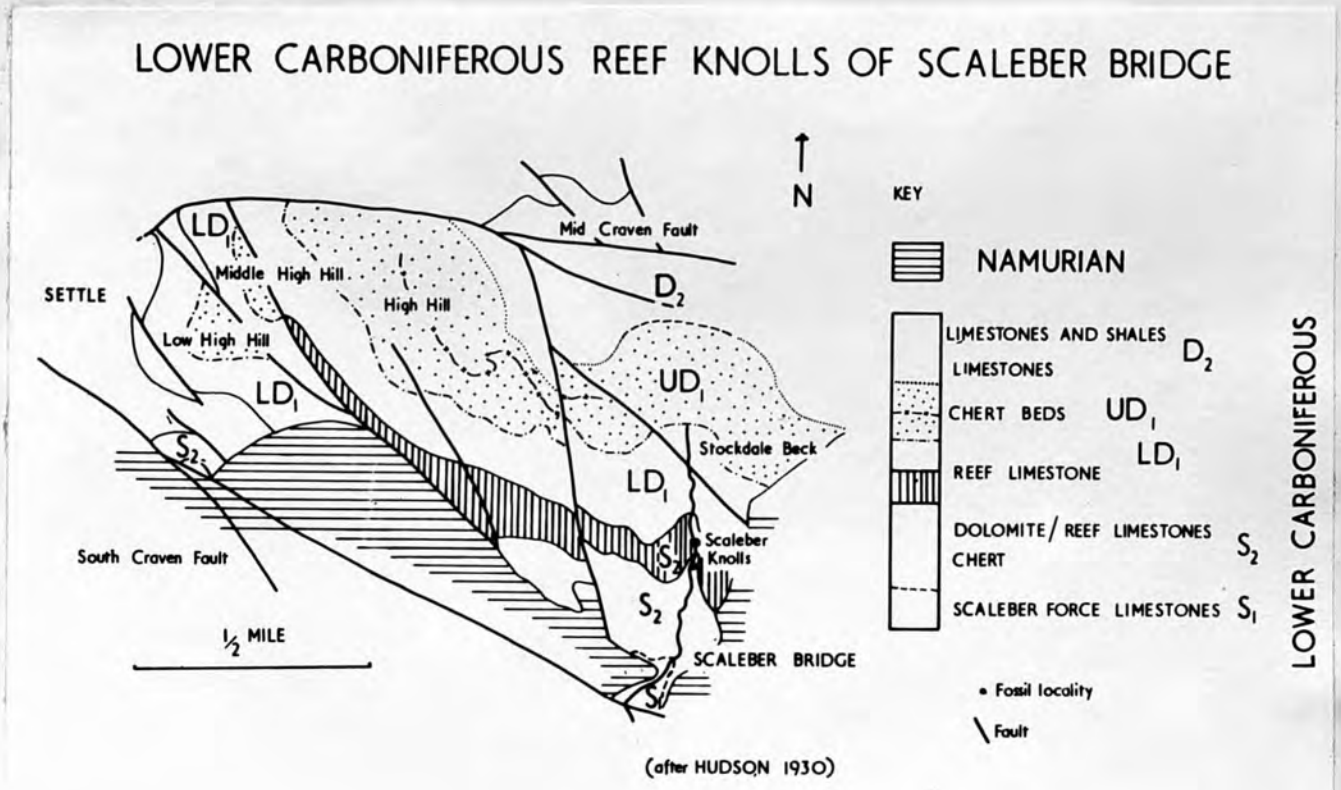
Upper Bowland Shales
— unconformity —
D2 LIMESTONES and SHALES
UD1 LIMESTONES
DOLOMITES and LIMESTONES of HIGH HILLS and SCALEBER KNOLLS — Limestones S2-LD1 / Dolomite Series S2

SCALEBER FORCE SERIES — Scaleber Quarry Limestones S2 / Scaleber Force Limestones S1

(text-fig. 15)

The Scaleber reefs are a sector of a line of reef lime-

stones developed on the southern edge of the Carboniferous Limestone massif of Yorkshire.



Text-fig. 15

The reef limestones, S2-LD1 in age, are poorly bedded or unbedded, fine-grained, porcellanous or clastic, light-grey coloured rocks, interbedded with dolomite.

Garwood and Goodyear (1924, p.229) dated the Scaleber Quarry Limestones as D2-3 in age, and the succeeding reef limestones as D3 in age. Hudson (1930, p.295) stated that he had recently described the Lithostrotion arachnoideum fauna found in the Scaleber Quarry Limestones, and suggested that it is S2 in age. The succeeding reef limestones are then S2-LD1 in age.

Schizophoria connivens (Phillips), S. resupinata (Martin), and S. resupinata var. pinguis Demanet have been examined from S2-LD1 reef limestone of the Scaleber Knolls.

Specimens belonging to the Tiddeman Collection (Skipton

Museum) are localized as "Craven", but were collected from D1 to LD2 subzones between Settle and Greenhow (Parkinson, 1954, p.371). The collection is composed of Schizophoria connivens (Phillips), S. linguata (Quenstedt), S. sp. nov., S. resupinata (Martin), the variants lata and pinguis Demanet, and S. woodi Bond.

SYSTEMATIC DESCRIPTIONS

The principal collections from which specimens were studied have the following abbreviations:

BM — British Museum (Natural History)
GMUS — Geological Museum, University of Saskatchewan
GSI — Geological Survey of Ireland (Dublin)
GMS — Geological Survey Museum (London)
GSL — Geological Survey, Leeds
HMUG — Hunterian Museum, University of Glasgow
IC — Imperial College, London
IRIG — Institut royal des Sciences naturelles de Belgique
SM — Skipton Museum, Yorkshire
SME — Sedgwick Museum, University of Cambridge
SMF — Senckenberg Museum, Frankfurt
TCD — Trinity College, Dublin
UR — University of Reading

Additional material is deposited in the Geology Department, Bedford College, University of London (BC B).

Sub-order DALMANELLOIDEA Moore, 1952
Family SCHIZOPHORIIDAE Schuchert and Le Vene, 1929
Sub-family SCHIZOPHORIINAE Schuchert and Le Vene, 1929
Genus SCHIZOPHORIA King, 1850

Outline generally transversely rectangular to elliptical, ventribiconvex to biconvex to dorsibiconvex, the brachial valve generally deeper. Hingeline straight, submegathyrid. Anterior commissure varying from rectimarginate to uniplicate, unisulcate, sulciplicate, biplicate. Shell costellate, rugate, fibrous and punctate. Pedicle valve interior with divergent or subparallel diductor muscle field separated by median septum representing adductor muscle field. Pair of subparallel pallial sinus trunks originate from anterior of muscle field. Brachial valve interior with divergent brachiophores supported by divergent or curved brachiophore plates; adductor muscle field quadripartite, with a

pair of oblique septa separating anterior and posterior adductor muscle fields; frequently with additional septum separating each posterior adductor scar into two digitate parts. Four or six subparallel pallial sinus trunks originate from anterior of muscle field.

DEVONIAN

Schizophoria antiqua Solle

Pl.1, figs.1, 2; text-figs.16-18.

Orthis (Schizophoria) striatula Schl., Walther, 1908, p.279, pl.13, fig.9.

Orthis striatula Schl., Assman, 1910, p.161, pl.9, figs.1, 2.

_____, Viétor, 1916, p.452, pl.18, fig.10.

Schizophoria antiqua n.sp., Solle, 1936, p.208, figs.14, 15.

Type. — Solle (1936, p.208, figs.14, 15) deposited the holotype (Nr.XVll 533a) and specimen Nr.XVll 533b in the Senckenberg Museum, Frankfurt.

Diagnosis. — Shell medium to small, rectangular to elliptical, generally dorsibiconvex, tumid in adult form, with broad, uniplicate anterior commissure. Shell rugate. Pedicle muscle field strongly incised, flabellate, longitudinally divided by broad, rounded median septum. Brachial muscle field moderately incised, elongate oval, bounded posteriorly by curved brachiophore plates supporting stubby brachiophores.

Description. — Shell medium to small, ventribiconvex to dorsibiconvex, rectangular to elliptical in outline, wider than long, with greatest width at midlength. Pedicle valve convex umbonally, flattening laterally, depressed medially. Brachial valve generally more convex, greatest convexity umbonally, or evenly convex longitudinally, flattening laterally. Beaks small, pointed, incurved; brachial beak more incurved, and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea prominent, high, curved to beak; delthyrium triangular, higher than wide, open. Brachial interarea lower, curved to beak; notothyrium triangular, as wide as high, open.

Pedicle sinus ill-defined, originating near anterior border. Anterior commissure uniplicate, due to broad, low, subrounded, dorsal, linguiform extension of pedicle valve. Shell costellate, rugate. Radial costellae coarse, 4 to 5 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation. Prominent growth rugae concentric. Puncta evenly distributed in inner shell layers, concentrated along costellae in higher shell layers, concentrated along striae on surface of shell.

Teeth compound, supported by anteriorly divergent ventrally subparallel to divergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.17, section 3.4). Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.17, sections 1.1-1.8).

Pedicle muscle field (text-fig.17a) one third to one half valve length, broad, flabellate, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, reflexed to form deep, broad, rounded anterior re-entrant, uniting with anterior termination of median septum. Median septum prominent, originating near apex of delthyrial cavity, rounded, with slight furrow along crest, broadening and increasing in height, and becoming flat-topped anteriorly; as broad as diductor muscle field anteriorly (text-fig.17, sections 1.1-9.5, a). No evidence of pedicle muscle scars. Pallial sinus pattern consisting of two slightly divergent trunks originating from ends of diductor muscle field (text-fig.17a). No evidence of genital markings.

Myophore small, simple, or rudimentarily compound, with central ridge bordered by two shorter ridges, one either side, all serrated. Shell partially filling notothyrial cavity,

decreasing in thickness and disappearing anteriorly (text-fig. 17, sections 0.5-2.4). Stubby brachiophores fused to strong, curved brachiophore plates bounding notothyrial cavity (text-fig.17, sections 1.4-3.7). Dental sockets oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.17, section 3.2). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig.17, sections 2.1-3.5).

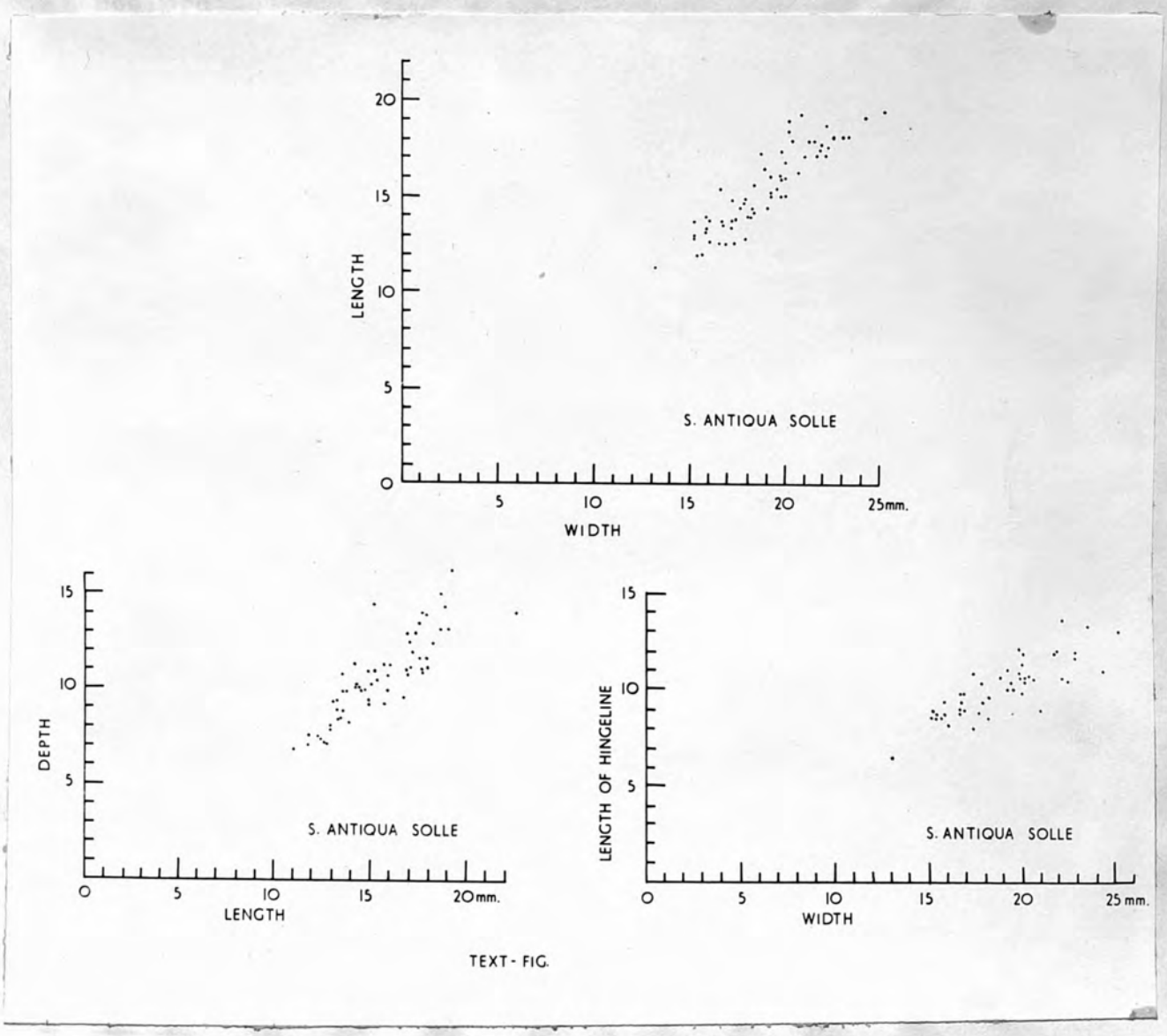
Brachial muscle field (text-fig.17b) moderately incised, elongate oval, with greatest width anteriorly, one third to one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges continuous with brachiophore plates. Ridges decreasing in height anteriorly, and smoothly reflexed, uniting with median septum. Median septum originating in notothyrial cavity, angular, increasing in height and broadening very slightly anteriorly (text-fig.17, sections 1.1-7.8, b). Weak, obliquely trending line dividing adductor muscle field (text-fig.17b). Pallial sinus pattern consisting of four weakly divergent trunks originating from anterior end of muscle field, and pair of divergent trunks from antero-lateral limits of muscle field (text-fig.17b). No evidence of genital markings.

Dimensions of available muscle fields:

	Length of pedicle muscle field	Width of pedicle muscle field
IRIG 4591	5.2 (+)	3.8
IRIG 4591	4.5	3.5
IRIG 4591	4.9 (+)	4.1
IRIG 6418	7.0	5.4
IRIG 9179	9.6	6.0
SMF	8.3	6.0
SMF	6.0	3.9
SMF	7.3	6.0

	Length of brachial muscle field	Width of brachial muscle field
IRIG 6418	8.9	6.4
IRIG 6418	7.0	5.5
SMF	7.2	7.4

External dimensions are plotted on text-figure 16.



TEXT-FIG.

Remarks. — The material is generally well preserved.

There is an increase in dorsibiconvexity, globosity and height of the anterior plication with age.

Solle described Schizophoria antiqua from the Lower Devonian of Germany. Other specimens from the Senckenberg

Museum Frankfurt were collected from the upper-Middle Devonian of Villmar. The bulk of the material examined is from the Institut royal des Sciences naturelles de Belgique, and was collected from the Frasnian of the Dinant basin, Belgium. Additional specimens collected by Mr. P. Copper, and deposited at Bedford College, have been examined from the Frasnian of the Paffrather syncline, near Cologne.

This medium to small, tumid, rugate form of Schizophoria is distinct from other Devonian species (see text-fig.18).

Schizophoria antiqua Solle closely resembles S. woodi Bond from the Carboniferous in outline, tumidity, prominent rugae, curved brachiophore plates and flabellate pedicle muscle field (cf. text-figs.17 and 72, 73). There is also a resemblance in size with the smaller form of S. woodi from Treak Cliff, and Cracoe and Craven. But S. antiqua is more coarsely costellate, lacks spine bases, and the brachial muscle field is more elongate oval in outline. However, S. antiqua and S. woodi are probably closely related (see Phylogeny).

Youthful forms of Schizophoria antiqua resemble S. connivens (Phillips) from the Carboniferous in rectangular outline and coarse costellae, but internally there are distinct differences (cf. text-figs. 17 and 44). The flabellate pedicle muscle field and broad median septum of S. antiqua contrast with the less flabellate, oval form and narrower septum of S. connivens. In the brachial valve, the elongate oval brachial muscle field, curved brachiophore plates and six pallial sinus trunks of S. antiqua contrast with the elliptical to rounded muscle field, divergent brachiophore plates and four pallial sinus trunks of S. connivens.

Material. —

Belgium

IRIG 4591 (including 3 fragmentary pedicle internal moulds),

6418 (partial internal mould, fragmentary internal mould) — Frasnien, F 2h, Solre-St. Gery, Carrière a 430m. E-S-E église S. route de Vergnies.

IRIG 5911, 6154, 9179 (including partial internal mould) — Frasnien, Assise de Frasnes, F 2d, Frasnes, Carrière de l'Arche, Couvin.

IRIG 8439 (including partial internal mould) — Frasnien, Assise de Frasnes, F 2d, Frasnes, Boussu-Récif d'Hublet, Couvin.

IRIG 8701 — Frasnien, F 2i, Boussu-en-Fagne, Carrière du Cimetière, Couvin.

Germany

BC B1-9 (7 - fragmentary, 9 - plaster cast) — Lowermost Frasnian Shales, Paffrath, Paffrather Syncline, near Cologne, MTB Mulheim-Rhein r 7814 : h 4754.

SMF (including internal mould, partial internal mould, pedicle internal mould) — Ober Mittel Devon, Villmar, Brücham Bahnhof.

TEXT-FIG.17 — Schizophoria antiqua Solle

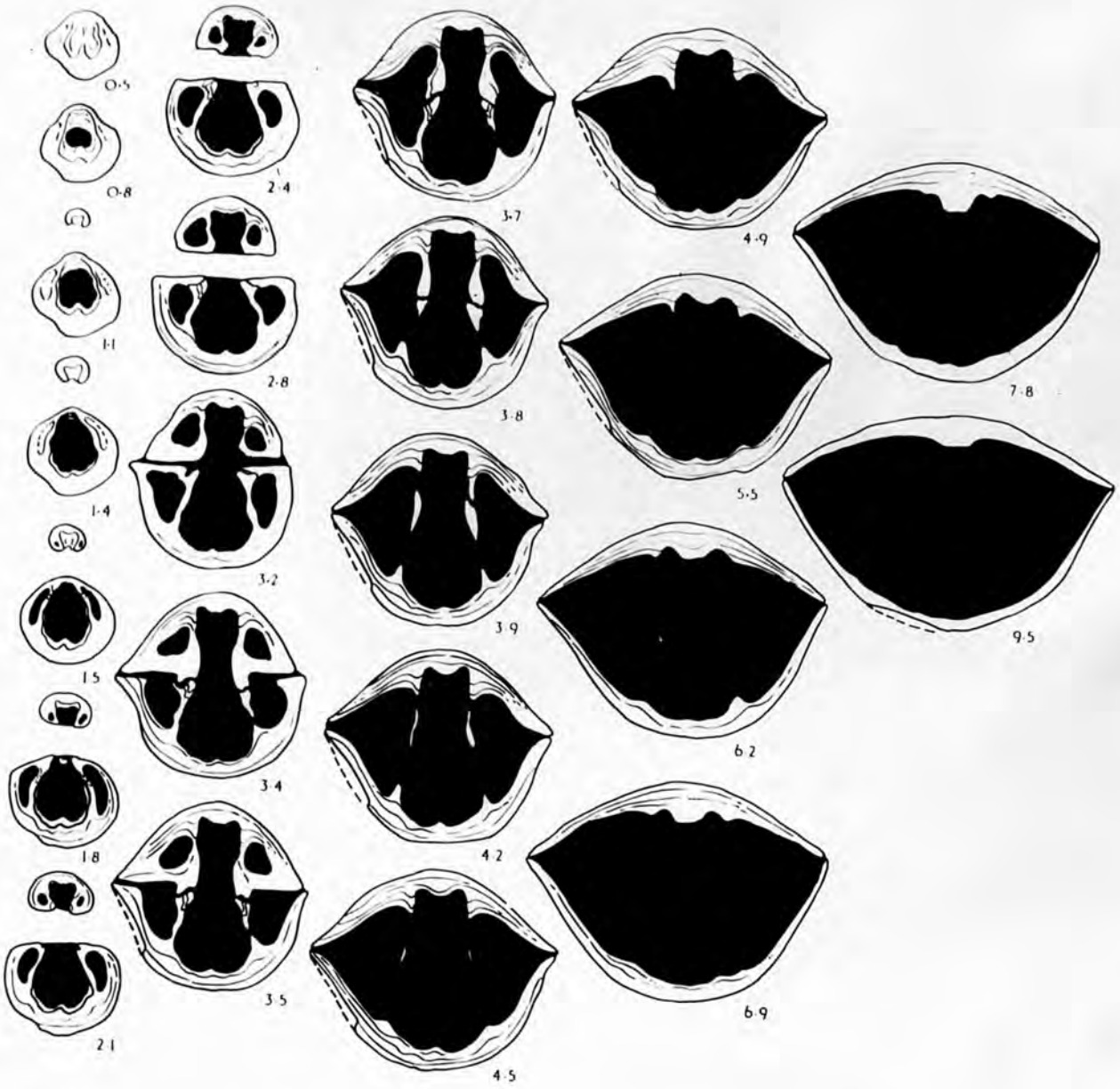
Measurements of sectioned specimen in millimetres

Length	Width	Depth
19.6	25.2	16.0

Numbers below serial sections indicate distances in millimetres measured anteriorly from pedicle umbo. Sections x 2.

IRIG 6154 — Frasnien, Assise de Frasnes, F 2d, Frasnes, Carriere de l'Arche, Couvin, Belgium.

a -- Pedicle muscle field x 2.
b -- Brachial muscle field x 2.


0·5
0·8
1·1
1·4
1·5
1·8
2·1
2·4
2·8
3·2
3·4
3·5
3·7
3·8
3·9
4·2
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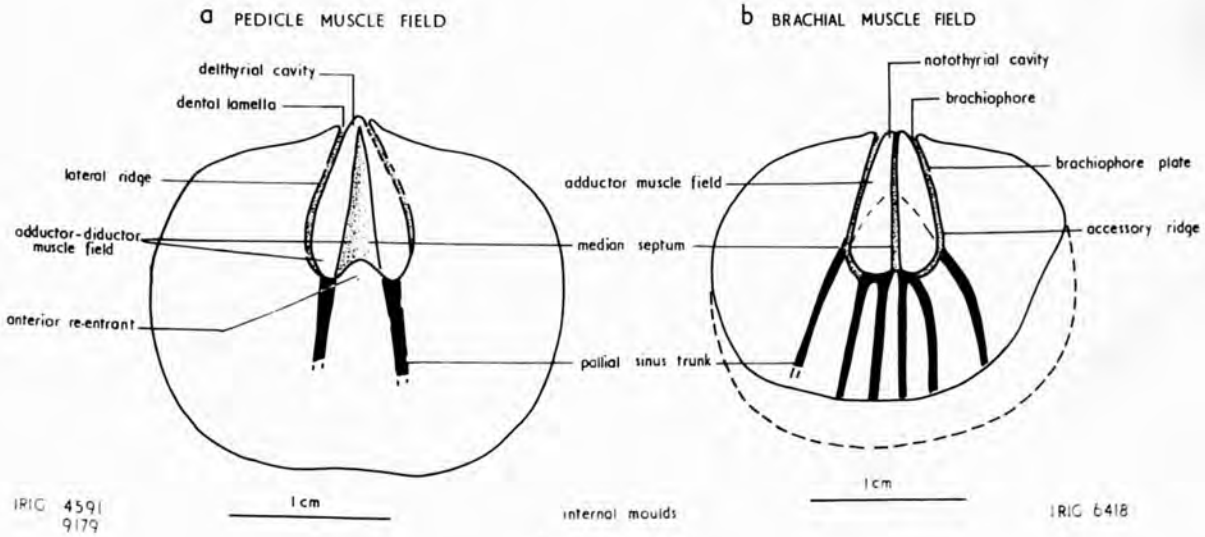
6·2
6·9
7·8
9·5


a PEDICLE MUSCLE FIELD
delthyrial cavity
dental lamella
lateral ridge
adductor-diductor muscle field
anterior re-entrant
pallial sinus trunk
median septum
1 cm
IRIG 4591 9179
b BRACHIAL MUSCLE FIELD
notothyrial cavity
brachiophore
brachiophore plate
adductor muscle field
accessory ridge
1 cm
IRIG 6418
internal moulds

Text-fig. 17

COMPARISON OF DEVONIAN SPECIES OF SCHIZOPHORIA

SPECIES	SIZE	OUTLINE	CONVEXITY	ANTERIOR COMMISSURE	ORNAMENT	DENTAL LAMELLAE	PEDICLE MUSCLE FIELD	BRACHIOPHORES BRACHIOPHORE PLATES	BRACHIAL MUSCLE FIELD
Schizophoria antiqua Solle	medium small	rectangular elliptical	dorsibiconvex tumid	rounded uniplicate	costellae coarse rugae prominent	ventrally subparallel to divergent	broad flabellate strongly incised	stubby brachiophores curved brachiophore plates	elongate oval moderately incised
Schizophoria provulvaria (Maurer)	large	elliptical	dorsibiconvex	rounded uniplicate	——	ventrally subparallel to convergent	broad flabellate strongly incised	stubby brachiophores strong subparallel brachiophore plates	rectangular elliptical moderately incised digitate posterior adductor scars
Schizophoria pygmaea Struve	small	rectangular elliptical	weakly dorsibiconvex generally thin form	rounded uniplicate	costellae fine rugae weak	ventrally divergent	broad flabellate strongly incised	stubby brachiophores curved brachiophore plates	rectangular rounded moderately incised
Schizophoria pygmaea subspecies A	large	rectangular elliptical	weakly dorsibiconvex generally thin form	rounded uniplicate	costellae fine rugae weak spine bases	ventrally divergent	broad flabellate strongly incised	stubby brachiophores curved brachiophore plates	rectangular rounded moderately incised digitate posterior adductor scars
Schizophoria striatula (Schlotheim)	medium large	quadrate elliptical	dorsibiconvex	rounded uniplicate	costellae coarse rugae prominent	ventrally subparallel to divergent	elongate oval flabellate strongly incised	stubby brachiophores strong divergent brachiophore plates	quadrate rounded moderately incised digitate posterior adductor scars
Schizophoria strigosa (Sowerby)	medium large	quadrate elliptical	dorsibiconvex	rounded uniplicate	——	——	broad elongate oval flabellate strongly incised	——	quadrate rounded moderately incised digitate posterior adductor scars
Schizophoria vulvaria (Quenstedt)	large	quadrate rectangular elliptical	dorsibiconvex	rounded uniplicate	——	ventrally convergent	elongate oval flabellate strongly incised	stubby brachiophores strong divergent brachiophore plates	quadrate rounded moderately incised digitate tripartite posterior adductor scars

Text-fig. 18

Schizophoria provulvaria (Maurer)

Pl.1, figs.3-6; text-figs.19-22.

Orthis hipparionix, Vanuxem (?), Davidson, 1864-5, p.90, pl.17, figs.9, 10?; non. 8, 11.

? O. hipparionix, vel Orthis striatula., Etheridge, 1882, p.156, pl.4, fig.8.

Orthis personata Zeiler, Kayser, 1890, pl.12, fig.3.

Orthis provulvaria Maurer, 1893, p.7, pl.3, figs.1-4.

Orthis (Schizophoria) provulvaria Maur., Drevermann, 1904, p.267, pl.30, figs.29? 30; pl.31, figs.11-15, 16? 17, 18? 19.

Schizophoria provulvaria (Maurer), Péneau, 1929, p.218, pl.11, fig.10.

Schizophoria provulvaria Maurer, Laverdière, 1930, p.87, pl.3, fig.4.

_____, Schuchert and Cooper, 1932, pl.23, fig.11.

Schizophoria provulvaria, Maillieux, 1933, pl.4, fig.5l.

Schizophoria provulvaria (Maurer), Ussher, 1933, p.24, pl.3, figs.5, 9.

Schizophoria provulvaria Maurer, Termier and Termier, 1936, p.1126, pl.3, figs.3, 4: 1950, pl.71, figs.10, 11?, pl.72, figs.12? 13?

Orthis (Schizophoria) provulvaria Maur., Dahmer, 1936, p.270, pl.34, fig.7.

Schizophoria provulvaria (Maurer), Shirley, 1938, p.465, pl.4, figs.10-13.

?_____, Simpson, 1940, pl.5, fig.2e.

_____, Gill, 1942, p.36, pl.6, fig.1.

Schizophoria provulvaria Maurer, Gigout, 1951, p.316, pl.5, figs.7, 9.

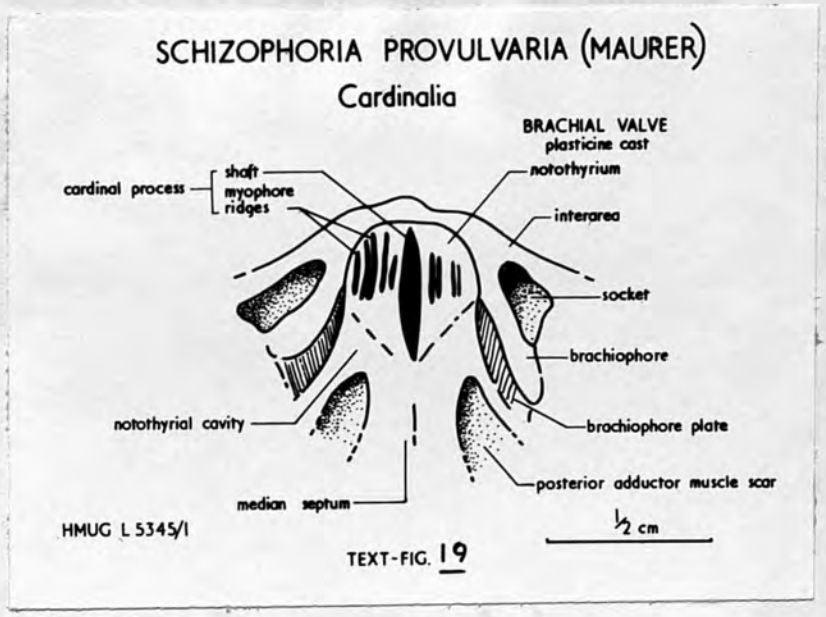
Type material — Maurer (1886, p.21; 1893, p.7, pl.3, figs.1-4) gave no reference to where his specimens had been deposited, and they cannot be traced. It is hereby proposed that a neotype will be selected in due course.

Diagnosis. — Internal mould large, elliptical, with rounded uniplicate anterior commissure. Pedicle muscle field broad, flabellate, strongly incised, longitudinally divided by broad, rounded median septum. Brachial muscle field moderately incised, bounded posteriorly by thick, subparallel to divergent brachiophores and brachiophore plates. Short follicular markings developed peripherally on moulds.

Description. — Internal mould large, dorsibiconvex, elliptical in outline, wider than long, with greatest width at or slightly anterior to midlength. Anterior commissure uniplicate, due to high, broad, rounded, dorsal, linguiform extension of pedicle valve.

Pedicle muscle field (text-fig.22b) one half to two-thirds valve length, broad, anteriorly flabellate, strongly incised, bounded posteriorly by anteriorly divergent dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, smoothly reflexed to form subrounded re-entrant, uniting with anterior termination of median septum (text-fig.22b). Median septum originating near point of delthyrial cavity, narrow, rounded, broadening and increasing in height anteriorly (text-fig.21A, sections 6.8-16.1). Muscle field subdivided anteriorly by longitudinal ridges (text-fig.22b). Pallial sinus pattern consisting of two parallel trunks originating in anterior re-entrant of muscle field. Genital markings developed laterally and postero-laterally (text-fig.22b).

Prominent cardinal process, differentiated into broad myophore supported by narrower shaft. Myophore compound, with as many as nine lateral ridges (ridges generally symmetrically developed), (text-fig.19). Stubby brachiophores curved postero-laterally, and fused to strong, thick, subparallel to divergent



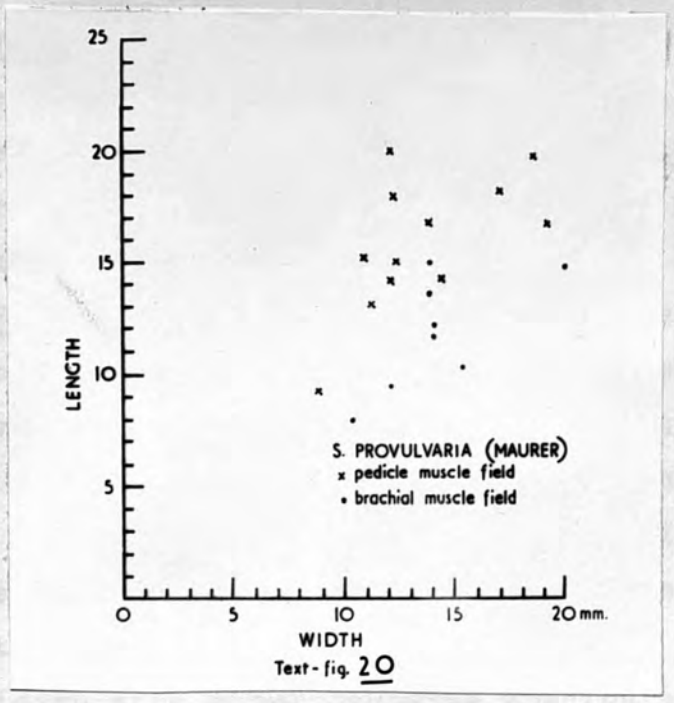
brachiophore plates bounding narrow notothyrial cavity (text-fig. 21B, sections 3.3-4.6). Dental sockets deep, oval, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates (text-fig.19).

Brachial muscle field (text-fig.22c) moderately incised, rectangular to elliptical, wider than long, one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by low accessory ridges. Ridges smoothly reflexed anteriorly to form shallow, subrounded anterior re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, low, broad, rounded, narrowing anteriorly (text-fig.21B, sections 3.8-10.5; text-fig.22c). Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts. Anterior adductor muscle scar pyriform. Posterior adductor muscle scar more incised, digitate, with slightly longer inner lobe, separated from outer lobe by rounded, curved, minor septum (text-fig.21B, sections 5.0-5.8; text-fig. 22c). Pallial sinus pattern consisting of two trunks, each bifurcating, originating from anterior re-entrant of muscle field (text-fig.22c). No evidence of genital markings. Short follic-

ular markings developed peripherally on moulds.

Dimensions of available muscle fields are plotted on text-figure 20.

External dimensions of S. provulvaria have been omitted, since specimens are fragmentary.



Remarks. — All specimens are generally preserved as internal moulds, so that details of external morphology are lacking. However, a few doubtful fragmentary external moulds illustrate a coarsely costellate shell. For comparative purposes, serial sections of plaster internal moulds (Stanley, 1964, p.105) have been taken to show the general appearance of internal structures in transverse section. Only discrete internal moulds were available, so that these have been sectioned separately, and show no pedicle valve-brachial valve relationship (text-fig.21).

The asymmetrical nature of the myophore in text-figure 19

is probably due to unequal preservation of the lateral ridges.

Schizophoria provulvaria (Maurer) superficially resembles S. strigosa (Sowerby), and these similarities and differences are listed under the latter species (see text-fig.37).

Schizophoria provulvaria is distinct from S. vulvaria (Quenstedt), another Lower Devonian species, as follows. Schizophoria provulvaria is generally wider in outline. Internally, the flabellate pedicle muscle field, broad, rounded median septum, and deep anterior re-entrant of S. provulvaria, contrast with the longer, lanceolate to weakly flabellate muscle field, narrow, subrounded median septum, and shallow or lack of anterior re-entrant of S. vulvaria. In the brachial valve, the moderately incised, rectangular muscle field, thick brachiophores and parallel to divergent brachiophore plates, and bipartite posterior adductor muscle scar of S. provulvaria, contrast with the more quadrate, strongly incised muscle field, thinner brachiophores and divergent brachiophore plates, and frequently tripartite posterior adductor muscle scar.

Comparisons with other Devonian species are shown on text-figure 18.

The specimen of Schizophoria provulvaria illustrated by Davidson (1864-5, pl.17, fig.8) resembles Proschizophoria personata (Zeiler), which lacks a pedicle median septum. Figure eleven of the above plate illustrates an extremely elongate pedicle muscle field and very high pedicle interarea, atypical of Schizophoria.

Maurer (1893, p.9) referred to specimens of Béclard (1891, p.101, pl.4, figs.1-6), who described and illustrated a new species Orthis musischura. Maurer recognised Béclard's species as resembling S. provulvaria, and also as occurring at a similar stratigraphical horizon. Maurer stated, that since

Orthis musischura and S. provulvaria differed only in the form of the brachial valve, he considered that the two forms should not have separate names, but that Orthis musischura was probably a local variety.

But some later authors (eg. Leriche, 1912, p.26, and Maillieux, 1931, p.11) have listed O. musischura in synonymy with Proschizophoria, although Béclard made no reference to Proschizophoria, but compared his species with S. striatula and S. vulvaria. Orthis musischura lacks a pedicle median septum, and has transverse septa dividing the brachial muscle field, characteristic of Proschizophoria. Béclard's specimens are here listed under Proschizophoria.

Davidson's use of Orthis hipparionix (1864-5, p.90) for his specimens resembling S. provulvaria is invalid. He did state that his large internal moulds resembled Orthis hipparionyx of American authors, but could not be certain as to their identification. The genus Hipparionyx was established by Vanuxem in 1842, and is synonymous with the genus Streptorhynchus King. In 1853, Schnur, working in the Eifel, discovered specimens with a similar flabellate pedicle muscle field, which he considered belonged to the genus Orthis, and changed Vanuxem's nomenclature to Orthis hipparionyx. But Schnur's specimens are orthotetid brachiopods. Davidson (1864-5) presumably recognised the flabellate pedicle muscle field of his specimens and listed them in synonymy with Schnur's Orthis hipparionyx.

The following authors have given short, unillustrated descriptions or synonymies of S. provulvaria:

Orthis provulvaria n.sp., Maurer, 1886, p.21.
O(S) provulvaria Maurer, Hüffner, 1917, p.289.
Orthis (Schizophoria) provulvaria Maur., Simionescu, 1925, p.5.
Schizophoria provulvaria (Maurer), Paeckelmann and Sieverts, 1932, p.34.

Schizophoria (Orthis) provulvaria Maur., Wilschowitz, 1932, p.14.
Schizophoria provulvaria (Maurer), Maillieux, 1936, p.53.
Schizophoria provulvaria Maurer, Renaud, 1942, p.19.
Schizophoria provulvaria (Maurer), Solle, 1950, p.336.

The following specimens have been listed in synonymy with S. provulvaria. Descriptions and figures are absent.

Orthis provulvaria Maurer, Asselburghs, 1913, p.93.
Schizophoria provulvaria Maurer., Maillieux, 1913, p.45.
Orthis (Schizophoria) provulvaria Maur., Cowper-Reed, 1920, p.340, 341.
Schizophoria provulvaria (Maurer), Maillieux and Asselburghs, 1925, p.124; Maillieux, p.135,p.137,p.140.
Schizophoria provulvaria, Asselburghs and Le Blanc, 1931, p.1366.
Orthis provulvaria Maur., Dahmer, 1931, p.88.
Orthis (Schizophoria) provulvaria Maurer, 1893, Mauz, 1935, p.74.

Material. —

Belgium

IRIG 5382 (brachial internal mould) — Dévonien Inférieur, Siegenien, Grauwacke de Saint-Michel, Sg 3, Saint Hubert.

IRIG 5746 (two pedicle internal moulds, brachial internal mould, fragmentary internal mould) — same stratigraphical level, Bois de Saint Michel, Thiers des Grippes, Saint Hubert.

IRIG 5746 (distorted internal mould) — same stratigraphical level, Grupont.

IRIG 8219 (two pedicle internal moulds, fragmentary brachial internal mould) — same stratigraphical level, tranchée chemin de fer, Mirwart, Grupont.

IRIG 8390 (brachial internal mould) — Dévonien Inférieur, Emsien Inférieur, Grès de Mormont, Em 1g, Erezée.

IRIG 8633 (brachial internal mould) — Dévonien Inférieur, Siegenien, Quartzophyllades de Saint-Vith, Sg 5III,

tranchée chemin de fer, 650m. s-o-de Breitfeld, Saint Vith.

IRIG 8791 (two pedicle internal moulds, brachial internal mould) — Dévonien Inférieur, Emsien Inférieur, Grauwacke de Pesche, Em la, tranchée chemin de fer de Gedinne, Pondrome.

IRIG 9383 (brachial internal mould) — Dévonien Inférieur, Siegenien, Grauwacke Inférieur de Laroche, Sg 3III.

IRIG 12533 (brachial internal mould) — Dévonien Inférieur, Siegenien, Grès d'Anor, Sg 2, Petigny, Couvin.

Germany

BM B 24563 (fragmentary pedicle internal mould), B 42945 (brachial internal mould), B 42946 (pedicle internal mould) — Lower Devonian, Seifen, Dierdorf.

BM B 24565 (fragmentary pedicle internal mould), B 42935 (pedicle internal mould), B 42936, 7 (brachial internal moulds), B 42941 (pedicle internal mould), B 42943 (fragmentary internal mould) — Lower Devonian, Seifen.

BM B 49,920 (pedicle internal mould) — Lower Devonian, near Seifen, Nassau.

HMUG L5341/4 (brachial internal mould) — Lower Devonian, Seifen.

HMUG L5345/1 (brachial internal mould), /2 (pedicle internal mould) — Lower Devonian, Siegener, Schichten, Seifen.

SMF (pedicle and brachial internal moulds) — Lower Devonian, Seifener Schichten, Seifen.

South-west England

GSM 49692 (pedicle internal mould) — Lower Devonian, New Drive above Hope's Nose, Torquay.

TEXT-FIG. 21 — Schizophoria provulvaria (Maurer)

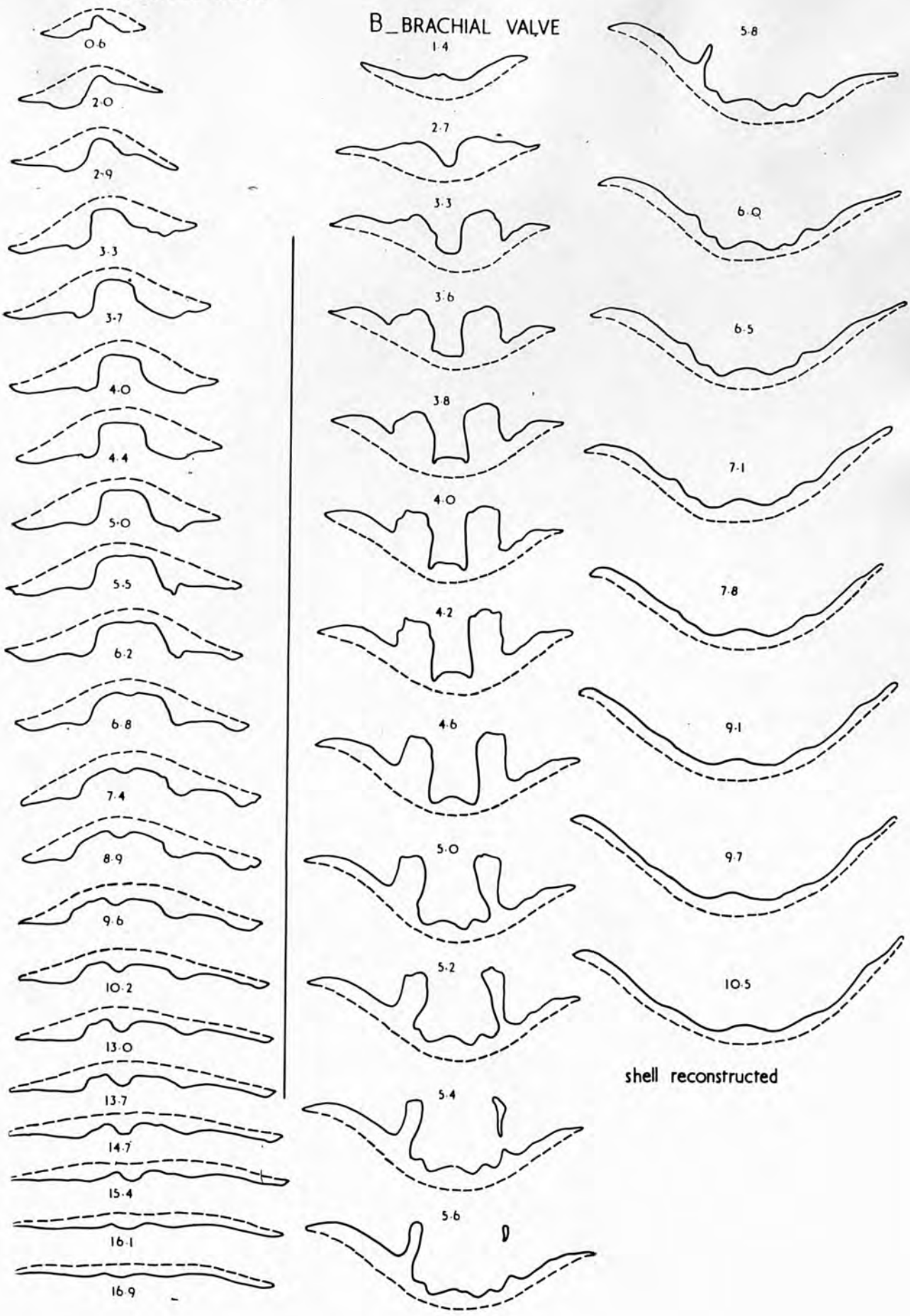
Measurements of sectioned internal moulds in millimetres

	Length	Width
A — pedicle valve	30.0	35.9
B — brachial valve	30.1	40.0

Numbers below serial sections indicate distances in millimetres measured anteriorly from umbones.

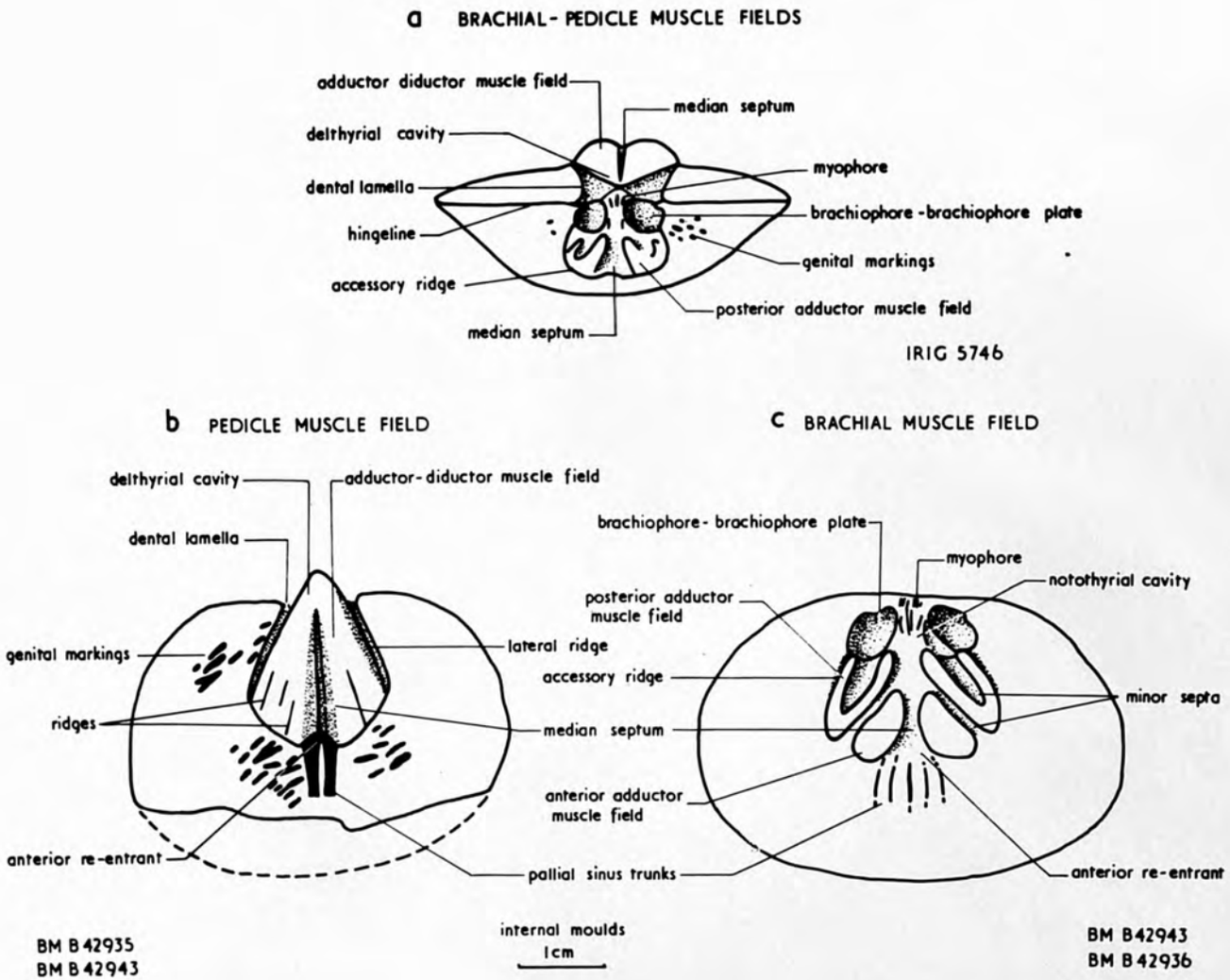
A — HMUG L5345/2 — Lower Devonian, Siegener Schichten, Seifen. Sections x 1½.

B — HMUG L5341/2 — Lower Devonian, Seifen. Sections x 1½.


A_PEDICLE VALVE
0.6
2.0
2.9
3.3
3.7
4.0
4.4
5.0
5.5
6.2
6.8
7.4
8.9
9.6
10.2
13.0
13.7
14.7
15.4
16.1
16.9
B_BRACHIAL VALVE
1.4
2.7
3.3
3.6
3.8
4.0
4.2
4.6
5.0
5.2
5.4
5.6
5.8
6.0
6.5
7.1
7.8
9.1
9.7
10.5
shell reconstructed

Text-fig. 21

SCHIZOPHORIA PROVULVARIA (MAURER)



Text-fig. 22

Schizophoria pygmaea Struve

Pl.1, figs.7-10; text-figs.24, 25, 27.

Schizophoria pygmaea Struve, 1963, p.251, pl.39, 40.
(see Struve 1963 for synonymy)

Schizophoria pygmaea subspecies A

Pl.2, figs.1-5; text-figs.23, 24, 26, 28.

Schizophoria excisa (Quenstedt), Spriesterbach, 1942, p.182, pl.5, figs.9-14.

Types. — Struve (1963, p.251, pl.39, 40) deposited his holotype (SMF 17298) and paratypes of Schizophoria pygmaea in the Senckenberg Museum, Frankfurt. Type material of S. pygmaea subspecies A (see Remarks) will be selected in due course from material collected from Blankenheim, in the Eifel, and deposited in the Geology Department, Bedford College.

Diagnosis. — Shell small (S. pygmaea) to large (S. pygmaea subspecies A), rectangular to elliptical, weakly dorsibiconvex, with prominent pedicle sinus. Pedicle muscle field flabellate, strongly incised, longitudinally divided by broad, rounded median septum. Brachial muscle field moderately incised bounded posteriorly by strong, curved brachiophore plates supporting stubby brachiophores.

Description. — Shell small to large, weakly dorsibiconvex, thin, rectangular to elliptical in outline, wider than long, with greatest width at or anterior to mid-length. Pedicle valve weakly convex umbonally, flattening laterally, depressed medially. Brachial valve more convex, greatest umbonally, or evenly convex longitudinally, flattening laterally. Beaks small, pointed, incurved; brachial beak more incurved, and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle

interarea prominent, high, curved to beak; delthyrium higher than wide, open. Brachial interarea lower, curved to beak; notothyrium as wide as high, open. Pedicle sinus well defined, originating below umbo, flaring and deepening anteriorly. Gentle brachial fold developed in older specimens adjacent to anterior commissure. Anterior commissure uniplicate, due mainly to moderately broad, high, rounded, dorsal, linguiform extension of pedicle valve. Shell costellate, rugate, punctate. Radial costellae rounded, separated by narrower striae, 5 to 6 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation. Hollow spine bases developed at anterior terminations of some costellae. Growth rugae concentric, weakly developed, present anteriorly and laterally on older specimens. Puncta evenly distributed on inner shell layers, concentrated along costellae in higher layers, concentrated along striae on surface.

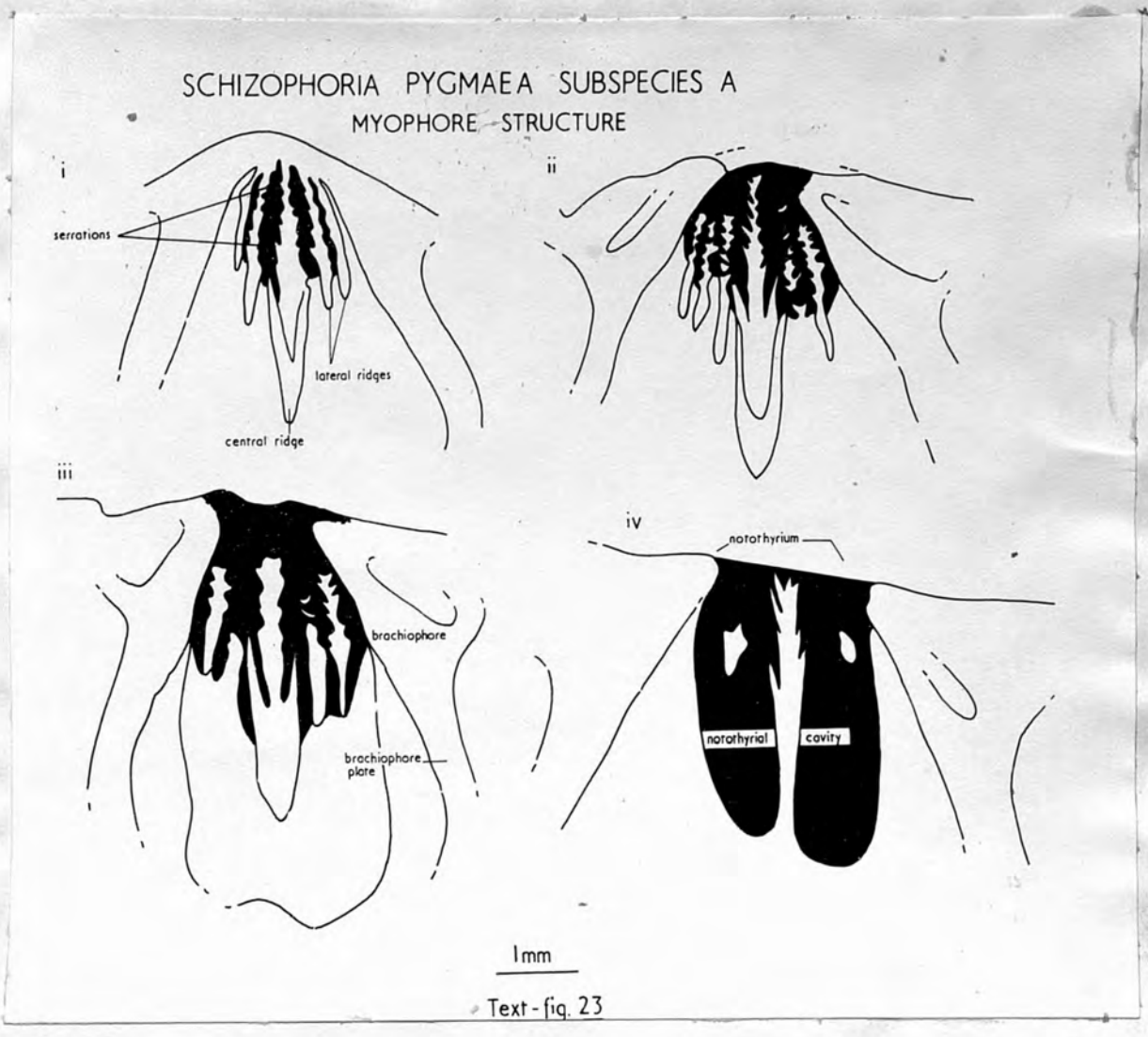
Teeth prominent, compound, supported by anteriorly and ventrally divergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.25A (S. pygmaea), sections 1.0-1.3; text-fig.26 (S. pygmaea subspecies A), sections 2.7-3.4). Articulation supplemented by interlocking ends of brachiophores and dental lamellae (text-fig.25A, sections 1.4-1.75; text-fig.26, sections 4.2-5.0). Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.26, sections 0.8-6.1).

Pedicle muscle field (text-figs.27a, 28a) one third to one half valve length, broad, anteriorly flabellate, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, reflexed to form deep, subrounded anterior re-entrant, uniting with anterior termination of median septum. Median septum prominent, originating near apex of

delthyrial cavity, rounded, broadening and increasing in height, and becoming flat-topped anteriorly (text-fig.25A, sections 0.4-5.2, B, sections 1.3-4.8; text-fig.26, sections 0.8-14.0). No evidence of pedicle muscle scars. Pallial sinus pattern consisting of two slightly divergent trunks originating from ends of diductor muscle field (text-fig.28a). Genital markings developed postero-laterally (text-fig.28a).

Myophore prominent, compound, average width 2.3mm., with central ridge, bordered by four shorter, narrower ridges, two either side, all finely serrated (text-fig.23). Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.25A, sections 0.2-1.75; text-fig.26, sections 0.6-5.3). Stubby brachiophores fused to strong, curved brachiophore plates bounding notothyrial cavity (text-fig.25A, sections 0.4-1.5; text-fig.26, sections 1.1-5.0). Brachiophore plates thickened posteriorly by shell filling the notothyrial cavity (text-fig.26, sections 2.2-4.2). Dental sockets deep, oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.25A, sections 0.7-1.0; text-fig.26, sections 2.2-2.8). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig.25A, sections 0.7-1.0; text-fig.26, sections 2.2-3.2).

Brachial muscle field (text-fig.27b, 28b) moderately incised, rectangular to rounded, one third to one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly, and smoothly reflexed to form deep subrounded re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, rounded,

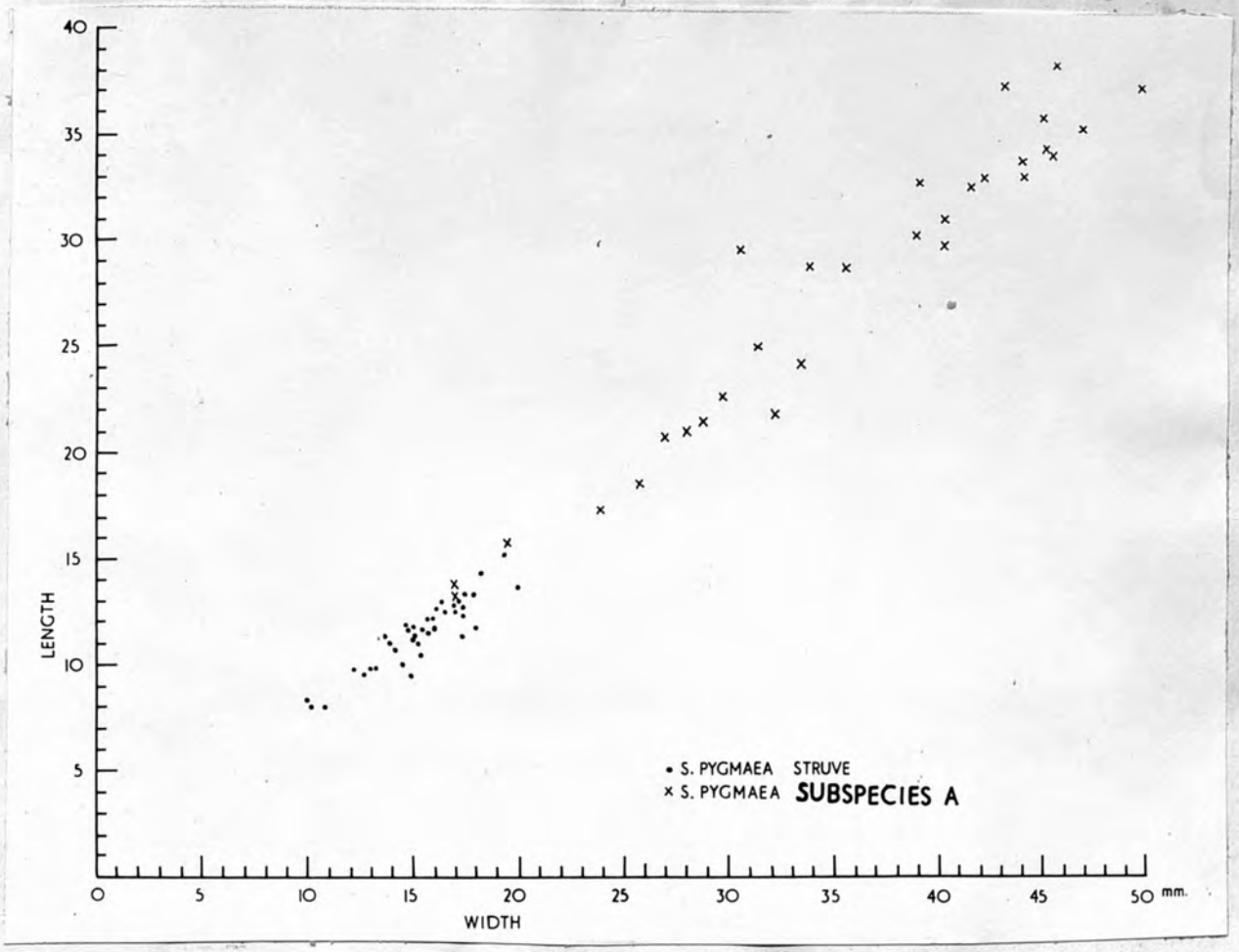


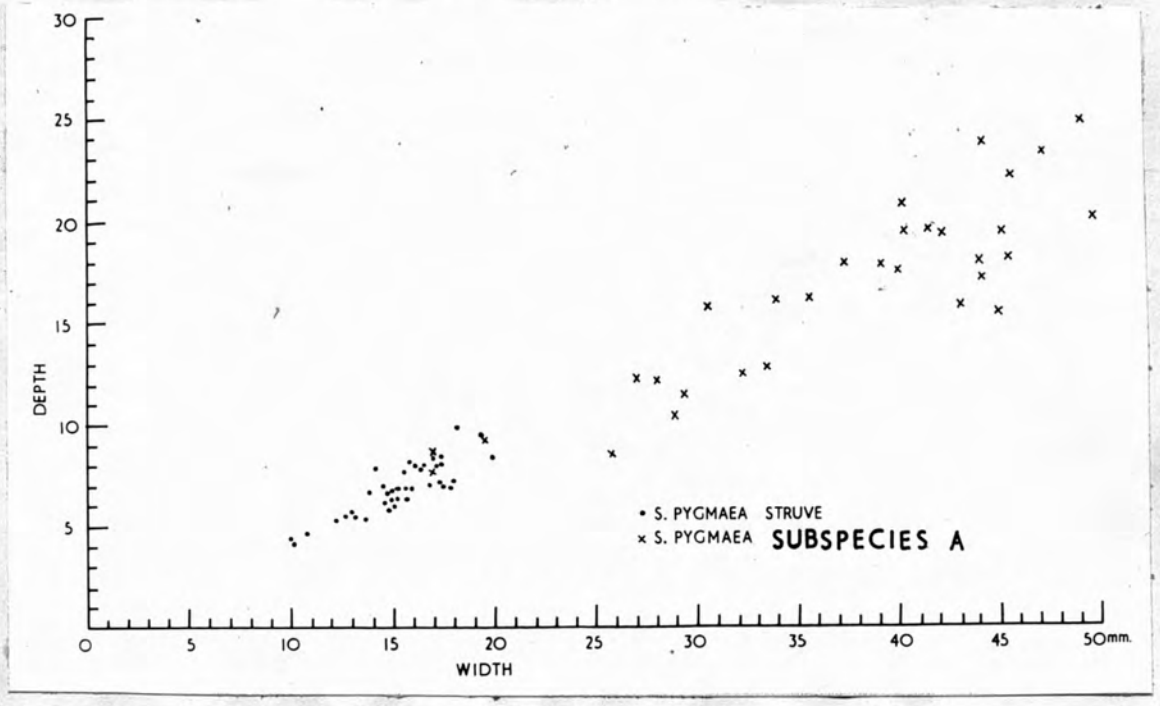
Text-fig. 23

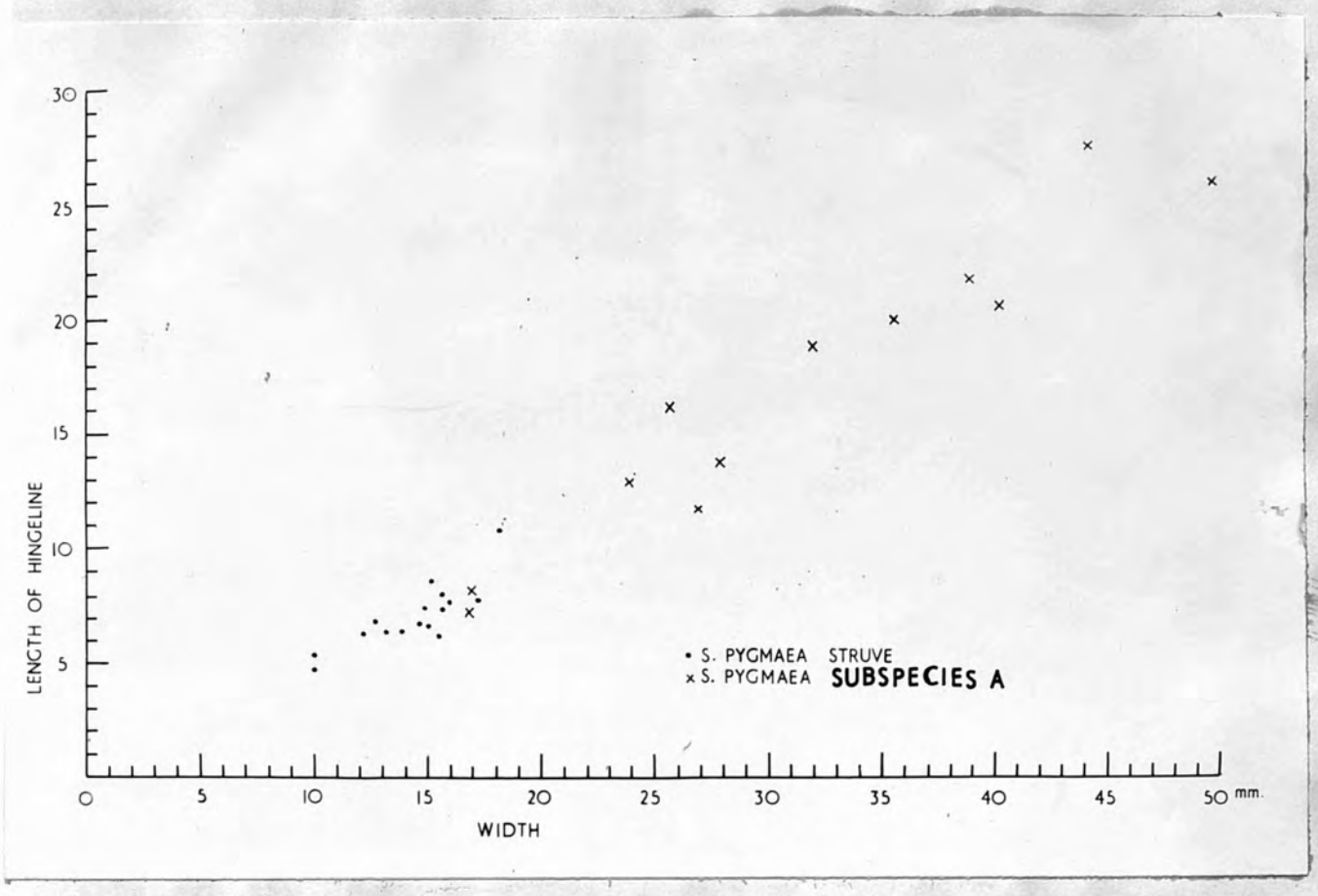
decreasing in width and becoming more angular anteriorly (text-fig.25A, sections 0.7-4.2; text-fig.26, sections 0.6-13.0). Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts. Anterior muscle scar pyriform, posterior muscle scar digitate, both parts generally equal in length (text-figs.27b, 28b). Pallial sinus pattern consisting of two trunks originating from anterior re-entrant of muscle

field, each bifurcating, to give four parallel trunks. Genital markings elongate, developed laterally and postero-laterally (text-fig.26, sections 2.8-3.8; text-fig.28b).

