BIOSTRATIGRAPHY AND PALAEOECOLOGY OF SOME STROPHEODONTID BRACHIOPODS FROM THE LUDLOW ROCKS (SILURIAN) OF THE WELSH BORDERLAND OF BRITAIN, AND SWEDEN.

BY

RAMZI KHADER HANNA

Thesis submitted in fulfilment of the degree of Doctor of Philosophy (by research) in the Faculty of Science, Department of Geology, University of Glasgow.

1986

DEDICATED TO

My wife EMAN and daughters HIBA & HALA, without whose constant Love, Support and Encouragement this work would never have been completed.

C O N T E N T S

SECTION III

PALAEOECOLOGY AND CONCLUSIONS

SECTION IV

APPENDICES

SECTION V

PLATES AND EXPLANATIONS

LIST OF TEXT-FIGURES

LIST OF TABLES

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

CHAPTER SEVEN

CHAPTER NINE

ACKNOWLEDGEMENTS

I am particularly grateful to Dr J.D. Lawson for supervising this research, for his advice, guidance and encouragement. He also allowed me access to his collections and his willingness to discuss the subject at all times is greatly appreciated. I would also like to thank Dr G.B. Curry, who supervised me in the first year during Dr Lawson's absence, for all the help on modern brachiopods and statistics, encouragement and for his valuable discussions and comments on the manuscript. I would also like to thank Professor B.E. Leake, Professor D. Bowes and Mr R.M. Morrison for providing facilities in the Geology Department, Glasgow University.

I am most grateful to Dr M.G. Bassett (National Museum of Wales), Dr D.E. White (British Geological Survey), Dr L.R.M. Cocks (British Museum of Natural History) and Mr W.J. Norton (Ludlow Museum) for providing access to collections in their care. They kindly granted me working space and use of facilities during my visits to their museums and also provided valuable discussions of the problems.

I would also like to thank Sir Alwyn Williams (Principal of Glasgow University), Professor A.J. Boucot (Oregon State University, U.S.A.), Dr J.M. Hurst (B.P.), Dr M. Lockley, Dr. C.J. Burton and Dr M.C. Keen for their valuable comments and discussions. Mr Douglas Maclean and Mrs Sheila Hall kindly assisted with the preparation of photographs and diagrams respectively.

I am very grateful to my colleagues for their willing co-operation and help; in particular, Dr D. Al Mansoori and Dr E. Elias. I would like to thank Mrs B. Mackenzie for typing the thesis.

The author gratefully acknowledges an Iraqi Government Scholarship from Mosul University which funded this research project.

Finally, I wish to sincerely thank my wife (Eman), my daughters (Hiba and Hala), my parents (Josephine and Khader), and all my family, in particular, my mother and father in law (Amel and Edmon), and my brother(Suhair), for all the help, support and encouragement they have given me.

S U M M A R Y

This thesis provides detailed studies of the five stropheodontid species which occur commonly in the Ludlow rocks of the Welsh Borderland. These are Shaleria ornatella (Davidson), Leptostrophia filosa (J. de C. Sowerby), Pholidostrophia (Mesopholidostrophia) lepisma (J. de C. Sowerby), Amphistrophia funiculata (McCoy), and Strophonella euglypha (Dalman).

About 2250 specimens have been collected from well-spaced geographical localities in the shelf facies of the Welsh Borderland (i.e. Ludlow, Abberley Hills, Woolhope inlier and Usk inlier) and, where possible, from different levels in the Ludlow succession. In addition, a large collection of Shaleria aff. ornatella Bassett & Cocks from Gotland, Sweden plus museum and other specimens of the Wenlock forms of S. euglypha and A. funiculata were studied statistically for comparison with the Welsh Borderland Ludlovian forms.

After preparation, accurate measurements were made of: shell length and width, pedicle muscle field length and width, angle of divergence of the pedicle valve muscle field, width of denticulation, the number of ribs per mm at 5 or 10mm from the dorsal umbo, and some other special morphological features.

All five species are fully described and illustrated: some previously undescribed morphological features have been recognised, discussed and figured.

For each species, also, statistical analyses of the range of variation of the most significant morphological features have been carried out.

In the case of P. (M.) lepisma, the emphasis is on the full description of the species and its variation as it has not previously been adequately described and figured.

The study of L. filosa also concentrates on the description and the range of variation, together with a comparison with Wenlock forms of the same species.

Shaleria ornatella is fully described and its range of variation is such that there seems little doubt that the Gotland form Shaleria aff. ornatella should be included in this species. The small but consistent difference in the Gotland form can be related to environmental rather than genetic controls.

The intraspecific variation in a present-day species of Brachiopoda; Kraussina rubra (Pallas) from one locality was also studied; the range of variation is comparable to that in S. ornatella, thereby supporting the palaeontological interpretation of this (& other) species.

In both S. euglypha and A. funiculata, particular interest lies in the morphological differences between the Wenlock and Ludlow forms of these species. These changes have been analysed in detail and attention directed to the containing sediments in order to determine whether changes of substrate or other environmental factors might explain the vertical changes. The accumulated evidence, however, seems to favour gradual evolutionary changes from the Wenlock to the Ludlow although there are too many gaps in the record to be certain.

Finally, the functional morphology and palaeoecology of stropheodontid brachiopods in general, and of these five Ludlow specimens in particular, are discussed.

SECTION
I
GENERAL

SECTION I

CHAPTER ONE

INTRODUCTION AND PREVIOUS WORK

CONTENTS

CHAPTER ONE

INTRODUCTION AND PREVIOUS WORK

1.1. AIMS OF STUDY.

a) To describe fully the five species of stropheodontid brachiopod which occur in the Ludlow rocks of the Welsh Borderland (i.e. Shaleria ornatella (Davidson, 1871), Leptostrophia filosa (J. de C. Sowerby, 1839), Mesopholidostrophia lepisma (J. de C. Sowerby, 1839), Amphistrophia funiculata (McCoy, 1846) and Strophonella euglypha (Dalman, 1828)), by using statistical methods and liberal illustrations.

b) To deduce the autecology of these five species by considering the evidence from sedimentology and functional morphology.

c) To compare, where relevant, the morphology of the Ludlow forms with the Wenlock forms of the same species and to attempt to explain the differences in terms of evolution and/or environment (e.g. Amphistrophia funiculata and Strophonella euglypha).

d) To compare Shaleria ornatella with similar forms abundant at the same level on the Island of Gotland (Sweden), and to decide if they are conspecific.

e) To compare the variation in Shaleria ornatella with that of modern Brachiopoda (e.g. Kraussina rubra (Pallas, 1776)), in order to assess the degrees of variability in brachiopod species.

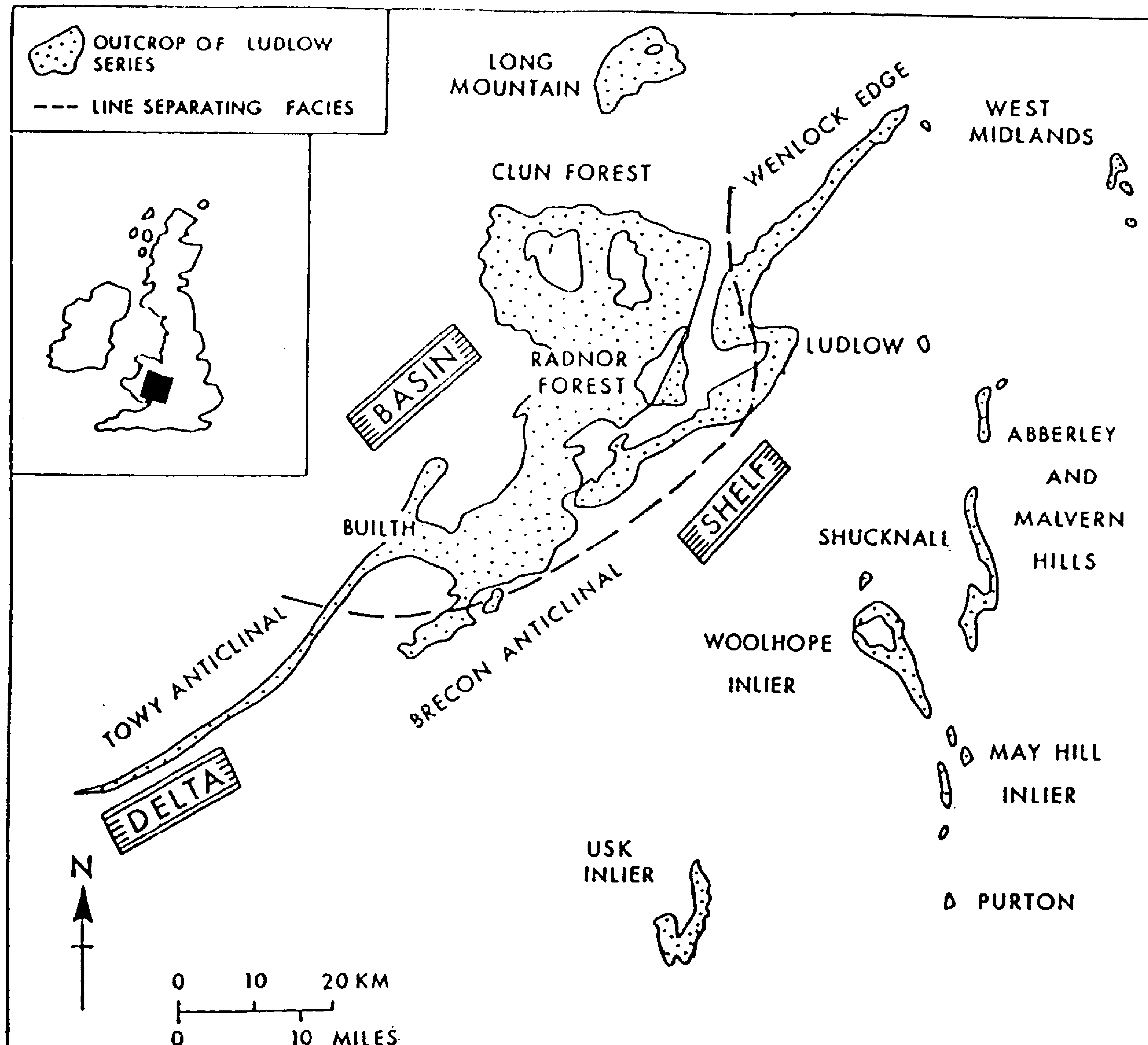
1.2. AREAS OF STUDY.

a) Welsh Borderland of Britain.

The area of study is the Ludlow district and the surrounding inliers of the Ludlovian (Upper Silurian) rocks of the Welsh Borderland. The Welsh Borderland is the area adjacent to the outer edge of a marine shelf which extended over the English Midlands and comprises mainly three different facies, basin, shelf and delta (text-fig.1.1). It is historically important as the type area of the Ludlow Series since the first comprehensive investigation of the rocks of the area was made by Sir Roderick Murchison, who introduced the well-known name of "Silurian". His great work "The Silurian System" was published in 1839 and it still remains a fund of information and a basis for the work of investigators in the region. Probably, the earliest reference to the geology of the Ludlow district was by Wright (1832). Subsequently, Murchison in 1833 established the descending sequence of the Upper Ludlow rock, Wenlock Limestone and Lower Ludlow rock.

During the Silurian period in the British area there was a stable uplifting shelf area over the Midlands and the Welsh Borderland with a subsiding region to the north-west. The contrast in the thickness and lithology between the shelf and basin in Ludlow times is clearly summarised by Holland and Lawson (1963). They pointed out that the shelf deposits are represented by about 360 metres of well sorted silty and calcareous beds, whereas sedimentation in the basin region has resulted in the formation of up to ten times this thickness of rock, comprising less calcareous and less well sorted siltstones.

The Ludlow type area displays a sequence of dominantly terrigenous strata deposited under marine open shelf conditions



TEXT-FIG. 1.1. Map outlining the outcrop of the Ludlow Series in the Welsh Borderland of Britain, with a key map.

(Watkins 1978). It is situated in the outer shelf facies and its uppermost division of Murchison's original Silurian system, the Ludlow Series, has been intensively studied by palaeontologists and stratigraphers.

Other areas, such as Woolhope, Abberley Hills, Malvern, May Hill and Usk have also been studied. They are located in the inner shelf facies of the Welsh Borderland and show characteristic shelf features, with brachiopods occurring through most of the Ludlow succession.

The field work has been restricted by limited finances. Otherwise, it would have been possible to collect from several other areas. Formations such as the Elton Formation would have been studied more thoroughly. This formation is less productive for shelly fauna, but important for checking the transitions from the Wenlock limestone forms to the Bringewood forms. More time would also have been spent searching for the less common Shaleria sp.nov. (Holland et.al. 1963).

b) Gotland.

The Swedish island of Gotland in the Baltic Sea is a classic region for the study of Silurian strata. The exposed Silurian sequence, is about 500m thick, comprising shallow marine sedimentary rocks, mostly carbonates, ranging from the latest Llandovery to Late Ludlow age (Cherns 1982, 1983 and Martinsson 1967). The strata are almost undisturbed, with a NE-SW strike and very gentle dip to the SE. The oldest deposits are found along the NW coast, the youngest in the SE. The major limestone developments in the succession include moderate to high water energy, inshore shelf deposits with reefs and carbonate mounds. To the SW along the strike, these carbonate sequences pass laterally into more offshore, lower energy deposits of fine-grained, muddy calcareous rocks called marls.

Even though Gotland was not visited during the present study because of the limited finances, sufficient samples of S. aff. ornatella (Bassett and Cocks 1974), from the northeastern localities of Gotland were kindly made available by Dr. J.D. Lawson (see text-figs. 1.3 and 1.4 for detailed localities). This material is mainly from the uppermost Hemse Beds of the eastern region of Gotland (see 1.3b).

1.3. STRATIGRAPHY.

a) Welsh Borderland of Britain.

Stratigraphical research has been carried out by numerous workers. The pioneer work by many of these researchers before 1950 is not reviewed here. From 1952 onwards, work on the area was much stimulated by a group of geologists who formed the "Ludlow Research Group", in which their activities were co-ordinated for many years by Dr. Lawson and Dr. Walmsley. The Ludlovian strata of the Welsh Borderland were re-classified in the published work of Holland, Lawson and Walsmley (1959, 1963), in which they introduced four Ludlovian stages - Eltonian, Bringewoodian, Leintwardinian and Whitcliffian. Subsequently, the subcommission on Silurian stratigraphy has approved two Ludlow stages instead of four. They have chosen the name Gorstian for the new lower stage, combining the previously used Eltonian and Bringewoodian stages, and Ludfordian for the new upper stage, combining the previously used Leintwardinian and Whitcliffian stages (see Holland (1980) and Holland, Lawson, Walmsley and White (1980)).

One of the most important collections during this study is from the type area of Ludlow. The stratigraphical divisions are described below. Structurally, the strata of the Ludlow district are folded into an asymmetrical anticline plunging east-north-eastwards, see Earp and Hains (1971) and text-fig.1.2. Holland _et al_ (1963) defined nine stratigraphic units (i.e. Beds) within the Ludlow Series in this area. These divisions were mapped mainly on the basis of their faunal assemblages, but lithological characteristics also proved very helpful in their identification. These units (Beds) are regarded as Formations by Holland _et al_ (1980) (see also Holland 1978 and Lawson 1979). These stratigraphic units are as follows:

1. <u>Elton Formations</u>.

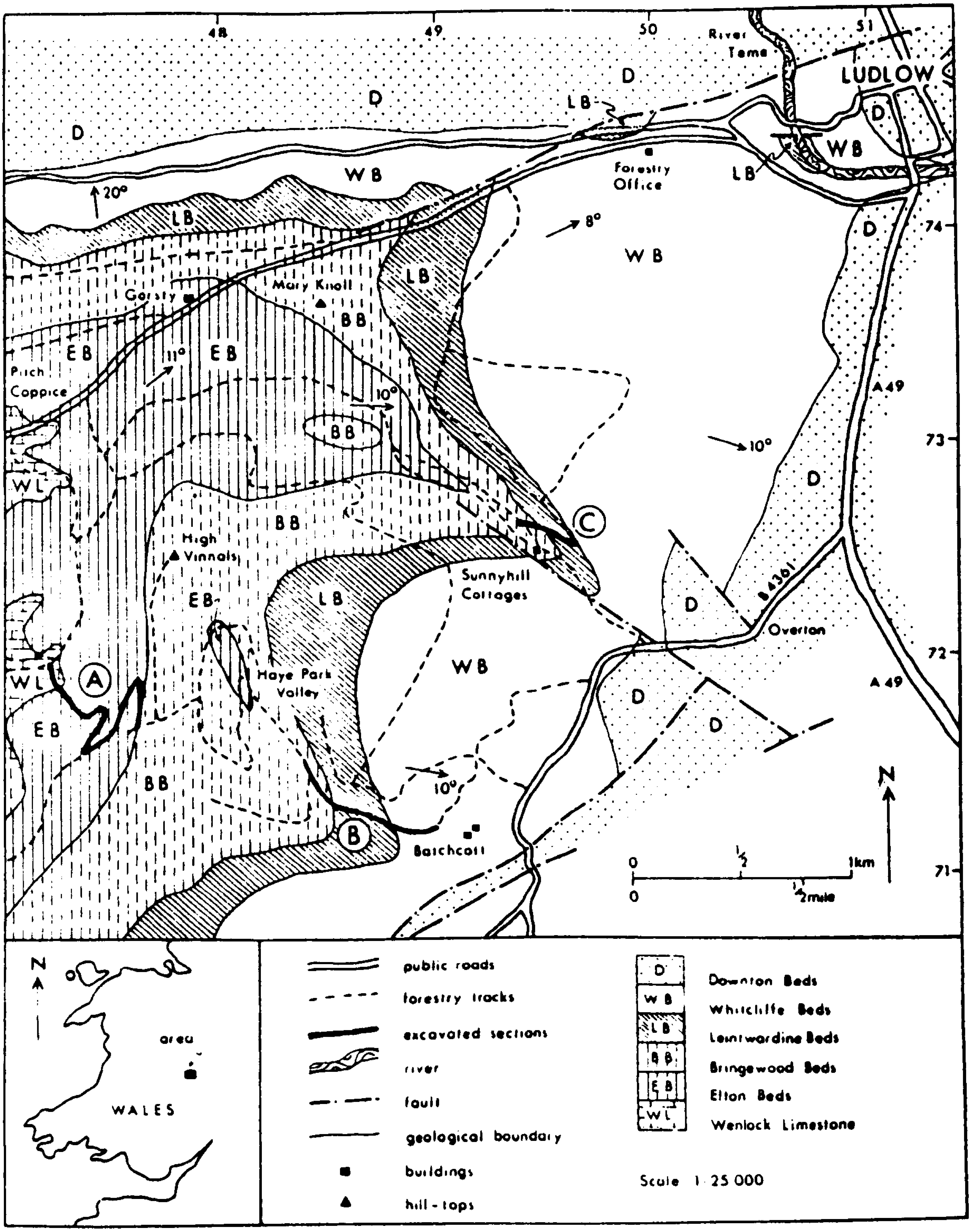
Lithologically, the Elton Formations are predominantly mudstones and fine siltstones. Their fauna is characterised by varied shelly fossils in the lower part (i.e. the Lower Elton Formation), and by graptolites which become abundant in the higher strata (i.e. in the Middle and Upper Elton Formations).

a) <u>Lower Elton Formation</u>.

Soft, poorly bedded, shaly and flaggy, pale olive calcareous siltstones, with layers of limestone nodules becoming harder and more compact in the lower part of the division. They are approximately 30 to 45m thick and poorly exposed. Small brachiopods (relevant to the present study) and trilobites predominate, whereas graptolites are exceedingly rare. For a detailed faunal list see Holland _et al_ 1959 and 1963.

b) <u>Middle Elton Formation</u>.

Well-bedded, shaly and thinly flaggy, light olive-grey to yellowish-grey, more or less calcareous siltstones with smooth, conchoidal fracture. This formation thins appreciably eastwards from approximately 106 to 45m. In this formation, graptolites and



TEXT-FIG. 1.2. Geological map summarising the structural setting of the Ludlow area, and the location of sections A, B and C. After White and Lawson (1978).

orthoconic cephalopods predominate while brachiopods become rare.

c) Upper Elton Formation.

The sediments of the Upper Elton Formation are hard, well-bedded, flaggy, light olive-grey, calcareous siltstones with common and conspicuous thin limestone bands. This formation varies in thickness from approximately 45 to 75m. A graptolitic fauna predominates (*Pristiograptus tumescens*).

2. Bringewood Formations.

The Bringewood Formations reflect a shallower water and more calcareous phase across the whole shelf area of the Welsh Borderland. The lower subdivision consists of irregularly-bedded calcareous siltstones passing up into the impure limestone (i.e. the Aymestry limestone) of the Upper Bringewood Formation. The change in environment resulted in the appearance of large strophomenid brachiopods in the lower siltstones and of corals in the upper limestone division.

a) Lower Bringewood Formation.

Irregularly bedded, flaggy, pale greyish-olive to greenish-grey, calcareous siltstones, with limestone nodules. Their base is marked by the appearance of many bands of shelly fossils, by more frequent bands and lenses of silty limestone, and by the development of calcareous siltstones somewhat thicker and more irregularly bedded than those of the Upper Elton Formation. These beds thicken slightly eastwards from approximately 48 to 60m. The Lower Bringewood Formation shows a marked faunal contrast to the Upper Elton Formation; graptolites are rare, whereas large brachiopods (particularly strophomenids) are abundant such as, *S. euglypha*, *L.*

filosa, A. funiculata and small or medium sized strophomenids like P.(M.) lepisma.

b) Upper Bringewood Formation.

Hard, irregularly bedded, flaggy and nodular, greenish-grey silty limestones with thin shaly partings at intervals of several feet. The Upper Bringewood Formation has a maximum thickness of about 45m in the west of the Ludlow district, from which it thins eastwards to a minimum of about 12m. The strophomenids are similar but less abundant than in the Lower Bringewood Formation except for S. euglypha, whereas compound corals and Kirkidium knightii become common. Both K. knightii and corals are good indications of shallow water environments.

3. Leintwardine Formations.

The Leintwardine Formations are characteristically flaggy calcareous siltstones with thin shelly limestones. The fauna is easily distinguishable from the Upper Bringewood Formation near Ludlow. In these formations important fossils for correlation appear for the first time and become dominant in the succeeding Whitcliffe Formations (Holland et al 1959). Some other fossils occur typically in the upper formation which help for correlation purposes, such as S. ornatella.

a) Lower Leintwardine Formation.

Flaggy, light olive-grey, calcareous siltstones, with bands of shelly limestones which weather to dark yellowish-brown rottenstones. The approximate thickness of this formation is about 30m. Brachiopods are abundant but many species characteristic of the Bringewood Formations have disappeared, for example, K. knightii, corals and S. euglypha. Some strophomenids are fairly common here such as L. filosa and S. ornatella.

b) Upper Leintwardine Formation.

Irregularly bedded, flaggy, light olive-grey, calcareous siltstones, with an abundant and most distinctive faunal assemblage. The thickness here reaches a maximum value of 6m. The fauna of this formation combines most of the fauna of the lower division with the increased abundance of the incoming Whitcliffe fossils (Lawson 1960). In addition, there are several fossils common only in this formation, e.g. *S. ornatella*.

4. Whitcliffe Formations.

The Whitcliffe Formations comprise a less variable sequence of flaggy siltstones, often calcareous. In this topmost Ludlovian division, there is a relative abundance (but not many species) of brachiopods whereas, molluscs become relatively more important in the shelly fauna.

a) Lower Whitcliffe Formation.

Irregularly bedded, massive or thickly flaggy, olive-grey to dusky-yellow, calcareous siltstones, with occasional calcareous nodules and with contorted siltstones at the top. The approximate thickness is about 24m. Fossils are fairly common. Many of the brachiopods characteristic of the lower formations have disappeared and molluscs have become more important.

b) Upper Whitcliffe Formation.

Well-bedded, flaggy, light olive-grey to dusky yellow, calcareous siltstones, with shelly limestone bands. The approximate thickness is about 30m. Fauna similar to that of the Lower Whitcliffe Formation, but some brachiopod species have become more abundant, in particular *Salopina lunata*.

The successions in the Ludlow rocks of the shelf inliers are not much different from that of the type area of Ludlow. The most important variations are:

1) The shelly facies of the Middle and Upper Elton Formations rather than the graptolitic facies seen at Ludlow.

2) The Upper Bringewood Formation is less calcareous than that of the Ludlow area.

3) The stratigraphic divisions of these inliers are often much thinner, particularly in the south-eastern inliers such as May Hill and Gorsley.

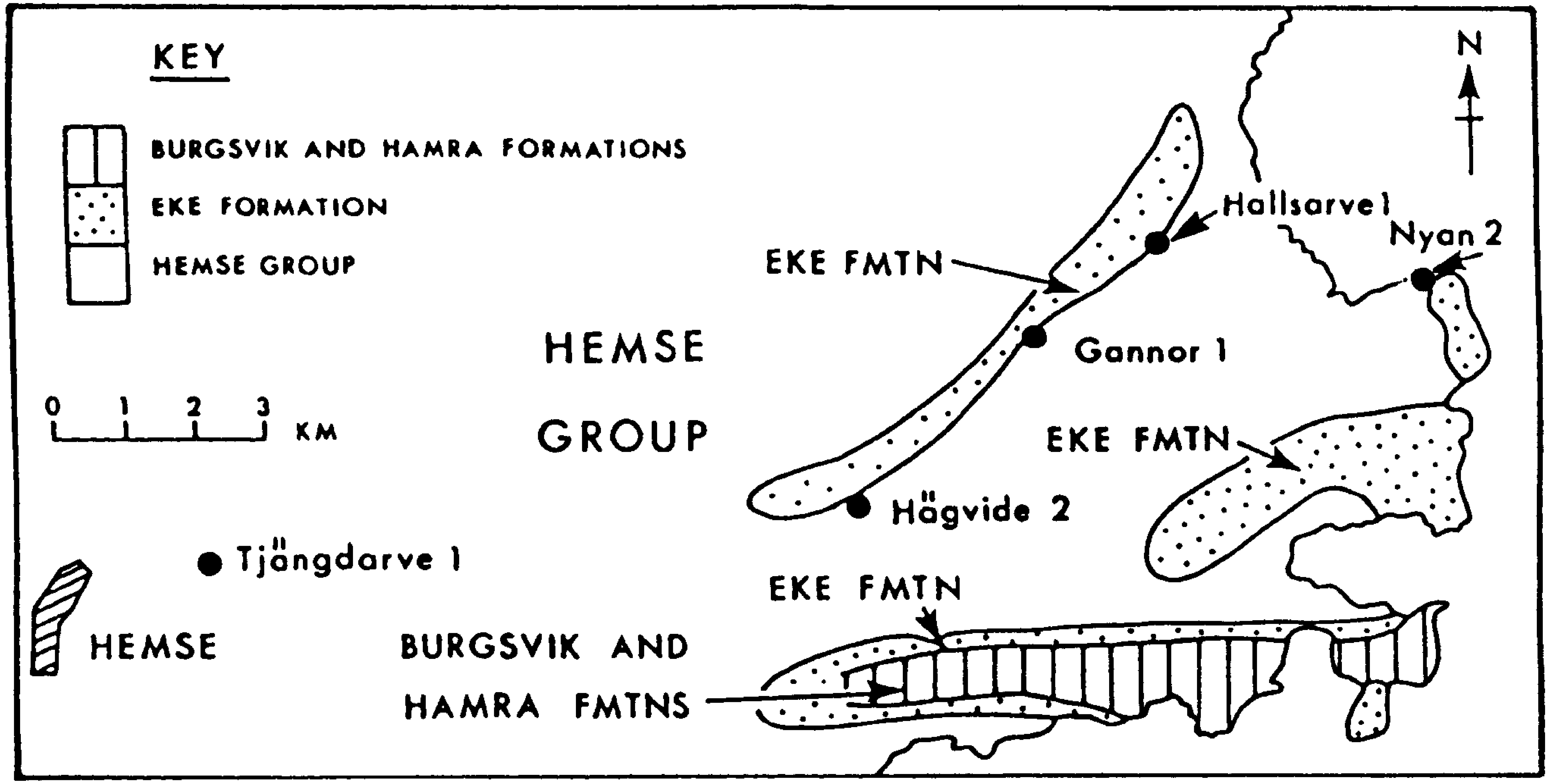
4) The Lower Leintwardine Formation often has conglomeratic layers at its base.

1.3.b) Gotland

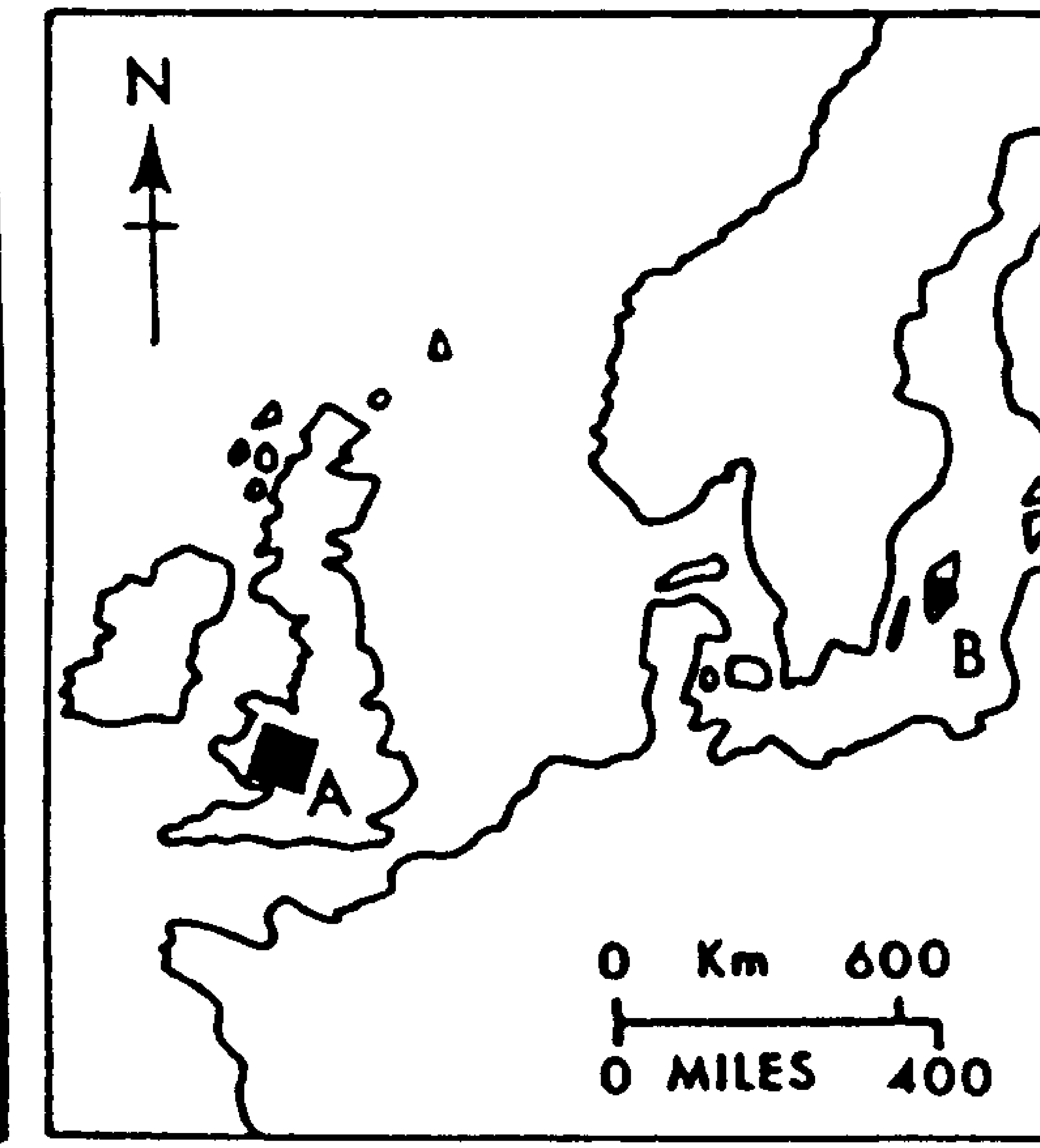
The succession of the Silurian in Gotland is subdivided into mappable units based on lithological characteristics in combination with some diagnostic faunal studies (Hede 1921; Cherns 1983).

Several hundred Ludlovian specimens of *S.* aff. *ornatella* (Bassett & Cocks 1974), from the E area of Gotland, were studied (text-figs. 1.3 and 1.4). These specimens are of great relevance to the Welsh Borderland specimens because of their close similarity to *S. ornatella* from the Welsh Borderlands and because of their occurrence in a stratigraphic horizon which is roughly equivalent to the stratigraphic level in the Welsh Borderlands (see the Table below):

TEXT-FIG. 1.3.



TEXT-FIG. 1.4.



TEXT-FIG. 1.3. Outline map showing the studied localities of N.E. Gotland (Sweden).

TEXT-FIG. 1.4. Map showing the British (A) and Swedish (B) areas of study.

Series	Stage	Rrevious used Stages	Graptolitic biozones	Middle & Upper Silurian of Gotland
L U D L O W	Ludfordian			Sundre
				Hamra
		Whitcliffian		Burgsvik
				Eke
		Leintwardinian	leintwardinensis	
	Gorstian	Bringewoodian	tumescens	
			scanicus	Hemse
		Eltonian	nilssoni	
W E N L O C K	Homerian	Upper	ludensis	
				Klinteberg
			lundgreni	
	Sheinwoodian		ellesae	Mulde / Halla
		Middle	linnarssoni	Slite
			rigidus	
		Lower	riccartonensis	Högklint
			murchisoni	
			centrifugus	Upper Visby

The Table shows the stratigraphical succession in the middle and upper Silurian of Gotland and the correlation with the standard British graptolite and shelly sequences (mainly after Bassett and Cocks 1974, with modifications).

Hemse Group.

The lithology of the uppermost Hemse Group consists of fairly carbonate-rich sequences of marlstones interbedded with thin, argillaceous and silty limestones. The bedding is mostly thinly flaggy, with harder, more calcareous lenses. Bioturbation affects all the Upper Hemse Group sediments to varying extents. The Hemse Beds are estimated by Hede (1921, 1925) to be about 100m thick. The fauna is dominantly of benthic invertebrates, particularly articulate brachiopods. Throughout the Hemse Beds outcrop, a typical British Ludlow brachiopod fauna is found, with localities in the NE (where the studied specimens were collected) containing distinctive "Leintwardine" fossils such as S. aff. ornatella and Dayia navicula.

Eke Formation.

The lithology of the Eke Formation is mainly of thin beds of grey, argillaceous limestones, alternating with very thin beds of grey, slightly arenaceous marlstone rich in calcareous algae, and some other beds which are commonly conglomeratic (Cherns 1983). The calcium carbonate content increases towards the NE, where the Eke Formation is mainly crinoidal limestone. The Eke Formation is a relatively thin division about 14m thick and decreases towards the NE to about 10m (Hede 1925; Stel and de Coo 1977). Isolated colonial organisms are scattered through the massive limestones. Mound and biostrome faunas are dominated by colonies and laminar stromatoporoids and tabulate corals. Brachiopods become numerically reduced and less diverse upwards through this part of the stratigraphic column (Bassett and Cocks 1974; Cherns 1983).

A few British Museum samples, mostly of A. funiculata, were also studied and compared with the same species from the Welsh Borderland of roughly equivalent stratigraphic horizon. These specimens are mainly from the Mulde Marl Formation of Eksta in the upper division of the Wenlock Series (see the Correlation Table above and Appendix I for detailed localities).

Many people have worked on the systematic palaeontology and ecology of the stropheodontid brachiopods and on the stratigraphy of this area (e.g. Bassettand Cocks 1974; Hurst 1975; Cherns 1982 & 1983; Spjeldnaes 1984; Bassett 1984----etc.). However, none of them has statistically described or compared the Welsh Borderland specimens with representative Gotland samples (for more details, see Chapter 3).

1.4. SYSTEMATIC PALAEONTOLOGY

The author here summarises some of the systematic work, which has been carried out on the strophomenid brachiopods of the Welsh Borderland. Sowerby in Murchison (1839) "described" the Ludlovian strophomenids of the Welsh Borderland with brief diagnoses and drawings. Davidson, in his monograph of the British fossil brachiopods (1871, part IIV), was first to describe these forms in any detail and with an adequate number of drawings. Williams (1953) studied the morphology and systematics of the stropheodontids from North America and Europe. Cocks (1967) described the lower Silurian stropheodontids (i.e. Llandovery) from the Welsh Borderland and used statistical data in an attempt to determine the evolution of these species. Subsequently, the morphology and evolution of the Ordovician, Silurian and Devonian pholidostrophiin brachiopods were studied by Harper, Johnson and Boucot (1967). Hurst (1974) described the taxonomy, ecology and functional morphology of the Llandovery and Wenlock *Pholidostrophia* species from the Welsh Borderland. Taxonomically, the Stropheodontacea were also studied by Harper and Boucot (1978), who re-assigned some of the studied species to new genera and subgenera names (for details see Section II). Bassett (1971) described the Wenlock Stropheodontidae from the Welsh Borderland and South Wales and in 1977 published further descriptions of them in part four of his monograph. None of these studies dealt in any detail with the Ludlow stropheodontids. Five species of these brachiopods are abundant in the Ludlovian rocks of the Welsh Borderland. By using statistical data, the morphology and variation of these five species are thoroughly described (see Chapters 3-7).

Among those working on the brachiopods of Gotland Hurst (1975) and Bassett and Cocks (1974) are noteworthy. The latter have reviewed the Silurian brachiopods, in particular the *S.* aff. *ornatella* species, which the writer has compared with the British samples.

1.5. STROPHEODONTID DISTRIBUTION.

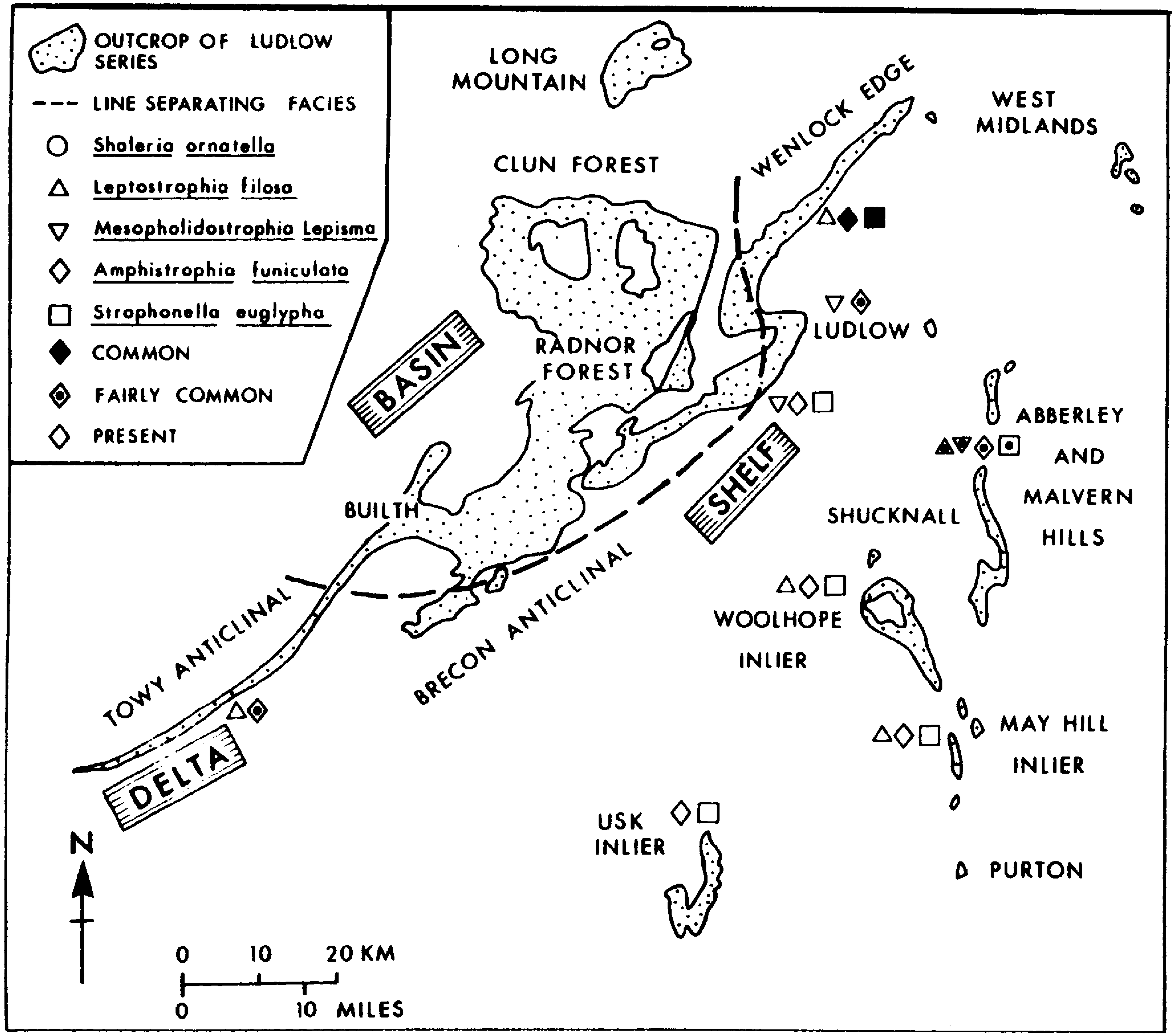
During the present study, stropheodontid species were collected from the shelf areas of the Welsh Borderland including Ludlow, Abberley Hills, the Woolhope inlier and the Usk inlier. In addition, workers in the Ludlow Research Group have recorded these species from many other areas in the Ludlow Series of the Welsh Borderland. Their research covered the Ludlow area by Holland *et al* (1959, 1963), Leintwardine by Whitaker (1962), Wenlock Edge by Shergold and Shirley (1962), Amestrey by Lawson (1973), Woolhope by Squirrell and Tucker (1960), Malvern and Abberley by Phipps and Reeve (1967), Gorsley by Lawson (1954), May Hill by Lawson (1955) and Cherns (1977), Usk inlier by Walmsley (1959), Llandovery and Llandeilo by Potter and Price (1965), Builth by Straw (1937), Knighton by Holland (1959), Clun by Earp (1940) and Kerry by Earp (1938).

The occurrence of these species is best covered by distribution maps which illustrate their frequency in the Ludlow successions of the Welsh Borderland (see text-figs. 1.5-1.9). These maps were mainly derived from the present data collection and the researchers mentioned above. Full descriptions for each species are to be found in the distribution sections of Chapters 3-7.

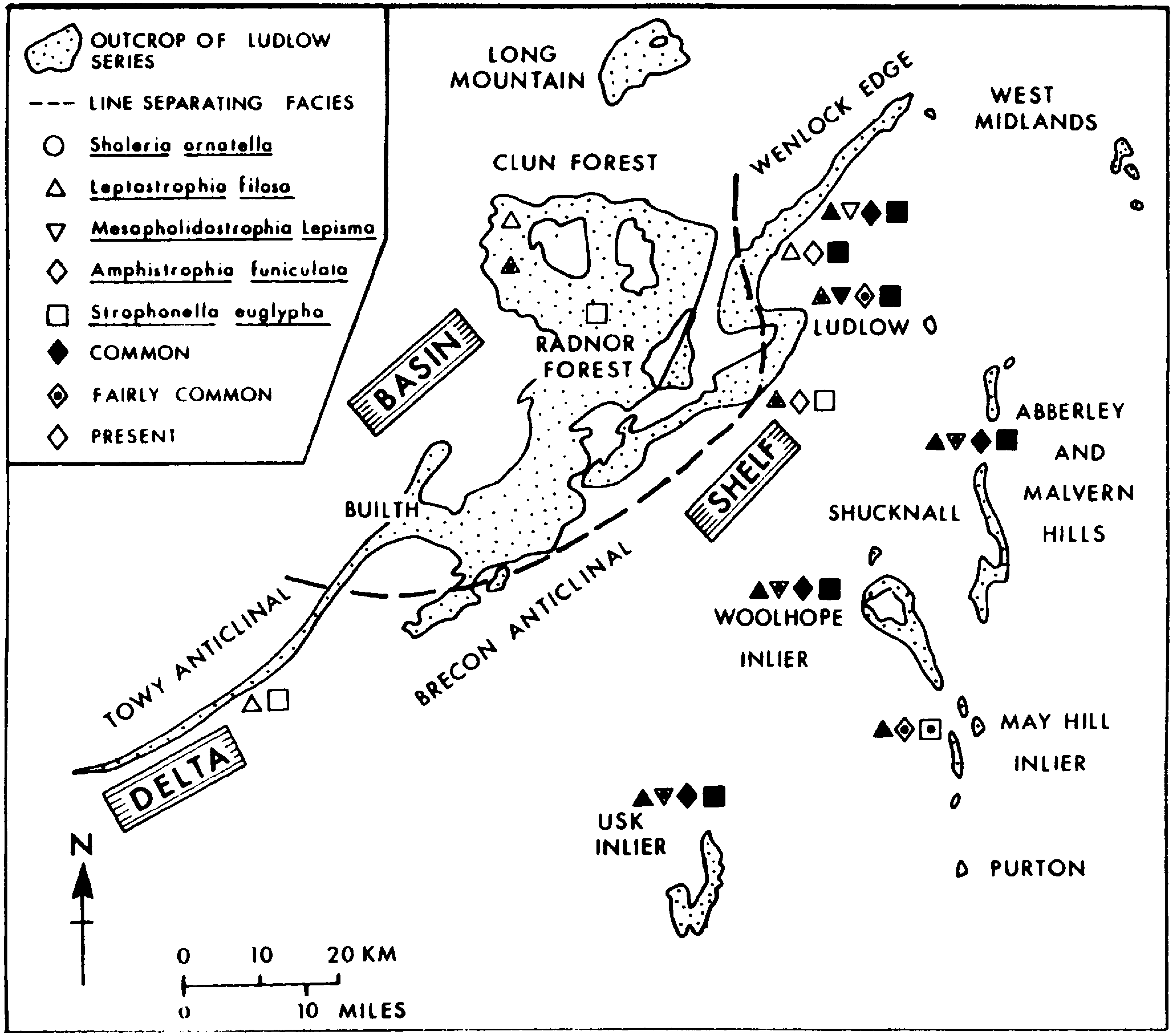
Stropheodontid species occur in the Lower Elton Formation (particularly A. funiculata), but they are rare or absent in the Middle and Upper Elton Formations. Apart from S. ornatella, S. euglypha, A. funiculata, P. (M.) lepisma and L. filosa become common or fairly common in the Lower and Upper Bringewood Formations. Following the Ludlow successions upwards, S. euglypha, A. funiculata and P.(M.) lepisma are rare in the Lower Leintwardine Formation, whereas L. filosa and S. ornatella are fairly common in this formation. In the Upper Leintwardine Formation, the species S. ornatella is very common, where it dominates some bedding planes. It is considered as a key fossil throughout this sequence. In the Whitcliffe Formations these five species become rare or absent (see also Lawson 1960).

It seems that the high concentration of these species in the shelf sequences (text-figs. 1.5-1.9), and their rarity westwards (towards the basin) indicates that these species are intolerant of the intense sedimentation and turbidity in the basin (see also Chapter 8).

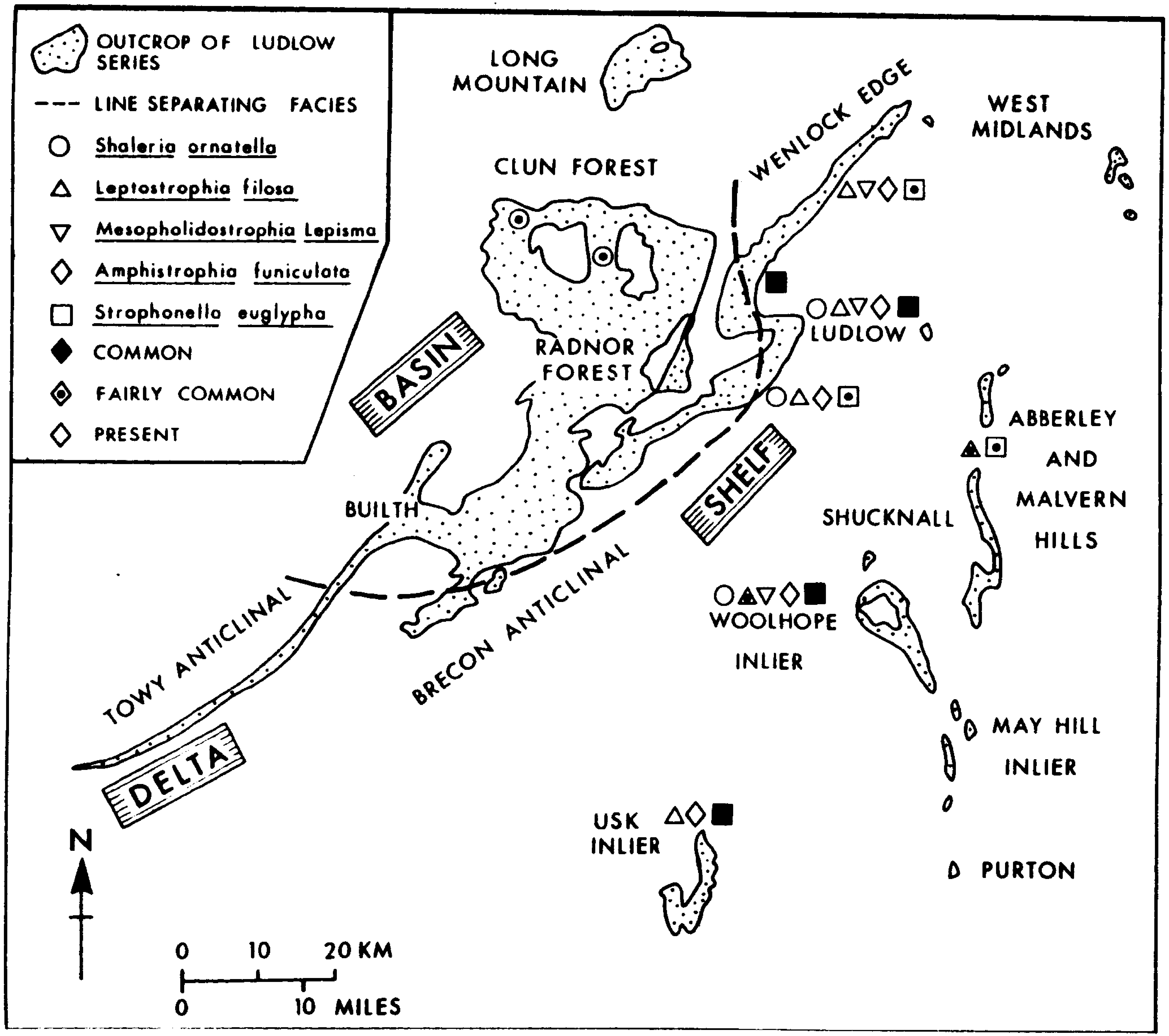
Specimens of the species S. aff. ornatella from the north-eastern localities of Gotland (Sweden) were also studied. It is present in a roughly equivalent horizon to the species S. ornatella from Britain (i.e. Upper Leintwardine Formation), see Bassett and Cocks (1974). The Gotland form is common at this level and covers the bedding planes of the studied localities (text-fig. 1.3).



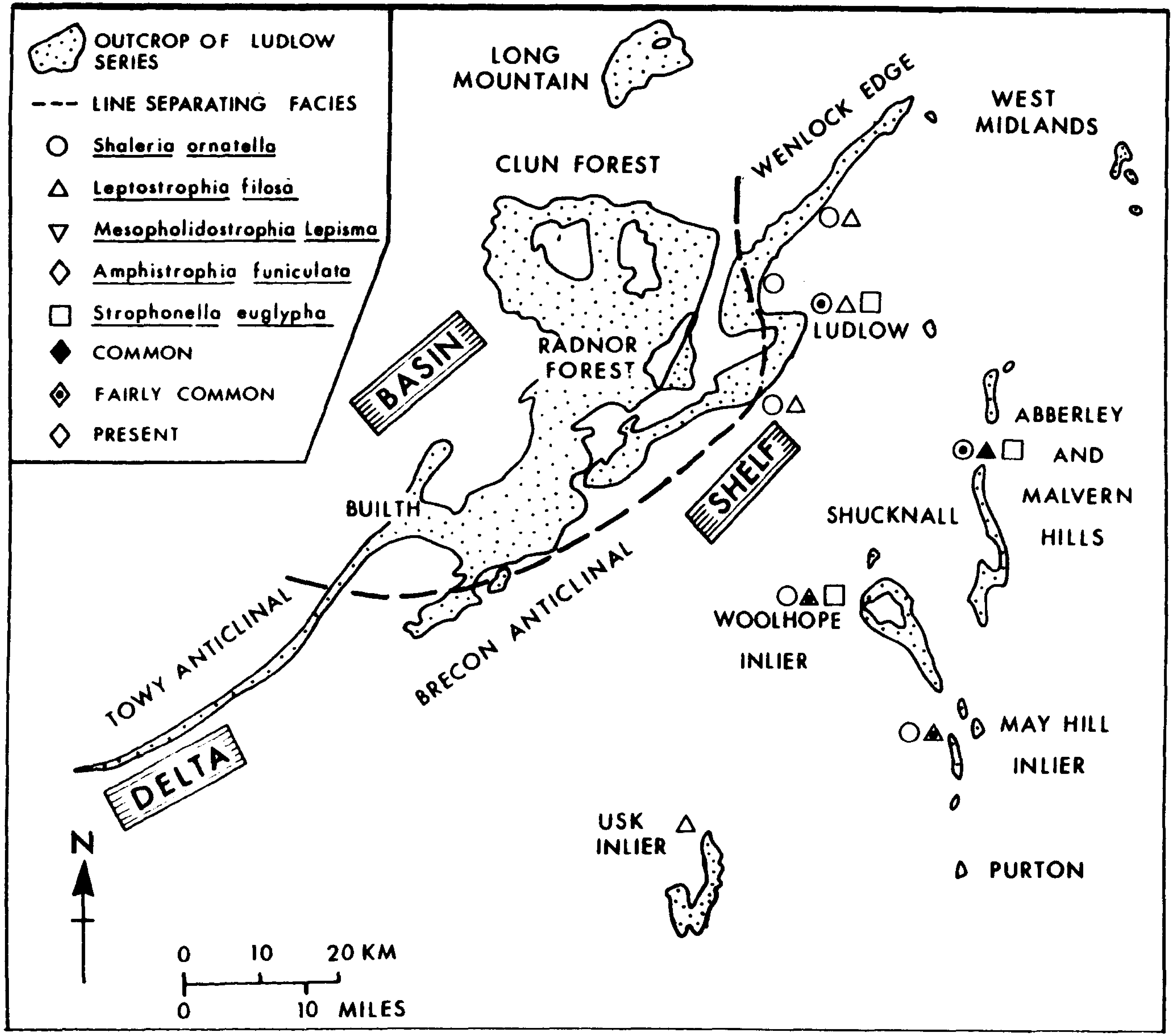
TEXT-FIG. 1.5. Map showing the distribution of the stropheodontid species in the Lower Elton Formation of the Welsh Borderland.



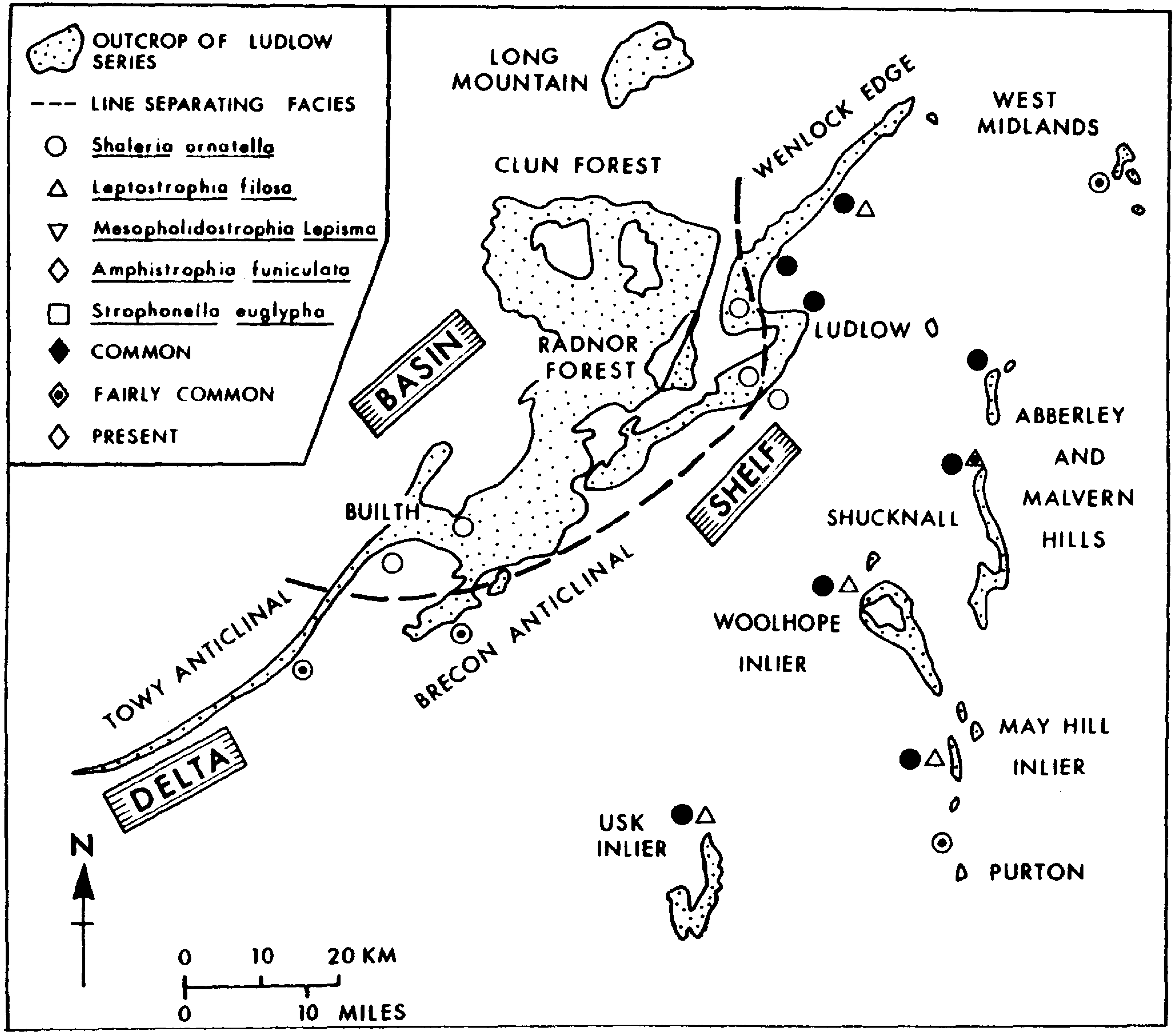
TEXT-FIG. 1.6. Distribution map of the stropheodontid species in the Lower Bringewood Formation of the Welsh Borderland.



TEXT-FIG. 1.7. Distribution map of the stropheodontid species in the Upper Bringewood Formation of the WBL.



TEXT-FIG. 1.8. Distribution map of the stropheodontid species in the Lower Leintwardine Formation of the Welsh Borderland.



TEXT-FIG. 1.9. Map illustrating the distribution of the stropheodontid species in the Upper Leintwardine Formation of the Welsh Borderland.

1.6. PALAEOECOLOGY.

The Ludlovian rocks in this area have also been examined in the field of palaeoecology by many workers and especially since the pioneer work of Ziegler (1965) and Ziegler *et al* (1968) in their investigation of the Silurian marine ecology of the Welsh Borderland. Subsequently, Calef and Hancock (1974) examined the Wenlock and Ludlow rocks of the Welsh Borderland using a bulk sampling technique involving the removal of large amounts of material from single beds, which were widely spaced both stratigraphically and geographically. They claimed the identification of five depth-related brachiopod communities. Their findings were criticised by Lawson (1975) who described four benthic assemblages characterising the Ludlow stages of the Shelf sequence. Lawson (1975) used one of the studied stropheodontid genera (*Strophonella*) as one of his important assemblages called *Strophonella*-*Gypidula*. This assemblage is of high diversity dominated by strophomenid brachiopods such as *S. euglypha*, *A. funiculata*, *M. lepisma* and *L. filosa*. Fürsich and Hurst (1975) discussed the environmental factors determining Silurian brachiopod distribution and they concluded that only the brachiopods with more complex lophophores could live in the deep offshore waters. Watkins (1975, 1979) made a detailed study of Ludlovian benthic communities and used two of the studied species, *S. ornatella* and *M. lepisma* for the names of the associations characterising the Upper Leintwardine Formation and Lower and Upper Bringewood Formations respectively. Cherns (1977) examined the functional morphology and palaeoecology of the fauna, such as *L. filosa* and *S. ornatella*, in the Lower Leintwardinian. In 1979 she discussed the distribution and ecology of Lower Leintwardine lingulids and presented data supporting Lawson's suggestion (1975), that Calef and Hancock's(1974) communities are unlikely to be depth-related. Hurst (1978) and Hurst and Watkins (1978) related the morphology of different isorthids to their position in a series of offshore to onshore facies in the Ludlovian. Atkins (1979) determined the geographical and stratigraphical distribution of the fauna in the Lower Bringewoodian of the Welsh Borderland. He also examined the functional morphology of the fauna and determined the factors affecting the faunal distribution, in an attempt to reconstruct the environments.

Other brachiopod workers such as Bassett (1984) and Spjeldnaes (1984) tried to deduce the autecology of the stropheodontid species from the functional morphology and the growth of the epifauna. Their studies are of great relevance to the present research (see Chapters 8 and 9).

RECENT BRACHIOPODS.

Living brachiopods are of great importance to palaeontologists seeking a framework for the reconstruction of the life habits and habitats of fossil brachiopods. Among these is Curry (1979, 1982, 1983 and 1984) who studied them in the field of taxonomy, anatomy, ecology, ---- etc. Brunton (1982) tried to deduce the palaeoecology of fossil brachiopods from the functional morphology and compared them with the living ones. In this thesis, the observed morphological variability in the modern brachiopod Kraussina rubra (Pallas,1776) from the Atlantic Ocean, was statistically studied. The results were applied to the fossil ones (i.e. S. ornatella), in an attempt to determine the degree of variation (for details, see Chapter 3).

CHAPTER TWO

COLLECTIONS AND METHODS OF STUDY

CONTENTS

CHAPTER TWO

COLLECTIONS AND METHODS OF STUDY

2.1. FIELD WORK AND COLLECTIONS.

2.1.1. From the type area (Ludlow).

The study is based on a field work survey and collection, which is mainly composed of Ludlovian stropheodontid brachiopods. These fossils are common throughout most of the Ludlow Series in the shelf area and become rare or absent in the basin. Therefore, the collection was primarily from the shelf areas of the Welsh Borderland. The first field work was carried out in the Mortimer Forest near Ludlow (Shropshire), in which hundreds of specimens of the stropheodontid species; *Strophonella euglypha*, *Amphistrophia funiculata*, *Leptostrophia filosa*, *Shaleria ornatella* and *Mesopholidostrophia lepisma*, were collected from three new road sections in the Ludlow rocks (see White and Lawson 1978 and text-figs. 2.1-2.3). These sections are:

1. Section A.

This section is on the south-western slopes of High Vinnals hill. The exposed rocks range from Wenlock Limestone up to the Lower Bringewood Formation and have a total estimated thickness of about 174m. The junction between the Wenlock and Ludlow Series is taken near the base of the section at locality A1 (text-fig.2.3) at the level where mudstone predominates over the nodular limestone and above which there are no layers of limestone. Collections were particularly made from six localities numbered A1 to A6 from the bottom to the top of the section (text-fig.2.3), in which the stropheodontid species are abundant.

Localities A1 - A3 are in the Lower Elton Formation from which numerous specimens of A. funiculata were collected. The estimated thickness of the strata comprising these three localities is about 45 metres.

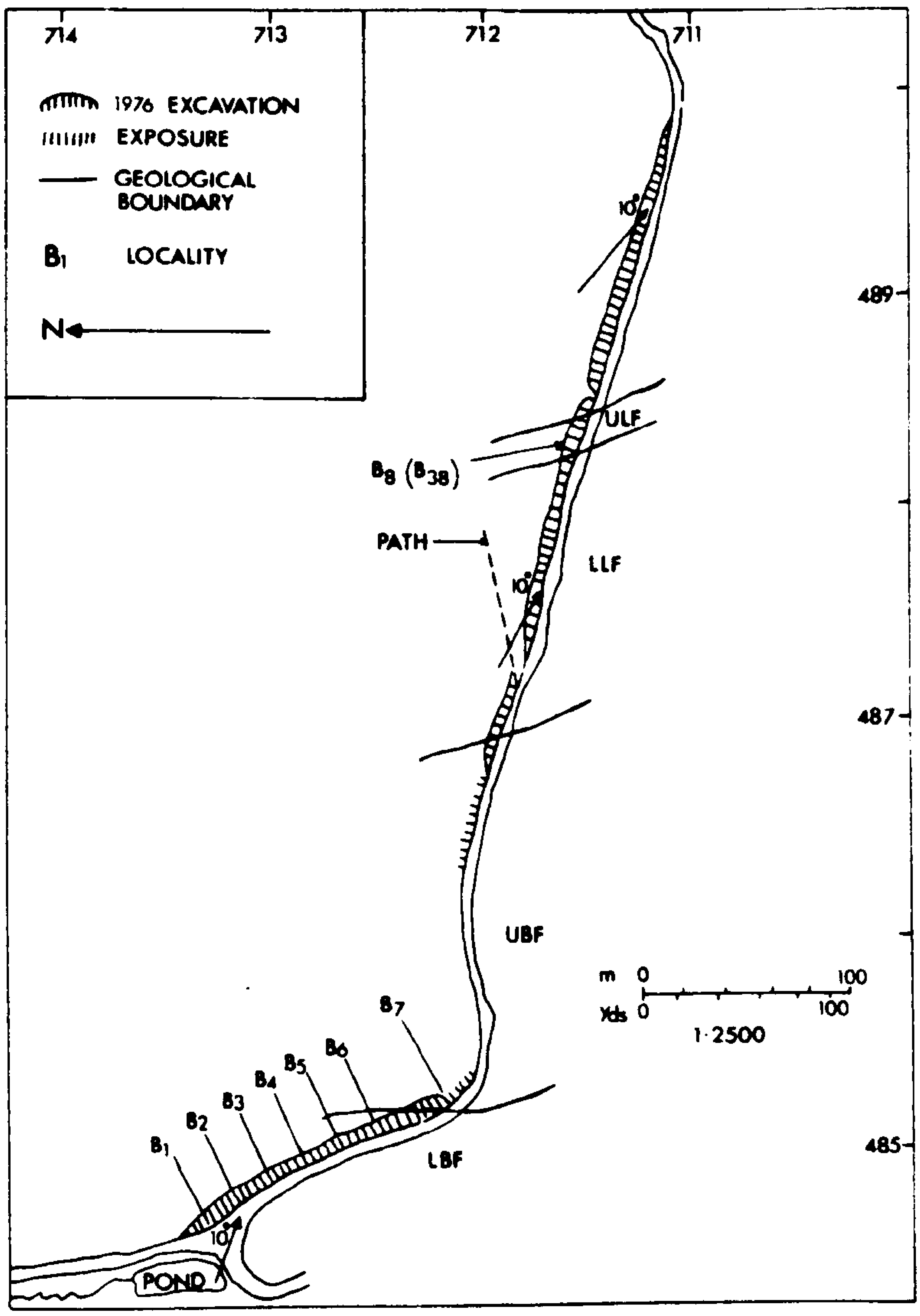
No collection has been made from the Middle or Upper Elton Formation due to the rarity or absence of the stropheodontid species. The other collection was made in the Lower Bringewood Formation from localities A4 - A6, whose estimated exposed thickness of the strata is about 17 metres. This Formation mainly includes M. lepisma, A. funiculata, L. filosa and few S. euglypha.

2. Section B.

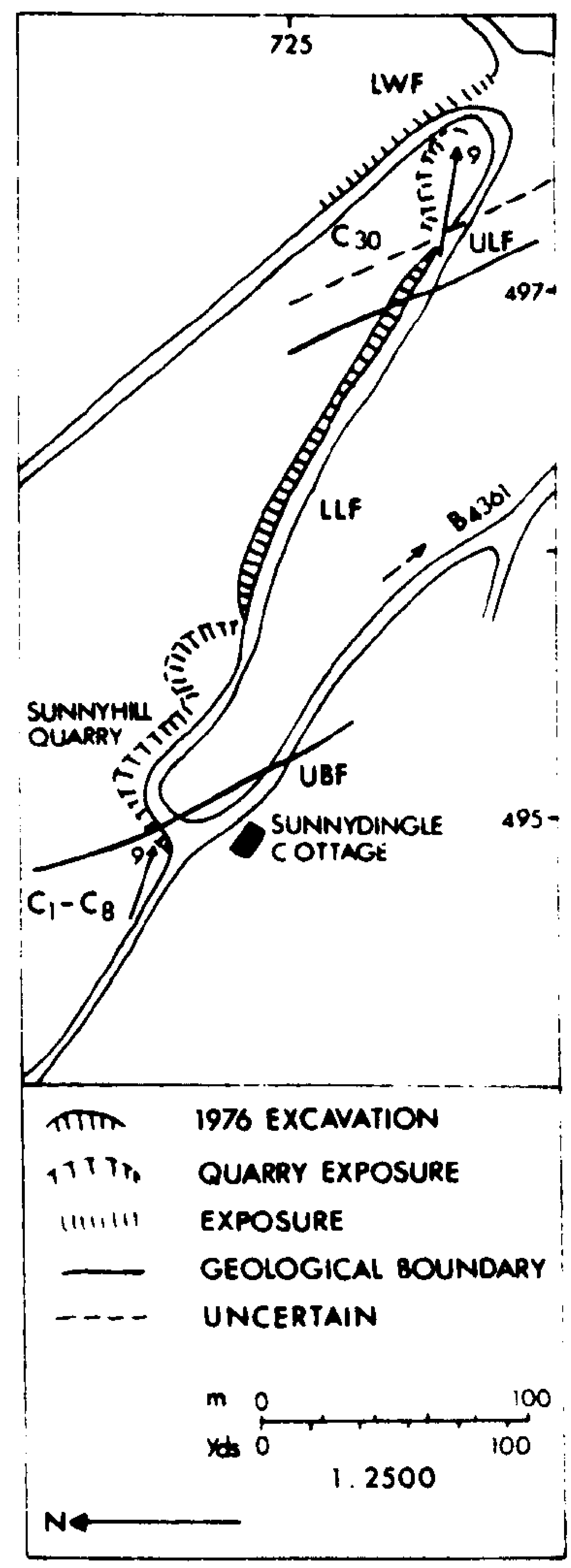
This section occurs along the Deer Park Road of Mortimer Forest and ranges from high Lower Bringewood Formation into the Lower Whitcliffe Formation with a total thickness of 84 metres. Collections were particularly made from eight localities; the first six localities were taken at the bottom of the section (Localities B1 to B6) in the Lower Bringewood Formation at about four metres apart from each other as shown in text-fig.2.1. The estimated thickness of the exposed strata in this formation is about 24m. P. (M.) lepisma, A. funiculata and some S. euglypha were collected from this formation. Locality B7 was chosen in the lower part of the Upper Bringewood Formation whose estimated thickness is about 5.5m. The fauna in this formation included S. euglypha and some L. filosa, A. funiculata and P. (M.) lepisma.

No collection was made from the Lower Leintwardine Formation because most of these species become rare or absent. Therefore, the last collection was mainly made from locality B8 of the Upper Leintwardine Formation (text-fig.2.1). This locality (i.e. B8) is

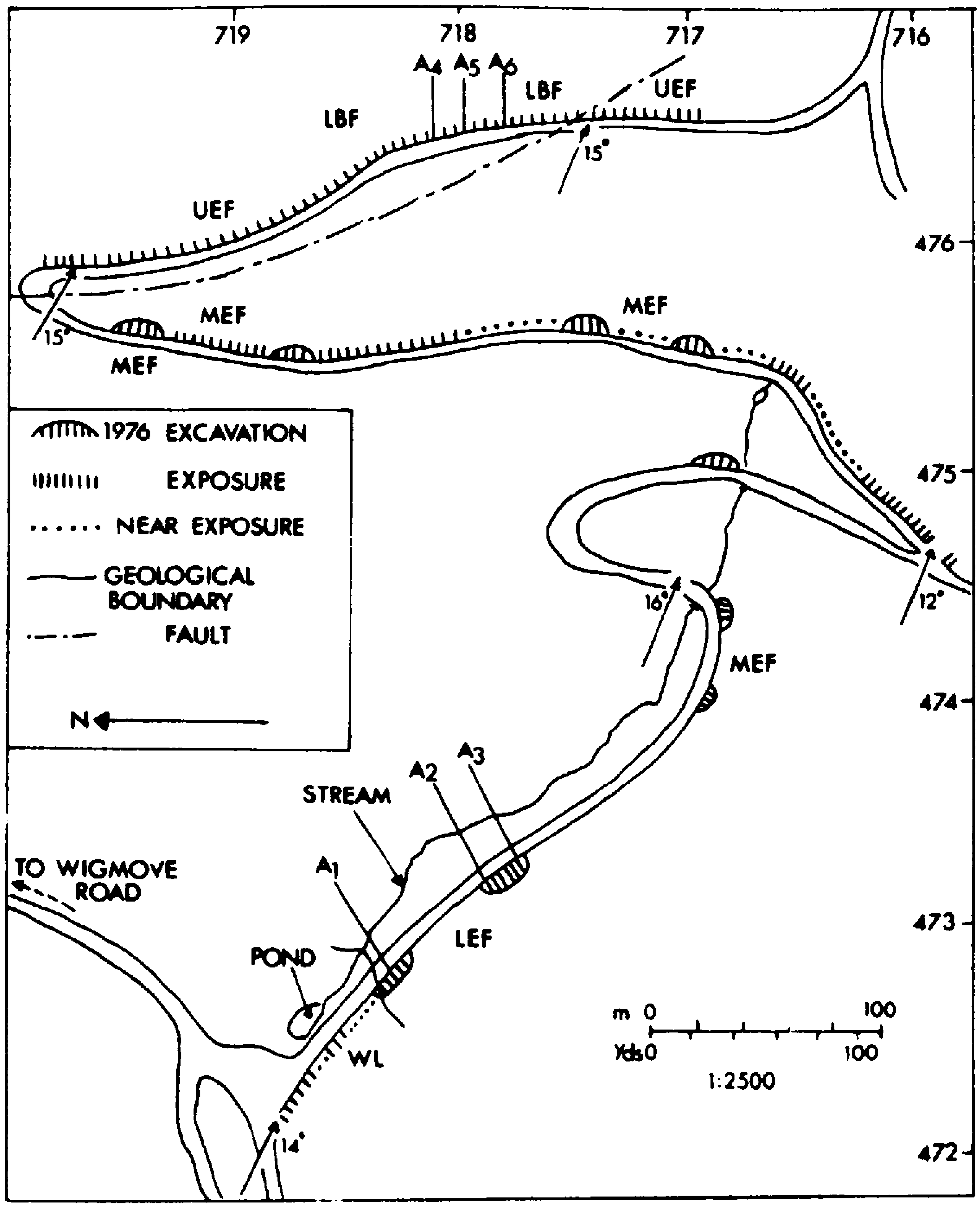
TEXT-FIG. 2.1.



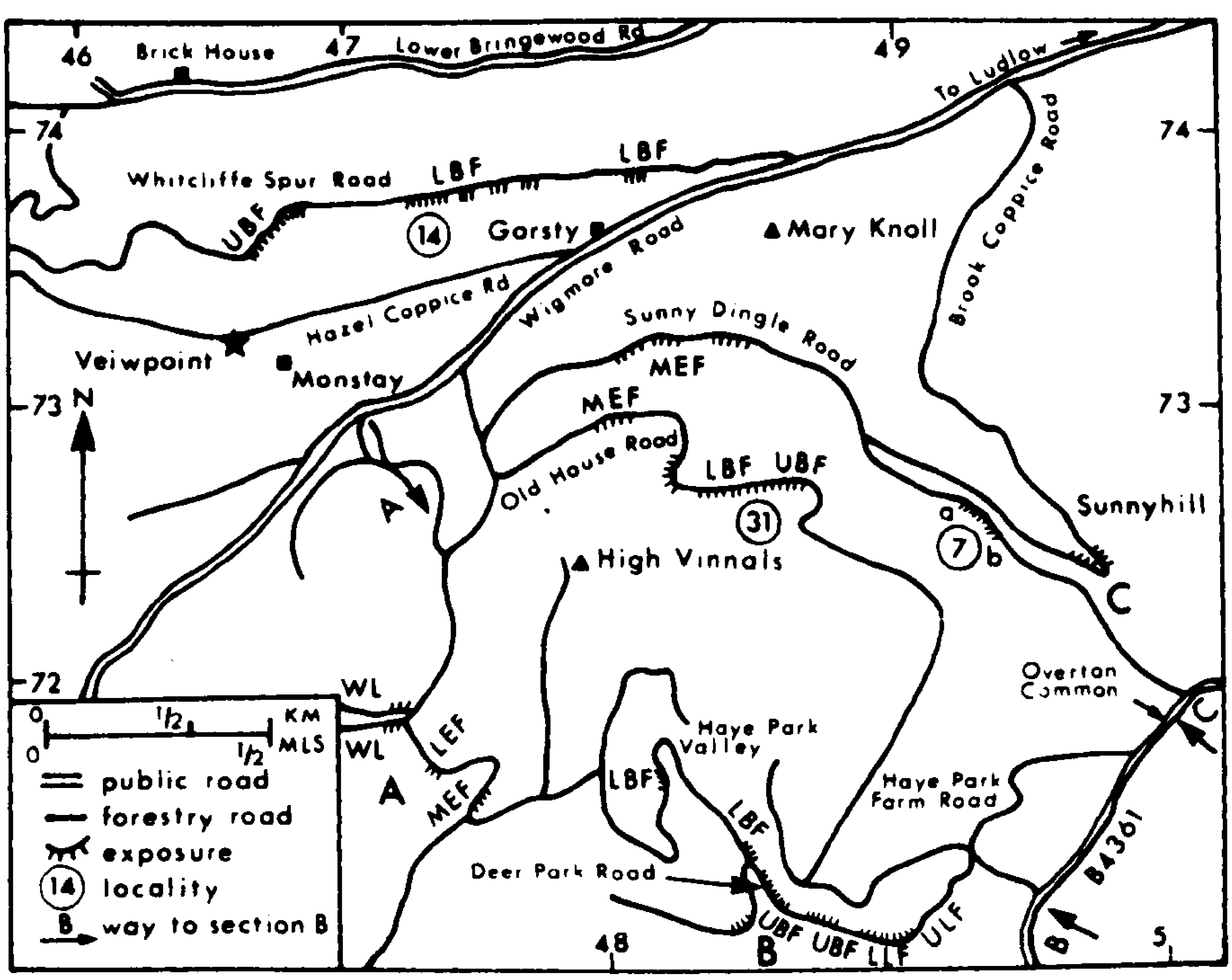
TEXT-FIG. 2.2.



TEXT-FIGS. 2.1. & 2.2. Locality maps for section B (Deer Park and Haye Park) and section C (Sunnyhill) respectively.



TEXT-FIG. 2.3. Locality map for section A, below High Vinnals.



TEXT-FIG. 2.4. Location map of the other localities (7, 14, 31) studied on the forestry roads near Ludlow.

equivalent to locality B38 in White and Lawson's report (1978). The most important fossil characterising this formation is *S. ornatella* which occurs crowded in bedding planes. The estimated thickness here is about 3.5m.

3. Section C.

This section consists of the exposures in Sunnyhill Quarry and the overlying sequence of beds exposed along the track to the east-south-east. The succession ranges in age from high Upper Bringewood Formation to high Lower Whitcliffe Formation, with a total thickness of about 50m. In the Upper Bringewood Formation of this section and particularly at localities C1-8 (text-fig. 2.2), collections were made including mainly *S. euglypha*. The estimated thickness of the exposed strata is about 4.7m according to White and Lawson (1978).

Another collection in this section has been made from locality C30 (text-fig. 2.2) of the Upper Leintwardine Formation in which *S. ornatella* becomes very common and occurs in bands. The strata in this formation are only about 3.0m thick.

Other localities were selected in the Lower Bringewood Formation, near Ludlow for further statistical study of the stropheodontid brachiopods (text-fig.2.4). These are:

1. Locality 7a.
   The fauna at this locality mainly includes *S. euglypha*, *L. filosa*, *A. funiculata* and *P.* (*M.*) *lepisma*.

2. Locality 14.
   S. euglypha and *L. filosa* were found in this locality but only a few specimens were collected.

3. Locality 31.
   This locality is dominated by stropheodontid brachiopods.

This locality was divided during the present study into twelve parts along the exposure, named as 31a, 31b - 31L; with an average distance of ten metres apart. Collections included S. euglypha, L. filosa, P. (M.) lepisma and few specimens of A. funiculata.

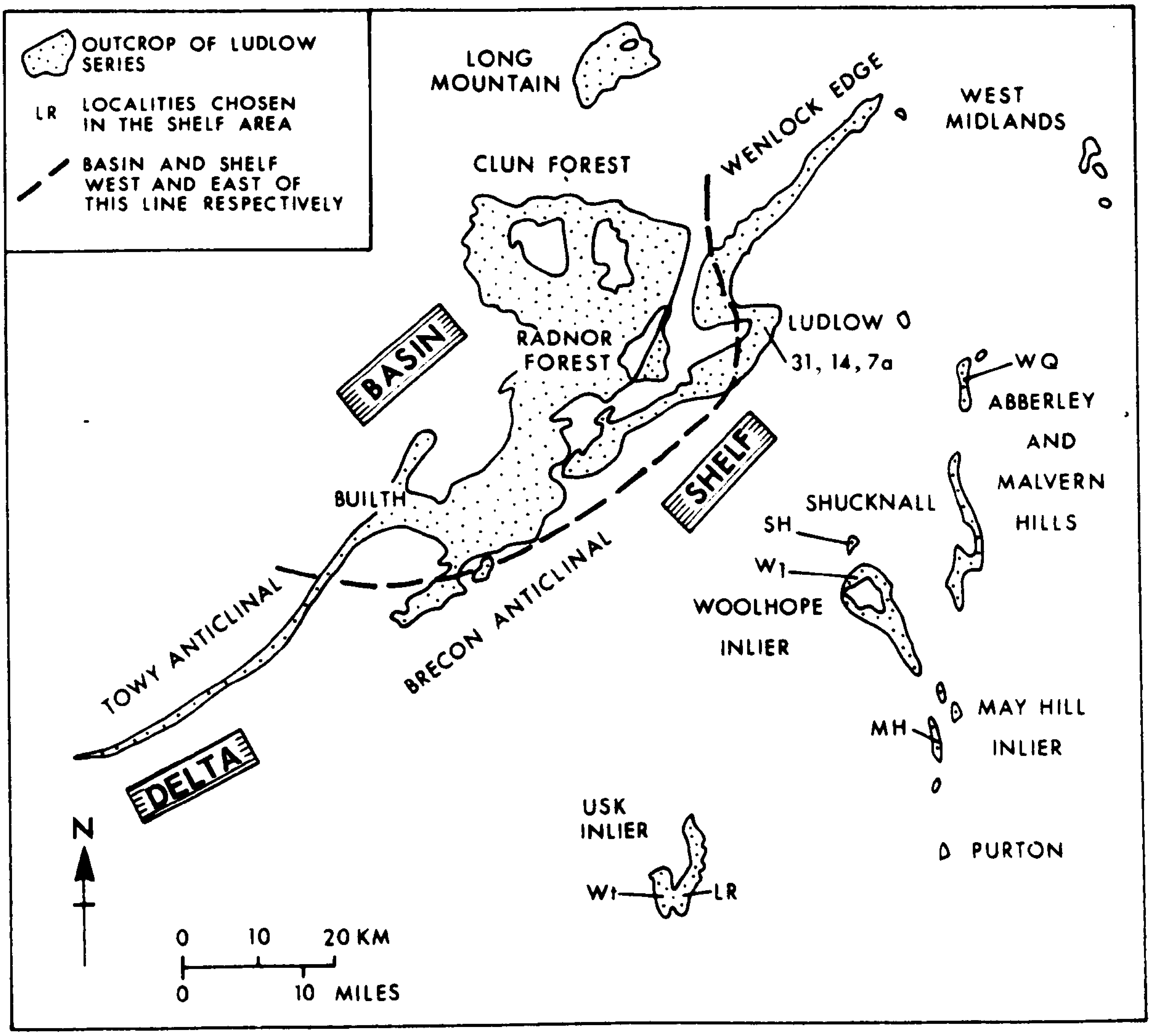
2.1.2. From the surrounding areas.

Further collection was made from the Ludlovian of the Silurian inliers of the Welsh Borderland. Stratigraphically, these inliers have been comprehensively studied by many workers such as; May Hill by Lawson (1955); Usk inlier by Walmsley (1959); Woolhope inlier by Squirrell and Tucker (1960) and Abberley by Phipps & Reeve (1967). The purpose of this collection was mainly to decide whether the species similarities or differences are due to local or geographical environmental factors or to species evolution. The localities chosen in these inliers are as follows (text-fig. 2.5):

(1) Shucknall Quarry (SH) in the Woolhope inlier.
The Upper Bringewood Formation here consists of a silty limestone with common calcareous nodules. The collection mainly includes S. euglypha.

(2) Perton Lane (W1) in the Woolhope inlier.
The strata exposed here are of the Lower Bringewood Formation, composed of thinly bedded siltstones and fossiliferous limestones and containing an abundance of P. (M.) lepisma and some Shaleria sp.nov. For the site of this locality see the Geologists' Association Guides No.5, fig. 5 and text-fig. 2.5.

(3) Woodbury Quarry (WQ) in the Abberley Hills.
This large quarry in the Abberley Hills exposes most of the Ludlow Series rocks. The beds are slightly overturned. The top of the Lower Bringewood Formation and the base of the Upper Bringewood Formation are calcareous siltstones with calcareous



TEXT-FIG. 2.5. Outline map showing the studied Ludlovian localities selected in different shelf facies areas.

nodules, yielding many stropheodontids among which S. euglypha and P. (M.) lepisma are dominant throughout. L. filosa and A. funiculata are also common.

(4) Llandegveth Reservoir (LR) in the Usk inlier.

The beds are of the Lower Bringewood Formation, consisting of calcareous siltstones with calcareous nodules. This locality is excellent for collecting stropheodontid brachiopods, e.g. many L. filosa and S. euglypha and some A. funiculata and P. (M.) lepisma were collected.

(5) Walnut Tree Farm (Wt) in the Usk inlier.

The beds are of the Upper Leintwardine Formation. They consist of light olive-grey, thinly bedded calcareous muddy siltstones and shelly and muddy limestones yielding abundant S. ornatella.

(6) Rocklands (MH) in the May Hill inlier.

This locality is a small exposure of basal Lower Ludlow rocks in the May Hill inlier. It is composed of beds of calcareous siltstones and mudstones with some scattered calcareous nodules containing some S. euglypha and A. funiculata.

2.1.3. Repository of Collections.

All the samples which were collected during this study will be housed in the Department of Geology, National Museum of Wales, Cardiff.

2.1.4. Other Collections.

a) Dr. Lawson's Collection:

1. Specimens of stropheodontid brachiopods from the Wenlock (mainly Wenlock Limestone) and Ludlow (mainly Lower and Upper Bringewood Formations) Series of the Welsh Borderland were studied for

comparison purposes between Wenlock and Ludlow forms of the same species, e.g. A. funiculata and S. euglypha.

2. Collections from numerous shelf areas of Upper Leintwardine Formation with S. ornatella, (see Appendix I, for detailed localities list) were examined. This study was made to clarify the S. ornatella distribution and ecology in the Welsh Borderland (see text-figs. 1.8 & 1.9).

3. Gotland specimens. More than three hundred specimens had been collected by Dr Lawson from the eastern region of the Island of Gotland (Sweden), mostly from the uppermost Hemse Group (see text-fig. 1.3 for localities). These specimens are of great relevance to the present study because they contain S. aff. ornatella in beds of roughly equivalent age to the Upper Leintwardine Formation of the Welsh Borderland of Britain (Bassett and Cocks 1974). Consequently, these specimens provided the opportunity (i) to decide whether the samples (Britain and Sweden) are similar or different (i.e. conspecific), (ii) to study the species variation between the two geographical areas, (iii) to study the species distribution within both areas and (iv) to construct the environmental differences between the two areas from the lithology and sedimentation.

b) Museum Collections.

Many specimens of stropheodontids were chosen from the collections of the British Geological Survey (BGS), National Museum of Wales (NMW), Natural History Museum (NHM) and Ludlow Museum (LM). Among these specimens, S. euglypha and A. funiculata were particularly selected from the Dudley Limestone of Wenlock age for detailed study. Then all the Wenlock materials of the same species and the same horizons, if not the same locality and area, were added and treated together for detailed statistical and morphological comparison. The results of this comparison will be described in the comparison sections of Chapters 6 and 7. Some other specimens of *S. ornatella* and *A. funiculata* from Gotland were also selected and studied. In general, however, such selection was made in an attempt to describe some of the species variation laterally (geographically) such as the Wenlock *A. funiculata* from both Sweden and Britain; and vertically (i.e. during time) such as Wenlock and Ludlow *A. funiculata* and *S. euglypha*.

2.2. LABORATORY METHODS AND TECHNIQUES.

2.2.1. Collection method.

It is believed that the only way to ensure a complete and representative picture of the Ludlovian stropheodontid fauna is to use a bed-by-bed sampling technique. Stropheodontid fossils are mostly concentrated into bands with few in the intervening sediments. However, every layer within the sequence was carefully hammered and examined laterally and vertically for stropheodontid species, together with any lithological and palaeoecological observations and/or any other morphological variations. The collections were also made to reflect the nature of the fauna and its distribution. Subsequently, each sampled rock was split carefully in an attempt to get the counterpart of the fossil. Then, all the specimens were labelled and wrapped carefully in the field, the counterparts being wrapped separately but kept together to avoid any confusion during unpacking.

2.2.2. Preparation of material.

Over 2,200 samples were prepared for study by the following procedure:

a. Excavation and cleaning.

The specimens were cleaned and excavated by using needles and dental tools until all the possible external and internal shell features were cleared for further studies, then every separate specimen was given a number (see the method of numbering in Appendix II).

b. Peels.

Latex peels were made from some specimens (i.e. positive peels were made from a negative mould) where the process improved resolution of crucial features, and allowed more precise measurements.

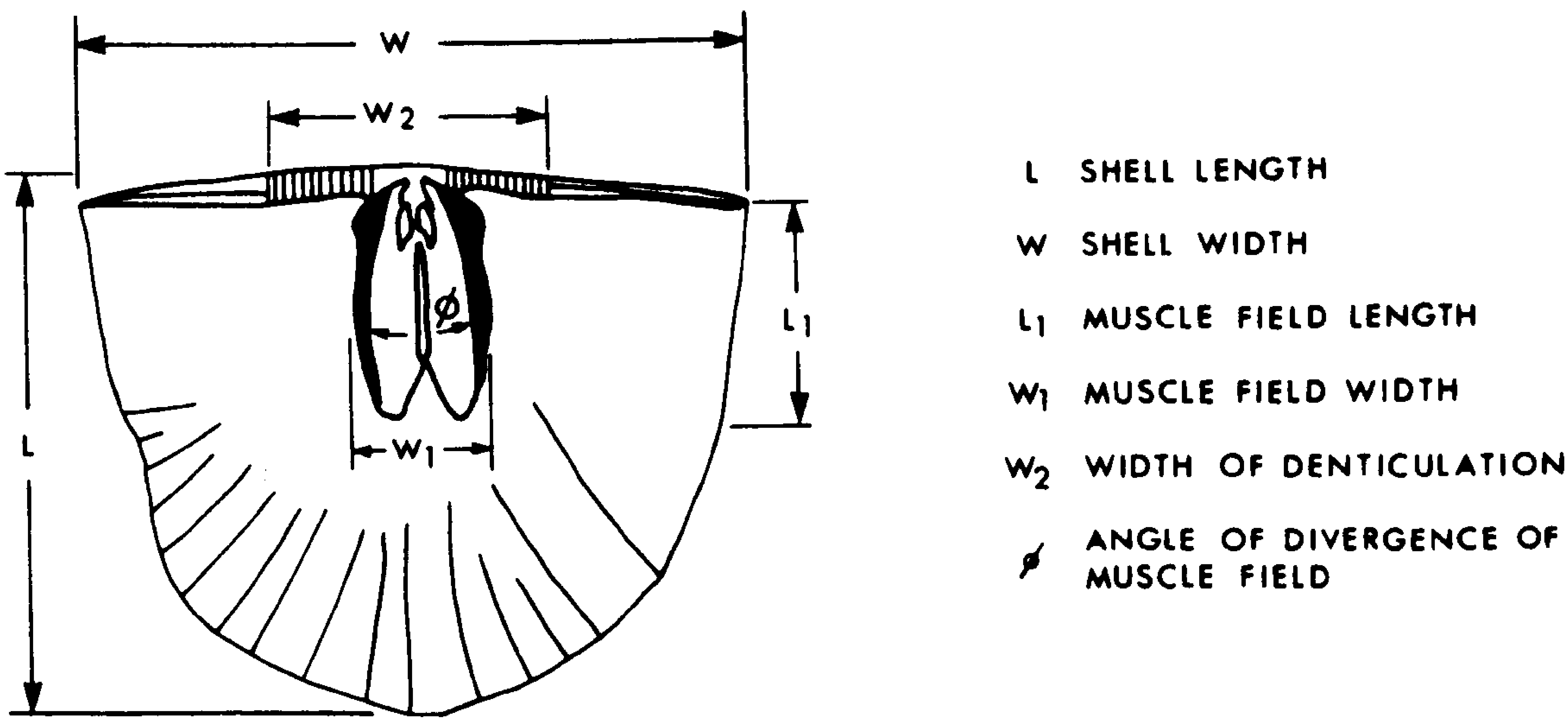
2.2.3. Study of material and techniques.

After the specimens had been prepared (see above), they were separated into the five species for study. These are:

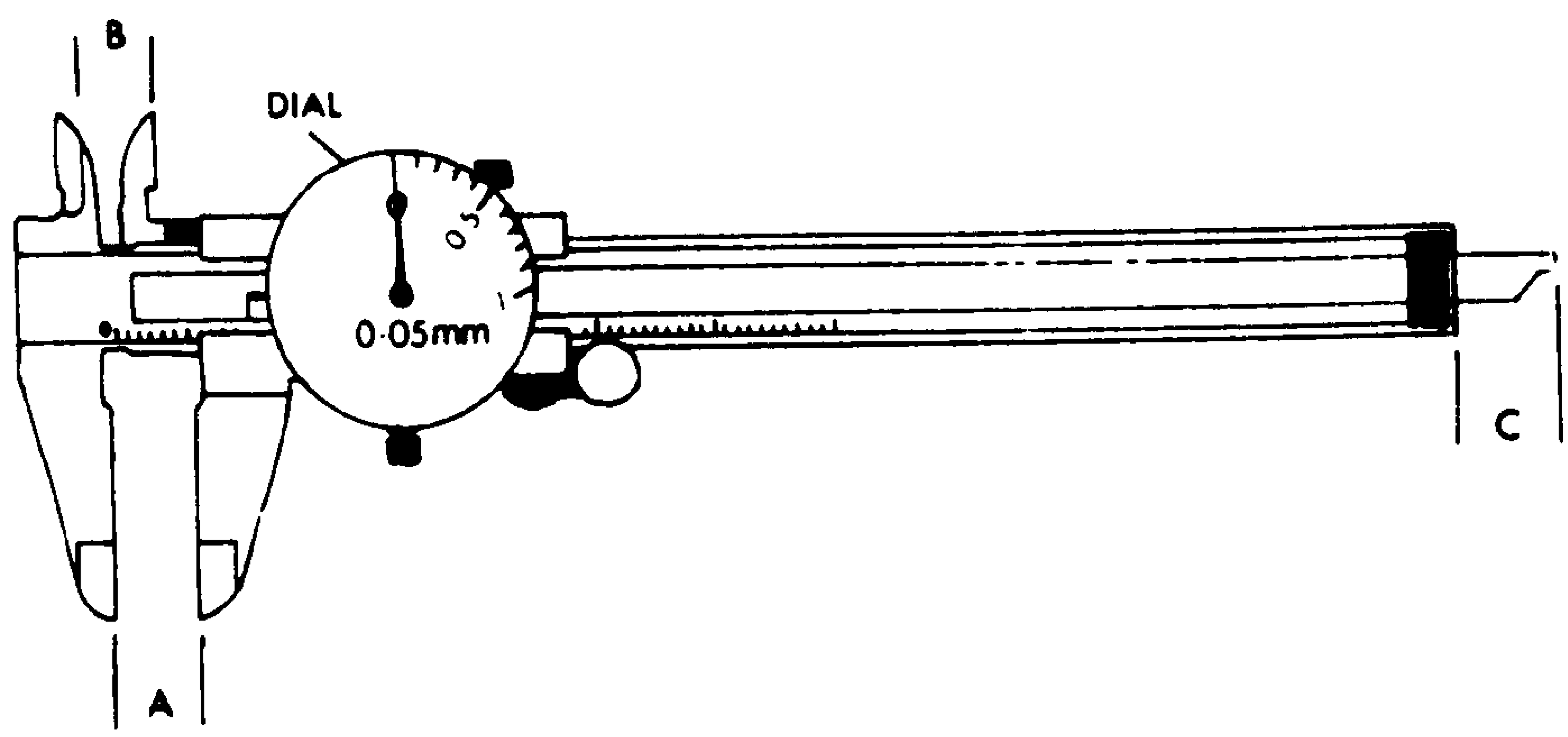
S. ornatella
L. filosa
P. (M.) lepisma
S. euglypha
A. funiculata

These species revealed some morphological differences from the same species studied by the previous workers from the lower and middle Silurian rocks (i.e. Llandovery and Wenlock respectively). In order to constrain precisely these morphological variations laterally between different geographical areas and vertically from Middle to Upper Silurian (i.e. during time), certain parameters were measured and statistically studied. The locations of the measured parameters are shown on text-fig.2.6. These parameters are:-

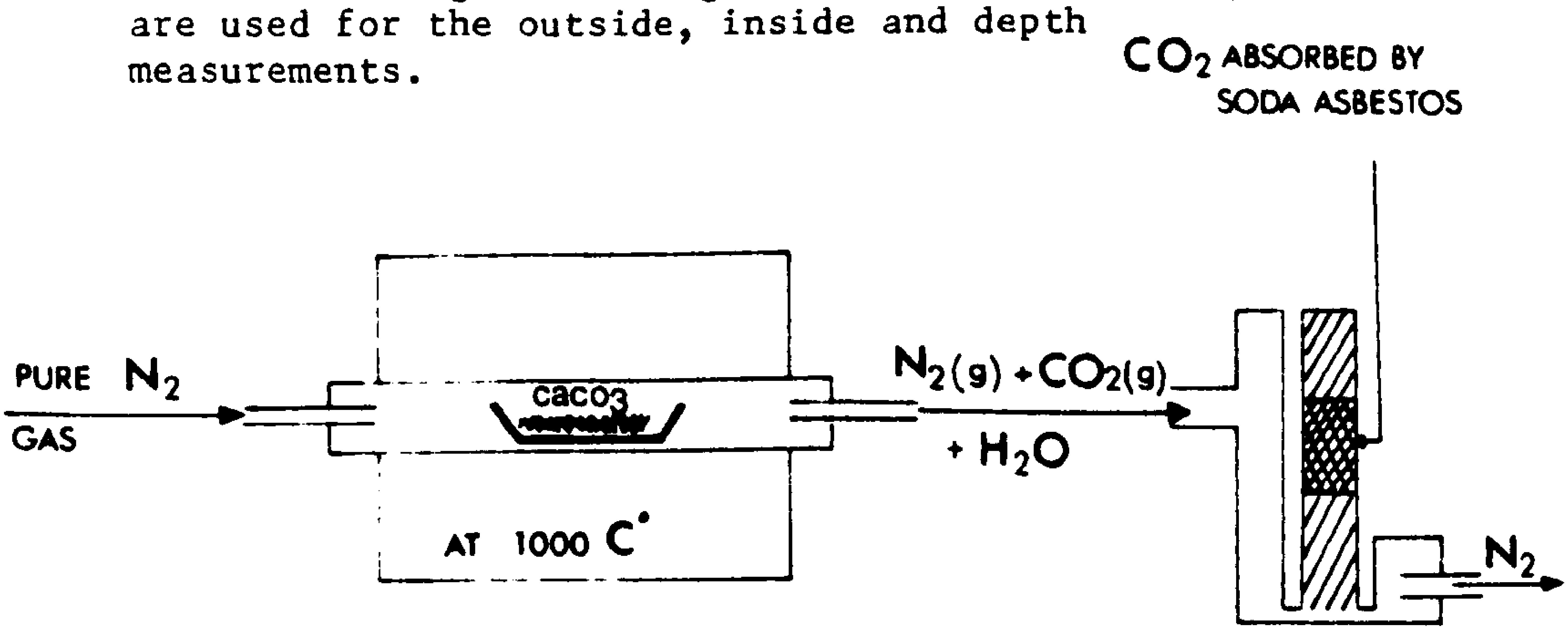
1. Shell length and width.
2. Muscle field length and width.
3. Hinge line width.
4. Denticulation width.
5. Angle of divergence of the pedicle valve muscle field.
6. Diameter of the pits when they are visible.
7. Number of ribs per mm at 5 or 10mm from the dorsal hinge.



TEXT-FIG. 2.6. Sketch illustrating the position of the measured fossil parameters. The sketch is based on specimen number ZW5624b.



TEXT-FIG. 2.7. Diagram showing the dial vernier calipers. A, B & C are used for the outside, inside and depth measurements.



TEXT-FIG. 2.8. Sketch diagram demonstrating the procedure of Co_2 weight determination.

In addition, some other structural features were also measured such as, the angle of divergence of the socket plates; the length and angle of divergence of the auxiliary ridges; adductor and diductor muscle scars length and width; number of the growth lines; the number of extra muscle ridges if present; number of capillae (fine ribs) in between each two costellae (coarse ribs) of some species; number of the lateral ridges (crenulations) along the lateral ends of the hinge line (ears) and the shell thickness and depth of some specimens.

The procedure of measuring these parameters was carried out by using a binocular microscope equipped with a 10mm graticule divided into 0.1mm segments and dial vernier callipers accurate to 0.05mm (text-fig.2.7).

Statistical analyses of bivariate data were performed using an Olivetti P652 Computer running a BIVA programme. This programme, which has been widely used in brachiopod bivariate analysis (e.g. Lockley and Williams 1981; Williams and Curry 1984), provides Mean, Variance and Coefficient of correlation for any pair of the parameters shown in the text-fig.2.6.

Graphs and size frequency histograms for each two related parameters were prepared such as:

1. Shell length versus shell width.
2. Muscle field length versus muscle field width.
3. Shell length versus muscle field length.
4. Shell width against muscle field width.
5. Shell width and width of the denticulation.
6. Shell length and width against muscle field area.
7. Shell length-width ratio versus the angle of divergence of the pedicle muscle field.

8. Shell length and width against socket plates angle.

9. Denticulation width against muscle field area.

Subsequently, the standard deviation was calculated in order to find the equation of the best fit line.

In addition to studying the species morphology and variations statistically, the author has also tried to demonstrate these features and variations photographically. Therefore, photographs for some specimens have been taken to illustrate the excellently preserved external and internal shell features using a 55mm wide-angle lens, occasionally with an adaptor to get a higher magnification (see Table below):

Magnification	Lenses and Adaptor
x ½	55mm wide-angle lens (extended)
x 1	PK3 + 55mm wide-angle lens (extended)
x 2	K1+K3+K4+K2+PK3+BR2+55mm (reversed)
x 3	K1+K3+K4+K2+BR2+28mm lens (reversed)
x 4	K1+K3+K4+K2+PK3+BR2+28mm lens (reversed)
x 5	K1+K3+K4+K5+K2+PK3+BR2+28mm lens (reversed)

The fossil specimens were cleaned, extracted and painted carefully with matt black poster paint and then coated with ammonium chloride before photographing them. Each specimen was given different exposure times during photography and with the aperture at a fixed point (e.g. f32). The exposure times used mainly depended on the magnification, the darkness or lightness of the rock sample, thick or thin coating, lighting and other factors. For the exposure times, see the Table below:

Focal length (f) / Magnification (x)	f5.6	f8	f11	f16	f22	f32	used exposure at f32
							s = second
x ½	⅛s	¼s	½s	1s	2s	4s	4s, 8s, 16s
x 1	¼s	½s	1s	2s	4s	8s	8s, 16s, 24s
x 2	½s	1s	2s	4s	8s	16s	16s, 24s, 36s

Subsequently, and after developing the film, they were printed by myself on different grades of paper in order to bring out the obscure and contrasting features.

Thin sections were made to see whether or not the sediment grain size bore any relationship to the nature of the radial ornament.

The percentage of calcium carbonate was also calculated from some main areas, such as Ludlow, Usk and Gotland, to investigate the possible relationship between the variations and the richness of the environments in calcium carbonate. In order to calculate the percentage of the calcium carbonate in the rock sample, the specimen was heated to about 1000° to produce the calcium oxide and carbon dioxide, as the reaction below:

$$CaCo_3\ (Solid) \xrightarrow[1000^{o}C]{Heat} CaO\ (Solid) + Co_2\ (gas)$$

The carbon dioxide produced was removed by passing a current of nitrogen as illustrated in text-fig.2.8.

Subsequently, the weight and percentage of $CaCo_3$ in the rock samples were calculated as follows, after deriving the weight of the Co_2 absorbed by the soda asbestos (see text-fig.2.8).

$$\text{Weight of } CaCo_3 = \text{Weight } Co_2 \times \frac{\text{Molecular weight of } CaCo_3}{\text{Molecular weight of } Co_2}$$

$$\text{Percentage weight of } CaCo_3 = \frac{\text{Weight of } CaCo_3}{\text{Weight of the sample}} \times 100$$

SECTION
II

SYSTEMATIC PALAEONTOLOGY

SECTION II

SYSTEMATIC PALAEONTOLOGY

Phylum	Brachiopoda
Class	Articulata
Order	Strophomenida Öpik, 1934
Suborder	Strophomenidina Öpik, 1934
Superfamily	Stropheodontacea Caster, 1939
Family	Stropheodontidae Caster, 1939

GENERAL INTRODUCTION

The order Strophomenida comprises articulated brachiopods with plano- to concavo-convex or convexi-concave, resupinate or geniculated shells. They have smooth to unequally parvicostellate radial ornament with a well-developed bilobed cardinal process, chilidium, pseudodeltidium and simple teeth which are supplemented in some groups by accessory denticles.

The Stropheodontidae is a family in the Stropheodontacea superfamily ranging from the early part of the Upper Ordovician, until the Upper Devonian (Williams 1953, 1965). The stropheodontids are characterized by simple teeth and dental plates which are replaced by denticles , subsequently spread along the hinge line, and by a closed pedicle opening (i.e. apical foramen sealed) after the earliest growth stages, indicating an unattached adult mode of life (see Chapter 8). They have also concavo-convex or convexi-concave to resupinate shells with a well-developed pseudodeltidium, chilidium and usually bilobed cardinal process. The mantle canal patterns in both valves are lemniscate with a densely pseudopunctate shell.

Stropheodontid brachiopods are common fossils in the Ludlovian shelf rocks of the Welsh Borderland of Britain. The studied species have been collected from Ludlow, Abberley Hills, Woolhope and the Usk inlier, and descriptions and variation analyses are mainly based on this Ludlovian shelf material. These areas in the Ludlow rocks of the Welsh Borderland are geographically well-spaced and contain only five abundant stropheodontid fossils. These species are: Shaleria ornatella, Leptostrophia filosa, Pholidostrophia (Mesopholidostrophia) lepisma, Amphistrophia funiculata and Strophonella euglypha. These species are compared geographically from the British shelf areas mentioned above. S. ornatella from Britain was also compared geographically with its representative, Shaleria aff. ornatella (Bassett and Cocks 1974), from Gotland (Sweden) at roughly the same horizon. Within the Ludlow Series, the majority of the specimens were collected from the Lower Bringewood Formation (except S. ornatella specimens which are mostly from the Upper Leintwardine Formation), with additional samples from the Upper Bringewood and Lower Elton Formations. There is no significant vertical variation in the characteristics of the species in the latter two formations from the typical Lower Bringewood Formation specimens; therefore, they have all been considered as representatives of the Ludlow forms to facilitate lateral and vertical comparison with forms of different areas and ages. Furthermore, the Ludlovian S. euglypha and A. funiculata are vertically compared with the same species from the Wenlock Series of Britain. However, the study of the Wenlock stropheodontids was mainly based on Bassett's description (1971, 1977) and the author's selection and examination of the British Museum specimens.

The new generic and subgeneric names proposed by Harper and Boucot (1978) for some of these stropheodontids are not adopted in this study because the distinctions between their new taxa become blurred when a large number of specimens are examined. Most of their subdivisions seem to possess neither practical value nor genetic validity.

The terminology for brachiopod morphology used by Williams (1965) and adopted by Harper and Boucot (1978) is utilized in this thesis.

Abbreviations used in this section.

1. The fossil names are given in full at the first mention in each Chapter and the generic and subgeneric names are abbreviated for subsequent ones.

2. The measured parameters used in the statistical Tables of this Section are abbreviated as follows:-

Y	Equation
n	Number of specimens
Ls	Shell length
Ws	Shell width
Lmf	Muscle field length } on the pedicle valve
Wmf	Muscle field width } on the pedicle valve
Wd	Width of denticulation
Amf	Muscle field area
r	Coefficient of correlation
S.D.	Standard deviation
-( )	A bar above a letter gives the Mean, followed by the variance in brackets, e.g. $\overline{Ls}$(var. Ls).
Dp	Depth measured from the top of the pedicle valve up to the level of the trail margin.
Dd	Depth measured from the bottom of the brachial valve up to the level of the trail margin.
BM	British Museum
Ac	Author's collection
Wc	Walmsley collection
Lc	Lawson collection
Cc	Curry collection (will be housed in the Hunterian Museum).
SMNH	Swedish Museum Natural History

AD	Adductor muscle scars
AX	Auxiliary ridge
BI	Brachial (dorsal) interarea
CH	Chilidium
DI	Diductor muscle scars
DN	Denticles
E	Ventral process
GL	Growth lines
Lp	Lophophore platform
M	Myophragm
MCS	Mantle canal system
MF	Muscle field
MR	Muscle bounding ridge
PI	Pedicle (ventral) interarea
PL	Cardinal process lobe
PMR	Partitioned muscle ridges
PS	Pseudodeltidium
R	Ribs
S	Sulcus
SO	Socket plates
S.PL	Socket for the cardinal process lobes
T	Tubercles
TE	Teeth

CHAPTER THREE

SHALERIA (*SHALERIA*) *ORNATELLA* (DAVIDSON, 1871)

CONTENTS

CHAPTER THREE

SHALERIA (SHALERIA) ORNATELLA (DAVIDSON, 1871)

3.1. INTRODUCTION

Shaleria ornatella is a distinctive biplanate stropheodontid brachiopod characterized by coarse and fine radial ribs. It is an abundant species which covers bedding planes in the Upper Leintwardine Formation of the Welsh Borderland. In order to compile a comprehensive description of this species and its variation, large collections were made from three major British samples (two localities at Ludlow and one in the Usk inlier). Smaller collections from many other localities were also obtained. Watkins (1979) considered this form as an "opportunistic species", because of its rapid appearance in great abundance in the Upper Leintwardine Formation which gives the species a great value in using it for correlation and variation purposes.

Biometric analyses of a large collection of the form known as Shaleria aff. ornatella from the topmost Hemse Groups of Gotland (Sweden) has facilitated comparison with S. ornatella from the Upper Leintwardine Formation of the Welsh Borderland of Britain. The differences within and between different populations have been described statistically in order to define the extent of the variation. Furthermore, comparison has been made with the variation seen in the Recent brachiopod, Kraussina rubra from the Atlantic Ocean.

This Chapter contains an up-dated full description of S. ornatella from the Ludlow Series. It illustrates some of the external and internal shell features more clearly than heretofore and particularly emphasizes the variability in the shapes of the muscle field and muscle bounding ridges, shape of the socket plates, coarse and fine radial ornament, and the corrugation.

3.2. SPECIES DESCRIPTION.

Subfamily SHALERIINAE Williams, 1965.

Genus SHALERIA Caster, 1939, Pl.35, figs.1-16; Pl.43, figs. 7-12 (in part 3).

Subgenus SHALERIA (SHALERIA) Caster, 1939, Pl.35, figs.13,14,16; Pl.43, figs.7-12 (part 3).

3.2.1. Type species.

Strophomena gilpeni Dawson, 1881; pp.33-34; from the Upper Silurian, Nova Scotia, Canada.

Shaleria (Shaleria) ornatella (Davidson, 1871) Pls.1-7.

3.2.2. Synonymy.

1867 Strophomena ornatella Salter and Lindström; (named only). Nomina Foss. Sil. Gotlandiae, P.S.

1871 Strophomena ornatella (Salter Ms); Davidson, p.309, Pl.43, figs. 16-20.

1902 Strophomena impressa Munthe, p.233, fig.3, p.234, fig.4.

1963 Shaleria ornatella (Davidson) Holland et al, p.154, Pl.3, fig.1.

1974 Shaleria aff. ornatella (Davidson); Bassett and Cocks, p.17 (named) only.

1978 Shaleria (Protoshaleria) ornatella (Davidson); Harper and Boucot, p.162, Pl.35, figs. 1-10.

1978 Shaleria ornatella (Davidson); Cocks, p.129.

1979 Shaleria ornatella (Davidson); Watkins p.234, figs. 16-18 and 20.

3.2.3. Lectotype.

The lectotype specimen of S. ornatella is GSM (Geological Society collection) 13397. It is an external mould of the pedicle valve from the "Upper Ludlow" at Whitcliffe, Ludlow. It is examined and refigured herein (Pl.6, figs. 1 & 2 and Pl.7, figs. 2 & 3. The gross shell proportion Ls/Ws is 72% (Ls (shell length) = 12.7mm; Ws (shell width) = 17.5mm)). This value falls within the range of variation of the shell proportion value of the specimens studied from Ludlow and Usk in the Welsh Borderland. Three additional and measurable specimens on the same bedding plane as the lectotype have also been studied. They show the same range of variations in their shell as the specimens studied herein.

The lectotype specimen is semicircular in its outline shell shape, wider than long, slightly concavo-convex, with a small mucronate wing at the left side of the hinge line. This (pedicle) valve is slightly convex with an apsacline interarea and a small convex pseudodeltidium, a pair of minute teeth and denticles developed along the hinge line for about half the shell width. The pedicle muscle field is well impressed for about ⅓-½ of the valve length. The diductor muscle scars are oval or triangular in shape enclosing a pair of lanceolate adductor muscle scars and are bounded laterally and anteriorly by a pair of well developed muscle bounding ridges separated medianly by a narrow, rounded myophragm tapering anteriorly. The external shell surface shows numerous radial ribs (costellae) radiating from the beak to the valve margin and leaving wide interspaces which are occupied by three finer radial ribs (capillae); growth lines are few in number (one or two) and are faintly developed postero-laterally.

The lectotype was first selected by Cocks (1978) from the original specimens of Davidson (1871, p.309, Pl.43, figs. 16-20). Davidson described this specimen as Strophomena ornatella from the "Upper Ludlow Beds" at Whitcliffe, Ludlow. Subsequently, Holland, Lawson and Walmsley (1963, P.154, Pl.3, fig. 1) figured this species from the "Upper Leintwardine Beds" of the Ludlow area. Watkins (1979, P.234, figs. 16-18 & 20) figured S. ornatella and used it as an index of one of his associations in the Welsh Borderland.

To study the statistical variability and distribution of *S. ornatella*, large collections have been made from different areas in the Welsh Borderland but particularly from localities close to Davidson's (1871) original type locality. A few specimens collected by Dr. J.D. Lawson from the type locality on the Whitcliffe were studied. These specimens are similar to the type specimen but the number of these specimens is not significant for statistical study. Large collections of this species have also been made by Dr. J.D. Lawson from the uppermost Hemse Beds of eastern Gotland. These specimens have been studied herein.

The external and internal shell features (radial ornament, growth lines, outline shell shape, pedicle and brachial muscle and muscle bounding ridges) in the specimens studied are all similar to the type specimen features and fit very closely with it as shown in the writer's redescription of the type specimen. Moreover, the shell and muscle field proportions for the type specimen and the three additional specimens occurring with it have been measured and analysed statistically (see Tables 1 & 2).

TABLE 1. Summary of statistical results of the shell length-width proportion of *S. ornatella* from Whitcliffe, Ludlow and the Usk inlier:

Specimens	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	% $\bar{Ls}$/$\bar{Ws}$
from Whitcliffe (Type slab)	4	11.88 (2.52)	16.68 (15.53)	0.80	1.38	3.41	71%
from Ludlow	249	9.37 (4.44)	13.48 (8.1)	0,86	2.05	2.78	70%
From Usk	228	10.7 (7.63)	15.3 (14.97)	0.95	2.76	3.86	70%

TABLE 2. Summary of statistical results of the muscle field length-width proportion of S. ornatella from Whitcliffe, Ludlow and the Usk inlier:

Specimens	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	% $\frac{\bar{L}mf}{\bar{W}mf}$
from Whitcliffe (Type slab)	4	5.68	3.78	0.96	0.98	0.58	67%
from Ludlow	74	4.24 (1.167)	2.96 (0.36)	0.74	1.18	0.64	70%
from Usk	108	4.09 (1.96	3.65 (o.86)	0.85	1.39	0.93	89%

It is evident from the Tables above that the shell and muscle field proportions fall within the range of variations of the Ludlow and Usk specimens. The type specimen with the other three specimens have nearly the same shell size as the Usk specimens, but they are larger than the Ludlow ones. The largeness of these specimens is not significant due to small sample of the type locality (n = 4). However, the three samples (Whitcliffe, Ludlow and Usk) keep the same gross shell proportions.

Details of the internal and external shell features are also figured and discussed during the present study (Pls. 1-7).

3.2.4. Material

1. Welsh Borderland.

a. Principal collections. These collections were specially made in order to obtain large numbers of S. ornatella from the Upper Leintwardine Formation for the variation study. Two hundred and thirty four specimens were made from two prolific localities (B38 & C30; see Table 3) near the type area of Ludlow, which lies close to the edge of the shelf. The other large collection of two hundred and twenty eight specimens was made from the Usk inlier, on the inner shelf, where the "*S. ornatella* Beds" are particularly well developed. All the specimens occurred as internal and external moulds of both pedicle and brachial valves.

b. Secondary collections. Two hundred and nine specimens in the Lawson collection and some in the Cherns collection were also studied. The specimens are from the following areas: West Midlands, Malvern, Abberley, Woolhope inlier, Usk inlier, Wenlock Edge, Ludlow, Towy Anticlinal, Brecon Anticlinal, May Hill, Builth and Amestrey. Several of these localities involve occurrences of *S. ornatella* in strata of the Lower Leintwardine Formation and these are so indicated in Appendix 1. Twelve specimens from Ludlow Museum were also examined. These specimens are mainly from the Upper Leintwardine Formation of the Ludlow area.

2. Gotland.

Two hundred and forty nine specimens in the Lawson collection were examined as part of a comparative study of specimens from the topmost Hemse Beds with those from Upper Leintwardine Formation and twenty Gotland specimens from the National Museum of Wales were also studied.

3.2.5. Horizons and localities.

S. ornatella is fairly common in the higher beds of the Lower Leintwardine Formation of the Welsh Borderland (see Cherns 1977). The species is very common in the Upper Leintwardine Formation, often covering bedding planes. It has been collected from two main localities (B38 & C30, text-figs. 2.1 & 2.2) near Ludlow and from the Usk inlier at locality Wt.

On Gotland, S. ornatella occurs in the Hemse, Eke and Burgsvik Beds (Bassett and Cocks 1974), which probably range in age from the Upper Leintwardine Formation to the Upper Whitcliffe Formation.

3.2.6. Diagnosis.

Weakly concavo-convex to plano-convex, almost biplanate Shaleria, averaging 69% as long as wide; strong parvicostellate radial ornament with two to three ribs (costellae) per mm at 10mm antero-medianly of dorsal umbo, leaving very wide interspaces between them which are normally occupied by four to five finer ribs (capillae), often with numerous corrugations on the external surface of the shell interrupted by the coarser costellae; internally with parallel sided, oval, triangular pedicle muscle field ranging from 70%, as wide as long (in Ludlow) to 89% as wide as long(in Usk inlier); hinge line denticulation occupying an average of 41% of the shell width; brachial value interior showing S-shaped muscle bounding ridges and socket plates, diverging antero-laterally at about 90^{o}-120^{o}.

3.2.7. Description (see Pls. 1,2,3, &5).

Medium-sized, subquadrate to semicircular Shaleria, plano-convex to very weakly concavo-convex, biplanate in profile, with very narrow body cavity; hinge line straight, probably always forming point of maximum width (Pl.3, figs. 1-3 & 7-9); valves averaging 70% as long as wide (e.g. $\bar{L}$smm (var Ls) 9.368 (4.44), $\bar{W}$s (var Ws) 13.477 (8.095), r = 0.866, n = 249; and $\bar{L}$smm (var Ls) 10.745 (7.630); $\bar{W}$s (var Ws) 15.313 (14.975), r = 0.952, n = 228 (Ludlow area and Usk inlier respectively)); lateral margins of shell sub-parallel to gently curved anteriorly, anterior margin rounded; commissures smooth, rectimarginate; radial ornament finely and equally parvicostellate with up to 3 rounded ribs per mm at 10mm antero - medianly of dorsal umbos (Pl.2, figs. 1-5); costellae well impressed, rounded, straight along mid-line of shell, becoming gently curved laterally, widely separated with 4-5 intermediate capillae; often with small, numerous corrugations (rugae) on the external surface of the shell, interrupted by the coarse costellae (Pl.2, figs. 10,11 & Pl.3, figs. 3,6,9,12); some specimens showing fine, short, oblique crenulations of shell along the postero-lateral margin of the hinge line with a few fine to coarse concentric growth fila developed postero-laterally of the muscle field (Pl.3, figs. 3,4,5,7,8); ventral interarea short, planar, apsacline (Pl.5, figs. 7-12); dorsal interarea narrow, anacline (Pl.5, figs. 1-6), delthyrium almost completely closed by pseudodeltidium, notothyrium sealed by small chilidium which is convex outwards.

Interior of pedicle valve with low, flat, ventral process, prolonged anteriorly as slender myophragm, longitudinally bisecting muscle field (see Pl.1); teeth minute, strong denticulation extending laterally for an average of 41% of hinge width (e.g. $\overline{W}$smm (Var Ws) 14.275 (8.179), $\overline{W}$d (var Wd) 5.887 (1.057), r = 0.765, n = 16 (Ludlow) and $\overline{W}$smm (var Ws) 15.159 (16.13), $\overline{W}$d (var Wd) 6.174 (e.046), r = 0.817, n = 42 (Usk inlier)); pedicle muscle field strongly impressed, almost triangular in outline (Pl.5, fig. 8), averaging 70% as wide as long in the Ludlow area, (e.g. $\overline{W}$mfmm (var Wmf) 2.966 (0.362), $\overline{L}$mf (var Lmf) 4.24 (1.167), r = 0.739, n = 74) and 89% as wide as long in the Usk inlier (e.g. $\overline{W}$mfmm (var Wmf) 3.653 (0.863), $\overline{L}$mfmm (var Lmf) 4.089 (1.955), r = 0.859, n = 108); muscles bounded laterally by moderately strong ridges, arising immediately anterior to the hinge line, parallel and divergent anteriorly at angles of: 20°-30°, 30°-40°, 40°-50°, and 50° respectively in 36, 34, 19, 1 (specimens from Ludlow) and 30, 50

20, 1 specimens from locality Wt in the Usk inlier; a few specimens having parallel ridges which die out anteriorly (Pl.1, fig. 12), other specimens with ridges curving anteriorly to intersect the myophragm and bound the muscle field (Pl.1, figs. 7-11); muscle field divided by myophragm, which bifurcates (in some specimens) at its anterior end at an angle of 50^{o}-70^{o}; adductor scars narrow, elongate, separated by the myophragm and extending anteriorly up to ½ of muscle field length, bounded by large, oval, subtriangular to triangular diductor muscle scars (Pl.5, fig. 7), averaging 43% as long as valve length in Ludlow specimens (e.g. $\bar{L}$mfmm (var Lmf) 4.211 (1.25), $\bar{L}$s (var Ls) 9.706 (3.954), r = 0.644, n = 63); 37% as long as valve length in Usk inlier specimens, (e.g. $\bar{L}$mfmm (var Lmf) 4.083 (1.964), $\bar{L}$s (var Ls) 10.957 (7.579), 4 = 0.873, n = 108).

Brachial valve interior with narrow, bifid (in some specimens), subparallel to divergent cardinal process lobes, postero-ventrally directed and bearing a groove on their attachment face (see Pl.2); socket plates small, diverging antero-laterally at about 90^{o}-140^{o} (Pl.5, figs. 1-6); hinge straight, dorsal muscle field well impressed, truncated, subparallel to triangular in shape; adductor scars semielliptical, open anteriorly, extending anteriorly for about ⅓ valve length, bounded laterally by subparallel ridges which are straight or slightly arcuate (S-shaped ; Pl.5, fig. 2), broad at their posterior end, bisected posteriorly by median, rounded ridges and anteriorly by straight, slightly divergent ridges at about 20^{o}-30^{o} antero-laterally and extending for a small length anteriorly; valve floor finely to coarsely tuberculate, particularly developed around and close to the muscle field.

3.2.8. Distribution.

1. Welsh Borderland (text-figs. 1.8 & 1.9)

S. ornatella is characteristically abundant in the Upper Leintwardine Formation of the Ludlow Series and equivalent strata of the shelf facies in the Welsh Borderland. Indeed in the Usk inlier (Walmsley 1959) there is an acme of this species in the Lower Llangibby Beds (which have a maximum thickness of only 8m) with only very rare occurrences below and above, thus providing a valuable mappable unit. In the other south-eastern inliers, however, *S. ornatella* is not uncommon in the upper part of the underlying Lower Leintwardine Formation and on the outer shelf, around Ludlow and Wenlock Edge, the species is abundant at this level.

The Upper Leintwardine Formation evidently corresponds with the final occurrences of the graptolite *Saetograptus leintwardinensis* recorded from May Hill, Woolhope, Usk Wenlock Edge and Builth in association with the *S. ornatella* fauna. The top of the *leintwardinensis* zone coincides in the Welsh basin facies with the restricted yet abundant occurrence of the ostracode *Neobeyrichia lauensis* and associated species (i.e. *N. scissa* and *N. confluens*). At the shelf edge, west of Ludlow, this distinctive ostracode assemblage, associated with an abundance of the small brachiopod *Aegiria grayi*, interfingers with the typical *S. ornatella* association in the Upper Leintwardine Formation. These distinctive neobeyrichiids also occur, although less commonly, in the Upper Leintwardine Formation of some of the south-eastern inliers (e.g. Malverns, Woolhope and May Hill). Trilobites also aid the correlation, *Calymene puellaris* and *Encrinurus stubblefieldi* both being commonest in this formation, whilst *Calymene lawsoni* and *Proetus obconicus* have acmes just below, in the highest part of the Lower Leintwardine Formation.

2. Gotland (text-figs. 1.3 & 1.4)

The Silurian brachiopod fauna of the island of Gotland (Sweden) has been reviewed recently by Bassett and Cocks (1974). They record S. aff. ornatella from the Hemse, Eke and Burgsvik Beds. In the eastern part of the island the coquina layers of shaleriids (Cherns 1983, p.15) in the topmost Hemse Beds are strongly reminiscent of the slabs of S. ornatella from the Welsh Borderland, except that the latter are most frequently preserved as moulds whereas the Gotland specimens normally have the shells intact. The zonal fossils for these uppermost Hemse Beds of eastern Gotland are the ostracodes Neobeyrichia lauensis and N. scissa and they provide a refined correlation with the Upper Leintwardine Formation and equivalent strata of the Welsh Borderland area. This is supported by the similarity of the trilobite fauna, including the fairly common occurrence of Calymene puellaris in the high Hemse and low Eke Beds of Gotland (Siveter 1983, p.87).

3.2.9. Discussion.

S. ornatella is a flat and distinctive stropheodontid fossil, characterising the Upper Leintwardine Formation of the Welsh Borderland (Watkins 1979). It was described and figured by Davidson (1871) as Strophomena ornatella, who demonstrated its morphological variability, particularly those observed in the shape and angle of divergence of the pedicle valve muscle field. In this study, detailed external and internal shell variability within and between different populations have been illustrated statistically (see Section 3.3.).

The species is compared with a closely related form known as S. aff. ornatella (Bassett and Cocks 1974) from the topmost Hemse Groups in eastern Gotland. Bassett and Cocks (1974) suggested that this species displayed a wide range of morphological variation. Furthermore, it is also compared with a few specimens of the related form named as Shaleria sp.nov. Shaleria sp.nov. specimens are poorly preserved in the Lower Bringewood Formation of the Woolhope inlier, which makes the comparison with S. ornatella difficult. Although it was impossible to study these specimens thoroughly, gross shell measurements show a smaller shell size than in S. ornatella, with an average shell length of 4.3mm and shell width of 6.5mm for n = 7.