External dimensions are plotted on text-figure 24.







Text-figure 24

Dimensions of available muscle fields:

		Length of pedicle muscle field	Width of pedicle muscle field
BC B56	(S. pygmaea)	5.0	4.5
BC B61	(" ")	6.4	5.1
BC B61	(" ")	5.7	4.8
BC B61	(" ")	6.0	4.8
BC B62	(" ")	7.2	5.2
BC B63	(" ")	6.5	5.5
SMF 17267	(" ")	7.1	6.0
SMF 17287	(" ")	9.0	8.4
	(S. pygmaea		
BC B69	(subspecies A)	18.2	13.7
BC B70	(")	18.8	14.0
BM B42948	(")	9.6	7.5

		Length of brachial muscle field	Width of brachial muscle field
BC B60	(S. pygmaea)	4.0	5.0
SMF 17278	(" ")	6.0	6.4

BC B71	(S. pygmaea (subspecies A)	11.9	14.6

Remarks. — The material is generally well preserved.

Struve (1963, p.251, pl.39, 40) described and illustrated a small, relatively thin form of Schizophoria, S. pygmaea, from Hundsdell Horizon (Nohn Beds) and Bildstock and Flesten Horizons (Ahrdorf Beds), Eifelian in age, from the Eifel region.

Spriesterbach (1942, p.182, pl.5, figs.9-14) had previously described and illustrated a large, relatively thin form of Schizophoria, from the Middle Devonian of the Blankenheim region, also in the Eifel, which he listed in synonymy with S. excisa (Quenstedt). But S. excisa (Quenstedt), (1868-71, p.561, pl.55, figs.138-146) is a separate distinct form, and is synonymous with another species, S. striatula (Schlotheim), (Schlotheim, 1813, p.8, pl.1, fig.6; 1820, p.254, pl.5, fig.4). Although the specific name excisa is no longer occupied, it cannot be used for the large form as described by Spriesterbach (see Internat. Comm. Zoo. Nom., p.11).

Although the small form has been named Schizophoria pygmaea Struve, the large form, as first described by Spriesterbach, has hereby been included under a new subspecies of S. pygmaea. A new subspecific name will be selected in due course, but it will be referred to temporarily as S. pygmaea subspecies A. Some difficulty may be encountered in naming an apparently 'normal' subspecies of an apparently 'dwarf' species.

Although Schizophoria pygmaea is generally a thin form, some specimens become more convex with increasing age. The specimen on text-figure 25A is more convex than that on 25B.

Struve (1963, p.251) recognised the similarity between S. pygmaea and the specimens illustrated by Spriesterbach (1942, pl.5, figs.9-14), (herein listed under S. pygmaea subspecies A), since he listed the specimen of figure 14 in synonymy with his

species. However, he made no further reference to the larger specimens illustrated on this plate (figs.9-13). Figure 14 is probably a more youthful, smaller specimen of S. pygmaea subspecies A. The only distinction between S. pygmaea and S. pygmaea subspecies A is one of size (see text-fig.24). The largest (i.e. adult) specimens of S. pygmaea are comparable with the smallest (i.e. youthful) specimens of S. pygmaea subspecies A. The two forms are similar externally and internally (cf. text-figs.25 and 26; 27 and 28).

Schizophoria pygmaea appears to be a dwarf form of S. pygmaea subspecies A, occurring in the Hundsdell, Bildstock and Flesten Horizons. Other brachiopod genera and species from these horizons are also smaller than normal. This dwarf form is preceded and succeeded stratigraphically by the larger form of S. pygmaea. Since these two forms are separated morphologically by size, and are stratigraphically distinct, they have here been separated taxonomically.

Schizophoria pygmaea subspecies A superficially resembles S. provulvaria (Maurer) in the form of the flabellate pedicle muscle field and strong median septum, and the form of the brachial muscle field and four parallel pallial sinus trunks. However, externally, S. pygmaea subspecies A is generally less convex, and has a well defined pedicle sinus. A specimen (BC B64) from the lowermost Middle Devonian (Wolfenbach Horizon, Lauch Beds) is more convex, but when sectioned, illustrated the characteristic internal structures of S. pygmaea subspecies A. Schizophoria pygmaea subspecies A is therefore considered to be related to S. provulvaria, possibly replacing the Lower Devonian species (S. provulvaria) in the Middle Devonian (see Phylogeny).

Schizophoria pygmaea Struve resembles S. provulvaria in the same manner, but is much smaller in size.

Schizophoria pygmaea subspecies A is distinguished from

S. striatula (Schlotheim) by its more rectangular outline, and weaker convexity. Schizophoria striatula is generally more quadrate to rounded in outline, with greatest shell width situated anteriorly, and is more convex. Internally there are differences in the muscle fields (cf. text-figs. 26, 28 and 34). The strongly flabellate pedicle muscle field, deep re-entrant, broad median septum, and widely separate, slightly divergent pallial sinus trunks of S. pygmaea subspecies A, contrast with the less flabellate to elongate oval muscle field, narrower re-entrant and median septum, and closely spaced, parallel pallial sinus trunks of S. striatula from the Middle Devonian. In the brachial valve, S. striatula has a longer inner portion to the posterior adductor muscle scar, more acute apex to the anterior muscle scar, divergent pallial sinus trunks, and shorter genital markings. The divergent brachiophore plates also contrast with the curved plates of S. pygmaea subspecies A.

Comparisons of S. pygmaea and S. pygmaea subspecies A with other species is shown on text-figure 18.

Material. —

Germany

BC B10 (S. pygmaea) — Middle Devonian, Eifelian, Ahrdorf Beds, Bildstock Horizon, MTB Dollendorf, r 5452 : h 8064, Eifel.

BC B11 (S. pygmaea), (fragmentary shell) — same stratigraphical level, MTB Dollendorf, r 5537 : h 7536, Eifel.

BC B12, 13 (S. pygmaea), (12 - plaster cast) — Middle Devonian, Eifelian, Ahrdorf Beds, Flesten Horizon, MTB Dollendorf, r 5621 : h 8211, Eifel.

BC B14, 15 (S. pygmaea) — same stratigraphical level, MTB Dollendorf, r 5595 : h 8214, Eifel.

BC B16-59 (S. pygmaea), (56 - pedicle internal mould, 57-59 plaster casts) — same stratigraphical level, Ahrdorf Syncline, MTB Dollendorf, r 5580 : h 8149, Eifel.

BC B60-63 (S. pygmaea), (internal moulds) — Middle

Devonian, Eifelian, Ahrdorf Beds, MTB Mechernich, Eifel.

SMF 17267 (S. pygmaea), (pedicle internal mould) — Middle Devonian, Eifelian, Nohn-Ahrdorf Beds, Hundsdell-Bildstock Horizon, Sotenicher Syncline, MTB Mechernich, r 37560 : h 97080.

SMF 17278 (S. pygmaea), (internal mould) — Middle Devonian, Eifelian, Schwirzheim Horizon, Gerolstein, Eifel.

SMF 17286 (S. pygmaea), (internal mould) — Middle Devonian, Eifelian, Ahrdorf Beds, Bildstock Horizon, Hillesheimer Syncline, MTB Dollendorf, r 55370 : h 75360, Eifel.

BC B64 (S. pygmaea subspecies A), (plaster cast) — Middle Devonian, Eifelian, Lauch Beds, Wolfenbach Horizon, MTB Dollendorf, r 5248 : h 8038, Eifel.

BC B65-71 (S. pygmaea subspecies A), (69 - pedicle internal mould, 70 - fragmentary pedicle valve, 71 - brachial internal mould) — Middle Devonian, Eifelian, Junkerberg Beds, Blankenheim Railway Cutting, Eifel.

BC B72-82 (S. pygmaea subspecies A), (80 - fragmentary shell, 81 - partially sectioned specimen, 82 - plaster cast) — same stratigraphical level, MTB Blankenheim, r 4538 : h 8962, Eifel.

BM B42948 (S. pygmaea subspecies A), (pedicle internal mould) — Middle Devonian, Gerolstein, Eifel.

GMUS EuDE 77(5), (S. pygmaea subspecies A) — Middle Devonian, Eifelian, Spirifer latistriatus horizon, Upper Junkerberg Beds, railway cutting between Blankenheim and Blankenheimerdorf, Blankenheimer Syncline, Eifel.

SMF (S. pygmaea subspecies A), (including 3 partial internal moulds) — Middle Devonian, Gerolstein, Eifel.

Specimens are generally preserved as entire shells, except where otherwise indicated.

TEXT-FIG.25 — Schizophoria pygmaea Struve

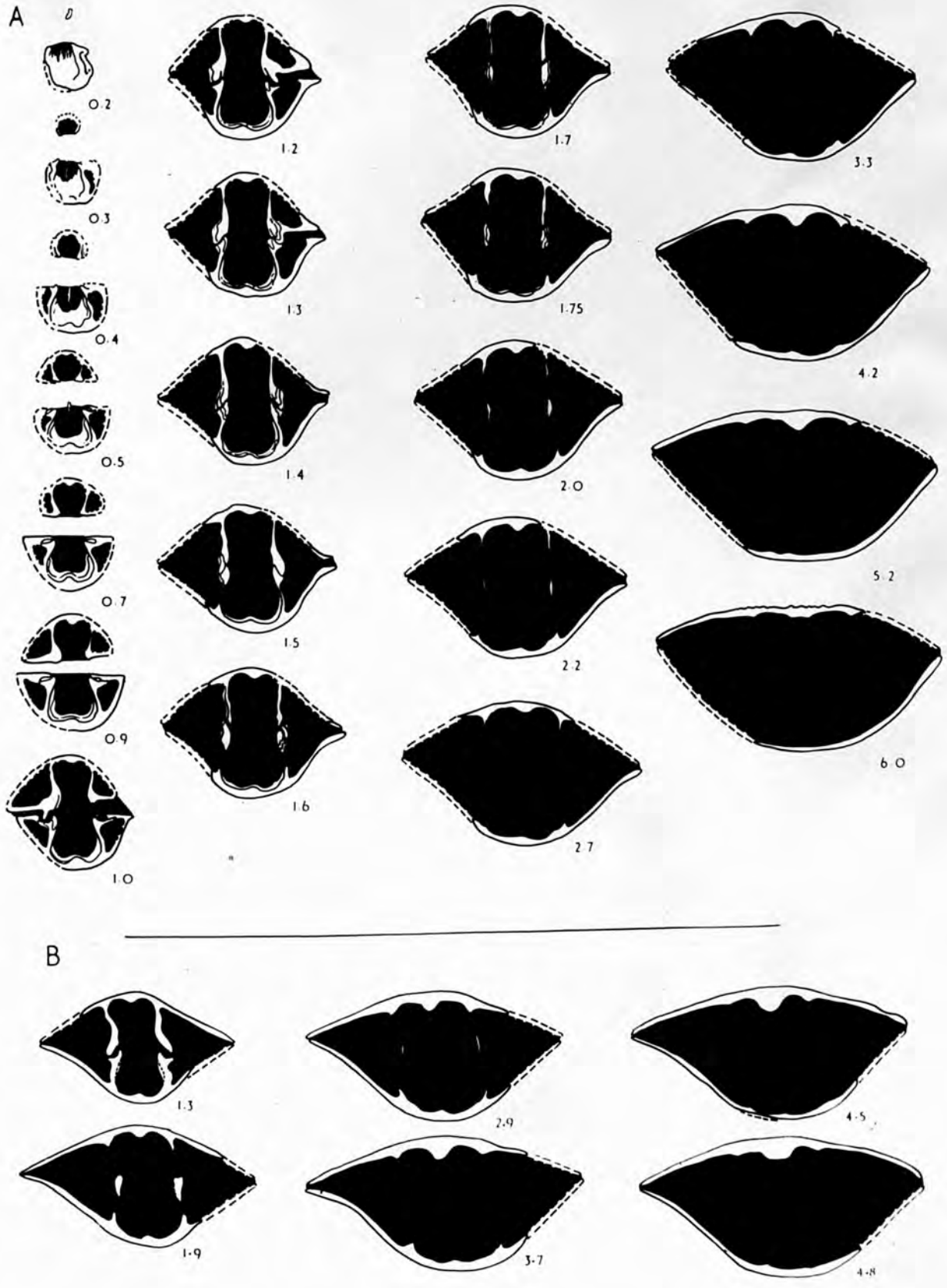
Measurements of sectioned specimen in millimetres

	Length	Width	Depth
A	12.2	15.8	8.0
B	13.9	19.4	9.5

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 3.

A — BC B58 - Middle Devonian, Eifelian, Ahrdorf Beds, Flesten Horizon, Ahrdorf Syncline, MTB Dollendorf, r 5580 : h 8149, Eifel.

B — BC B12 - same stratigraphical level, MTB Dollendorf, r 5621 : h 8211. Sections x 2½.


A
D
0.2
0.3
0.4
0.5
0.7
0.9
1.0
1.2
1.3
1.4
1.5
1.6
1.7
1.75
2.0
2.2
2.7
3.3
4.2
5.2
6.0
B
1.3
1.9
2.9
3.7
4.5
4.8

Text-fig 26

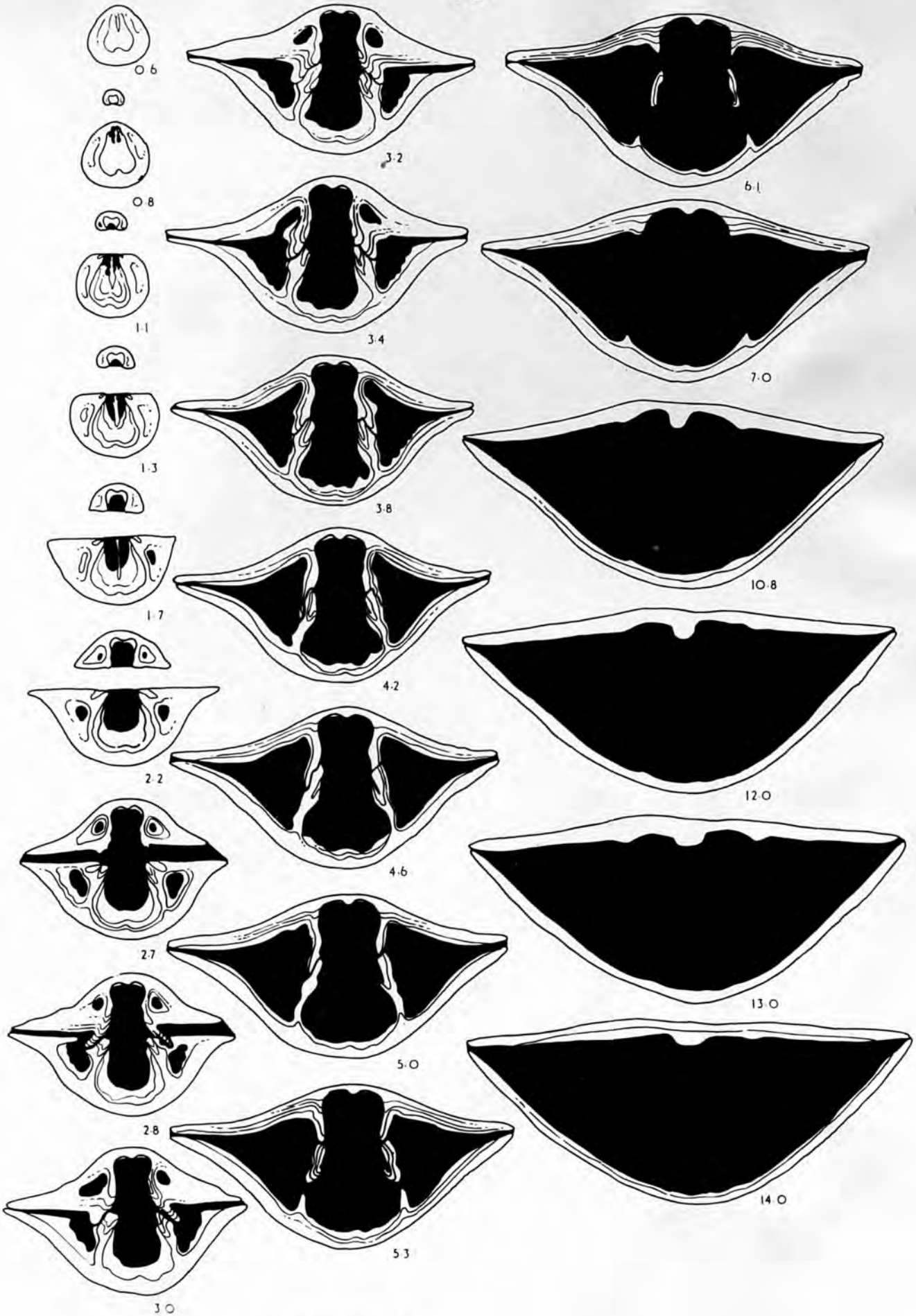
TEXT-FIG.26 — Schizophoria pygmaea subspecies A

Measurements of sectioned specimen in millimetres

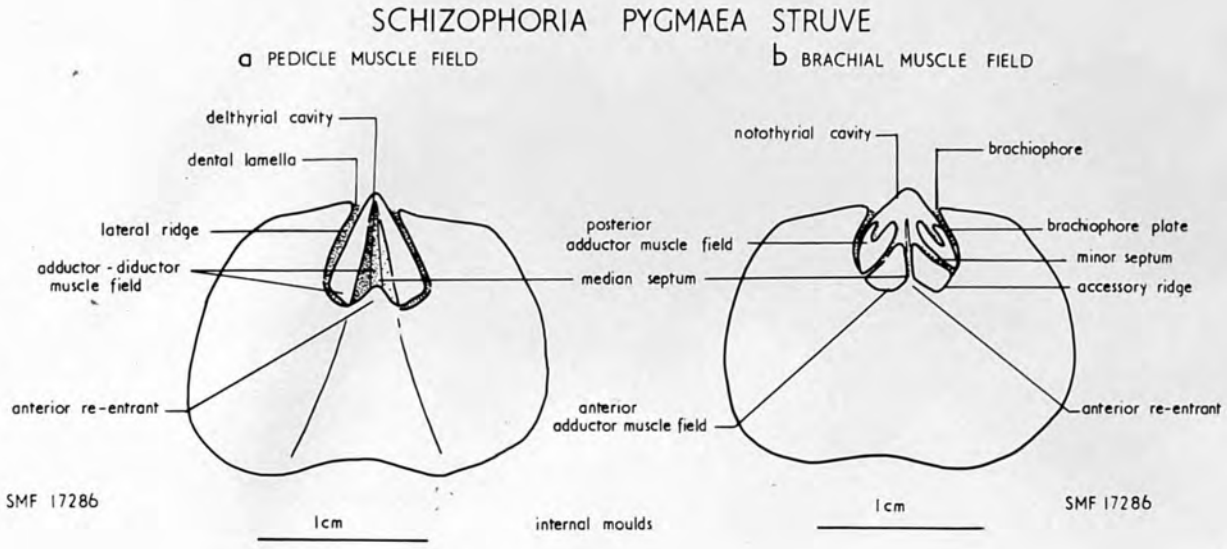
Length	Width	Depth
30.2	36.3	22.5

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2.

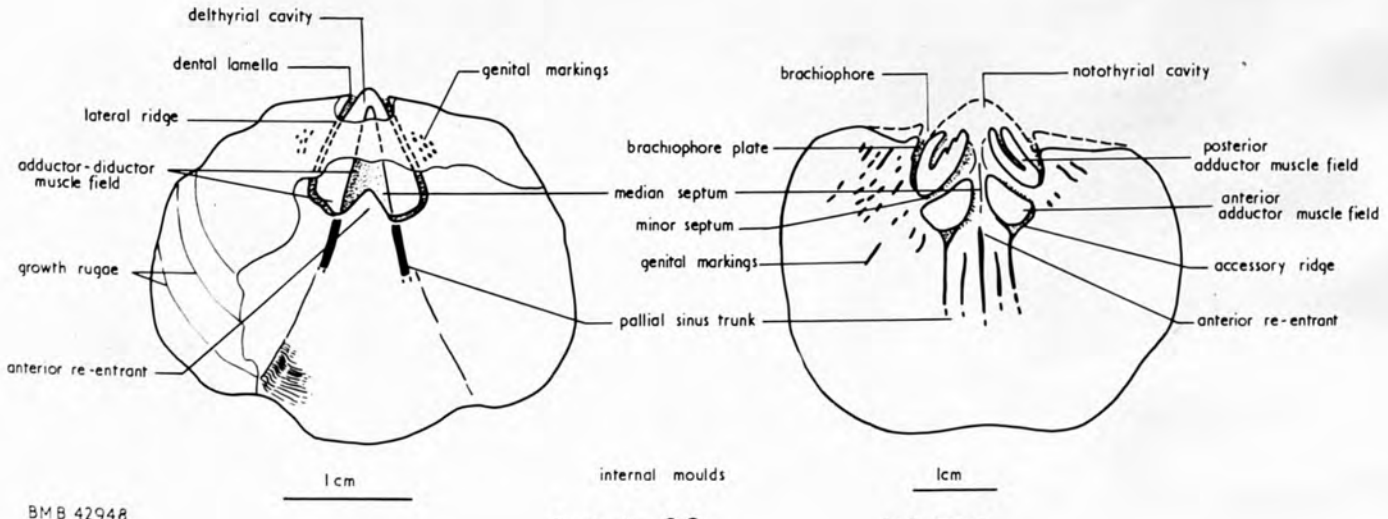
BC B70 — Middle Devonian, Eifelian, high Junkerberg beds, road cut near Blankenheim, Eifel.



Text-fig. 26



Text-fig. 27



Text-fig. 28

Schizophoria striatula (Schlotheim)

Pl.2, figs.6-12; pl.3, fig.1; text-figs.29-34.

Terebratulae minutissime striatae, Schröter, 1777, p.390, pl.4, fig.24.

Anomia terebratulites striatulus Schlotheim, Leonhard, 1813, p.8, pl.1, fig.6.

Terebratulites striatulus, Schlotheim, 1820, p.254, pl.15, fig.4,

Spirifera striatulus Schl., Buch, 1840, p.203, pl.10, fig.31.

Orthis striatula., De Koninck, 1842-4, p.224, pl.13 , fig.6; non. pl.13², fig.11.

? Sp. striatulus v. Schloth., Roemer, 1843, p.14, pl.5, fig.14; pl.12, fig.18.

Orthis resupinata var. striatula Schl., Murchison, Verneuil, and Keyserling, 1845, pl.12, fig.6.

Orthis striatula, Sandberger and Fridolin, 1850-6, p.355, pl.34, fig.4.

Orthis striatula, Schloth., Davidson, 1851-5, pl.7, figs.128-133: 1864-5, p.87, pl.17, figs.4-7.

Spirifer striatulus Schl.sp., Geinitz, 1853, p.61, pl.15, figs.10-12.

Orthis striatula d'Orb., Schnur, 1853, p.215, pl.38, fig.1.

Orthis, striatula, Woodward, 1854, fig.147.

Orthis striatula v. Schloth., Grünewaldt, 1860, p.87, pl.2, fig.6.

Orthis excisa, Quenstedt, 1868-71, p.561, pl.55, figs.138-146.

Orthis striatula De Koninck, Roemer, 1876, pl.28, figs.10, 12.

? Orthis striatula Schl., Kayser, 1878, p.188, pl.28, figs.9, 10.

? Orthis striatula. Schl, Romanovskij, 1878-80, p.112, pl.17, fig.4, non. fig.3.

? Orthis striatula Schl., Kayser, 1883, p.90, pl.13, fig.1.

? Orthis striatula : Schl., Maurer, 1885, p.133, pl.5, figs.3, 4.

Orthis aff. striatula (Schlotheim), Oehlert, 1887, pl.5, figs.10-13.

? Orthis striatula Schlotheim, Toll, 1889, p.18, pl.1, fig.10.

Orthis striatula Schlotheim, 1813, Smyčka, 1897, p.16, pl.2, fig.17.

? Orthis striatula Schl., McHahon and Huddleston, 1902, p.53, pl.2, figs.6, 7.

Orthis striatula Schloth., Sobolev, 1904, p.68, pl.8, figs.12, 13.

Orthis (Sch) striatula (Schl), Reed, 1908, p.79, pl.13, figs. 19-24: 1922, p.34, pl.6, figs.12, 13.

Orthis striatula Schl, Torley, 1908, p.32, pl.7, fig.2.

Schizophoria striatula Schloth., Gurich, 1909, p.129, pl.42, fig.4.

Schizophoria resupinata var. iowensis Hall, Klahn, 1912, p.7, pl.2, figs.2-4.

? Dalmanella striatula Schl., Hayasaka, 1922, p.58, pl.2, figs.20-22.

Schizophoria striatula (Schloth.), Bekker, 1924, p.29, pl.5, figs.12, 13.

? Schizophoria striatula, Schloth., Hosking, 1932-3, p.73, pl.7, fig.6.

Orthis (Schizophoria) resupinata var. striatula (v. Schloth), Paeckelmann, 1930, p.158, pl.9, figs.3-10.

Schizophoria striatula (Schl), Torley, 1934, p.126, pl.9, fig.81.

Schizophoria striatula (Schl), Termier and Termier, 1949, fig.10: 1950, pl.71, figs.14-18; pl.72, figs.1? 2? 3, 4; ? pl.73, figs.8, 9.

Schizophoria striatula Sarycheva and Sokolskaja, 1952, p.29 pl.2, fig.10.

? Schizophoria striatula, Fedorova, 1955, pl.1, figs.8-10.

Schizophoria striatula (Schlotheim), Biernat, 1959, p.54, pls.7-9; pl.10, fig.3.

non. Orthis striatula (Schlotheim), Bronn, 1835-7, p.359, pl.11, fig.10.

non. Orthis pectoralis n.sp., Romer, 1850, p.56, pl.9, fig.4.

non. Orthis striatula d'Orbigny (Hysterolites vulvarius Schlotheim), Roemer, 1876, pl.23, fig.8.

non. Orthis (Schizophoria) striatula Schl., Walther, 1907, p.279, pl.13, fig.9.

non. Orthis striatula (Schlotheim), Assman, 1910, p.161, pl.9, figs.1, 2.

non. Orthis striatula Schl, Viétor, 1916, p.452, pl.18, fig.10.

non. Schizophoria aff. striatula (Schlotheim), Schuchert and Cooper, 1932, pl.23, figs.22-25.

Type material.— The holotype illustrated by Schlotheim

(1813, pl.1, fig.6; 1820, pl.15, fig.4) cannot be traced. However, this specimen was a youthful shell, biconvex to weakly dorsibiconvex, with a low anterior plication, and could represent almost any species of Schizophoria at that growth stage. However, the only other Middle Devonian species occurring at a similar stratigraphical level is S. pygmaea Struve, and this species is quite distinct. Specimens from the Middle Devonian (Eifelian) of the Eifel region have been taken as representative of S. striatula. They are closely comparable with Middle Devonian illustrated references of previous workers who described more typical adult specimens (see Synonymy). A neotype will be selected in due course.

Diagnosis.— Shell medium to large, quadrate to elliptical, dorsibiconvex, with prominent anterior hump-like brachial fold in older specimens. Pedicle muscle field oval to flabellate, strongly incised. Brachial muscle field moderately incised, bounded posteriorly by strong divergent brachiophore plates supporting stubby brachiophores.

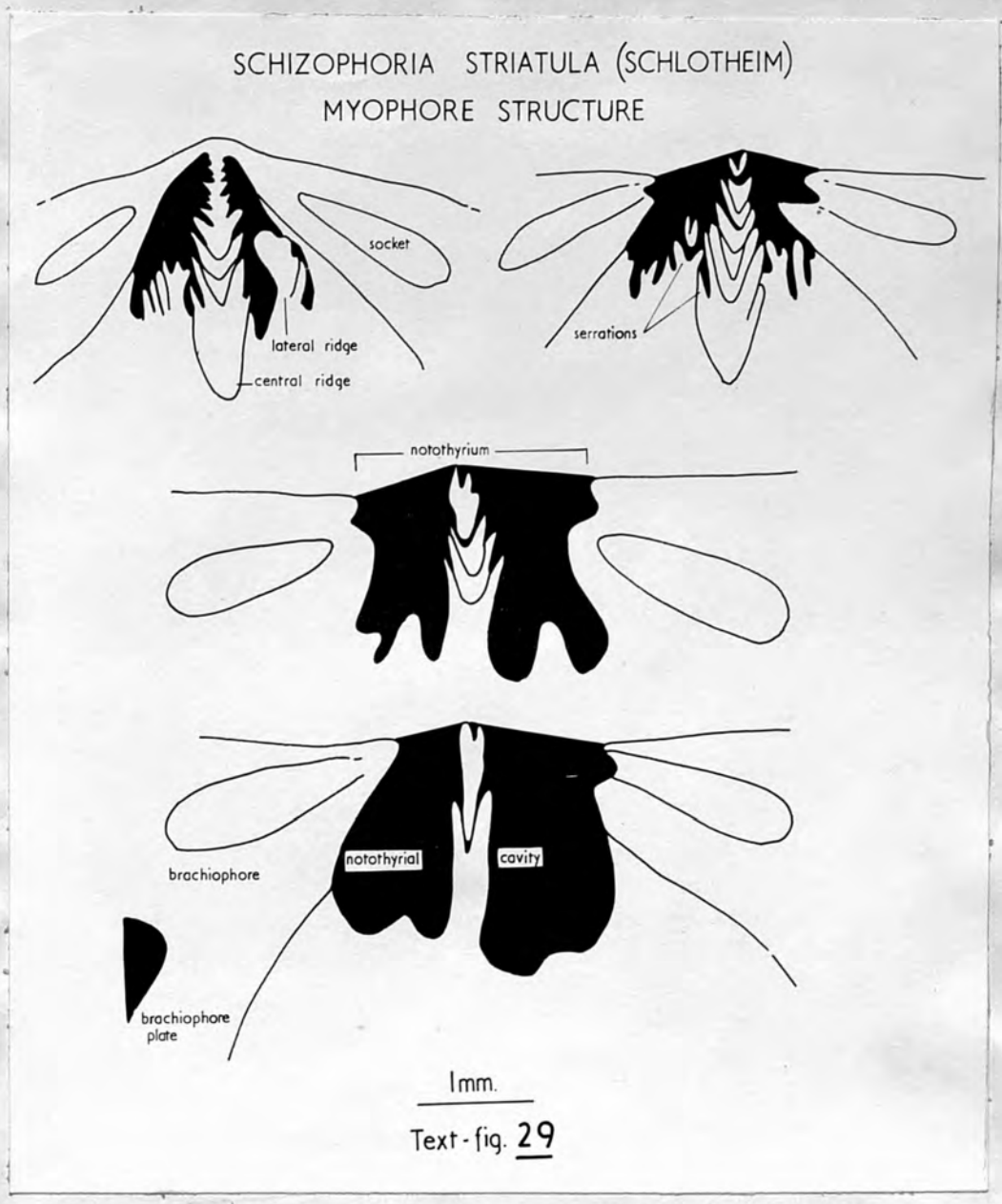
Description.— Shell medium to large, dorsibiconvex, quadrate to elliptical in outline, with greatest width generally anterior to mid-length. Pedicle valve convex umbonally, flattening laterally, depressed medially. Brachial valve more convex, greatest convexity umbonally, flattening anteriorly and laterally, Beaks small, pointed, incurved; brachial beak more incurved, and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea prominent, high, curved to beak; delthyrium higher than wide, open. Brachial interarea lower, half height of pedicle interarea, curved to beak; notothyrium as wide as high, open. Pedicle sinus originating half way along valve, broadening and deepening anteriorly. Brachial fold developed in older specimens adjacent to anterior commissure. Anterior commissure uniplicate,

due mainly to broad, deep, rounded, dorsal, linguiform extension of pedicle valve. Shell costellate, rugate, punctate. Radial costellae rounded, separated by narrower, more angular striae, 4 to 5 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation. Growth rugae concentric, prominent in older specimens, concentrated anteriorly and laterally.

Teeth prominent, compound, supported by anteriorly divergent and ventrally parallel to divergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.32, sections 1.1-2.6). Articulation supplemented by interlocking ends of brachiophores and dental lamellae. Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.32, sections 0.5-2.6).

Pedicle muscle field (text-fig.34a) one third to one half valve length, longitudinally oval to flabellate, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, smoothly reflexed, united with anterior termination of median septum. Median septum originating near point of delthyrial cavity, rounded, broadening and increasing in height anteriorly (text-fig.32, sections 1.1-9.0; text-fig.34a). No evidence of pedicle muscle scars. Pallial sinus pattern consisting of two trunks originating from ends of diductor muscle field, parallel, diverging anteriorly, giving off short lateral branches (text-fig.34a). Genital pittings developed postero-laterally (text-fig.34a).

Myophore (text-fig.29) prominent, compound, average width 3mm., with central ridge generally bordered by two shorter, narrower ridges, all coarsely serrated. Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.32, sections 0.3-2.6). Stubby brachiophores fused to strong, divergent brachiophore plates bounding notothyrial cavity (text-fig.32, sections 0.9-2.6). Dental sockets

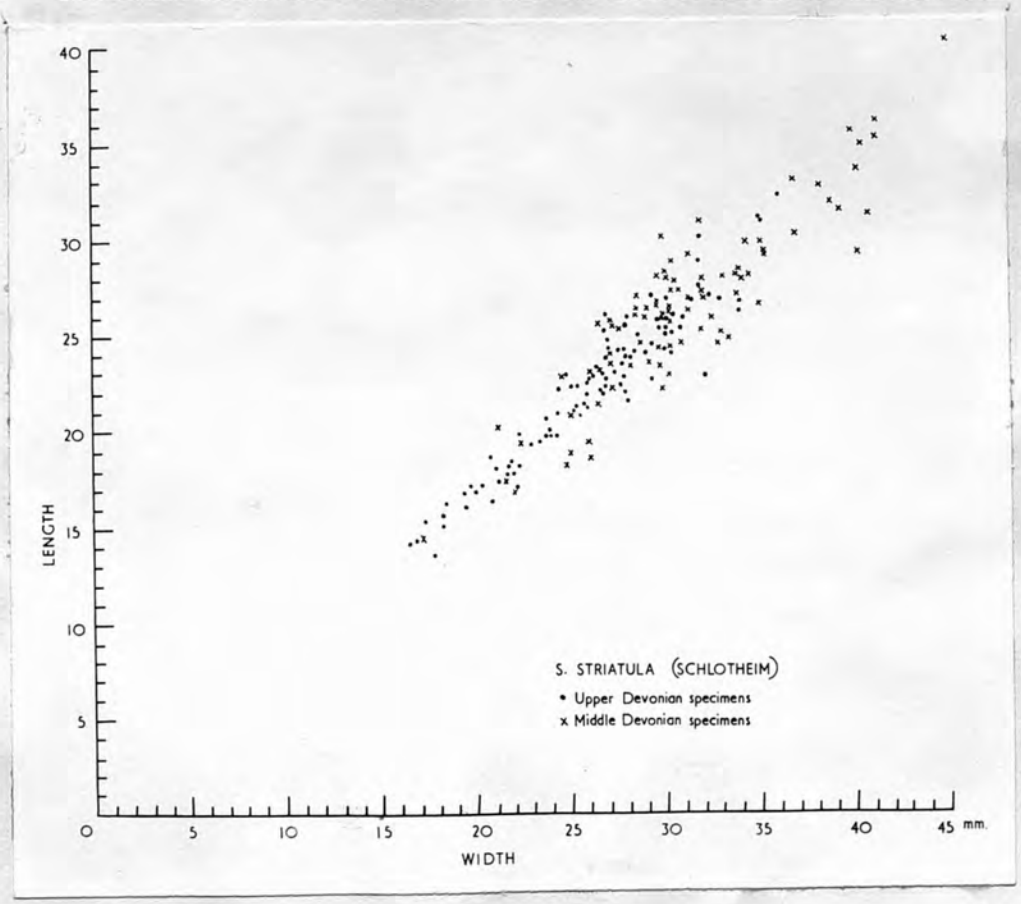


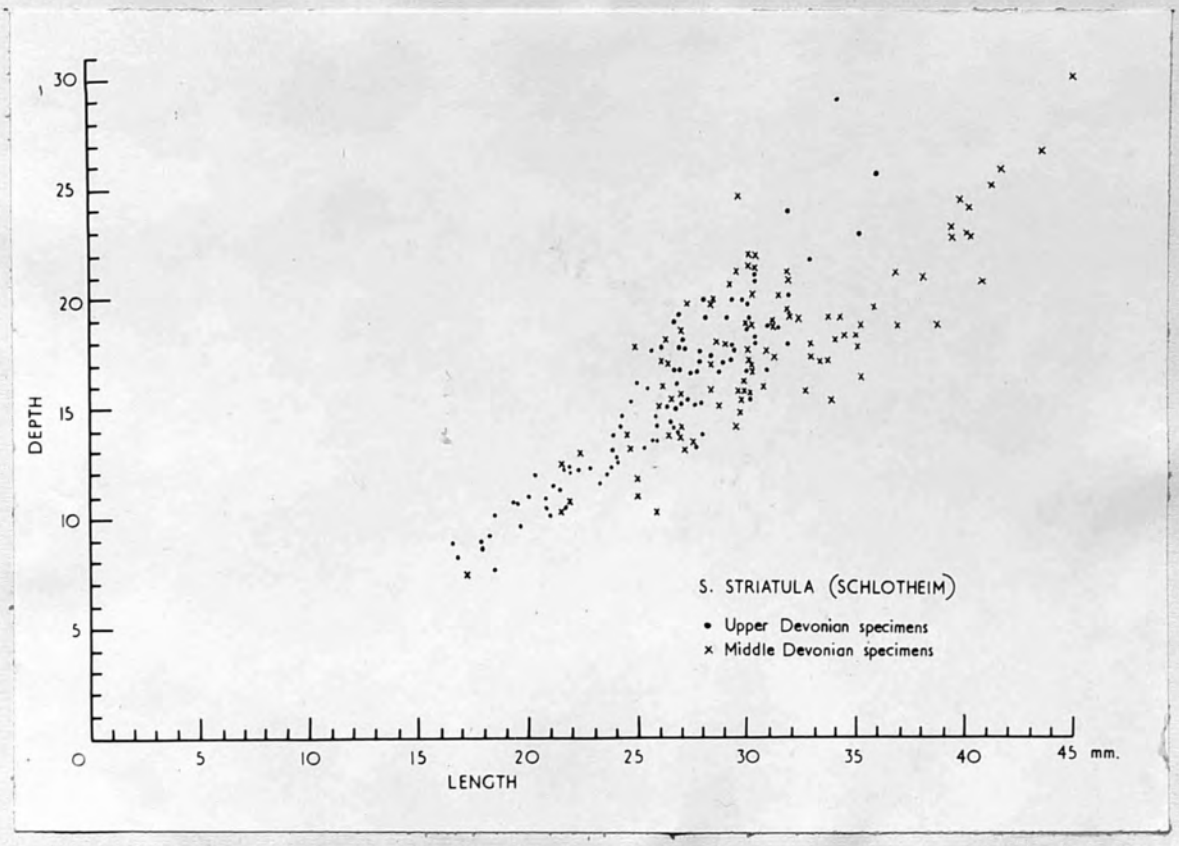
Text-fig. 29

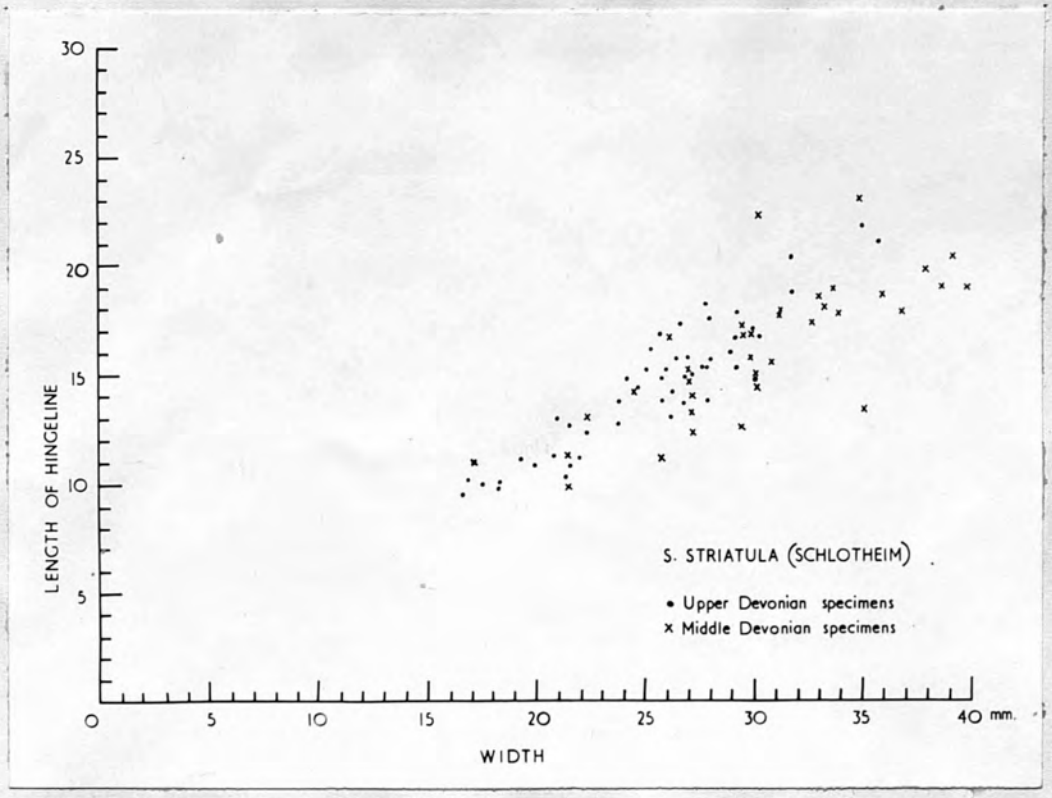
deep, oval in transverse section, bounded posteriorly by hinge-line, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.32, sections 0.9-2.0). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig. 32, sections 1.7-2.5). Fulcral plates strong, uniting brachiophores and brachiophore plates with postero-lateral shell margin (text-fig.32, section 1.9, 2.0).

Brachial muscle field (text-fig.34b) incised, quadrate to rounded, one third to one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly, and smoothly reflexed to form moderately deep, rounded anterior re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, angular to subrounded, broadening and increasing in height, then narrowing anteriorly (text-fig. 32, sections 0.9-7.0; text-fig.34b). Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts. Anterior muscle scar pyriform, with acute apex; posterior muscle scar digitate, with longer inner portion (text-fig.34b). Pallial sinus pattern consisting of four divergent trunks, two originating from anterior re-entrant, and each bifurcating. Two narrower trunks, one either side, possibly developed lateral to main trunks, giving off lateral markings. Genital markings developed postero-laterally (text-fig.34b).

External dimensions are plotted on text-figure 30.




DEPTH
30
25
20
15
10
5
0
5
10
15
20
25
30
35
40
45 mm.
LENGTH
S. STRIATULA (SCHLOTHEIM)
• Upper Devonian specimens
× Middle Devonian specimens

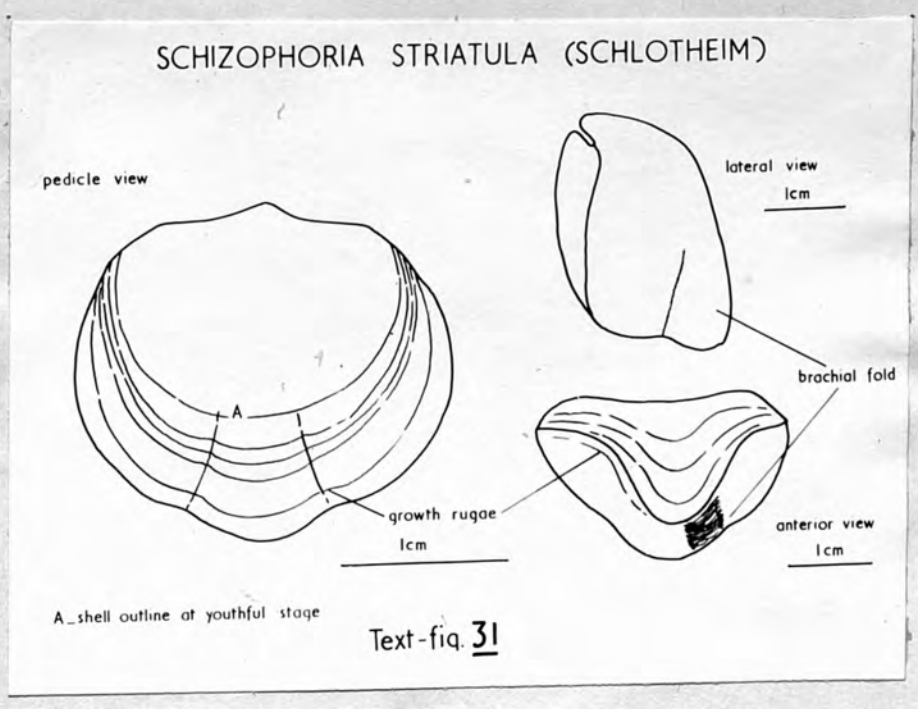

LENGTH OF HINGELINE
30
25
20
15
10
5
0
5
10
15
20
25
30
35
40 mm.
WIDTH
S. STRIATULA (SCHLOTHEIM)
• Upper Devonian specimens
× Middle Devonian specimens

Text-fig. 30

Dimensions of available muscle fields:

	Length of pedicle muscle field	Width of pedicle muscle field
BC B92	11.1	7.2
BC B118	9.4(+)	8.5
BC B127	14.3	9.7
BC B129	11.4	6.7
BC B131	11.2	8.6
IRIG 3031	11.2	9.9
IRIG 3031	9.5	7.8
IRIG 4591	7.2	4.5
IRIG 8254	11.5	7.8
IRIG 8633	10.2	6.6
	Length of brachial muscle field	**Width of brachial muscle field**
BC B127	12.4(+)	14.7
IRIG 5911	10.4	11.3
IRIG 8633	8.6	10.0
NMS	8.7	12.0

Remarks.— The material is generally well preserved. There is an increase in dorsibiconvexity, height of the anterior plication, development of an anterior brachial fold, and prominence of rugae with age (text-fig.31).



Text-fig. 31

Variation in the form of the pedicle muscle field is

shown on text-figure 34c.

Schizophoria striatula (Schlotheim) is a long ranging species (Eifelian-Frasnian), and apparently shows little variation in morphology (cf. text-figs.32, 33A). Although specimens from the Middle and Upper Devonian have been differentiated on text-figure 30, they have comparable dimensions. But many specimens from the Upper Devonian appear to lack the characteristic brachial anterior fold of the Middle Devonian form , and have their greatest shell width at the mid length of the valves. Internally, the pedicle muscle field of many Upper Devonian specimens is more flabellate, with a broader median septum. However, specimen BC B131 collected from the Middle Devonian, although representing a minority, has a flabellate muscle field, and specimen GSM 34/20 from the Upper Devonian is an exception, and has an elongate oval muscle field (text-fig.34c).

Specimens of S. striatula from the Geisdorf horizon (Eifelian) of the Eifel region are much larger in size. Other fauna at this level is also larger.

A number of specimens from the Upper Frasnian (F 2i) of Belgium, and Upper Frasnian shales near Aachen Germany, show some external variation in shape (pl.3, fig.1). These have a more rounded, more strongly dorsibiconvex outline, with an inflated brachial umbo in older specimens (text-fig.33C). The anterior plication is angular, in contrast to the rounded form of S. striatula s.s., and the frequently occurring hump-like brachial fold of S. striatula s.s. is lacking. The prominent growth rugae of S. striatula s.s. are absent. However, internally the two forms have similar stubby brachiophores and strong divergent brachiophore plates, and similar muscle field outlines in transverse section (cf. text-figs.32 and 33B).

Since there have been only a few specimens of this Upper Frasnian form available for this present study, they have been included under S. striatula s.s., but could possibly represent

an offshoot in the Frasnian from the main striatula stem of development (see Phylogeny). Examination of larger collections, if available, of this form could result in the establishment of a new species.

Comparisons with other Devonian species are given on text-figure 18.

Schizophoria striatula superficially resembles S. resupinata (Martin) of the Carboniferous in general outline and form of the muscle fields. Early workers frequently considered them as one species. But S. striatula is generally smaller in size, more quadrate in outline, lacks a brachial mesial sinus, has a higher anterior plication, and lacks spine bases. Schizophoria resupinata is frequently larger, rectangular to elliptical in outline, with a rectimarginate-uniplicate-unisulcate-sulciplicate anterior commissure, and is frequently covered in spine bases. The elongate oval to weakly flabellate pedicle muscle field of S. striatula superficially resembles that of S. resupinata, and the brachial muscle fields of the two species are comparable. An attempt to explain these similarities is made in the section on phylogeny.

The following authors have given short, unillustrated descriptions of S. striatula:

Orthis striatula. Schlott.sp., Keyserling, 1846, p.223.
O. striatula, Steininger, 1853, p.81.
Orthis striatula Schloth. O. resupinata Vern., Pacht, 1859, p.41.
O. striatula (Schl)., D'Eichwald, 1860, p.814.
Orthis striatula Schl., Kayser, 1871, p.598.
Ortiis striatula Schl., Tschernyschew, 1887, p.103.
Orthis striatula v. Schl., Holzapfel, 1895, p.293.
Schizophoria striatula Schlotheim., Peetz, 1901, p.74.
? Schizophoria striatula Schl., Sobolev, 1909, p.465.
Orthis striatula Schl, Loewe, 1913, p.31.
Orthis (Schizophoria) striatula, Paeckelmann, 1913, p.311: 1922, p.64.
Orthis striatula Schl. typus, Dahmer, 1915, p.238: 1917, p.517.
Schizophoria striatula, Leidhold, 1928, p.16.

Orthis (Schiz) striatula Schl., Reed, 1929, p.239.
? Schizophoria striatula Schl., Nalivkin, 1930, p.17.
Schizophoria striatula Schlotheim, Renaud, 1942, p.23.

The following specimens have been listed in synonymy with S. striatula. Descriptions and figures are absent.

Delthyris striatula. Keferstein, 1834, p.613.
? Atrypa striatula, Sedgwick and Murchison, 1840, p.704.
Orthis striatula, d'Orb. 1847, D'Orbigny, 1850, no.821, p.90.
Orthis striatula (Schl), 1869, Zeuschner, 1869, p.267.
? Orthis striatula Schloth., Wenjukoff, 1886, p.465.
Orthis striatula, Schlotheim sp., Whidbourne, 1893, p.143.
Orthis striatula Schl., Beushausen, 1900, p.77.
Orthis striatula v. Schloth., Liebrecht, 1913, p.463.
Schizophoria striatula Schlotheim, Asselburgh, 1923, p.14.
Orthis (Schizophoria) striatula (Schlotheim), Paeckelmann, 1925, p.116.
Schizophoria striatula (Schlotheim), Le Maitre, 1929, p.53: 1934, p.49: 1947, p.97: 1952, p.102.
_____, Termier, 1936, p.1126, 1194.
Schizophoria striatula Schl, Compte, 1938, p.14 (52).
Orthis (Schizophoria) striatula Schl., Cottreau, 1940, p.195.

References of specimens listed in the synonymy as non. S. striatula have been assigned as follows:

Bronn (1835-7) — a lamellibranch
De Koninck (1842-4, pl.13, fig.11) — S. connivens
Romer (1850) — orthoid brachiopod ?
Roemer (1876) — S. vulvaria (Quensted)
Romanovskij (1878-80, pl.17, fig.3) — rhipidomellid ?
Walther (1907), Assman (1910), Viétor (1916) — S. antiqua Solle
Schuchert and Cooper (1932) — S. allani Warren

Material.—

France (Boulonnais)

BC B83-89 — Lower Frasnian dolomitic shales, N.E. end Carrière Parisienne.

BM B19213 — Devonian, Ferques.

BM B26,209 — Devonian.

BM B82765-82778 — Devonian, Ferques.

Belgium

IRIG 3031 (including two pedicle internal moulds) —

Frasnien Moyen, F 2a, Nismes, Olloy. Frasnien Moyen, F 2i, Senzeilles, Carrière de Beauchateau.

IRIG 2731 — Frasnien Moyen, F 2i, Marche, Bord Oriental Synclinal Dinant.

IRIG 3349 — Frasnien Moyen, F 2b, Chimay au S. de la Maladrie, Seloignes.

IRIG 4591 (some fragmentation, one partial internal mould) — Frasnien Moyen, F 2e, tranchée chemin de fer 600m. N. station Marloie, Aye.

IRIG 4761 (some fragmentation) — Couvinien Supérieur, CO 2c, tranchée chemin de fer entre Jemelle et Rochefort. IRIG 4761 — Frasnien Moyen, F 2i, 1020m. au sud du village, Senzeilles.

IRIG 4916 (including one partial internal mould) — Couvinien Supérieur, Assise de Couvin, CO 2a, 600 m. N. Tellin, Grupont. IRIG 4916 — CO 2c, Route de Champlon-Famenne, Marche.

IRIG 5078 — Couvinien Supérieur, Assise de Couvin, CO 2a, Jemelle, Rochefort.

IRIG 5127 (some fragmentation) — Couvinien Supérieur, CO 2c, N. de la Haie d'Oppagne, Durbuy.

IRIG 5408 — Frasnien Moyen, F 2i, Olloy, Nismes.

IRIG 5911 (including one brachial internal mould) — Frasnien Moyen, F 2a, Petigny (Adugeoir), Couvin.

IRIG 6887 (partial internal mould) — Couvinien Supérieur, CO 2a, tranchées en face de la gare, Jemelle, Rochefort.

IRIG 8254 (some fragmentation) — Frasnien Moyen, F 2a, Boussu, Couvin. IRIG 8254 (including one partial internal mould) — same stratigraphical level, Petigny, Couvin. IRIG 8254 — F 2i, tranchée E. de la gare de Lompret, Chimay.

IRIG 8663 (including crushed internal mould) — Couvinien Supérieur, CO 2a, Jemelle, Rochefort.

IRIG 9694 (some fragmentation) — Couvinien Supérieur, Assise de Couvin, CO 2c, Schistes supérieur de Couvin, Fond des Valaines, Rochefort.

IRIG 11.349 — Frasnien Moyen, F 2a, Nismes (Pont d'Avignon), Olloy.

Germany

BC B90 — Eifelian, Lower Nohn Beds, Weilersbach Horizon, Hillesheimer Syncline, MTB Dollendorf r 5698 : h 7835, Eifel.

BC B91, 92 (pedicle internal mould) — same stratigraphical level, MTB Dollendorf, r 5434 : h 7904.

BC B93, 94 (plaster cast) — Eifelian, Lower Nohn Beds, low Schleit Horizon, MTB Dollendorf, r 5688 : h 7813.

BC B95 — Eifelian, Upper Junkerberg Beds, Geisdorf Horizon, MTB Gerolstein, r 3688 : h 6591, Eifel.

BC B96-8 (97, 8 - fragmentary) — same stratigraphical level, Prum Syncline, Eifel.

BC B99 — Eifelian, Upper Junkerberg Beds (possibly Low Freilingen Beds), Geisdorf Horizon, MTB Mechernich, r 4095 : h 9701, Eifel.

BC B100-112 (109, 110 - fragmentary, 111, partial internal mould, 112, plaster cast) — Eifelian, Upper Junkerberg Beds to Upper Freilingen Beds, MTB Gerolstein, r 3688 : h 6591.

BC B113-117 (some fragmentation) — Eifelian, Lower Freilingen Beds, MTB Mechernich, r 4650 : h 0149.

BC B118 (pedicle internal mould), 119 (partial internal mould), 120-122, 123-124 (partial internal moulds), 125 (fragmentary), 126 (partial internal mould), 127 (internal mould), 128 (plaster cast) — same stratigraphical level, MTB Münstereifel, r 4736 : h 0180, Eifel.

BC B129 (fragmentary pedicle valve) — Eifelian, Freilingen Beds, MTB Dollendorf, r 5446 : h 7555.

BC B130, 131 (internal mould) — Eifelian, Freilingen Beds, Eilenberg Horizon, MTB Dollendorf, r 5434 : h 7532.

BC B132, 133 (plaster cast) — Givetian, Loogh Beds, Rech Horizon, Hillesheimer Syncline, MTB Dollendorf, r 5455 : h 7778.

BC B134-136 — Upper Frasnian Shales, quarry entrance near Walheim, Aachen, MTB Stolberg r 1296 : h 1876-1880.

BM B39562, 3 — Middle Devonian, Gerolstein, Eifel.

BM B62946 — Devonian, Eifel.

BM B86023 — Middle Devonian, Eifel.

SMF (including one internal mould) — Mitteldevon, ostiolatus Horizon, 400m. N.E. Geisdorf.

SMF — Mitteldevon, Gerolstein.

Southwest England

GSM 34/20 (internal mould) — Upper Devonian, (probably

Petherwin Beds, Gatehouse Quarry), Petherwin, Cornwall.

Specimens are preserved as entire shells, except where otherwise indicated.

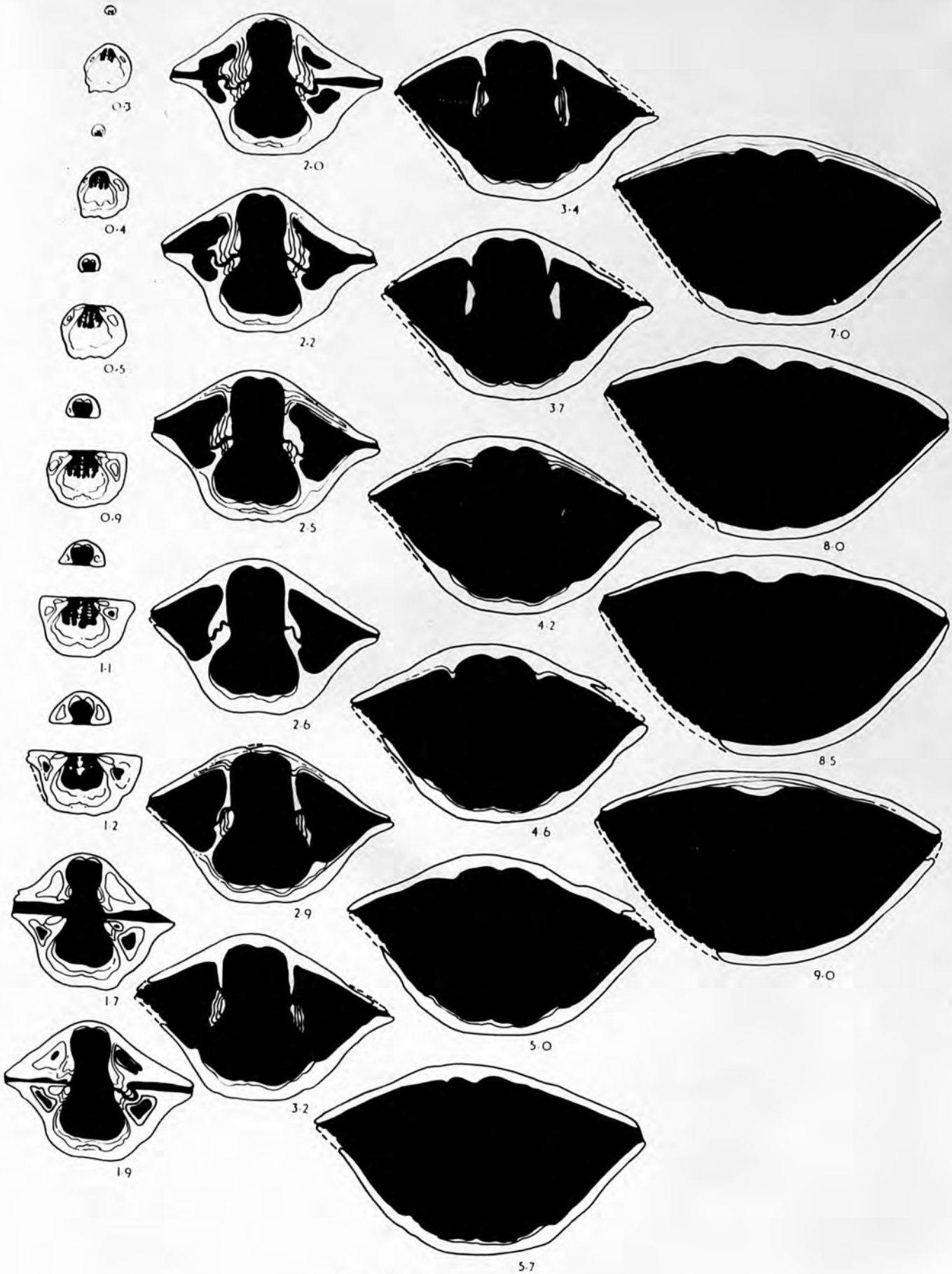
TEXT-FIG. 32 — Schizophoria striatula (Schlotheim)

Measurements of sectioned specimen in millimetres

Length	Width	Depth
24.0	27.5	14.1

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2½.

BC B94 — Middle Devonian, Eifelian, Lower Nohn Beds, Hillesheimer Syncline, Eifel.



Text- fig. 32

TEXT-FIG. 33 — Schizophoria striatula (Schlotheim)

Measurements of sectioned specimens in millimetres

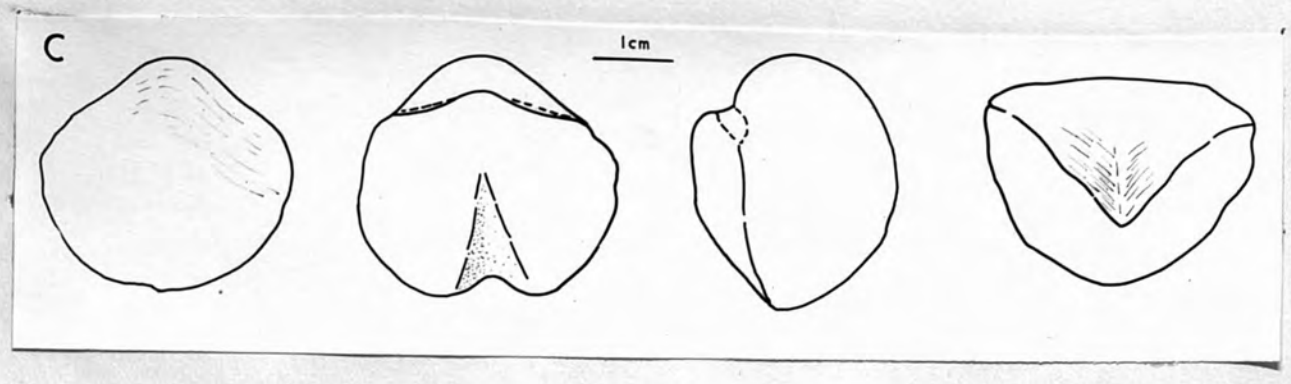
	Length	Width	Depth
A	22.8	29.4	17.0
B	27.7	29.0	17.3

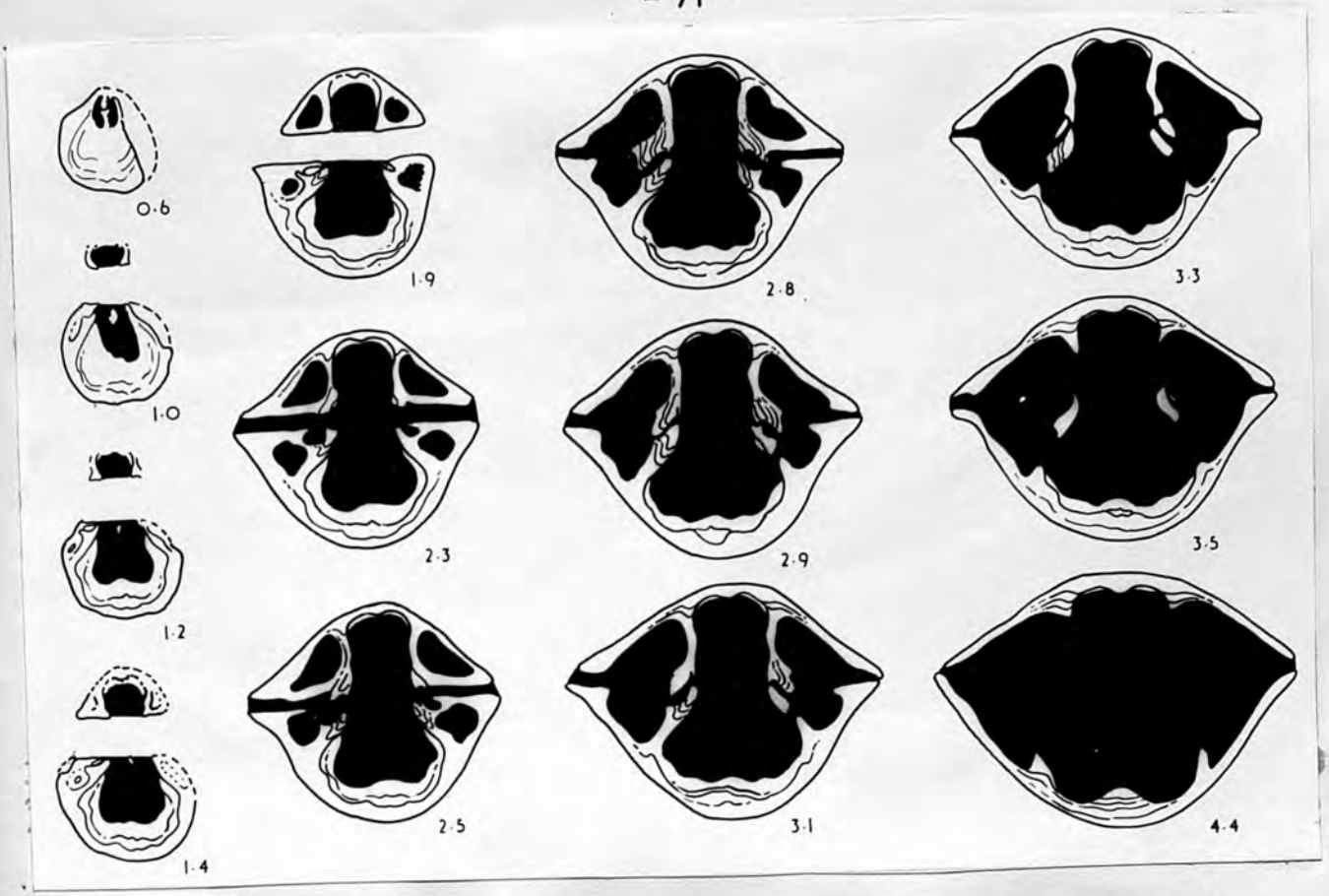
Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbones.

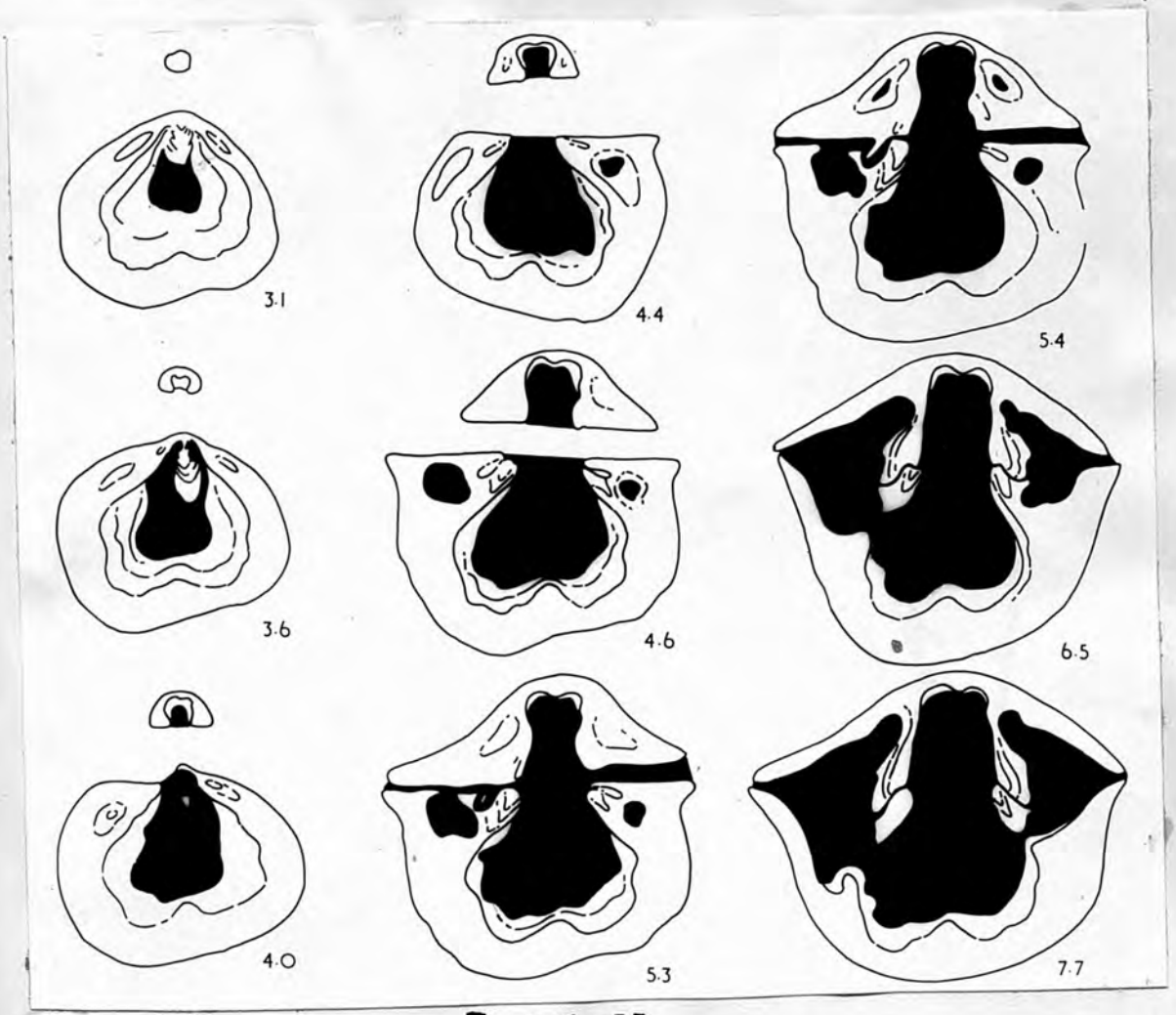
A — IRIG 4591 — Frasnian Moyen, F 2e, tranchee chemin de fer 600m. N. station Marloie, Aye. Sections x 2.

B — BC B — ground specimen, Upper Frasnian Shales, quarry entrance near Walheim, Aachen. Sections x 2.

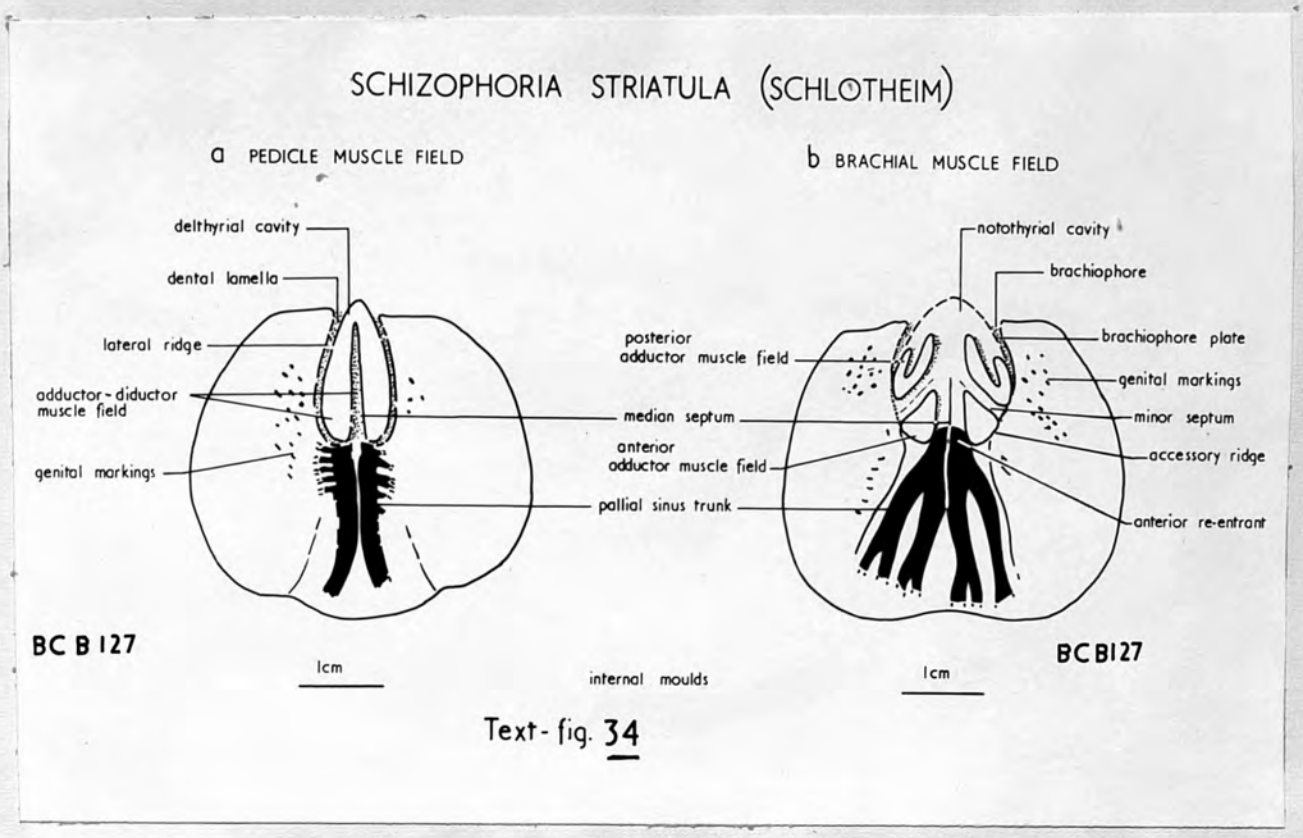
C — BC B135 — outline drawings of brachial, pedicle, lateral, and anterior views of Upper Frasnian form. Natural size.



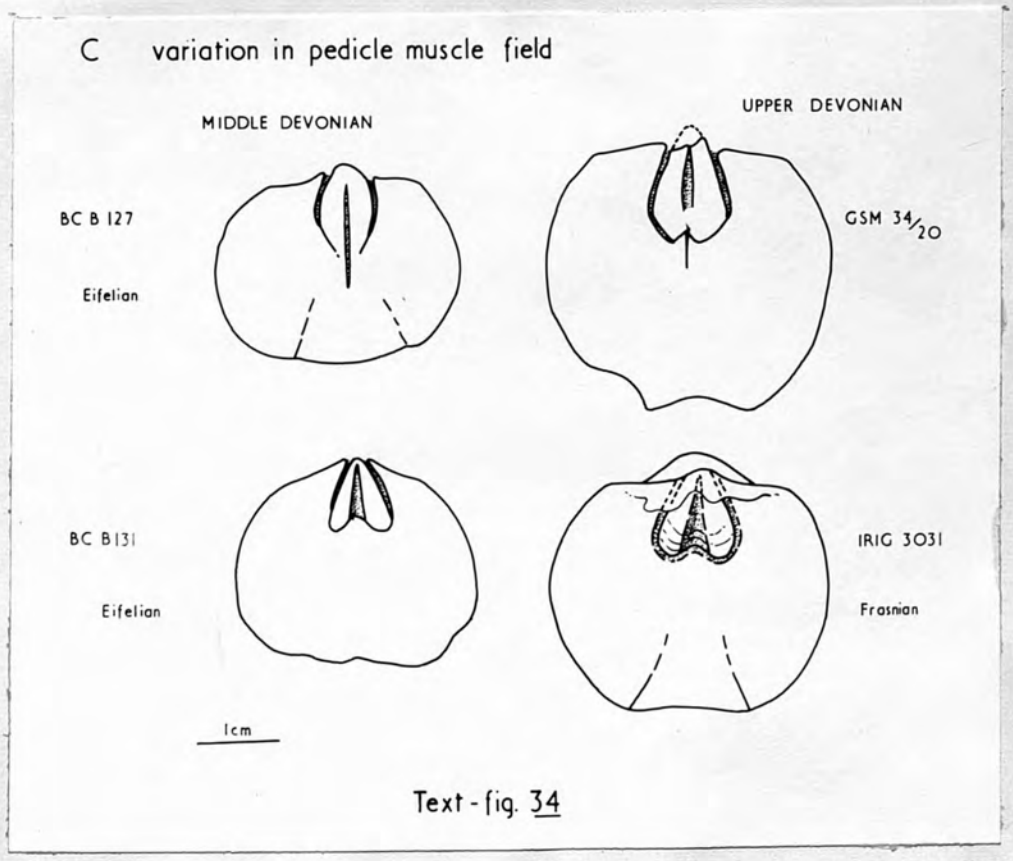




Text-fig. 33



Text-fig. 34



Text-fig. 34

Schizophoria strigosa (Sowerby)

Pl.3, fig.2; text-figs.35-37.

Orthis ? strigosa, Sowerby, 1842, p.409, pl.38, fig.7.
Orthis strigosa, Sow., Béclard, 1887, p.88, pl.4, figs.15, 16.
Orthis occulta, Maurer, 1893, p.9, pl.3, figs.5-9.
Orthis, Maurer, 1888, p.18.
non. Orthis strigosa, Quenstedt, 1871, pl.56, figs.55, 56.
non. Orthis personata Zeiler, Kayser, 1890, pl.2, figs.3-6.

Type material. — Sowerby (1842, p.409, pl.38, fig.7) gave no reference to where his specimen had been deposited, and it is probably lost. New type material will be selected in due course, if Sowerby's material cannot be traced.

Diagnosis. — Internal mould medium to large, quadrate to elliptical, with rounded uniplicate anterior commissure. Pedicle muscle field moderately long, flabellate, strongly incised, longitudinally divided by moderately narrow or broad, rounded median septum. Brachial muscle field incised, quadrate to rounded, bounded posteriorly by moderately thin brachiophore and brachiophore plates. Long follicular markings developed peripherally on moulds.

Description. — Internal mould medium to large, dorsibiconvex, quadrate to elliptical in outline, with greatest width at midlength. Anterior commissure uniplicate, due to high, broad, dorsal, linguiform extension of pedicle valve.

Pedicle muscle field (text-fig.36a) one half to two-thirds valve length, broad, flabellate, with greatest width towards anterior, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly,

convergent, reflexed to form shallow re-entrant, or uniting with anterior termination of median septum without a re-entrant (text-fig.36a). Median septum originating near point of delthyrial cavity, varying in width, rounded, broadening and increasing in height anteriorly (text-fig.36a). No evidence of pallial sinus pattern or genital markings.

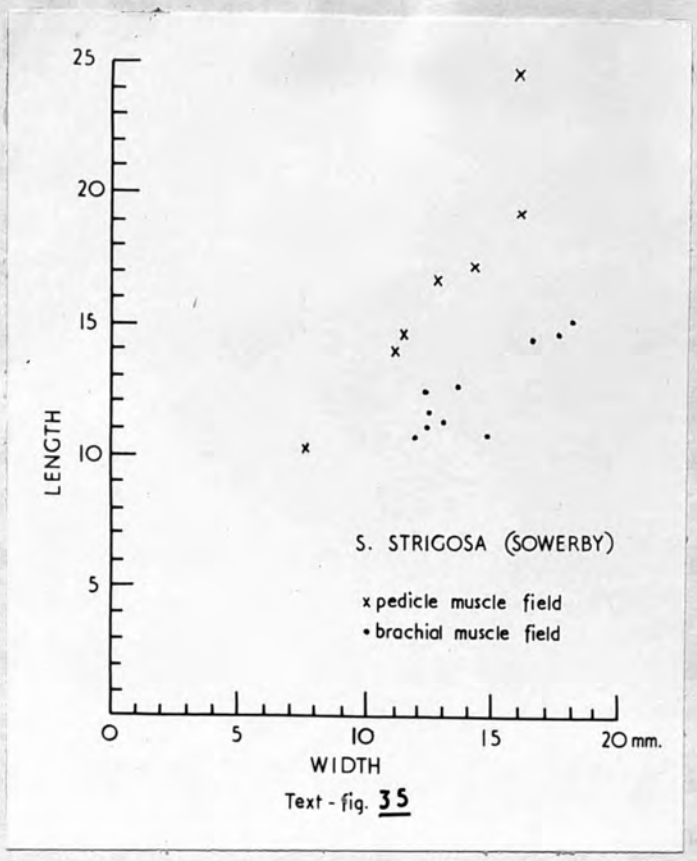
Cardinal process differentiated into oval myophore supported by narrower shaft (text-fig.36b). Brachial muscle field (text-fig.36b) incised, quadrate to rounded, one third to one half valve length, bounded posteriorly by ends of moderately thin brachiophore plates, laterally and anteriorly by accessory ridges. Ridges reduced in height anteriorly, smoothly reflexed to form shallow, subrounded anterior re-entrant, united with median septum. Median septum originating at base of notothyrial cavity, narrow, subangular, narrowing and decreasing in height anteriorly (text-fig.36b). Obliquely trending septum divides each half of adductor muscle field into anterior and posterior parts. Anterior adductor muscle scar pyriform. Posterior adductor muscle scar bipartite, with longer inner lobe, separated from outer lobe by minor septum (text-fig.36b). No evidence of pallial sinus pattern or genital markings. Long follicular markings developed peripherally on moulds.

Dimensions of available muscle fields are plotted on text-figure 35.

External dimensions of S. strigosa have been omitted, since specimens are fragmentary.

Remarks. — All specimens examined are preserved as internal moulds, so that details of external morphology are lacking.

Sowerby (1842, pl.38, fig.7), (text-fig.37 here), illustrated under Orthis ? strigosa, a fragmentary pedicle internal mould, from the Silurian of Haiger Sulbach (Dillen-



Text - fig. 35

burg) in the German Rhineland. More recent work has shown that Devonian rocks outcrop in the Dill synclinorium, Dillenburg, and not Silurian rocks as previously supposed. Other German and Belgium material of this species is Lower Devonian in age.

Beclard (1887, pl.4, fig.17) illustrated a similar pedicle internal mould under Orthis strigosa Sowerby, from the Dinant basin, Belgium (see text-fig.37).

Maurer (1893, p.10, pl.3, figs.5-9) described and illustrated another species, Schizophoria occulta, which is here considered synonymous with S. strigosa. The pedicle muscle fields and follicular markings are similar (text-fig.37). Maurer also illustrated a brachial internal mould, not shown by Beclard or Sowerby. Maurer recognised S. occulta (i.e. S. strigosa) as distinct from the contemporaneous species S. provulvaria. Text-figure 37 illustrates Maurer's illustrations of the two

species. The pedicle muscle field of S. occulta (S. strigosa) is strongly incised, flabellate, with a rounded median septum, while that of S. provulvaria is much more strongly incised, protuberant in profile, and often with a broader median septum. The profiles of the pedicle muscle fields of the two species have been added to text-figure 37.

There are distinct differences in the brachial muscle fields of S. occulta (S. strigosa) and S. provulvaria. The more slender brachiophores and brachiophore plates, longer inner lobe of the digitate posterior adductor muscle scar and pointed notothyrial cavity of S. occulta (S. strigosa), contrast with the strong brachiophores and brachiophore plates, lobes more equal in length, and more parallel sided notothyrial cavity of S. provulvaria.

Detailed and accurately localised collections from the Lower Devonian of Belgium (deposited in the Institut royal des Sciences naturelles) include forms closely resembling Sowerby's, Beclard's and Maurer's illustrations. These have been listed under S. strigosa (Sowerby). The brachial muscle fields of these specimens (eg. text-figure 36b) closely resemble Maurer's illustrations (eg. pl.3, fig.6), (see text-fig.37). But the pedicle muscle field is often less flabellate, and the median septum narrower, as shown by Sowerby.

The pedicle muscle field on text-figure 36b resembles that of Schizophoria vulvaria (Quenstedt) in outline and narrow median septum. Specimens showing variations in length of median septum listed under S. vulvaria and S. provulvaria have been illustrated by previous authors (Oehlert, 1887, pl.5, figs.1, 5; Renaud, 1928, pl.1, figs.1a, 2a: Drevermann, 1904, pl.30, fig.20, respectively). These could possibly belong to S. strigosa. The specimens of S. vulvaria illustrated by Oehlert (1887) have also been listed by Maillieux (1936, p.53) under S. provulvaria,

indicating further the presence of specimens with close similarities with both S. provulvaria and S. vulvaria.

The specimens illustrated by Drevermann (1904, pl.31, figs.16-18) under Schizophoria provulvaria have long peripheral follicular markings characteristic of S. strigosa. Those of S. provulvaria are much shorter.

Schizophoria strigosa first appears in the third division of the Siegenian Stage (see text-fig.2), and ranges into the first division of the Emsian Stage, where it is succeeded by S. vulvaria.

Asselburghs (1913, p.89, pl.3, figs.1-5) described and illustrated Orthis subvulvaria n.sp., which he considered to be a link between S. provulvaria and S. vulvaria. Schizophoria subvulvaria resembles S. vulvaria more closely than S. provulvaria, but differs in its smaller size, subcircular outline, longer pedicle muscle field, and shorter median septum. However, slight variations in size, outline, length of muscle field and septum can be seen linking it with specimens of S. vulvaria. Although S. strigosa has features in common with S. provulvaria and S. vulvaria, it is not considered as synonymous with S. subvulvaria. Schizophoria subvulvaria is hereby listed in synonymy with S. vulvaria.

The specimen illustrated by Quenstedt (1871, pl.56, figs.55, 56) under Orthis strigosa is probably an orthoid. But the long hingeline and muscle fields do not resemble Schizophoria.

Maurer (1893, p.9) questionably listed specimens illustrated by Kayser (1890, pl.11, figs.3-6) in synonymy with S. occulta. However, these specimens closely resemble Proschizophoria, as described by Kayser.

Material. —

Belgium

IRIG 8254 (three pedicle internal moulds, brachial internal mould), IRIG 5039 (brachial internal mould) —

Dévonien Inférieur, Siegenien, Grauwacke de Petigny, Sg 3b (Hersdorferschichten), Couvin.

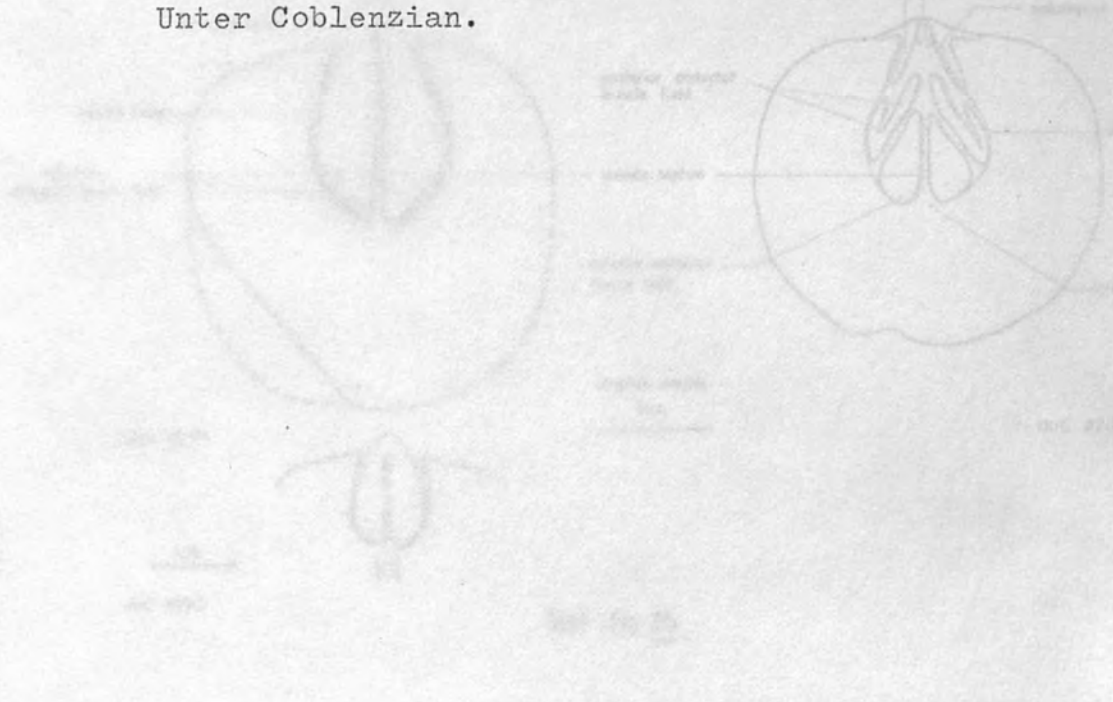
IRIG 8190 (fragmentary internal mould, distorted internal mould, pedicle internal mould) — Dévonien Inférieur, Siegenien, Grauwacke de Petigny, Sg 4, Couvin.

IRIG 8219 (three brachial internal moulds) — Dévonien Inférieur, Siegenien, Grauwacke de saint-Michel, Sg 3, tranchée chemin de fer, Mirwart, Grupont.

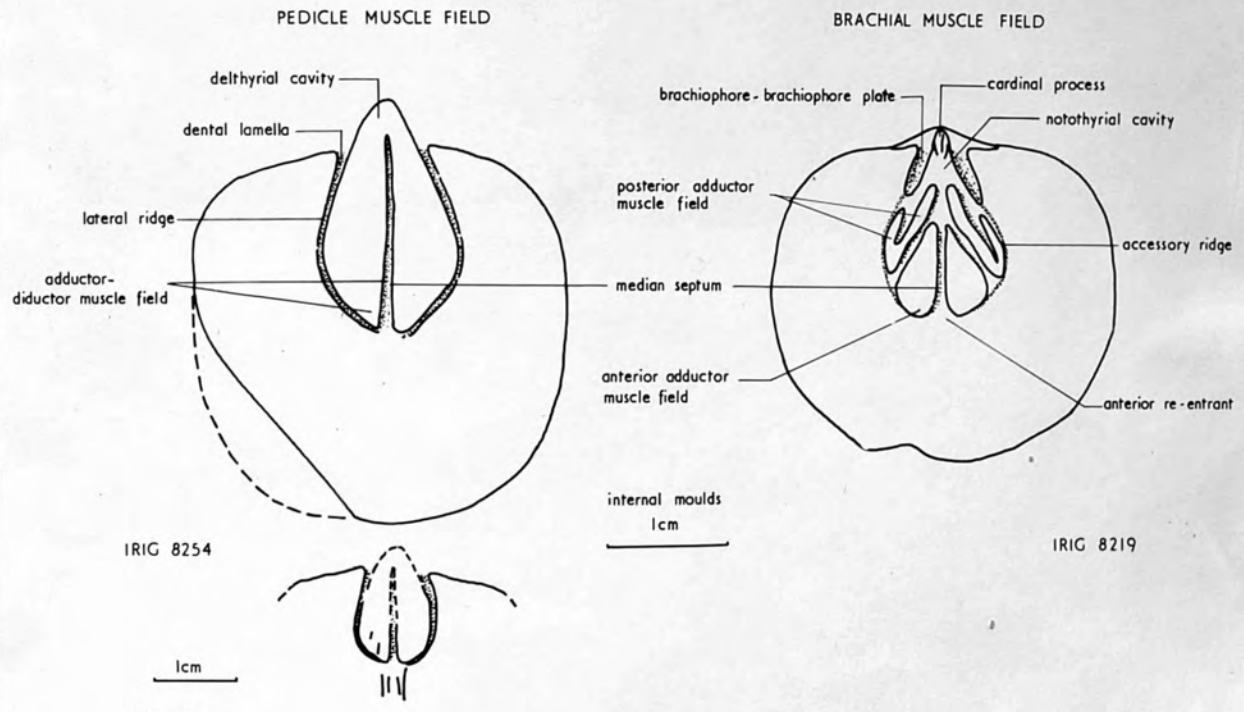
IRIG 8791 (pedicle internal mould) — Dévonien Inférieur, Emsien Inférieur, Grauwacke de Pesche, Em 1a, tranchée chemin de fer de Gedinne, Pondrome.

Germany

SMF (two brachial internal moulds) — Lower Devonian, Unter Coblenzian.



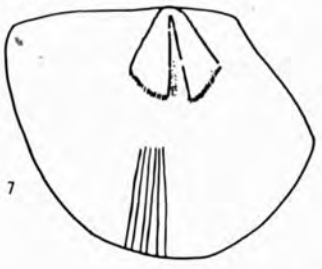
SCHIZOPHORIA STRIGOSA (SOWERBY)



Text-fig. 36

SCHIZOPHORIA STRIGOSA (SOWERBY)

1. Sowerby 1842
ORTHIS ? STRIGOSA



Pl 38 fig 7

2. Béclard 1887
ORTHIS STRIGOSA, SOWERBY

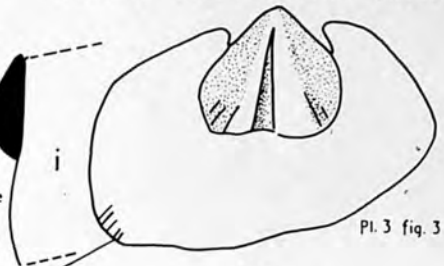
Pl. 4 fig 16

4. Maurer 1893
ORTHIS PROVULVARIA MAURER

PEDICLE MUSCLE FIELDS

3. Maurer 1893
ORTHIS OCCULTA MAURER

Pl. 3 fig. 8



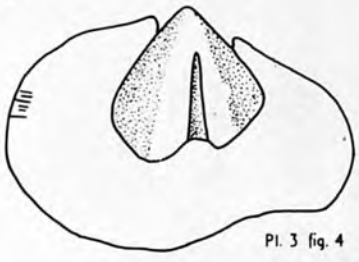
i

lateral profile

Pl. 3 fig. 3

follicular markings

lateral profile

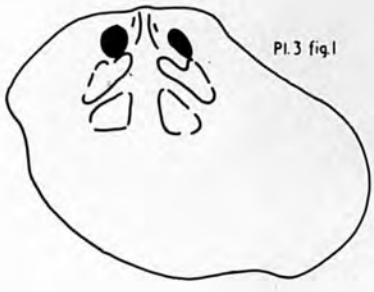


ii

Pl. 3 fig. 4

BRACHIAL MUSCLE FIELDS

Pl. 3 fig. 6
i



i

Pl. 3 fig.1

Pl. 3 fig. 6

X 2

ii

Pl. 3 fig. 2

BRACHIOPHORES BRACHIOPHORE PLATES INFILLED

DRAWINGS NATURAL SIZE

Text - fig. 37

Schizophoria vulvaria (Quenstedt)

Pl.3, figs.3-5; text-figs.38-42.

Hysterolithos, Worm, 1655, p.83, text-fig. on same page.

Hysterolithus, Wolfart, 1719, pl.3, figs.3,5, non.4.

Hysterolites vulva marina, Baumer, 1763-4, p.327, fig.28.

Hysterolites, Walch, 1768, p.90, pl.B4, fig.5, 6.

Hysterolites vulvarius, Schlotheim, 1820, p.247, pl.29, fig.2b ? non. 2a, 3.

Orth. Beaumonti de Vern., Schnur, 1853, p.215, pl.37, fig.9.

O. striatula d'Orbigny (Hysterolites vulvarius Schl), Roemer, 1876, pl.23, fig.8.

Hysterolithes vulvarius, Quenstedt, 1867, p.577, pl.49, fig.2: 1882, p.737, fig.252: 1885, pl.57, fig.13.

Hysterolithus vulvarius, Quenstedt, 1868-71, p.565, pl.56, figs.2-6.

Orthis (Hysterolithes) vulvarius Schl sp., Oehlert, 1887, p.53, pl.5, figs.1-9.

Orthis hysterita Gmelin, Kayser, 1889, p.53, pl.5, figs.1, 7-9: 1890, pl.11, fig.7.

Orthis vulvaria Schlotheim, Maurer, 1893, pl.4, figs.1, 2.

Orthis hysterita Gmelin, Walther, 1903, p.60, pl.2, fig.11.

? Schizophoria vulvarius Schlotheim, Renaud, 1928, p.147, pl.1, figs.1, 2.

Schizophoria vulvaria Schloth., Laverdière, 1930, p.87.

Schizophoria vulvaria (Schlotheim), Schuchert and Cooper, 1932, pl.23, figs.11, 17.

Schizophoria vulvaria, Maillieux, 1933, pl.4, fig.72.

Schizophoria hysterita, Schmidt, 1935, pl.2, fig.27.

Schizophoria vulvaria, Schl. var. typ., Karrenberg, 1936, p.284, pl.16, fig.15.

? Schizophoria vulvaria Schl. var. curvata nov. var., Karrenberg, 1936, p.285, pl.16, fig.16.

Schizophoria vulvaria, Termier and Termier, 1950, pl.72, figs.16? 17.

non. Hysterolithus, Tessin, 1753, p.90, pl.5, fig.2.

non. Orthis Beaumonti n.sp., De Verneuil, 1850, p.180, pl.4, fig.8.

non. Schizophoria vulvaria (Schlotheim), Compte, 1938, p.13, pl.1, figs.2, 3.

Type material. — Schlotheim's specimens (1820, pl.29, figs.2a, 3, and possibly 2b) were probably spiriferids (see Remarks). Quenstedt (1868-71, p.565, pl.29, figs.2-6) is apparently the first author to describe and illustrate Schizophoria vulvaria proper. However, there is no reference as to the location of his types, and they cannot be traced. It is hereby proposed that a neotype be selected in due course.

Diagnosis. — Internal mould large, quadrate to rectangular, with rounded uniplicate anterior commissure. Pedicle muscle field long, lanceolate to weakly flabellate, strongly incised, longitudinally divided by narrow, subrounded median septum. Brachial muscle field incised, bounded posteriorly by strong, divergent brachiophore plates. Each posterior adductor muscle scar tripartite or quadripartite.

Description. — Internal mould large, dorsibiconvex, quadrate to rectangular in outline, wider than long, with greatest width at or slightly anterior to mid-length. Anterior commissure uniplicate, due to high, broad, subrounded to rounded, dorsal, linguiform extension of pedicle valve.

Pedicle muscle field (text-fig.42a) long, one half to two thirds valve length (see text-fig.38), lanceolate to weakly flabellate, strongly incised, bounded posteriorly by ventrally convergent anteriorly divergent dental lamellae, laterally and anteriorly by strong ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, weakly convergent, sharply reflexed to form shallow, subangular re-entrant, or uniting with anterior termination of median septum without a re-entrant (text-fig.42a). Median septum originating near point of delthyrial

cavity, narrow, subrounded, broadening slightly anteriorly, first increasing, then decreasing, in height (text-fig.41, sections 3.5-16.2). Muscle field occasionally subdivided anteriorly by longitudinal ridges. Pedicle muscle scars not evident. Pallial sinus pattern consisting of two subparallel trunks originating from ends of diductor muscle field or anterior re-entrant, giving off lateral branches (text-fig.42a). Genital markings developed laterally and postero-laterally, arranged concentrically (text-fig.42a).

Prominent cardinal process, differentiated into broad myophore supported by narrower shaft (text-fig.42b, c). Myophore compound, with up to six lateral ridges. Stubby brachiophores curved postero-laterally, and fused to strong, divergent brachiophore plates bounding notothyrial cavity (text-fig.41, sections 2.2-4.1). Dental sockets deep, oval (text-fig.42c).

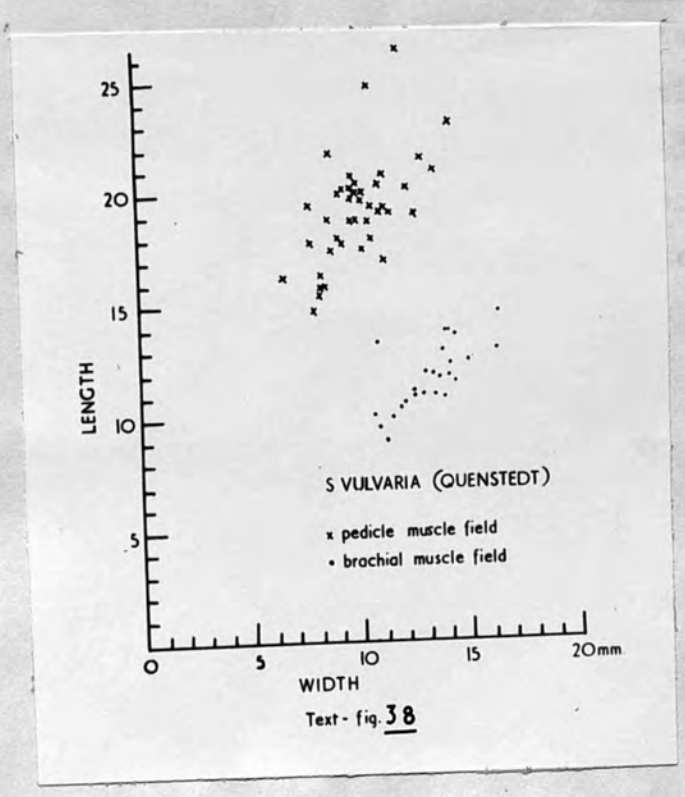
Brachial muscle field incised, quadrate to rounded, length and width approximately equal, one third to one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges reduced in height anteriorly, smoothly reflexed to form shallow, subrounded anterior re-entrant, united with median septum. Median septum originating at base of notothyrial cavity, low, broad, rounded, decreasing in height and narrowing anteriorly (text-fig.41, sections 2.2-9.6; text-fig.42b, c). Strong, obliquely trending septum divides each half of adductor muscle field into anterior and posterior parts. Anterior adductor muscle scar pyriform. Posterior adductor muscle scar large, generally tripartite or quadripartite, with longer inner lobe, shorter middle lobe(s), and short outer lobe, separated by minor septa (text-fig.42b, c). Pallial sinus pattern consisting of two main trunks, each bifurcating, originating from anterior re-entrant of muscle field, divergent, branching peripherally (text-fig.42b); two lateral trunks occasionally developed from anterior adductor scars.

Genital markings developed laterally and postero-laterally (text-fig.42b). Short follicular markings developed peripherally on internal moulds.

Dimensions of available internal moulds in millimetres.—

	Length	Width	Depth
BM B19002	27.8	34.1	19.8
BM B19002	29.2	35.1	19.8
BM B23179	28.7	35.2	20.8
BM B23179	28.8	—	19.1
BM B23179	32.9	37.4(+)	22.2
BM B34290	28.3	33.0	22.2
BM B39435	—	33.5	17.2
BM B49920	26.0	32.6	16.6
BM B62947	30.2	35.7	17.0

Dimensions of available muscle fields are plotted on text-figure 38.



Text-fig. 38

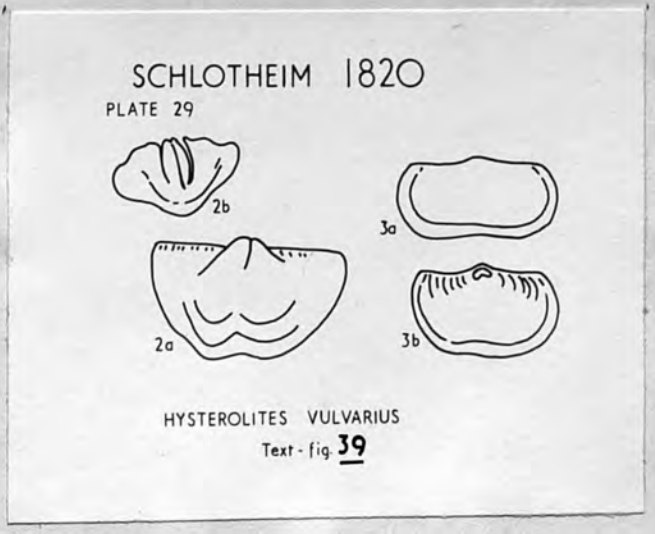
Remarks.— All the specimens are preserved as entire or fragmentary internal moulds, so that details of external morphology are lacking.

There is some variation in the digitation of the posterior adductor muscle scar. The tripartite scar is replaced in specimen IRIG 8284 by six parts.

Comparisons with Schizophoria strigosa (Sowerby), S. provulvaria (Maurer), and S. striatula (Schlotheim) are made under these species. Schizophoria strigosa and S. provulvaria range from the Siegenian to Lower Emsian stages. Schizophoria vulvaria appears higher in the Emsian stage, ranging into the Lower Eifelian stage, when it is succeeded by S. striatula.

Maillieux (1932, p.24) presented a long synonymy of Schizophoria vulvaria, and discussed the naming of the species, with reference to authors of the seventeenth century. The name S. vulvaria is synonymous with Hysterolites. Gmelin (1790, p.3345) very briefly described a form under Anomia hysterita, which has been included under S. vulvaria by later authors. However, this description is apparently not specific.

Schlotheim (1820, p.247, pl.29, figs.2, 3), (reproduced in text-figure 39), the stated author of the species, by Quenstedt and later authors, described and illustrated some specimens grouped under Hysterolites vulvarius, which have the transverse



outline and long hingeline characteristic of a spiriferid. His

figure 2b has a lanceolate pedicle muscle field characteristic of S. vulvaria, but the hingeline is curved, obscuring its length. The mould outline and muscle field in this figure also probably represents a spiriferid.

Later authors have apparently misinterpreted Schlotheim's work as actually representing the schizophoriid species S. vulvaria, mainly on the basis of the pedicle muscle field in his figure 2b.

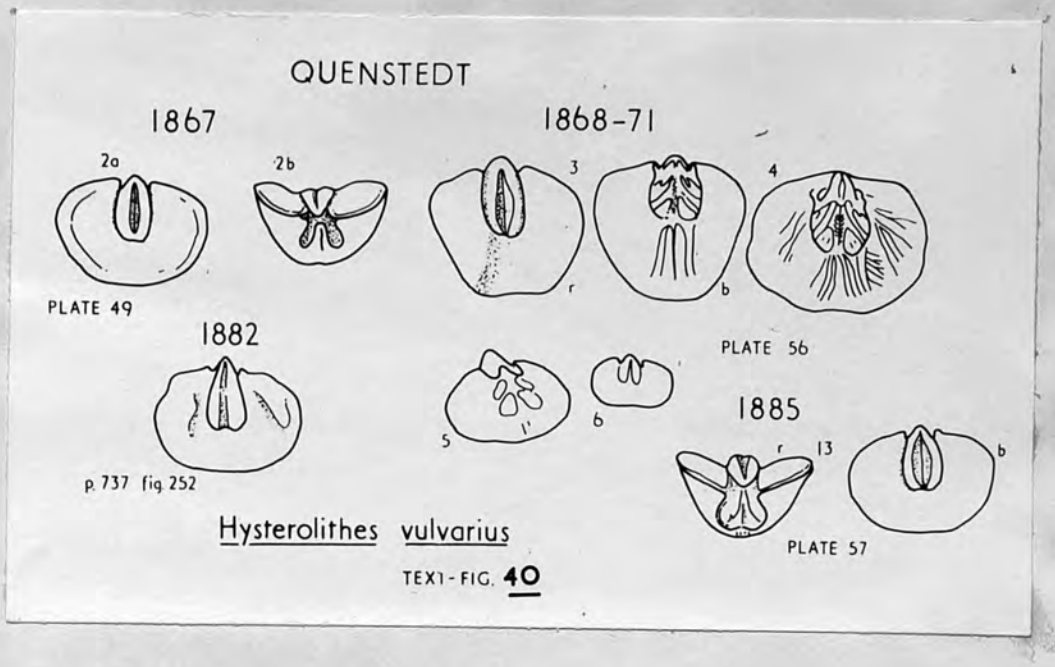
Quenstedt (1868-71, p.565) stated that Schlotheim (1820, p.247, pl.29, figs.2a, 3) incorrectly described and figured specimens under S. vulvaria, and that only figure 2b could possibly represent the pedicle valve of S. vulvaria. However, Schlotheim makes no reference to the genus Schizophoria (then Orthis) in his description, and was probably describing a new spiriferid, since Hysterolithes is an old group term for spiriferids. He described the specimens under Hysteroliten.

The pedicle muscle field of Schlotheim (1820, pl.29, fig.2b) has confused later authors, who incorrectly recognised Schlotheim as author of the schizophoriid species S. vulvaria.

Quenstedt (1867, 1868-71, 1882, 1885) was the first author to describe and illustrate S. vulvaria as such (text-fig. 40). Quenstedt is hereby listed as the author of S. vulvaria.

The specimen illustrated by Wolfart (1719, pl.3, fig.4), and the specimens illustrated by Tessin (1753, pl.5, fig.2) are spiriferid in shape.

De Verneuil (1850, p.180, pl.4, fig.8a-d) described and illustrated a new species Orthis Beaumonti from the Devonian of northern Spain, which resembles S. vulvaria in shell outline, and elongate form of the pedicle muscle field. But the pedicle valve pallial sinus and genital markings of O. Beaumonti are radially arranged, in contrast to the concentric arrangement in S. vulvaria. In the brachial valve of O. Beaumonti, the anterior adductor muscle scars are very small, the posterior adductor



Hysterolithes vulvarius

TEXT-FIG. 40

scars apparently non-digitate, and only two parallel pallial sinus trunks originate from the anterior of the muscle field (De Verneuil, pl.4, fig.8d). In S. vulvaria the anterior muscle scar is larger, the posterior muscle scar tripartite or quadripartite, and four to six trunks diverge from the muscle field.

Compte (1938, p.13, pl.1, figs.2, 3) described and illustrated specimens from the Lower and Middle Devonian of northern Spain under S. vulvaria, with Orthis Beaumonti De Verneuil listed in synonymy. Compte's specimens resemble those of De Verneuil, and were collected from the Upper Siegenian, Emsian and Lower Eifelian stages. Schizophoria vulvaria from Belgium and Germany is restricted to the Emsian and Lower Eifelian stages.

Although resembling and probably related to S. vulvaria, Orthis Beaumonti has not been listed in synonymy with S. vulvaria, but is here considered a separate form, based on its brachial

muscle field and pallial sinus markings.

The following authors have given unillustrated descriptions or synonymies of S. vulvaria:

Anomia hysterita, Linnaeus, 1758, p.703, no.203.
_____, Gmelin, 1790, p.3345.
? Orthis vulvarius, Schlt., Barrois, 1889, p.72.
Orthis vulvaria Maur., Vietor, 1919, p.449.
Schizophoria vulvaria (Schlotheim), Maillieux, 1932, p.24.
Schizophoria vulvaria Schlotheim, Renaud, 1942, p.21.
Schizophoria vulvaria Schl., Renaud, 1952, p.132.

The following specimens have been listed in synonymy with S. vulvaria. Descriptions and figures are absent.

Orthis (Schizophoria) vulvarius, Schlotheim sp., Kerforne, 1896, p.230.
Orthis hysterita Gmel., Beushaven, 1900, p.77.
Orthis hysterita Gmelin, Dahmer, 1917, p.518.
Schizophoria vulvaria (Schlotheim), Maillieux, 1938, p.11: 1941, p.21.

Material.—

Belgium

BM B15708 (internal mould) — Lower Devonian, Gemelle, Rochefort, Namur.

IRIG 4916 (two pedicle internal moulds) — Dévonien Inférieur, Emsien Supérieur, Grauwacke de Hierges, Em 3, 2,200m. N.O. d'Ambly, Rochefort.

IRIG 5391 (brachial internal mould) — same stratigraphical level, chemin de fer Belair, 600m. S. de la station de Grupont.

IRIG 5746 (two pedicle internal moulds) — same stratigraphical level, 400m. S.O. de Masbourg, Rochefort.

IRIG 5746 (brachial internal mould) — Dévonien Moyen, Couvinien, Assise de Bure, CO 1b, chemin de Lesterny à la halte du chemin de fer, Rochefort.

IRIG 5910 (fragmentary internal mould, brachial internal mould) — Dévonien Inférieur, Emsien Supérieur, Grauwacke de Hierges, Em 3, 1800m. N.O. de Masbourg, Rochefort.

IRIG 5910 (pedicle internal mould) — same stratigraphical level, route de Saint Hubert, 1400m. N.O. de Masbourg, Rochefort.

IRIG 5911 (three pedicle internal moulds, brachial internal

mould) — same stratigraphical level, 750m. S. de Petigny, Couvin.

IRIG 5911 (pedicle internal mould) — same stratigraphical level, 1100m. S.S.O. de Petigny, Couvin.

IRIG 8254 (internal mould) — same stratigraphical level, tranchee chemin de fer Vicinal, Olloy.

IRIG 8254 (two pedicle internal moulds, fragmentary pedicle internal mould) — same stratigraphical level, 150m. N. de Grimbiémont, Marche.

IRIG 8254 (brachial internal mould) — same stratigraphical level, 1400m. S.E. de Couvin, N. du Bois Hestren.

IRIG 8254 (internal mould) — same stratigraphical level, 150m. S. de Petigny, Couvin.

IRIG 8284 (fragmentary brachial internal mould) — same stratigraphical level , 150m. N. de Grimbiémont, Marche.

IRIG 8390 (pedicle internal mould, brachial internal mould); 8633 (pedicle internal mould) — Dévonien Moyen, Couvinien Inférieur, Assise de Bure, CO la, 200m. S. station de Jemelle, tranchée route de Jemelle à Forrières, Rochefort.

IRIG 8573 (fragmentary brachial internal mould, pedicle internal mould); 8633 (three fragmentary internal moulds, pedicle and brachial internal moulds) — Dévonien Inférieur, Emsien Supérieur, Grauwacke de Hierges, Em 3, tranchée chemin de fer Jemelle, Rochefort.

IRIG 12409 (crushed internal mould, pedicle internal mould) — Dévonien, Moyen, Couvinien Inférieur, Assise de Bure, CO la, tranchée Vicinal Olloy-Oignies.

Germany

BM B19002 (internal moulds) — Lower Devonian, Lahnstein.

BM B23179 (fragmentary internal moulds); B34290 (internal mould); B49,920 (internal mould, pedicle internal mould) — Lower Devonian, Eifel.

BM B39435 (internal mould); B62947 (internal moulds) — Lower Devonian, Coblenz.

BM B39450 (internal mould, fragmentary internal mould) — Lower Devonian, Daleyden, Eifel.

BM B86626, 7 (internal moulds) — Lower Devonian, mouth of R. Lahn.

HMUG L2031 (brachial internal mould) — Lower Devonian, Ober Coblenzian, Daleiden.

HMUG L5344 (pedicle internal mould) — Lower Devonian, Coblenzian, Grimbach.

SMF (internal mould, two pedicle internal moulds) — Lower Devonian, Ober Ems.

SMF (pedicle internal mould) — Lower Devonian, Ober Ems, Niederprüm. Prüm.

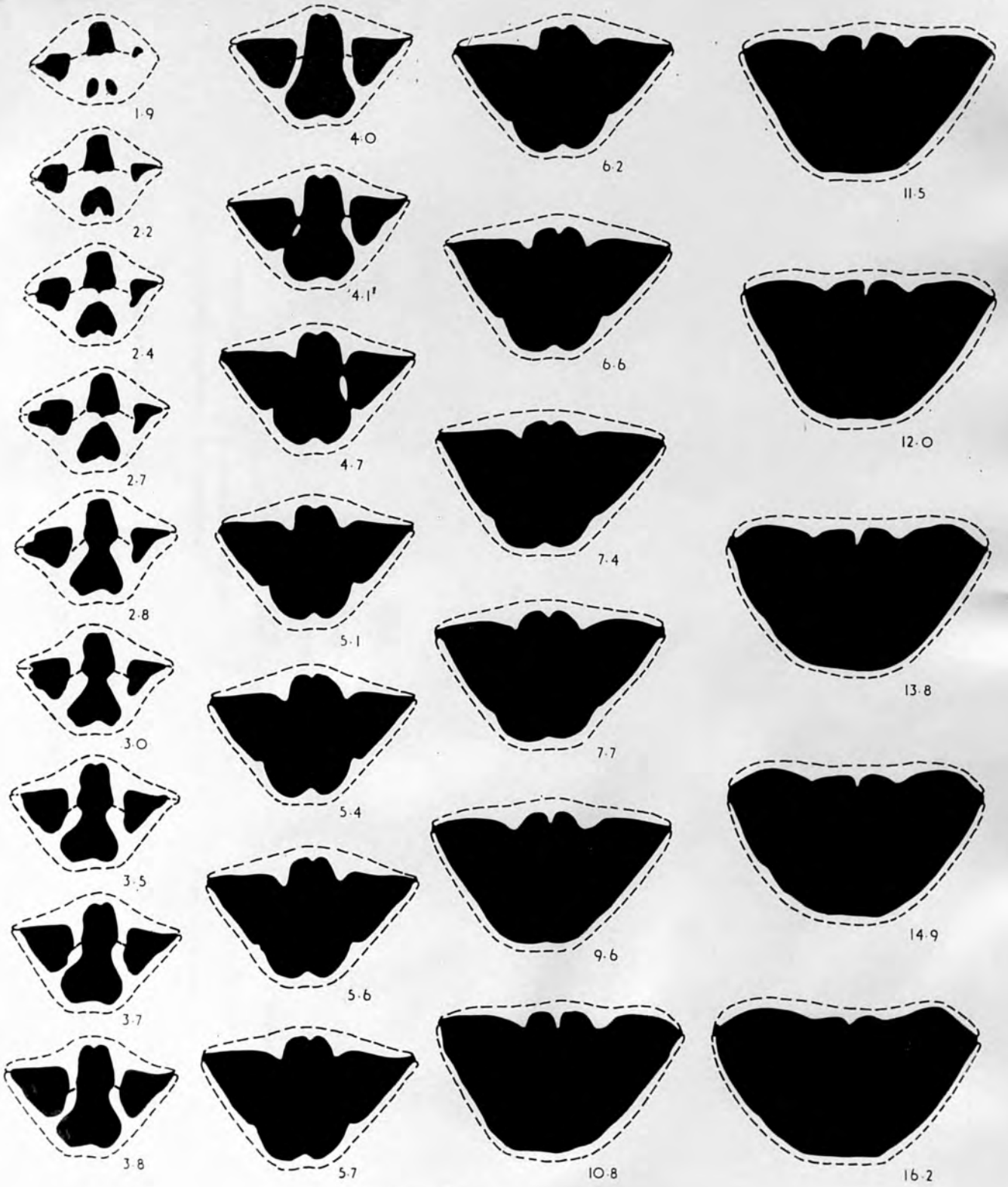
TEXT-FIG.41 — Schizophoria vulvaria (Quenstedt)

Measurements of sectioned internal mould in millimetres

Length	Width	Depth
31.7	38.5	22.6

Numbers below serial sections indicate distances in millimetres measured anteriorly from umbones. Sections x 1.

BM B23179 — Lower Devonian, Eifel.

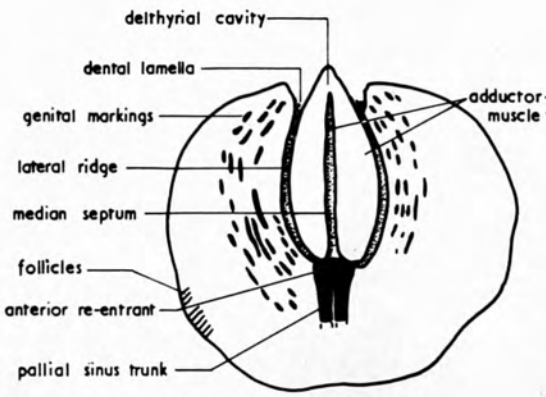


shell reconstructed

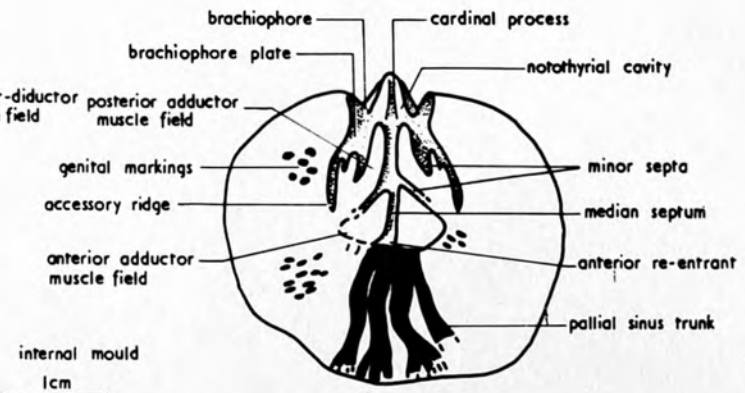
Text-fig. 41

SCHIZOPHORIA VULVARIA (SCHLOTHEIM)

a PEDICLE MUSCLE FIELD

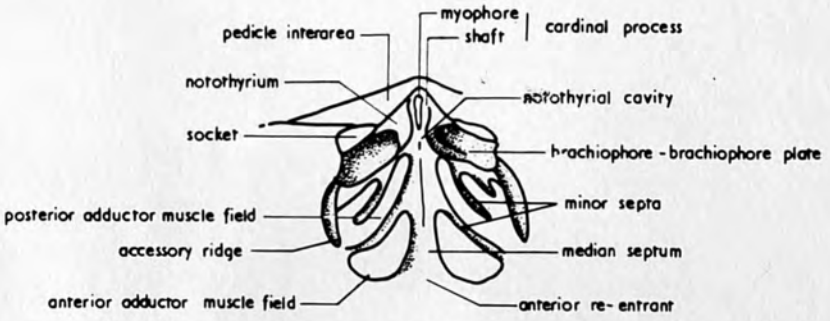


b BRACHIAL MUSCLE FIELD



BM B 62947
B 34290

c BRACHIAL MUSCLE FIELD ENLARGED



Text-fig. 42

CARBONIFEROUS

Schizophoria connivens

Pl.1, figs.1-11; text-figs.43-46.

Spirifera connivens, Phillips, 1836, p.220, pl.11, fig.2.

Orthis striatula, De Koninck, 1842-4, p.224, pl.13, fig.11a,b; non. 13bis, fig.6.

Schizophoria resupinata var. connivens, Phillips, Davidson, 1858-63, p.131, pl.29, figs.6,7.

? Orthis resupinata W. Martin. Abich, 1878, p.78, pl.8, fig.9.

Schizophoria resupinata var. connivens (Phillips), Demanet, 1921, p.121, pl.5, fig.3: 1934, p.56, pl.4, figs.5,6.

? Schizophoria resupinata var. gibbera (Portlock), Demanet, 1921, pl.5, fig.2.

Schizophoria connivens (Phillips), Bond, 1941, p.293, text-fig.35.

Schizophoria aff. S. resupinata (Martin), Yanagida, 1962, pl.21, fig.5.

? non. Schizophoria connivens Phillips, Termier and Termier, 1950, pl.71, fig.34.

non. Spirifer connivens, Phillips, Murchison, 1840, p.255.

non. _____, D'Archaic and Verneuil, 1842, p.371, 393.

Neotype. — The holotype illustrated by Phillips (1836, pl.11, fig.2) is lost. The neotype, chosen and figured by Bond (1941, text-fig.35), is in the British Museum (Natural History), B 387.

Diagnosis. — Shell small, tumid, rounded to rectangular, with biplicate, sulciplicate or quadrate-uniplicate anterior commissure. Shell coarsely costellate, with scattered prominent costellae, and rugate. Pedicle muscle field oval, strongly incised, longitudinally divided by median septum continuing beyond anterior boundary. Brachial muscle field moderately incised, bounded posteriorly by short, strong,

divergent brachiophore plates supporting stubby brachiophores.

Description. — Shell small, ventribiconvex to weakly dorsibiconvex, tumid, rectangular to rounded in outline, wider than long, with greatest width at or slightly anterior to mid-length. Pedicle valve convex umbonally, flattening laterally, depressed medially. Brachial valve generally more convex, evenly convex longitudinally, flattening laterally; convexity frequently broken by longitudinal median sinus, originating anterior of umbo, broadening and deepening anteriorly. Beaks small, pointed, close; brachial beak more incurved and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea prominent, high, curved to beak, with horizontal growth lines; delthyrium higher than wide, open. Brachial interarea lower, half height of pedicle interarea, curved to beak; notothyrium as wide as high, open. Pedicle sinus ill-defined, originating anterior of umbo, broadening and deepening anteriorly. Gentle brachial fold occasionally developed adjacent to anterior commissure. Anterior commissure varying from biplicate to sulciplicate or uniplicate. Shell costellate, rugate, punctate. Radial costellae coarse, 4 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation. Scattered costellae thickened, with hollow spine bases developed anteriorly. Growth rugae concentric (text-fig. 44, sections 3.7-4.2), thick, more closely grouped anteriorly. Puncta subrounded, 1/45-1/60mm. in diameter on inner shell surface.

Teeth prominent, compound, supported by anteriorly and ventrally divergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.44, sections 2.8-3.5). Articulation supplemented by interlocking

ends of brachiophores and dental lamellae. Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.44, sections 1.6-3.0).

Pedicle muscle field (text-fig.44a) half valve length, longitudinally oval in outline, strongly incised, bounded posteriorly by dental lamellae, laterally by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly; anterior boundary of muscle field ill-defined. Muscle field longitudinally divided by median septum, originating near point of delthyrial cavity, narrow, subangular, broadening slightly and increasing in height, then decreasing in width and continuing for short distance anterior of muscle field (text-fig.44, sections 0.9-5.9, a). No evidence of pedicle muscle scars or genital markings. Pallial sinus pattern consisting of two trunks originating from ends of diductor muscle field, slightly divergent anteriorly (text-fig.44a).

Myophore compound, average width 1.15mm., with central ridge, bordered by two shorter, narrower ridges, one either side, (text-fig.44, sections 1.6-2.2), all serrated. Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly. Stubby brachiophores curved posterolaterally, and fused to strong, thick, short, divergent brachiophore plates bounding notothyrial cavity (text-fig.44, sections 2.6-4.4). Dental sockets deep, oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.44, sections 2.6-3.0). Sockets bounded internally and externally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig.44, sections 2.6-3.3). Fulcral plates strong, uniting brachiophores with postero-lateral shell margin (text-fig.44, sections 2.8, 2.9).