3.3. DESCRIPTION OF VARIATION

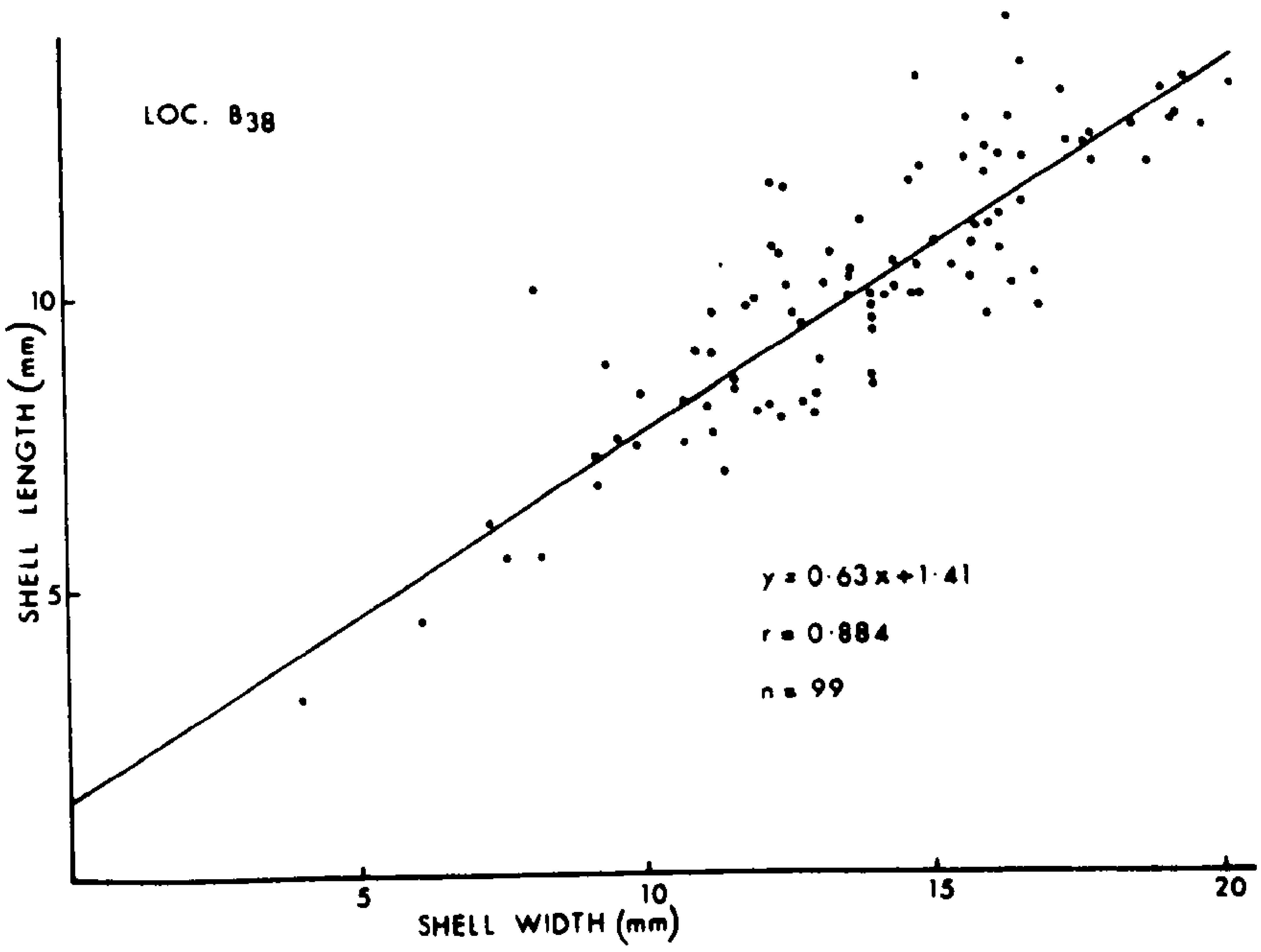
Before describing the variation seen in the shell length-width proportions of S. ornatella from the three primary areas (Ludlow, Usk and Gotland), the writer concentrated on the Ludlow area collection which mainly comes from two major localities B38 and C30 (text-figs. 2.1 & 2.2). The specimens from these two localities are slightly different in the value of their gross shell proportions but the lines representing these two localities have nearly the same trend and are also parallel to each other (text-figs. 3.1 & 3.2). However, the specimens from locality B38 are slightly longer than those from locality C30; i.e. $\overline{Ls}/\overline{Ws}$: 73% (n = 99) and 67% (n = 136) respectively (Table 3).

TABLE 3. Summary of statistical results of the shell length-width proportion of S. ornatella from localities B38 and C30:

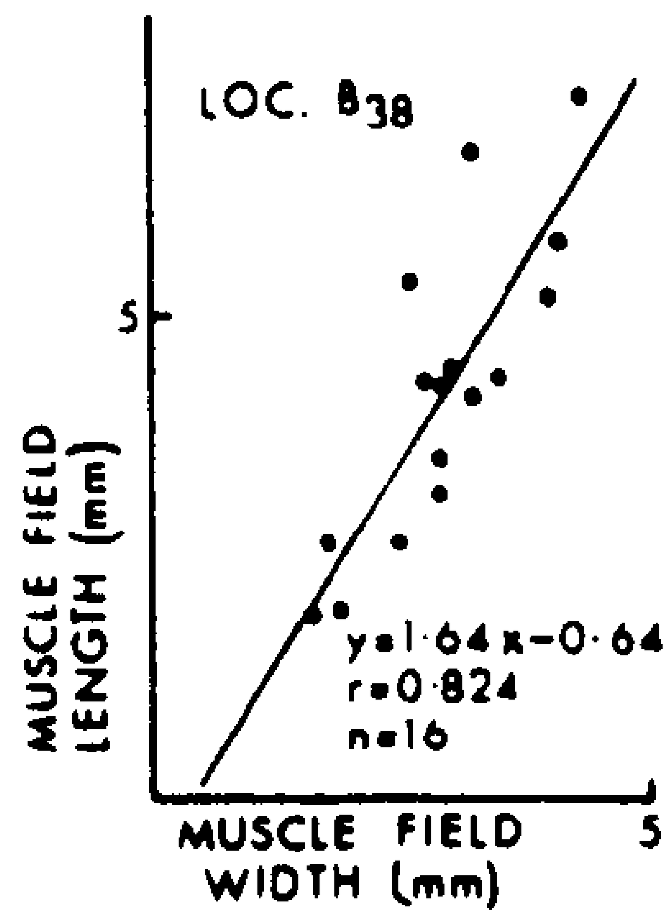
Locality	n	$\overline{Ls}$	$\overline{Ws}$	r	S.D. (Ls)	S.D. (Ws)	% $\frac{\overline{Ls}}{\overline{Ws}}$
B38	99	10.09 (5.06)	13.78 (9.93)	0.884	2.238	3.136	73%
C30	136	8.95 (3.35)	13.41 (6.75)	0.878	1.823	2.588	67%

The muscle-field width-length has also been plotted. Both B38 and C30 localities show a value of $\overline{Wmf}/\overline{Lmf}$ of 70% (text-figs.

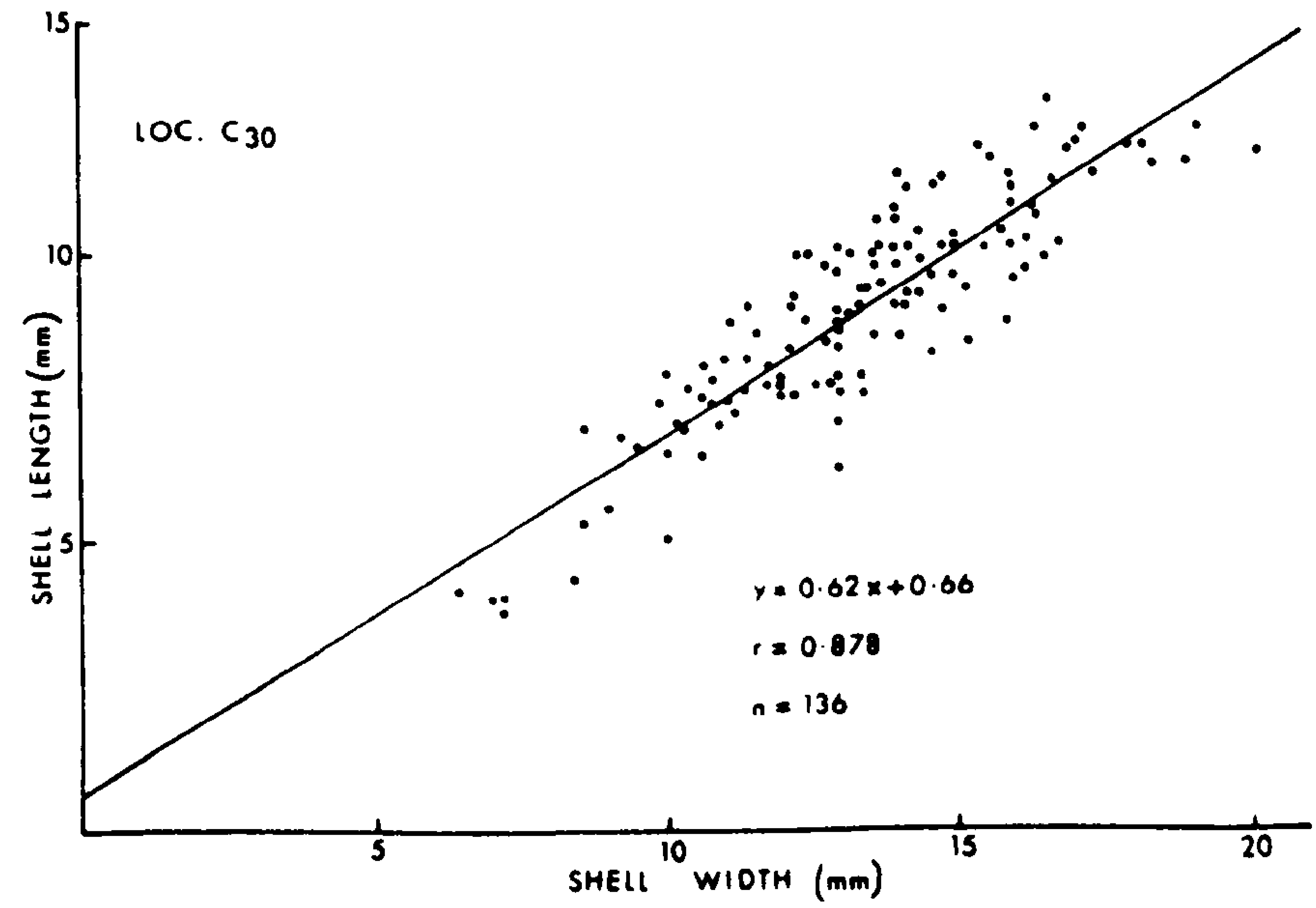
TEXT-FIG.3.1



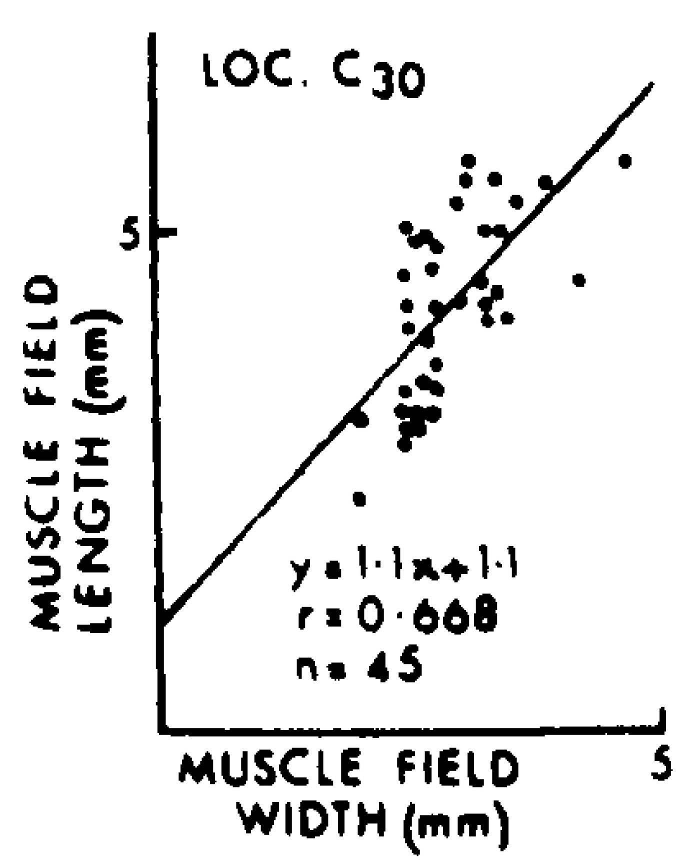
TEXT-FIG.3.3



TEXT-FIG.3.2



TEXT-FIG.3.4



TEXT-FIGS.3.1 & 3.2. Shell length-width distribution of S. ornatella in two main localities; B38 & C30 in the Ludlow area.

TEXT-FIGS.3.3 & 3.4, are for muscle field length-width relationship of the same localities respectively.

3.3 & 3.4 and Table 4).

TABLE 4. Summary of statistical results of the muscle field length-width of S. ornatella from localities B38 and C30:

Locality	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	% $\frac{Lmf}{Wmf}$
B38	16	4.21 (2.44)	2.95 (0.62)	0.824	1.51	0.76	70%
C30	45	4.3 (0.76)	2.97 (0.28)	0.668	0.86	0.53	70%

Consequently, the collections from these two localities are treated as one major collection for the Ludlow area as the morphological differences are so small and for easier comparison with other areas.

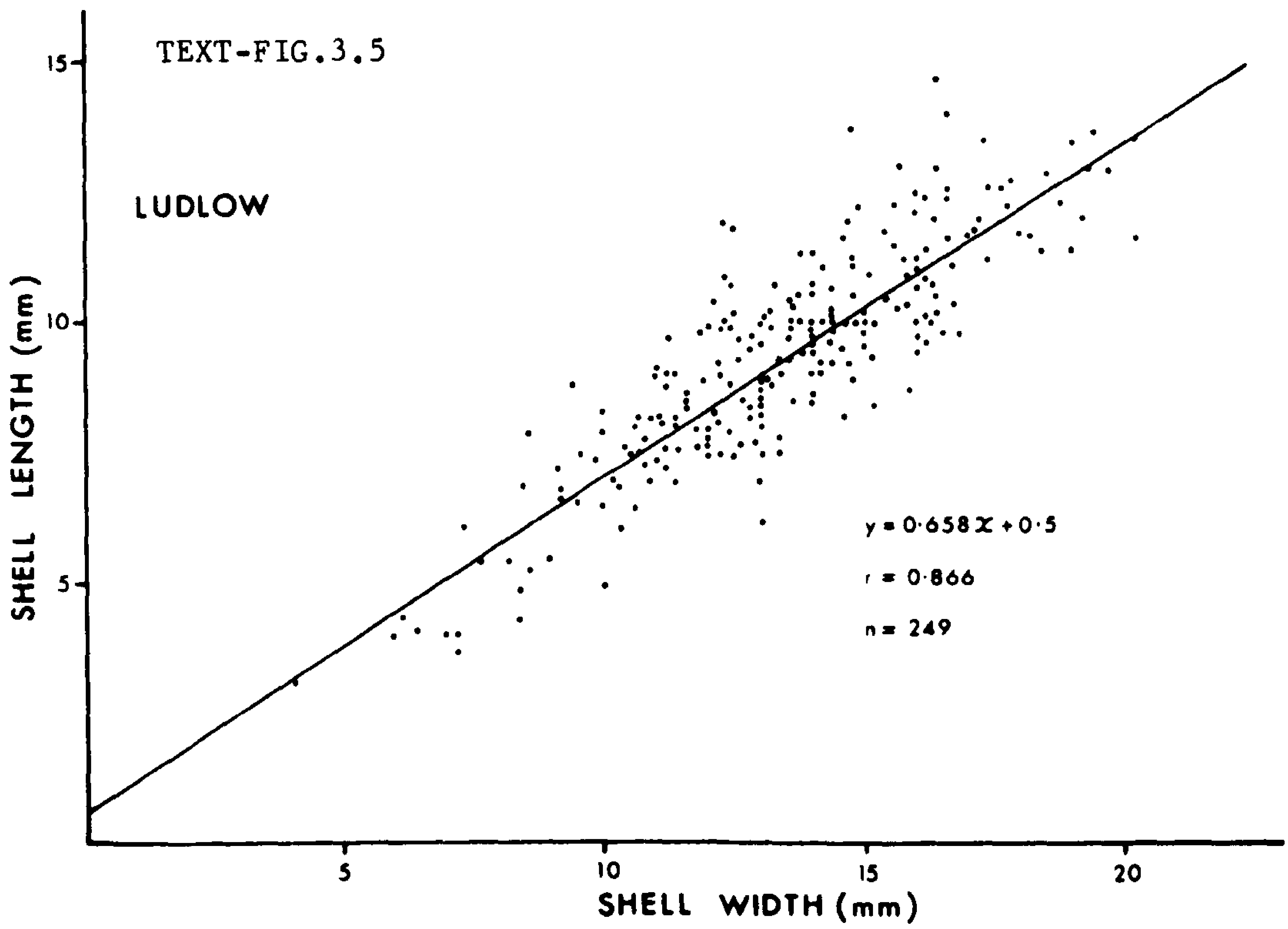
3.3.1. In S. ornatella from the Welsh Borderland of Britain and E Gotland major areas.

A. External shell features

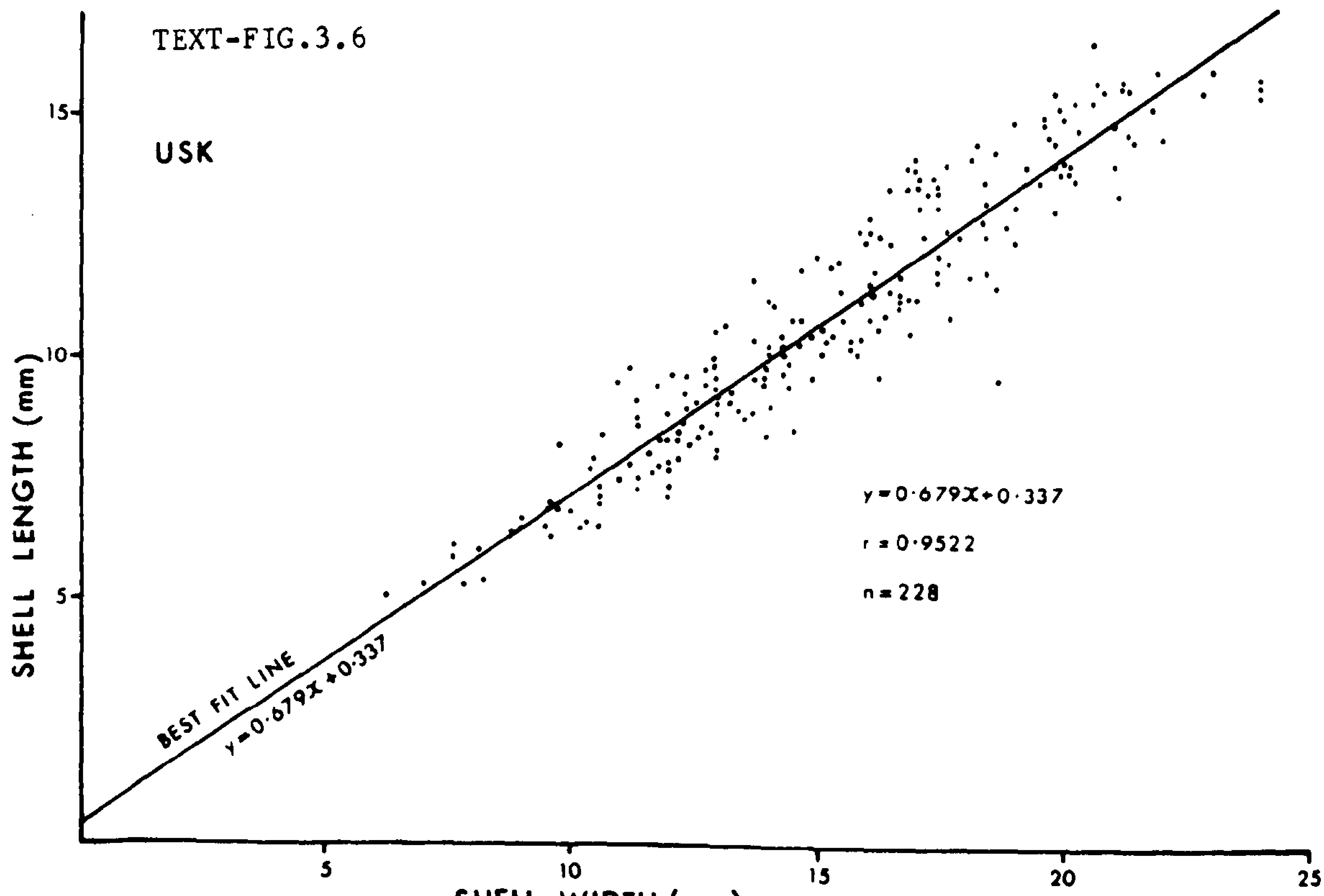
1. Shell proportions (Plate 3)

S. ornatella is subquadrate to semi-circular in outline (Pl.3, figs. 1-12) and plano-convex to weakly concavo-convex or is almost biplanate in lateral profile. The body cavity is very restricted as in many stropheodontid brachiopods. Posteriorly the hinge line is straight (strophic) and the lateral margins of the shell are sub-parallel to gently curved anteriorly, while the commissure is smooth and rectimarginate. The variation in the shell proportions for the three primary areas (Ludlow, Usk and Gotland) is shown in Table 5 and is also displayed graphically in text-figs. 3.5, 3.6 and 3.7.

TEXT-FIG.3.5

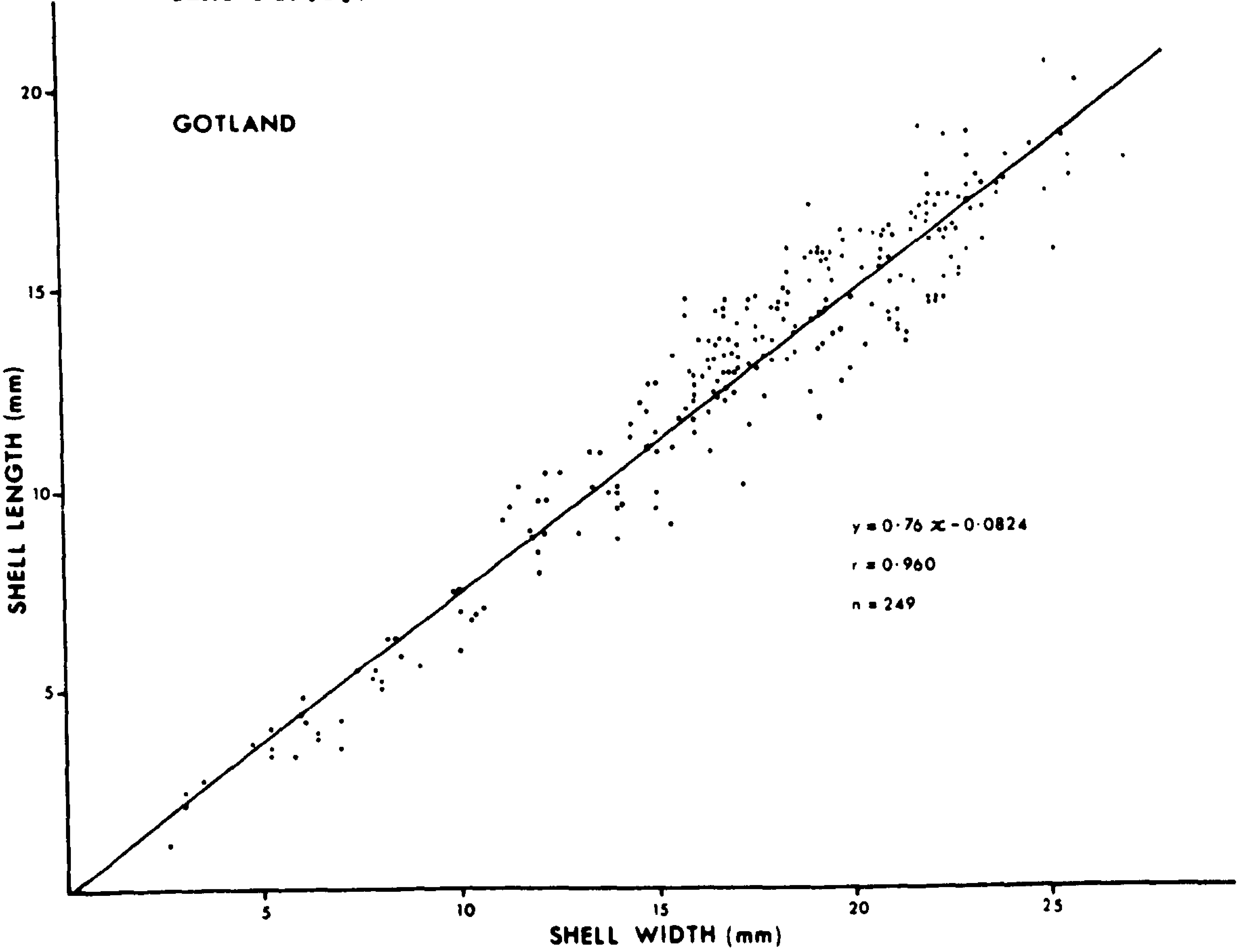


TEXT-FIG.3.6

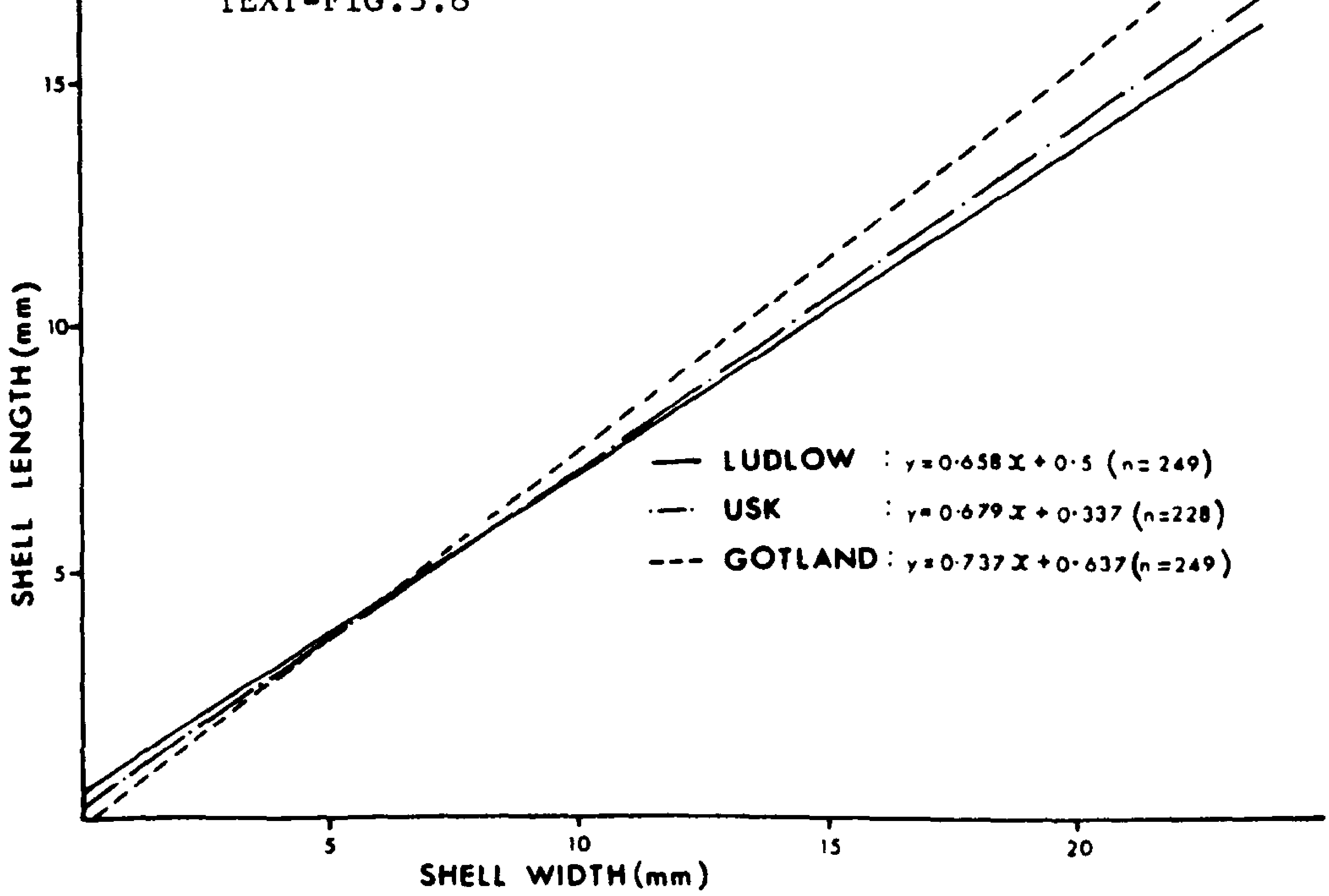


TEXT-FIGS.3.5 & 3.6. Shell length-width distribution for S. ornatella in Ludlow and Usk respectively.

TEXT-FIG.3.7



TEXT-FIG.3.8



TEXT-FIG.3.7. Shell length-width distribution for S. ornatella in Gotland specimens.

TEXT-FIG.3.8. Superimposition of shell length-width distribution of S. ornatella in Ludlow, Usk and Gotland.

TABLE 5. Summary of shell length (Ls) and width (Ws) statistics for S. ornatella from Ludlow, Usk and Gotland.

Area	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	% $\frac{\bar{Ls}}{\bar{Ws}}$
Ludlow	249	9.3679 (4.4436)	13.477 (8.0952)	0.866	2.047	2.785	70%
Usk	228	10.7452 (7.63)	15.3132 (14.975)	0.952	2.756	3.861	70%
Gotland	249	12.8855 (17.0964)	17.0378 (27.3859)	0.963	4.127	5.223	76%

The high value of the coefficient of correlation (r) in all the three samples demonstrates that the length and width increase in direct proportion to each other. From the data shown in Table 5, it is evident that the Gotland specimens are longer and wider than the specimens from Ludlow and Usk. Within Britain, Usk specimens are larger, on average, than Ludlow specimens, but the ratio of the shell proportion (Ls/Ws) for both Ludlow and Usk specimens is identical (Ls/Ws: 70%) while the Gotland specimens are proportionately longer (Ls/Ws: 76%) (see text-figs. 3.8 & 3.25).

2. Pedicle valve convexity

The convexity (depth) was measurable on the pedicle valve in only a small proportion of specimens from each area. The average depth for the Welsh Borderland specimens was 1.01mm (S.D. = 0.189, n = 17) as compared with 1.83mm (S.D. = 0.219, n = 17) for the significantly more convex specimens from Gotland.

3. Ornamentation (Plate 3)

One of the distinctive external features on the valves of S. ornatella is the radial ornament, which is finely parvicostellate. The coarse rounded ribs (costellae) are straight along the mid line of the shell becoming gently curved laterally (Pl.3, figs.3, 4,5,7 and 10). The costellae leave wide spaces between each other, which are occupied by numerous fine ribs (capillae) (Pl.3, figs. 3, 4,5,10,11 and 12). There are in some specimens numerous corrugations (rugae) on the external surface of the shell, which are interrupted by coarser costellae (Pl.3, figs.6 and 9). Some specimens show fine, short, oblique crenulations of the shell along the postero-lateral margin of the hinge line (i.e. near the shell ears) (Pl.3, figs.3, 6 and 9). Some other specimens show one to three fine to coarse concentric growth fila (Pl.3, figs. 3,4,7 and 8). These growth fila developed postero-laterally to the muscle field. Studying the radial ornament in detail, it is evident that although the Gotland and Welsh Borderland specimens have a similar density of costellae, the finer capillae are much more numerous in the Gotland forms, thereby giving a noticeably larger number of capillae between each of the thicker costellae. In Britain for example, the number of capillae per mm at 10mm antero- medianly of the dorsal umbo range from 5 to 7 (n = 12) for Ludlow and Usk specimens (Pl.3, figs. 1-9) and up to 10 ribs (n = 14) for Gotland specimens (Pl.3, figs. 10-12).

B. Internal shell features

1. Denticulation

All stropheodontids were articulated by teeth and sockets, in addition to a series of sharp protruding small ridges (denticles) arranged along part or all of the hinge line (Pl.2, figs. 2-5 and 10), (Williams 1953, p.8). The development of such denticles along the hinge line acts as an interlocking system which was accompanied by a progressive reduction and final atrophy of the original teeth and sockets on the pedicle and brachial valves respectively (Rudwick 1970, p.52). In *S. ornatella* strong denticulation extends laterally for varying proportions of the hinge width in different localities (text-figs.

3.9-3.12) (Table 6).

TABLE 6. Summary statistical data on denticulation in S. ornatella (from Ludlow, Usk and Gotland)

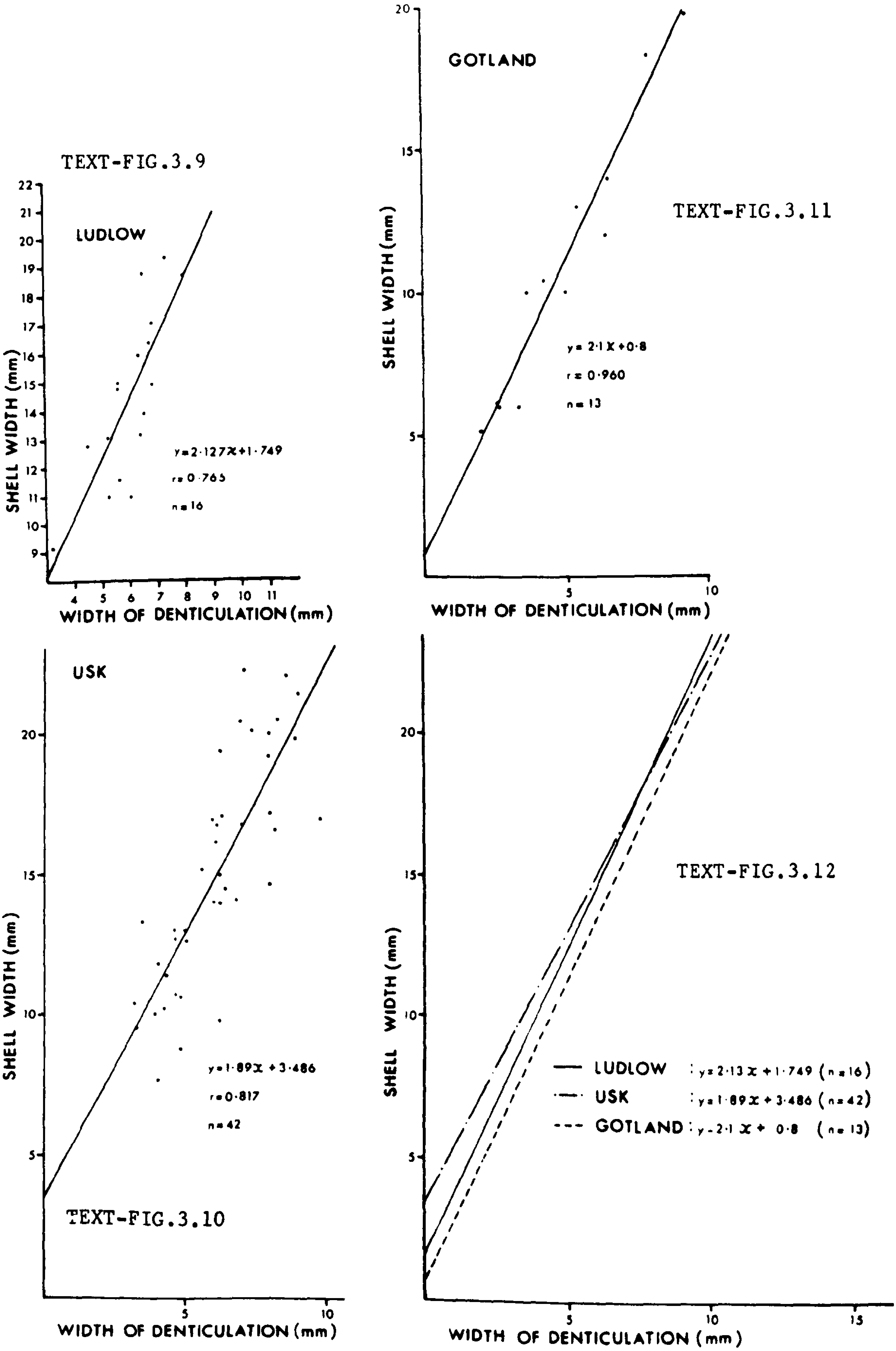
Area	n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (Ws)	S.D. (Wd)	% $\frac{\overline{Wd}}{\overline{Ws}}$
Ludlow	16	14.275 (8.179)	5.887 (1.057)	0.765	2.769	0.996	41%
Usk	42	15.16 (16.3)	6.174 (3.046)	0.817	3.989	1.724	41%
Gotland	13	11.154 (22.223)	4.939 (4.719)	0.966	4.529	2.087	44%

It is evident from the text-figs. 3.9-3.12 that the width of the hinge line denticulation increased in direct proportion to the shell width in all three areas. From Table 6, it can be seen that the average width of the denticulations compared with the hinge width in both Ludlow and Usk areas is the same (41%) while in Gotland it is 44%. This increase in the growth of denticles on the hinge line in Gotland specimens will be discussed later.

In addition, the muscle field area (A^2) has been plotted against the denticulation width on the hinge line (text-fig. 3.27). It is evident from text-fig. 3.27 that the denticulation increased in direct proportion to the muscle field area.

2. Muscle fields on the pedicle valve (Pl.1 and Pl.5, figs. 7-12)

In S. ornatella the diductor muscle scars are always bounded by narrow, high ridges (Pl.1, fig. 10) which arise immediately anterior to the hinge line and may or may not unite with the median septum (myophragm). These ridges encircle the diductor muscle scars anteriorly (Pl.1, figs. 1,3,7,10 and 11). The specimens do however show a variation in the shape of the muscle fields from parallel sided, dying out anteriorly (very few specimens), as shown in Plate 1, figs 7 and 12, to a strongly divergent shape up to an angle of 50°



TEXT FIGS.3.9 - 3.11. Plots of shell width versus width of denticulation in Ludlow, Usk and Gotland respectively, with their superimposition in text-fig.3.12.

(see Table 7 below and Pl.1, figs. 1,3,6 and 11).

TABLE 7. Angles of divergence of muscle bounding ridges in S. ornatella from Ludlow, Usk and Gotland.

Areas	20^o	20^o-30^o	30^o-40^o	40^o-50^o	$>50^o$	$\bar{x}$	n
Ludlow	-	36	34	19	1	33^o	90
Usk	-	30	50	20	1	34^o	101
Gotland	3	16	32	25	4	35^o	80

The muscle bounding ridges curved anteriorly towards the myophragm making a bilobed shape (Pl.1, figs. 3,8,11 and 16) or, in a few specimens, curved outwards towards the lateral margins of the shell (Pl.1, figs. 4,5, 9 and 15) and the myophragm in the latter type bifurcates at its anterior end at an angle of 50-70^o to follow the curvature of the ridges (Pl.2, figs.4,5 and 9). The most common and typical shape is seen in Plate 1, figs. 7,11 and 16. The variation in the angle of divergence of the muscle bounding ridges can be detected from locality to locality and even on the same bedding plane (Pl.1, figs. 13-16 showing both parallel and divergent types). The shape of the muscle fields is almost subtriangular to triangular and differs in proportions in each of the three main areas as illustrated in Table 8 and also displayed graphically in text-figs. 3.13-3.15.

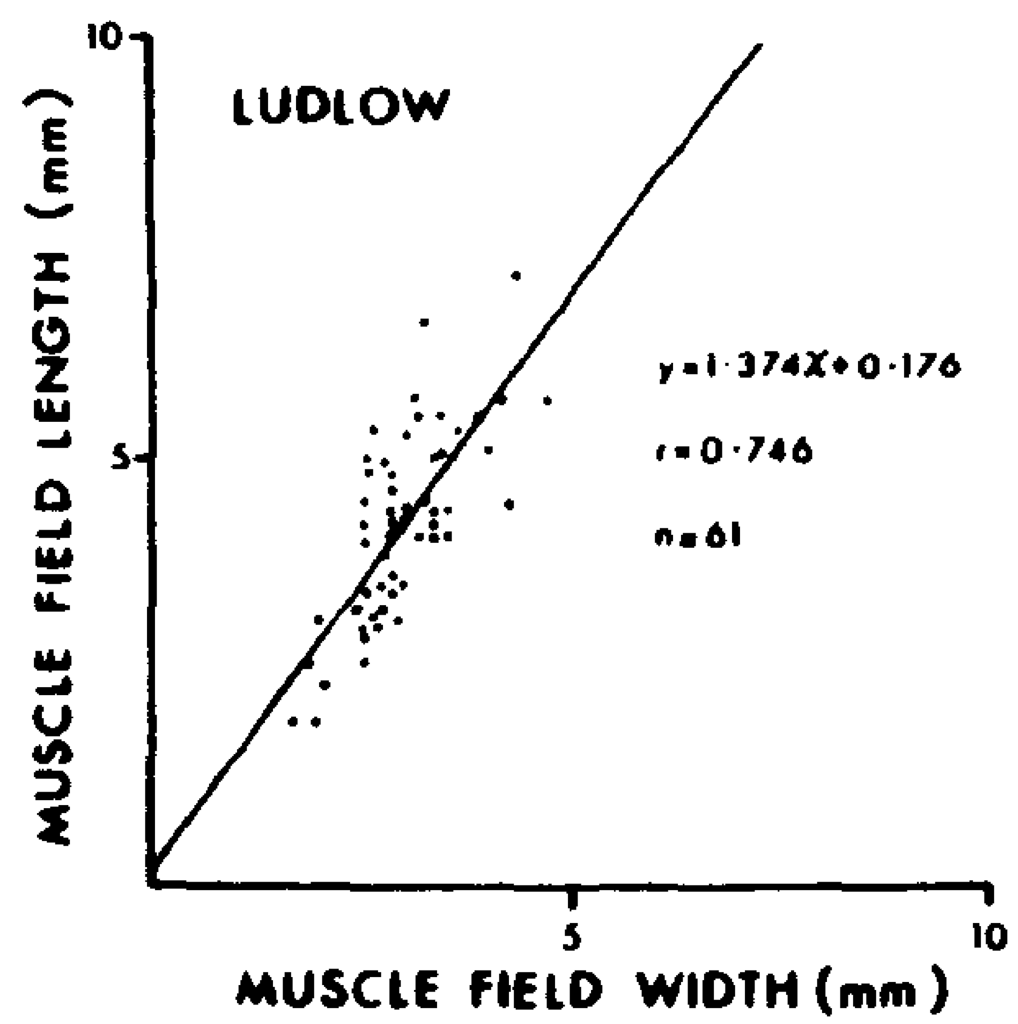
TABLE 8. Summary of statistical data on muscle field proportions field proportions in S. ornatella.

Area	n	$\bar{Lmf}$	$\bar{Wmf}$	r	S.D. (Lmf)	S.D. (Wmf)	% $\frac{\bar{Wmf}}{\bar{Lmf}}$
Ludlow	74	4.244 (1.167)	2.966 (0.362)	0.746	1.186	0.644	70%
Usk	108	4.089 (1.955)	3.653 (0.863)	0.859	1.392	0.925	89%
Gotland	84	5.164 (1.676)	4.317 (0.794)	0.832	1.286	0.885	84%

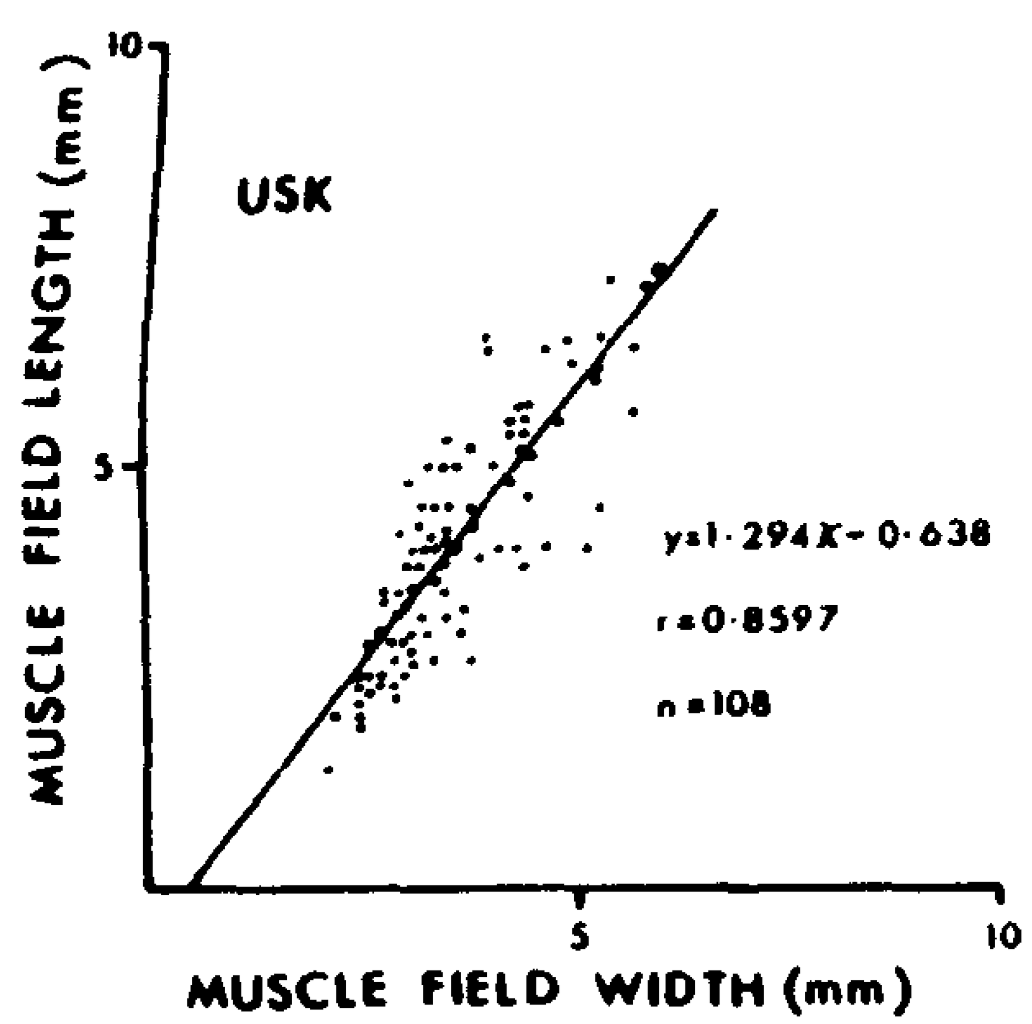
TEXT-FIGS.3.13 - 3.15. Muscle field length-width distribution for *S. ornatella* in Ludlow, Usk and Gotland respectively.

TEXT-FIGS.3.16 - 3.18. Plots of shell length against muscle field length in Ludlow, Usk and Gotland areas.

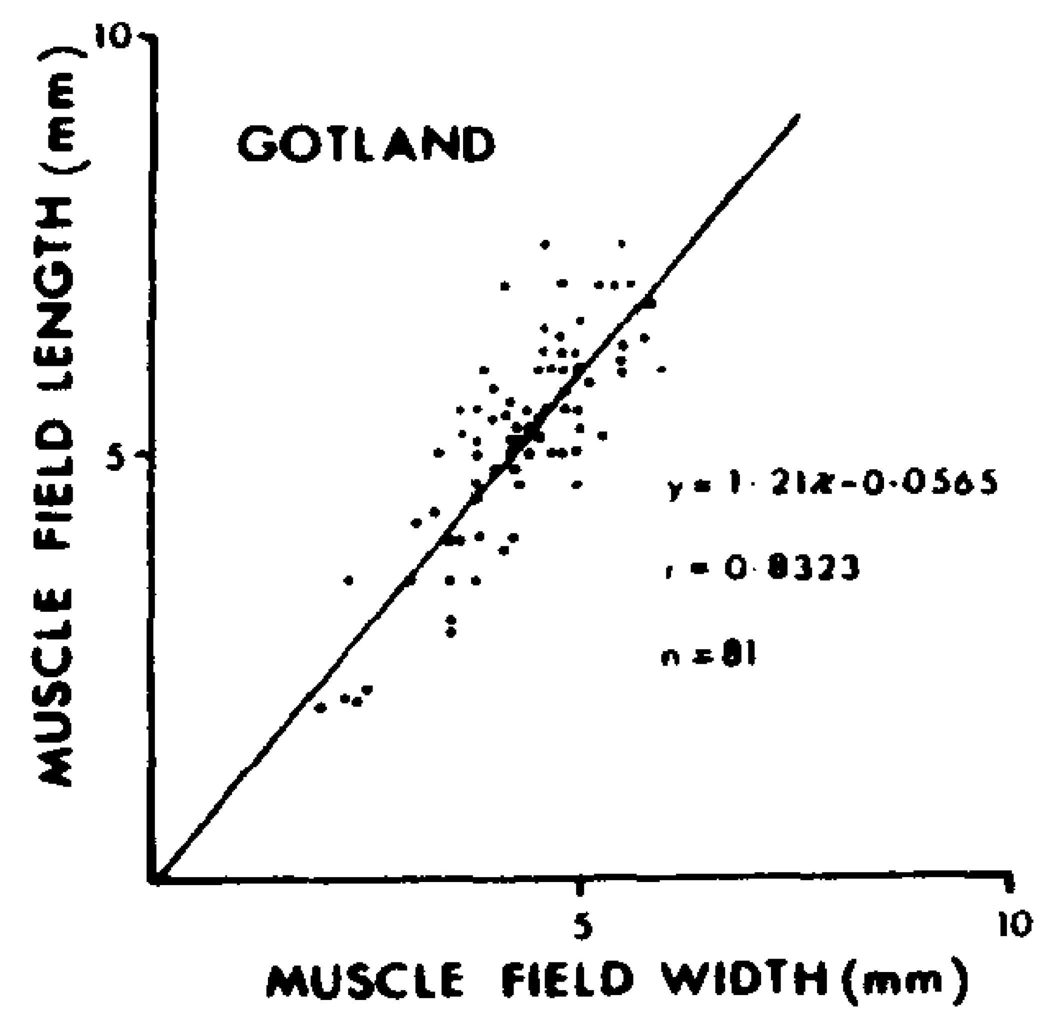
TEXT-FIG.3.13



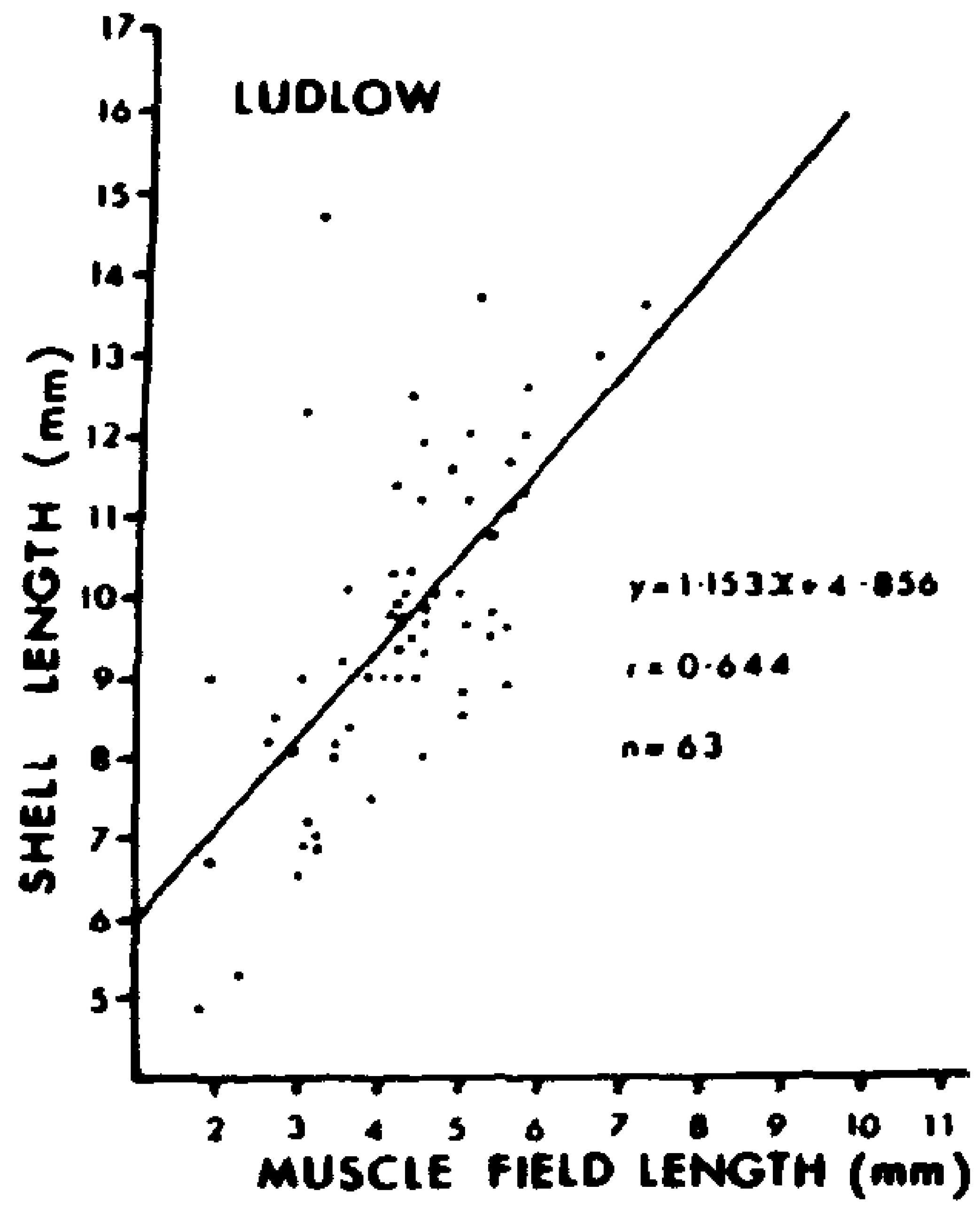
TEXT-FIG.3.14



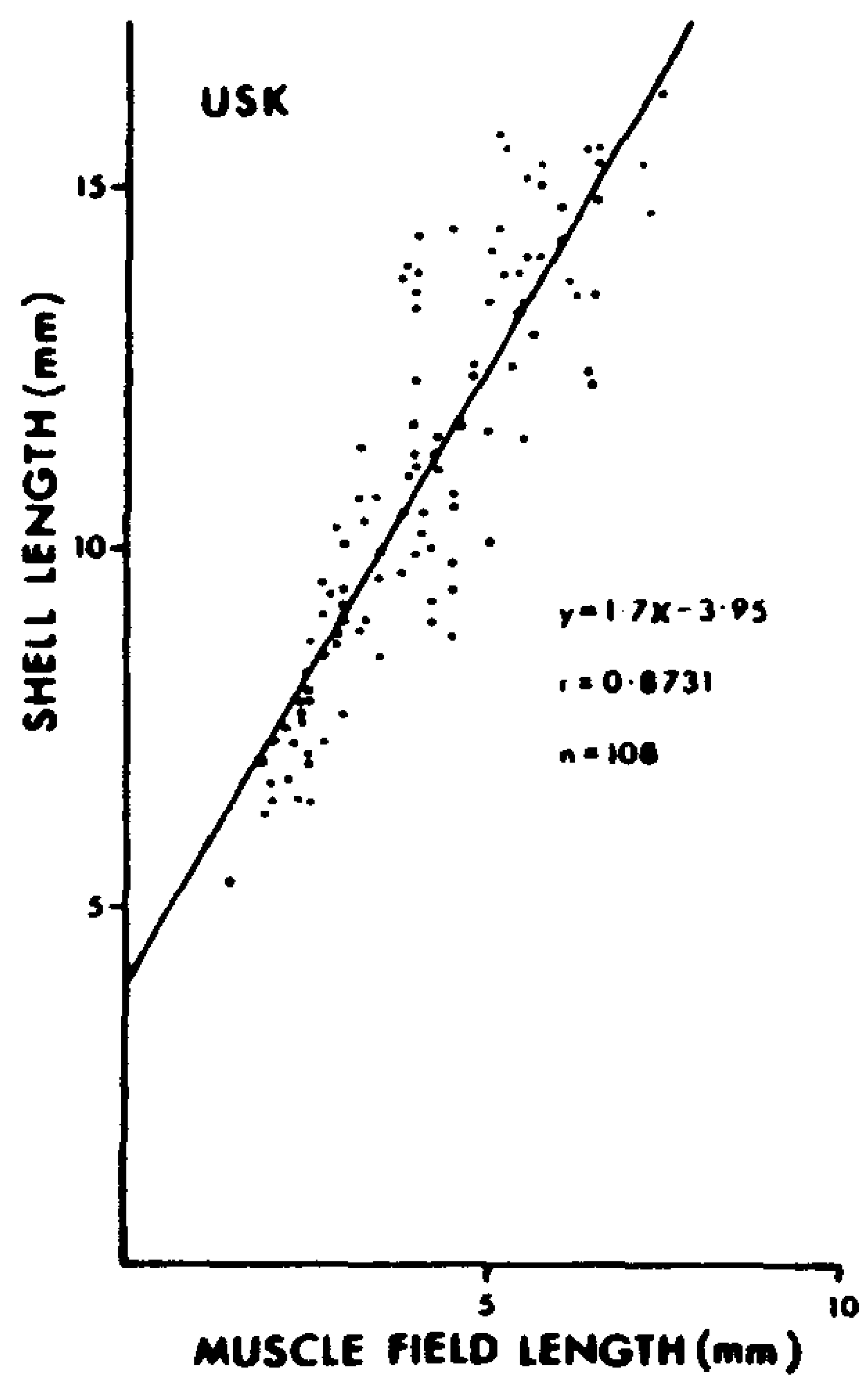
TEXT-FIG.3.15

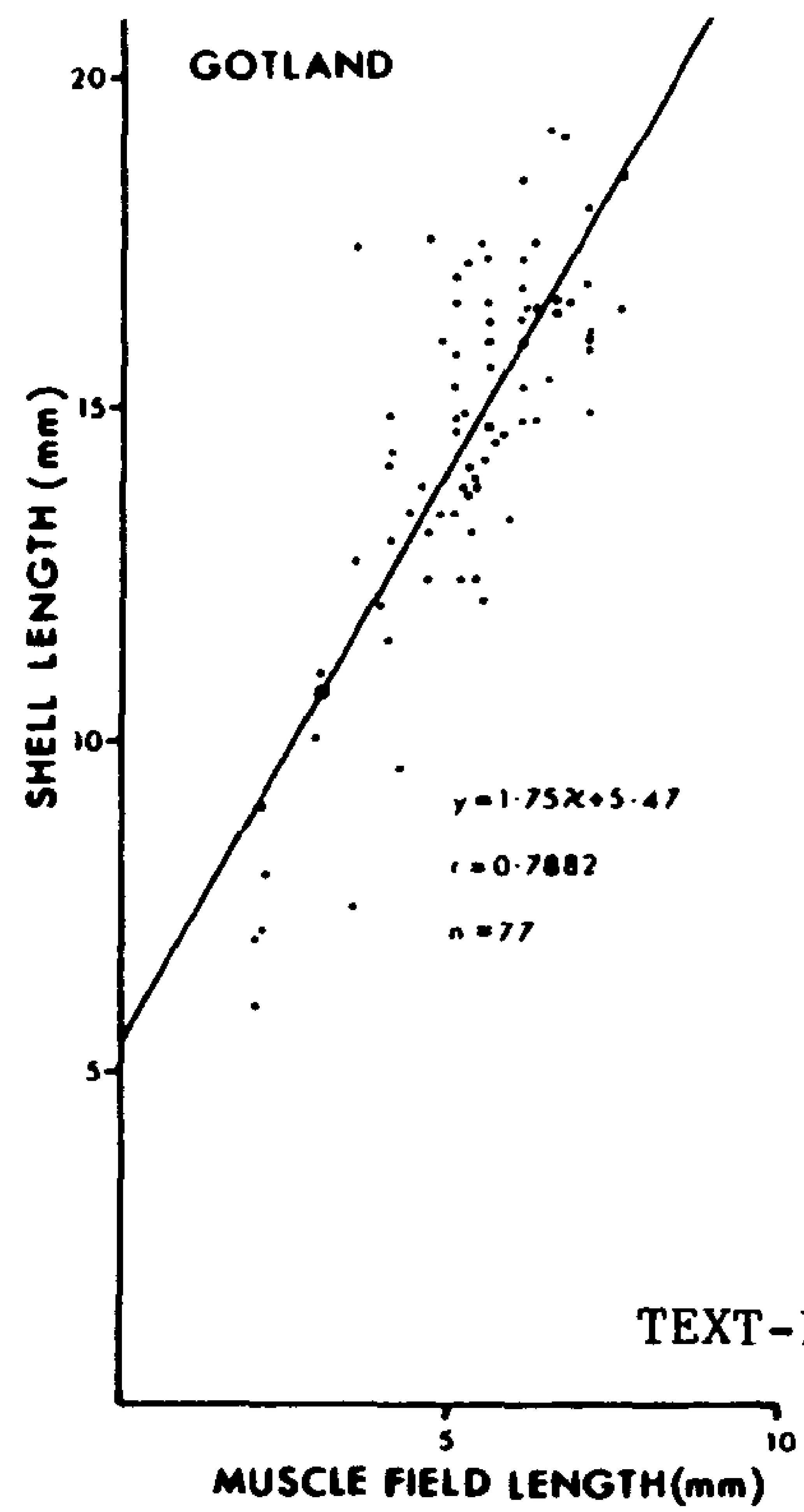


TEXT-FIG.3.16



TEXT-FIG.3.17





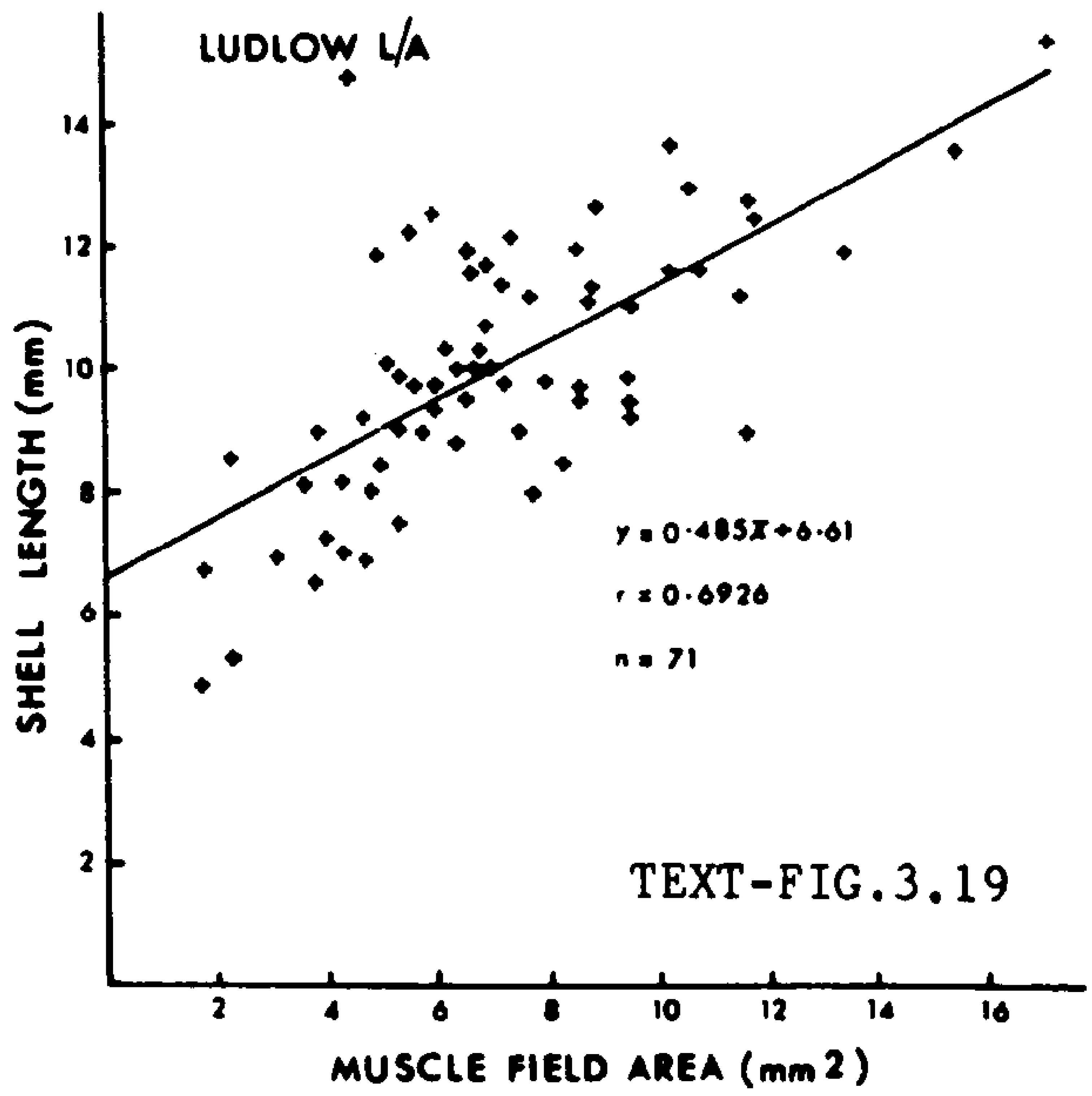
TEXT-FIG.3.18

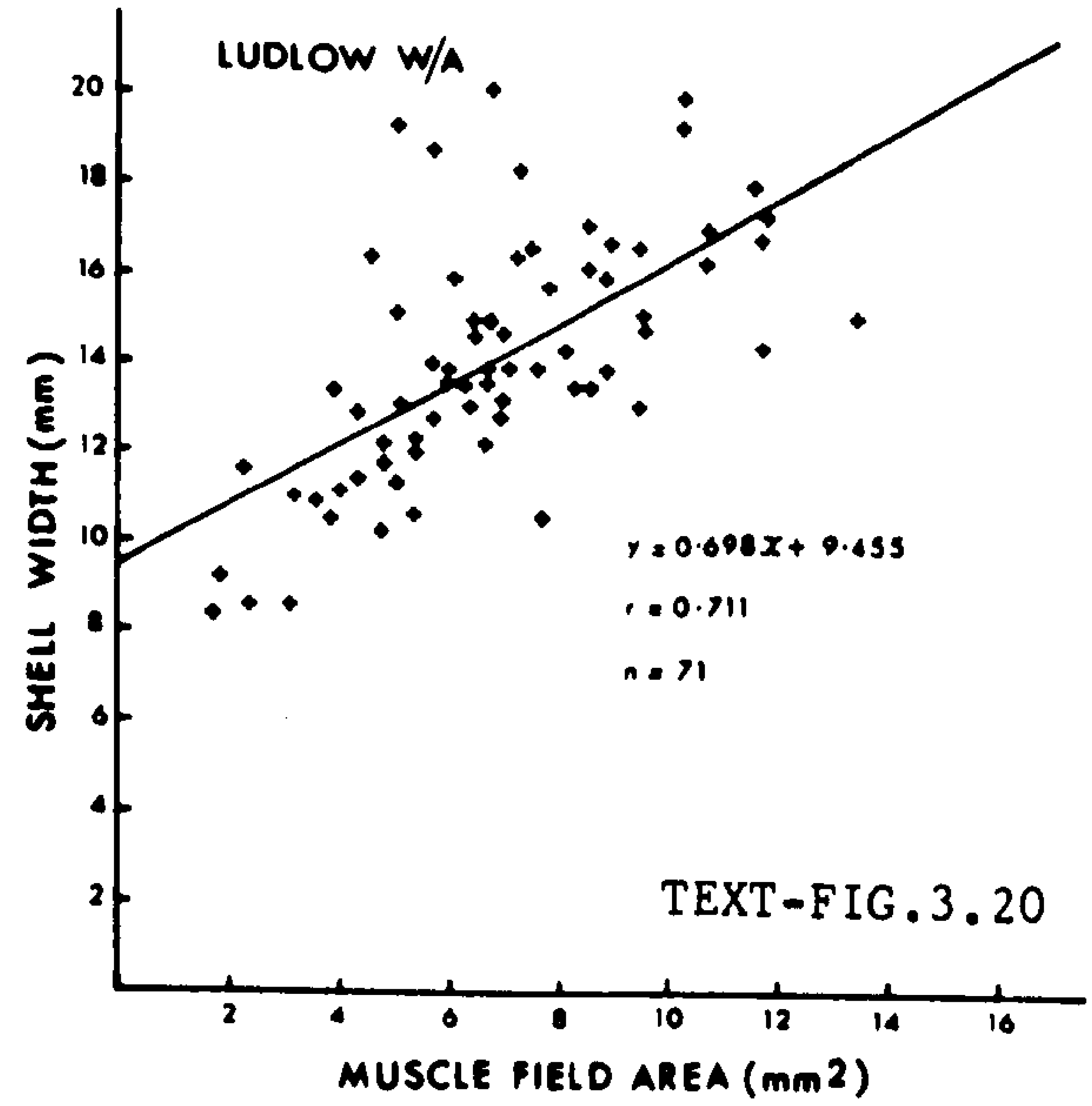
It is evident from the text-figs. 3.13-3.15 that the length of the muscle fields increases in direct proportion to their width across the size range (possibly ontogenetic) of the specimens in all three areas. The length of the muscle fields also increases in direct proportion to the length of the shell in all three areas (text-figs. 3.16-3.18).

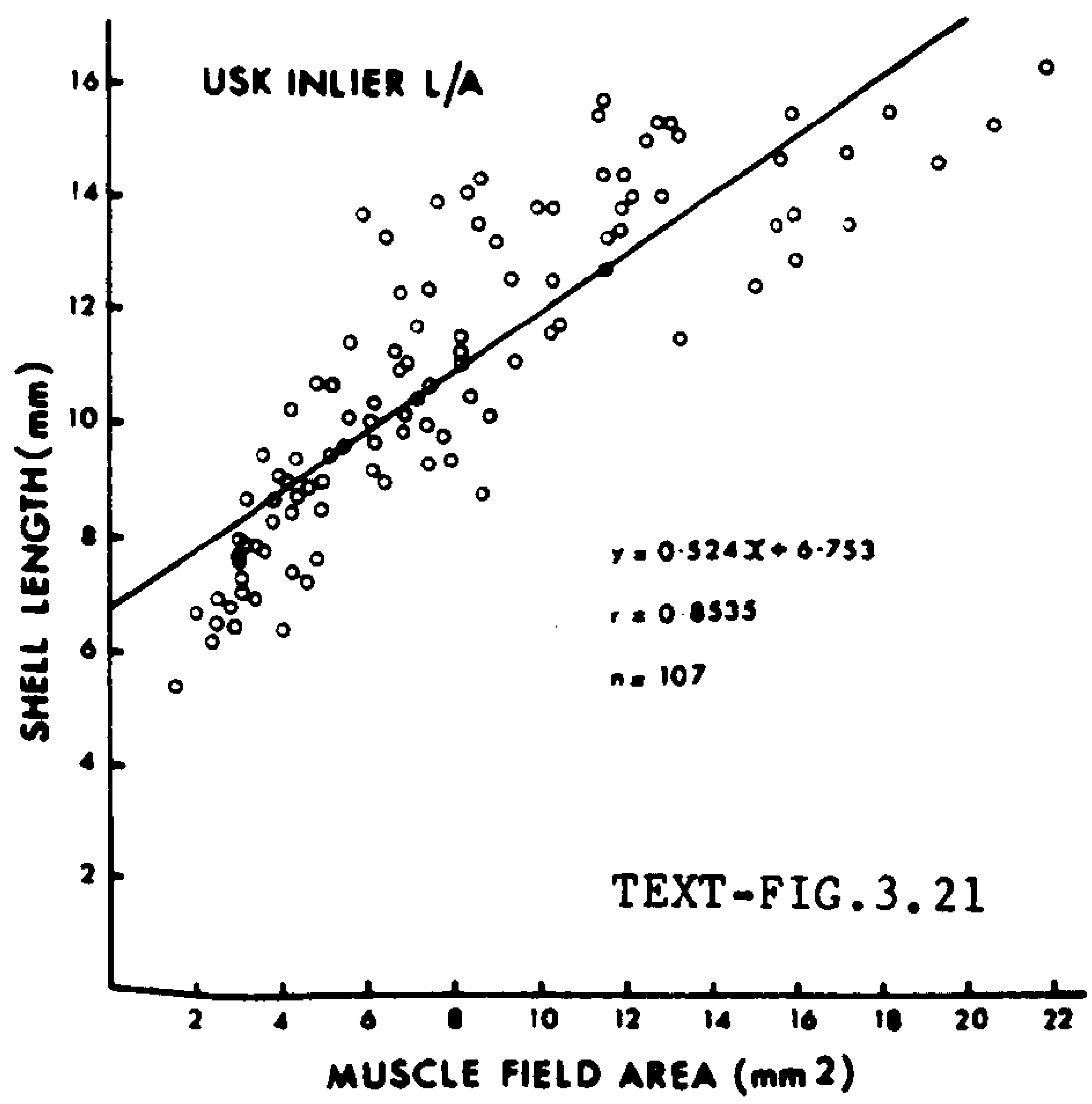
In addition, the muscle field area was calculated for the three localities (Ludlow, Usk and Gotland) using the formula A = 1/2 W x L (text-fig.2.6). These data were plotted against the shell length and shell width (text-figs. 3.19-3.24). It is evident from the text-figs. that the muscle field area increased over the plotted size range (ontogenetic?) in direct proportion to the shell length and shell width in all three areas. The areas of the muscle fields in Gotland specimens are larger than those in Ludlow and Usk specimens, but the Swedish shells are much longer and the ratio of the muscle area to the shell length and muscle area to the shell width are similar in each area (See text-fig. 3.28a&b and Table 9).

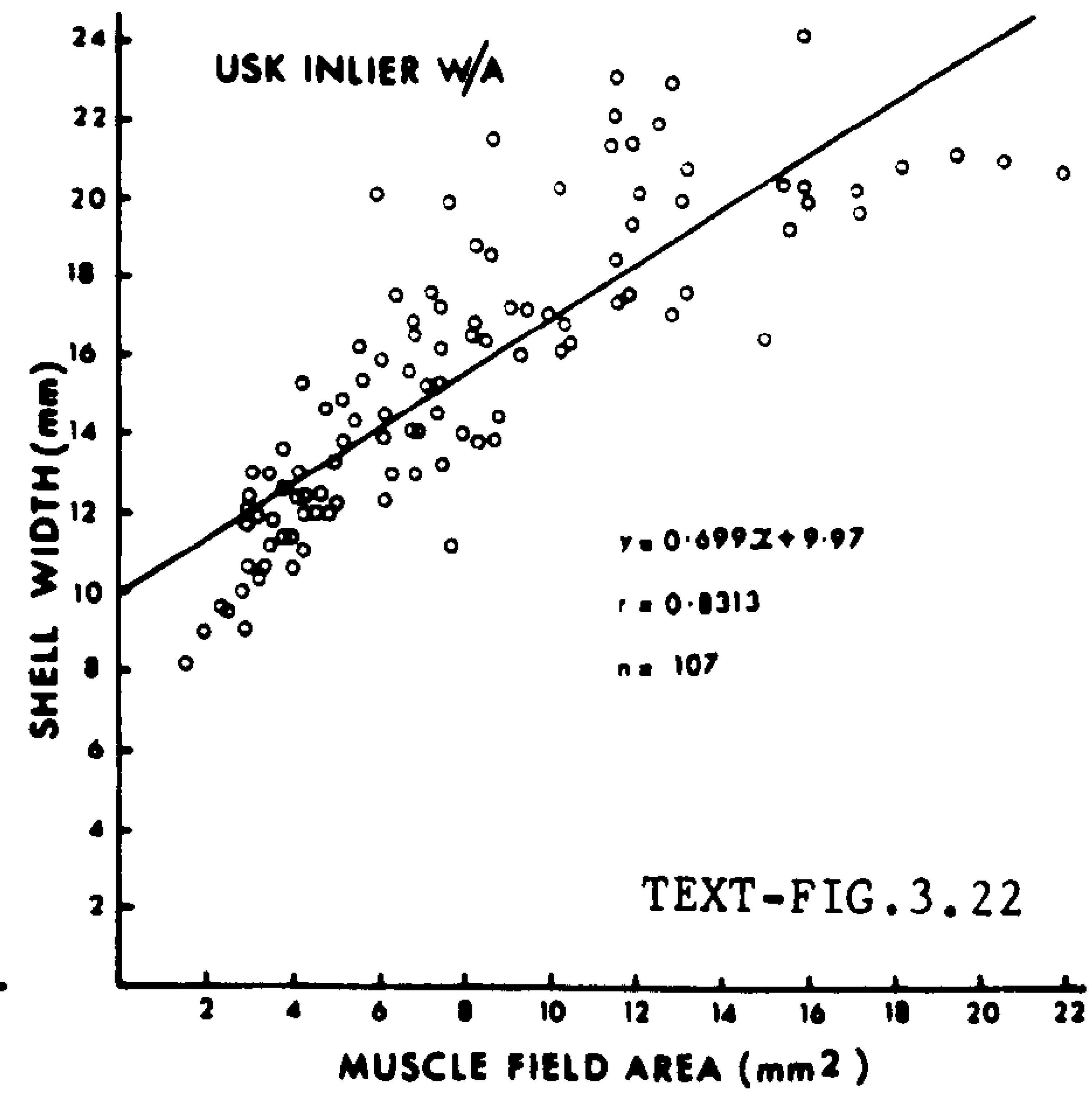
TABLE 9. Comparative mean shell proportions and area of muscle fields in S. ornatella from Ludlow, Usk and Gotland. ($\overline{Ls}$ = mean of shell lengths; $\overline{Ws}$ = mean of shell widths; $\overline{Amf}$ = mean of muscle field areas)

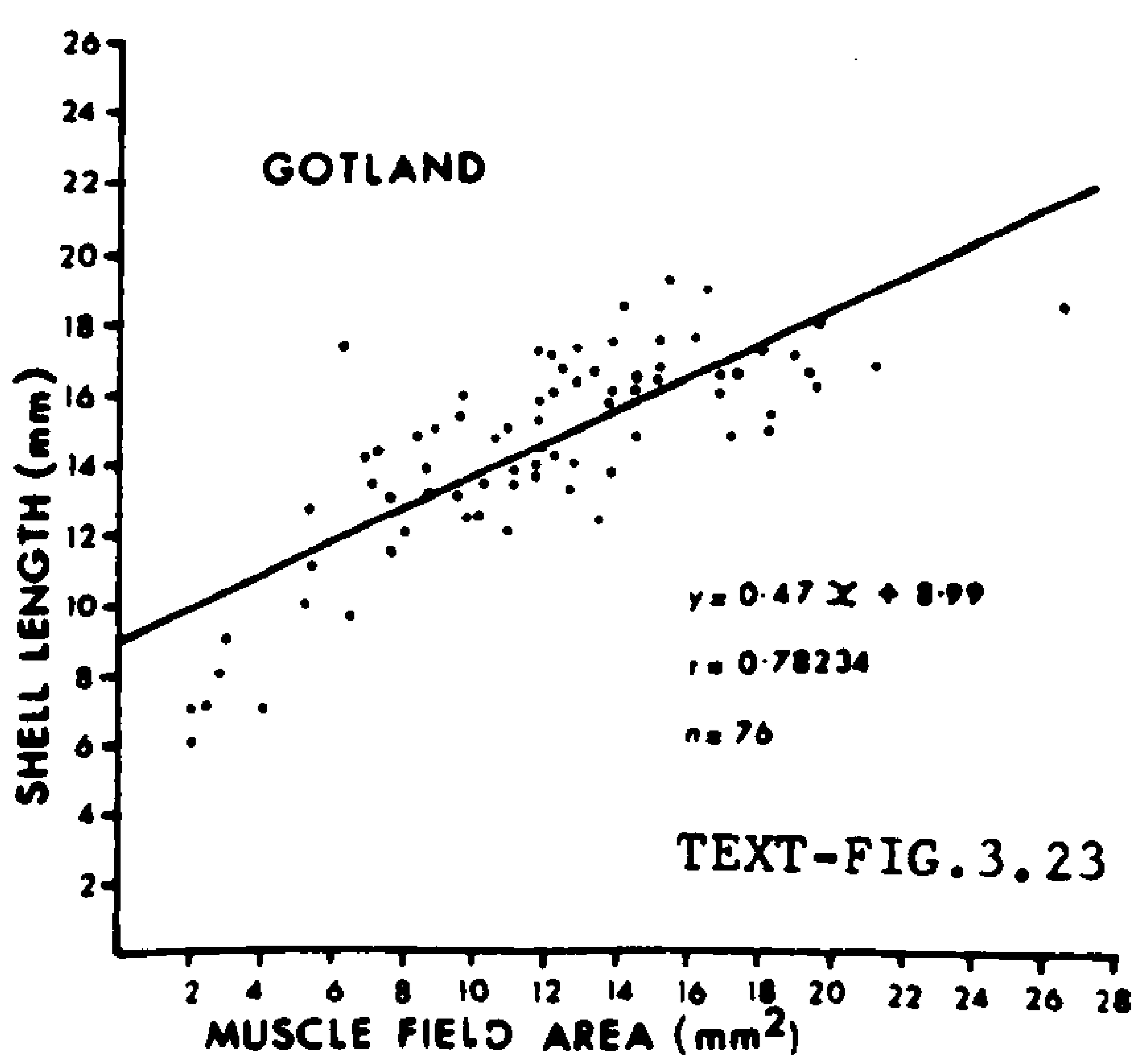
Locality	$\overline{Ls}$	$\overline{Ws}$	$\overline{Amf}$	n	% $\frac{\overline{Amf}}{\overline{Ls}}$	% $\frac{\overline{Amf}}{\overline{Ws}}$
Ludlow	10.02	14.36	7.02	71	70%	49%
Usk	10.95	15.57	8.00	107	73%	51%
Gotland	14.47	18.76	11.75	76	81%	63%

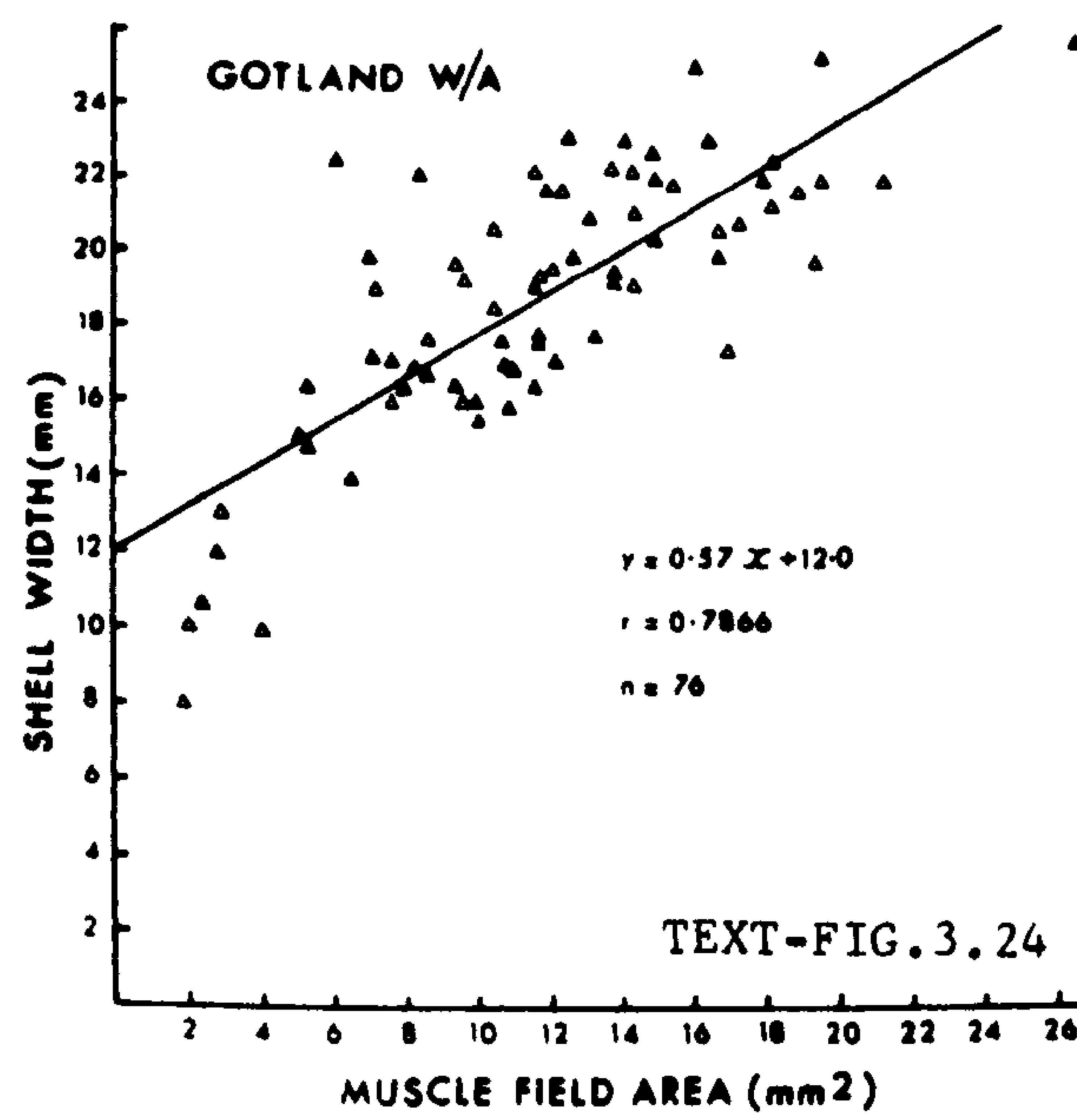












TEXT-FIGS.3.19-3.24. Plots of shell length and shell width (mm) versus muscle field area (mm^2) of S. ornatella from Ludlow, Usk and Gotland respectively.

In these text-figs. (3.28a and b), the very high value of the coefficient of correlation (r = 0.999 and 0.998) demonstrates that the mean of the muscle field area increased in direct proportion to the mean of the shell length and shell width in all the three areas (i.e. as the shell increased in size the area of the muscle field attachment increased too).

3. Socket plates (Pl.2 and Pl.5, figs. 1-6).

The socket plates are a pair of outgrowths of the secondary shell located in the postero-median region of the brachial valve and always attached to the cardinal process, pointing antero-laterally from it (see Williams 1965, pp. 95-98 and p.153).

The function of these plates is to support the socket ridges on the brachial valve for the purpose of articulation and they do not extend beyond the lateral edges of the sockets. The most common shape of socket plates are the bladed ones which are shown in Plate 2 (figs. 4-6). However, a few specimens appear to have double socket plates (i.e. about three specimens only out of our present study) and are therefore of particular interest.

The socket plates diverge antero-laterally at an angle ranging from 90-140^{o} (Pl.2, figs. 9 and 1 respectively) and are either prolonged entero-laterally with a blade or rod-like shape (Pl.2, figs. 1,2,3,9, and 10d) or recurve postero-laterally forming S-shaped ridges as shown in Plate 2, figs. 4,5 and 6. Some specimens show wide bounding ridges posteriorly forming arcuate ridges at the posterior margins of the adductor muscle scars (Pl.2, fig. 6). A few other specimens show double, short ridges which may have been supports for the socket and the lophophore (Pl.2, Figs. 7,8,10a and 11).

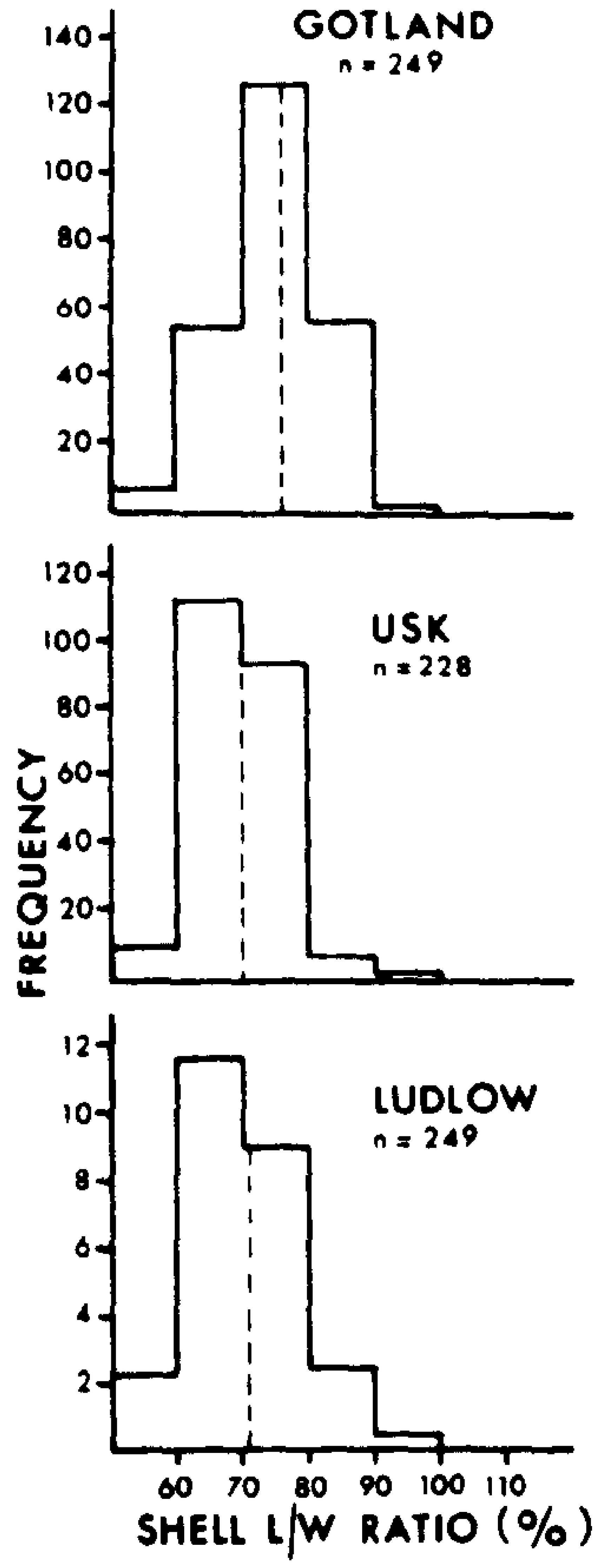
TEXT-FIG.3.25. Shell length-width ratio frequency histograms for Ludlow, Usk and Gotland specimens.

TEXT-FIG.3.26. Muscle field width-length ratio frequency histograms for the studied area.

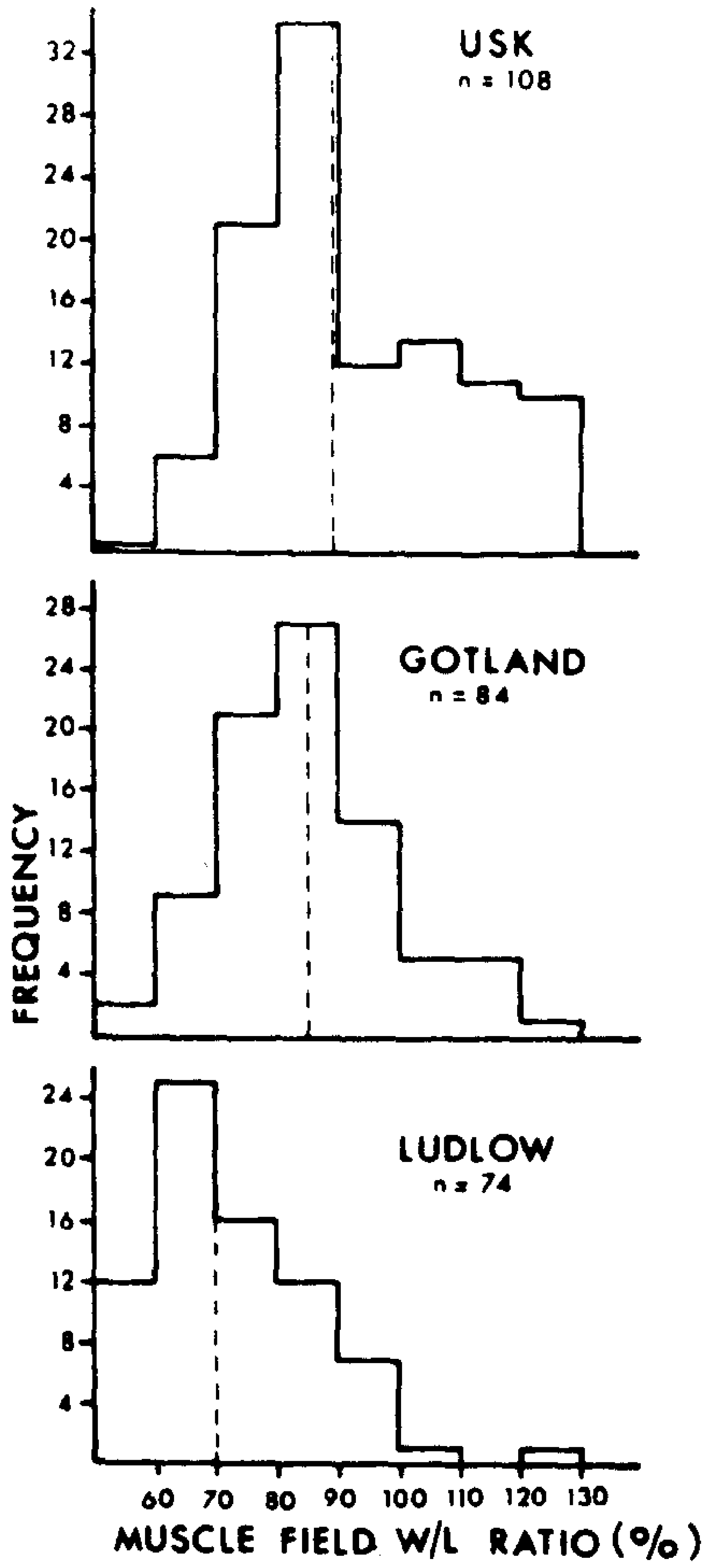
TEXT-FIG.3.27. Plot of the width of denticulation (mm) against muscle field area (mm^2) for Ludlow, Usk and Gotland.

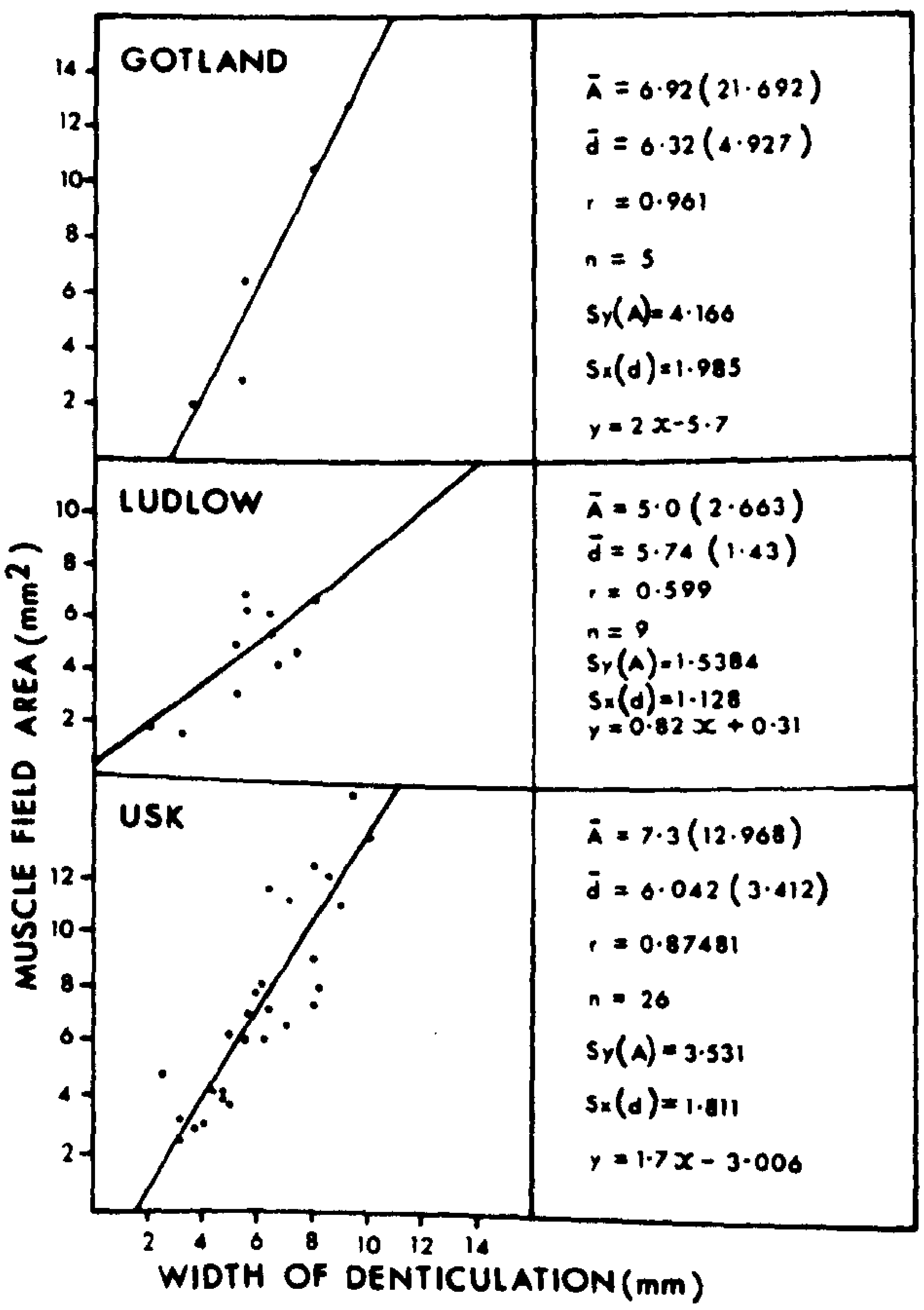
TEXT-FIG.3.28. (a&b) Plots of the mean of the muscle field area (mm^2) against the mean of the shell length (mm) and the shell width (mm) respectively for Ludlow, Usk and Gotland.

TEXT-FIG.3.25

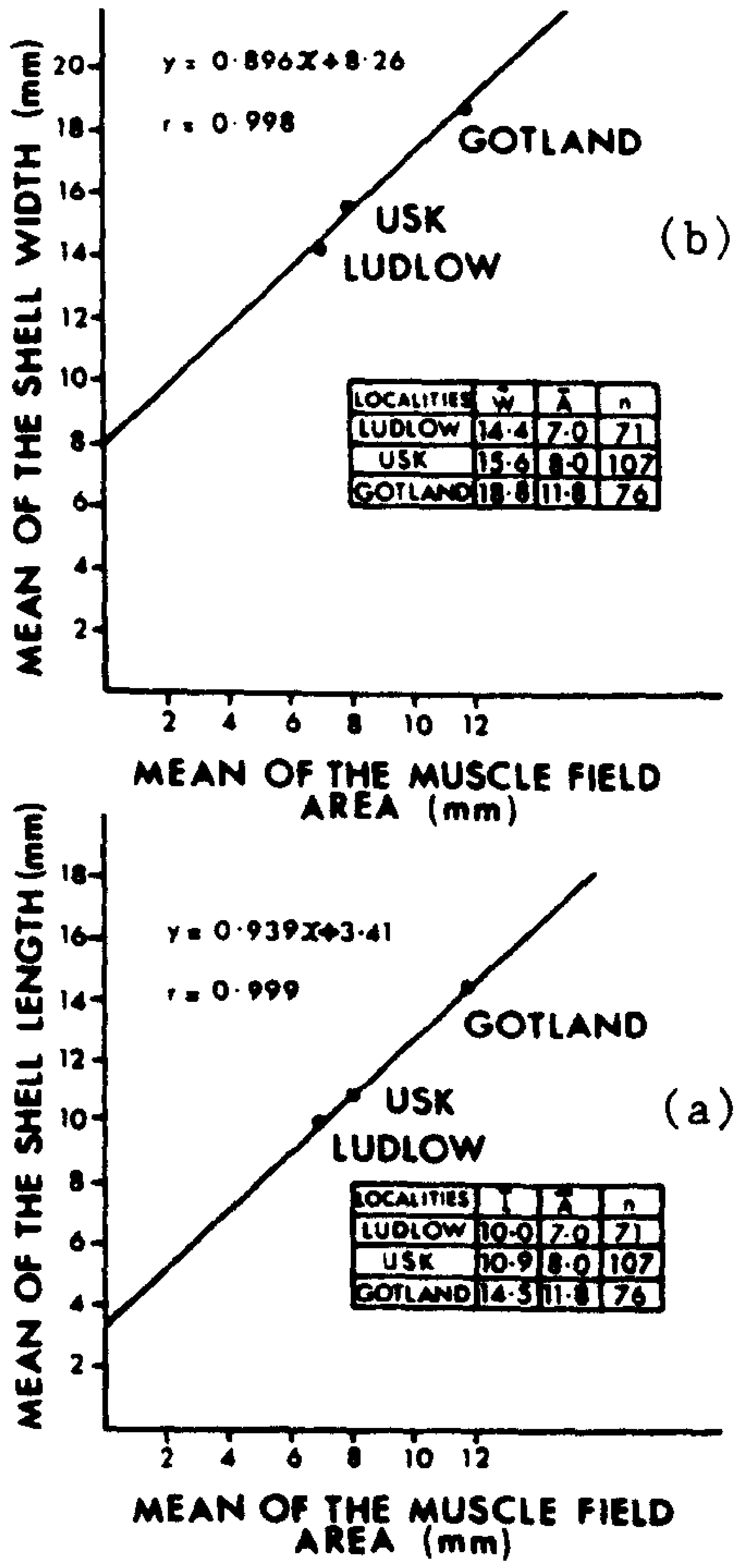


TEXT-FIG.3.26





TEXT-FIG.3.27



TEXT-FIG.3.28

C. Conclusion.

The main aim of this section has been a comparative description of the specimens of Ludlow, Usk and Gotland. The Gotland specimens are larger, of roughly similar shell proportions (albeit slightly longer) have higher convexity, a greater density of capillae, larger but shorter muscle field areas and proportionately increased denticulation. The main difference between the two British populations lies in muscle development, i.e. the width to the length of the muscle field in the Ludlow area is 70% for n = 74, while in the Usk area it is 89% for n = 108 (see text-fig. 3.26).

3.3.2. Interpretation of variations in Recent brachiopoda.

A. Introduction.

In the present study of the fossil brachiopod S. ornatella important variations were detected in shell shape, muscle field shape and proportions, and in the angle of divergence of muscle bounding ridges. Some indication of the taxonomic significance or otherwise of such variability can be provided by studying and measuring the shape of the shell, together with some of its external and internal features and the extent of muscle field variation in a single population of a living brachiopod. Muscle field impressions are particularly well developed in the Recent Kraussina rubra (Pallas) and consequently a sample of this species, collected from a single population at a depth of 47.5 metres in the Atlantic Ocean, was studied statistically. The figured specimens (L14737-L14742) will be housed in the Hunterian Museum, University of Glasgow.

B. External shell features.

1. Shell proportions

K. rubra is a biconvex shell and subquadrate to semi-circular in outline (Pl.4, figs. 1-12). The data of the parameters measured and their statistical analysis are shown in Table 10 below.

TABLE 10. Summary of shell length-width data for K. rubra.

n	T.V.	$\bar{L}s$	$\bar{W}s$	r	S.D. (Ls)	S.D. (Ws)	% $\bar{L}s/\bar{W}s$
63	P.V.	18.02 (10.88)	17.27 (10.82)	0.9119	3.272	3.263	104%
62	B.V.	16.03 (9.357)	17.22 (10.83)	0.9363	3.034	3.264	93%

From text-figure 3.29C, the high value of the coefficient of correlation (r = 0.9119) in the sample demonstrates that the length and width increase in direct proportion to each other (i.e. no discernible allometry). In addition, the shell length and width have been plotted against the thickness of the shell (text-figs. 3.29a & 3.29b) with which they also show a very good correlation (i.e. the thickness increases in direct proportion to the shell length and width).

Both the nature and extent of the variation in the shell shape was quite evident (Pl.4, figs. 1,2,3,7,8 and 9). The main variations occur near the hinge line and the ears. The posterior margin of the shell (i.e. along the hinge line) is normally straight (Pl.4, figs. 8 and 11), but in some specimens the hinge line makes an obtuse angle which diverges antero-laterally as shown on Plate 4, figs. 1 and 4. Some other shells show an arcuate excavation near the ear at one side of the hinge line (i.e. part of the hinge line at one end unites with the lateral margin of that end) as shown on Plate 4, figs. 3,6,8 and 11. Other specimens are semi-circular in outline (Pl.4, figs. 7 and 10) or show a little crenulation laterally (Pl.4, figs. 1 and 4). All these variations are shown in one population from one locality. The proportion of the shell length to the shell width of the pedicle valve shows a higher value than the shell length to the shell width of the brachial valve in such populations (i.e. the pedicle valve is longer than the brachial valve, see Table 10).

2. Ornamentation

The external surface of the shell in K. rubra is ornamented by subrounded to subtriangular coarse radial ribs (costellae) with numerous fine to strong growth lines (fila) developed postero-laterally from the umbo in both valves and concentrated near the anterior margin of the shell (Pl.4, figs. 1-3 and 7-9).

C. Internal shell features.

1. Muscle field

Precise measurements have been made on the muscle field of the pedicle valve. The proportions of the muscle field are shown statistically in Table 11 and are also displayed graphically in text fig. 3.30a.

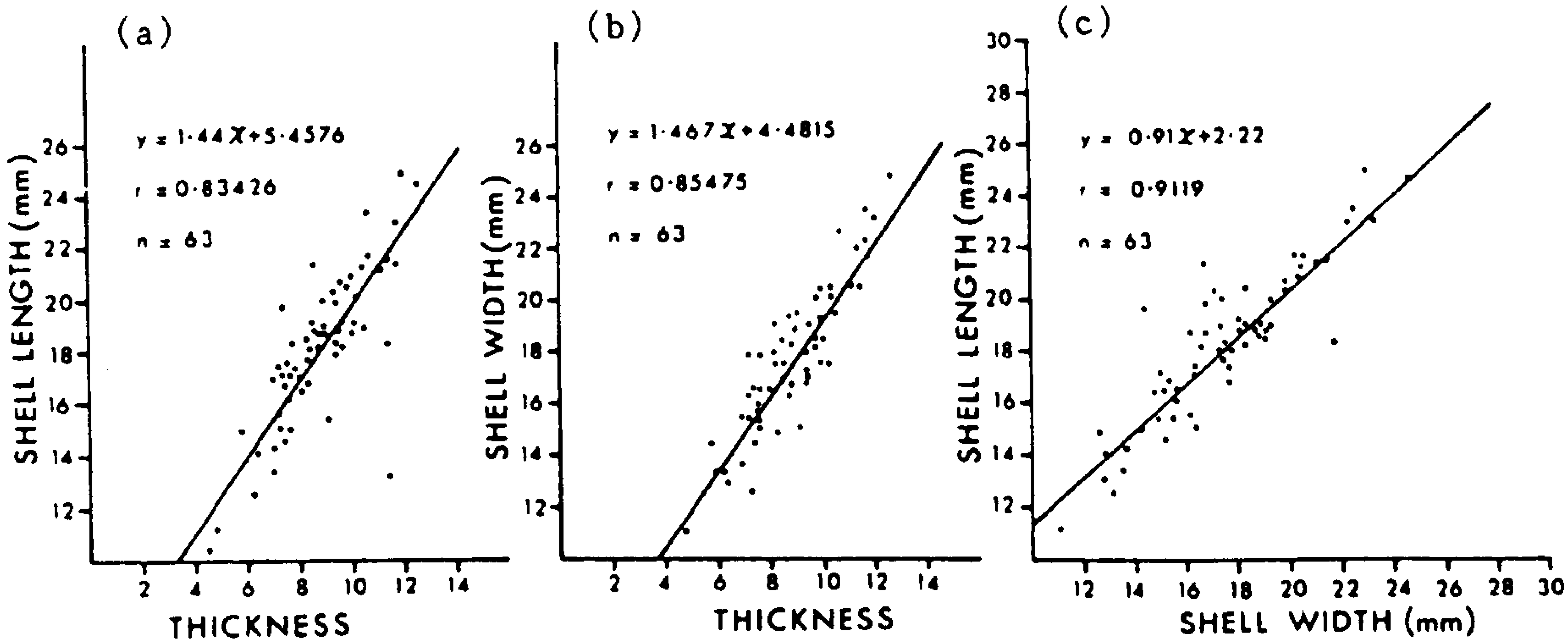
TABLE 11. Summary of statistical data on muscle field proportions in Recent K. rubra.

n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	% $\bar{L}mf/\bar{W}mf$
27	4.33 (1.64)	5.35 (2.01)	0.925	1.256	1.392	81%

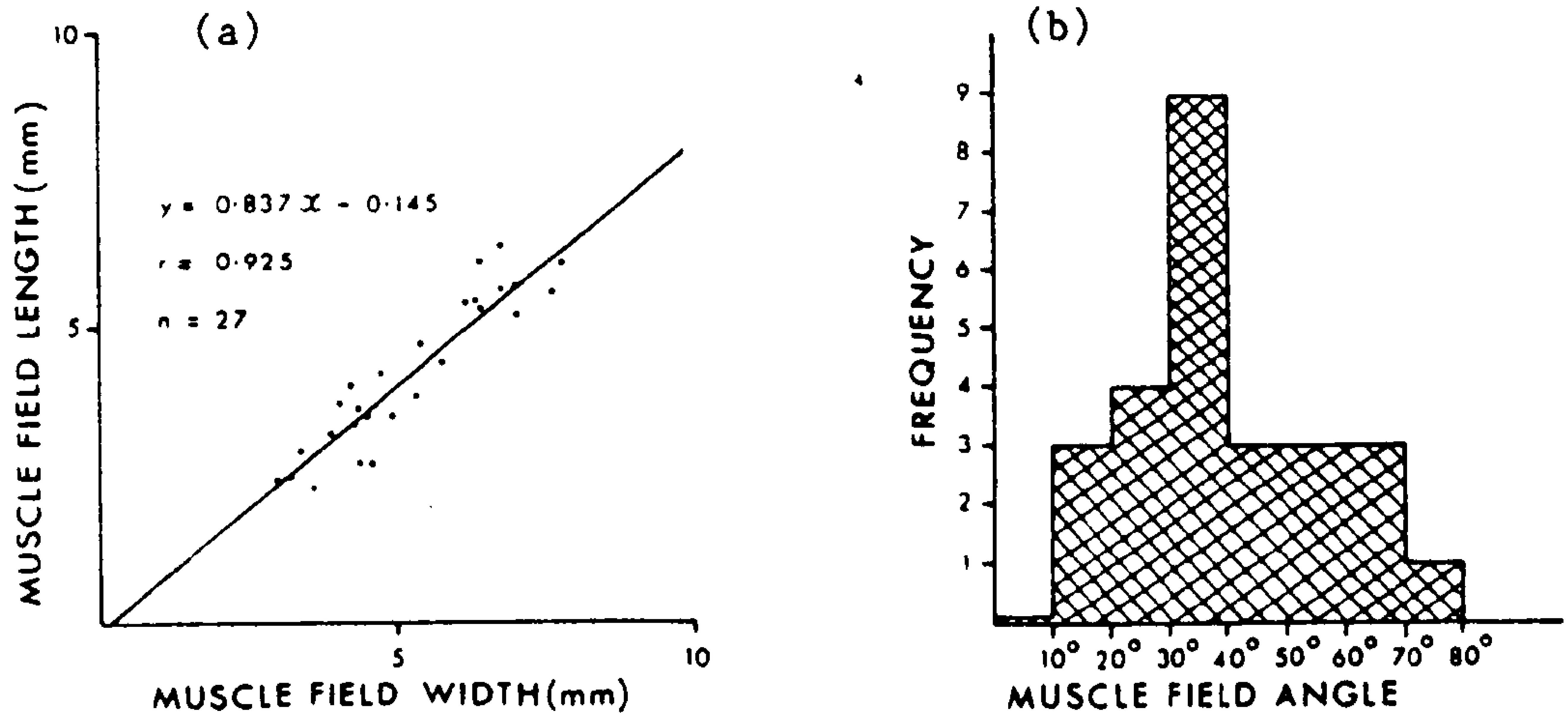
It is evident from text-fig. 3.30a that the length of the muscle field increases in direct proportion to the muscle field width, showing a high value of the coefficient of correlation (r = 0.925). The shapes of the muscle field vary from the parallel-sided (see Pl.4, fig. 6) to the divergent-sided as shown on Plate 4, figs. 4 & 5). The angles of divergence of the muscle bounding ridges have been measured and show a very wide range, e.g.

$10^{\circ} \leqslant \phi \leqslant 75^{\circ}$, see Table 12 and text-fig. 3.30b.

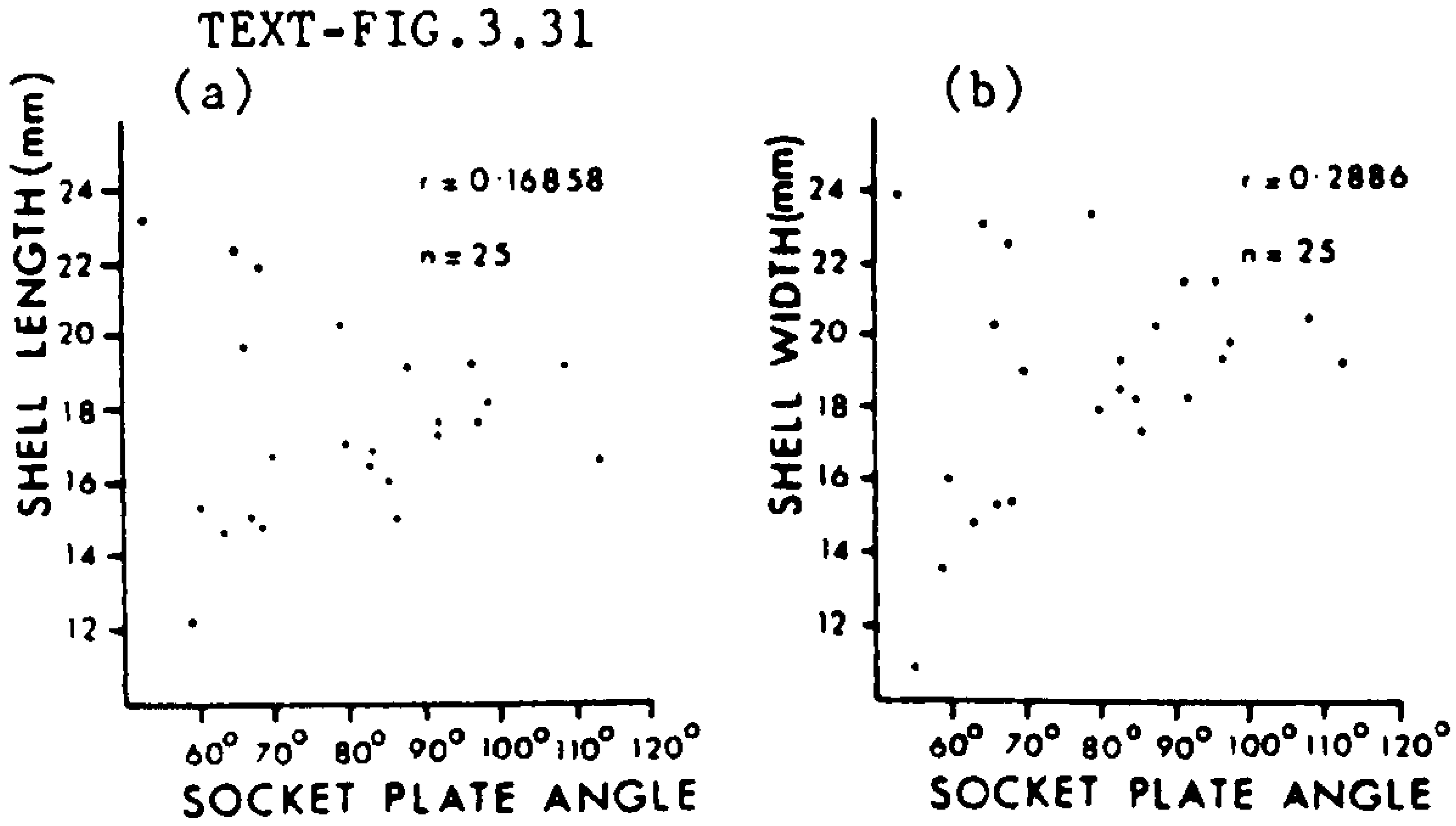
TEXT-FIG.3.29



TEXT-FIG.3.30



TEXT-FIG.3.31



TEXT-FIG.3.29 a, b & c. Shell length-thickness, shell width-thickness and shell length-width for K. rubra from the Atlantic Ocean.

TEXT-FIG.3.30. (a) Plot of the muscle field length against muscle field width of K. rubra.

(b) Muscle field angle frequency histogram.

TEXT-FIG.3.31 a & b. Plots of the socket plates angle versus the shell length and shell width respectively.

TABLE 12. Analyses of divergence of muscle bounding ridges in Recent K. rubra.

10°	10°-20°	21°-30°	31°-40°	41°-50°	51°-60°	61°-70°	70°	$\bar{x}$	n
0	3	4	5	3	3	3	1	40°	27

2. Socket plates.

The socket plates in K. rubra are present as strong, bladed ridges (S-shape) (Pl.4, figs. 4,5,6,10 and 11). They are attached to the cardinal process and diverge antero-laterally at a wide range (e.g. 55°-115°, n = 25). The angle of divergence was plotted against the length and width of the brachial valve as displayed graphically in text-figs. 3.31a & b. The statistics give very low values of the coefficient of correlation (e.g. r = 0.1686, 0.2886 respectively), indicating very little relationship between these features.

D. Conclusion on variation.

In conclusion, K. rubra, collected and studied from one locality, showed a wide range of variations in the shape and angle of divergence of the muscle bounding ridges and of the socket plates. These variations are definitely intraspecific. A similar degree of variation in the shape and angle of divergence of the muscle field and socket plates has been demonstrated above for the fossil brachiopod, S. ornatella. The magnitude of variation is similar in any one area to the overall variation from all three areas, including Gotland. Single bedding planes are often crowded with specimens of S. ornatella, presumably representing part of a single population, and even here the degree of variation is high.

3.3.3. In *S. ornatella* from the Welsh Borderland and E Gotland other areas.

The Usk, Ludlow and Gotland areas were chosen for major statistical investigations as large numbers (over 225) of specimens of *S. ornatella* were available from each locality, allowing detailed biometric comparisons over a wide geographical area. *S. ornatella* is, however, distributed throughout the Welsh Borderland and Wales, and specimens have been collected from many other areas. The species is mainly confined to shelf habitats but does occur in the Builth area, on the margin of the Welsh basin. *S. ornatella* has not been collected in sufficient numbers from these localities (listed in Table 13) to allow reliable statistical analyses. These smaller samples have, however, been measured in an identical fashion to facilitate consideration of their morphologic relationships with the two major samples from the Usk inlier and the Ludlow area. Data have been assembled for specimens from 29 additional localities in 11 areas (see text-fig. 1.1 and Appendix 1).

Specimens from the four additional localities within the Usk inlier are all of very similar biometric proportions, demonstrating the homogeneity of these populations. Similarly, measurements from seven additional localities in the Ludlow area yield results indistinguishable from those for the two major Ludlow localities. Small samples of *S. ornatella* were also measured from Wenlock Edge, West Midlands, Towy Anticlinal, Brecon Anticlinal, Malvern and Abberley, Woolhope and May Hill. The fossils in all these areas occur mainly in calcareous siltstones as at Ludlow and Usk and show no significant difference in variability compared with those two main areas.

Two other localities are, however, of particular significance because they appear to provide evidence of environmental influences on the variation of *S. ornatella*. The Aymestrey area is situated on the shelf edge and the Builth area lies on the eastern margin of the Welsh basin (see text-figs. 1.1 & 2.5). At both localities the sediments are less calcareous than in the other areas discussed previously. The fauna in each case is dominated by N. lauensis and A. grayi, typical of this level (Upper Leintwardine) in the basin facies. At both localities, specimens of S. ornatella are not uncommon, although never abundant. Dr. Lawson has noted during frequent visits to both areas that S. ornatella is characteristically smaller than in the rich shell-beds of the shelf areas. Unfortunately, statistically valid collections are not available and only a few measurements are listed in Table 13. These do, however, fit well with the subjective assessment. Such a reduction in size related to a less calcareous sediment would support suggestions that the larger size of the Gotland forms might be related to the much more calcareous sediments.

This evidence of variability related to environment does, however, support my view that the consistent range of variability in S. ornatella over the main shelf region, where the lithological facies is consistent, is intraspecific (see Chapter 9).

Additional Gotland specimens from different localities but the same stratigraphical horizon were borrowed from the British Museum (Natural History). Statistical measurement of this material showed that it fitted into the range of variability revealed by the large collections from Gotland. For example $\bar{L}_s$ mm (var L_s) 14.91 (7.99), $\bar{W}_s$ (var W_s) 19.51 (13.22), $r = 0.975$, $\bar{L}_s/\bar{W}_s = 76\%$ ($n = 20$).

TABLE 13. Summary of shell length (Ls) and width (Ws) statistics for S. ornatella from subsidiary localities in the WBL

Area	Localities	n	$\bar{L}s$	$\bar{W}s$	S.D. (Ls)	S.D. (Ws)	% $\bar{L}s/\bar{W}s$
West Midlands	GO	6	6.7	9.83	2.191	2.746	68%
Malvern and Abberley	WO, UL3, Ph.1 & CP Wb/A, Wb/C	29	8.85	12.865	2.026	2.977	69%
Woolhope inlier	PL & WC	43	9.36	13.565	0.04	0.025	69%
Usk inlier	LGY, WB91, U9 & SR	44	11.558	16.282	1.058	1.094	71%
Wenlock Edge	HC & MW4	16	10.419	14.15	1.206	1.225	73%
Ludlow	LU7, Whit, Wh., MF/A, WB1, WB40, OR8 & UL8B	41	9.535	13.152	0.633	0.949	72%
Towy Anticlinal	CB2	11	10.1	13.4	1.743	2.483	75%
Brecon Anticlinal	YH	2	9.95	16.1	0.85	2.7	62%
May Hill	MH	15	8.11	11.61	1.095	1.685	70%
Builth	PS	1	4.4	8.0	-	-	-
Aymestrey	AM	1	3.8	5.8	-	-	-

3.3.4. Conclusion

S. ornatella shows morphological variability particularly in the shape and angle of divergence of the pedicle muscle field. Shape variability has been detected from locality to locality. Therefore, morphometric comparison between populations from the three major localities (Ludlow, Usk and Gotland) were made. These comparisons provided an opportunity to assess geographical distribution of the morphological variation in slightly different environments, of roughly equivalent age. The Gotland specimens were found to fall within the range of morphological variability displayed by the British _S. ornatella_. Therefore, the author is confident that the Swedish and British material must be considered as conspecific, even though it displays some consistent minor differences. The reasons for this variation will be discussed in Chapter 9. It has also become apparent that the British and Swedish specimens are quite distinct from other species found in other parts of the world, and that they share with each other the same major and minor structural shell features.

Moreover, the Recent brachiopod _K. rubra_ from the Atlantic Ocean was also studied, and its variability was compared with that of the fossil _S. ornatella_. The range of variation in _S. ornatella_ was closely comparable with that in the Recent species, _K. rubra_. This fact, together with the continuous nature of the variation, suggests strongly that we are dealing with variation within one fossil species and that there is no justification for subdivision or splitting.

CHAPTER FOUR

LEPTOSTROPHIA (LEPTOSTROPHIA) FILOSA (J. de C. SOWERBY, 1839).

CONTENTS

CHAPTER FOUR

LEPTOSTROPHIA (LEPTOSTROPHIA) FILOSA

4.1. INTRODUCTION.

Leptostrophia filosa is an almost flat stropheodontid with equally parvicostellate radial ornament and a distinctive triangular muscle scar in the more commonly found pedicle valve. It is a common species in the Wenlock and Ludlow rocks of the shelf facies in the Welsh Borderland. The Wenlock form has been described by Bassett (1971, 1977). In this work a large number of Ludlovian specimens has been studied statistically in order to describe fully the range of variation of the species. Comparisons have been made with the Wenlock specimens. In addition, some previously un-described morphological features are noted and illustrated.

4.2. SPECIES DESCRIPTION.

Subfamily LEPTOSTROPHIINAE Caster, 1939

Genus *LEPTOSTROPHIA* Hall and Clarke, 1893

Subgenus *LEPTOSTROPHIA* (*LEPTOSTROPHIA*) Hall & Clarke, 1893

4.2.1. Type species.

Stropheodonta magnifica Hall 1857, by original designation of Hall and Clarke 1892, p.288.

4.2.2. Synonymy.

Leptostrophia (*Leptostrophia*) *filosa* (J. de C. Sowerby)
((Pl.9, figs.1-9); (Pl.10, figs.1-9) and (Pl.11, figs. 1 & 2))

1839 *Orthis filosa* J. de C. Sowerby in Murchison, p.630, Pl.13, fig.12.

1846 Orthis filosa (J. de C. Sowerby); McCoy, p.30.

1847 Orthis filosa (J. de C. Sowerby); Davidson, p.62, Pl.13, fig.24.

1848 Leptaena filosa (J. de C. Sowerby) Davidson, p.318, Pl.3, fig.9.

1848 Strophomena filosa (J. de C. Sowerby) Salter, in Phillips and Slater, p.380.

1861 Strophomena filosa (J. de C. Sowerby); Lindström, p.373.

1871 Strophomena filosa (J. de C. Sowerby); Davidson, p.397, Pl.44, figs.14.-20.

1884 Strophomena filosa (J. de C. Sowerby); La Touche, p.70, Pl.13, figs.406, 407.

1893 Leptostrophia filosa (J. de C. Sowerby) Hall and Clarke, p.288 (name only).

1951 Leptostrophia filosa (J. de C. Sowerby); Williams, p.125 (name only).

1963 Leptostrophia filosa (J. de C. Sowerby); Holland et al, Pl.3 figs.3, 5.

1971 Leptostrophia (Leptostrophia) filosa (J. de C. Sowerby); Bassett, p.315, Pl.56, figs.9,10; Pl.57, figs.1-6.

1974 Leptostrophia filosa (J. de C. Sowerby); Bassett and Cocks, p.15.

1977 Leptostrophia (Leptostrophia) filosa (J. de C. Sowerby); Bassett p.145, Pl.39, figs.3-8.

1978 Leptostrophia (Leptostrophiella) filosa (J. de C. Sowerby) Harper and Boucot, p.74, Pl.3, fig.1; Pl.4, figs 1-7,9; Pl.5, figs.4,6-9; Pl.6, fig.10.

4.2.3. Lectotype.

The lectotype specimen of L.(L.) filosa, GSM (Geological Society collection) 6644, external mould of brachial valve, from Coalbrookdale Formation (Wenlock Shale), Oldcastle, Malvern Hills, Worcestershire has been examined and refigured herein (see Pl.8, figs.1,2 and 3).

The outline shell shape of the lectotype is subquadrate to semicircular with rounded or gently curved lateral and anterior margins, wider than long; hinge line straight forming part of maximum width and prolonged into angular mucronate ears. There is a trace of a lobate and subtriangular area located postero - medianly and looking like muscle scars. This feature is not related to any structural features of the shell and probably occurs as a result of the weathering of the surface of the shell. The gross shell proportion is ~ 81% (Ls, shell length = 20.6mm; Ws, shell width = 25.4mm). These measurements are partly estimated due to the broken left hand end of the hinge line. The radial ornament consists of rounded, straight fila along the mid line of the shell becoming gently curved laterally. The radial ribs are finely and equally parvicostellate with about 3-4 ribs per mm at 10mm antero-laterally from the dorsal umbo. The dorsal interarea is plane and anacline; a small, convex chilidium is present which covers the notothyrium. There are also traces of three denticles developed along the right hand side of the dorsal interarea or hinge line.

The species <u>L</u>.(<u>L</u>.) <u>filosa</u> was first described by J. de C. Sowerby in Murchison (1839, p.630, Pl.13, fig.12) as <u>Orthis</u> <u>filosa</u>. Davidson (1871, p.307, Pl.44, figs.14-20) studied and redescribed this species as <u>Strophomena</u> <u>filosa</u> from different localities in the Welsh Borderland. His description of the species was similar to the Sowerby original description. Subsequently, Bassett (1971, p.315, Pl.57, fig.5) selected and refigured the Sowerby original specimen as a lectotype of <u>L</u>.(<u>L</u>.) <u>filosa</u>. No collections have been made by the present author from the type locality of Sowerby's original specimen and all the material was collected from Ludlow localities at Ludlow, Abberley Hills and the Usk inlier.

These areas provided sufficient material to study the variations between the representatives of this species statistically. The gross shell proportions of the type specimen is about 81% as long as wide, which exactly fits with the mean value of the shell proportions of the presumed conspecific specimens from Ludlow, Abberley Hills and the Usk inlier ((e.g. 79% (n = 186); 81% (n = 38) and 80% (n = 150) respectively)).

The shape and the number of the radial ribs on the external shell surface of the type specimen compare very closely with the specimens studied from the above areas. Moreover, 2-3 faintly developed growth lines were also seen in the external surface of the type specimen. These were illustrated in Sowerby's original figure and were also observed commonly during the present study of the species.

Therefore, it is evident from the similarity in the outline, external shell features, shell shape and proportion and the flatness of the shell that the type specimen is consistent in all its characters with the presumed conspecific specimens herein studied from the Welsh Borderland localities. To be more precise in defining the species, some more information is needed on the internal features of both pedicle and brachial valves. Consequently, interior details are comprehensively demonstrated during the present study from Ludlow, Abberley Hills and the Usk inlier (see Pls.9-11), together with a study of the variation of the species.

4.2.4. Material.

Three hundred and forty eight specimens in the author's collection, mainly from the Ludlow, Abberley Hills and the Usk areas. In addition, fifteen specimens in the Lawson collection from the Ludlow area and eleven specimens from the Ludlow Museum collection were also studied. The specimens mostly occur as moulds of both pedicle and brachial valves, but the most common are the internal moulds of the pedicle valve.

4.2.5. Horizons and localities.

The specimens are from the Lower Elton Formation, Lower and Upper Bringewood Formations and Lower Leintwardine Formation. In the Ludlow area, a few specimens were collected from the Lower Elton Formation at the localities A2 and A3 (see text-fig.2.3 and Appendix I), but the bulk of the Ludlow area collection comes from the Lower Bringewood Formation at the following localities: 31, 14, A4, A6, B1, B2, B4, B5, B6 and 7a, where it is common (see text-figs.2.1, 2.3, 2.4 and Appendix I for details of localities). The species has also been collected from the Silurian inliers, e.g. at Shucknall Quarry (SH) in the Woolhope inlier, from the Upper Bringewood Formation; at Woodbury Quarry (WQ) in the Abberley Hills and at Llandegveth reservoir (LR) in the Usk inlier (see text-fig. 2.5 and locality list in Appendix I). The specimens from both latter localities (i.e. WQ and LR) are from the Lower Bringewood Formation. A few specimens from the Lower Leintwardine Formation near Ludlow area were also studied.

4.2.6. Diagnosis.

Almost biplanate through plano-convex to weakly concavo-convex Leptostrophia, averaging 78% as long as wide; ornament fine, equally parvicostellate of about 4-6 ribs per mm at 10mm antero-medianly of dorsal hinge with subdued concentric rugae; internally with sharply triangular ventral (pedicle) muscle field ranging from 82% as long as wide (Usk) to 88% as wide as long (Ludlow); hinge line denticulation occupying an average 53% of the shell width. Cardinal process, bladed socket plates, chilidium and the muscle scars are well developed in the brachial valve.

4.2.7. <u>Description</u>. (See Pl.11 for detailed structural features).

Medium-sized, subquadrate to semicircular <u>Leptostrophia</u>, plano-convex to very weakly concavo-convex or almost biplanate in profile, with very narrow body cavity; hinge line straight, probably always forming point of maximum width; valves averaging 80% as long as wide ((e.g. $\bar{L}$smm (var Ls) 15.729 (19.246), $\bar{W}$smm (var Ws) 19.487 (26.531), r = 0.847, n = 38 (Woodbury Quarry in Abberley Hills)) ; 79% as long as wide in the Usk inlier ((e.g. $\bar{L}$smm (var Ls) 16.306 (24.414), $\bar{W}$smm (var Ws) 20.428 (30.571), r = 0.944, n = 150)) and in Ludlow ((e.g. $\bar{L}$smm (var Ls) 13.169 (27.729), $\bar{W}$s (var Ws) 16.608 (36.527), r = 0.919, n = 186)); lateral margins of shell sub-parallel to gently curved anteriorly (see Pl.9, figs.1,6 & 7); anterior margin rounded, commissures smooth, rectimarginate; radial ornament finely and equally parvicostellate with 4, 5, 6 rounded ribs per mm at 10mm antero-medianly of dorsal hinge of 6, 15, 3 valves respectively, costellae low, straight along mid-line of shell but very gently curved laterally; external surface with numerous fine, low concentric growth fila developed postero-laterally (see Pl.10, figs.2a & 2b); ventral interarea short, planar, apsacline, dorsal interarea narrow, planar, anacline; delthyrium initially open, progressively filled by pseudodeltidium, notothyrium sealed by small, convex chilidium (Pl.11, figs.1 & 2).

Interior of pedicle valve with low, flat ventral process (Pl.9, figs.1, 2 & 5 and Pl.11, fig.1), prolonged anteriorly as a slender myophragm, longitudinally bisecting the muscle field; minute teeth; strong denticulation extending laterally for an average of 53% of hinge width (about 17-21 denticles on each side) ((e.g. $\overline{W}$smm (var Ws) 16.403 (27.410), $\overline{W}$d (var Wd) 8.675 (5.44), r = 0.895, n = 32 (Ludlow) and $\overline{W}$smm (var Ws) 19.831 (28.596), $\overline{W}$d (var Wd) 10.544 (11.49), r = 0.884, n = 61 (Usk inlier)); ventral muscle field triangular in outline (Pl.9, figs.1-9 and Pl.11, fig.1), well impressed, unbounded anteriorly, averaging 82% as long as wide in Abberley Hills and the Usk inlier ((e.g. $\overline{L}$mfmm (var Lmf) 4.058 (3.763), $\overline{W}$mf (var Wmf) 4.967 (4.14), r = 0.852, n = 12; and $\overline{L}$mfmm (var Lmf) 4.944 (2.51), $\overline{W}$mf (Wmf) 5.937 (2.847), r = 0.945, n = 78)) and 88% as wide as long in Ludlow ((e.g. $\overline{W}$mfmm (var Wmf) 5.245 (7.427), $\overline{L}$mfmm (Lmf) 5.89 (8.181), r = 0.921, n = 40)); muscles bounded laterally by moderately strong ridges, arising immediately anterior to hinge line, diverging antero-laterally at an angle range of: 45°-50°, 50°-55°, 55°-60° and $> 65^{\circ}$ in 21, 30, 39, 20 and 6 valves respectively in Ludlow area specimens and 1, 12, 39, 26, 8 valves in Abberley Hills and Usk inlier specimens respectively. These ridges die out laterally and the muscle field remains unbounded anteriorly, divided by the narrow myophragm and partitioned anteriorly by two sets of radial ridges (Pl.9, figs.4, 5 & 8 and Pl.11, fig.1); muscle field bisected by short, oblique septa anteriorly; adductor scars narrow, elongate, separated by myophragm and extending anteriorly for about ⅓ - ½ of muscle field length (Pl.11, fig.1); diductor scars large, triangular, averaging 31% as long as valve length in Abberley Hills ((e.g. $\overline{L}$mfmm (var Lmf) 4.255 (3.631), $\overline{L}$smm (var Ls) 13.955 (19.685), r = 0.819, n = 11)) ; 32% as long as valve length in Usk inlier ((e.g. $\overline{L}$mfmm (var Lmf) 4.95 (2.547), $\overline{L}$smm (var Ls) 15.491 (26.821), r = 0.819, n = 75)) and 37% as long as valve length in Ludlow ((e.g. $\overline{L}$mfmm (var Lmf) 5.036 (5.426),

$\bar{L}$smm (var Ls) 13.439 (36.649), r = 0.911, n = 28)) ; valve floor with coarse to fine tubercles particularly well developed postero-laterally.

Brachial valve interior with narrow, upright, subparallel cardinal process lobes and with attachment faces directed slightly postero-ventrally; socket plates subparallel or weakly divergent from cardinal process lobes with an extension (in some specimens) like a pair of auxiliary ridges making an angle ranging between 0-15° to the hinge line (Pl.11, fig.2); dorsal muscle field strongly impressed, truncated, oval in outline, bisected longitudinally by a median, rounded ridge, narrowing anteriorly (myophragm) and bounded laterally by low, broad, oblique ridges but unbounded anteriorly, a pair of semioval to subtriangular adductor scars, occupying about ½ - ⅓ of valve width (Pl.10, figs. 1-6), valve floor coarsely to finely tuberculate particularly well developed postero-laterally.

4.2.8. Distribution.

In the Wenlock Series Leptostrophia (Leptostrophia) filosa occurs most commonly in the upper "Wenlock Shale" and in the Wenlock Limestone throughout the Welsh Borderland (Bassett 1971, p.317). It also occurs rarely in late Wenlock calcareous siltstone of Carmarthenshire, but is unknown from Pembrokeshire (Bassett 1977, p.146).

In the Ludlow Series, L. filosa is well-distributed laterally throughout the Welsh Borderland, and extends vertically from the Lower Elton to the Upper Leintwardine Formations. The distribution maps (text-figs.1.5-1.9) are based on the present study and previous records. From these maps, it is clear that the species is common throughout most of the Ludlow areas at the shelf. It is also recorded as rare from the basin at Kerry (Earp 1938) and Clun (Earp 1940). On the Shelf, the species is present in the Lower Elton Formation, common in the Lower Bringewood Formation, fairly common in the Upper Bringewood and Lower Leintwardine Formations and present in the Upper Leintwardine Formation, where it became rare or absent after that (see also Lawson 1960).

On Gotland, it occurs in the Upper Visby, Hogklint and Hemse Groups (Bassett and Cocks 1974), indicating an age range from early Sheinwoodian to the Lower Ludfordian.

4.2.9. Discussion.

For the purpose of this thesis _L._(_L._)_filosa_ has been collected and studied from various horizons and localities of the Ludlow Series of the Welsh Borderland. The present study has shown that _L._(_L._) _filosa_ shows some variability, particularly, in the gross shell and pedicle valve muscle field proportions. This will be described in detail later in this Chapter.

In general, _L._(_L._) _filosa_ from the Ludlow Series shows little difference from the same species described by Bassett in 1971 and 1977 from the Wenlock Series (Silurian). _L._(_L._) _compressa_ from the early Silurian (Llandovery Series) differs from _L._(_L._) _filosa_ in the more variable curvature of the valve and the slightly less regular ornament,having a larger ventral muscle field with weaker but more widely divergent bounding ridges and socket plates. _L._(_L._) _filosa_ is particularly distinctive in having a sharply triangular ventral muscle field, subparallel to weakly divergent cardinal process lobes and equally parvicostellae radial ornament (Bassett) 1977, p.47).

Some foreign species of _Leptostrophia_ differ from _L._(_L._) _filosa_ in the following ways. The Nova Scotia species Leptostrophia beechhillensis (McLearn, 1924) from the Arisaig area (early Llandovery age) differs from L. (L.) filosa in being unequally parvicostellate and in having prominent dental plates. L.(L.) filosa also differs from Leptostrophia species from Czechoslovakia, for example; Leptostrophia cuspidata (Barrande 1879), Leptostrophia index (Havlicěk 1967), Leptostrophia conferta (Barrande 1879) and Leptostrophia nebulosa (Barrande (1848) in some of the external and internal structural features (see Havlicek 1967, p.150-153 for details).

Harper and Boucot (1978) recognised nine genera and subgenera in the subfamily Leptostrophiinae (Caster 1939), using features such as the valve convexity, equally or unequally parvicostellate radial ornament, the shape and angle of divergence of the pedicle valve muscle field, presence or absence of the dental plates and the shape of the socket plates. According to these features, they assigned new names, which are considered here as unnecessary and unhelpful because it is evident from large collections that some at least of the proposed new taxa grade one into the other. Therefore, the author has avoided using their names.

4.3. DESCRIPTION OF VARIATION

A. External shell features.

1. Shell proportion.

L.(L.) filosa is subquadrate to semicircular in outline (Pl.9 and Pl.10) and plano-convex to very weakly concavo-convex or almost biplanate in profile and is more flattened than S. ornatella. The species was collected and studied from seven localities near Ludlow (see Table 1), and the specimens provided an opportunity to investigate the shell shape variability statistically. The results of the gross shell proportions of these specimens are shown in Table 1 below and are also displayed graphically in text figs. 4.1-4.7.

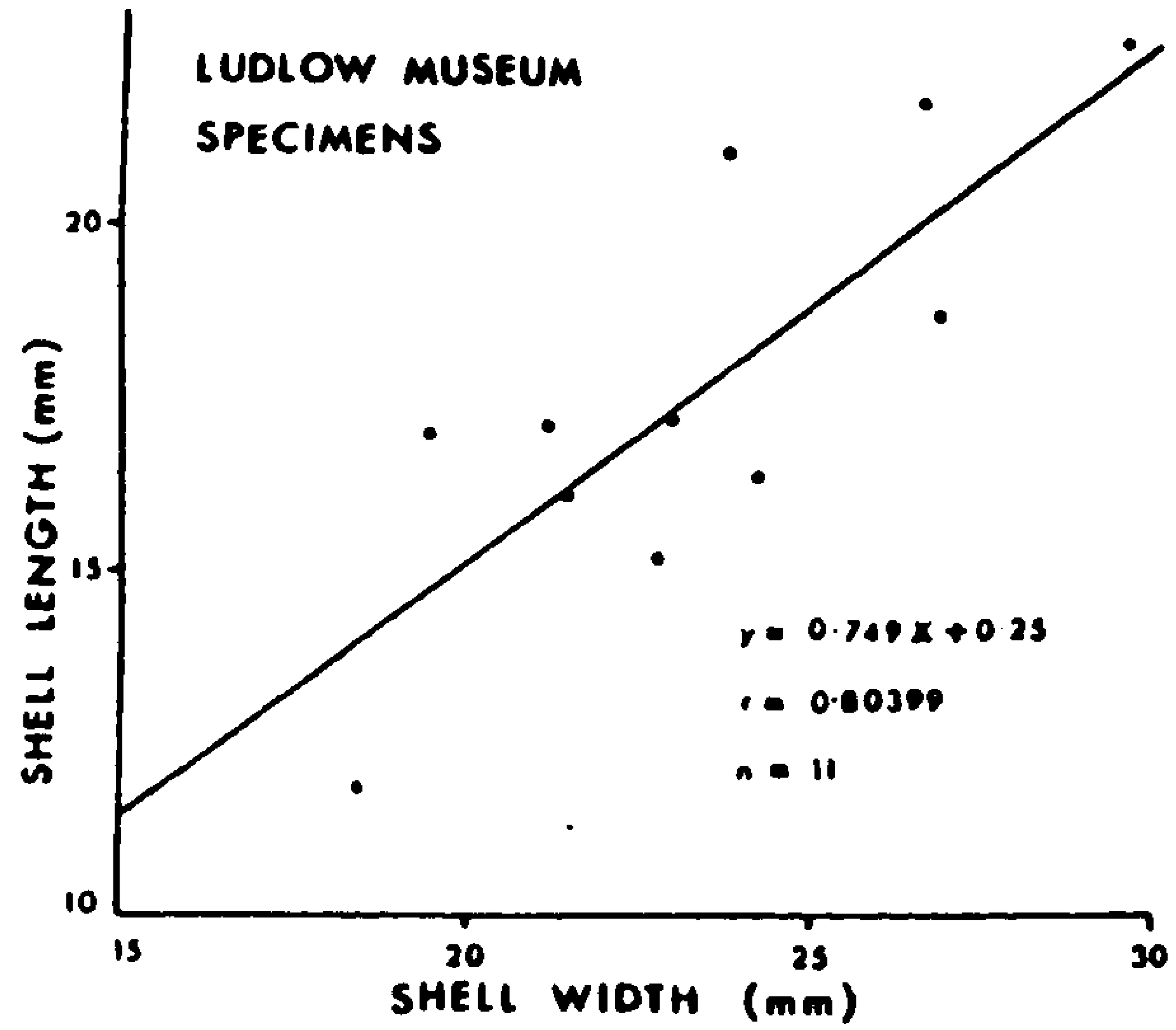
TABLE 1: Summary of statistical results of the shell length, shell width of the L.(L.) filosa from seven collections near Ludlow area (Shropshire).

Loc	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
7a	11	11.245 (23.561)	14.945 (24.251)	0.975	4.628	4.695	Y= 0.96X - 3.1	75%
31	96	13.231 (27.584)	16.469 (34.321)	0.893	5.225	5.828	Y= 0.8X + 0.034	80%
Sec. A	10	11.15 (7.676)	13.31 (14.899)	0.910	2.628	3.662	Y= 0.653X + 2.46	83%
Sec. B	34	12.197 (42.197)	15.6 (52.241)	0.966	6.437	7.121	Y= 0.874X - 1.44	78%
14	9	13.65 (6.718)	17.24 (11.368)	0.851	2.44	3.18	Y= 0.653X + 2.39	79%
Lud. Mus.	11	17.718 (9.912)	23.318 (11.372)	0.803	3.002	3.2153	Y= 0.749X + 0.25	76%
Lc (31a)	15	14.1 (20.457)	17.88 (35.194)	0.906	4.369	5.731	Y= 0.69X + 1.8	78%

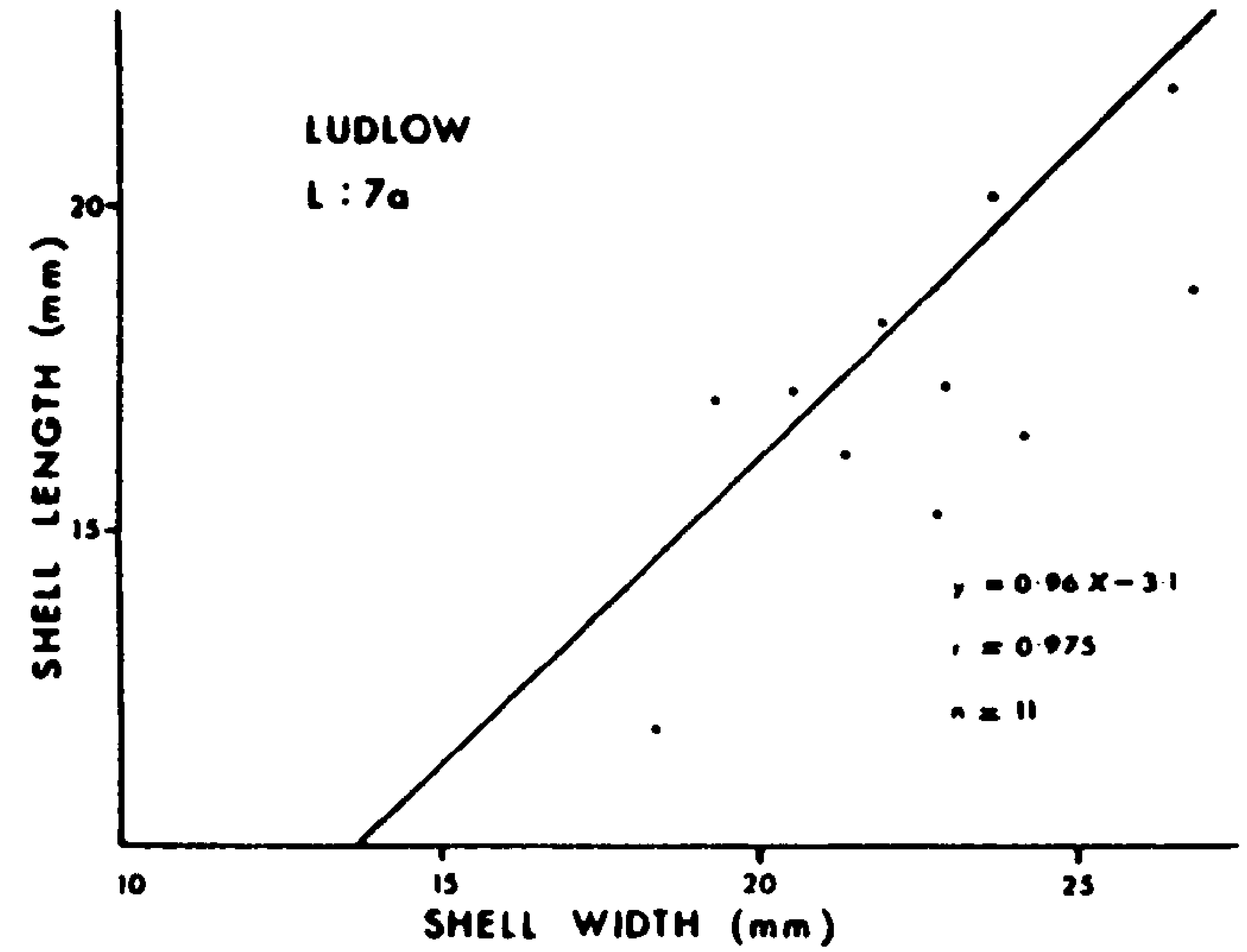
It is evident from the text-figs 4.1-4.7 that the trends and the slopes of the best fit lines for the localities mentioned in Table 1 are nearly the same. Therefore, the collections from these localities are treated as only one unit called the Ludlow area collection.

Subsequently, more specimens were collected and studied from the Llangegveth reservoir (LR) and Woodbury Quarry (WQ) localities in the Usk inlier and Abberley Hills respectively. The variation in the shell proportions for these three localities (Ludlow, Usk and Woodbury Quarry) is shown in Table 2 and are also displayed graphically in text-figs 4.8-4.10.

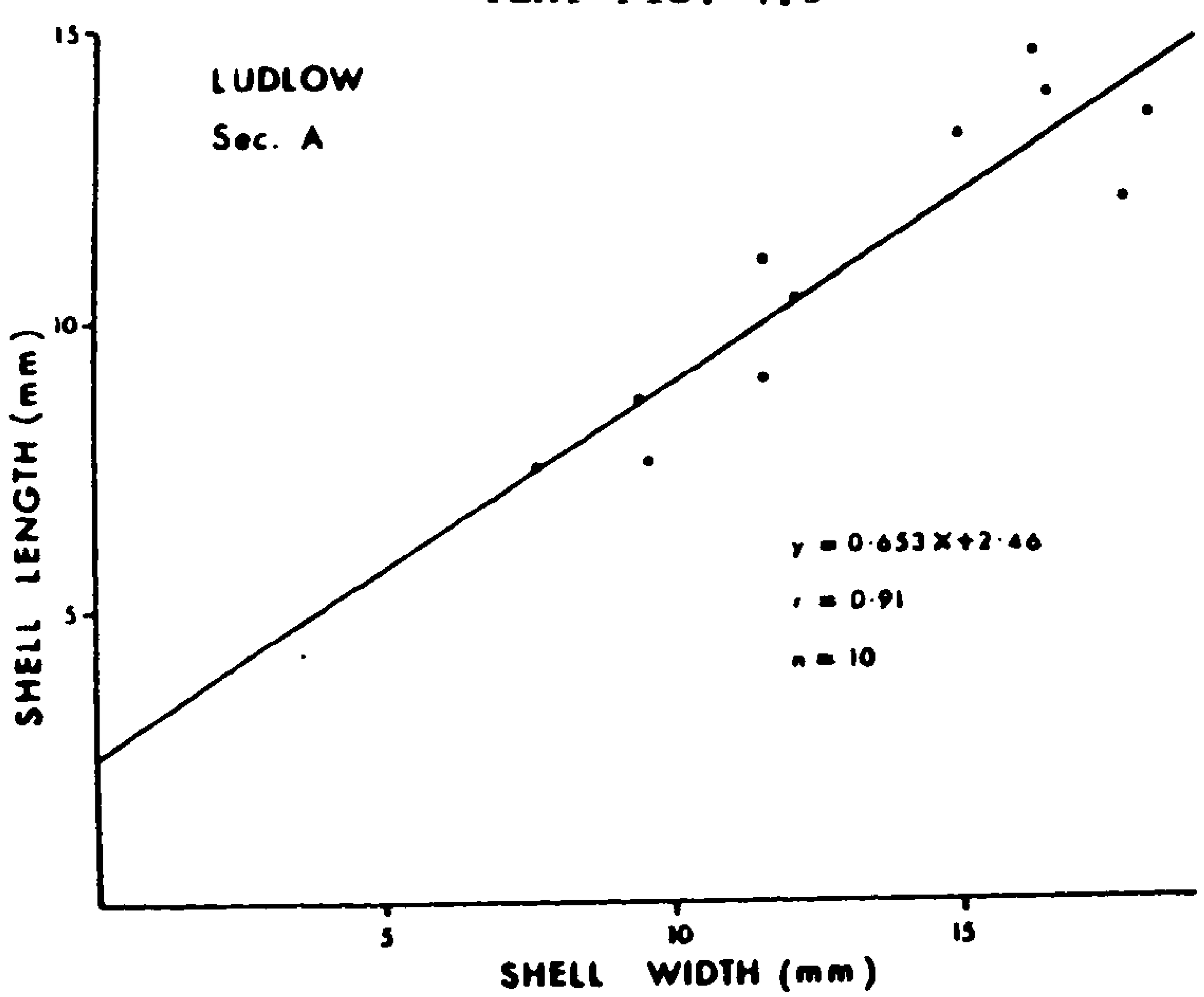
TEXT-FIG. 4.1



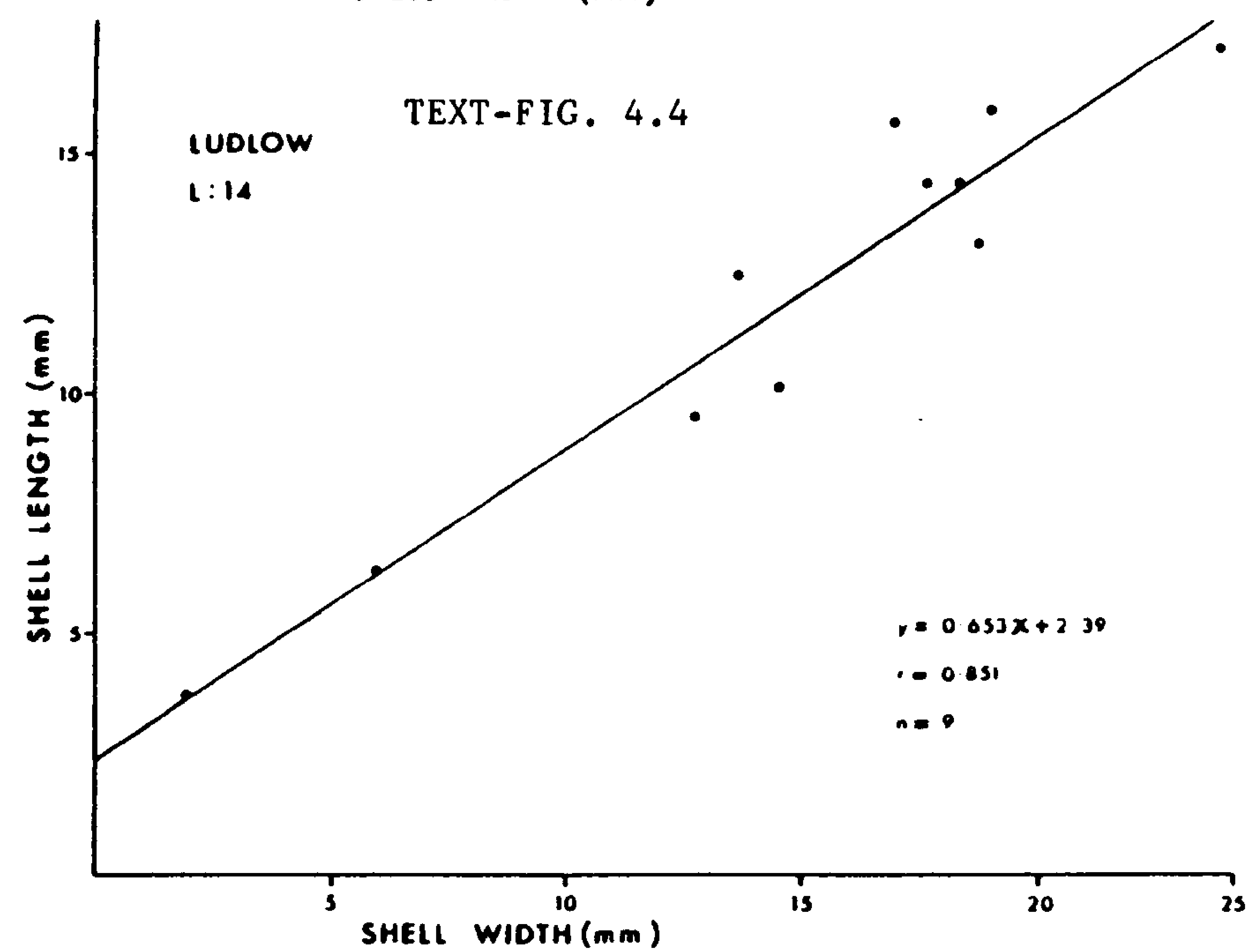
TEXT-FIG. 4.2



TEXT-FIG. 4.3

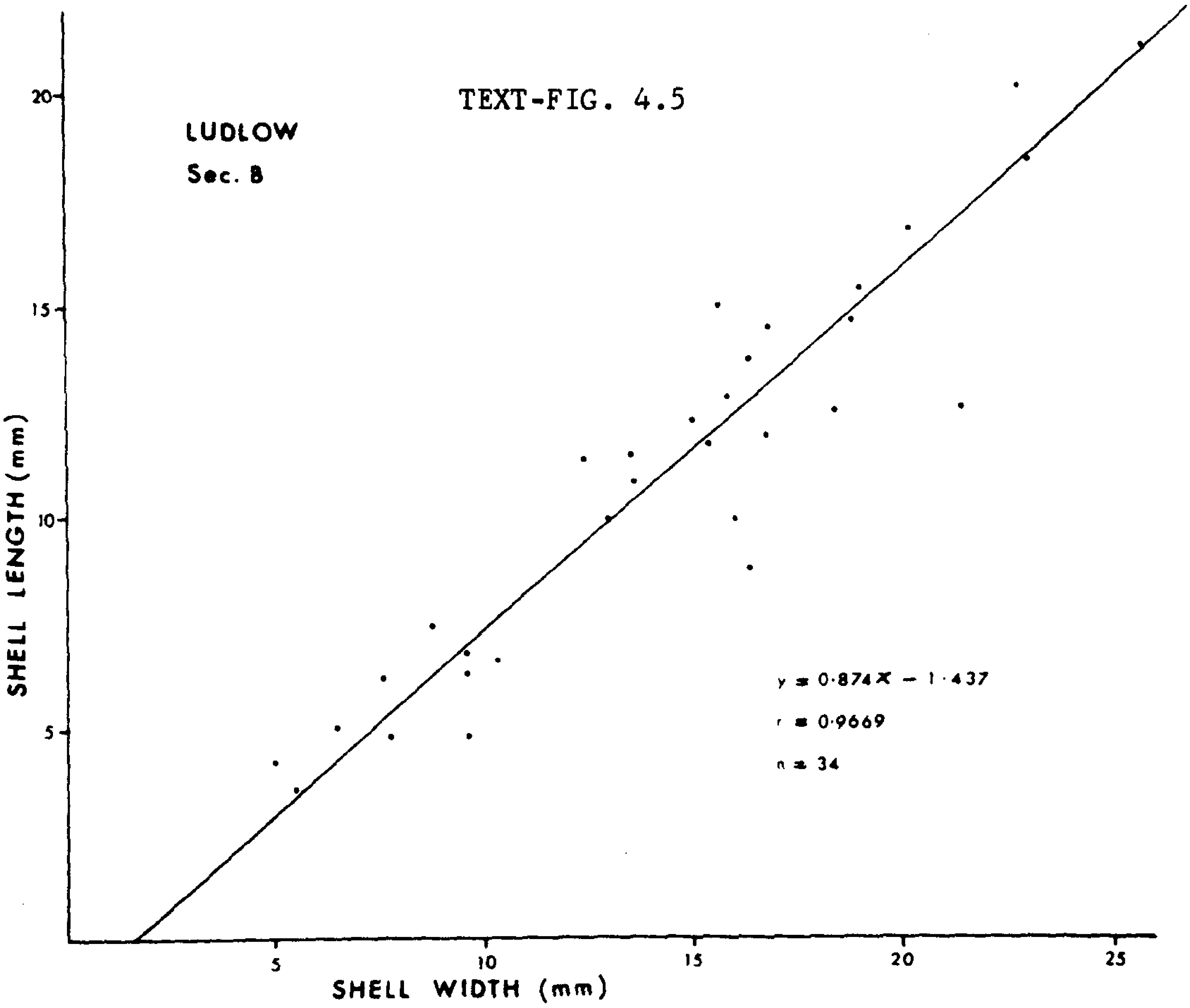


TEXT-FIG. 4.4

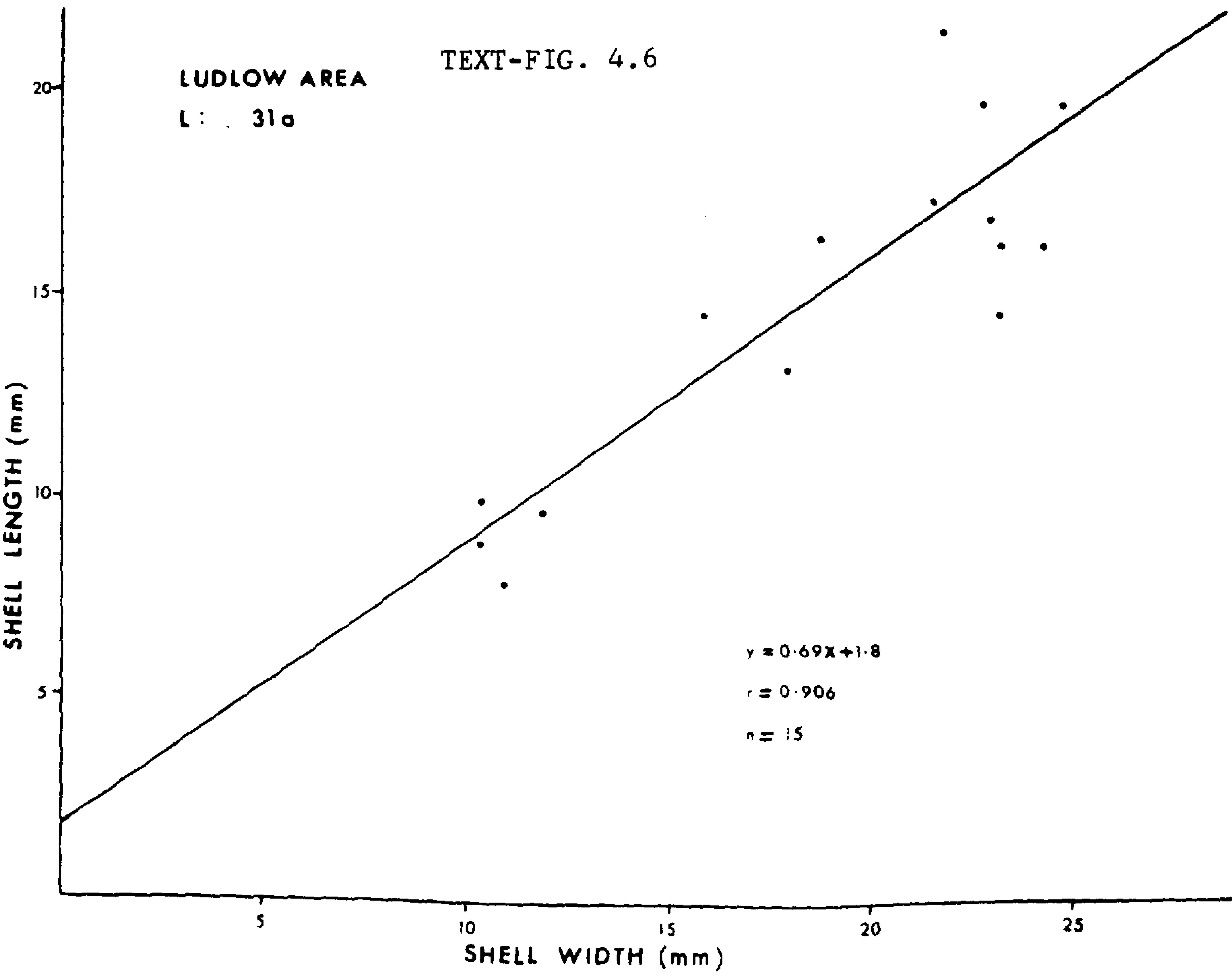


TEXT-FIGS. 4.1–4.4. Shell length-width distribution of L. filosa in the Ludlow area (Ludlow Museum, Section A, localities 7a and 14).

TEXT-FIG. 4.5

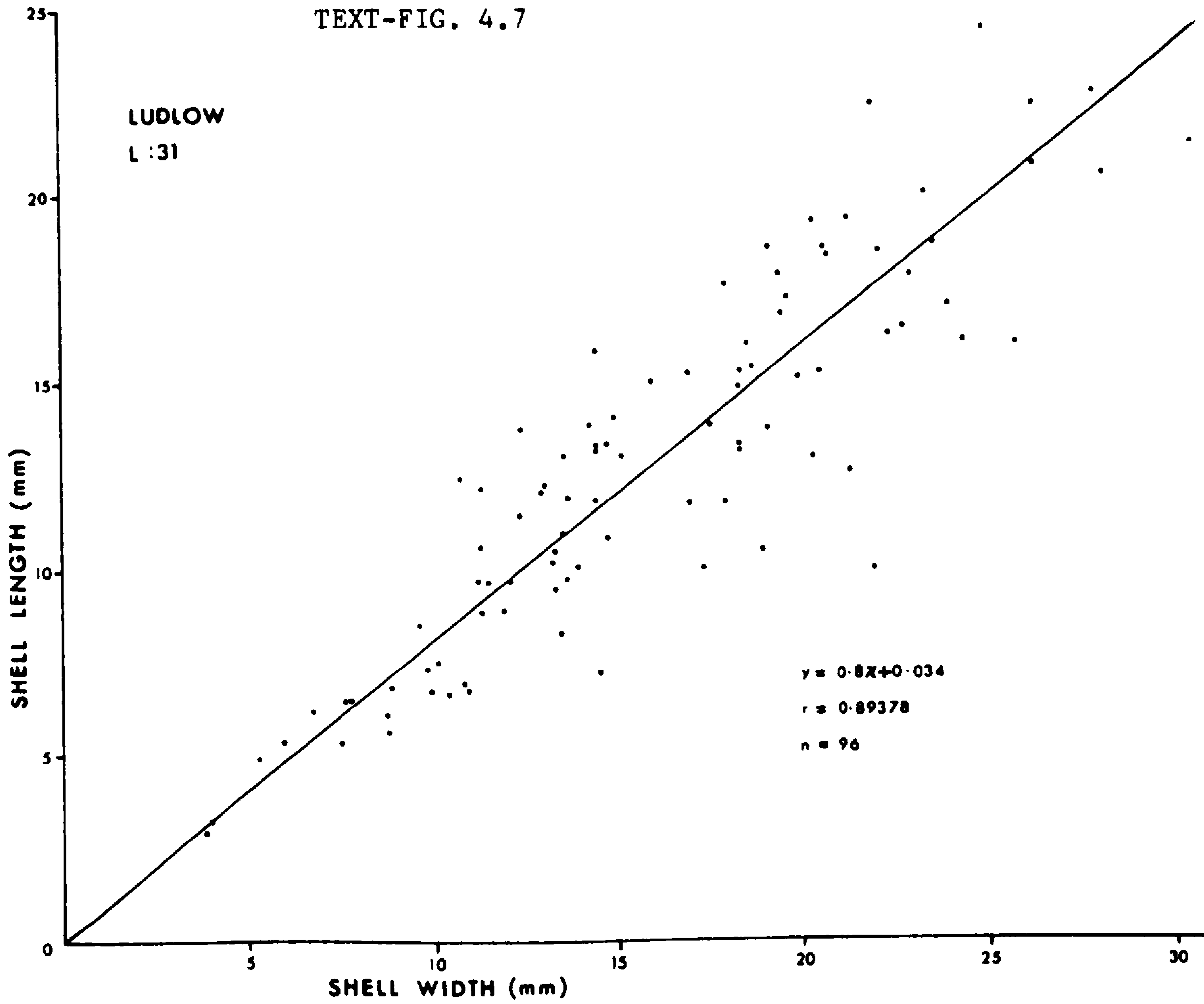


TEXT-FIG. 4.6

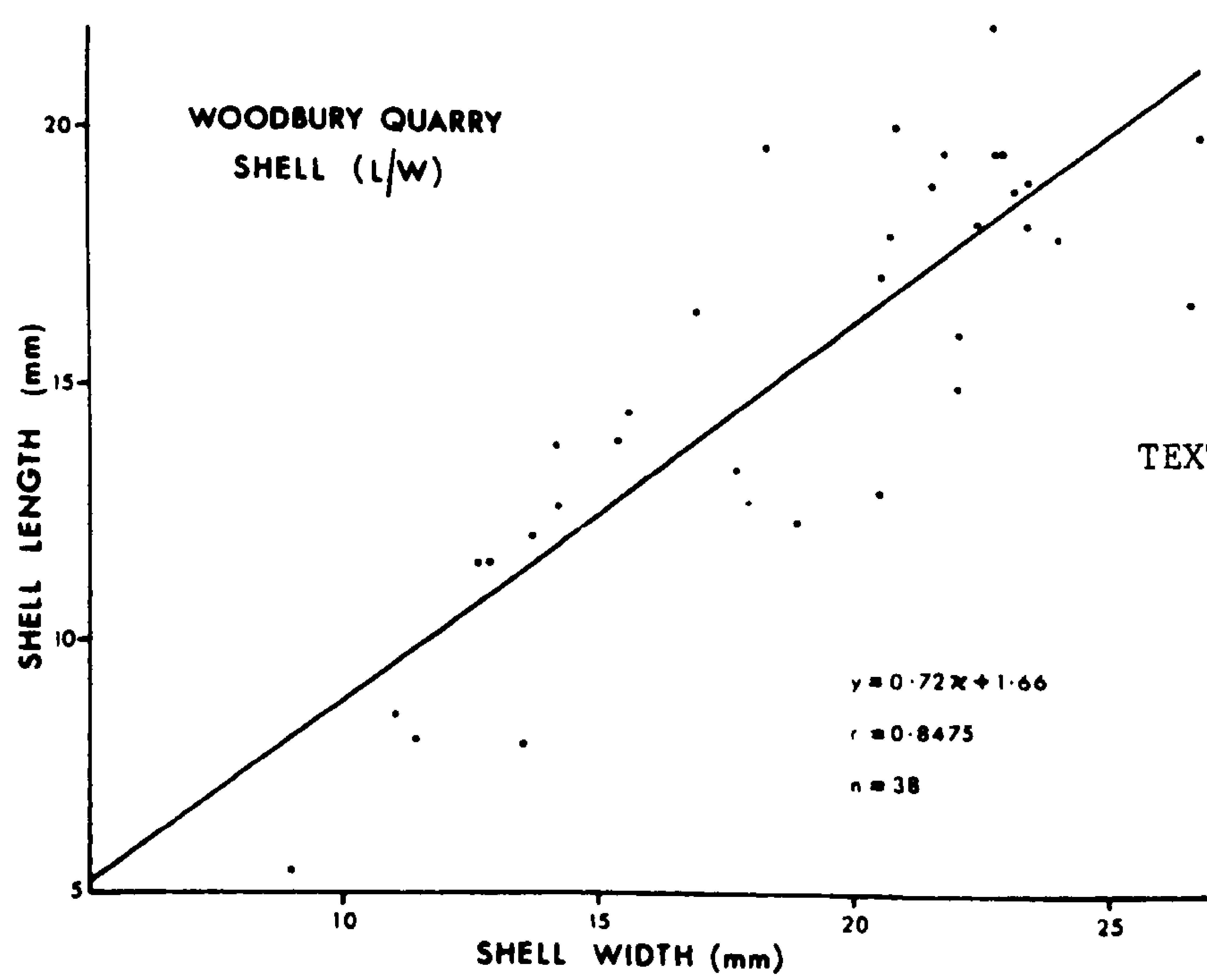


TEXT-FIGS. 4.5 & 4.6 Plots of the shell length against shell width of L. filosa from Section B and locality 31a of the Ludlow ar

TEXT-FIG. 4.7

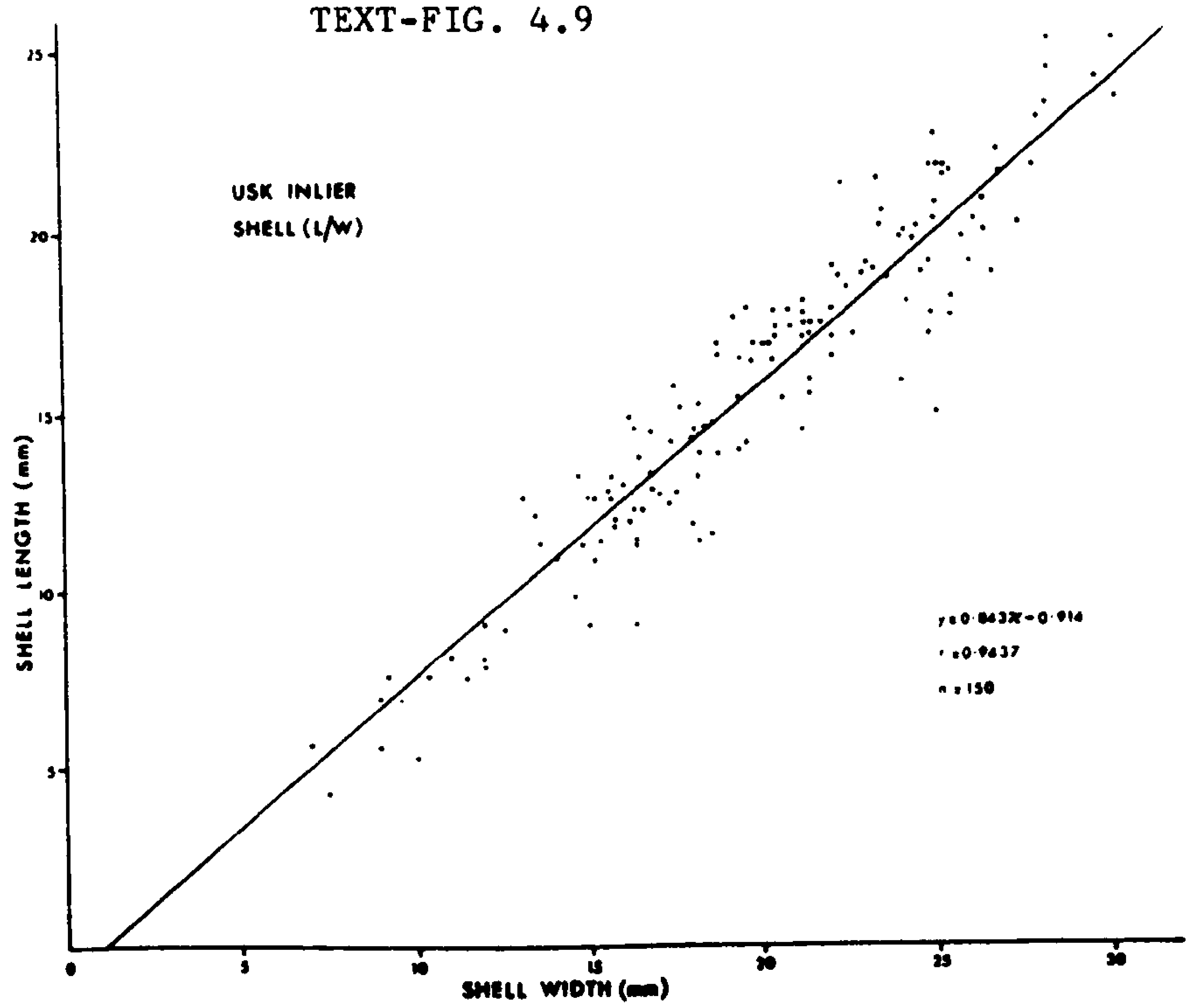


TEXT-FIG. 4.8

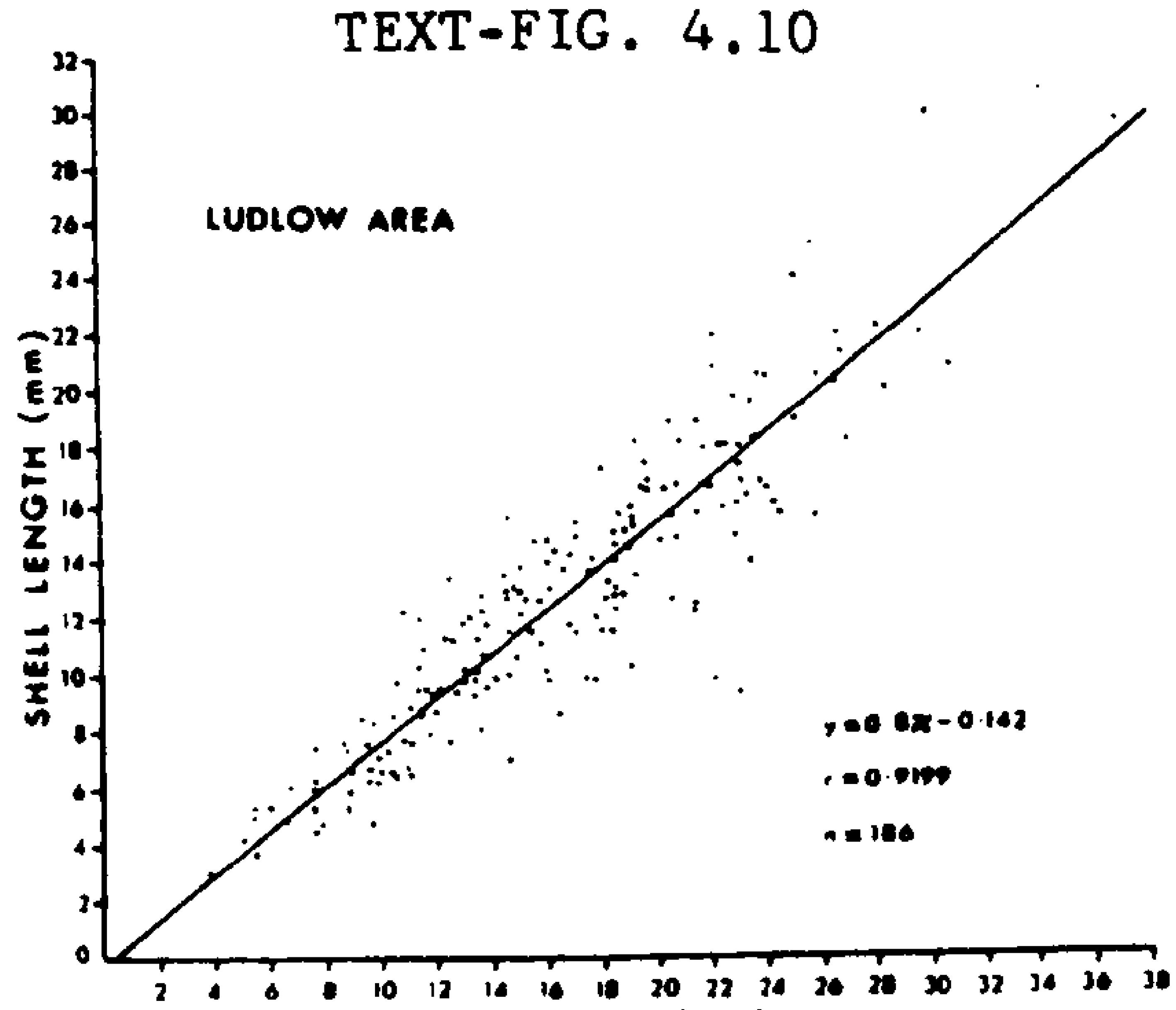


TEXT-FIGS. 4.7 & 4.8. Shell length-width distribution of L. filosa in Ludlow area (L31) and Abberley Hills (WQ) respectively.

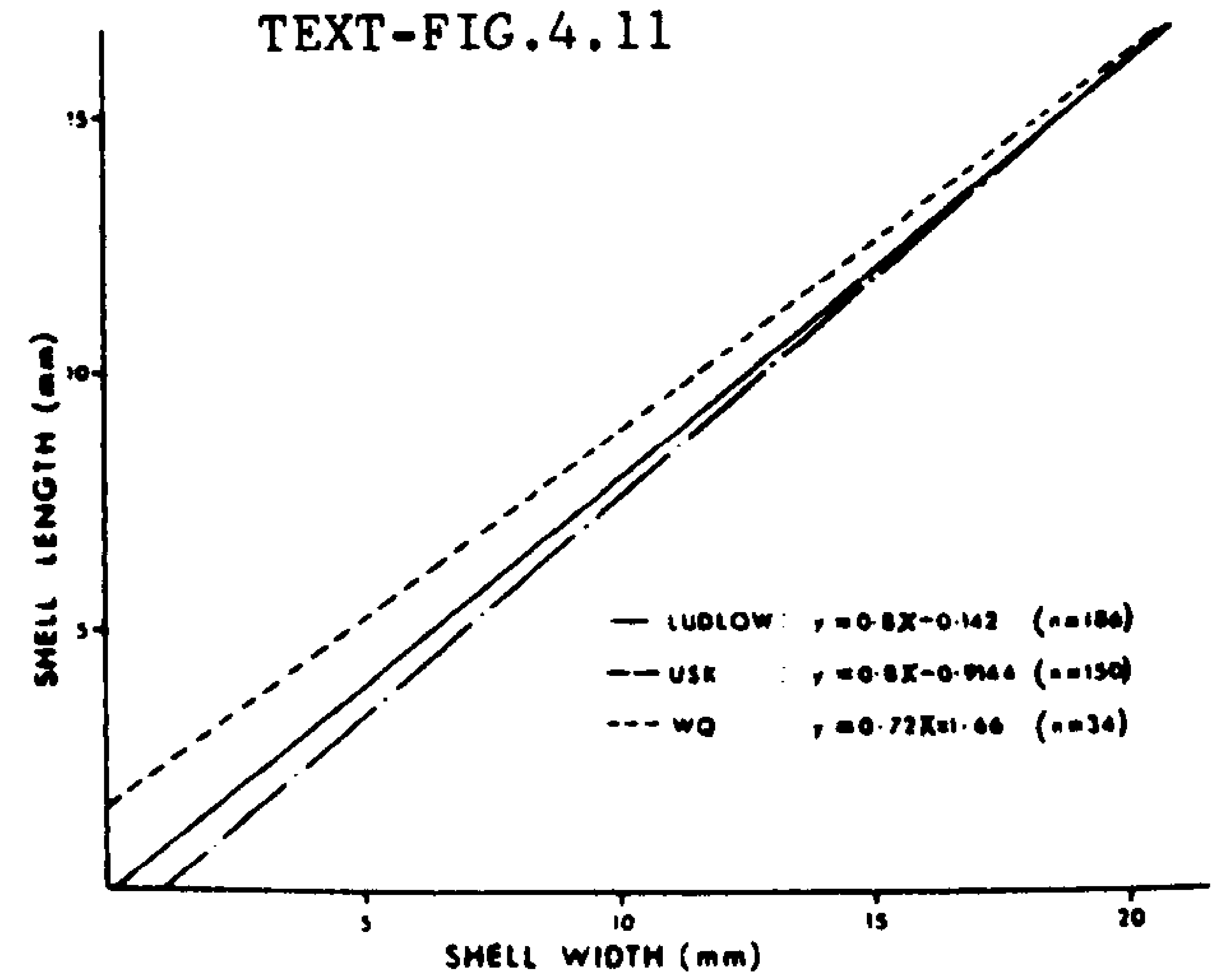
TEXT-FIG. 4.9



TEXT-FIG. 4.10



TEXT-FIG. 4.11



TEXT-FIGS. 4.9 & 4.10. Shell length-width distribution of L. filosa from Usk and Ludlow respectively.

TEXT-FIG. 4.11. Superimposition of shell length-width distribution of L. filosa in Ludlow, Usk and Abberley Hills.

TABLE 2: Summary of statistical results of the shell length-width proportions of L.(L.) filosa from Abberley Hills, Usk and Ludlow area respectively.

Area	n	$\bar{L}s$	$\bar{W}s$	r	S.D. (Ls)	S.D. (Ws)	equation	% $\bar{L}s/\bar{W}s$
WQ (Abberley Hills)	38	15.729 (19.246)	19.487 (26.531)	0.847	4.329	5.083	Y= 0.72X + 1.66	81%
LR (Usk)	150	16.306 (24.414)	20.428 (30.571)	0.944	4.925	5.512	Y= 0.84X - 0.914	80%
Ludlow	186	13.169 (27.729)	16.608 (36.527)	0.919	5.252	6.027	Y= 0.8X - 0.142	79%

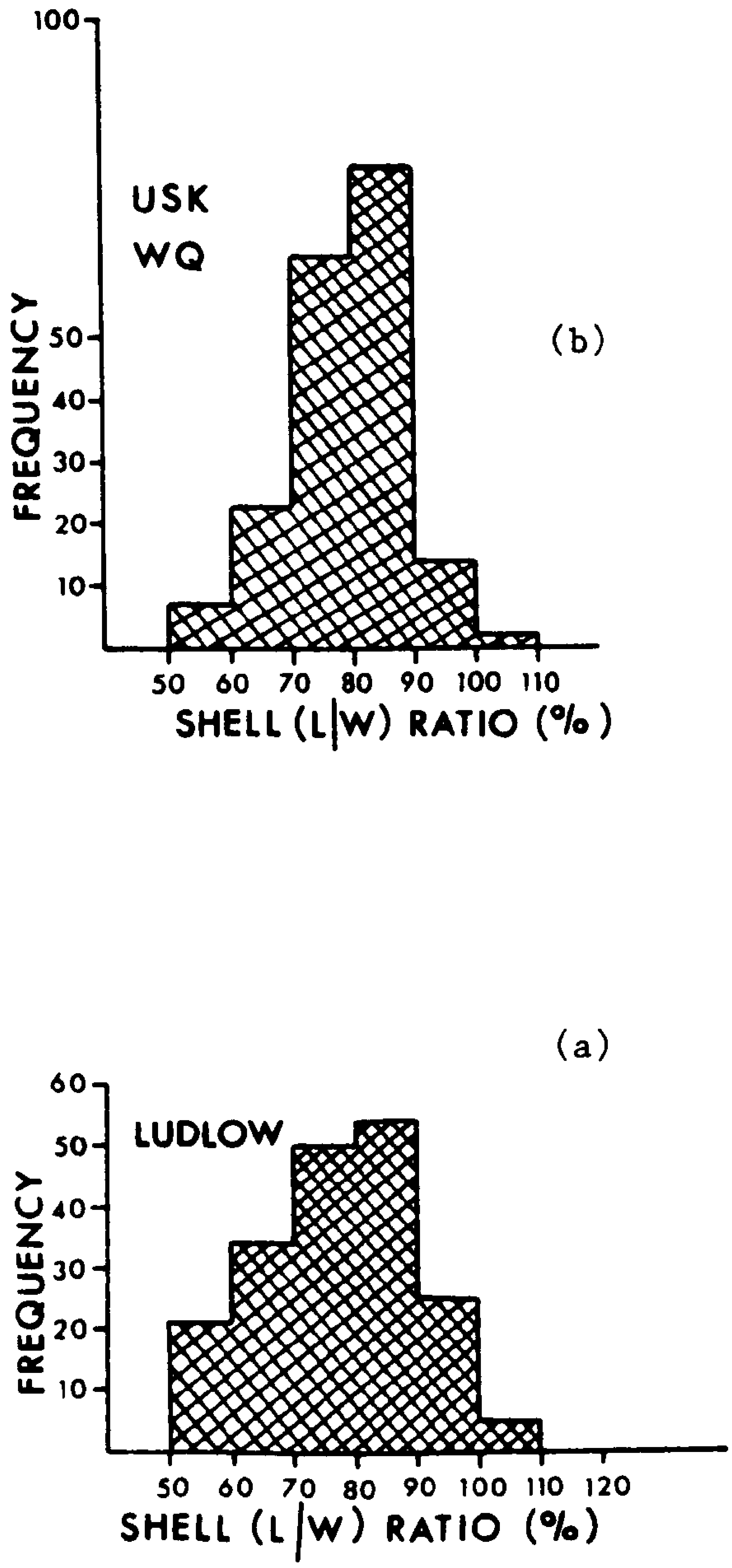
The high value of the coefficient of correlation (r) in all three samples demonstrates that the length and width increase in direct proportion to each other.

The ratio of the shell proportion (Ls/Ws) shown in Table 2 for Ludlow, Woodbury Quarry and Usk specimens is nearly identical. Usk specimens are larger in both the shell length and shell width than Woodbury Quarry and Ludlow specimens, but still keep the same shell proportions as Ludlow and Abberley Hills specimens. For example, the average shell length and shell width for Ludlow specimens are 13.169, 16.608 respectively (for n = 186), while in Usk are 16.306, 20.428 respectively (for n = 150); (see text-figs. 4.11 & 4.12). The larger shell in the Usk specimens is likely to be related to environmental controls, such as food supply, oxygen etc. (see section III).

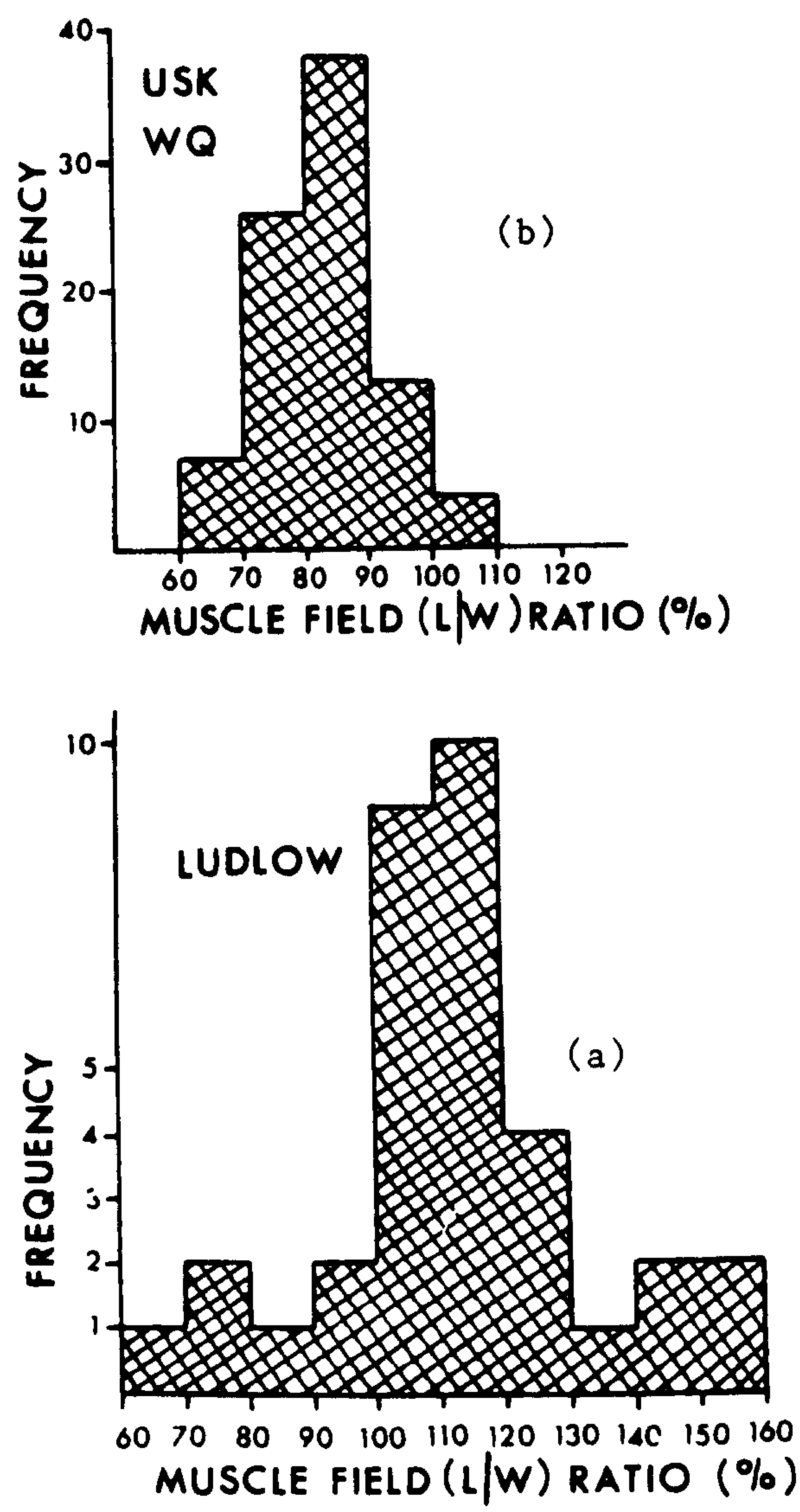
2. Ornamentation.

The radial ornament in L.(L.) filosa is finely and equally parvicostellate. The costellae are straight along the mid line of the shell becoming gently curved laterally (Pl.5, figs. 1a,1b, 2a,2b & 8; Pl.10, figs. 1a, 7,8 & 9). Some specimens have short,

TEXT-FIG. 4.12



TEXT-FIG.4.13



TEXT-FIG. 4.12. Shell length-width ratio frequency histograms for (a) Ludlow and (b) Usk and Abberley Hills.

TEXT-FIG. 4.13. Muscle field length-width ratio frequency histograms for (a) Ludlow and (b) Usk and Abberley Hills.

oblique crenulations of the shell along the postero-lateral margin of the hinge line (i.e. near the shell ears)(Pl.10, figs. 1a & 6). Some few other specimens show two to three faint concentric fila which developed postero-laterally of the muscle field as seen on (Pl.9, figs.8,3a and 3b and Pl.10, figs.3a & 3b). The radial ornament is similar in all the specimens studied and similar also to those specimens described from the Wenlock Series (Silurian) by Bassett (1971 & 1977).

B. Internal shell features.

1. Denticles.

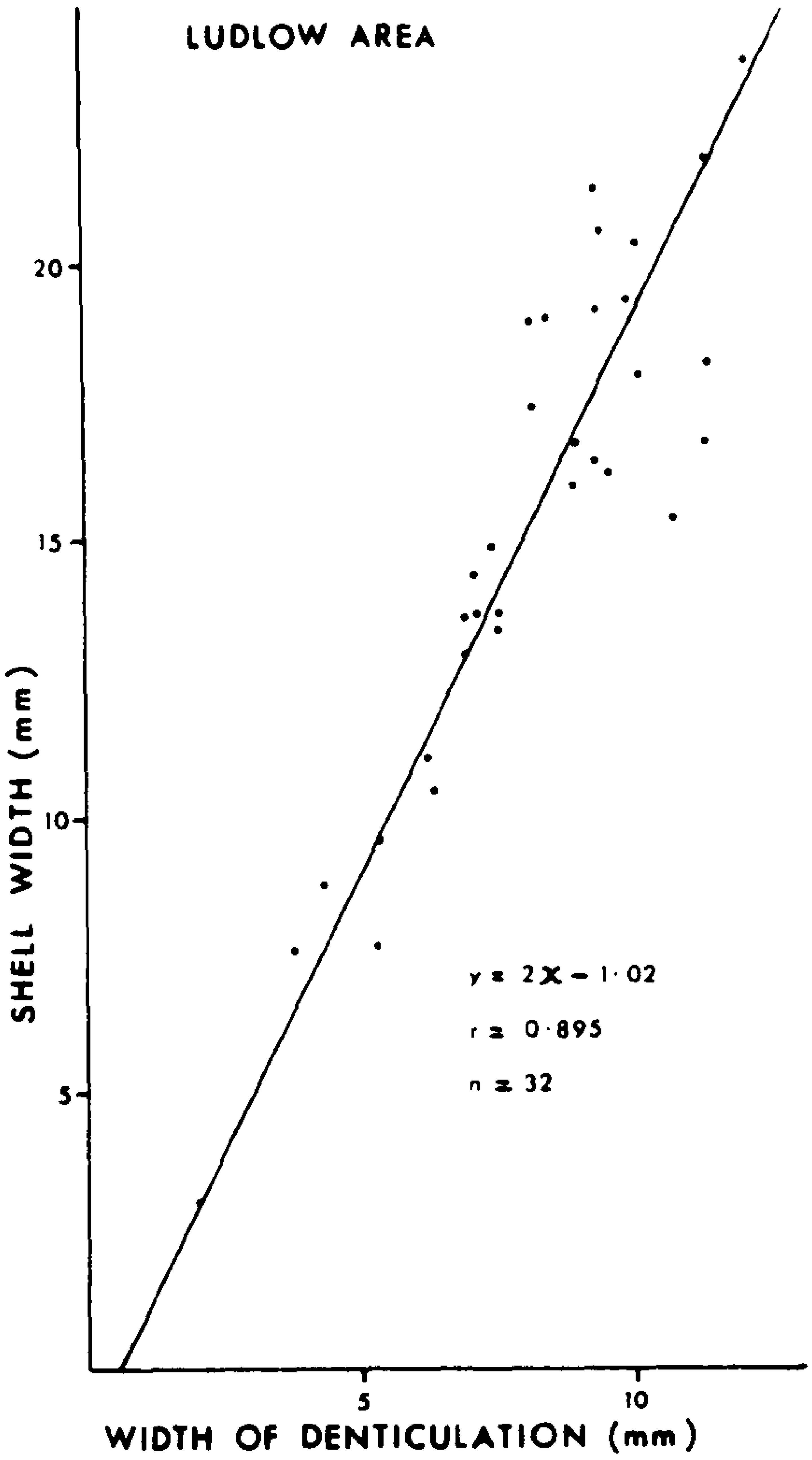
Denticles are developed as small sharp ridges along part of the hinge line in all stropheodontids (Williams, 1953); (see Pl.10, figs. 3a,3b,4,5,6 & 8; Pl.11, fig.2). These denticles act as an interlocking system. The development of such denticles along the hinge line was accompanied by a progressive reduction of the original teeth and sockets (Rudwick, 1974).

In *L.(L.) filosa* strong denticulation extends laterally for varying proportions of the hinge width in different localities (see Table 3 below and text-figs. 4.14-4.17).

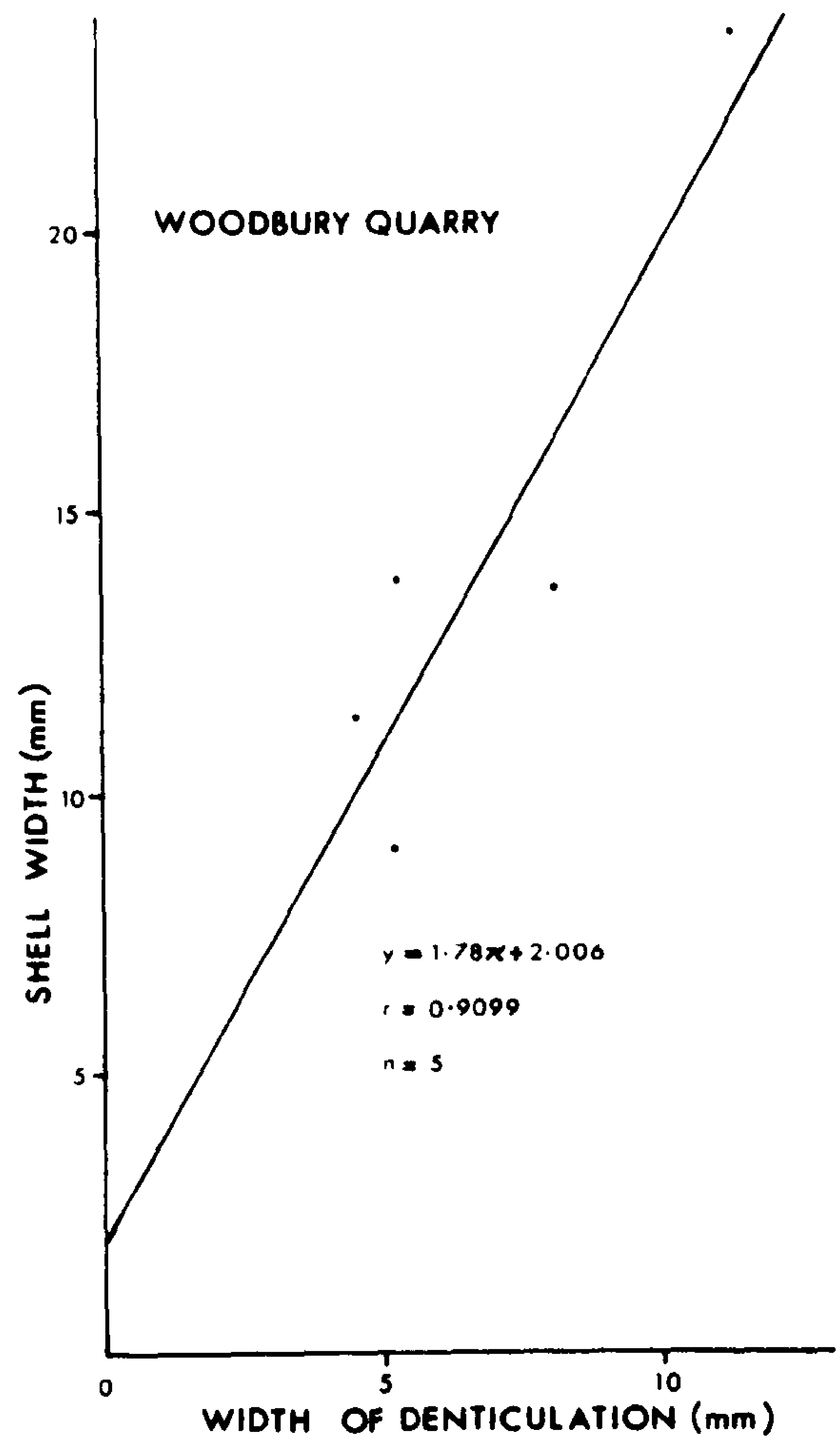
TABLE 3. Summary of statistical results of the denticulation of *L.(L.) filosa* from Woodbury Quarry, Ludlow and Usk inlier.

Area	n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (W.s)	S.D. (Wd)	The equation	% $\overline{Wd}/\overline{Ws}$
Woodbury Quarry (WQ)	5	14.3 (30.9)	6.92 (8.11)	0.909	4.972	2.547	Y= 1.78X + 2.0	48%
Ludlow	32	16.403 (27.406)	8.675 (5.44)	0.895	5.153	2.296	Y= 2X - 1.02	53%
Usk (LR)	61	19.831 (28.596)	10.544 (11.490)	0.844	5.303	3.362	Y= 1.4X + 5.12	53%

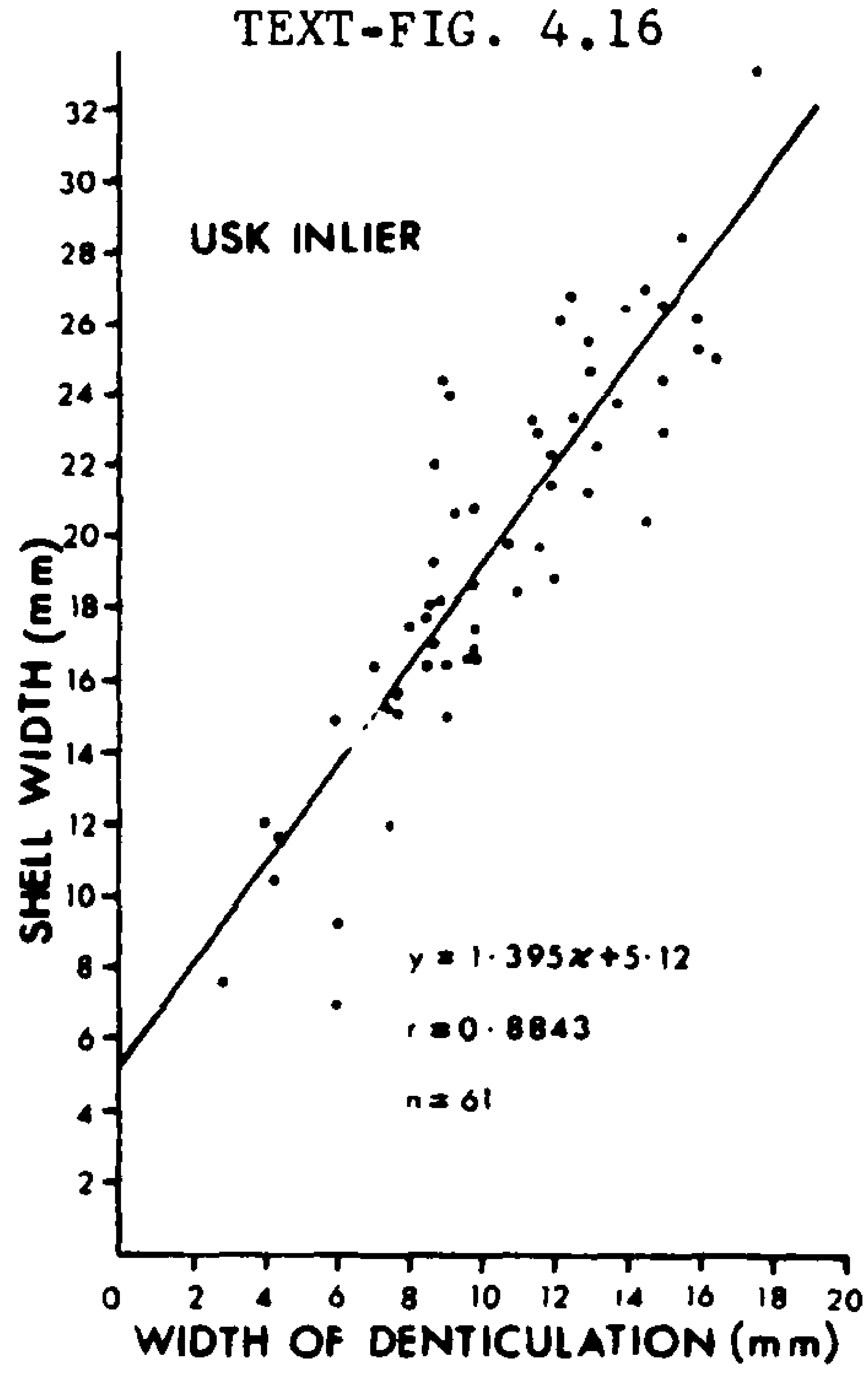
TEXT-FIG. 4.14



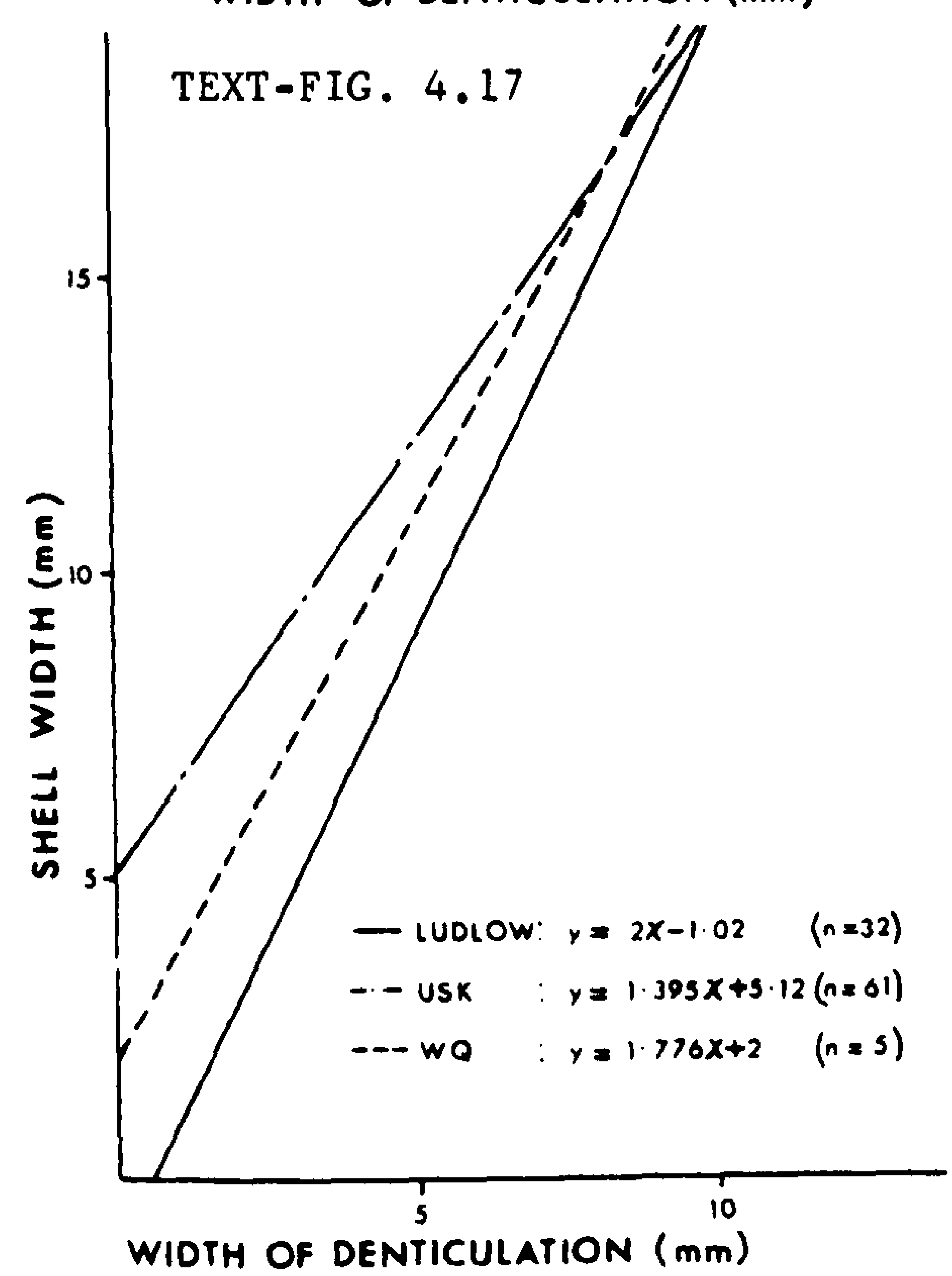
TEXT-FIG. 4.15



TEXT-FIG. 4.16



TEXT-FIG. 4.17



TEXT-FIGS. 4.14-4.16. Plots of shell width versus width of denticulation of L. filosa in Ludlow, Abberley Hills and Usk respectively with their superimposition in text-fig. 4.17.

From the Table above, it is evident that the width of denticulations compared with the hinge width at both Ludlow and Usk localities is the same (53%), while the ratio at Woodbury Quarry is 48%. The latter value (WQ = 48%), however, came from very few specimens (n = 5), not enough for statistical analyses or comparison with the other two localities (Ludlow and Usk).

As discussed before, the Usk specimens are (on average) larger than the Ludlow specimens, but they still show the same shell (Ls/Ws) proportions and the same proportions of the hinge line width occupied by the denticulations. The significance of these features will be discussed later in the palaeoecology (Chapter 9).

It is also evident from the text-figs (4.14-4.17) that the width of the hinge line denticulation increased in direct proportion to the shell width at all three locations.

2. <u>Pedicle valve muscle field.</u>

In <u>L</u>.(<u>L</u>.) <u>filosa</u>, the pedicle valve muscle field is triangular in outline (Pl.9, figs.1-9). A pair of narrow, lanceolate adductor muscle scars is well developed. They are located postero-medianly on the interior of the pedicle valve and are enclosed by a pair of diductor muscle scars (Pl.9, figs.1a,4,8,9; Pl.11, fig.1). The diductor muscle scars are triangular in shape, divided by a narrow, rounded myophragm which tapers anteriorly. The muscle scars are partitioned by 2-3 pairs of fine, radial ridges (Pl.9, figs.1a,2a, 2b,4,5,8,9 and Pl.11, fig.1). However, the diductor muscle scars are always bounded laterally by well impressed, nearly straight ridges which usually die out anteriorly. In a few specimens, these ridges are curved very gently either towards the lateral margins of the shell (Pl.9, fig. 5) or antero-medianly (towards the myophragm) (Pl.9, figs. 7 and 9). The most common shape of the muscle field, however, is shown in Pl.9, figs. 1,2,4,6 & 8. The angle of divergence of the muscle bounding ridges does not show any significant variability amongst the specimens studied from the three areas (Ludlow, Abberley Hills and Usk).

The variations in the muscle field proportions from these three localities are shown on Table 4 below and are also displayed graphically in text-figs. 4.18-4.21.

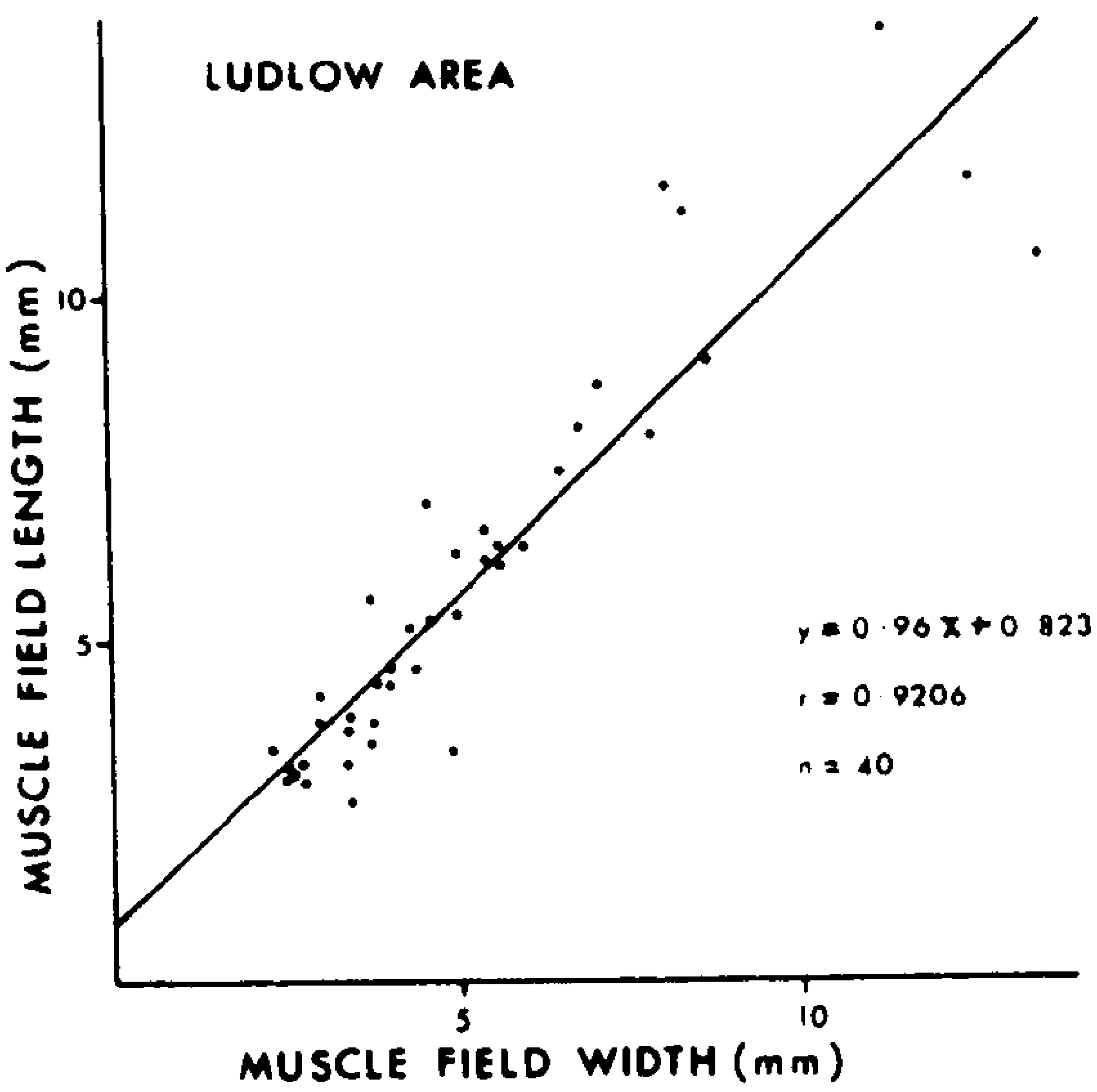
TABLE 4: Summary of statistical results of the muscle field length-width proportions of L.(L.) filosa from Woodbury Quarry, Usk and Ludlow areas.

Area	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	The equation	% $\bar{L}mf/\bar{W}mf$
(WQ) Abberley Hills	12	4.058 (3.763)	4.967 (4.148)	0.852	1.857	1.949	Y= 0.81X + 0.029	82%
(LR) Usk	78	4.944 (2.511)	5.937 (2.847)	0.945	1.574	1.677	Y = 0.88X - 0.326	83%
Ludlow	40	5.89 (8.181)	5.245 (7.427)	0.921	2.824	2.691	Y= 0.96X + 0.823	112%

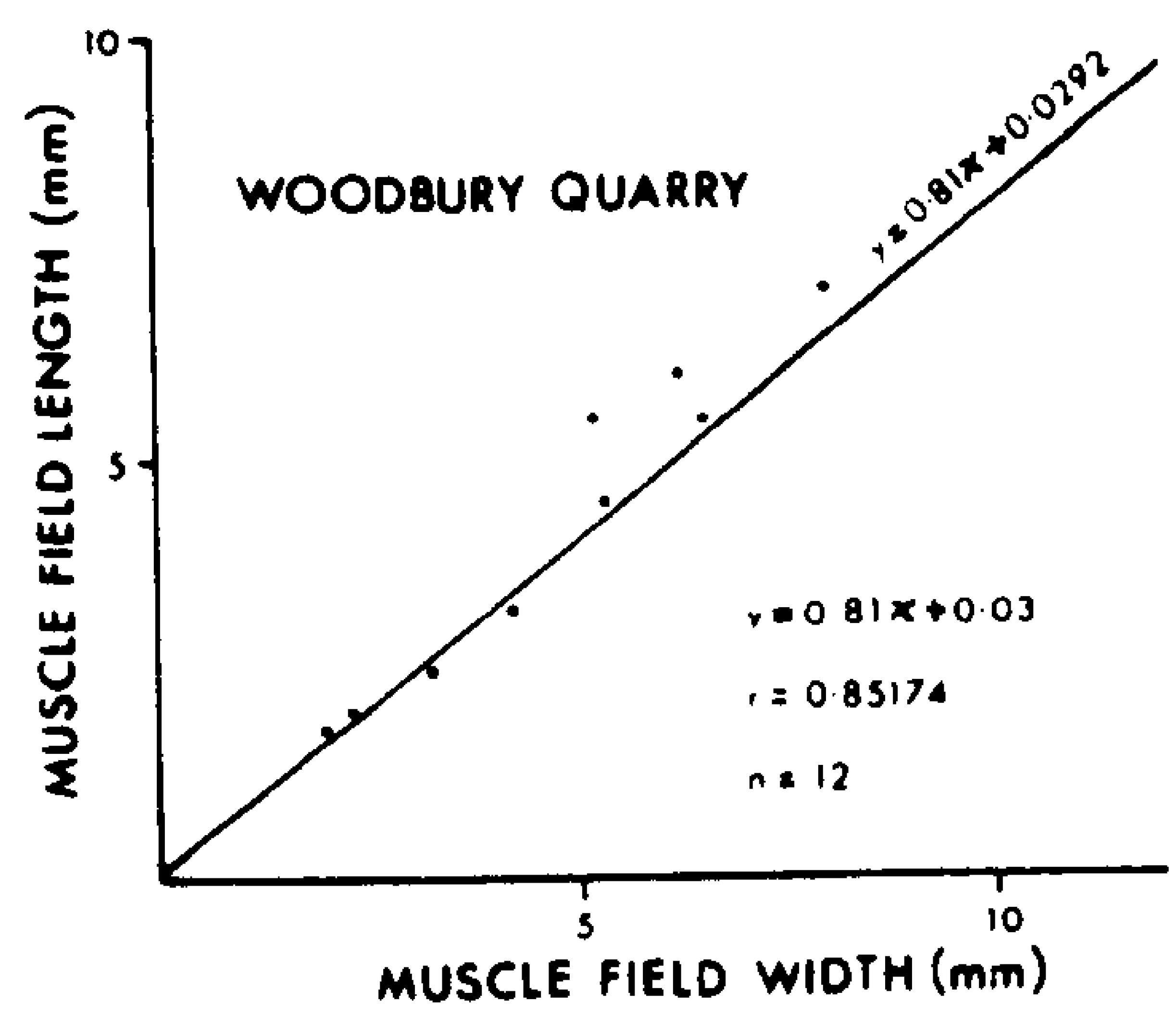
It is evident from text-figs.4.18-4.21 that the length of the muscle field increased in direct proportion to its width in all localities.

From the Table shown above, Woodbury Quarry and Usk specimens show nearly the same muscle field proportions (i.e. $\simeq$ 82%), While those from Ludlow (112%) have relatively longer muscle fields than both Woodbury Quarry and Usk specimens (see the size frequency histograms in text-fig.4.13). Usk specimens have wider muscle fields than both the Ludlow and the Woodbury Quarry specimens and may be related to the wider shell of the Usk specimens, (i.e. the muscle field width has increased in a direct proportion to the shell width). The relationship between the muscle field length against the shell length is also plotted graphically (see text-figs.4.22-4.25)

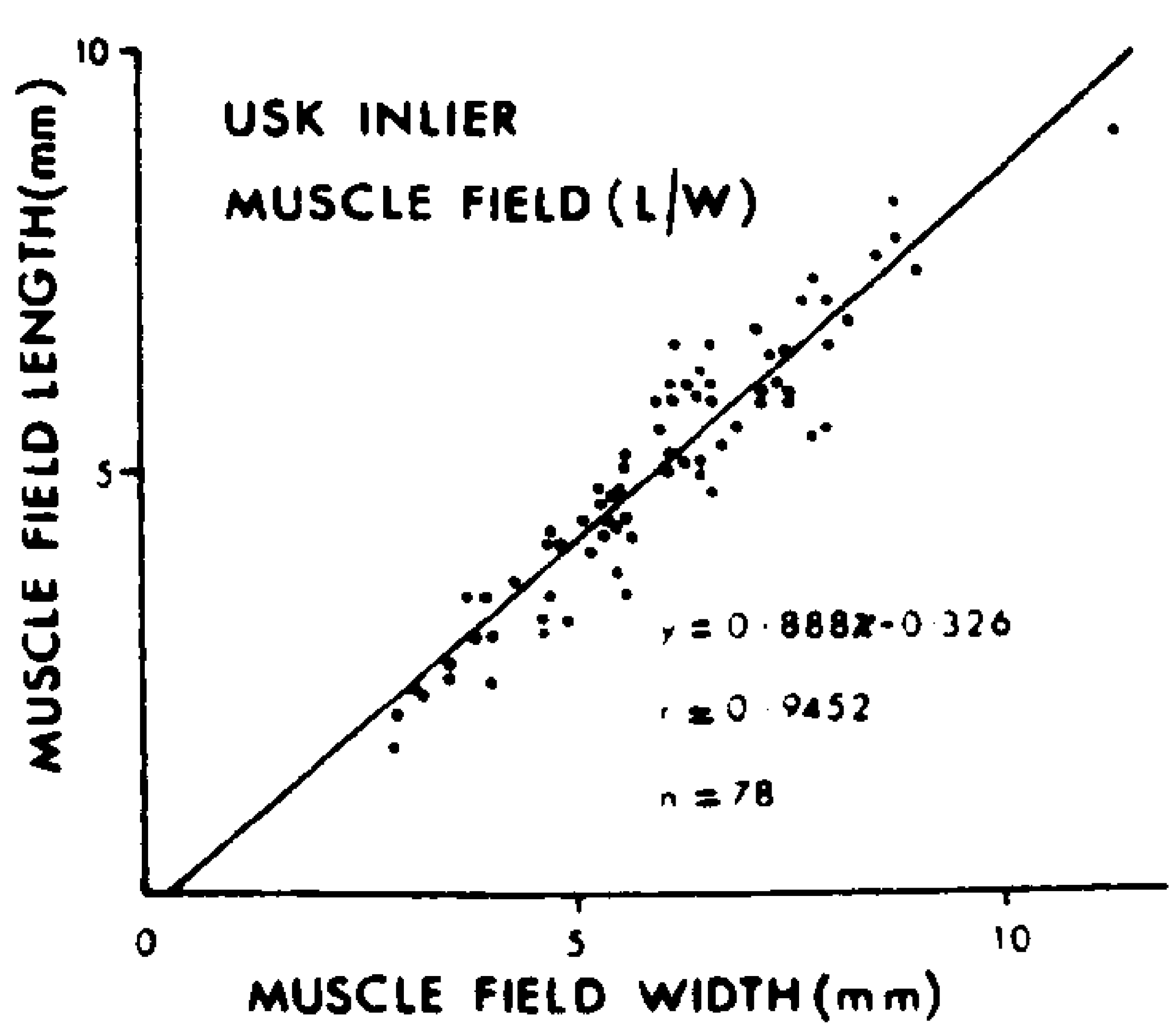
TEXT-FIG. 4.18



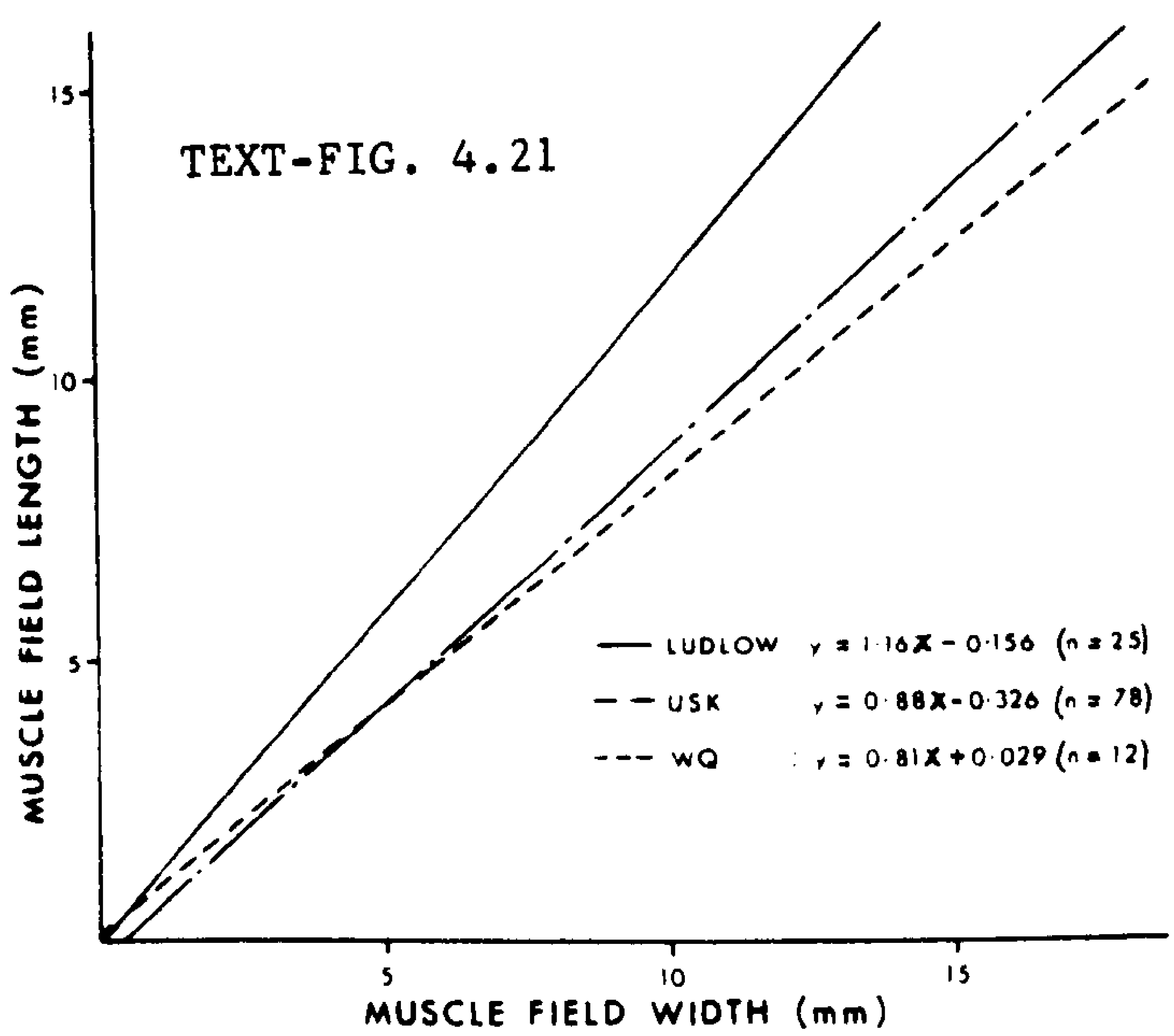
TEXT-FIG. 4.19



TEXT-FIG. 4.20



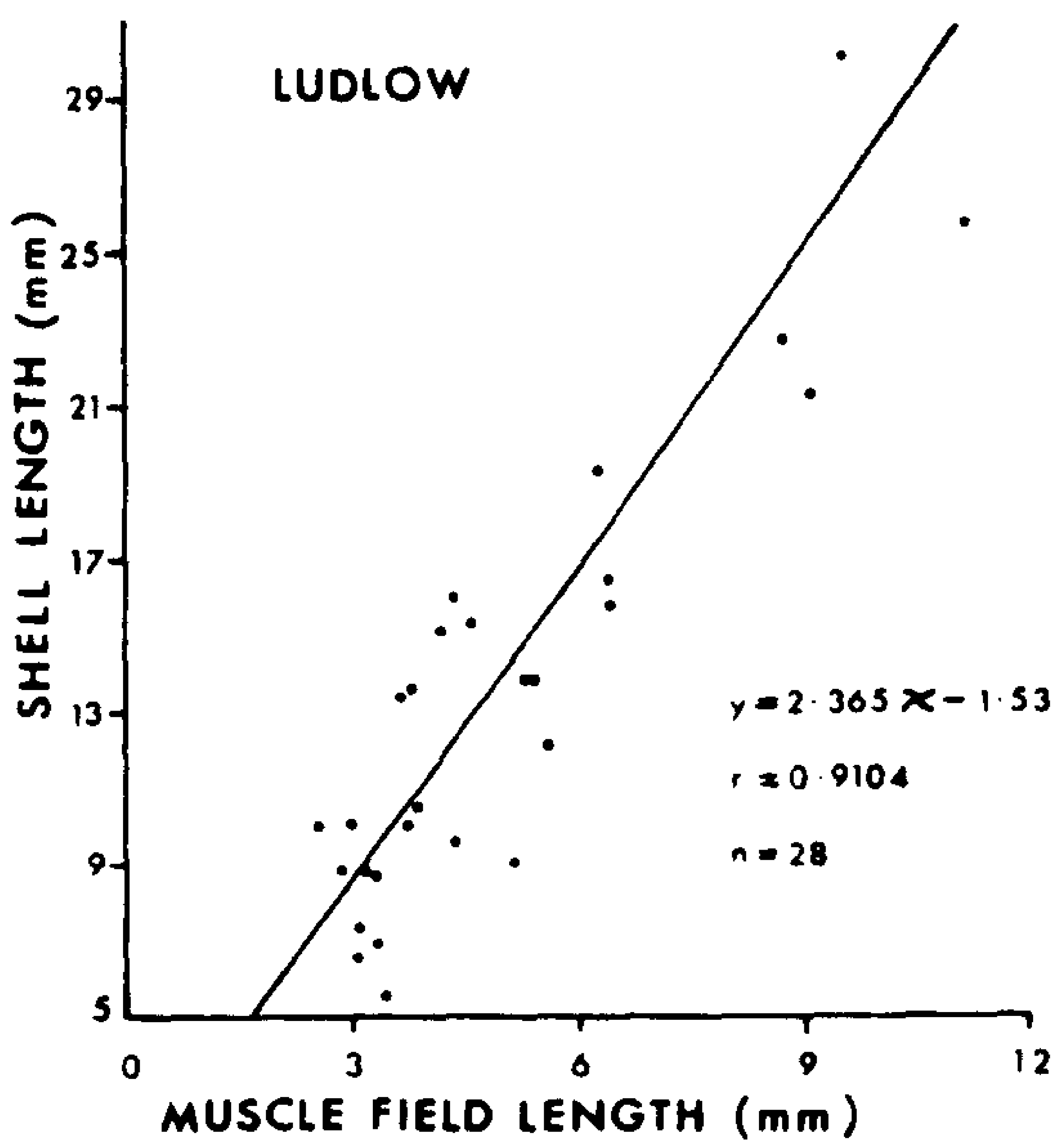
TEXT-FIG. 4.21



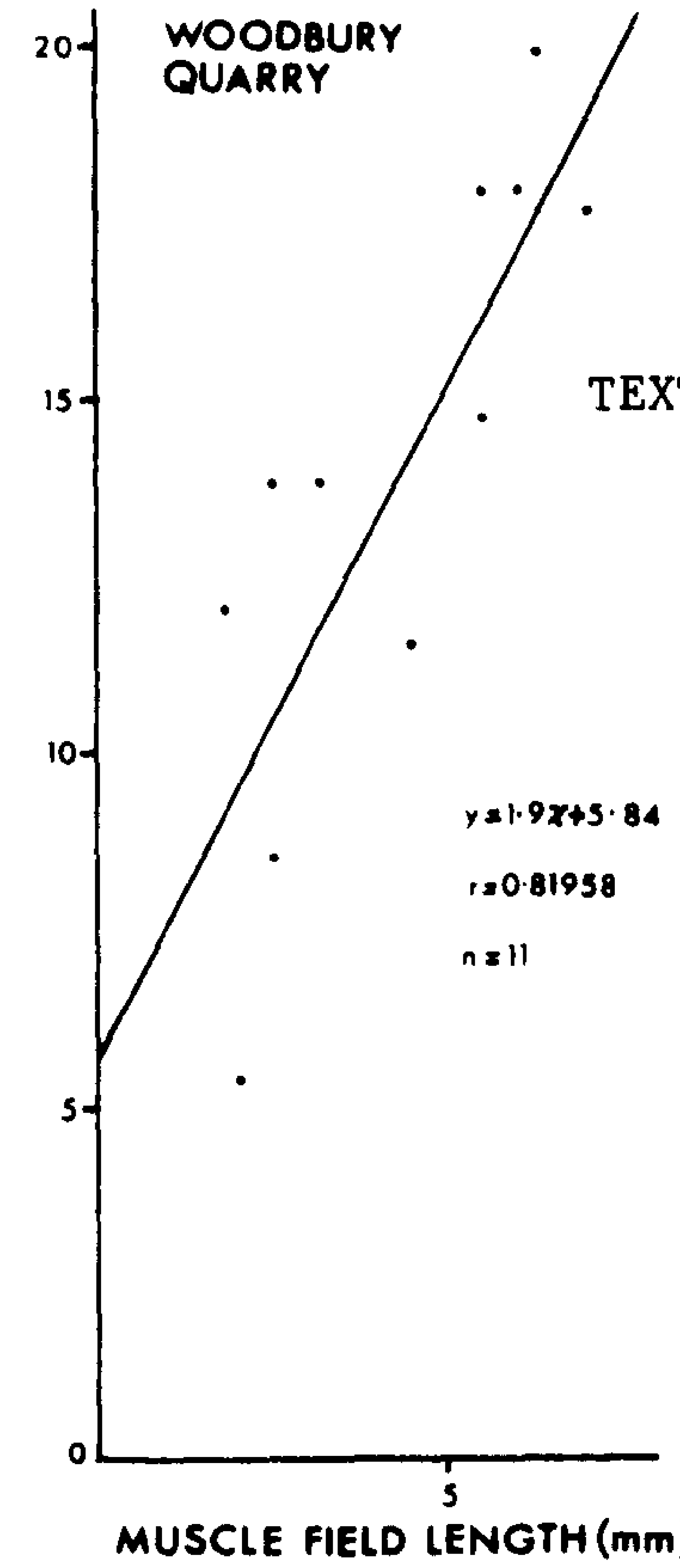
TEXT-FIGS. 4.18-4.20. Muscle field length-width distribution of *L. filosa* from Ludlow, Abberley Hills and Usk respectively.

TEXT-FIG. 4.21. Superimposition of muscle field length-width distribution of *L. filosa* in Ludlow, Abberley Hills and Usk inlier.

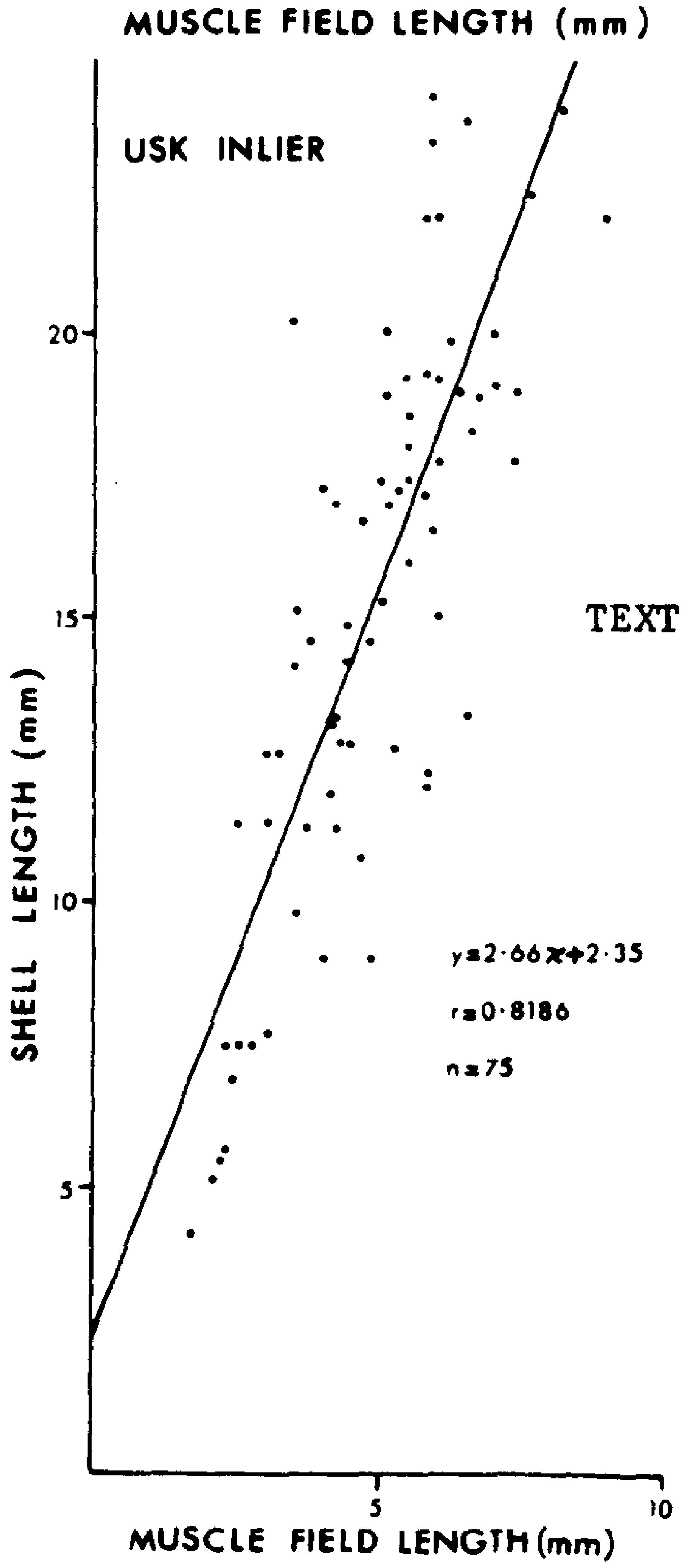
TEXT-FIG. 4.22



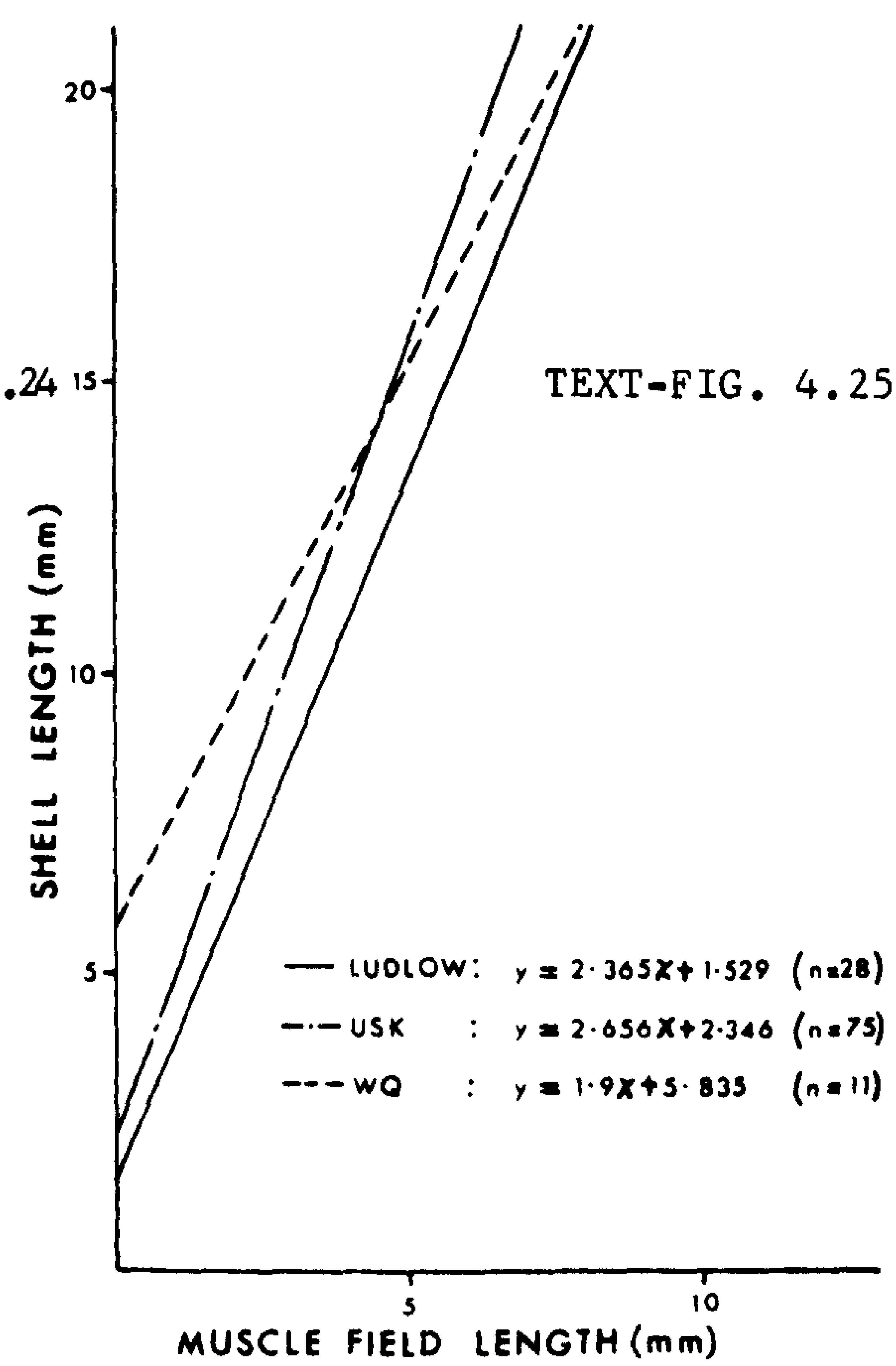
TEXT-FIG. 4.23



TEXT-FIG. 4.24



TEXT-FIG. 4.25



TEXT-FIGS. 4.22-4.24. Plots of shell length against muscle field length of L. filosa from Ludlow, Abberley Hills and Usk, with their superimposition in text-fig. 4.25.

and the variations in the proportions are shown on Table 5 below:

TABLE 5: Summary of statistical results of the shell length-muscle field length proportion of L.(L.) filosa from Woodbury Quarry, Usk and Ludlow:

Area	n	$\overline{Ls}$	$\overline{Lmf}$	r	S.D. (Ls)	S.D. (Lmf)	The equation	% $\overline{Lmf}/\overline{Ls}$
(WQ) Abberley Hills	11	13.955 (19.685)	4.255 (3.631)	0.819	4.23	1.817	Y= 1.9X + 5.8	31%
(LR) Usk	75	15.491 (26.821)	4.948 (2.547)	0.819	5.144	1.585	Y= 2.7X + 2.4	32%
Ludlow	28	13.439 (36.649)	5.036 (5.426)	0.910	5.95	2.287	Y= 2.4X + 1.5	37%

It will be noted that the proportion of the muscle field length to the shell length for both Woodbury Quarry and the Usk inlier specimens are nearly the same (31% and 32% respectively), while in the Ludlow specimens, the proportion is relatively longer (37%).

3. Dorsal valve muscle field.

The dorsal muscle field is strongly impressed and is truncated in its outline shape. It occupies a variable ratio (about ⅓-½) of the valve length (Pl.10, figs.1-6). The dorsal muscle scars are bounded laterally by parallel to divergent strong ridges (Pl.10, figs.6 and 5 respectively).

4. Socket plates.

These are a pair of outgrowths of the secondary shell, located in the postero-median region of the brachial valve (Pl.11, fig.2). They diverge at about 90°-125° and point antero-laterally from the cardinal process for less than ½ the shell width (Pl.10, figs.2,3,4,5, 6 and 8).

The most common shape among these plates is the bladed shape (Pl.10, figs.2,3,4 and 5). A very few specimens show an S-like shape which, after diverging antero-laterally as with the bladed shape, start to recurve again towards the hinge line (Pl.10, fig.6). Some other specimens show a pair of narrow and long auxiliary ridges which look like an extension to these socket plates. These ridges occur either parallel to the hinge line(Pl.10, figs.2a and 2b) or make an angle of about 15° to the hinge line (diverging antero-laterally) (Pl.10, figs. 3a,3b and Pl.11, fig.2). These structural features have not been described before in Leptostrophia filosa. It is also evident from the present study that these ridges are present only in large specimens. The function of these ridges will be discussed later in the palaeoecology section (Chapter 8). Harper and Boucot 1978, p.70 described such ridges in Mesoleptostrophia which differs from Leptostrophia in having unequally parvicostellate radial ornament.

C. Conclusion on variation.

In conclusion, the main aim in describing these variations was for comparisons between Ludlow, Woodbury Quarry and Usk specimens. The Usk specimens are larger than both Ludlow and Woodbury Quarry specimens, but of roughly similar shell proportions and are also of similar hinge line width ratio occupied by denticulations. Proportionally, Ludlow specimens have longer pedicle valve muscle fields than both Usk and Woodbury Quarry specimens. The pedicle valve muscle field ratio (Lmf/Wmf) for both Usk and Woodbury Quarry specimens is nearly the same, but Usk specimens have wider muscle fields than both the Ludlow and Woodbury Quarry specimens.

Therefore, the main differences between the populations of

L.(L.) filosa from these localities lie in the muscle development; i.e. the length to the width of the muscle field in both Usk and Woodbury Quarry specimens is 82% for n = 90, while in the Ludlow area it is 112% for n = 40. The significance of these differences will be discussed in Chapter 9.

CHAPTER FIVE

PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) LEPISMA (J. de C. SOWERBY, 1839)

CONTENTS

CHAPTER FIVE

PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) LEPISMA

5.1. INTRODUCTION.

This common Ludlow species is here described for the first time. For many years, members of the Ludlow Research Group have recorded it as Brachyprion sp.nov. whilst awaiting description, until Boucot and Harper in 1968 pointed out that it is a Pholidostrophia (Mesopholidostrophia). Its importance is indicated by its adoption by Watkins (1979) as the name fossil for one of his benthic associations. In addition to the description of the species, its variation has been thoroughly studied. The species is well preserved as moulds in the Ludlow rocks of the Welsh Borderland. Therefore, its external and internal morphological features can be very well illustrated. For example, the cardinal process, socket plates, chilidium, pseudodeltidium, ventral process, denticulation, pedicle interarea, pedicle and dorsal muscle fields and the faint radial ornament. In a few specimens, some discontinous striations, shaped like needles, appear on the external surface of the shell. These are most probably micro-tectonic structural features.

5.2. SPECIES DESCRIPTION.

Subfamily PHOLIDOSTROPHIINAE Stainbrook, 1943.

Genus PHOLIDOSTROPHIA Hall and Clark, 1893

Subgenus PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) Williams, 1950

5.2.1. Type species

Pholidostrophia (Mesopholidostrophia) nitens (Williams, 1950, p.280, figs.7-10) from the Mulde Beds (Wenlock) of Gotland, was designated by Williams as the type species of the subgenus *Pholidostrophia* (*Mesopholidostrophia*). Bassett and Cocks (1974, p.18) considered *Leptaena laevigata* (J. de C. Sowerby in Murchison, 1839, p.629, Pl.13, fig.3) from the Coalbrookdale Formation (Wenlock Shale) of Burrington, near Ludlow, to be a senior subjective synonym of *Pholidostrophia* (*Mesopholidostrophia*) *nitens* (Williams 1950). Thus *Leptaena laevigata* J. de C. Sowerby (which is now *Pholidostrophia* (*Mesopholidostrophia*) *laevigata* becomes the type species of the subgenus *Pholidostrophia* (*Mesopholidostrophia*).

PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) LEPISMA (J. de C. Sowerby 1839)

5.2.2. *Synonymy*.

1839 *Leptaena lepisma* J. de C. Sowerby in Murchison, p.618, Pl.8, fig.7.

1871 *Chonetes lepisma* (J. de C. Sowerby) Davidson, p.333, Pl.49, fig.14, non fig.13.

1963 *Brachyprion* sp.nov. Holland *et al* pp.110-112, Pl.4, fig.4, in the Silurian rocks of Ludlow district, Shropshire.

1968 *Pholidostrophia* (*Mesopholidostrophia*) *lepisma* (J. de C. Sowerby) Boucot and Harper, p.168.

5.2.3. *Lectotype*.

As the type specimen as the originally figured specimen of *Pholidostrophia* (*Mesopholidostrophia*) *lepisma* is lost, the lectotype, GSM

(Geological Society collection) 6638 was chosen by Cocks (1978). This specimen (GSM6638) was from "Aymestry" at Garden House Quarry, Herefordshire near Clungunford (Murchison, 1839, p.618 and Cocks, 1978, p.131). The lectotype is the external of a pedicle valve; it has been examined and refigured in this study (Pl.12, figs.2 and 3). The specimen was embedded in a calcareous siltstone rock and only the external shell surface of the convex pedicle valve is visible with a few extraneous punctures (Pl.12, fig.2).

The shell is small, convex, wider than long and semi-circular in outline shell shape. The hinge line is slightly shorter than the shell width but that is most probably because the ends of the straight hinge line (i.e. ears) are broken. Therefore some allowance has been made in the measurements for the missing ears. The measurement of the gross shell proportion (i.e. Ls/Ws) is about 71%, Ls = 7.5mm and Ws = 10.5mm. The external shell surface is nacreous and almost smooth but marked by a few very weakly developed fine concentric growth lines and faint external radial ornamentation.

The lectotype selected by Cocks (1978) was first described by J. de C. Sowerby in Murchison (1839, p.618, Pl.8, fig.7) as <u>Leptaena lepisma</u>. Davidson (1871, p.333, Pl.49, fig.14) mistakenly assigned the species to the genus <u>Chonetes</u> (see Discussion). Subsequently, the species was figured by Holland, Lawson and Walmsley (1963, Pl.4, figs. 4 & 5) from the Lower Bringewood Formation at Mary Knoll House, Ludlow, and the Usk inlier under the name of <u>Brachyprion</u> sp.nov. Harper (1968) examined Sowerby's specimen of Leptaena lepisma and decided that it was a Pholidostrophia (Mesopholidostrophia) Williams, 1950. Lawson (1973, p.274) studied the facies and faunal changes in the Ludlovian rocks of Amestrey and made collections from Garden House Quarry, the type locality for Pholidostrophia (Mesopholidostrophia) lepisma. However, he did not find any specimens of this. Consequently, the present extensive collections were made from the nearby Ludlow area, the Abberley Hills and the Usk inlier. The collections were made to provide sufficient material to carry out a statistical study of the variations in this species from different localities. The type specimen (GSM 6638), was re-examined and in terms of gross shell proportions clearly falls within the range of morphological variation of the specimens from Ludlow, Usk and the Abberley Hills. Furthermore, it is evident that the type specimen (which is refigured in Pl.12, figs. 2 & 3) has an outline, external shell features and convexity consistent with the range of variability shown by the other specimens collected during the present study. The faint external radial ornamentation becomes stronger at the valve margins in most of the specimens studied and this feature is also found in the type specimen. As with many specimens from Ludlow, Abberley Hills and Usk, the ornamentation of the type specimen is very weakly developed and can be easily overlooked. Boucot and Harper (1968) have also concluded that the Welsh Borderland specimens were most appropriately assigned to Pholidostrophia (Mesopholidostrophia) lepisma.

To more precisely define the species, much more information is required about the internal features of both brachial and pedicle valves. This cannot be obtained from the lectotype. Consequently, interior details are comprehensively illustrated in specimens from Ludlow, Abberley Hills and Usk (Pls.12-16).

5.2.4. Material.

Four hundred and eighty three specimens in personal collection and twenty specimens in the Lawson collection. The specimens occur as internal moulds of both pedicle and brachial valves, but the most common specimens occur as internal moulds of pedicle valve.

5.2.5. Horizons and localities.

The specimens were collected from the Ludlow Series of the Welsh Borderland (Ludlow, Woolhope and Abberley Hills). Some specimens were collected from the Lower Elton Formation, but the major collection is from the Lower Bringewood Formation where the species becomes abundant. A few other specimens were collected from the Upper Bringewood Formation.

5.2.6. Diagnosis.

Gently to strongly concavo-convex Pholidostrophia, semi-circular in outline, averaging 60% as long as wide, shell surface nacreous with a few radial ribs particularly at the shell margin, a few, faint concentric growth lines; internally with moderately developed subtriangular to triangular ventral muscle field averaging about 70% as long as wide; hinge line denticulation occupying an average of about 44% of the shell width with up to fifteen denticles on each side; well impressed socket plates and chilidium, valve floor with numerous tubercles up to 0.125mm in diameter.

5.2.7. Description.

Medium sized, semicircular, weakly to strongly concavo-convex Pholidostrophia; hinge line straight, widest point of the shell produced as fine mucronate ears, (Pl.13, figs. 1 & 3, 7 and 8); valves averaging 62% as long as wide in Ludlow area ((e.g. $\bar{L}$smm (var Ls) 6.119 (3.392), $\bar{W}$s (var Ws) 9.934 (10.757), r = 0.897, n = 306)), 59% as long as wide ((e.g. $\bar{L}$smm (var Ls) 5.785 (2.431), $\bar{W}$s (var Ws) 9.695 (7.188), r = 0.923, n = 20 (Locality W_1 in Woolhope inlier)) and 60% as long as wide in Woodbury Quarry in Abberley Hills ((e.g. $\bar{L}$smm (var Ls) 7.749 (2.539), $\bar{W}$s (var Ws) 12.746 (6.739), r = 0.859, n = 177)); lateral margins evenly curved anteriorly, anterior margin rounded, commissure smooth, rectimarginate; surface of shell nacreous, which when removed shows widely spaced, faint, fine, irregular parvicostellae with 3 to 4 rounded ribs per mm at 5 mm antero- medianly of dorsal hinge, most strongly developed at anterior margins, (see Pl.13, figs.2,3,6,9 and 11 and Pl.16, fig.1), very fine, faint concentric growth fila present; some specimens showing fine, short, oblique micro-structure striations along the postero-lateral margin of the hinge line; ventral interarea planar, weakly to moderately apsacline (see Pl.13, fig.10), up to two times as long as the dorsal interarea which is planar, anacline (Pl.14, figs. 4. and 7); delthyrial angle about 60°-70°; delthyrium small, closed by flat to gently convex apical pseudodeltidium, chilidium massive, convex, filling the notothyrium (Pl.16, fig.2).

Interior of pedicle valve with low ventral process, prolonged anteriorly as a very fine, rounded myophragm, bisecting muscle field longitudinally (Pl.13, figs.1,2,6 and 10), strong denticulation extending laterally in both valves (up to 15 denticles on each side) (Pl.13, figs.1,7,8 & 10; Pl.14, figs. 1,2 & 6 and Pl.15, fig.2) for an average of 45% of hinge width ((e.g. $\bar{W}$smm (var Ws) 9.789 (10.572), $\bar{W}$d (var Wd) 4.533 (2.929), r = 0.823, n = 57 (Ludlow)), and 44% in Woodbury Quarry in Abberley Hills ((e.g. $\bar{W}$smm (var Ws) 12.342 (5.697), $\bar{W}$dmm (var $\bar{W}$d) 5.442 (1.129, r = 0.779, n = 19)); pedicle muscle field moderately impressed, subtriangular to triangular in outline (Pl.13 and Pl.15, fig.1) averaging 70% as long as wide in Woodbury Quarry in Abberley Hills ((e.g. $\bar{L}$mfmm (var Lmf), 2.15 (0.41), $\bar{W}$mfmm (var Wmf) 3.075 (1.233), r = 0.853, n = 12)); muscles bounded laterally by weak to strong ridges, straight, divergent antero-laterally at: 55°-60°, 60°-65°, 65°-70° respectively in 12, 20, 19 (Ludlow specimens) and 7, 4, 3 specimens from Woodbury Quarry, dying out anteriorly, almost straight and in some specimens very faintly curved anteriorly to intersect myophragm and bound the pedicle muscle field anteriorly, bisected longitudinally by rounded myophragm, adductor scars subparallel to parallel, lanceolate, separated by rounded, narrow myophragm (Pl.13, figs. 6 & 10), averaging 69% as wide as long ((e.g. $\bar{L}$admm (var Lad) 1.3 (0.487), $\bar{W}$admm (var Wad) 0.9 (0.247), r = 0.875, n = 4)), about 20% as long as valve length and 10% as wide as valve width, enclosed by subtriangular to triangular diductor muscle field, averaging 29% as wide as valve width in

Ludlow ((e.g. $\overline{W}mf$ (var Wmf) 2.869 (0.698), $\overline{W}s$ (var Ws) 9.917 (9.36), r = 0.728, n = 54)) and 26% as wide as valve width ((e.g. $\overline{W}mf$ (var Wmf) 3.388 (1.093), $\overline{W}s$ (var Ws) 13.006 (7.294), r = 0.676, n = 16 (Woodbury Quarry in Abberley Hills)).

Brachial valve interior with narrow, conjunct, subparallel cardinal process lobes, pear-shaped in outline, postero-ventrally directed (Pl.14, figs.1a,1b,2 & 6 and Pl.15, fig.2), each bearing a groove on the distal face; socket small, socket ridges diverging antero-laterally at about 90^{o} - 140^{o} to one another (Pl.14, figs.1 & 2 and Pl.15, fig.2), dorsal adductor scars moderately impressed, occupying about one-third shell length, defined by lateral bounding ridges and subdivided medianly by low, rounded myophragm, elongate, oval to triangular in outline (Pl.15, fig.2).

Valve floors finely tuberculate being particularly well developed close to the muscle field, with average diameters of: 0.05, 0.075, 0.1, 0.125mm in 2, 10, 11 and 5 valves respectively (Ludlow and Abberley Hills), large diameter tubercles developed close to the muscle fields, becoming finer peripherally (Pl.13, fig.10 and Pl.15, figs.1 & 2).