Brachial muscle field (text-fig.44b) moderately incised, elliptical to rounded, length and width approximately equal, one half to two thirds valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly and reflexed to form shallow, subangular re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, low, subrounded, broadening and increasing in height, and becoming sharp-crested anteriorly (text-fig.44, sections 2.6-5.9, b). Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts. Anterior muscle scar pyriform, acute anteriorly; posterior muscle scar probably digitate (text-fig.44b). Pallial sinus pattern consisting of four slightly divergent trunks, two originating from ends of minor septa, two originating from ends of anterior adductor muscle scars (text-fig.44b). Genital markings not evident. Follicular markings, consisting of long follicles separated by 5 to 8 shorter follicles, occasionally developed peripherally on internal moulds.

Dimensions in millimetres. —

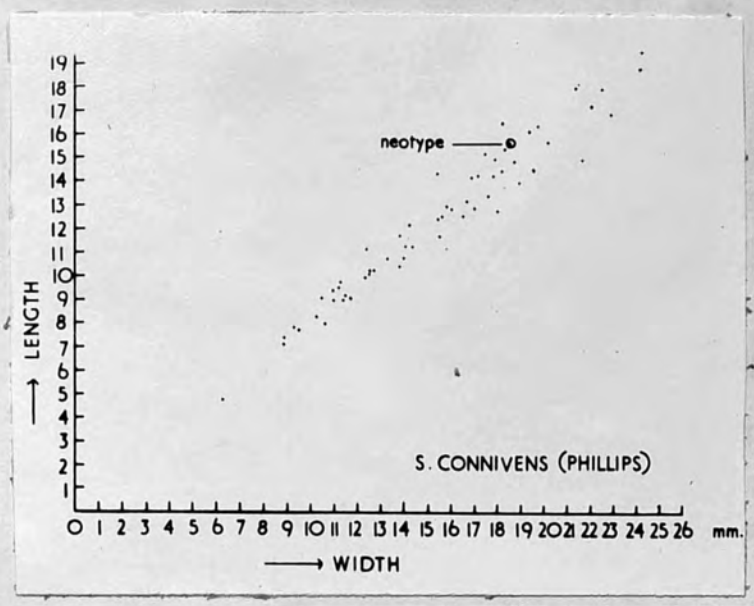
	Length	Width	Depth	Length of hingeline
Neotype BM B387	15.8	18.5	12.0	9.2

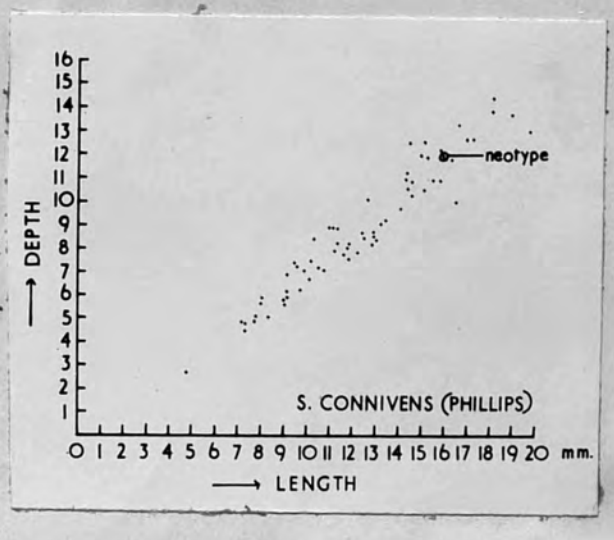
biplicate anterior commissure

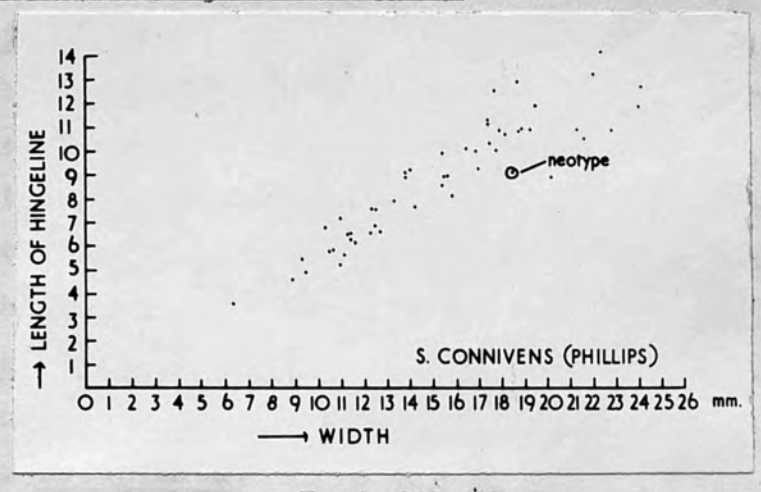
External dimensions of other material are plotted on text-figure 43.

Dimensions of available muscle fields:

	Length of pedicle muscle field	Width of pedicle muscle field
BC B152	5.3	3.8
BC B153	5.8	4.2
BC B154	6.0	4.3
BM B5709	6.9	4.0
HMUG L4273/2	7.8	5.0
UR 13595	4.6	3.3







Text-fig.43.

	Length of brachial muscle field	Width of brachial muscle field
BC B153	5.8	5.8
BC B154	7.4	7.9
BM B5709	5.8	5.5
HMUG L4273/2	6.3	7.1
HMUG L5321/6	6.6	6.7
UR 13595	4.8	5.0

Remarks. — The neotype (Bond, 1941, p.293) and other material are generally well preserved.

There is an increase in dorsibiconvexity, inflation of the brachial umbo, and height of anterior plication with age.

Youthful specimens are biconvex or ventribiconvex, the umbones level, and the anterior commissure rectimarginate.

The shape of the anterior commissure varies from rectimarginate in the neanic stage to uniplicate, biplicate or sulciplicate in the ephebic stages. Phillips' original holotype and Bond's neotype (1941, text-fig.35) have a well developed biplication.

Pedicle and brachial sinuses, thickened costellae and spine bases are variably developed.

Concentric growth rugae are characteristically thick on ephebic specimens, and the commissural junction may be thick and ridged (pl.1, fig.8a).

Schizophoria connivens (Phillips) superficially resembles small, rugate forms of S. resupinata (Martin), but is distinguished externally by its more tumid outline, biplicate or quadrate anterior uniplication, higher pedicle interarea and coarser costellae. Internally, the oval pedicle muscle field, stubby brachiophores and short, stout brachiophore plates of S. connivens contrast with the flabellate muscle field, more tapered brachiophores and longer, more slender brachiophore plates of S. resupinata.

Schizophoria connivens superficially resembles older, rugate specimens of S. woodi Bond from Treak Cliff, in size, outline and prominent growth rugae. But S. connivens has coarse costellae, and a biplication or quadrate uniplication, in contrast to the finer costellae and an angular uniplication of S. woodi. Additional specimens of S. woodi from Craven and the Isle of Man are also distinguished by their larger size.

Comparisons with other species are given on text-figure 69.

Although S. connivens is a long ranging species, there is apparently little internal variation between the C2 or C2 S1

and Pla subzones (text-fig.46). From its preservation, specimen BM B25423/24764, although localised as Carboniferous Limestone, Lancashire, was probably collected from C2 reef knolls of Bolland, or C2 S1 reef knolls of Clitheroe. Specimen TCD 3595 was collected from the D1 subzone County Meath, and specimen HMUG L5346/5 was collected from the Upper Carboniferous Limestone, Poolvash, Isle of Man, which spans the Pla subzone.

Specimens closely resembling S. connivens from the K2 to Pla subzones of the Dinantian have been examined at higher horizons, from Corrie Burn (P2), and Gair (E2), in the Scottish Carboniferous sequence. Scottish forms, like those lower in the Dinantian, are small, dorsibiconvex, quadrate to rectangular in outline, with a quadrate-uniplicate or biplicate anterior commissure, and a coarsely costellate and rugate shell. Internal similarities are shown on text-figures 44 and 45. The ventrally divergent dental lamellae, stubby brachiophores and short, stout, divergent brachiophore plates are common to both forms, but there are small differences in muscle field outlines. Forms from Scotland have a more flabellate pedicle muscle field and broader, more rounded median septum (text-fig.45, sections 0.9-6.5, a). In the brachial valve, the anterior boundary of the muscle field is more defined, and the adductor muscle field divided by a broader, rounded median septum, which narrows anteriorly (text-fig.45, sections 1.1-4.3, b).

These specimens from Scotland appear to represent a trend in variation towards the form of Schizophoria hudsoni George of the Namurian. The Corrie Burn Limestone (P2) is highest Dinantian, and the Gair Limestone (E2) is lower Namurian in age, while S. hudsoni, collected from the Cayton Gill Beds (R1), is higher in the Namurian succession.

Similarities between S. connivens and S. hudsoni are discussed under the latter species.

Finer preservation of Corrie Burn specimens enabled determination of some additional structures. Two parallel pallial sinus trunks originate from the ends of the pedicle diductor muscle field, and slight genital markings are developed laterally (text-fig.45a). The pedicle median septum is bifid anteriorly, probably indicating division of the adductor muscles at the point of attachment (text-fig.45, section 6.5). Brachial genital markings developed laterally (text-fig.45b).

The following authors have listed or described S. connivens, but have not given illustrations:

Orthis connivens (Phillips), M'Coy, 1844, p.123.
Orthis konincki, d'Orb., 1850, no.726, p.146.
Orthis connivens Phill., Etheridge, 1888, p.257.

Material. —

Belgium

IRIG 2737 — Viséan, Visé.

Derbyshire

BC B137,138 — D1 reef limestones, Dielasma bed, north end, near summit, Treak Cliff, near Castleton.

BM B34460 — Carboniferous Limestone, Longnor.

GSM 34243, 34247, 84682, 84686 — Carboniferous Limestone, Park Hill, Longnor.

Isle of Man

HMUG L5346/1,2,5 (plaster cast) — Carboniferous Limestone, Poolvash.

Ireland

BM B13184 — Lower Carboniferous, Millicent, Kildare.

UR 13593, 13595 (internal mould) — Waulsortian phase reef limestones, C1-2 subzones, quarry 1/3 mile north-west Greeves, Foynes Road, Ballylin, County Limerick.

TCD 3593-8 (3595 - plaster cast) — Lower Carboniferous, Viséan, County Meath.

Lancashire

SM E6502, 6505, 6506 — Carboniferous Limestone, Clitheroe.

Scotland

HMUG L131/2,3; L4272/2,3; L5343/1 — Carboniferous Limestone, Corrie Burn, Campsie.

HMUG L127; L129/1,2 (partial internal mould), 3,4 (fragmentary shell), 5 (partial internal mould), 6; L130/1,5 — Carboniferous Calmy Limestone, Gair, Carluke.

HMUG L4273/2 (internal mould), 3 — Carboniferous Limestone, Lesmahagow.

Staffordshire

GSM 84678 — Carboniferous Limestone, Narrowdale.

Yorkshire

Neotype BM B387 — Lower Carboniferous, Bolland.

BC B139-156 (152 - partial internal mould, 153,154 - internal moulds, 155,156 - deformed shells) — Elbolton Limestone Series, Tufa Beds, Middle D1 subzone, south-west flank Elbolton Knoll, Cracoe.

BC B157 — Elbolton Limestone Series, Tufa/*Cyrtina septosa* Beds, Middle D1 subzone, same locality.

BC B158-161 — Elbolton Limestone Series, Tufa Beds, Middle D1 subzone, south-east flank Stebden Knoll, Cracoe.

IC 11130-11133 — Carboniferous Limestone, Swinden, near Grassington.

BC B162,163 — S2 reef limestones, right bank Stockdale Beck above Force, Scaleber Bridge, near Settle.

BM B5709 (internal mould) — Lower Carboniferous, Settle.

Specimens are preserved as entire shells, except where otherwise indicated.

TEXT-FIG. 44 — Schizophoria connivens (Phillips)

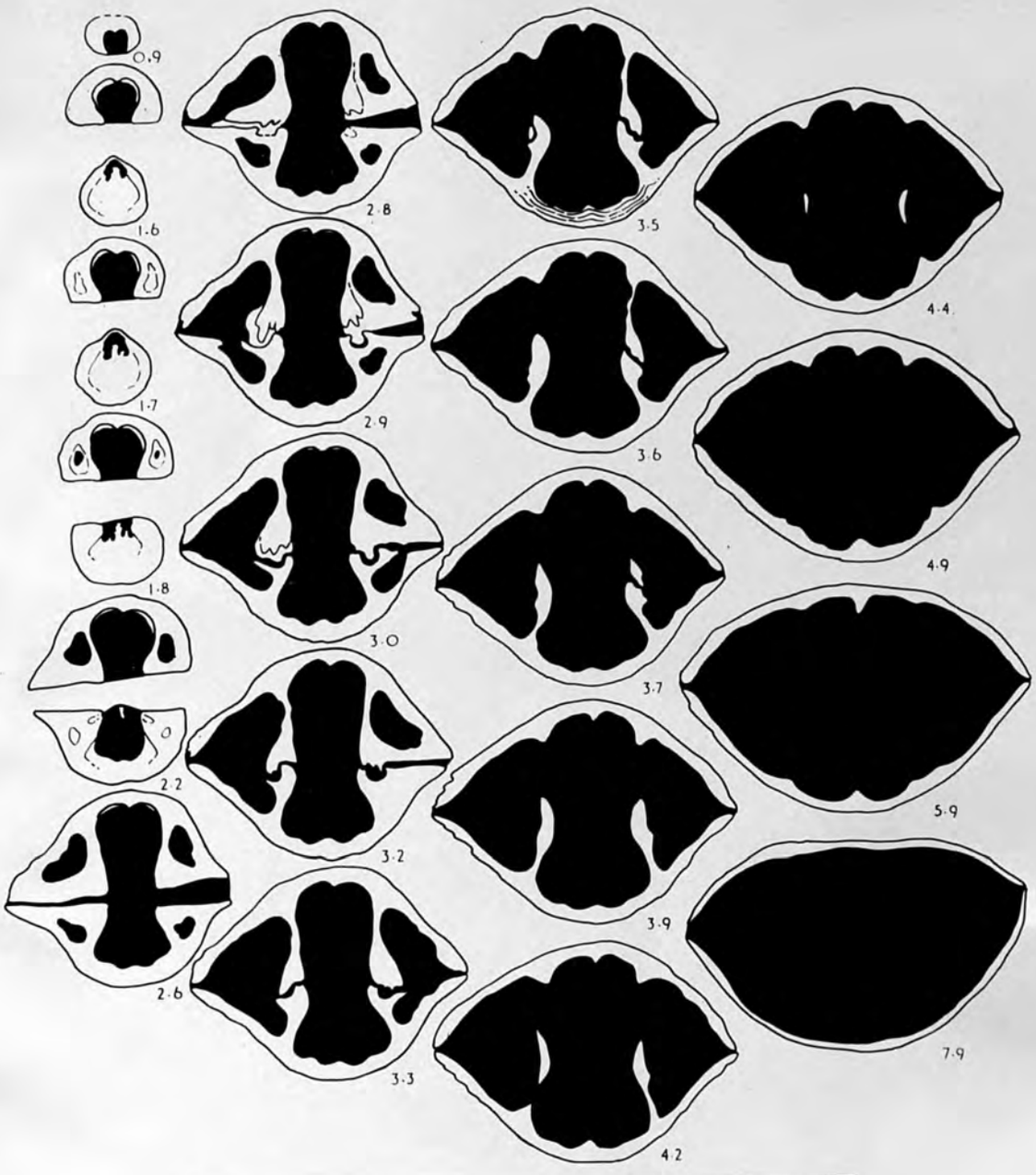
Measurements of sectioned specimen in millimetres

Length	Width	Depth
13.7	16.7	11.5

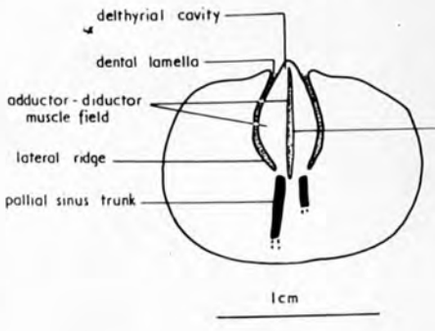
Numbers below serial sections indicate distances in millimetres measured anteriorly from pedicle umbo. Sections x 3.

IC specimen — Carboniferous Limestone, Swinden, Yorkshire.

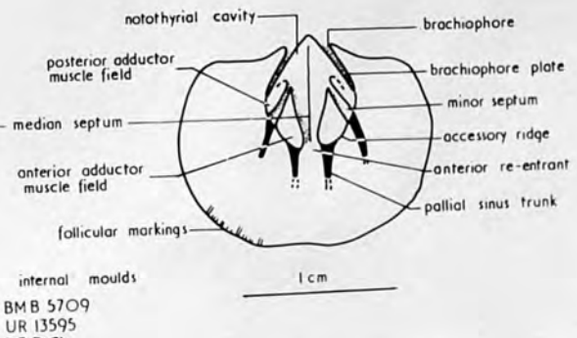
a — Pedicle muscle field, x 2.
b — Brachial muscle field, x 2.



a PEDICLE MUSCLE FIELD



b BRACHIAL MUSCLE FIELD



internal moulds
BMB 5709
UR 13595
BC B154

Text-fig. 44

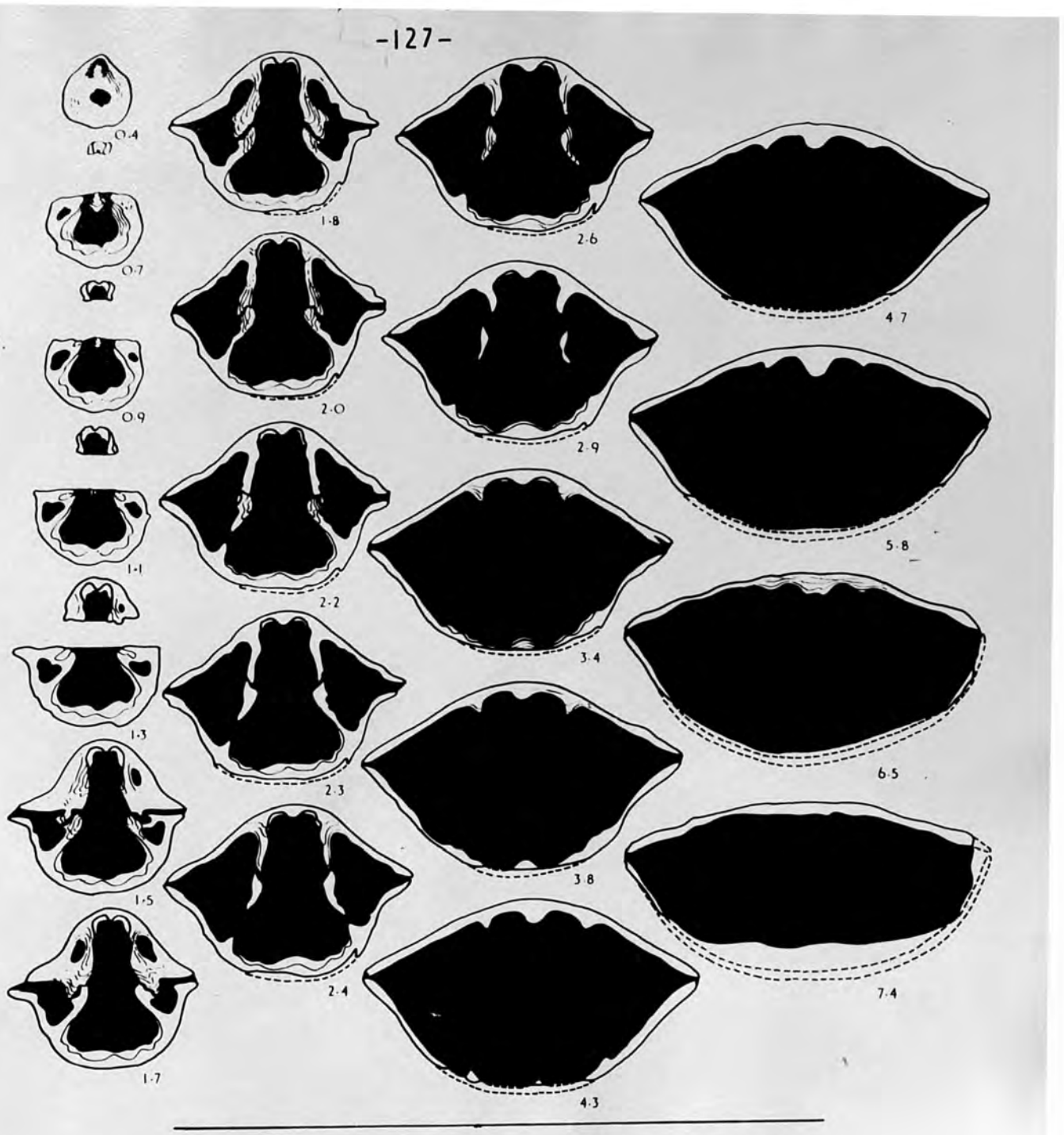
TEXT-FIG. 45 — Schizophoria connivens (Phillips)

Measurements of sectioned specimen in millimetres

Length	Width	Depth
-	18.6	9.4

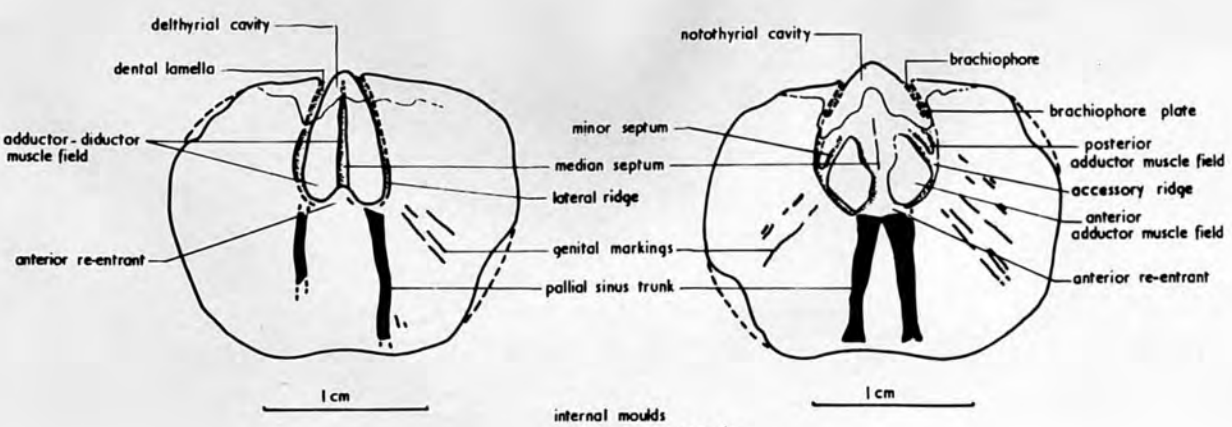
Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 3. HMUG L4258/1, Carboniferous Hurlet Limestone, Lesmahagow.

a — Pedicle muscle field, x 2.
b — Brachial muscle field, x 2.



a PEDICLE MUSCLE FIELD

b BRACHIAL MUSCLE FIELD



internal moulds

HMUG L4273/2

Text-fig. 45

TEXT-FIG. 46 — Schizophoria connivens (Phillips)

Measurements of sectioned specimens in millimetres

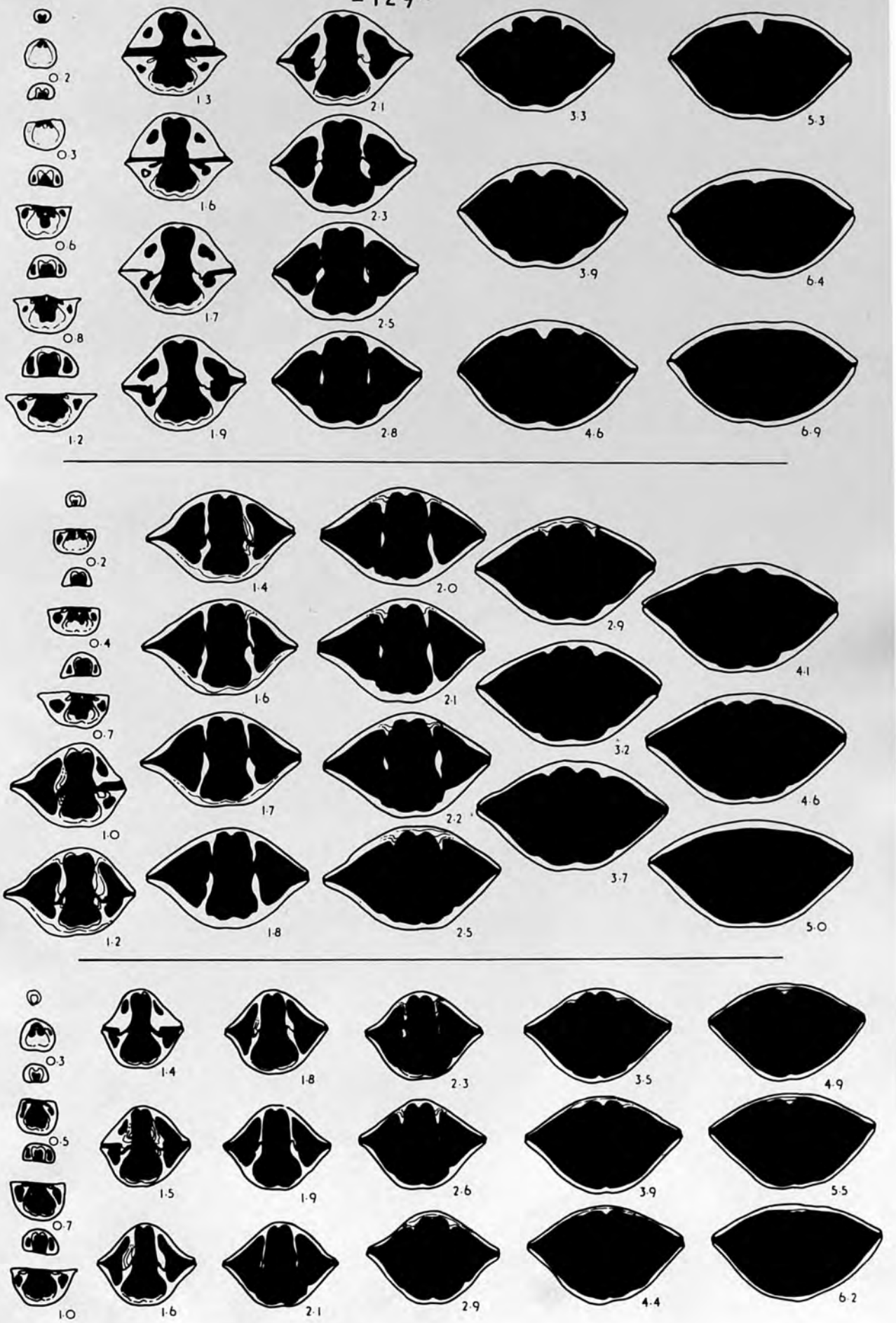
	Length	Width	Depth
A	13.0	15.8	9.1
B	12.3	14.3	7.8
C	12.4	14.8	8.4

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbones.

A — BM B25423/24764 — Carboniferous Limestone, Lancashire. Sections x 1½.

B — TCD 3595 — Lower Carboniferous, Viséan, County Meath. Sections x 2.

C — HMUG L5346/5 — Upper Carboniferous Limestone, Poolvash, Isle of Man. Sections x 2.


0·2
0·3
0·6
0·8
1·2
1·3
1·6
1·7
1·9
2·1
2·3
2·5
2·8
3·3
3·9
4·6
5·3
6·4
6·9
0·2
0·4
0·7
1·0
1·2
1·4
1·6
1·7
1·8
2·0
2·1
2·2
2·5
2·9
3·2
3·7
4·1
4·6
5·0
0·3
0·5
0·7
1·0
1·4
1·5
1·6
1·8
1·9
2·1
2·3
2·6
2·9
3·5
3·9
4·4
4·9
5·5
6·2

Text-fig. 46

Schizophoria gibbera (Portlock)

Pl.2, figs.1-5; text-figs.47-50.

Atrypa (Porambonites) gibbera, Portlock, 1843, p.460, pl.38, fig.1.

Orthis gibbera. Portk. Sp., M'Coy, 1844, p.124, pl.18, fig.9.

Orthis resupinata var. gibbera (Portlock), Davidson, 1858-63, p.130, pl.29, fig.5.

Schizophoria resupinata var. gibbera (Portlock), Demanet, 1934, p.55, pl.4, fig.4, non.1-3.

Schizophoria gibbera (Portlock), Bond, 1941, p.295, pl.22, figs.A-D, H.

non. Schizophoria resupinata var. gibbera (Portlock), Demanet, 1921, p.121, pl.5, fig.2.

Holotype. — The holotype illustrated by Portlock (1843, pl.38, fig.1) is in the Geological Survey Museum, GSM 70646.

Diagnosis. — Shell medium to large, strongly dorsibiconvex, elliptical to rounded, deeper than long, with rounded uniplicate anterior commissure. Pedicle valve convex, unbroken by sinus; brachial valve with concentric fold. Shell finely costellate with scattered thickened costellae. Pedicle muscle field very narrow, parallel-sided, strongly incised, longitudinally divided by median septum continuing beyond anterior boundary. Brachial muscle field rectangular to elliptical, strongly incised, bounded posteriorly by long, slender, curved brachiophore plates supporting stubby brachiophores. Adductor muscle field tapered posteriorly, longitudinally divided by broad median septum.

Description. — Shell medium to large, strongly dorsibiconvex, gibbous, elliptical to rounded in outline, wider and

deeper than long, with greatest width near midlength. Pedicle valve very convex, evenly convex longitudinally, flattening laterally; weak concentric fold developed anteriorly, decreasing postero-laterally; valve unbroken by sinus. Brachial valve more convex, most convex below umbo, at point of concentric fold, with abrupt anterior and lateral slopes. Brachial fold concentric, developed posteriorly, disappearing postero-laterally. Beaks broad, pointed; brachial beak more incurved; umbonal slopes steeper. Brachial umbo projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea prominent, very high, curved to beak, with horizontal growth lines. Brachial interarea lower, one half to one third height of pedicle interarea, curved to beak. Delthyrium and notothyrium open. Low, flat-topped brachial fold occasionally developed adjacent to anterior commissure. Anterior commissure uniplicate, due mainly to high, broad, rounded, dorsal, linguiform extension of pedicle valve. Lateral commissure forming lip postero-laterally. Shell costellate, rugate, punctate. Radial costellae fine, rounded, separated by narrower, more angular striae, 6 to 7 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation. Scattered costellae thickened, 1/10mm. in width, irregularly spaced, 6 to 15 normal costellae apart, extending for a part of the length, or the whole length, of the valves. Growth rugae concentric, more prominent anteriorly. Puncta evenly distributed in innermost shell layers; distributed along costellae in higher shell layers.

Teeth prominent, compound, supported by anteriorly parallel ventrally convergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.47, sections 6.7-8.4).

Pedicle muscle field (text-fig.48a) approximately one half valve length, narrow, approximately one tenth valve width,

parallel sided, incised, bounded posteriorly by thick dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, uniting anteriorly with median septum. Median septum originating near point of delthyrial cavity, narrow, rounded, increasing in height, and broadening slightly anteriorly; becoming club-shaped anteriorly, and continuing for short distance anterior of muscle field (text-fig.47, sections 8.4-22.6; text-fig.48a). No evidence of pedicle muscle scars. Pallial sinus pattern consisting of two divergent trunks originating from anterior end of median septum. Genital markings developed postero-laterally (text-fig.48a).

Myophore small, compound, with central ridge, bordered by two shorter, narrower ridges, one either side (text-fig.47, sections 4.6-6.7), all serrated. Shell filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.47, sections 2.6-6.4). Stubby brachiophores curved postero-laterally, and fused to slender, long, curved brachiophore plates bounding notothyrial cavity (text-fig.47, sections 2.2-5.9). Dental sockets deep, oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates (text-fig.47, sections 6.4-8.4). Sockets bounded internally by smaller, shallower accessory sockets, and externally by long, narrow, deep accessory cavities (text-fig. 47, sections 8.3, 2.6-7.1). Outer margin of accessory cavities serrated in transverse section, representing genital markings (text-fig.47, sections 4.6-5.6).

Brachial muscle field (text-fig.48b) strongly incised, rectangular to elliptical, longer than wide, one half to two-thirds valve length, bounded posteriorly by ends of brachiophore plates, laterally by strong accessory ridges. Ridges decreasing in height anteriorly; anterior boundary ill-defined. Median septum originating at base of notothyrial cavity, broad, angular,

first broadening, then becoming narrower, and decreasing in height, and becoming subrounded anteriorly. Low, discontinuous, angular ridge surmounting broad septum (text-fig.47, sections 2.6-9.4; text-fig.48b). Pallial sinus pattern not evident. Genital markings developed postero-laterally (text-fig.47, sections 4.6-5.9; text-fig.48b).

Dimensions of available material in millimetres: —

	Length	Width	Depth	Length of hingeline
Holotype GSM 70646	31.1	34.6	31.2	—
BC B164(aff. gibbera)	26.6	29.3	26.8	—
BM BB7350	29.0	35.6	33.9	25.2
BM BB7351	25.0	27.9	25.0	—
GSM 5758	24.0	26.3	25.6	18.2
GSI 21/4	24.4	30.5	26.0	23.9
GSI 21/4	26.7	31.8	26.2	22.3
GSI 21/4	29.4	37.7	29.3	—
SME 6577	27.5	31.8	31.0	—
TCD 1265	23.2	31.8	27.5	20.3

— uniplicate anterior commissure —

Dimensions of available muscle fields:

	Length of pedicle muscle field	Width of pedicle muscle field
GSM 5758	13.0	2.8

	Length of brachial muscle field	Width of brachial muscle field
BC B165(aff. gibbera)	16.4	11.6
TCD 1270	13.8	11.3

Remarks. — The holotype and other material are well preserved.

Schizophoria gibbera (Portlock) is the most convex and gibbous species in the Carboniferous. Specimens are deeper than long, and almost as deep as wide.

Dorsibiconvexity, inflation of the brachial umbo and height of the anterior plication increase with age. A youthful

specimen is less dorsibiconvex, the brachial umbo only projecting a short distance, and the anterior plication is low.

Spine bases at the anterior ends of thickened costellae are not evident.

Schizophoria gibbera only superficially resembles adult specimens of S. linguata (Quenstedt) in outline and costellation. Both species are strongly convex, gibbous, have concentric folds on the valves, a rounded uniplication, and are finely costellate with scattered thickened costellae. But specific differences in size and outline are shown on text-figure 49. Internally, the two species are superficially similar. Both have a narrow, parallel-sided pedicle muscle field with a median septum continuing beyond the anterior boundary, and a pair of anteriorly divergent pallial sinus trunks. But S. gibbera has a wider muscle field in proportion to valve width, but is shorter, one half of valve length, and the median septum and diductor muscle field are similar in width. The pedicle muscle field of S. linguata is one half to two-thirds of valve length, with a median septum broadening anteriorly, and becoming wider than the diductor muscle field (text-fig.49). The parallel lateral ridges of S. gibbera are attached to the valve floor, in contrast to the curved ridges of S. linguata, which are attached to the median septum ventrally. The dental lamellae of S. gibbera are thicker. In the brachial valve, both species have a rectangular to elliptical shaped muscle field, bounded posteriorly by long, slender, curved brachiophore plates. But S. gibbera has a more strongly incised muscle field, with prominent accessory ridges continuous with the brachiophore plates, and a strong median septum. The moderately incised muscle field of S. linguata is bounded by lower accessory ridges separated from the brachiophore plates, and a lower, platform-like median septum (text-fig.49).

Specimens from C2 S1 limestones of Bellman Quarry Clitheroe apparently have features in common with both S. gibbera

and S. linguata. The large size, and the form of the pedicle muscle fields resemble S. gibbera, but the quadrate to rectangular outline, more angular pedicle fold, slight pedicle sinus, and moderately incised brachial muscle field are reminiscent of S. linguata (text-fig.50). These specimens have been included under S. aff. gibbera. Since abundant material of S. gibbera is lacking, the complete range of variation within the species is unknown. If more material was available, it is possible that these specimens listed as S. aff. gibbera would fall within the range of species variation.

Schizophoria gibbera also superficially resembles adult forms of S. woodi Bond. Demanet (1934, pl.5, fig.1-3) figured S. woodi under S. gibbera. Both species are dorsibiconvex, gibbous, and finely costellate, but S. gibbera is more convex, and has a more inflated brachial umbo. Schizophoria gibbera is more rounded in outline, and wider than long, while S. woodi may also be as long as wide or longer than wide. Other characters show distinct differences. Schizophoria gibbera has a fold on both valves, no pedicle sinus, and a deep, broad, rounded anterior plication, in contrast to the generally smoother valve profiles or brachial fold, angular sinus, and subangular uniplication of S. woodi.

The specimen illustrated by Demanet as S. gibbera (1921, pl.5, fig.2) probably belongs to S. connivens (Phillips).

Bond questionably listed a specimen of Schizophoria swallovi (Hall), described by Weller (1910, p.296, pl.12, figs. 6, 7), under S. gibbera. This specimen is an inflated form of S. resupinata (Martin), hereby listed under S. resupinata var. pinguis (Demanet).

Etheridge, 1888, p.257, listed the species under Orthis gibbera Portl.

Material. —

Ireland

TCD 1265 (partial internal mould), 1270 (fragmentary brachial internal mould) — Waulsortian reef facies, C1-2 zones, Ballybeg Quarry, Buttevant, County Cork.

GSM 5758 (partial internal mould) — Carboniferous Limestone, Little Island, Cork.

SM E6577 (fragmentary shell) — Upper Carboniferous Limestone, Cornacarrow.

GSI 21/4 (including plaster cast) — Carboniferous Limestone, Limerick.

Holotype GSM 70646 — Carboniferous Limestone, Tyrone.

Lancashire

BM BB7350, 7351 — Lower Carboniferous, Bolland.

BC B164(aff. gibbera), (plaster cast), 165 (brachial internal mould) — Worston Shale Group, C2 S1 reef limestone, Bellman Quarry, Clitheroe.

Specimens are preserved as entire shells, except where otherwise indicated.

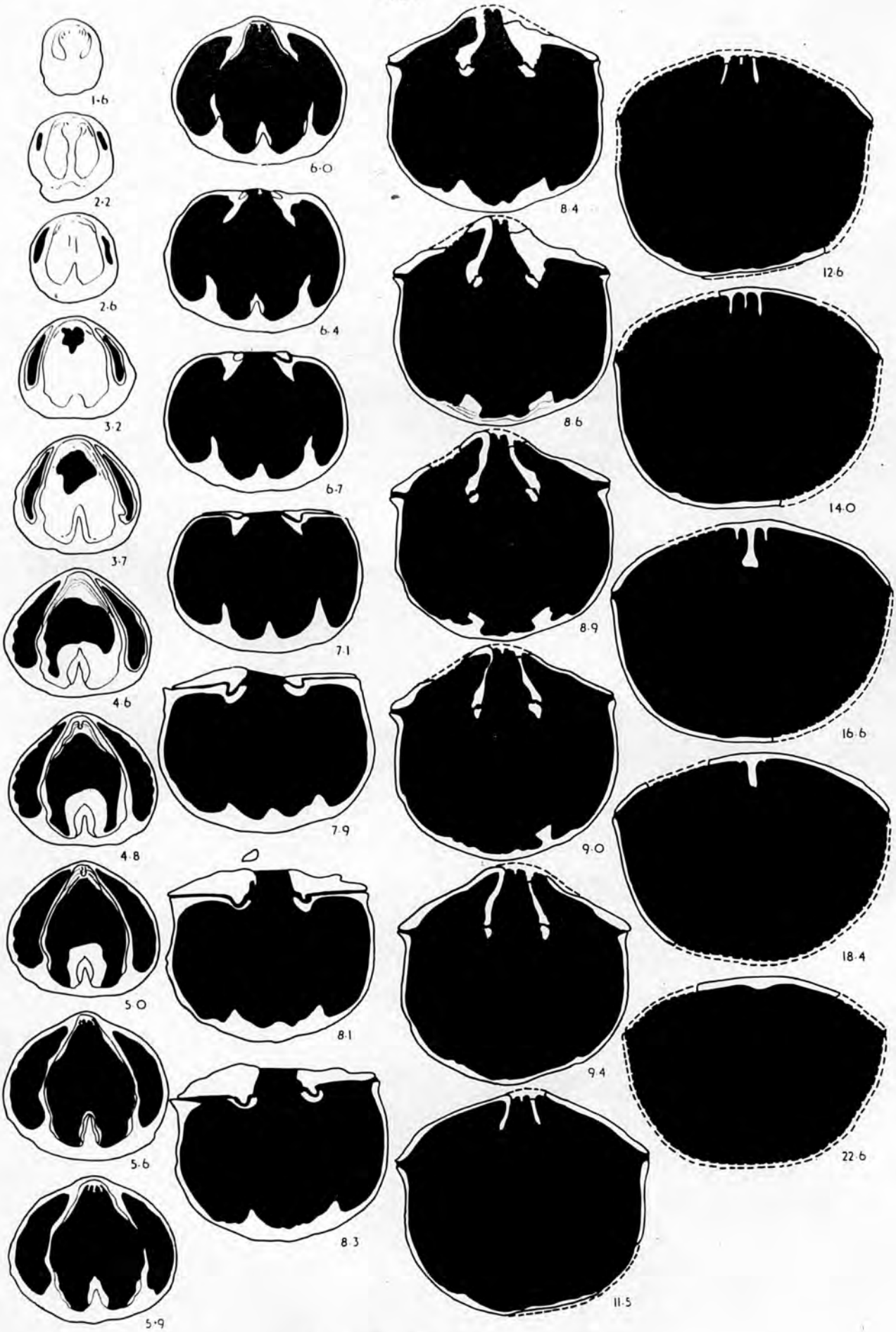
TEXT-FIG. 47 — Schizophoria gibbera (Portlock)

Measurements of sectioned specimen in millimetres

Length	Width	Depth
26.7	31.8	26.2

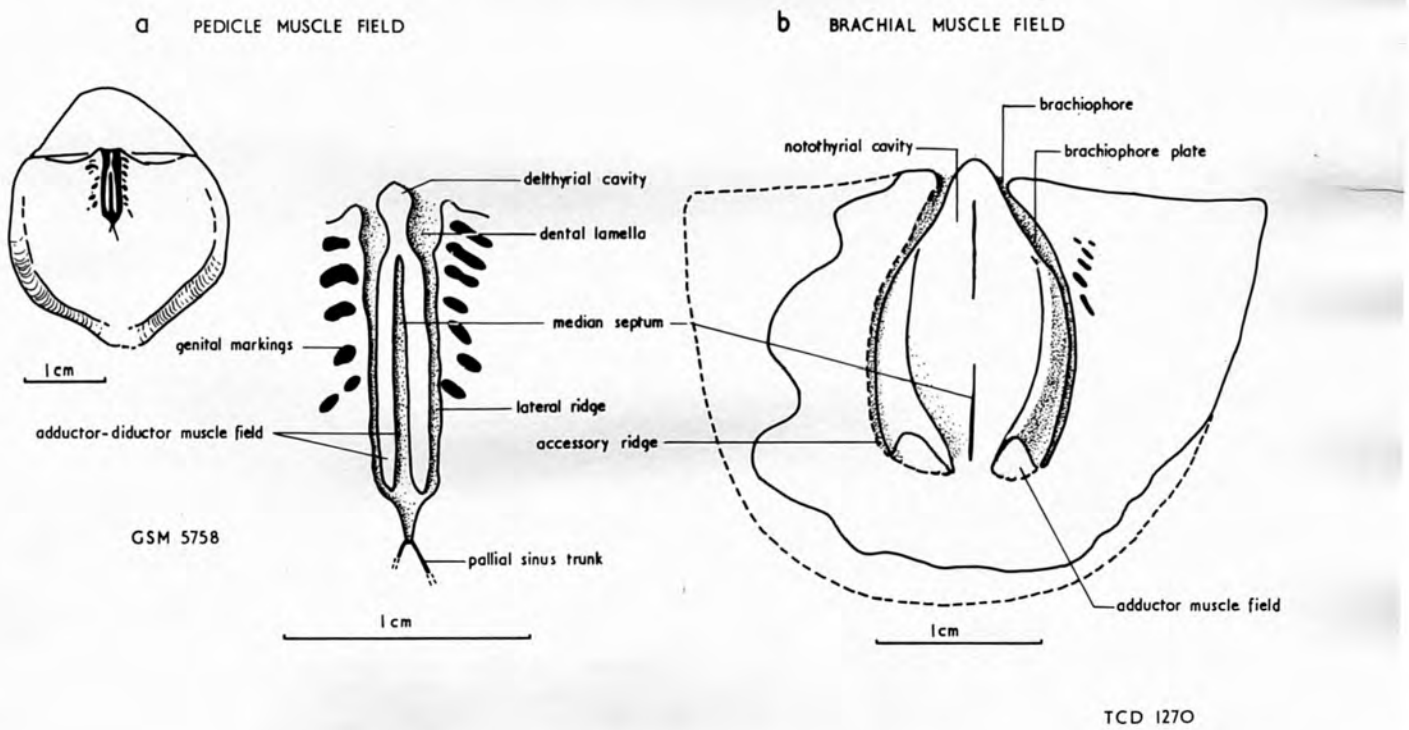
Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 1½. GSI 21/4, Carboniferous Limestone, Limerick.

(the great inflation of the brachial umbo results in the sectioning of brachial structures before pedicle structures)


1·6
2·2
2·6
3·2
3·7
4·6
4·8
5·0
5·6
5·9
6·0
6·4
6·7
7·1
7·9
8·1
8·3
8·4
8·6
8·9
9·0
9·4
11·5
12·6
14·0
16·6
18·4
22·6

Text-fig. 47

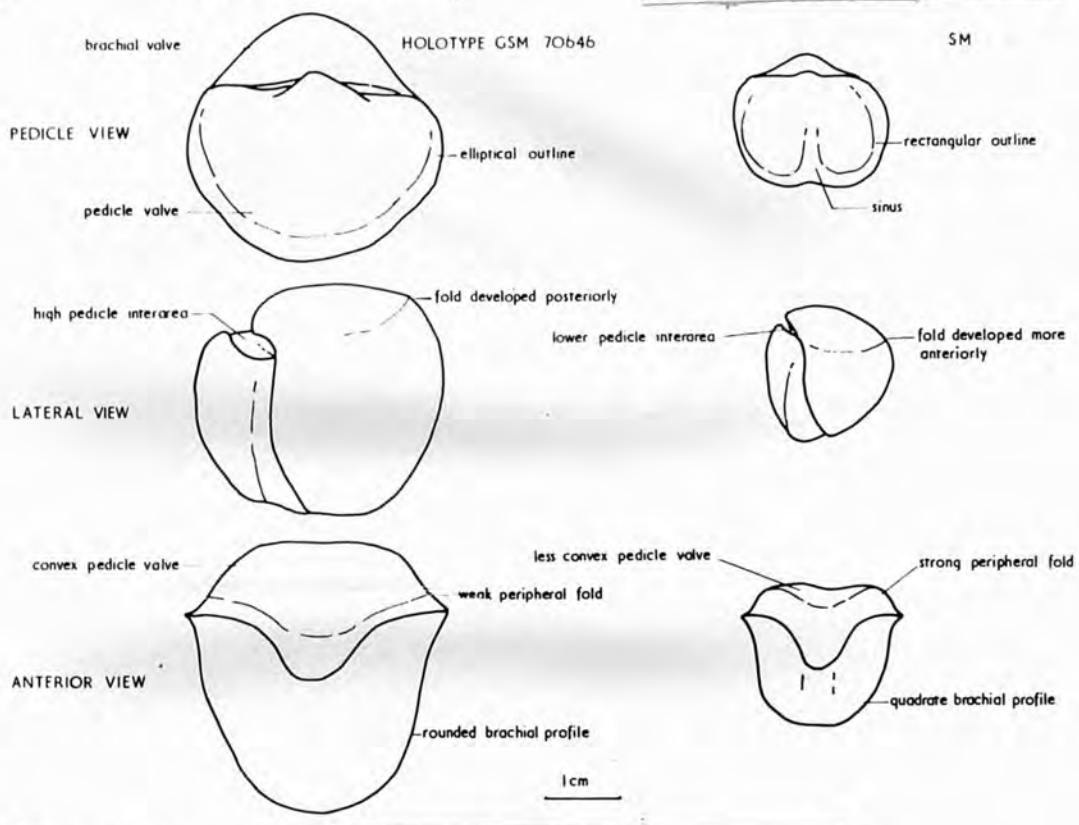
SCHIZOPHORIA GIBBERA (PORTLOCK)



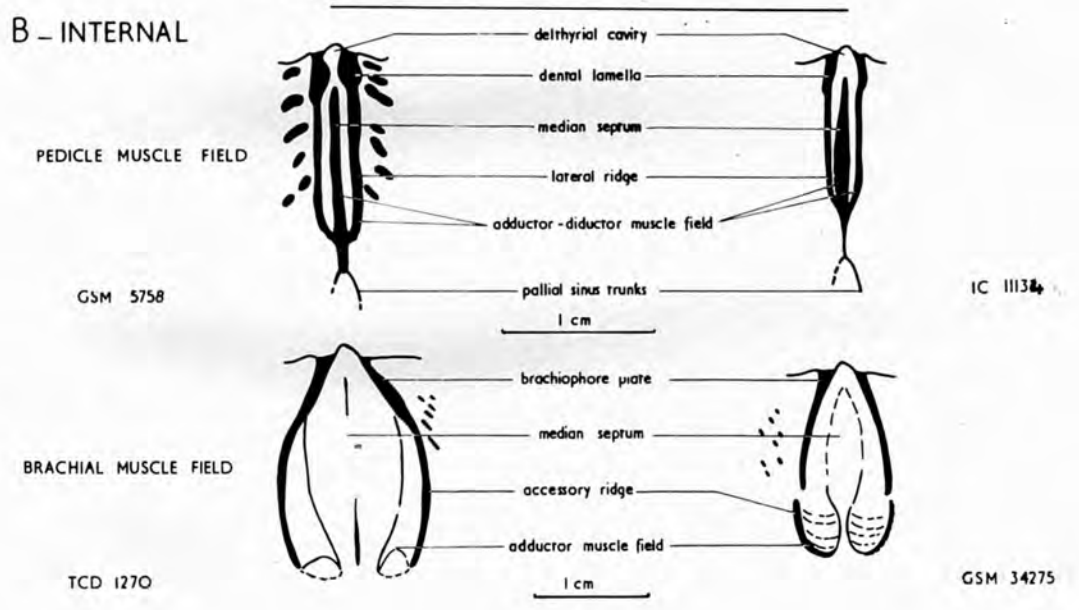
Text-fig. 48

SPECIFIC DIFFERENCES BETWEEN SCHIZOPHORIA GIBBERA (PORTLOCK) AND SCHIZOPHORIA LINGUATA (QUENSTEDT)

A – EXTERNAL



B – INTERNAL



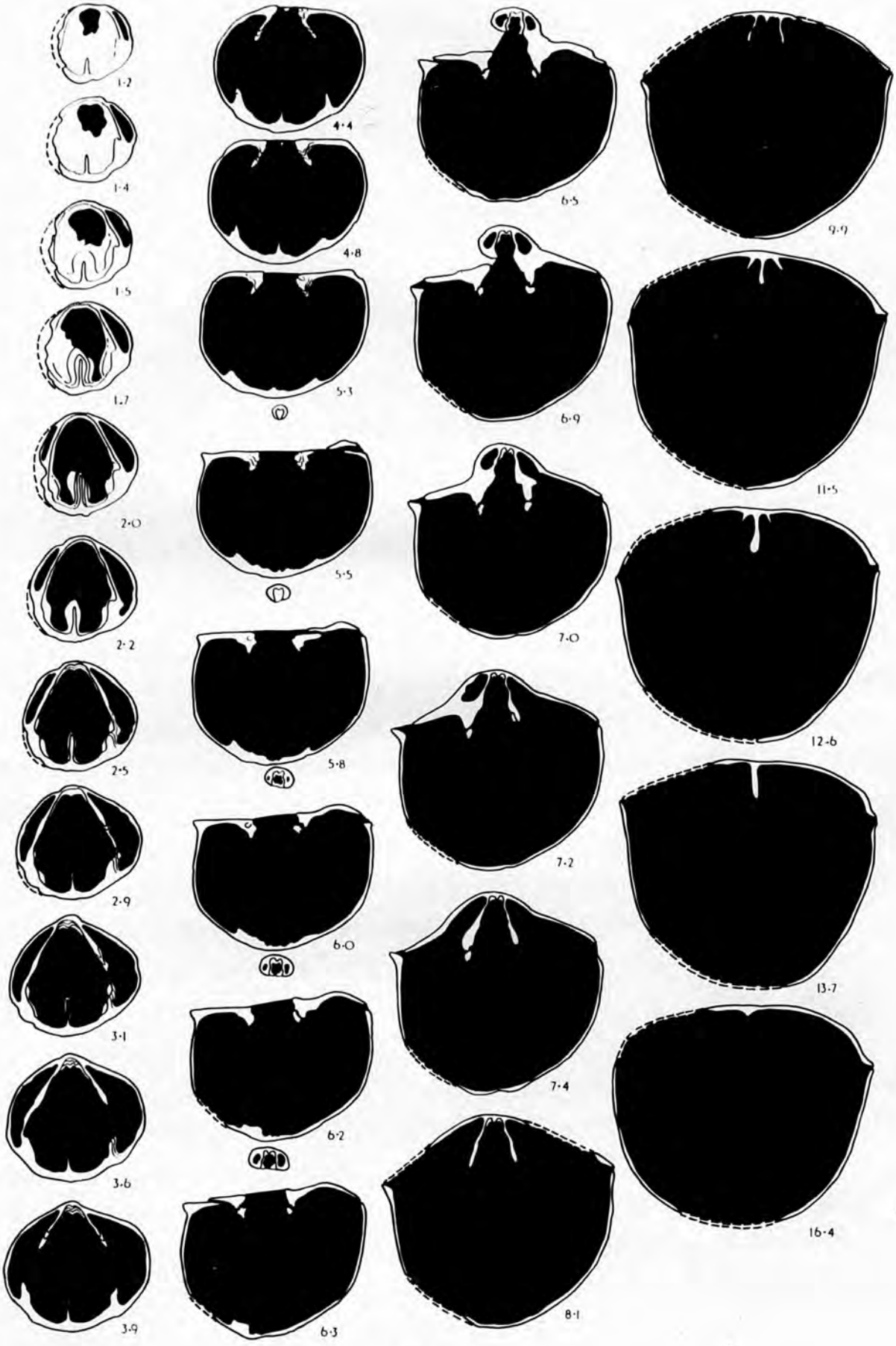
Text-fig. 49

TEXT-FIG. 50 — Schizophoria aff. gibbera (Portlock)

Measurements of sectioned specimen in millimetres

Length	Width	Depth
26.6	29.3	26.8

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 1½.
BC B164 — Worston Shale Group, C2 S1 reef limestone, Bellman Quarry, Clitheroe.


1·2
1·4
1·5
1·7
2·0
2·2
2·5
2·9
3·1
3·6
3·9
4·4
4·8
5·3
5·5
5·8
6·0
6·2
6·3
6·5
6·9
7·0
7·2
7·4
8·1
9·9
11·5
12·6
13·7
16·4

Text-fig. 50

Schizophoria hudsoni George

Pl.2, figs.6-9; text-figs.51-53.

Schizophoria hudsoni George, 1932, p.38, figs.1-4.

Type — The holotype illustrated by George (1932, p.39, fig.1) is in the Geological Survey Museum (London), 49,959.

Diagnosis — Moulds medium to small, quadrate to rectangular, weakly dorsibiconvex, with biplicate or quadrate-uniplicate anterior commissure. External moulds coarsely costellate, rugate. Pedicle muscle field oval to weakly flabellate, strongly incised. Brachial muscle field moderately incised, with pyriform anterior adductor muscle scar with acute apex, and digitate posterior adductor scars. Specimens preserved as internal and external moulds.

Description — Moulds medium to small, weakly dorsibiconvex, quadrate to rectangular in outline, generally wider than long, with greatest width at mid-length. Pedicle valve convex umbonally, flattening anteriorly and laterally. Brachial valve more convex, evenly convex longitudinally, flattening laterally. Convexity sometimes broken by longitudinal median sinus. Details of beaks, interareas and hingeline not evident. Broad, shallow pedicle sinus developed anteriorly. Anterior commissure biplicate or broadly quadrate-uniplicate. External moulds coarsely costellate, rugate.

Pedicle muscle field (text-fig.53a) generally one half to two-thirds valve length, elongate-oval to weakly flabellate, strongly incised, bounded posteriorly by strong dental lamellae, laterally and anteriorly by ridge-like continuations of lamellae. Ridges decreasing in height anteriorly, reflexed to form shallow subangular anterior re-entrant, or uniting with median septum without a re-entrant. Median septum originating near apex of delthyrial cavity, narrow, rounded, first increasing in height

and width, then decreasing, anteriorly. Pallial sinus pattern consisting of two slightly divergent trunks originating from anterior ends of diductor muscle field, with short peripheral channels. Genital markings developed laterally.

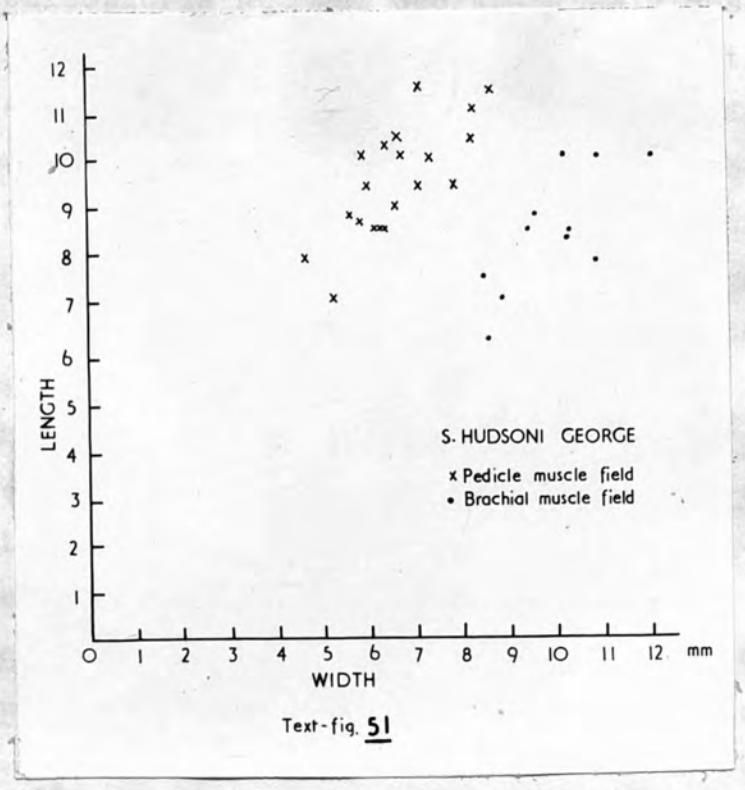
Myophore compound, with central ridge bordered by two lateral ridges, one either side (text-fig.53b).

Brachial muscle field (text-fig.53b) moderately incised, elliptical to rounded, generally wider than long, approximately one third of valve length, bounded posteriorly by ends of strong brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly, smoothly reflexed to form shallow anterior re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, broad, low, subangular, decreasing in height and width anteriorly. Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts. Anterior muscle scar pyriform, with acute posterior apex; posterior muscle scar digitate, with longer outer lobe (text-fig.53b). Pallial sinus pattern consisting of four divergent trunks, two originating from anterior adductor muscle scars, two originating from ends or near ends of minor septa. Slight genital markings developed laterally. Follicular markings, consisting of long follicles separated by shorter follicles, developed peripherally on internal moulds (text-fig.53b).

Dimensions of available internal moulds in millimetres. —

	Length	Width	Depth
BM B34252	22.1	24.6	13.7
BM B34252	20.9	23.6	12.0
BM B34252	19.5	24.0	12.5
BM B34252	19.8	24.6	12.9
BM B34252	18.8	23.6	10.4

Dimensions of available muscle fields from the above internal moulds, together with other muscle fields are plotted on text-figure 51.

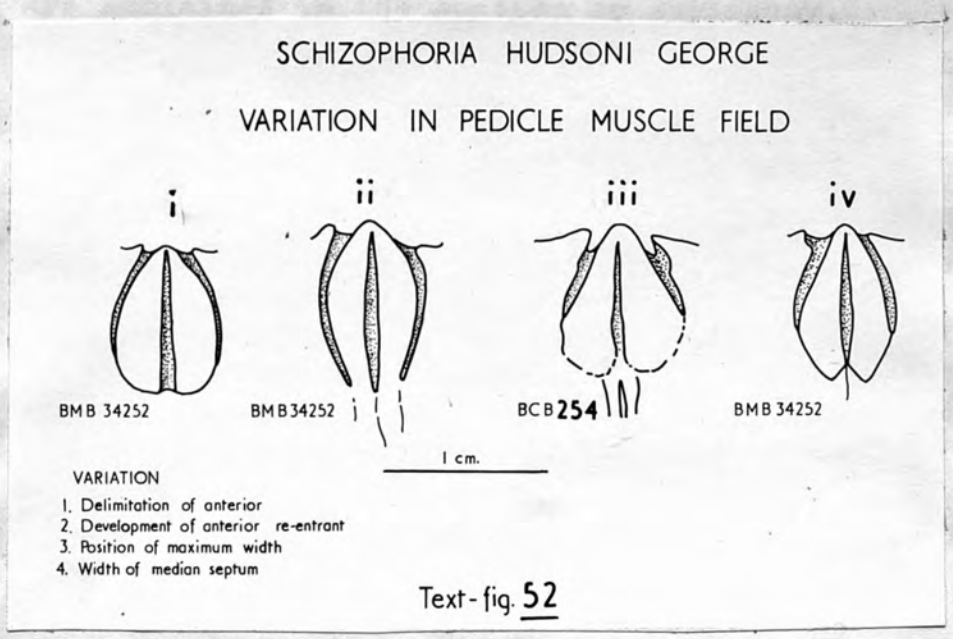


Text-fig. 51

Remarks. — All the specimens are preserved as entire or fragmentary moulds.

Pedicle and brachial peripheral folds are occasionally developed (George, 1932, p.39, fig.4).

Variation in the form of the pedicle muscle field is shown in text-figure 52.



Text-fig. 52

Schizophoria hudsoni George closely resembles S. connivens (Phillips) in quadrate to rectangular outline, quadrate-uniplicate or biplicate anterior commissure and coarsely costellate and rugate shell. But S. hudsoni is generally slightly larger. Internally, the muscle fields of the two species are similar, although the pedicle muscle field shows greater variation in S. hudsoni. Follicular markings, although variably developed, are similar in both species.

Thus Schizophoria hudsoni and S. connivens are obviously closely related, S. hudsoni replacing S. connivens of the Dinantian and Lower Namurian, higher in the Namurian (see Phylogeny).

George (1932, p.42) himself compared S. hudsoni with S. connivens, but stated that the plicated anterior commissure of S. connivens is not so markedly developed, and S. hudsoni is larger in size. It has been decided to follow George and consider S. hudsoni as a distinct species from S. connivens. Although closely similar, S. hudsoni can be distinguished from S. connivens, and is also stratigraphically distinct.

Some forms of the pedicle muscle field of S. hudsoni resemble that of S. resupinata (Martin) (text-fig.52(iii)) in flabellation and narrow septum. These resemblances to S. resupinata are explained in the section on phylogeny.

Comparisons with other species are shown on text-figure 69.

Material. —

Yorkshire

BC B255-278 (moulds), (253, 255-262 pedicle internal moulds in various states of preservation, 254, 263-267, 276-278 blocks of moulds, 268-275 brachial internal moulds in various states of preservation) — Millstone Grit, Cayton Gill Beds, R1, Fewston Bents Quarry, NE Fewston Bents, near Harrogate.

BM B34252 (three internal moulds, two pedicle internal moulds) — Millstone Grit, Cayton Gill Series, Cayton Gill, Markington.

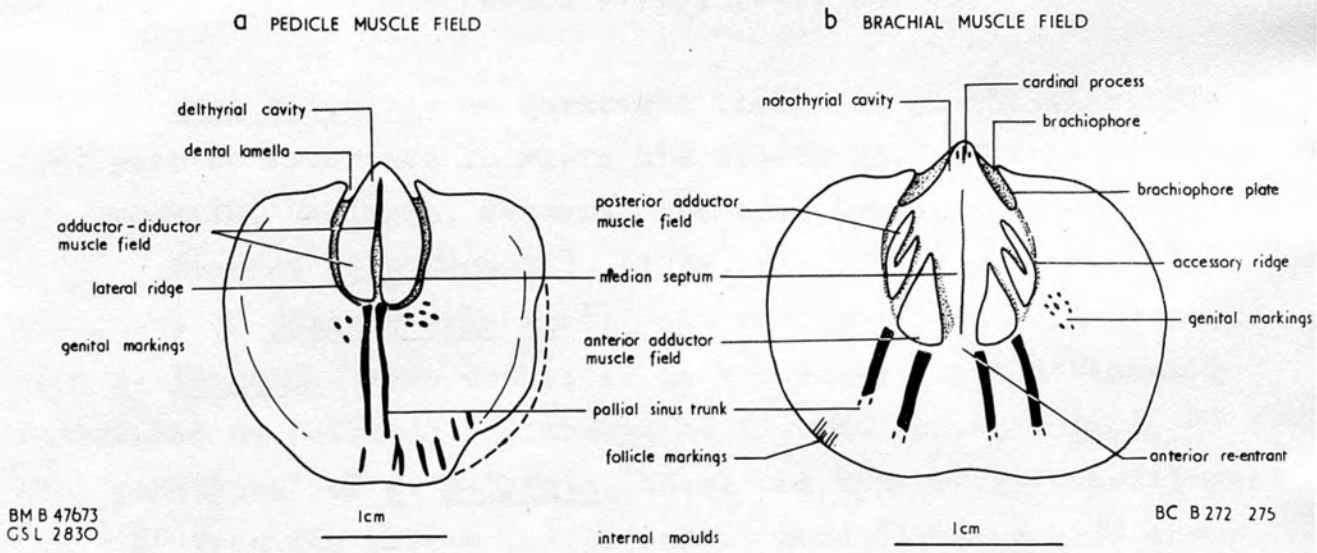
BM B47673 (pedicle internal mould) — Millstone Grit, near Pateley Bridge.