5.2.8. Distribution.

The species is well distributed through the Ludlow Series of the Welsh Borderland, see distribution maps (text-figs. 1.5-1.7). It was first figured by J. de C. Sowerby in Murchison (1839) from the Lower Ludlow. Subsequently, Holland, Lawson and Walmsley (1963) figured this species from the Lower Bringewood Formation at Maryknoll House and the Usk inlier as Brachyprion sp.nov. Other Ludlow Research Group workers have recorded this species from many areas at the Welsh Borderland, such as Walmsley (1959) at Usk, Squirrell and Tucker (1960) at Woolhope, Shergold & Shirley (1968) at Much Wenlock, Lawson (1973) at Amestrey, Squirrell and White (1978) in the Towy Anticlinal area (Llandovery to Llandeilo) in Wales,...etc. During the present study, it was found that this species is fairly common in the Lower Elton Formation of the Ludlow area, becoming rare or absent throughout the Middle and Upper Elton Formations till it becomes common in the Lower Bringewood Formation of Ludlow, Woolhope and Abberley Hills. Therefore, the major collections have been made from this latter formation. Pholidostrophia (Mesopholidostrophia) lepisma is less common in the Upper Bringewood Formation where only a few specimens were collected. No collections have been made above the Upper Bringewood Formation because the species is unrecorded from the Ludfordian stage.

It has been collected during the present study from the following localities: 31, A3, A4, A5, A6, B4, B5, B6, B7, 7a, W1 and WQ (text-figs.2.1 & 2.3-2.5 and locality list in Appendix I). The other collection studied was made by Dr. J.D. Lawson from the Ludlow area.

5.2.9. Discussion.

A. Sub-generic assignment.

Harper, Johnson and Boucot (1967) erected a new genus known as Eopholidostrophia and drew attention to the fact that in this genus only three to five denticles occur on each denticular plate. Williams (1951), in his original description of the type species, observed that over twelve denticles occur on the denticular plates. Subsequently, Hurst (1974) considered this difference as an unreliable taxonomic character and he placed this genus as a subgenus within Pholidostrophia, following Williams (1953, pp.30-31).

Harper and Boucot (1978) recognised four taxa of subgeneric and generic rank: Eopholidostrophia; Pholidostrophia (Pholidostrophia); Pholidostrophia (Mesopholidostrophia) and Parapholidostrophia. They defined Eopholidostrophia by its unequally parvicostellate ribbing, its socket plates, obscured brachial valve muscle field and small number of denticles. The authors described Pholidostrophia as commonly having a nacreous shell with or without faint radial ornament, ½ to ⅔ of the hinge line is denticulate and the brachial valve has two pairs of adductor scars which are commonly defined by ridges and are bisected by a medium septum. Within Pholidostrophia, however, forms with socket plates were placed in Pholidostrophia (Mesopholidostrophia) and those lacking socket plates were included in Pholidostrophia (Pholidostrophia). Harper and Boucot also recognised Parapholidostrophia (Johnson, 1971) with its unequally parvicostellate ribbing and with a brachial valve interior as that in Pholidostrophia (Mesopholidostrophia) except that its socket plates are fused to the cardinal process lobes.

Consequently, Pholidostrophia (Mesopholidostrophia) Williams 1950 is restricted to include forms possessing an incompletely developed pseudodeltidium, prominent chilidium, cardinal process conjunct to disjunct socket plates and variably defined muscle scars. Pholidostrophia (Pholidostrophia) Hall and Clarke 1892 differs from Pholidostrophia (Mesopholidostrophia) in having a smooth and complete pseudodeltidium, no chilidium, a highly disjunct cardinal process, no socket plates and well-defined muscle scars (Williams, 1950; 1953; 1965); see Table below:

Morphological features / Subgeneric & generic rank	Ribs	Socket plates	Chilidium	Pseudodeltidium	Muscle scars	Cardinal process	Denticles
Eopholidostrophia Harper, Johnson & Boucot, 1967	unequally parvi-costellate	present	convex		obscure		3-5 on each denticular plate
Parapholidostrophia Johnson, 1971	unequally parvi-costellate	present, but fused with the cardinal process lobes	flat		strongly impressed		very few in number
Pholidostrophia (_Pholidostrophia_) Hall & Clarke, 1892	present	not present	not present	complete	well-defined	highly disjunct	present
Pholidostrophia (_Mesopholidostrophia_) Williams, 1950	smooth or very faintly parvi-costellate	present	convex	incom-pletely developed	variably defined and well impressed	conjunct to dis-conjunct	12 on each side
Pholidostrophia (_Mesopholidostrophia_) _lepisma_ (J. de C. Sowerby, 1839)	smooth or faintly parvi-costellate peripherally	present	convex	incom-pletely developed	well impressed	conjunct	15 on each side

The present study confirms that the characteristics of the species lepisma (i.e. prominent convex chilidium, presence of a cardinal process and socket plates, variably-defined muscle scars and an incompletely developed pseudodeltidium) resemble most of those of the subgenus Pholidostrophia (Mesopholidostrophia). Therefore, the species lepisma is assigned to Pholidostrophia (Mesopholidostrophia).

B. Species name.

Pholidostrophia (Mesopholidostrophia) lepisma was first described by J. de C. Sowerby as Leptaena lepisma (1839, p.618, Pl.8, fig.7). Davidson (1871, p.333, Pl.49, fig.14) had incorrectly assigned Sowerby's lepisma to Chonetes. Holland, Lawson and Walmsley (1963, Pl.4, fig.4) figured this species as Brachyprion sp.nov. Subsequently, Boucot and Harper (1968) considered Leptaena lepisma (J. de C. Sowerby, 1839) to belong to Pholidostrophia (Mesopholidostrophia) Williams, 1950, and proposed the name Shagamella ludloviensis for the small chonetid species which had been known incorrectly by Davidson (1871) as Chonetes lepisma as well as in the publications of the Ludlow Research Group (e.g. Holland et al 1963, Pl.5, fig.1). However, Shagamella ludloviensis possesses spines along the hinge line whereas they are missing in Sowerby's species Leptaena lepisma. Recently, Cocks (1978, p.135) decided that Shagamella ludloviensis Boucot and Harper (1968) is a junior synonym of Shagamella minor (Salter 1848).

C. Species comparison.

A comparison between Pholidostrophia (Mesopholidostrophia) lepisma and Pholidostrophia (Mesopholidostrophia) nitens has been made. The study shows that these two species are similar in some of the external and internal shell features but mostly differ from each other in the following aspects:

Species / Morphological features	P.(M.) lepisma	P.(M.) nitens
Radial ornament (ribs)	faint to moderate	smooth
Ventral process	moderately developed	faintly developed
Diductor scars	triangular	subcircular
Adductor scars	triangular	subquadrate

Furthermore, the variability in the gross shell proportion for nitens was derived by using Williams' (1950) shell length and width measurements. The variation ranges between 50 to 90% which is similar to that calculated for lepisma (40 to 90%). Therefore, nitens and lepisma display a wide range of variation in both the shell shape and proportions.

Bassett (1971, pp.330-331) suggested the possibility that nitens Williams from Scandinavia was conspecific with the shell described by J. de C. Sowerby (1839, p.39 and p.629) as Leptaena laevigata from Britain. However, due to lack of material, he was unable to compare Laptaena laevigata and Pholidostrophia (Mesopholidostrophia) nitens in detail. Subsequently, Bassett and Cocks (1974) formally considered Leptaena laevigata as a senior synonym of Pholidostrophia (Mesopholidostrophia) nitens. Thus Pholidostrophia (Mesopholidostrophia) laevigata becomes the type species of subgenus.

The results of the writer's study of a large number of _lepisma_ species from the Ludlow Series, indicate that the species probably displays the same diagnostic features attributed to _Pholidostrophia_ (_Mesopholidostrophia_) _salopiensis johnsoni_ (Hurst 1974) from the Lower Wenlock of the Welsh Borderland. For example, _johnsoni_ (Hurst's subspecies) is moderately to strongly concavo-convex with a faint radial ornament and the denticulation occupies an average of 47% of the hinge width. It is also characterised by up to 12 denticles on each side; while the denticulation of _lepisma_ measured in the Ludlow specimens occupies an average of 45% of the hinge width with up to 15 denticles on each side.

In effect the statistical analyses of several hundred specimens of _lepisma_ reveals a range of morphological features which have previously been used to differentiate additional species and sub-species in other areas. Such a conclusion can be anticipated when large numbers of a considerably subdivided but morphologically conservative species become available for study. Some previous studies had been based on very few specimens.

Many of the _lepisma_ features are shared by _Pholidostrophia_ (_Mesopholidostrophia_) _deflecta_ (Bassett 1971) and _Pholidostrophia_ (_Mesopholidostrophia_) _salopiensis_ (Cocks 1967) from Britain. The variability of development of the muscle bounding ridges within the Ludlow specimens suggests that this characteristic is a poor taxonomic indicator. In addition, the overall shell shape and proportions, and the presence or absence of faint peripheral ornamentation are factors likely to be considerably affected by environmental conditions. The variations in this species are discussed in the next section (5.3).

5.3. DESCRIPTION OF VARIATION.

A. External shell features.

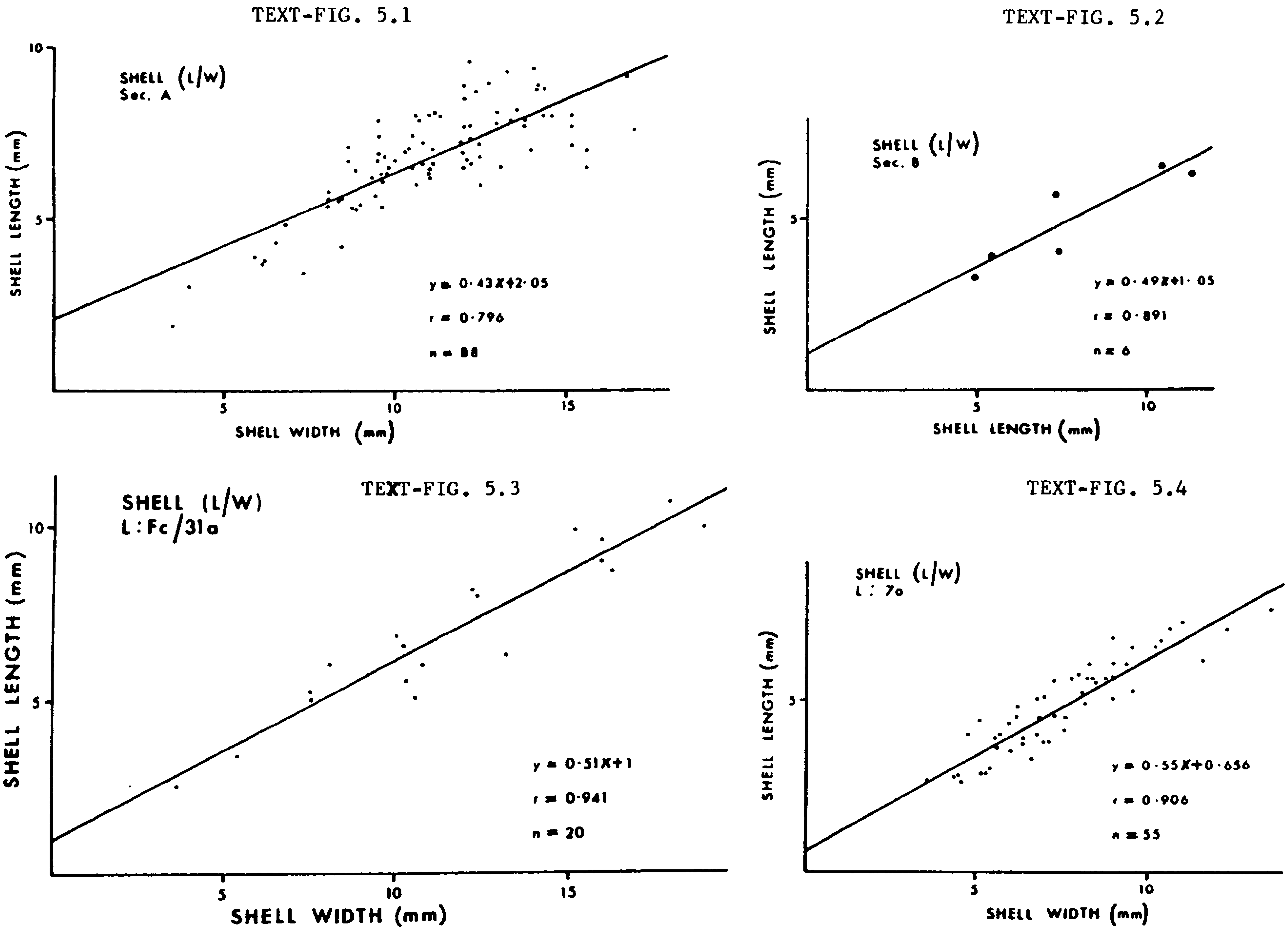
1. Shell proportions.

P. (M.) lepisma is semicircular in shell outline and gently concavo-convex (Pl.13 & Pl.16). The widest point of the shell is at the hinge line. P.(M.) lepisma has been studied from many localities in the Welsh Borderland particularly near Ludlow, the Woolhope inlier and the Abberley Hills areas (see Table 2). Specimens from each of these localities provided an opportunity to study the variation in shell shape statistically. Five localities have been studied near Ludlow and about three hundred and twenty specimens collected, showing approximately the same gross shell length-width proportion.

The summary of statistical results of the shell proportions for localities near Ludlow are shown in Table 1 below and are also displayed graphically in text-figs. 5.1 - 5.5.

TABLE 1: Shell proportion results of P.(M.) lepisma from localities near Ludlow area:

Loc	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
7a	55	4.804 (1.667)	7.527 (4.508)	0.906	1.279	2.104	Y=0.55X + 0.66	64%
31	131	6.295 (3.061)	10.309 (9.849)	0.876	1.743	3.126	Y=0.48X + 1.25	61%
Sec. A	88	6.823 (2.194)	11.026 (7.442)	0.796	1.473	2.712	Y=0.43X + 2.05	62%
Sec. B	6	4.933 (1.971)	7.816 (6.326)	0.891	1.281	2.295	Y=0.49X + 1.05	63%
Fc/31a	20	6.97 (5.097)	11.71 (17.359)	0.941	2.20	4.06	Y=0.51X + 1	60%



TEXT-FIGS. 5.1-5.4. Shell length-width distribution of P.(M.)lepisma in four different localities in the Ludlow area.

After studying these localities (listed on Table 1 above) near Ludlow, it was evident that the slopes of the best fit lines for these localities are nearly the same. Therefore, the total collections from these five localities are treated as only one unit called the Ludlow area collection.

Subsequently, more specimens were collected and studied statistically from the Woolhope inlier (L.W_1) and the Abberley Hills (L.WQ). The variation in the shell proportions for these three areas (Ludlow, Woolhope and Abberley Hills) is shown in Table 2 and is also displayed graphically in text-figs. 5.6-5.8.

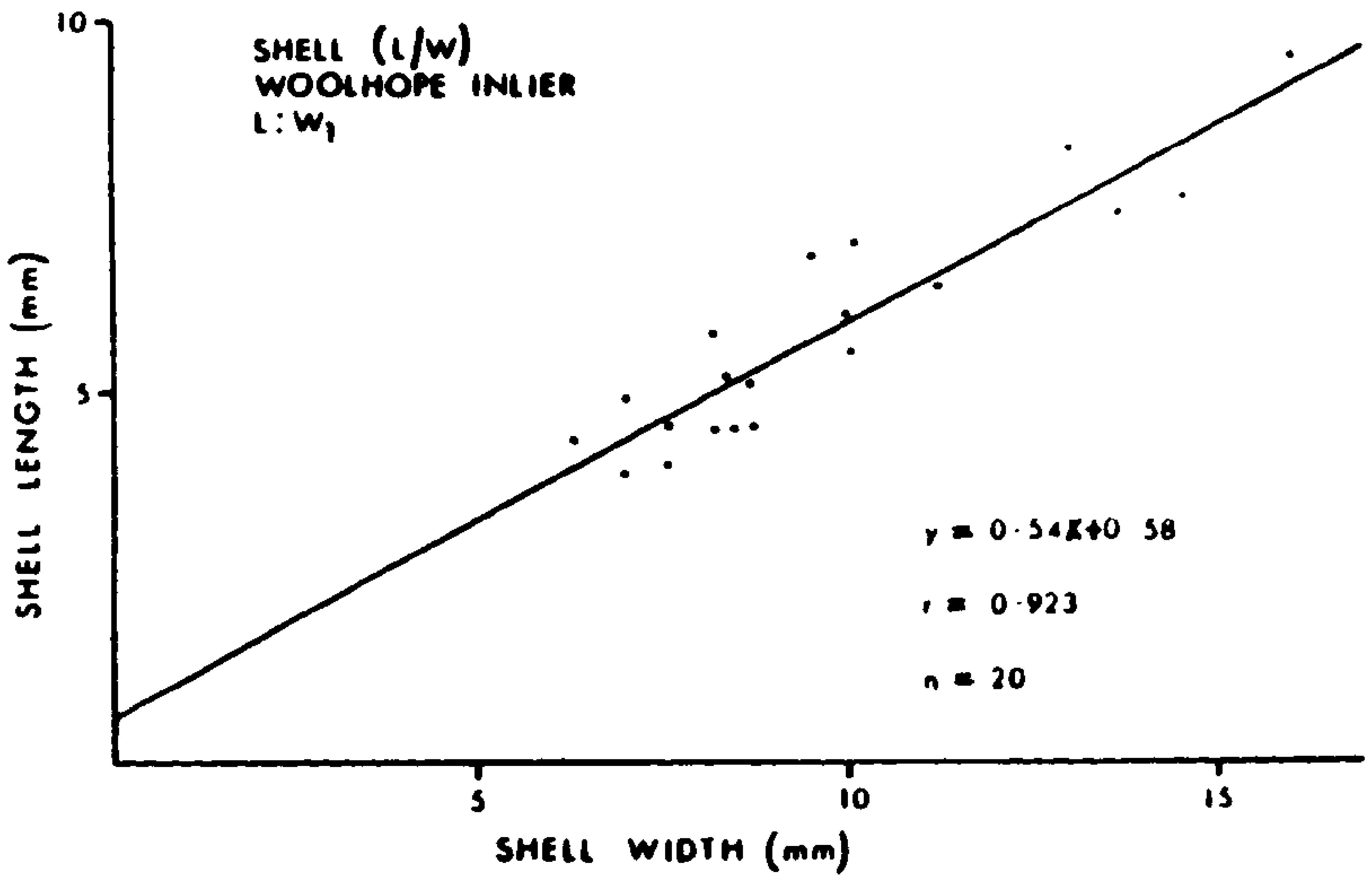
TABLE 2. Summary of statistical results of the shell proportions of *P.*(*M.*) *lepisma* from Ludlow, Woolhope and Abberley Hills:

Locality	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	equation	% $\bar{Ls}/\bar{Ws}$
Ludlow area collection	306	6.119 (3.392)	9.934 (10.757)	0.897	1.839	3.274	Y=0.5X + 1.116	62%
Woolhope inlier (W_1)	20	5.785 (2.431)	9.695 (7.118)	0.923	1.519	2.613	Y=0.54X + 0.58	60%
Abberley Hills (WQ)	177	7.749 (2.539)	12.746 (6.739)	0.859	1.589	2.589	Y=0.53X + 1.03	61%

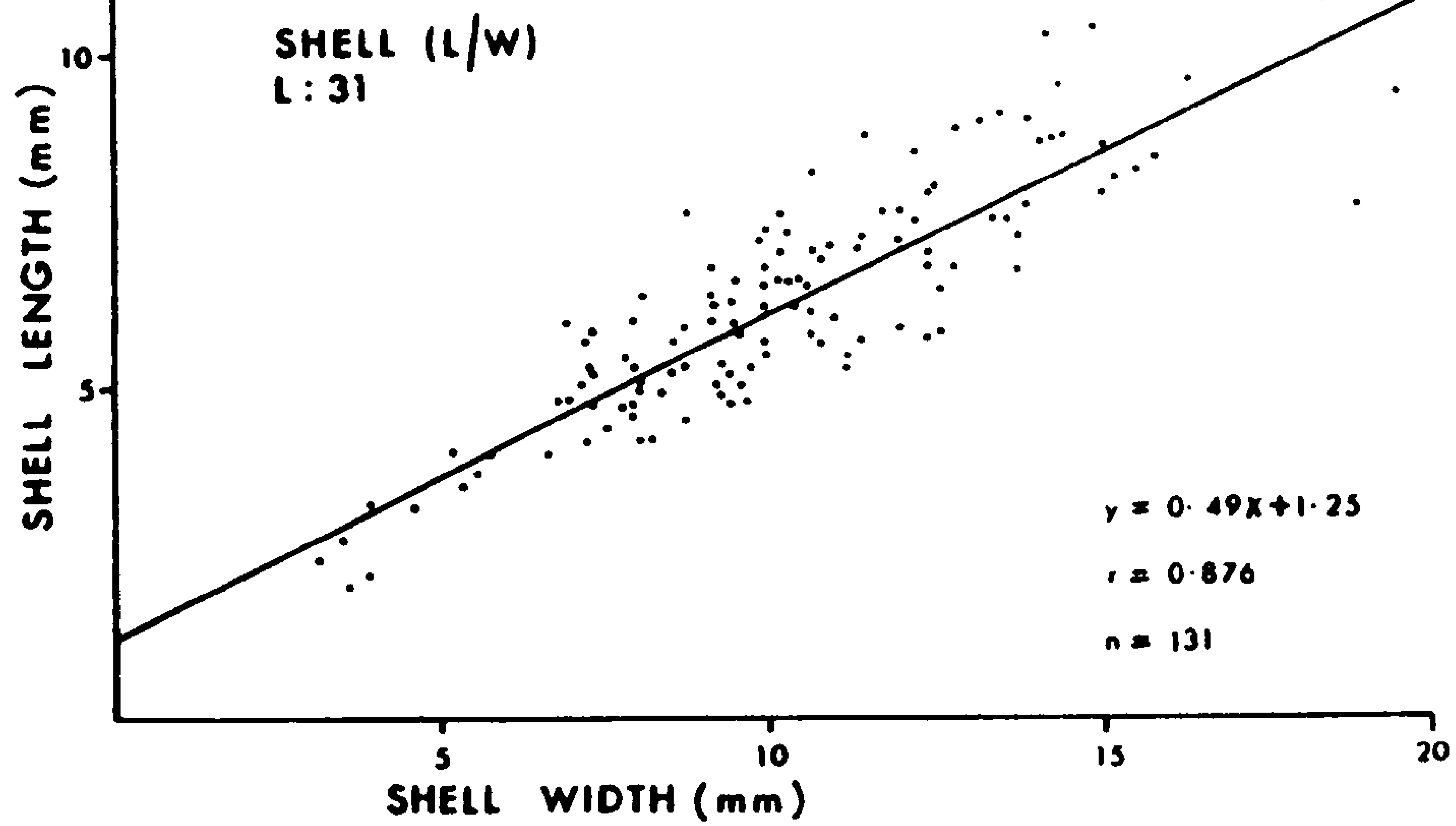
It is evident from Table 2 above that the high value of the coefficient of correlation (r) in all three areas demonstrates that the shell length and shell width increase in direct proportion to each other.

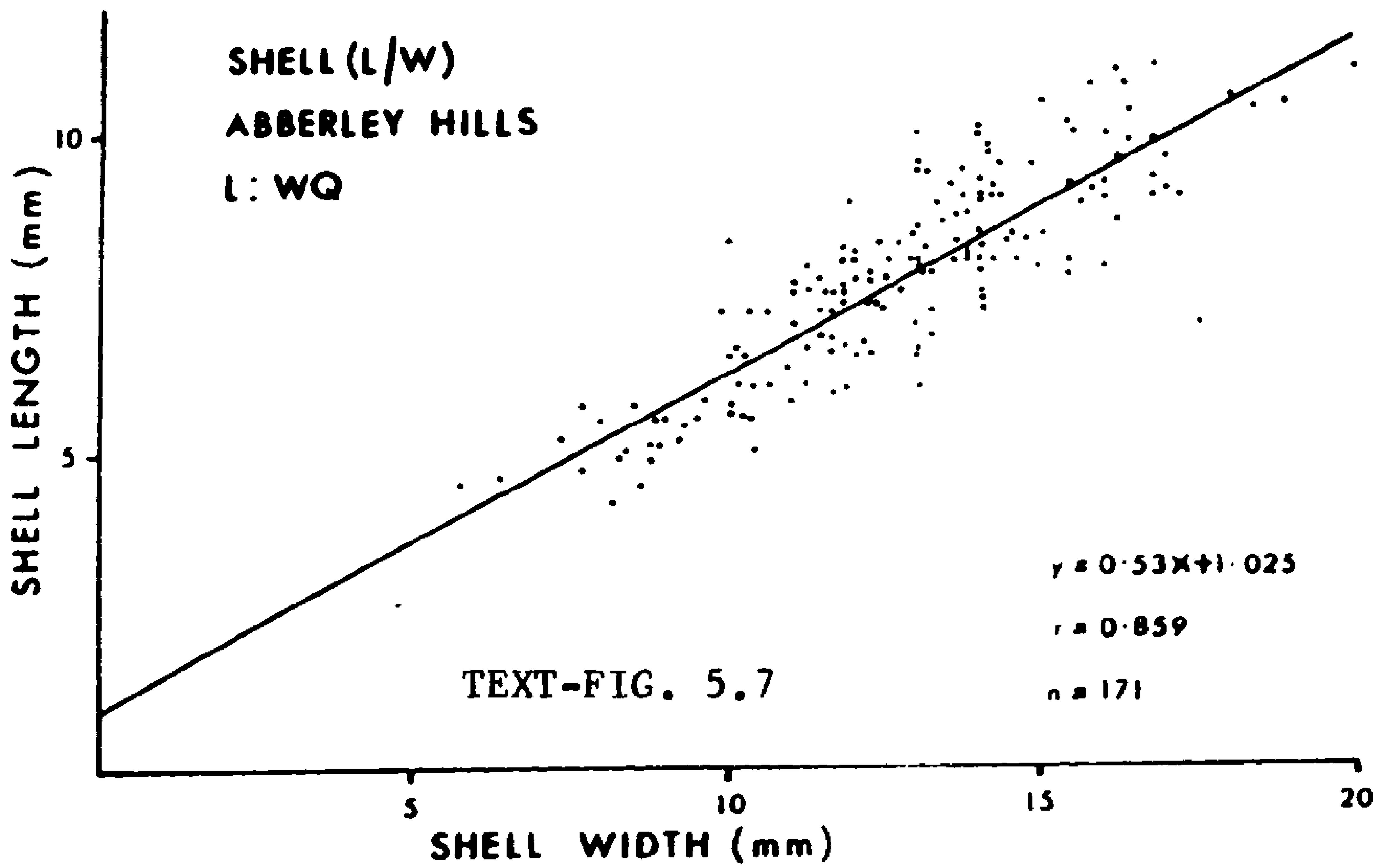
The ratio of the shell proportion (Ls/Ws) shown on Table 2 for Ludlow, Woolhope and Abberley specimens is nearly identical

TEXT-FIG. 5.5

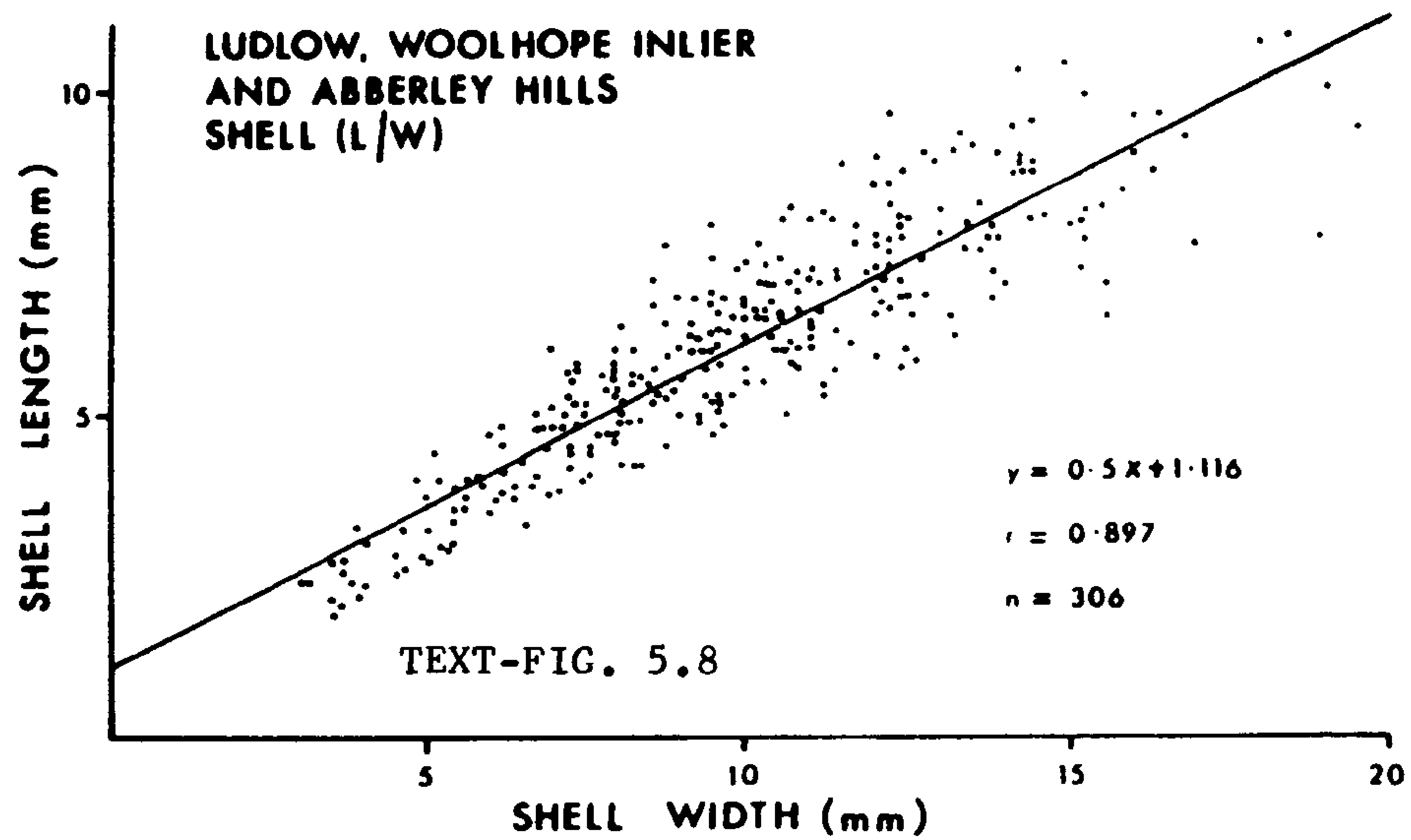


TEXT-FIG. 5.6





TEXT-FIG. 5.7



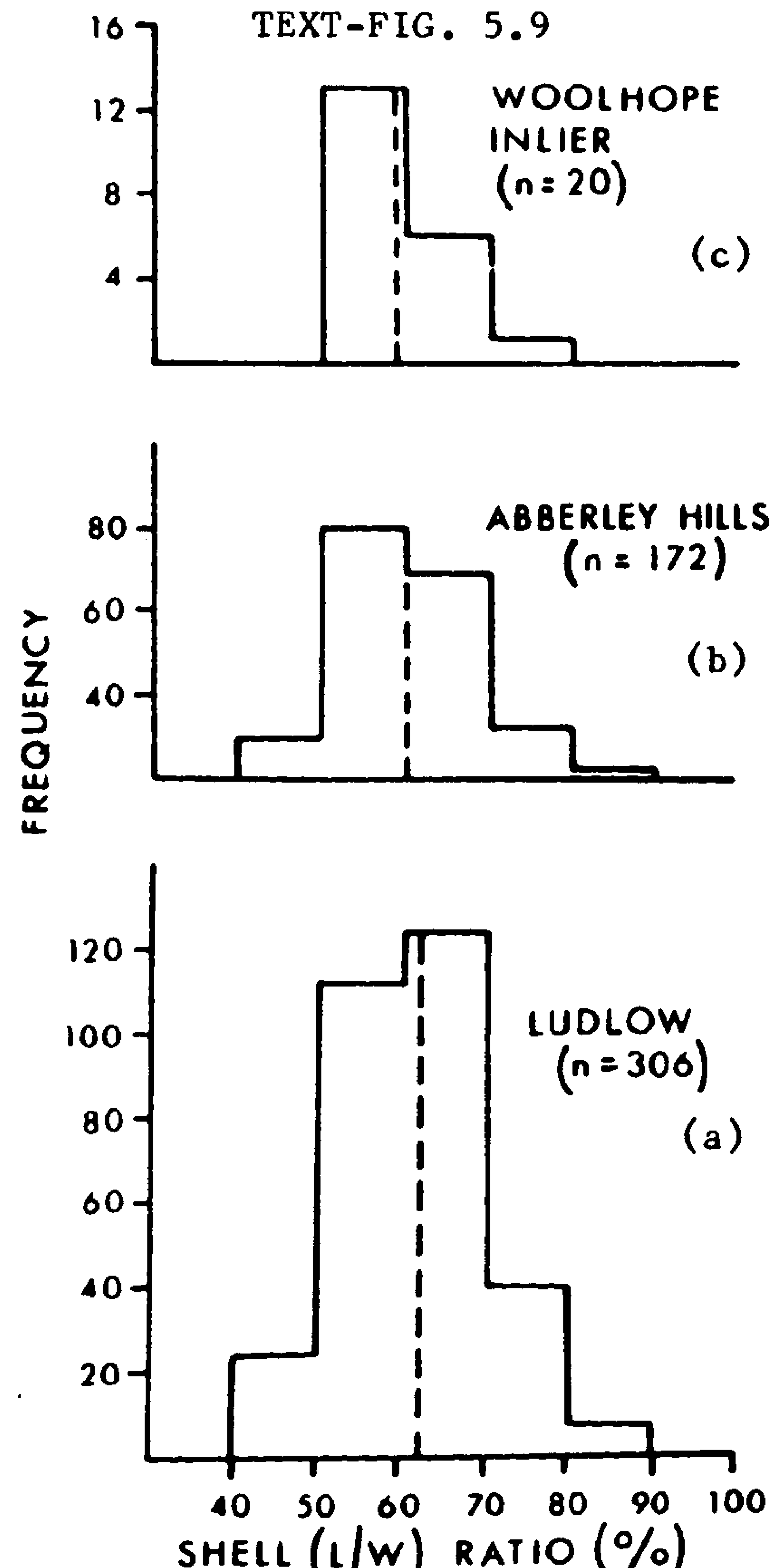
TEXT-FIG. 5.8

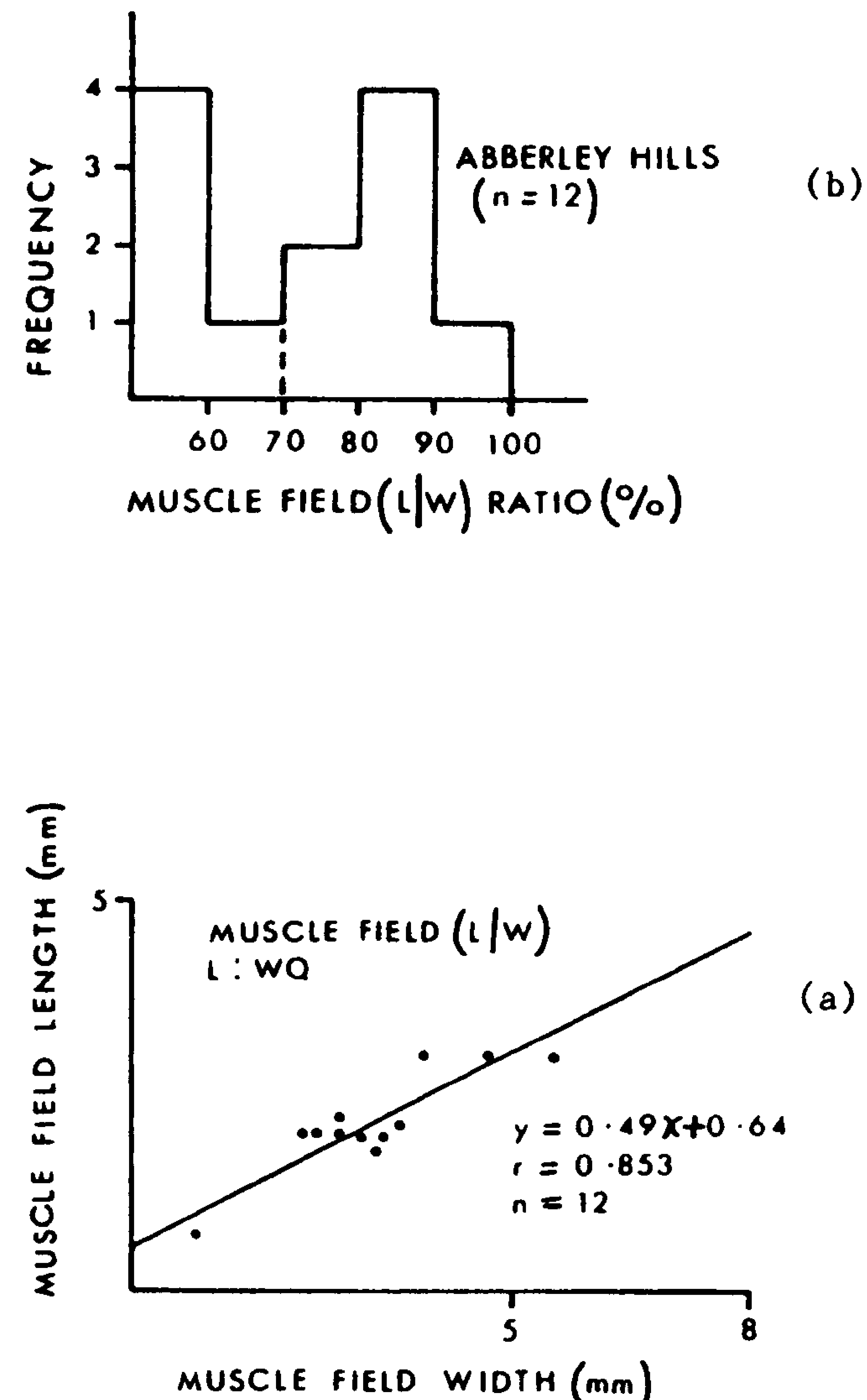
TEXT-FIGS. 5.5-5.7. Shell length-width distribution of P.(M.)lepisma from Woolhope, Ludlow (L.13) and Abberley Hills (L.WQ) respectively, with their combined plot in text-fig. 5.8.

except that the Abberley Hills specimens are larger in both shell length and shell width than the Woolhope and Ludlow specimens, but still have the same shell proportions as the Ludlow and Woolhope specimens (see text-figs. 5.9a,b & c); for example, the average mean of the shell length and shell width for the Ludlow area collection are 6.1, 9.9 respectively for n = 306, while in the Abberley Hills specimens are 7.7, 12.7 respectively for n = 177. The largeness of shell in the Abberley specimens is likely to be related to environmental factors such as, food supply, oxygen etc. (see section III).

2. Ornamentation.

P.(M.) lepisma has often been considered to be smooth as its radial ornament (costellae) is delicate. This ornament is unequally parvicostellate particularly at the shell margins with 3 to 4 fine-rounded ribs per mm. These costellae develop on the external surfaces of both valves and they are straight along the mid line of the shell, with gentle lateral curvature towards the margins (Pl.13, figs.1,2,4,9,11 and Pl.16, fig.1). In most of the specimens studied, the radial ornament is strongly developed at the anterior and lateral margins of the shell (see Pl.13 figs.4,7 and Pl.14, fig.9). Other specimens have a smooth shell, lacking any radial ornament (Pl.14, figs.3a,3b,7,8; Pl.13, figs.6,8,10 and Pl.16, fig.2). A few other specimens show up to two faint concentric fila (growth lines) which develop postero-laterally of the hinge line (Pl.16,fig.1). The radial ornament in lepisma species is considered in the present study as an important external feature in distinguishing lepisma (Ludlow) from laevigata (Wenlock) as the radial ornament is lacking in the latter.





TEXT-FIG.5.9. Shell length-width ratio frequency histograms of P.(M.) lepisma from a) Ludlow, b) Abberley Hills and c) Woolhope inlier.

TEXT-FIG.5.10. a) Muscle field length-width distribution for P.(M.) lepisma in Abberley Hills and b) the ratio frequency histogram.

B. Internal shell features.

1. Denticulation.

As discussed in the previous Chapter, denticles developed as small sharp ridges along part of the hinge line, (Pl.13 figs.1,7,8, 10; Pl.14, figs.1,2 and Pl.15, fig.2) which act as an interlocking system in all the stropheodontids (Williams, 1953).

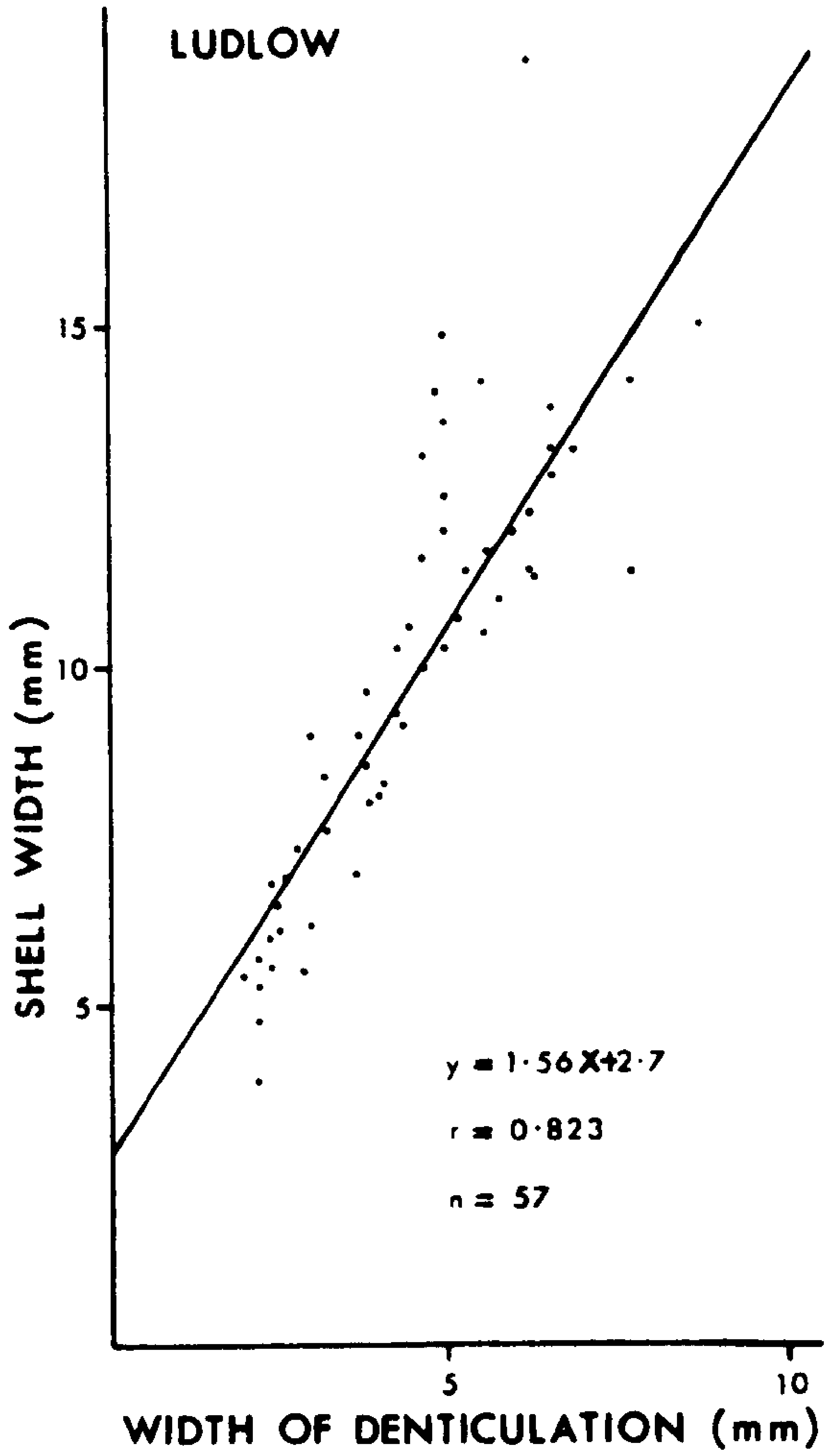
In P.(M.) lepisma strong denticulation extends laterally along the hinge line for nearly the same proportions of the hinge width in different geographical areas (see Table 3 below and text-figs.5.11-5.13).

TABLE 3: Summary of statistical results for denticulation of P.(M.) lepisma from Ludlow, Woolhope and Abberley Hills.

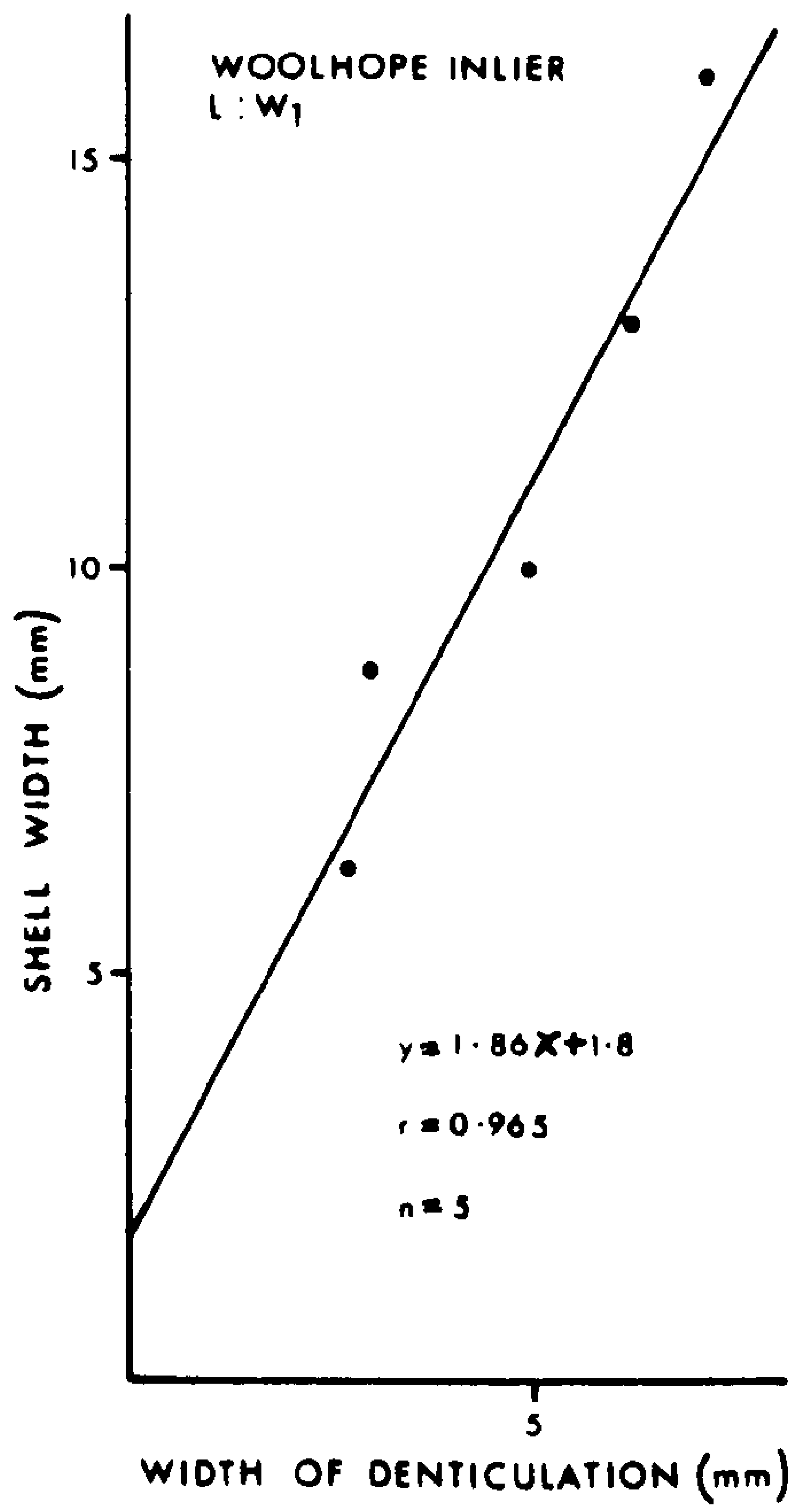
Locality	n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (Ws)	S.D. (Wd)	equation	% $\overline{Wd}/\overline{Ws}$
Ludlow area	57	9.789 (10.572)	4.533 (2.929)	0.823	3.223	1.697	Y=1.56X + 2.7	45%
Woolhope inlier	5	10.8 (14.295)	4.82 (3.852)	0.966	3.382	1.755	Y=1.86X + 1.8	44%
Abberley Hills	19	12.342 (5.697)	5.442 (1.129)	0.779	2.323	1.034	Y=1.75X	43%

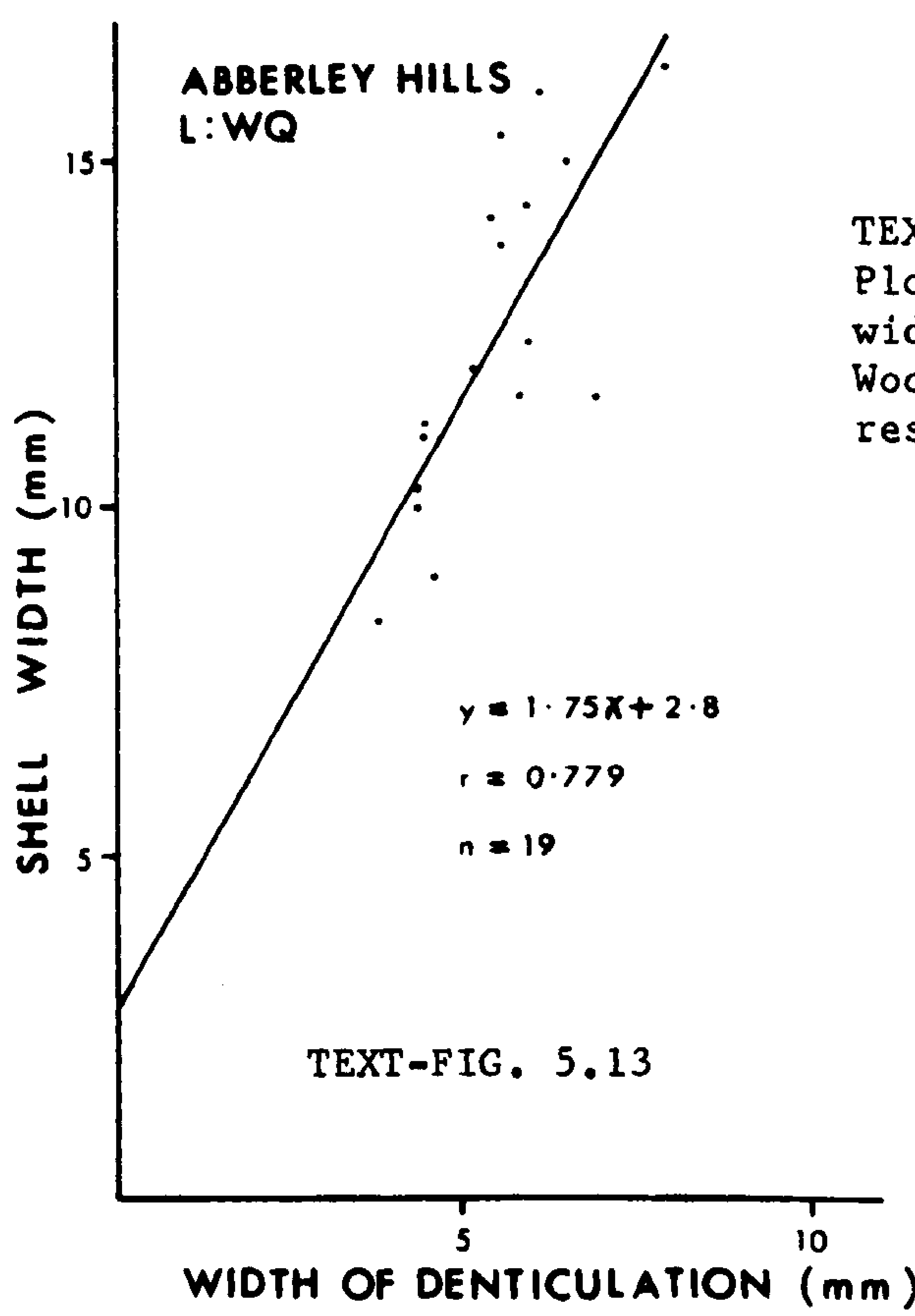
From Table 3 above, it is evident that the width of denticulations occupied by the hinge width in all three samples (Ludlow, Woolhope and Abberley) is nearly similar. It is also evident from the text-figs.5.11-5.13 that the width of the hinge line denticulation increases in direct proportion to the shell width at all three localities. As discussed before in the shell proportions, the Abberley Hills specimens are larger than both Ludlow and Woolhope specimens but they still show the same proportion of the hinge width occupied by denticulations. The significance of these features will be discussed later in the palaeoecology section.

TEXT-FIG. 5.11



TEXT-FIG. 5.12





TEXT-FIG. 5.13

TEXT-FIGS. 5.11-5.13
Plots of shell width against width of denticulation in Ludlow, Woolhope and Abberley Hills respectively.

2. Pedicle valve muscle field.

In P.(M.) lepisma, the pedicle valve muscle field in most of the specimens is triangular in outline (Pl.13 and Pl.15,fig.1). The muscle fields are strongly impressed postero-medianly on the interior of the pedicle valve as a pair of narrow and subparallel to parallel lanceolate adductor muscle scars which are separated by a narrow myophragm (Pl.13,figs.1,6 & 10). The mean of the adductor muscle scar proportion is 69%, as wide as long, and occupying about 20% of the shell length and 10% of the shell width. The adductor muscle scars are enclosed by a pair of triangular diductor muscle scars which are bounded by moderate to strong ridges making an average angle of 55°-70°. The muscle bounding ridges die out anteriorly and do not bound the muscle field anteriorly in most of the specimens studied (Pl.13 and Pl.15, fig.1). The statistics of the muscle field proportions from Woodbury Quarry in Abberley Hills are shown on Table 4 below and are also displayed graphically in text-fig. 5.10a. The percentage ratio of the muscle field proportions are also displayed in a size frequency histogram, text-fig. 5.10b.

TABLE 4: Summary of statistical results of muscle field proportions of P.(M.) lepisma from Abberley Hills.

Locality	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	equation	% $\bar{L}mf/\bar{W}mf$
Abberley Hills	12	3.15 (0.41)	3.075 (1.233)	0.853	0.013	1.063	Y=049X + 0.637	70%

It is evident from the text-fig.5.10 that the length of the muscle field increases in direct proportion to its width. From Table 4 above the ratio of the muscle field length to the muscle field width is 70% (as long as wide). Some more measurement has been done on specimens from Ludlow and Woolhope, but they are not significant for statistical studies. The difficulty in measuring these specimens is either because they are moulds and strongly concavo-convex or have faint muscle bounding ridges. By looking to the specimens from these two areas (Ludlow and Woolhope) and measuring some of them, it is evident that these specimens have approximately the same muscle field proportions as the Abberley Hills specimens.

The dorsal muscle field is moderately to strongly impressed and is truncated and subtriangular to triangular in outline shape (Pl.14, figs. 1a,1b,2,3 and Pl.15, fig.2), occupying about $\frac{1}{2}$ - $\frac{1}{3}$ of the valve length. The dorsal muscle field is bounded laterally by divergent strong ridges making an angle of about 50° - 70° (Pl.14, figs.1a,10 and Pl.15, fig.2).

3. Socket plates.

These are a pair of outgrowths of the secondary shell located in the postero-median region of the brachial valve and extend antero-laterally from the cardinal process for about 1/10 - 1/20 of the hinge width. They diverge at an average angle ranging between 90° and 140° (Pl.14, figs.1a,1b,2,6 and Pl.15, fig.2).

There is not much difference or variation seen in the shape of the socket plates of the *P.*(*M.*) *lepisma* except in the angle of divergence. The most common shape among the specimens studied is the bladed shape with an average angle of divergence (90° - 110°) (see Pl.15, fig.2).

4. Interior valve floors.

The valve floors of both the pedicle and brachial valves are finely to coarsely tuberculate. The coarse tubercles are well developed around the muscle fields of both valves, becoming finer (i.e. smaller in diameter) laterally and near the shell margins (i.e. the diameter of these pits reduced peripherally) in most of the studied specimens (Pl.15, figs.1 & 2). In some other specimens, the whole valve floor is tuberculate with nearly the same diameter of pits (Pl.13, fig.10). The average diameter of these tubercles is ranged between 0.05 - 0.125mm; however, the mean diameter falls between 0.075 - 0.1mm.

C. Conclusion on variations.

In conclusion, the main aim in describing these variations is to compare collections from the Ludlow area, the Woolhope inlier and Woodbury Quarry in the Abberley Hills. The shell length-width proportions in the three samples studied are nearly similar except that the Abberley Hills specimens are larger than both the Ludlow and Woolhope specimens (Table 2), but they still have the same gross shell proportions and have nearly the same ratio of denticulations occupied by the hinge line.

Therefore, the main difference between these three samples (Ludlow, Woolhope and Abberley Hills) lies in the largeness of the Abberley Hills specimens which will be discussed later in Chapters 8 and 9. There is no significant variation seen in this species from other localities of the Welsh Borderland but the collections from these localities are not adequate for statistical analyses.

CHAPTER SIX

AMPHISTROPHIA (AMPHISTROPHIA) FUNICULATA (McCOY, 1846)

CHAPTER SIX

AMPHISTROPHIA (AMPHISTROPHIA) FUNICULATA (McCOY,1846)

INTRODUCTION

6.1.

Amphistrophia funiculata is a resupinate stropheodontid species, as in Strophonella euglypha, but has a wider shell, smaller size and equally parvicostellate ornament. The species is characterised by subequally to equally parvicostellate radial ornament and a distinctive bilobed to subtriangular scar in the more commonly found pedicle valve. It is a common species in the Wenlock and Ludlow rocks of the shelf facies in the Welsh Borderland. The Wenlock form has been adequately described by Bassett (1971, 1977). In this work a large number of Ludlovian specimens has been studied statistically in order to describe fully the range of variation of the species. Wenlock specimens from Britain and Sweden have also been studied and compared statistically with the Ludlow forms to relate the differences to evolution or ecology. Moreover, some previously undescribed and better seen morphological features are observed and illustrated in this Chapter.

6.2. SPECIES DESCRIPTION.

Subfamily DOUVILLININAE Caster 1939.

Genus AMPHISTROPHIA Hall and Clarke 1892.

Subgenus AMPHISTROPHIA (AMPHISTROPHIA) Hall and Clarke 1892.

6.2.1. Type Species.

Strophomena striata Hall, 1843, p.104, fig.3, and illustration Pl.12, No.3; from the Silurian ('Niagara Group', Wenlock-Ludlow) of Lockport and Rochester, New York State, U.S.A. By original designation of Hall and Clarke 1893, p.292.

AMPHISTROPHIA (AMPHISTROPHIA) FUNICULATA (McCOY, 1846); see Pls.17-26.

6.2.2. Synonymy.

1846 *Orthis funiculata* McCoy, p.30, Pl.3, fig.11.

1847 *Leptaena funiculata* (McCoy) Davidson, p.57, Pl.12, figs.5-8.

1848 *Leptaena funiculata* (McCoy) Davidson, p.317, Pl.3, fig.5.

1852 *Leptaena* (*Strophomena*) *funiculata* (McCoy) McCoy, p.244.

1871 *Strophomena funiculata* (McCoy); Davidson , p.290, Pl.40, figs. 9-13.

1884 *Strophomena funiculata* (McCoy); La Touche, p.70, Pl.13, figs. 398-400.

1953b *Amphistrophia* aff. *funiculata* (McCoy); Williams, Pl.12, figs. 7, 8.

1971 *Amphistrophia* (*Amphistrophia*) *funiculata* (McCoy) Bassett, p.321, Pl.58, figs.5-16.

1972 *Amphistrophia funiculata* (McCoy); Curtis, Pl.2, fig.J.

1974 *Amphistrophia funiculata* (McCoy); Bassett and Cocks, p.16.

1977 *Amphistrophia* (*Amphistrophia*) *funiculata* (McCoy); Bassett, p.150, Pl.41, figs.1-12; Pl.42, figs.1-5.

1978 *Amphistrophiella* (*Amphistrophiella*) *funiculata* (McCoy) Harper and Boucot, p.157, Pl.33, figs.21-26, 29-30.

6.2.3. Lectotype.

National Museum of Ireland No. III 11, external mould of pedicle valve; from Doonquin, Dingle peninsula, Co. Kerry, Ireland; selected and figured Bassett 1971, p.323, Pl.58, fig.9; figured McCoy 1846, Pl.3, fig.11.

6.2.4. Material.

About one hundred and thirty specimens in the author's collection from the Ludlow area, Woodbury Quarry in the Abberley Hills and the Usk inlier of the Welsh Borderland; thirty seven specimens in the Lawson collection from the Usk inlier and nine specimens from the Ludlow Museum collections. These specimens occurred as internal and external moulds of both pedicle and brachial valves, but the most common specimens are those which occur as internal moulds of the pedicle valve (see Chapter 9). However, the description is based on these collections (i.e. from the Ludlow Series only).

6.2.5. Horizons and localities.

The majority of specimens come from the Lower and Upper Bringewood Formations of the Ludlow, Abberley Hills and Usk areas but some have also been collected from the Lower Elton Formation near Ludlow.

6.2.6. Diagnosis.

Medium sized, convexi-concave, gently to strongly sulcate, *Amphistrophia*, about 56% as long as wide and internally with ventral muscle fields averaging 92% as long as wide; hinge line denticulations occupying an average 42% of shell width.

6.2.7. Description.

Medium-sized, *Amphistrophia*, plano-convex to weakly concavo-convex posteriorly, becoming strongly convexi-concave at about ¾ of maximum length; maximum width at straight hinge line (see Pl.20, fig.3); valves averaging 56% as long as wide ((e.g. $\bar{L}$smm (var Ls) 9.952 (13.746), $\bar{W}$smm (Var Ws) 17.036 (14.799), r = 0.858, n = 80 (Ludlow); $\bar{L}$smm (var Ls) 9.327 (1.212), Wsmm ($\bar{V}$ar Ws) 17.234 (9.98), r = 0.714, n = 44 (from Woodbury Quarry in the Abberley Hills) and $\bar{L}$smm (var Ls) 9.543 (2.506), $\bar{W}$s (var Ws) 16.981 (10.286), r = 831, n = 37 (from various localities in the Usk inlier)); lateral margins evenly rounded, anterior margin curved, commissures crenulate, anteriorly gently to strongly sulcate (see Pl.17, figs.1 & 2), umbo low, ventral beak suberect, protruding only slightly posteriorly of hinge, ventral interarea apsacline (Pl.23, fig.2), about 3 times as long as anacline (Pl.23, fig.1), narrow, dorsal interarea, pseudo-deltidium prominent, convex, covering delthyrium (Pl.18, fig.1 and Pl.20, fig.3); small subtriangular notothyrium occupied by cardinal process, covered apically by small convex chilidium (Pl.23, fig.1); radial ornament equally to subequally parvicostellate (Pl.17 & Pl.21) with 4,5,6 rounded ribs per mm at 5 mm antero-medianly of brachial valves respectively at 14, 13 and 4 valves, few specimens exhibit fine crenulations of shell along posterior margins, inclined, oblique at about 45^{o}-50^{o} to hinge line, directed towards the muscle fields.

Interior of pedicle valve with low, triangular ventral process, produced anteriorly as slender myophragm (Pl.18, fig.1), bearing shallow surface pits; strong denticulation extending laterally for an average of 42% of hinge width ((e.g. $\bar{W}$smm (var Ws) 16.291 (10.445), Wdmm (var Wd) 6.845 (1.25), r = 0.821, n = 11 (Ludlow)); ventral muscle field longitudinally suboval to subtriangular (Pl.18, fig.1 & Pl.19, fig.1) averaging 92% as long as wide ((e.g. $\bar{L}$mfmm (var Lmf) 4.939 (3.154), $\bar{W}$mf (var Wmf) 5.456 (3.336), r = 0.937, n = 23 (Ludlow)); adductor scars narrow, lanceolate, flanking myophragm and enclosed by subtriangular diductor scars, muscle fields also averaging 61% as long as valve length ((e.g. $\bar{L}$smm (var Ls) 9.088 (1.047), $\bar{L}$mf (var Lmf) 5.613 (0.382), r = 0.778, n = 8 (L: LR in the Usk inlier)) and 32% as wide as valve width ((e.g. $\bar{W}$smm (var Ws) 17.03 (12.96), $\bar{W}$mf (var Wmf) 5.5 (1.729), r = 0.715, n = 10 (Usk inlier)).

Brachial valve interior with a bilobed pear-shaped cardinal process (Pl.18, fig.2), with attachment faces directed postero-ventrally, separated medianly by rounded groove; socket deep, defined by strong socket ridges; dorsal adductor scars strongly impressed, defined by lateral bounding ridges and subdivided medianly by low, rounded ridge (Pl.25, figs.1-6).

6.2.8. Distribution.

It is interesting to consider the occurrences of the species in the Ludlow Series of the Welsh Borderland. A.(A.) funiculata is common usually as moulds of either pedicle or brachial valves in the Lower Elton Formation of Ludlow forming about 28% of the total specimens, becoming very rare in the Middle and Upper Elton Formations till it becomes common, usually as moulds but with some specimens having shells of both valves, in the Lower Bringewood Formation, forming an average of 69% of the total specimens. The species occurs also in the Upper Bringewood Formation, where the rock becomes more limey, comprising about 3% of the total specimens. It is absent after that in the Leintwardine and Whitcliffe Formations (Lawson 1960).

During the present study, the species has been collected from the following localities: 31, A2, A3, A4, 14, B1, B2, B4, B6, B7, 7a in the Ludlow area; WQ in Abberley, LR and PL in the Usk inlier (see text-figs.2.1, & 2.3, 2.5, and the locality list in Appendix I). The species has also been recorded by the Ludlow Research Group from many areas in the Welsh Borderland; e.g. Woolhope by Squirrell and Tucker (1960), Leintwardine by Whitaker (1962), Much Wenlock by Shergold and Shirley (1968), Malvern and Abberley by Phipps and Reeve (1967), Usk by Walmsley (1959), May Hill by Lawson (1955) and Llandovery and Llandeilo by Potter and Price (1965), see text-figs.1.5-1.7.

6.2.9. Discussion.

A.(A). funiculata is a common species in the Wenlock Series (Silurian) of the Welsh Borderland. The species description and its variation were well summarised by Bassett (1977) in which he dealt particularly with the differences in the late Wenlock and Lower Ludlow populations of the Welsh Borderland, such as ornamentation, development of dorsal and pedicle muscle field and muscle bounding ridges.

Before discussing the variations occurring in this species from the Ludlow Series of the Welsh Borderland, it is important here to emphasize that there are no significant variations between the studied Ludlow Series specimens to use them for taxonomic purposes. The observed variations mostly lie in the shape and proportion of the shell, muscle field shape and proportion, muscle bounding ridges and degree of sulcation (see 6.4).

Therefore, the statistical analysis of the morphological variability shows that there is no justification for erecting new subspecies as suggested by Bassett (1977, p.152). The variation appears to be intraspecific, controlled by genetic and/or environmental factors, which will be discussed later.

6.3. VARIATION IN LUDLOW SPECIMENS.

A. External shell features.

1. Shell shape and proportion:

A.(A.) funiculata is weakly concavo-convex posteriorly but becomes strongly convexi-concave anteriorly forming the resupinate valve shape (text-fig.6.26). The species is roughly semicircular (Pl.25, figs.1-4 and Pl.24, figs.4 & 6) to subtriangular or triangular in outline shell shape (Pl.17, figs. 1 & 2 and Pl.25, figs.5-15).

The valves are gently to strongly sulcate antero- medianly at the geniculation in most of the specimens from the Ludlow Series (Pl.17, fig.2 and Pl.25, figs.5,6,8,9 & 10 for strongly sulcate and Pl.25, figs.7, 11,13 & 14 for gently sulcate examples).

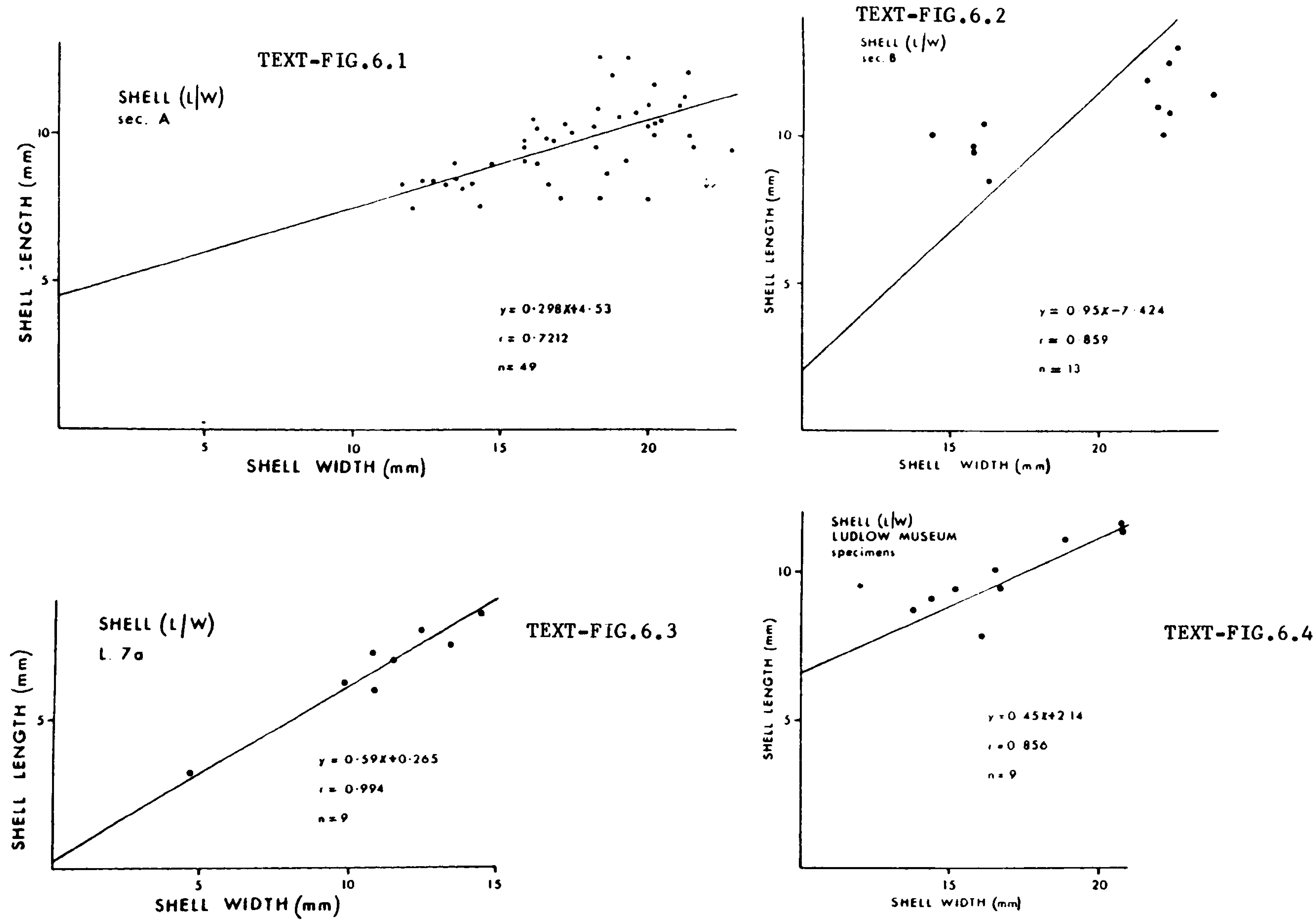
The species has been studied from selected areas in the Welsh Borderland, particularly the Ludlow area, Woodbury Quarry in the Abberley Hills and the Usk inlier. Specimens from each of these areas provided an opportunity to study the shell shape variability statistically.

Specimens from three localities near Ludlow and a few others from the Ludlow Museum are studied and analysed statistically, showing roughly similar shell length-width variability. The statistics for the shell proportions for the Ludlow area localities are shown in Table 1 below and are also displayed graphically in text-figs.6.1-6.4.

TABLE 1. Summary of statistical results of the shell proportions of *A. (A.) funiculata* from different localities in the Ludlow area.

Loc.	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
Sec.A	49	9.722 (1.68)	17.394 (9.796)	0.721	1.283	3.098	Y=0.29X + 4.53	56%
Sec.B	13	12.362 (36.399)	20.808 (29.746)	0.859	5.796	5.24	Y=0.95X - 7.4	59%
L.7a	9	7.911 (15.339)	12.922 (43.194)	0.994	3.692	6.196	Y=0.59X + 0.27	61%
LM Specimens	9	9.811 (1.571)	17.022 (6.734)	0.856	1.182	2.247	Y=0.45X + 2.14	58%

From the text-figs.6.1-6.4, it is evident that the trends and the slopes of the lines for the separate localities shown on Table 1 are similar. Consequently the collections from these localities are



TEXT-FIGS.6.1-6.4. Shell length-width distribution of A. funiculata in the Ludlow area (sections A & B, locality 7a and Ludlow museum specimens).

treated as only one unit called the Ludlow area collection. It is also evident from Table 1 above that the locality 7a specimens are smaller than those from Sec.A and Sec.B but still have nearly the same shell proportions.

More specimens were collected and studied statistically from one locality in the Abberley Hills (WQ) and two localities in the Usk inlier (LR & PL). The statistical results from the two localities studied in the Usk inlier are shown on Table 2, below, and are displayed in text-figs.6.5 & 6.6.

TABLE 2. Summary of statistical results of the shell proportions of *A.* (*A.*) *funiculata* from two localities in the Usk inlier.

Loc.	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
PL	37	9.543 (2.506)	16.981 (10.286)	0.831	1.561	3.164	Y=0.4X + 2.6	56%
LR	15	8.52 (0.852)	15.287 (2.811)	0.528	0.892	1.619	Y=0.3X + 4.1	56%

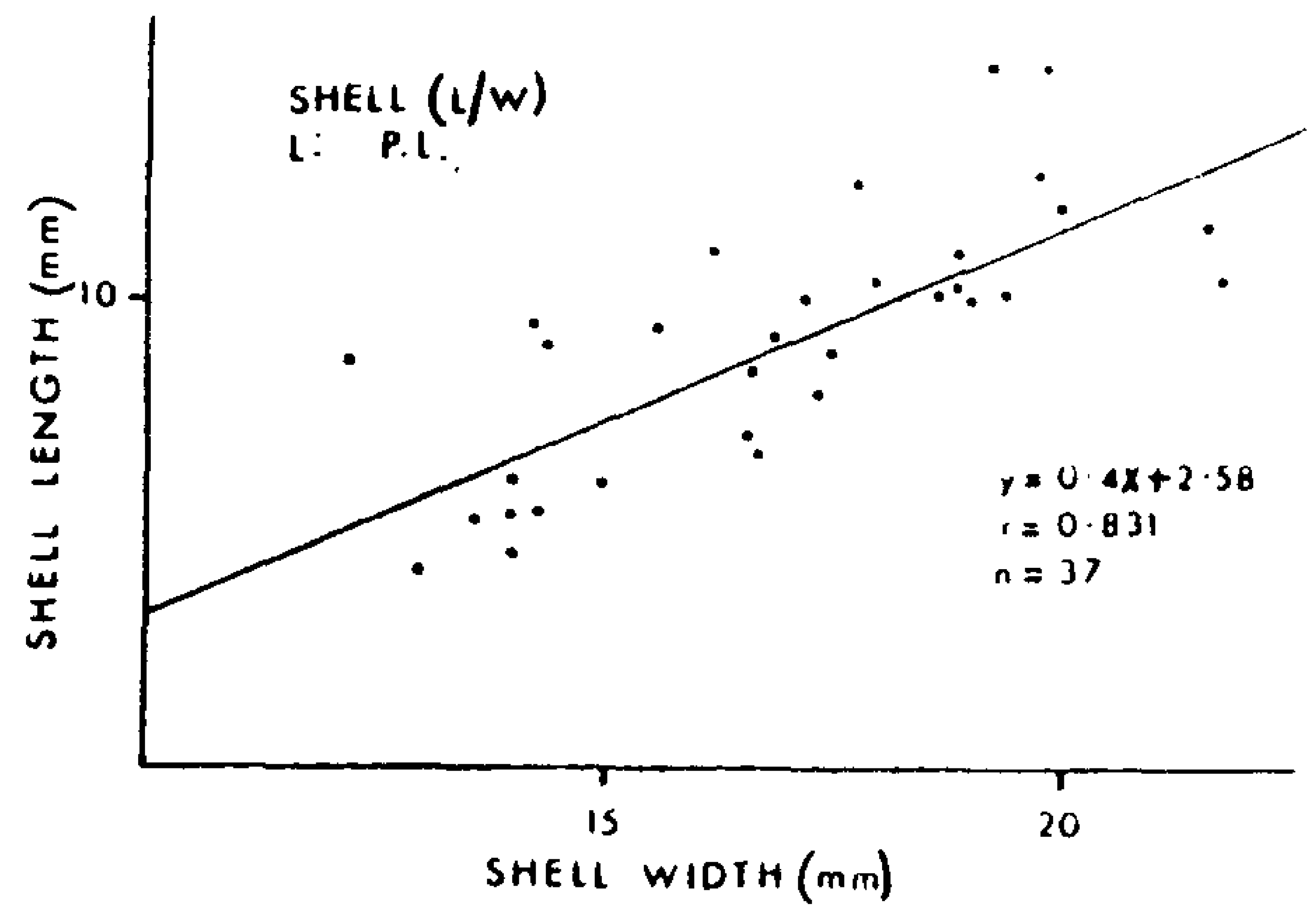
Both localities show approximately the same trends and shell proportions. Consequently both localities are treated as one unit called the Usk inlier.

The variation in the shell proportions for the three main areas (i.e. Ludlow, Abberley Hills and Usk) is shown in Table 3 and are also displayed graphically in text-figs. 6.7-6.9.

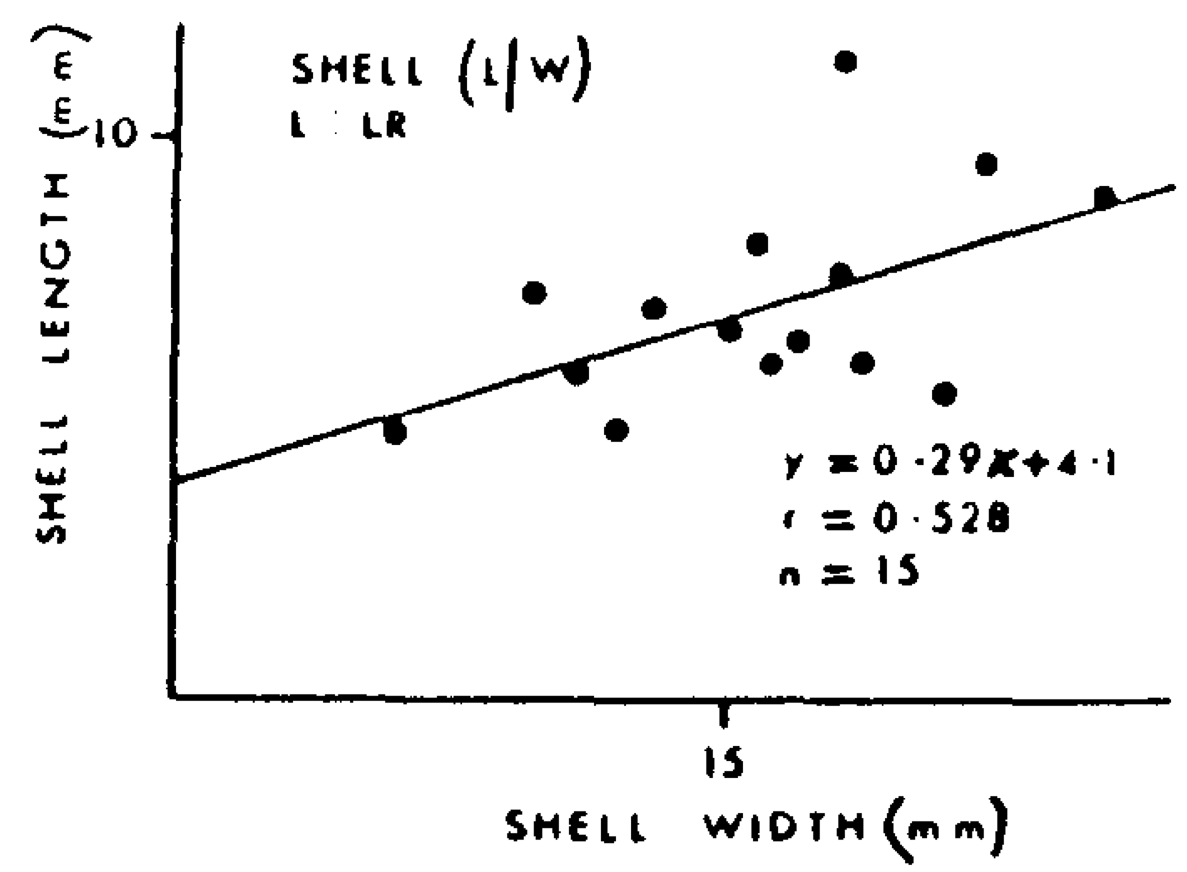
TABLE 3. Summary of statistical results of the shell proportions of *A.*(*A.*) *funiculata* from Ludlow, Abberley Hills and the Usk inlier.

Loc.	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
Ludlow Area	80	9.958 (9.727)	17.403 (19.755)	0.819	3.099	4.417	Y= 0.57 - 0.04	58%
Abberley Hills	44	9.327 (1.212)	17.234 (9.981)	0.714	1.088	3.123	Y= 0.25X + 5.0	54%
Usk inlier	52	9.256 (2.222)	16.492 (8.633)	0.814	1.471	2.909	Y= 0.4X + 2.5	56%

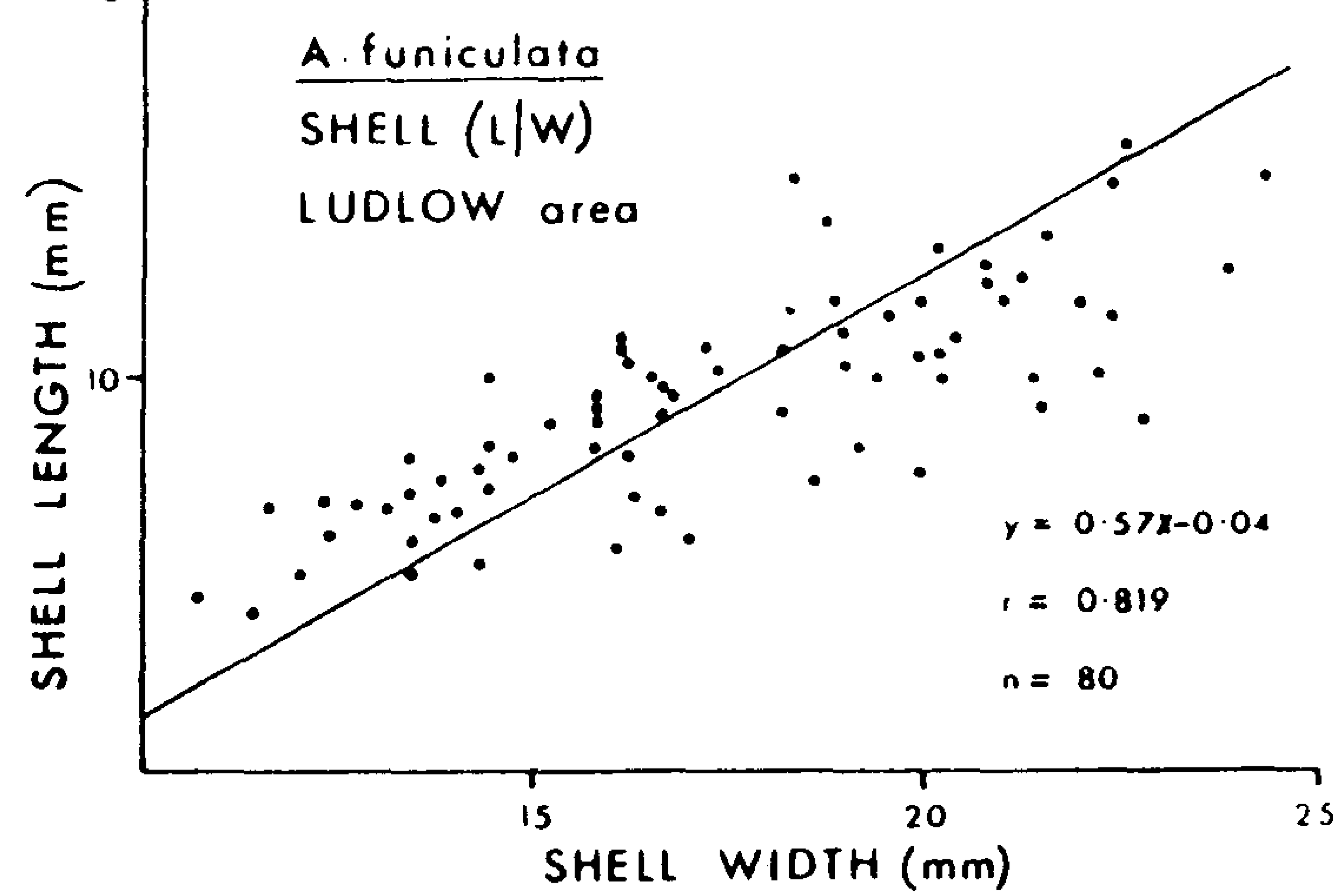
TEXT-FIG.6.5



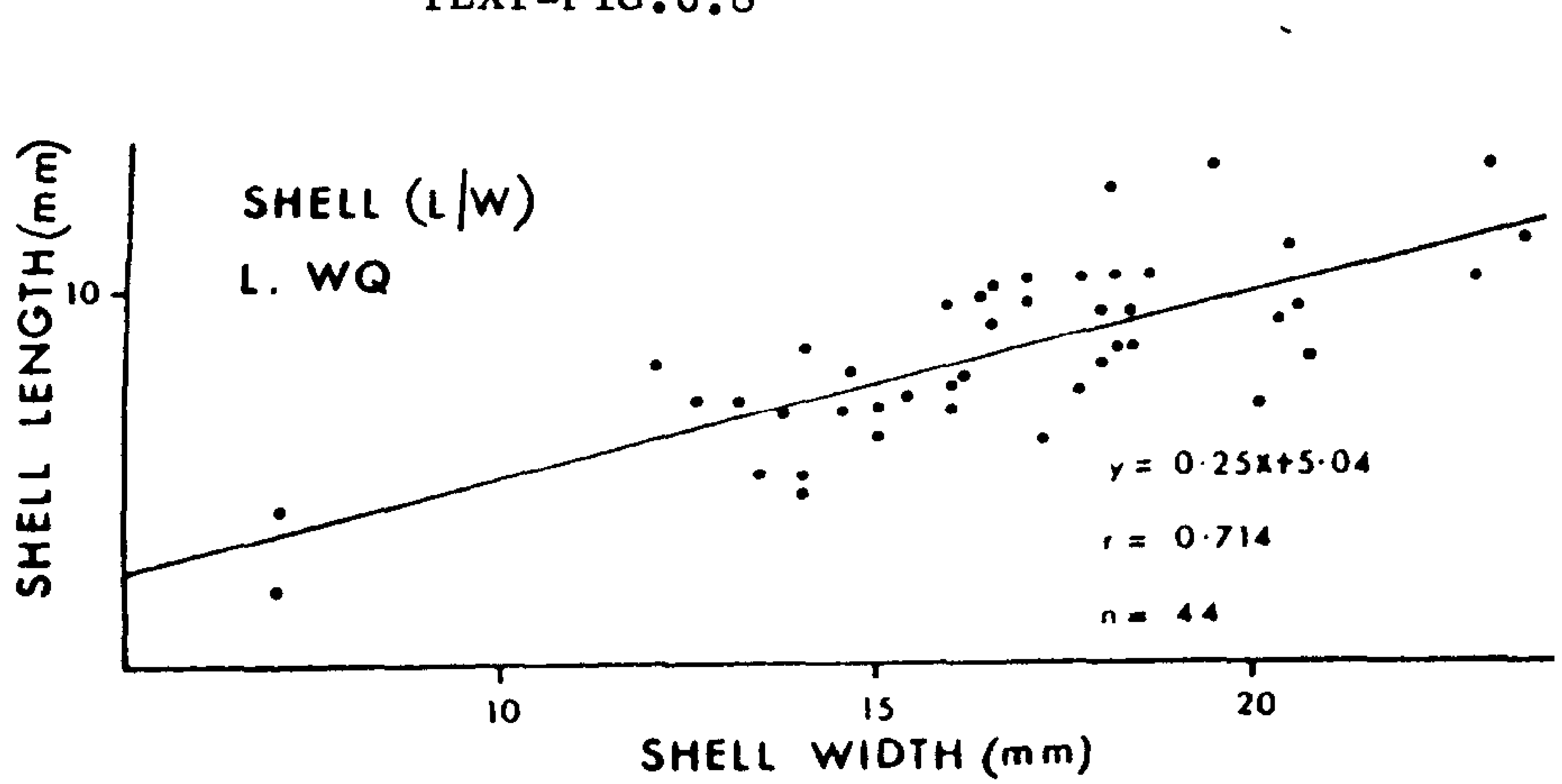
TEXT-FIG.6.6



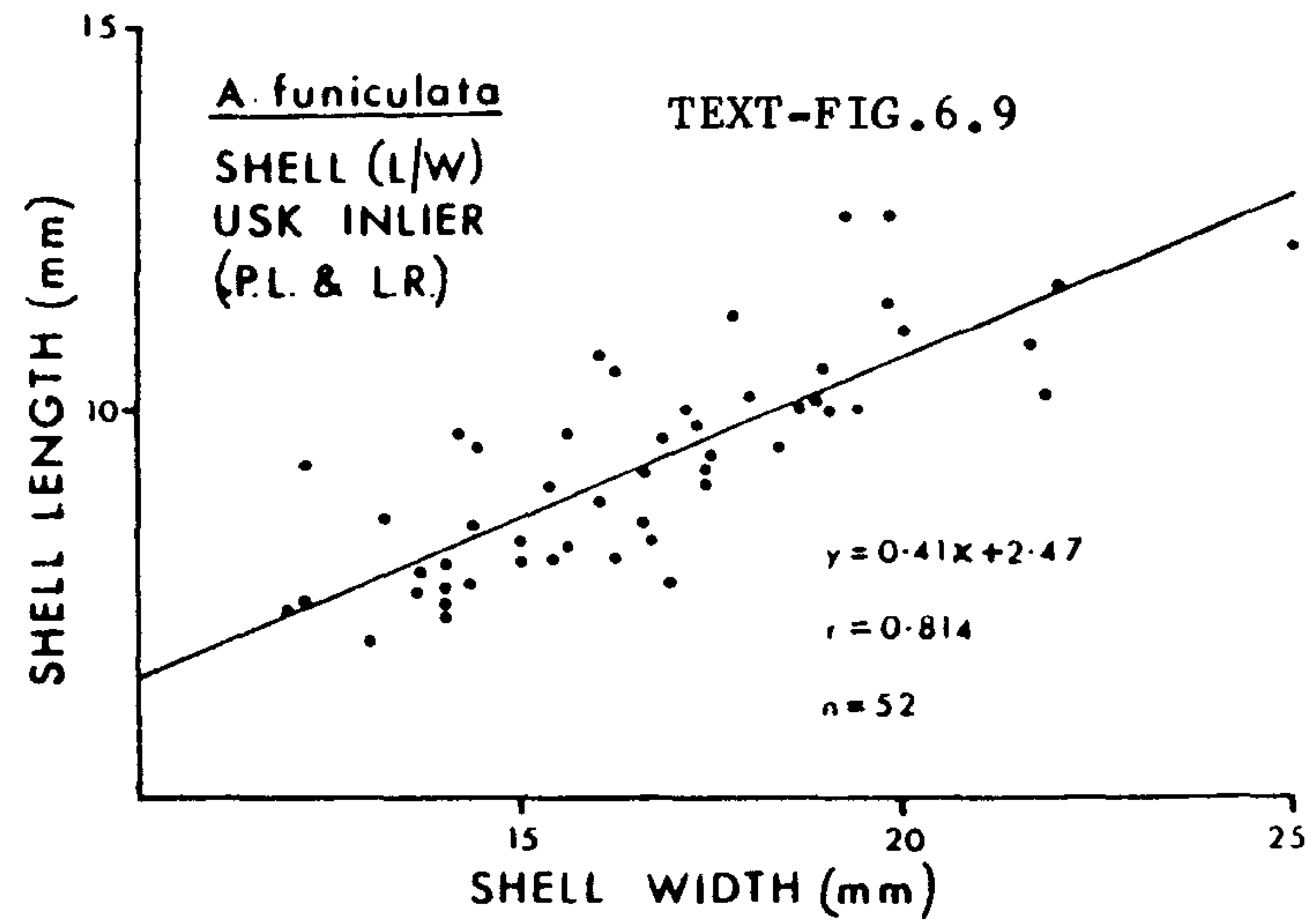
TEXT-FIG.6.7



TEXT-FIG.6.8



TEXT-FIG.6.9



TEXT-FIGS.6.5 & 6.6. Plots of the shell length against shell width of A. funiculata from two localities (PL & LR) in the Usk inlier.

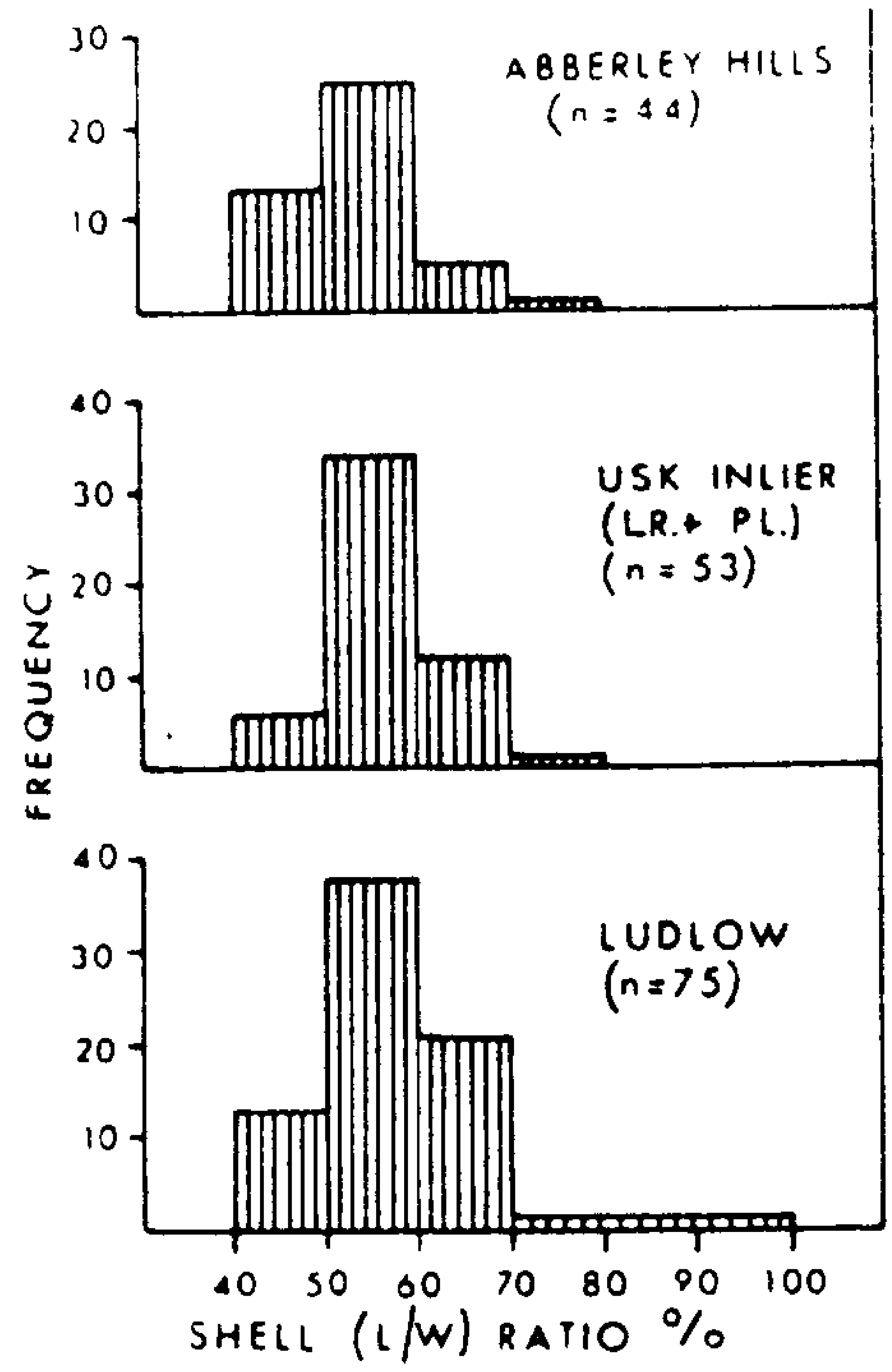
TEXT-FIGS.6.7-6.9. Shell length-width distribution for A. funiculata from Ludlow, Abberley Hills and Usk respectively.

It is evident from Table 3 above that the value of the coefficient of correlation (r) in the three areas demonstrates that the shell length and shell width increase in direct proportion to each other in all three areas. The ratio of the shell proportions (Ls/Ws) for Ludlow, Usk and the Abberley Hills are 58%, 56% and 54% respectively. These small differences in the value of the shell proportions are most probably due to the difference in the number of specimens studied from each area and/or environmental influence, but still the average of the shell length and shell width are nearly the same in the three studied areas. For example, the mean of the shell length is 9.5mm and 17.0mm for the shell width with an average shell proportion of 56% in all three areas (text-fig.6.10). The shell width was also measured at ¾ of the shell length in an attempt to quantify the observed differences in the shape of the shell outline statistically (see Table 4) and graphically (text-figs.6.11-6.14) for Abberley Hills, Usk inlier and the Ludlow area respectively. From the three text-figures, it is confirmed that the shell outline in the three main areas is nearly the same. Therefore, they were all combined in text-fig.6.14.

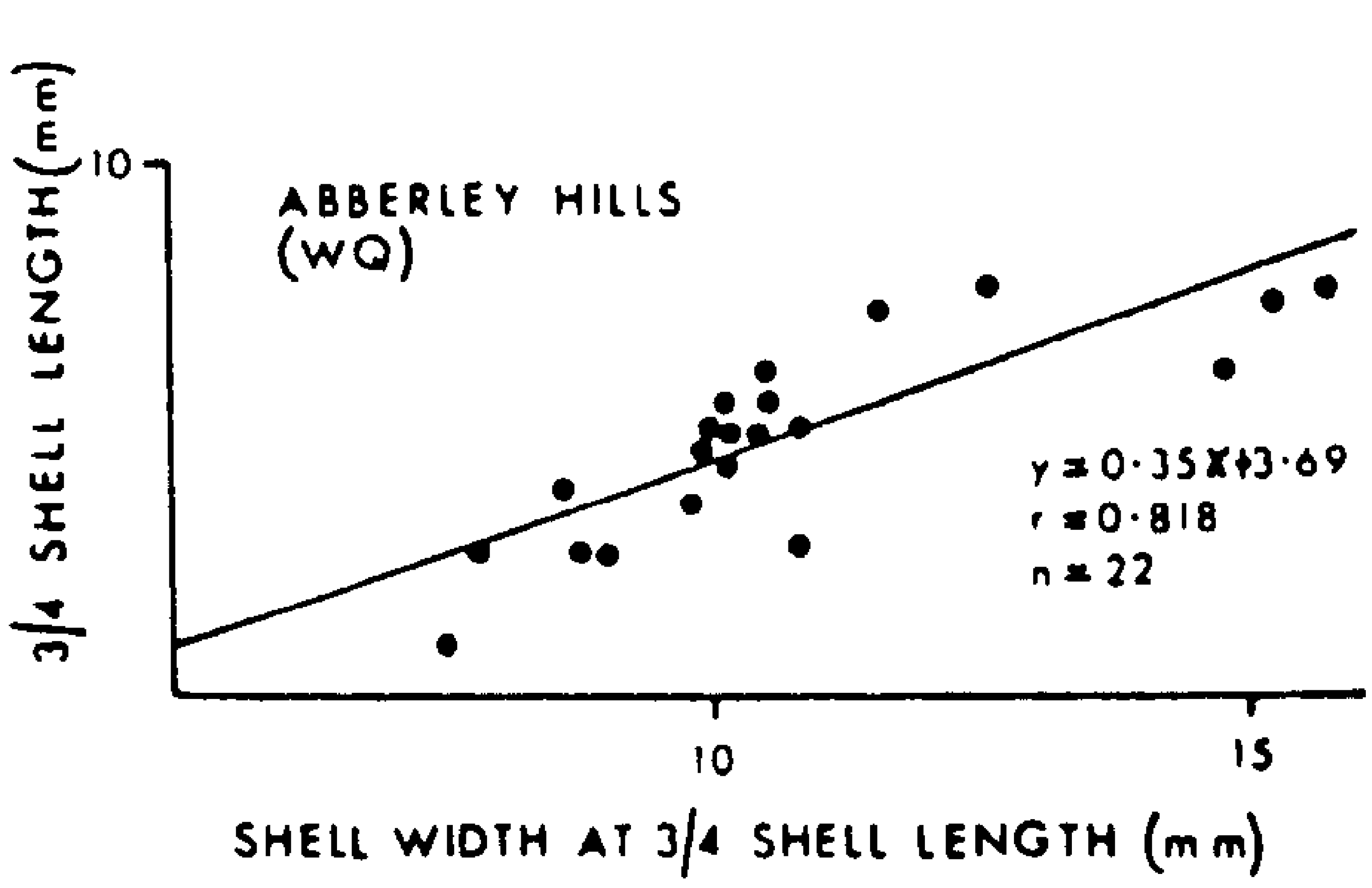
TABLE 4. Summary of statistical results of ¾ of the shell length to the shell width at this point for A.(A.)*funiculata* from Ludlow, Usk and Abberley Hills.

Loc.	n	$\frac{3}{4}\bar{L}s$	$\bar{W}s$ at $\frac{3}{4}\bar{L}s$	r	S.D. ($\frac{3}{4}$Ls)	S.D. (Ws $\frac{3}{4}$Ls)	The equation	% $\frac{3}{4}\bar{L}s/\bar{W}s_{\frac{3}{4}\bar{L}s}$
Abberley Hills	22	7.38 (0.78)	10.62 (4.32)	0.818	0.863	2.03	Y= 0.35X + 3.7	69%
Usk inlier	9	6.43 (0.343)	8.72 (0.489)	0.849	0.552	0.659	Y= 0.7X + 0.23	74%
Ludlow area	22	7.51 (1.435)	10.96 (2.44)	0.842	1.171	1.527	Y= 0.65X + 0.44	69%

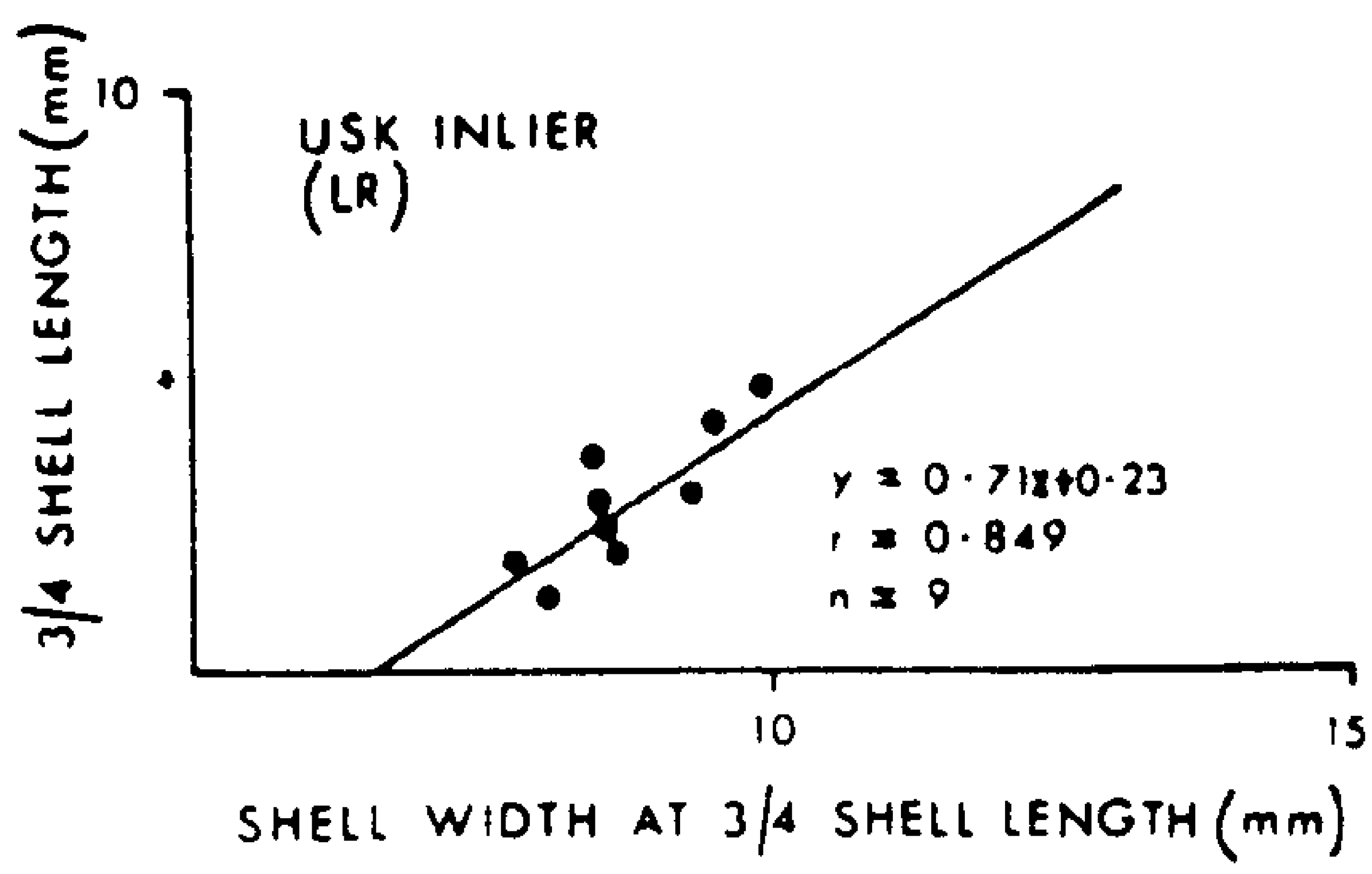
TEXT-FIG.6.10



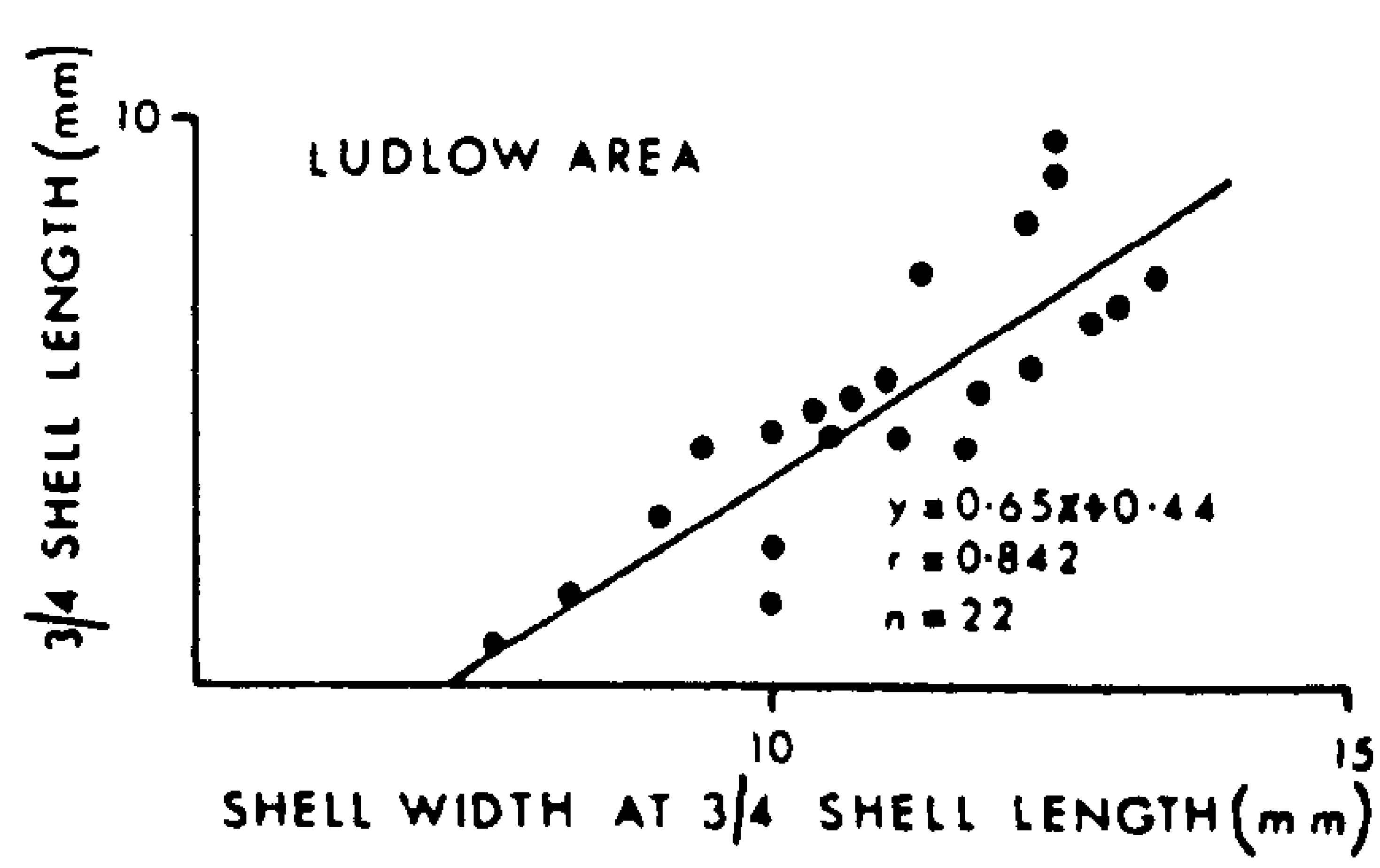
TEXT-FIG.6.11



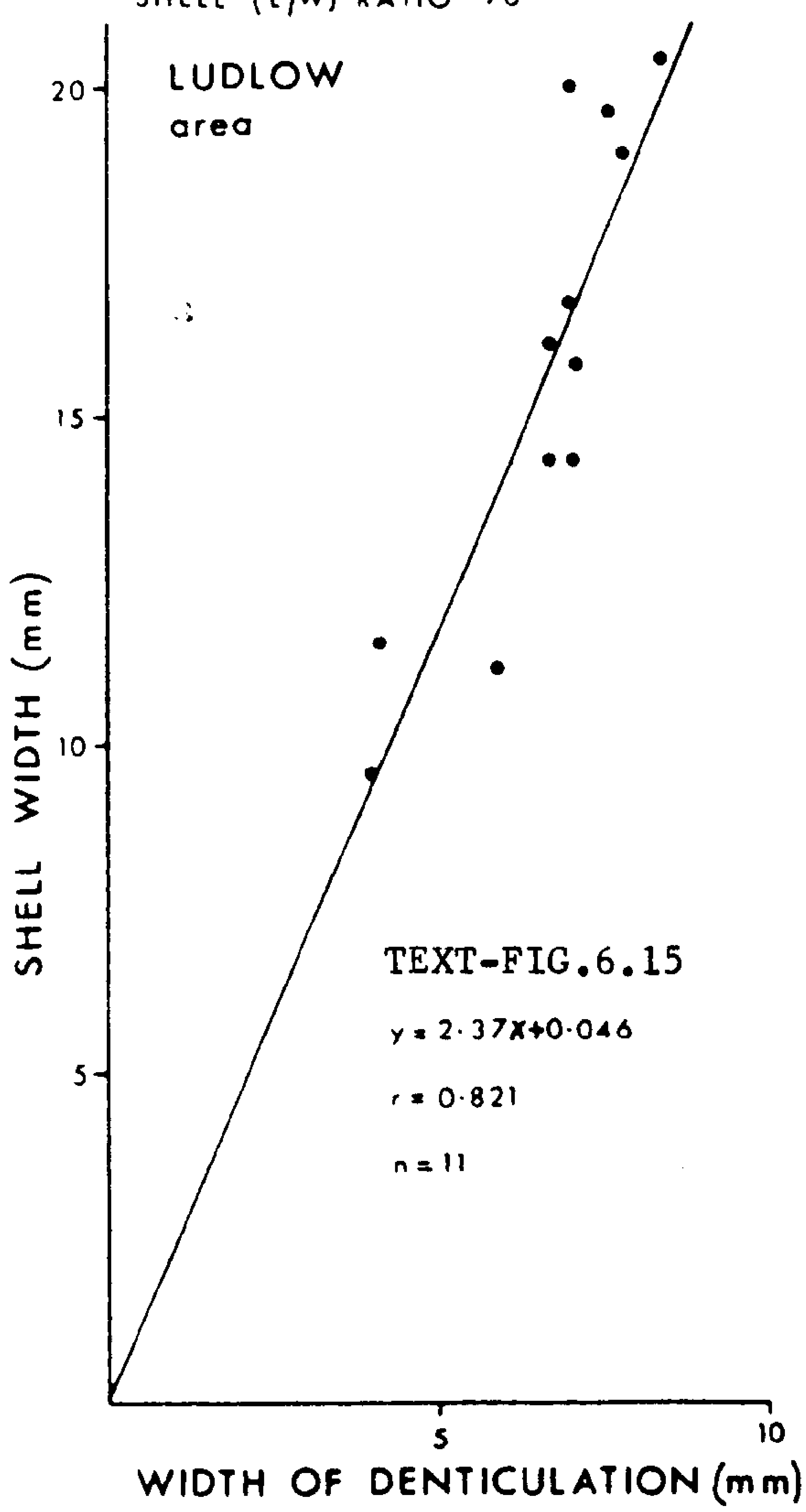
TEXT-FIG.6.12



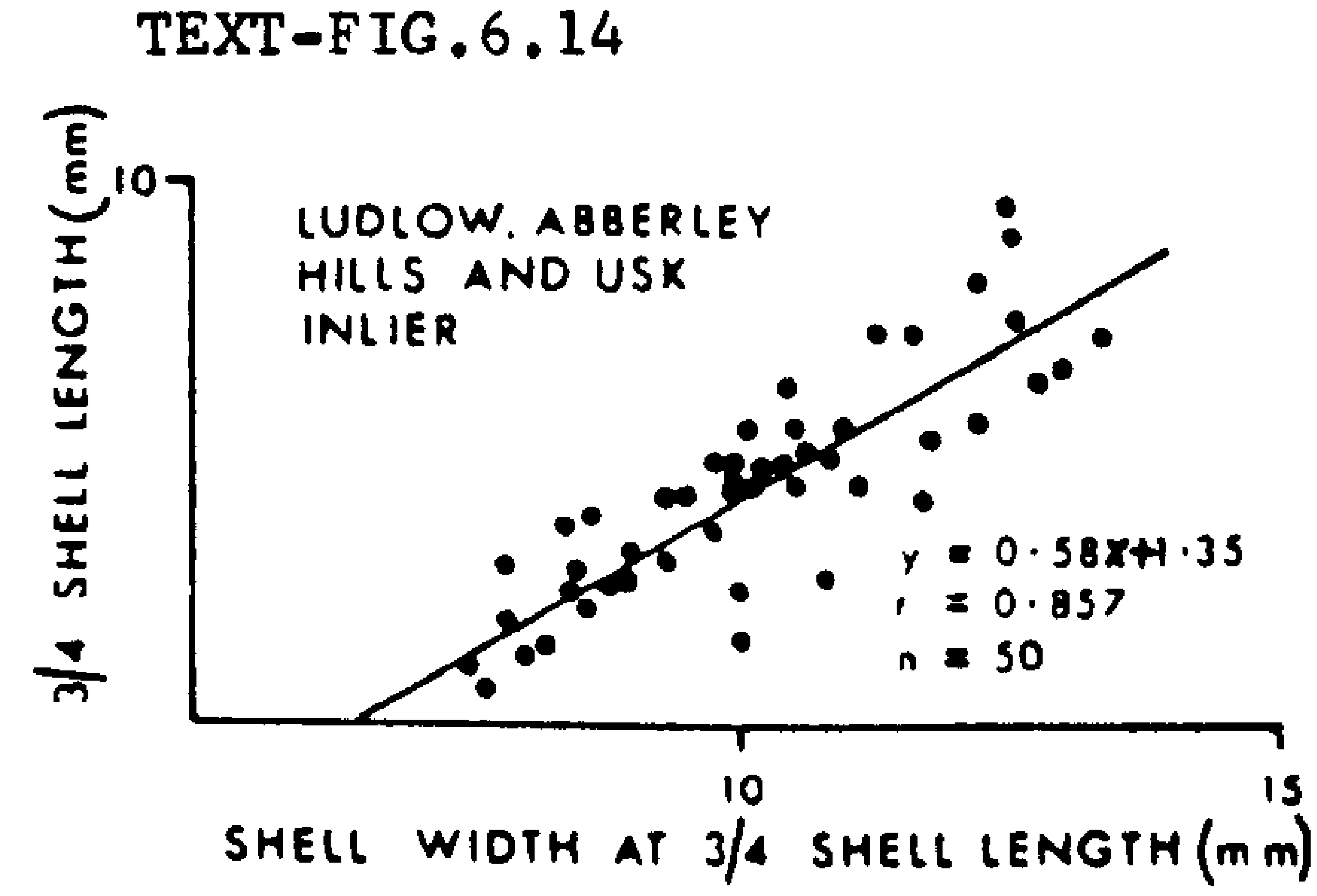
TEXT-FIG.6.13



TEXT-FIG.6.15



TEXT-FIG.6.14



TEXT-FIG.6.10. Shell length-width ratio frequency histograms of A. funiculata from three different areas.

TEXT-FIGS.6.11-6.13. Plots of ¾ shell length against shell width at this point for A. funiculata from Abberley Hills, Usk and Ludlow respectively, with their combined plot in text-fig.6.14.

TEXT-FIG.6.15. Plot of shell width versus width of denticulation of A. funiculata from Ludlow area.

2. Ornamentation.

The radial ornament in A.(A.) funiculata consists normally of equally to subequally, well-developed parvicostellae, which are straight along the mid line of the shell but become very gently curved laterally. There are no capillae between them (Pl.25, figs. 1-15 and Pl.17, figs.1 & 2) in contrast to the radial ornament of S. euglypha. In some well-preserved specimens, these costellae were measured at 5mm from the umbo antero-medianly on the brachial valve, showing about 4,5 and 6 rounded ribs for 14,13 and 4 valves respectively.

A few specimens show fine, short and oblique crenulations along the postero-lateral margin of the hinge line (i.e. near the shell ears) which make an angle of about 45° to the hinge line and extend antero-medianly from the hinge line (towards the muscle field). This feature is also seen in some well-preserved Wenlock specimens (Pl.21, fig.2).

B. Internal shell features.

1. Denticulation.

Denticles in A.(A.) funiculata are well developed as strong, small ridges on a pair of denticular plates, which are parallel and adjacent to the anterior margin of the hinge line of both pedicle and brachial valves (Pl.24, fig.1 and Pl.25, figs.1,2,6).

In A.(A.) funiculata strong denticulation extends laterally along the hinge line for varying proportions of the hinge width. For specimens from the Ludlow area the average mean of denticulation width occupied by the hinge width is 42%, see Table 5 and text-fig. 6.15.

TABLE 5. Summary of statistical results for denticulation of A.(A.) funiculata from Ludlow area.

Area	n	$\bar{W}s$	$\bar{W}d$	r	S.D. (Ws)	S.D. (Wd)	The equation	$\bar{W}d\%/\bar{W}s$
Ludlow	11	16.291 (10.445)	6.845 (1.251)	0.821	3.081	1.066	Y= 2.37X + 0.05	42%

It is evident from the text-fig.6.15 that the width of the hinge line denticulations increases in direct proportion to the shell width.

Only a few specimens from the Abberley Hills and the Usk inlier could be measured so that they are not significant for statistical analysis, but it is evident from studying these specimens (Abberley Hills and Usk inlier) that the proportions of the hinge width occupied by the denticulations are approximately similar in the two areas.

2. Muscle field.

a) On the pedicle valve.

In most of the specimens studied, the muscle field in A.(A.) funiculata is well developed as a pair of lanceolate adductor muscle scars (Pl.24, figs.2,3 & 8), enclosed by subtriangular (in a few specimens)(Pl.24, figs.7 and 9) to more commonly triangular bilobed diductor muscle scars (Pl.24, figs.1,2,3,8 & 10). The adductor and diductor muscle scars are separated by a narrow medium septum called a myophragm (Pl.24, figs.1,2,3,8 & 10 and Pl.18,fig.1). The muscle field is always bounded by moderate to strong muscle ridges. The muscle ridges diverge antero-laterally at an average angle ranging between 50-65^{o} and extending laterally to bound the diductor muscle scars anteriorly in most of the studied specimens (Pl.24, figs.1,2 & 10 and Pl.18, fig.1). In a few specimens the muscle bounding ridges die out antero-laterally (i.e. do not bound the muscle field anteriorly), (Pl.24, figs. 4 & 5) or are weak as shown in Pl.24, figs. 3 & 8.

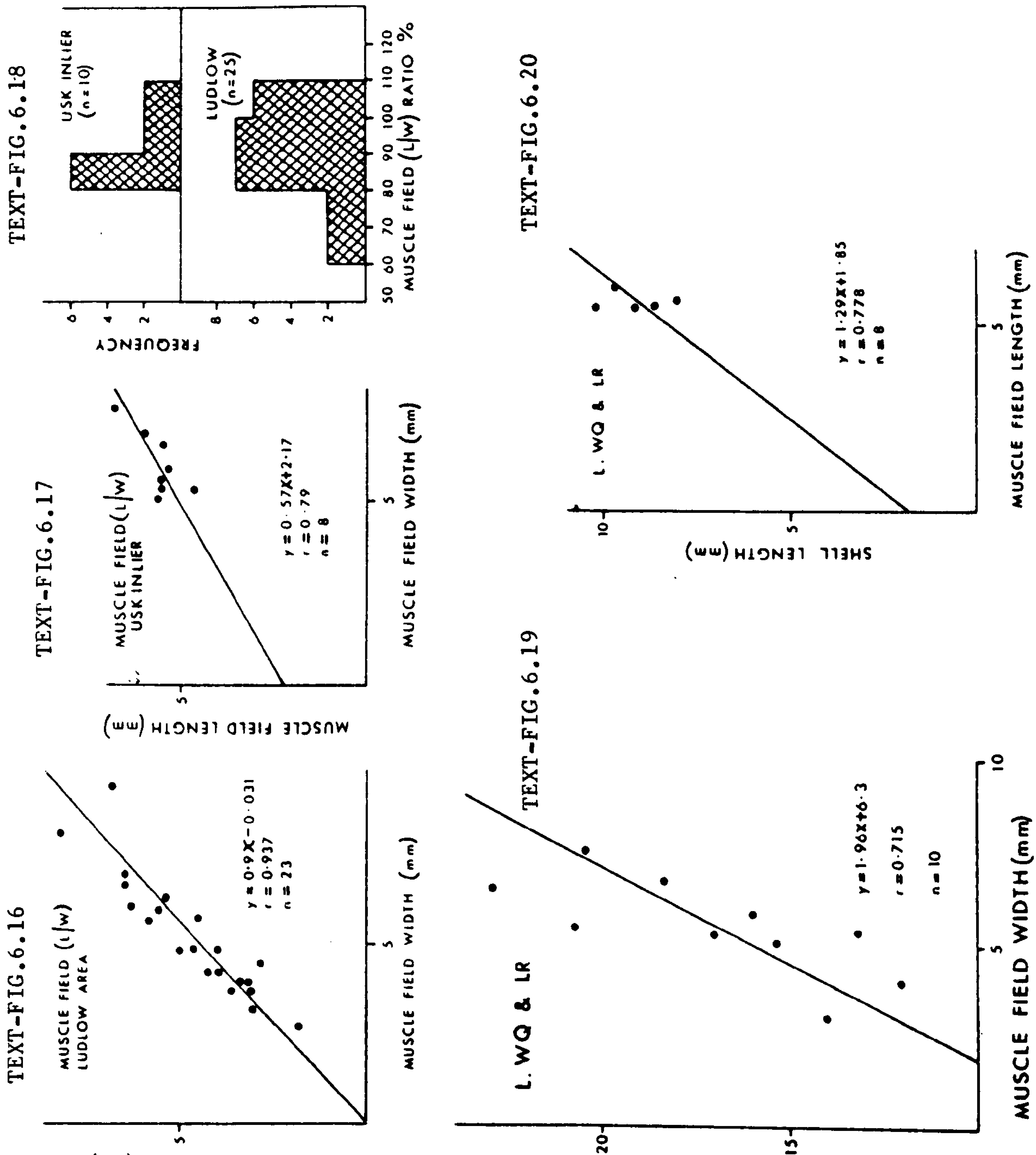
The analysis of the muscle field proportions from Ludlow and Usk areas is shown in Table 6 below and the data are displayed graphically in text-figs. 6.16 & 6.17.

TABLE 6. Summary of statistical results of the muscle field proportion of *A.(A.) funiculata* from Ludlow and Usk inlier.

Area	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	The equation	% $\bar{L}mf/\bar{W}mf$
Ludlow	23	4.939 (3.154)	5.456 (3.336)	0.937	1.737	1.786	Y= 0.9X - 0.031	90%
Usk inlier	8	5.613 (0.381)	6.0 (0.723)	0.789	0.578	0.975	Y= 0.57X + 2.17	93%

It is evident from the text-figs.6.16 & 6.17 that the muscle field length increased in direct proportion to its width. From Table 6 above, the ratio of the muscle field length to the muscle field width for both Ludlow and Usk is 90% and 93% respectively, very nearly the same. This small difference may be due to the different number of specimens measured from each locality.

A size-frequency histogram was drawn to show the range of variation in the muscle field proportions for both Ludlow and the Usk inlier (see text-fig.6.18). The variation in the Ludlow



TEXT-FIGS.6.16 & 6.17. Muscle field length-width distribution of A. funiculata from Ludlow and Usk inlier, with their ratio-frequency histograms in text-fig.6.18.

TEXT-FIGS.6.19 & 6.20. Plots of shell width and shell length against muscle field width and length respectively in A. funiculata from Abberley Hills and Usk specimens.

specimens is between 60-110, and 80-110 for those from Usk.

The muscle field length and width was plotted against the shell length and width for a small measureable number of Woodbury Quarry and Usk specimens (text-figs.6.19 & 6.20). It occupies about 32% of the valve width and about 60% of the valve length. it is also evident from text-figs. 6.19 & 6.20 that the muscle field width and length increased in direct proportion to the width and length of the shell respectively.

b) On the brachial valve.

The muscle field is moderately to strongly impressed and is subtriangular to triangular in shape, bounded by a pair of muscle ridges, which diverge at varying degrees (Pl.25, fig.1,2,4,6 and Pl.18, fig.2).

3. Socket plates.

These are a pair of ridges located postero-medianly in the brachial valve and extend antero-laterally from the cardinal process for about 1/20 - 1/30 of the hinge width. Some variation was seen in the shape of these socket plates. The most common type among the studied specimens are the blade-like plates which diverge antero-laterally at about 100° - 120° (Pl.25, figs. 1 & 2). In some specimens, however, after initial divergence the plates are recurved very gently towards the hinge line (Pl.25, figs. 5 & 6) but still occupy about the same ratio of the hinge width which is not more than 25%.

In conclusion, it can be appreciated that there is not any great variation shown between the specimens of the three studied areas (i.e. Ludlow, Abberley Hills and the Usk inlier). Therefore, all the Welsh Borderland specimens from Ludlow, the Abberley Hills and the Usk inlier of Ludlow age are considered to belong to one unit called the Welsh Borderland.

6.4. WENLOCK SPECIMENS.

6.4.1. Introduction

A.(A.) funiculata from the Wenlock Series was adequately described (although not statistically) by Bassett (1971 & 1977). Some morphological variability between Ludlow and Wenlock A. (A.) funiculata were observed. In order to see whether the differences between the two populations (i.e. Wenlock and Ludlow forms) are due to evolution or ecology, some well-preserved Wenlock specimens were selected and statistically studied. Consequently, studying these specimens in detail and taking into consideration Bassett's description of the Wenlock form from the Welsh Borderland and South Wales in 1971 and 1977, it is evident that the present observations on the Wenlock A.(A.) funiculata are consistent with Bassett's description except that some statistical information has been included herein to facilitate the comparison with Ludlow forms.

6.4.2. Material.

a) from Britain.

Thirty one specimens from the Natural History Museum (London), fourteen from the British Geological Survey Museum, eighteen from the National Museum of Wales (Cardiff) and twenty in the Lawson collection.

b) from Gotland (Sweden).

Fifteen specimens from the Natural History Museum (London) and fourteen specimens in the Walmsley collection at the National Museum of Wales (Cardiff).

The material from both areas (i.e. Britain and Sweden) occurred mainly as internals and externals of both pedicle and brachial valves.

6.4.3. Horizons and localities.

Most of the specimens studied here from Britain are from the Wenlock Limestone of the Dudley area, but a few are from the Wenlock Shale. The latter are not sufficient for a statistical analysis. Therefore, the statistical data used here to define some of the external and internal shell features are dependant mainly on the Wenlock Limestone material from the Dudley area (West Midlands). The external and internal morphological features of the shell are well developed and preserved in these Wenlock Limestone specimens.

In Gotland, most of the specimens are from"marl & shale of Klinte & Eksta(Wenlock age)"; Djupvik, Mulde Formation in the nassa zone.

6.4.4. Distribution.

A.(A.) funiculata is common throughout the Wenlock and Ludlow

Series of South Wales and the Welsh Borderland, and ranges through the Middle and Upper Wenlock (Bassett 1977). In Gotland, the species occurs commonly in the Slite and Mulde Formations (Bassett and Cocks 1974).

6.5. VARIATION IN WENLOCK SPECIMENS.

A. In British material.

1. Shell shape and proportion.

A.(A.) funiculata is generally semicircular (rounded) in the shell shape outline (Pl.19, fig.1; Pl.20, figs.1-3; Pl.23, figs. 2 & 3 and Pl.26, figs.1,2,7,8,10,11 & 12). In some specimens the anterior margin of the shell shows a very gentle sulcus (Pl.25, figs.8-11).

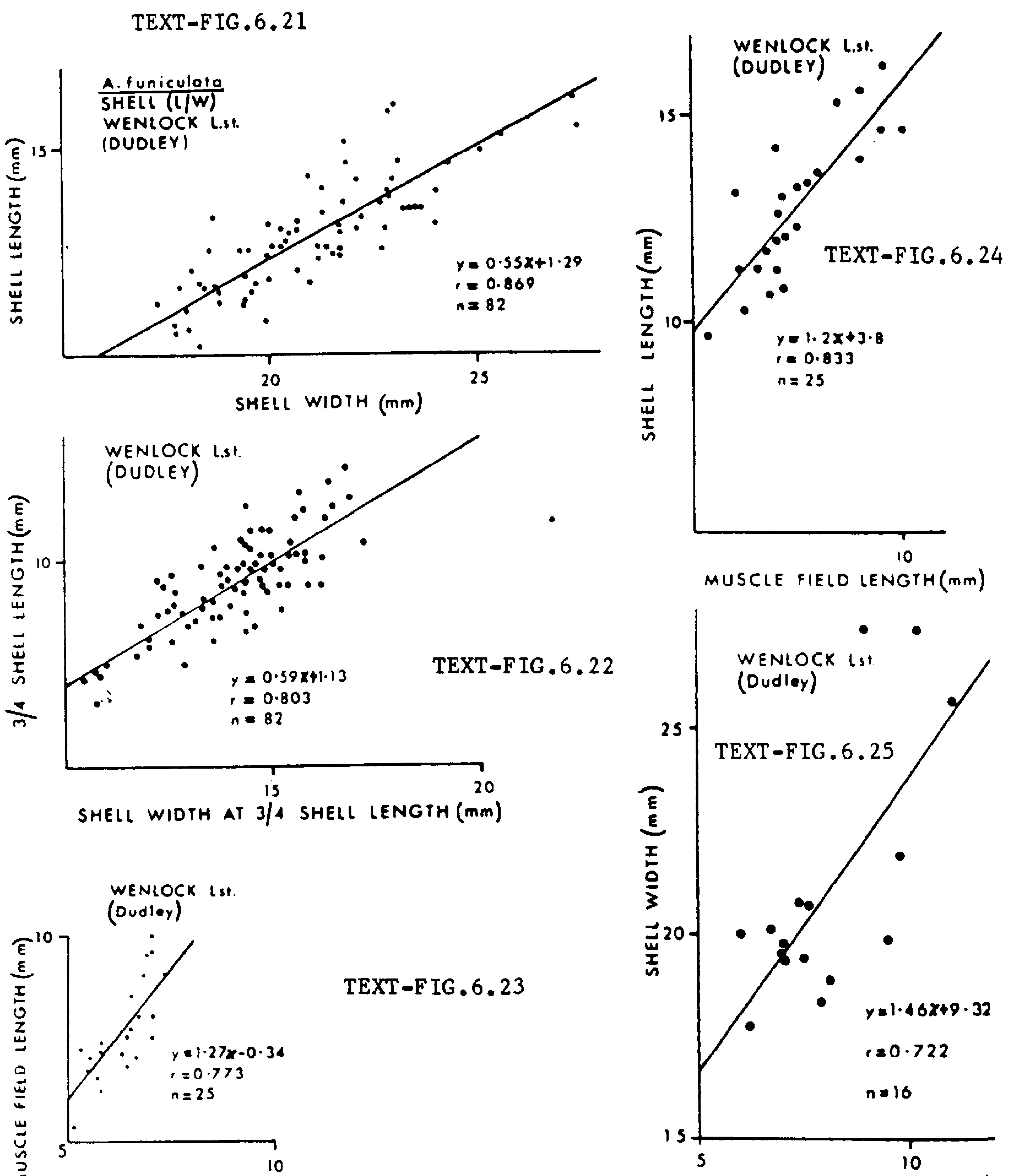
The statistics on the shell proportions are shown in Table 7 below and in text-fig.6.21.

TABLE 7. Summary of statistical results of the shell proportions of A.(A.) funiculata from the Wenlock limestone (Dudley).

n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
82	12.6 (2.37)	20.699 (5.979)	0.869	1.529	2.43	Y=0.55X + 1.29	61%

It is evident from Table 7 above that the high value of the coefficient of correlation (r) demonstrates that the length and width of the shell increase in direct proportion to each other.

The shell width was measured at ¼ of the shell length in an attempt to demonstrate the variation of the shell shape outline statistically as illustrated in the text-fig.6.22 and Table 8 below.



TEXT-FIGS.6.21-6.25. Distribution plots of A. funiculata from the Wenlock limestone of Dudley area demonstrating; shell length-width (6.21), ¾ shell length against shell width at this point (6.22), muscle field length-width (6.23), shell length against muscle field length (6.24) and shell width versus width of denticulation (6.25).

TABLE 8. Summary of statistical results of the $\frac{1}{4}$ shell length to the shell width at this point for A. funiculata from Dudley (Wenlock).

n	$\frac{1}{4}\bar{L}s$	$\bar{W}s$ at $\frac{1}{4}Ls$	r	S.D. ($\frac{1}{4}$Ls)	S.D. ($Ws_{\frac{1}{4}Ls}$)	The equation	$\frac{1}{4}\bar{L}s / \bar{W}s_{\frac{1}{4}Ls}$ %
82	9.465 (1.339)	14.11 (2.476)	0.803	1.150	1.564	Y=0.59X + 1.13	67%

2. Pedicle valve muscle field.

The muscle field in the Wenlock funiculata is well-developed as a pair of lanceolate adductor muscle scars which are enclosed by sub-triangular bilobed diductor muscle scars. Both adductor and diductor muscle scars are separated by a narrow, rounded myophragm (Pl.19, fig.1; Pl.23, fig.2 and Pl.26, figs.1 and 2). In most of the specimens studied, the muscle field is bounded by strong muscle ridges which then bound the muscle field anteriorly. In some other few specimens these ridges die-out antero-laterally (Pl.26, fig.3 and Pl.22, fig.2). The shape of the muscle field varies, particularly at its anterior end from rounded to triangular shaped as shown in Pl.26, fig.2 and 1 respectively.

The muscle field in the Wenlock funiculata occupies about 59% (n = 25) of the valve length (text-fig.6.24).

The statistics of the muscle field proportions are shown in Table 9 below and are also displayed graphically in text-fig.6.23.

TABLE 9. Summary of statistical results of the muscle field proportion of A.(A.) funiculata from the Wenlock limestone of the Dduley area.

n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	The equation	% $\bar{W}mf/\bar{L}mf$
25	7.468 (1.446)	6.168 (0.539)	0.773	1.178	0.719	Y=1.27X + 0.34	83%

It is evident from the text-fig.6.23 that the muscle field length increased in direct proportion to its width. The percentage ratio of the muscle field width to the muscle field length is 83%.

3. Denticulation

Denticles in Wenlock funiculata are well developed as strong ridges on a pair of triangular denticular plates along the hinge line of both valves (Pl.23, fig.2 and Pl.26, figs.1,4, & 6). These denticles extend laterally along the hinge line for varying proportions of the hinge width and at an average value of 38% of the hinge width, see Table 10 below and text-fig.6.25.

TABLE 10. Summary of statistical data on denticulation of A. funiculata from Dudley.

n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (Ws)	S.D. (Wd)	The equation	% $\overline{Wd}/\overline{Ws}$
16	21.025 (9.19)	8.01 (2.24)	0.722	2.94	1.45	Y=146X + 9.3	38%

It is evident from the text-fig.6.25 that the width of the hinge line denticulations increased in direct proportion to the shell width.

4. Other features.

In addition to the features described above by the aid of the statistical data, there are some well-preserved specimens showing some well-developed morphological features. Such features are not clearly visible in the moulds of the Ludlow specimens. For example, it can be clearly seen that the pseudodeltidium is a small and triangular outgrowth of the shell which covered the deltidium in the ventral apsacline interarea of the pedicle valve. Also well seen is a smaller plate in the opposite valve called a chilidium which covered the notothyrium in the dorsal anacline interarea of the brachial valve (Pl.20, figs.2 & 3; Pl.23, fig.1 and Pl.26, figs. 8-12).

One specimen from the Walmsley collection in the National Museum of Wales (Cardiff) shows two kidney-shaped depressions with numerous tubercles, flanking the muscle scars on the floor of the brachial valve. These lobes may correspond to areas of gonad attachments and appear to be enclosed within faint impressions which may indicate the position of the brachial canal of the lophophore (lophophore platform?), see Williams (1965) and Pl.22, fig.1; Pl.26, figs.4 & 5.

Some other well-preserved specimens of Wenlock <u>funiculata</u> provided the opportunity to carry out some statistical studies. Therefore, measurements were made on complete-conjoined valves and are as follows:

a) The maximum depth (Db), from the base of the lower brachial valve to the level of the trail margin was measured (text-fig.26a). The mean value of this depth was equal to 5.787mm for twenty three valves.

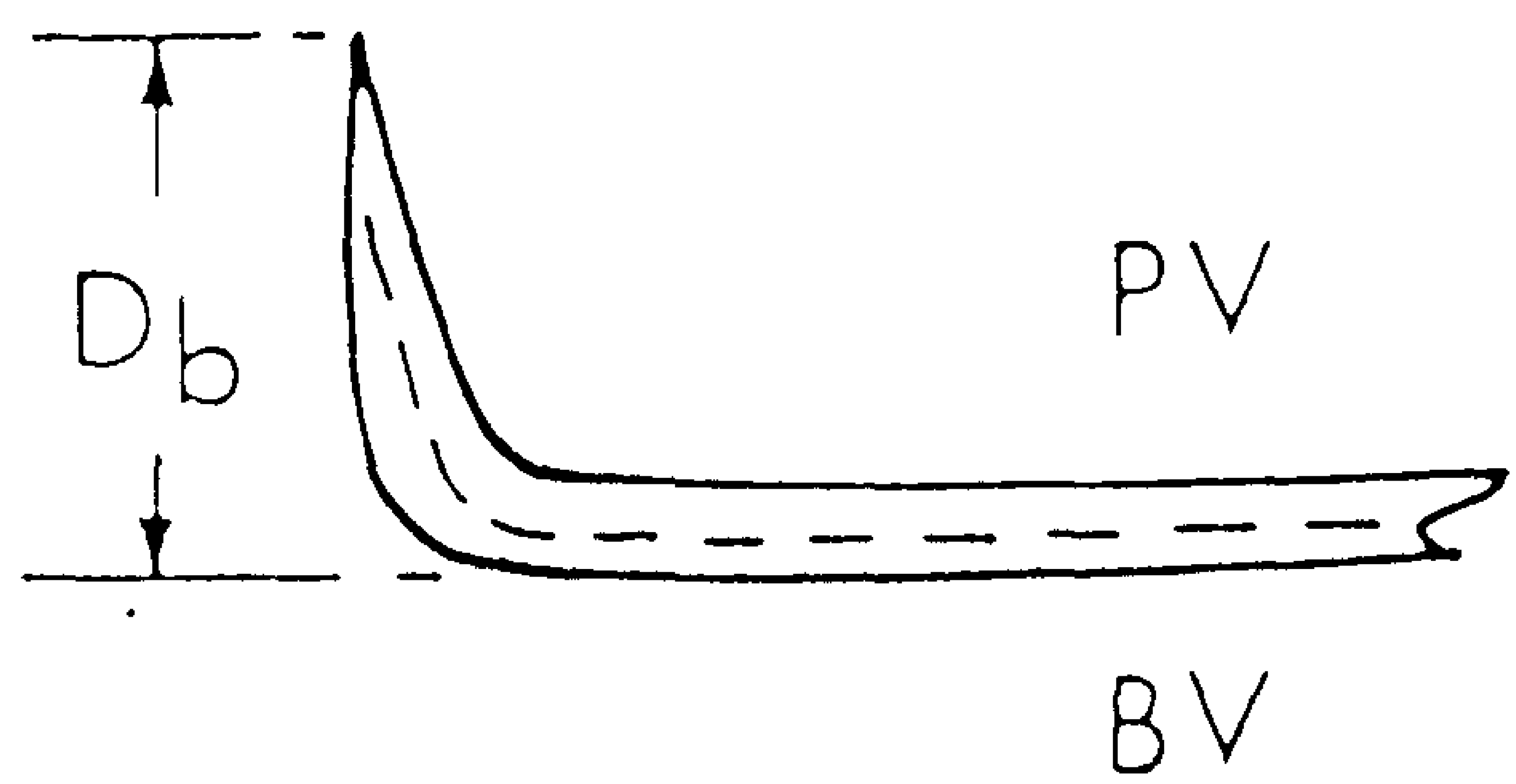
b) The maximum depth (Dp), from the top of the pedicle valve up to the level of the trail margin was measured on fifteen valves showing an average value of 1.813mm (text-fig.26b).

c) The maximum thickness postero-medianly (Tp) and at the maximum shell geniculation (TA) were measured showing an average value of 1.837 ($n = 20$) and 1.232 ($n = 19$) respectively (text-fig. 26c).

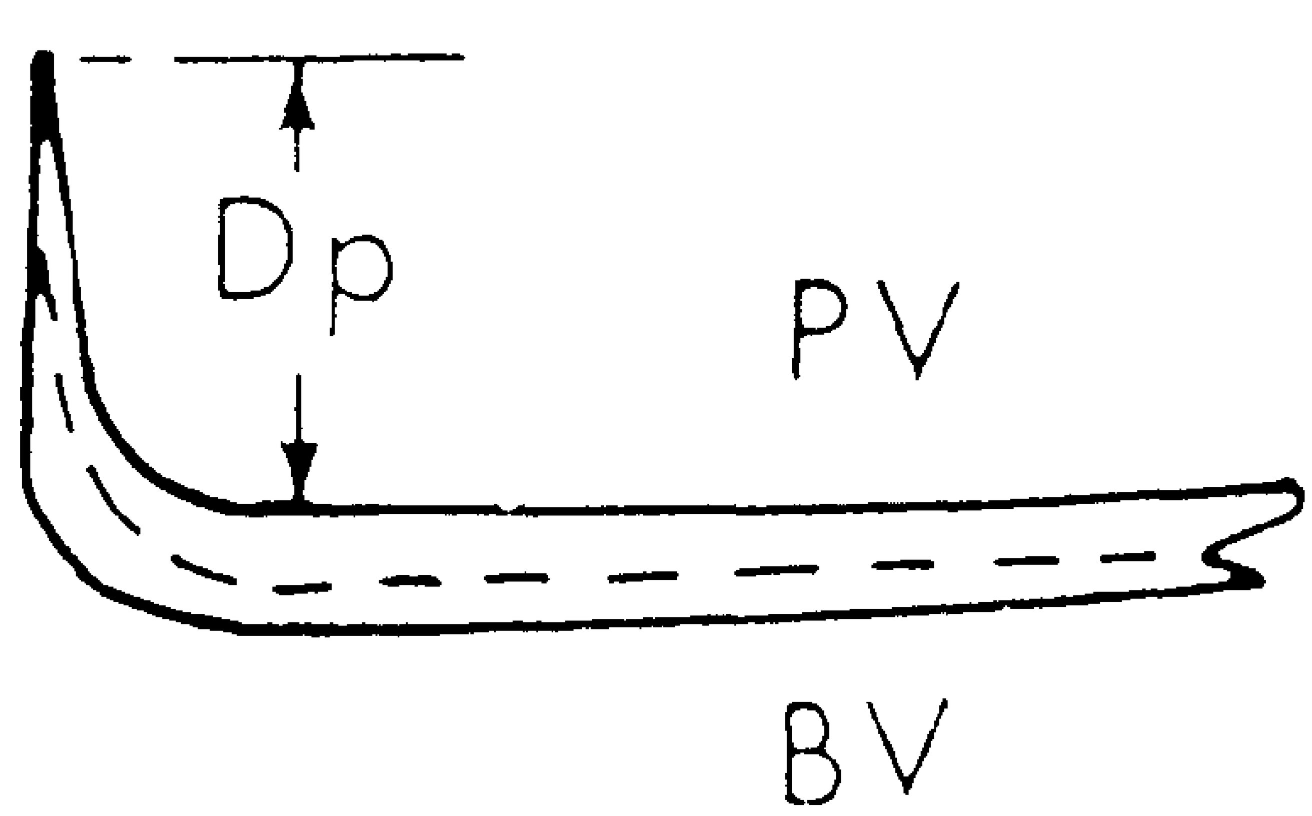
Some specimens found in the Wenlock Shale have slightly longer shell than those preserved in the Wenlock Limestone, but they still have nearly the same gross shell proportions. However, in most of the specimens studied from the Wenlock Shale have the muscle bounding ridges which die-out antero-laterally leaving the muscle

TEXT-FIG. 6.26

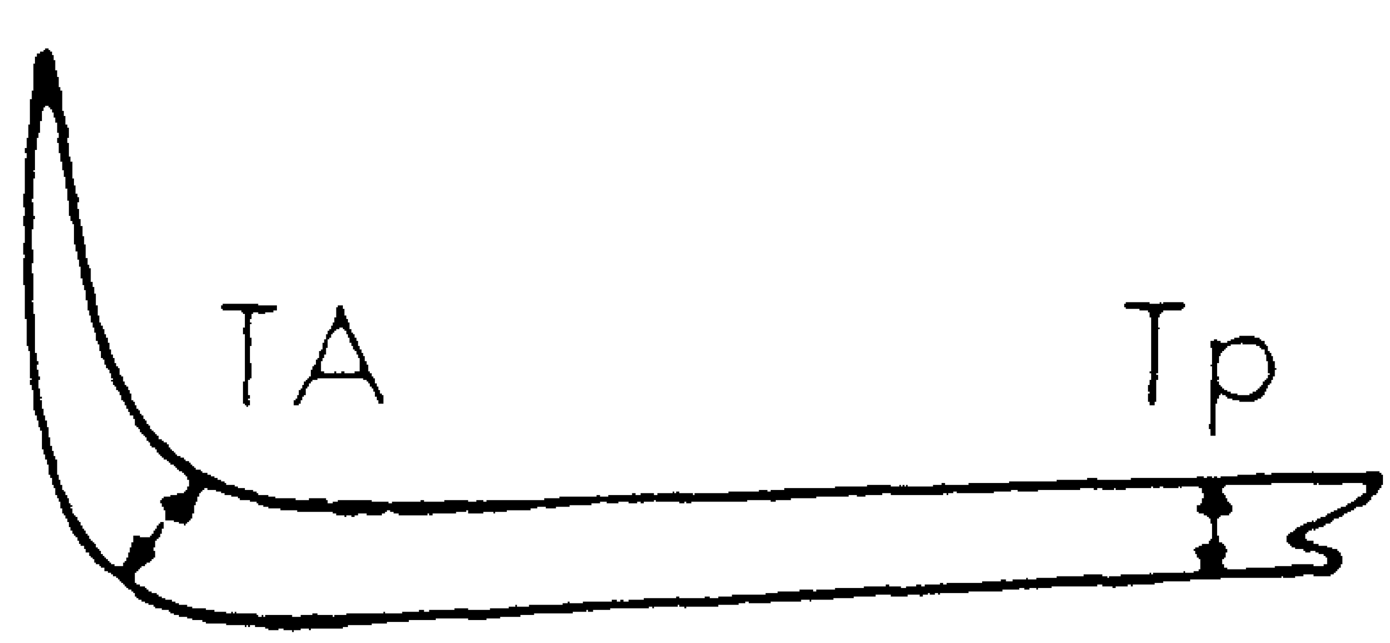
Sketch diagram showing:



a) Brachial depth (D_b): measured from the bottom of the brachial valve up to the level of the trial margin.



b) Pedicle depth (D_p): The depth measured from the top of the pedicle valve up to the level of the trial margin.



c) T_p: Maximum thickness postero-medianly.

T_A: Maximum thickness at the shell geniculation.

field unbounded anteriorly (Pl.22, fig.2). Therefore, the difference between funiculata occurring in the limestone compared with these specimens from the shale lies mainly in the shape of the muscle bounding ridges.

B. In Swedish material.

1. Shell shape and proportion.

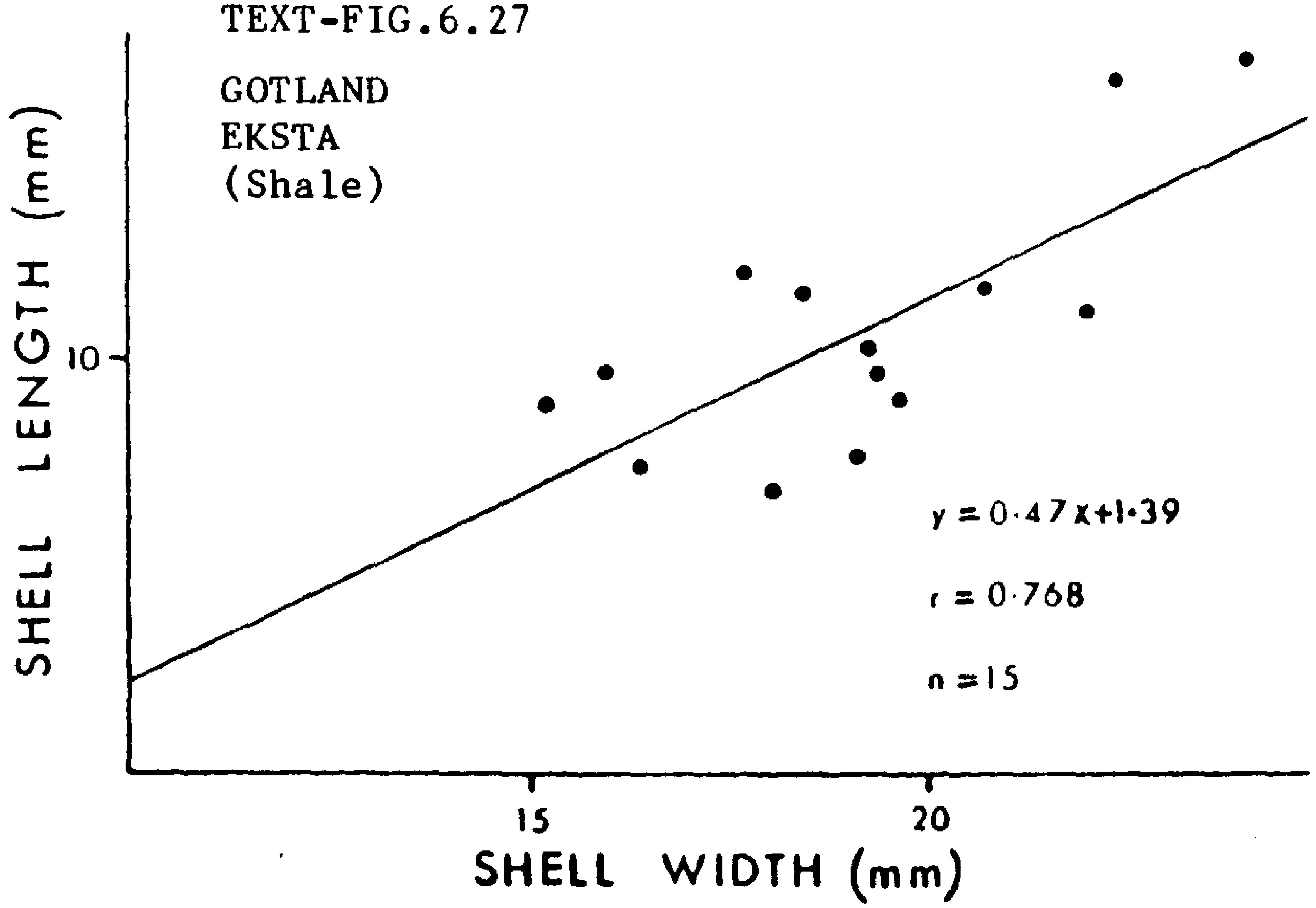
Some Gotland funiculata has also been studied herein. The specimens mostly come from shale, marl and limestone rocks of the Mulde Formation of Eksta and Klinte (see Appendix I). These specimens are roughly Wenlock in age.

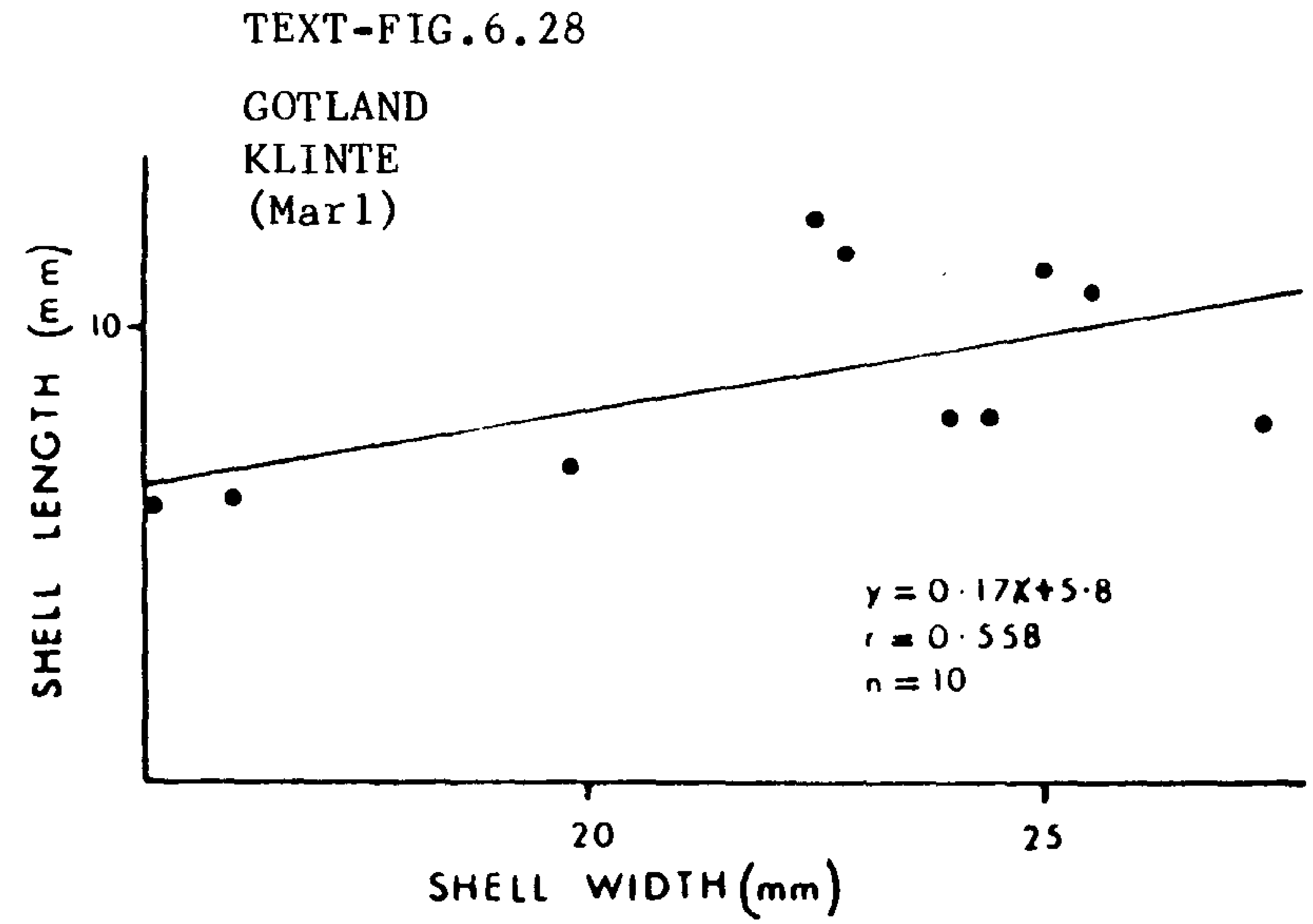
The A.(A.) funiculata studied from these different lithologies (i.e. shale, marl and limestone) show some variations in the gross shell proportions. The statistical analyses are shown in Table 11 below and are also displayed graphically in text-figs.6.27-6.29.

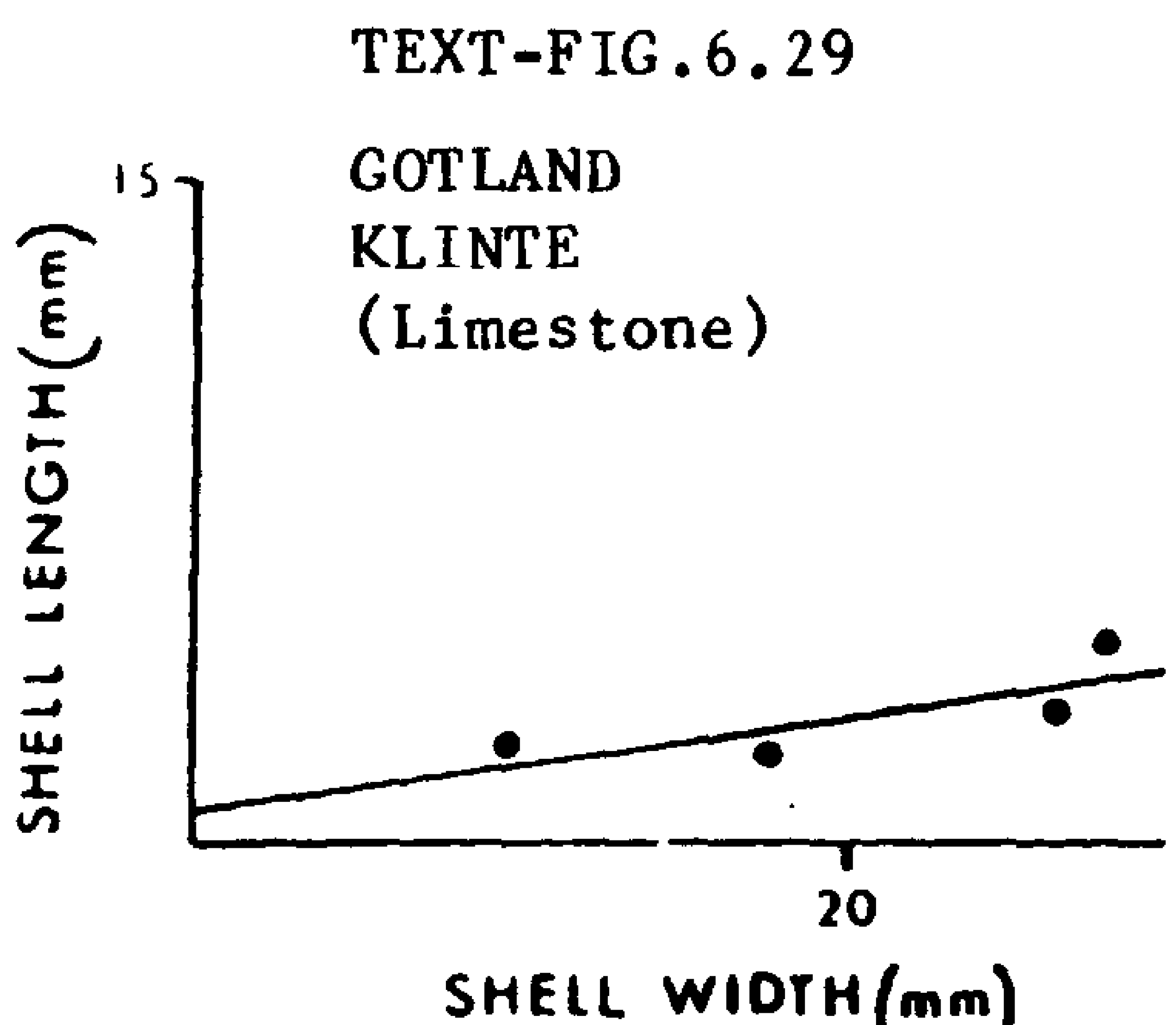
TABLE 11. Summary of statistical analyses of the shell length-width proportions of A.(A.) funiculata from Gotland.

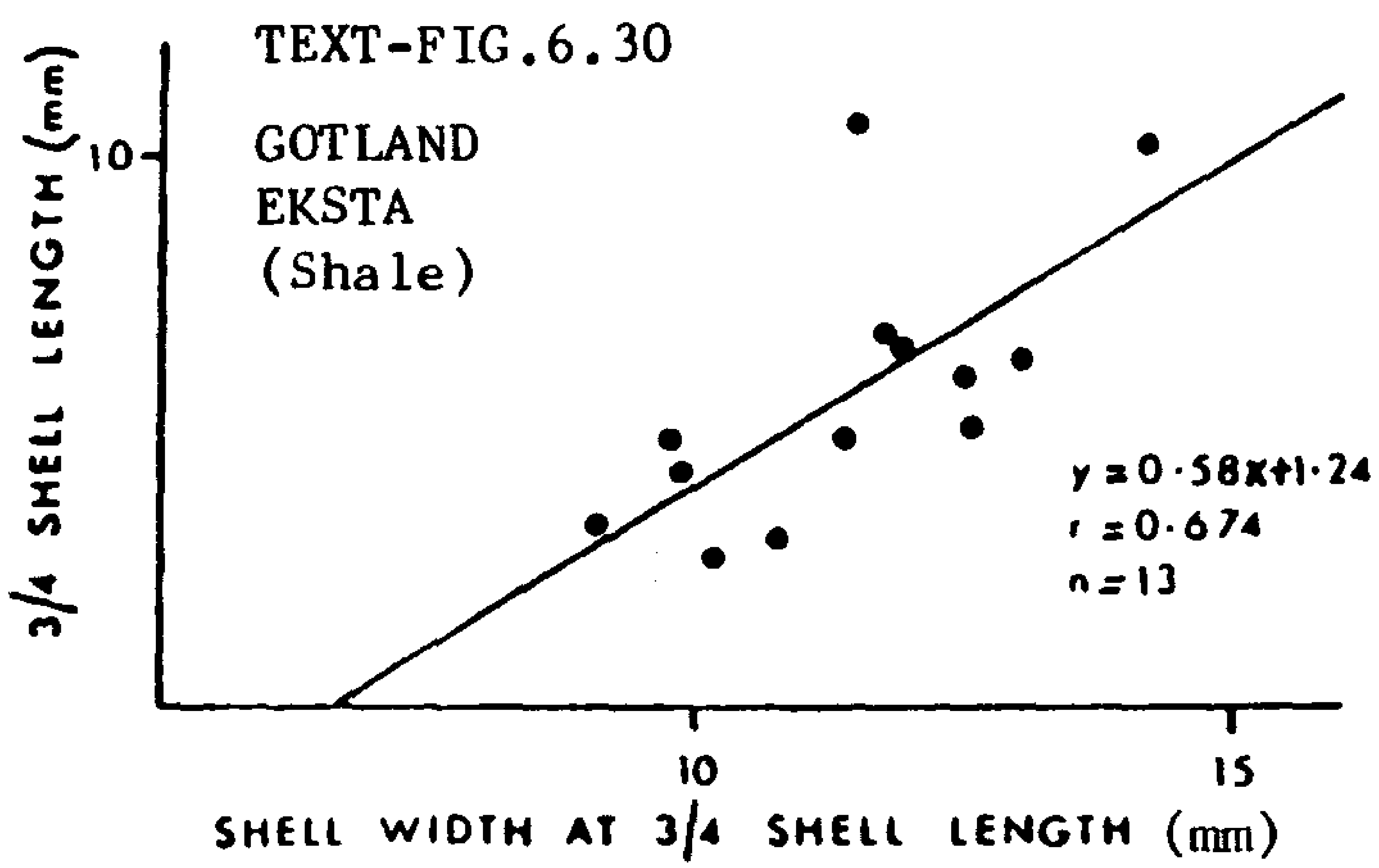
Lithology	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	The equation	% $\bar{Ls}/\bar{Ws}$
Shale	15	10.23 (2.64)	18.83 (7.06)	0.768	1.569	2.567	Y=0.47X + 1.386	54%
Marl	10	9.5 (1.51)	22.26 (16.89)	0.558	1.166	3.899	Y=0.17X + 5.8	43%
Limestone	4	10.98 (0.14)	20.1 (4.55)	0.816	0.327	1.847	Y=0.14X + 8.1	55%

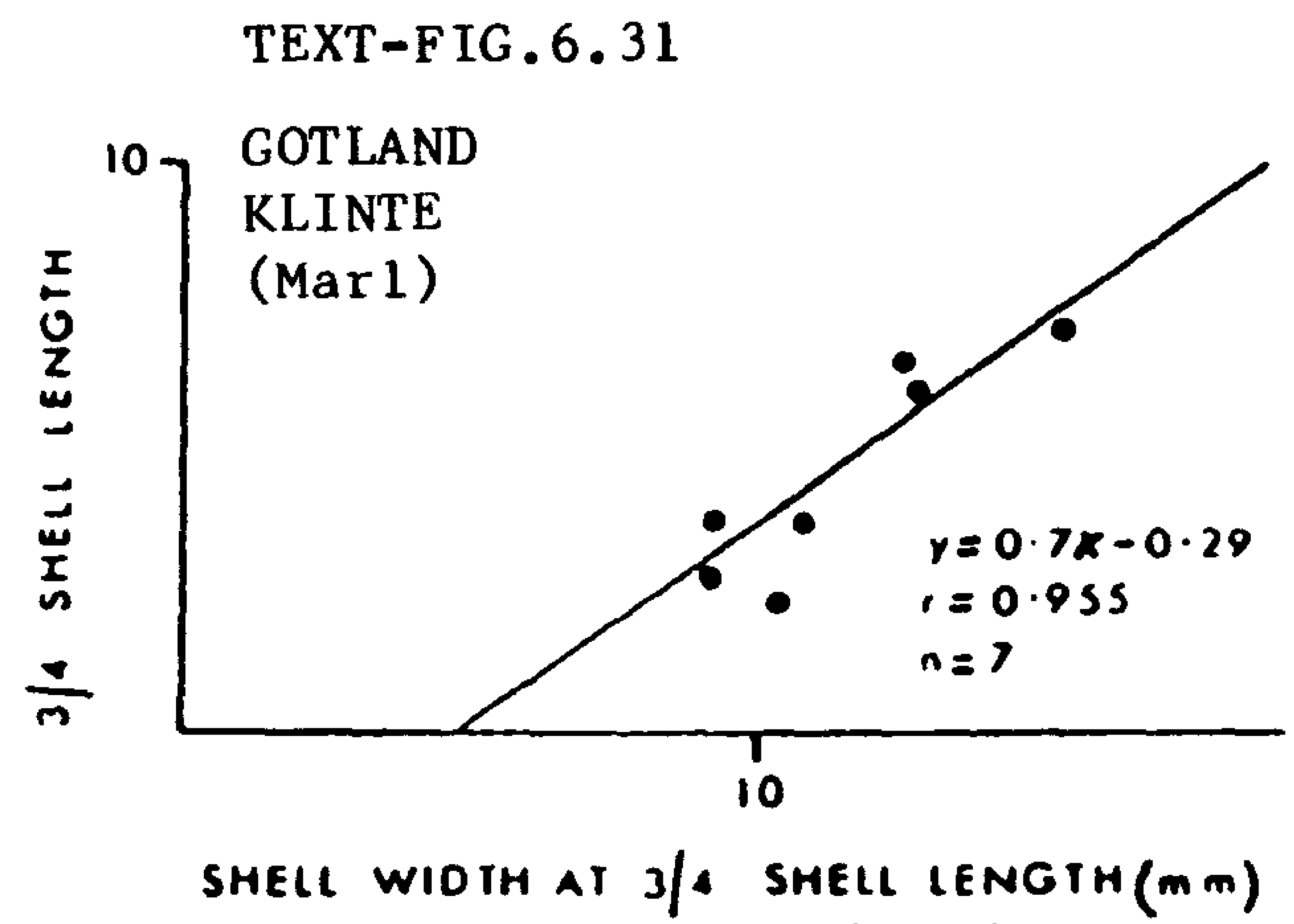
It is evident from the text-figs.6.27-6.29 that the shell length and width increase in direct proportion to each other, but it is also apparent from Table 11 above that the shell proportions vary in the three different samples studied. For example, the two samples from the shale and limestone rocks show roughly the same shell proportions











TEXT-FIGS.6.27-6.29. Shell length-width distribution of A. funiculata from the Wenlock Shale, Marl and Limestone of Gotland respectively.

TEXT-FIGS.6.30 & 6.31. Plots of ¾ shell length against shell width at this point for A. funiculata from the Wenlock Shale and Marl of Gotland.

(54/55%), while the specimens from the marl show a ratio of only 43%, i.e. the marl specimens are proportionately wider. They are indeed relatively broader than any other specimens studied from either Wenlock and Ludlow rocks in the Welsh Borderland (Britain) or Gotland (Sweden)(Pl.26, fig.3). This feature will be discussed in the palaeoecology section (Chapter 9).

The change in the outline shell shape was also illustrated statistically by measuring the shell width at ½ of the shell length. The results are displayed graphically in text-figs.6.30 & 6.31. The result shows that the Gotland funiculata is roughly similar to the Wenlock funiculata from Britain (i.e. have rounded outline).

2. Other features.

Measurements of other parameters were also made on some completely preserved specimens of the Gotland funiculata as follows:

a) The maximum depth (Db), from the base of the lower brachial valve to the level of the trail margin was measured (text-fig.26a). The average value of the depth measured on eight specimens was 6.7mm.

b) The maximum depth (Dp), from the top of the pedicle valve up to the level of the trail margin was measured on six valves and showed a mean of 2.2mm (text-fig.26b).

The variation recognised between the Gotland and British funiculata of the Wenlock age will be discussed in the subsequent comparison section.

6.6. COMPARATIVE STUDIES.

6.6.1. Comparisons between British and Swedish specimens from the Wenlock Series.

A.(A.) funiculata studied from the British Wenlock shows some differences from the form occurring in Gotland (Sweden) at approximately equivalent horizons.

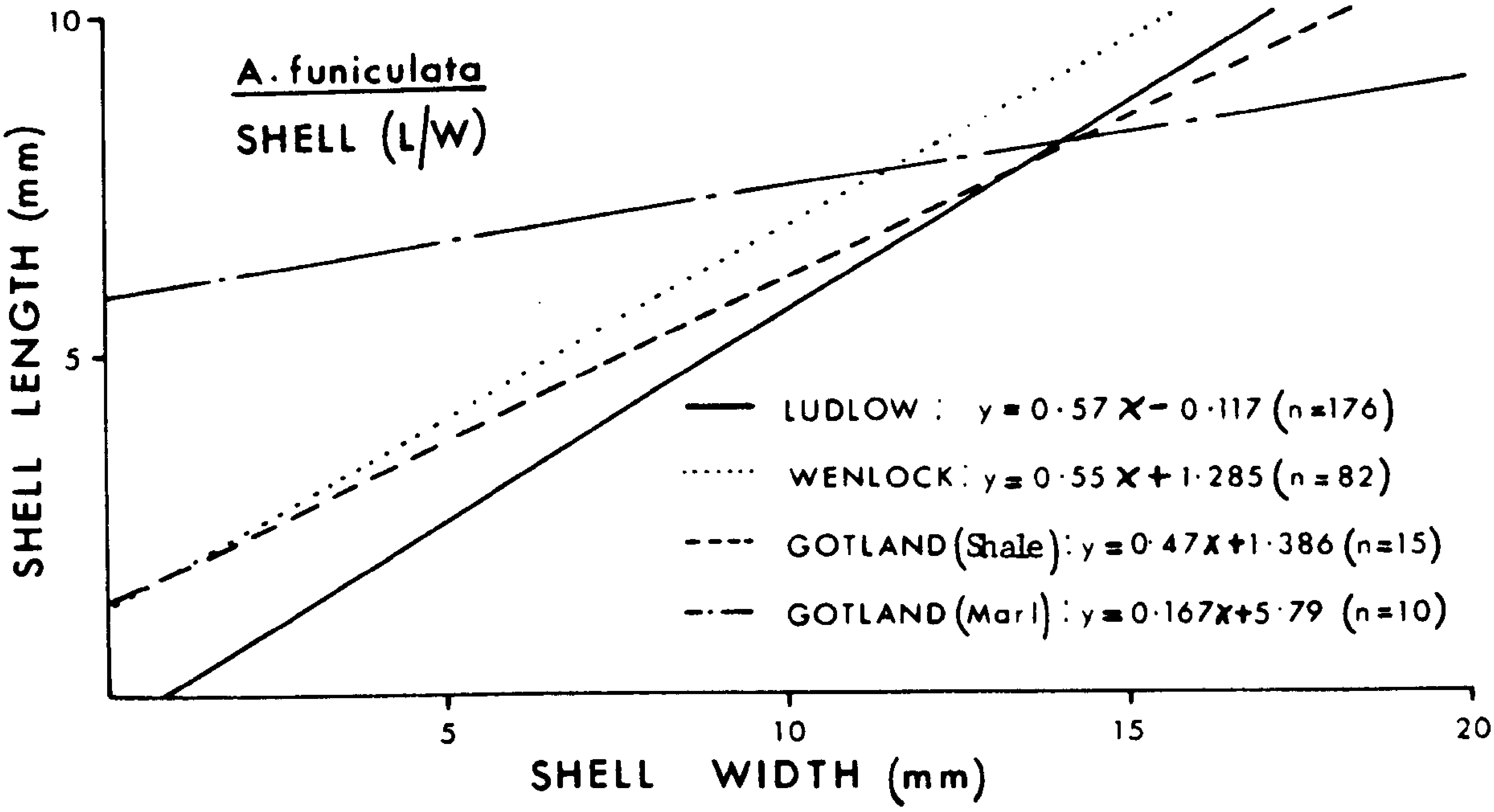
The variability in the gross shell proportion was observed within the same area, but in different rock samples. For example, the shell proportions of the specimens studied from the limestone and shale rocks of Gotland area are nearly the same and they have longer shells than those studied from the marl rock of the same area (i.e. marl specimens show wider shell), see Pl.26, fig.3.

In general, the shell proportions of the specimens studied from the Dudley area in Britain indicate a longer shell compared with the Gotland specimens (Table 12 and text-fig.6.32).

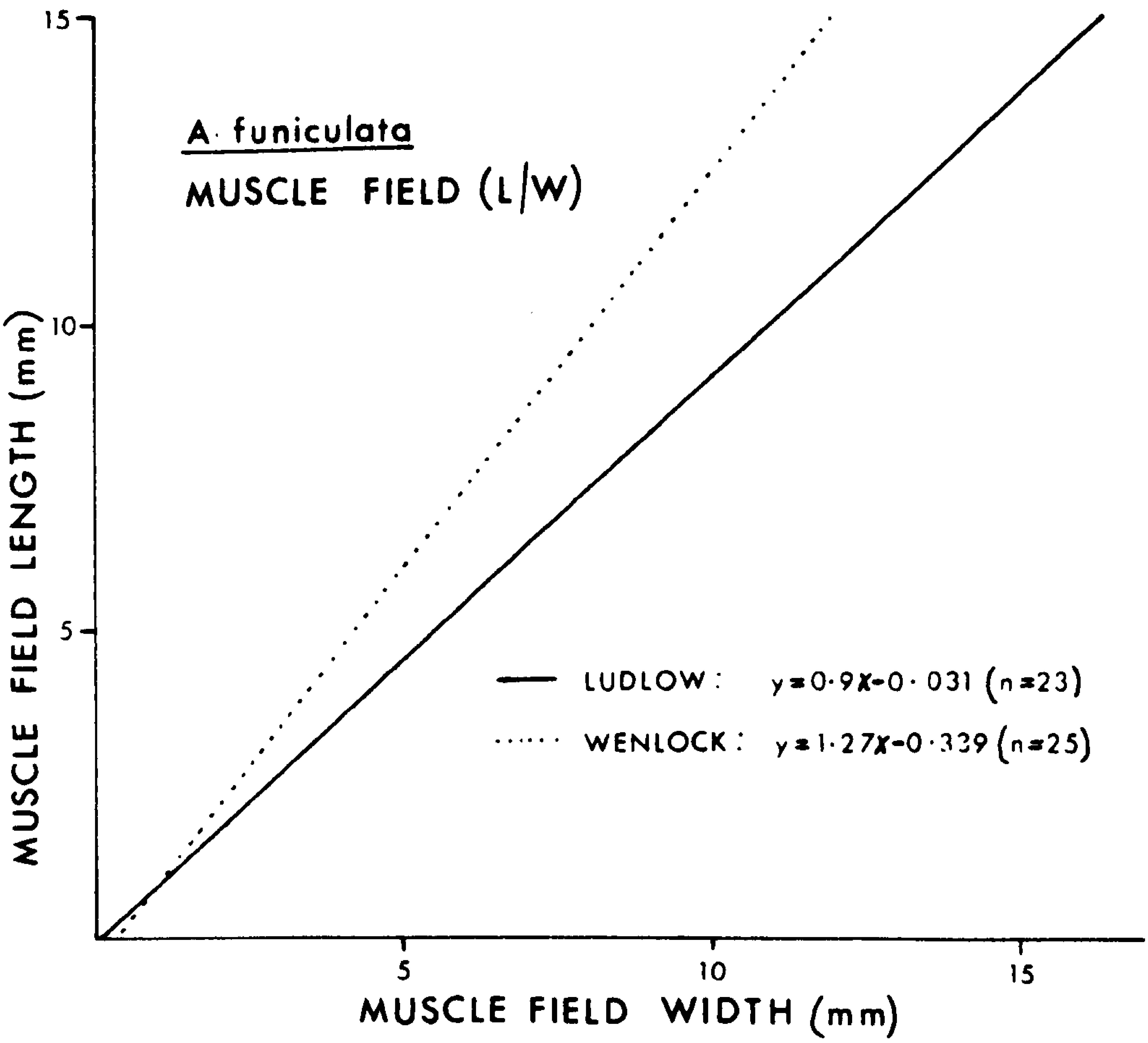
TABLE 12. Summary of the statistical results of the *A.(A.) funiculata* specimens studied from the Wenlock Series of Britain and Sweden.

Area	Formation	Type of rock	% $\overline{Ls}/\overline{Ws}$	n	% $\overline{\tfrac{1}{4}Ls}/\overline{Ws}_{\tfrac{1}{4}Ls}$	n	$\overline{Dp}$	n	$\overline{Db}$	n
BRITAIN (Dudley)	Wenlock Limestone	Limestone	61%	82	67%	82	1.8	15	5.8	22
GOTLAND (Eksta & Klinte)	Mulde Formation	Shale	54%	15	69%	13	2.2	6	6.7	8
		Marl	43%	10	68%	10	-	-	-	-
		Limestone	55%	4	-	-	-	-	-	-

TEXT-FIG.6.32



TEXT-FIG.6.33



TEXT-FIG.6.32. Comparison of shell length against shell width of A. funiculata from Ludlow and Wenlock of Britain and Wenlock of Sweden.

TEXT-FIG.6.33. Comparison of muscle field length against muscle field width of A. funiculata from Ludlow and Wenlock of Britain.

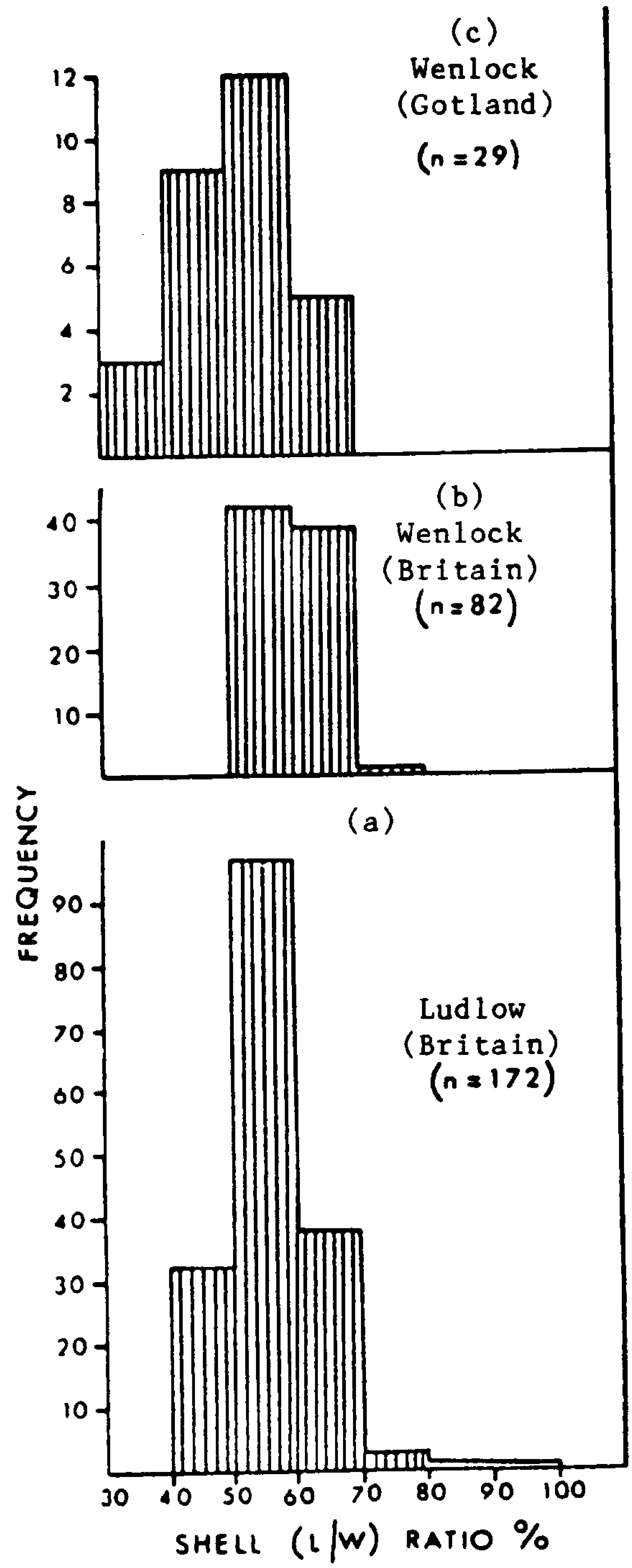
The mean proportion of the ½ shell length to the shell width at this point was calculated in both Britain and Swedish areas, showing nearly the same ratio (Table 12). The mean ratio of the anterior shell thickness to the posterior shell thickness was also calculated in both areas showing roughly the same value, i.e. Britain 72% (n = 24) and Gotland 74% (n = 10) respectively.

Variations between the two areas are also apparent from measurements made on well-preserved conjoined valves. These measurements show the depths from the bottom of the brachial valve and the top of the pedicle valve, up to the level of the trail margin (Db and Dp respectively, text-fig.26a &b). However, the specimens from Eksta & Klinte on Gotland show an average brachial depth (Db) of 2.2mm and pedicle depth (Dp) of 6.7mm, while the British specimens from Dudley show an average brachial depth (Dd) of 1.8mm and pedicle depth (Dp) of 5.8mm. These variations in the brachial and pedicle depth of the shell from both areas will be discussed later in the palaeoecology section.

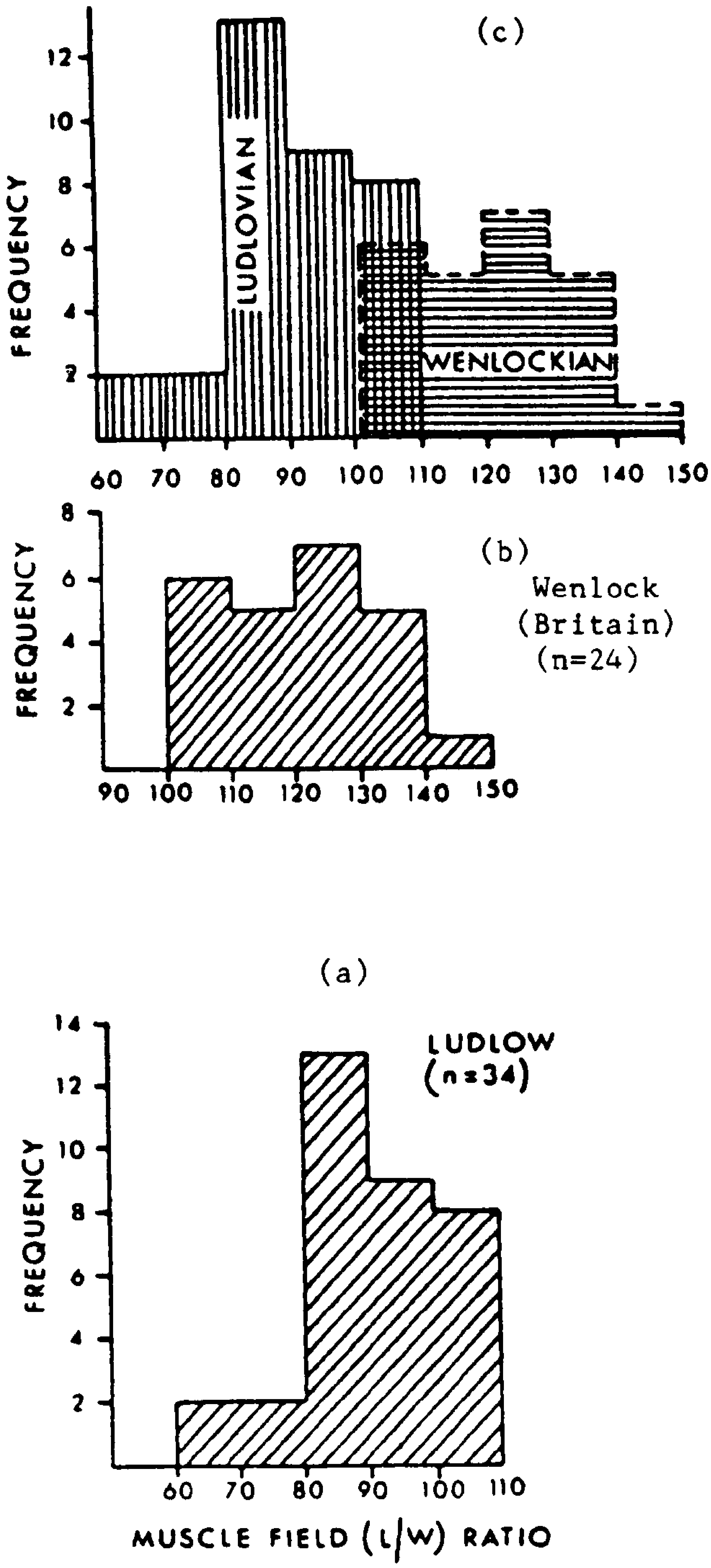
6.6.2. Comparisons between Wenlock and Ludlow specimens from the Welsh Borderland of Britain.

Wenlock funiculata are characterised by a semicircular rounded shell shape (Pl.26; Pl.20, fig.2; Pl.21, fig.2 and Bassett's 1977, Pl.41, figs.4,7,8 & 10) as compared with the Ludlow specimens which are becoming subtriangular (Pl.23, fig.1). For a visual comparison between both Ludlow and Wenlock samples see also Pl.21, figs.1 and 2. The shell length-width proportions are slightly different, see Table 13 and the shell length-width ratio frequency histogram (text-fig.6.34).

TEXT-FIG.6.34



TEXT-FIG.6.35



TEXT-FIG.6.34. Shell length-width ratio frequency histograms for A. funiculata from a) Ludlow and b) Wenlock of Britain, and c) Wenlock of Gotland.

TEXT-FIG.6.35. Muscle field ratio frequency histograms of A. funiculata from a) Ludlow and b) Wenlock of Britain, and c) their superimposition.

TABLE 13. Summary of statistical results of the shell, muscle field and denticulation for Ludlow and Wenlock funiculata from Britain.

AGE	$\overline{L}s/\overline{W}s$	n	$\overline{L}mf/\overline{W}mf$	n	$\overline{L}mf/\overline{L}s$	n	$\overline{W}d/\overline{W}s$	n	% $\frac{1}{4}\overline{L}s/\overline{W}s_{\frac{1}{4}Ls}$	n
LUDLOW	56%	176	92%	35	62%	8	42%	18	71%	50
WENLOCK	61%	82	121%	25	59%	25	38%	16	67%	82

In an attempt to demonstrate the shell shape variability in the Wenlock and Ludlow funiculata, measurements have been made of the shell width at ¼ of the shell length. The mean proportions of the ¼ shell length to the shell width at this point are 71%, (n = 50) and 67% (n = 82) for the Ludlow and Wenlock specimens respectively (see Tables 4 and 8 for detail). The higher value of the Ludlow specimens (i.e. 71% than the Wenlock specimens (i.e. 67%) reflects the subtriangular shape of the Ludlow specimens as a triangle is less wide at this point than a semicircle.

Most of the Ludlow specimens studied are gently to strongly sulcate at the antero-median region of the shell. The average depth of sulcus ranges between 0.4-0.8mm (Pl.17, figs.1 & 2). Wenlock specimens show no sulcation except for a few specimens which are very gently sulcate, see Bassett (1977, Pl.41, figs.1-12).

The muscle fields in both Ludlow and Wenlock specimens are in general bilobed in shape and subtriangular to triangular in outline (Pl.24, figs.1-3 and Pl.26, figs.1 & 2) with roughly the same angle of divergence of the pedicle muscle field. Variation was detected only in the muscle field proportions by measuring the muscle field length and width. The muscle field length-width ratio for the Wenlock specimens is 121% (n = 25); while specimens from Ludlow show 92% (n = 35), see Tables 6 and 9 for detail. Best fit lines between the muscle field length and width for both Ludlow and Wenlock specimens were drawn and are displayed in text-fig.6.33. These lines confirmed that the length and width of the muscle field are directly proportional to each other. The line representing Wenlock specimens shows a longer muscle field than the line representing Ludlow specimens. One of the reasons why Wenlock specimens have longer muscle fields may be due to the longer shell of the Wenlock specimens. A muscle field length-width ratio frequency histogram was drawn for both Ludlow and Wenlock together in text-fig.6.35, which confirms the relatively longer muscle field in Wenlock specimens.

Denticles extend laterally along the hinge line in both the brachial and pedicle valves of funiculata from the Ludlow and the Wenlock Series (Pl.24, fig.1 and Pl.26, fig.1). The proportions of these denticles along the hinge line in Ludlow and Wenlock specimens vary. The mean proportion of the hinge-line occupied by the denticulations in Ludlow specimens is more than in Wenlock specimens. For example, 42% (n = 18) in the Ludlow as compared with 38% (n = 16) in the Wenlock (Table 13). These differences will be discussed later in the palaeoecology section.

6.6.3. Conclusion.

The main differences between Ludlow and Wenlock A.(A.) funiculata occurred in the largeness of the Wenlock forms, both in the shell and muscle field, their rounded shell shape and their longer muscle field. In addition, the Ludlow species has increased development of denticles along the hinge line and are gently to strongly sulcate.

CHAPTER SEVEN

STROPHONELLA (STROPHONELLA) EUGLYPHA (Dalman, 1828)

CONTENTS

CHAPTER SEVEN

STROPHONELLA (STROPHONELLA) EUGLYPHA (Dalman,1828).

7.1. INTRODUCTION.

Strophonella (*Strophonella*) *euglypha* is the largest stropheodontid brachiopod among other similar stropheodontid species such as *A.*(*A.*) *funiculata*. It is a common species in the calcareous facies of both the Wenlock and Ludlow Series of the Welsh Borderland. The valve shape of this form is resupinated and develops a strongly convexi-concave profile (similar to that in *A.*(*A.*) *funiculata*) and has unequally parvicostellate ornament (i.e. bundles of capillae within stronger costellae). The author's investigation was stimulated by the observation of morphological differences between the Wenlock and Ludlow populations. Therefore, the species description and its variation (based mainly on the Ludlow material) is fully illustrated photographically and statistically. Furthermore, the variation of some selected Wenlock specimens has also been studied and statistically compared with that of the Ludlow form. It appears that the morphological variability between the Wenlock and Ludlow populations lies mainly in the shell and muscle field shapes and proportions. The external and internal shell features are clearly shown in the present study, such as, the pseudodeltidium, chilidium, cardinal process and socket plates.

7.2. SPECIES DESCRIPTION.

Subfamily STROPHONELLINAE Caster, 1939.
Genus *STROPHONELLA* Hall, 1879.
Subgenus *STROPHONELLA* (*STROPHONELLA*) Hall, 1879.

7.2.1. Type species.

Strophomena semifasciata Hall, 1863, p.210; from the Silurian ('Niagara Group' probably Waldron Shale, Wenlock) of Waldron, Indiana, U.S.A. By subsequent designation of Hall and Clarke 1893, p.291.

Strophonella (Strophonella) euglypha (Dalman, 1828); Pls.(27-36).

7.2.2. Synonymy.

1828 Leptaena euglypha Dalman, p.108, Pl.1, figs.3a,c. non fig.3b.

1828 Leptaena euglypha Dalman; Hisinger, p.220, Pl.6, figs.4a,b.

1839 Leptaena euglypha Dalman; J. de C. Sowerby in Murchison, p.622, Pl.12, fig.1.

1847 Leptaena euglypha Dalman; Davidson, p.56, p.12, figs.1-4.

1848 Leptaena euglypha Dalman; Davidson, p.316, Pl.3, fig.4.

1852 Leptaena (Strophomena) euglypha (Dalman) McCoy, p.243.

1861 Strophomena euglypha (Dalman); Lindström, p.372.

1871 Strophomena euglypha (Hisinger); Davidson, p.288, pars Pl.40, figs.1-3, non figs. 4,5.

1884 Strophomena euglypha (Dalman); La Touche, p.70, Pl.13, figs. 394-7.

1893 Strophonella euglypha (Dalman) Hall & Clarke, p.292 (name only).

1971 Strophonella (Strophonella) euglypha (Dalman) Bassett, p.310, Pl.55, figs.4-11, Pl.56, figs.1,2.

1974 Strophonella (Strophonella) euglypha (Dalman); Bassett and Cocks, p.17.

1977 Strophonella (Strophonella) euglypha (Dalman); Bassett, Pl.38, figs.3-7.

1978 Strophoprion euglypha Twenhofel, 1914; Harper and Boucot, Pl.15, figs.6,7 and Pl.16, figs.1-4,6,7,11.

7.2.3. Lectotype.

SMNH Br 2342 (Hisinger sample 472), brachial valve; Pl.38, fig.3; from the Mulde Beds (Wenlock) of Djupvik, Gotland; the original of Dalman 1828, Pl.1, figs.3a,c and Hisinger 1828, Pl.6, figs.4a,b; selected and refigured by Bassett 1971, p.312, Pl.55, fig.5.

7.2.4. Material (from Ludlow Series only).

Two hundred and thirty nine specimens have been collected from the Ludlow area, Woodbury Quarry in the Abberley Hills and the Usk inlier in the Welsh Borderland. Forty three specimens are from the Ludlow Museum collections, ten specimens from the National Museum of Wales and four specimens from the British Geological Survey Museum. The collected specimens are mostly internal and external moulds of the pedicle and brachial valves. The general description of the species is based on all these specimens (i.e. 296 specimens).

7.2.5. Horizons and localities:

The specimens are mainly from the Lower and Upper Bringewood Formations of the Ludlow Series of the Welsh Borderland (Ludlow area, Abberley Hills and Usk inlier), but a few specimens are from the Lower Elton Formation of the Ludlow area.

7.2.6. Diagnosis.

Resupinate, convexi-concave Strophonella, averaging 78% as long as wide; ornament fine to coarse unequally parvicostellate ranging from three to six ribs per mm at 10mm antero-medianly of dorsal hinge with small, short and oblique crenulations of the shell along the posterior margins of the hinge in some specimens, see Pl.29, figs.1-5. internally with deeply impressed, subquadrate, flabellate, ventral muscle fields ranging from 78% as long as wide (Ludlow area) to 85% as long as wide in the Usk inlier and Abberley Hills; hinge line denticulation ranging from 40% (Ludlow) to 36% (Usk) of the shell width.

7.2.7. Description.

Medium-sized, subtriangular to triangular Strophonella (see Pls.27; 28 and Pl.29, fig.1), initially plano-convex to weakly concavo-convex becoming strongly convexi-concave in profile, resupinate, averaging 81% as long as wide at Ludlow ((e.g. $\bar{L}$smm (var Ls) 28.69 (55.89), $\bar{W}$s (var Ws) 35.29 (57.86), r = 0.771, n = 135)), 75% as long as wide in the Usk inlier ((e.g. $\bar{L}$smm (var Ls) 25.7 (20.474), $\bar{W}$smm (var Ws) 34.36 (48.23), r = 0.787, n = 39)) and 79% as long as wide in Woodbury Quarry in the Abberley Hills ((e.g. $\bar{L}$smm (var Ls) 28.75 (23.14), $\bar{W}$s (var Ws) 36.49 (38.77), r = 0.746, n = 77)), maximum width at or slightly anterior to the straight hinge line, which is commonly produced as short ears (see Pl.28, fig.2); lateral margins of shell straight or gently curved anteriorly, anterior margin sometimes produced as a subtriangular tongue, commissures smooth, rectimarginate; radial ornament fine to coarse unequally parvicostellate with 2,3,4, 5,6 rounded ribs per mm at 10mm antero-medianly of dorsal hinge of 6,11,16,12,13 valves respectively, with 5-7 very fine capillae occupying wide interspaces between rounded costellae, becoming less numerous near beaks (see Pl.29, fig.2), some specimens showing fine, short crenulations of shell along posterior margin, inclined obliquely, making an angle of between 20°-30° to the hinge line and directed towards the muscle field (see Pl.29, fig.2); ventral interarea is apsacline, dorsal interarea is anacline, delthyrium almost completely closed by well-developed, triangular, convex pseudodeltidium (see Pl.31, figs 1 and 2), chilidium strong, convex, completely sealing notothyrium (see Pl.30, fig.2).

Interior of pedicle valve with stout, diamond-shaped ventral process, supporting base of pseudodeltidium (Pl.31, figs.1 & 2), longitudinally concave along its mid length and produced anteriorly as a strong, rounded myophragm, process pits deep, laterally bounding ventral process; strong denticulation (about 17-22 denticles on each side) extending laterally for an average of 40% of hinge width in Ludlow ((e.g. $\overline{W}$smm (var Ws) 37.39 (51.62), $\overline{W}$d (var Wd) 15.13 (13.207), r = 0.646, n = 33)) and 36% in Usk inlier ((e.g. $\overline{W}$smm (var Ws)35.06 (48.84), $\overline{W}$dmm (var Wd) 12.43 (5.03), r = 0.681, n = 12)); ventral muscle field subquadrate, flabellate, deeply impressed (Pl.31, figs. 1,2, Pl.32, figs.1,3,4,6), averaging 86% as long as wide ((e.g. $\overline{L}$mfmm (var Lmf) 10.62 (13.87), $\overline{W}$mfmm (var Wmf) 12.38 (18.52), r = 0.948, n = 9)); and $\overline{L}$mfmm (var Lmf) 11.65 (4.44), $\overline{W}$mfmm (var Wmf) 13.61 (7.25), r = 0.86, n = 10; in the Abberley Hills and the Usk inlier respectively)), and 78% as long as wide in Ludlow ((e.g. $\overline{L}$mfmm (var Lmf) 11.47 (6.88), $\overline{W}$mf (var Wmf) 14.81 (11.18), r = 0.835, n = 14)); strong muscle bounding ridges arise immediately anterior to hinge, diverging at about 100°-125°, becoming parallel to subparallel then curving sharply posteriorly to intersect myophragm (Pl.32, fig.3); adductor muscle scars narrow, lanceolate, bisected by myophragm (Pl.31, figs.1 & 2, Pl.32, figs. 1 & 3), averaging 60% as wide as long, bounded by large, oval diductor muscle scars, averaging 39% as long as shell length at Ludlow ((e.g. $\overline{L}$mfmm (var Lmf) 11.72 (7.67), $\overline{L}$smm (var Ls) 30.4 (51.79), r = 0.664, n = 12)) .

Brachial valve interior with cardinalia raised on broad platform, produced anteriorly as a convex median ridge, cardinal process lobes directed postero-ventrally, divergent, stout, pear-shaped and grooved along their mid length (Pl.27, Pl.28, fig.2, Pl.29, fig.2, Pl.30, fig.2 and Pl.32, figs.7-12)), sockets shallow, socket ridges strong, short, blade-shaped, divergent at about 120°-130°, muscle field moderately well impressed, truncated, oval in shape occupying about ½ valve width and about ⅔ valve length, defined by curved ridges laterally, posterior scars suboval, narrow, subparallel, bisected by tapering, rounded end of ridge; a few specimens showing the lemniscate type of mantle canal system (vascula myaria), developed on the floor of the brachial valve as a pair of narrow ridges, diameter of each one about 0.4mm, radiating from the middle length of the adductor muscle scars and extending anteriorly, separated by a maximum width of 9.3mm, (see Pl.28, figs. 1 & 2).

Valve floor with numerous coarse to fine tubercles, particularly well-developed around the muscle field, with an average diameter of 0.1, 0.125, 0.15, 0.175, 0.2 and 0.225mm in 5,13,5,4,2 and 6 valves respectively.

7.2.8. Distribution.

S. euglypha mainly occurs as a mould of both pedicle and brachial valves throughout the Ludlow successions of the Welsh Borderland. It is present in the Lower Elton Formation and becomes very rare in the Middle and Upper Elton Formations. The species occurs fairly commonly in the Lower Bringewood Formation becoming common in the Upper Bringewood Formation. It is very rare in the Leintwardine Formation, although it is recorded from that formation by Holland *et. al* (1963) from Ludlow and by Squirrell and Tucker (1960) from Woolhope. It is not recorded from the Whitcliffe Formation in the Welsh Borderland.

The species has been collected in this study from the following localities: 31, 14, B1, B2, B4, B5, B6, B7, 7a, SH, WQ and LR (see text-figs.2.1, 2.4, 2.5 and Appendix I for locality list). The species has been recorded by Ludlow Research Group workers from many of the shelf areas of the Welsh Borderland; e.g. from Ludlow by Holland et al (1963), Leintwardine by Whitaker (1962), Much Wenlock by Shergold and Shirley (1968), Aymestrey by Lawson (1973), Woolhope by Squirrell and Tucker (1960), Usk by Walmsley (1959), May Hill by Lawson (1955) and Llandovery and Llandeilo by Potter and Price (1965). S. euglypha has also been recorded from the basin at Knighton by Holland (1959). Consequently, S. euglypha is a common Ludlow species on the shelf, but very rare (and probably derived) in the basin facies of the Welsh Borderland; see text-figs.1.5-1.8, for the species distribution.

7.2.9. Discussion.

Williams (1950) introduced a new Strophonella subgenus (Eostrophonella) during his study of the Llandovery specimens. The Wenlock specimens of S. euglypha have been examined and described by Bassett (1971, 1977), where he assigned these specimens to the subgenus Strophonella Hall, 1879. He also summarised the differences between the species of both subgenera, in that the Llandovery species differs from the Wenlock one in having short dental plates and a less prominent, more rounded pedicle muscle field, which is always bounded laterally and seldom anteriorly. Subsequently, Harper and Boucot (1978) recognised a new Strophonella subgenus, Quasistrophonella, which differs completely in its character from both of the preceding subgenera (i.e. Eostrophonella and Strophonella). Quasistrophonella subgenus has wide interspaces between the costellae, which are free of any fine ribs (capillae).

The subgenus Strophonella (Strophonella) is characterised by its unequally parvicostellate radial ornament with very fine capillae occupying the wide interspaces between the major rounded costellae. The valves are resupinate in profile and develop a strongly convexi-concave profile. The dental plates are absent, but the hinge line bears a pair of well-developed denticular plates. In addition, the pedicle valve muscle field is bounded laterally and anteriorly. The morphological features of the studied specimens are consistend with the Strophonella subgenus characteristics and therefore, they are firmly included in it.

It is confirmed that the morphological features of the specimens from the silty calcareous Ludlow rocks are consistent with those coming from the more limy rocks of the Wenlock Series (see the species description by Bassett 1971, 1977), with slight differences in the denticulation and in both shapes and proportions of the shell and muscle field.

Within the Ludlow population, an interesting feature, not previously recorded, is the presence of numerous, oblique, parallel striations appearing on the external surface of a few specimens (Pl.30, fig.1). These are probably micro-tectonic structural features.

The statistical analysis made on the morphological variability of this species shows that it is unjustified to erect new species or subspecies, and that the variation appears to be most likely controlled by genetic and/or environmental factors (see Chapter 9).

7.3. DESCRIPTION OF VARIATION IN S. EUGLYPHA FROM LUDLOW SERIES.

A. External shell features.

1. Shell proportion and shape variation.

S.(S.) euglypha is convexi-concave in profile, posteriorly, it is weakly concavo-convex, then becomes strongly convexi-concave anteriorly forming the resupinate shell profile . S.(S.) euglypha has a subtriangular to triangular outline shell shape (Pl.27, fig.1, Pl.28, figs.1,2 and Pl.29, fig.1 for the triangular outline and Pl.27, fig.2, Pl.31, fig.2 for the subtriangular shape).

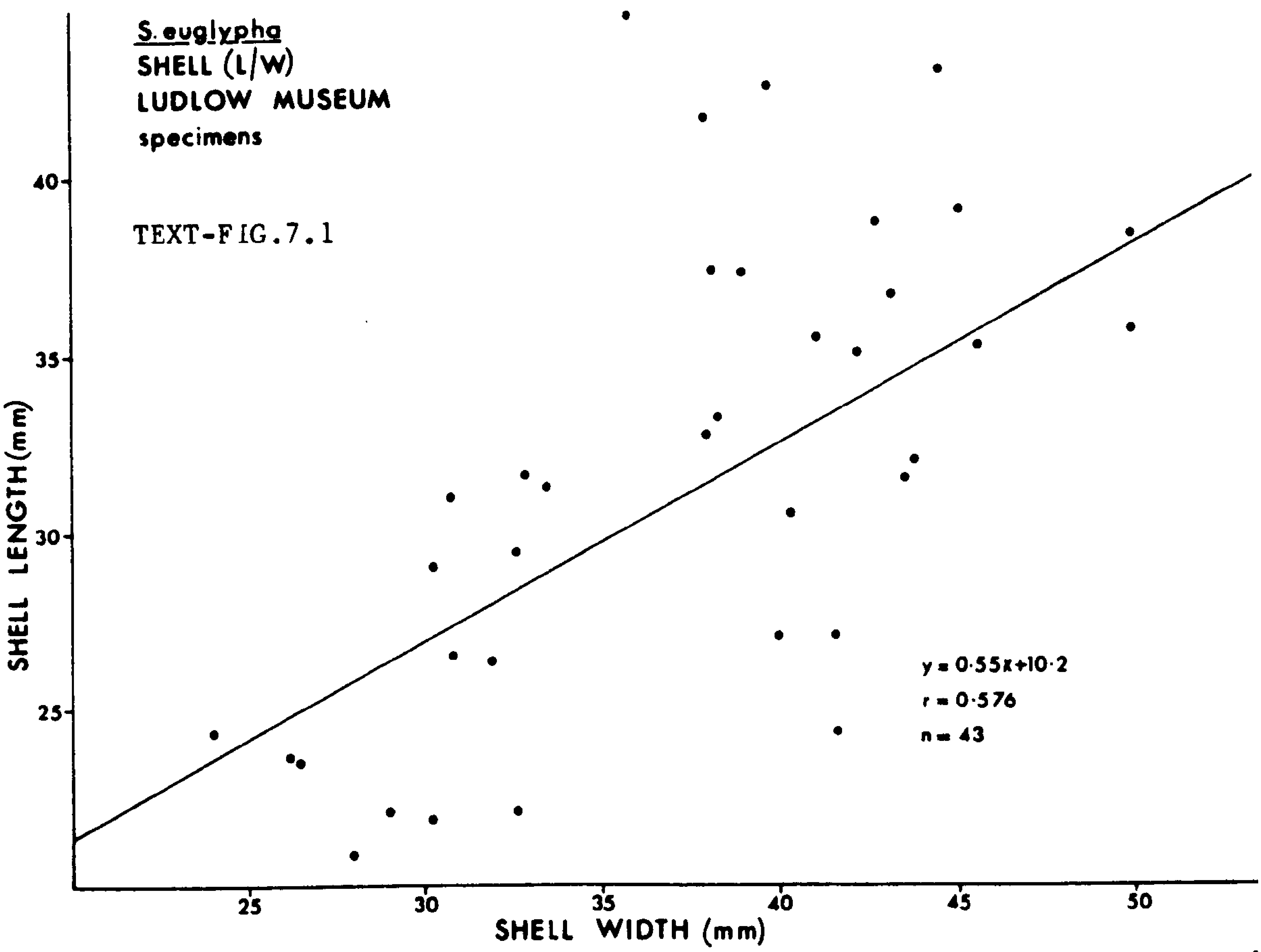
S.(S.) euglypha has been particularly studied from three areas in the Welsh Borderland (Ludlow, Abberley Hills and the Usk inlier). Specimens from each of these three areas provided an opportunity to study the shell shape variability statistically.

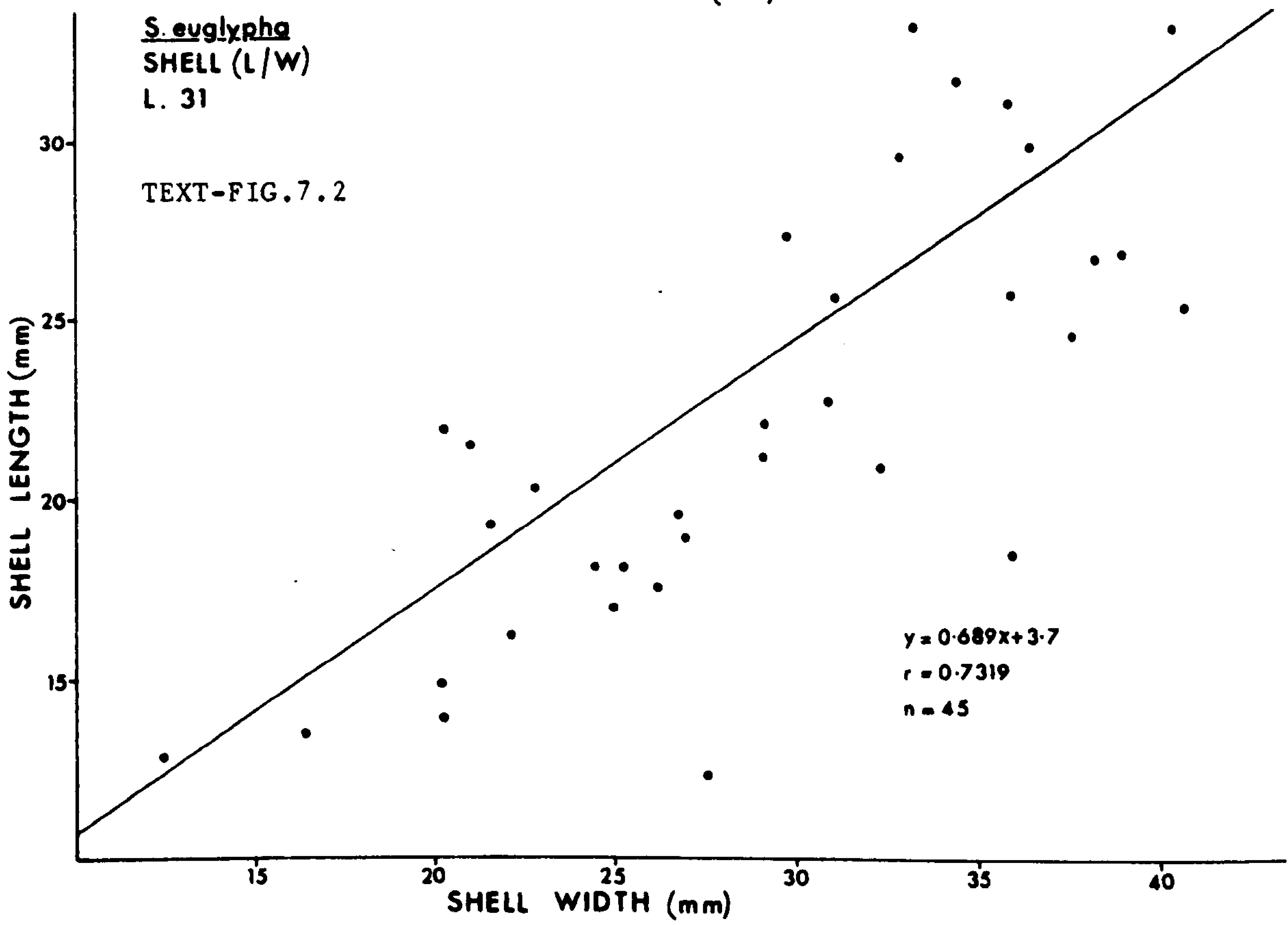
Near Ludlow, specimens from three localities have been measured (31, sec.B & sec.C); in addition some Ludlow Museum specimens have been studied statistically. These specimens show nearly the same shell length-width ratio. The results of the study of shell proportions from these localities are shown in Table 1 below and are also displayed graphically in text-figs.7.1-7.4.

TABLE 1. Summary of statistical results on the shell proportions of S.(S.) euglypha from different localities in the Ludlow area of the Welsh Borderland.

Loc.	n	$\overline{Ls}$	$\overline{Ws}$	r	S.D. (Ls)	S.D. (Ws)	equation	% $\overline{Ls}/\overline{Ws}$
31	45	25.415 (61.703)	31.466 (69.67)	0.732	7.767	8.244	Y= 0.69X + 3.7	81%
Sec.B	42	34.63 (31.729)	40.028 (32.531)	0.742	5.565	5.635	Y= 0.73 + 5.32	86%
Sec.C	7	32.528 (31.172)	40.986 (32.275)	0.599	5.169	5.259	Y= 0.59 + 8.37	79%
Lud. Mus.	43	31.36 (47.543)	37.919 (50.565)	0.576	6.814	7.028	Y= 0.55X + 10.2	83%

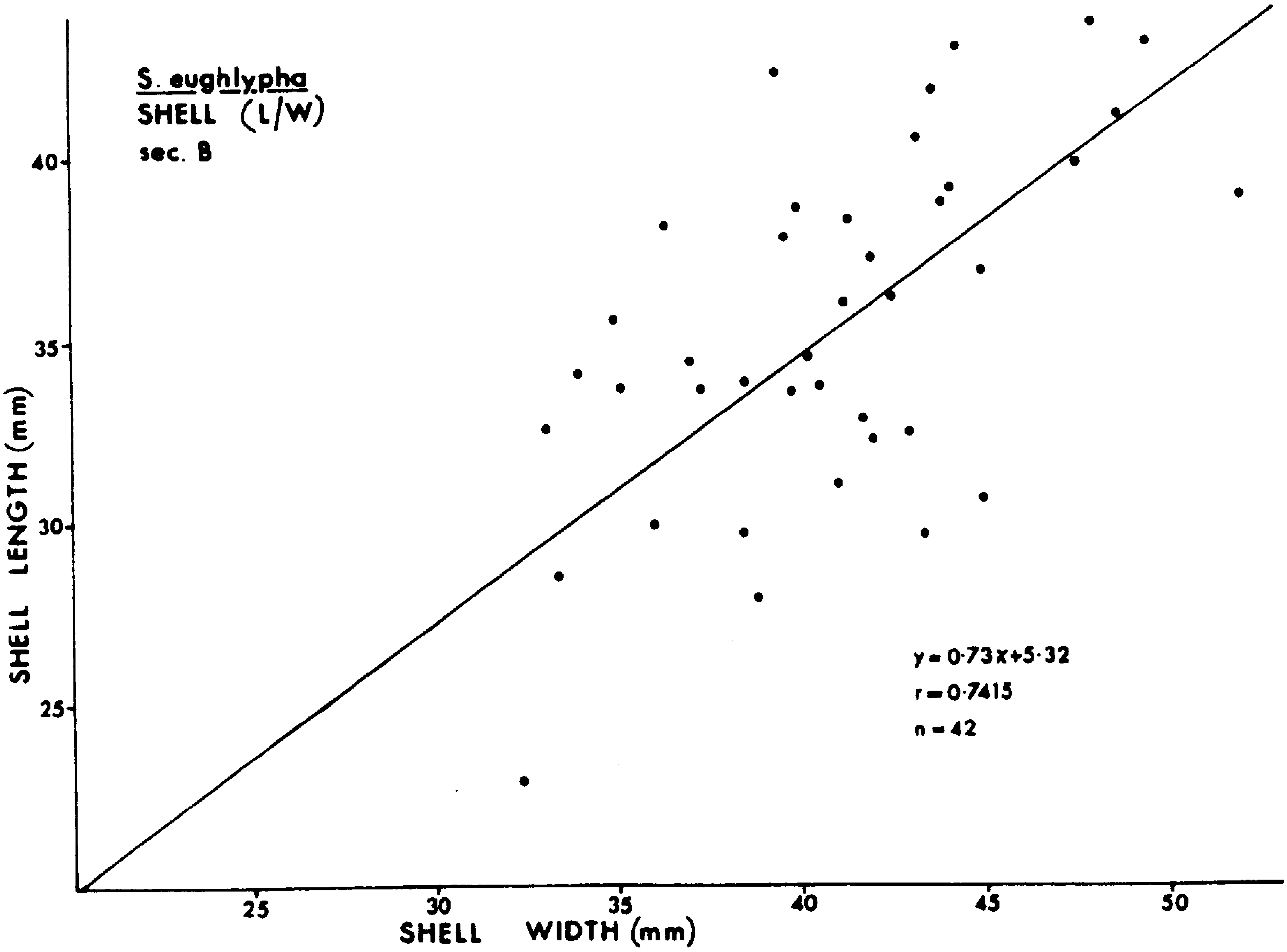
It is evident from text-figs.7.1-7.4 that the trends and the slopes of the lines in each of the localities listed above (Table 1) are nearly the same. Therefore, these localities are treated as only one unit called the Ludlow area collection. Some more specimens were collected from locality 7a near Ludlow, but there were not enough for statistical analyses. Specimens from both sec.B and C (see Table 1

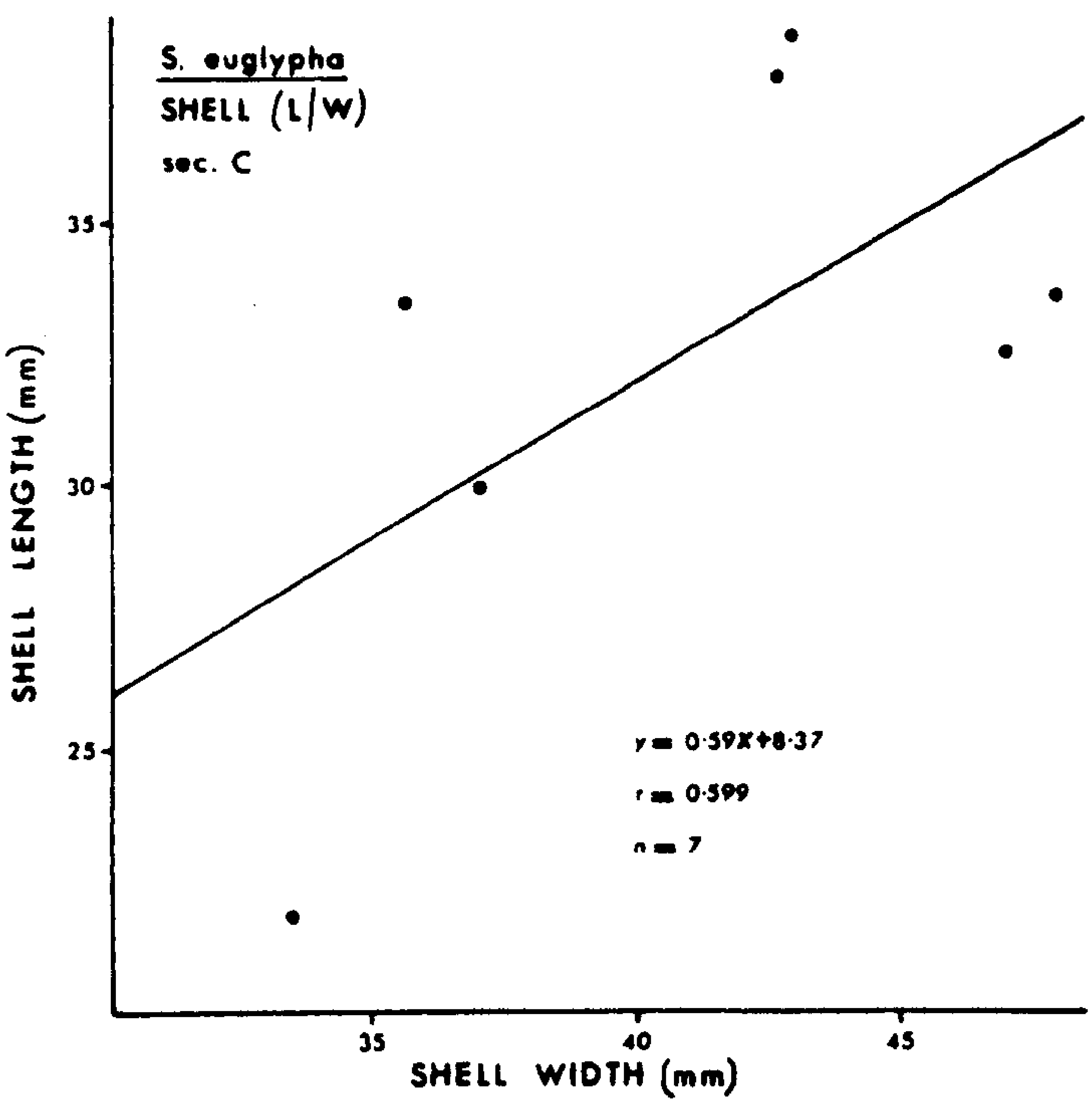




TEXT-FIGS.7.1 & 7.2. Shell length-width distribution of S. euglypha in the Ludlow area (Ludlow Museum and locality 31 specimens).

TEXT-FIG.7.3





TEXT-FIG.7.4

TEXT-FIGS. 7.3 & 7.4. Shell length-width distribution of <u>S. euglypha</u> from sections B and C of the Ludlow area.

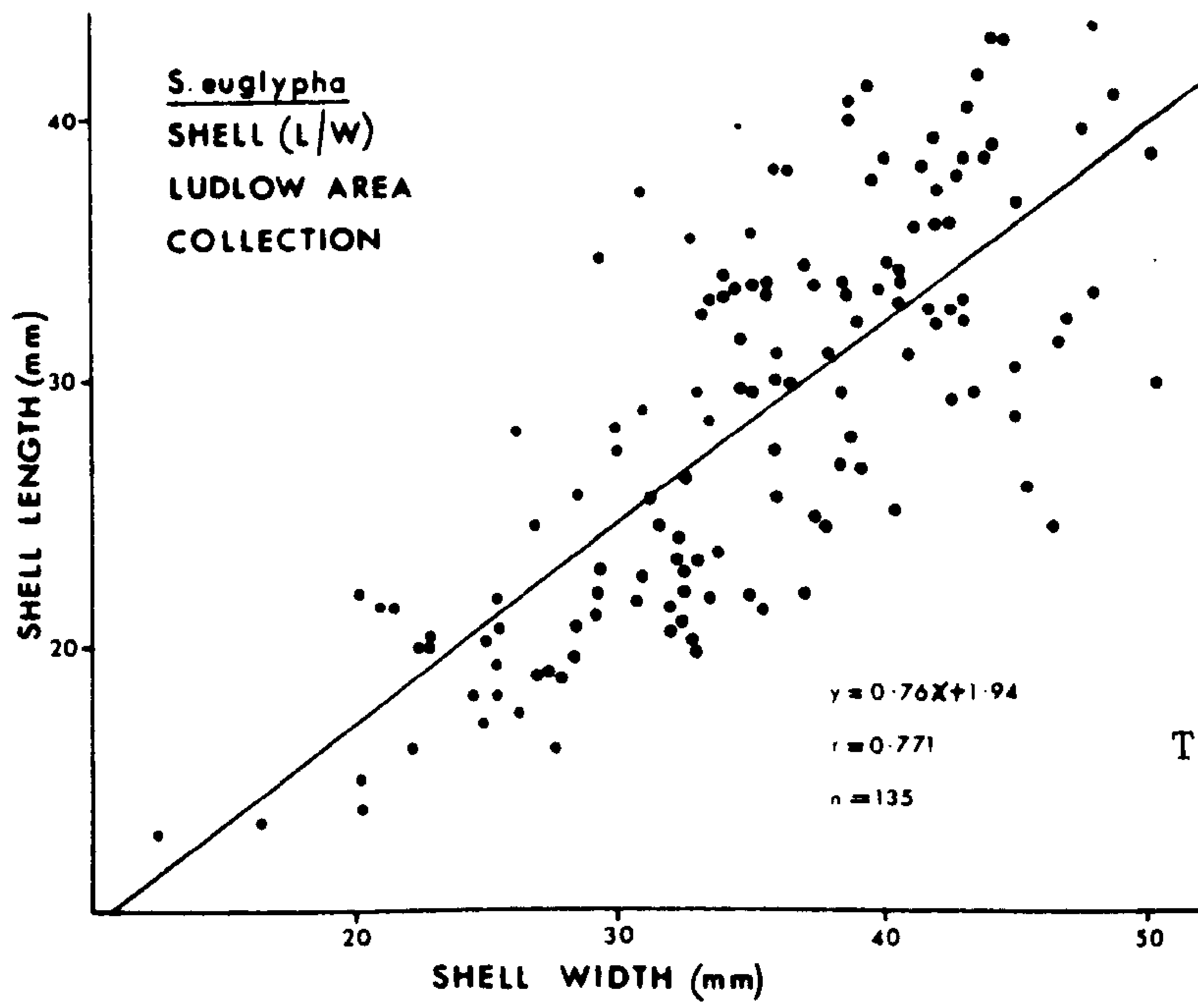
above) are larger than specimens from both locality 31 and Ludlow Museum. The first two localities (B & C) are mainly comprised of rocks of the Upper Bringewood Formation, while the last two are from the Lower Bringewood Formation. The differences in size are probably due to the more limy environment in the Upper Bringewood Formation, thereby providing more calcium carbonate for shell growth (see palaeoecology section, Chapter 9).

Subsequently, specimens were studied from Woodbury Quarry in the Abberley Hills and locality LR in the Usk inlier. The variations in the shell proportions of S.(S.) euglypha from all three areas (Ludlow, Abberley Hills & Usk) are shown in Table 2 below and text-figs. 7.5-7.7.

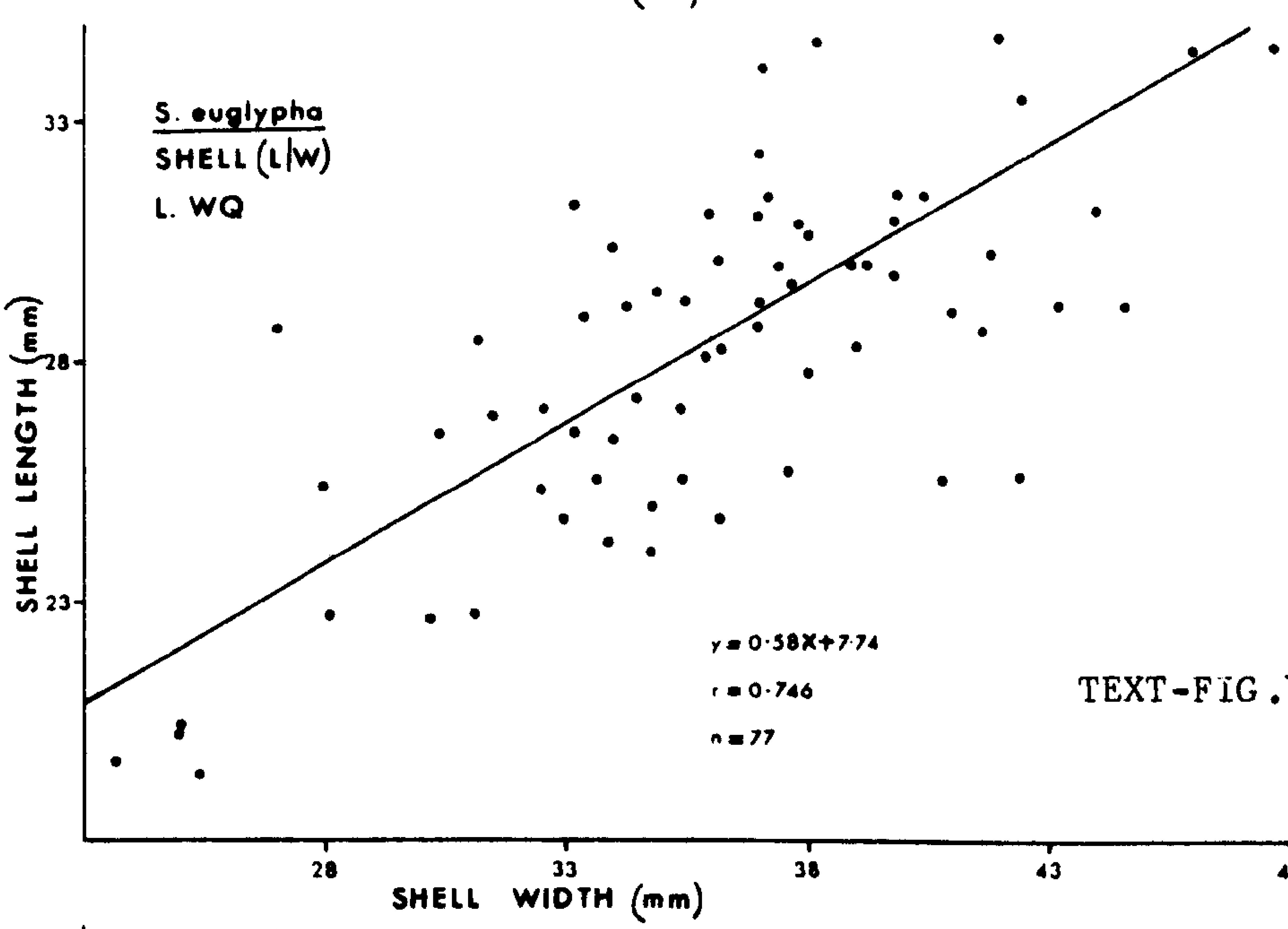
TABLE 2. Summary of statistical results of the shell proportions of S.(S.) euglypha from Ludlow, Abberley Hills and the Usk inlier.

Loc.	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	equation	% $\bar{Ls}/\bar{Ws}$
Ludlow Area Coll.	135	28.689 (55.899)	35.295 (57.859)	0.771	7.449	7.578	Y= 0.76X + 1.94	81%
(WQ) Abberley Hills	77	28.752 (23.136)	36.491 (36.491)	0.746	4.779	6.186	Y= 0.57X + 7.74	79%
(LR) Usk inlier	39	25.7 (20.47)	34.364 (48.231)	0.786	4.466	6.855	Y= 0.5X + 8.089	75%

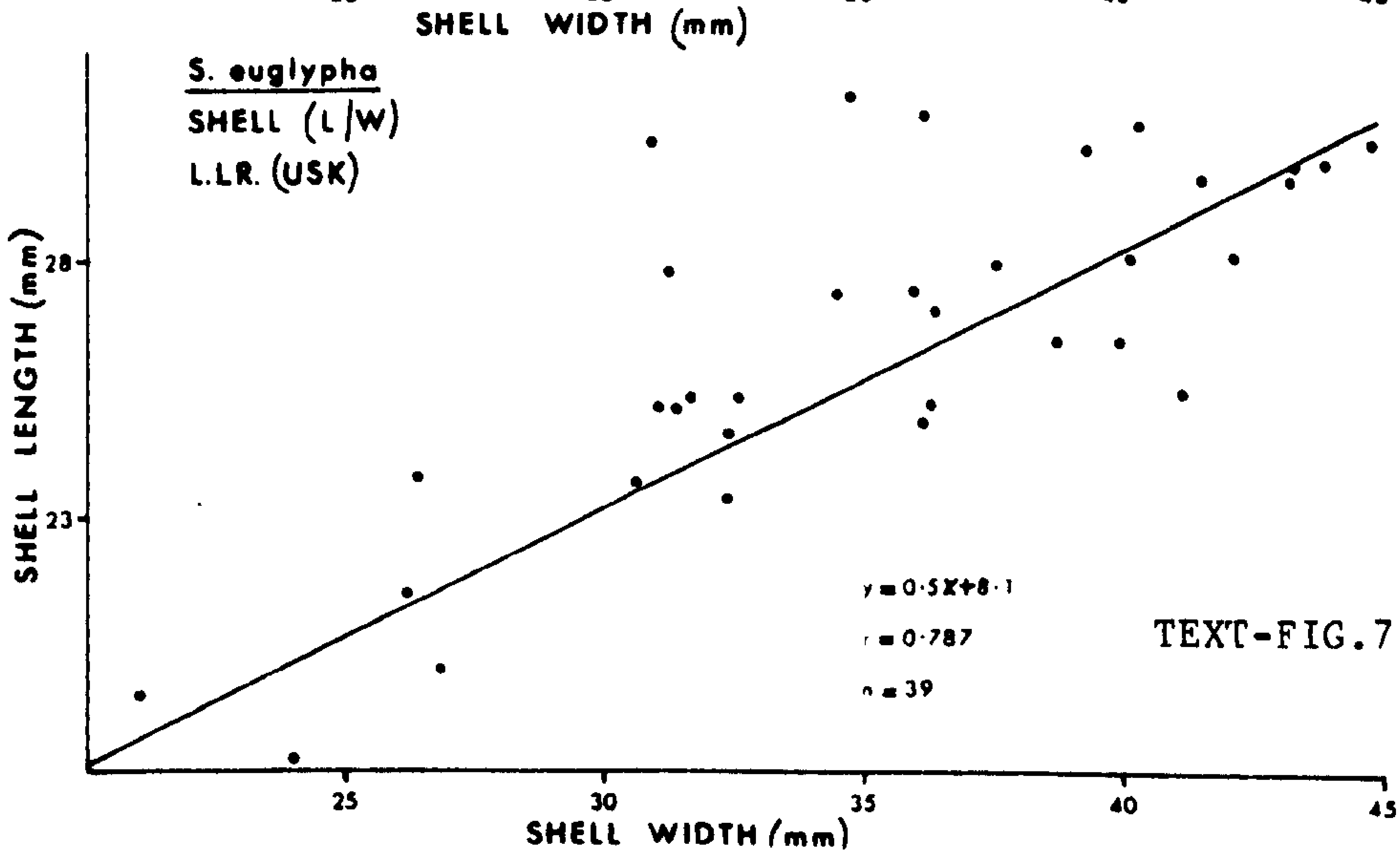
It is evident from Table 2 above that the value of the coefficient of correlation (r) in the three areas demonstrates that the shell length and shell width increase in direct proportion to each other. The shell length-width ratio for both Ludlow and the Abberley Hills is nearly the same, while in the Usk specimens the Ls/Ws is slightly smaller (Table 2), for example, the average shell length for both Ludlow and Abberley specimens is about 28mm in contrast with the



TEXT-FIG.7.5



TEXT-FIG.7.6



TEXT-FIG.7.7

TEXT-FIGS.7.5-7.7. Shell length-width distribution of S. euglypha from Ludlow, Abberley Hills and Usk inlier respectively.

average of 25mm for Usk specimens. These differences may be due to some environmental control or merely the difference in the number of specimens studied from each area. Shell length-width ratio histograms were also drawn for the Usk, Abberley Hills and Ludlow areas (text-fig.7.8).

The shell width was also measured at ¼ of the shell length in an attempt to detect and demonstrate any variation in the shell outline statistically for the three studied areas; Ludlow, Abberley Hills and the Usk inlier (text-fig.7.9 and Table 3).

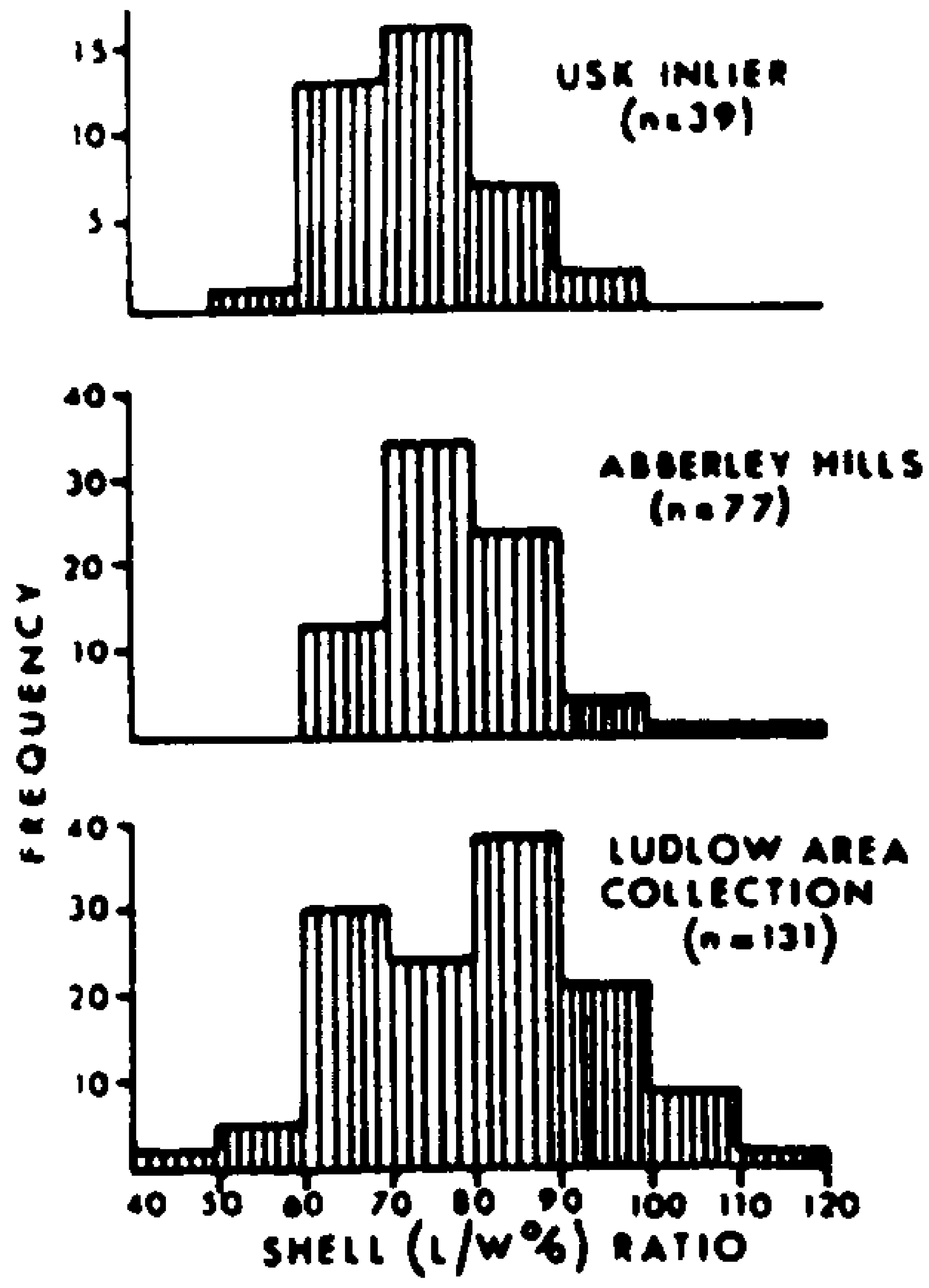
TABLE 3. Summary of statistical results of ¼ of the shell length to the shell width at this point for S.(S.) euglypha from Usk, Abberley Hills and Ludlow.

Loc.	n	$\frac{1}{4}\bar{L}s$	$\bar{W}s_{\frac{1}{4}Ls}$	r	S.D. (¼ Ls)	S.D ($WS_{\frac{1}{4}Ls}$)	equation	$\frac{\bar{W}s_{\frac{1}{4}Ls}}{\frac{1}{4}\bar{L}s}$ %
(LR) Usk	6	19.95 (4.96)	18.58 (4.75)	0.967	2.032	1.989	Y= 0.99X + 1.58	93%
(WQ) Abberley Hills	16	22.94 (5.15)	19.73 (4.73)	0.86	2.197	2.115	Y= 0.89X + 5.3	86%
Ludlow Area	20	25.55 (16.22)	21.84 (8.69)	0.71	3.925	2.875	Y= 0.97X + 4.34	86%

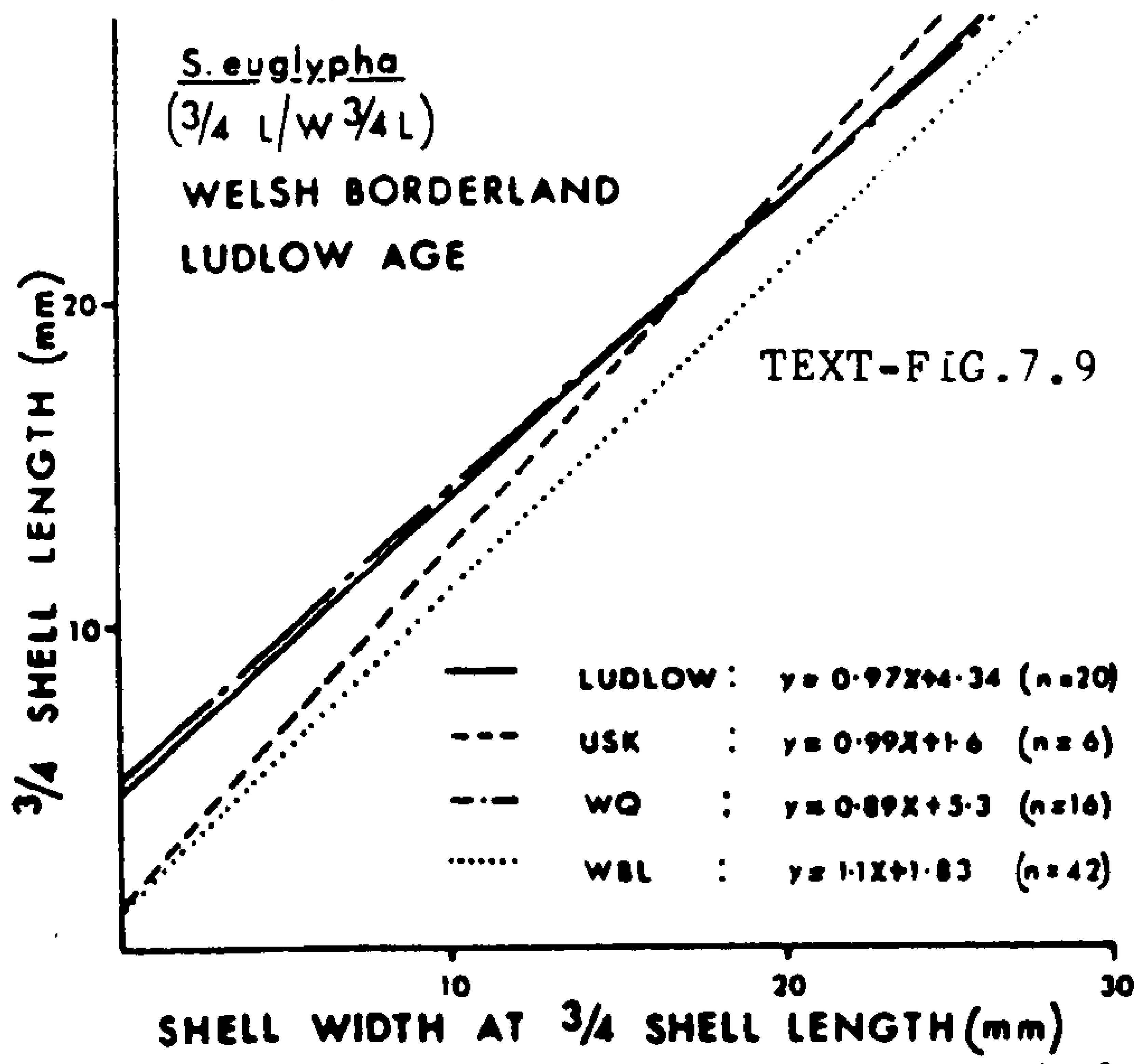
The W/L figure in the Table 3 above indicates roughly the same shell outline for all three areas, particularly Woodbury Quarry and Ludlow area specimens. Usk specimens appear to be wider at ¼ of the shell length with an average mean valve of 93% as wide as long.

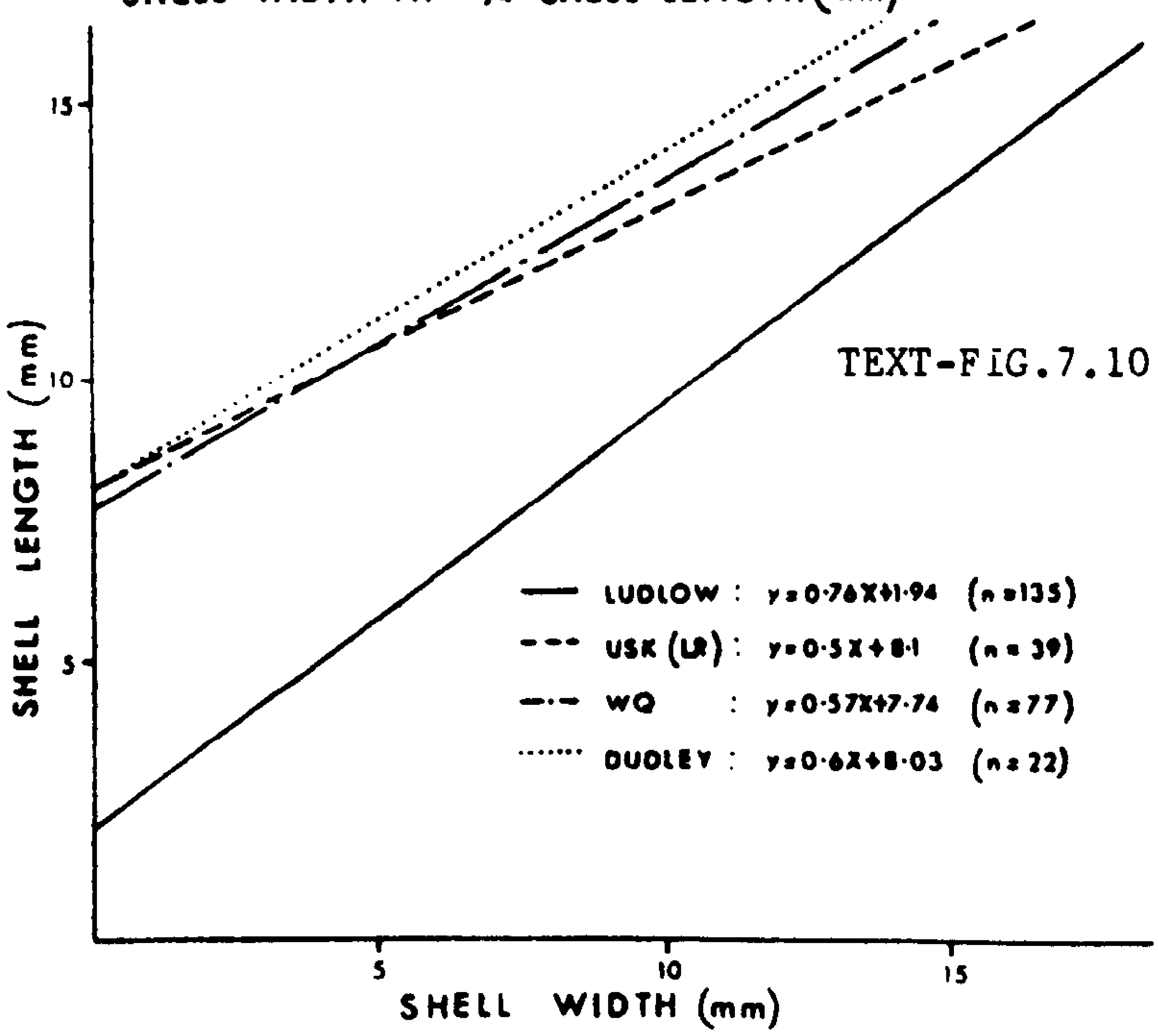
2. Ornamentation.

The radial ornament in S.(S.) euglypha is equally to subequally parvicostellate. The coarse ribs (costellae) are straight along the mid line of the shell becoming very gently curved laterally leaving a wide space between them which is then occupied by numerous fine ribs (capillae) ranging in number from 5 to 7, (see Pl.29, fig.2,



TEXT-FIG.7.8





TEXT-FIG.7.8. Shell length-width ratio frequency histograms for S. euglypha in the three studied areas

TEXT-FIG.7.9. Superimposition of ¾ shell length against shell width at this point of S. euglypha from three different areas.

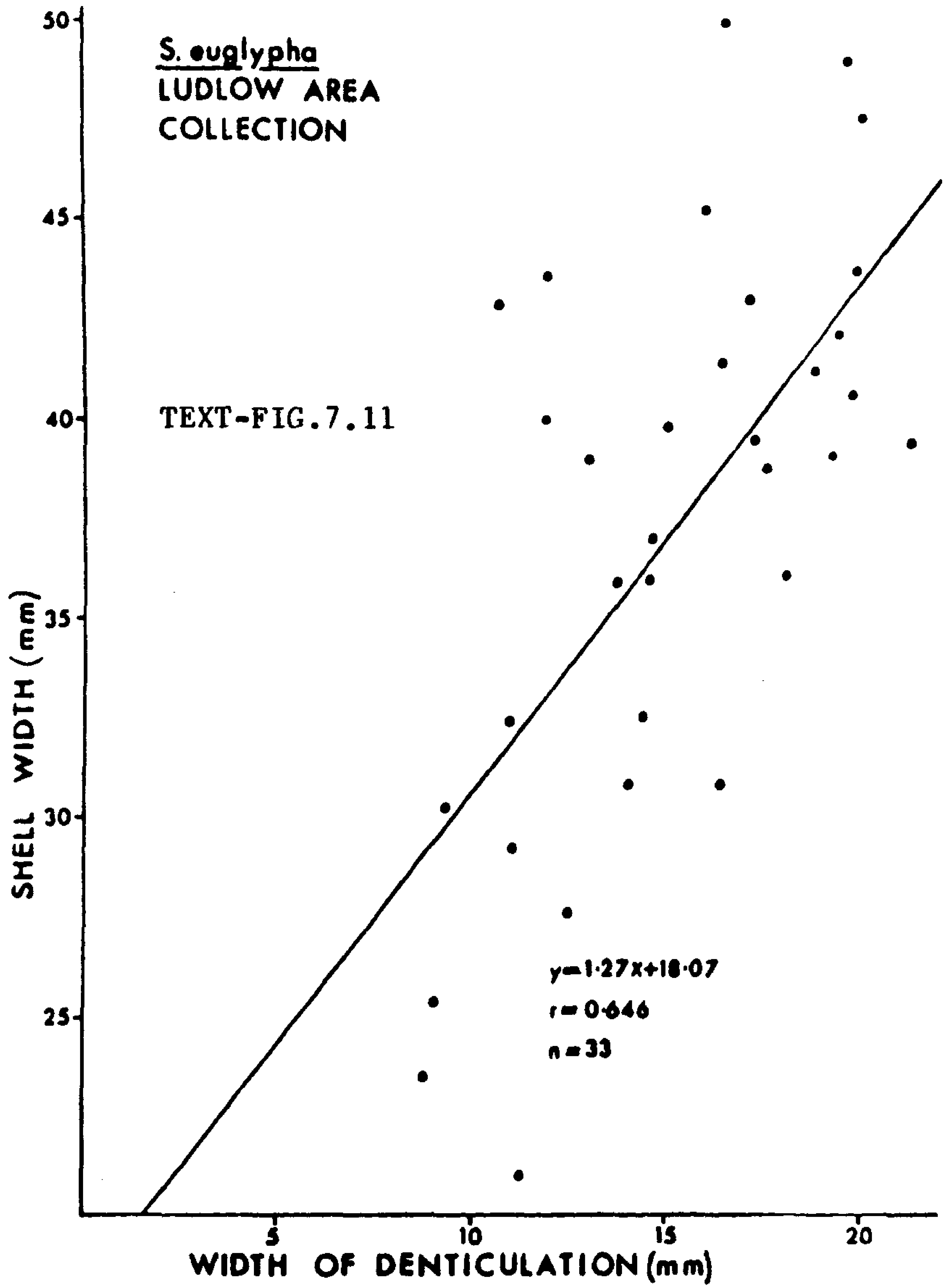
TEXT-FIG.7.10. Comparison of shell length against shell width of S. euglypha from Ludlow, Usk, Abberley and Dudley.

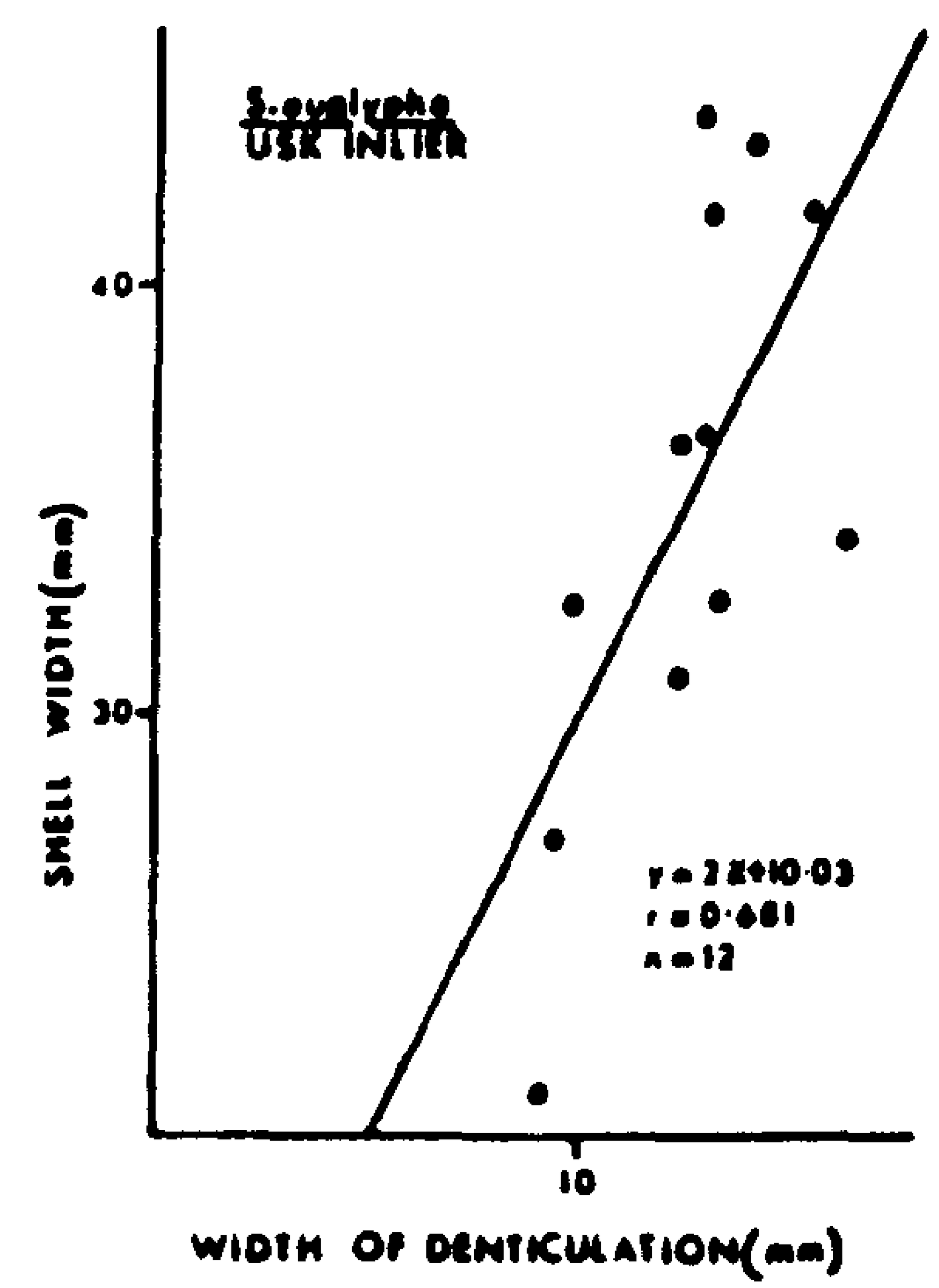
Pl.30, fig.2 & Pl.33, figs.1-12). The space between the costellae is only decreased near the beaks and the capillae are also less numerous (Pl.29, fig.2). The number of these ribs (costellae and capillae) differ from specimen to specimen. For example, six valves have 2 rounded ribs per mm at 10mm antero-medianly of the dorsal hinge, 11 have 3, 16 have 4, 12 have 4 and 13 have 6. About fifty percent of the specimens studied, showed oblique crenulations, faintly to strongly impressed along the postero-lateral margins of the hinge line (near the valve ears) with about 3 to 5 crenulations on each side of the hinge line. However, these crenulations radiate from the shell ears (i.e. postero-lateral ends of the hinge line) and extend towards the muscle field for about ¼ of the shell width from each side (i.e. antero-medianly from the hinge line), see Pl.29, fig.2, Pl.32, fig.6 and Pl.33, figs.1-5. This ornamental feature has not been clearly shown before in S. (S.) euglypha.