BM B54126, 7 (pedicle internal moulds) — Millstone Grit, Oswestry race course.

GS L2914 (two pedicle internal moulds), 2915 (three pedicle internal moulds, one brachial internal mould), 2829, 2830 (pedicle internal moulds) — Millstone Grit, Cayton Gill shell bed, 570 yards W.35 S. of Turpin hair, near Darley.

Text-fig. 53

SCHIZOPHORIA HUDSONI GEORGE



Text-fig. 53

Schizophoria linguata (Quenstedt)

Pl.2, figs.10-13, pl.3, figs.1-3; text-figs.54-58.

Orthis linguata, Quenstedt, 1868-71, p.565, pl.55, figs.152-154.

Schizophoria resupinata var. palliata nov. var., Demanet, 1934, p.58, pl.4, figs.7, 8.

Schizophoria palliata Demanet, Bond, 1941, p.297, pl.22, fig.E; fig.36.

? non. Orthis (Schizophoria) linguata Quenstedt, Paeckelmann, 1930, p.175, pl.9, fig.15.

Type material. — Quenstedt (1868-71, pl.55, figs.152-154) gave no reference to where his specimens, collected from the Bergkalk, Ratingen, Germany, had been deposited.

Demanet (see Remarks), (1934, p.6) stated that his specimens of Schizophoria resupinata var. palliata (synonymous with S. linguata) were deposited in the Musee royal d'Histoire naturelles de Belgique. Although he figured (pl.4, figs.7, 8) two 'paratypes' of S. palliata, these are apparently uncatalogued and lost from the museum collections. Bond (1941, p.297) chose one of Demanet's specimens (pl.4, fig.7), (reproduced here on text-fig.55), as holotype, although he makes no mention of its being available for examination. This was perhaps a poor choice, since the specimen is a single, youthful pedicle valve. Demanet's other 'paratype' (pl.4, fig.8) is a more complete shell.

Quenstedt's apparently lost type was an entire ephebic/gerontic shell, illustrating the characteristic dorsibiconvexity of the species.

If Quenstedt's or Demanet's type material still cannot be found, a neotype will be selected in due course.

The most suitable choice from Belgium material, to which this study was confined on the continent, would be specimen IG 3200, from the Institut royal des Sciences naturelles de

Belgique. This is an entire shell, and was collected from the Tournaisian, Tn 3bR, at Dréhance, Dinant, from a similar stratigraphical horizon to Demanet's 'paratypes'. However, specimen IG 3200 is also relatively youthful, and does not illustrate the characteristic dorsibiconvexity and pedicle and brachial folds of an adult form, as shown by Quenstedt's and Bond's material (see text-fig.55).

Diagnosis. — Shell medium to small, rectangular to quadrate, with concentric pedicle and brachial folds, and a broad, high, rounded uniplicate anterior commissure. Great ontogenetic variation in dorsibiconvexity. Shell very finely costellate, with scattered prominent costellae. Pedicle muscle field very narrow, parallel-sided, strongly incised, longitudinally divided by prominent median septum continuing beyond anterior boundary. Brachial muscle field rectangular to oval, moderately incised, bounded posteriorly by long, slender, curved brachiophore plates supporting stubby brachiophores.

Description. — Shell medium to small, biconvex to dorsibiconvex in young stages, dorsibiconvexity increasing with age, rectangular to quadrate in outline, wider than long, with greatest width at midlength. Pedicle valve convex umbonally, flattening laterally, depressed medially; concentric marginal fold developed, increasing with age, broken medially by sinus. Brachial valve generally more convex, evenly convex longitudinally in youthful stages, flattening laterally; most convex below umbo in adult stages. Brachial concentric marginal fold developed, moving posteriorly with age. Beaks small, pointed; brachial beak more incurved and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea moderately high, curved to beak; delthyrium open. Brachial interarea lower, half height of pedicle interarea, curved to beak; notothyrium open. Pedicle

sinus beginning just anterior of umbo, or half way along valve, broadening and deepening anteriorly. Gentle brachial fold occasionally developed adjacent to anterior commissure. Anterior commissure uniplicate, due mainly to high, broad, rounded, dorsal, linguiform extension of pedicle valve. Shell costellate, rugate. Radial costellae very fine, rounded, separated by narrower, more angular striae, 6 to 7 costellae in 1mm. at 10mm. from beaks. Scattered costellae thickened. Growth rugae concentric, developed anteriorly and laterally.

Teeth prominent, compound, supported by anteriorly parallel and ventrally parallel to convergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.56, sections 1.9-2.3). Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.56, sections 1.1-2.7).

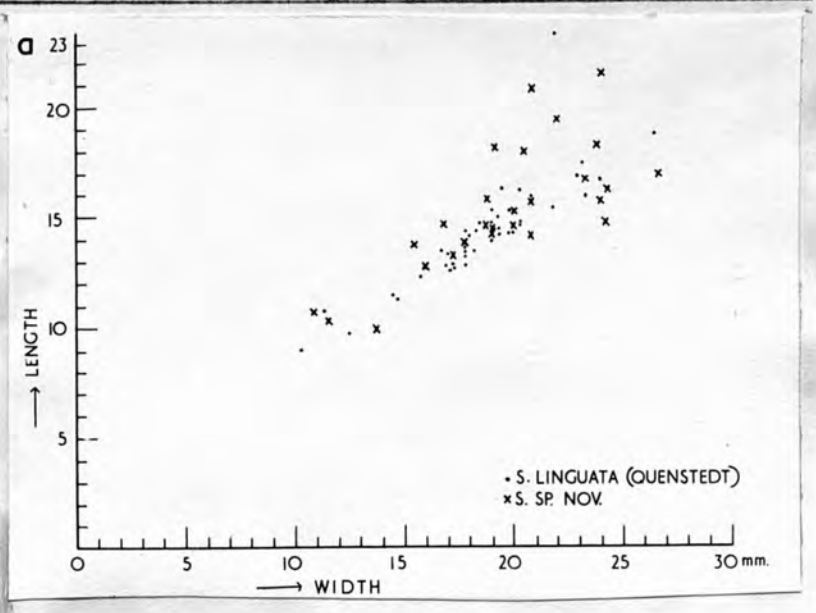
Pedicle muscle field (text-fig.57a) one half to two thirds valve length, very narrow, parallel-sided, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, uniting with median septum. Ridges attached to lateral margins of median septum (text-fig.56, sections 3.1-4.7). Median septum originating near point of delthyrial cavity, rounded, increasing in height and becoming subrounded anteriorly, then narrowing and decreasing in height, and continuing for short distance beyond anterior of muscle field (text-fig.56, sections 1.1-5.7; text-fig.57a). No evidence of pedicle muscle scars or genital markings. Pallial sinus pattern consisting of two divergent trunks, originating from anterior end of median septum (text-fig.57a).

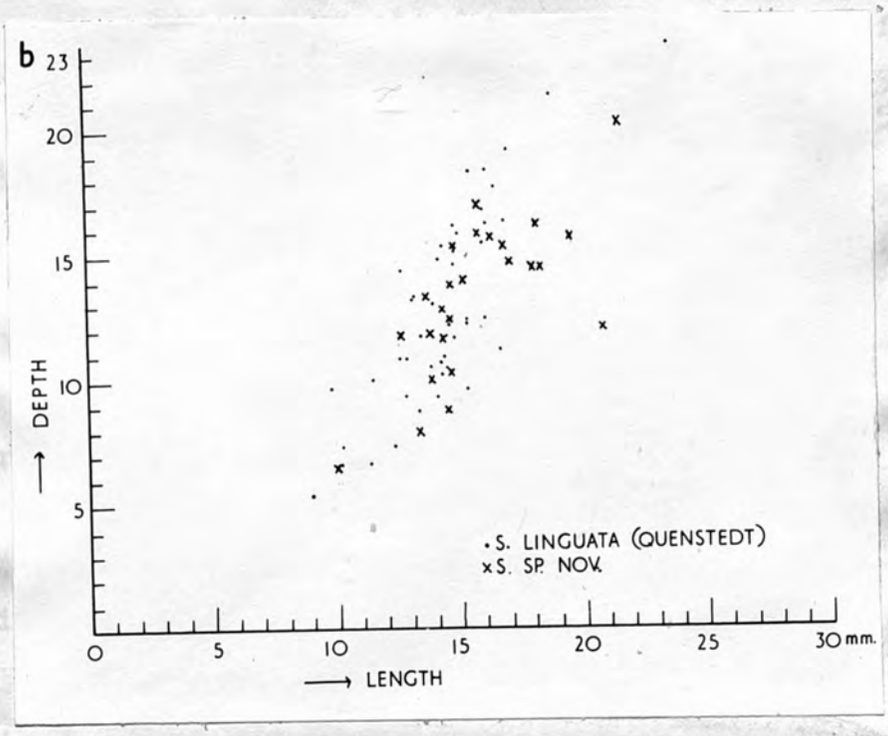
Myophore simple, or rudimentarily compound, with central ridge bordered by two shorter, narrower ridges, one either side, (text-fig.56, sections 1.0-1.4), all serrated. Shell partially filling notothyrial cavity, decreasing in thickness and dis-

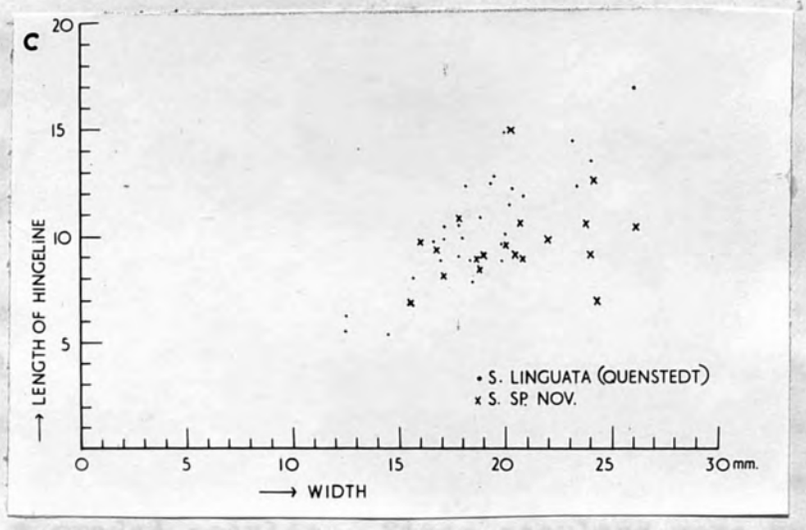
appearing anteriorly (text-fig.56, sections 0.8-1.4). Stubby brachiophores curved postero-laterally, and fused to slender, long, curved brachiophore plates bounding notothyrial cavity (text-fig.56, sections 0.8-2.5). Dental sockets oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.56, sections 1.4-2.2). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, oval-shaped accessory cavities, underlying fulcral plates (text-fig.56, sections 1.7-2.2).

Brachial muscle field (text-fig.57b) moderately incised, rectangular to oval, longer than wide, one half to two thirds valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly, and smoothly reflexed to form shallow, subrounded re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, broad, low, narrowing anteriorly (text-fig.56, sections 0.8-3.8; text-fig.57b). Pallial sinus pattern poorly preserved, but consisting of two divergent trunks originating from anterior re-entrant, and genital markings developed postero-laterally (text-fig.57b). Follicular markings, consisting of long follicles separated by shorter ones, developed peripherally on internal mould GSM 5732.

External dimensions plotted on text-figure 54.







Text-fig.54

External dimensions of Schizophoria sp. nov. are also plotted on text-figure 54, to indicate its affinities with S. linguata, (see Remarks).

Dimensions of available muscle fields. —

	Length of pedicle muscle field	Width of pedicle muscle field
BM B75348	8.0	2.7
IC 11134	14.0	1.7

	Length of brachial muscle field	Width of brachial muscle field
GSM 34275	15.1	7.5
SM E6773	8.0	5.5

Remarks. — The material is generally well preserved.

Quenstedt (1868-71, p.565, pl.55, figs.152-154) described and illustrated an ephebic/gerontic specimen from the Bergkalk, Ratingen, under Orthis linguata.

Demanet (1934, p.58, pl.4, figs.7, 8) described and illustrated two specimens from the Tournaisian of Dinant, Belgium, under Schizophoria resupinata var. palliata nov. var. His specimens were two youthful individuals, unlike the older, strongly dorsibiconvex, inflated specimen of Quenstedt. But Schizophoria linguata displays a great ontogenetic increase in dorsibiconvexity.

Bond (1941, fig.36), (reproduced here in text-fig.55) illustrated the range in dorsibiconvexity of the species, listed under Schizophoria palliata, enclosing both Demanet's and Quenstedt's specimens. Bond however (1941, p.297) did not list Quenstedt in synonymy with S. palliata, but stated that S. linguata cannot be considered conspecific with S. palliata, since Demanet (1934, p.59) stated that S. linguata only has 5 costellae per millimetre. Although Bond (ibid., p.297) gives 9 to 10 costellae per millimetre, only 6 to 7 costellae have here been measured with a graded occular. Since occulars were probably not used in earlier measurements, such variation in costellae number is clearly tolerable.

Orthis linguata and S. palliata are considered to be synonymous, and Schizophoria linguata (Quenstedt) is used in priority of S. palliata.

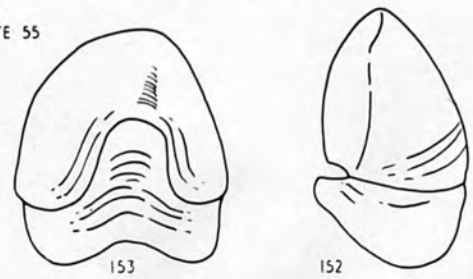
Quenstedt (ibid) compared his specimens with a specimen illustrated by M'Coy (1862, pl.4, fig.9) under Atrypa alta. But M'Coy rightly lists his specimen in synonymy with S. gibbera

SCHIZOPHORIA LINGUATA (QUENSTEDT)

QUENSTEDT 1868-71

Orthis linguata

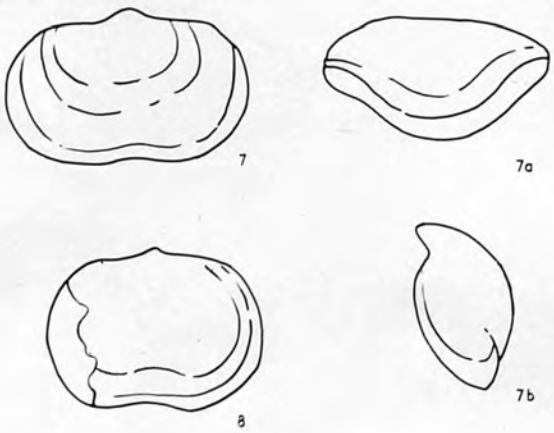
PLATE 55



DEMANET 1934

Schizophoria resupinata var. palliata n. var.

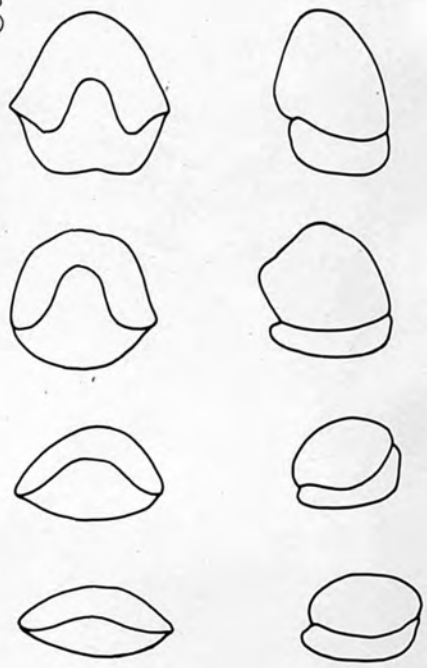
PLATE 4



BOND 1941

Schizophoria palliata Demanet

FIG. 36 (in part)



Text-fig. 56

(Portlock), (1843). Although adult specimens of S. linguata and S. gibbera are both strongly dorsibiconvex, inflated species, the strong concentric folds and prominent pedicle sinus of S. linguata are lacking in S. gibbera.

Dorsibiconvexity, gibbosity, inflation of the brachial umbo, and height of the anterior plication increase with age.

These characters have been illustrated by Bond (1941, p.298, fig.36). Older specimens may be deeper than long. This increase in inflation is greater than in any other Carboniferous species.

An indistinct, longitudinal median sinus is occasionally developed anteriorly on the brachial valve of old age specimens.

Specimens from Little Island Cork, Cork Harbour, and three others from a collection of S. linguata from Craven, Yorkshire, show morphological differences (text-fig.58). These specimens have been listed under Schizophoria sp.nov., but they do show affinities with S. linguata.

Youthful specimens of Schizophoria sp.nov. resemble S. linguata in outline, convexity, shape of the anterior plication and costellation (text-fig.58A i,ii). Both are finely costellate, with scattered thickened costellae, rectangular to elliptical in outline and biconvex. But S. sp.nov. has a narrower anterior plication.

Adult specimens of Schizophoria sp.nov. similarly resemble S. linguata, but S. sp.nov. have a more elliptical outline, are less strongly dorsibiconvex, and lack the characteristic concentric folds (text-fig.58B i,ii). Some adult specimens of S. sp.nov. have a more quadrate outline, width slightly exceeding length (text-fig.54a), and many have a shorter hingeline (text-fig.54c).

Internally there are also close similarities in the muscle fields, dental lamellae, brachiophores and brachiophore plates, but Schizophoria sp.nov. has a much more prominent, rounded to anteriorly flat-topped pedicle median septum (text-fig.60, sections 1.0-6.0). Variation in the strength of the pedicle septum of S. linguata is seen in another sectioned specimen from Craven (text-fig.56B, sections 2.8-5.7). Although the septum is wider, it is still less prominent than that of S. sp.nov.

Adult, strongly dorsibiconvex forms of S. linguata

resemble S. gibbera (Portlock). Similarities and differences are dealt with under the latter species.

Youthful biconvex, rectangular to elliptical forms of S. linguata superficially resemble S. resupinata (Martin) in convexity and outline, but S. linguata has finer costellae and lower interareas. Internally, the narrow, parallel-sided pedicle muscle field, rectangular to oval brachial muscle field, and curved brachiophore plates of S. linguata contrast with the broader, flabellate pedicle muscle field, transversely elliptical brachial muscle field, and divergent brachiophore plates of S. resupinata.

Comparisons of Schizophoria linguata with other species is given in text-figure 69.

The specimen described and illustrated by Paeckelmann (1930, p.175, pl.9, fig.15) under Orthis (Schizophoria) linguata Quenstedt, closely resembles material listed here as Schizophoria sp.nov. (see Remarks of S. sp.nov.).

Material. —

Belgium

IRIG 3200 — Tournaisian, Tn 3bR, Dréhance, Dinant.

Caldbeck, Cumberland

BM B75348 (including one plaster cast, one partial internal mould) — Lower Carboniferous Limestone, Fall's Brew.

Derbyshire

BM BB40846 — Lower Carboniferous, Upper D1 zone, north bluff Treak Cliff.

GSM 34274 (fragmentary shell), 34275 (brachial internal mould), 34277, 34279 — Lower Carboniferous, Dovedale.

BM B54108 (internal mould) — Lower Carboniferous, D2 subzone, Thorpe Cloud.

Staffordshire

BM B13190 (fragmentary shell); B34459 — Lower Carboniferous, Wetton.

BM B4906568 — Lower Carboniferous, D2 subzone, Narrowdale.

GSM 39/29; 84675-7 — Lower Carboniferous, Narrowdale.

Yorkshire

BM B26199 — Carboniferous Limestone, Bolland.

SM E6773 (brachial internal mould) — Carboniferous Limestone, Settle.

BM B34453 — Lower Carboniferous, Wharfedale.

IC 11134 (pedicle internal mould) — locality unknown.

Specimens are preserved as entire shells, except where otherwise indicated.

TEXT-FIG.56 — *Schizophoria linguata* (Quenstedt)

Measurements of sectioned specimens in millimetres

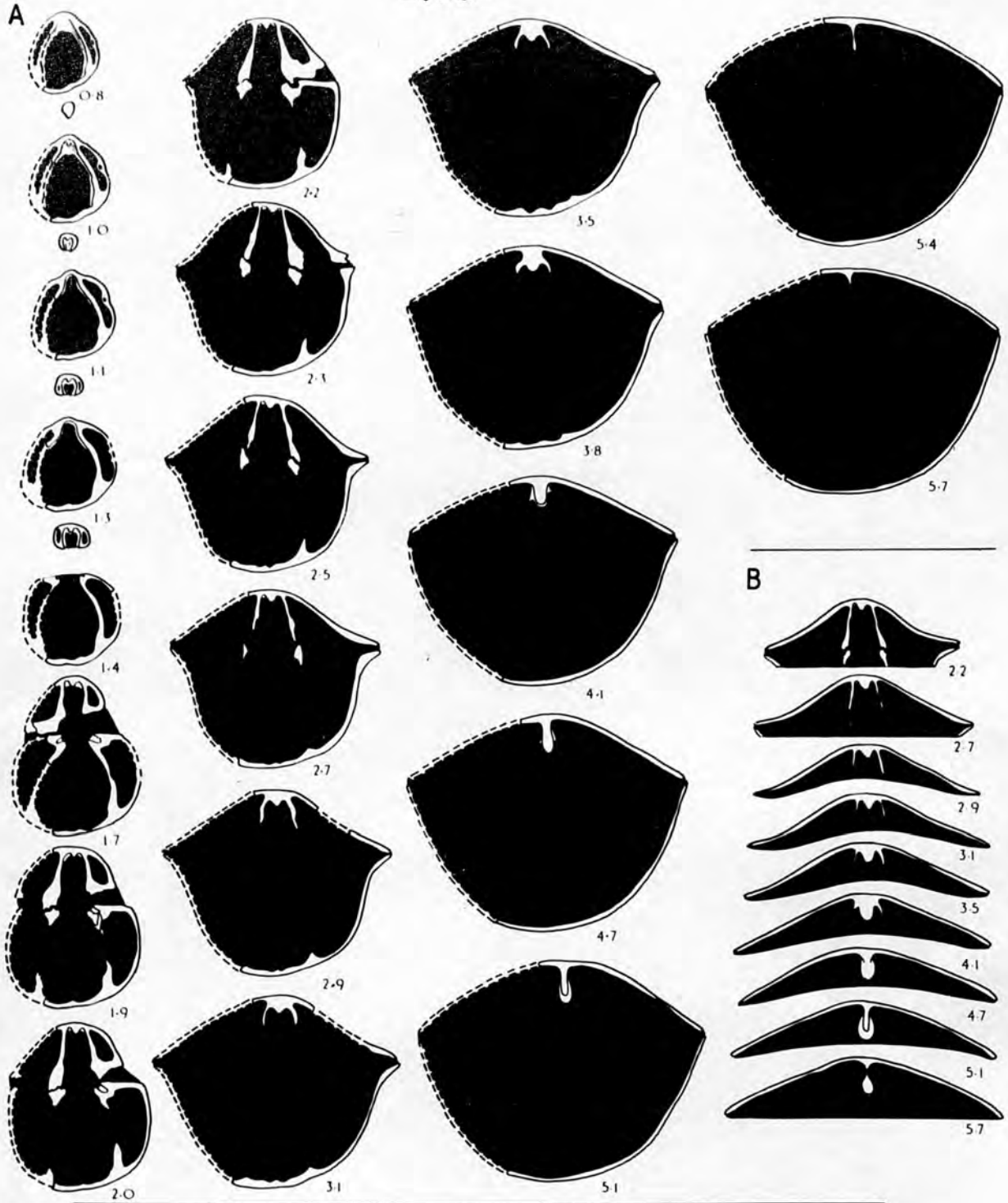
	Length	Width	Depth
A	14.1	16.4	9.7
B	14.9	18.8	14.4
C	11.3	13.8	7.0

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbones.

A — SM - Carboniferous Limestone, Craven, Yorkshire. Sections x 2½.

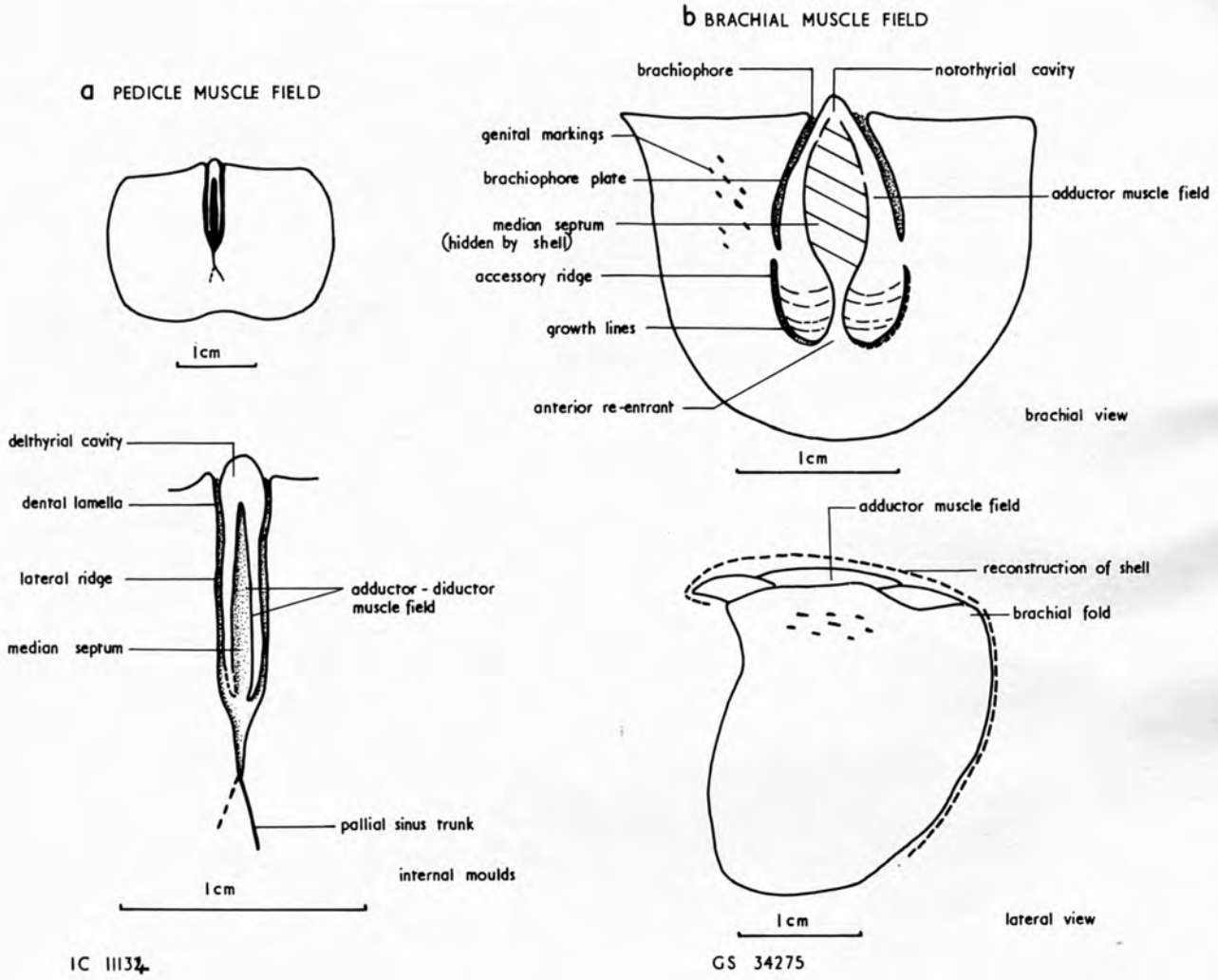
B — SM - same horizon and locality. Sections x 2.

C — BM B54025 - Dovedale, D2, Wetton. Sections x 2½.


A
0·8
1·0
1·1
1·3
1·4
1·7
1·9
2·0
2·2
2·3
2·5
2·7
2·9
3·1
3·5
3·8
4·1
4·7
5·1
5·4
5·7
B
2·2
2·7
2·9
3·1
3·5
4·1
4·7
5·1
5·7
C
0·3
0·8
1·1
1·5
2·5
3·4
0·6
0·9
1·2
2·0
3·0
3·8
0·7
1·0
1·3
2·3
3·2
4·0

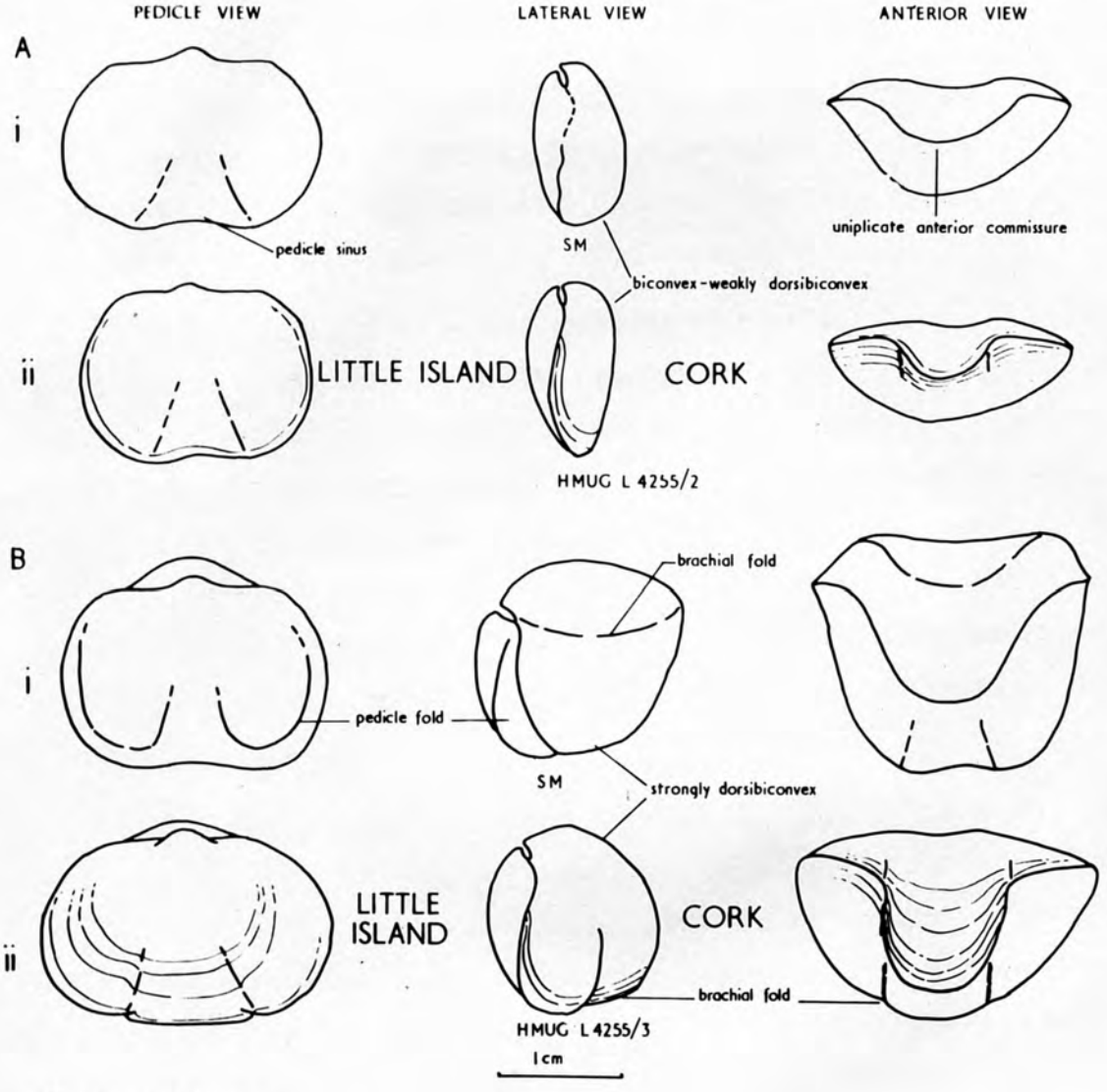
Text-fig. 56

SCHIZOPHORIA LINGUATA (QUENSTEDT)



Text-fig. 57

COMPARISON OF SCHIZOPHORIA LINGUATA (QUENSTEDT) WITH SCHIZOPHORIA SP. NOV. FROM LITTLE ISLAND CORK



A EPHEBIC SPECIMENS

B EPHEBIC - GERONTIC SPECIMENS

Text-fig. 58

Schizophoria sp. nov.

Pl.3, figs.4-6; text-figs.59, 60.

? Orthis (Schizophoria) linguata Quenstedt, Paeckelmann, 1930, p.175, pl.9, fig.15.

? cf. Schizophoria cf. Krotovi Tschernyschew, Sobolev, 1909, p.466, pl.5, fig.17.

Types. — Type material will be selected in due course, from the available material from the Lower Carboniferous of Cork, Ireland, in the British Museum (Natural History) or Hunterian Museum, University of Glasgow.

Diagnosis. — Shell medium to small, rectangular to elliptical, with broad, high, rounded uniplicate anterior commissure. Shell very finely costellate, with scattered prominent costellae, and rugate. Pedicle muscle field narrow, parallel-sided, strongly incised, longitudinally divided by very prominent median septum continuing beyond anterior boundary. Brachial muscle field moderately to strongly incised, bounded posteriorly by long, strong, curved brachiophore plates supporting stubby brachiophores.

Description. — Shell medium to small, biconvex to moderately dorsibiconvex, rectangular to elliptical in outline, wider than long, with greatest width at midlength. Pedicle valve convex umbonally, flattening laterally, depressed medially. Brachial valve generally more convex, evenly convex longitudinally, flattening laterally. Beaks small, pointed; brachial beak more incurved and umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea weakly developed, curved to beak; delthyrium open. Brachial interarea lower, curved to beak; notothyrium open. Pedicle sinus beginning anterior of umbo, broadening and deepening anteriorly, well defined laterally

in older specimens. Brachial fold occasionally developed adjacent to anterior commissure. Anterior commissure uniplicate, due mainly to high, broad, rounded, dorsal, linguiform extension of pedicle valve. Shell costellate, rugate, punctate. Radial costellae very fine, rounded, separated by narrower, more angular striae, 6 costellae in 1mm. at 10mm. from beaks. Scattered costellae thickened. Growth rugae prominent, concentrated anteriorly and laterally.

Teeth prominent, compound, supported by anteriorly parallel and ventrally parallel to convergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.60, sections 2.2-2.6). Articulation supplemented by interlocking ends of dental lamellae and brachiophores (text-fig. 60, sections 2.7-2.8). Pedicle muscle field approximately half valve length, narrow, parallel-sided, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, uniting with median septum. Median septum originating near point of delthyrial cavity, rounded, broadening and increasing in height anteriorly, becoming flat-crested, decreasing in height, and continuing for short distance beyond muscle field (text-fig.60, sections 1.0-6.6). No evidence of pallial sinus pattern or genital markings.

Myophore simple, or rudimentarily compound, with central ridge bordered by two shorter, narrower ridges, one either side (text-fig.60, sections 1.3-1.6), all serrated. Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.60, sections 1.3-1.9). Stubby brachiophores fused to strong, long, curved brachiophore plates bounding notothyrial cavity (text-fig.60, sections 1.4-2.7). Dental sockets oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.60, sect-

ions 2.2, 2.3). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig. 60, sections 1.6-2.5).

Brachial muscle field moderately to strongly incised, longer than wide, approximately half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by strong accessory ridges. Ridges decreasing in height anteriorly, and uniting with median septum. Median septum originating at base of notothyrial cavity, broad, low, rounded, increasing, then decreasing in height anteriorly (text-fig.60, sections 1.2-6.0). No evidence of pallial sinus pattern or genital markings.

Remarks. — The specimens are well preserved, except that some from little Island Cork have been distorted to varying degrees by Hercynian earthmovements.

Dorsibiconvexity and height of the anterior plication increase with age. Youthful specimens are more biconvex, and have a rectimarginate to weakly uniplicate anterior commissure.

Illustrations of pedicle and brachial muscle fields are not presented as with other species, since internal moulds of Schizophoria sp.nov. are not available. But in transverse serial sections the muscle fields have a similar general outline as those of S. linguata (Quenstedt).

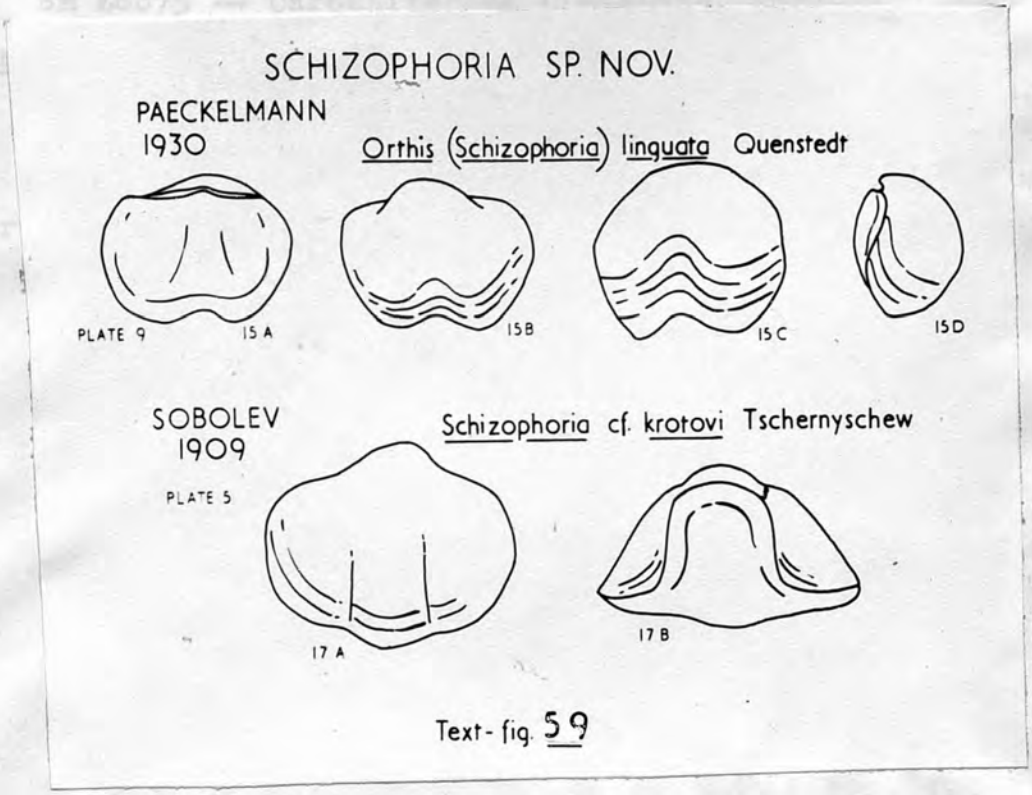
In the British Isles, Schizophoria sp.nov. is apparently limited to Little Island Cork and the Valley of the Maine, Ireland, apart from three specimens from the Craven area of Yorkshire.

Although possessing affinities with Schizophoria linguata (Quenstedt), S. sp.nov. does show external and internal morphological differences. These have been described under S. linguata, (see text-fig.58). A new specific name will be given in due course.

External dimensions of Schizophoria sp.nov. have been

plotted with those of S. linguata, to indicate their affinities (text-fig.54).

Paeckelmann (1930, p.175, pl.9, fig.15), (see text-fig. 59), described and illustrated a specimen from the Lower Carboniferous of Germany under Orthis (Schizophoria) linguata (Quenstedt). This resembles Schizophoria sp.nov. in outline, fine costellae and prominent rugae, anterior uniplication, and short anterior brachial fold. Until this has been examined, it is tentatively listed in synonymy.



Text-fig. 59

Sobolev (1909, p.466, pl.5, fig.17), (see text-fig.59), described and illustrated a specimen under Schizophoria cf. Krotovi Tschernyschew. This also resembles S. sp.nov. in outline, anterior plication and fold, but is coarsely costellate, and was collected from the Devonian of Russia. This specimen

does not belong to S. Krotovi.

Material. —

Ireland

BM B40126 (including three distorted shells, one plaster cast); BM B68454; GSI 75/3 — Carboniferous Limestone, Little Island, Cork.

GSM 3758, 3759 — Carboniferous Limestone, Valley of the Maine.

GSM 5730, 5732 — Carboniferous Limestone, Cork Harbour.

HMUG L1841/2, 5; L4255/1-5 (1 - plaster cast) — Carboniferous Limestone, Little Island, Cork.

SM E6875 — Carboniferous Limestone, Cork.

Yorkshire

SM (three specimens) — Lower Carboniferous, Craven.

Specimens are preserved as entire shells, except where otherwise indicated.

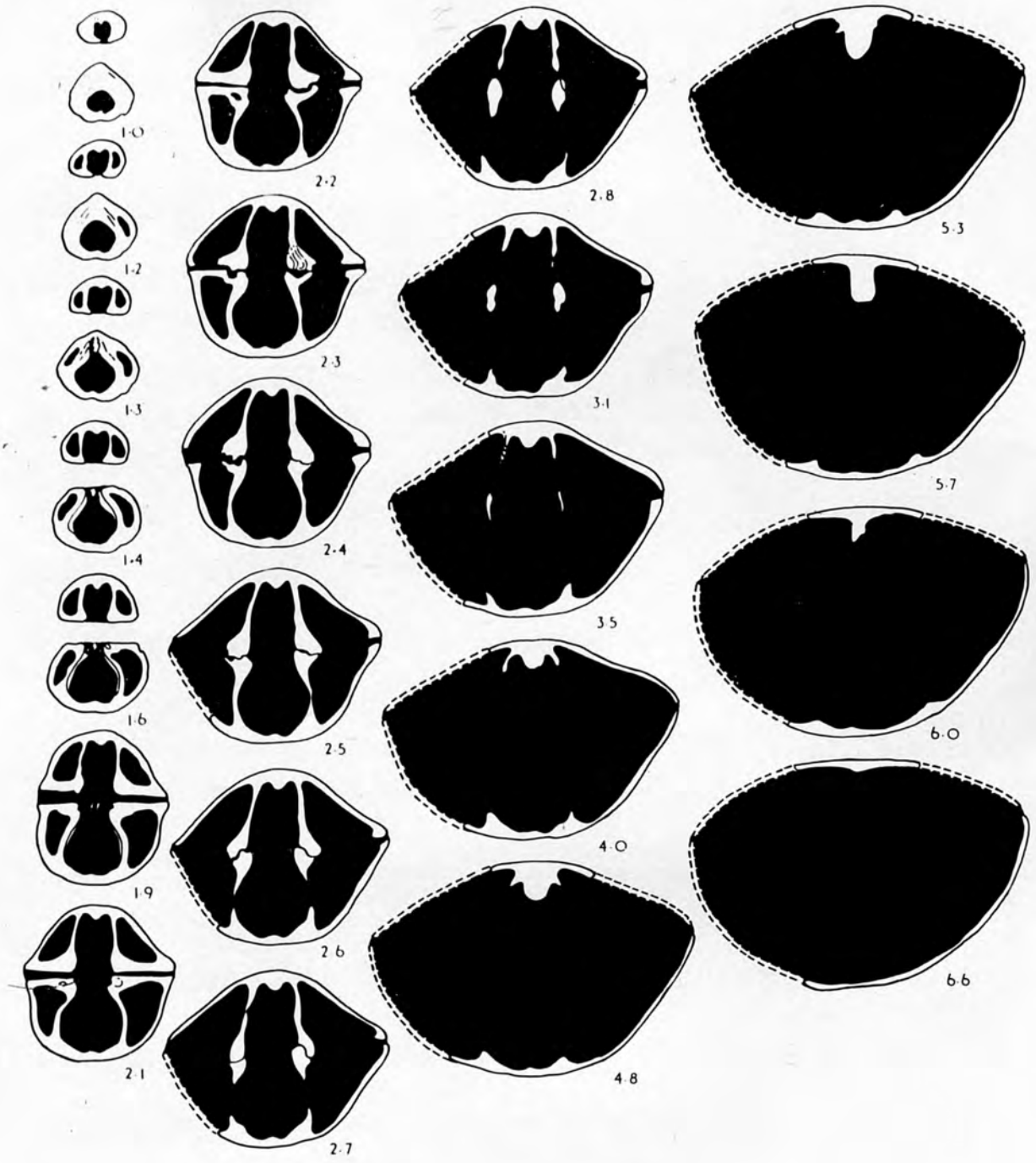
TEXT-FIG.60 — *Schizophoria sp. nov.*

Measurements of sectioned specimen in millimetres

Length	Width	Depth
12.8	19.8	14.3

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2½.

HMUG L4255/1 — Carboniferous Limestone, Little Island, Cork.



Text-fig. 60

Schizophoria resupinata (Martin)

Pl.3, figs.7-12; pl.4, figs.1-3; text-figs.61-69.

Anomites, Schröter, 1777, p.352, pl.5, fig.2.

Conchyliolithus anomites (resupinatus), Martin, 1809, pl.49, figs.13, 14.

Terebratulites vestitus, Schlotheim, 1820, p.253; 1822, pl.15, fig.1.

Terebratula resupinata, Sowerby, 1823, pl.325.

Spirifer resupinata, Phillips, 1836, p.220, pl.11, fig.1.

Spirifer resupinatus Martin, De Buch, 1840, p.203, pl.10, fig.32.

Orthis resupinata, De Koninck, 1842, p.226, pl.13, figs.9, 10: 1873, p.47, pl.2, fig.5b: 1877, p.214, pl.10, fig.9.

Orthis latissima. M'Coy, 1844, p.125, pl.20, fig.20.

Orthis resupinata, Murchison, Verneuil, Keyserling, 1845, p.183, pl.12, fig.5.

Orthis resupinata, Martin, Davidson, 1853, pl.7, fig.135: 1858-63, p.130, pl.29, figs.1-3, pl.30, figs.1-5.

? Orthis swallovi (n.s.), Hall, 1858, p.597, pl.12, fig.5.

Orthis resupinata, Roemer, 1863, p.591, pl.16, fig.4: 1876, pl.43, fig.4.

_____, Quenstedt, 1871, p.563, pl.55, figs.146-149 (148 - var. lata?); pl.56, fig.1: 1873, p.47, pl.2, fig.56: 1877, p.214, pl.10, fig.9.

? Orthis resupinata W. Martin., Abich, 1878, p.78, pl.8, figs.9,9a.

? Orthis resupinata Mart., Romanovskij, 1880, p.112, pl.17, figs.5, 6, 8.

? Orthis swallovi, Hall, Hall and Clarke, 1892, v.8, pt.2, pl.6, figs.23, 24.

Orthis resupinata, Martin, sp, Jack and Etheridge, 1892, p.224, pl.11, figs.27, 28.

? Orthis resupinata Mart. sp., Tornquist, 1895, p.455, pl.15, fig.5.

Orthis resupinata, Martin, Julien, 1896, p.87, pl.8, fig.2; pl.9, fig.6; pl.11, fig.16; pl.15, figs.4, 5.

Schizophoria resupinata, Dun, 1902, p.78, pl.21, figs.3-9.

Orthis resupinata Martin, Parkinson, 1903, p.359, pl.16, fig.10.

_____, Sommer, 1909, p.625, pl.29, fig.13 (cf. lata); non. pl.27, fig.8.

? Dalmanella resupinata Mart. sp, Frech, 1911, p.85, pl.12, fig.5.

Orthis (Schizophoria) resupinata Mart., Nebe, 1911, p.445, pl.12, fig.16.

? Orthis resupinata Martin, Cramer, 1912, p.42, pl.3, fig.2.

? Orthis (Schizophoria) resupinata Mart., Klebelsberg, 1912, p.465, pl.19, fig.14.

? Schizophoria swallovi (Hall), Weller, 1914, p.167, pl.22, figs.1-6.

Schizophoria resupinata Martin., Yanishevsky, 1918, p.19, pl.1, fig.12; pl.4, fig.2; pl.6, fig.16.

Schizophoria resupinata (Martin), Demanet, 1921-3, p.119, pl.5, fig.1: 1934, p.47, text-fig.9, pl.3, figs.1-5.

Orthis (Schizophoria) resupinata, Howchin, 1925, p.158, fig.61, 1-3.

? Orthis (Schizophoria) cf. resupinata Martin., Reed, 1927, p.40, pl.8, fig.5.

Orthis (Schizophoria) resupinata Martin, Daguin, 1929, p.30, pl.7, fig.9.

Orthis (Schizophoria) resupinata (Martin), Paeckelmann, 1930, p.158, pl.9, fig.11.

? Schizophoria sp. nov. ind., Rakusz, 1930, p.21, pl.1, fig.12.

? Orthis (Schizophoria) resupinata Martin., Aigner, 1931, p.3, pl.1, figs.1-4.

Schizophoria resupinata, Rotai, 1931, p.44, pl.14, fig.5.

_____, Gallwitz, 1932, p.92, pl.6, figs.11-14.

_____, Anderson and Lamont, 1935, p.6, fig.6, no.4.

Schizophoria resupinata Martin, Miloradovich, 1935, p.6, pl.1, figs.11, 12.

Schizophoria aff. resupinata (Martin), George and Ponsford, 1938, text-fig.15.

Schizophoria elboltonensis sp. nov., George and Ponsford, 1938, text-figs.6, 7.

Schizophoria nuda, George and Ponsford, 1938, p.224, pl.5, figs.1-5; text-figs.1-5.

Schizophoria resupinata (Martin), Bond, 1941, p.289, pl.21, figs.A-C.

Schizophoria resupinata Martin., Délépine, 1942, p.59, pl.6, figs.16, 17: 1946, p.27, pl.6, figs.16, 17.

Schizophoria resupinata, David and Browne, 1950, p.308, pl.31, fig. f.

Schizophoria resupinata Martin, Termier and Termier, 1950, pl.71, figs.27-30, non. fig.31; pl.73, figs.1-7, 10, 11; pl.77, figs.8, 9.

Schizophoria resupinata, Sarytcheva and Sokolskaja, 1952, p.29, pl.2, fig.12.

Schizophoria resupinata (Martin), Minato, 1952, p.150, pl.5, fig.3; pl.6, fig.4.

? Schizophoria resupinata (Mart.), Zakowa, 1953, p.15, pl.3, fig.1.

S. aff. resupinata (Martin), Maxwell, 1954, pl.3, figs.1-5.

S. cf. resupinata var. lata, Maxwell, 1954, pl.3, figs.6-8.

Schizophoria resupinata, Parkinson, 1954, p.368, figs.1, 2a-e.

Schizophoria cf. S. resupinata (Martin), Campbell, 1957, p.48, pl.12, figs.1-5; text-figs.3-5.

Schizophoria verulamensis n.sp., Cvancara, 1958, p.856, pl.109, figs.14-16; pl.110, figs.1-5.

Schizophoria resupinata (Martin), Dedeev and Lapina, 1960, pl.21, figs.4, 6-13, non. fig.5.

non. Anomiae striatae, Ure, 1763, p.314, pl.4, figs.13, 14.

non. Anomites terebratula similis, Schlotheim, 1820, p.66, pl.15, figs.2, 3.

non. Orthis resupinata, Phillips, 1841, no.115, pl.27, fig.115.

non. Orthis resupinata, Hall, 1843, p.215, fig.2.

non. Schizophoria resupinata (Martin), Vaughan, 1908, p.470, pl.L, fig.5.

non. Orthis (Schizophoria) resupinata, Paeckelmann, 1930, p.158, pl.9, figs.3-10; pl.13, figs.1-9.

non. Schizophoria resupinata Martin, Rakusz, 1930, p.24, pl.2, fig.7.

non. Schizophoria resupinata Mart., Schmidt, 1933, p.26, pl.4, figs.1, 2.

non. Spirifer resupinatus, Archaic and Verneuil, 1942, p.371,394.

Schizophoria resupinata var. dorsosinuata nov. var., Demanet, 1934, pl.3, figs.14, 15.

Schizophoria cf. dorsosinuata Demanet, George and Ponsford, 1938, text-figs.10-14.

S. resupinata var. dorsisinuata Demanet, Bond, 1941, p.289; figs.33, 34.

Orthis resupinata Martin, Sommer, 1909, pl.29, fig.13.

Schizophoria resupinata var. lata, Demanet, 1921-3, p.122, pl.5, fig.4: 1934, pl.3, figs.6-8.

S. resupinata var. lata. Demanet, Bond, 1941, p.290, figs.33, 34.

Schizophoria resupinata var. gigantea nov. var., Demanet, 1934, p.60, pl.4, figs.12, 13.

Orthis resupinata, Martin, Davidson, 1858-63, pl.29, fig.3.

? Schizophoria swallovi Hall, Weller, 1910, p.296, pl.12, figs.6, 7.

Schizophoria resupinata var. pinguis nov. var., Demanet, 1934, p.59, pl.4, figs.9-11.

Schizophoria pinguis Demanet, George and Ponsford, 1938, text-figs.8, 9.

S. resupinata var. pinguis. Demanet, Bond, 1941, p.290.

Schizophoria resupinata Martin, Termier and Termier, 1950, pl.73, fig.3.

S. resupinata, Parkinson, 1954, p.368, fig.2f.

Schizophoria resupinata var. rotundata, Demanet, 1934, p.17, pl.3, figs.9-13.

Neotype. — The holotype illustrated by Martin (1809, pl.49, figs.13,14) is lost. The neotype, which also becomes the new genotype, chosen by George and Ponsford (1938, p.228), and figured by Bond (1941, p.121, fig.E), is a specimen from the Davidson Collection in the British Museum (Natural History), BB 2420.

Diagnosis. — Shell medium to large, rectangular to elliptical. Shell finely costellate, with thickened costellae terminating in spine bases. Pedicle muscle field flabellate, moderately incised, longitudinally divided by narrow median septum often continuing beyond anterior boundary. Brachial muscle field moderately incised, with digitate posterior adductor muscle field bounded by long, slender, divergent brachiophore plates supporting stubby brachiophores.

Description. — Shell medium to large, ventribiconvex to moderately dorsibiconvex, transversely rectangular to elliptical in outline, with greatest width at midlength. Pedicle valve convex umbonally, flattening anteriorly and laterally. Brachial valve more convex, evenly convex longitudinally, flattening laterally; convexity frequently broken by longitudinal median sinus, originating on umbo, increasing in depth and width, then decreasing, anteriorly. Beaks small, pointed, well separated;

brachial beak more incurved; brachial umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle interarea prominent, high, curved to beak, with horizontal growth lines and vertical striations; delthyrium higher than wide, open. Brachial interarea lower, half to two-thirds height of pedicle interarea, curved to beak; notothyrium open. Pedicle sinus generally ill-defined, except for broad, shallow depression developed anteriorly. Anterior commissure varying from rectimarginate to broadly uniplicate, unisulcate or weakly sulciplicate. Shell costellate, rugate, punctate. Radial costellae fine, rounded, separated by narrower, more angular striae, 4 to 5 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation, intercalation more prominent anteriorly. Scattered costellae thickened, with hollow spine bases developed anteriorly. Spine bases, diameter 1/3mm., generally more prominent and closely spaced anteriorly and laterally. Growth rugae concentric, generally weakly developed, more closely grouped anteriorly and laterally. Puncta subrounded, 1/30mm. in diameter, evenly distributed in innermost shell layers; concentrated along costellae in median shell layers; concentrated along striae on surface.

Teeth prominent, compound, central main tooth with minor laterals (text-fig.64, sections 2.8-3.0, c), supported by anteriorly divergent ventrally subparallel dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-fig.64, sections 2.6-3.0). Articulation supplemented by interlocking ends of dental lamellae and brachiophores (text-fig.64, sections 3.2-3.7, d). Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.64, sections 0.7-4.1).

Pedicle muscle field (text-fig.64a) less than half valve

length, broad, anteriorly flabellate, moderately incised, bounded posteriorly by dental lamellae, laterally by ridge-like extensions of lamellae, diverging for two-thirds of length, converging anteriorly. Ridges decreasing in height anteriorly; anterior boundary of muscle field often ill-defined. Muscle field longitudinally divided by median septum, originating near point of delthyrial cavity, narrow, subrounded, generally broadening and increasing in height slightly anteriorly, and often continuing for short distance anterior of muscle field (text-fig.64, sections 0.7-6.9, a). Diductor muscle field longitudinally striated. Pallial sinus pattern consisting of two parallel trunks originating from ends of diductor muscle field (text-fig.64a). No evidence of pedicle muscle scars or genital markings.

Prominent cardinal process, differentiated into myophore supported by shaft. Myophore compound, average width 2.5mm., with central ridge, bordered by two or four shorter, narrower ridges, one or two either side, all serrated (text-fig.64, sections 0.7-1.4, b, e). Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-fig.64, sections 0.8-5.4). Stubby brachiophores curved postero-laterally, and fused to slender, long, divergent brachiophore plates bounding notothyrial cavity (text-fig.64, sections 2.8-3.5, b). Dental sockets deep, oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-fig.64, sections 2.6, 2.8). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-fig.64, section 2.8). Fulcral plates strong, uniting brachiophores with postero-lateral shell margin (text-fig.64, sections 2.6, 2.8).

Brachial muscle field (text-fig.64b) moderately incised,

elliptical, wider than long, one third to one half of valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges decreasing in height anteriorly, and smoothly reflexed to form rounded re-entrant, uniting with median septum. Median septum originating at base of notothyrial cavity, low, subangular, broadening anteriorly. Low, obliquely trending septum divides adductor muscle field into anterior and posterior parts; anterior part pyriform; posterior part further subdivided into pair of digitate scars (text-fig.64, sections 1.1-6.9, b). Pallial sinus pattern consisting of six trunks, four originating from anterior re-entrant, two originating from ends of anterior adductor muscle field. Genital markings developed laterally and postero-laterally (text-fig.64b). Follicular markings, consisting of main follicles separated by shorter, narrower follicles, occasionally developed peripherally on internal moulds.

Dimensions in millimetres. —

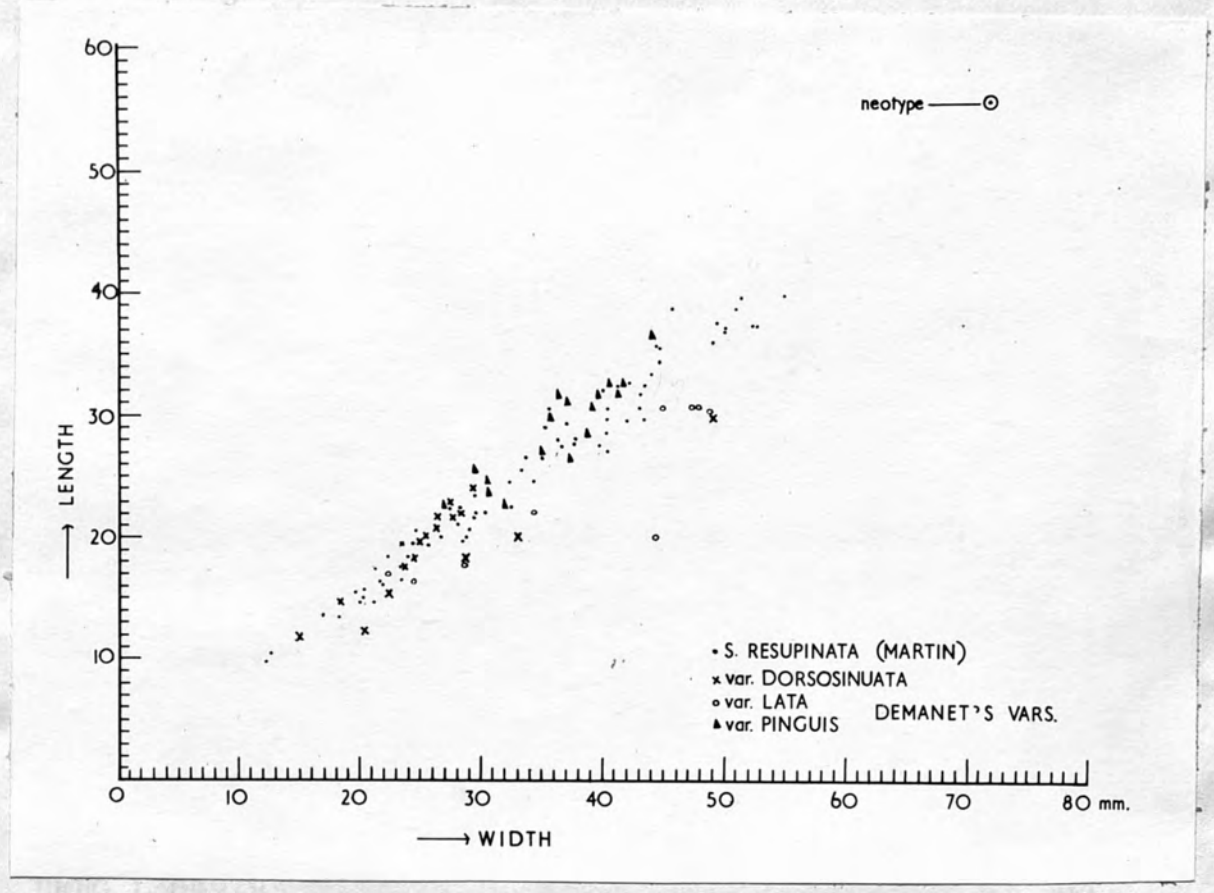
	Length	Width	Depth	Length of hingeline
Neotype BM B2420	55.2	71.9	31.5	43.9

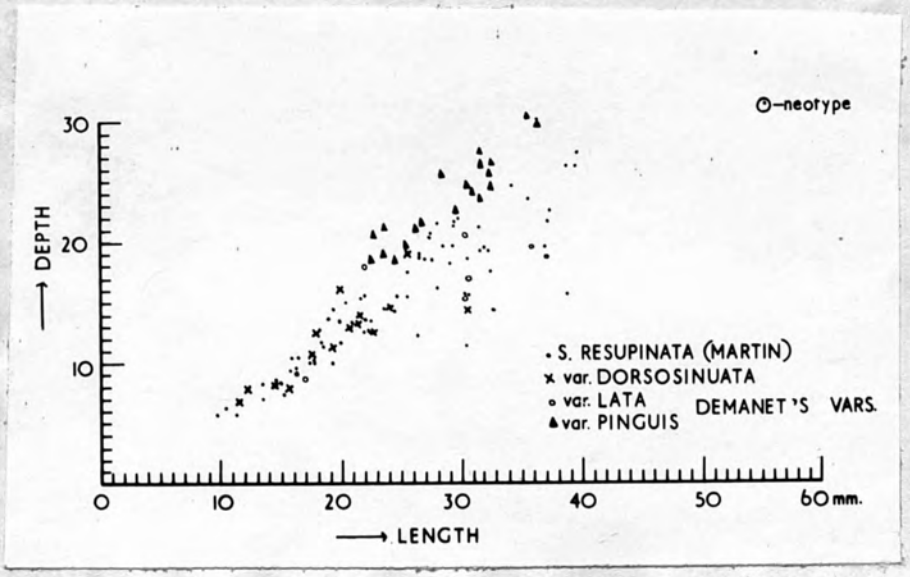
— weakly uniplicate anterior commissure —

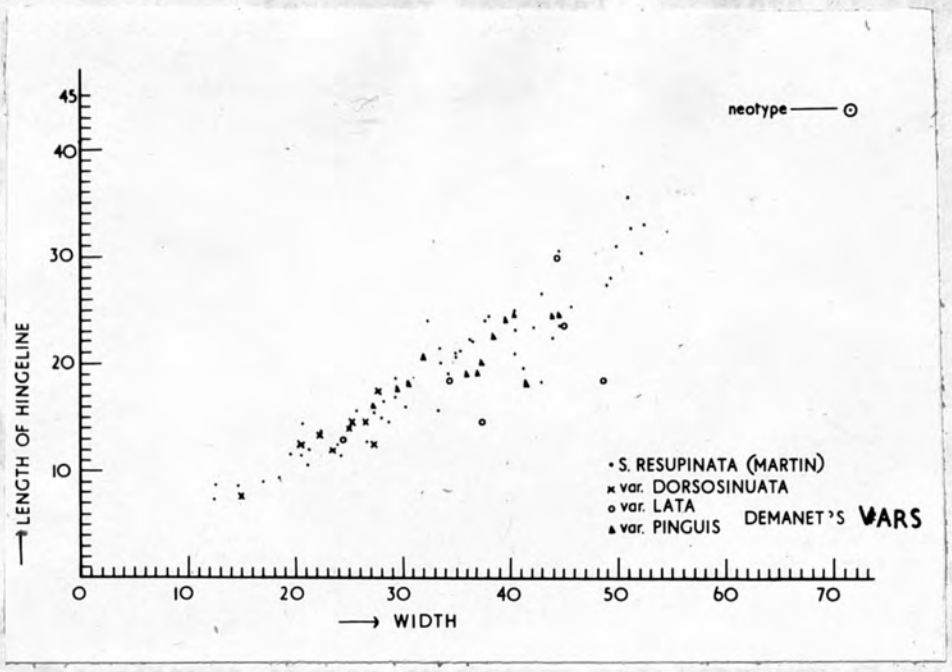
External dimensions of other material including variants are plotted on text-figure 61.