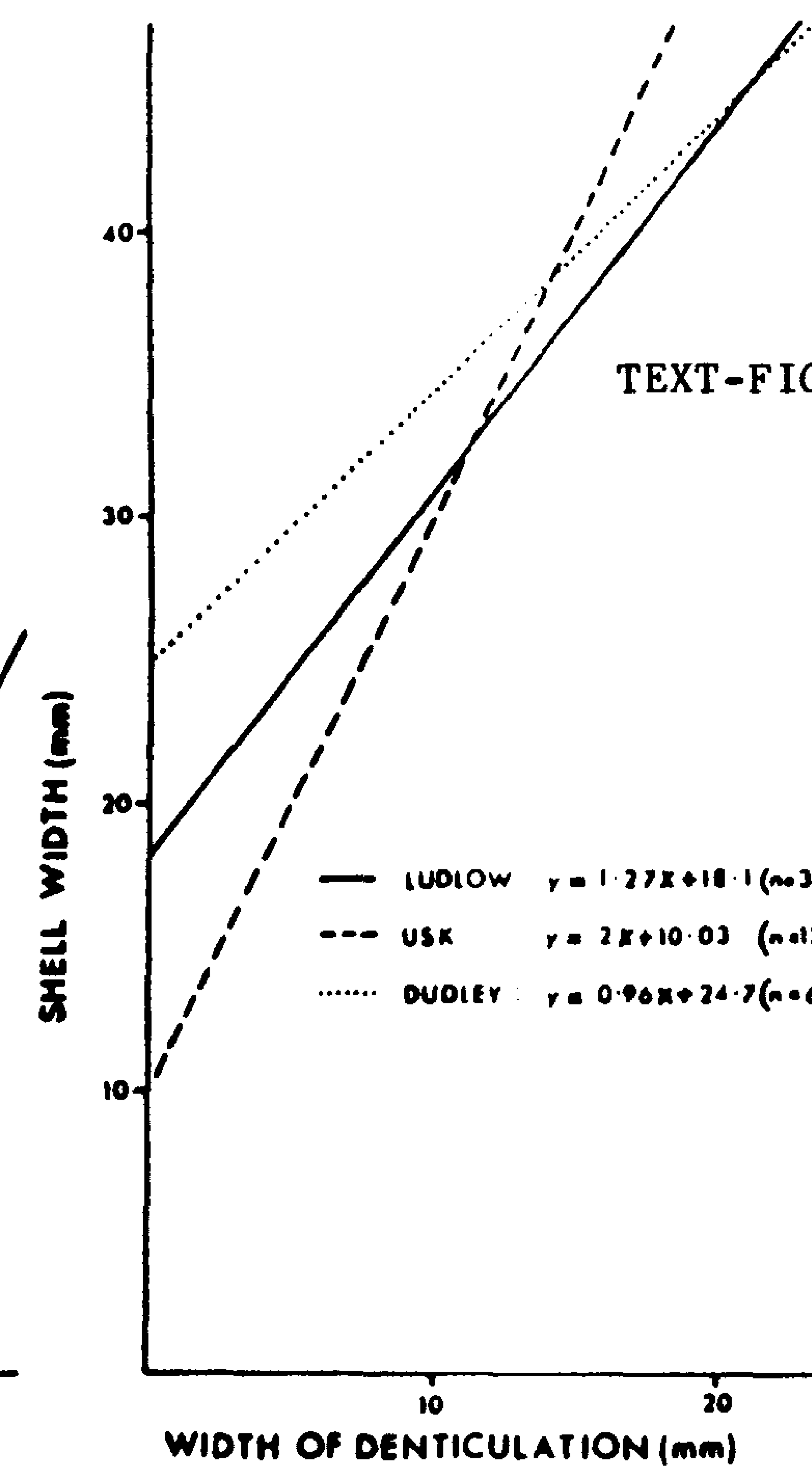
B. Internal shell features.

1. Denticulation.

In both valves of S.(S.) euglypha, the hinge line bears a pair of well developed denticular plates (Pl.27; Pl.28; Pl.30, fig.2; Pl.32, figs.7-12 and Pl.33, fig.1). They extend laterally for varying proportions of the hinge width. Although most of the studied specimens are in a good state of preservation, not all of them show the denticulation for measurement purposes. However, the amount of the hinge width occupied by the denticulations in the Usk area is 35% (n = 12) and 40% (n = 33) for the Ludlow material, see Table 4 below and text-figs.7.11 & 7.12.







TEXT-FIGS.7.11 & 7.12. Plots of shell width versus width of denticulation of S. euglypha from Ludlow and Usk, with their comparison with Dudley in text-fig.7.13.

TABLE 4. Summary of statistical results of denticulation in S.(S.) euglypha from Ludlow and Usk areas of the Welsh Borderland.

Loc.	n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (Ws)	S.D. (Wd)	equation	% $\overline{Wd}/\overline{Ws}$
Usk	12	35.058 (48.84)	12.43 (5.029)	0.681	6.346	2.147	Y= 2X + 10.03	35%
Ludlow	33	37.396 (51.615)	15.133 (13.207)	0.646	7.07	3.578	Y= 1.27X + 18.1	40%

It is evident from the text-figs.7.11 & 7.12 that the width of the hinge line denticulations increased in direct proportion to the shell width. Ludlow specimens carried more denticles along the hinge line (Table 4) because their shells are wider (on average) than those at the Usk inlier, (see text-fig.7.13 for comparison).

2. Muscle field.

a) On the pedicle valve.

In S.(S.) euglypha, the muscle field is strongly impressed as a pair of lanceolate nearly parallel adductor muscle scars. These adductor scars are enclosed by subquadrate or flabellate diductor muscle scars (Pl.31, figs.1 & 2, Pl.32, figs.1,3 & 6). The muscle scars are separated by a narrow medium septum called a myophragm (Pl.31, figs.1 & 2). The muscle field is usually bounded by moderate (Pl.32, fig.4) to fairly strong muscle ridges (Pl.31, figs. 1 & 2). These muscle ridges arise directly anterior to the hinge and diverge at about 100^{o}-125^{o} to one another, then become parallel and finally turn medially and posteriorly to intersect the myophragm slightly posterior to its anterior extremity (see also Pl.31, figs. 1 & 2).

The shapes of the muscle and muscle bounding ridges in most of the specimens are similar, but the muscle field proportions vary slightly from different areas (Table 5 below). Although the specimens studied are well preserved, not all of them are suitable for internal measurement purposes. The variations in the muscle field proportions are also displayed graphically in text-figs. 7.14-7.16.

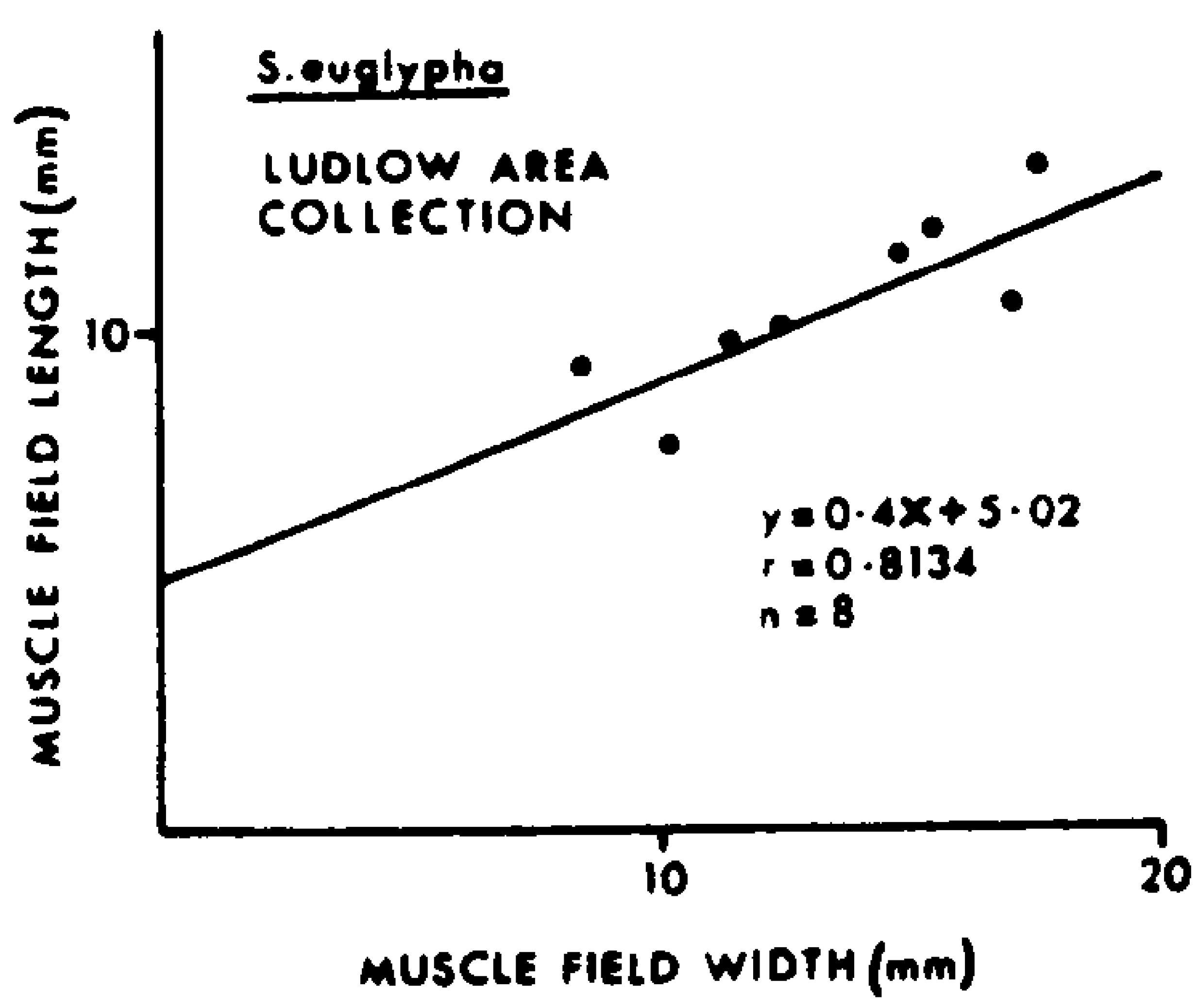
TABLE 5. Summary of statistical results of the muscle field proportions of S.(S.) euglypha from Ludlow, Abberley Hills and the Usk inlier.

Area	n	$\overline{Lmf}$	$\overline{Wmf}$	r	S.D. (Lmf)	S.D. (Wmf)	equation	% $\overline{Lmf}/\overline{Wmf}$
Ludlow area	8	10.38 (2.73)	13.39 (11.20)	0.813	1.55	3.13	Y= 0.4X + 5.02	78%
Abberley Hills	9	10.62 (13.87)	12.34 (18.52)	0.948	3.51	4.06	Y= 0.8X + 0.47	86%
Usk inlier	10	11.51 (4.44)	13.61 (7.25)	0.86	1.99	2.55	Y= 0.67X + 2.4	85%

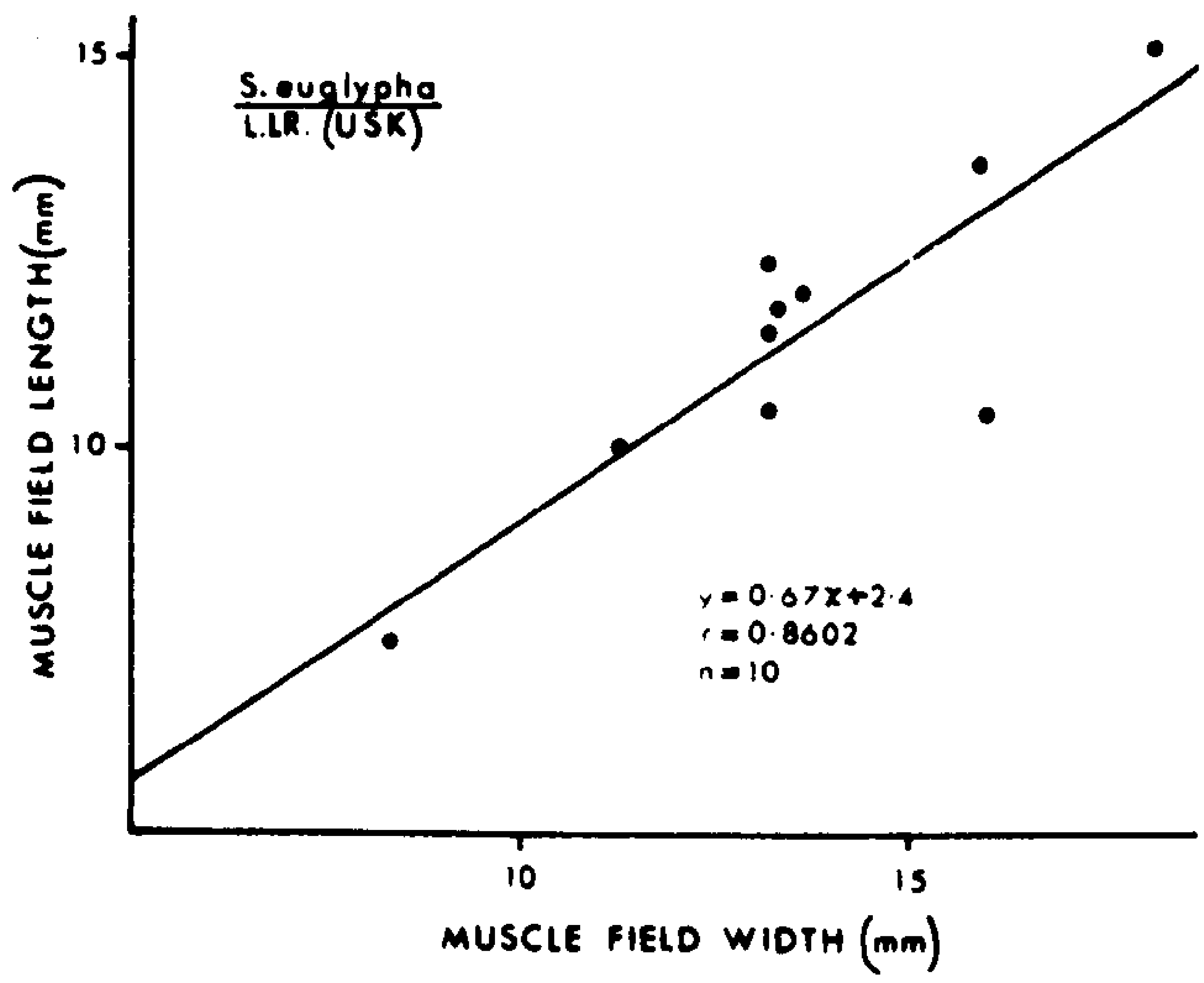
It is evident from the text-figs. 7.14-7.16 that the muscle field length increases in direct proportion to its width. The muscle field length-width ratio for both Abberley Hills and the Usk inlier is almost the same (86% and 85% respectively), while the ratio for the Ludlow area collection is slightly different (78%) (i.e. the muscle field is relatively wider).

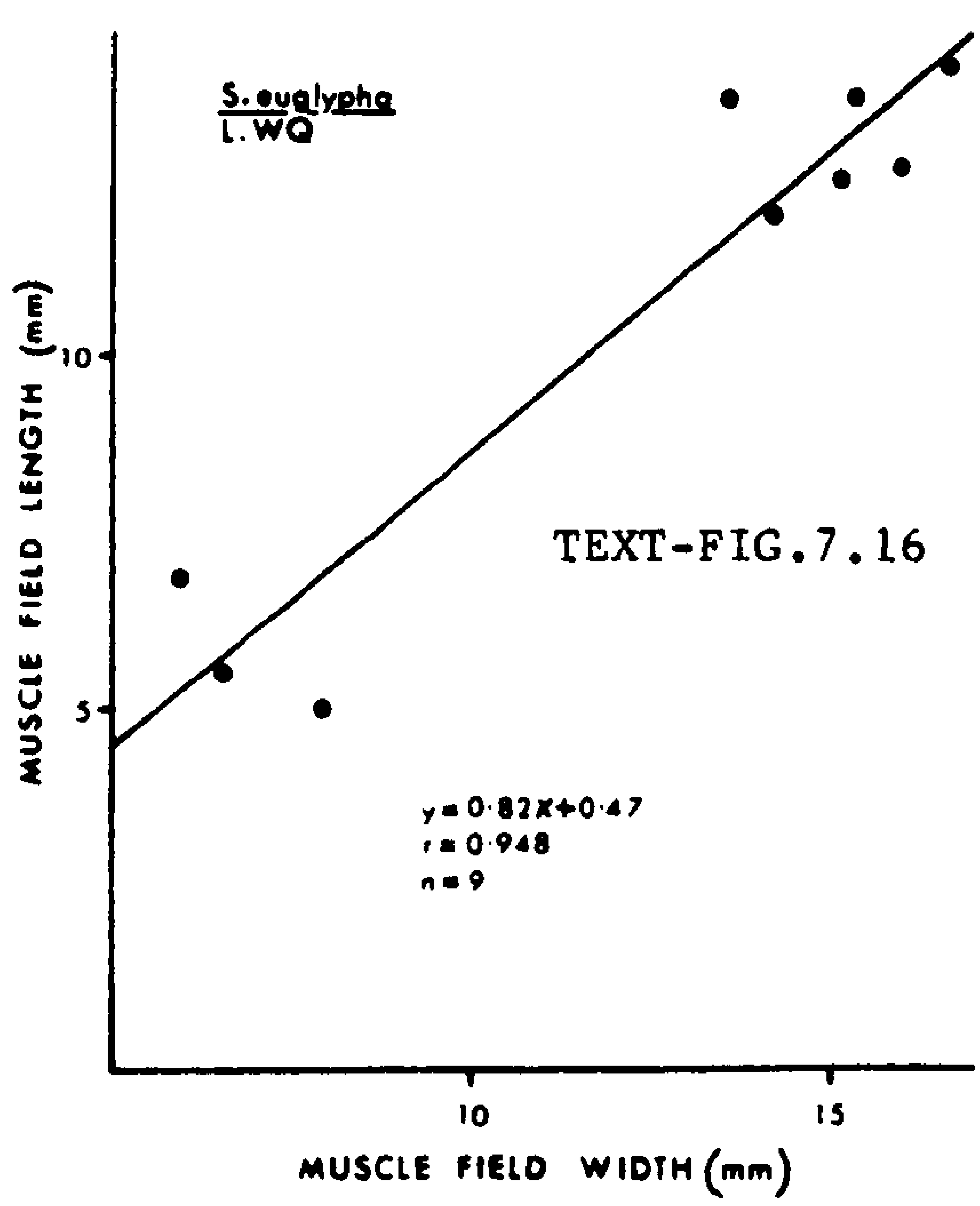
The frequency histograms for the muscle field length-width ratio were drawn for the Ludlow and Usk specimens (text-fig. 7.17) to show the range of variation in the muscle field proportions and the slightly longer muscle field in the Usk specimens. The ratio of the muscle field length to the valve length for both Ludlow and Usk materials is the same, i.e. 40% (see Table 6 below and text-figs. 7.18 & 7.19).

TEXT-FIG.7.14

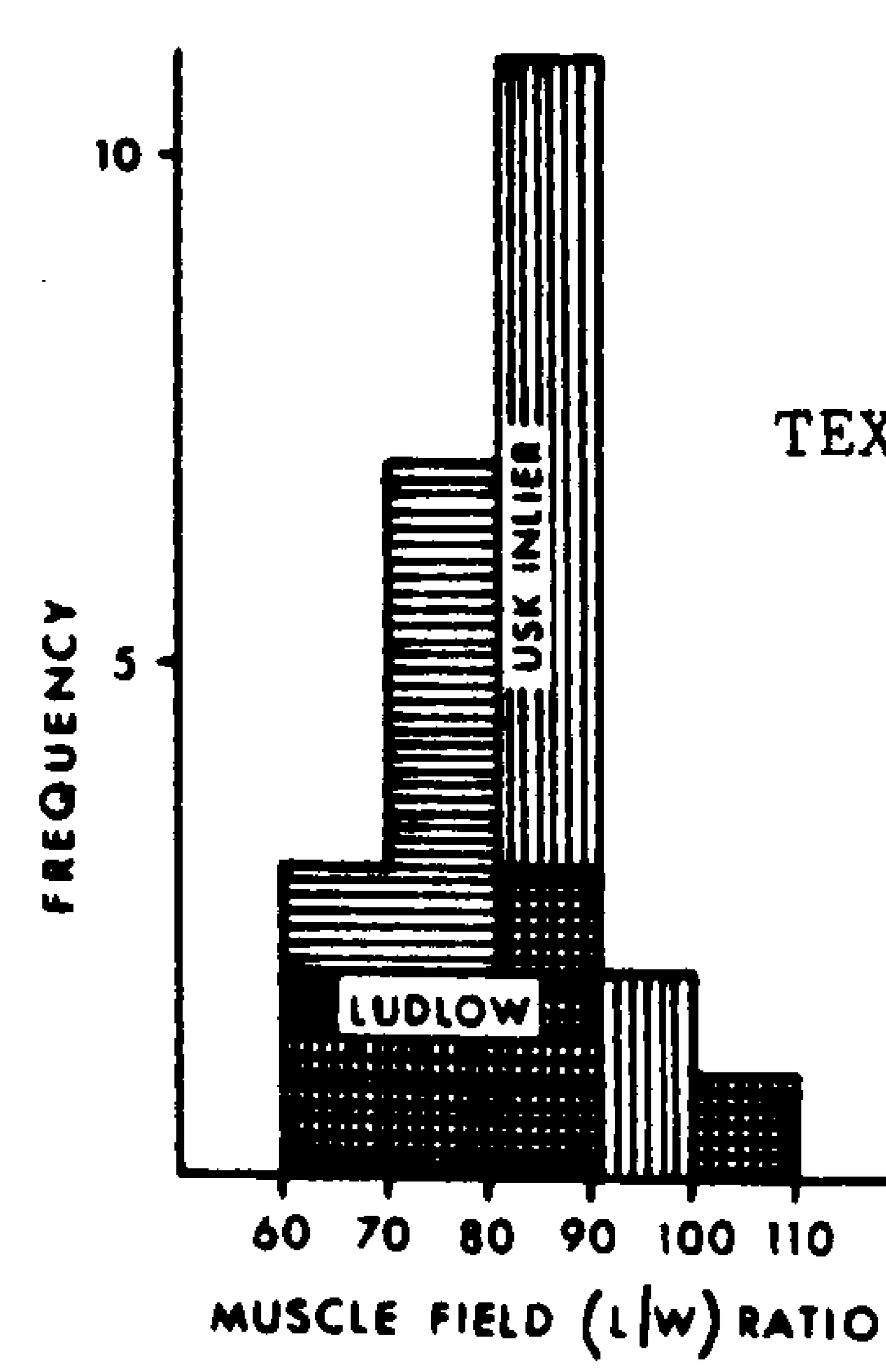


TEXT-FIG.7.15





TEXT-FIG.7.16



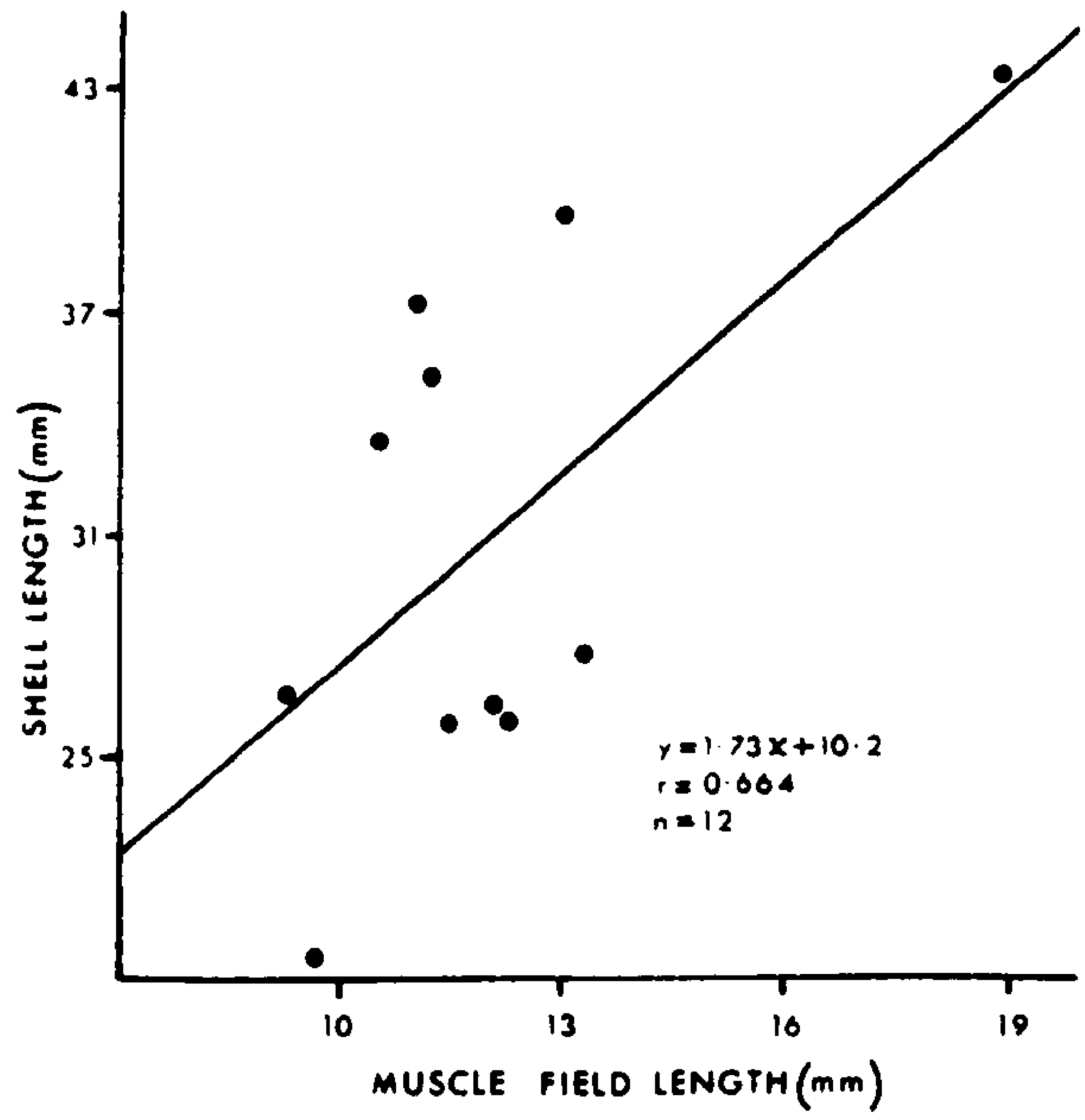
TEXT-FIG.7.17

TEXT-FIGS.7.14-7.16. Muscle field length-width distribution of *S. euglypha* from Ludlow, Usk and Abberley Hills respectively.

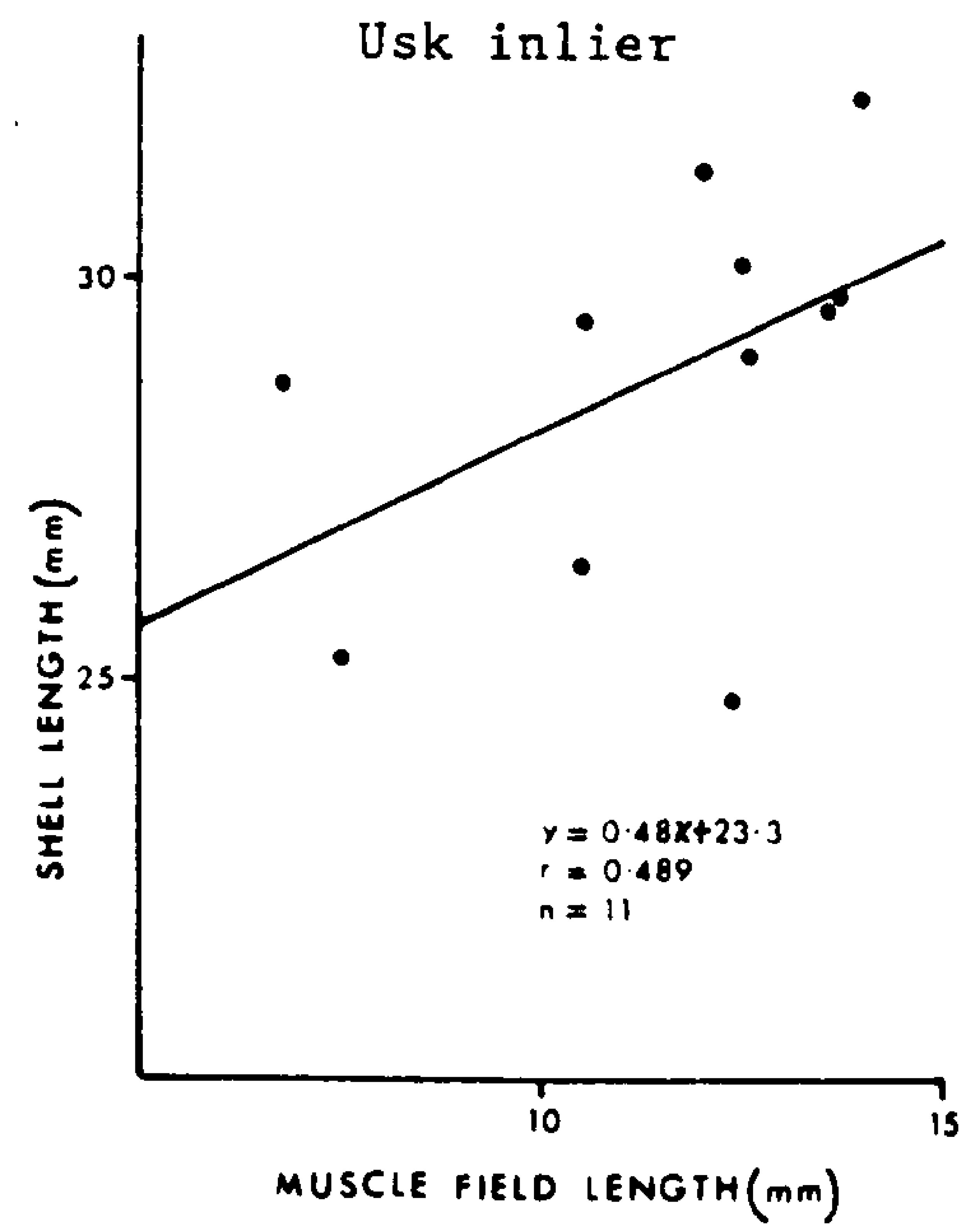
TEXT-FIG.7.17. Comparison histogram of muscle field length-width ratio against frequency for *S. euglypha* in Ludlow and Usk specimens.

TEXT-FIG.7.18

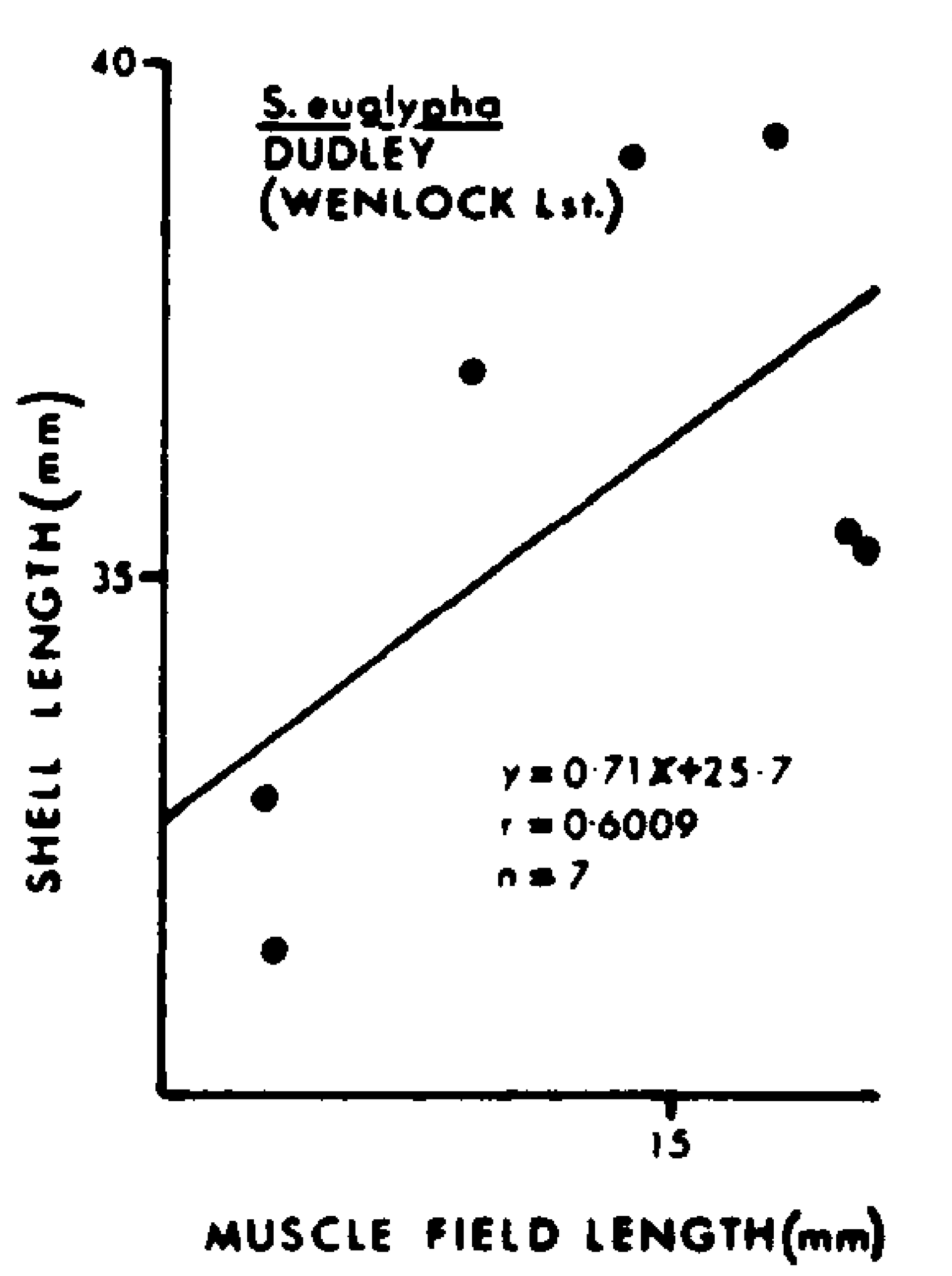
Ludlow area

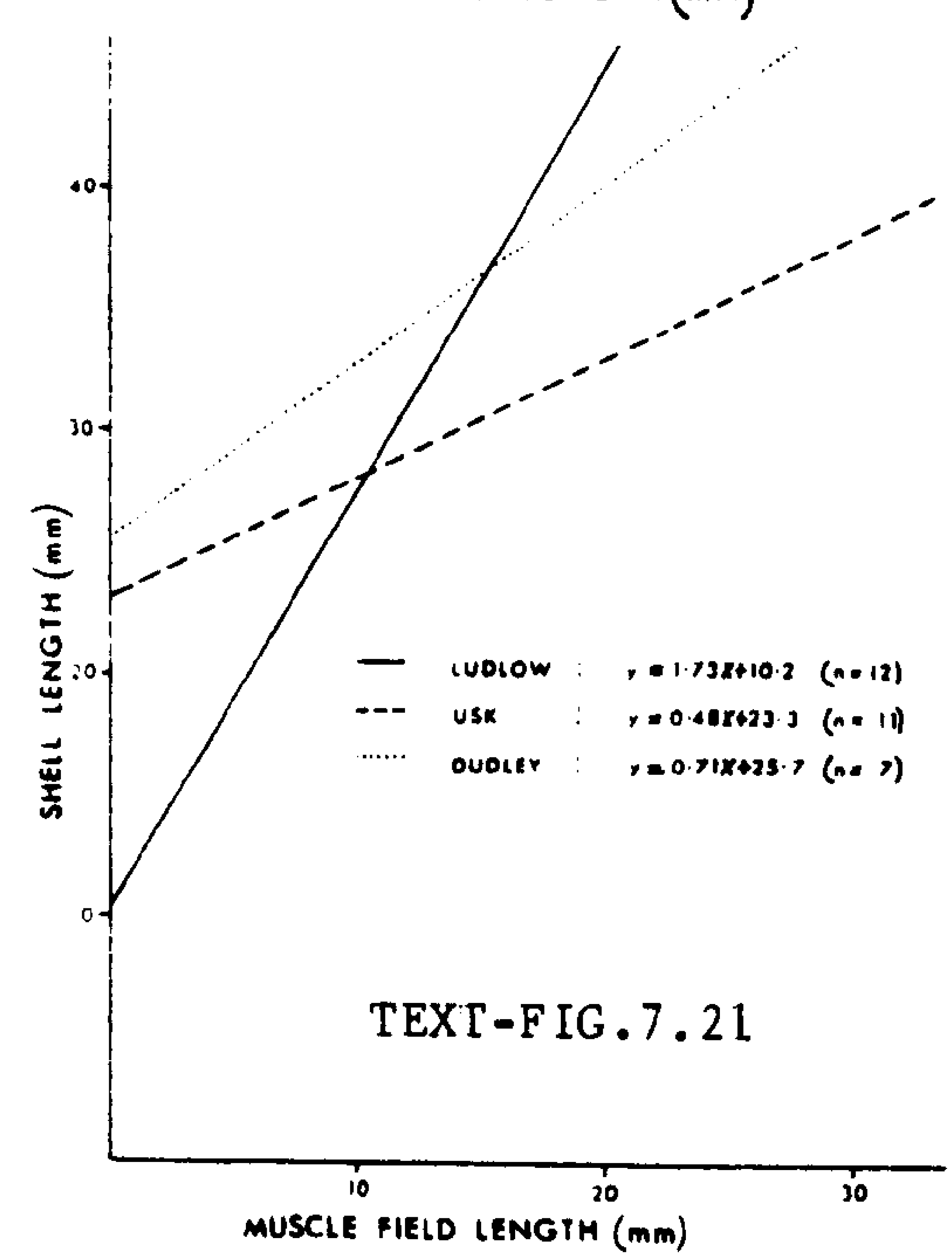


TEXT-FIG.7.19



TEXT-FIG.7.20





TEXT-FIG.7.21

TEXT-FIGS.7.18-7.20. Plots of shell length against muscle field length for S. euglypha from Ludlow, Usk and Dudley, with their comparison in text-fig.7.21.

TABLE 6. Summary of statistical results of the muscle field length and valve length of S.(S.) euglypha in Ludlow and Usk specimens.

Area	n	$\bar{L}s$	$\bar{L}mf$	r	S.D. (Ls)	S.D. (Lmf)	equation	% $\bar{L}mf/\bar{L}s$
Ludlow	12	30.4 (51.79)	11.72 (7.67)	0.664	6.89	2.65	Y= 1.7X + 10.2	39%
Usk	11	28.84 (5.74)	11.46 (5.89)	0.489	2.28	2.31	Y= 0.5X + 23.3	40%

It is obvious from the text-figs.7.18 and 7.19 that the muscle field length increased in direct relation to the shell length.

b). On the brachial valve.

The muscle field is moderately impressed as a pair of subtriangular to triangular adductor muscle scars which are bounded by a pair of muscle ridges laterally but leave the muscle field unbounded anteriorly. These muscle ridges diverge antero-laterally from being nearly sub-parallel up to an angle of 85° (see Pl.27, figs.1 & 2). In a few well preserved specimens the muscle bounding ridges can be seen to bound the muscle field anteriorly (Pl.28, figs.1 & 2). The adductor muscle scars shown in Pl.28 consist of a pair of bilobed scars bisected by a myophragm and surrounded laterally by another shorter pair of bilobed muscle scars (Pl.28, fig.1). The most common shape of the muscle and muscle bounding ridges among the specimens studied is the subtriangular to triangular shape.

3. Socket plates.

These occur as a pair of strong ridges, located postero-medianly in the brachial valve and they extend antero-laterally for about ¼ of the hinge line width. The most common shape is the bladed one and they diverge antero-laterally at about 110° (Pl.27 and Pl.28).

C. Conclusion on variation.

The majority of the studied specimens was collected from the Lower Bringewood Formation with additional examples from the Upper Bringewood Formation and to a lesser extent the Lower Elton Formation. There is no significant variation of the latter two from the typical Lower Bringewood Formation, therefore, they have been considered collectively as representative Ludlow forms.

The significant variation of the major morphological features between the three studied areas (i.e. Ludlow, Abberley Hills and the Usk inlier) is also not substantial enough to justify separation between these areas (see 7.3). Therefore, the specimens from all these areas are treated as only one unit called the Ludlow Series specimens of the Welsh Borderland. Subsequently, comparison between the Ludlow and Wenlock Series specimens has been made (see 7.5).

7.4. STROPHONELLA EUGLYPHA FROM THE WENLOCK SERIES.

7.4.1. Introduction.

Bassett (1971, 1977) has described and figured *S.*(*S.*) *euglypha* from the Wenlock Series. This section supplements his account by providing statistical analyses of certain morphological parameters for subsequent comparison with the Ludlow specimens. This is therefore a statistical analysis of thirty one Wenlock specimens.

7.4.2. Material.

For the purpose of this statistical study of morphological variations in the Wenlock form of *S.*(*S.*) *euglypha*, some well-preserved specimens were selected as follows: sixteen from the British Museum of Natural History (London), six specimens from the National Museum of Wales (Cardiff), five from the Museum of the British Geological

Survey and five in the Lawson collection at Glasgow. Most of these specimens occurred as internals and externals of brachial and pedicle valves rather than as moulds as they do in the silty, calcareous rocks of the Ludlow Series.

7.4.3. Horizons and localities.

Most of the studied specimens came from the Wenlock Limestone of the Dudley area, West Midlands (text-fig.2.5), in which S.(S.) euglypha occurs most commonly. A few other specimens from the Wenlock Shale were also studied, but the species is less common in this formation. The Wenlock Shale specimens were not subjected to statistical analysis since they consist of only a few specimens from several different areas. The morphological description of the species is based on the selected and examined museum material, but the statistical variation and comparison is only based on the Wenlock Limestone material of the Dudley area. However, the major morphological features of the Wenlock specimens from other areas (e.g. Woolhope) seem to fit very closely with the Dudley material.

7.4.4. Distribution.

S.(S.) euglypha is widespread in the Wenlock of the Welsh Borderland, occurring most commonly in the Wenlock Limestone and less commonly in calcareous layers of the Wenlock Shale. According to Bassett (1971, 1977) the species is unknown in Pembrokeshire, but occurs in the late Wenlock calcareous sandstones, siltstones and mudstones in the Rumney (Cardiff) and Tortworth inliers.

On Gotland, it is recorded by Hede (1960) and Bassett and Cocks (1974) from localities in the Mulde Marl (late Wenlock) and the Hemse group (early Ludlow).

7.4.5. Description.

7.4.5.1. External shell features:

Shell shape and proportion.

S.(S.) euglypha is mostly subtriangular to semicircular in the outline shell shape (see Pl.36, fig.4,12 for the subtriangular and figs.5-10 for the rounded outline). The analysis of the shell proportions is shown in Table 7 below and they are also displayed graphically in text-fig.7.22.

TABLE 7. Summary of statistical results of the shell proportions of S.(S.) euglypha from the Wenlock Limestone of Dudley area.

Area	n	$\bar{Ls}$	$\bar{Ws}$	r	S.D. (Ls)	S.D. (Ws)	equation	% $\bar{Ls}/\bar{Ws}$
Dudley	22	33.99 (12.02)	43.32 (19.11)	0.76	3.39	4.27	Y= 0.6X+8.03	78%

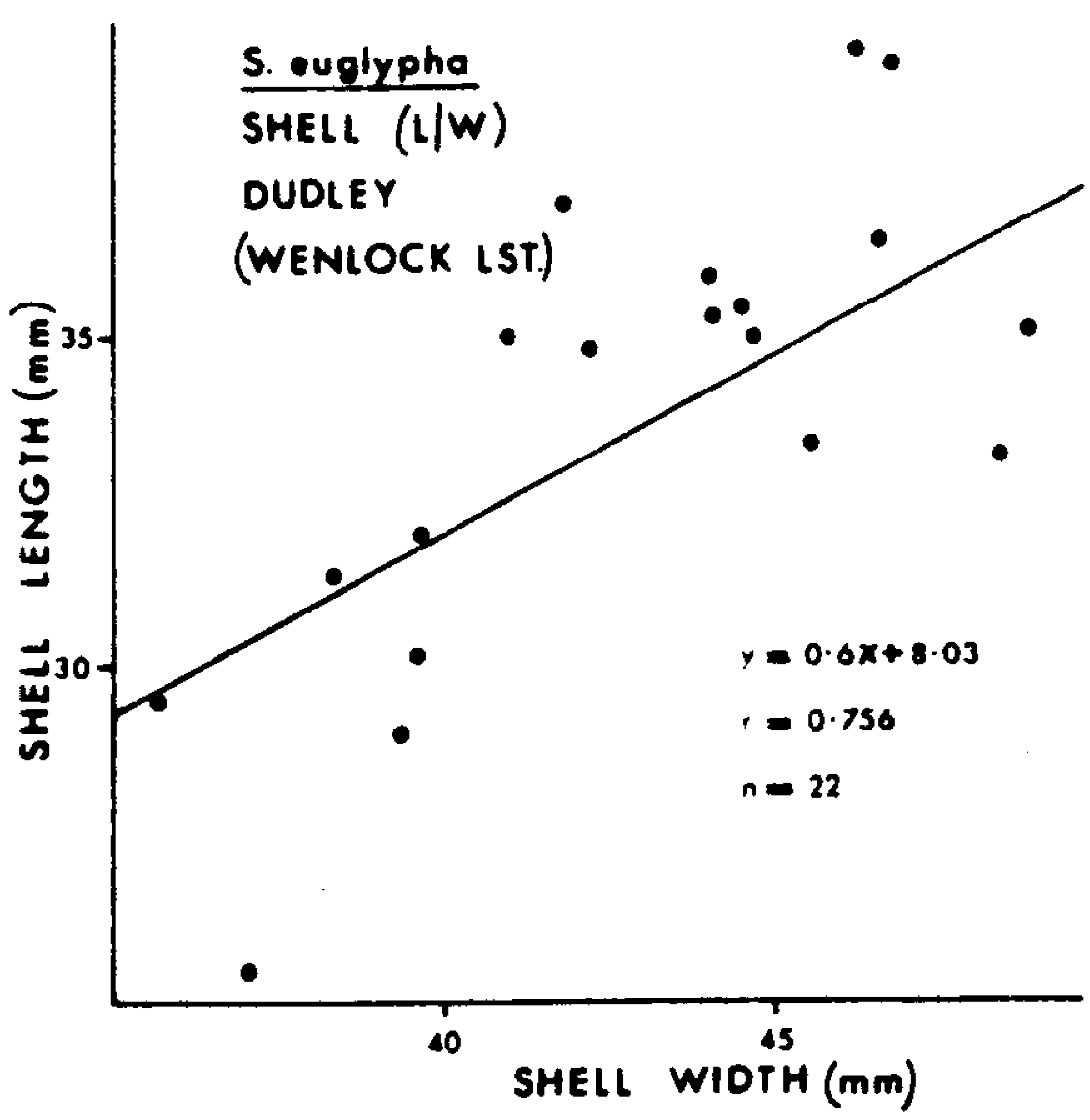
The value of the coefficient of correlation (r) shown in the Table above demonstrates that the shell length and shell width increase in direct proportion to each other.

A partial shell width was also measured at ¼ of the shell length from the umbo, in an attempt to illustrate the outline shape variation statistically (see Table 8 below and text-fig.7.26), as was done for the Ludlow specimens.

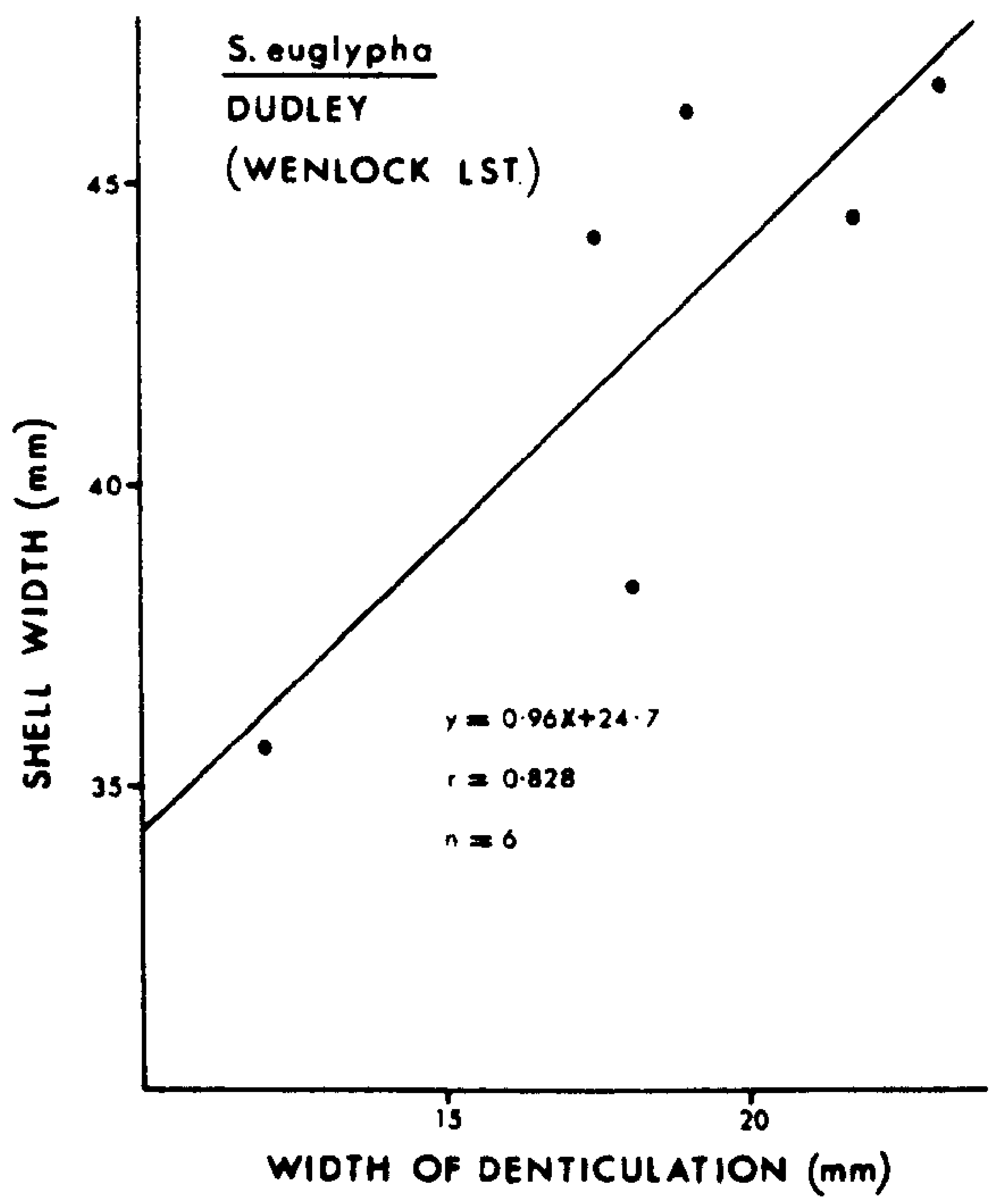
TABLE 8. Summary of statistical results of the shell width at ¼ of the shell length for S.(S.) euglypha from Dudley.

Area	n	$\bar{¼Ls}$	$\bar{Ws}_{¼Ls}$	r	S.D. (¼Ls)	S.D. ($Ws_{¼Ls}$)	equation	% $\bar{¼Ls}/\bar{Ws}_{¼Ls}$
Dudley	21	25.44 (7.13)	31.86 (17.84)	0.557	2.61	4.12	Y=0.35X + 14.2	80%

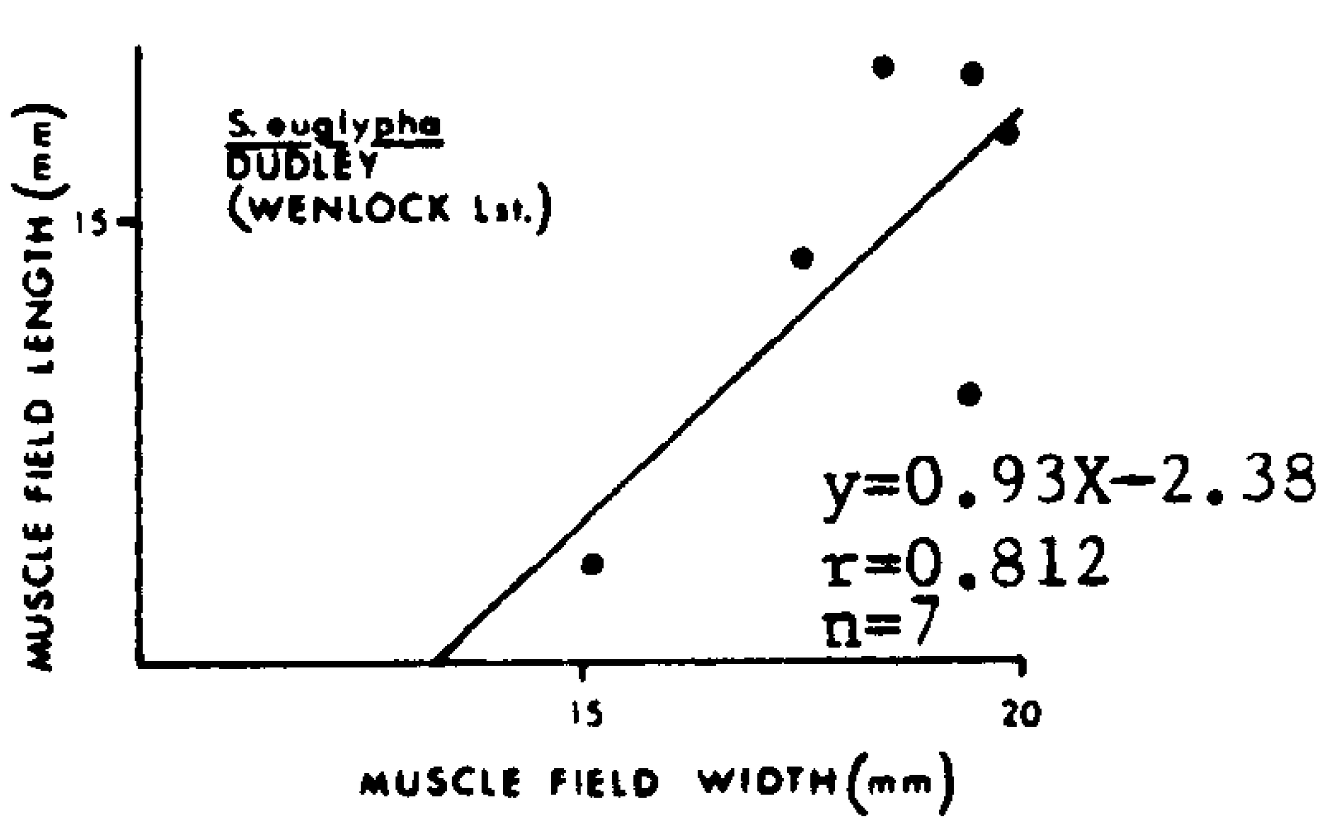
TEXT-FIG.7.22



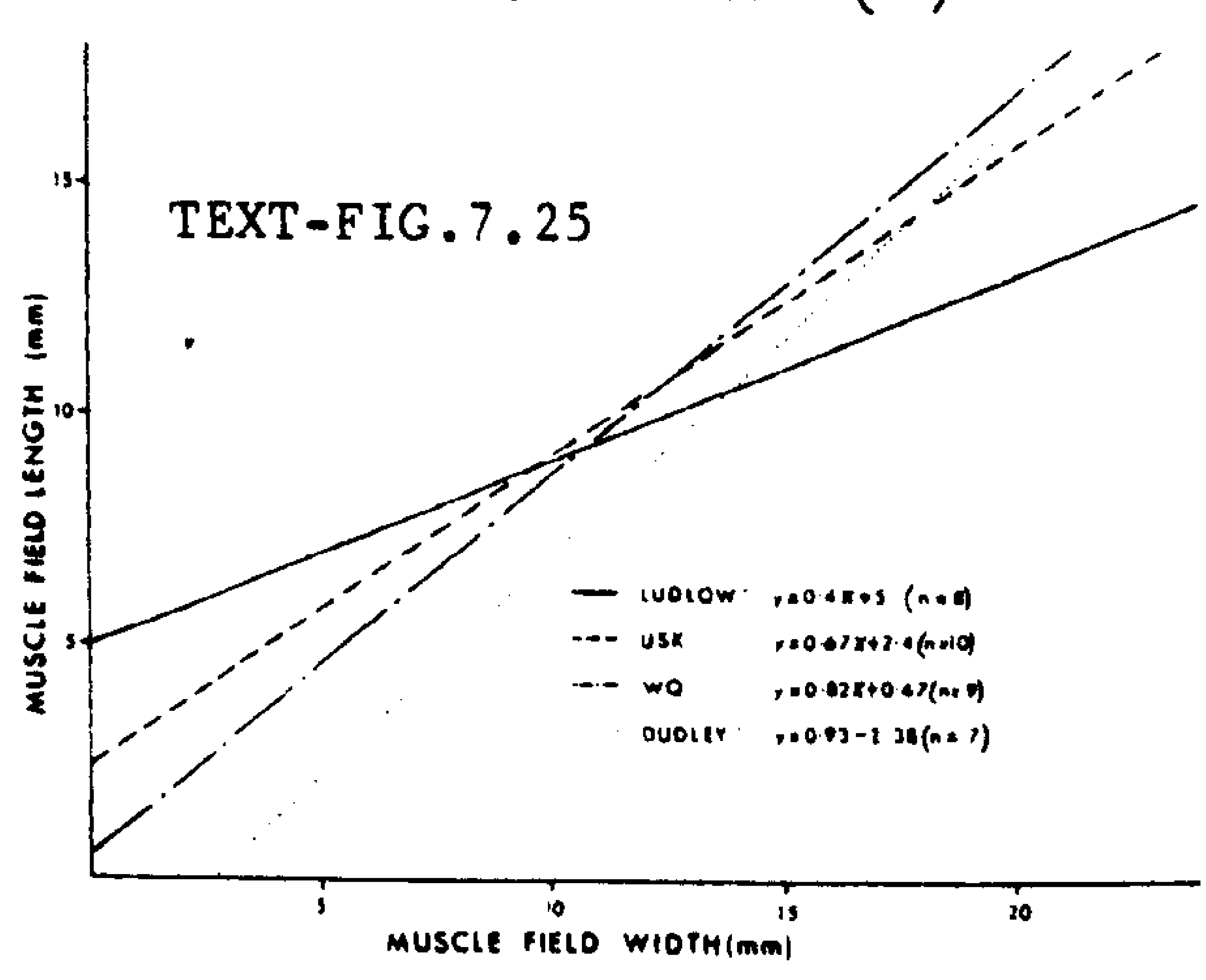
TEXT-FIG.7.24



TEXT-FIG.7.23



TEXT-FIG.7.25



TEXT-FIGS.7.22-7.24. Distribution plots of S. euglypha from the Wenlock Limestone of Dudley area illustrating; shell length-width (7.22), muscle field length-width (7.23) and shell width versus width of denticulation (7.24).

TEXT-FIG.7.25. Superimposition of muscle field length-width distribution of S. euglypha from four different areas.

7.4.5.2. Internal shell features.

a) Pedicle valve muscle field.

The muscle field shape in S.(S.) euglypha of the Wenlock of Dudley is similar to that of Ludlow specimens in the shape of both the adductor and diductor muscle scars and the muscle bounding ridges. The only difference appears in the muscle field proportions (Table 9 and text-fig.7.23).

TABLE 9. Summary of statistical results of the muscle field proportion of S.(S.) euglypha from the Wenlock Limestone of Dudley area.

Area	n	$\bar{L}mf$	$\bar{W}mf$	r	S.D. (Lmf)	S.D. (Wmf)	equation	$\bar{\%}$ $\frac{Lmf}{\bar{W}mf}$
Dudley	7	14.171 (6.282)	17.729 (4.752)	0.812	2.321	2.018	Y=0.93X-2.32	80%

It is evident from text-fig.7.23 that the muscle field length increases in direct proportion to its width. The muscle field in the Wenlock S.(S.) euglypha occupies about 40% of the valve length (see Table 10 below and text-fig.7.20).

TABLE 10. Summary of statistical results of the muscle field length/ shell length proportions of S.(S.) euglypha from Dudley.

Area	n	$\bar{L}s$	$\bar{L}mf$	r	S.D. (Ls)	S.D. (Lmf)	equation	$\bar{\%}$ $\frac{Lmf}{\bar{L}s}$
Dudley	7	35.77 (8.79)	14.17 (6.28)	0.601	2.745	2.32	Y=0.71X +25.7	40%

b) Denticulations.

Denticles in Wenlock S.(S.) euglypha are well developed as strong ridges on a pair of triangular denticular plates along the hinge line of both valves (see Pl.34, fig.2, Pl.35, fig.2 and Pl.36, figs.5 & 6). These denticles extend laterally along the hinge line for varying proportions of the hinge width (see Table 11 below and text-fig.7.24).

Among the studied specimens, only six showed good denticles for measurement purposes.

TABLE 11. Summary of statistical results of the denticulation of S.(S.) euglypha from Dudley (Wenlock).

Area	n	$\overline{Ws}$	$\overline{Wd}$	r	S.D. (Ws)	S.D. (Wd)	equation	% $\overline{Wd}/\overline{Ws}$
Dudley	6	42.58 (20.45)	18.62 (15.27)	0.83	4.13	3.57	Y=0.96X+24.7	44%

It is confirmed from text-fig.7.24, that the width of the hinge line denticulations increase in direct proportion to the shell width and that the percentage ratio of the hinge width occupied by the denticulations is 44% (see Table 11).

In the Wenlock specimens, there are some very well preserved specimens showing the development of the pseudodeltidium as a small strong and triangular outgrowth of the shell covering the delthyrium in the ventral apsacline interarea of the pedicle valve and a smaller strong and convex chilidium which covers the notothyrium in the dorsal anacline interarea of the brachial valve (Pl.36, fig.11) and (Pl.34, figs.1 & 2 for the pseudodeltidium only). Some other specimens show the position of the attachment of the cardinal process lobes in the internal of the pedicle valve, fitting on either side of the ventral process (Pl.34, figs.1 & 2).

7.5. COMPARISON BETWEEN THE WENLOCK AND LUDLOW S. EUGLYPHA FROM THE WELSH BORDERLAND OF BRITAIN.

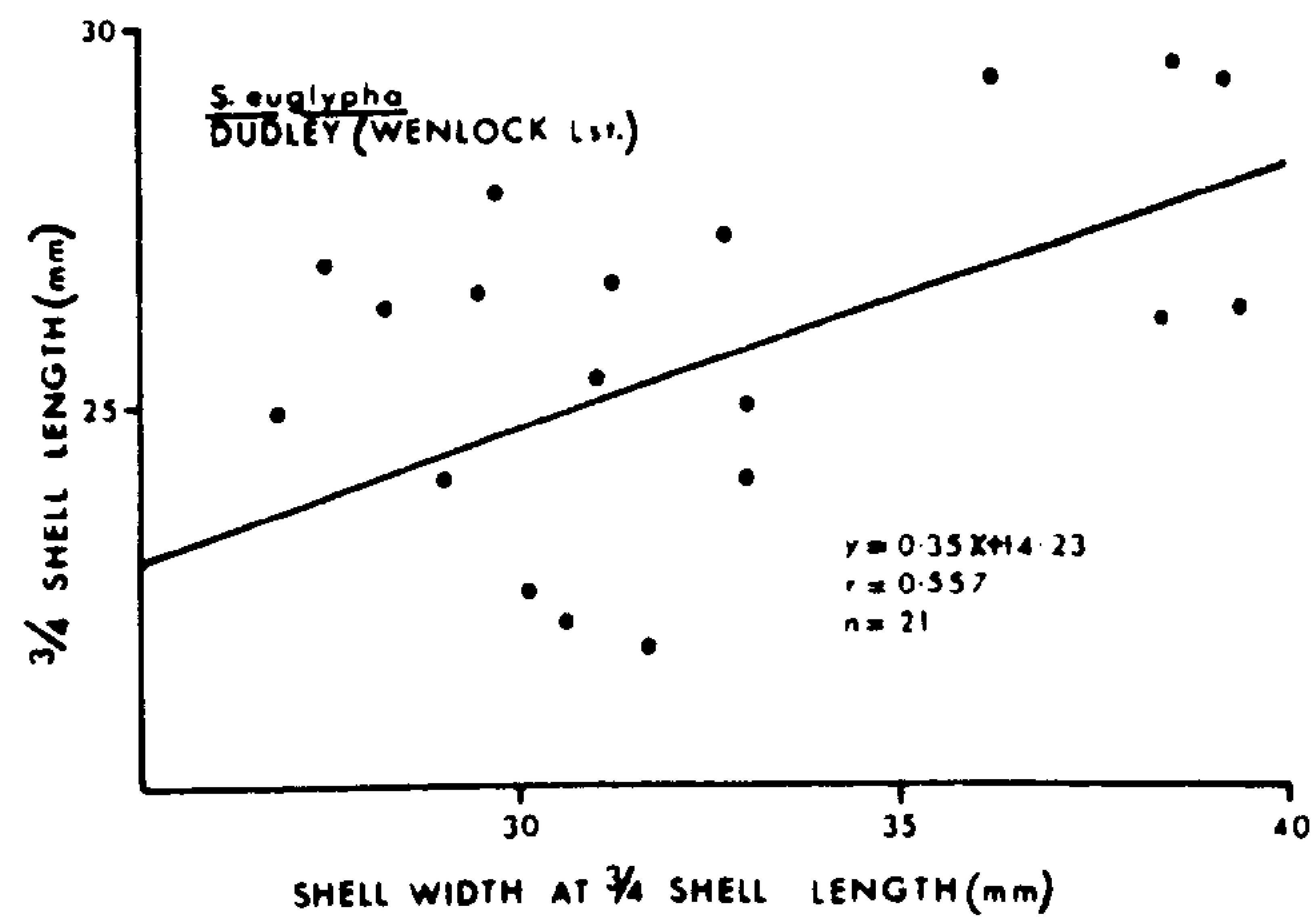
Generally the comparison discussed in this section is based only on the observed variations between the Ludlow and Wenlock specimens of the Welsh Borderland.

In the Wenlock, S.(S.) euglypha is most frequently semicircular (rounded) in outline shell shape (Pl.35, figs.1 & 2) but in the Ludlow rocks it is almost subtriangular to triangular in outline (Pl.33, figs.7-12, Pl.28, figs. 1 & 2 and Pl.29, fig.1). Most of the Ludlow specimens are strongly convexi-concave particularly at the point of geniculation, in which the shell is pinched out antero-medianly in conformity with the triangular shell shape of the Ludlow specimens. Statistical data shows that the shell length to width proportions for the species from Ludlow and Wenlock rocks are nearly similar, ranging between 75-81% as long as wide. It is also evident that the Wenlock shells are on average larger than the Ludlow shells (text-fig.7.10). This will be discussed later in the palaeoecology section (Chapter 9). For these comparisons, see Table 12 and for detailed data, Tables 2 and 7.

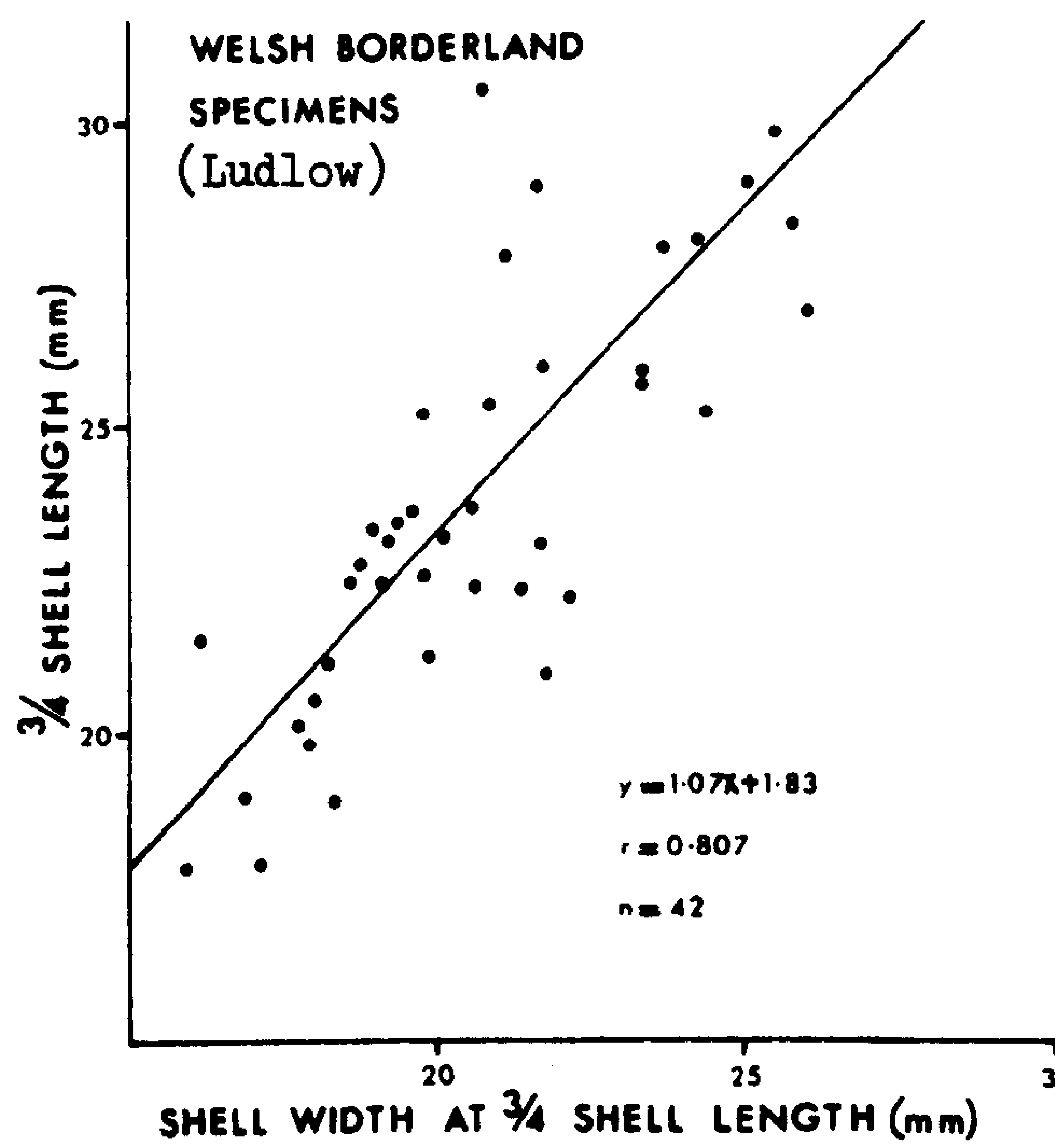
TABLE 12. Statistical comparison of <u>S</u>.(<u>S</u>.) <u>euglypha</u> from the Ludlow and Wenlock rocks of the Welsh Borderland.

Age	% $\overline{Ls}/\overline{Ws}$	n	% $\overline{Lmf}/\overline{Wmf}$	n	% $\overline{Wd}/\overline{Ws}$	n	$\overline{Lmf}/\overline{Ls}$	n	% $\frac{3}{4}\overline{Ls}/\overline{Ws}_{(\frac{3}{4}Ls)}$	n
Ludlow	78	251	83	27	39	45	40	23	115	42
Wenlock	78	22	80	7	44	6	40	7	80	21

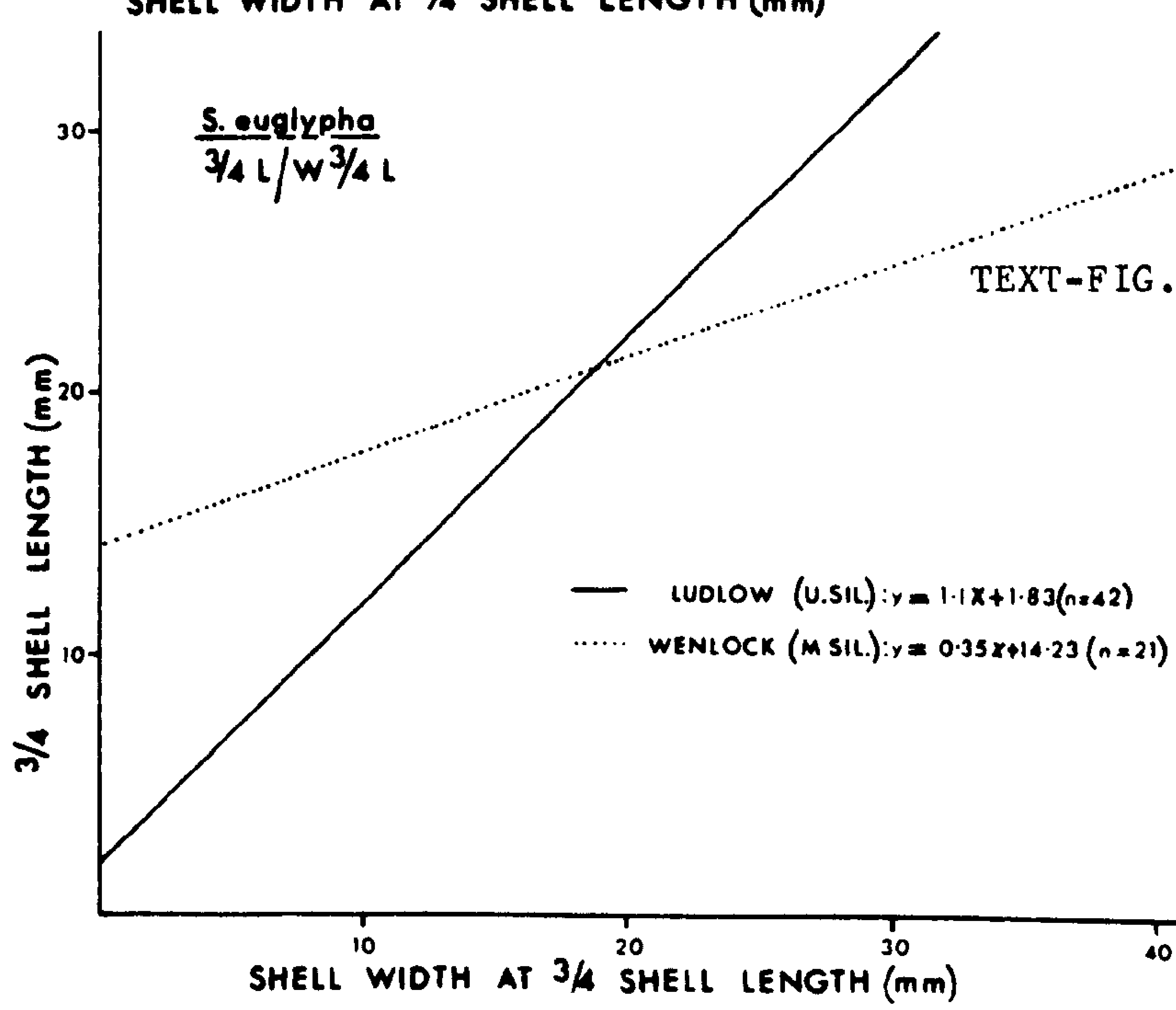
In the hope of providing an objective demonstration of the contrast in the outline shell shape between Ludlow and Wenlock specimens, the shell width was measured at ¾ of the shell length. The results of these measurements are shown in Table 13 below and are also displayed in text-figs.7.26-7.28.



TEXT-FIG.7.26



TEXT-FIG.7.27



TEXT-FIG.7.28

TEXT-FIGS.7.26 & 7.27. Plots of ¾ shell length against shell width at this point for S. euglypha from the Wenlock and Ludlow of the Welsh Borderland, with their comparison in text-fig.7.28.

TABLE 13. Summary of statistical results on the outline shell variation of S.(S.) euglypha.

Age	n	$\overline{¾Ls}$	$\overline{Ws}_{(¾Ls)}$	r	S.D. (¾Ls)	S.D. $Ws_{(¾Ls)}$	equation	% $\overline{¾Ls}$ / $\overline{Ws}(¾Ls)$
Ludlow	42	23.76 (13.94)	20.57 (7.99)	0.807	3.69	2.79	Y=1.1X+1.83	115%
Wenlock	21	25.44 (7.13)	31.86 (17.84)	0.557	2.61	4.12	Y=0.35X+14.23	80%

The value of the percentage ratio of the ¾ shell length to the shell width at this point in Ludlow specimens is higher than the Wenlock specimens value (e.g. 115%, 80% respectively); i.e. the Wenlock specimen is wider at this point (¾Ls) which gives the shell a rounded outline appearance (Table 13 and text-fig.7.28).

The shapes and proportions of the muscle field and muscle bounding ridges in both Wenlock and Ludlow specimens are nearly similar (see Tables 5 and 9 for details and Table 12 for comparison). As seen from both Tables 5 and 9 the Wenlock specimens had larger muscle fields than the Ludlow specimens (see text-fig.7.25 for comparison) and this is obviously related to the larger shell of the Wenlock specimens as will be discussed in Chapter 9. The muscle field length in the Wenlock specimens has a higher mean value relative to the valve length than in Ludlow specimens, but still both Ludlow and Wenlock specimens have the same proportions of the valve length occupied by the muscle field length (see Table 12 and text-fig.7.21 for comparison).

Denticles extend laterally along the hinge line in both valves of S.(S.) euglypha and for varying proportions in Ludlow and Wenlock specimens (Pl.27, fig.2, Pl.28, figs.1 & 2, Pl.32, figs.7-12, Pl.34, fig.2, Pl.35, fig.2 and Pl.36, figs.5 & 6).

The mean ratio of the denticulation width to the hinge line width in Wenlock specimens is more than in that of the Ludlow specimens, for example 44% (n = 6) in the Wenlock as compared with 39% (n = 45) in the Ludlow (Tables 4 and 11 for details data; Table 12 and text-fig.7.13 for comparison). The significance of these variations in the denticulation between Ludlow and Wenlock specimens will be discussed later in Chapter 9.

7.6. CONCLUSION.

The main differences between Ludlow and Wenlock S.(S.) euglypha are the greater size of the Wenlock species both in the shell and muscle field proportions, their more rounded outline, and the increased development of denticles along the hinge line.

SECTION
III

PALAEOECOLOGY AND CONCLUSION

SECTION III

CHAPTER EIGHT

FUNCTIONAL MORPHOLOGY AND PALAEOECOLOGY

Page No.

CHAPTER EIGHT

FUNCTIONAL MORPHOLOGY AND PALAEOECOLOGY

8.1. FUNCTIONAL MORPHOLOGY OF STROPHEODONTID BRACHIOPODS.

8.1.1. Introduction.

In general, brachiopods are entirely sessile benthic marine invertebrates having bilaterally symmetrical but unequal brachial and pedicle valves. Brachiopods are divided into two classes according to the presence or absence of articulating structures between the two valves of the shell - the Articulata and the Inarticulata. They are less diverse than in past ages when their shells were commonly preserved in marine sediments. As a result, fossil brachiopods are commonly more familiar than the Recent species (see Brunton & Curry 1979). From the literature (e.g. Ager 1967) it is clear that the Brachiopoda reached their maximum abundance and diversity during the late Palaeozoic, and progressively declined since the beginning of the Cenozoic.

In attempting functional interpretations of fossil brachiopods, it is necessary to consider not only their morphology but also the morphology of living brachiopods as well as their ecology (e.g. Rudwick, 1970; Curry, 1982, 1983). Unfortunately, there are no living stropheodontid brachiopods to be studied and compared with the fossil ones.

Most of the specimens studied during this project were well preserved and provided considerable information on external and internal shell features. This excellent preservation provided a good opportunity to speculate on the functional significance of some of these features. Previous studies of the functional morphology of brachiopods have considered some aspects of stropheodontid morphology (e.g. Rudwick 1965, 1970 and Ager 1967) with the most detailed analysis being that of Williams (1953) in his paper on North American and European stropheodontids. However, before elaborating on the functional morphology of the species it is useful to list those features of the stropheodontid shell which have been examined in detail in this project and to consider their functional morphology before discussing the possible mode of life of these particular species.

8.1.2. External shell features and their functional morphology.

8.1.2.1. Shell.

The shell is the most conspicuous part of a living brachiopod; in a fossil it is all that is normally preserved. The primary function of the shell seems to be to provide the animal with protective armour (Rudwick 1970). The shells of most fossil brachiopods are essentially similar to those of living brachiopods, in which the valves are wholly external to the living tissues of the body, with their edges fitting tightly together. In this way they can seal all the internal living tissues from direct contact with the external environment. It is therefore reasonable to say that protection has always been a primary function of the shell in brachiopods.

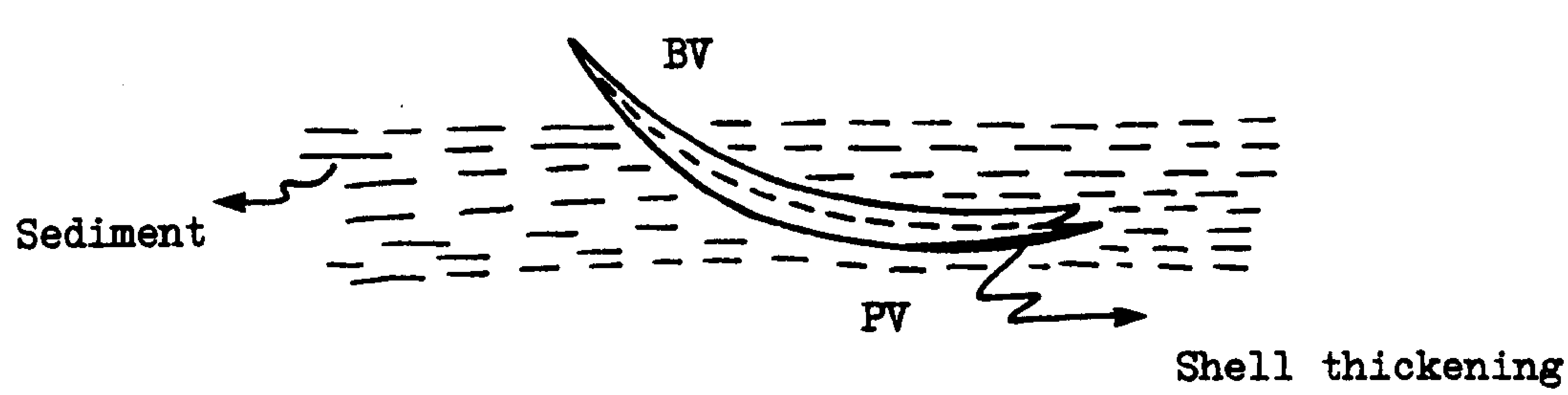
8.1.2.2. Ribbing.

Fine and coarse radial ornament were well developed on the external surface of both valves of stropheodontids and radiate from the umbo towards the margins of the shell. The shape and number of these ribs vary from species to species and from one area of the shell to another. The number of ribs was measured on each of the species studied and are described in detail in the systematic section. Mostly, among the specimens studied, the radial ribs are equally to subequally, finely to coarsely parvicostellate e.g. A. funiculata. In P.(M.) lepisma the ribs are weakly to moderately developed but are best developed around the valve margins. In S. ornatella and S. euglypha, the coarse radial ribs (costellae) are widely separated, and the intervening spaces have numerous fine radial ribs (capillae). In general, the mantle of the brachiopod has a great number of marginal setae. In modern Lingula these have been observed erected along the lateral margins for the exclusion of sand and mud. It is reasonable, therefore, to suspect that the ribbing pattern of the Strophomenacea may reflect the number of setae, as happens in some living brachiopods, and also these setae help to exclude unwanted material from the mantle cavity or may also have a sensory role (see Lamont, 1934). Lamont (1934) also reported that the nature of the substrate may be an important factor affecting the coarseness or fineness of the ribs, i.e. strongly ribbed forms lived in clean water on a sandy sea floor while fine ribbing appears to be characteristic of adaptation for a muddy environment. If so, however, the variation in radial ornamentation in the Welsh Borderland stropheodontid brachiopods may be related to different environments, for example, muddy environment in the Lower Elton Formation and silty, or limy, in the Lower and Upper Bringewood Formations. But this interpretation does not explain why some stropheodontids have both fine and coarse ribs. Lamont (1934,p.181) speculated that the fine striations would eventually replace the coarser ribs to allow the animal to survive in an environment characterised by fine mud.

The heterorthids are probably a good example of a group in which the ribs may reflect the number of setae and this is also likely for the stropheodontids of the Welsh Borderland. The setae could use mucus from the brachial cavity to bind sediment and could have helped to keep the shell attached to the substrate.

8.1.2.3. Shell thickening.

Stropheodontid brachiopod species were pedically attached only as juveniles. Later in life, the pedicle atrophied and the adults lay unattached on the sea floor (Williams, 1953 and Hurst 1974). Many workers (e.g. Lamont 1934; Rudwick 1962; Rudwick 1965 and Pope 1976) asserted that such organisms (i.e. those which lost their pedicle when adult) were resting on the convex valve (usually the pedicle valve). In such cases a great thickening of shell material in the postero-ventral part of the pedicle valve would produce a centre of gravity situated postero-medianly and would serve to stabilise the shell and to raise the anterior commissure above the sediment surface to guarantee feeding efficiency (see sketch below):



Shell thickening of this type was observed in the shells of S.(S.) euglypha and A.(A.) funiculata. The measurements show that the shells are strongly weighted posteriorly (see Chapter 6). Posterior weighting of brachiopod shells can also be seen in Recent species such as Neothyris lenticularis (see Brunton 1982), as well as in many fossil taxa (Williams 1953, 1965 and Rudwick 1970).

8.1.2.4. Growth lines.

Brachiopods grow by the accretion of new shell material secreted by the peripheral mantle epithelium. When shell secretion is interrupted, the result is a mantle regression and a growth line is formed (Pl.3 and Pl.11, fig.2). These growth-lines are preserved within the shell fabric and provide a record of the ontogenetic development (Curry 1979). Several brachiopod workers have considered that the growth lines develop periodically as a result of regular disturbances (see for example, Williams 1968; Rudwick 1976; Curry 1982, 1984).

Among the specimens studied, the growth lines are faintly to strongly developed postero-laterally from the hinge line and are very few in number (i.e. not exceeding four lines). The implication is that growth continued with only rare interruption during early life, but was more frequently disrupted in older specimens. These lines are smooth and equally spaced, having nearly the same distance from each other in most of the studied specimens. Therefore, they are more likely to represent the annual growth of the animals (Curry 1985 pers.comm.).

8.1.2.5. Oblique rugae.

Rugae are quite common in most stropheodontids, and are usually developed on the postero-lateral margins of the shell at a low angle to the hinge line (Pl.29, fig.2). This modification, as Lamont (1934) suggested, would tend to direct the mud thrown off by the valve in opening away from the open delthyrium. In addition, the author favours the opinion that such ornament may also help to stabilise the posterior end of the animal in the sediment while the anterior part projects above the sediment.

8.1.2.6. Concentric corrugations.

Corrugations are observed in some specimens as discontinuous growth lines interrupted by the radial ornament and are more pronounced at the postero-lateral area of the shell and occasionally extend across the whole surface of the shell as a concentric arc (Pl.3, fig.9). In some species, for example, S. ornatella, these concentric arcs develop together with the parvicostellate ornamentation to form a reticulate "woven" like pattern of small rectangles (Pl.3, figs.6. & 9). During the present study, it was noticed that such ornament (concentric arcs) is more common on the flat or weakly concave valves and also on those specimens which lived in a more agitated environment (e.g. S. ornatella from Gotland). The function of such ornamentation is probably also related to the maintenance of a stable life position. As the centre of gravity of the organism was changed and weight added postero-medianly by the lifting of the upper valve, these corrugations would prevent the pedicle valve from sliding forward and sinking along the hinge line. Such sinking would (and as Lamont suggests) have allowed the ingress of the foreign materials, which is clearly very undesirable.

8.1.2.7. Shell wings (alae).

Among the specimens studied, postero-lateral extensions of the shell are developed in some specimens (Pl.20, fig.3). It is suggested that such outgrowths may arise in response to the necessity of warding off silt from the lateral edges of the opening shell. The expansion of these wings was also interpreted by Fenton and Fenton, 1932 as a "snow shoe" device to prevent sinking into soft sediment. This idea was supported by Ivanova (1962) and Ager (1965) in a different type of brachiopod.

8.1.3. Internal shell features and their functional morphology.

8.1.3.1. Hinge structure.

The brachiopods under study have a strophic shell, which means that they have a straight hinge line (see Pl.11).

The main components of the hinge in articulate brachiopods are normally a pair of ventral teeth which fit into corresponding sockets in the brachial valve. These lie just inside the median posterior edges of the valves and interlock when the shell opens or closes to prevent lateral slippage. In strophic shells a large contact area was needed between the hinge-teeth and hinge-socket to fix the axis of rotation along the hinge line.

The teeth are bounded on the median or anterior side by inner socket ridges. Both teeth and socket ridges are composed of secondary layer material, and grow by accretion during ontogeny. They may be connected to the valve floor by reinforcing struts, termed denticular plates and socket plates respectively (Pl.19, figs. 1 & 2), which likewise grow forward by accretion (see Rudwick 1970). The teeth and sockets constrain the movements of the valves and keep them in the correct orientation. Interlocking "denticles" occur as a series of sharp, small ridges spread along the hinge line for about half of the shell width (Pl.10, figs.3a, 4 & 6). Such structures clearly act as supplementary or accessory structures for teeth and sockets. The denticles, therefore, fulfil the same function as the teeth and sockets but in addition, would have prevented twisting of the valves. Denticles evolved independently in several strophomenides (Rudwick 1970) and it has been observed that the spread of denticles outwards along the hinge line was often accompanied by a progressive reduction and possibly even complete atrophy of the original teeth and sockets (see also Williams 1953 and Rudwick 1970).

The strong development of denticular plates in the studied stropheodontids indicates that the denticles played a primary role in shell articulation, which may have led eventually to the disappearance of the teeth and sockets.

Examination of articulated shells of the modern brachiopods by Jaanusson et al (1979) suggested, that the articulating structures serve four main functions:

a. They make possible a rotating movement of the valves relative to each other (i.e. shell opening).
b. They prevent the transverse (lateral) and longitudinal movement of the valves relative to each other.
c. When the shell is being closed they direct the valves so that the free valve edges can fit snugly.
d. They limit the extent to which the shell can be opened.

Similar functions are likely for the denticulation in the stropheodontid species studied.

8.1.3.2. Socket plates.

Socket plates are pairs of plates situated postero-medianly on the brachial valve floor, attached or laterally adjacent to the cardinal process lobes (Pl.30, fig.2). In general, they diverge antero-laterally and are blade- and recurve-shaped (Pl.2, figs.1-6). These plates are short in most specimens, and only in a very few specimens are they extended laterally for about half the shell width as auxiliary ridges which are parallel to the hinge line or diverge at a very low angle from it (see Pl.10, figs.1-3). Such features were clearly seen in a large number of specimens of _L. filosa_ (about 350 specimens). The auxiliary ridges which flank the socket plates and are directed outwards towards the lateral shell margins are most likely to have functioned as secondary aids in articulation (i.e. to give extra strength to the denticulations when the shell opened) and could also have prevented the lateral slippage of the valves (see Brunton 1982). Therefore, the function of the socket plates in stropheodontids is intimately connected with the strengthening of the dorsal socket and the articulatory system. These plates may also have a role in the support of the lophophore.

8.1.3.3. Cardinal process and chilidium.

In stropheodontid brachiopods, the cardinal process consists of a bilobed pair of plates to which the dorsal ends of the diductor muscles were attached. It is located postero-medianly to the brachial valve hinge line and was separated by a small septum or groove (Pl.30, fig.2). This septum may have functioned as Williams suggested (1953) to plug the gap between the cardinal process lobes. The other part of the diductor muscles were attached to this structure (i.e. to the cardinal process lobes) which could help the diductor muscle to open the shell by pulling backwards and forwards when the diductor muscles contract for opening the shell.

The posterior ends of the cardinal process lobes are concealed by a convex structure called a chilidium (Pl.23, fig.1). It was developed as a triangular plate which probably functioned as a protective covering for the bases of diductor muscles implanted on the notothyrial floor or on the cardinal process.

8.1.3.4. Ventral process and pseudodeltidium.

The ventral process occurred as a medium-sized triangular or diamond shaped callus of secondary shell, located postero-medianly from the pedicle hinge line (Pl.12, fig.1) and projected dorsally to fit between the lobes of the cardinal process in the brachial valve. However, the ventral process was underlain by a small structure called a pseudodeltidium. The latter occurred as a single, convex or flat plate completely covering a median triangular delthyrium in the ventral interarea (Pl.34, figs.1 & 2). However, the growth of the pseudodeltidium in stropheodontids was a specialisation dependent upon the growth of the ventral process (see Williams 1953).

8.1.3.5. The relationship between cardinal process, ventral process, chilidium and pseudodeltidium.

In general, the fits of the pedicle ventral process between the lobes of the cardinal process in the brachial valve may act not only as a support to the pseudodeltidium and the chilidium respectively, but may also be useful as interlocking structures during valve opening and closing.

The development of both pseudodeltidium and chilidium for the purpose of covering the delthyrium and notothyrium at the ventral and dorsal interarea respectively, was also accompanied by their overslide occurrence (i.e. the pseudodeltidium over the chilidium) which may also have helped as a fulcrum point when the valves opened (see Pl.20, fig.3).

8.1.3.6. Adductor muscle scars.

The most distinctive elements in the stropheodontid internal morphology are the muscle scars of both valves. The adductor muscles extend more or less vertically through the coelom near the anterior body wall, being strongly attached to the inner surface of both valves and their line of action is well in front of the hinge axis. Brachiopods in general, have a pair of smooth adductor and a pair of striate adductor scars which originate as four separate muscles on the brachial valve and are attached by a single tendon on the pedicle valve (Rudwick 1970; Eshleman and Wilkens 1979). The adductor scars in the pedicle valve occur as a pair of lanceolate adductor scars, impressed on either side of the median ridge (known as the myophragm).

Rudwick (1961) suggested that the striate adductors (the small posterior scars) were responsible for "quick" snap responses and that the smooth adductors (i.e. large anterior scars) for the prolonged "catch" type of closing behaviour. Wilkens (1978) demonstrated in Recent brachiopods that the initial snapping reaction resulted from a single twitch contraction of the striate adductors and that the sustained closure was caused by the subsequent contraction of the smooth adductors.

8.1.3.7. Diductor muscle scars.

The diductor muscles of brachiopods run from the floor of the pedicle valve to the cardinal process. The muscle scars are oval to triangular in outline. The pedicle valve diductor scars lie antero-laterally to the lanceolate adductor scars and are separated by the myophragm (see Pl.11, fig.1). The diductor scars serve to open the shell when their contraction draws the posterior edges of the valves closer together.

The adductor and diductor muscles act to close and open the shell autogenistically.

In the stropheodontids studied in this project the muscle scars are invariably bounded laterally or totally enclosed by a pair of straight or slightly curved muscle bounding ridges. The ridges are either parallel or divergent antero-laterally, and are very variable in the angle at which they diverge and in their outline. The nature of the muscle bounding ridges also differs greatly between different species of stropheodontids.

In some large specimens of L. filosa, the anterior part of the muscle field is partitioned by a series of low, fine radial ridges. These extra muscle ridges probably functioned to increase the muscle attachment area. This tends to suggest more shell snapping possibly related to a higher energy environment (see Pl.11, fig.1). In addition, ridges may help with shell articulation, by preventing the swivelling of the larger valves.

8.1.3.8. Tuberculae.

The valve floors and commonly the internal surface of the stropheodontid brachiopods are finely to coarsely ornamented by rounded or conical tubercles or pseudopunctae (Williams 1965), (Pl.15, figs.1 & 2). These have been interpreted as the scars of minute muscle attachments of the mantle epithelium to the shell in regions of coelomic mantle canals (Brunton 1982).

8.2. DEGREE OF TRANSPORTATION.

The problem arising in any consideration of palaeoecology is to determine whether the fossils are preserved in situ or have been moved after death by current or other agencies. However, it is difficult in the fossil record to determine the exact degree and distance of transportation. Boucot, Brace and Demar (1958) studied the effect of transport on three brachiopod genera in a large block of Lower Devonian sandstone. They discovered from the numbers of pedicle and brachial valves present that species such as Leptostrophia were represented by proportionately fewer brachial valves as compared with pedicle valves. This was attributed to preferential transport of the brachial valve after death (see also Raup and Stanley 1971). The present study revealed a similar pattern, with the species studied mostly occurring as moulds of pedicle valves (about 60-70%) and with less brachial valves (about 30-40%). Very few specimens are found with both valves together; because this type of unattached form is largely held together by muscles and therefore, they would disarticulate readily on death. It is also suggested during the present study, that the shape of the shells may also affect the degree of transportation, particularly when dealing with three different shapes, flat, concavo-convex and resupinate forms. However, the resupinate and strongly concavo-convex shells are less easily transported than the weakly concavo-convex or flat shaped shells in the same environment and under the same current activity. However, in the stropheodontid brachiopods, the relatively larger and thicker single pedicle valve is more common in the majority of assemblages, whereas, the brachial valve is rare. This has been confirmed by Dr. Lawson (1985 pers. comm.), who observed mostly pedicle valves for many other genera (e.g. Kirkidium, Dayia) during his studies on the Ludlow rocks of the Welsh Borderland. The presence of more pedicle valves than brachial valves may indicate that the latter had undergone more extensive transport (perhaps being twice as likely to be moved as the pedicle valves), and/or removed selectively by currents because they were relatively lighter and smaller than the pedicle valves (Worsley and Broadhurst 1975). Consequently, as the brachial valve is in an upward position during life, is weaker, thinner, smaller and likely to be transported further, it would be more likely to be damaged and destroyed by turbulent conditions. The same process could explain the relatively low proportion of small sized specimens (see Trewin and Walsh 1972). Once again, such small individuals may be broken more quickly into numerous fragments before being preserved in the rocks, i.e. they have suffered selective destruction during transportation.

Middlemiss (1962) reported that the shells drifting from their place of origin become more liable to abrasion the further they are transported, and that the brachiopods would break up if moved more than one mile from their life position. He concluded that the percentage of disarticulated and broken valves is roughly proportional to the distance drifted from the original site of life.

During the present study, there is little indication of either abrasion or disintegration of the shells, which would undoubtedly occur if they had been subjected to significant post-mortem transportation (see discussion below). Williams (1953) considered that "stacking" of stropheodontid valves occurred as a result of current action. This suggestion is favoured by Cherns (1977), when she reported that the "stacked" assemblages of S. ornatella in the silty calcareous rocks represented current accumulations.

The five species which have been studied from the Ludlow Series of the Welsh Borderland usually occur as disarticulated, unbroken and unworn specimens. This suggests that these species were transported by currents but the distance of transportation is unknown. However, to study the transportation of these species, the writer has dealt with them as two separate groups as follows:

1. The concavo-convex and resupinated shell shapes of P.(M.) lepisma, A. funiculata and S. euglypha:

These three species are not normally found in shell beds (coquinas). From the evidence in the sediments and the species shell shapes (which were geometrically unstable), it is likely that they preferred to live in a fairly low energy environment. Furthermore, the convex shape of these species would not encourage transport by gentle currents and therefore, the fossils concerned have merely been flipped over into a stable position and have not been moved far.

As these fossils have been shifted a very short distance from their life position, their shell occurrences could best be considered as disturbed neighbourhood assemblages as Watkins (1979) suggested for other Ludlow forms.

2. Flattish shell shapes of S. ornatella and L. filosa:

S. ornatella is most commonly found in the shell beds of the Upper Leintwardine Formation, whereas L. filosa often dominates bedding planes in the Lower Bringewood and Lower Leintwardine Formations. The evidence from the study of the sediments suggests that L. filosa and S. ornatella lived in moderate energy environments of the Lower and Upper Leintwardine Formations respectively. However, the abundance of L. filosa in the Lower Bringewood Formation might suggest that it also tolerated a lower energy environment but it could have been living in a temporary phase of higher energy environment within the general low energy conditions of the Lower Bringewood Formation.

S. ornatella and L. filosa were more easily transported than the resupinated forms because they are both flat in profile.

Furthermore, the disarticulated but unbroken condition of the valves would suggest that these forms were transported after death by bottom currents, probably for a very short distance and their abundance is likely to be the result of current accumulations (Williams 1953). However, their shells are unbroken and have not been moved a great distance or with great violence (possibly a little further than _S. euglypha_, _A. funiculata_ and _P.(M.) lepisma_). Their shell occurrences are still considered here as a disturbed neighbourhood assemblages.

8.3. AUTECOLOGY OF STROPHEODONTID BRACHIOPODS.

8.3.1. Introduction.

Boucot (1982) defined palaeoecology simply as the ecology of the past and stressed the fact that the fossil record is almost totally restricted to organisms having preservable hard parts. Ager (1963) and Gall (1976) divided the palaeoecological field into autecology and synecology. The former, based on functional morphology and the interpretation of the environment may be defined as ecological information concerning an organism or individual species that can be derived from a study of the rock matrix and of the individual species (see Boucot 1982). Synecology was defined by Odum (1959) as the ecology of a group of organisms which are associated together as a unit.

Fossil brachiopods are ideal subjects for palaeoecological analysis for a number of reasons:

1. Their great abundance in Phanerozoic rocks of almost all ages.
2. Their presence in many different sedimentary facies and environments.
3. Their skeletal characters which are such as to record physiological differences related to their way of life.
4. The survival of a wide range of representative forms to the present day (see also Ager 1967).

Brachiopods are entirely marine sessile benthic invertebrates, feeding from suspended nutrients and they often form the dominant constituents of many shelf assemblages and are unlikely to be fossilized in life position (Ager 1967). Therefore, it is difficult to reconstruct the life orientation of the stropheodontid brachiopods without using (1) information on the life orientation of Recent forms; (2) interpretation of functional morphology; (3) any data on life position preserved in the strata and (4) studies of the relationship between the epizoans and the host (Richards 1972). During the present study no specimens were seen preserved in the life position and unfortunately very few specimens have attached epifauna. The collected stropheodontids are normally represented by a single valve and not by both valves, which would be expected if found in life position. Furthermore, none of the exposed formations or bedding planes contain a single orientation for the stropheodontid shells, concave and convex upward valve surface are almost equally abundant indicating that the valves were split during transportation from life position to their present place (see section 8.2). However, the important factor in determining the shell orientation of the stropheodontid species is the loss of the pedicle during ontogeny. The result was that adult shells rested unattached on the sediment surface (Lamont 1934; Williams 1953; Rudwick 1970; Richards 1972 and Bassett 1984). Williams (1953) also noticed that stropheodontid brachiopods flourished in limy mud substrate; such deposits are likely to have been accumulated in quiet environments.

No concavo-convex or convexi-concave brachiopods survive today, although similar morphological adaptations for a free lying mode of life have been adopted with great success at various stages in the geological history of the phylum. The lack of living examples has not in any way hindered reconstructions of life-habits for concavo-convex brachiopods, as the fundamental requirements governing brachiopod survival are well known and can be combined with morphometric analysis to yield a suite of viable reconstructions. As far as can be determined, all concavo-convex or convexi-concave brachiopods, including the stropheodontids, were attached as post-larvae to small particles, algae, sponges, etc., but became free-lying following the progressive atrophy during ontogeny of the pedicle and the concomitant sealing of the pedicle aperture (Williams 1953; Rudwick 1970; Havlicek 1967 and Richards 1972). The survival of non-attached brachiopods such as the stropheodontids thereafter depended upon ensuring free access for the valve margins to the surrounding sea-water to allow vital feeding, respiration and excretion to proceed. In simple terms, this necessitated morphological adaptations to prevent the shell sinking into the substrate and thereby smothering the animal.

8.3.2. Flattish stropheodontids.

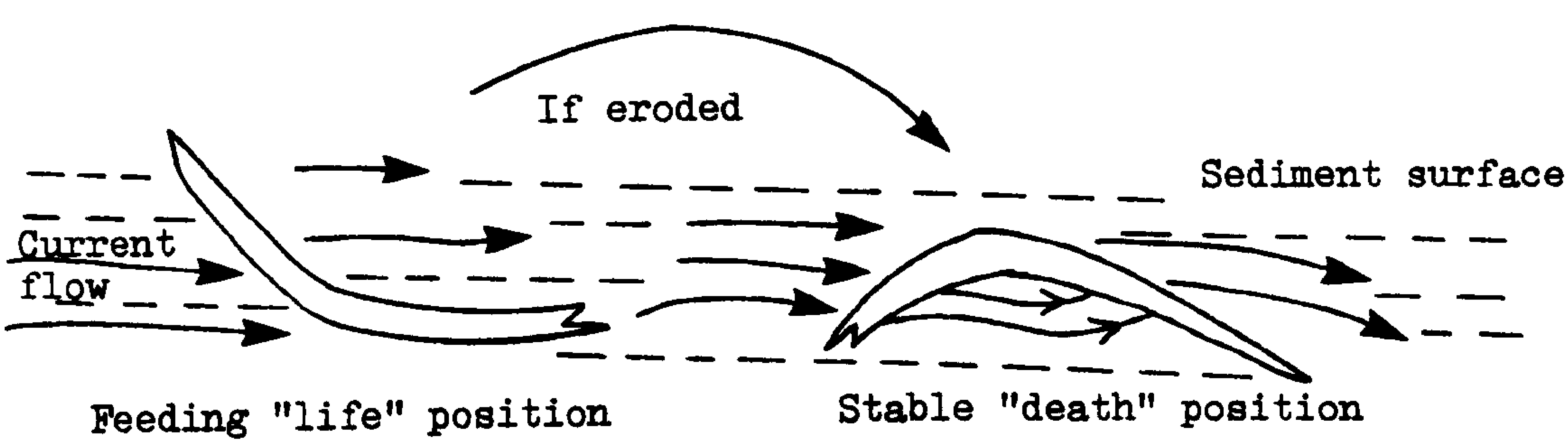
For *L. filosa* and *S. ornatella*, as for many other species, the development of a narrow plano-convex to gently concavo-convex shell resulted in a very low downward force per unit area of shell in contact with the sediment surface, and allowed the animal to grow, reproduce, etc., at the nutrient rich sediment-water interface. Detailed analyses of life habit have been carried out on a wide range of concavo-convex brachiopods (e.g. Brunton 1982; Shiells 1968) and such data leave little doubt that *S. ornatella* and *L. filosa* lived with the anterior and antero-lateral valve margins exposed above the substrate with the shell posterior shallowly buried.

Speculation that some concavo-convex brachiopods had the ability to swim by snapping of the valves (Rudwick 1970) is not pertinent, as if this did occur it would be a short-lived escape phenomenon. Therefore, for biplanate or weakly concavo-convex shells, the large surface area to volume of many stropheodontid shells (e.g. L. filosa and S. ornatella) was a major factor in achieving stability, by helping the animals to stay 'afloat' in fine grained sediment. Atkins (1979) concluded that Leptostrophia showed good adaptations for living close to the sediment surface and is unlikely to have lived vertically as Ziegler et al (1968) claimed, since as an adult it had no pedicle opening (Williams 1953 and Rudwick 1965 & 1970). A further adaptation for living close to the sediment surface is shown by the development of closely spaced fine costae. These costae are considered by Rudwick (1970) to correspond to the position of the mantle setae. The setae could use mucus from the brachial cavity to bind sediment during the feeding and respiration processes. As discussed in section 8.1.2.2., the setae are likely to reflect the number of the ribs (Hurst 1983, personal communication). Therefore, Leptostrophia was probably able to lie on the sediment surface with a very low angle of rest, raising the upper valve above the sediment for feeding and respiration purposes.

8.3.3. Gently concavo-convex stropheodontids.

In the case of concavo-convex shells, Lamont (1934) asserted that most of the Strophomenacea lived on the convex valve on the muddy bottoms and he pointed out that, in such a position, the shell could be opened without danger of fouling. Rudwick (1965 & 1970) favoured this orientation in which the concavo-convex profile would elevate the commissure above the sediment surface. Many other brachiopod workers (e.g. Williams, 1953; Havlicek, 1967; Bassett, 1984 etc.) have come to the same conclusion.

P.(M.) lepisma is a concavo-convex brachiopod which was attached only as a juvenile. The pedicle atrophied in the adult and it lay unattached on the sea bottom (Hurst 1974). Adult P.(M.) lepisma have no pedicle opening as claimed by Ziegler et al (1968). Therefore, these shells probably rested on the convex pedicle valve for feeding and respiration purposes, assisted by umbonal secondary shell deposits producing a postero-medianly situated centre of gravity for partial burial (i.e. umbonal thickening) to keep in this position. Such a feature would have served to raise the anterior commissure above the sediment surface. However, many of these fossils are found with their convex valve uppermost in the sediment (i.e. stable position). This probably reflects erosion and redeposition of the specimen after death by strong currents (see sketch below).

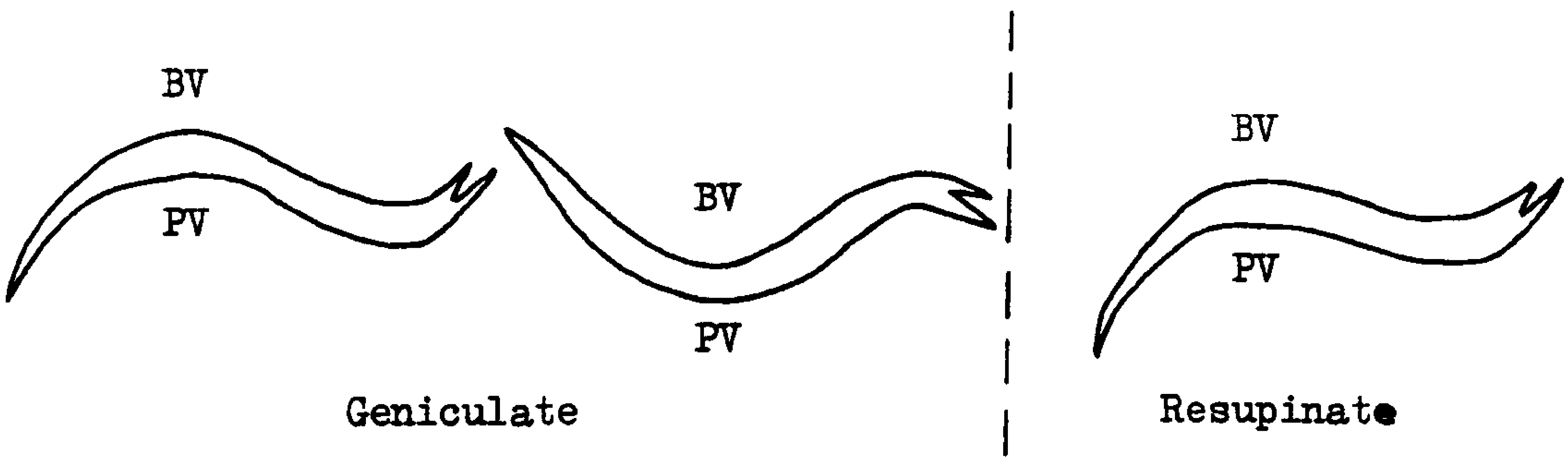


8.3.4. Geniculate and resupinate stropheodontids.

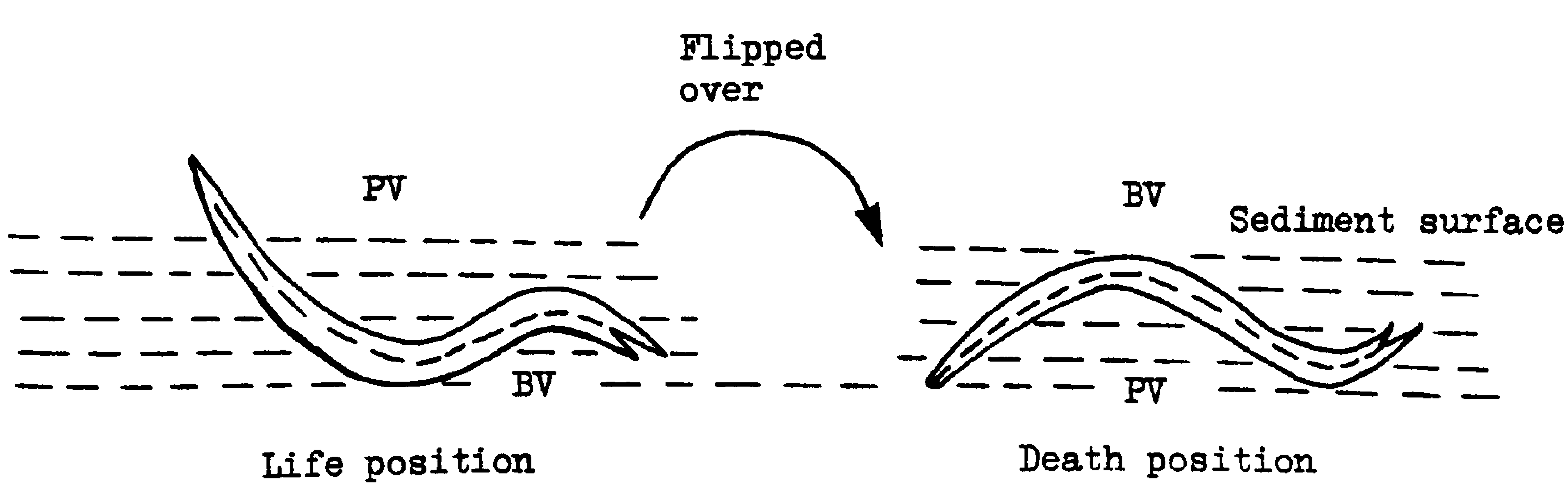
The life orientation of the resupinate forms of stropheodontid brachiopods was also considered herein (e.g. S. euglypha and A. funiculata). These resupinate forms, S. euglypha and A. funiculata, are concavo-convex posteriorly, but become convexi-concave anteriorly. Because of their overall morphological similarity to species such as P.(M.) lepisma, they are thought to have had a similar life style. Lamont (1934) suggested that morphologically similar brachiopods such as Leptaena also rested on the convex valve during life. Havlicek (1967) favoured this suggestion when he asserted that the resupinate shells of brachiopods were lying on the sea bottom in an inverted position, the brachial valve (the convex side in this case) being on the substrate. Subsequently Rudwick (1970) argued that shells with the resupinate shape, were probably adapted for a sessile semi-infaunal mode of life with the shell sunk into the sediment, giving stability to the shell, with only the valve margins held free of substrate for feeding and respiration. Bassett (1984) supported such an interpretation, suggesting that the shell curvature increased strongly during ontogeny in order to raise the commissure, as the animal became more deeply buried (e.g. Strophonella, Amphistrophia and Leptaena). He also suggested that such groups of brachiopods could have lived almost entirely within the sediment with no need to 'snap' to the surface periodically. Therefore, the life orientation of the geniculated strophomenids (e.g. Leptaena and Strophonella) is generally assumed (e.g. Richards 1972 and Pope 1976) to have been resting on the convex pedicle valve, with the geniculated fringe upwards. Spjeldnaes (1984), however, concluded from the growth of the epifauna on the external surface of pedicle and brachial valves of some strophomenid brachiopods (e.g. Leptaena and S. euglypha) that such brachiopods lived with their shells in a vertical position. After death, these animals would have fallen onto the sediment with the brachial valve and the geniculated fringe downwards. The epifaunal evidence was also taken to indicate that

A. funiculata probably lived in a 'conventional' way (i.e. resting on the dorsal valve with the geniculated fringe upwards).

At this stage, it is important to emphasize the difference between the geniculate and resupinate shell forms. In geniculate forms, the growth of the valve could occur in any direction, whereas, in the case of the resupinate forms the growth occurs only in one direction (see Williams, 1965 and the sketch below) as it occurs in S. euglypha and A. funiculata with the concave brachial valve becoming convex and the convex pedicle valve becoming concave during successive adult stages of growth. Therefore, the reversal in the relative convexity of the shells occurred during ontogeny.



Consequently, the resupinate specimens of S. euglypha and A. funiculata probably lived resting on the sea bottom in an inverted position and with the convex valve down, resting on the sediment as suggested for other previous species such as P.(M.) lepisma, but in this case (i.e. resupinate forms) the brachial valve would be turned downwards with the anterior and antero-lateral valve margins upwards and away from the sediment to facilitate feeding and respiration processes (see the sketch below).



Clearly these resupinate forms were often overturned after death by current action. In such positions they are much more stable hydrodynamically. Very few specimens of S. euglypha have attached epifauna such as bryozoans, Spirorbis, worms etc. (Pl.37, figs.1-5 and Pl.32, fig.2) on the external of the brachial valve. They are found on the anterior margins of the shell and on the valve interarea, which suggests that they grew after death when the inverted brachial valve was often uppermost.

8.3.5. Summary.

Stropheodontids, after they lost their pedicle during ontogeny, became recumbent and/or free lying as adults, with the convex valve resting on, or just in, the sediment (meniscus-like). Often the lower valve is thickened secondarily for stability. The dish shaped concavity of the upper valve allowed the commissures and the growing mantle edges to project above the substrate, and if the shell sank too far, it is likely that snapping action of the valve would have lifted it back upwards (Rudwick 1970).

So, in conclusion, the stropheodontid shells lived resting on the convex valve which is generally the pedicle valve in the case of L. filosa, S. ornatella and P.(M.) lepisma; and the brachial in the case of the resupinate forms (i.e. S. euglypha and A. funiculata).

CHAPTER NINE

DISCUSSION OF VARIATIONS AND CONCLUSIONS

CONTENTS

CHAPTER NINE

DISCUSSION OF VARIATIONS AND CONCLUSIONS.

In this section, the morphological variations documented in the previous chapters will be discussed and interpretation attempted. Each species will be dealt with separately.

9.1. SHALERIA ORNATELLA.

This species is mainly confined to the shelf habitats but does also occur in the Builth area, on the margin of the Welsh Borderland basin. S. ornatella has been studied mainly from two localities at Ludlow (Shropshire) and one locality in the Usk inlier in the Welsh Borderland of Britain and several localities on the Island of Gotland (Sweden). In Britain, these 3 major localities yielded hundreds of specimens of S. ornatella which made the statistical description and comparison possible. British samples normally occur in fine grained silt-grade sediments of very similar particulate size, but the Swedish sediments contain significantly more calcium carbonate. From stained thin-sections it is evident that the Usk and Ludlow sediments contain 1% and 1.6% CaCo3, although weathering partly explains this low concentration. The figure for the Gotland limestone is over 90%. It is possible, therefore, that the greatly increased availability of CaCo3 at the Swedish localities may be a factor in the considerably enlarged size of specimens from these localities (see Chapter 3, Table 5). This suggestion is supported by the small size of specimens of S. ornatella from even more poorly calcareous sediments at Aymestrey and Builth on the shelf edge and on the eastern margin of the Welsh basin respectively. These specimens do, therefore, fit well with the subjective assessment of a link between size and percentage carbonate. This would appear to be supported by the large size of the Gotland forms from the strongly calcareous sediment, although clearly other factors are also important in determining size.

The Gotland faunas are considered to have lived under higher energy conditions than characterised the Welsh and Welsh Borderland habitats (Hurst 1975 and personal communication 1983), and this environmental factor may in part explain the increased convexity of the Swedish specimens. An increase in convexity would compensate for a higher sedimentation rate to ensure that the valve margins remained clear of the sediment. The consistently greater proportion of the hinge-line occupied by denticulation in the Gotland specimens (an average of 44% as compared with the 40% of the British samples) probably also relates to larger shells and higher energy environment; denticles prevent valves twisting during the mechanical opening and closing of the shell. The muscle fields of the Gotland shells are also proportionately larger than the British specimens, perhaps again reflecting the higher energy environment. The higher density of fine ribbing on the Swedish _S. ornatella_ may again be a reflection of increased sedimentation (Hurst 1975) and disturbance, especially if correlatable with the number of sensory setae developed at the valve peripheries. The variation in muscle bounding ridges is as much apparent within as between living and fossil populations and cannot therefore be related to macro-environmental changes. Other physical factors which may cause morphological variability include geographical position (the Swedish localities were closer to the Silurian equator), food supply (relatively greater in Sweden due to increased water currents?) and a wide range of environmental parameters which could have a direct effect on brachiopod physiology ; e.g. temperature, salinity, etc. (see Loomis 1903; Curry 1984). In effect, the larger size of the Swedish specimens is probably a reflection of environmental conditions (sediment, food, temperature etc.) which are more conducive to brachiopod growth. The morphological variability related to environment (probably ecophenotypic variation, Hurst 1975) does, however, support the author's view that the consistent range of variability in S. ornatella over the main shelf region, where the lithological facies is consistent, is intraspecific (see also Aldridge 1981).

9.2. LEPTOSTROPHIA FILOSA.

L. filosa is similar to S. ornatella in outline and shell shape. It is, however, flatter than S. ornatella and shows adaptations for living close to the sediment surface (see Atkins 1979).

L. filosa has similar gross shell proportion values in all the three British samples studied, Woodbury Quarry in the Abberley Hills, the Usk inlier and the Ludlow area. Usk specimens showed a larger shell than both Woodbury Quarry and Ludlow area specimens (see Chapter 4, Table 2). The increased size of Usk specimens most likely relates to physical factors such as food supply which may have been greater in the Usk area than in the Ludlow and Woodbury Quarry areas. The proportion of the hinge line denticles are the same in both Ludlow and Usk specimens, i.e. about half the hinge width. The fact that the denticles extend for an average of 53% of the hinge width suggests that such accessory articulatory denticles are more necessary in these flatter forms than in more concavo-convex species such as

S. ornatella and P.(M.) lepisma. For example, in S. ornatella the extent of these denticles along the hinge line is much less than half of the hinge width (i.e. about 40%). There are consistently less denticles in the more convex shells. The extension of these denticles along the hinge line may also depend on other environmental factors such as high energy conditions, turbidity, etc. However, the same proportional values of denticulation in both the Ludlow and the Usk specimens most likely reflect the same degree of flatness rather than the effect of any other environmental factors.

The well-developed wider muscle field in both the Woodbury Quarry and Usk samples, as compared with the Ludlow specimens, is probably due to the much wider shell in the Woodbury Quarry and Usk specimens (average shell width is 19.5mm and 20.4mm respectively), whereas Ludlow specimens show an average shell width of 16.6mm. Presumably the larger muscle field on larger shells reflects the need for stronger muscles to open the larger valves (see Maxwell 1954). However, the large muscle area helps articulation, particularly when the valves open, because it stops the rotation and swivel of the valves. Therefore, if the attachment area increases, it reflects a greater probability of more actively snapping muscles (Hurst 1983 pers.comm.).

In some localities such as Wt and LR in the Usk inlier (text-fig.2.5) and C30, B38 and 31 localities in the Ludlow area (text-figs.2.1, 2.2 & 2.4), L. filosa and S. ornatella shells occur crowded and in great abundance. This fact suggests that they have been aggregated into local shell beds by strong currents as Brunton (1982) suggested for other types of brachiopods. Watkins (1979) however, considered that S. ornatella lived in large numbers as an "opportunistic" species, see Chapter 8 (section 8.2.).

9.3. PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) LEPISMA.

P.(M.) lepisma was studied from three areas in the Welsh Borderland. These areas are Woodbury Quarry in the Abberley Hills, the Ludlow area and the Woolhope inlier. It was evident that the specimens studied from Woodbury Quarry have a larger shell than those from both the Ludlow and Woolhope areas (see Chapter 5, Table 2). This difference is again attributed to differences in the environmental factors such as food supply, oxygen, sediment, etc.

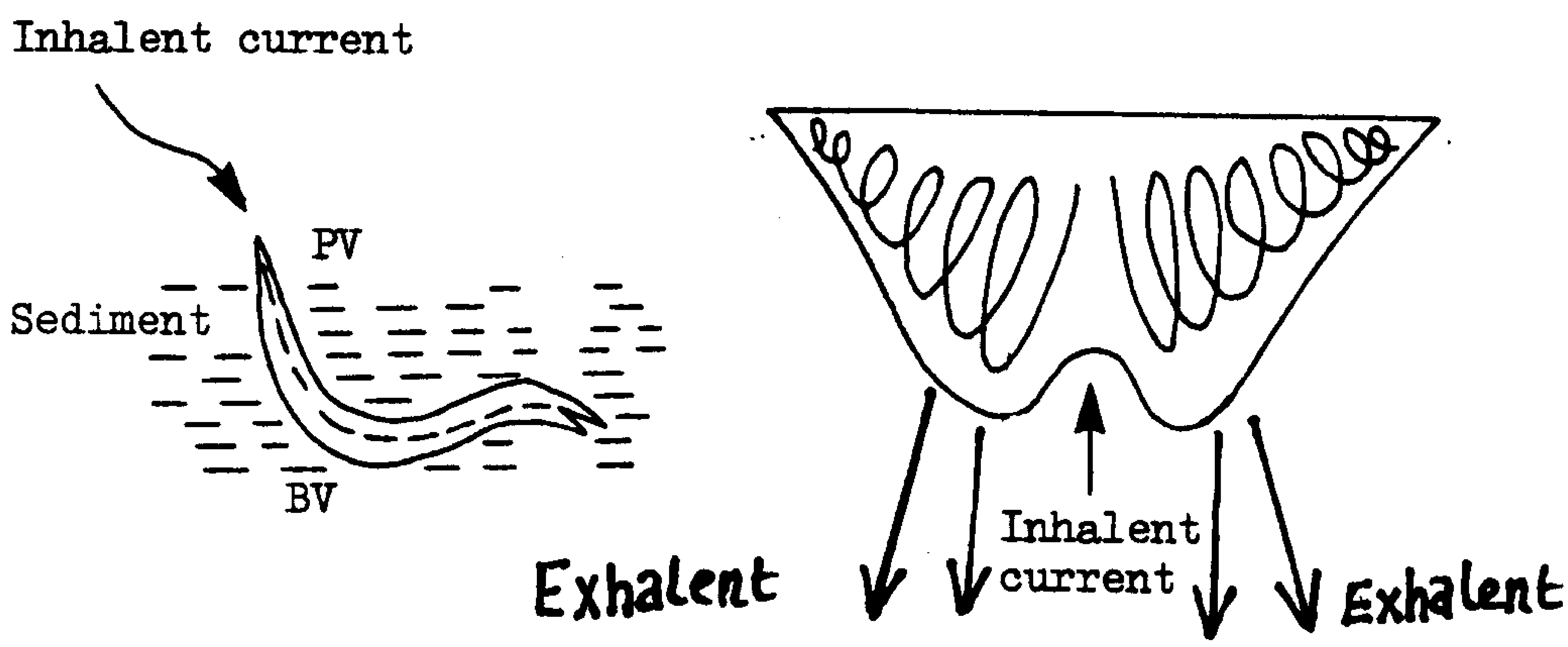
In both Ludlow and Abberley Hills specimens, the denticles extend for about 44% of the hinge width. This may suggest that the environmental conditions in the two areas were similar.

9.4. AMPHISTROPHIA (AMPHISTROPHIA) FUNICULATA.

A. funiculata lacks the large, massive shell of S. euglypha and was therefore probably unable to live in such strongly turbulent conditions. However, the finer ribbing developed on the A. funiculata shell more likely indicates the existence of a more sensitive grill of setae at the commissure capable of detecting finer particles. Therefore, it probably lived in quieter environments where fine grained sediments were accumulating (Atkins 1979).

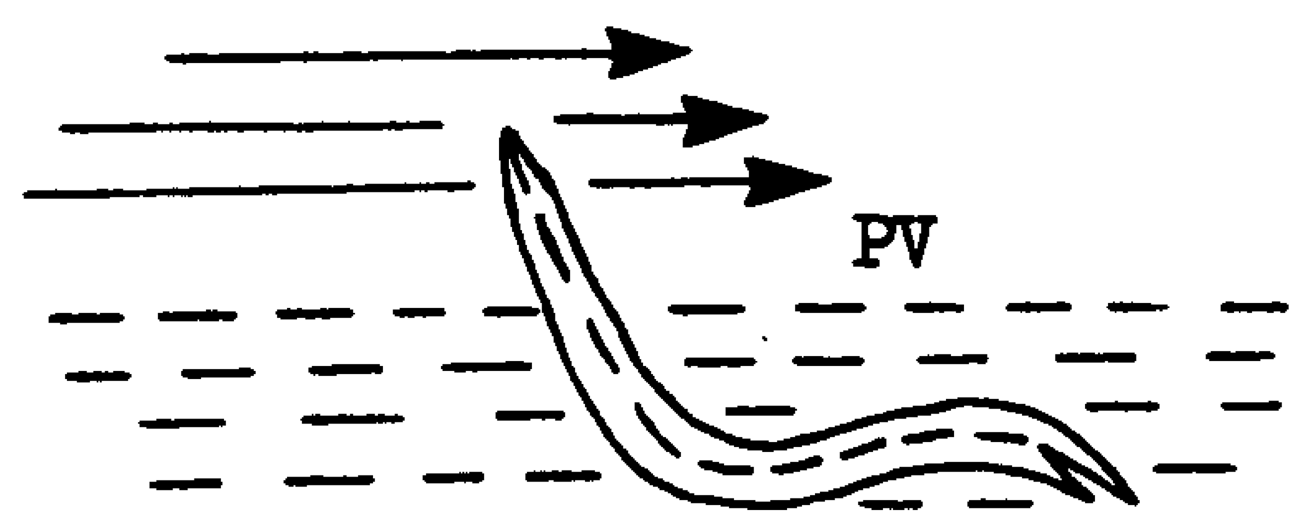
A. funiculata populations from the Ludlow Series show a gently to strongly developed anterior sulcus (Pl.17, figs. 1 & 2), which is more prominent than in the Wenlock specimens. This may be interpreted as follows:

A. funiculata is unattached in the adult form and probably lived with its convex brachial valve resting on, or even slightly below, the sediment, to keep the trail margin away from the substrate during feeding and with its posterior and postero-lateral margins partly sunk into the sediment. In such a position it would be impossible for the inhalent current to enter laterally and postero-laterally as some brachiopod workers have suggested. It is more likely in this species, that the inhalent current entered the median gape in the trail well above the sediment surface, and the exhalent waters would have been expelled at the lateral to the postero-lateral commissure (see Ager 1965 and sketch below).