Dimensions of available muscle fields. —

	Length of pedicle muscle field	Width of pedicle muscle field
BC B183	14.3	9.2
BC B184	10.5 (+)	6.8
BC B185	14.9	11.7
BC B193	9.6	5.9
BC B202	11.6	6.0
BC B203	10.6	7.6
GSM 3287	10.1	9.2
GSM 3377	17.4	13.5
HMUG L3123/4	13.0	9.1


neotype
LENGTH
WIDTH
• S. RESUPINATA (MARTIN)
× var. DORSOSINUATA
○ var. LATA
▲ var. PINGUIS
DEMANET'S VARS.
0
10
20
30
40
50
60
70
80 mm.


⊙–neotype
DEPTH
LENGTH
• S. RESUPINATA (MARTIN)
× var. DORSOSINUATA
○ var. LATA
▲ var. PINGUIS
DEMANET'S VARS.
0
10
20
30
40
50
60 mm.



Text-fig.61

	Length of pedicle muscle field	Width of pedicle muscle field
HMUG L3649/60	13.9	8.8
HMUG L3649/63	15.9 (+)	11.3
HMUG L3649/90	15.3	11.0
HMUG L3649/93	13.7	8.7
HMUG L3882/2	10.3	9.0
HMUG L5335/1	11.5	7.8
HMUG L5335/2	10.9	7.5
UR 13590	10.0	8.2
var. dorsosinuata		
IRIG	17.5	13.2
IRIG 8261(ii)	8.0	5.0
var. gigantea		
BC B186	31.3	22.3
var. pinguis		
IRIG 4447	10.0	6.7

	Length of brachial muscle field	Width of brachial muscle field
BC B194	18.3	19.3
BC B204	15.0	17.6
SM E6536	21.0	30.0
var. dorsosinuata		
IRIG	11.5	11.4
var. pinguis		
IRIG 4447	10.8	10.5

Remarks. — The neotype and other material are generally well preserved.

The neotype chosen by George and Ponsford (1938, p.228), and figured by Bond (1941, p.121, fig.E), closely resembles Martin's illustrations of the lost holotype (1809, pl.49, figs.13, 14), in outline, dorsibiconvexity and brachial mesial sinus, but is larger in size. Other material examined illustrates a size range, but only one other specimen of a similar size has been plotted on the graph of dimensions (text-fig.61). Other specimens are smaller. Although possessing characters resembling the holotype, it was perhaps an unfortunate choice of neotype, since it is so much larger than an average specimen.

Variation

Although S. resupinata is a long ranging species, (K-D zones), there is apparently little internal morphological variation from early to late forms (text-fig.65). Variations in convexity, outline, shape of the anterior commissure, and development of a brachial sinus and spine bases occur within specimens from one horizon, and between specimens from different horizons.

Dorsibiconvexity generally increases with age. Youthful specimens may be ventribiconvex or biconvex, with beaks level, or pedicle beak projecting. Adult specimens are generally

dorsibiconvex, with the brachial umbo more inflated, projecting posterior of the pedicle valve.

The shape of the anterior commissure varies from rectimarginate to sulciplicate, uniplicate or unisulcate. Specimens from the Isle of Man show an increase in plication with age, but others apparently retain a rectimarginate commissure throughout life.

A longitudinal, mesial, pedicle sinus is variably developed, and a well developed sinus is frequently correlated with a broad, uniplicate anterior commissure. The brachial sinus is also variably developed. Although developed on the holotype and neotype, a sinus is absent on many specimens. Specimens from the Isle of Man have a prominent sinus.

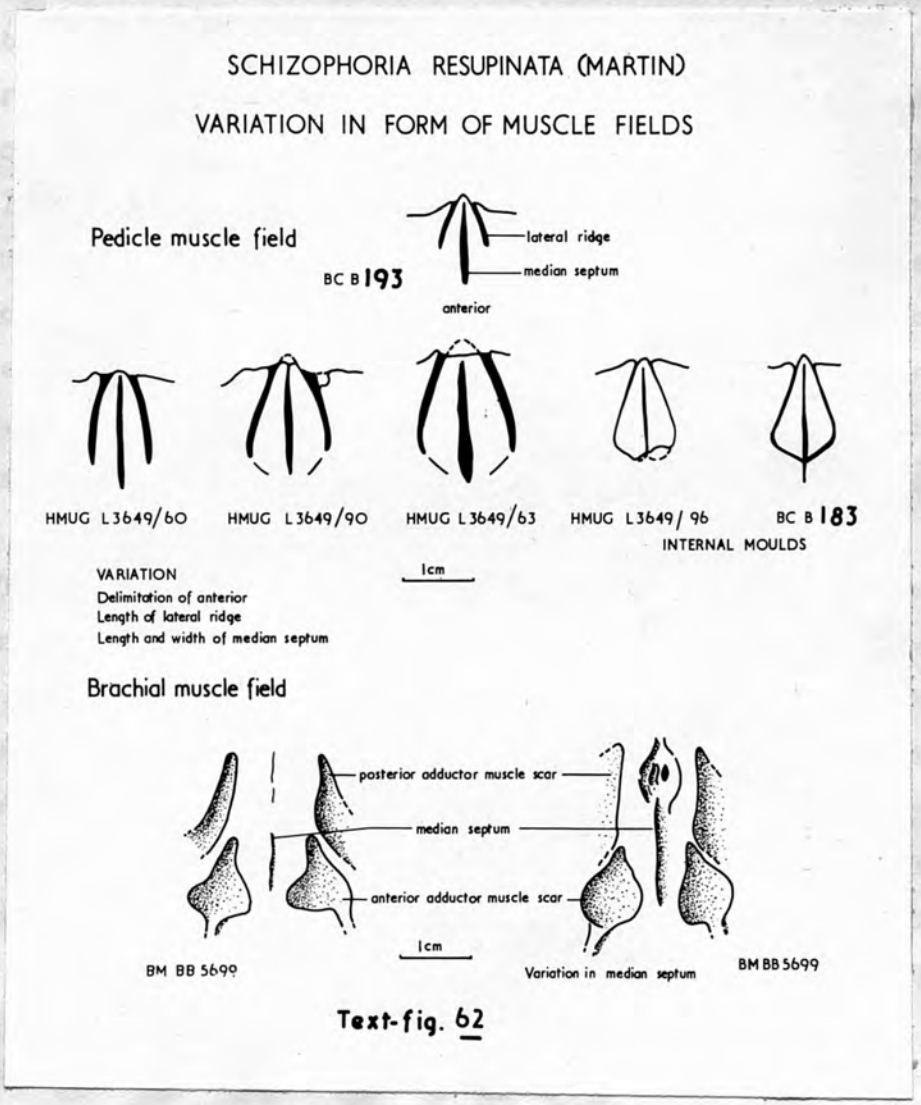
Growth rugae of S. resupinata are generally weakly developed or absent, although there is individual variation. Rugate and non-rugate specimens occur together.

Schizophoria resupinata shows considerable variation in the development of thickened costellae and spine bases. Costellae may be thickened for short or long distances over the valve, thickening anteriorly towards a spine base, then regaining the normal width, followed by a re-thickening to form another spine base. Spacing of prominent costellae varies, with one to three or more normal intervening costellae. Prominent costellae and spine bases are randomly distributed, sometimes more frequently developed on one valve or the other, evenly distributed, or concentrated anteriorly and laterally. Specimens from the Isle of Man lack spine bases, while others from Withgill are well covered. Yet there is apparently no relationship with stratigraphical position or environment, as spinose and non-spinose individuals occur together.

Some specimens from Treak Cliff, Derbyshire, differ externally from the characteristic form of S. resupinata in outline, convexity and costellation. They are more elliptical

in outline, biconvex to ventribiconvex, and more coarsely costellate, with 3 to 4 costellae in 1mm. Differences in relative convexity of the two valves is correlated with internal variations in the relative lengths of the dental lamellae and brachiophore plates. Ventribiconvex specimens have longer dental lamellae, while dorsibiconvex specimens have brachiophore plates as long as, or longer than, dental lamellae. Internally, the Treak Cliff forms resemble other forms of S. resupinata, except that the pedicle median septum is broader. Characteristic forms of S. resupinata are also present.

Variations in the pedicle and brachial muscle fields are illustrated on text-fig.62. Incision increases with age.



Text-fig. 62

The follicles on internal moulds are thought to represent hollows which contained setae in the living organism (Rudwick, 1958, p.799). The setae projected from within the shell, and their interlocking arrangement would filter inhalent currents and prevent entry of harmful particles.

Varieties

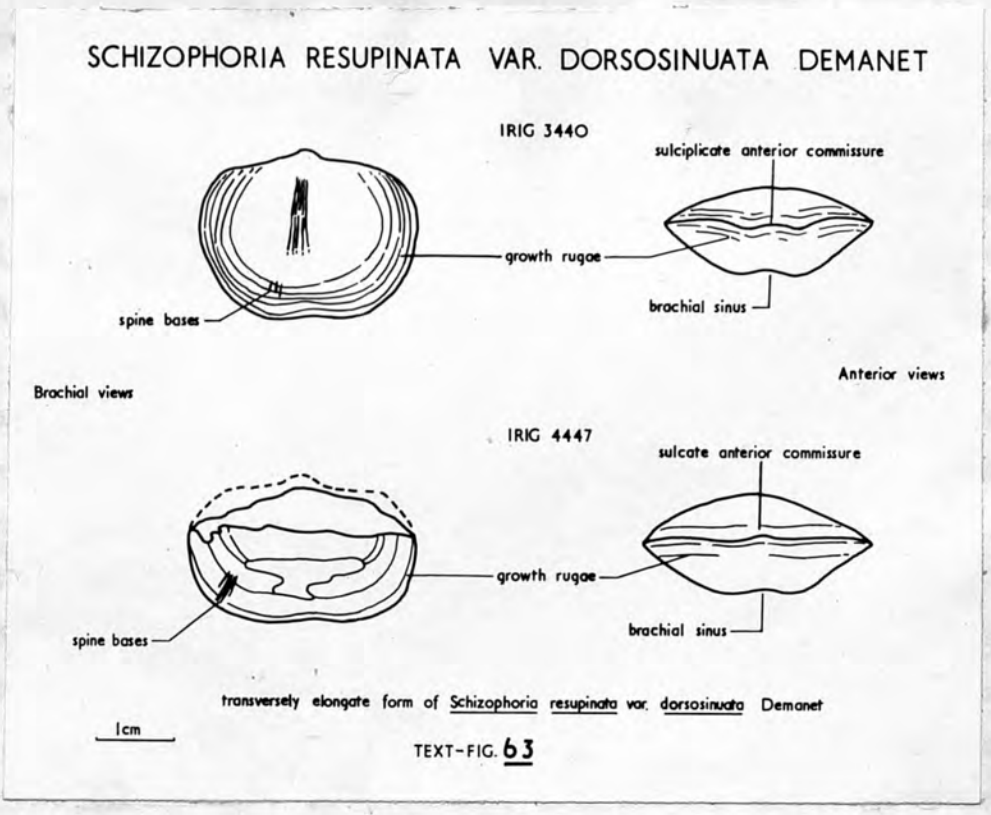
Demanet (1921-3, 1934) established five varieties of S. resupinata, dorsosinuata, gigantea, lata, pinguis and rotundata.

Schizophoria resupinata var. dorsosinuata, (text-fig. 63), is characterised by medium size, quadrate to rectangular outline, with a brachial sinus, sulciplicate anterior commissure, fine costellae and prominent growth rugae. Externally, the variant resembles S. resupinata, except that the brachial sinus is more consistently developed, and the growth rugae more prominent. Internally, there is close similarity, except that the pedicle muscle field of var. dorsosinuata is more incised, and the pedicle septum broader (text-fig.66). George and Ponsford (1938, text figs.11, 14) gave serial sections of two specimens of S. cf. dorsosinuata, and these illustrate strongly incised pedicle muscle fields with strong lateral ridges and median septum.

There is a tendency for some specimens to become much wider than long (text-fig.63). They resemble the variant lata in width, but have the typical brachial sinus and growth rugae of the variant dorsosinuata. Their greater width relative to length is shown on text-figure 61, the length-width graph.

The variant gigantea (pl. 4, fig.1a) is recognised by its large size, semi-elliptical outline, and strongly inflated brachial valve. Internally the pedicle muscle field resembles that of S. resupinata (pl. 4, fig. 1a).

Demanet established var. lata on its length-width ratio,



TEXT-FIG. 63

elliptical outline, broad anterior pedicle sinus, and higher pedicle interarea (pl. 4, fig. 2a). Internally var. lata resembles S. resupinata in the form of the pedicle muscle field. Demanet (1934) stated that var. lata has a lower angle of divergence of the dental lamellae.

The variant pinguis (pl. 4, fig. 3) was diagnosed on its inflated outline. It is characterised by large size, a rounded, strongly dorsibiconvex outline, relatively short hingeline and prominent growth rugae. Internally it closely resembles S. resupinata, but the muscle fields are more incised (text-figs. 67, 68). George and Ponsford (1938, text-fig.9), illustrated strongly incised muscle fields. Specimen IRIG 4447, a partial internal mould from Dinant, illustrates a strongly incised, flabellate pedicle muscle field, with a strong median septum and lateral and anterior boundary ridges. Externally, the specimen has a strongly dorsibiconvex, rounded outline, and prominent growth rugae (text-fig.68).

Specimens BM BB40159 and B54136 are more transversely elongate forms of var. pinguis, resembling var. lata in length-width ratio.

Specimens of S. resupinata range from weakly dorsibiconvex to more strongly dorsibiconvex forms. These represent Parkinson's thin and thick forms. Parkinson (1954) attempted to show an evolutionary trend from thin to thick forms collected from C and D zones of the Lower Carboniferous. Thick forms are characteristic of the D zone, and although thin forms are characteristic of the C zone, they also occur in the D zone. The neotype is a thin form, and although not accurately defined stratigraphically, it was probably collected from the C zone (Parkinson, ibid). Schizophoria resupinata var. pinguis appears to represent the acme of inflation, and is restricted to the D zone (Parkinson, ibid). However, specimen BM B386 was collected from the C2 subzone of Bolland, Lancashire-Yorkshire, and BM B54136 from the C1-2 subzones of Thorpe Cloud, Derbyshire.

Schizophoria resupinata var. rotundata was established on small size, rounded outline, even convexity and lack of pedicle sinus. No specimens other than Demanet's type have been recognised. The pedicle muscle field resembles that of S. resupinata.

All variants of S. resupinata are rare, and generally re-occur at different horizons, although most have been examined from the D zone. Out of approximately several hundred specimens of S. resupinata, the following variant specimens have been examined:

var.	dorsosinuata	— 22
	gigantea	— 4
	lata	— 10
	pinguis	— 17
	rotundata	— 1

Externally they are recognised by their varietal features, but internally they closely resemble S. resupinata, except for slight details of muscle field incision and width of pedicle septum.

A sporadic appearance of a few variant specimens probably suggests that they merely represent a few mutant forms showing extreme variation. Many intermediate stages are seen trending towards extreme forms. Combinations of variation are seen in inflated and transversely elongated forms of var. pinguis, and transversely elongated forms of var. dorsosinuata.

Extreme variation may have been induced by environmental conditions. Bond stated (1941, p.290) that var. dorsosinuata may be the result of unfavourable conditions causing stunting and development of rugae, after a period of normal growth. But rugate and non-rugate specimens of S. resupinata occur together. The variant gigantea could represent a few large individuals which flourished under favourable conditions. The inflated var. pinguis occurs alongside less convex specimens of S. resupinata.

The varietal names are descriptive of the several variation trends, but synonymies and descriptions of variants have been included under S. resupinata to emphasize their close relationship to the species and as merely representing extreme individual variation.

Schizophoria elboltonensis George and Ponsford is distinguished externally from S. resupinata by its more quadrate outline. Serial sections by George and Ponsford (1938, text-fig.7) illustrated stubby brachiophores and short, stout brachiophore plates, in contrast to the more tapered brachiophores and longer, more slender brachiophore plates. But short brachiophore plates occur in ventribiconvex forms of S. resupinata, where the dental lamellae of the opposite valve are correspondingly longer (see p.182). Since S. elboltonensis differs only in respect of its quadrate outline and brachiophores and brachiophore plates, and no other specimens have been encountered in this study, the species is hereby considered as an additional variant of S. res-

upinata. This is in agreement with Bond (1941, p.290).

Comparisons of species

In 1938 George and Ponsford described S. nuda n.sp. This is a large species, characterised by an elliptical outline with the greatest width situated near the hingeline, a lack of brachial sinus, and strongly incised muscle fields. They compared S. nuda with one of Davidson's illustrations (1858, pl.29, fig.2). Campbell (1957, pl.12, fig.4) illustrated a specimen as S. aff. resupinata, but having a strongly incised brachial muscle field comparable with S. nuda.

The form of the pedicle muscle field of S. nuda, its flabellate outline, shape of the median septum, and even the variation in muscle field outline and width of median septum (1938, pl.5, figs.4, 5) apparently closely conforms to that of S. resupinata. In the brachial valve, (1938, pl.5, fig.1), the muscle field outline, digitate posterior adductors, variations in median septum, and pallial sinus trunks of the two species are similar.

The only distinction is relative incision, but incision is generally correlated with age. Although younger specimens of S. resupinata have moderately incised muscle fields, more convex forms have thicker shell over the umbones, and therefore more strongly incised muscle fields. Specimens from Elbolton Cracoe include several larger internal moulds with strongly incised muscle fields, occurring together with smaller, less incised moulds. Both forms have a comparable shell outline, differing only in convexity.

Many examples of strongly incised brachial muscle fields are preserved as fragmentary shells. Although incomplete in outline, the characteristic brachial sinus of S. resupinata is frequently present. Davidson (1858, pl.30, figs.1, 2) illustrates deeply incised muscle fields.

The holotype and paratypes of S. nuda are fragmentary, so that the shell outline has had to be reconstructed. Although S. nuda has greatest width situated posteriorly and lacks a brachial sinus, both outline variation and variation in development of a brachial sinus are seen also in S. resupinata. Schizophoria nuda is here considered as a synonym of S. resupinata.

Youthful specimens of S. resupinata superficially resemble young forms of S. woodi Bond in their rectangular to elliptical outline. But S. resupinata has a rectimarginate to rounded uniplicate, unisulcate or sulcate anterior commissure, coarser costellae, and a lack of growth rugae, in contrast to the rectimarginate to angular uniplication, finer costellation and more prominent growth rugae of S. woodi. Adult forms of the two species are similarly distinguished by their anterior plication and ornament, but also by their outline and dorsibiconvexity. Schizophoria resupinata is wider than long, and moderately dorsibiconvex, while S. woodi may also be as long as wide, or longer than wide, and strongly dorsibiconvex. Internal differences in muscle field outlines and incision, and form of the brachiophores and brachiophore plates are seen by comparing text-figures 64 and 72.

Text-figure 69 illustrates the specific distinctions of S. resupinata.

Australian specimens identified as S. resupinata by Koninck (1842, 1877), Jack and Etheridge (1892), Dun (1902), Howchin (1925) and Campbell (1957) have more strongly incised pedicle muscle fields and broader median septum than European specimens, although Dun stated that there was no feature in which the Australian forms differed from European forms. In other features the two forms are similar. Campbell's specimens of S. cf. resupinata are apparently smaller than the neotype, and possess fewer spines. But European specimens illustrate

great variation in these two characters. Cvancara's new Australian species S. verulamensis (1958, p.856) closely resembles these other Australian specimens identified as S. resupinata or S. cf. resupinata in outline and form of the pedicle muscle field. Cvancara's types were collected from a similar stratigraphical level as those of Campbell. All these Australian specimens are here considered to belong to one species, and apparently only differ from the European form of S. resupinata in the incision of the pedicle muscle field and width of the median septum.

Yanagida stated (1962) that his specimens of S. aff. S. resupinata from Japan differ from British ones in size, general lack of a brachial median sinus, relatively finer costellation and oblique brachial plates. However, variations in these characters are seen in British specimens, and the brachial (= brachiophore?) plates are oblique (= divergent?). These specimens have been listed under S. resupinata.

Schizophoria swallovi (Hall) from the Burlington Limestone of North America has previously been listed in synonymy with S. resupinata by Paeckelmann (1930) and Demanet (1934). Five specimens (No.6990) of S. swallovi have been examined from the James Hall Collection[1] of the American Museum of Natural History. These resemble S. resupinata in size, outline and costellation, but have a more strongly incised pedicle muscle field and growth rugae. Hall (1892, pl.6, fig.24), and Weller (1914, pl.22, fig.6) illustrated strongly incised pedicle muscle fields resembling those of Australian forms. An inflated form of S. swallovi resembling the European variant pinguis is illustrated by Weller (1910, pl.12, figs.6, 7). Schizophoria swallovi has tentatively been listed in synonymy with S. resupinata.

Schröter (1777, p.352, pl.5, fig.2) figured and described

a specimen grouped under Anomites from Costteton (= Castleton?) Derbyshire, which closely resembles Martin's illustrations (1809, pl.49, figs.13, 14).

Synonymies

The following authors have given short, unillustrated descriptions of S. resupinata:

Spirifer resupinatus, Fleming, 1828, p.375.
Orthis resupinata, Semenow, 1854, p.340.
Orthis resupinata Mart., Eichwald, 1860, p.813.
Orthis resupinata, Drevermann, 1902, p.515.
? Orthis (Schizophoria) resupinata Mart., Krenkel, 1913, p.27.
Schizophoria resupinata, Tolmatchoff, 1924, p.216.
? Orthis (Schizophoria) resupinata Martin, Gallwitz, 1928, p.515.
Schizophoria resupinata Martin, Termier, 1936, p.1216.
Schizophoria resupinata (Mart.), Paul, 1937, p.89, 110.

The following authors have had their specimens listed in synonymy with S. resupinata. Descriptions and figures are absent.

Terebratula resupinata, Sow., Levrault, 1828, p.154.
Terebratula resupinata So., Hoeninghaus, 1830, p.235.
? Terebratula resupinata. Sowerb., Keferstein, 1834, p.685, no.239.
Orthis resupinata (Phill.), Bronn, 1848, p.858.
Orthis resupinata, D'Orbigny, 1850, p.146, no.727.
?_____, Morris, 1854, p.141.
Orthis resupinata Koninck, Roemer, 1870, p.90.
Orthis resupinata Mart., Gumbel, 1879, p.532.
Orthis resupinata, Mart., Bleicher and Meig, 1884, p.109.
Orthis resupinata Martin, Etheridge, 1888, p.257.
Orthis resupinata Mart., Koch, 1893, p.295.
Orthis resupinata Martin., Stuckenberg, 1898, p.227.
Orthis resupinata, Martin, Cornet, 1905/6, p.150.
Schizophoria resupinata (Martin), Vaughan, 1905, p.296.
Schizophoria resupinata Mart., Keidel, 1906, p.373.

Orthis resupinata Mart., Grober, 1908, p.238.

Dalmanella resupinata Mart., Jarosz, 1909, p.692.

Schizophoria resupinata (Martin), Fredericks, 1926, p.42.

O. (Schizophoria) resupinata Martin, Lecointre, 1926, p.131.

Schizophoria resupinata Martin, Délépine, 1928, p.14; 1930, p.9.

Schizophoria resupinata Martin., Loweneck, 1932, p.12.

References listed as non. S. resupinata have been assigned to other species of Schizophoria or other genera or brachiopod group. These are as follows:

Ure (1763) — rhipidomellid ?
Phillips (1841) — S. striatula (Schlotheim)
Hall (1843) — S. tulliensis ?, (American sp.)
Schlotheim (1820, pl.15, fig.2) — lamellibranch ?
(1820, pl.15, fig.3) — S. woodi ? Bond
Vaughan (1908) — Aulacophoria ?
Sommer (1909, pl.27, fig.8) — rhipidomellid ?
Paeckelmann (1930) — S. striatula (Schlotheim)
Rakusz (1930) — rhipidomellid ?
Schmidt (1933) — S. striatula ? (Schlotheim)
Archaic and Verneuil (1942) — reference to Devonian locality.
Termier and Termier (1950, pl.71, fig.31) — S. woodi
Yanagida (1962, pl.21, fig.5) — Aulacophoria.

Material. —

Avon Gorge

BC B166 (plaster model) — limestones of Z1-2 subzones, quarry 2.

Belgium

IRIG (i)-(iii) — Waulsortian, Weve.

IRIG 1301 — Viséan, Furfooz.

IRIG(var. dorsosinuata), (internal mould); 3440 (including one fragmentary shell) — Tournaisian, horizon Tn 3, Tournai.

IRIG 3200(var. dorsosinuata), (including one fragmentary shell) — Tournaisian, horizon Tn 3, Trou du Frontal, Furfooz, Dinant.

IRIG 4447(var. dorsosinuata), (including three fragmentary shells) — Tournaisian, horizon Tn 3bR, Weve, Dinant.

IRIG 5496(var. dorsosinuata), (including one fragmentary shell); 8261 (including one partial pedicle internal mould) — Tournaisian, Tournai.

IRIG 3200(var. lata), (fragmentary shell) — Tournaisian, Tn 3bR, Dréhance, Dinant.

IRIG 8760(var. lata), (including two fragmentary shells) — Tournaisian (Waulsortian), Assise de Celles, Lez-Fontain, Natoye.

IRIG 1301(var. pinguis), (including one fragmentary shell) — Tournaisian (Waulsortian), Furfooz.

IRIG 4447(var. pinguis), (partial internal mould) — Tournaisian (Waulsortian), Tn 3bR, Vère chateau, Dinant.

Derbyshire

BC B167, 168 — reef limestone, Dielasma Bed, Middle D1 subzone, north end near summit, Treak Cliff, near Castleton.

BC B169 — similar stratigraphical position, south end near summit, Treak Cliff.

BM BB14879 — Lower Carboniferous, B2 subzone, Treak Cliff.

HMUG L5333/3 — Avonian reef limestones, north end near summit, Treak Cliff.

GSM 84681, 84683 — Carboniferous Limestone, Park Hill, Longnor.

GSM 84670 — Carboniferous Limestone, Park Hill, Longnor.

BM B54136(var. pinguis), (fragmentary shell) — Lower Carboniferous, D2 zone, Thorpe Cloud.

HMUG L5333/1(var. pinguis) — Lower Carboniferous, Avonian, west flank Eldon Hill.

BM BB40159(var. pinguis), (fragmentary shell), 40161, 40167 (fragmentary shell), 40169 (plaster cast), 40171 (fragmentary shell), 40172 — Lower Carboniferous, high D1 zone, Eldon Hill Quarry.

Isle of Man

BC B170-185 (182-plaster cast, 183, 184-pedicle internal moulds) — Poyllvaaish Limestone, Upper Knoll Limestone, (D2)P1a subzone, Ghaw Gortagh, near Poyll Vaaish.

BC B185 (pedicle internal mould) — Poyllvaaish Limestone, Lower Knoll Limestone, B zone, west of Ghaw Gortagh.

GSM 34260 — Carboniferous Limestone, Poolvash.

HMUG L3123/4 (partial internal mould) — Carboniferous Limestone Series, Balladoole.

BC B186(var. gigantea), (partial internal mould) — Poyllvaaish Limestone, Lower Knoll Limestone, B zone, west of Ghaw Gortagh, near Poyll Vaaish.

BC B187(var. lata), (partial internal mould) — Poyllvaaish Limestone, Upper Knoll Limestone, (D2)P1a subzone, Ghaw Gortagh.

HMUG L4256(var. pinguis) — Carboniferous Limestone, Poolvash.

SM E 6487(var. pinguis) — Carboniferous Limestone.

Ireland

GSM 39/28 — Carboniferous Limestone.

HMUG L3882/2 (internal mould) — Viséan, Carrick syncline.

TCD 3019, 3042, 3044 (fragmentary shells), 3048 — Tournaisian, D zone, Curkeen Hill, Dublin.

SM E 6559 — Carboniferous Limestone, Limerick.

UR 13590 (partial internal mould) — Waulsortian phase reef limestones, C1-2 zones, quarry one-third mile north-west Greeves, Foynes road, Ballylin, County Limerick.

UR 13596 (partial internal mould) — similar stratigraphical position, County Limerick.

GSI 3/4(var. dorsosinuata) — Carboniferous Limestone, Ballydoole, Limerick.

HMUG L127/1(var. lata), (distorted shell) — Carboniferous, near Cork.

Lancashire

BC B188 — Clitheroe Limestone, C1-2 reef limestone, south-west flank New Laund Hill, Bolland.

HMUG L123/1, 2 — Carboniferous Limestone, Bolland.

BC B189, 191 (plaster cast), 192 (internal mould), 193 (fragmentary internal mould) — Worston Shale Group, C2 S1 reef limestone, south face Bellman Quarry, Clitheroe.

BC B190 — same stratigraphical level, NW end Withgill Knoll, near Clitheroe.

BC B194 (internal mould) — same stratigraphical level, south face Salthill Quarry, Clitheroe.

GSM 3691; 3709 (partial internal mould); 84666 — Carboniferous Limestone, Withgill, Clitheroe.

SM E 6500, 6501 — Carboniferous Limestone, Clitheroe.

SM E 13607 (partial internal mould) — Carboniferous Limestone, Withgill Knoll, two miles south-west of Clitheroe.

BM B5699 (interior brachial valves) — Carboniferous Shale, Ulverston.

BM B386(var. pinguis) — Carboniferous Limestone, Bolland.

Mendips

GSM 3287 (partial internal mould); 3377 (fragmentary pedicle internal mould) — Lower Limestone Shales, K2 subzone, west side of north-south limb of Burrington Combe, Somerset.

Staffordshire

BM B49073 — Lower Carboniferous, D2 subzone, Narrowdale.

BM B4698 — Carboniferous, Wetton.

GSM 84672-4 — Carboniferous Limestone, Wetton, seven miles north-west of Ashbourne.

Yorkshire

Neotype BM BB2420; BM B384; 8328 — Carboniferous Limestone, Bolland.

BC B195 — Elbolton Limestone Series, Cyrtina septosa Beds, Middle D1 subzone, south flank Elbolton Knoll, Cracoe.

BC B196-205 (198-200 partial internal moulds, 202, 203 pedicle internal moulds, 204, 205 brachial internal moulds) — Elbolton Limestone Series, Tufa/Cyrtina septosa Beds, Middle D1 subzone, east-south-east flank Elbolton Knoll.

BC B206 — Elbolton Limestone Series, Cyrtina septosa Beds, Middle D1 subzone, G.P.O. post, Byra Bank, near Burnsall, Cracoe.

BM BB8150 — Lower Carboniferous, D1 subzone, Elbolton.

HMUG L3649/11 (fragmentary shell), 60, 63, 90, 96 (fragmentary internal moulds); L5335/1 (partial internal mould) — Avonian reef limestones, south-west flank Elbolton Knoll, Cracoe.

SM E 11, 123, E 11, 124 (fragmentary shell) — Carboniferous Limestone, D zone (C. juddi bed in reef knoll), Wedber, near Malham.

SM E 6536 (interior brachial valve) — Carboniferous Limestone, Settle.

BM BB8149; B54027(var. lata) — Lower Carboniferous, Viséan, D1 subzone, Elbolton, Thorpe.

BM B54146(var. pinguis) — Viséan, D1 zone, Elbolton.

IC 11135(var. pinguis) — Carboniferous Limestone, Elbolton, Thorpe.

BC B207(var. pinguis), (fragmentary shell) — S2 reef limestone, right bank Stockdale Beck above Force, Scaleber Bridge, near Settle.

SM (var. pinguis) — Carboniferous Limestone, Craven.

Specimens are preserved as entire shells, except where otherwise indicated. Occurrences of variants are also indicated.

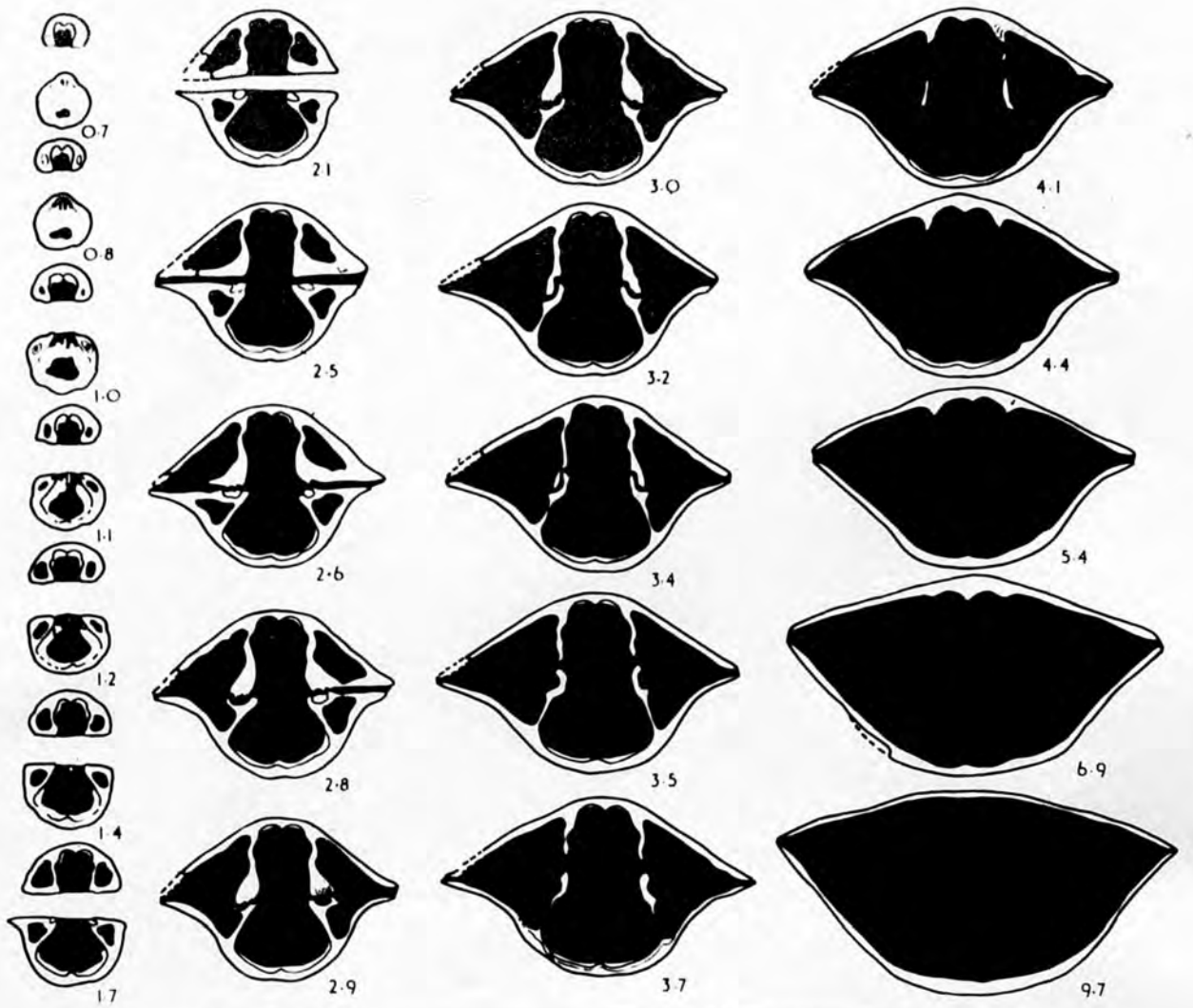
TEXT-FIG.64 — Schizophoria resupinata (Martin)

Measurements of sectioned specimen in millimetres.

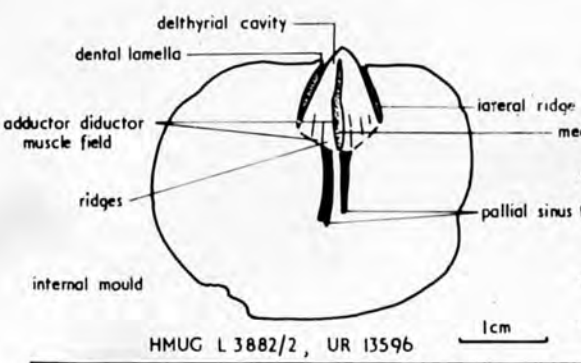
Length	Width	Depth
23.0	30.0	16.0

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 1½. IC specimen, Carboniferous Limestone, Swinden, near Grassington, Yorkshire.

a -- Pedicle muscle field, natural size.
b -- Brachial muscle field, natural size.
c -- Articulation x 5.
d -- Supplementary articulation x 5.
e -- Myophore structure x 10.

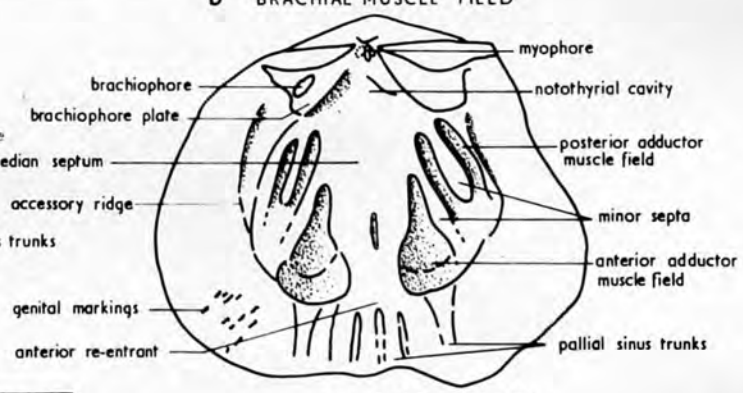


a PEDICLE MUSCLE FIELD



HMUG L 3882/2, UR 13596

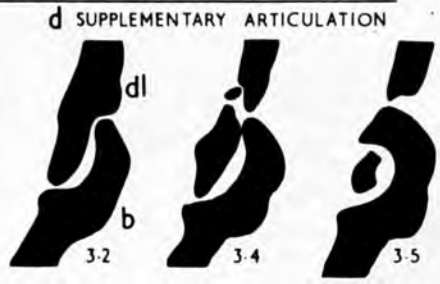
b BRACHIAL MUSCLE FIELD



BM B 5699, SM E 6536

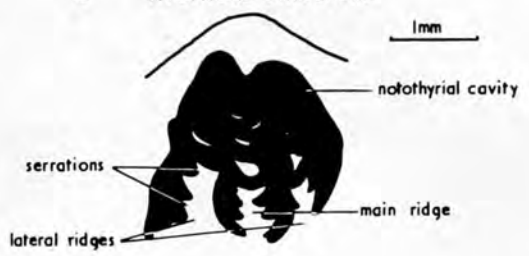
c ARTICULATION

d SUPPLEMENTARY ARTICULATION



as accessory socket
at accessory tooth
b brachiophore
dl dental lamella
S socket
t tooth
1mm

e MYOPHORE STRUCTURE



Text-fig. 64

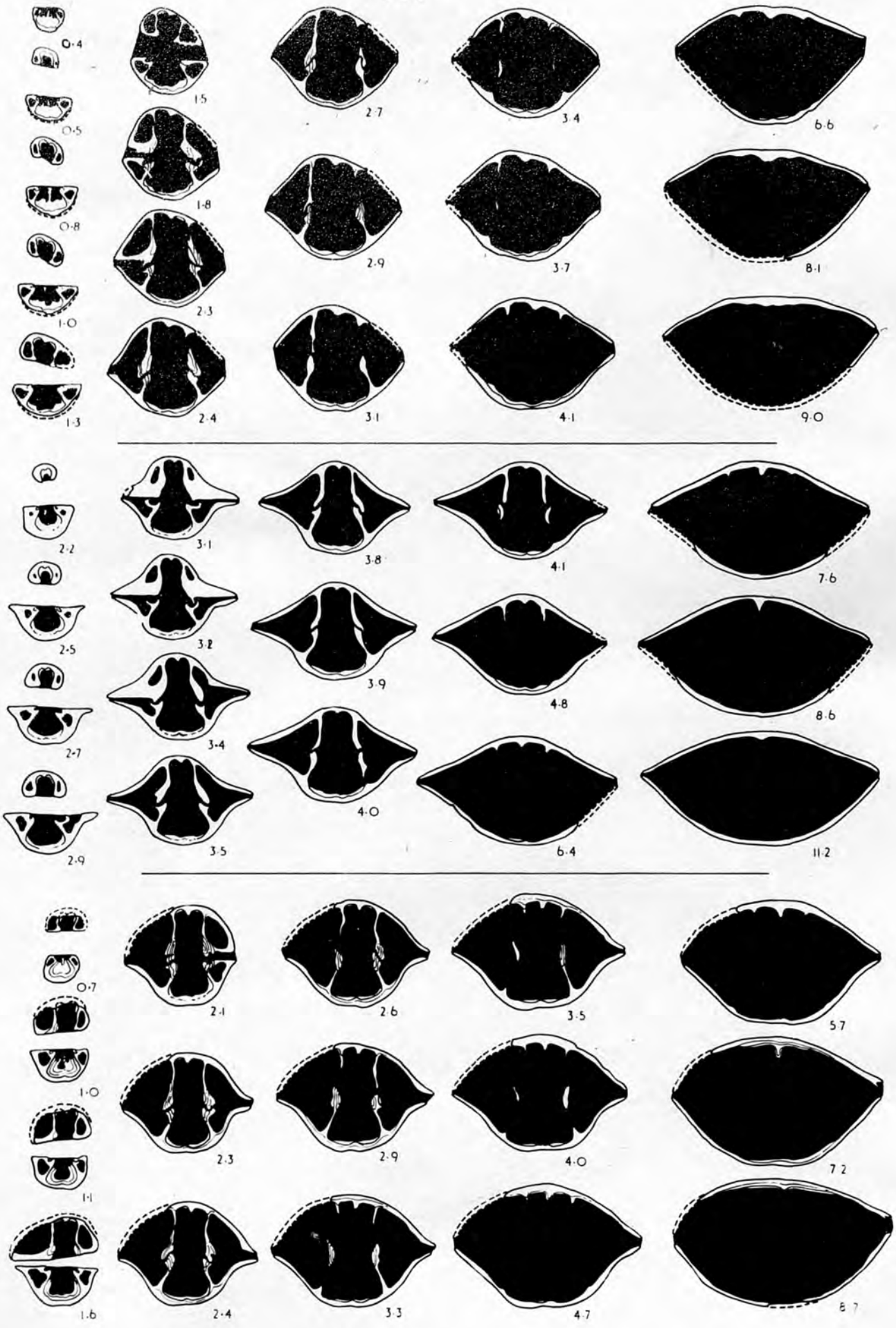
TEXT-FIG.65 — Schizophoria resupinata (Martin)

Measurements of sectioned specimens in millimetres

	Length	Width	Depth
A	19.0	24.6	13.6
B	20.3	26.0	14.5
C	20.9	26.3	13.5

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbones.

A — BC B191 — C2 S1 reef limestone, south-west end Bellman Quarry, Clitheroe, Sections x 1½.
B — BC B166 — Z1-2 limestones, Quarry 2, Avon Gorge. Sections x 1½.
C — BC B182 — Poyllvaaish Limestone, Upper Knoll Limestone, P1a subzone, Ghaw Gortagh, near Poyll Vaaish, Isle of Man. Sections x 1½.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Text-fig. 65

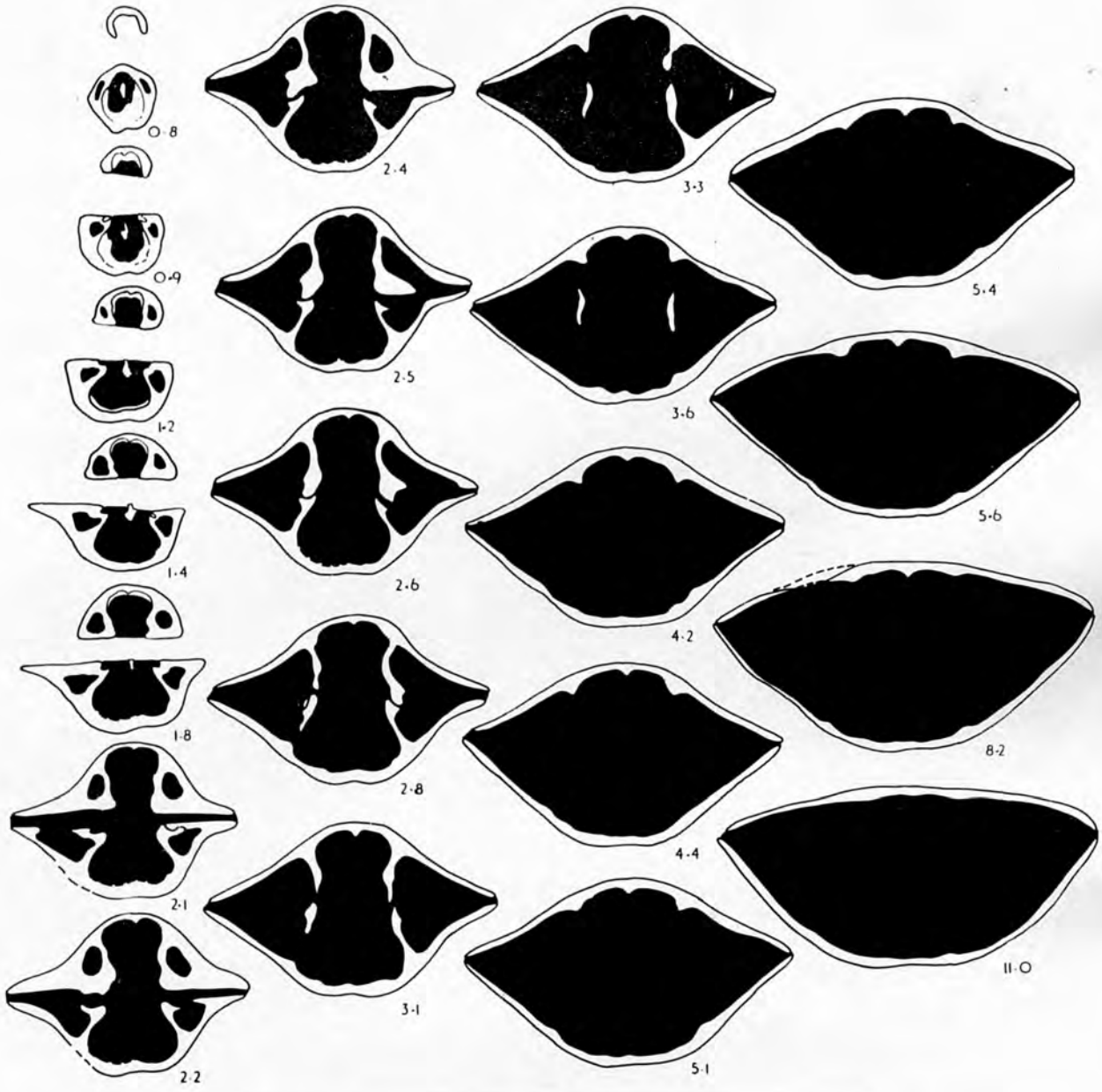
TEXT-FIG.66 — Schizophoria resupinata var. dorsosinuata Demanet.

Measurements of sectioned specimen in millimetres

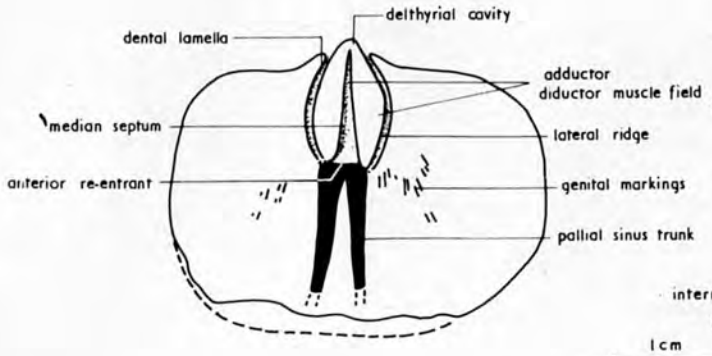
Length	Width	Depth
20.2	26.5	13.4

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2. GSI 3/4 Carboniferous Limestone, Ballydoole, Limerick, Ireland.

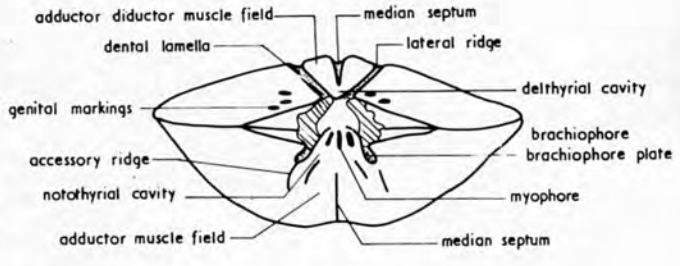
a -- Pedicle muscle field x 1½.
b -- Brachial muscle field x 1½.



a PEDICLE MUSCLE FIELD



b BRACHIAL-PEDICLE MUSCLE FIELD



internal mould
IRIG

1 cm

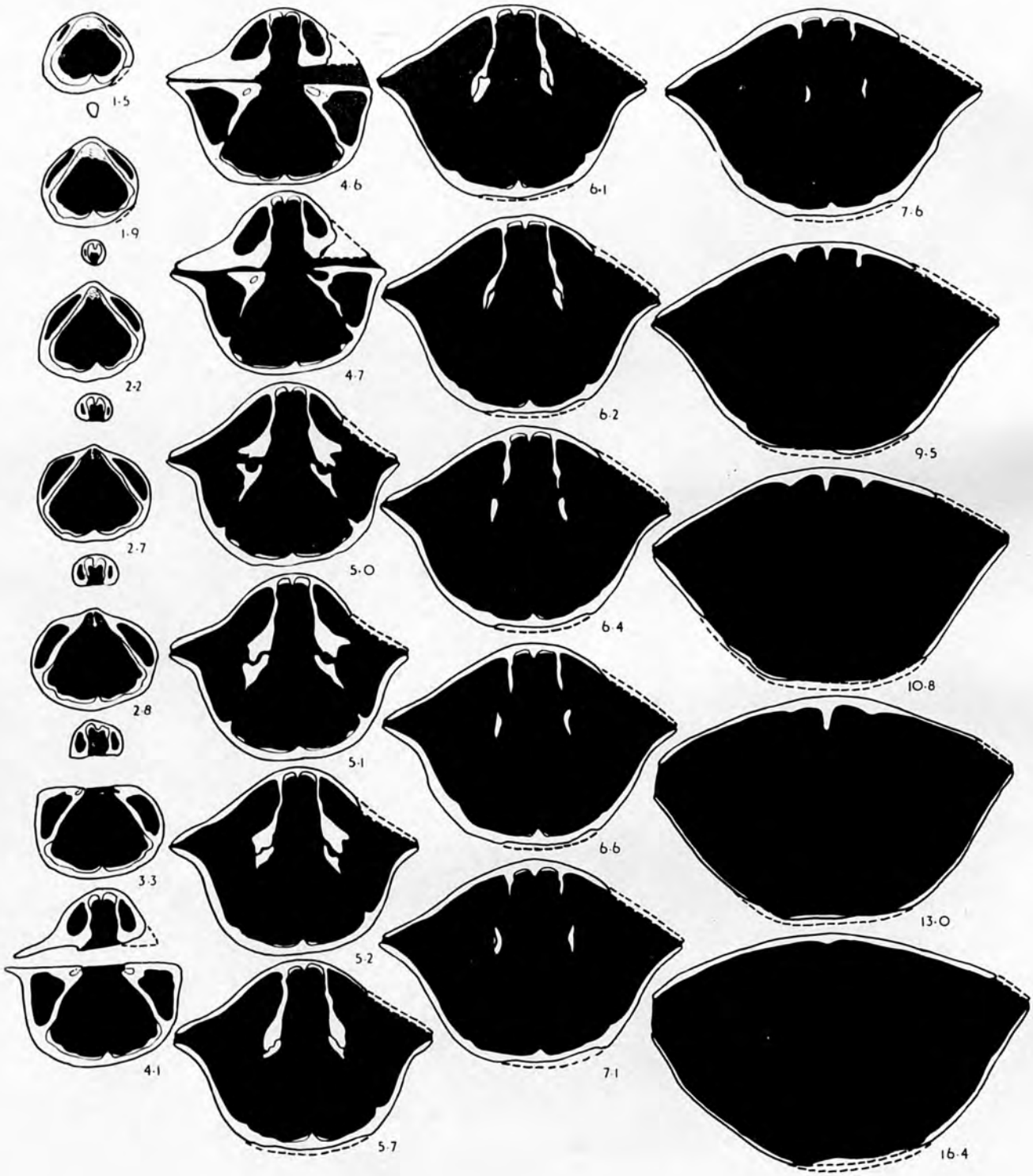
Text-fig. 66

TEXT-FIG.67 — Schizophoria resupinata var. pinguis Demanet.

Measurements of sectioned specimen in millimetres

Length	Width	Thickness
32.0	40.2	23.5

Numbers below serial sections indicate distances measured anteriorly from brachial umbo.
Sections x 1½. BM BB40169, Lower Carboniferous, high D1 zone, Eldon Hill Quarry, Derbyshire.



Text-fig. 67

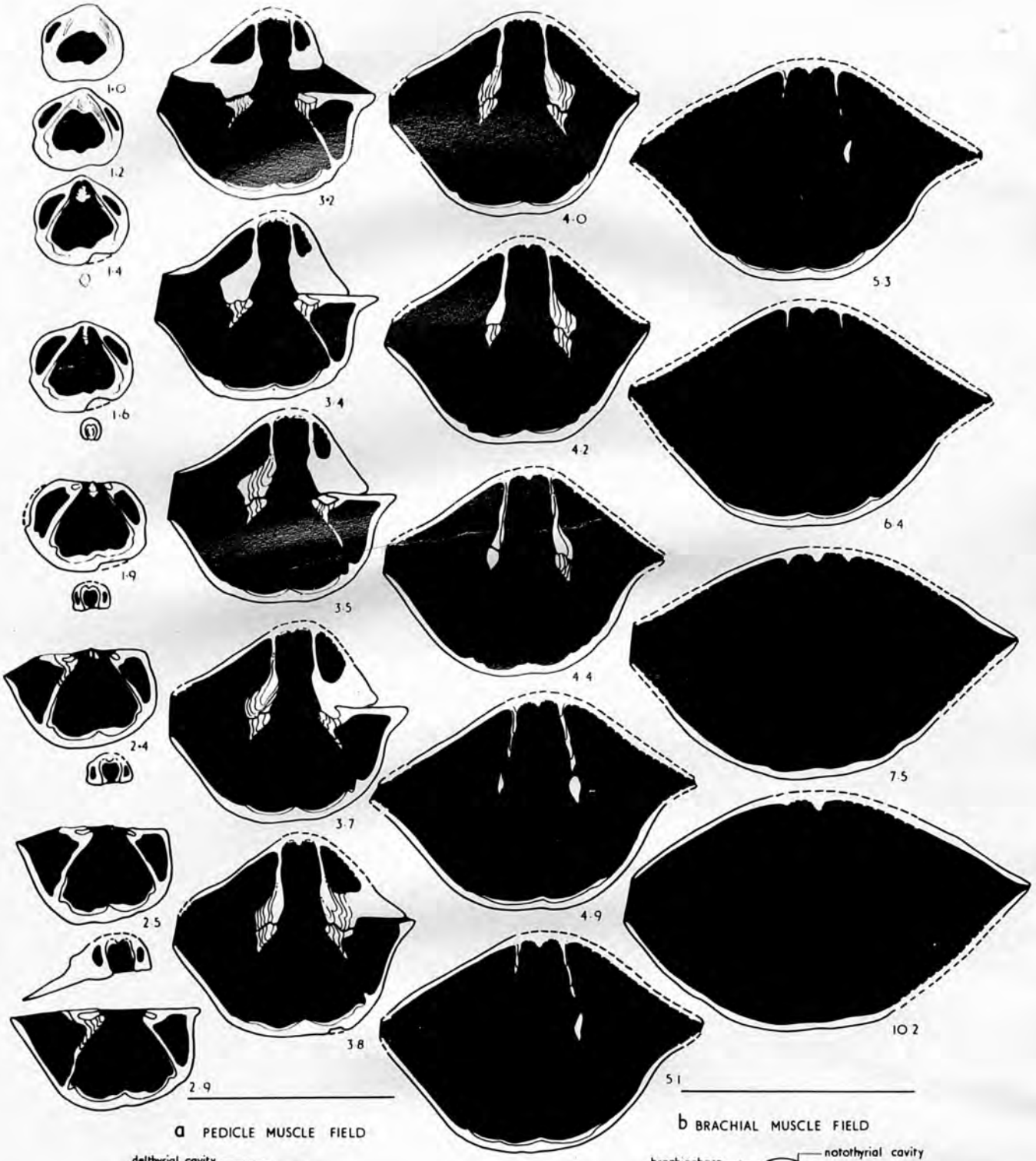
TEXT-FIG.68 — Schizophoria resupinata var. pinguis Demanet.

Measurements of sectioned specimen in millimetres

Length	Width	Depth
26.9	35.9	19.3

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2. IRIG 3200 — Tournaisien (Waulsortien), Drehance, Belgium.

a -- Pedicle muscle field x 1½.
b -- Brachial muscle field x 1½.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4·0
4·2
4·4
4·9
5·1
5·3
6·4
7·5
10·2
a PEDICLE MUSCLE FIELD
b BRACHIAL MUSCLE FIELD
delthyrial cavity
dental lamella
adductor diductor muscle field
lateral ridge
median septum
anterior re-entrant
1cm
brachiophore
notothyrial cavity
brachiophore plate
adductor muscle field
accessory ridge
pallial sinus trunk
growth rugae
partial internal moulds
IRIG 4447
1 cm

Text-fig. 68

COMPARISON OF CARBONIFEROUS SPECIES OF SCHIZOPHORIA

SPECIES	SIZE	OUTLINE	CONVEXITY	ANTERIOR COMMISSURE	ORNAMENT	DENTAL LAMELLAE	PEDICLE MUSCLE FIELD	BRACHIOPHORES BRACHIOPHORE PLATES	BRACHIAL MUSCLE FIELD
Schizophoria resupinata (Martin)	medium large	rectangular elliptical	ventribiconvex biconvex moderately dorsibiconvex	rectimarginate uniplicate unisulcate sulciplicate	costellae fine some thick costellae with spine bases rugae weak absent	ventrally subparallel	broad flabellate moderately incised	stubby brachiophores slender divergent brachiophore plates	elliptical digitate posterior adductor scars moderately incised
Schizophoria connivens (Phillips)	small	rectangular rounded	ventribiconvex biconvex moderately dorsibiconvex	quadrate uniplicate biplicate sulciplicate	costellae coarse some thick costellae with spine bases rugae prominent	ventrally subparallel-divergent	moderately narrow oval weakly flabellate strongly incised	stubby brachiophores -stout divergent brachiophore plates	elliptical rounded moderately incised
Schizophoria gibbera (Portlock)	medium large	elliptical rounded	strongly dorsibiconvex	rounded uniplicate	costellae very fine some thick costellae rugae present	ventrally convergent	narrow parallel-sided incised	stubby brachiophores long slender curved brachiophore plates	rectangular elliptical strongly incised
Schizophoria hudsoni George	medium small	rectangular quadrate	weakly dorsibiconvex	quadrate uniplicate biplicate	costellae coarse rugae prominent	—	oval flabellate strongly incised	stout brachiophore plates	elliptical rounded moderately incised
Schizophoria linguata (Quenstedt)	medium small	rectangular elliptical	great ontogenetic increase in dorsibiconvexity	rounded uniplicate	costellae very fine some thick costellae rugae present	ventrally subparallel	narrow parallel-sided incised	stubby brachiophores long slender curved brachiophore plates	rectangular elliptical moderately incised
Schizophoria sp. nov.	medium small	rectangular elliptical	biconvex moderately dorsibiconvex	rounded uniplicate	costellae very fine some thick costellae rugae prominent	ventrally subparallel	narrow parallel-sided incised	stubby brachiophores long curved brachiophore plates	rectangular elliptical moderately incised
Schizophoria woodi Bond	large small	rounded rectangular elliptical	strongly dorsibiconvex	angular uniplicate	costellae very fine some thick costellae with spine bases rugae prominent	ventrally subparallel	broad flabellate strongly incised	stubby brachiophores long slender curved brachiophore plates	flabellate moderately incised

Text-fig. 69

Schizophoria woodi Bond

Pl.4, figs.4-13; text-figs.70-76.

Schizophoria resupinata var. gibbera, Demanet, 1934, pl.4, figs.1-3, non. 4.

Schizophoria woodi Bond, 1941, p.299, pl.22, figs.F, G; text-fig.37.

Schizophoria resupinata Martin, Termier and Termier, 1950, pl.71, fig.31.

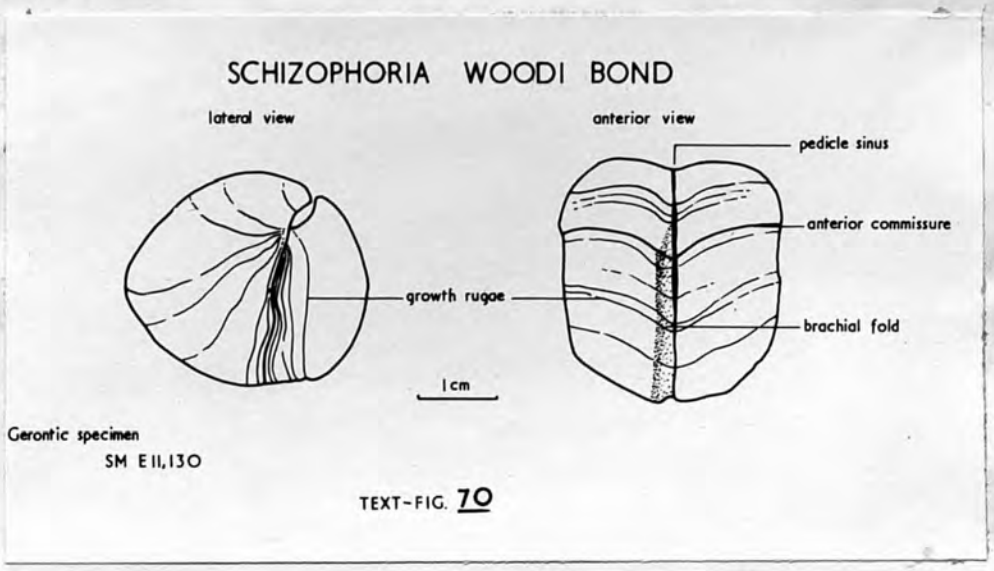
Schizophoria resupinata (Martin), Wright, 1952, text-fig.5 (3).

Holotype. — The holotype illustrated by Bond (1941, pl.22, figs.F, G) was selected from the Tiddeman Collection of Skipton Museum and deposited in the British Museum (Natural History), BB8152.

Diagnosis. — Shell medium to large, rounded to transversely elongate-elliptical, generally strongly dorsibiconvex, with narrow, groove-like pedicle sinus and subangular uniplicate anterior commissure. Shell finely costellate, rugate. Pedicle muscle field flabellate, strongly incised, longitudinally divided by broad, rounded median septum. Brachial muscle field flabellate, moderately incised, bounded posteriorly by slender, curved brachiophore plates supporting stubby, hoof-like brachiophores.

Description. — Shell medium to large, biconvex to strongly dorsibiconvex, rounded to transversely elongate-elliptical in outline, with greatest width at midlength. Pedicle valve convex umbonally, flattening laterally, depressed medially. Concentric peripheral ridge occasionally developed in older individuals. Brachial valve more convex, generally evenly convex longitudinally, flattening laterally. Beaks small, pointed, close, almost touching in old age specimens; brachial beak more incurved; umbonal slopes steeper. Umbones level, or either valve projecting. Hingeline submegathyrid. Cardinal angles rounded. Pedicle

interarea prominent, high, curved to beak; delthyrium higher than wide, open. Brachial interarea lower, half height of pedicle interarea, curved to beak; notothyrium as wide as high, open. Pedicle sinus narrow, angular, groove-like, originating half-way along valve, slightly broadening and deepening anteriorly. Narrow brachial fold generally developed adjacent to anterior commissure (text-fig.70). Anterior commissure uniplicate, due mainly to high, broad, subangular dorsal, linguiform



TEXT-FIG. 70

extension of pedicle valve. Lateral commissure occasionally produced into lip postero-laterally. Shell costellate, rugate, punctate. Radial costellae fine, rounded, separated by narrower, more angular striae, 6 to 7 costellae in 1mm. at 10mm. from beaks; costellae increasing by bifurcation and intercalation. Scattered costellae thickened, with hollow spine bases developed anteriorly. Growth rugae concentric, thick, concentrated laterally and anteriorly.

Teeth prominent, compound, supported by anteriorly divergent, ventrally subparallel to convergent dental lamellae, which bound delthyrial cavity, articulating with brachial dental sockets (text-figs.72, 73, sections 4.2-5.3; 2.1-2.7). Articulation supplemented by interlocking ends of dental lamellae and

brachiophore plates (text-fig.73, sections 3.1, 3.4). Shell partially filling delthyrial cavity, decreasing in thickness and disappearing anteriorly (text-figs.72, 73, sections 1.6-7.2; 0.6-3.1).

Pedicle muscle field (text-figs.72a, 73a) one third to one half valve length, flabellate, strongly incised, bounded posteriorly by dental lamellae, laterally and anteriorly by ridge-like extensions of lamellae. Ridges decreasing in height anteriorly, smoothly reflexed to form deep, subrounded anterior re-entrant, uniting with median septum. Muscle field longitudinally divided by median septum, originating near point of delthyrial cavity, narrow, rounded, broadening and increasing in height anteriorly, forming one third to one half width of muscle field (text-figs.72, 73, sections 1.6-8.5, a; 0.6-7.1, a). Pallial sinus pattern consisting of two parallel trunks originating from anterior ends of diductor muscle field (text-fig.73a). No evidence of genital markings or pedicle muscle scars.

Myophore compound, average width 1.5mm., with central ridge bordered by two shorter, narrower ridges, one either side (text-figs.72, 73, sections 1.6-2.3; 0.6-1.6), all serrated. Shell partially filling notothyrial cavity, decreasing in thickness and disappearing anteriorly (text-figs.72, 73, sections 0.5-4.2; 0.6-4.1). Stubby, hoof-like brachiophores curved postero-laterally, and fused to slender, long, curved brachiophore plates bounding notothyrial cavity (text-figs.72, 73, sections 1.3-5.6; 0.6-3.8). Dental sockets deep, oval in transverse section, bounded posteriorly by hingeline, antero-medially by brachiophores and brachiophore plates, postero-laterally by fulcral plates (text-figs.72, 73, sections 3.8-4.2; 2.0-2.4). Sockets bounded internally by smaller, shallower accessory sockets, and externally by larger, deeper, irregularly shaped accessory cavities, underlying fulcral plates (text-figs.72, 73, sections 3.8; 2.3, 2.4). Fulcral plate slender, uniting

brachiophores with postero-lateral shell margin (text-figs.72, 73, sections 3.8, 4.2; 2.0-2.4).

Brachial muscle field (text-figs.72b, 73b) moderately incised, flabellate, longer than wide, one half valve length, bounded posteriorly by ends of brachiophore plates, laterally and anteriorly by accessory ridges. Ridges divergent for one half to two-thirds length of muscle field, convergent anteriorly, reduced in height, reflexed to form shallow, subangular re-entrant, united with median septum. Median septum originating at base of notothyrial cavity, low, subrounded, slightly increasing in width and height anteriorly (text-figs.72, 73, sections 1.3-7.2, b; 0.8-5.6, b). Pallial sinus pattern consisting of four trunks, two originating from anterior ends of adductor muscle field, two originating from antero-lateral limits of muscle field (text-figs.72b, 73b). No evidence of genital markings.

Dimensions in millimetres. —

	Length	Width	Depth	Length of hingeline
Holotype BM B8152	24.1	27.3	22.5	-

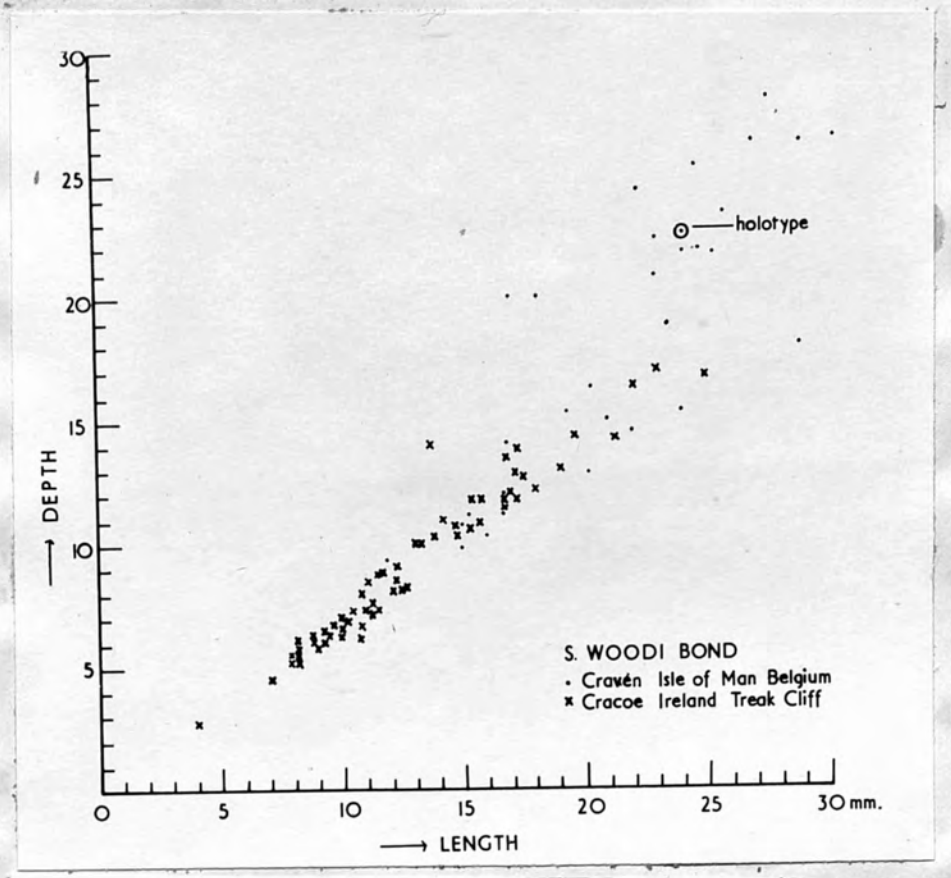
— uniplicate anterior commissure —

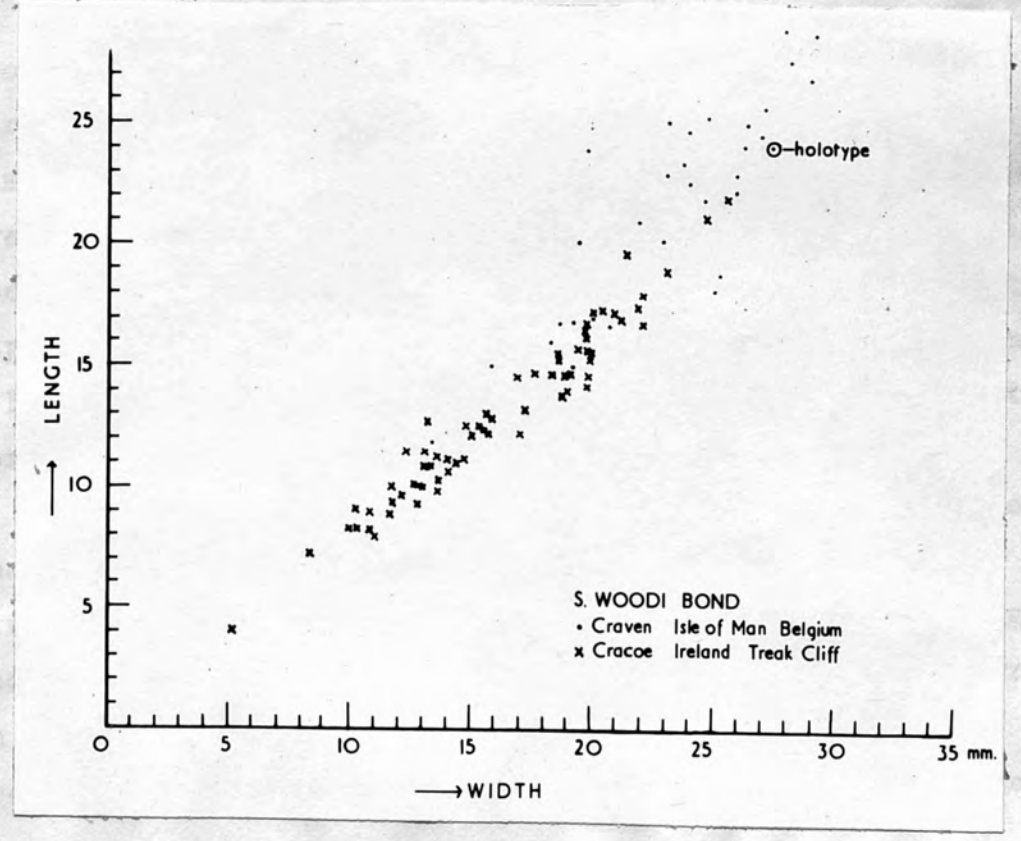
External dimensions of other material are plotted on text-figure 71. Some smaller forms of S. woodi from Cracoe, Ireland, and Treak Cliff have been plotted separately.

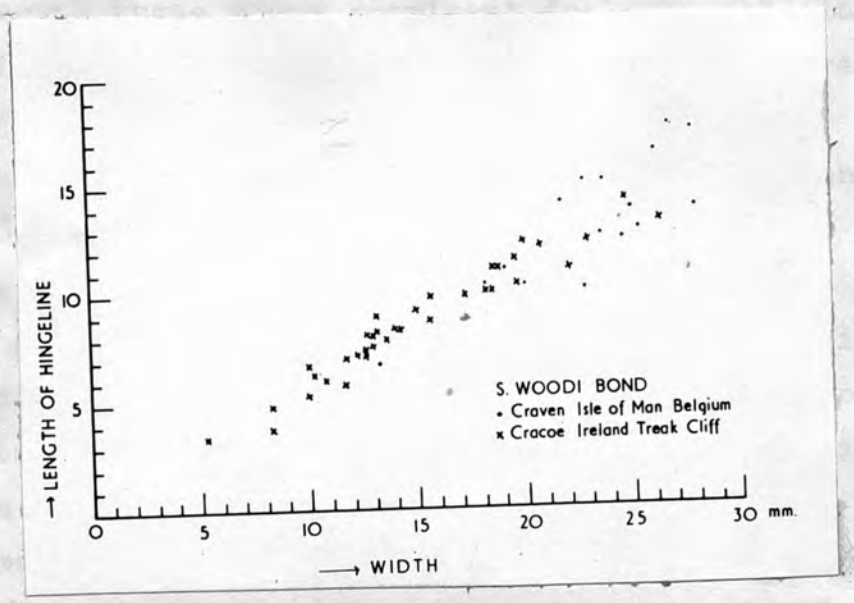
Dimensions of available muscle fields;

	Length of pedicle muscle field	Width of pedicle muscle field
BC B249	10.2	3.8
BC B250	7.9	4.8
BM BB39886	6.8(+)	4.5
BM BB39953	7.3	6.4
HMUG L5321/9	6.0	5.4
HMUG L5323/9	5.1	3.5
	Length of brachial muscle field	Width of brachial muscle field
BM BB39957	7.8	5.8

BM BB39885	9.0	6.4
BM BB39906	8.3(+)	7.0
BM BB39926	11.2(+)	9.3







Accurate measurement of the hingeline of the holotype was not possible.

Text-fig.71.

Remarks. — All specimens are well preserved except for slight distortion and fragmentation of some Belgian material. The pedicle beak of the holotype has been ground away.

Dorsibiconvexity, gibbosity, inflation of the brachial umbo, length-width ratio, and height of the anterior commissure increase with age. Various stages of these are seen in specimens examined. Youthful individuals are more biconvex, with beaks level or pedicle beak projecting posteriorly of the brachial umbo, much wider than long, and have a rectimarginate to weakly uniplicate anterior commissure (text-fig.75). Specimen SM E11,130, probably a gerontic individual, is deeper than wide (text-fig.70).

There is considerable phenotypic variation in shell outline, as illustrated by Bond (1941, p.299, and fig.37) from the British Museum specimens. Similar trends shown by Belgian specimens are illustrated on text-figure 75. The central specimen is comparable with the holotype, longer than wide, and strongly dorsibiconvex, with a broad subangular anterior plication.

Growth rugae are a prominent feature, especially on older individuals (text-fig.70), where the commissural junction may be difficult to distinguish.

The brachial, ridge-like fold is prominent on specimen SM E11,130, and the opposing pedicle sinus continues dorsally across the anterior commissure (text-fig.70).

Specimens assigned to S. woodi from Treak Cliff, Derbyshire, and Swinden and Elbolton Knolls, Yorkshire, do not generally attain the same size, dorsibiconvexity, and gibbous appearance as those from Craven and the Isle of Man. The former are also much wider than long. The lack of dorsibiconvex forms could be due to lack of collecting, although several hundred specimens have been examined. External and internal characters of the two forms are very similar (cf. text-figs.73, 72).

Variation in the pedicle muscle field of S. woodi is shown on the serial sections and inset figure of text-figure 72. The lateral ridges and median septum are narrower, and the anterior limits of the muscle field ill-defined.

Belgian forms are similar internally to British specimens (text-fig.74A).

Small, biconvex forms of S. woodi, especially from Elbolton and Swinden Knolls, and Treak Cliff, superficially resemble S. connivens (Phillips) in size, tumid outline, and prominent growth rugae. But S. woodi has fine costellae, less prominent growth rugae and an angular uniplicate anterior commissure, in contrast to the coarse costellae, thick rugae and quadrate-uniplicate or biplicate commissure. Internally they are quite distinct (cf. text-figs.73 and 44).

Schizophoria woodi superficially resembles S. gibbera (Portlock) in dorsibiconvexity and costellation. Although strongly dorsibiconvex and finely costellate, S. woodi has slightly coarser costellae, and rugae developed, and is less strongly dorsibiconvex. In other characters the two species

are readily distinguishable. Schizophoria woodi may be as long or longer than wide, has a subangular anterior plication, narrow, groove-like pedicle sinus, and a lack of concentric folds. In contrast, S. gibbera is wider than long, has a broad, rounded anterior plication, no pedicle sinus, and a concentric fold on both valves. Internally, the flabellate pedicle muscle field and broad rounded median septum contrasts strongly with the narrow, parallel-sided muscle field and narrower septum of S. gibbera. The flabellate brachial muscle field, with the greatest width near the mid-length, and narrow median septum contrasts with the rectangular to oval muscle field, with the greatest width situated more anteriorly, and broad median septum of S. gibbera.

Strongly dorsibiconvex individuals of S. woodi also superficially resemble comparable forms of S. linguata (Quenstedt) in outline and costellation. Both are strongly dorsibiconvex and finely costellate, but S. woodi is more rounded in outline, and has a narrower, more angular pedicle sinus and anterior plication, in contrast to the quadrate to rectangular outline, and rounded sinus and plication of S. linguata. The concentric marginal ridges characteristic of S. linguata are less frequently developed. Internally, S. woodi differs from S. linguata in similar features as S. gibbera.

Youthful specimens of the two species are generally distinct. Schizophoria woodi is more rounded in outline, more convex, especially umbonally, and has a subangular anterior plication, in contrast to the rectangular to elliptical outline, and rounded plication of S. linguata. However, specimens of S. woodi from Elbolton, Swinden and Treak Cliff superficially resemble S. linguata in their wider outline.

Specimens of S. woodi from Elbolton and Swinden Knolls and Treak Cliff have previously been assigned to S. resupinata (Martin), (Wright, 1952, Parkinson, 1954). Differences between these specimens and S. resupinata are shown on text-figure 76.

Figures 1 and 2 represent youthful stages of the two species, and 6 and 7, more adult forms. Figures 3 to 5 are included to illustrate the range of variation of S. resupinata .

Externally there are differences in convexity, inflation of the brachial valve, shape of the anterior plication, presence of a brachial sinus, coarseness of costellation and development of growth rugae. Internally there are differences in the incision of the pedicle muscle field, width of the median septum (Wright, 1952, p.15), and development of an anterior re-entrant. In the brachial valve there are differences in muscle field length, brachiophore and brachiophore plates, and width of the median septum.

Specimens of S. resupinata (Martin) s.s. do occur with S. woodi at these localities.

Material. —

Belgium

BM B13197/1,6,9 (distorted shells) — Lower Carboniferous, Visé.

HMUG L1152/1 (plaster cast), 2 — Carboniferous.

IRIG 2737 — Viséan, Visé.

IRIG 3440 — Lower Carboniferous, Calcaire de Visé, Visé.

Derbyshire

BC B208-231 (224, fragmentary shell, 225-7, plaster casts, 228, fragmentary pedicle internal mould, 229, pedicle internal mould, 230, internal mould, 231, pedicle internal mould) — reef limestones, Middle D1 subzone, south end near summit, Treak Cliff.

BC B232-236 — same stratigraphical level, Dielasma bed, north end near summit, Treak Cliff.

BM BB39846, 39852, 39757 (brachial internal mould), 39883, 39885 (brachial internal mould), 39886 (pedicle internal mould), 39903, 39906 (brachial internal mould), 39913, 39925, 39926 (brachial internal mould), 39942, 39953 (pedicle internal mould), 39962, 39984 — Lower Carboniferous, Dielasma Bed, Upper/Middle D1 subzone, Treak Cliff.

HMUG L5323/5,9 (pedicle internal mould, 14,44,45,63,64,

68,70,84,87,95,123-125,128 — Avonian reef limestones north end near summit, Treak Cliff.

Ireland

TCD M2647 b, 27125 b (fragmentary shell) — Viséan, D1 subzone, County Meath.

Isle of Man

BC B237-252 (239 partial internal mould, 246 pedicle valve, 249,250 pedicle internal moulds, 251,252 partial brachial internal moulds — Poyllvaaish Limestone, Upper Reef Knoll Limestone, (D2)Pla zone, Ghaw Gortagh, near Poyll Vaaish.

BM B54118, 54119 (fragmentary shells), 54120 (plaster cast), 54121 (fragmentary shell) — Lower Carboniferous, Poolvash.

GSM — Lower Carboniferous, Poolvash.

Yorkshire

HMUG L5321/7 (pedicle internal mould) — Avonian reef limestones, Elbolton Knoll, Cracoe.

Holotype BM BB8152 (pedicle beak ground) — Lower Carboniferous, Craven.

HMUG L3674/2 — Wedber reef Knoll C2 subzone, near Malham.

IC 11136 — Lower Carboniferous, Wedber, Malham.

SM E11,128, 11,129 (fragmentary shell), 11,130 — Carboniferous Limestone, D reef Knoll, Wedber, near Malham.

Specimens are preserved as entire shells, except where otherwise indicated.

TEXT-FIG.72 — Schizophoria woodi Bond

Measurements of sectioned specimen (A) in millimetres

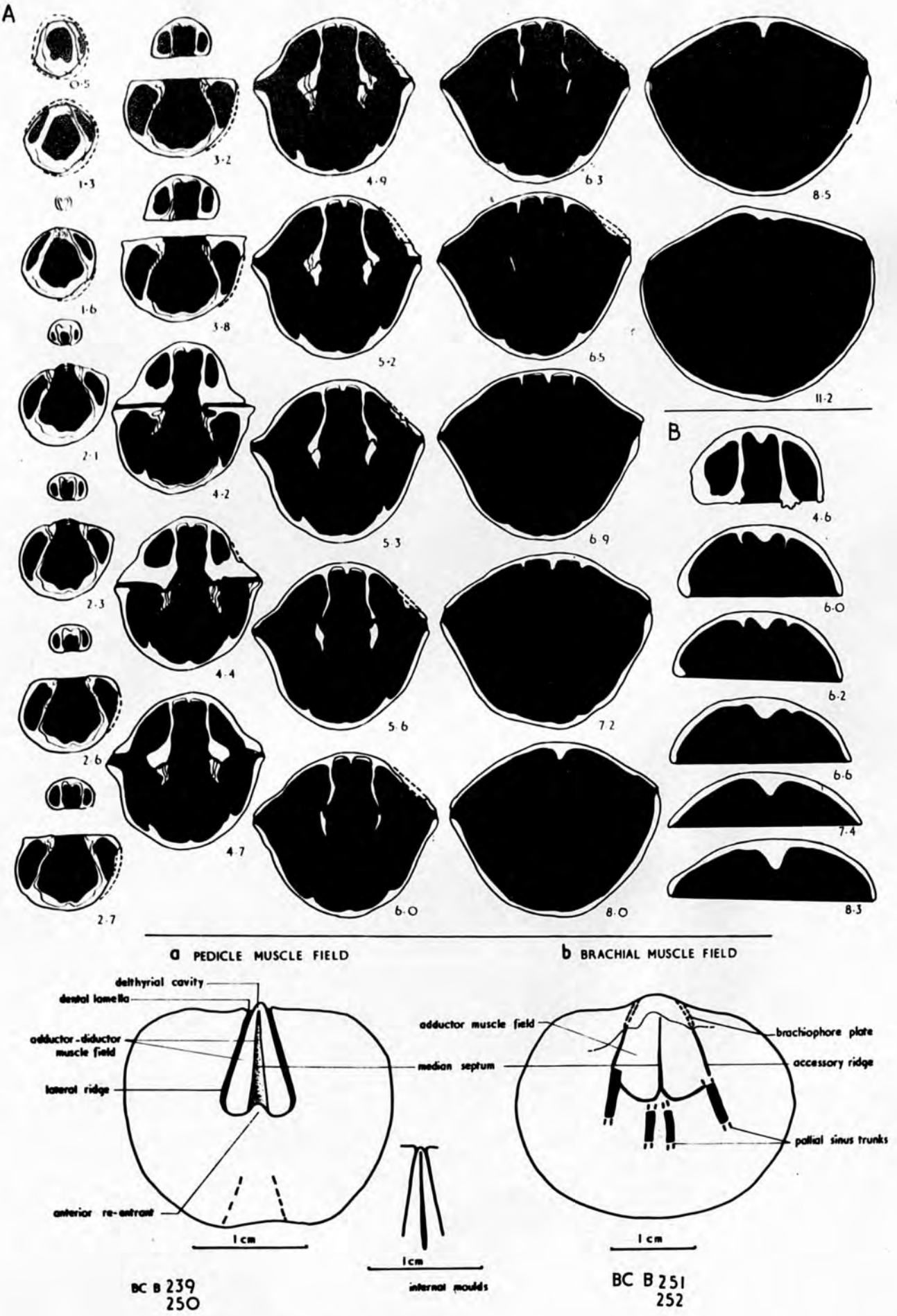
Length	Width	Depth
26.1	27.1	22.5

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 1½.

A — BC B248 — Poyllvaaish Limestone, Upper Reef Knoll Limestone, (D2)Pla zone, Ghaw Gortagh, near Poyll Vaaish, Isle of Man.

B — BM B54120 (sections of pedicle muscle field) — Carboniferous Limestone, D2 zone, Poolvash, Isle of Man. Sections x 1½.

a — Pedicle muscle field x 2.
b — Brachial muscle field x 1½.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6·3
6·5
6·9
7·2
8·0
8·5
11·2
B
4·6
6·0
6·2
6·6
7·4
8·3
a PEDICLE MUSCLE FIELD
b BRACHIAL MUSCLE FIELD
delthyrial cavity
dental lamella
adductor-diductor muscle field
lateral ridge
anterior re-entrant
1 cm
median septum
internal moulds
BC B 239
250
adductor muscle field
brachiophore plate
accessory ridge
pallial sinus trunks
BC B 251
252

Text-fig. 72

TEXT-FIG.73 — *Schizophoria woodi* Bond

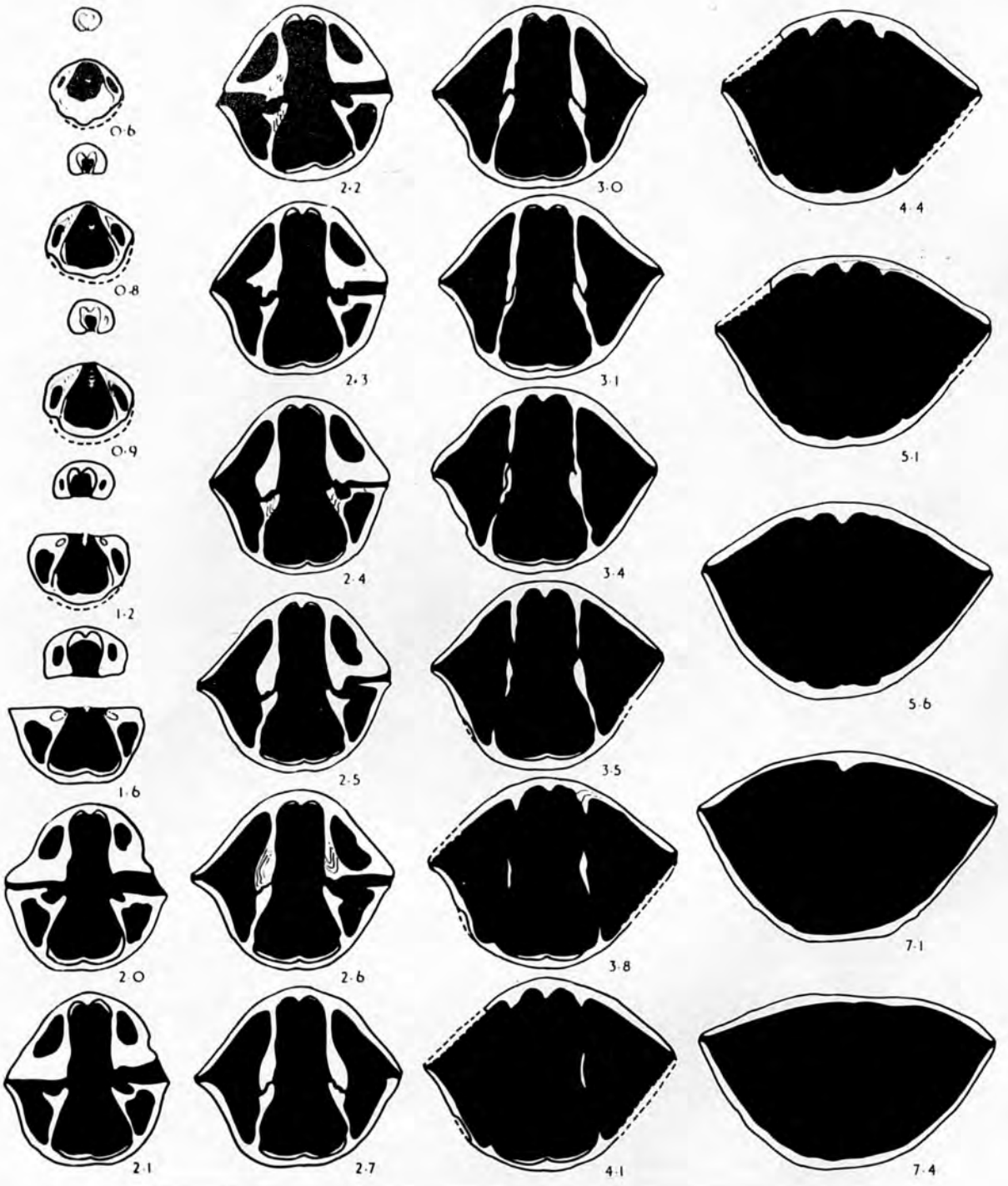
Measurements of sectioned specimen in millimetres

Length	Width	Depth
16.0	18.3	11.7

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbo. Sections x 2½.

Specimen BC B227 - reef limestones, mid D1 subzone, *Dielasma* bed, south end near summit, Treak Cliff, Derbyshire.

a — Pedicle muscle field x 2.
b — Brachial muscle field x 2.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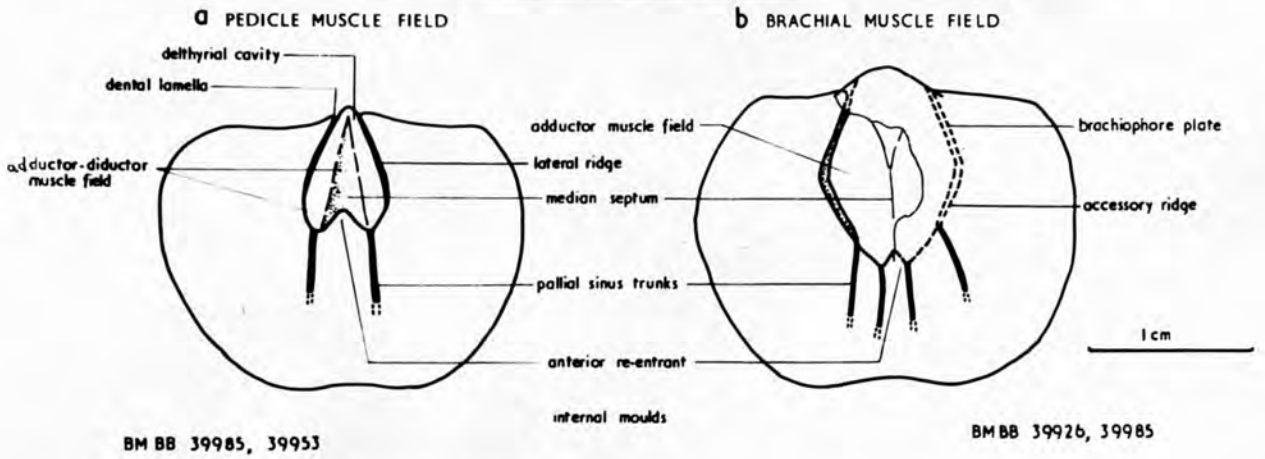
3·5
1·6
2·0
2·6
3·8
7·1
2·1
2·7
4·1
7·4


a PEDICLE MUSCLE FIELD
b BRACHIAL MUSCLE FIELD
delthyrial cavity
dental lamella
adductor-diductor muscle field
adductor muscle field
lateral ridge
median septum
pallial sinus trunks
anterior re-entrant
brachiophore plate
accessory ridge
1 cm
internal moulds
BM BB 39985, 39953
BM BB 39926, 39985

Text-fig. 73

TEXT-FIG.74 — Schizophoria woodi Bond

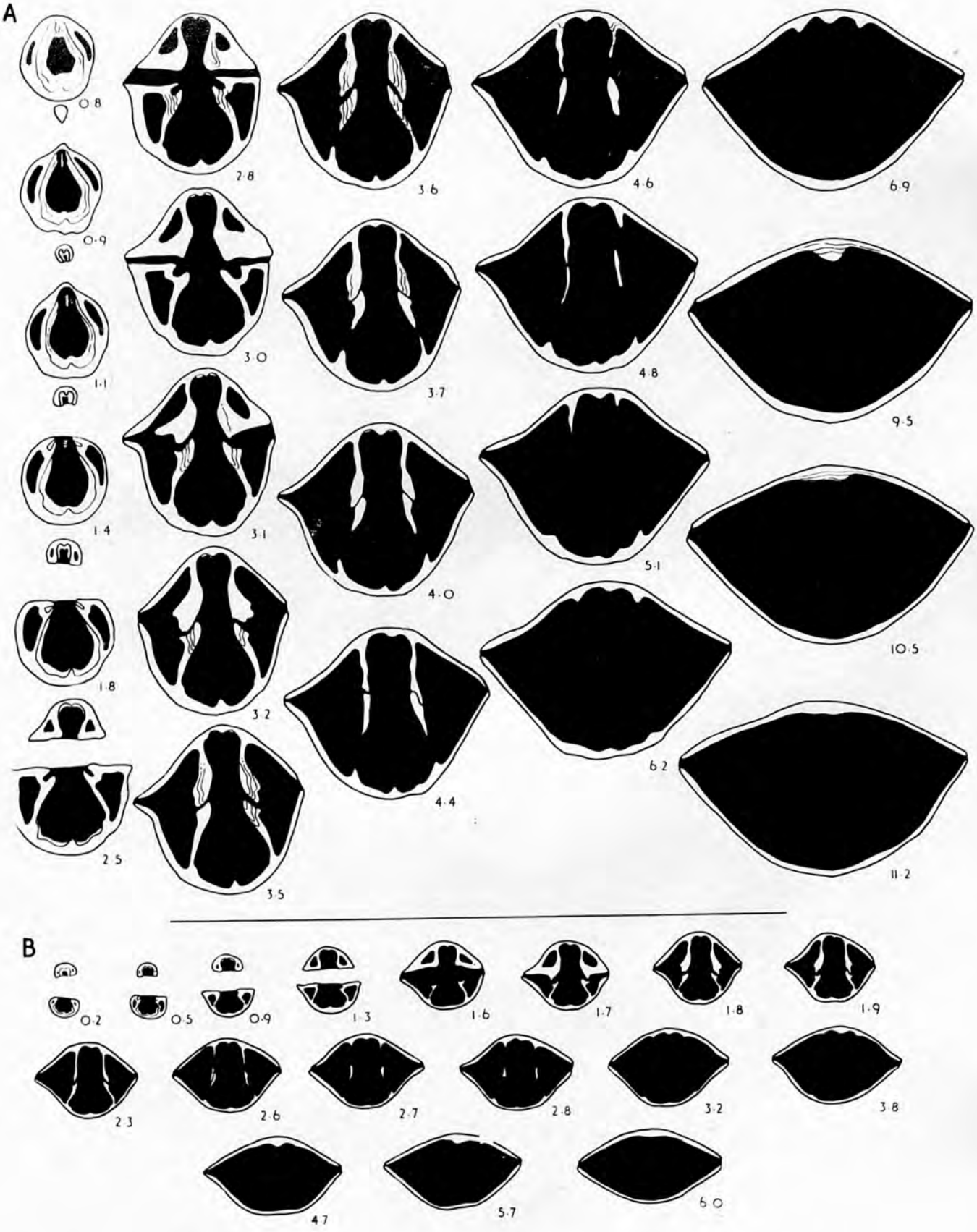
Measurements of sectioned specimens in millimetres

	Length	Width	Depth
A	20.1	22.6	15.3
B	12.6	15.0	8.6

Numbers below serial sections indicate distances in millimetres measured anteriorly from brachial umbones.

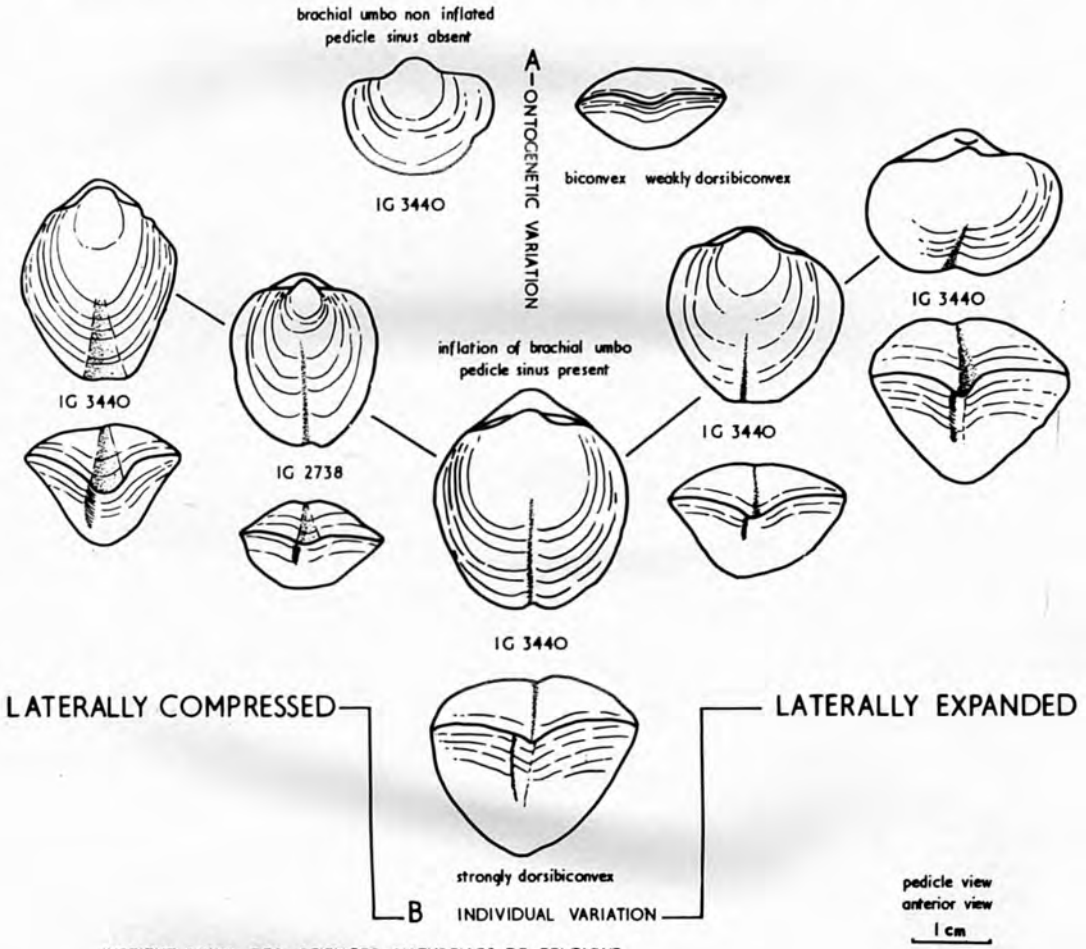
A — HMUG L1152/1 — Carboniferous Limestone, Belgium. Sections x 2.

B — BC247 — Poyllvaaish Limestone, Upper Knoll Limestone, (D2)Pla zone, Ghaw Gortagh, near Poyll Vaaish, Isle of Man. Sections of youthful specimen x 1½.


A
0·8
2·8
3·6
4·6
6·9
0·9
3·0
3·7
4·8
9·5
1·1
1·4
3·1
4·0
5·1
10·5
1·8
3·2
4·4
6·2
2·5
3·5
11·2
B
0·2
0·5
0·9
1·3
1·6
1·7
1·8
1·9
2·3
2·6
2·7
2·8
3·2
3·8
4·7
5·7
6·0

Text-fig. 74

EXTERNAL VARIATION IN SCHIZOPHORIA WOODI BOND



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Text-fig. 75

Explanation of text-figure 76.

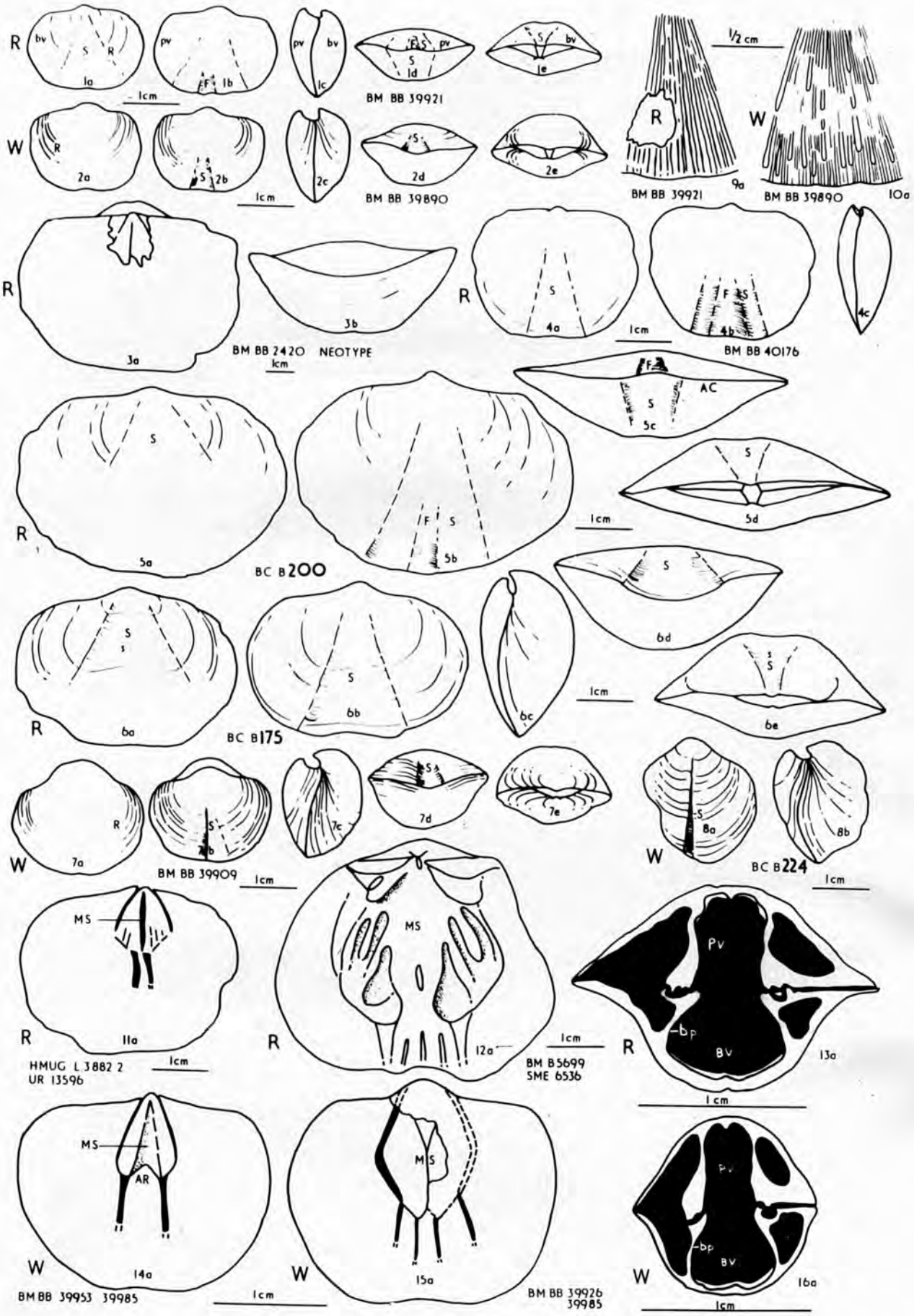
Figs. 1, 3-6, 9, 11-13 — Schizophoria resupinata (Martin) — R.

1a-e, brachial, pedicle, lateral, anterior and posterior views; 3a,b, pedicle and anterior views of neotype; 4a-c, brachial, pedicle and lateral views; 5a-d, brachial, pedicle, anterior and posterior views; 6a-e, brachial, pedicle, lateral, anterior and posterior views; 9a - ornament; 11a - pedicle internal mould; 12a - interior brachial valve; 13a - transverse serial section of ground specimen.

2, 7, 8, 10, 14-16 — Schizophoria woodi Bond — W.

2a-e, brachial, pedicle, lateral, anterior and posterior views; 7a-e, brachial, pedicle, lateral, anterior and posterior views; 8a,b, pedicle and lateral views; 10a - ornament; 14a, pedicle internal mould; 15a, brachial internal mould; 16a, transverse serial section of ground specimen.

AC — anterior commissure
AR — anterior re-entrant
bp — brachiophore plate
BV — brachial valve
F — fold
MS — median septum
PV — pedicle valve
R — rugae
S — sulcus


R
W
1a
1b
1c
1d
1e
2a
2b
2c
2d
2e
1cm
BM BB 39921
BM BB 39890
1/2 cm
9a
10a
3a
3b
BM BB 2420 NEOTYPE
4a
4b
4c
BM BB 40176
5a
5b
5c
5d
BC B200
6a
6b
6c
6d
6e
BC B175
7a
7b
7c
7d
7e
BM BB 39909
8a
8b
BC B224
11a
12a
HMUG L 3882 2
UR 13596
BM B5699
SME 6536
13a
14a
15a
16a
BM BB 39953 39985
BM BB 39926
39985
MS
AR
S
F
AC
bv
pv
bp

Text-fig. 76

STATISTICAL APPROACH

Statistical approaches to the differentiation of forms within and between samples of Schizophoria have been made by Wright (unpubl. Ph.D. thesis, 1952), and Parkinson (1954). Wright's work illustrates the limitations of statistics, and Parkinson's work the misinterpretation of statistics, without detailed morphological studies of the various species. Quantitative methods are valuable in supplementing qualitative studies.

Wright applied statistical methods to collections from Yorkshire and Derbyshire. He considered the specimens were sufficiently alike to require finer analyses than were possible by qualitative means. He noted changes in ribs, anterior commissure and dental lamellae; yet apparently failed to apply these to supplement and interpret his statistics. Although he recognised specimens as possibly belonging to other species such as Schizophoria linguata or S. woodi, he grouped them under S. resupinata. Wright's collections have been deposited in the Hunterian Museum, University of Glasgow. These were borrowed for examination and re-measurement. Three species are included in the collections, S. connivens (Phillips), S. resupinata (Martin) and S. woodi Bond, all labelled as S. resupinata.

Specimens from Elbolton, Yorkshire (Wright's locality Y34), and Middle Hill, Derbyshire (Wright's locality D15) only belong to S. resupinata s.s. Wright did recognise specimens from Y34 as probably confined to a distinct species. With detailed morphological studies further specific differentiation of his collections is possible, not apparent by statistics alone.

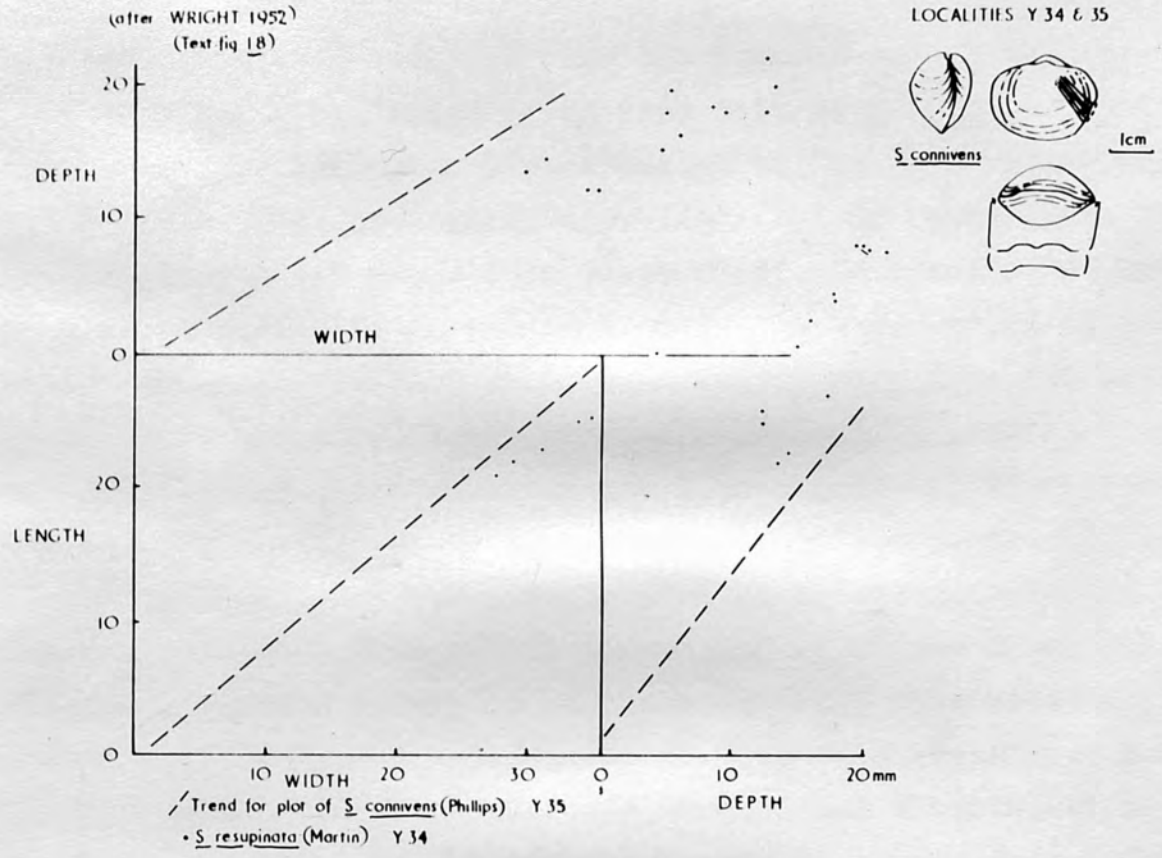
Wright's text-figure 9 illustrates frequency histograms for width-length and depth-length ratios. Separation on the former ratio is not very apparent, since most species are wider than long in a similar proportion, except for the sample from

Y34, which has a higher ratio. Schizophoria resupinata is wider in relation to length, in comparison with other species. Separation on depth-length ratio is more precise. Specimens from localities Y34 and D15 have a lower ratio, since S. resupinata is only a moderately convex form. Specimens from localities Y24, 35, 37, 39 (Elbolton, Stebden), and D21 (Treak Cliff), have higher ratios. These specimens are here assigned to S. connivens and S. woodi respectively, which are two more globose species.

Statistically, the specimens plotted on Wright's text-figures 18, 19 and 20 are similar, all representing forms which are wider than long, and deep. But morphologically, two forms are represented, S. connivens in text-figures 18 and 19, and S. woodi in text-figure 20. Wright's text-figures 18 and 20 have been reproduced and modified (see present text-figs. 77, 78). Wright's points have been omitted, but his general trend lines retained. The trend lines bisected a narrow, elongate zone of points. The two larger specimens plotted by Wright on text-figure 20 (Treak Cliff) do belong to S. resupinata, and have not been omitted with the general plot. Specimens of S. resupinata have hereby been added to text-figure 18. Wright's inset drawings of a hypothetical specimen on each text-figure are not typical, and appear to be youthful forms. A characteristic ephebic specimen of S. connivens has a biplicate or quadrate-uniplicate anterior commissure and coarse costellae, while S. woodi has an angular uniplication and fine costellae. These features have been superimposed on the simple outline drawings of Wright (text-figs. 77, 78).

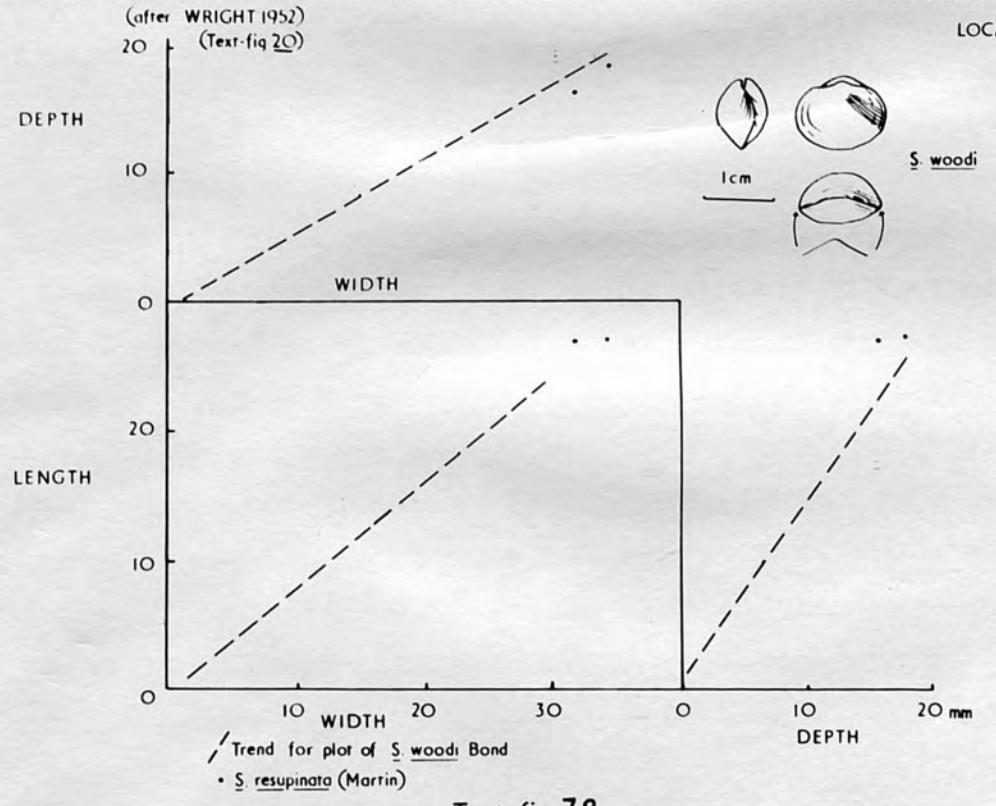
The statistical similarities of Wright's text-figures 18 to 20 are illustrated in his text-figure 21, where population trend lines have been superimposed, and lie in similar positions. But specific differentiation into S. connivens and S. woodi is considered to be shown in his text-figure 22, which illustrates

STATISTICAL ANALYSES OF SCHIZOPHORIA FROM ELBOLTON YORKSHIRE



Text-fig. 77

STATISTICAL ANALYSES OF SCHIZOPHORIA FROM TREAK CLIFF DERBYSHIRE



Text-fig. 78

the correlation co-efficient for the samples used. Schizophoria connivens has a different trend from that of S. woodi.

One or two other discrepancies in Wright's thesis are due to lack of morphological appreciation. In text-figure 12 Wright plotted specimens from Treak Cliff, Derbyshire, to show continuous variation is schizophorias. He then stated (p.33) that whereas Bond (1941) separated Schizophoria into two groups based on rib density, he had found no separation possible. The distribution of plots shown in his text-figure 12, Wright accepted as a series of specimens showing continuous variation, and hence emphasizing the conspecific nature of the individuals. However, Bond's separation is valid, but since the Treak Cliff specimens plotted belong to one species (with fine ornament), Wright would not have appreciated the two-fold grouping. But by a comparison of specimens from Stebden and Elbolton (i.e. S. connivens with coarse ornament), with specimens from Treak Cliff, this grouping would have been apparent. The continuous variation illustrated by Wright is ontogenetic, the specimens illustrating increasing depth with age.

Wright's diagrammatic reconstruction of the morphology of S. resupinata, text-figure 5, also includes S. woodi, diagram number 3.

Wright's conclusion on variation (p.37) is misleading, since he has not recognised the incomplete specific separation possible by statistics. He found greater variation between samples from Elbolton and Stebden localities, 750 yards apart, than between samples from Stebden and Treak Cliff, 75 miles apart. This is due to the comparison of different species. Specimens from Elbolton (Y34) are different from Stebden (Y24), since a comparison is made between S. resupinata and S. connivens. The comparison between Stebden and Treak Cliff (D21) is again between two species, S. connivens and S. woodi, but they are sufficiently alike in length-width and length-depth

ratios (i.e. small and relatively globose) to appear as similar plots.

Parkinson (1954) made statistical analyses on approximately 2,000 specimens from the C reefs of Withgill, Clitheroe, Slaidburn and Little Island Cork, and from the D reefs of the Craven Reef belt, Beresford Dale, Narrowdale, Wetton Hill, Park Hill, Eldon Hill, Mich Low and Treak Cliff. He found significant differences between samples from the D zone, but even greater differences between C and D zone samples. Parkinson stated (p.367) that "he is reasonably satisfied that he has not made use of specimens superficially resembling S. resupinata but with different internal structure. No attempt (p.380) has been made in this paper to explain the statistical differences between the synchronous populations or topodemes".

From detailed morphological studies, it appears that most of Parkinson's differences between population samples are the result of grouping several distinct species under S. resupinata. No actual museum specimen numbers were given by Parkinson, but most of his samples have been re-examined, and include S. connivens, S. linguata, S. resupinata and S. woodi. The distinct morphological features of these are seen in the systematic descriptions (see text-fig.69). Parkinson refers to museum collections he had examined and his collections from Treak Cliff and Eldon Hill donated to the British Museum (Natural History). Numbers of specimens from Little Island Cork in the British Museum, and specimens from Narrowdale, Wetton Hill and Park Hill in the British Museum and Geological Survey Museum (London) correspond to the total number used by Parkinson. The Tiddeman collection from Craven in the Skipton Museum still have references written by Parkinson during his study.

The Withgill, Clitheroe and Slaidburn specimens are S. resupinata s.s. Specimens in the British Museum (Natural

History) collection from Little Island Cork belong to S. sp.nov. Parkinson did recognise the difference between these and the Withgill collection, but could not say whether the differences were real or a consequence of a non-random sample. The Tiddeman collection (Skipton Museum) from the Craven Reef belt is essentially composed of S. connivens, S. linguata and S. woodi, with subordinate numbers of S. resupinata. Parkinson's collection from Treak Cliff consists of S. woodi, with subordinate numbers of S. connivens and S. resupinata. Specimens from Eldon Hill do belong to S. resupinata, and also include S. resupinata var. pinguis. Specimens from Narrowdale, Wetton Hill and Park Hill from the British Museum (Natural History) and Geological Survey Museum collections also include S. connivens and S. linguata. It has been estimated therefore that the number of specimens belonging to S. resupinata s.s. is approximately one hundred and fifty out of two thousand specimens.

Different species are in part being compared, so that statistical differences are inevitable. The presence or absence of significant differences of table 2 (Parkinson, p.371) can now be re-interpreted.

Parkinson found no significant differences between the Withgill and Clitheroe-Slaidburn specimens, since specimens of S. resupinata are being compared. The length-width ratio between Treak Cliff and Craven Reef belt specimens shows significant differences. This is due to the comparison of S. woodi (Treak Cliff), with S. connivens, S. woodi and possibly S. linguata (Craven). Schizophoria connivens and S. linguata are generally wider. There are no significant differences in the thickness-width and thickness-length ratios, since all species are globose forms. Significant differences in the length of the brachial valve-length of the pedical valve ratio is expected, since the brachial valve of S. woodi is often longer, while S. connivens may have either valve projecting. Schizophoria

linguata generally has a longer brachial valve.

Significant differences between Withgill and Treak Cliff are inevitable, since the comparison is between two distinct species, S. resupinata and S. woodi.

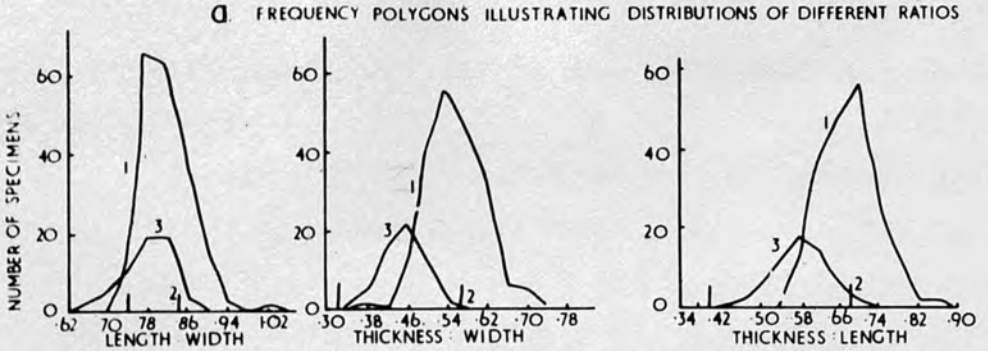
Parkinson's frequency polygons (text-fig.5), reproduced in text-figure 79a, illustrate the distribution of different ratios of specimens from Treak Cliff (D zone) and Withgill, Clitheroe and Slaidburn (C zone). His differences in the ratios between the C and D zones are due to a comparison of two species, S. woodi and S. resupinata respectively. The greatest differences occur between the thickness-width and thickness-length ratios. Schizophoria woodi (Treak Cliff) is more globose (i.e. high ratios), while S. resupinata (Withgill, Clitheroe, Slaidburn) is a less convex form (i.e. lower ratios). Significant differences in the length-width ratio are smaller, although S. resupinata is proportionally wider than S. woodi. The ratio of the lengths of the two valves illustrates further differences, since S. woodi often has a longer brachial valve, while S. resupinata has either valve projecting.

Superimposed on Parkinson's graphs are measurements of specimens of S. resupinata s.s. from Treak Cliff and neighbouring Eldon Hill (text-fig.79a). Since specimens are few in number, only the lateral limits of the ratios have been plotted. But these plots do indicate the similarity of S. resupinata from Withgill and S. resupinata s.s. from Treak Cliff and Eldon Hill.

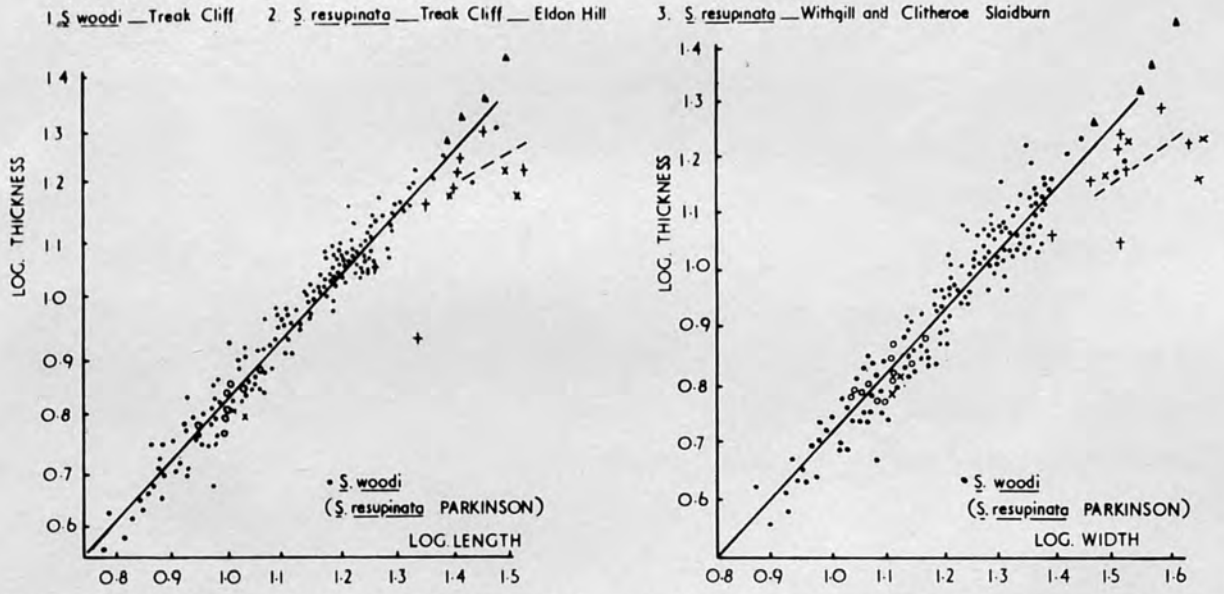
Parkinson's text-figure 8 (p.374) illustrates the relationship of log thickness to log width of Treak Cliff specimens. This ratio is valuable in specific differentiation, since the thickness of species varies. The graph shown by Parkinson represents S. woodi. Specimens of S. resupinata s.s. from Treak Cliff and Eldon Hill have again been added (text-fig.79b). Although few in number, the latter specimens lie aside of the general trend. However, specimens from Treak Cliff do have a

STATISTICAL ANALYSES OF SCHIZOPHORIA

a. FREQUENCY POLYGONS ILLUSTRATING DISTRIBUTIONS OF DIFFERENT RATIOS (after PARKINSON 1954)



1. S. woodi — Treak Cliff 2. S. resupinata — Treak Cliff — Eldon Hill 3. S. resupinata — Withgill and Clitheroe Slaidburn

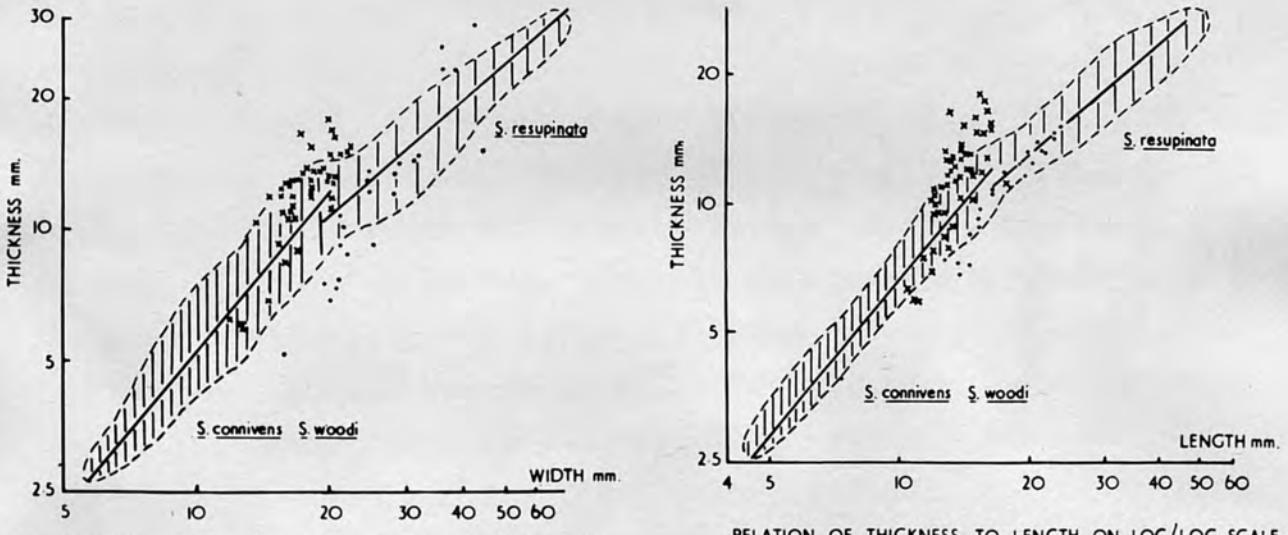


b. RELATION OF LOG THICKNESS TO LOG LENGTH, TREAK CLIFF

RELATION OF LOG THICKNESS TO LOG WIDTH, TREAK CLIFF

• S. connivens — Treak Cliff × S. resupinata — Treak Cliff † S. resupinata — Eldon Hill ▲ S. resupinata var. pinguis — Eldon Hill

CRAVEN REEF BELT



C. RELATION OF THICKNESS TO WIDTH ON LOG/LOG SCALE

RELATION OF THICKNESS TO LENGTH ON LOG/LOG SCALE

× S. linguata • S. resupinata

S. connivens S. woodi S. resupinata (Parkinson's plot)

Text-fig. 79

slightly higher ratio, since they are more convex forms of S. resupinata.