The suggested median inhalent flow for A. funiculata is the same as that suggested for Levitusia and chonetaceans by Brunton in 1982 and 1972 respectively. This suggestion differs from the studies of adult living brachiopods, in which the median sector of the commissure normally acts as the exhalent aperture. It is possible, therefore, that the presence of the sulcus at the anterior valve region of A. funiculata most probably represents the gape for the inhalent current.

A pair of lobed margins probably indicating the lophophore platform are well impressed and preserved on the brachial cavity of the brachial valve of a few specimens (see Pl.22, fig.1; Pl.26, figs.4 & 5) demonstrating the lophophore separation in A. funiculata. In addition to its purpose of separating the incoming and outgoing streams of water, the sulcus would also determine the position of the animal in relation to current direction and the incidence of foreign particles, which would always direct its anterior region opposite to the current flow for feeding and respiration purposes (see sketch below).



A. funiculata was studied from the Ludlow succession of the Welsh Borderland in three areas; Ludlow, Woodbury Quarry and the Usk inlier. Within the Ludlow area, the specimens from locality 7a are smaller than in other localities such as section A and section B localities. The smallness could be due to the sparseness of the available samples or could be evidence of low food supply and a soft mud bottom adaptation (Hancock *et al* 1974; Calef & Hancock 1974).

It has been confirmed that Wenlock specimens of *A. funiculata* display more variability than Ludlow specimens (Bassett 1977), as some Wenlock Shale specimens have a longer shell and fainter pedicle muscle bounding ridges than those preserved in the Wenlock Limestone. Other Wenlock specimens, from the Mulde Marl of Gotland, have wider than normal shells. However, *A. funiculata* from the Mulde Marl has a wider shell than those found in limestone from Gotland. This is more likely to be related to the fact that the muddy environments are often poor in oxygen, so that there is a need for *A. funiculata* to extend its shell laterally for maximum oxygen absorption. However, the production of mucronated ears may have provided greater stability (Lamont 1934).

The depth and the maximum thickness of the Wenlock *A. funiculata* from both Britain and Sweden were measured (see Chapter 6). The maximum depth measured from the bottom of the brachial valve up to the level of trail (i.e. Db) for the Gotland A. funiculata is greater than those measured from the Wenlock of Britain; for example, the average for the Swedish forms is 6.7mm, whereas for British representatives, it is 5.8mm. The increased brachial depth of the Swedish forms is either due to higher energy conditions at Gotland localities in general (Hurst 1975; Bassett 1984), or (more likely) the large, thick shells in Gotland can be reasonably related to high water temperature (Hallam 1965), as the Swedish localities were nearer to the equator than the British ones in the Silurian times. The mean pedicle depth (Dp) of the Swedish specimens (2.2mm) is also greater than in the British samples, again probably reflecting higher energy and higher water temperature, but it has been suggested that turbulence is the environmental variable most directly affecting shell convexity (Clark 1976).

The well developed denticles along the hinge line of the Ludlow forms may also be related to the wider shell in Ludlow than in Wenlock specimens and such well developed ridges along the hinge line of the Ludlow specimens confirm the need for better articulation to prevent valves twisting in such strongly resupinated forms.

In section 9.6 of this chapter, it is argued that the variability in the gross shell and muscle field proportions for both Ludlow and Wenlock A. funiculata is more likely to be controlled by environmental factors, whereas the change in the shell outline from Wenlock (rounded) to Ludlow (triangular) is more probably an example of an evolutionary trend.

9.5. STROPHONELLA (STROPHONELLA) EUGLYPHA.

S. euglypha has been studied in this project from many localities in the Ludlow Series of the Welsh Borderland, but mainly from Ludlow, Woodbury Quarry and the Usk inlier. Additional specimens were studied from the Wenlock age for comparison purposes.

It is apparent that *S. euglypha* from the Ludlow area have larger shells than those from the Usk inlier, as was discovered in *A. funiculata*. It would seem, therefore, that the resupinate forms such as *A. funiculata* and *S. euglypha* grew relatively slowly in the Usk environment, whereas, the flat forms such as *L. filosa* and *S. ornatella* grew well in such conditions. The difference in sediments may have been a contributory cause along with other environmental factors. It was also observed that *S. euglypha* was well adapted to live in various other environments, such as the silty and limy condition of the Ludlow area. Specimens from the Upper Bringewood Formation are slightly longer than those found in the Lower Bringewood Formation, having similar shell shape outline. From the sedimentological evidence, the Upper Bringewood Formation specimens are from a more limy habitat than the Lower Bringewood Formation specimens. It seems, therefore, that specimens from limestones are larger than those found in the silty calcareous rocks. This relationship has also been recognised between Ludlow and Wenlock specimens of the Welsh Borderland.

Ludlow Specimens show well-developed denticles along the hinge line and also have a larger muscle attachment area than in other areas, such as the Usk inlier and Woodbury Quarry. However, the large muscle field for the Ludlow specimens is more likely to be related to a larger shell of the Ludlow forms as compared with other areas and the proportion of the denticulation along the hinge line also has a slightly higher value in the Ludlow area than in other areas. This small difference in the muscle field and denticulation proportions may, however, reflect the fact that the Usk and Woodbury Quarry specimens have only been studied from one locality, whereas the Ludlow data comes from many localities which are all added together for comparison with other areas such as Usk and Woodbury Quarry.

Similarly, the differences in the percentage value of the denticulation occupied on the hinge lines between Wenlock and Ludlow specimens may be due to very few Wenlock specimens being studied as compared with the Ludlow specimens, but may be due to the occurrence of this species in two different environments (the limy Wenlock and the silty Ludlow).

In general, as in A. funiculata, the Ludlow S. euglypha have a shorter shell and muscle field than the Wenlock representatives. The Ludlow material is generally more triangular in outline than the more rounded Wenlock specimens. The shortness of the shell and muscle field lengths may be best related to the convexity of the valves (Maxwell 1954; Williams 1953). If this suggestion, for the Ludlow material with its higher convexity than the Wenlock specimens is accepted, then this higher convexity could be one of the reasons for this shortening.

The variability in the gross shell and muscle field proportions are more likely to be controlled by environmental factors, whereas the difference in the outline shell shape between Ludlow and Wenlock specimens is more likely to be indicative of an evolutionary trend from Wenlock to Ludlow times, as will be discussed in section 9.6

of this chapter.

9.6. CONCLUSION ON THE VARIATION OF BOTH LUDLOW AND WENLOCK SPECIMENS OF S. EUGLYPHA AND A. FUNICULATA.

From the displayed variations between the Wenlock and Ludlow stropheodontid brachiopods S. euglypha and A. funiculata, it is evident that the Wenlock representatives show some differences in the shell and muscle field shapes and proportions from the Ludlow specimens. In general, the change in the shell shape from a rounded shape in the Wenlock rocks to a more triangular shell shape in the Ludlow rocks, appears to be independent of the sedimentary facies (see Table 1).

TABLE 1. Variability in the shell shape of S. euglypha and A. funiculata against the rock type of both Ludlow and the Wenlock Series.

Type of rocks / Series	Shale	Mudstone	Calcareous Siltstone	Marl	Silty Limestone
Ludlow	-	Subtriangular to triangular e.g. Lr.Elton Formation.	Triangular e.g. Lr. Bringewood Formation.	-	Triangular e.g. Upper Bringewood Formation.
Wenlock	Rounded e.g. Wenlock Shale	-	-	Rounded e.g. Mulde Formation of Gotland	Rounded e.g. Wenlock Limestone.

From the Table above, it is evident that the Ludlow forms which have been collected from three different lithologies, show mostly triangular shell outlines, whereas the Wenlock forms, based mainly on the British Museum specimens and Bassett's plates (1971, 1977), have mainly a rounded shell shape. The change in the shell shape between the Wenlock (rounded) and the Ludlow (triangular) forms can be used to differentiate between species populations from the Wenlock and

Ludlow Series. This change is considered to be an example of evolution (see discussion below).

The variations seen in a population collected from the same stratigraphic horizon (e.g. A. funiculata from the Lower Elton Formation and S. euglypha from the Lower Bringewood Formation of the Ludlow area) or even from the same bedding plane may best be considered as intraspecific variations. Other differences between Ludlow and Wenlock populations, such as the largeness of the shell and muscle field of the Wenlock forms appear to be related to environmental factors rather than other geographic or evolutionary influences, for three reasons: (1) The largeness of the shell and muscle field occurred during Wenlock and not Ludlow times. (2) The slight differences in the morphological features are observed within the same area (e.g. in S. euglypha from the Lower and Upper Bringewood Formations of the Ludlow area). (3) The Wenlock specimens studied were mainly collected from more calcium carbonate rich rocks than the Ludlow specimens, which were collected from silty calcareous sediments. It is possible, therefore, that the limy conditions in Wenlock times may be a factor in the considerably enlarged size of the Wenlock specimens. The consistently greater width of hinge-line denticulation is most likely directly related to the larger shell of the Wenlock species and may also be due to higher energy conditions. In such conditions, the increased development of denticles along the hinge line would help to prevent valves twisting during the mechanical opening and closing of the shell, particularly as these forms are free-living (i.e. unattached). The muscle fields in Ludlow specimens are also proportionately smaller than Wenlock specimens, perhaps again reflecting environmental factors such as lower food supply. The relatively small size of many brachiopods in the Lower Elton Formation of the Welsh Borderland was also observed by Holland and Lawson (1963). Other factors which may cause morphological variability include geographic position, food supply, oxygen, temperature and salinity, i.e. the whole range of environmental parameters which could have a direct effect on brachiopod physiology (Loomis 1903; Curry 1984).

As discussed before in section 9.4, the well developed sulcus in Ludlow specimens, particularly those from the Lower Ludlow succession (e.g. Lower Elton Formation) may be due to a greater water depth and very low food supply (Calef and Hancock 1974) and/or to muddy conditions and high sedimentation rates during the transgressive phase of the early Ludlow times (Lawson 1975). The sulcation could have helped feeding in these environments (Brunton 1982).

It is obvious, therefore, that most of the morphological variability between Ludlow and Wenlock populations could be considered here as ecophenotypic variation, which results from an active response of the organism towards the environment (Johnson 1981; Harper et al 1982). Furthermore, the stropheodontid species studied herein could be classed as eurytopic because they are not restricted to one sedimentary facies (Hurst 1975) and they have relatively long stratigraphic ranges (Boucot 1975) except maybe the species S. ornatella.

In effect, the large size of the Wenlock specimens may just be a reflection of environmental conditions which were more conducive to brachiopod growth. But the gradual change in the shell shape of S. euglypha and A. funiculata from Wenlock (rounded) to Ludlow (triangular) is independent of substrate (see Table 1), and therefore is most likely to be an example of evolution. The presence of intermediate subtriangular forms in the Lower Elton Formation suggests that this evolution took place by phyletic gradualism (Hallam 1977; Stanley 1970, 1979; Curry 1985 (personal communication) and Hanna 1986 (in press)).

SECTION
IV

APPENDICES

APPENDICES

APPENDIX I

FOSSIL LOCALITIES

a) WELSH BORDERLAND (see text-fig. 2.5)

b) GOTLAND (see text-fig. 1.3)

a) WELSH BORDERLAND

WL	=	Wenlock Limestone
LEF	=	Lower Elton Formation
LBF & UBF	=	Lower and Upper Bringewood Formations
LLF & ULF	=	Lower and Upper Leintwardine Formations
CGB	=	Chonetoidea grayi Beds
W & L	=	White and Lawson (1978)

West Midlands

WN	SO 937.920	WL	Wren's Nest - Dudley
GO2	SO 919.932	ULF	temporary trench S. of Sedgley

Abberley and Malvern Hills

WQ	SO 743.636	LBF	Woodbury Quarry
AA	SO 722.385	LBF	Road junction east of Ledbury
Wb/A & Wb/c	SO 743.636	LLF	Woodbury Quarry
UL3	SO 723.403	ULF	500m W. of Petty France Farm
CP	SO 746.403	ULF	exposures beside old road, Chances Pitch, 1km SE of Barton Court
WO	SO 743.636	ULF	Woodbury Quarry

Woolhope Inlier

DQ	SO 597.391	WL	Dormington Quarry
PL(35)	SO 596.397	LBF	roadside, 40 yards north of Copgrove Farm, Perton Lane
W_1	SO 595.399	LBF	Perton Lane Quarry
SH	SO 592.430	UBF	Shucknall Hill Quarry
WC	SO 643.310	ULF	roadside Quarry 200m NE of Welsh Court
PL	SO 596.402	ULF	roadside, Perton Lane

May Hill Inlier

MH	SO 687.203	LEF	section on N side of A40 road
MH	SO 693.186	ULF	roadside section on A4136 just SE of Longhope Village

Usk Inlier

LR	ST 328.985	LBF	Llandegveth Reservoir
PL & H.L.W.21	SO 352.978	LBF	roadside Quarry, Porthllong
U_1	SO 334.982	LBF	Coed y Paen Farm
Wt	ST 330.968	ULF	old Quarry 400m NW of Walnut Tree Farm
SR	ST 334.958	ULF	stream section 400m WNW of Llandegfedd church
U9	ST 337.966	ULF	old quarry 500m E of Walnut Tree Farm
LGY	ST 368.982	ULF	exposures in field 700m N of Llangibby Castle

Wenlock Edge

JS_{11}	SO 479.861	LBF	Titterel, Siefton Batch
HC	SO 546.906	ULF	roadside Quarry 200m NW of Hopescross
MW4	SO 529.889	ULF	road cutting 750m NNW of Beambridge

<u>Ludlow area</u>

A_1 (A1-5 of W & L)	SO 4727.7184	LEF)	forestry track section (A), Mortimer Forest, Ludlow (see text-fig. 2.3)
A_2 & A_3 (A6 of W & L)	SO 4735.7181	LEF)	
$A_{4,5,6}$ (A29, 30 & 31 of W & L)	SO 4766.7180	LEF)	
B_1, B_2, B_3, B_4 B_5 & B_6	SO 4850.7128 to SO 4852.7122	LBF	forestry track section (B), Mortimer Forest, Ludlow (see text-fig. 2.1)
7a	SO 492.727	LBF	exposure on forestry road, near Ludlow
14	SO 473.737	LBF	- as above -
31 & FC/31	SO 485.727	LBF	- as above -
H.L.W. 19	SO 483.738	LBF	roadside exposure, 170 yards, NNE Mary Knoll House
LS	SO 473.739	LBF	Landslip, Bringewood Chase
B_7	SO 4852.7122	UBF	forestry track section (B), Mortimer Forest, Ludlow
C_{1-8}	SO 4953.7255	UBF	Sunnyhill Quarry
H.L.W. 23A	SO 487.738	UBF	exposure, left of forestry track, 330 yards from Wigmore Road
WB40	SO 464.740	top LLF	quarry north of Deepwood aqueduct
OR8	SO 472.690	top LLF	quarry 800m SE of Oldfield Farm
MF/A	SO 489.711	top LLF	forestry track, Mortimer Forest
B_8 (B38 of W & L)	SO 4882.7116	ULF	forestry track section (B), Mortimer Forest, Ludlow
C_{30}-C_{31}	SO 4969.7246	ULF	forestry track section (C), Mortimer Forest, Ludlow
WB_1	SO 500.744	ULF	roadside quarry, Deepwood Road
LU7	SO 492.741	ULF	quarry on Wigmore Road
WH or Whit	SO 507.743	ULF	Whitcliffe section, Ludlow

AM	SO 423.655	ULF	trackside cut above Crown Inn, Aymestrey
9X	SO 496.725	ULF	track exposure and Overton Quarry excavations

<u>Brecon Anticlinal</u>

YH	SO 056.382	CGB	forestry tracks, Ysgwydd Hwch

<u>Builth area</u>

PS	SO 078.468	CGB	Crags, Pont Shoni, Aberedw

<u>Towy Anticlinal</u>

CB	SN 874.367	CGB	quarry near Clawdd British

b) GOTLAND

GANNOR 1, CJ 5562 5020, ca. 1850m NW of När church. Topographical map sheet 6 J Roma SV. Geological map sheet Aa 156 Ronehamn. Drainage ditch section (Lau Kanal or Närkån) at the northeastern side of the ditch and NW of the bridge. Highest Hemse Groups and lowest Eke Formations.

HÄGVIDE 2, CJ 635044 166634, ca. 3925m WSW of När church. Topographical map sheet 6 J Roma SV. Geological map sheet Aa 156 Roneham. Large field exposure in ditch immediately N of the road, ca. 250m WSW of the southernmost crossroads at Hägvide. Hemse Groups.

HALLSARVE 1, CJ 5779 5140, ca. 2850m NNE of När church. Topographical map sheet 6 J Roma SV. Geological map sheet Aa 156 Ronehamn. Inland cliff section immediately NW of the road and close to the cross-roads at Hallsarve and ca. 1580m SSW of the triangulation point at Lausbackar. The locality is located at the fountain. Highest Hemse Groups and lowest Eke Formations.

NYAN 2, CJ 6168, 5057, ca. 5190m ESE of Lau church. Topographical map sheet 6 J Roma SV. Geological map sheet Aa 156 Ronehamn. Section on the beach, ca. 15m NW of the sharp bend of the field road immediately NW of the solitary house NE of Nyan. Highest Hemse Groups and lowest Eke Formations.

TJÄNGDARVE 1, CJ 4375 4371, ca. 2560m NE of Hemse church. Topographical map sheet 5 I Hoburgen NO & 5 J Hemse NV. Geological map sheet Aa 164 Hemse. Hemse Marl. Ditch exposure immediately SW of the main road and immediately E of the field road, ca. 60m SE of point 24, 1 at Tjängdarve.

EKSTA (Mulde Marl)	CJ 328615	Wenlock	From Brickyard at Mulde, 2km NNE of Fröjd.
W.G.12 (Mulde Marl)	CJ 313606 Sheet 61SO	Wenlock	Spoil heaps at Mulde Brickyard, 3.3km SW of Klinte (Walmsley collection).
W.G.14	CJ 329616 Sheet 61SO	Wenlock	Shelly limestone in old railway cutting by road, 1.8km SSW of Klinte (Walmsley collection).

APPENDIX II

SPECIMEN DATA AND MEASUREMENTS

The system of numbering the specimens and the abbreviations used in this Appendix are as follows:

A. Numbering the specimens:

1. A piece of rock containing specimen has been given a number e.g. No.90.
2. Specimens found in the same rock samples were numbered in relation to the main rock number, e.g. 90/1, 90/2, 90/3 etc.
3. For reasons of simplicity the part, counterpart and latex cast were numbered a, b and c respectively after the rock numbers, e.g. 90a, 90b, 90c.

B. Measurements and abbreviations:

All the measurements were made in mm and the abbreviations used are as follows:

Sp. no.	Specimen number
T.V.	Type of valve
Ls	Maximum Shell length
Ws	Maximum Shell width
Lmf	Muscle field length
Wmf	Muscle field width
ϕ	Angle of divergence of the pedicle valve muscle field
Amf	Area of the muscle field
Wd	Width of the denticulation
Db	Depth measured from the bottom of the B.V. up to the level of the trail margin
Dp	Depth measured from the top of the P.V. up to the level of the trail margin

Ts	Shell thickness
R	Number of ribs per mm at 5 or 10mm antero-medianly from the dorsal umbo
Ls/Ws	Ratio of the shell length to the shell width
Lmf/Wmf	Ratio of the muscle field length to the muscle field width
Wd/Ws	Ratio of the denticulation width to the shell width
$Ws_{3/4L_s}$	Shell width at 3/4 the shell length
ad	Adductor muscle field
in	Internal
ex	External
P	Pedicle
B	Brachial
V	Valve
Con. V.	Conjoined valve
QP	Counterpart
PV & QP	Pedicle valve with its counterpart
QP PV	Counterpart of the pedicle valve only
loc. or L	Locality
est	Estimate
%	Percentage
Lud Mus or LM	Ludlow Museum
NMW	National Museum of Wales
NHM	Natural History Museum
BGS	British Geological Survey Museum
WBL	Welsh Borderland
G	Gotland
Bar (-)	Mean
M	Mould

SHALERIA ORNATELLA

(LUDLOW AREA)

Sp. No.	T.V.	SHELL Ls	SHELL Ws	P.V. MUSCLE FIELD Lmf	Wmf	Ø	Amf	Wd	R	% Ls/Ws	% Wmf/Lmt	% Wd/Ws	Loc
107	in MBV	11.9	19.4	3.3	3.0	-	5.0	est 7.3	-	61	91	38	Lud.Mus
110	in MPV	11.7	14.8	4.2	3.3	40°	6.9	est 5.6	-	79	79	38	"
115	"	9.0	16.9	5.8	4.0	34°	11.6	-	-	53	69	-	"
116a	"	12.7	16.8	5.9	3.0	-	8.9	-	-	75	51	-	"
116b	"	12.8	14.5	5.8	4.0	50°	11.6	-	-	88	69	-	"
116c	"	11.6	est 20.0	5.1	4.0	37°	10.2	-	-	58	78	-	"
117	"	15.4	21.4	7.6	4.5	29°	17.1	-	-	71	59	-	"
121/1	"	12.2	16.6	4.0	3.7	-	7.4	-	-	73	93	-	"
121/2	"	11.3	18.2	5.0	4.6	40°	11.5	-	-	62	92	-	"
121/3	"	-	14.0	4.6	3.1	43°	7.1	-	-	-	67	-	"
122	"	-	24.8	6.6	5.5	33°	18.2	-	-	-	83	-	"
191	in MPV	4.9	8.4	1.8	1.9	-	-	-	-	58	101	-	31
230	PV	4.0	5.9	-	-	-	-	-	-	67	-	-	"
242	"	9.1	14.7	-	-	-	-	-	-	61	-	-	"
259/3	"	7.5	12.4	-	-	-	-	-	-	60	-	-	"
271	ex PV	-	14.4	-	-	-	-	-	-	-	-	-	"
272	"	9.6	14.3	-	-	-	-	-	-	67	-	-	"
279/2	-	10.-	15.2	-	-	-	--	-	-	65	-	-	"
281/1	PV	8.0	12.0	-	-	-	-	-	-	66	-	-	"
286/4	"	10.4	12.1	-	-	-	-	-	-	85	-	-	"
286/5	-	7.2	11.2	-	-	-	-	-	-	64	-	-	"
369	PV	8.9	11.9	-	-	-	-	-	-	75	-	-	"
382/2	-	6.1	10.3	-	-	-	-	-	-	59	-	-	"
564	BV	10.0	12.3	-	-	-	-	-	4	81	-	-	14
608	QP BV	est 8.5	est 12.7	-	-	-	-	-	5	67	-	-	B5
621	ex PV	11.6	14.6	-	-	-	-	-	-	79	-	-	"

657	in MPV	11.9	12.3	4.4	3.0	36°	6.6	-	-	68	68	-	B38
658/1	in MBV	12.3	18.8	3.0	3.7	-	5.6	6.5	6	65	123	34	"
658/2	BV	13.0	19.2	-	-	-	-	-	7	68	-	-	"
659	"	7.0	11.4	-	-	-	-	-	6	61	-	-	"
660	PV	12.9	18.5	-	-	-	-	-	-	70	-	-	"
661	in MBV	-	17.1	-	-	-	-	6.8	-	-	-	39	"
662	in MPV	12.3	est 15.6	-	-	-	-	-	-	79	-	-	"
663	"	10.5	est 14.8	-	3.3	42°	-	-	-	71	-	-	"
664	"	10.2	16.4	-	3.8	43°	-	-	-	62	-	-	"
665	"	7.5	est 9.6	-	-	-	-	-	-	78	-	-	"
666	QP PV	10.5	15.4	-	-	-	-	-	-	68	-	-	"
667/1	in BV	10.9	est 15.8	-	-	-	-	-	-	69	-	-	"
667/2	in MPV	9.7	16.0	-	-	-	-	-	-	60	-	-	"
667/3	"	13.6	est 20.2	7.2	4.3	-	15.5	-	-	67	60	-	"
668	"	10.7	13.3	5.3	2.6	28°	6.9	-	-	80	49	-	"
669	"	10.2	est 13.2	-	2.5	-	-	-	-	77	-	-	"
670	"	11.6	16.6	-	2.8	-	-	-	-	69	-	-	"
671	"	12.5	16.0	4.3	2.8	38°	6.0	-	-	78	65	-	"
672/1	"	12.6	17.4	5.7	4.1	48°	11.7	-	-	72	72	-	"
672/2	"	9.6	est 14.0	-	3.3	35°	-	-	-	68	-	-	"
672/3	"	7.5	9.6	-	2.5	45°	-	-	-	78	-	-	"
672/4	in MBV	8.4	est 11.6	-	-	-	-	5.6	-	72	-	48	"
673	in MPV	12.4	est 16.6	-	2.7	28°	-	-	-	74	-	-	"
674/2	PV	9.0	11.2	-	-	-	-	-	-	80	-	-	"
675/1	in MPV	10.2	12.5	-	2.7	40°	-	-	-	81	-	-	"
675/2	BV	13.5	17.3	-	-	-	-	-	8	78	-	-	"
676	in MBV	14.0	16.6	-	-	-	-	-	-	84	-	-	"
677/1	in MPV	12.6	17.7	-	-	-	-	-	-	71	-	-	"
677/2	"	9.7	11.2	-	-	-	-	-	-	86	-	-	"
678	BV	10.6	14.4	-	-	-	-	-	-	73	-	-	"
679/1	PV	9.3	12.6	-	3.3	45°	-	-	-	73	-	-	"
679/2	BV	8.5	14.0	-	-	-	-	-	-	60	-	-	"
680/1	"	10.0	est 14.8	-	-	-	-	-	-	67	-	-	"
680/2	"	9.4	14.0	-	-	-	-	-	-	67	-	-	"

680/3	BV	10.9	15.1	-	-	-	-	-	-	72	-	-	B38
681	in MPV	8.0	12.0	-	3.0	50°	-	-	-	66	-	-	"
682/1	in MBV	est 11.4	est 16.2	-	-	-	-	-	-	70	-	-	"
682/2	in MPV	4.4	6.1	-	1.6	-	-	-	-	72	-	-	"
682/3	PV	3.1	4.0	-	-	-	-	-	-	77	-	-	"
682/4	"	6.1	7.3	-	-	-	-	-	-	83	-	-	"
683	in MPV	10.0	est 14.2	-	3.4	-	-	-	-	70	-	-	"
684	"	10.1	13.1	3.5	2.9	39°	4.2	5.2	-	77	83	40	"
685/1	"	8.2	10.9	-	-	-	-	-	-	75	-	-	"
686	"	13.7	19.4	5.1	4.0	40°	10.2	-	-	70	78	-	"
687	PV	10.7	12.4	-	-	-	-	-	-	86	-	-	"
688/1	BV	12.9	19.7	-	-	-	-	-	-	65	-	-	"
688/2	in MPV	7.6	est 11.2	-	-	48°	-	-	-	67	-	-	"
689	in MBV	8.2	12.8	-	-	-	-	-	-	64	-	-	"
690	ex BV	9.0	est 11.0	-	-	-	-	-	-	81	-	-	"
691	in MPV	10.0	14.7	-	3.6	35°	-	-	-	68	-	-	"
692	BV	10.8	12.3	-	-	-	-	-	-	87	-	-	"
693	PV	11.8	12.3	-	2.4	42°	-	-	-	94	-	-	"
694/1	in MBV	11.9	14.7	-	-	-	-	-	4	80	-	-	"
694/2	ex BV	12.7	17.8	-	-	-	-	-	-	71	-	-	"
695	in MPV	11.2	15.8	4.4	3.5	36°	7.7	-	-	70	80	-	"
696	in MBV	12.2	14.9	-	-	-	-	-	-	81	-	-	"
697	QP PV	11.3	13.8	-	-	-	-	-	-	81	-	-	"
698	in MPV	13.5	est 19.0	-	2.6	40°	-	-	-	71	-	-	"
699	"	8.6	14.0	-	3.2	50°	-	-	-	61	-	-	"
700	"	8.0	13.0	-	2.6	38°	-	-	-	61	-	-	"
701/1	PV	13.0	15.7	-	-	-	-	-	-	82	-	-	"
701/2	"	8.1	11.1	-	-	-	-	-	-	72	-	-	"
702/2	in MPV	7.9	12.4	-	2.7	50°	-	-	-	63	-	-	"
703/1	"	9.7	12.6	-	2.8	38°	-	-	-	76	-	-	"
703/2	"	10.0	est 13.6	-	2.9	45°	-	-	-	73	-	-	"
703/3	"	8.9	est 13.6	-	2.4	39°	-	-	-	67	-	-	"
704	in MBV	14.7	16.4	3.1	2.9	-	4.5	6.7	-	89	94	40	"

705	in MPV	8.1	12.2	-	-	-	-	-	-	66	-	-	B38
706	PV	10.1	14.4	-	-	-	-	-	-	70	-	-	"
707	"	9.5	12.8	-	-	-	-	-	-	74	-	-	"
708	in MBV	9.0	est 11.0	1.9	1.6	-	-	est 6.0	-	81	84	55	"
709	ex BV	13.7	est 14.8	-	-	-	-	-	-	92	-	-	"
710	in MPV	8.2	11.0	2.6	2.5	40°	3.3	5.2	-	74	96	47	"
711	"	6.7	9.2	1.9	1.9	55°	1.8	est 3.2	-	72	100	35	"
712	in MBV	10.3	15.7	-	-	-	-	-	-	65	-	-	"
713	in MPV	5.5	est 7.6	-	-	-	-	-	-	72	-	-	"
714	"	13.0	16.4	6.6	3.2	40°	10.6	-	-	79	48	-	"
715	ex PV	9.9	12.0	-	-	-	-	-	-	82	-	-	"
716	"	12.4	16.2	-	-	-	-	-	-	76	-	-	"
717/1	"	13.6	20.2	-	-	-	-	-	-	67	-	-	"
717/2	in MPV	7.4	9.9	-	-	-	-	-	-	74	-	-	"
718	"	10.4	16.8	-	3.7	43°	-	-	-	61	-	-	"
719/1	"	8.5	11.6	2.6	1.8	38°	3.6	-	-	73	69	-	"
719/2	"	7.2	9.1	-	2.4	39°	-	-	-	79	-	-	"
720	"	10.3	13.6	4.3	2.9	40°	6.2	-	-	75	67	-	"
721	ex BV	12.1	16.0	-	-	-	-	-	-	75	-	-	"
721/2	in MPV	9.8	11.9	-	-	-	-	-	-	82	-	-	"
721/3	"	8.2	10.7	-	-	-	-	-	-	76	-	-	"
722	"	5.5	8.2	-	1.9	-	-	-	-	67	-	-	"
723	"	11.2	est 16.0	-	-	-	-	-	-	70	-	-	"
724	ex PV	7.5	10.7	-	-	-	-	-	-	70	-	-	"
725	in MPV	12.3	17.8	-	3.1	32°	-	-	-	69	-	-	"
726	"	9.8	est 14.0	4.1	3.2	42°	6.6	-	-	70	78	-	"
727/1	PV	9.8	16.8	-	-	-	-	-	-	58	-	-	"
727/2	"	10.8	16.2	-	-	-	-	-	-	66	-	-	"
728	in MPV	8.8	9.4	-	-	-	-	-	-	93	-	-	"
729	BV	8.3	13.0	-	-	-	-	-	-	63	-	-	"
730	"	10.4	13.6	-	-	-	-	-	-	76	-	-	"
731/1	in MPV	10.0	14.4	-	3.2	40°	-	-	-	69	-	-	"
731/2	"	8.3	10.0	-	-	-	-	-	-	83	-	-	"

739	PV	12.0	19.2	-	-	-	-	-	-	62	-	-	C30
740	in MBV	9.5	14.6	-	2.7	36°	-	-	-	65	-	-	"
741	in MPV	7.9	est 10.0	-	-	-	-	-	-	79	-	-	"
742	"	est 12.0	16.4	5.7	4.7	42°	13.4	-	-	73	82	-	"
743	in MBV	4.3	8.4	-	-	-	-	-	-	51	-	-	"
744	PV	10.1	16.2	-	-	-	-	-	-	62	-	-	"
745/1	in MPV	11.1	16.7	5.5	3.4	23°	9.4	-	-	66	62	-	"
745/2	"	10.5	16.4	-	-	-	-	-	-	64	-	-	"
746	"	9.6	16.2	5.5	3.1	30°	8.5	-	-	59	56	-	"
747	ex PV	11.5	15.6	-	-	-	-	-	-	73	-	-	"
748	ex BV	7.0	10.2	-	-	-	-	-	-	68	-	-	"
749	in MPV	9.8	16.5	4.5	3.2	26°	7.2	-	-	59	71	-	"
750	"	9.2	12.2	3.5	2.7	-	4.7	-	-	75	77	-	"
751/1	"	6.8	9.2	-	-	-	-	-	-	73	-	-	"
751/2	BV	9.3	est 13.4	-	-	-	-	-	-	69	-	-	"
752	PV	7.5	13.4	-	-	-	-	-	-	55	-	-	"
753	"	8.9	14.8	-	-	-	-	-	-	60	-	-	"
754	in MBV	11.2	est 14.8	-	-	-	-	-	-	75	-	-	"
755	PV	7.0	est 10.9	-	-	-	-	-	-	64	-	-	"
756	in MBV	4.0	7.2	-	-	-	-	-	-	55	-	-	"
758	ex BV	6.2	est 13.0	-	-	-	-	-	-	47	-	-	"
759	in MPV	10.3	est 15.8	-	-	-	-	-	-	65	-	-	"
760	"	9.0	11.4	4.0	2.5	34°	5.0	-	-	78	63	-	"
761	"	9.9	12.3	4.2	2.5	24°	5.3	-	-	80	60	-	"
762	PV & QP	9.3	15.2	4.5	4.2	39°	9.5	-	-	61	93	-	"
763	ex BV	7.3	10.8	-	-	-	-	-	-	67	-	-	"
764	in MBV	11.2	est 17.4	-	-	-	-	-	-	64	-	-	"
757	in MPV	7.5	12.0	-	2.8	31°	-	-	-	62	-	-	"
765/1	"	7.5	10.6	3.9	2.7	30°	5.3	-	-	70	69	-	"
765/2	"	6.5	10.6	3.0	2.5	24°	3.8	-	-	61	83	-	"
765/3	"	7.0	est 13.0	3.2	2.7	28°	4.3	-	-	53	84	-	"
766/1	"	11.4	18.4	4.1	3.5	-	7.2	-	-	61	85	-	"
766/2	"	8.4	est 15.2	3.6	2.8	30°	5.0	-	-	55	78	-	"

767/1	BV	8.5	14.0	-	-	-	-	-	-	60	-	-	C30
767/2	in MPV	11.6	est 20.2	4.8	2.8	-	6.7	-	-	57	58	-	"
767/3	"	9.0	est 13.4	3.0	2.6	22^{o}	3.9	-	-	67	87	-	"
768/1	"	8.8	11.1	-	3.1	33^{o}	-	-	-	79	-	-	"
768/2	"	7.8	10.8	-	2.4	26^{o}	-	-	-	72	-	-	"
769	ex PV	7.0	10.2	-	-	-	-	-	-	68	-	-	"
770	PV	9.4	16.0	-	-	-	-	-	-	58	-	-	"
771/1	"	4.1	6.4	-	-	-	-	-	-	64	-	-	"
771/2	"	10.7	14.0	-	-	-	-	-	-	76	-	-	"
771/3	ex BV	7.8	12.0	-	-	-	-	-	-	65	-	-	"
771/4	PV	8.6	11.6	-	2.4	-	-	-	-	74	-	-	"
772	in MPV	10.0	15.0	4.9	2.6	28^{o}	6.4	-	-	66	53	-	"
773	BV	9.9	est 12.4	-	-	-	-	-	-	79	-	-	"
774	in MPV	9.0	14.0	4.1	2.8	28^{o}	5.7	-	-	64	68	-	"
775b/1	"	9.5	15.0	-	2.8	-	-	-	-	63	-	-	"
775b/2	"	11.8	17.1	-	-	-	-	-	-	69	-	-	"
775b/4	"	9.5	15.0	4.3	3.0	23^{o}	6.5	est 5.6	-	63	70	37	"
775b/3	"	10.7	16.0	-	-	-	-	-	-	66	-	-	"
775b/5	"	11.0	14.2	-	-	-	-	-	-	77	-	-	"
775b/6	ex PV	12.5	est 16.6	-	-	-	-	-	-	75	-	-	"
775b/7	in MPV	10.0	15.0	-	-	-	-	-	-	66	-	-	"
775b/8	"	8.2	11.4	-	-	-	-	-	-	71	-	-	"
775b/9	"	8.1	est 11.4	3.4	2.5	0^{o}	-	-	-	71	74	-	"
775b/10	"	8.8	13.2	5.0	2.5	20^{o}	6.3	est 6.4	-	66	50	48	"
775b/11	"	5.3	8.6	2.3	2.0	-	2.3	-	-	61	87	-	"
775b/12	"	7.8	est 13.0	-	2.2	26^{o}	-	-	-	60	-	-	"
776/1	in MPV	11.3	14.0	5.7	3.1	20^{o}	8.8	-	-	80	54	-	"
776/2	BV	7.5	12.2	-	-	-	-	-	-	61	-	-	"
776/3	PV	8.7	13.0	-	-	-	-	-	-	66	-	-	"
777b/1	"	11.7	18.2	-	-	-	-	-	-	64	-	-	"
777b/2	in MPV	8.5	13.6	5.0	3.3	22^{o}	8.3	-	-	62	66	-	"
777b/3	"	7.5	13.0	-	2.9	-	-	-	-	57	-	-	"
777b/4	"	10.0	14.8	4.6	2.8	36^{o}	6.4	-	-	67	61	-	"
778/1	PV & QP	8.0	11.8	3.4	2.8	26^{o}	4.8	-	-	67	82	-	"
778b/2	"	9.0	est 12.2	3.9	2.7	30^{o}	5.3	-	-	73	69	-	"

778b/3	PV & QP	6.9	8.6	3.1	2.0	20°	3.1	-	-	80	65	-	C30
779/1	in MBV	10.2	15.0	-	2.7	40°	-	6.8	-	68	-	45	"
779b/2	in MPV	9.7	13.6	5.0	3.4	31°	8.5	-	-	71	68	-	"
779b/3	"	10.0	14.2	-	2.7	-	-	-	-	70	-	-	"
779b/4	"	8.8	12.4	-	2.8	42°	-	-	-	70	-	-	"
779b/5	"	12.0	est 17.2	5.0	3.4	-	8.5	-	-	69	68	-	"
779b/6	"	8.0	10.6	4.5	3.2	28°	7.2	-	-	75	71	-	"
779b/7	"	11.0	16.0	-	-	-	-	-	-	68	-	-	"
779b/8	"	11.0	14.2	-	-	-	-	-	-	77	-	-	"
779b/9	"	7.6	10.4	-	-	-	-	-	-	73	-	-	"
780	"	9.8	14.4	5.3	3.0	22°	8.0	-	-	68	57	-	"
781	ex PV	8.4	12.8	-	-	-	-	-	-	65	-	-	"
782	in MPV	7.2	est 11.2	3.1	2.6	-	4.0	-	-	64	84	-	"
783	"	9.2	14.4	-	2.8	-	-	-	-	63	-	-	"
784	"	6.9	10.3	3.2	2.4	31°	4.5	-	-	66	75	-	"
785	ex PV	10.0	15.5	-	-	-	-	-	8	64	-	-	"
786	in MPV	11.2	16.0	5.0	3.5	-	8.8	6.3	-	70	70	-	"
787/1	"	9.0	14.0	-	-	-	-	-	-	64	-	-	"
787/2	"	9.5	est 15.0	-	-	-	-	-	-	63	-	-	"
787/3	"	11.7	est 18.0	-	-	-	-	-	-	65	-	-	"
788	"	11.4	19.0	-	-	-	-	-	-	60	-	-	"
789	in MBV	9.7	est 14.0	-	2.8	-	-	6.5	-	69	-	46	"
790	in MPV	9.4	13.8	4.2	2.8	24°	5.9	-	-	68	67	-	"
791	ex PV	6.6	9.5	-	-	-	-	-	6	69	-	-	"
792	in MBV	3.7	7.2	-	-	-	-	-	-	51	-	-	"
793/1	in MPV	7.6	11.8	-	2.4	20°	-	-	-	64	-	-	"
793/2	"	7.4	9.9	-	-	-	-	-	-	74	-	-	"
793/3	"	5.5	9.0	-	-	-	-	-	-	61	-	-	"
794/1	BV	8.5	est 14.0	-	-	-	-	-	-	60	-	-	"
794/2	PV	4.0	7.0	-	-	-	-	-	-	57	-	-	"
795/1	"	9.0	14.0	4.4	3.4	22°	7.5	-	-	64	77	-	"
795/2	"	8.7	15.9	-	-	-	-	-	-	54	-	-	"
796	ex PV	8.3	12.1	-	-	-	-	-	-	68	-	-	"

797/1	in MPV	9.0	14.1	-	3.5	34°	-	-	-	63	-	-	C30
797/2	"	11.7	17.0	5.5	3.9	26°	10.7	-	-	68	71	-	"
797/3	"	5.0	10.0	-	2.3	44°	-	-	-	50	-	-	"
797b/4	"	9.7	est 12.8	4.5	2.5	28°	5.6	4.5	-	75	56	35	"
797b/5	"	9.9	13.6	-	-	-	-	-	-	72	-	-	"
797b/6	"	6.5	10.0	-	-	-	-	-	-	65	-	-	"
797b/7	"	10.3	est 14.4	4.1	3.3	44°	6.8	-	-	71	80	-	"
797b/8	"	9.0	14.1	-	-	-	-	-	-	63	-	-	"
797b/9	"	8.2	14.6	-	-	-	-	-	-	56	-	-	"
798/1	"	9.5	15.0	5.3	3.6	24°	9.5	-	-	63	68	-	"
798/2	QP PV	9.7	13.6	4.2	2.8	22°	5.9	-	-	71	67	-	"
798/3	"	10.0	13.7	4.9	2.7	24°	6.6	-	-	72	55	-	"
798/5	ex BV	9.3	13.5	-	-	-	-	-	-	68	-	-	"
798b/4	"	7.7	12.9	-	-	-	-	-	-	59	-	-	"
798b/6	QP PV	8.1	11.0	2.9	2.5	24°	3.6	-	-	73	86	-	"
799b/1	in MPV	10.0	13.0	4.2	3.3	25°	6.9	-	-	76	79	-	"
799b/2	PV	10.5	13.7	-	-	-	-	-	-	76	-	-	"
799b/3	"	10.0	14.0	-	-	-	-	-	-	73	-	-	"
799b/4	"	9.6	13.0	-	-	-	-	-	-	73	-	-	"
806/1	QP PV	11.7	est 15.4	-	-	-	-	-	-	75	-	-	"
800/2	"	8.3	13.0	-	-	-	-	-	-	63	-	-	"
800/3	"	10.7	16.3	-	-	-	-	-	-	65	-	-	"
800/4	"	10.5	14.0	-	-	-	-	-	-	75	-	-	"
800/5	"	10.0	16.8	-	-	-	-	-	-	59	-	-	"
800/6	"	7.7	12.0	-	-	-	-	-	-	64	-	-	"
800/7	in MPV	7.8	est 13.4	-	-	-	-	-	-	58	-	-	"
800/8	"	7.7	12.6	-	-	-	-	-	-	61	-	-	"
800/9	in MBV	11.1	14.8	-	-	-	-	-	-	75	-	-	"
801/1	PV	10.0	16.0	-	-	-	-	-	-	62	-	-	"
801/2	"	9.2	est 14.2	-	-	-	-	-	-	64	-	-	"
801/3	"	8.6	13.0	-	-	-	-	-	-	66	-	-	"
802/1	in MPV	7.6	11.4	-	2.8	31°	-	-	-	66	-	-	"
802/2	ex PV	7.4	11.0	-	-	-	-	-	-	67	-	-	"
802/3	in MPV	9.9	est 13.2	5.5	3.4	24°	9.4	-	-	75	62	-	"
802/4	ex PV	8.9	13.0	-	-	-	-	-	-	68	-	-	"

(USK INLIER)

1565	PV & QP	7.8	12.0	2.4	2.5	43°	3.0	-	-	65	104	-	Wt
1566	"	9.8	11.2	4.5	3.4	22°	7.7	-	-	87	76	-	"
1567	in MPV	13.3	17.6	4.0	3.2	31°	8.6	-	-	75	80	-	"
1568	"	7.3	11.4	-	-	-	-	-	-	64	-	-	"
1569	QP PV	6.9	9.7	-	-	-	-	-	-	71	-	-	"
1570	in MPV	7.8	11.2	2.4	2.9	34°	3.5	-	-	69	121	-	"
1571/1	"	9.3	14.5	4.2	3.5	44°	7.4	est 6.4	-	64	83	44	"
1571/2	QP PV	7.5	11.0	-	-	-	-	-	-	68	-	-	"
1572	in MBV	10.8	16.4	-	-	-	-	-	-	65	-	-	"
1573	PV	8.3	12.0	-	-	-	-	-	-	69	-	-	"
1574/1	"	12.4	17.3	-	3.3	25°	-	-	-	71	-	-	"
1574/2	"	6.7	9.0	2.0	2.2	-	2.2	-	-	74	110	-	"
1575/1	in MPV	10.0	15.2	4.2	3.5	34°	7.4	-	-	65	83	-	"
1575/2	"	13.6	17.5	-	-	-	-	-	-	77	-	-	"
1576	"	10.0	15.9	3.5	3.5	27°	6.1	-	-	62	100	-	"
1577	"	9.0	13.0	3.0	2.7	22°	4.1	-	-	69	90	-	"
1578	"	7.1	10.6	-	-	-	-	-	-	66	-	-	"
1579	"	11.9	est 15.4	-	-	-	-	-	-	77	-	-	"
1580	QP PV	10.3	est 16.0	-	-	-	-	-	-	64	-	-	"
1581	in MPV	9.5	14.0	-	-	-	-	-	-	59	-	-	"
1582	in MBV	10.8	17.8	-	-	-	-	-	-	60	-	-	"
1583/1	PV	7.0	9.6	1.9	2.5	30°	2.4	-	-	72	132	-	"
1583/2	"	7.9	13.0	2.5	2.7	21°	3.4	-	-	60	108	-	"
1583/3	"	8.6	11.4	-	-	-	-	-	-	75	-	-	"
1584	"	12.3	16.1	-	-	-	-	-	-	76	-	-	"
1585	"	13.0	19.2	-	3.9	-	-	-	-	67	-	-	"
1586	"	9.5	13.8	2.7	3.8	60°	5.1	-	-	68	141	-	"
1587	QP BV	11.1	16.0	-	-	-	-	-	-	69	-	-	"
1589	"	10.5	13.0	-	-	-	-	-	-	80	-	-	"
1590	in MPV	10.7	14.8	3.2	3.2	45°	5.1	-	-	72	100	-	"
1591	"	9.7	12.8	-	-	-	-	-	-	75	-	-	"
1592/1	QP PV	15.3	21.5	-	-	-	-	-	-	71	-	-	"
1592/2	in MBV	14.5	20.5	-	-	-	-	8.3	-	70	-	41	"

1593/1	in MBV	8.2	9.8	-	-	-	-	est 6.2	-	83	-	63	Wt
1593/2	QP PV	9.1	13.0	-	-	-	-	-	-	70	-	-	"
1576	in MPV	10.0	15.9	3.5	3.5	27°	6.1	-	-	62	100	-	"
1577	"	9.0	13.0	3.0	2.7	22°	4.1	-	-	69	90	-	"
1578	"	"7.1	10.6	-	-	-	-	-	-	66	-	-	"
1579	"	11.9	15.4	-	-	-	-	-	-	77	-	-	"
1580	QP PV	10.3	est 16.0	-	-	-	-	-	-	64	-	-	"
1581	in MPV	9.5	14.0	-	-	-	-	-	-	59	-	-	"
1582	in MBV	10.8	17.8	-	-	-	-	-	-	60	-	-	"
1583/1	in MPV	7.0	9.6	1.9	2.5	31°	2.4	-	-	72	132	-	"
1583/2	"	7.9	est 13.0	2.5	2.7	21°	3.4	-	-	60	108	-	"
1583/3	"	8.6	11.4	-	-	-	-	-	-	75	-	-	"
1584	"	12.3	16.1	-	-	-	-	-	-	76	-	-	"
1585	"	13.0	19.2	-	3.9	-	-	-	-	67	-	-	"
1586	"	9.5	13.8	2.7	3.8	60°	5.1	-	-	68	141	-	"
1587	QP BV	11.1	16.0	-	-	-	-	-	-	69	-	-	"
1589	BV& QP	10.5	13.0	-	-	-	-	-	-	80	-	-	"
1590	in MPV	10.7	14.8	3.2	3.2	45°	5.1	-	-	72	100	-	"
1591	"	9.7	12.8	-	-	-	-	-	-	75	-	-	"
1592/1	QP PV	15.3	21.5	-	-	-	-	-	-	71	-	-	"
1592/2	in MBV	14.5	20.5	-	-	-	-	8.3	-	70	-	41	"
1593/1	"	8.2	9.8	-	-	-	-	6.2	-	83	-	63	"
1593/2	QP PV	9.1	13.0	-	-	-	-	-	-	70	-	-	"
1593/2	"	6.9	9.6	-	-	-	-	-	-	71	-	-	"
1594/1	in MPV	7.5	11.0	2.2	2.9	31°	3.2	-	-	68	132	-	"
1594/2	"	11.7	18.6	-	-	-	-	-	-	62	-	-	"
1595	BV	7.6	11.7	-	-	-	-	-	-	64	-	-	"
1596/1	in MPV	9.1	11.4	2.7	2.9	34°	3.9	4.3	-	79	107	38	"
1596/2	in MBV	7.7	10.4	-	-	-	-	4.0	-	74	-	39	"
1597/1	in MPV	6.6	10.3	-	-	-	-	-	-	64	-	-	"
1597/2	"	13.5	18.6	4.0	4.3	-	8.6	-	-	72	108	-	"
1598	"	8.7	12.3	2.5	2.5	21°	3.1	-	-	70	100	-	"
1599	"	11.7	16.3	4.6	4.5	36°	10.4	-	-	71	98	-	"
1600	"	11.5	13.8	4.3	3.8	-	8.2	-	-	83	88	-	"

1603	in MBV	8.9	12.6	-	-	-	-	-	-	70	-	-	Wt "
1604/1	PV & QP	9.2	12.4	3.6	3.4	44°	6.1	-	-	74	94	-	"
1604/2	"	9.2	13.3	-	-	-	-	-	-	69	-	-	"
1601/1	in MPV	13.8	20.3	4.0	5.1	46°	10.2	-	-	67	127	-	"
1601/2	"	13.9	20.0	3.9	3.9	34°	7.6	est 8.0	-	69	100	40	"
1602/1	"	14.1	18.8	5.0	3.3	21°	8.3	-	-	75	66	-	"
1602/2	"	8.7	13.6	2.5	3.0	36°	3.8	-	-	63	120	-	"
1605	QP PV	15.4	24.2	-	-	-	-	-	-	63	-	-	"
1606/1	in MBV	8.8	13.0	-	-	-	-	-	-	67	-	-	"
1606/2	QP BV	11.3	16.2	-	-	-	-	-	-	69	-	-	"
1607	in MBV	9.5	15.0	-	-	-	-	est 6.2	-	63	-	41	"
1608/1	in MPV	15.0	20.0	6.5	4.0	21°	13.0	-	-	76	62	-	"
1608/2	QP PV	8.4	14.6	-	-	-	-	-	-	57	-	-	"
1609	"	11.9	17.8	-	-	-	-	-	-	66	-	-	"
1610/1	in MPV	15.3	23.0	5.7	4.5	39°	12.8	-	-	66	79	-	"
1610/2	"	12.3	19.2	6.4	4.0	-	12.8	est 8.0	-	64	63	42	"
1611	"	11.1	17.2	4.0	4.7	38°	9.4	8.0	-	64	118	47	"
1612	in MBV	9.8	14.5	-	-	-	-	-	-	67	-	-	"
1613	QP PV	9.0	12.6	-	-	-	-	-	-	71	-	-	"
1614/1	in MPV	13.4	17.2	-	-	-	-	-	-	77	-	-	"
1614/2	"	12.5	16.2	4.8	4.3	40°	10.3	-	-	77	90	-	"
1615/1	in MBV	11.1	17.0	-	-	-	-	6.0	-	65	-	35	"
1615/2	"	10.4	15.6	-	-	-	-	-	-	66	-	-	"
1615/3	"	6.4	8.8	-	-	-	-	4.8	-	72	-	55	"
1617	PV	10.1	15.4	3.0	3.7	45°	5.6	-	-	65	123	-	"
1622	"	11.4	16.2	3.2	3.5	42°	5.6	6.1	-	70	109	38	"
1616/1	in MPV	14.7	19.2	6.0	5.2	41°	15.6	-	-	76	87	-	"
1616/2	"	15.5	est 24.2	6.5	4.9	31°	15.9	-	-	64	75	-	"
1616/3	"	13.4	17.6	5.5	4.3	34°	11.8	-	-	70	78	-	"
1618/1	in MBV	12.5	17.8	-	-	-	-	-	-	70	-	-	"
1618/2	"	13.9	17.8	-	-	-	-	-	-	78	-	-	"
1618/3	QP PV	13.1	18.6	-	-	-	-	-	-	70	-	-	"
1618/4	PV	11.6	16.8	5.0	4.1	38°	10.3	-	-	69	82	-	"

1620/1	in MPV	6.3	9.6	1.9	2.5	40°	2.4	-	-	65	131	-	Wt
1620/2	"	7.3	11.4	-	-	-	-	-	-	64	-	-	"
1620/3	"	8.3	14.0	-	-	-	-	-	-	59	-	-	"
1621/1	QP BV	12.0	17.6	-	-	-	-	-	-	68	-	-	"
1621/2	in MPV	11.1	14.1	4.3	3.2	30°	6.9	-	-	78	74	-	"
1621/3	"	10.6	13.2	4.5	3.3	26°	7.4	-	-	80	73	-	"
1621/4	"	6.0	8.1	-	-	-	-	-	-	74	-	-	"
1623	"	13.6	17.2	-	-	-	-	-	-	79	-	-	"
1624	"	12.7	18.5	5.1	4.5	40°	11.5	-	-	68	88	-	"
1625/1	QP PV	12.8	16.2	-	-	-	-	-	-	79	-	-	"
1625/2	"	14.0	18.3	-	-	-	-	-	-	76	-	-	"
1625/3	"	13.5	20.4	6.2	5.0	31°	15.5	-	-	66	81	-	"
1626/1	"	8.3	12.2	-	-	-	-	-	-	68	-	-	"
1626/2	"	9.0	12.6	-	-	-	-	-	-	71	-	-	"
1627/1	PV & QP	12.4	16.4	6.4	4.7	36°	15.0	-	-	75	73	-	"
1627/2	in MPV	12.5	16.0	5.3	3.5	32°	9.3	-	-	78	66	-	"
1627/3	"	8.3	12.6	2.5	3.0	44°	3.8	5.0	-	65	120	38	"
1627/4	"	5.3	7.8	-	-	-	-	-	-	67	-	-	"
1628/1	"	13.5	20.4	-	-	-	-	-	-	66	-	-	"
1628/2	BV & QP	12.0	15.1	-	-	-	-	5.4	-	79	-	36	"
1628/3	"	12.6	19.0	-	-	-	-	6.2	-	66	-	33	"
1629	PV & QP	13.5	19.7	6.5	5.3	42°	17.2	-	-	68	82	-	"
1630/1	in MPV	13.8	19.4	5.4	4.4	37°	11.9	6.3	-	71	81	33	"
1630/2	"	14.3	est 18.4	-	-	-	-	-	-	77	-	-	"
1631/1	in MBV	15.1	20.4	-	-	-	-	7.0	-	74	-	34	"
1631/2	PV	15.0	20.1	-	-	-	-	-	-	74	-	-	"
1631/3	BV	13.8	17.1	-	-	-	-	6.3	-	80	-	37	"
1632	PV & QP	9.0	13.0	4.2	3.0	35°	6.3	5.0	-	69	71	39	"
1633	QP BV	6.7	9.0	-	-	-	-	-	-	74	-	-	"
1635/1	in MPV	7.3	10.6	2.3	2.6	44°	3.0	-	-	68	113	-	"
1635/2	"	6.5	9.5	2.0	2.5	45°	2.5	3.2	-	68	125	34	"
1636	"	7.9	10.4	2.4	2.7	38°	3.2	3.2	-	75	113	31	"
1637	"	13.4	17.2	5.0	3.6	-	9.0	-	-	77	72	-	"
1628	in MBV	6.5	10.2	-	-	-	-	est 4.2	-	63	-	41	"
1639	in MPV	11.5	17.6	5.5	4.8	39°	13.2	-	-	65	87	-	"

1640	in MPV	8.5	12.2	3.5	2.8	33°	4.9	-	-	69	80	-	Wt
1641	"	15.0	22.0	5.7	4.4	26°	12.5	est 8.6	-	68	77	39	"
1642	"	10.3	15.8	-	-	-	-	-	-	65	-	-	"
1634/1	in MPV	15.1	20.8	5.5	4.8	40°	13.2	-	-	72	87	-	"
1634/2	"	13.8	17.0	5.2	3.8	32°	10.0	-	-	81	73	-	"
1643/1	"	8.0	13.0	2.5	2.5	27°	3.1	-	-	61	100	-	"
1643/2	in MBV	7.8	12.0	-	-	-	-	-	-	65	-	-	"
1644	QP PV	9.4	13.4	-	-	-	-	-	-	70	-	-	"
1645	in MPV	9.5	14.0	-	2.8	24°	-	-	-	67	-	-	"
1647	QP PV	13.4	16.6	-	-	-	-	-	-	80	-	-	"
1648	PV	14.4	19.9	-	-	-	-	-	-	72	-	-	"
1649	"	13.9	20.2	-	-	-	-	-	-	68	-	-	"
1650	"	9.5	16.4	-	-	-	-	-	-	57	-	-	"
1652	in MPV	9.0	13.3	3.3	3.0	40°	5.0	3.5	-	67	91	26	"
1653	in MBV	8.4	10.7	-	-	-	-	4.6	-	78	-	43	"
1654	"	10.2	14.4	-	-	-	-	-	9	70	-	-	"
1655/1	PV	11.6	18.2	-	-	-	-	-	-	63	-	-	"
1655/2	"	13.7	20.1	-	-	-	-	-	-	68	-	-	"
1655/3	"	13.2	21.3	-	-	-	-	-	-	61	-	-	"
1656/1	in MPV	9.4	12.4	2.8	3.1	39°	4.3	-	-	75	111	-	"
1656/2	"	12.4	18.0	-	-	-	-	-	-	68	-	-	"
1656/3	"	8.8	12.0	2.9	3.0	40°	4.4	-	-	73	103	-	"
1656/4	"	9.6	14.3	3.5	3.1	31°	5.4	-	-	67	86	-	"
1656/5	"	7.7	11.8	2.4	2.5	24°	4.8	4.0	-	65	104	34	"
1656/6	"	11.8	15.4	-	-	-	-	-	-	76	-	-	"
1656/7	"	10.7	15.6	-	-	-	-	-	-	68	-	-	"
1656/9	"	11.0	14.2	-	-	-	-	-	-	77	-	-	"
1656/11	in MBV	10.4	17.0	-	-	-	-	9.8	-	61	-	58	"
1656/10	in MPV	8.2	12.5	-	-	-	-	-	-	65	-	-	"
1656/12	"	10.7	14.6	3.4	2.8	-	4.8	-	-	73	82	-	"
1656/8	"	5.1	6.2	-	-	-	-	-	-	82	-	-	"
1657/1	PV & QP	11.3	15.6	4.0	3.3	34°	6.0	-	-	72	83	-	"
1657/2	"	11.3	16.6	4.3	3.8	42°	8.2	est 8.2	-	68	88	49	"
1657/3	"	9.7	14.0	3.8	3.2	34°	6.1	6.2	-	69	84	44	"
1658	"	14.0	20.2	5.5	4.4	23°	12.1	-	-	69	80	-	"
1659/1	in MPV	12.3	16.6	4.0	3.4	31°	6.8	-	-	74	85	-	"

1659/2	in MPV	16.3	20.8	7.3	6.0	48^o	21.9	-	-	78	82	-	Wt
1659/3	PV & QP	12.4	18.0	-	-	-	-	-	-	68	-	-	"
1659/4	"	15.5	20.9	6.4	5.7	44^o	18.2	-	-	74	89	-	"
1659/5	"	15.7	est 23.2	5.1	4.5	38^o	11.5	-	-	67	88	-	"
1660/1	in MPV	15.5	21.4	5.2	4.4	29^o	11.4	est 9.0	-	72	85	42	"
1660/2	"	14.4	22.2	5.1	4.5	31^o	11.5	7.1	-	64	88	32	"
1661	"	5.3	7.0	-	-	-	-	-	-	75	-	-	"
1662/1	"	7.7	12.0	-	-	-	-	-	-	64	-	-	"
1662/2	"	7.3	12.0	2.7	3.4	38^o	4.6	-	-	60	126	-	"
1662/3	"	8.9	12.4	3.2	2.9	22^o	4.6	-	-	71	91	-	"
1662/4	"	8.5	12.7	2.7	3.1	38^o	4.2	4.7	-	66	115	37	"
1662/5	"	6.8	10.0	2.2	2.5	28^o	2.8	3.9	-	68	114	39	"
1662/6	"	15.2	24.2	-	-	-	-	-	-	62	-	-	"
1662/7	"	19.2	26.4	-	-	-	-	-	-	72	-	-	"
1663/1	"	10.5	15.2	4.1	3.5	41^o	7.2	-	-	69	85	37	"
1663/2	QP PV	15.7	22.1	-	-	-	-	-	-	71	-	-	"
1664	in MBV	14.3	20.0	-	-	-	-	8.0	-	71	-	40	"
1665	"	14.7	19.8	-	-	-	-	-	-	74	-	-	"
1666	QP PV	8.3	11.9	-	-	-	-	-	-	69	-	-	"
1667	in MPV	13.3	est 17.4	5.4	4.3	32^o	11.6	-	-	76	80	-	"
1668/1	in MBV	10.2	14.7	-	-	-	-	8.0	-	69	-	54	"
1668/2	in BV	8.4	12.9	-	-	-	-	-	-	65	-	-	"
1668/3	in MPV	5.4	8.2	-	-	-	-	-	-	65	-	-	"
1669	"	8.8	13.8	4.5	3.8	33^o	8.6	-	-	63	84	-	"
1670	"	9.6	12.1	-	-	-	-	-	-	79	-	-	"
1671/1	"	9.4	11.8	3.0	2.3	21^o	3.5	-	-	79	77	-	"
1671/2	"	8.0	11.6	-	-	-	-	-	-	68	-	-	"
1672	"	13.0	17.2	-	-	-	-	-	-	75	-	-	"
1673	QP BV	13.8	21.2	-	-	-	-	-	-	65	-	-	"
1674	QP PV	10.7	15.6	-	-	-	-	-	-	68	-	-	"
1675	in MPV	7.5	11.4	-	-	-	-	-	-	65	-	-	"
1676/1	QP BV	13.0	17.6	-	-	-	-	-	-	73	-	-	"
1676/2	in MPV	12.4	17.2	4.8	3.1	28^o	7.4	-	-	72	65	-	"
1676/3	"	10.4	14.4	3.3	3.7	33^o	6.1	-	-	72	112	-	"
1677/1	"	14.4	21.5	4.5	5.3	48^o	11.9	-	-	66	117	-	"

1677/2	in MPV	10.3	15.3	2.9	2.9	-	4.2	-	-	67	100	-	Wt
1677/3	BV	11.4	18.8	-	-	-	-	-	-	60	-	-	"
1677/4	"	10.4	est 15.4	-	-	-	-	-	-	67	-	-	"
1680/1	in MPV	6.5	10.6	2.5	2.6	-	3.3	4.8	-	61	104	45	"
1680/2	QP BV	9.8	est 13.0	-	-	-	-	-	-	75	-	-	"
1680/3	in MBV	9.3	13.0	-	-	-	-	4.6	-	71	-	35	"
1682/1	"	10.0	14.1	-	-	-	-	-	-	70	-	-	"
1682/2	QP PV	9.5	13.8	-	-	-	-	-	-	68	-	-	"
1681/1	in MPV	11.1	16.8	4.0	4.1	33°	8.2	6.1	-	66	103	36	"
1681/2	"	10.5	16.4	3.8	4.4	42°	8.4	-	-	64	116	-	"
1683	"	10.1	14.4	5.0	3.5	29°	8.8	-	-	70	70	-	"
1684	"	11.8	14.8	-	-	-	-	-	-	79	-	-	"
1684/2	"	8.8	13.5	-	-	-	-	-	-	65	-	-	"
1684/3	in BV	5.9	7.6	-	-	-	-	-	-	77	-	-	"
1684/4	BV	11.2	16.9	-	-	-	-	-	-	66	-	-	"
1685/1	in MPV	13.7	20.3	6.1	5.2	35°	15.7	-	-	67	85	-	"
1685/2	"	14.6	21.2	7.2	5.4	28°	19.4	-	-	68	75	-	"
1687	"	9.9	13.0	4.0	3.4	27°	6.8	-	-	76	85	-	"
1686/1	"	15.3	21.0	7.1	5.8	42°	20.6	-	-	72	82	-	"
1686/2	"	14.8	20.2	6.5	5.3	35°	17.2	-	-	73	82	"	
1686/3	"	14.0	17.1	5.7	4.5	26°	12.8	-	-	81	79	-	"
1686/4	in MBV	13.7	20.1	3.8	3.1	-	5.9	7.4	-	68	82	37	"
1688/1	"	14.8	19.8	-	-	-	-	8.9	-	74	-	45	"
1688/2	in MPV	12.9	est 20.0	5.6	5.7	33°	16.0	-	-	64	102	-	"
1689/1	"	7.7	12.0	3.0	3.1	38°	4.7	-	-	64	103	-	"
1689/2	"	6.5	9.0	2.4	2.3	22°	2.8	-	-	72	96	-	"
1689/3	QP PV	12.4	18.6	-	-	-	-	-	-	66	-	-	"
1689/4	in MPV	9.4	14.0	4.5	3.5	34°	7.9	6.0	-	67	78	43	"
1689/5	"	8.7	11.4	2.9	2.6	28°	3.8	-	-	76	90	-	"
1689/6	"	10.2	14.1	4.1	3.3	24°	6.8	-	-	72	80	-	"
1689/7	in MBV	8.7	est 13.6	-	-	-	-	-	-	63	-	-	"
1690/1	PV	10.3	est 13.8	-	-	-	-	-	-	74	-	-	"
1690/2	"	7.9	12.2	-	-	-	-	-	-	57	-	-	"
1691/1	in MPV	7.0	10.6	2.5	2.6	35°	3.3	-	-	66	104	-	"
1691/2	"	7.1	12.0	2.5	2.5	34°	3.1	-	-	59	100	-	"

1692	in MPV	14.3	21.6	4.0	4.3	37°	8.6	-	-	66	108	-	Wt
1693	"	11.0	16.8	3.9	3.5	29°	13.7	7.0	-	-65	90	42	"
1694	"	11.7	17.6	4.0	3.6	22°	7.2	-	-	66	90	-	"
1696/1	"	10.7	16.2	4.5	3.3	27°	7.4	-	-	66	73	-	"
1696/2	"	9.6	12.4	-	-	-	-	-	-	77	-	-	"
1696/3	"	6.1	7.6	-	-	-	-	-	-	80	-	-	"
1696/4	"	9.5	11.0	-	-	-	-	-	-	86	-	-	"
1696/5	in MBV	8.9	14.1	-	-	-	-	6.8	-	63	-	48	"

GOTLAND

G1	in PV	14.8	est 16.8	5.0	3.3	28°	8.3	-	-	88	86	-	Gannor 2 (GT13)
G2	ex PV	18.5	24.0	-	-	-	-	-	-	77	-	-	"
G3	in PV	16.0	19.5	5.5	4.4	43°	12.1	-	-	82	80	-	"
G4	"	10.1	11.5	-	-	-	-	-	-	87	-	-	"
G5	PV	14.6	18.0	-	-	-	-	-	-	81	-	-	"
G6	"	11.1	14.8	-	-	-	-	-	-	75	-	-	"
G7	"	14.4	16.8	-	-	-	-	-	8	85	-	-	"
G8	in PV	14.8	est 19.4	-	-	-	-	-	-	76	-	-	"
G9	ex PV	15.9	18.9	-	-	-	-	-	-	84	-	-	"
G10	"	17.5	est 23.8	-	-	-	-	-	-	73	-	-	"
G11	"	16.7	21.0	-	-	-	-	-	-	79	-	-	"
G12	ex BV	13.2	est 17.4	-	-	-	-	-	-	75	-	-	"
G13	in PV	15.3	21.6	-	-	-	-	-	-	70	-	-	"
G14	"	17.0	21.6	6.0	4.8	30°	14.4	-	-	78	96	-	"
G15	ex PV	12.4	15.8	-	-	-	-	-	-	78	-	-	"
G16	"	17.2	est 19.0	-	-	-	-	-	-	90	-	-	"
G17	"	14.2	est 21.2	-	-	-	-	-	-	66	-	-	"
G18	in PV	12.7	est 15.0	-	-	-	-	-	-	84	-	-	"
G19	"	14.7	18.4	5.0	4.2	25°	10.5	7.9	-	79	84	42	"
G20	in BV	10.0	14.0	-	-	-	-	6.5	-	71	-	46	"
G21	ex PV	17.2	est 23.4	-	-	-	-	-	-	73	-	-	"
G22	in BV	7.5	10.0	-	-	-	-	5.0	-	75	-	50	"

G23	ex PV	15.6	est 22.8	-	-	-	-	-	-	68	-	-	Gannor 2 (GT 13
G24	in MPV	9.8	12.2	-	-	-	-	-	-	80	-	-	"
G25	ex PV	12.3	16.0	-	-	-	-	-	-	76	-	-	"
G26	"	19.0	25.4	-	-	-	-	-	-	74	-	-	"
G27	"	14.7	18.2	-	-	-	-	-	-	80	-	-	"
G28	"	14.5	16.6	-	-	-	-	-	-	87	-	-	"
G29	"	16.1	18.4	-	-	-	-	-	-	87	-	-	"
G30	in BV	8.9	est 11.8	-	-	-	-	-	-	75	-	-	"
G31	"	3.5	est 7.0	-	-	-	-	-	-	50	-	-	"
G32	ex PV	13.7	est 20.4	-	-	-	-	-	-	67	-	-	"
G33	"	10.0	est 13.8	-	-	-	-	-	-	72	-	-	"
G34	in MPV	9.7	14.1	-	-	-	-	-	6	69	-	-	Gannor 2 (36)
G35	"	16.8	22.0	6.0	7.1	55°	21.3	-	-	76	118	-	"
G36	PV	13.0	15.9	-	-	-	-	-	-	82	-	-	"
G37	in MPV	17.6	25.0	4.6	7.0	33°	16.1	-	-	70	152	-	"
G38	"	8.0	12.0	2.2	2.5	35°	2.8	-	-	67	114	-	"
G39	"	13.0	17.0	4.0	3.8	34°	7.6	-	-	76	95	-	"
G40	"	17.3	22.0	6.0	6.0	45°	18.0	-	-	79	100	-	"
G41	ex MBV	14.1	est 21.2	-	-	-	-	-	6	67	-	-	"
G42	in MPV	16.4	est 23.4	-	5.8	43°	-	-	-	70	-	-	"
G43	"	13.3	16.4	5.8	4.0	39°	11.6	-	-	81	69	-	"
G44	"	14.1	17.6	5.2	4.5	40°	11.7	-	-	80	86	-	"
G45	"	14.8	est 22.2	6.0	4.8	36°	14.4	-	-	67	80	-	"
G46	"	14.5	19.3	5.6	4.2	33°	11.8	-	-	75	75	-	"
G47	ex MBV	11.3	est 15.0	-	-	-	-	-	9	75	-	-	"
G48	in MPV	13.5	est 18.6	-	-	20°	-	-	-	73	-	-	"
G49	ex MBV	10.5	12.6	-	-	-	-	-	-	83	-	-	"
G50	in MPV	13.8	16.9	5.1	4.3	34°	11.0	-	-	82	84	-	"
G51/1	ex MBV	11.8	15.6	-	-	-	-	-	6	76	-	-	"
G51/2	"	13.5	17.0	-	-	-	-	-	7	79	-	-	"
G52	in MPV	12.4	16.0	5.1	3.8	25°	9.7	-	-	78	75	-	"
G53	"	15.3	19.0	6.0	3.9	21°	11.7	-	-	81	65	-	"

G55	ex MBV	13.0	15.9	-	-	-	-	-	6	82	-	-	36
G56	in MPV	12.6	16.8	-	-	27°	-	-	-	75	-	-	"
G57	ex PV	12.5	16.5	-	-	-	-	-	-	76	-	-	"
G58	"	14.1	18.6	-	-	-	-	-	-	76	-	-	"
G59	"	11.1	est 15.4	-	-	-	-	-	-	72	-	-	"
G60	"	9.6	11.3	-	-	-	-	-	-	85	-	-	"
G61	in MPV	-	-	6.0	4.8	30°	14.4	-	-	-	80	-	"
G62	in PV	12.4	16.0	4.6	4.3	34°	9.9	-	-	78	93	-	"
G63	"	11.5	16.0	4.0	3.8	36°	7.6	-	-	72	95	-	"
G64	ex BV	13.3	18.0	-	-	-	-	-	-	74	-	-	"
G65/1	in PV	12.1	15.8	5.4	4.0	-	10.8	-	-	77	74	-	"
G65/2	ex BV	12.3	16.8	-	-	-	-	-	-	73	-	-	"
G66	in MPV	16.6	20.9	5.5	4.8	42°	13.2	-	-	79	87	-	"
G67	"	13.4	17.1	4.3	3.3	30°	7.1	-	-	78	77	-	"
G68	"	11.8	16.0	-	-	-	-	-	-	74	-	-	"
G69	PV	14.6	19.4	-	-	-	-	-	-	75	-	-	"
G70	"	-	-	6.2	4.6	33°	14.3	-	-	-	74	-	"
G71	in PV	18.5	25.6	7.5	7.1	15°	26.6	-	-	72	95	-	"
G72	"	14.6	est 21.2	5.7	4.8	-	13.7	-	-	69	84	-	"
G73	ex BV	14.0	21.4	-	-	-	-	-	-	65	-	-	"
G74	ex MPV	11.7	est 17.4	-	-	-	-	-	-	67	-	-	"
G75	"	10.1	14.0	-	-	-	-	-	-	72	-	-	"
G76	ex MBV	11.0	est 15.0	-	-	-	-	-	-	73	-	-	"
G77	ex MPV	5.9	8.5	-	-	-	-	-	-	69	-	-	"
G78	"	9.2	15.4	-	-	-	-	-	-	60	-	-	"
G79	in PV	14.7	20.6	5.5	3.8	26°	10.5	-	-	71	69	-	"
G80	ex PV	13.3	16.5	-	-	-	-	-	-	81	-	-	"
G81	in MPV	17.2	22.2	5.2	4.5	31°	11.7	-	-	77	86	-	"
G82	"	16.5	20.6	6.1	5.5	21°	16.8	-	-	80	90	-	"
G83	in PV	12.5	19.0	-	-	-	-	-	-	66	-	-	"
G84	"	16.5	20.8	7.5	4.6	19°	17.3	-	-	79	61	-	"
G85	"	12.7	est 14.8	3.5	3.0	30°	5.3	-	-	86	86	-	"
G86	ex BV	12.0	14.8	-	-	-	-	-	-	81	-	-	"

G87	in PV	9.3	11.1	-	-	-	-	-	-	84	-	-	"
G88	"	-	-	3.5	3.8	35°	6.7	-	-	-	108	-	"
G89	in MPV	16.1	20.8	-	-	-	-	-	-	77	-	-	"
G90	"	13.8	16.4	-	-	46°	-	-	-	84	-	-	"
G91	in PV	19.0	22.4	-	-	-	-	-	-	85	-	-	"
G92	PV	1.1	2.6	-	-	-	-	-	-	42	-	-	"
G93	"	2.4	3.0	-	-	-	-	-	-	80	-	-	"
G94	"	3.9	6.4	-	-	-	-	-	-	61	-	-	"
G95	in MPV	13.8	16.1	-	-	-	-	-	-	86	-	-	Nyan 2 (35)
G96	"	16.6	19.8	6.7	5.8	39°	19.4	-	-	84	87	-	"
G97	"	13.1	est 20.0	-	-	-	-	-	-	66	-	-	"
G98	"	13.4	est 17.8	-	-	-	-	-	-	75	-	-	"
G99	"	13.9	17.8	5.3	4.4	38°	11.7	-	-	78	83	-	"
G100	ex PV	17.1	23.1	-	-	-	-	-	-	74	-	-	"
G101	in MPV	14.3	est 19.0	4.0	3.6	22°	7.2	-	-	75	90	-	"
G102	"	13.7	19.3	5.2	5.3	51°	13.8	-	-	71	101	-	"
G103	"	17.3	23.0	5.5	4.6	48°	12.7	-	-	75	84	-	"
G104	"	18.0	22.0	7.0	5.6	33°	19.6	-	-	82	80	-	"
G105	ex MPV	11.0	13.3	-	-	-	-	-	-	83	-	-	"
G106	in MPV	14.8	17.4	6.2	5.5	51°	17.1	-	-	85	89	-	"
G107	"	13.1	16.4	5.2	3.6	25°	9.4	-	-	80	69	-	"
G108	ex PV	11.0	13.6	-	-	-	-	-	-	81	-	-	"
G109	in MPV	17.5	22.3	5.4	5.1	31°	13.8	-	-	78	94	-	"
G110	"	est 18.0	23.2	-	-	-	-	-	-	78	-	-	"
G111	"	16.6	21.6	5.0	4.9	41°	12.3	-	-	77	98	-	"
G112	"	14.3	18.3	-	-	-	-	-	-	78	-	-	"
G113	"	16.1	25.2	7.0	5.6	54°	19.6	-	-	64	80	-	"
G114	"	16.0	19.2	4.8	4.0	36°	9.6	-	-	83	83	-	"
G115	"	11.4	14.4	-	-	-	-	-	-	79	-	-	"
G116	ex MPV	14.6	17.4	-	-	-	-	-	-	84	-	-	"
G117	in PV	11.7	14.4	-	-	-	-	-	-	81	-	-	"
G118	in MPV	12.4	est 17.8	5.3	5.0	44°	13.3	-	-	70	94	-	"
G119	ex MPV	13.3	18.4	-	-	-	-	-	-	72	-	-	"
G120	in PV	14.5	16.8	-	-	-	-	-	-	86	-	-	"

G121	ex MPV	6.8	10.3	-	-	-	-	-	-	66	-	-	35
G122	in MPV	16.6	22.3	-	-	-	-	-	-	74	-	-	"
G123	"	19.2	21.8	6.4	4.8	20°	15.4	-	-	88	75	-	"
G124	in BV	6.9	10.4	-	-	-	-	est 4.2	-	66	-	40	Tjängdarve (41)
G125	in PV	6.0	10.0	-	-	-	-	-	-	66	-	-	"
G126	"	7.5	9.9	3.5	2.3	28°	4.0	-	-	76	66	-	"
G127	"	3.3	5.2	-	-	-	-	est 2.0	-	63	-	38	"
G128	"	9.6	14.0	4.2	3.1	26°	6.5	5.5	-	69	74	39	"
G129	ex PV	8.5	12.0	-	-	-	-	-	-	71	-	-	"
G130	in PV	4.2	7.0	-	-	-	-	-	-	60	-	-	"
G131	ex PV	5.6	est 9.0	-	-	-	-	-	-	62	-	-	"
G132	"	6.3	est 8.4	-	-	-	-	-	-	75	-	-	"
G133	ex MPV	10.2	est 17.2	-	-	-	-	-	-	59	-	-	Nyan 2 (35)
G134	in PV	13.8	16.7	4.5	3.8	33°	8.6	-	-	83	84	-	"
G135	"	15.4	21.3	6.4	5.7	38°	18.2	-	-	72	89	-	"
G136	ex MPV	11.5	15.0	-	-	-	-	-	-	77	-	-	"
G137	ex PV	17.0	22.0	-	-	-	-	-	-	77	-	-	"
G138	PV	13.8	17.6	-	-	-	-	-	-	78	-	-	"
G139	ex MBV	16.6	22.4	-	-	-	-	-	7	74	-	-	"
G140	PV	14.9	20.0	-	-	-	-	-	-	75	-	-	"
G141	"	20.8	25.0	-	-	-	-	-	-	83	-	-	"
G142	"	15.5	est 22.8	-	-	-	-	-	-	68	-	-	"
G143	"	13.7	17.1	-	-	-	-	-	-	80	-	-	"
G144	ex PV	14.9	22.2	-	-	-	-	-	-	67	-	-	"
G145	"	13.7	16.6	-	-	-	-	-	-	83	-	-	"
G146	"	15.9	est 20.8	-	-	-	-	-	-	76	-	-	"
G147	"	13.8	18.0	-	-	-	-	-	-	77	-	-	"
G148	in MPV	14.8	est 22.0	-	-	-	-	-	-	67	-	-	"
G149	ex MPV	13.1	17.1	-	-	-	-	-	-	77	-	-	"
G150	"	18.0	est 25.6	-	-	-	-	-	-	70	-	-	"
G151	ex BV	18.0	25.6	-	-	-	-	-	9	70	-	-	"
G152	QP PV	14.0	19.6	-	-	-	-	-	-	71	-	-	"

G153	in PV	12.8	19.8	-	-	-	-	-	-	65	-	-	35
G154	"	16.7	22.6	-	-	-	-	-	-	74	-	-	"
G155	PV	13.8	21.4	-	-	-	-	-	-	64	-	-	"
G156	in MPV	17.5	22.5	3.5	3.5	-	6.1	-	-	78	100	-	"
G157	in PV	14.9	22.4	7.0	5.2	38°	18.2	-	-	67	74	-	"
G158	"	18.5	est 23.0	6.0	4.7	24°	14.1	-	-	80	78	-	"
G159	in BV	9.8	est 12.0	-	-	-	-	est 6.4	-	82	-	53	"
G160	in PV	16.0	19.1	7.0	4.1	21°	14.4	-	-	84	59	-	"
G161	BV	9.6	15.0	-	-	-	-	-	8	64	-	-	"
G162	"	9.0	11.8	-	-	-	-	-	10	76	-	-	"
G163	PV	8.8	14.0	-	-	-	-	-	-	63	-	-	"
G164	"	14.2	17.1	5.4	4.5	30°	12.2	-	-	83	83	-	"
G165	in MPV	10.0	15.0	2.9	3.5	34°	5.1	-	-	67	120	-	"
G166	"	14.4	15.8	-	-	-	-	-	-	91	-	-	"
G167	"	15.1	18.3	-	-	-	-	-	-	83	-	-	"
G168	"	13.4	15.5	4.8	4.2	31°	10.1	-	-	86	88	-	"
G169	in MPV	15.8	19.3	5.0	4.7	38°	11.8	-	-	82	94	-	"
G170	"	16.6	20.3	-	-	-	-	-	-	-	-	-	"
G171	"	12.9	16.0	-	-	-	-	-	-	81	-	-	"
G172	"	7.1	10.6	2.1	2.3	18°	2.4	-	-	67	110	-	"
G173	ex PV	est 12.5	est 17.0	-	-	-	-	-	-	74	-	-	"
G174	ex MPV	13.0	est 16.8	-	-	-	-	-	-	77	-	-	"
G175	"	17.8	23.8	-	-	-	-	-	-	75	-	-	"
G176	ex PV	15.4	22.4	-	-	-	-	-	-	69	-	-	"
G177	"	10.5	12.2	-	-	-	-	-	-	86	-	-	"
G178	PV	18.4	27.0	-	-	-	-	-	-	68	-	-	"
G179	"	15.7	20.8	-	-	-	-	-	-	75	-	-	"
G180	"	16.4	22.0	-	-	-	-	-	-	75	-	-	"
G181	ex MPV	11.8	19.2	-	-	-	-	-	-	61	-	-	"
G182	"	13.6	est 19.2	-	-	-	-	-	-	71	-	-	"
G183	"	17.4	22.8	-	-	-	-	-	-	76	-	-	"
G184	"	15.9	21.0	-	-	-	-	-	-	76	-	-	"
G185	"	17.8	23.4	-	-	-	-	-	-	76	-	-	"
G186	"	17.8	23.9	-	-	-	-	-	-	74	-	-	"
G187	"	14.4	21.0	-	-	-	-	-	-	69	-	-	"

G188	ex MPV	12.9	16.2	-	-	-	-	-	-	80	-	-	35
G189	"	15.9	22.6	-	-	-	-	-	-	70	-	-	"
G190	ex PV	17.7	23.0	-	-	-	-	-	-	77	-	-	"
G191	"	10.0	14.0	-	-	-	-	-	-	71	-	-	"
G192	in PV	15.6	19.5	5.5	5.0	45°	13.8	-	-	80	91	-	"
G193	ex MPV	14.5	est 21.0	-	-	-	-	-	-	69	-	-	"
G194	"	12.7	est 16.0	-	-	-	-	-	-	79	-	-	"
G195	"	18.8	est 24.6	-	-	-	-	-	-	76	-	-	"
G196	in PV	16.4	22.4	6.0	5.0	40°	15.0	-	-	73	83	-	"
G197	"	16.5	21.1	6.2	4.8	39°	14.9	-	-	78	77	-	"
G198	"	16.1	23.0	-	6.5	40°	-	-	-	70	-	-	"
G199	ex BV	15.3	est 21.0	-	-	-	-	-	-	73	-	-	"
G200	ex BV	13.1	15.4	-	-	-	-	-	-	85	-	-	"
G201	in PV	13.1	17.6	4.6	3.8	36°	8.7	-	-	85	83	-	"
G202	"	13.8	17.6	5.3	4.4	39°	11.7	-	-	78	83	-	"
G203	"	14.9	17.6	5.1	4.2	45°	10.7	-	-	88	82	-	"
G204	PV	17.2	21.8	-	-	-	-	-	-	79	-	-	"
G205	in PV	16.9	21.7	7.0	5.4	40°	18.9	-	-	78	77	-	"
G206	"	-	-	5.8	5.1	44°	14.8	-	-	-	88	-	"
G207	"	17.5	22.0	6.2	5.0	42°	15.5	-	-	80	81	-	"
G208	"	16.0	19.3	6.0	4.6	41°	13.8	-	-	83	77	-	"
G209	ex PV	12.2	14.6	-	-	-	-	-	-	84	-	-	"
G210	in PV	15.6	20.3	-	-	-	-	-	-	77	-	-	"
G211	"	15.3	19.6	5.0	3.8	41°	9.5	-	-	78	76	-	"
G212	"	19.1	23.0	6.6	5.0	46°	16.5	-	-	83	76	-	"
G213	"	16.6	22.7	6.5	4.6	40°	15.0	-	-	73	71	-	"
G214	PV	14.0	18.6	-	-	-	-	-	-	75	-	-	"
G215	in PV	14.1	19.8	4.0	3.5	37°	12.3	-	-	71	88	-	"
G216	"	12.8	16.6	-	-	-	-	-	-	77	-	-	"
G217	PV	20.4	25.8	-	-	-	-	-	-	79	-	-	"
G218	"	9.0	12.1	-	-	-	-	-	-	74	-	-	"
G219	in BV	4.8	6.0	-	-	-	-	3.3	-	80	-	55	"
G221	-	2.1	3.0	-	-	-	-	-	-	70	-	-	"
G222	-	3.6	4.8	-	-	-	-	-	-	75	-	-	"
G223	in MPV	2.7	3.5	-	-	-	-	-	-	77	-	-	"

G224	in PV	15.9	19.9	7.0	4.8	23°	16.8	-	-	80	69	-	Hallsarve (26)
G225	"	11.0	16.4	3.0	3.5	40°	5.3	-	-	67	117	-	"
G226	in BV	6.3	est 8.2	-	-	-	-	-	9	77	-	-	Hägvide 2 (23)
G227	in PV	6.0	est 8.0	2.0	2.0	-	2.0	-	8	75	100	-	"
G228	"	est 5.5	est 7.4	-	-	-	-	-	-	74	-	-	"
G229	ex PV	3.5	est 5.2	-	-	-	-	-	-	67	-	-	"
G230		7.0	10.0	2.0	2.0	-	2.0	3.6	-	70	100	36	"
G231	in PV	5.2	8.0	-	-	-	-	-	-	65	-	-	"
G232	"	4.4	6.0	-	-	-	-	2.6	-	73	-	43	"
G233	"	4.0	5.2	-	-	-	-	-	-	77	-	-	"
G234	ex PV	3.5	est 7.0	-	-	-	-	-	-	50	-	-	"
G235	in PV	3.8	6.4	-	-	-	-	-	-	59	-	-	"
G236	in BV	4.2	6.1	-	-	-	-	2.6	-	69	-	43	"
G237	in PV	5.2	est 8.0	-	-	-	-	-	-	65	-	-	"
G238	"	5.3	7.8	-	-	-	-	-	-	68	-	-	"
G239	in BV	7.0	10.0	-	-	-	-	-	-	70	-	-	"
G240	ex PV	5.5	7.9	-	-	-	-	-	-	70	-	-	"
G241	ex BV	3.3	est 5.8	-	-	-	-	-	10	57	-	-	Hallsarve (26)
G242	ex PV	5.0	8.0	-	-	-	-	-	-	80	-	-	"
G243	"	-	20.2	-	-	-	-	-	-	-	-	-	"
G244	ex BV	14.6	18.2	-	-	-	-	-	10	80	-	-	"
G245	in PV	16.3	19.9	5.5	4.6	40°	12.7	est 9.2	-	82	84	46	"
G246	"	13.4	16.8	5.0	4.4	44°	11.0	-	-	80	88	-	"
G247	ex MPV	15.5	18.4	-	-	-	-	-	-	84	-	-	"
G248	ex PV	10.1	13.4	-	-	-	-	-	-	75	-	-	"
G249	in MPV	15.0	18.4	-	-	-	-	-	-	82	-	-	"
G250	"	14.9	22.0	4.0	4.2	42°	8.4	-	-	68	105	-	"
G251	in PV	12.0	est 16.4	3.9	4.1	48°	8.0	-	-	73	105	-	"
G252	ex PV	15.9	19.4	-	-	-	-	-	-	82	-	-	"
G253	in BV	9.0	13.0	2.1	2.4	-	2.5	5.4	-	69	114	42	"

BC 7737	ex PV	11.7	15.0	-	-	-	-	-	-	78	-	-	Gornor
9167/1	"	13.7	16.9	-	-	-	-	-	-	81	-	-	"
9167/2	"	16.4	22.1	-	-	-	-	-	-	74	-	-	"
9167/3	"	15.1	20.2	-	-	-	-	-	-	75	-	-	"
9167/4	"	16.3	21.6	-	-	-	-	-	-	75	-	-	"
9167/5	"	7.3	9.4	-	-	-	-	-	-	78	-	-	"
9167/6	"	17.2	22.4	-	-	-	-	-	-	77	-	-	"
9167/7	"	17.3	22.4	-	-	-	-	-	-	77	-	-	"
9167/8	"	19.9	24.6	-	-	-	-	-	-	81	-	-	"
9167/9	"	12.1	15.6	-	-	-	-	-	-	78	-	-	"
9167/10	"	13.5	19.0	-	-	-	-	-	-	71	-	-	"
9167/11	"	15.0	18.0	-	-	-	-	-	-	83	-	-	"
9167/12	"	13.6	17.9	-	-	-	-	-	-	76	-	-	"
9168	"	13.0	18.6	-	-	-	-	-	-	70	-	-	"
9169	in PV	12.4	16.4	5.0	5.5	53^{o}	13.8	-	-	76	110	-	"
7592	in MPV	15.6	20.7	-	-	-	-	-	-	75	-	-	"
BC 8742/1	"	16.1	22.2	-	-	-	-	-	-	73	-	-	Nyan
8742/2	"	17.8	23.2	-	-	-	-	-	-	77	-	-	"
8742/3	"	17.7	23.0	-	-	-	-	-	-	77	-	-	"
BC 8749	"	16.5	21.0	-	-	-	-	-	-	79	-	-	"

OTHER LOCALITIES

Area	n	$\overline{Ls}$	$\overline{Ws}$
West Midlands (Gornal)	6	6.7	9.83
Malvern and Abberley	29	8.85	12.86
Woolhope (Perton Lane and Welsh Coart)	43	9.36	13.56
Usk Inlier	44	11.55	16.28
Wenlock Edge (Hopes Cross)	16	10.41	14.15
Ludlow	41	9.5	13.2
Towy Anticlinal (Clawdd British)	11	10.1	13.4
Brecon Anticlinal (Ysgwydd Hwch)	2	9.95	16.1
Builth	1	4.4	8.0

LEPTOSTROPHIA FILOSA

Sp. No.	T.V.	SHELL		P.V. MUSCLE FIELD			Wd	R	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	Loc
		Ls	Ws	Lmf	Wmf	∅						
100	in MPV	11.8	18.4	6.1	5.5	52°	-	-	64	111	-	Lud.Mus.
101	PV	22.6	29.5	13.9	11.4	48°	-	-	77	122	-	"
102	in MPV	21.8	est 26.6	11.7	est 12.6	57°	-	-	82	93	-	"
103	in MPV	17.1	20.6	11.6	8.1	48°	est 9.5	-	83	143	46	"
104	in MPV	21.0	23.7	8.1	6.8	48°	est 12.2	-	89	119	51	"
105	PV	18.7	26.9	-	-	-	-	-	70	-	-	"
106	in MPV	17.0	est 19.4	-	-	-	-	-	88	-	-	"
108	in MPV	19.3	-	est 6.6	5.4	50°	-	-	-	122	-	"
118	in MPV	16.1	est 21.4	8.0	7.9	64°	-	-	75	101	-	"
119	PV	16.4	est 24.2	-	-	-	-	-	68	-	-	"
120	in MPV	17.2	23.0	7.5	6.5	60°	-	-	75	115	-	"
172/1	in PV	18.4	est 20.8	-	9.3	-	-	-	88	-	-	31b
172/2	BV	9.7	13.7	-	-	-	7.6	-	70	-	55	"
172/3	in MBV	13.0	20.4	-	-	-	est 10.2	-	63	-	50	"
174	ex PV	13.2	14.5	-	-	-	-	-	91	-	-	31a
175	ex BV	15.4	18.8	-	-	-	-	4	81	-	-	31b
176	in PV	12.2	-	-	6.0	57°	-	-	-	-	-	"
177	in PV	-	15.0	3.4	4.9	59°	-	-	-	69	-	"
178	PV	15.8	est 14.5	6.4	5.6	60°	-	-	108	114	-	31a
179	PV	est 12.2	13.1	-	-	-	-	-	93	-	-	31b
180	-	-	17.5	-	-	-	-	-	-	-	-	"
183a	BV	-	16.0	-	-	-	9.0	-	-	-	56	"
183b	BV	6.7	8.9	-	-	-	-	-	75	-	-	"
185	-	15.2	17.0	-	-	-	-	-	89	-	-	"
188/1	PV	7.1	est 14.6	-	-	-	-	-	50	-	-	"
188/2	-	10.4	est 13.0	-	-	-	-	-	80	-	-	"

190/1	in PV	6.0	8.8	-	-	-	-	-	68	-	-	31b
190/2	ex PV	9.6	11.3	-	-	-	-	-	84	-	-	"
194	PV	22.5	est 22.0	-	6.5	51°	-	-	102	-	-	"
196	-	10.8	est 14.8	-	-	-	-	-	72	-	-	"
200/1	in MPV	25.8	25.6	11.2	8.4	45°	-	-	100	133	-	"
200/2	in PV	-	10.8	6.1	5.6	66°	-	-	-	108	-	"
203	ex PV	14.9	18.4	-	-	-	-	-	80	-	-	31c
205	BV	-	19.4	-	-	-	10.0	-	-	-	52	"
208	in MPV	6.5	est 10.5	-	-	-	6.4	-	61	-	61	"
209	PV	-	est 13.5	-	5.3	57°	-	-	-	-	-	"
211	-	10.4	13.4	-	-	-	-	-	77	-	-	"
212	PV	-	-	-	5.3	57°	-	-	-	-	-	"
213	"	12.4	est 10.8	-	3.0	54°	-	-	110	-	-	"
214	"	-	-	-	9.2	64°	-	-	-	-	-	"
215	-	17.6	18.0	-	-	-	-	-	97	-	-	"
216	PV	12.1	est 11.4	5.6	3.7	54°	-	-	106	151	-	"
217	in MPV	5.4	8.8	3.5	3.7	60°	-	-	61	94	-	"
218	-	10.5	est 19.0	-	-	-	-	-	55	-	-	"
219	-	13.0	est 13.6	-	-	-	-	-	95	-	-	"
220/1	in MPV	17.1	est 24.0	-	6.3	58°	-	-	71	-	-	"
220/2	"	13.7	est 12.5	-	5.9	61°	-	-	109	-	-	"
220/3	"	15.0	est 16.0	-	5.1	65°	-	-	93	-	-	"
220/4	"	-	13.8	-	4.6	63°	-	-	-	-	-	"
220/5	"	8.4	9.7	-	3.7	50°	-	-	86	-	-	"
220/6	"	9.6	est 11.6	-	3.4	58°	-	-	82	-	-	"
220/7	BV	11.8	18.0	-	-	-	10.2	-	65	-	57	"
223	in PV	17.9	23.0	-	7.9	60°	-	-	77	-	-	31d
224	"	18.6	20.7	-	6.9	62°	-	-	89	-	-	"
226	PV	13.3	14.8	-	-	-	-	-	89	-	-	"
227/1	"	8.8	11.4	3.2	3.4	53°	-	-	77	94	-	"
229	BV	8.7	-	3.2	2.7	-	-	-	-	118	-	"
231	PV	13.0	est 15.2	-	-	-	-	-	85	-	-	"
232	"	17.2	19.7	-	4.5	56°	-	-	87	-	-	"

233	-	16.0	est 25.8	-	-	-	-	-	62	-	-	"
235	PV	20.6	est 28.2	-	5.4	63°	-	-	73	-	-	"
236	"	16.5	22.8	6.4	6.0	60°	-	-	72	100	-	"
241	"	6.6	est 10.0	-	2.4	54°	-	-	66	-	-	"
243	"	11.8	14.5	-	-	-	-	-	81	-	-	"
245	"	16.0	est 18.6	-	-	-	-	-	86	-	-	"
246	in PV	8.2	13.5	-	3.7	-	-	-	60	-	-	"
247	-	6.6	est 11.0	-	-	-	-	-	60	-	-	"
248	in PV	18.1	-	-	4.7	61°	-	-	-	-	-	"
234	BV	6.4	est 7.7	3.1	2.6	-	4.3	-	83	119	59	"
251	"	12.6	est 21.4	-	3.3	50°	10.4	-	58	-	49	"
255	"	17.9	19.5	-	-	-	-	-	91	-	-	"
259/1	PV	6.1	6.8	-	2.7	53°	-	-	89	-	-	31e
264	BV	13.8	14.4	-	-	-	7.1	-	95	-	-	"
267	PV	9.6	12.1	-	-	50°	-	-	79	-	-	"
268	in PV	13.1	14.5	-	-	55°	-	-	90	-	-	"
273	PV	-	est 16.6	-	-	62°	-	-	-	-	-	"
279a/1	-	16.9	19.6	-	-	-	-	-	86	-	-	"
280/1	ex MPV	11.4	12.5	-	-	-	-	-	91	-	-	"
284/3	PV	8.8	12.0	-	-	-	-	-	73	-	-	"
284/4	ex BV	13.2	18.4	-	-	-	-	-	71	-	-	"
285	in PV	19.4	21.4	6.3	5.0	50°	-	-	90	126	-	"
289	in MPV	18.6	19.2	-	4.4	49°	-	-	96	-	-	"
315	in MPV	15.3	18.4	4.6	4.0	60°	-	-	83	115	-	31f
322	in PV	-	-	-	8.2	56°	-	-	-	-	-	31g
331	BV?	20.1	est 23.4	-	-	-	-	-	85	-	-	31f
335	in MBV	16.3	est 22.4	-	-	-	-	5	72	-	-	31h
336	in MBV	15.1	est 20.0	-	-	-	-	6	75	-	-	"
338	in MBV	10.0	est 22.0	2.6	3.4	53°	11.4	6	76	-	52	"
339	PV	18.8	23.6	-	-	56°	-	-	79	-	-	"
340	BV	16.1	24.4	-	-	-	-	-	65	-	-	"

343	-	11.8	17.0	-	-	-	-	-	69	-	-	31h
344	BV	10.0	est 17.4	-	-	-	8.2	-	57	-	47	"
245/1	in MPV	13.9	est 17.6	5.3	4.6	68^{o}	-	-	78	115	-	"
245/2	in MPV	21.4	30.6	9.1	8.7	64^{o}	-	-	69	104	-	"
346	ex BV	15.2	20.6	-	-	-	-	-	73	-	-	"
347/1	in MPV	10.5	11.4	3.9	3.4	59^{o}	-	-	92	114	-	31i
347/2	in MPV	22.8	28.0	8.7	7.1	52^{o}	-	-	81	122	-	"
348	PV	14.0	est 15.0	-	-	-	-	-	93	-	-	"
350	"	22.5	26.4	-	7.9	63^{o}	-	-	85	-	-	"
359/1	in MPV	24.5	25.0	-	6.7	60^{o}	-	-	98	-	-	31j
359/2	in MBV	18.5	22.2	-	-	-	-	-	83	-	-	"
360	in MPV	7.4	10.2	-	2.4	52^{o}	-	-	75	-	-	"
361/1	in MPV	-	14.0	-	4.7	53^{o}	-	-	-	-	-	"
365/2	BV	20.9	est 26.4	-	-	-	-	-	79	-	-	"
365/3	in MPV	16.0	20.4	4.4	4.0	59^{o}	-	-	78	110	-	"
366/1	in MPV	6.4	9.9	-	2.4	70^{o}	-	-	64	-	-	"
366/2	"	2.9	3.9	-	-	-	-	-	74	-	-	"
366/3	PV	12.0	13.0	-	-	-	-	-	92	-	-	"
370/1	"	4.9	5.4	-	-	55^{o}	-	-	90	-	-	"
370/2	in MPV	7.2	9.9	3.1	2.5	48^{o}	-	-	72	124	-	"
370/3	BV	13.4	18.4	3.7	3.4	-	-	-	72	108	-	"
370/4	"	10.0	14.0	3.0	2.5	-	-	-	71	120	-	"
377/2	-	5.3	7.6	-	-	-	-	-	69	-	-	31k
381	PV	10.1	13.3	-	-	-	-	-	75	-	-	"
382/1	BV	10.9	13.6	-	-	-	-	-	80	-	-	"
386	PV	19.3	est 20.4	-	-	-	-	-	94	-	-	"
392	BV	30.4	29.8	-	-	-	-	4	102	-	-	31l
394	PV	13.8	19.2	-	3.1	52^{o}	9.4	-	71	-	49	"
398	"	13.8	-	5.4	5.0	53^{o}	-	-	-	108	-	"
403/1	BV	11.9	13.8	-	-	-	-	-	86	-	-	"
403/2	in MBV	-	13.7	-	2.6	48^{o}	7.2	-	-	-	53	"
403/3	BV	5.3	6.0	-	-	-	-	-	88	-	-	"

422	in MPV	-	16.8	7.0	4.6	53°	11.4	-	-	152	67	A2
440	"	7.5	7.6	-	2.7	56°	-	-	98	-	-	A3
407	"	15.2	-	4.2	3.0	49°	-	-	-	140	-	"
458	in MBV	13.6	18.2	3.8	3.0	-	11.4	-	74	126	63	"
461	PV	8.6	9.4	-	2.9	60°	-	-	91	-	-	"
463b	QP PV	13.2	14.9	-	3.8	53°	7.5	-	88	-	50	"
464b/1	in MPV	9.0	11.5	5.2	4.3	54°	-	-	78	120	-	"
464/2	in MPV	14.7	16.2	-	4.5	49°	est 9.6	-	90	-	59	"
465b	in MPV	7.6	9.5	-	3.5	67°	-	-	80	-	-	"
472	in MBV	12.2	17.8	-	-	-	-	-	68	-	-	A4
540	in MPV	11.1	11.5	-	3.2	60°	-	-	90	-	-	A6
547	ex MPV	14.0	16.5	-	-	-	-	-	84	-	-	"

548	in MPV	15.9	19.0	-	-	-	8.5	-	83	-	45	14
552	QP PV	10.2	14.5	-	-	-	-	-	70	-	-	"
553	in MPV	17.2	est 23.8	-	6.5	70°	-	-	72	-	-	"
555	"	14.6	-	-	4.1	51°	-	-	-	-	-	"
561	"	13.1	18.7	-	4.6	56°	-	-	70	-	-	"
562	"	-	22.0	-	6.3	61°	-	-	-	-	-	"
568	PV	12.5	13.6	-	-	-	-	-	91	-	-	"
567/1	in MPV	14.4	18.3	-	5.5	63°	-	-	78	-	-	"
567/2	in MBV	15.7	17.0	-	-	-	-	-	92	-	-	"
567/3	"	14.4	17.6	-	-	-	-	4	81	-	-	"
567/4	in MPV	-	16.6	4.6	4.4	66°	-	5	-	104	-	"
567/5	"	9.5	12.7	4.4	3.8	55°	-	-	74	115	-	"

573	in MPV	15.1	15.6	-	5.3	61°	-	-	96	-	-	B1
589	"	10.0	est 16.0	3.8	3.7	55°	-	-	62	102	-	B2
591/2	in MBV	4.2	5.0	-	1.8	-	-	-	84	-	-	"
596	QP PV	3.6	5.5	-	-	-	-	-	65	-	-	B4
598	in MBV	est 12.0	est 16.8	-	3.8	53°	est 9.0	-	71	-	54	"
599	"	-	16.5	-	4.5	53°	-	-	-	-	-	"

600/1	ex BV	11.4	12.4	-	-	-	-	5	91	-	-	B4
600/2	in MPV	est 6.8	9.6	-	3.6	59°	-	-	70	-	-	"
601/1	in MPV	-	23.4	-	-	60°	-	-	-	-	-	"
601/2	in MBV	4.8	9.6	-	1.7	50°	est 5.4	-	50	-	56	"
602/1	"	8.8	16.4	2.9	2.7	50°	9.4	-	53	107	57	"
602/2	"	11.8	15.4	-	4.3	58°	10.8	-	76	-	70	"
602/3	in MPV	-	21.4	-	5.3	59°	-	-	-	-	-	"
602/4	"	-	-	-	6.7	52°	-	-	-	-	-	"
603/1	"	4.8	est 7.8	-	1.8	51°	-	-	61	-	-	"
603/2	"	5.0	6.5	-	2.0	59°	-	-	76	-	-	"
603/3	"	est 10.0	est 13.0	-	4.0	56°	-	-	76	-	-"	"
604	BV	12.4	15.0	-	-	-	-	5	82	-	-	B5
605/2	ex BV	6.2	7.6	-	-	-	-	6	64	-	-	"
605/3	PV	6.3	9.6	-	2.6	50°	-	-	65	-	-	"
606	BV	10.0	13.0	-	-	-	-	4	76	-	-	"
607	in MPV	20.2	22.8	-	5.4	53°	-	-	88	-	-	"
609b	QP PV	15.5	19.0	-	-	-	-	-	81	-	-	"
610	in MPV	14.8	est 18.9	-	-	-	-	-	78	-	-	"
612	BV	13.9	16.4	-	-	-	-	-	84	-	-	"
613	in MPV	11.5	13.5	-	4.4	60°	-	-	85	-	-	"
614	ex BV	12.9	15.8	-	-	-	-	-	81	-	-	"
615	BV	14.6	16.8	-	-	-	-	-	86	-	-	"
617	-	6.6	10.4	-	-	-	-	-	63	-	-	"
618	PV	16.9	20.2	-	5.1	50°	-	-	83	-	-	"
619/1	"	12.6	18.4	-	-	-	-	-	68	-	-	"
619/2	"	-	est 14.0	-	-	58°	-	-	-	-	-	"
622	PV	7.4	8.8	-	-	-	4.4	-	84	-	50	B6
623	in MPV	31.3	est 34.0	-	6.7	58°	14.2	-	92	-	42	"
624	in MBV	10.9	13.6	-	-	-	est 7.0	5	80	-	51	"
627	in MPV	30.1	est 36.8	10.6	13.5	70°	-	-	81	78	-	"
629	"	21.1	est 25.8	-	-	-	-	-	81	-	-	"
631	"	18.5	23.0	-	5.6	53°	-	-	80	-	-	"
632	"	-	est 25.6	-	9.0	58°	-	-	-	-	-	"

633	in MPV	12.7	21.4	-	7.1	65°	-	-	59	-	-	B6
809	-	7.8	est 10.8	-	-	-	-	-	72	-	-	7a
810	in MPV	18.4	est 22.4	-	8.0	62°	-	-	82	-	-	"
811	in MBV	10.3	est 16.0	-	-	-	-	-	64	-	-	"
837	in MPV	21.0	est 23.8	-	7.8	61°	-	-	88	-	-	"
838	in MBV	4.5	7.6	-	1.2	-	est 3.8	5	59	-	50	"
839	PV	11.4	15.7	-	-	-	-	-	72	-	-	"
840	in MPV	7.8	12.4	-	4.1	52°	-	-	62	-	-	"
850	in MPV	13.3	16.0	-	5.5	61°	est 9.0	-	83	-	56	"
855/2	PV	12.0	16.8	-	4.6	63°	-	-	71	-	-	"
858/5	"	8.2	11.8	-	-	-	-	-	69	-	-	"
859/1	"	9.0	11.1	-	3.3	50°	6.3	-	81	-	57	"
864	in MPV	-	est 19.0	-	7.5	62°	-	-	-	-	-	Lawson FC/31
895/3	"	9.5	12.0	-	-	-	-	-	79	-	-	"
895/4	in MBV	7.7	est 11.0	-	-	60°	-	-	70	-	-	"
897/1	in MPV	7.7	est 8.6	-	2.7	55°	-	-	89	-	-	"
897/2	"	17.1	21.8	-	5.0	60°	-	-	78	-	-	"
897/3	"	16.7	est 23.2	-	5.2	55°	-	-	71	-	-	"
897/4	"	19.5	25.0	-	6.7	57°	-	-	78	-	-	"
897/5	"	16.1	est 24.4	-	6.3	-	-	-	65	-	-	"
899	QP PV	21.3	est 22.0	-	-	-	-	-	96	-	-	"
900	in MPV	9.8	10.5	-	4.1	50°	-	-	93	-	-	"
904/1	"	19.5	est 23.0	-	8.2	60°	-	-	84	-	-	"
904/2	in MBV	16.2	19.0	-	3.2	-	8.2	5	85	-	44	"
905	in MPV	14.4	23.3	-	6.0	60°	-	-	61	-	-	"
906	QP PV	-	22.5	-	7.5	60°	-	-	-	-	-	"
910	in MPV	14.3	16.0	-	5.8	62°	-	-	89	-	-	"
912/2	in MBV	13.0	18.1	-	2.7	-	-	5	71	-	-	"
912/3	in MPV	8.7	est 10.4	-	-	-	-	-	83	-	-	"

1108	in MPV	12.6	est 18.0	-	-	-	-	-	70	-	-	SH
1101	in PV	12.7	est 20.6	-	-	-	-	-	62	-	-	"
1133	ex MPV	19.4	est 23.0	-	-	-	-	-	84	-	-	WQ
1157b/3	ex BV	17.8	20.9	-	-	-	-	-	85	-	-	"
1159	QP PV	16.4	17.0	-	-	-	-	-	96	-	-	"
1164	ex MPV	est 21.3	est 31.4	-	-	-	-	-	68	-	-	"
1183	in MPV	8.5	11.0	2.5	3.0	58°	-	-	77	83	-	"
1192	BV & QP	19.7	27.0	-	-	-	-	-	73	-	-	"
1194/1	in MBV	21.9	est 23.0	-	-	-	-	5	95	-	-	"
1194/2	"	17.0	20.7	-	-	-	-	4	82	-	-	"
1194/3	in MPV	19.4	est 22.0	-	5.9	57°	-	-	88	-	-	"
1198	in BV	18.8	21.7	-	-	-	-	5	87	-	-	"
1214	in MPV	14.4	est 15.6	-	-	-	-	-	92	-	-	"
1227/2	in MBV	12.0	est 13.7	1.8	2.0	-	8.1	-	88	90	59	"
1236/2	"	8.0	11.4	-	-	-	4.6	-	70	-	40	"
1251	in MPV	22.3	23.0	-	-	-	-	-	97	-	-	"
1256	in BV	18.8	23.6	-	-	-	-	-	80	-	-	"
1261	in PV	12.6	14.2	-	-	-	-	-	89	-	-	"
1262	in MPV	12.5	est 18.0	-	4.5	-	-	-	69	-	-	"
1287	in MPV	est 13.8	est 14.2	3.2	4.2	57°	-	-	97	76	-	"
1288	"	7.9	13.8	2.5	3.2	61°	5.3	-	59	78	38	"
1294	ex MPV	16.4	26.8	-	-	-	-	-	61	-	-	"
1295	"	13.9	15.4	-	-	-	-	-	90	-	-	"
1296	"	13.2	est 17.8	-	-	-	-	-	74	-	-	"
1309/2	"	19.4	23.1	-	-	-	-	-	84	-	-	"
1310/2	in MBV	5.4	9.0	2.0	2.3	-	5.2	-	60	87	57	"
1322/1	in PV	23.4	25.7	-	-	-	-	-	91	-	-	"
1323	QP PV	19.7	19.0	-	-	-	-	-	104	-	-	"
1324	in MPV	18.0	est 22.6	6.0	6.2	59°	-	-	80	97	-	"
1325	"	18.0	23.6	5.5	5.2	54°	11.4	-	76	106	48	"

1326	ex MBV	18.7	23.4	-	-	-	-	-	80	-	-	WQ "
1327	"	12.2	19.0	-	-	-	-	-	64	-	-	"
1354	in MPV	11.5	12.7	-	-	-	-	-	91	-	-	"
1396	"	est 15.8	est 22.2	-	-	-	-	-	72	-	-	"
1395	"	17.7	24.2	7.0	8.0	62°	-	-	73	88	-	"
1397	PV & QP	14.8	est 22.2	5.5	6.5	52°	-	-	64	85	-	"
1403	in MPV	11.5	12.8	4.5	5.3	54°	-	-	90	85	-	"
1413	in PV	20.0	21.0	6.3	7.8	63°	-	-	95	81	-	"
1421/1	in MBV	22.0	25.2	-	-	-	est 16.0	-	87	-	63	LR
1421/2	PV	17.2	21.2	-	-	-	-	-	81	-	-	"
1422	in MBV	18.2	21.2	-	4.0	-	-	-	86	-	-	"
1424	in MPV	5.5	est 9.0	2.3	3.2	61°	-	-	61	72	-	"
1425	-	15.5	19.4	-	-	-	-	-	80	-	-	"
1426	in MPV	24.5	29.6	-	-	-	-	-	83	-	-	"
1428	in MPV	5.2	10.2	2.1	2.9	62°	-	-	51	72	-	"
1433	"	6.9	9.0	2.4	3.1	67°	-	-	77	77	-	"
1423/1	PV	25.0	30.7	-	-	-	-	-	81	-	-	"
1423/2	in MBV	21.9	25.4	-	-	-	12.9	-	86	-	50	"
1423/3	in MBV	25.5	28.3	-	4.7	-	15.6	-	90	-	55	"
1423/4	PV	13.9	18.8	-	-	-	-	-	74	-	-	"
1423/5	in MBV	14.7	18.4	-	-	-	11.0	-	80	-	59	"
1423/6	ex MPV	17.5	20.4	-	-	-	-	-	86	-	-	"
1423/8	"	20.3	23.8	-	-	-	-	-	85	-	-	"
1427	BV	13.8	16.5	-	-	-	9.6	-	84	-	58	"
1427/2	PV	-	-	-	-	70°	-	-	-	-	-	"
1431	-	22.9	25.0	-	-	-	-	-	92	-	-	"
1430	BV	19.0	26.6	-	-	-	-	-	71	-	-	"
1434	in PV	28.2	31.2	-	-	-	-	-	90	-	-	"
1436/1	PV & QP	19.1	23.3	7.0	8.0	62°	11.4	-	82	88	49	"
1436/2	"	12.8	17.6	4.3	5.5	60°	-	-	73	78	-	"
1440/3	in MPV	14.9	est 16.2	4.4	5.4	63°	-	-	92	82	-	"

1435/4	PV & QP	12.6	15.2	3.0	4.6	59°	7.4	-	83	65	48	LR
1435/5	"	14.6	est 16.4	3.8	5.5	60°	9.0	-	89	69	54	"
1435/6	BV & QP	20.5	25.0	-	-	-	-	5	82	-	-	"
1435/7	"	20.3	24.6	-	-	-	-	5	83	-	-	"
1442	in MBV	18.0	22.0	-	-	-	est 12.0	-	82	-	54	"
1444/1	"	20.5	26.1	-	4.1	-	16.0	5	79	-	61	"
1444/2	QP PV	24.7	28.2	-	-	-	-	-	88	-	-	"
1445	"	17.9	24.9	-	-	-	-	-	72	-	-	"
1447	in MBV	21.6	23.3	-	-	-	12.6	-	93	-	54	"
1448	in MPV	-	22.0	5.0	5.6	55°	-	-	-	89	-	"
1450	PV	27.0	est 39.8	-	-	-	-	-	68	-	-	"
1451	in MBV	10.9	14.1	-	-	-	-	-	77	-	-	"
1453/1	PV & QP	13.3	18.2	6.5	6.2	60°	est 8.8	-	73	105	48	"
1454	PV	21.5	22.3	-	-	-	-	-	96	-	-	"
1455/1	PV	11.3	13.6	4.2	4.7	-	-	-	83	89	-	"
1455/2	"	14.3	18.0	4.4	5.6	56°	8.6	-	79	79	47	"
1455/3	"	12.8	15.6	4.4	5.1	59°	7.7	-	82	86	49	"
1456	QP PV	23.9	30.2	-	-	-	-	-	79	-	-	"
1457/1	in MPV	23.3	28.0	5.9	7.5	61°	-	-	83	79	-	"
1457/2	"	18.0	est 20.8	5.5	8.0	66°	9.8	-	87	69	47	"
1457/3	"	17.0	est 20.2	4.2	5.7	63°	-	-	84	73	-	"
1457/4	"	20.0	24.0	5.1	6.5	56°	-	-	83	78	-	"
1457/5	"	19.0	22.9	7.4	9.0	62°	est 15.0	-	83	82	65	"
1461	BV	21.1	est 26.4	-	-	-	-	-	80	-	-	"
1460/1	PV	19.9	24.4	6.2	6.5	55°	9.0	-	81	95	36	"
1460/2	"	18.6	22.4	5.5	6.5	62°	-	-	83	84	-	"
1460/3	BV	16.3	20.4	-	-	-	-	4	80	-	-	"
1452/3	PV	10.8	15.2	4.6	5.3	61°	-	-	71	86	-	"
1452/5	"	22.0	25.0	5.8	6.6	58°	-	-	88	87	-	"
1463/1	BV & QP	9.0	12.0	-	-	-	7.4	-	75	-	61	"
1463/2	"	11.3	14.8	3.7	4.3	57°	6.0	-	76	86	40	"
1463/3	"	12.3	16.6	5.8	6.0	61°	9.8	-	74	96	59	"
1463/4	"	7.5	11.5	2.5	3.5	60°	est 4.4	-	65	71	38	"

1463/6	PV & QP	5.6	7.0	2.3	3.2	60°	est 6.0	-	80	71	85	LR
1477	in MPV	-	26.4	6.4	7.3	63°	est 14.0	-	-	87	53	"
1478	"	9.8	14.6	3.5	3.9	58°	-	-	67	89	-	"
1479	"	18.3	est 25.4	6.5	8.0	-	-	-	72	81	-	"
1480	"	17.5	20.8	5.5	6.0	61°	-	-	84	91	-	"
1481	"	4.2	7.5	1.7	1.9	57°	2.8	-	56	89	37	"
1482/1	"	11.3	16.4	2.5	4.0	61°	-	-	68	62	-	"
1482/2	"	12.7	est 17.0	5.2	6.1	60°	8.6	-	74	85	50	"
1485	"	11.4	18.2	-	-	-	-	-	62	-	-	"
1486	QP PV	14.5	16.8	-	-	-	-	-	86	-	-	"
1487/1	in MPV	7.5	10.4	2.3	3.2	58°	4.2	-	72	71	40	"
1487/2	in MBV	13.0	est 16.0	- -	-	-	-	-	81	-	-	"
1488	-	19.3	24.8	-	-	-	-	-	77	-	-	"
1489	in MPV	7.5	9.2	2.7	3.5	58°	6.0	-	81	77	65	"
1490/1	QP PV	8.0	est 11.0	-	-	-	-	-	72	-	-	"
1490/2	"	12.6	13.1	-	-	-	-	-	96	-	-	"
1490/3	"	11.6	18.6	-	-	-	-	-	62	-	-	"
1490/4	"	11.4	15.4	-	-	-	-	-	74	-	-	"
1484/1	in MBV	12.0	15.8	-	-	-	-	-	75	-	-	"
1484/2	PV	19.3	est 26.0	5.8	6.1	60°	-	-	74	95	-	"
1491	"	17.0	19.8	-	5.1	58°	10.7	-	85	-	54	"
1492	"	16.0	21.4	-	-	-	-	-	74	-	-	"
1493/1	in MBV	15.5	20.6	-	-	-	9.2	-	75	-	44	"
1494	in MPV	17.0	est 18.8	5.1	5.6	60°	est 12.0	-	90	91	63	"
1495	"	19.0	24.6	6.4	7.5	66°	est 13.0	-	77	85	52	"
1496	ex MPV	12.3	16.3	-	-	-	-	-	75	-	-	"
1497	in MPV	12.6	est 15.0	3.2	4.9	58°	est 9.0	-	84	65	60	"
1499	in MBV	11.8	15.8	-	-	-	-	-	74	-	-	"
1500	in MPV	15.1	est 25.0	6.0	6.2	58°	-	-	60	96	-	"
1501	in MBV	14.2	19.6	-	-	-	11.6	-	72	-	59	"
1502	in MPV	17.2	est 20.4	5.8	7.5	63°	14.6	-	84	77	71	"
1503	"	13.3	est 16.8	4.2	5.3	58°	9.8	-	79	79	58	"

1504	in MBV	25.8	25.3	-	-	-	est 14.4	-	101	-	56	LR
1505	in MPV	18.9	est 23.6	5.1	6.3	55^{o}	13.8	-	80	80	58	"
1507	"	22.0	24.9	9.0	11.4	67^{o}	est 16.4	-	88	78	65	"
1512	in MBV	20.2	26.4	3.5	3.8	-	15.0	5	76	92	56	"
1513	PV	16.6	20.3	5.9	7.2	61^{o}	-	-	81	81	"	"
1514	"	9.0	16.4	4.0	4.8	58^{o}	8.5	-	54	83	51	"
1515	BV	14.6	21.2	-	-	-	13.0	-	68	-	61	"
1516/1	PV	18.9	est 22.2	6.7	7.2	60^{o}	12.0	-	85	93	54	"
1517	"	16.0	24.0	5.5	6.9	65^{o}	9.1	-	66	79	37	"
1522	ex MBV	15.6	21.4	-	-	-	-	-	72	-	-	"
1524	in MBV	17.6	21.4	-	-	-	-	5	82	-	-	"
1525	"	12.5	17.4	-	-	-	8.0	-	71	-	45	"
1529	PV & QP	23.9	33.0	8.2	8.7	60^{o}	17.7	-	72	94	53	"
1527/1	PV	11.9	18.0	4.1	4.8	45^{o}	-	-	66	85	-	"
1527/2	BV	13.9	18.2	-	-	-	-	-	76	-	-	"
1528/1	PV	20.1	24.1	5.9	6.5	55^{o}	-	-	83	90	-	"
1528/2	BV	16.5	19.7	-	-	-	-	-	83	-	-	"
1530/1	PV& QP	17.3	21.4	4.0	5.2	56^{o}	est 12.0	-	80	76	56	"
1530/2	"	18.2	24.4	-	-	-	15.0	-	74	-	61	"
1531/2	in MPV	12.0	16.2	5.8	7.2	61^{o}	-	-	74	80	-	"
1532/1	"	15.3	18.2	5.0	6.5	-	-	-	84	76	-	"
1532/2	in MBV	8.0	12.0	-	-	-	4.0	-	66	-	33	"
1533	"	12.6	15.7	-	-	-	-	-	80	-	-	"
1534	in MPV	17.3	22.6	5.3	6.7	51^{o}	13.2	-	76	79	58	"
1535	"	14.6	18.1	4.8	5.3	60^{o}	8.8	-	80	90	48	"
1538	"	17.8	19.2	6.0	6.6	56^{o}	8.6	-	92	90	44	"
1539	"	17.8	25.4	7.3	7.8	73^{o}	-	-	70	93	-	"
1540	"	13.2	14.7	-	-	-	-	-	89	-	-	"
1541	in MBV	15.8	17.4	-	-	-	-	5	90	-	-	"
1544	in MPV	14.2	17.4	3.5	5.6	60^{o}	est 9.8	-	81	-	56	"
1545/1	"	7.7	12.0	3.0	3.8	58^{o}	-	-	64	79	-	"
1545/2	"	13.2	15.7	4.1	4.7	59^{o}	-	-	84	87	-	"
1545/3	in MBV	17.2	22.0	-	-	-	-	-	78	-	-	"
1548	-	17.0	20.1	-	-	-	-	-	84	-	-	"

1549	PV	17.4	24.8	5.0	6.1	55°	-	-	70	81	-	LR
1550	"	11.4	16.4	3.0	4.0	57°	est 7.0	-	69	75	42	"
1552	QP PV	16.7	18.8	-	-	-	-	-	88	-	-	"
1553	in MPV	15.2	17.7	3.5	4.7	55°	8.5	-	85	74	48	"
1554	"	-	12.9	3.2	4.6	58°	-	-	-	69	-	"
1551	BV	12.9	16.8	-	-	-	-	5	76	-	-	"
1555	in MPV	20.0	26.8	7.0	7.7	62°	12.4	-	74	90	46	"
1556/1	"	21.0	est 25.0	-	-	-	-	-	84	-	-	"
1556/2	"	20.4	27.4	-	-	-	-	-	74	-	-	"
1556/3	BV	12.1	13.5	-	-	-	-	-	89	-	-	"
1557	QP PV	18.0	19.6	-	-	-	-	-	91	-	-	"
1559	PV	8.8	est 12.6	-	-	-	-	-	69	-	-	"
1563/2	in MBV	17.6	21.2	-	-	-	-	-	83	-	-	"
1564/1	PV	19.3	26.0	5.4	7.8	68°	12.2	-	74	69	46	"
1564/2	BV & QP	17.9	21.2	-	-	-	-	5	84	-	-	"
1564/3	PV & QP	23.7	28.2	6.5	6.6	62°	-	-	84	98	-	"
1564/4	"	26.3	30.0	7.8	8.7	55°	-	-	87	89	-	"
1564/5	"	16.7	22.0	4.7	5.4	52°	-	-	75	87	-	"
1564/6	"	16.6	19.4	-	-	-	-	-	85	-	-	"
1564/7	"	14.0	est 19.4	-	-	-	-	-	72	-	-	"
1564/8	"	25.5	30.1	6.8	8.2	64°	-	-	84	82	-	"
1564/9	"	19.2	22.0	6.0	7.4	56°	8.7	-	87	81	39	"
1564/10	BV	21.7	25.2	-	-	-	-	-	86	-	-	"
1564/11	-	20.7	23.5	-	-	-	-	-	88	-	-	"
1564/12	PV & QP	22.4	26.8	7.6	8.6	64°	-	-	83	88	-	"
1564/13	BV & QP	21.8	26.8	-	-	-	14.6	-	81	-	54	"
1564/14	"	17.6	21.7	-	-	-	-	-	81	-	-	"
1564/15	PV & QP	17.9	20.3	-	-	-	-	-	88	-	-	"

PHOLIDOSTROPHIA (MESOPHOLIDOSTROPHIA) LEPISMA

Sp. No.	T.V.	SHELL Ls	SHELL Ws	P.V. MUSCLE-FIELD Lmf	P.V. MUSCLE-FIELD Wmf	P.V. MUSCLE-FIELD Ø	Wd	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	Loc.
184/1	PV	4.8	7.0	-	-	-	-	68	-	-	31a
184/2	"	5.8	7.4	-	-	-	-	78	-	-	"
189	in MPV	7.7	18.9	-	4.5	63°	6.3	40	-	33	"
173	"	7.3	10.3	-	3.2	60°	5.0	70	-	49	"
182	"	9.0	est 13.2	-	-	-	6.6	68	-	50	"
192/2	"	4.8	est 7.4	-	-	-	-	64	-	-	"
193	"	4.5	8.8	-	2.9	68°	-	51	-	-	"
199/1	-	5.0	7.2	-	-	-	-	69	-	-	"
199/2	-	2.4	3.1	-	-	-	-	77	-	-	"
200/3	in MPV	7.5	13.4	-	-	-	-	55	-	-	"
202	PV	8.7	14.4	-	-	-	-	60	-	-	31c
206/1	ex PV	7.6	11.7	-	-	-	-	64	-	-	"
206/2	-	5.7	10.0	-	-	-	-	57	-	-	"
206/3	in MPV	5.3	est 8.0	-	-	-	-	66	-	-	"
207/1	"	8.0	12.5	-	-	-	6.6	64	-	53	"
207/2	"	9.0	13.9	-	3.6	60°	-	64	-	-	"
207/3	"	9.1	13.5	-	-	-	-	67	-	-	"
209/2	"	6.0	11.0	3.4	4.3	70°	-	54	79	-	"
221	in PV	6.4	est 9.2	-	2.7	67°	4.4	69	-	48	"
222	"	3.3	3.9	-	1.5	55°	2.2	84	-	56	31d
225	"	4.0	5.2	-	-	-	-	76	-	-	"
227/2	PV	4.2	8.3	-	-	-	4.1	50	-	49	"
227/3	"	5.3	est 8.8	-	2.8	60°	-	60	-	-	"
228	"	5.7	est 12.4	-	-	-	-	45	-	-	"
238	ex PV	7.1	est 11.4	-	-	-	7.8	62	-	68	"
240	in PV	7.0	10.2	-	3.0	70°	-	68	-	-	"
244	"	3.2	4.6	-	-	-	-	69	-	-	"
237	"	5.3	7.3	-	2.0	66°	-	72	-	-	"
239	ex BV	6.8	10.0	-	-	-	-	68	-	-	"
249/1	ex PV	7.2	9.9	-	-	-	-	72	-	-	"
249/2	PV	4.8	6.9	-	-	-	-	69	-	-	"
249/3	"	8.9	12.9	-	4.3	-	-	68	-	-	"
253/2	"	8.2	10.7	-	-	-	-	76	-	-	31e
257	-	6.2	est 10.0	-	-	-	-	62	-	-	"
258	PV	10.3	14.2	-	-	-	-	72	-	-	"
259/2	"	4.8	9.7	-	-	-	-	49	-	-	"