Parkinson found relative growth between different parts of the shell as allometric, with a change in the growth ratio at a width of 20mm. This change could only be demonstrated in the large Craven Reef collection. The departure from isometry was very small for the length-width ratios. On re-examination, the Craven Reef collection includes S. connivens, S. linguata and S. woodi, with subordinate numbers of S. resupinata. Parkinson's change in growth ratio is the break between plots of species. On text-figure 79c specimens of S. linguata and S. resupinata have been plotted. The pre-existing points apparently represent S. connivens, S. resupinata and S. woodi. Schizophoria resupinata is the largest species, with lower thickness-width and thickness-length ratios. The other species are smaller, and more globose (i.e. higher ratios). The break of slope is less for the length-width ratio since all species are generally wider than long.

No similar change in slope is found for specimens from the Dielasma bed, Treak Cliff (Parkinson, p.373, fig.6), since this plot represents S. connivens and S. woodi, two medium to small, thick species. The Withgill plots do not show breaks, since one is working with one species, S. resupinata.

Parkinson discovered a tendency for an increase in globosity from C to D zones within S. resupinata. The thick forms belong to Demanet's variant of S. resupinata, var. pinguis. Although thinner forms are present in the D zone, specimens of var. pinguis are moderately frequent in comparison with other variants. Approximately fifteen specimens have been examined, out of many hundred specimens of S. resupinata. Thick forms are generally absent from the C zone, except for specimen BM B386, (Davidson, 1858-63, pl.29, fig.3), from Bolland, and BM B54136, from Thorpe Cloud. Parkinson disregarded the globose specimen from Bolland, since it was unlike any of the specimens examined.

He also recognised an increase in globosity amongst the Treak Cliff collection, but this is an ontogenetic trend, seen in all species to some extent.

Schizophoria resupinata does show a definite trend towards inflation within the D zone, but the importance of this has probably been overestimated by Parkinson, by his disregard of morphology in the interpretation of his statistics. The occurrence of inflated specimens is very limited, and probably represents individual variation affecting a few specimens.

A simple graphical method of plotting two characters has been used to supplement morphological descriptions of Carboniferous species.

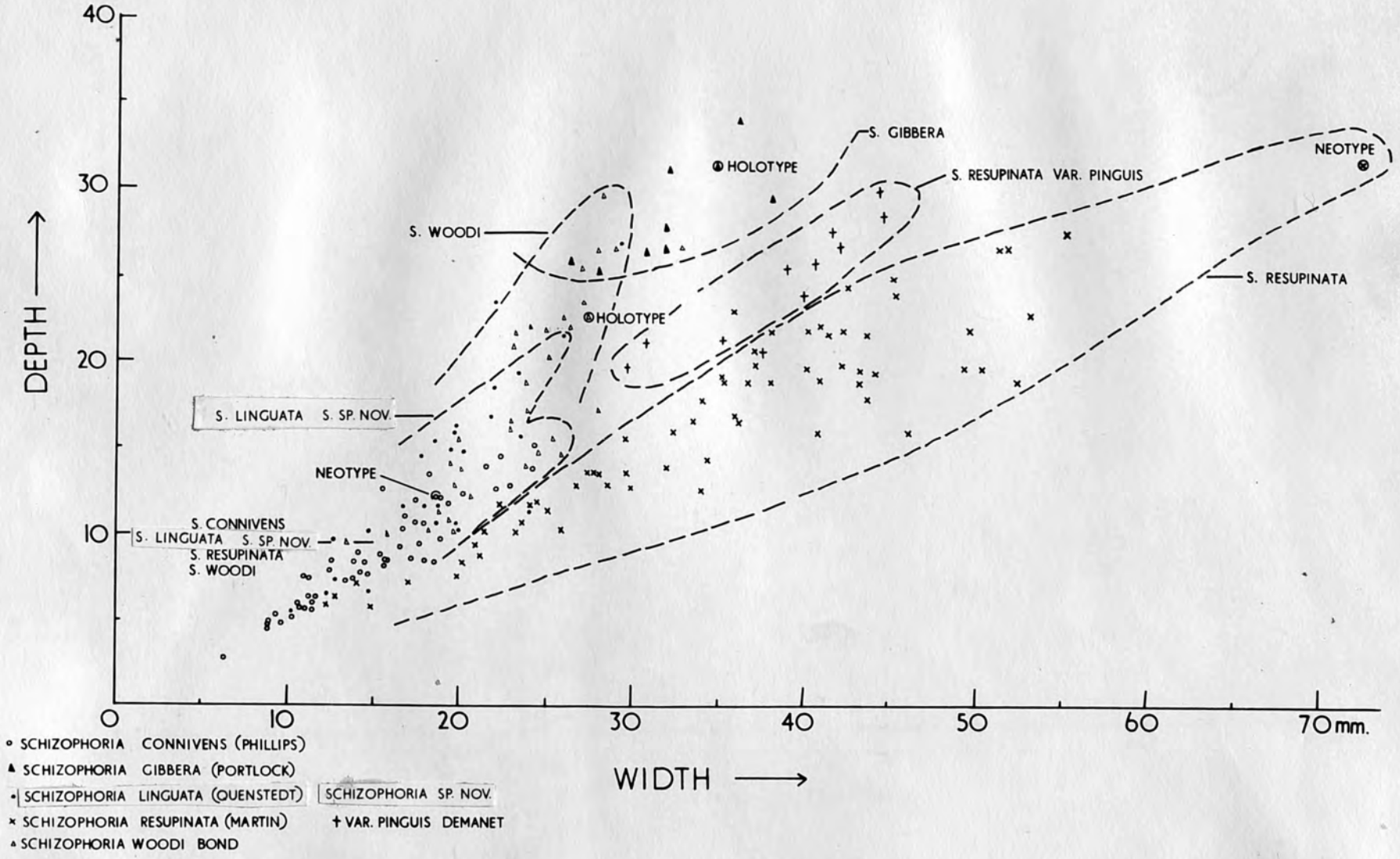
Since Carboniferous species of Schizophoria are long ranging and show little or no morphological change throughout, specimens from different horizons have been grouped together.

Suitable characters need to be selected. The depth-width ratio is important, since species vary in globosity, but the length-width ratio is of little use, since in most species width exceeds length in a similar proportion.

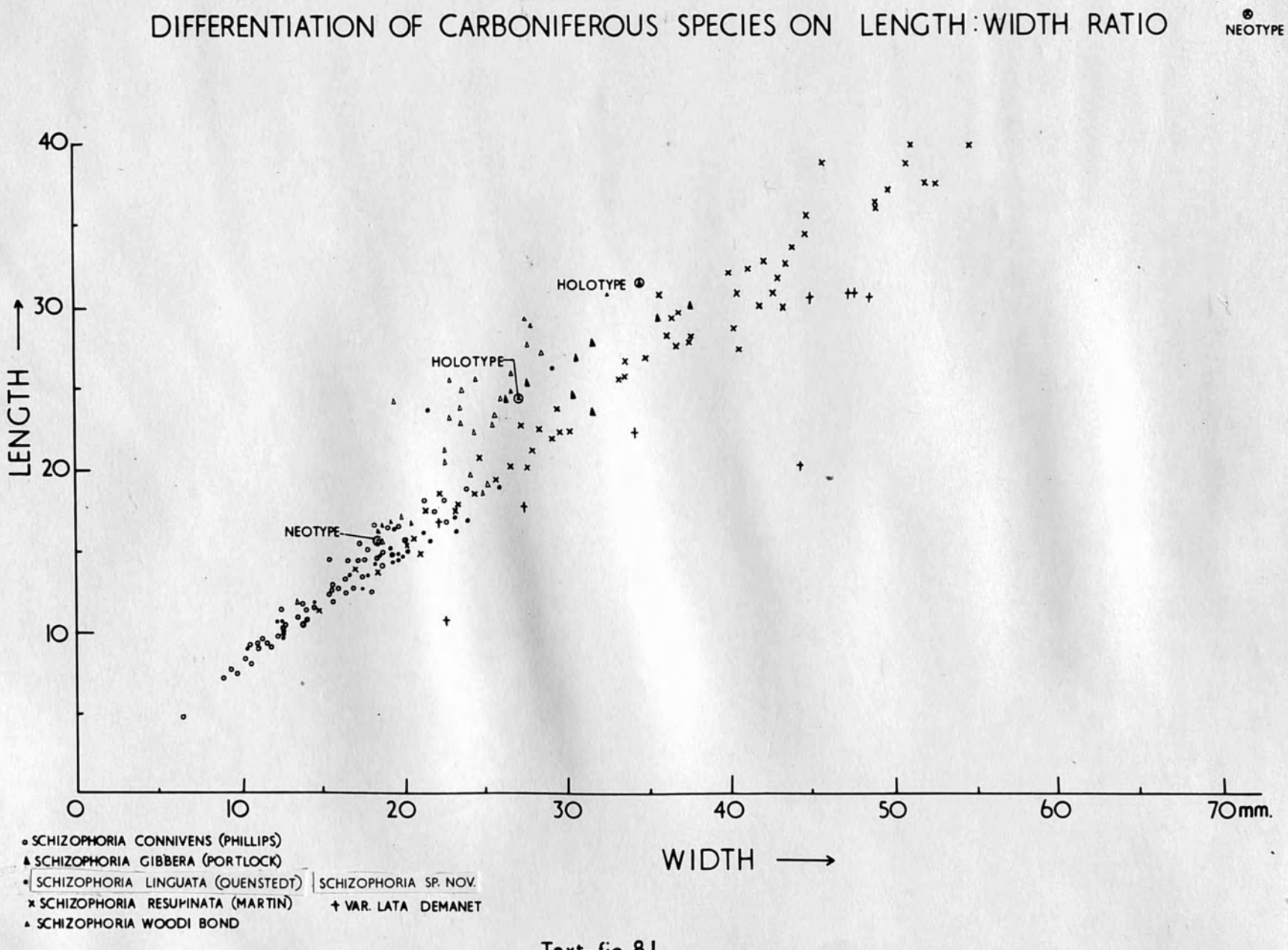
Differentiation of species has been attempted on these ratios (text-figs.80, 81). Separation on depth-width ratio is shown on text-figure 80, and approximate species' boundaries have been inserted where possible. Differences in size and depth are apparent, from the small, globose form of S. connivens to the larger, less convex form of S. resupinata. Specimens of S. gibbera are almost as deep as wide, and S. linguata demonstrates a great range in the ratio (i.e. ontogenetic range in depth). The diagnostic feature, inflation, of S. resupinata var. pinguis is shown, the points lying aside of the general trend. There is some mingling of points in the smaller, younger stages, but these are distinct when studied qualitatively.

The length-width ratio of text-figure 81 fails to

DIFFERENTIATION OF CARBONIFEROUS SPECIES ON DEPTH:WIDTH RATIO



Text-fig. 80


DIFFERENTIATION OF CARBONIFEROUS SPECIES ON LENGTH : WIDTH RATIO
NEOTYPE
HOLOTYPE
HOLOTYPE
NEOTYPE
LENGTH
WIDTH
0
10
20
30
40
50
60
70mm.
10
20
30
40
SCHIZOPHORIA CONNIVENS (PHILLIPS)
SCHIZOPHORIA GIBBERA (PORTLOCK)
SCHIZOPHORIA LINGUATA (QUENSTEDT)
SCHIZOPHORIA SP. NOV.
SCHIZOPHORIA RESUPINATA (MARTIN)
+ VAR. LATA DEMANET
SCHIZOPHORIA WOODI BOND

Text-fig. 81

separate the species, since most species show a similar trend. Without detailed morphological studies the plots appear as representatives of a single species, illustrating a great size range. Points of S. woodi lie aside of the general trend, since many specimens are almost as long, or longer than wide. The great width of S. resupinata var. lata is also apparent.

In conclusion, statistics cannot be used confidently without knowledge of morphology, or cannot show the finer differentiation of species.

ECOLOGICAL ASSOCIATIONS

In the Carboniferous, two or more species of Schizophoria are frequently collected from a similar level, and different species appear to be dominant in various areas of reef limestones. Some areas of reef limestones, and their species are given below:

Derbyshire

Treak Cliff — S. connivens
S. woodi (small form)

Eldon Hill — S. resupinata var. pinguis

Dovedale — S. connivens
S. linguata
S. resupinata
S. woodi

Ireland

Little Island Cork — S. sp. nov.

Isle of Man

S. resupinata
S. woodi (large form)

Yorkshire

Cracoe — S. connivens — Elbolton,
S. resupinata — Swinden
S. woodi (small form) — Knolls
S. connivens — Stebden Knoll

Craven — S. connivens
S. linguata
S. sp. nov.
S. woodi (large and small forms)

Scaleber Bridge — S. connivens

This grouping could be due to lack of material, but is unlikely, since extensive museum collections have been examined, supplemented by the author's collections.

Two or more species are frequently found together at the same stratigraphical level - eg. S. connivens and S. resupinata, Elbolton Knoll, Cracoe, and S. resupinata and S. woodi, Isle of Man. Many of the shells are well preserved, with many growth

stages present, suggesting little or no selective removal of shells by currents. In other cases, specimens occur as discrete valves, one resting in another, as in the Cyrtina septosa beds (Middle D1) of Elbolton Knoll, Cracoe. The abundance of rolled and broken shell fragments here suggests accumulation under more turbulent conditions (Bond, 1941, p.167). But it is necessary to explain the association of those well preserved specimens, which are probably in situ, or if moved, they have not travelled far.

Closely related biospecies usually occupy different geographical areas or different habitats in the same area, in order to avoid competition. Alternatively, they may avoid competition by differences in daily or seasonal activity, or differences in food.

The occurrence of two species of Schizophoria apparently from the same stratigraphical and geographical position could perhaps be explained by differences in food supply or life cycle. In this way, they would have avoided competition and become morphologically isolated from each other within the same habitat.

On the other hand, the reef environment could have changed (eg. in light, salinity) within a relatively short distance, so that two closely occurring species could have occupied different niches within close proximity. Parkinson (1954, p.380) stated that "their environment would change according to such factors as depth of water and position on the reef in relation to basin and massif".

Little can be said about the association of Schizophoria with other organisms, except that in the Carboniferous athyrid and productid brachiopods are frequently found with Schizophoria. Along Treak Cliff, Derbyshire, species of Schizophoria are also found within the Dielasma bed. In the Devonian, Schizophoria is apparently rarely found with Atrypa, another very abundant Devonian brachiopod.

STRATIGRAPHICAL DISTRIBUTION

A — Devonian

Belgium, France, Germany

The genus Schizophoria is especially an abundant brachiopod in the Middle Devonian of the Eifel region (Germany), and in the Middle-Upper Devonian of the Dinant basin (Belgium).

The stratigraphical ranges of species of Schizophoria from the Devonian of Belgium, France and Germany are given on text-figure 82.

Schizophoria striatula (Schlotheim) is a long ranging species (Eifelian-Frasnian). Other species are more restricted. Schizophoria provulvaria (Maurer) and S. strigosa (Sowerby) are the two earliest species, appearing above the base of the Siegenian, and disappearing at the base of the Emsian stage.

Although such species as S. provulvaria and S. strigosa are restricted to the Lower Siegenian to Lower Emsian stages, and S. vulvaria (Quenstedt) is restricted to the Lower Emsian to Lower Eifelian stages, they have little zonal value, since they are not very abundant, and other groups have more restricted ranges. However, they can be used to determine stages, but not smaller divisions.

In the Middle Devonian, Schizophoria pygmaea (Struve) and S. pygmaea subspecies A appear to be stratigraphically and geographically restricted. They occur in the Eifelian stage of the Eifel region.

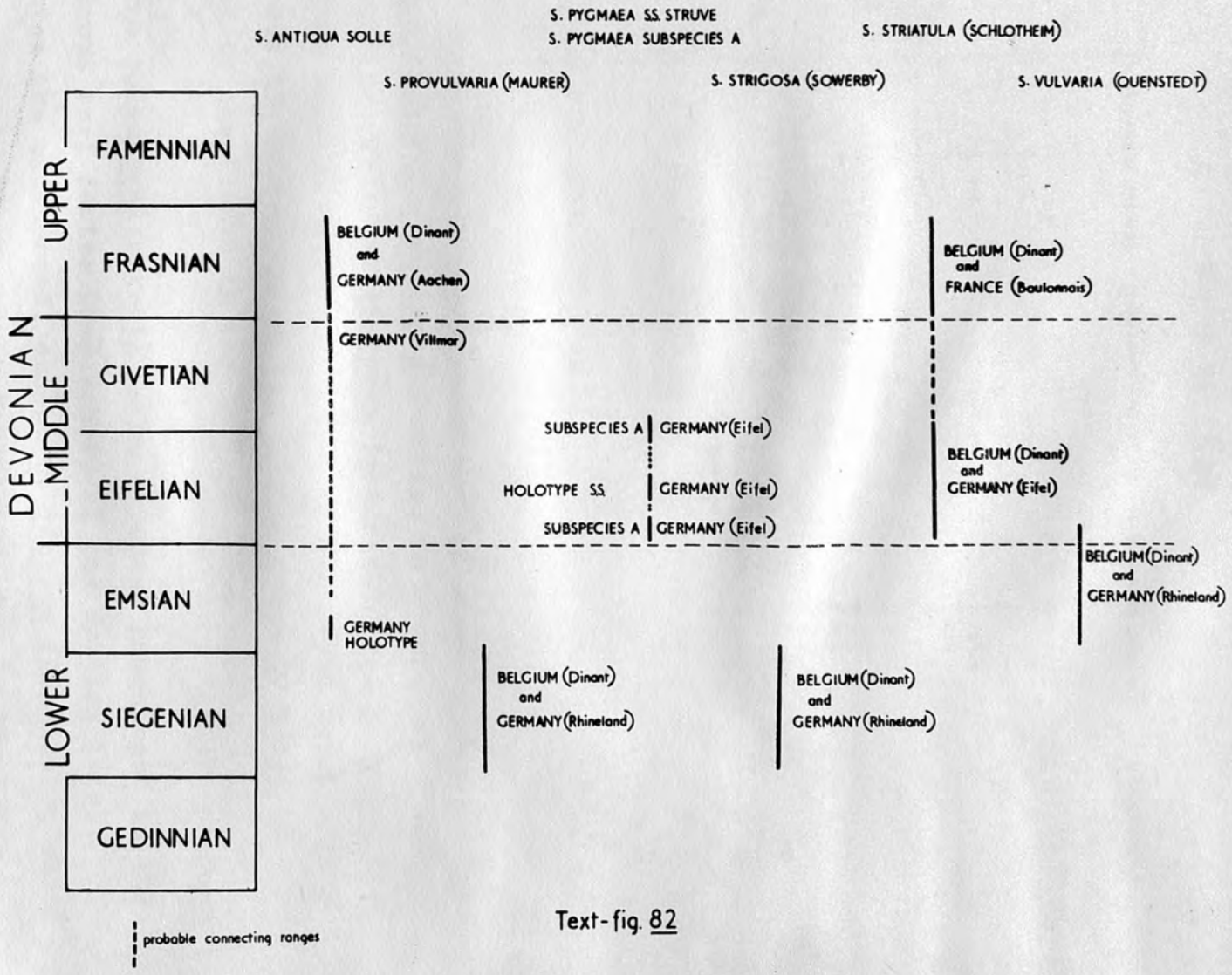
B — Carboniferous

Belgium

The relative abundance of the genus Schizophoria from Belgium is unknown due to limited collections available for study.

The stratigraphical ranges of species of Schizophoria from the Carboniferous of Belgium are shown on text-figure 83, although some precise information on stratigraphical horizons

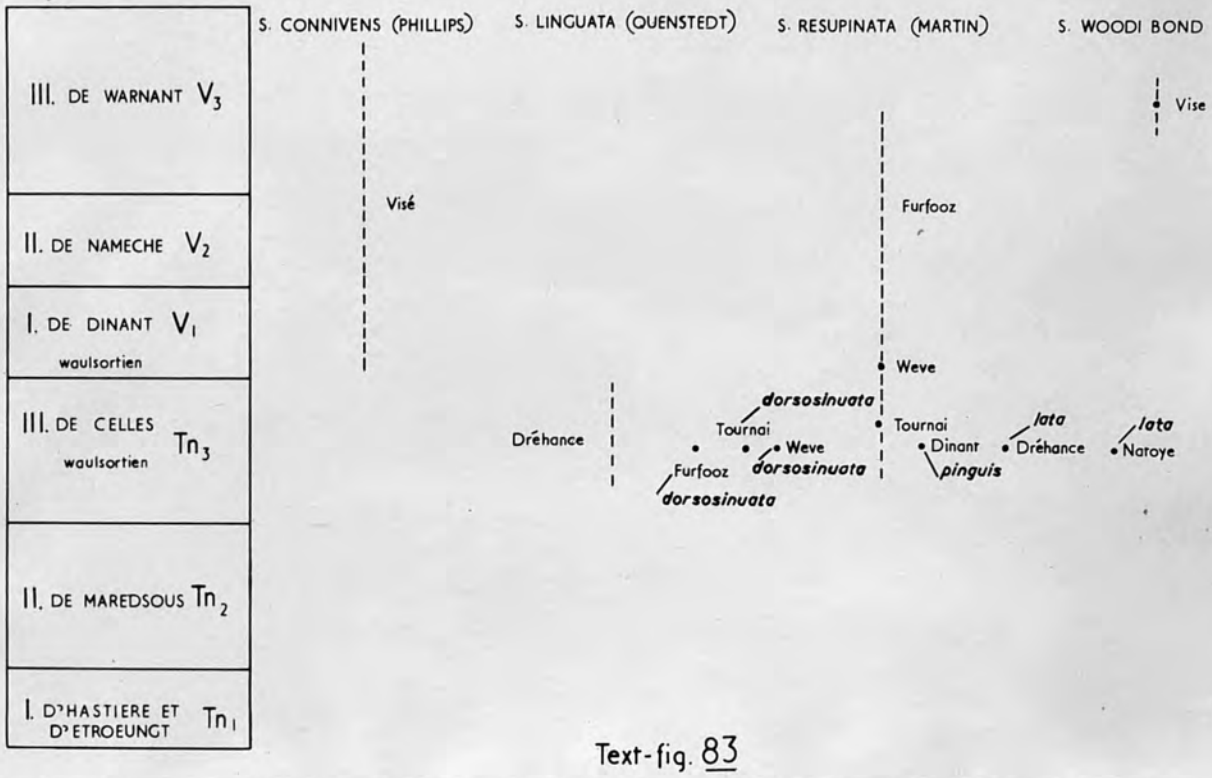
STRATIGRAPHICAL RANGE OF SPECIES OF SCHIZOPHORIA FROM BELGIUM N.E. FRANCE AND GERMANY



Text-fig. 82

are lacking.

STRATIGRAPHICAL RANGE OF SPECIES AND VARIANTS OF SCHIZOPHORIA A FROM BELGIUM



Text-fig. 83

Schizophoria resupinata (Martin) is apparently a long ranging species, while S. linguata (Quenstedt) and S. woodi Bond have shorter ranges. The short range of the first species is probably due to lack of extensive material, but S. woodi is restricted to the Viséan in the British Isles also.

British Isles

The genus Schizophoria is an abundant brachiopod in the Carboniferous reef facies (C-D zones) of the British Isles. Most species are widespread, except S. gibbera (Portlock), which is a rare species, found mainly in Ireland, and S. sp. nov., which is apparently restricted to Little Island Cork, County Kerry and Craven, Yorkshire.

The few occurrences in the K and Z zones may be due to the

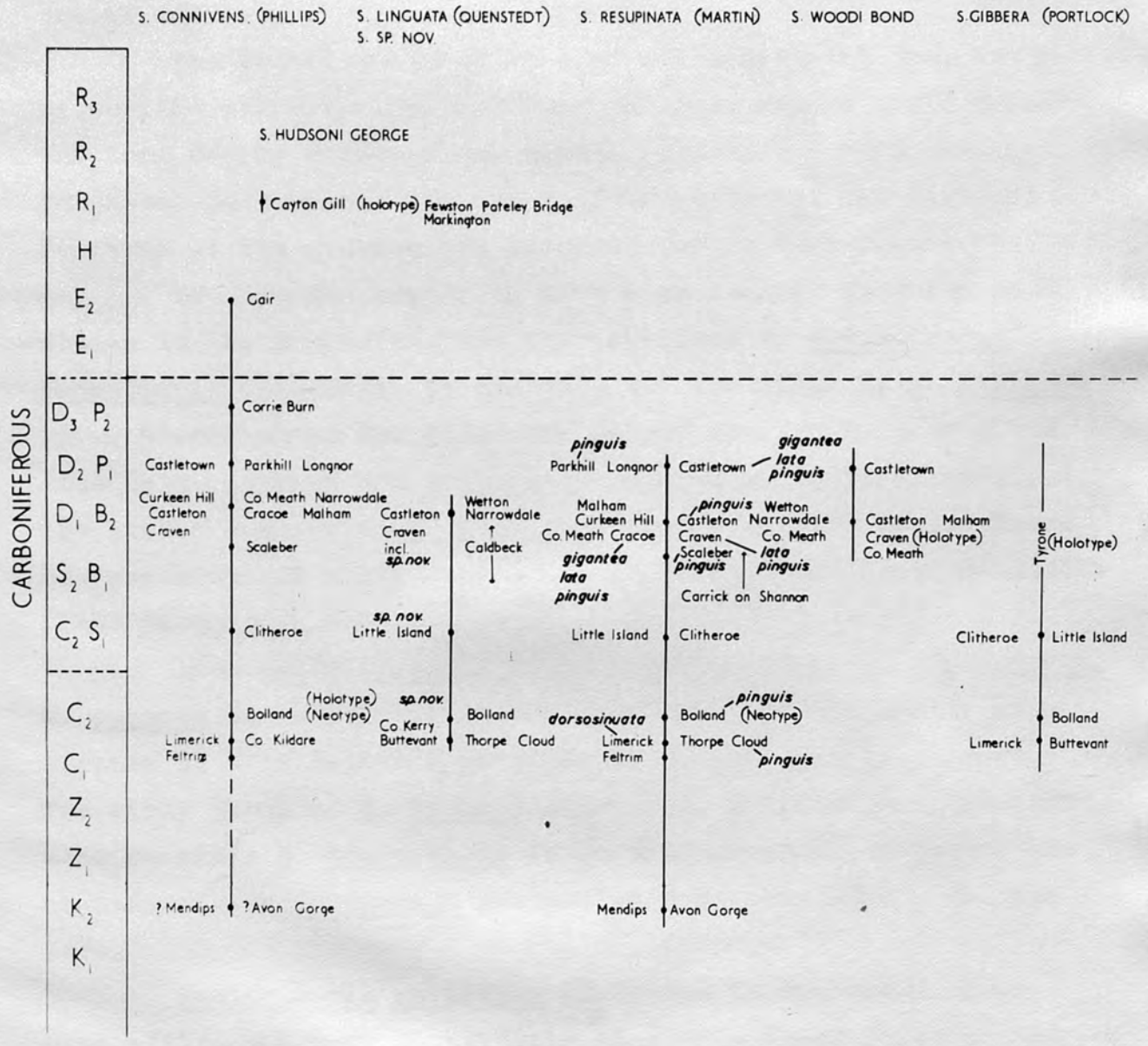
absence of reef limestones. Specimens are fewer in number, and more difficult to extract from the massif facies. Rocks of the K and Z zones are also more restricted geographically.

The stratigraphical ranges of Schizophoria from the Carboniferous of the British Isles is shown on text-figure 84.

Schizophoria connivens (Phillips), S. gibbera (Portlock), S. linguata (Quenstedt), and S. resupinata (Martin) range throughout most of the Lower Carboniferous, but S. woodi Bond is restricted to the Viséan. Schizophoria connivens and S. resupinata are the earliest species, appearing in the K zone. Schizophoria connivens extends into the Lower Namurian (E2), and is succeeded by S. hudsoni George, higher in the sequence (R1).

The appearance and disappearance of the species is probably related to environmental conditions. The Lower Carboniferous marine transgression caused an influx of species, which eventually disappeared with the onset of essentially non-marine Namurian sedimentation. Schizophoria connivens and S. hudsoni appear to have been more adaptable, the former occurring in limestone bands in the Scottish Namurian sequence, and S. hudsoni occurring in the marine Cayton Gill Beds (R1), Yorkshire. Other species such as S. gibbera, S. linguata, S. resupinata, and S. woodi disappear at the top of the Dinantian.

STRATIGRAPHICAL RANGES OF SPECIES AND VARIANTS OF SCHIZOPHORIA FROM THE BRITISH ISLES



Text-fig. 84

PHYLOGENY

The postulated phylogeny of the species of Schizophoria studied is shown on text-figure 85 (in back cover pocket). This chart is based solely on material examined in this study, and could conceivably represent only a part of the true picture of descent.

The relationship of species has been based externally on outline and ornament, and internally on muscle field patterns and form of the brachiophore plates, correlated with stratigraphical occurrence. Drawings of the external and internal features of the species are incorporated in text-figure 85.

The species appear to have been derived from two root stocks in the Siegenian, one characterised by Schizophoria provulvaria (Siegenian to Emsian), and the other by S. strigosa (also Siegenian to Emsian). The former appears to have given rise to S. pygmaea and S. pygmaea subspecies A (Eifelian), and the latter species to S. vulvaria (Emsian to Eifelian). There are resemblances along both lines in external outline and muscle field patterns.

Although S. pygmaea is much smaller than S. provulvaria, S. pygmaea is here considered a dwarf form of the larger subspecies A. The latter does resemble S. provulvaria in size. Two early forms of S. pygmaea subspecies A (lowermost Eifelian) also resemble S. provulvaria in dorsibiconvexity, although the characteristic S. pygmaea subspecies A is generally a thinner form.

Schizophoria striatula (Eifelian to Frasnian) shows some affinities with S. vulvaria in muscle field patterns and divergent brachiophore plates, and was probably derived from this stock. The strongly dorsibiconvex, angular uniplicated form of S. striatula from the Frasnian (F 2i), is represented as an offshoot from the striatula line.

Derivation of Schizophoria antiqua (Emsian to Frasnian) is more difficult to determine. The flabellate pedicle muscle field and curved brachiophore plates resemble the S. provulvaria line of development, but S. antiqua is a much smaller species, and has a more elliptical to flabellate brachial muscle field. The holotype described by Solle was collected from the Emsian (Koblenzquarzit), and so may have developed in late Siegenian to early Emsian time from the S. provulvaria stock.

Four main lines of development are recognised in the Carboniferous. The line of development represented by S. connivens and S. hudsoni contain small to medium, coarsely costellate, rugate forms, with divergent brachiophore plates and an elliptical to weakly flabellate pedicle muscle field.

The line represented by S. resupinata and its varieties is characterised by larger forms, with finer costellae, divergent brachiophore plates, and a flabellate pedicle muscle field.

Schizophoria gibbera, S. linguata, and S. sp. nov. represent a line characterised by greater dorsibiconvexity, very fine ornament, a narrow, parallel-sided pedicle muscle field, rectangular to elliptical brachial muscle field, and curved brachiophore plates.

Schizophoria woodi is the fourth line of development, and is similarly a strongly dorsibiconvex form with very fine costellae and curved brachiophore plates. But S. woodi has a flabellate pedicle muscle field.

Schizophoria resupinata (K-D zones) was probably derived from the S. striatula line of development, based on general outline and muscle fields. The varieties are shown as sporadic offshoots, representing extreme variation at different levels.

Schizophoria connivens (K-D zones) has been derived as an offshoot from S. resupinata, possibly in late Devonian to early Carboniferous. Although distinct from S. resupinata, there are some resemblances in the brachial muscle field and

brachiophore plates. Schizophoria connivens probably gave rise to S. hudsoni in the Namurian (R 1). Both species are closely similar in morphology.

Derivation of the gibbera-linguata-sp. nov. line (C-D zones) is difficult to postulate. Although S. provulvaria and S. antiqua have curved brachiophore plates, they have different external outline and muscle fields. The strongly dorsibiconvex forms, with narrow, parallel-sided pedicle muscle fields of the Carboniferous are not represented by any closely comparable forms in the Devonian. Although S. gibbera, S. linguata and S. sp. nov. have been derived from the S. provulvaria-S. pygmaea line on text-figure 85, they could have alternatively developed outside of the area studied, appearing during the Lower Carboniferous transgression.

Schizophoria woodi (D zone) could have developed from S. antiqua. Both are dorsibiconvex, rugate forms, with a flabellate pedicle muscle field, elliptical to flabellate brachial muscle field, and curved brachiophore plates. But S. antiqua is more coarsely costellate, and although smaller in size than the larger form of S. woodi, closely resembles the smaller form of S. woodi.

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DEVONIAN

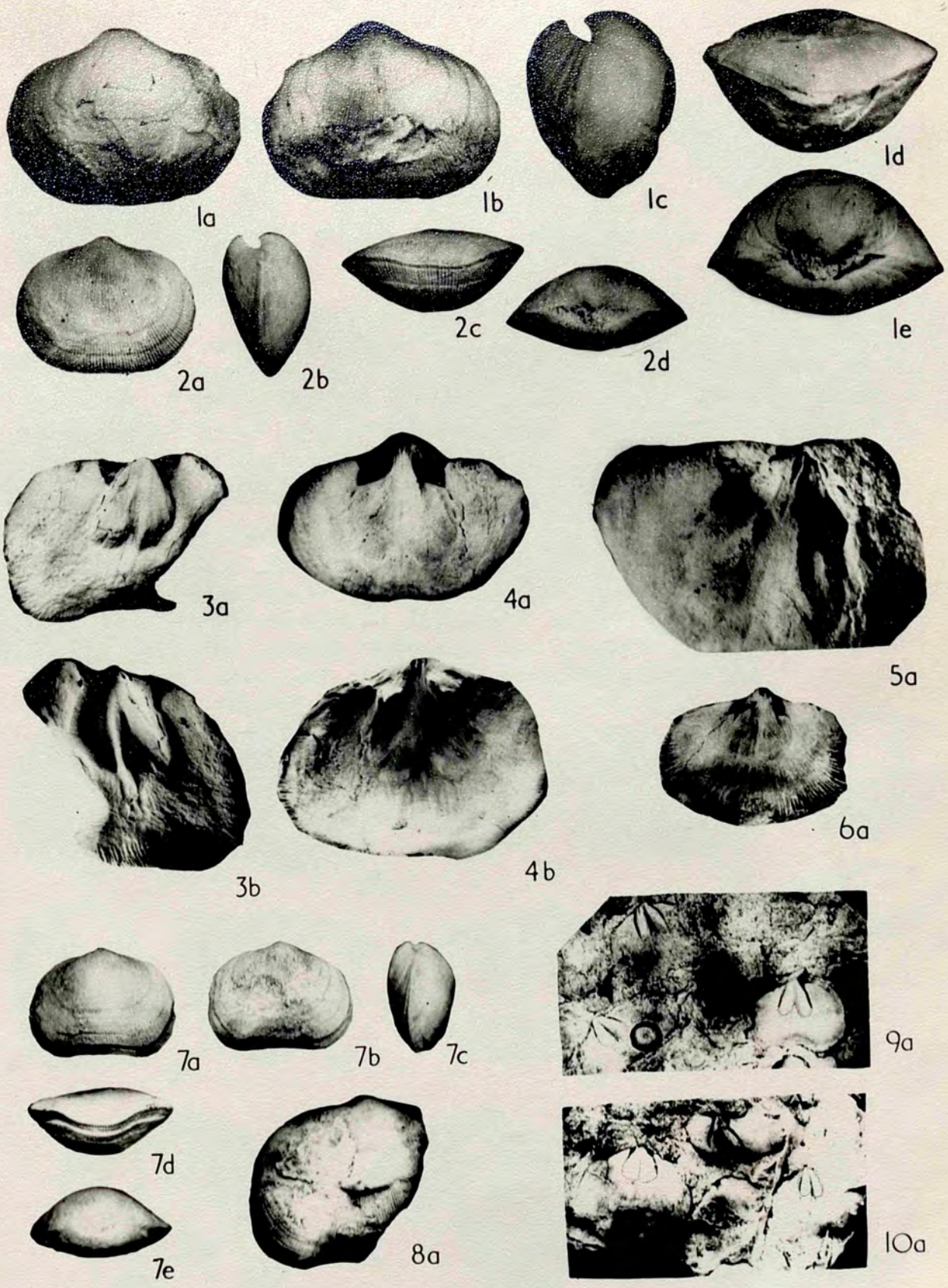
EXPLANATION OF PLATE 1

FIGS. 1, 2 — *Schizophoria antiqua* Solle. 1a-e, brachial, pedicle, lateral, anterior, and posterior views, IRIG 6154 (ground specimen), x 1½; 2a-d, brachial, pedicle, lateral, and anterior views, more youthful specimen, IRIG 6154, x 1½.

3-6 — *Schizophoria provulvaria* (Maurer). 3a, b, pedicle internal mould and plasticine cast of mould, HMUG L5345/2, x 1; 4a, b, brachial internal mould and plasticine cast of mould, HMUG 5341/2, x 1; 5a, posterior region, HMUG L5341/2, x 1½; 6a, brachial internal mould of more youthful specimen, HMUG L5341/4, x 1.

7-10 — *Schizophoria pygmaea* Struve. 7a-e, brachial, pedicle, lateral, anterior, and posterior views, BC B55, x 1½; 8a, pedicle view of large fragmentary specimen, BC B19, x 1½; 9a, block of pedicle internal moulds, BC B61, x 1; 10a, block of pedicle and brachial internal moulds, BC B63, x 1.

PLATE 1



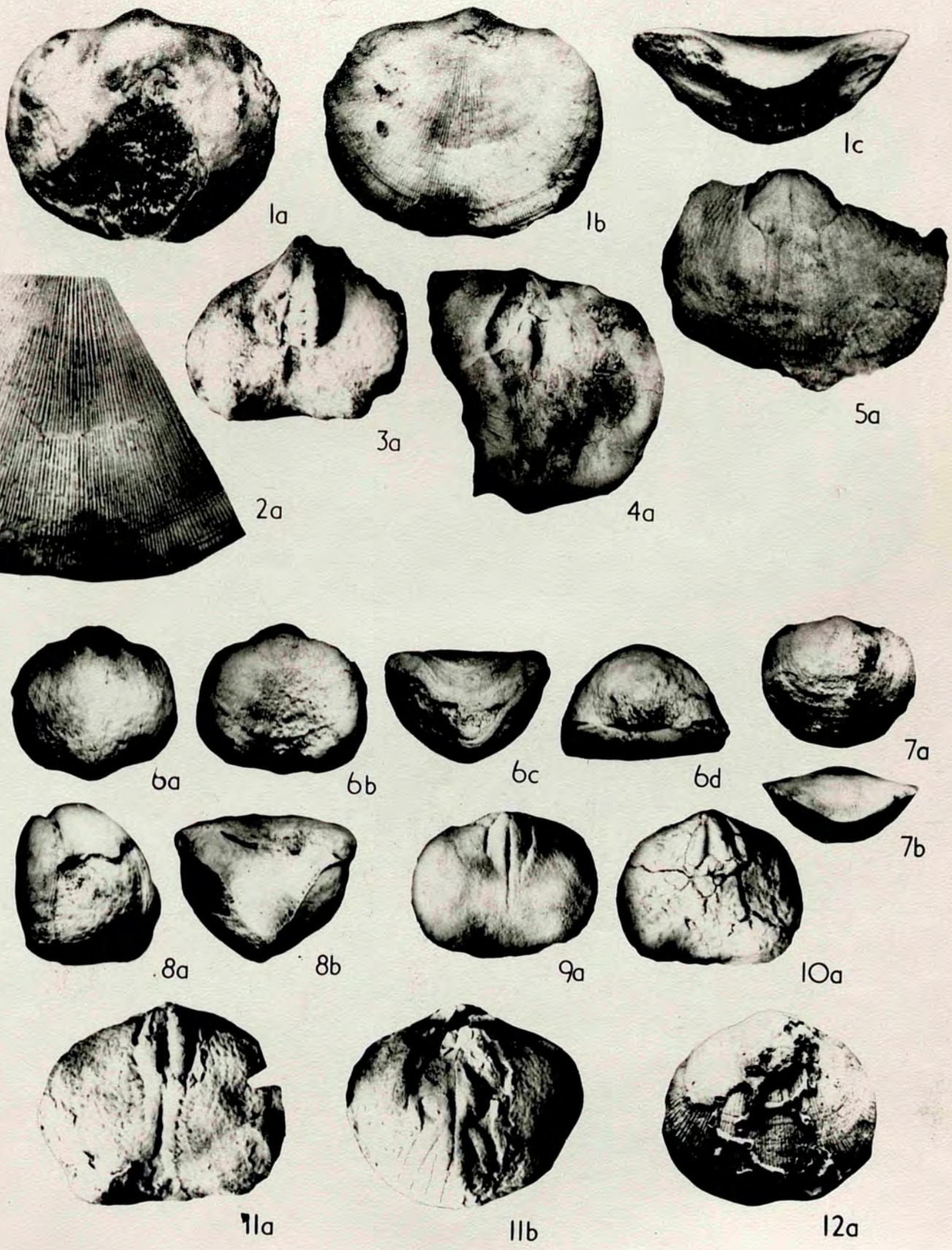
EXPLANATION OF PLATE 2

Figs. natural size, except where indicated.

FIGS. 1-5 — *Schizophoria pygmaea* subspecies A. 1a-c, brachial, pedicle, and anterior views, BC B68; 2a, part of pedicle valve showing spine bases, BC B68, x 3; 3a, pedicle internal mould, BC B69; 4a, fragmentary pedicle valve interior, BC B70; 5a, fragmentary brachial internal mould, BC B71.

6-12 — *Schizophoria striatula* (Schlotheim). 6a-d, brachial, pedicle, anterior, and posterior views, BC B96; 7a, b, brachial and anterior views, youthful specimen, BC B130; 8a, b, lateral and anterior views, ephebic-gerontic specimen, BC B108; 9a, pedicle internal mould, BC B92; 10a, pedicle internal mould, more flabellate muscle field, BC B131; 11a, b, pedicle and brachial views of internal mould, BC B127; 12a, brachial view of specimen encrusted by auloporid coral, BM B19581.

PLATE 2



EXPLANATION OF PLATE 3

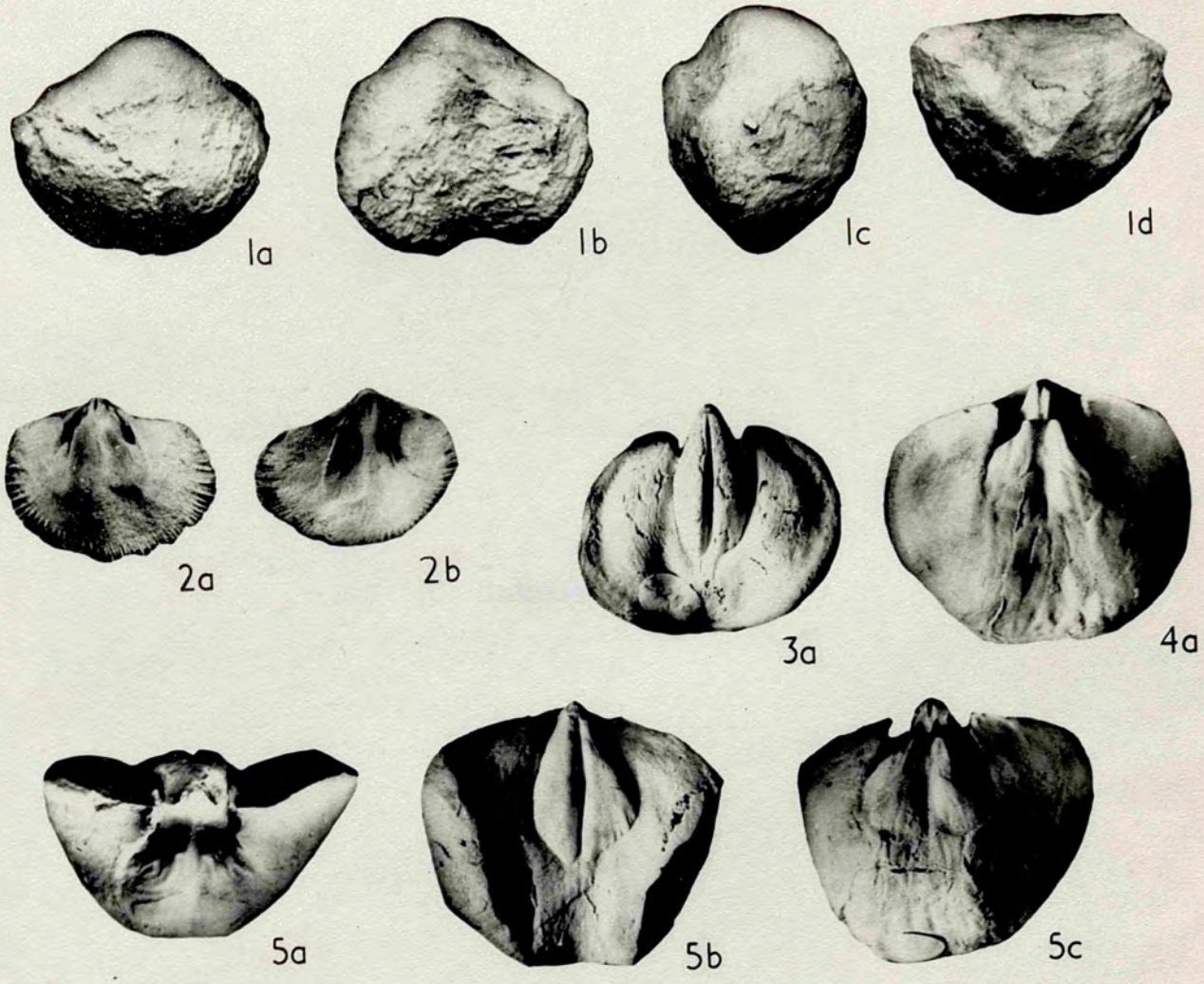
Figures natural size.

FIGS. 1 — *Schizophoria striatula* (Schlotheim). 1a-d, brachial, pedicle, lateral, and anterior views of Frasnian form, BC B135.

2 — *Schizophoria strigosa* (Sowerby). 2a, b, brachial internal mould and plasticine cast of mould, HMUG L5345/1.

3-5 — *Schizophoria vulvaria* (Quenstedt). 3a, pedicle internal mould, BM B24290; 4a, brachial internal mould, BM B2949; 5a-c, posterior, pedicle, and brachial views, BM B23179.

PLATE 3

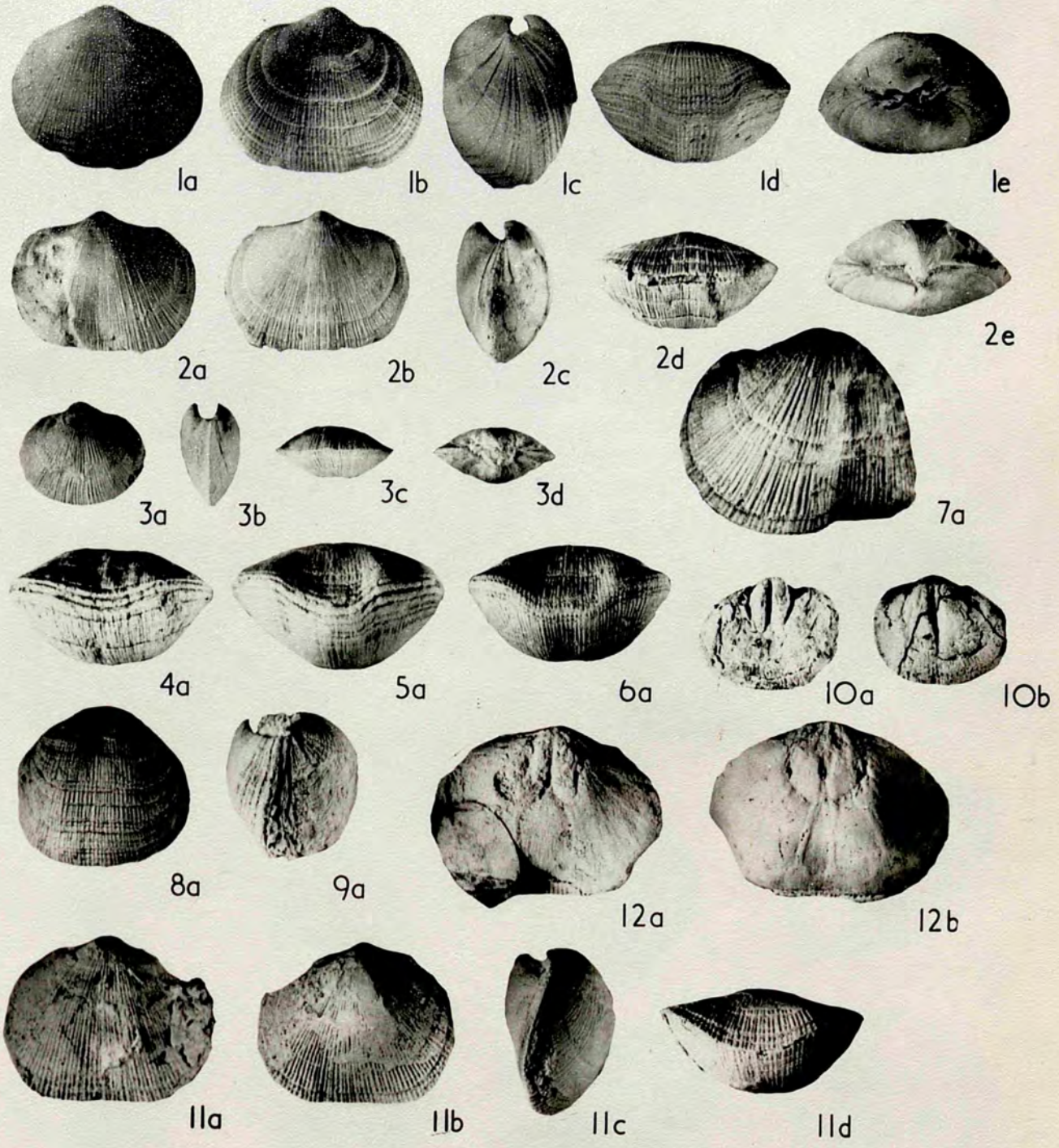


CARBONIFEROUS

EXPLANATION OF PLATE 1

FIGS.1-12 — *Schizophoria connivens* (Phillips). 1a-c, brachial, pedicle, lateral, anterior, and posterior views, neotype, BM B387, x 1½; 2a-e, brachial, pedicle, lateral, anterior, and posterior views, BC B146, x 1½; 3a-d, brachial, lateral, anterior, and posterior views, youthful specimen, BC B140, x 2; 4a, 5a, 6a, anterior views, SM, x 1½; 7a, spine bases, BC B155, x 2; 8a, rugate specimen, IC 11131, x 1½; 9a, tumid specimen, IC 11133, x 1½; 10a, b, pedicle and brachial views of internal mould BC B153, x 1½; 11a-d, brachial, pedicle, lateral, and anterior views, HMUG L4273/3, x 1½; 12a, b, pedicle and brachial views of internal mould, HMUG L4273/2, x 1½.

PLATE I


1a
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5a
6a
10a
10b
8a
9a
12a
12b
11a
11b
11c
11d

EXPLANATION OF PLATE 2

FIGS. 1-5 — *Schizophoria gibbera* (Portlock). 1a-e, brachial, pedicle, lateral, anterior, and posterior views, holotype, GSM 70646, x 1; 2a, b, lateral and posterior views, GSI 21/4, x 1; 3a, anterior view of holotype showing ornament, x 2; 4a, pedicle internal mould, GSM 5758, x 1; 5a, fragmentary brachial internal mould, TCD 1270, x 1.

6-9 — *Schizophoria hudsoni* George. 6a, block of internal moulds, BC B266, x ½; 7a, pedicle internal mould, BC B254, x 1; 8a, pedicle internal mould, BC B253, x 1; 9a, fragmentary brachial internal mould, BC B275, x 1.

10-13 — *Schizophoria linguata* (Quenstedt). ontogenetic increase in dorsibiconvexity (10-13) a, lateral view, b, anterior view, SM, x 1½.

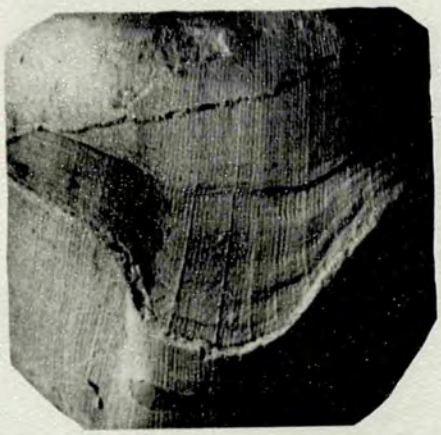
PLATE 2

1a

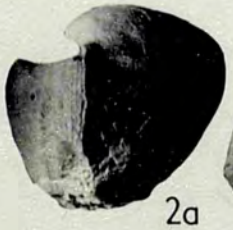
1b

1c

1d



3a



2a

2b

1e

4a

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7a

8a

9a

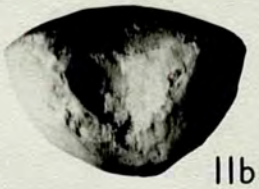
10a

11a

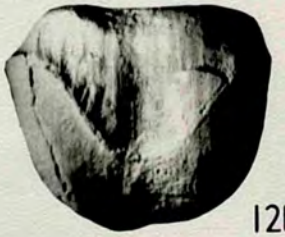
12a

13a

10b



11b



12b

13b

EXPLANATION OF PLATE 3

FIGS. 1-3 — *Schizophoria linguata* (Quenstedt). 1a, pedicle view, SM, x 1½; 2a, b, brachial and pedicle views, showing ornament, BM B75348 (ground specimen), x 2; 3a, pedicle internal mould, IC 1134, x 1.

4-6 — *Schizophoria sp. nov.* 4a-e, brachial, pedicle, lateral, anterior, and posterior views, HMUG L5255/3, x 1½; 5a, b, brachial and anterior views, more youthful specimen, HMUG L5255/2, x 1½; 6a, b, lateral and anterior views of rugate specimen, GSI, x 1.

7-12 — *Schizophoria resupinata* (Martin). 7a-e, brachial, pedicle, lateral, anterior, and posterior views, neotype, BM BB2420, x ½; 8a, b, brachial and anterior views, thin form, BC B206, x 1; 9a, b, brachial and anterior views, thicker form, BC B175, x 1; 10a, spine bases, GSM 84666, x 1; 11a-d, brachial, pedicle, anterior and posterior views, youthful specimen, BM BB39921 (ground specimen), x 1; 12a, fragmentary pedicle internal mould, BC B193, x 1.

PLATE 3


1a


2a


2b


3a


4a


4b


4c


4d


5b


5a


6a


6b


4e


7a


7b


7c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8a


9a

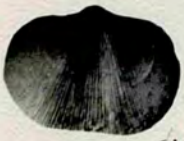

10a


8b


9b


12a


11c


11a


11b

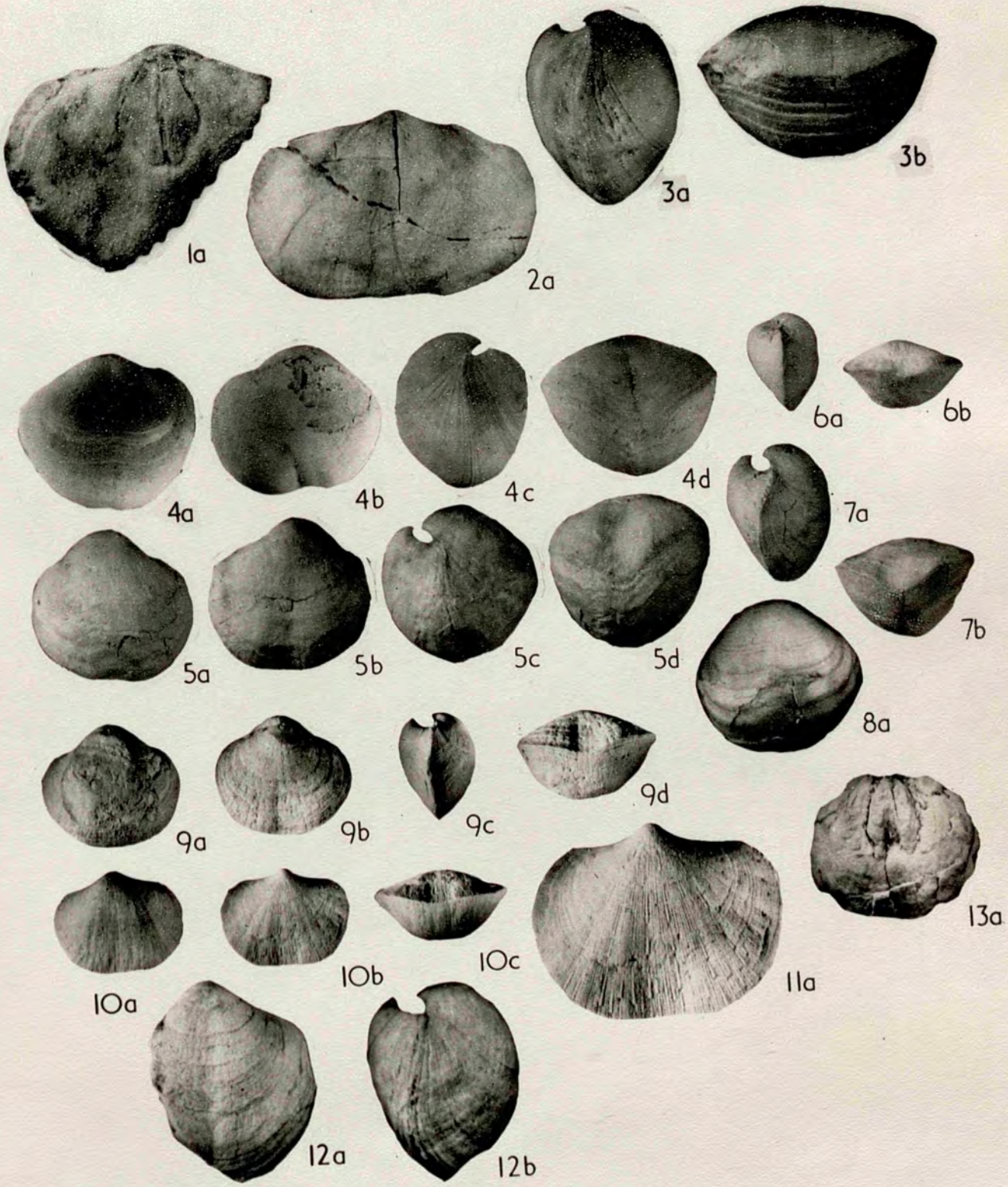

11d

EXPLANATION OF PLATE 4

FIGS. 1-3 — *Schizophoria resupinata* - vars. 1a, fragmentary pedicle internal mould, var. *gigantea* Demanet, BC B186, x ½; 2a, brachial view, var. *lata* Demanet, BC B187, x 1; 3a, b, lateral and anterior views, var. *pinguis* Demanet, HMUG L5333/1, x 1.

4-13 — *Schizophoria woodi* Bond. 4a-d, brachial, pedicle, lateral, and anterior views, holotype, BM BB8152, x 1; 5a-d, brachial, pedicle, lateral, and anterior views, BC B243, x 1; 7a, b, lateral and anterior views, older specimen, BC B246, x 1; 8a, rugate specimen, BC B246, x 1; 9a-d, brachial, pedicle, lateral, and anterior views, BM B39909 (ground specimen), x 1; 10a-c, brachial, pedicle, and anterior views, more youthful specimen, BM B39890 (ground specimen), x 1; 11a, pedicle view showing ornament, BM B39890, x 2; 12a, b, pedicle and lateral views of older, more rugate specimen, BC B224, x 1½; 13a, pedicle internal mould, BC B230, x 1½.

PLATE 4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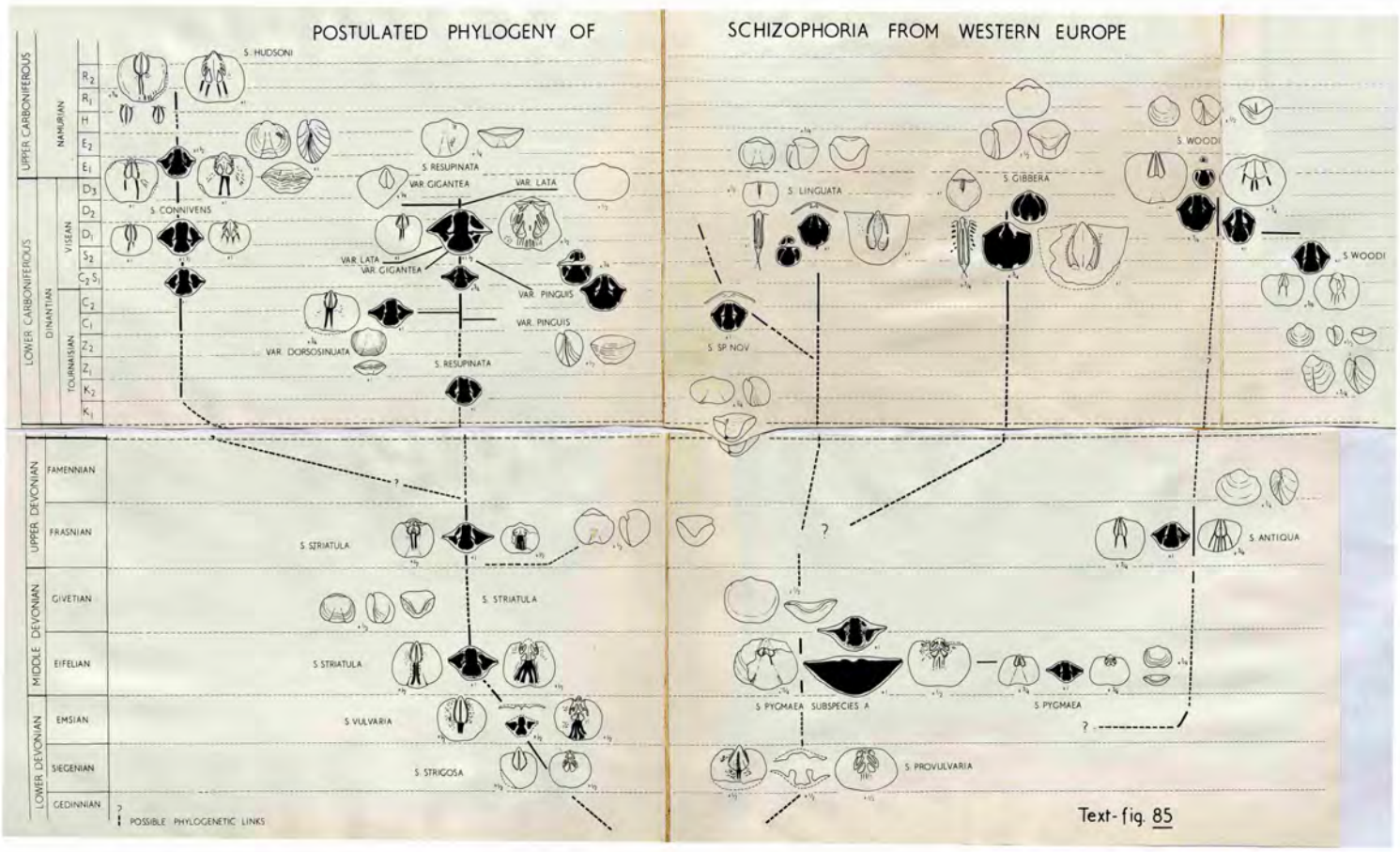
POSTULATED PHYLOGENY OF
SCHIZOPHORIA FROM WESTERN EUROPE
UPPER CARBONIFEROUS
LOWER CARBONIFEROUS
NAMURIAN
VISEAN
DINANTIAN
TOURNASIAN
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
SIEGENIAN
GEDINNIAN
UPPER DEVONIAN
MIDDLE DEVONIAN
LOWER DEVONIAN
S. HUDSONI
S. CONNIVENS
S. RESUPINATA
VAR. GIGANTEA
VAR. LATA
VAR. PINGUIS
VAR. DORSOSINUATA
S. SZRIATULA
S. STRIATULA
S. VULVARIA
S. STRIGOSA
S. LINGUATA
S. GIBBERA
S. WOODI
S. SP. NOV
S. ANTIQUA
S. PYGMAEA SUBSPECIES A
S. PYGMAEA
S. PROVULVARIA
? POSSIBLE PHYLOGENETIC LINKS

Text-fig. 85