260	PV	10.8	est 18.4	-	-	-	-	58	-	-	31e
262	"	5.8	est 9.6	-	-	-	-	60	-	-	"
263	"	6.0	8.0	-	-	-	-	75	-	-	"
265	"	9.5	est 14.4	-	-	-	-	65	-	-	"
266	"	9.0	13.9	-	-	-	-	64	-	-	"
269	"	6.0	est 7.0	-	3.1	63°	-	85	-	-	"
270	ex PV	6.8	est 12.4	-	-	-	-	54	-	-	"
280/2	in PV	3.7	est 5.0	-	1.7	54°	-	70	-	-	"
281/2	ex PV	5.2	7.4	-	-	-	-	70	-	-	"
281/3	"	4.7	8.0	-	-	-	-	58	-	-	"
282	PV	7.0	12.4	-	-	-	-	56	-	-	"
283/1	QP PV	7.2	est 13.8	-	-	-	-	52	-	-	"
283/2	"	8.2	15.5	-	-	-	-	52	-	-	"
283/3	"	7.1	est 11.0	-	-	-	-	64	-	-	"
283/4	"	8.4	est 15.8	-	-	-	-	53	-	-	"
283/5	"	4.0	5.8	-	-	-	-	68	-	-	"
283/6	"	4.8	7.1	-	-	-	-	67	-	-	"
283/7	"	3.9	6.7	-	-	-	-	58	-	-	"
284/1	PV	6.6	10.5	-	-	-	-	62	-	-	"
284/2	"	6.0	est 9.2	-	-	-	-	65	-	-	"
287/2	"	5.0	9.6	-	-	-	-	52	-	-	"
288	"	4.2	8.1	-	2.3	55°	4.0	51	-	49	"
290	-	6.1	10.7	-	-	-	5.2	57	-	49	31f
291	PV	5.2	9.5	-	-	-	-	54	-	-	"
292	BV	9.4	19.5	-	-	-	-	48	-	-	"
293	PV	2.2	3.9	-	-	-	-	56	-	-	"
295	"	7.5	13.6	-	3.1	60°	-	55	-	-	"
296	"	5.8	10.7	-	-	-	-	54	-	-	"
297	"	7.6	12.0	-	-	-	-	63	-	-	"
294	"	10.4	14.9	2.9	3.0	70°	5.0	69	96	33	-
298	-	7.2	est 11.4	-	-	-	-	63	-	-	"
299	BV	7.4	12.7	-	-	-	-	58	-	-	"
300	PV	6.3	9.5	-	-	-	-	66	-	-	"
301	BV	5.5	10.0	-	-	-	-	55	-	-	"
303	PV	5.7	11.4	-	2.9	70°	6.3	50	-	55	"
302	"	7.5	12.2	-	-	-	-	61	-	-	"
304	"	6.8	9.2	-	-	-	-	73	-	-	"
305	BV	7.1	est 12.1	-	-	-	-	58	-	-	"
306	PV	est 7.9	est 15.0	-	-	-	est 8.8	52	-	59	"
307	"	5.2	8.6	-	-	-	-	60	-	-	"

308	PV	4.7	est 7.8	-	-	57°	-	60	-	-	31f
309	"	6.4	8.1	-	-	-	-	79	-	-	"
310	"	5.4	7.9	-	-	-	-	68	-	-	"
311	BV	7.9	12.4	-	-	-	-	63	-	-	"
312	PV	6.8	12.8	-	-	-	-	53	-	-	"
313	"	8.8	11.5	-	-	-	-	76	-	-	"
314	BV	8.7	14.3	-	-	-	-	60	-	-	"
316	PV	4.6	est 8.0	-	-	-	-	57	-	-	31g
317	"	4.7	9.5	-	-	-	-	49	-	-	"
318	-	4.9	8.1	-	-	-	-	60	-	-	"
323	PV	8.5	12.2	-	-	-	-	69	-	-	"
319	"	7.6	est 10.2	-	-	-	-	74	-	-	"
324	"	6.8	13.8	-	-	-	-	49	-	-	"
325	"	7.7	13.9	-	-	-	-	55	-	-	"
326	"	est 9.6	16.4	-	-	-	-	58	-	-	"
328	"	8.6	15.0	-	-	-	-	57	-	-	"
329	"	5.0	9.3	-	-	-	-	53	-	-	"
330	"	8.7	14.1	-	-	-	-	61	-	-	31f
321	"	7.5	13.6	-	-	-	-	55	-	-	"
332b	PV & QP	7.3	10.0	-	-	-	-	73	-	-	"
332/1	BV	5.0	est 8.1	-	-	-	-	61	-	-	"
332/2	"	5.3	est 11.2	-	-	-	-	47	-	-	"
333b/1	"	6.2	10.4	-	-	-	-	59	-	-	"
333b/2	PV	8.1	est 15.2	-	-	-	-	53	-	-	"
333b/3	BV	5.9	8.8	-	-	-	-	67	-	-	"
337	"	5.7	10.8	-	-	-	-	52	-	-	31h
342	in MPV	6.5	10.0	-	2.0	63°	4.7	65	-	47	"
341	PV	6.5	10.6	-	-	-	-	61	-	-	"
351	ex PV	7.2	est 12.0	-	-	-	-	60	-	-	31i
353	in MPV	3.7	5.6	-	-	-	-	66	-	-	"
354	PV	5.3	est 9.8	-	-	-	-	54	-	-	"
358	"	6.5	est 12.6	-	-	-	-	51	-	-	31j
361/2	in MPV	5.9	12.0	2.4	2.1	69°	-	49	114	-	"
361/3	"	5.7	est 8.6	-	-	-	-	66	-	-	"
362	BV	6.2	9.2	-	-	-	-	67	-	-	"
363	in MPV	6.6	9.6	-	-	-	-	68	-	-	"
364	"	6.3	9.5	-	-	-	-	66	-	-	"
365/4	"	4.7	7.9	-	-	-	-	59	-	-	"
365/6	"	5.3	9.4	-	-	-	-	56	-	-	"

370/5	in MPV	3.5	5.4	-	-	-	-	64	-	-	31J
370/6	"	4.2	7.3	-	-	-	-	57	-	-	"
370/7	"	4.4	7.6	-	-	-	-	57	-	-	"
371	"	6.6	10.3	-	2.8	63°	-	64	-	-	31K
372	"	6.0	9.5	-	-	-	-	63	-	-	"
373	QP PV	6.9	est 10.8	-	-	-	-	63	-	-	"
374	PV	5.8	est 12.6	-	-	-	-	53	-	-	"
375	"	5.4	11.2	-	-	-	-	48	-	-	"
377/1	"	2.0	3.6	-	-	-	-	55	-	-	"
385/1	"	6.6	10.2	-	-	-	-	64	-	-	"
385/2	"	4.9	9.3	-	-	-	-	52	-	-	"
389	"	5.7	7.3	-	-	-	-	78	-	-	31L
393/1	"	7.6	8.8	-	-	-	-	86	-	-	"
393/2	"	7.0	10.7	-	-	-	-	65	-	-	"
396	"	4.9	8.4	-	-	-	-	58	-	-	"
410	PV	6.9	9.5	-	3.4	66°	-	72	-	-	A1
411	"	8.2	13.6	-	-	-	-	60	-	-	A2
418	in MPV	8.0	11.3	-	4.0	62°	6.4	61	-	57	"
427	"	7.4	9.5	-	-	-	-	77	-	-	"
428/1	"	6.7	est 8.6	-	3.2	-	-	77	-	-	"
428/3	"	1.9	3.5	-	-	-	-	54	-	-	"
431	"	8.0	10.6	-	3.6	70°	4.5	75	-	42	"
439	"	6.2	9.3	-	3.7	63°	4.3	66	-	46	A3
446	-	3.8	6.2	-	-	-	-	61	-	-	"
459	in MPV	7.1	8.6	-	2.9	-	3.8	82	-	44	"
467	"	6.1	9.6	-	3.7	62°	-	63	-	-	"
474	PV	6.0	10.6	-	-	-	-	56	-	-	"
470	QP PV	8.0	est 15.2	-	-	-	-	52	-	-	A4
475	QP BV	7.2	11.9	-	-	-	-	60	-	-	"
476	in MPV	9.6	est 12.2	-	3.1	68°	6.3	78	-	66	"
477/1	BV	7.2	est 15.2	-	-	-	-	47	-	-	"
477/2	PV	6.9	12.0	-	-	-	-	57	-	-	"
477/3	"	8.7	12.4	-	-	-	-	70	-	-	"
477/4	"	9.2	est 16.8	-	-	-	-	54	-	-	"
478	in MPV	7.9	est 13.8	-	-	-	6.6	57	-	48	"
479	PV	7.7	est 12.2	-	-	-	-	63	-	-	"
480	-	5.3	8.8	-	-	-	-	60	-	-	"

481	QP PV	6.3	9.6	-	-	-	-	65	-	-	A4
482	PV	6.2	11.0	-	-	-	-	56	-	-	"
483	in BV	6.8	12.5	-	-	-	-	54	-	-	"
484	in MPV	7.4	10.5	4.0	3.8	64°	est 5.6	70	105	53	"
485	in MBV	9.3	13.3	-	-	-	-	69	-	-	"
486	-	8.9	est 12.0	-	-	-	-	66	-	-	"
487	PV	8.0	est 14.4	-	-	-	-	55	-	-	"
488	PV	3.9	5.9	-	-	-	-	66	-	-	"
489	BV	7.9	est 13.4	-	-	-	-	58	-	-	"
490	PV	5.7	9.4	-	-	-	-	60	-	-	"
491	ex BV	6.6	12.2	-	-	-	-	54	-	-	"
492	-	5.3	8.7	-	-	-	-	60	-	-	"
493	ex PV	7.7	15.2	-	-	-	-	50	-	-	"
494	in PV	7.3	est 12.2	-	-	-	-	59	-	-	"
495	ex MPV	6.6	11.1	-	-	-	-	59	-	-	"
496	in MPV	6.8	9.7	-	-	-	-	70	-	-	"
497	"	5.6	est 8.4	-	2.8	62°	-	66	-	-	"
498	BV	8.1	13.0	-	-	-	-	62	-	-	"
499	in MPV	7.9	11.7	-	3.3	52°	5.7	67	-	52	"
500	QP PV	7.8	est 13.0	-	-	-	-	60	-	-	"
501	in MPV	8.9	est 14.2	-	4.8	67°	7.8	62	-	55	"
502	BV	7.7	12.0	-	-	-	-	64	-	-	"
503	"	7.7	13.8	-	-	-	-	55	-	-	"
504	in MPV	8.8	est 14.2	-	-	-	5.6	61	-	39	"
505	BV	6.6	10.8	-	-	-	-	61	-	-	"
507	PV	7.6	est 17.0	-	-	-	-	44	-	-	A5
506	PV	7.7	12.4	-	-	-	-	62	-	-	"
509	in MPV	8.0	est 11.0	-	3.4	62°	-	72	-	-	"
508	"	6.4	est 8.8	-	-	-	-	72	-	-	"
510	PV	6.7	9.5	-	-	-	-	70	-	-	"
511	"	5.3	est 9.6	-	-	-	-	55	-	-	"
512	"	7.9	9.5	-	-	-	-	83	-	-	"
513	BV	9.4	14.1	-	-	-	-	66	-	-	"
514	QP PV	7.2	10.8	-	-	-	-	66	-	-	"
515	ex PV	6.6	12.5	-	-	-	-	48	-	-	"
517	ex MBV	6.7	12.1	-	-	-	-	55	-	-	"
518	PV	6.5	10.5	-	-	-	-	61	-	-	"
520	"	5.5	8.3	-	-	-	-	66	-	-	"

519	BV	6.7	10.0	-	-	-	-	67	-	-	A5
521	PV	8.8	est 14.4	-	-	-	-	61	-	-	"
522	ex PV	6.3	11.0	-	-	-	-	57	-	-	"
523	in MBV	est 6.5	est 12.0	-	-	-	5.0	54	-	42	"
524	ex PV	6.3	9.7	-	-	-	-	64	-	-	"
525	"	6.4	11.0	-	-	-	-	58	-	-	"
526	in MPV	6.5	13.1	-	2.6	61°	4.7	49	-	36	"
527	in BV	7.0	est 15.6	-	-	-	-	44	-	-	"
527b/1	in MPV	3.7	6.1	2.0	2.5	68°	2.5	61	80	41	"
528/1	in MBV	8.5	12.0	-	1.7	-	6.0	70	-	50	"
528/2	PV	8.1	est 11.2	-	-	-	-	72	-	-	"
529	"	5.8	est 8.0	-	-	-	-	72	-	-	"
530	-	5.6	8.0	-	-	-	-	70	-	-	"
531	ex PV	7.0	10.3	-	-	-	-	67	-	-	A6
532	in MPV	9.0	12.8	-	4.0	60°	6.6	70	-	52	"
534	BV	6.5	9.8	-	-	-	-	66	-	-	"
535	PV	7.0	est 10.4	-	-	-	-	67	-	-	"
536	BV	7.0	11.1	-	-	-	-	63	-	-	"
537	in MPV	7.0	est 14.0	-	3.2	60°	4.9	50	-	35	"
538	PV	5.4	8.9	-	-	-	-	60	-	-	"
539	om MBV	4.2	est 8.4	-	-	-	3.2	50	-	38	"
541	ex PV	6.5	est 15.6	-	-	-	-	41	-	-	"
542	in MBV	4.8	6.8	-	-	-	2.4	70	-	35	"
543	QP BV	3.0	4.0	-	-	-	-	75	-	-	"
544	in MPV	4.4	7.3	-	1.8	62°	2.8	60	-	38	"
533	in MBV	5.4	8.0	-	-	-	-	67	-	-	"
545b	in MPV	8.0	14.6	-	3.5	67°	-	54	-	-	"
546b	ex PV	4.3	6.5	-	-	-	-	66	-	-	"
595	in MPV	5.7	7.4	-	-	-	-	77	-	-	B4
620	"	6.3	est 11.4	-	-	-	5.3	55	-	46	B5
626	"	6.5	10.1	-	2.7	64°	-	64	-	-	"
630	"	4.0	7.5	-	-	-	-	53	-	-	B6
625	"	3.2	5.0	-	-	-	-	64	-	-	"
656b	QP PV	3.9	5.5	-	2.3	67°	2.9	70	-	53	B7

803	in MPV	7.2	11.0	-	-	-	5.8	65	-	53	7a
804/1	"	5.0	6.8	-	2.4	68°	-	73	-	-	"
805	"	5.6	8.4	-	-	-	-	66	-	-	"
806/1	in MBV	5.5	7.3	-	-	-	-	75	-	-	"
806/2	"	4.0	est 6.8	-	-	-	-	58	-	-	"
807/1	QP PV	5.5	8.5	-	-	-	-	64	-	-	"
807/2	in MPV	5.0	9.0	-	3.0	68°	3.7	55	-	41	"
807/3	"	4.0	4.8	-	-	-	2.2	83	-	46	"
812	"	7.0	est 12.4	-	-	-	-	56	-	-	"
814/2	in MBV	3.3	est 6.6	-	-	-	4.2	50	-	64	"
815	in MPV	5.6	8.3	-	-	-	-	67	-	-	"
816	"	6.0	8.3	-	-	-	-	72	-	-	"
818/1	ex MBV	3.6	est 5.6	-	-	-	-	64	-	-	"
818/2	in MBV	est 3.7	est 6.4	-	-	-	-	57	-	-	"
819/1	in MPV	4.5	6.2	-	-	-	-	72	-	-	"
819/2	"	4.8	6.2	-	-	-	-	77	-	-	"
822	QP PV	6.0	9.0	-	-	-	-	66	-	-	"
835	"	3.8	7.1	-	-	-	-	53	-	-	"
834	in MPV	6.7	10.4	-	-	-	-	64	-	-	"
843/1	in MBV	6.8	9.0	-	-	-	-	75	-	-	"
843/2	"	3.5	6.0	-	-	-	-	58	-	-	"
844	"	6.5	est 9.0	-	-	-	-	67	-	-	"
845/1	"	5.6	7.8	-	-	-	-	71	-	-	"
845/2	PV	4.0	5.7	-	-	-	est 2.2	70	-	39	"
845/3	"	4.7	est 6.0	-	-	-	2.4	78	-	40	"
848/1	"	5.6	9.0	-	2.1	-	3.0	62	-	33	"
848/2	BV	4.5	7.3	-	-	-	-	61	-	-	"
848/3	"	4.4	5.1	-	-	-	-	86	-	-	"
851/1	in MPV	4.5	est 7.6	-	-	-	3.2	59	-	42	"
851/2	"	4.9	8.2	-	-	-	-	59	-	-	"
851/3	PV	2.7	3.6	-	-	-	-	75	-	-	"
853/1	"	4.1	7.6	-	-	-	-	53	-	-	"
853/2	BV	6.5	10.3	-	-	-	-	63	-	-	"
854	"	5.5	8.8	-	-	-	-	62	-	-	"
855/1	PV	6.1	11.6	-	3.0	68°	est 4.7	52	-	41	"
856	"	5.1	7.0	-	2.0	66°	3.7	72	-	53	"
858/1	"	7.0	10.7	-	-	-	-	65	-	-	"
858b/2	in MPV	4.1	6.2	-	1.5	62°	3.0	66	-	48	"
858b/3	"	3.7	5.6	-	-	64°	2.4	66	-	43	"

858b/4	in MPV	2.6	4.6	-	-	-	-	56	-	-	7a
859/2	QP PV	3.8	7.0	-	-	-	-	54	-	-	"
859/3	PV	2.9	5.3	-	1.5	63°	2.2	54	-	42	"
859/4	"	3.0	5.4	-	1.5	62°	2.0	55	-	37	"
859/5	"	3.9	est 5.6	-	-	-	2.4	69	-	43	"
859/6	"	3.9	6.4	-	1.8	64°	2.5	60	-	39	"
859/7	BV	2.8	4.4	-	-	-	-	63	-	-	"
859/8	PV	2.9	5.2	-	-	-	-	55	-	-	"
859/9	"	2.8	4.5	-	-	-	-	62	-	-	"
860/3	in MPV	7.5	est 13.6	-	3.0	64°	5.0	55	-	37	"
860/4	"	5.2	est 9.6	-	2.6	65°	3.9	54	-	41	"
860/5	"	4.5	6.9	-	1.1	-	est 2.6	65	-	38	"
860/6	BV	5.7	8.0	-	-	-	-	71	-	-	"
860/8	"	5.2	8.1	-	-	-	-	64	-	-	"
860/9	"	6.0	9.4	-	-	-	-	63	-	-	"
860/10	QP BV	4.9	8.2	-	-	-	-	59	-	-	"

867	in MPV	6.0	8.0	-	2.2	64°	est 3.9	75	-	49	Lawson FC/31a
891	"	5.5	10.3	-	-	-	4.3	53	-	42	"
892	"	8.7	16.3	-	-	-	-	53	-	-	"
894	"	6.8	10.0	-	-	-	-	68	-	-	"
895/1	"	5.0	7.5	-	-	-	-	66	-	-	"
895/2	"	2.5	3.6	-	-	-	-	69	-	-	"
896/1	PV	8.2	12.2	-	-	-	-	67	-	-	"
896/2	"	8.0	12.4	-	-	-	-	64	-	-	"
898/1	in MPV	7.2	12.0	-	-	-	-	60	-	-	"
898/2	BV	5.2	7.5	-	-	-	-	69	-	-	"
898/3	PV	3.4	5.4	-	-	-	-	62	-	-	"
901	in MPV	6.2	13.2	-	3.2	63°	est 6.8	46	-	52	"
902/1	"	10.0	est 19.0	-	-	-	-	52	-	-	"
902/2	BV	9.0	est 16.0	-	-	-	-	56	-	-	"
902/3	"	6.5	10.2	-	-	-	-	63	-	-	"
903	PV	9.6	est 16.0	-	-	-	-	60	-	-	"
908	"	10.7	est 18.0	-	-	-	-	59	-	-	"
911/1	in MPV	6.0	10.8	-	-	-	-	55	-	-	"
911/2	"	9.9	15.2	-	-	-	-	65	-	-	"
912/2	"	5.0	10.6	-	-	-	-	47	-	-	"

1122	in MPV	9.5	est 16.0	-	-	-	7.2	59	-	45	W1
1123	ex MPV	6.4	est 11.2	-	-	-	-	57	-	-	"
1109	PV & QP	4.5	8.7	-	-	-	3.0	51	-	34	"
1110	in MPV	4.3	est 6.3	-	-	-	est 2.7	68	-	43	"
1116	"	4.5	7.6	-	-	-	-	59	-	-	"
1117	in MBV	4.5	8.2	-	-	-	-	54	-	-	"
1118	in MPV	7.6	14.5	-	3.8	60°	-	52	-	-	"
1119/1	"	3.9	7.0	-	-	-	-	55	-	-	"
1119/2	ex MPV	5.1	8.7	-	-	-	-	58	-	-	"
1119/3	"	5.2	8.4	-	-	-	-	61	-	-	"
1120	"	4.0	est 7.6	-	-	-	-	52	-	-	"
1121	in MBV	6.0	10.0	-	-	-	5.0	60	-	50	"
1124	in MPV	6.8	9.5	-	-	-	-	71	-	-	"
1125	"	8.3	13.0	-	-	-	6.2	63	-	48	"
1126	"	5.8	8.2	-	-	-	-	70	-	-	"
1127	"	7.0	10.1	-	-	-	-	69	-	-	"
1128	BV	7.4	est 13.6	-	-	-	-	54	-	-	"
1129	"	4.5	est 8.3	-	-	-	-	54	-	-	"
1130	PV	4.9	7.0	-	-	-	-	70	-	-	"
1131	BV	5.5	10.0	-	-	-	-	55	-	-	"

1135	PV	6.5	10.0	-	-	-	-	65	-	-	WQ
1137	"	6.6	10.1	-	-	-	-	65	-	-	"
1138	"	7.7	12.5	-	-	-	-	61	-	-	"
1136	"	9.4	13.0	-	-	-	-	72	-	-	"
1139	-	6.0	11.8	-	-	-	-	50	-	-	"
1142/1	in MPV	5.9	est 11.6	-	-	-	-	50	-	-	"
1142/2	"	8.2	est 14.0	-	-	-	-	58	-	-	"
1142/3	"	8.0	14.2	-	-	-	-	56	-	-	"
1142/4	"	7.5	11.2	-	-	-	-	66	-	-	"
1143/1	BV	8.0	13.8	-	-	-	-	57	-	-	"
1143/2	"	8.3	est 14.0	-	-	-	-	59	-	-	"
1144/1	QP PV	7.2	10.3	-	-	-	-	69	-	-	"
1144/2	"	7.5	12.7	-	-	-	-	59	-	-	"
1144/3	"	8.8	13.6	-	-	-	-	64	-	-	"
1145	in MPV	7.3	12.3	-	-	-	-	59	-	-	"
1146	"	9.1	15.8	-	-	-	-	57	-	-	"
1147	"	10.1	14.0	-	-	-	-	72	-	-	"

1149	ex MBV	7.8	13.2 est	-	-	-	-	59	-	-	WQ
1148/1	in MPV	8.2	13.8	-	-	-	-	59	-	-	"
1148/2	"	7.2	10.6	-	-	-	-	67	-	-	"
1148/3	ex MBV	8.0	12.0	-	-	-	-	66	-	-	"
1151	"	6.7	12.1	-	-	-	-	55	-	-	"
1152	in MPV	7.7	12.2	-	-	-	-	63	-	-	"
1153	"	11.1	16.8	-	-	-	-	66	-	-	"
1154/1	"	7.6	est 11.0	-	-	-	-	69	-	-	"
1154/2	"	7.7	est 11.4	-	-	-	-	67	-	-	"
1154/3	ex MBV	8.0	12.5	-	-	-	-	64	-	-	"
1155	"	8.1	12.0	-	-	-	-	67	-	-	"
1157a/1	PV & QP	9.4	13.7	-	-	-	-	68	-	-	"
1157a/2	in MPV	7.8	13.1	-	-	-	-	59	-	-	"
1157b/4	"	6.0	10.4	-	-	-	-	57	-	-	"
1162	"	7.5	11.8	-	-	-	-	63	-	-	"
1168	PV	10.8	16.3	-	-	-	-	66	-	-	"
1170	in MBV	8.1	13.8	-	-	-	5.6	58	-	41	"
1172	in MPV	5.2	9.2	-	-	-	-	56	-	-	"
1174	in BV	8.0	est 14.0	-	-	-	-	57	-	-	"
1173	QP PV	5.5	9.5	-	-	-	-	57	-	-	"
1179	in MPV	5.7	7.7	-	-	-	-	74	-	-	"
1180	"	5.5	8.9	-	-	-	-	61	-	-	"
1181	"	5.7	8.5	-	-	-	-	67	-	-	"
1182	"	4.5	5.8	-	-	-	-	77	-	-	"
1184	"	8.2	11.8	-	-	-	-	69	-	-	"
1185	"	6.8	est 13.2	-	-	-	-	51	-	-	"
1186	-	7.8	14.0	-	-	-	-	55	-	-	"
1187	BV	7.2	9.9	-	-	-	-	72	-	-	"
1189	in MPV	8.0	est 11.8	-	-	-	-	67	-	-	"
1190	"	5.5	10.2	-	-	-	-	53	-	-	"
1199	"	6.5	est 12.0	-	-	-	-	54	-	-	"
1200	"	4.9	8.8	2.0	2.3	55°	-	55	86	-	"
1202	QP PV	8.9	11.9	-	-	-	-	74	-	-	"
1205	in MPV	10.0	est 15.5	-	-	-	-	64	-	-	"

1207	in MPV	8.7	13.6	-	-	-	-	63	-	-	WQ
1210	PV	8.4	12.9	-	-	-	-	65	-	-	"
1212	BV	7.2	13.2	-	-	-	-	54	-	-	"
1213	PV	4.7	7.7	-	-	-	-	61	-	-	"
1215/1	"	10.4	est 18.4	-	-	-	-	56	-	-	"
1215/2	"	9.0	14.0	-	-	-	-	64	-	-	"
1216/1	in MBV	9.3	est 16.8	-	-	-	-	55	-	-	"
1216/2	in MPV	7.5	11.5	-	-	-	-	65	-	-	"
1220	ex MBV	8.9	14.0	-	-	-	-	63	-	-	"
1221/1	"	9.0	est 14.0	-	-	-	-	64	-	-	"
1221/2	in MPV	7.5	14.0	-	-	-	-	53	-	-	"
1222	QP PV	9.2	13.5	-	-	-	-	68	-	-	"
1223/1	in MPV	9.6	17.0	2.8	3.0	59°	-	56	93	-	"
1224	PV & QP	7.3	11.8	-	-	-	5.2	61	-	44	"
1225	in MPV	8.2	est 13.1	-	-	-	-	62	-	-	"
1226	"	6.6	est 11.8	-	-	-	-	55	-	-	"
1233	"	8.3	10.0	-	-	-	4.4	83	-	44	"
1235	"	5.8	11.0	2.0	2.4	-	-	52	83	-	"
1236/1	PV	6.8	11.6	-	-	-	-	58	-	-	"
1240	BV	8.0	15.4	-	-	-	-	51	-	-	"
1242	PV	7.0	11.0	-	-	-	-	63	-	-	"
1243	in MPV	5.2	est 7.4	-	-	-	-	70	-	-	"
1244	BV	11.0	16.2	-	-	-	-	67	-	-	"
1245	ex MBV	8.5	13.0	-	-	-	-	65	-	-	"
1247	PV	5.5	est 9.0	-	-	-	4.6	61	-	51	"
1248	in MPV	9.6	16.2	-	-	-	-	59	-	-	"
1249	-	10.6	18.0	-	-	-	-	58	-	-	"
1250	PV	9.5	14.3	-	-	-	-	66	-	-	"
1252	in MPV	7.8	15.4	3.0	3.8	60°	5.6	50	78	36	"
1252/2	ex MBV	5.0	10.4	-	-	-	-	48	-	-	"
1253/1	in MPV	7.2	12.4	2.0	3.3	64°	6.0	58	60	48	"
1253/2	ex MBV	10.0	16.0	-	-	-	-	62	-	-	"
1254/1	in MPV	9.9	est 16.8	-	-	-	-	58	-	-	"
1254/2	"	9.0	est 17.2	-	-	-	-	52	-	-	"
1255/6	in MBV	5.4	9.3	-	-	-	-	58	-	-	"
1255/7	QP PV	6.0	10.1	-	-	-	-	59	-	-	"
1255/8	ex MBV	5.6	10.0	-	-	-	-	56	-	-	"
1266/2	ex MBV	6.5	10.2	-	-	-	-	63	-	-	"
1268	QP PV	7.0	17.5	-	-	-	-	40	-	-	"

1269/1	ex MBV	9.0	13.7	-	-	-	-	65	-	-	"
1269/2	"	8.0	est 13.0	-	-	-	-	61	-	-	"
1270	-	5.7	10.0	-	-	-	-	57	-	-	"
1271/1	in MPV	6.0	10.6	-	-	-	-	56	-	-	"
1271/2	"	5.5	8.0	-	-	-	-	68	-	-	"
1271/3	"	8.7	13.8	-	-	-	-	63	-	-	"
1272/1	"	7.5	est 11.0	-	-	-	4.5	68	-	41	"
1272/2	"	7.7	12.0	-	-	-	5.2	64	-	43	"
1273/1	-	7.4	est 14.0	-	-	-	-	52	-	-	"
1273/2	ex BV	5.5	10.3	-	-	-	4.4	53	-	43	"
1274	ex MBV	5.8	9.6	-	-	-	-	60	-	-	"
1275	-	6.0	est 13.0	-	-	-	-	46	-	-	"
1276	in MBV	4.6	6.4	-	-	-	-	71	-	-	"
1277	in MPV	8.3	12.7	-	-	-	-	65	-	-	"
1278	"	8.9	13.3	-	-	-	-	66	-	-	"
1281	"	7.2	11.4	-	-	-	-	63	-	-	"
1280	"	10.5	15.0	-	-	-	-	70	-	-	"
1285	in BV	3.8	5.3	-	-	-	-	71	-	-	"
1279	BV & QP	9.4	13.1	-	-	-	-	71	-	-	"
1282	QP PV	7.8	12.2	-	-	-	-	63	-	-	"
1284	ex MBV	8.6	13.4	-	-	-	-	64	-	-	"
1283	QP PV	7.9	13.0	-	-	-	-	60	-	-	"
1286/1	ex MPV	8.0	13.6	-	-	-	-	58	-	-	"
1286/2	PV	8.9	15.6	-	-	-	-	57	-	-	"
1288/3	"	8.4	15.0	3.0	5.5	-	6.6	56	54	44	"
1307	"	9.0	est 16.0	-	-	-	-	56	-	-	"
1308	QP PV	10.0	14.0	-	-	-	-	71	-	-	"
1309/1	in MPV	5.0	8.4	-	-	-	3.8	59	-	45	"
1310/1	"	-	10.0	2.2	2.7	66°	4.4	-	81	44	"
1311	"	6.6	11.2	-	-	-	-	58	-	-	"
1312	"	4.5	est 8.6	-	-	-	-	52	-	-	"
1313	"	9.8	14.1	-	-	-	-	69	-	-	"
1314	"	6.0	9.5	-	-	-	-	63	-	-	"
1315	"	8.3	14.7	-	-	-	-	56	-	-	"
1316	ex MBV	9.5	13.0	-	-	-	-	73	-	-	"
1317	"	10.2	15.4	-	-	-	-	66	-	-	"
1318	in MPV	6.8	11.4	-	-	-	-	59	-	-	"
1319	"	9.7	14.1	-	-	-	-	68	-	-	"
1320	QP PV	9.3	14.0	-	-	-	-	66	-	-	"
1321	ex BV	8.4	14.5	-	-	-	-	57	-	-	"

1322/2	QP PV	8.0	14.0	-	-	-	-	57	-	-	WQ
1330	PV & QP	8.5	14.3	-	-	-	-	59	-	-	"
1340	in MPV	8.6	13.4	-	3.8	67°	-	64	-	-	"
1341	"	-	11.4	-	-	-	-	-	-	-	"
1342	ex MBV	6.5	est 13.0	-	-	-	-	50	-	-	"
1343	in MPV	7.2	est 11.6	2.1	3.5	61°	5.9	62	60	51	"
1344	in PV	6.6	13.0	3.0	3.7	65°	-	50	81	-	"
1345	ex MBV	8.0	12.0	-	-	-	-	66	-	-	"
1346	in MPV	9.0	16.8	-	-	-	-	53	-	-	"
1347/1	-	9.9	16.4	-	-	-	-	60	-	-	"
1347/2	in MPV	9.2	est 15.4	-	-	-	-	59	-	-	"
1348	-	7.6	11.8	-	-	-	-	64	-	-	"
1349	in MPV	6.0	11.2	-	-	-	-	53	-	-	"
1350/1	in MBV	7.5	est 11.6	-	-	-	7.0	64	-	60	"
1350/2	-	7.3	12.2	-	-	-	-	59	-	-	"
1350/3	in MPV	7.5	11.2	2.0	2.7	60°	4.5	66	74	40	"
1351	-	7.3	14.0	-	-	-	-	52	-	-	"
1352/1	BV	9.5	14.8	-	-	-	-	64	-	-	"
1352/2	ex MPV	5.1	8.9	-	-	-	-	57	-	-	"
1361	BV & QP	9.2	14.2	-	-	-	-	64	-	-	"
1368	in MPV	10.0	13.0	-	-	-	-	76	-	-	"
1369	"	9.1	17.0	-	-	-	-	53	-	-	"
1370	"	8.0	12.9	-	-	-	-	62	-	-	"
1371	"	8.5	14.0	-	-	-	-	60	-	-	"
1372	in BV	9.0	14.2	-	-	-	-	63	-	-	"
1373	in MPV	7.9	16.0	1.8	3.2	64°	6.2	49	56	39	"
1374	"	7.4	est 12.2	-	-	-	-	60	-	-	"
1375	"	8.5	14.2	2.0	3.0	60°	5.5	59	66	39	"
1377	"	4.2	est 8.2	-	-	-	-	51	-	-	"
1378	QP PV	8.6	est 16.2	-	-	-	-	53	-	-	"
1379	in MPV	10.4	16.4	-	5.7	66°	est 8.0	63	-	49	"
1380	QP PV	8.3	12.4	-	-	-	-	66	-	-	"
1381	in MPV	7.0	13.0	-	-	-	-	53	-	-	"
1382	"	10.8	est 15.8	-	-	-	-	68	-	-	"
1384/2	"	7.9	est 11.2	-	-	-	-	70	-	-	"
1383	-	7.7	12.2	-	-	-	-	63	-	-	"
1398	PV	5.1	8.8	-	-	-	-	57	-	-	"
1399	-	8.6	14.5	-	-	-	-	59	-	-	"

1404	in MPV	6.3	10.9	-	-	-	-	57	-	-	WQ
1406	"	4.9	8.3 est	-	-	-	-	59	-	-	"
1407	"	8.0	14.6	-	-	-	-	54	-	-	"
1408	ex MBV	6.5	12.2	-	-	-	-	53	-	-	"
1409	in MPV	6.5	11.6	-	-	-	-	56	-	-	"
1410	ex MBV	9.0	14.3	-	-	-	-	62	-	-	"
1411	ex BV	9.2	16.0	-	-	-	-	57	-	-	"
1412	Con.V	11.0	20.0	-	-	-	-	55	-	-	"
1415/1	in MBV	8.3	14.4	-	-	-	6.0	57	-	42	"
1415/2	ex MPV	10.5	18.9	-	-	-	-	55	-	-	"
1416	in MPV	7.9	14.9	-	-	-	-	53	-	-	"

AMPHISTROPHIA FUNICULATA

1. LUDLOW OF THE WELSH BORDERLAND

Sp. no.	T.V.	SHELL		P.V. MUSCLE FIELD			Wd	R	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	LOC.
		Ls	Ws	Lmf	Wmf	Ø						
111	in BV	8.7	13.8	-	-	-	-	4	63	-	-	LM
112	PV	9.4	20.6	-	-	-	-	-	45	-	-	"
113	BV	7.8	16.1	-	-	-	6.7	-	48	-	42	"
123	-	9.1	14.4	-	-	-	-	-	63	-	-	"
124	BV	9.5	16.7	-	-	-	-	-	56	-	-	"
320	-	11.5	est 20.8	-	-	-	-	-	55	-	-	31
327	QP PV	10.0	16.5	5.4	6.2	80°	-	-	60	87	-	"
349	"	11.3	20.8	6.8	9.2	-	-	-	54	73	-	"
383	PV	9.4	est 15.2	-	-	-	-	-	61	-	-	"
399	in MPV	11.0	18.9	8.2	8.0	-	-	-	58	102	-	"
406	in MBV	9.1	15.8	3.2	3.9	-	7.1	5	57	82	45	A2
412	ex BV	10.1	17.4	-	-	-	-	6	58	-	-	"
413	"	9.9	16.6	-	-	-	-	-	59	-	-	"
414	in MBV	8.4	12.3	1.8	2.7	-	-	-	68	66	-	"
415	ex BV	8.3	14.0	-	-	-	-	-	59	-	-	"
416	in MBV	10.2	16.2	4.5	5.7	-	-	-	62	78	-	"
417	"	9.0	16.2	3.1	3.7	-	-	-	55	83	-	"
419	PV	9.6	15.8	4.6	4.9	42°	-	-	60	93	-	"
420	ex BV	10.3	18.2	-	-	-	-	5	56	-	-	"
421	"	12.6	18.4	-	-	-	-	-	68	-	-	"
424	"	9.0	14.7	-	-	-	-	-	61	-	-	"
425	"	8.3	13.1	-	-	-	-	-	63	-	-	"
426	"	9.1	est 19.2	-	-	-	-	-	47	-	-	"
428/1	"	10.9	18.3	-	-	-	-	-	59	-	-	"
429	"	12.1	est 21.4	-	-	-	-	-	56	-	-	"
430	QP BV	10.6	19.0	-	-	-	-	-	55	-	-	"
432	in MBV	10.8	19.6	3.3	3.9	-	7.6	-	55	84	39	"
433	"	10.0	est 20.2	-	-	-	-	-	49	-	-	"
434	ex PV	7.6	14.3	-	-	-	-	5	53	-	-	"
435	"	9.5	22.8	-	-	-	-	6	44	-	-	"
436	BV	11.0	est 20.0	-	-	-	-	-	55	-	-	"
423	-	7.9	13.4	-	-	-	-	-	58	-	-	"

437b	in MPV	9.6	21.5	7.1	7.9	-	-	-	44	89	-	A3
438	QP PV	8.3	16.6	-	-	-	-	-	50	-	-	"
441	"	12.0	18.8	-	-	-	-	-	63	-	-	"
442	"	8.2	13.7	-	-	-	-	-	59	-	-	"
443	in MPV	8.5	13.4	3.8	3.7	-	-	-	63	102	-	"
444	in MBV	11.7	20.2	-	4.0	-	-	5	57	-	-	"
445	QP PV	11.3	21.2	-	-	-	-	-	53	-	-	"
447	"	8.4	12.7	-	-	-	-	-	66	-	-	"
448	"	12.6	24.4	-	-	-	-	-	51	-	-	"
449	in MPV	10.5	est 20.4	6.5	6.9	-	8.4	-	51	94	41	"
450	PV	11.0	21.0	-	-	-	-	-	52	-	-	"
452	"	10.0	21.4	-	-	-	-	-	46	-	-	"
453	"	9.8	15.8	-	-	-	-	-	62	-	-	"
456b	BV	7.9	17.0	-	-	-	-	6	46	-	-	"
451	"	7.5	12.0	-	-	-	-	6	62	-	-	"
454	PV	8.8	20.0	-	-	-	-	-	44	-	-	"
455	in MPV	10.3	20.0	5.9	5.6	60°	7.0	-	51	105	35	"
457	"	10.2	19.0	6.5	6.6	63°	7.8	-	53	98	41	"
460	QP PV	8.7	18.6	-	-	-	-	-	46	-	-	"
461	in MBV	8.8	14.5	-	-	-	-	-	61	-	-	"
462	ex BV	10.4	20.2	-	-	-	-	5	51	-	-	"
464/3	in MPV	8.3	11.6	3.0	3.2	68°	4.1	-	71	93	35	"
466/1	BV	10.5	16.1	-	-	-	-	-	65	-	-	"
468	in MPV	9.0	est 13.4	2.8	4.4	68°	-	-	67	63	-	"
469	"	9.8	16.7	8.0	6.3	-	est 7.0	-	58	126	42	"
471	QP PV	10.4	17.4	-	-	-	-	-	60	-	-	"
473	"	9.6	18.2	-	-	-	-	-	52	-	-	"
558	PV	8.5	13.8	-	-	-	-	-	61	-	-	14
560	in MPV	7.6	13.7	5.6	5.9	-	-	-	55	94	-	"
563	QP PV	9.4	11.2	6.3	6.0	-	5.9	-	83	105	53	"
565	ex PV	11.5	17.5	-	-	-	-	-	66	-	-	"
575	"	9.6	15.8	-	-	-	-	-	60	-	-	B1
582	in BV	10.0	14.4	4.0	4.2	-	est 7.0	5	69	95	49	B2
587	-	8.5	16.3	-	-	-	-	-	52	-	-	"
592	in MBV	9.5	15.8	-	-	-	-	-	60	-	-	"
597	"	11.4	23.9	-	-	-	-	5	47	-	-	B4
601/2	"	10.4	16.1	-	-	-	-	-	64	-	-	"
628	in MPV	13.0	est 22.6	-	-	-	-	-	57	-	-	B6
635	QP BV	10.1	est 22.2	-	-	-	-	5	45	-	-	"

637	in MBV	12.5	22.4	-	2.1	-	-	4	55	-	-	B7
893	QP PV	11.9	est 21.6	8.2	9.1	88^{o}	-	-	55	90	-	"
907	"	10.8	22.4	-	-	-	-	-	48	-	-	Fc/31a
909	PV	11.0	est 22.0	-	-	-	-	-	50	-	-	"
808	QP PV	7.2	10.7	-	-	-	-	-	67	-	-	7a
814/1	"	6.2	9.8	-	-	-	-	-	63	-	-	"
820	BV	6.0	10.8	-	-	-	-	-	56	-	-	"
852	"	8.0	12.4	-	-	-	-	4	64	-	-	"
859/10	ex BV	7.5	est 13.4	-	-	-	-	5	55	-	-	"
860/1	PV & QP	8.6	14.4	-	4.8	-	6.7	-	59	-	47	"
860/7	in MPV	3.2	4.6	-	-	-	-	-	69	-	-	"

1104	-	10.6	20.5	6.8	7.5	-	-	4	51	90	-	WQ
1141	BV	9.0	12.0	-	-	-	-	4	75	-	-	"
1161	ex BV	10.7	23.8	-	-	-	-	5	44	-	-	"
1167	in PV	9.1	20.8	5.5	5.5	-	-	-	43	100	-	"
1167/1	ex MBV	9.2	est 18.4	-	-	-	-	-	50	-	-	"
1177	PV	9.7	18.0	-	-	-	-	-	53	-	-	"
1195	ex MBV	10.2	est 18.2	-	-	-	-	4	56	-	-	"
1206/1	in MBV	8.5	est 12.6	-	-	-	-	-	67	-	-	"
1223/2	BV	7.5	est 13.4	-	-	-	-	4	55	-	-	"
1232	ex MPV	8.9	est 14.6	-	-	-	-	-	60	-	-	"
1238	"	9.2	14.0	-	-	-	-	-	65	-	-	"
1254/3	"	8.5	13.2	-	-	-	-	-	64	-	-	"
1255/1	in MPV	9.7	18.4	6.0	6.8	-	-	-	52	88	-	"
1255/2	ex MPV	8.4	est 13.8	-	-	-	-	-	60	-	-	"
1255/3	in MBV	10.2	est 18.6	-	-	-	-	-	54	-	-	"
1255/4	ex MBV	9.9	16.4	-	-	-	-	-	60	-	-	"
1255/5	"	10.2	17.8	-	-	-	-	-	57	-	-	"
1257	ex MPV	8.0	est 17.2	-	-	-	-	-	46	-	-	"
1263	ex MBV	9.8	20.6	-	-	-	-	5	47	-	-	"
1264	-	11.5	26.0	-	-	-	-	-	44	-	-	"
1265	-	8.7	est 16.0	-	-	-	-	-	54	-	-	"
1266/1	ex BV	8.5	14.0	-	-	-	-	-	60	-	-	"
1267	ex MPV	9.2	18.2	-	-	-	-	-	50	-	-	"
1288/2	"	10.0	16.5	-	-	-	-	-	60	-	-	"
1289	ex BV	8.6	17.7	-	-	-	-	5	48	-	-	"
1290	"	11.7	19.5	-	-	-	-	4	60	-	-	"

1291	-	9.8	est 17.0	-	-	-	-	-	57	-	-	WQ
1292	ex MBV	7.5	est 14.0	-	-	-	-	-	53	-	-	"
1293	-	8.4	15.0	-	-	-	-	-	56	-	-	"
1299/2		8.8	16.1	-	-	-	-	-	54	-	-	"
1328	ex BV	11.4	18.1	-	-	-	-	-	62	-	-	"
1329	ex PV	9.6	20.4	-	-	-	-	-	47	-	-	"
1326	PV	8.5	est 15.4	-	-	-	-	-	55	-	-	"
1357	ex MBV	8.5	20.1	-	-	-	-	-	42	-	-	"
1359	in MBV	8.0	14.0	-	3.0	-	-	4	57	-	-	"
1358	BV & QP	10.1	17.1	-	-	-	-	-	59	-	-	"
1360	in MPV	10.2	23.0	5.5	6.5	70°	-	-	44	84	-	"
1366	"	8.4	16.0	-	-	-	-	-	52	-	-	"
1384/1	ex BV	7.3	est 14.0	-	-	-	-	3	52	-	-	"
1393	"	9.5	16.5	-	-	-	-	-	57	-	-	"
1394	"	11.7	23.2	-	-	-	-	4	50	-	-	"
1400	"	9.0	18.0	-	-	-	-	-	50	-	-	"
1402	in MBV	9.8	15.9	-	-	-	-	-	61	-	-	"
1405	ex MPV	8.4	14.5	-	-	-	-	-	57	-	-	"
1423/7	ex MBV	8.3	15.0	-	-	-	-	4	55	-	-	LR
1453/2	in MPV	8.0	15.4	5.6	5.1	50°	6.8	-	51	109	44	"
1459	-	10.7	est 16.0	-	-	-	-	-	66	-	-	"
1463/7	in MBV	7.9	est 13.6	-	-	-	-	-	58	-	-	"
1463/8	in MPV	8.6	13.2	5.5	5.4	-	-	-	65	101	-	"
1498	"	7.4	est 12.0	-	4.0	-	-	-	61	-	-	"
1509/1	ex MBV	8.2	est 15.6	-	-	-	-	-	52	-	-	"
1509/2	in MBV	7.4	14.0	-	-	-	-	-	52	-	-	"
1510	in MPV	7.7	17.0	4.6	5.3	-	6.6	-	45	86	38	"
1516/2	in MBV	8.5	14.3	-	-	-	-	-	59	-	-	"
1520	in MPV	8.8	16.0	5.4	5.9	-	6.0	-	55	91	37	"
1526	ex MPV	9.0	15.3	-	-	-	-	5	52	-	-	"
1531/1	in MBV	9.8	17.3	-	-	-	-	-	56	-	-	"
1547	"	9.5	18.4	-	-	-	-	4	51	-	-	"
1546	BV & QP	8.0	16.2	-	-	-	-	4	49	-	-	"

LAWSON COLLECTION

9634	ex MPV	10.2	18.0	-	-	-	-	-	56	-	-	LS	
9632	"	10.0	19.0	-	-	-	-	-	52	-	-	"	
9612	"	9.7	est 17.4	-	-	-	-	-	55	-	-	PL	
9623	in PV	12.5	est 19.2	-	-	-	10.0	-	65	-	52	"	
9601	in MBV	7.7	est 14.0	-	-	-	-	-	55	-	-	"	
9096	PV	8.3	16.7	-	-	-	-	-	49	-	-	"	
9602	BV	7.3	14.0	-	-	-	-	4	52	-	-	"	
9595	ex MPV	12.1	est 25.0	-	-	-	-	-	48	-	-	"	
9596	in MPV	7.5	12.2	-	-	-	-	-	61	-	-	"	
9604	ex MPV	5.8	9.5	-	-	-	-	-	61	-	-	"	
9599	"	9.7	15.6	-	-	-	-	-	62	-	-	"	
9597	ex MBV	10.5	16.2	-	-	-	-	-	64	-	-	"	
9591	ex MPV	10.1	18.9	-	-	-	-	-	53	-	-	"	
9593	"	12.5	19.8	-	-	-	-	-	63	-	-	"	
9614	PV	11.4	19.8	-	-	-	-	-	57	-	-	"	
9608/1	in MPV	8.5	est 16.6	-	-	-	-	-	51	-	-	"	
9608/2	ex MPV	9.4	17.5	-	-	-	-	-	53	-	-	"	
9592	in MPV	9.2	16.6	-	-	60°	-	-	55	-	-	"	
9609/1	"	9.0	17.4	6.2	-	-	-	-	51	-	-	"	
9609/2	"	8.0	15.6	-	-	-	-	-	51	-	-	"	
9620	ex MPV	9.7	est 14.2	-	-	-	-	-	68	-	-	LS	
9638/1	in PV	9.6	16.9	-	-	-	-	-	56	-	-	"	
9638/2	in MBV	8.0	14.0	-	-	-	5.7	4	57	-	40	"	
9639	ex MBV	10.2	21.8	-	-	-	-	4	46	-	-	"	
9629	ex MBV	11.2	17.8	-	-	-	-	-	62	-	-	"	
9636	"	10.5	18.9	-	-	-	-	4	55	-	-	"	
9616	-	10.8	21.6	-	-	-	-	-	50	-	-	WN)	
9619	Con. V	11.6	22.0	-	-	-	-	-	52	-	-	")	Wenlock
9626	ex PV	10.0	17.2	-	-	-	-	-	58	-	-	")	
9627	in PV	10.0	18.6	4.9	5.5	49°	8.0	-	53	89	43	")	
9613	ex MPV	7.7	est 14.3	-	-	-	-	-	53	-	-	AA	
9617	ex MBV	9.5	14.4	-	-	-	-	4	65	-	-	"	
9618	PV	10.0	19.4	-	-	-	-	-	51	-	-	"	
9615	"	9.3	12.2	-	-	-	-	-	76	-	-	"	
9610	"	11.0	20.0	-	-	-	-	-	55	-	-	"	

2. WENLOCK OF THE WELSH BORDERLAND

A. WENLOCK LIMESTONE (NHM)

Sp. No.	T.V.	SHELL Ls	SHELL Ws	PV MUSCLE-FIELD Lmf	PV MUSCLE-FIELD Wmf	Wd	R	D_b	D_p	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	Loc.
B3912/1	Con.V	15.0	23.0	-	-	-	-	8.8	2.4	65	-	-	Dudley
B3912/2	"	10.0	16.4	-	-	-	-	3.0	1.4	61	-	-	"
B3912/3	in PV	14.6	21.9	9.5	6.9	9.8	-	3.4	-	67	138	45	"
BB50361	Con.V	12.6	21.4	-	-	-	5	5.6	-	59	-	-	"
B748	in PV	14.6	24.3	10.5	7.0	-	-	-	-	60	143	-	"
B23157/2	ex BV	11.7	21.0	-	-	-	5	-	-	56	-	-	"
24018/1	in PV	11.3	19.4	6.5	5.7	7.0	-	-	-	58	114	36	"
24018/2	"	12.0	20.7	7.2	5.3	7.4	-	5.1	-	58	136	36	"
24018/3	Con.V	12.4	20.0	-	-	-	4	6.5	2.1	62	-	-	"
24018/4	"	13.4	21.3	-	-	-	5	4.2	est 1.3	63	-	-	"
B747/1	in PV	11.7	19.7	6.7	5.5	7.0	-	-	-	59	121	36	"
B747/2	ex BV	11.5	18.8	-	-	-	4	-	-	61	-	-	"
B82155/1	Con.V	14.9	25.1	-	-	-	5	5.4	1.2	59	-	-	"
B82154	"	14.6	23.1	-	-	-	5	8.2	1.6	63	-	-	"
B23161/1	ex BV	12.5	21.7	-	-	-	5	5.5	-	58	-	-	"
B23161/2	Con.V	11.6	17.8	-	-	-	5	6.3	2.0	65	-	-	"
BB70270/1	"	12.0	18.1	-	-	-	5	6.5	-	66	-	-	"
BB70270/2	"	14.2	22.1	-	-	-	5	6.2	2.3	64	-	-	"
9776/1	"	13.7	21.3	-	-	-	5	6.3	1.6	64	-	-	"
97761	"	12.3	21.2	-	-	-	5	-	-	58	-	-	"
80404	in PV	15.5	27.4	9.0	7.3	9.0	-	-	-	57	123	33	"
80430	Con.V	12.9	21.7	-	-	-	4	5.8	-	59	-	-	"
21032/1	in PV	10.2	18.3	6.2	5.8	7.9	-	-	-	56	107	43	"
21032/2	"	10.8	19.9	7.1	6.3	9.5	-	-	-	54	112	48	"
BB77420/1	Con.V	14.3	est 21.0	-	-	-	4	5.2	-	68	-	-	Shropshire
BB77420/2	"	10.7	est 17.7	-	-	6.2	5	-	-	60	-	35	"
BB77420/3	"	13.3	est 18.6	-	-	-	-	4.0	-	72	-	-	"
BB77420/4	"	12.3	20.0	-	-	-	-	6.4	2.7	62	-	-	"

B. WENLOCK LIMESTONE (BGS)

Sp. No.	T.V.	Ls	Ws	Lmf	Wmf	Wd	R	D_b	D_p	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	Loc.
13311	Con.V	12.5	19.5	-	-	7.0	4	4.1	1.6	64	-	36	Dudley
13312	"	13.7	22.7	-	-	-	4	7.5	1.9	60	-	-	"
13313	in PV	13.0	20.7	7.1	5.8	7.7	-	-	-	63	122	37	"
13314	Con.V	11.1	18.0	-	-	-	5	-	-	62	-	-	"

13315	Con.V	9.9	17.2	-	-	-	5	5.4	1.5	58	-	-	Dudley
13316	"	12.5	19.3	-	-	-	-	7.4	-	65	-	-	"
ZL1564	in PV	12.6	21.2	7.0	5.5	-	-	-	-	59	127	-	"
ZL1565	Con.V	12.5	19.4	-	-	-	5	6.3	2.0	64	-	-	"
ZL1566	"	15.9	22.9	-	-	-	5	-	1.6	69	-	-	"
ZL1569	in PV	11.9	19.4	7.0	5.5	7.5	-	-	-	61	127	39	"
ZL1570	"	15.3	25.6	8.5	6.5	11.1	-	-	-	60	131	43	"
ZL1568	"	11.2	18.8	6.1	5.1	8.1	-	-	-	59	120	43	"
ZL1567	"	14.2	23.0	7.0	6.6	-	-	-	-	62	106	-	"
13310/1	"	16.2	27.3	9.6	7.0	10.2	-	-	-	59	137	37	"
13310/2	"	13.3	22.2	7.7	6.5	-	-	-	-	60	118	-	"
YFF9615	ex BV	13.0	22.1	-	-	-	5	-	-	59	-	-	Usk

C. WENLOCK SHALE (NHM)

B3314	in PV	10.5	20.7	6.0	5.7	7.2	-	-	-	51	105	35	Garcoed
B34850/1	Con.V	14.4	20.6	-	-	-	5	4.3	1.3	70	-	-	Dudley
B34850/2	"	10.1	16.6	-	-	-	5	3.4	1.1	61	-	-	"

D. WENLOCK SHALE (BGS)

RT463	ex BV	7.2	10.6	-	-	-	7	-	-	68	-	-	MW
DEX3394	QP PV	13.8	est 24.6	-	-	-	-	-	-	56	-	-	Dyfed
DEX2823	in MPV	7.5	13.0	-	-	-	-	-	-	58	-	-	"
DEX2887	"	16.6	26.3	5.1	5.3	-	-	-	-	63	96	-	"
DEX2888	QP PV	18.0	26.6	-	-	-	-	-	-	68	-	-	"

E. WENLOCK LIMESTONE (LAWSON COLLECTION)

JDL1	Con.V	12.5	22.7	-	-	-	-	-	-	55	-	-	WBL
JDL2	"	15.1	21.9	-	-	-	-	-	-	69	-	-	"
JDL3	ex BV	10.5	17.7	-	-	-	-	-	-	59	-	-	"
JDL4	"	14.0	21.3	-	-	-	-	-	-	66	-	-	"
JDL5	Con.V	12.5	18.5	-	-	-	-	-	-	68	-	-	"
JDL6	in PV	10.6	18.0	6.8	6.4	-	-	-	-	59	106	-	"
JDL7	ex BV	13.1	21.7	-	-	-	-	-	-	60	-	-	"
JDL8	in PV	13.2	20.7	7.5	7.0	-	-	-	-	64	107	-	"
JDL9	ex BV	11.2	17.3	-	-	-	-	-	-	65	-	-	"
JDL10	"	12.4	est 21.6	-	-	-	-	-	-	57	-	-	"
JDL11	-	13.1	24.0	-	-	-	-	-	-	55	-	-	"
JDL12	in PV	9.6	15.2	5.3	5.1	-	-	-	-	63	104	-	"

JDL13	ex BV	13.5	23.5	-	-	-	-	-	-	57	-	-	WBL
JDL14	"	13.2	20.7	-	-	-	-	-	-	64	-	-	"
JDL15	"	12.7	20.4	-	-	-	-	-	-	61	-	-	"
JDL16	"	13.9	22.9	-	-	-	-	-	-	61	-	-	"
JDL17	"	13.5	23.4	-	-	-	-	-	-	58	-	-	"
JDL18	"	8.7	17.0	-	-	-	-	-	-	51	-	-	"
JDL19	"	12.6	20.3	-	-	-	-	-	-	62	-	-	"
JDL20	Con.V	13.0	20.3	-	-	-	-	-	-	64	-	-	"

F. WENLOCK LIMESTONE (NMW)

70.3G.16	ex BV	11.7	18.3	-	-	-	5	-	-	64	-	-	Dudley
70.3G.17	in PV	13.1	20.0	6.0	4.7	6.0	-	-	-	66	128	30	"
70.3G.18	"	12.6	20.1	7.4	5.8	6.7	-	-	-	63	128	33	"
70.3G.19	in MBV	11.5	19.6	-	-	-	-	-	-	59	-	-	"
70.3G.21	in MPV	13.9	24.0	9.0	6.8	-	-	-	-	58	132	-	"
70.3G.22	in MBV	13.0	22.8	-	-	-	5	-	-	57	-	-	"
27.110G 1019/1	ex PV	11.8	20.0	-	-	-	-	-	-	59	-	-	"
27.110G 1019/2	ex BV	11.6	18.7	-	-	-	-	-	-	62	-	-	"
27.110G 1019/3	"	9.7	15.2	-	-	-	-	-	-	64	-	-	"
27.110G 1019/4	ex PV	13.8	22.9	-	-	-	-	-	2.0	60	-	-	"
14.311G 968	Con.V	11.6	18.4	-	-	-	-	-	-	63	-	-	"
G300/1	in PV	11.8	20.0	-	-	-	-	-	-	59	-	-	"
G300/2	"	13.5	23.6	8.0	6.7	-	-	-	-	57	119	-	"
93-136/1	ex BV	9.4	17.5	-	-	-	5	-	-	54	-	-	"
93-136/2	in PV	12.3	21.2	7.5	6.4	-	-	-	-	58	117	-	"
93-136/3	"	11.2	19.4	7.0	7.0	-	-	-	-	58	100	-	"
G774	Con.V	12.9	20.5	-	-	-	-	4.8	2.0	63	-	-	"

3. WENLOCK OF GOTLAND

A. WENLOCK SHALE OF EKSTA AND MULDE OF FRÖJD (NHM)

B88079	ex BV	9.8	19.3	-	-	-	7	6.0	-	51	-	-
B88080	Con.V	8.4	15.0	-	-	-	-	-	-	56	-	-
B13563	"	10.1	19.2	-	-	-	8	7.3	1.8	53	-	-
64644/1	"	10.8	18.4	-	-	-	6	-	-	59	-	-
64644/2	"	13.7	24.0	-	-	-	-	11.4	-	57	-	-
64644/3	"	10.9	20.6	-	-	-	6	5.5	2.2	53	-	-

64644/4	in PV	8.7	16.3	4.8	5.3	5.9	-	-	-	53	91	36
BC7728/1	Con.V	10.6	22.0	-	-	-	7	6.9	2.1	48	-	-
BC7728/2	"	11.0	17.6	-	-	-	6	5.9	2.0	62	-	-
BC7728/3	"	8.8	19.0	-	-	-	7	-	-	46	-	-
BC7728/4	"	9.4	15.2	-	-	-	7	-	2.2	62	-	-
BC7728/5	"	9.5	19.6	-	-	-	-	-	-	48	-	-
BC7728/6	"	9.8	15.9	-	-	-	6	4.1	-	62	-	-
BC4363	"	13.5	22.4	-	-	-	5	6.8	2.6	60	-	-
BC7511	in PV	8.4	18.0	4.3	4.8	-	-	-	-	47	90	-

B. WALMSLEY COLLECTION FROM MULDE MARL OF KLINTE (NMW)

W.G.12/1	ex PV	10.5	25.6	-	-	-	-	-	-	41	-	-
W.G.12/2	in PV	9.0	24.0	4.7	4.5	5.0	4	-	2.6	38	104	21
W.G.12/3	ex PV	11.3	22.5	-	-	-	-	-	3.0	50	-	-
W.G.12/4	"	10.7	est 25.0	-	-	-	-	-	-	43	-	-
W.G.12/5	in PV	9.0	24.4	-	-	-	-	-	-	37	-	-
W.G.12/6	"	8.1	16.0	-	-	-	-	-	-	51	-	-
W.G.12/7	"	10.9	22.8	5.5	5.2	6.1	-	-	-	48	106	27
W.G.12/8	"	8.0	est 15.0	-	-	-	-	-	-	53	-	-
W.G.12/9	"	8.5	19.8	4.0	5.0	-	-	-	-	43	80	-
W.G.12/10	"	9.0	27.5	-	-	-	-	-	-	33	-	-

C. WALMSLEY COLLECTION FROM SHELLY LIMESTONE OF KLINTE (NMW)

W.G.14/1	PV	11.0	21.6	-	-	-	-	-	-	51	-	-
W.G.14/2	"	11.5	22.0	-	-	-	-	-	-	52	-	-
W.G.14/3	"	10.7	17.4	-	-	-	-	-	-	61	-	-
W.G.14/4	"	10.7	19.4	-	-	-	-	-	-	55	-	-

STROPHONELLA EUGLYPHA

1. FROM LUDLOW SERIES OF THE WELSH BORDERLAND

Sp. no.	T.V.	SHELL		P.V. MUSCLE FIELD		Wd	R	3/4	W 3/4	% Ls/Ws	% Lmf/Wmf	% Wd/Ws	Loc.
		Ls	Ws	Lmf	Wmf			Ls	Ls				
127	BV	33.0	est 41.0	-	-	-	4	-	-	80	-	-	LM
128	ex BV	23.4	26.5	-	-	-	-	-	-	88	-	-	"
129	"	31.3	33.5	-	-	-	-	-	-	93	-	-	"
130	in BV	35.2	45.7	-	-	-	-	-	-	77	-	-	"
131	ex PV	26.3	est 31.9	-	-	-	-	-	-	82	-	-	"
132	PV	41.6	38.0	-	-	-	-	-	-	109	-	-	"
133	BV	24.3	24.0	-	-	-	-	-	-	101	-	-	"
134	PV	35.4	41.1	-	-	-	-	-	-	86	-	-	"
135	BV	20.8	est 28.0	-	-	-	-	-	-	74	-	-	"
136	in PV	19.6	36.4	9.7	11.4	-	-	-	-	53	85	-	"
138	in MPV	35.0	42.2	-	-	-	-	-	-	82	-	-	"
139	ex BV	24.3	41.6	-	-	-	-	-	-	58	-	-	"
140	ex PV	30.5	40.3	-	-	-	-	-	-	75	-	-	"
141	BV	27.0	est 40.0	-	-	11.9	-	-	-	67	-	31	"
142	"	31.5	est 43.6	-	-	est 11.9	-	-	-	72	-	27	"
143	"	26.5	30.8	-	-	-	-	-	-	86	-	-	"
144	"	31.0	30.8	-	-	-	-	-	-	100	-	-	"
145	-	22.0	est 29.0	-	-	-	-	-	-	75	-	-	"
146	BV	21.8	est 30.2	-	-	-	-	-	-	72	-	-	"
147	"	38.7	42.8	-	-	-	-	-	-	90	-	-	"
148	-	27.0	41.6	-	-	-	-	-	-	64	-	-	"
149	-	22.0	32.6	-	-	-	-	-	-	67	-	-	"
150	ex PV	29.4	est 32.6	-	-	14.4	-	-	-	90	-	44	"
151	"	32.7	38.0	-	-	-	-	-	-	86	-	-	"
152	"	38.3	est 50.0	-	-	16.2	-	-	-	76	-	32	"
153	in PV	18.2	est 42.8	-	-	10.7	-	-	-	42	-	25	"
154	BV	37.4	55.0	-	-	-	-	-	-	67	-	-	"
155	PV	36.6	42.2	-	-	-	-	-	-	84	-	-	"
156	"	37.3	38.2	-	-	-	-	-	-	97	-	-	"
157	in PV	26.0	est 28.4	11.5	14.7	-	-	-	-	91	78	-	"
158	-	32.0	43.8	-	-	-	-	-	-	73	-	-	"
159	PV	39.0	45.1	-	-	-	-	-	-	86	-	-	"
160	ex MPV	35.7	est 50.0	-	-	-	-	-	-	71	-	-	"
161	PV	33.2	38.3	-	-	-	-	-	-	86	-	-	"

162	PV	35.7	est 45.2	-	-	16.0	-	-	-	78	-	35	LM
163	"	31.6	32.9	-	-	-	-	-	-	96	-	-	"
164	"	37.2	39.0	-	-	-	-	-	-	95	-	-	"
165	"	42.5	est 39.8	-	-	est 15.0	-	-	-	106	-	37	"
166	"	43.0	est 44.6	-	-	-	-	-	-	96	-	-	"
167	-	29.0	30.3	-	-	9.3	-	-	-	95	-	30	"
168	-	23.6	26.2	7.7	10.1	-	-	-	-	90	76	-	"
169	PV	44.5	35.9	-	-	13.7	-	-	-	120	-	38	"
170	"	38.9	-	-	-	14.3	-	-	-	-	-	-	"
171	"	37.4	39.0	-	-	13.0	-	-	-	95	-	33	"
181	PV	39.3	41.9	-	-	-	-	-	-	93	-	-	31
186	"	25.2	est 40.4	-	-	-	-	-	-	62	-	-	"
195	"	40.7	est 38.8	-	-	-	-	30.5	20.8	104	-	-	"
197b	QP PV	25.6	36.0	-	-	-	-	-	-	71	-	-	"
198b	-	20.8	est 32.4	-	-	-	-	-	-	64	-	-	"
201	-	33.1	est 33.4	-	-	-	-	-	-	99	-	-	"
210	-	34.2	40.6	-	-	-	-	25.7	23.4	84	-	-	"
250	BV	22.6	31.0	-	-	-	-	-	-	72	-	-	"
252b	PV	26.7	est 38.4	-	-	-	-	-	-	69	-	-	"
253b/1	QP BV	22.0	20.2	-	-	-	6	-	-	108	-	-	"
254	ex PV	19.3	21.5	-	-	-	-	-	-	65	-	-	"
256	PV	33.2	est 43.0	-	-	-	-	-	-	77	-	-	"
261	"	30.0	50.4	-	-	-	-	-	-	59	-	-	"
274/1	"	17.0	est 25.0	-	-	-	-	-	-	68	-	-	"
274/2	"	-	43.8	-	-	-	-	-	-	-	-	-	"
275	-	18.1	24.5	-	-	-	-	-	-	73	-	-	"
276	ex PV	24.5	est 37.8	-	-	-	-	-	-	64	-	-	"
277	in BV	24.5	26.8	-	-	-	-	-	-	91	-	-	"
278	PV	27.3	36.0	-	-	-	-	20.5	18.0	51	-	-	"
286b/1	QP BV	16.2	22.1	-	-	-	6	-	-	73	-	-	"
286b/2	QP PV	13.9	20.2	-	-	-	-	-	-	68	-	-	"
286a/3	-	13.5	16.4	-	-	-	-	-	-	82	-	-	"
287/1	BV	21.5	est 21.0	-	-	est 11.2	6	16.1	14.5	102	-	53	"
334	"	20.3	22.8	-	-	-	5	-	-	89	-	-	"
352	"	12.3	27.6	-	-	12.4	-	-	-	44	-	44	"
355	PV	34.7	29.4	-	-	-	-	-	-	118	-	-	"
356	ex PV	17.5	26.2	-	-	-	-	-	-	66	-	-	"

365/1	BV	18.9	27.0	-	-	-	5	-	-	70	-	-	31
367	-	18.1	est 25.3	-	-	-	-	-	-	71	-	-	"
368	BV	12.9	12.4	-	-	-	-	-	-	104	-	-	"
370	-	25.6	31.2	-	-	-	5	-	-	82	-	-	"
376	BV	est 33.0	est 40.6	-	-	-	-	-	-	81	-	-	"
378/1	"	37.1	30.8	-	-	14.0	-	27.8	21.2	120	-	45	"
378/2	"	31.0	est 36.0	-	-	-	4	23.2	20.1	86	-	-	"
379	"	-	38.8	-	-	-	-	-	-	-	-	-	"
380/1	ex BV	31.6	est 34.6	-	-	-	-	-	-	91	-	-	"
384	BV	22.0	29.2	-	-	-	4-5	-	-	75	-	-	"
387	"	27.3	29.9	-	-	-	-	-	-	91	-	-	"
388	PV	21.1	29.2	-	-	11.0	-	-	-	72	-	37	"
390	"	40.0	38.7	-	-	-	-	-	-	103	-	-	"
391	BV	-	19.0	-	-	-	5	-	-	-	-	-	"
395	-	31.5	46.6	-	-	-	-	-	-	67	-	-	"
397	-	35.4	32.8	-	-	-	-	-	-	107	-	-	"
400	BV	14.9	20.2	-	-	-	-	-	-	73	-	-	"
401	PV	29.8	est 36.6	-	-	-	-	-	-	81	-	-	"
402	"	26.7	39.1	9.3	8.3	19.3	-	-	-	68	112	49	"
404	"	29.5	est 33.0	-	-	-	-	-	-	89	-	-	"
405	"	32.2	39.0	-	-	-	-	-	-	82	-	-	"
408	PV	23.3	33.9	-	-	-	-	-	-	68	-	-	A1
409	BV	29.5	35.0	-	-	-	-	-	-	84	-	-	"
549	PV	33.4	est 38.6	-	-	-	-	-	-	86	-	-	14
550	in MPV	33.3	35.6	-	-	-	-	-	-	93	-	-	"
551	"	29.7	34.7	-	-	-	-	-	-	85	-	-	"
554	in MBV	21.8	est 30.8	-	-	est 16.4	-	-	-	70	-	53	"
556	PV	29.3	42.6	-	-	-	-	-	-	68	-	-	"
557	BV	28.0	est 26.2	-	-	-	5	-	-	77	-	-	"
559	in MPV	33.5	34.4	-	-	-	-	-	-	97	-	-	"
566	"	32.8	42.5	-	-	-	-	-	-	77	-	-	"
578	in MBV	41.2	est 39.4	-	-	17.2	3	-	-	104	-	-	B1
577	BV	37.7	39.6	-	-	-	3	28.3	25.8	95	-	-	"
576	"	28.8	52.0	-	-	-	-	-	-	74	-	-	"
579	-	28.4	33.4	-	-	-	-	-	-	85	-	-	"
569	-	43.0	est 44.5	-	-	-	5	-	-	96	-	-	"
570	-	29.6	43.4	-	-	-	-	22.2	22.2	68	-	-	"

571	PV	41.7	est 43.7	-	-	19.9	-	-	-	95	-	45	B1
574	BV	43.5	48.0	-	-	-	5	32.6	23.4	90	-	-	"
580	-	42.9	44.3	-	-	-	-	-	-	96	-	-	"
583	BV	35.5	35.0	-	-	-	7	-	-	101	-	-	B2
584	"	38.5	est 40.0	-	-	-	-	28.9	21.7	96	-	-	"
585	in MPV	33.5	39.8	10.5	17.0	-	-	25.2	24.4	84	61	-	"
586	BV	34.0	34.0	-	-	-	3	-	-	100	-	-	"
588	in MBV	33.6	35.1	-	-	-	-	-	-	95	-	-	"
590	BV	32.5	33.1	-	-	-	3	-	-	98	-	-	"
581	in MPV	32.4	est 43.0	-	-	-	-	-	-	75	-	-	"
591/1	ex BV	33.7	38.5	-	-	-	4	-	-	87	-	-	"
594	in MPV	27.8	38.8	13.3	17.6	17.6	-	20.9	21.8	71	75	45	"
601/3	"	-	38.0	10.0	12.5	-	-	-	-	-	80	-	B4
602/5	ex MBV	29.6	38.4	-	-	-	5	22.5	19.3	77	-	-	"
605/1	ex BV	20.0	22.9	-	-	-	6	-	-	87	-	-	B5
611	in MBV	38.2	41.4	-	-	16.4	-	-	-	92	-	39	"
616/1	"	20.2	25.0	-	-	-	6	-	-	80	-	-	"
616/2	in MPV	29.9	est 36.0	-	-	18.1	-	22.4	18.6	83	-	50	"
634	ex BV	22.8	32.4	-	-	-	-	-	-	70	-	-	B6
636	in MPV	34.5	40.2	-	-	-	-	-	-	85	-	-	B7
638	BV	40.4	est 43.2	-	-	-	-	-	-	93	-	-	"
639	in MBV	35.9	est 41.2	-	-	est 18.8	4	26.9	26.0	87	-	45	"
640	PV	38.0	36.4	-	-	-	-	-	-	104	-	-	"
641	ex BV	33.7	40.6	-	-	-	3	25.3	20.9	83	-	-	"
642	-	30.6	est 45.0	-	-	-	-	-	-	68	-	-	"
643	in MBV	39.7	est 47.6	-	8.5	est 20.0	3	29.8	25.5	83	-	42	"
644	-	41.0	48.8	-	-	-	-	-	-	84	-	-	"
645	in MBV	38.6	43.9	-	7.7	-	3	29.0	25.1	87	-	-	"
646	"	32.2	42.0	-	-	-	-	-	-	76	-	-	"
647	"	33.6	37.3	-	-	-	3	25.2	19.8	90	-	-	"
648	BV	34.4	37.0	-	-	-	-	-	-	92	-	-	"
649	in MPV	37.2	42.0	11.0	15.5	-	-	27.9	23.8	88	70	-	"
650	-	-	45.7	-	-	-	-	-	-	-	-	-	"
651	in MPV	32.8	41.7	-	-	-	-	-	-	78	-	-	"
652	"	39.0	44.1	-	-	-	-	-	-	88	-	-	"
653	BV	36.8	est 45.0	-	-	-	-	-	-	81	-	-	"
654	"	36.1	42.5	-	-	-	-	-	-	84	-	-	"
655	"	31.0	est 41.0	-	-	-	-	-	-	75	-	-	"

813	QP PV	24.1	32.4	-	-	-	-	-	-	74	-	-	7a
821	PV	21.7	25.4	-	-	-	-	-	-	85	-	-	"
823	ex BV	22.8	est 29.4	-	-	-	-	-	-	77	-	-	"
824b/1	QP PV	23.2	est 32.2	-	-	-	-	-	-	72	-	-	"
824b/2	in MPV	22.0	37.0	-	-	-	-	-	-	59	-	-	"
824b/3	"	20.5	32.0	-	-	-	-	-	-	64	-	-	"
824b/4	"	19.8	est 33.0	-	-	-	-	-	-	60	-	-	"
825/1	PV	18.9	27.1	-	-	-	-	-	-	69	-	-	"
825/2	"	21.8	est 35.0	-	-	-	-	-	-	62	-	-	"
817/1	"	20.2	32.8	-	-	-	-	-	-	61	-	-	"
817/2	BV	20.7	est 28.4	-	-	-	6	-	-	72	-	-	"
826	in MBV	33.2	34.0	-	-	-	4	-	-	110	-	-	"
828	"	36.0	est 42.0	-	-	-	-	-	-	85	-	-	"
829	PV	24.5	46.4	-	-	-	-	-	-	52	-	-	"
830	"	est 21.4	est 45.4	-	-	-	-	-	-	47	-	-	"
831	BV	28.7	est 45.0	-	-	-	-	-	-	63	-	-	"
832	PV	24.9	est 37.4	-	-	-	-	-	-	66	-	-	"
833	"	22.0	32.4	-	-	10.8	-	-	-	67	-	33	"
836	in MBV	19.4	25.4	-	-	9.0	6	-	-	76	-	35	"
841	"	-	est 23.4	-	-	est 8.8	-	-	-	-	-	37	"
842	PV	18.8	est 27.8	-	-	-	-	-	-	67	-	-	"
846	"	21.3	35.4	-	-	-	-	-	-	60	-	-	"
847	"	20.7	est 25.4	-	-	-	-	-	-	81	-	-	"
849	-	28.8	31.0	-	-	-	-	-	-	92	-	-	"
857	BV	28.2	est 30.0	-	-	-	-	-	-	94	-	-	"
861b	"	21.5	32.0	-	-	-	-	-	-	67	-	-	"
862/1	-	24.5	31.7	-	-	-	-	-	-	77	-	-	"
862/2	BV	25.7	28.5	-	-	-	6	-	-	90	-	-	"
913/1	PV	19.5	28.2	-	-	-	-	-	-	69	-	-	"
913/2	"	26.4	32.5	-	-	-	-	-	-	81	-	-	"

731	ex BV	21.8	33.5	-	-	-	6	-	-	65	-	-	C1-8
732	-	30.0	37.0	-	-	-	-	-	-	81	-	-	"
733	in PV	33.5	35.6	-	-	-	-	-	-	94	-	-	"
734	BV	37.8	42.8	-	-	-	-	-	-	88	-	-	"
735	-	38.5	est 43.0	-	-	-	-	-	-	89	-	-	"
738	-	33.6	est 48.0	-	-	-	-	-	-	70	-	-	"
736	BV	32.5	47.0	-	-	-	-	-	-	69	-	-	"
1100	BV	24.9	37.2	-	-	-	-	-	-	71	-	-	SH
1102	in MPV	34.1	est 45.1	-	-	-	-	-	-	75	-	-	"
1103	"	30.4	38.8	-	-	est 19.2	-	-	-	78	-	49	"
1105	-	33.4	est 47.0	-	-	-	-	-	-	71	-	-	"
1106	BV	31.6	est 43.0	-	-	-	-	-	-	73	-	-	"
1107	ex PV	28.1	45.6	-	-	-	-	-	-	61	-	-	"
1134	in BV	19.4	25.4	-	-	-	-	-	-	76	-	-	WQ
1132	in MBV	24.7	est 33.0	-	-	-	4	-	-	74	-	-	"
1142/5	ex MBV	22.7	31.1	-	-	-	-	-	-	72	-	-	"
1150	in MBV	28.7	27.0	-	-	14.6	-	21.5	16.1	106	-	54	"
1156	ex BV	22.6	est 30.2	-	-	-	6	-	-	74	-	-	"
1158	"	39.0	-	-	-	-	-	-	-	-	-	-	"
1160	ex MBV	39.1	39.9	-	-	-	-	-	-	97	-	-	"
1163	PV	30.6	38.0	-	-	-	-	-	-	80	-	-	"
1165	ex MBV	31.4	37.2	-	-	-	6	23.6	20.6	84	-	-	"
1171	in MBV	34.5	est 46.0	-	-	-	-	25.9	21.8	75	-	-	"
1175	ex BV	25.0	34.8	-	-	-	-	-	-	71	-	-	"
1176	-	24.0	34.8	-	-	-	-	-	-	68	-	-	"
1166/1	ex MBV	27.0	32.6	-	-	-	-	20.1	17.8	82	-	-	"
1166/2	"	36.1	32.5	-	-	-	-	-	-	111	-	-	"
1178	in MBV	34.1	est 37.1	-	-	-	-	-	-	91	-	-	"
1188	ex MPV	31.0	37.0	-	-	-	-	23.3	19.0	83	-	-	"
1191	"	25.4	28.0	-	-	-	-	-	-	90	-	-	"
1193	ex MBV	28.1	35.9	-	-	-	-	21.1	18.2	78	-	-	"
1196	-	26.5	30.4	-	-	-	-	-	-	87	-	-	"
1197	PV	20.4	est 25.0	-	-	-	-	-	-	81	-	-	"
1201	ex MPV	37.3	est 52.0	-	-	-	-	28.0	24.3	71	-	-	"
1203	in PV	31.4	39.9	12.0	14.2	-	-	23.6	19.6	78	85	-	"
1204	in BV	30.9	est 39.8	-	-	-	-	-	-	77	-	-	"
1208	-	29.0	41.0	-	-	-	-	-	-	70	-	-	"
1209	-	28.6	41.6	-	-	-	-	-	-	68	-	-	"

1211	in MBV	34.8	est 42.0	-	-	-	-	-	-	82	-	-	WQ
1217	in PV	26.5	33.2	-	-	-	-	-	-	79	-	-	"
1218	"	29.2	35.5	-	-	-	-	-	-	82	-	-	"
1219	ex MPV	29.1	37.0	-	-	-	-	-	-	78	-	-	"
1227/1	ex MBV	19.6	est 23.6	-	-	-	-	-	-	83	-	-	"
1228	in MBV	30.1	36.2	-	-	-	-	-	-	83	-	-	"
1229	in PV	30.2	41.8	12.5	15.2	-	-	22.7	18.8	72	82	-	"
1230	"	29.1	44.6	12.6	16.0	-	-	-	-	65	78	-	"
1231	ex MPV	29.9	37.4	-	-	-	-	22.4	19.2	79	-	-	"
1234	"	25.5	33.7	-	-	-	-	-	-	75	-	-	"
1237	in MPV	20.3	est 25.0	-	-	-	-	-	-	81	-	-	"
1239	ex MPV	34.6	est 38.2	-	-	-	-	-	-	90	-	-	"
1258	"	29.6	37.7	-	-	-	-	-	-	78	-	-	"
1259	in PV	22.7	28.1	-	-	-	-	-	-	80	-	-	"
1260	-	39.0	est 43.0	-	-	-	-	-	-	90	-	-	"
1297	-	39.0	44.9	-	-	-	-	-	-	86	-	-	"
1298	ex MPV	31.1	44.0	-	-	-	-	-	-	70	-	-	"
1299/1	in MBV	28.7	est 37.0	-	-	-	-	-	-	77	-	-	"
1301	-	31.0	est 36.0	-	-	-	-	-	-	86	-	-	"
1302	in PV	29.7	39.8	13.6	13.6	-	-	22.3	21.4	74	100	-	"
1303	ex MPV	29.1	34.3	-	-	-	-	-	-	84	-	-	"
1305	QP BV	25.7	est 37.6	-	-	-	-	-	-	68	-	-	"
1306	ex MPV	28.2	36.2	-	-	-	-	-	-	77	-	-	"
1331	ex PV	31.2	33.2	-	-	-	-	23.4	19.4	93	-	-	"
1332	ex MPV	38.3	est 48.0	-	-	-	-	-	-	79	-	-	"
1333	"	34.5	47.7	-	-	-	-	25.9	23.4	72	-	-	"
1334	ex BV	25.5	35.4	-	-	-	-	-	-	72	-	-	"
1335	in MBV	33.5	42.5	-	-	-	-	-	-	78	-	-	"
1336	-	28.4	31.2	-	-	-	-	-	-	91	-	-	"
1337	ex MPV	30.8	37.8	-	-	-	-	23.1	19.2	81	-	-	"
1338	"	24.7	est 36.2	-	-	-	-	-	-	68	-	-	"
1339	ex PV	27.8	est 38.0	-	-	-	-	-	-	73	-	-	"
1362	ex MBV	25.3	32.5	-	-	-	-	19.0	16.9	77	-	-	"
1363	ex MPV	24.7	est 36.2	-	-	-	-	-	-	68	-	-	"
1364	wx MBV	30.0	est 39.2	-	-	-	-	-	-	76	-	-	"
1365/1	ex MBV	25.6	42.4	-	-	-	-	-	-	60	-	-	"
1365/2	"	25.5	est 40.8	-	-	-	-	-	-	62	-	-	"
1367	in PV	31.4	40.4	-	est 13.6	16.2	-	-	-	77	-	40	"
1385	"	32.3	37.0	14.0	16.6	-	-	-	-	87	84	-	"

1386	ex MPV	31.4	34.8	-	-	-	-	-	-	90	-	-	WQ
1387	-	26.4	34.0	-	-	-	-	-	-	77	-	-	"
1388	ex MPV	24.3	33.9	-	-	-	-	-	-	71	-	-	"
1389	-	28.9	33.4	-	-	-	-	-	-	86	-	-	"
1390	ex PV	29.4	34.9	-	-	-	-	-	-	84	-	-	"
1391	ex MPV	27.0	35.4	-	-	-	-	-	-	76	-	-	"
1392	in PV	30.6	49.5	-	-	-	-	-	-	61	-	-	"
1401	ex MPV	26.8	31.5	-	-	-	-	-	-	85	-	-	"
1414	"	11.4	13.6	-	-	-	-	-	-	83	-	-	"
1416/2	"	27.2	34.5	-	-	-	-	-	-	78	-	-	"
1417	"	28.3	39.0	-	-	-	-	21.2	19.9	72	-	-	"
1418	-	32.0	50.6	-	-	-	4	-	-	63	-	-	"
1419	in MPV	-	44.2	13.6	est 15.4	-	-	-	-	-	88	-	"
1420/1	in BV	30.3	34.0	-	-	-	-	-	-	89	-	-	"
1420/2	in PV	29.1	43.2	-	-	15.0	-	-	-	67	-	34	"
1429	in MBV	12.7	15.5	-	-	-	-	-	-	81	-	-	LR
1436/3	"	19.5	21.0	-	-	9.1	-	-	-	92	-	43	"
1436/4	in MPV	24.8	est 36.2	12.4	13.2	12.4	-	-	-	68	93	34	"
1437	ex MBV	29.5	43.3	-	-	-	-	-	-	68	-	-	"
1438	in MBV	30.6	31.0	-	-	-	-	23.0	21.7	98	-	-	"
1439	"	23.8	26.4	-	-	-	-	17.9	17.1	90	-	-	"
1440/1	in MPV	29.5	41.6	10.5	13.2	15.4	-	-	-	70	79	37	"
1440/2	in MBV	25.1	31.1	-	-	-	-	-	-	80	-	-	"
1441/1	"	18.2	24.0	-	-	-	-	-	-	75	-	-	"
1441/2	"	25.1	31.4	-	-	-	-	-	-	79	-	-	"
1443	ex MPV	28.0	est 42.2	-	-	-	-	-	-	66	-	-	"
1466	in MPV	-	-	11.5	13.2	-	-	-	-	-	87	-	"
1449	in MBV	24.6	32.4	-	-	9.8	-	-	-	75	-	30	"
1458	ex MPV	23.3	32.4	-	-	-	-	-	-	71	-	-	"
1462	ex MPV	34.0	est 38.2	-	-	-	-	-	-	89	-	-	"
1452/1	in MPV	26.4	40.0	10.5	16.0	-	-	-	-	66	62	-	"
1452/2	"	-	est 41.6	12.0	13.6	est 13.0	-	-	-	-	88	31	"
1452/4	"	-	est 32.4	10.0	11.3	-	-	-	-	-	88	-	"
1464	PV	20.0	est 26.8	-	-	est 9.4	-	-	-	74	-	35	"
1466	ex MPV	25.4	41.2	-	-	-	-	-	-	61	-	-	"
1465	"	18.0	25.6	-	-	-	-	-	-	70	-	-	"
1467	in MPV	28.0	40.2	-	-	-	-	-	-	69	-	-	"
1468	ex MBV	21.5	26.2	-	-	-	-	-	-	82	-	-	"
1469	QP BV	est 29.8	est 44.0	-	-	12.7	-	-	-	67	-	28	"

1472/1	ex MPV	27.9	37.6	-	-	-	-	-	-	74	-	-	LR
1472/2	"	27.3	34.5	-	-	-	-	-	-	79	-	-	"
1474	"	27.4	36.0	-	-	-	-	-	-	76	-	-	"
1475	in MBV	27.7	31.3	-	-	-	-	-	-	88	-	-	"
1476	ex BV	23.7	30.7	-	-	11.2	-	17.8	16.9	77	-	36	"
1470	-	30.2	45.0	-	-	-	-	-	-	67	-	-	"
1473	in MPV	-	-	15.2	18.1	-	-	-	-	-	83	-	"
1493/2	"	18.0	est 24.2	-	-	-	-	-	-	74	-	-	"
1506	in MPV	29.8	est 43.4	13.7	15.9	14.0	-	22.3	20.6	68	86	32	"
1508	"	-	43.0	11.8	13.3	-	-	-	-	-	88	-	"
1511	ex MPV	20.6	40.2	-	-	-	-	-	-	51	-	-	"
1518	"	30.6	40.4	-	-	-	-	-	-	75	-	-	"
1519	in MBV	-	34.0	-	-	16.2	-	-	-	-	-	47	"
1522	"	27.0	36.4	-	-	12.8	-	-	-	74	-	34	"
1523	ex MBV	25.3	31.7	-	-	-	-	-	-	79	-	-	"
1536	ex MPV	-	36.3	-	-	-	-	18.9	18.3	69	-	-	"
1558	QP BV	30.1	39.4	-	-	-	-	-	-	76	-	-	"
1560	in MPV	31.2	34.8	-	-	-	-	-	-	89	-	-	"
1561	ex MPV	26.4	est 38.8	-	-	-	-	19.8	17.9	68	-	-	"
1562	in MBV	30.8	36.2	-	-	-	-	-	-	85	-	-	"
1563	in MPV	25.3	32.6	7.5	8.3	13.2	-	-	-	77	90	40	"

- NMW COLLECTION -

23A/1	ex BV	28.1	33.0	-	-	-	-	21.1	21.5	85	-	-	Ludlow
23A/2	in BV	29.3	36.3	-	-	-	-	22.0	22.0	81	-	-	"
23A/3	ex PV	32.0	35.0	-	-	-	-	24.0	20.0	91	-	-	"
23A/4	-	31.7	31.7	-	-	-	-	23.8	17.5	100	-	-	"
23A/5	in BV	35.3	38.4	-	-	-	-	26.5	23.0	92	-	-	"
23A/6	-	37.0	32.0	-	-	-	-	27.8	18.0	116	-	-	"
HLW19/7	-	31.1	37.9	-	-	-	-	23.3	18.0	82	-	-	"
HLW19/8	-	27.1	36.0	-	-	-	-	20.3	20.9	75	-	-	"
HLW19/8	in MBV	35.0	39.0	-	-	12.0	-	26.3	17.5	90	-	31	"
HLW19/10	"	26.5	34.2	-	-	-	-	19.9	14.3	77	-	-	"

- LAWSON COLLECTION (WBL) -

863/1	in MPV	25.9	40.6	12.2	14.9	19.8	-	-	-	63	81	48	JS
863/2	BV	27.4	est 37.6	-	-	-	5	-	-	72	-	-	"

863/3	BV	28.2	38.8	-	-	-	-	-	-	72	-	-	JS
863/4	"	24.0	26.6	-	-	-	-	-	-	90	-	-	"
865	PV	17.8	19.8	-	-	-	-	-	-	89	-	-	"
869/1	in MBV	24.0	25.4	-	-	-	-	-	-	94	-	-	"
869/2	"	28.8	37.3	-	-	-	-	-	-	77	-	-	"
869/3	in MPV	26.4	43.0	12.1	est 16.4	-	-	-	-	61	73	40	"
871	PV	39.2	est 47.0	-	-	-	-	-	-	83	-	-	FC/31a
872	QP PV	35.8	46.7	-	-	-	-	-	-	76	-	-	"
873	BV	36.6	51.6	-	-	-	4-5	-	-	70	-	-	"
874	"	25.4	34.2	-	-	-	4	-	-	74	-	-	"
875	PV	39.7	est 43.0	13.0	16.8	17.2	-	-	-	92	77	40	"
876	BV	29.5	35.0	-	-	-	5	-	-	84	-	-	"
877	PV	37.0	38.5	-	-	-	-	-	-	84	-	-	LS
879	"	35.7	37.2	-	-	14.6	-	-	-	96	-	39	"
880	BV	36.2	39.0	-	-	-	-	-	-	92	-	-	"
882	"	36.0	42.1	-	-	19.4	-	-	-	85	-	46	"
883	in MPV	31.6	35.9	10.0	14.0	-	-	-	-	88	71	-	"
884	PV	42.4	est 48.0	-	-	-	-	-	-	88	-	-	"
870	BV	33.8	36.0	-	-	14.6	4-5	-	-	93	-	40	DQ
887	in MBV	37.0	est 39.0	-	-	-	3	-	-	94	-	-	"
889	in MPV	35.1	39.4	11.4	17.1	21.2	-	-	-	89	66	53	"
890	"	43.3	52.0	18.9	21.0	-	-	-	-	83	90	-	"

2. FROM WENLOCK LIMESTONE OF DUDLEY AREA (WBL)

A. NHM COLLECTION

B741/1	in PV	39.3	46.2	16.0	19.8	19.0	-	29.5	38.5	85	81	4	Dudley
B741/2	ex BV	34.8	42.2	-	-	-	5	26.1	38.4	82	-	-	"
B44906	"	36.9	46.5	-	-	-	5	27.3	32.7	78	-	-	"
35544	"	33.2	48.4	-	-	-	5	24.0	26.8	69	-	-	"
B3600	in PV	39.1	46.7	14.6	17.5	23.2	-	29.3	39.2	84	83	50	"
B3908/1	ex BV	29.0	39.3	-	-	-	5	21.8	31.7	74	-	-	"
B3908/2	Con.V	29.5	est 35.6	-	-	12.0	5	22.1	30.6	83	-	34	"
B24160	ex BV	25.4	est 37.0	-	-	-	4-5	19.1	26.3	69	-	-	"
BB6432	MPV	35.4	44.5	16.7	19.4	21.8	-	26.6	31.2	80	86	49	"
B23157/1	"	31.4	38.4	11.1	15.1	18.1	-	23.6	26.9	82	74	47	"
B5674	ex BV	30.1	39.6	-	-	-	6	22.6	30.1	76	-	-	"
B7675	in PV	37.0	41.8	13.0	19.4	-	-	27.8	29.7	89	67	-	"
97751	"	35.3	44.1	16.8	18.5	17.6	-	26.5	29.5	80	91	40	"

B. BGS COLLECTION

13365	ex BV	35.8	est 38.0	-	-	-	4-5	26.9	28.2	94	-	-	Dudley
13366	in BV	30.0	37.3	10.1	13.6	22.2	-	22.5	22.7	80	45	-	"
13435/1	ex BV	35.1	est 48.8	-	-	-	-	26.3	28.3	72	-	-	"
13435/2	"	35.9	44.0	-	-	-	-	26.9	27.5	81	-	-	"
13435/3	"	39.0	est 54.6	-	-	-	-	29.3	26.2	71	-	-	"

C. NMW COLLECTION

G291	ex BV	32.0	39.6	-	-	-	-	24.0	33.0	81	-	-	"
G907	ex PV	35.0	44.6	-	-	-	-	26.3	-	78	-	-	"
93.135	in PV	32.9	41.6	11.0	14.4	-	-	24.0	29.0	79	76	-	"
14.311 G965	ex BV	35.0	41.0	-	-	-	-	26.3	39.4	85	-	-	"
13.149 G75	in PV	33.4	45.5	-	-	14.0	-	25.0	33.0	73	-	-	"
80.33 G50	in BV	83.7	43.0	-	-	13.4	4	25.3	31.0	78	-	-	"

LIVING BRACHIOPODA

(KRAUSSINA RUBRA)

Ls (PV)	Ls (BV)	Ws	Ts
18.85	16.70	18.20	8.85
18.75	17.0	16.15	8.70
21.20	19.1	20.55	11.20
18.20	15.3	16.65	8.85
17.40	15.1	17.85	7.15
18.10	14.6	17.40	8.50
19.00	17.2	18.35	8.55
18.55	17.00	19.00	8.15
15.00	14.30	16.35	7.85
18.35	16.0	17.85	7.70
21.45	19.5	21.55	11.80
19.95	18.1	16.80	9.40
20.70	19.2	20.00	9.80
23.50	20.9	22.55	10.60
20.40	17.5	17.20	9.35
16.70	14.6	15.30	7.50
15.50	13.00	15.00	9.10
16.90	14.00	15.40	7.00
19.70	14.30	14.30	7.40
16.60	15.40	15.85	7.50
17.20	14.90	15.05	7.50
13.40	12.00	13.60	7.00
-	-	-	-
17.90	16.10	17.90	9.45
19.15	17.65	18.10	9.70
22.90	21.85	22.25	11.70
18.95	16.70	17.50	10.00
15.60	14.30	16.20	7.20
17.40	16.00	16.40	7.85
18.25	15.85	18.35	9.65
23.05	20.20	23.40	11.65
15.00	13.50	14.30	5.70
21.75	19.10	20.35	10.30
18.75	16.75	18.75	9.00

18.45	17.35	19.10	9.55
14.30	12.50	13.70	7.00
14.60	13.75	15.20	7.40
13.20	11.85	12.80	11.40
11.15	9.95	11.05	4.75
12.60	12.10	13.15	6.25
14.10	12.45	12.90	6.40
10.35	8.85	9.25	4.50
7.95	6.85	7.70	3.30
15.55	13.80	15.60	6.10
21.00	19.55	20.40	10.00
24.90	22.15	23.05	12.00
18.80	16.35	19.30	8.70
17.20	14.95	16.40	7.40
16.15	13.85	15.65	7.60
16.80	15.60	17.90	8.15
24.60	22.80	24.70	12.60
18.80	17.50	19.10	10.00
21.30	19.00	21.10	10.30
20.50	18.85	18.30	9.95
18.90	18.10	19.40	10.55
17.70	15.85	17.55	8.25
18.35	17.00	21.90	11.40
15.10	13.40	12.55	7.30
21.50	18.55	16.85	8.55
18.80	17.05	16.90	9.65
21.65	-	20.45	11.35
16.50	15.20	14.80	8.15
20.00	17.10	19.50	9.00
20.10	18.00	17.40	10.20

REFERENCES

AGER, D.V. 1961. The epifauna of a Devonian Spiriferid. Q. Jl geol. Soc. Lond. 117, 1-10.

_____ 1963. Principles of palaeoecology. Imperial College, London, 372pp.

_____ 1965. The adaptation of Mesozoic brachiopods to different environments. Palaeogeog., Palaeoclimat., Palaeoecol. 1, 143-172.

_____ 1967. Brachiopod palaeoecology. Earth Sci. Rev. 3, 157-179.

ALDRIDGE, A.E. 1981. Intraspecific variation of shape and size in subtidal populations of two Recent New Zealand articulate brachiopods. N.Z. Jl Zool. 8, 169-174.

ANTIA, D.D.J. 1980. Shell laminae and shell orientation in the Upper Silurian, Overton Formation, U.K. Palaeogeog., Palaeoclimat., Palaeoecol. 32, 119-133.

_____ 1981. Faunas from the Upper Silurian (Upper Ludlovian) in the Ludlow — Much Wenlock District, England. Geol. J. 16, 137-147.

ATKINS, D.R. 1979. Faunal distribution and depositional environments in the Lower Bringewoodian (Ludlovian) of Wales and the Welsh Borders. Ph.D. thesis (unpubl.), University of Glasgow.

BASSETT, M.G. 1971. Wenlock stropheodontids (Silurian Brachiopoda) from the Welsh Borderland and South Wales. Palaeontology, 14, 303-337.

_____ 1977. The articulate brachiopods from the Wenlock Series of the Welsh Borderland and South Wales. Palaeontogr. Soc. (Monogr.), 4, 123-176.

_____ 1979. Brachiopods. pp.185-206. In JAANUSSON, V., LAUFELD, S. and SKOGLUND, R. (eds.). Lower Wenlock faunal and floral dynamics — Vattenfallet section, Gotland. Sver. geol. Unders. C762, 1-294.

_____ 1984. Life strategies of Silurian brachiopods. Spec. Pap. Paleont. 32, 237-263.

_____ and COCKS, L.R.M. 1974. A review of Silurian brachiopods from Gotland. Fossils & Strata, 3, 1-56.

BOUCOT, A.J. 1960. A new Lower Devonian stropheodontid Brachiopod. J. Paleont. 34, 483-485.

_____ 1975. Evolution and extinction rate controls. Amsterdam, 427pp.

_____ 1981. Principles of benthic marine paleoecology. U.S.A., 463pp.

_____ BRACE, W. and DEMAR, R. 1958. Distribution of brachiopod shells by currents. J. sedim. Petrol. 28, 321-332.

BRADLEY, P.C.S. 1951. Subspecies in palaeontology. Geol. Mag. 88, 88-102.

BRUNTON, C.H.C. 1982. The functional morphology and palaeoecology of the Dinantian brachiopod Levitusia. Lethaia, 15, 149-167.

_____ and CURRY, G.B. 1979. British brachiopods; Keys and notes for the identification of species. Synopses Br. Fauna (KERMACK, D.M. and BARNET, R.S.K., eds.), 17, 1-64. (For the Linn. Soc. Lond. and Estuarine and Brackish-water Sci. Ass.).

CALEF, C.E. and HANCOCK, N.J. 1974. Wenlock and Ludlow marine communities in Wales and the Welsh Borderland. Palaeontology, 17, 779-810.

CASTER, K.E. 1939. A Devonian fauna from Colombia. Bull. Am. Paleont. 24, 1-214.

CHERNS, L. 1977. The palaeoecology of Lower Leintwardine (Upper Silurian) of the Welsh Borderlands and Wales. Ph. D. thesis, University of Glasgow.

_____ 1982. Palaeokarst, tidal erosion surfaces and stromatolites in the Silurian Eke Formation of Gotland, Sweden. Sedimentology, 29, 819-833.

_____ 1983. The Hemse—Eke boundary. Facies relationships in the Ludlow Series of Gotland, Sweden. Sver. geol. Unders. C800, 1-45.

CLARK, G.R., II. 1976. Shell convexity in Argopecton gibbus. Variation with depth in Harrington Sound, Bermuda. Bull. mar. Sci. 26, 605-610.

COCKS, L.R.M. 1967. Llandovery stropheodontids from the Welsh Borderland. Palaeontology, 10, 245-265.

_____ 1968. Some Strophomenacean brachiopods from the British Lower Silurian. Bull. Br. Mus. nat. Hist. (Geol.) 15, 283-324.

_____ 1970. The Silurian brachiopods of the Superfamily Plectambonitacea. Ibid. 19, 139-203.

_____ 1978. A review of British Lower Palaeozoic brachiopods, including a synoptic revision of Davidson's Monograph. Palaeontogr. Soc. (Monogr.), 1-256.

_____ and FORTEY, R.A. 1982. Faunal evidence for oceanic separation in the Palaeozoic of Britain. J. geol. Soc. Lond. 39, 467-480.

_____ and McKERROW, W.S. 1978. Silurian. In McKERROW, W.S. (ed.), The ecology of fossils, London, 92-124.

COOPER, G.A. and WILLIAMS, A. 1952. Significance of the stratigraphic distribution of Brachiopoda. J. Paleont. 26, 326-337.

COWEN, R. 1971. The food of articulate brachiopods. A discussion. Ibid. 45, 137-139.

CUBITT, J.M. and HENLEY, S. 1978. Statistical analysis in geology. Pennsylvania, 340pp.

CURRY, G.B. 1981. Variable pedicle morphology in a population of the Recent brachiopod Terebratulina septentrionalis. Lethaia, 14, 9-20.

_____ 1982. Ecology and population structure of the Recent brachiopoda Terebratulina from Scotland. Palaeontology, 25, 227-246.

_____ 1983. Ecology of the Recent deep-water Rhynchonellid brachiopod Cyrtopora from the Rockall Trough. Palaeogeog., Palaeoclimat., Palaeoecol. 44, 93-102.

_____ 1984. Growth variability in a Tertiary brachiopod from Antarctica. The significance for palaeoenvironmental reconstruction. Geobios, Mem. Spec. 8, 47-51.

CURTIS, M.L.K., LAWSON, J.D., SQUIRRELL, H.C., TUCKER, E.V. and WALMSLEY, V.G. 1967. The Silurian inliers of the south-eastern Welsh Borderland. Geol. Ass. Guide, 5, 1-32.

DAVIDSON, T. 1871. A Monograph of the British Fossil Brachiopoda, Part VII, No. IV. The Silurian Brachiopoda. Palaeontogr. Soc. (Monogr.), 249-397.

_____ 1881. Descriptions of New Upper Silurian Brachiopoda from Shropshire. Geol. Mag. 8, 145-156.

DAWSON, J.W. 1880. New facts respecting the geological relations and fossil remains of the Silurian iron ores of Pictou, Nova Scotia. Can. Nat. 9, 332-344.

EARP, J.R. 1939. The higher Silurian rocks of the Kerry District, Montgomeryshire. Q. Jl geol. Soc. Lond. 94, 125-160.

_____ 1940. The geology of the south-western part of Clun Forest. Ibid. 96, 11pp.

_____ and HAINS, B.A. 1971. British regional geology: The Welsh Borderland, London (3rd edition), 118pp.

ELDREDGE, N. 1971. The allopatric model and phylogeny in Paleozoic invertebrates. Evolution, 25, 156-167.

ESHLEMAN, W.P. and WILKENS, J.L. 1979. Actomyosin ATPase activities in the brachiopod Terebratalia transversa. Can. J. Zool. 57, 1944-1949.

FENTON, C.L. and FENTON, M.A. 1932. Orientation and injury in the genus Atrypa. Am. Midl. Nat. 13, 63-74.

FÜRSICH, F.T. and HURST, J.M. 1974. Environmental factors determining the distribution of brachiopods. Palaeontology, 17, 879-900.

GALL, J.C. 1976. "Environmennements sedimentaires anciens et milieux de vie: Introduction a la paleoecologie". Doin, Paris, 228pp.

GRANT, P.R. 1972. Convergent and divergent character displacement. Biol. J. Linn. Soc. 4, 39-68.

HALL, J. and CLARKE, J.M. 1892-94. An introduction to the study of the genera of Palaeozoic Brachiopoda. N.Y. State, Geol. Surv. Paleont. 8, 1-394.

HALLAM, A. 1965. Environmental causes of stunding in living and fossil marine benthic invertebrates. Palaeontology, 8, 132-155.

_____ 1977. Patterns of evolution as illustrated by the fossil record. Amsterdam, Elsevier, 591pp.

HANCOCK, N.J., HURST, J.M. and FÜRSICH, F.T. 1974. The depths inhabited by Silurian brachiopod communities. J. geol. Soc. Lond. 130, 151-156.

HANNA, R.K. 1986 (in press). Variability in two stropheodontid brachiopods from the Silurian of the Welsh Borderland. In RACHEBOEUF, P. et EMIG, C. (eds.), Biostrat. du Paleozoique, 5.

HARPER, C.W., Jr. 1973. Brachiopods of the Arisaig group (Silurian—Lower Devonian) of Nova Scotia. Bull. geol. Surv. Can. 215, 1-163.

_____ and BOUCOT, A.J. 1978a. The Stropheodontacea: Part I; Leptostrophidae, Eostropheodontidae and Strophonellidae. Palaeontography A161, 55-118.

_____ 1978b. The Stropheodontacea: Part II; Douvillinidae, Telaeoshaleriidae, Amphistrophiidae and Shaleriidae. Ibid. A161, 119-175.

_____ 1978c. The Stropheodontacea: Part III; Stropheodontidae, Pholidostrophidae and Lissostrophiidae. Ibid. A161, 1-80.

_____ JOHNSON, J.G. and BOUCOT, A.J. 1967. The Pholidostrophiinae (Brachiopoda; Ordovician, Silurian, Devonian). Senckenberg. Lethaia, 48, 403-461.

_____ TIPPER, J.C. and WALMSLEY, V.G. 1982. Ecophenotypic strategies of dalmanellid brachiopods. Ibid. 15, 31-40.

_____ TOWE, K.M. 1967. Shell structure of the brachiopod Pholidostrophia (Mesopholidostrophia) nitens from Gotland. J. Paleont. 41, 1184-1187.

HAVLICEK, V. 1967. Brachiopoda of the Suborder Strophomenidina in Czechoslovakia. Rozpr. ustred. Ust. geol. 33, 1-235.

HEDE, J.E. 1921. Gotlands Silurstratigrafi. Sver. geol. Unders. C305, 1-100.

_____ 1925. Berggrunden (Silursystemet). In: MUNTHE, H., HEDE, J.E. and VON POST, L. Beskrivning till kartbladet Ronehamn. Ibid. Aa 156, 1-96, Stockholm.

_____ 1960. The Silurian of Gotland. In REGNELL, G. and HEDE, J.E. The Lower Palaeozoic of Scania, The Silurian of Gotland. Int. Geol. Congr. 21st Sess. Norden, 1-89.

HOLLAND, C.H. 1959. The Ludlovian and Downtonian rocks of the Knighton district, Radnorshire. Q. Jl geol. Soc. Lond. 114, 449-482.

_____ 1978. Stratigraphical classification and all that. Lethaia, 11, 85-90.

_____ 1980. Silurian Series and Stages: decisions concerning chronostratigraphy. Ibid. 13, p.238.

_____ 1982. The state of Silurian stratigraphy. Episodes, 3, 21-23.

_____ 1984. Steps to a standard Silurian. Proceedings 27th Int. Geol. Congr. Moscow, 1, 127-156.

_____ 1985. Series and stages of the Silurian System. Episodes, 8, 101-103.

_____ and LAWSON, J.D. 1963. Facies pattern in the Ludlovian of Wales and the Welsh Borderland. Lpool Manchr Geol. J. 3, 269-288.

_____ _____ and WALMSLEY, V.G. 1959. A revised classification of the Ludlovian succession at Ludlow. Nature, Lond. 184, 1037-1039.

_____ _____ _____ 1963. The Silurian rocks of the Ludlow District, Shropshire. Bull. Br. Mus. nat. Hist. (Geol.), 8, 93-171.

_____ _____ _____ and WHITE, D.E. 1980. Ludlow stages. Lethaia, 13, p. 268.

HURST, J.N. 1974. Aspects of the systematics and ecology of the brachiopod Pholidostrophia in the Ashgill, Llandovery and Wenlock of Britain. Neues Jb. Geol. Palaeontol. Abh. 146, 298-324.

_____ 1975. Some observations on brachiopods and the Level-bottom community ecology of Gotland. Geol. För. Stockh. Förh. 97, 250-264.

_____ 1978. A phenetic strategy model for dalmanellid brachiopods. Palaeontology, 21, 535-554.

_____ and WATKINS, R. 1978. Evolution pattern in a Silurian orthid brachiopod. Geologica Paleont. 12, 73-102.

International Code of Zoological Nomenclature, 1961. International Trust for Zoological Nomenclature, London, 176pp.

IVANOVA, E.A. 1962. Ecology and evolution of Silurian and Devonian brachiopods of the Kuznetsk, Minusinsk and Tuvinsk basins. Trudy paleont. Inst. 88, 1-152 (in Russian).

JAANUSSON, V. 1979. Ecology and faunal dynamics. pp.253-294. In: JAANUSSON, V., LAUFELD, S. and SKOGLUND, R. (eds.) Lower Wenlock faunal and floral dynamics. Vattenfallet section, Gotland. Sver. geol. Unders. C762, 1-294.

JEFFREY, C. 1977. Biological Nomenclature. Special Topics in Biology. London, 69pp.

JOHNSON, A.L.A. 1981. Detection of ecophenotypic variation in fossils and an application to a Jurassic Scallop. Lethaia, 14, 277-285.

LAUFELD, S. 1974. Reference localities for palaeontology and geology in the Silurian of Gotland. Sver. geol. Unders. C705, 1-172.

LAWSON, J.D. 1954. The Silurian succession at Gorsley (Herefordshire). Geol. Mag. 91, 227-237.

_____ 1955. The geology of the May Hill inlier. Q. Jl geol. Soc. Lond. 111, 85-116.

_____ 1960. The succession of shelly faunas in the British Ludlovian. Rep. int. Geol. Congr. 21st Sess., Norden, 7, 114-125.

_____ 1973a. New exposures on forestry roads near Ludlow. Geol. J. 8, 279-284.

_____ 1973b. Facies and faunal changes in the Ludlovian rocks of Aymestrey, Herefordshire. Ibid. 8, 247-278.

_____ 1975. Ludlow benthonic assemblages. Palaeontology, 18, 509-525.

_____ 1979. Fossils and lithostratigraphy. Lethaia, 12, 189-191.

_____ and WHITAKER, J.H. McD. 1969. Correlation of the Leintwardine Beds. Geol. J. 6, 329-332.

LOCKLEY, M.G. and WILLIAMS, A. 1981. Ordovician Brachiopoda from Mid and S. Wales. Bull. Br. Mus. nat. Hist. (Geol.), 35, 1-78.

LOOMIS, F.G. 1903. The dwarf fauna of the pyrite layer at the horizon of the Tully Limestone in Western New York. Bull. N.Y. St. Mus. No.69, 892-900.

MARTINSSON, A. 1967. The succession and correlation of ostracode faunas in the Silurian of Gotland. Geol. För. Stockh. Förh. 89, 350-386.

MAXWELL, W.G.H. 1954. Strophalosia in the Permian of Queensland. J. Paleont. 28, 533-559.

MAYR, E. 1963. Animal species and evolution. Harvard Univ. Press, Cambridge, 797pp.

McCOY, F. 1846. A synopsis of the Silurian fossils of Ireland. Dublin, 72pp.

_____ 1851. On some new Cambro-Silurian fossils. Ann. Mag. nat. Hist. 8, 387-409.

MIDDLEMISS, F.A. 1962. Brachiopod ecology and Lower Greensand palaeogeography. Palaeontology, 5, 253-267.

MURCHISON, R.I. 1833. On the sedimentary deposits which occupy the Western parts of Shropshire and Herefordshire, etc. Proc. geol. Soc. Lond. 1, 474-477.

_____ 1839. The Silurian System. John Murray, London, 2 Vols, 768pp.

NIKIFOROVA, O.I., MODZALEVSKAYA, T.L. and BASSETT, M.G. 1985. Review of the upper Silurian and lower Devonian articulate brachiopods of Podolia. Spec. Pap. Paleont. 34, 1-66.

ODUM, E.P. 1959. Fundamentals of Ecology. (2nd ed.), W.B. Saunders Co. Philadelphia, 546pp.

PHIPPS, C.B. and REEVE, F.A.E. 1967. Stratigraphy and Geological History of the Malvern, Abberley and Ledbury Hills. Geol. J. 5, 339-368.

POPE, J.K. 1976. Comparative morphology and shell histology of the Ordovician Strophomenacea (Brachiopoda). Palaeontogr. Am. 49, 129-213.

POTTER, J.F. and PRICE, J.H. 1965. Comparative sections through rocks of Ludlovian-Downtonian Age in the Llandovery and Llandeilo Districts. Proc. geol. Ass. 76, 379-402.

RAUP, D.M. and STANLEY, S.M. 1971. Principles of Paleontology. W.H. Freeman & Co., San Francisco, 388pp.

RICHARDS, R.P. 1972. Autecology of Richmondian brachiopods (Late Ordovician of Indiana and Ohio). J. Paleont. 46, 486-405.

RUDWICK, M.J.S. 1961. The anchorage of articulate brachiopods on soft substrate. Palaeontology, 4, 475-476.

_____ 1962. Notes on the ecology of brachiopods in New Zealand. Trans. R. Soc. N.Z. 1, 327-335.

_____ 1965. Ecology and Palaeoecology. In MOORE, R.C. (ed.), Treatise of Invertebrate Palaeontology, H199-H214.

_____ 1970. Living and fossil Brachiopods. Hutchinson & Co., London, 199pp.

SHERGOLD, J.H. and SHIRLEY, J. 1968. The faunal stratigraphy of the Ludlovian rocks between Craven Arms and Bourton, near Much Wenlock, Shropshire. Geol. J. 6, 119-138.

SHIELLS, K.A.G. 1968. Kochiproductus coronus sp. nov. from the Scottish Visean and a possible mechanical advantage of its flange structure. Trans R. Soc. Edinb. 67, 477-508.

SHROCK, R.R. and TWENHOFEL, W.H. 1953. Principles of Invertebrate Paleontology. McGraw-Hill Book Company, USA, 816pp.

SIVETER, D.J. 1983. Calymene lawsoni and allied species from the Silurian of Britain and their stratigraphic significance. Spec. Pap. Paleont. 30, 69-88.

SPJELDNAES, N. 1984. Epifauna as a tool in autecological analysis of Silurian brachiopods. Ibid. 32, 225-235.

SQUIRRELL, H.C. and TUCKER, E.V. 1960. The geology of the Woolhope inlier (Herefordshire). Q. Jl geol. Soc. Lond. 116, 139-185.

_____ and WHITE, D.E. 1978. Stratigraphy of the Silurian and Old Red Sandstone of the Cennen Valley and adjacent areas, south-east Dyfed, Wales. Rep. Inst. geol. Sci. 78/6, 1-45.

STAINBROOK, M.A. 1943. Strophomenacea of the Cedar Valley Limestone of Iowa. J. Paleont. 17, 39-59.

STANLEY, S.M. 1970. Relation of shell form to life habits of the Bivalvia (Mollusca). Mem. geol. Soc. Am. 125, 1-296.

_____ 1979. Macroevolution; pattern and process. Freeman W.H. & Co., San Francisco, 332pp.

STEL, J.H. and DeCOO, J.C.M. 1977. The Silurian Upper Burgsvik and Lower Hamra-Sundre Beds, Gotland. Scr. Geol. 44, 1-43.

STRAW, S.H. 1937. The higher Ludlovian rocks of the Builth District. Q.Jl geol. Soc. Lond. 93, 406-456.

TOWE, K. and HARPER, C. 1966. Pholidostrophiid brachiopods; origin of the nacreous luster. Science, 154, 153-155.

TREWIN, N.H. and WELSH, W. 1972. Transport, breakage and sorting of bivalve Mactra corallina on Aberdeen beach, Scotland. Palaeogeog., Palaeoclimat., Palaeoecol. 12, 193-204.

WALMSLEY, V.G. 1959. The geology of the Usk inlier (Monmouthshire). Q.Jl geol. Soc. Lond. 114, 483-531.

WATKINS, R.M. 1975. British Ludlow palaeoecology and its bearing on the Silurian marine ecosystem. Ph.D. thesis (unpubl.), University of Oxford.

_____ 1978. Bivalve ecology in a Silurian shelf environment. Lethaia, 11, 41-56.

_____ 1979. Benthic community organisation in the Ludlow Series of the Welsh Borderland. Bull. Br. Mus. nat. Hist. (Geol.), 31, 175-280.

WHITAKER, J.H. McD. 1962. The geology of the area around Leintwardine. Q. Jl geol. Soc. Lond. 118, 319-351.

WHITE, D.E. and LAWSON, J.D. 1978. The stratigraphy of the type area, Ludlow, Salop, England. Rep. Inst. geol. Sci. 78/30, 1-10.

WHITE, M.J.D. 1978. Modes of speciation. Freeman & Co., San Francisco, 455pp.

WILKENS, J.L. 1978a. Adductor muscles of brachiopods; activation and contraction. Can. J. Zool. 56, 315-323.

_____ 1978b. Diductor muscles of brachiopods; activation and very low contraction. Ibid. 56, 324-332.

WILLIAMS, A. 1950. New stropheodontid brachiopods. J. Wash. Acad. Sci. 40, 277-282.

_____ 1951. Llandovery brachiopods from Wales with special reference to the Llandovery District. Q. Jl geol. Soc. Lond. 107, 85-136.

_____ 1953. North American and European stropheodontids. Mem. geol. Soc. Am. 56, 1-67.

_____ 1957. Evolutionary rates of brachiopods. Geol. Mag. 94, 201-211.

_____ 1965. In MOORE, R.C. (ed.). Treatise on Invertebrate Palaeontology. Geol. Soc. Am., Kansas, H1 and 2, 1-927.

_____ 1968. Evolution of the shell structure of articulate brachiopods. Spec. Pap. Paleont. 2, 1-55.

_____ and CURRY, G.B. 1984. Lower Ordovician Brachiopoda from the Tourmakeady Limestone, Co. Mayo, Ireland. Bull. Br. Mus. nat. Hist. (Geol.), 38, 185-272.

WILLIAMS, R.B.G. 1984. Introduction to statistics for Geographers and Earth Scientists. Univ. Sussex, 349pp.

WORSLEY, D. and BROADHURST, F.M. 1975. An environmental study of Silurian atrypid communities from Southern Norway. Lethaia, 8, 271-286.

WRIGHT, J.R. 1832. On the secondary formations in the neighbourhood of Ludlow. Proc. geol. Soc. Lond. 1, 387-388.

ZIEGLER, A.M. 1965. Silurian marine communities and their environmental significance. Nature, Lond. 207, 270-272.

_____ COCKS, L.R.M. and McKERROW, W.S. 1968. The Llandovery transgression of the Welsh Borderland. Palaeontology, 11, 736-782.

SECTION
V

PLATES

EXPLANATION OF PLATES

EXPLANATION OF PLATE 1

Pedicle valve morphology of Shaleria ornatella (Davidson,1871).

Figs.1,2. AC-NMW84.42G.27a & b, internal mould of pedicle valve showing the triangular muscle bounding ridges and its counterpart external mould, from Upper Leintwardine Formation, Walnut Tree Farm (Wt) in the Usk inlier; x 3.5.

Fig.3. AC-NMW84.42G.19, internal mould of pedicle valve showing faint anterior bounding muscle impression, from Upper Leintwardine Formation, locality C-30, Ludlow area (Shropshire); x 3.8.

Figs.4.5. AC-NMW84.42G.8a & b, internal mould and latex cast of pedicle valve showing concave muscle bounding ridges curved laterally and bifurcating myophragm, from Upper Leintwardine Formation, Llangibby (Usk inlier); x 1.1 and 1.4 respectively.

Figs.6-8. 6,7, AC-NMW84.42G.13 & 20, internal moulds of pedicle valve showing difference in the angle of divergence of the muscle bounding ridges, 8, AC-NMW84.42G.21c, latex cast of the internal mould of pedicle valve; all are from Upper Leintwardine Formation, locality C-30 near Ludlow; x 2.4, x 2.1 and x 3.8 respectively.

Figs.9,10. AC-NMW84.42G.2 & 1, internal moulds of pedicle valve, showing concave and convex muscle bounding ridges respectively, both are from the uppermost Hemse Groups in Gotland, 9 is from Nyan 2, 10 from Tjängdarve 2; x 4.1 and 1.9 respectively.

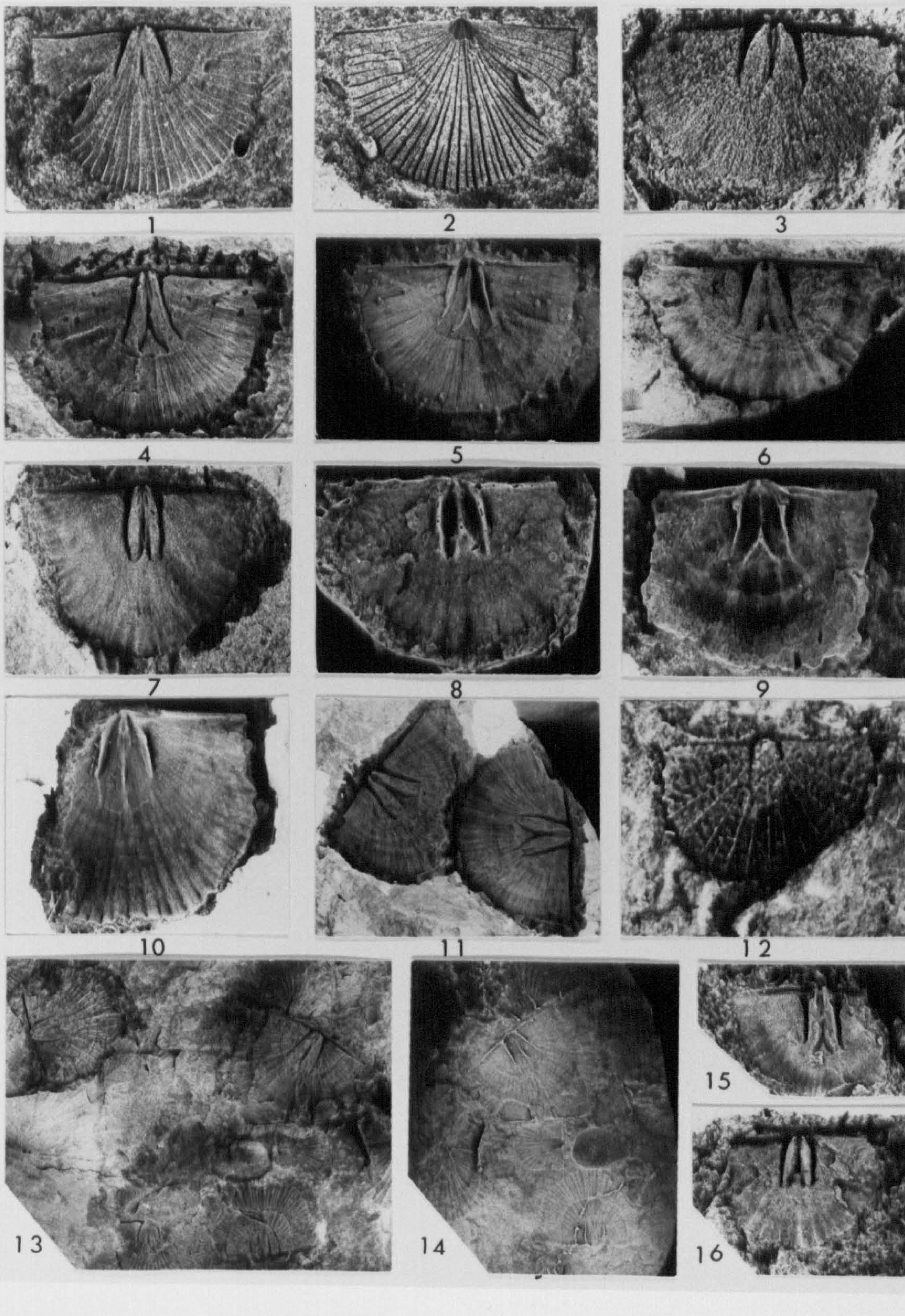
Fig.11. AC-NMW84.42G.25, internal moulds of pedicle valves showing the typical shape of the muscle bounding ridges, from Upper Leintwardine Formation, Walnut Tree Farm (Wt) in the Usk inlier; x 1.2.

Fig.12. AC-NMW84.42G.15a, internal mould of pedicle valve showing the development of the parallel-sided muscle field in the baby S. ornatella, from uppermost Upper Leintwardine Formation, locality C-30 near Ludlow; x 5.6.

Figs.13,14. AC-NMW84.42G.9a & b, internal mould and latex cast of pedicle valve respectively, showing the variations in the angle of divergence of the muscle bounding ridges on the same bedding plane, from Upper Leintwardine Formation, Towy anticlinal SW of the Welsh Borderland; x 1.2.

Figs.15,16. AC-NMW84.42G.21b, internal moulds of pedicle valve showing the differences in shape and angle of divergence of the muscle field in the same bedding plane, from uppermost Upper Leintwardine Formation, locality C-30 near Ludlow; x 2.1 and 2 respectively.

PLATE 1



EXPLANATION OF PLATE 2

Brachial valve morphology of *S. ornatella* (Davidson, 1871).

Figs. 1,2,5. 1, 2, AC-NMW84.42G.14a and b, internal mould and latex cast of a brachial valve showing blade shaped socket plates, 5, AC-NMW84.42G.11b, latex cast of a brachial valve showing recurved socket plates, all from Upper Leintwardine Formation, locality B38 near Ludlow (Shropshire); x 1.9, 2.0 and 1.6. respectively.

Figs.3,4. AC-NMW84.42G.23 & 28, internal moulds of brachial valves showing the bladed and recurved shaped socket plates respectively and S-shaped muscle bounding ridges, from Upper Leintwardine Formation, locality Wt in the Usk inlier; x 1.9 and x 1.7 respectively.

Fig.6. AC-NMW84.42G.18, internal mould of a brachial valve showing the arcuate shape formed from the uniting of the socket plates with the posterior side of the muscle bounding ridges, from Upper Leintwardine Formation, locality C-30 near Ludlow (Shropshire); x 1.6.

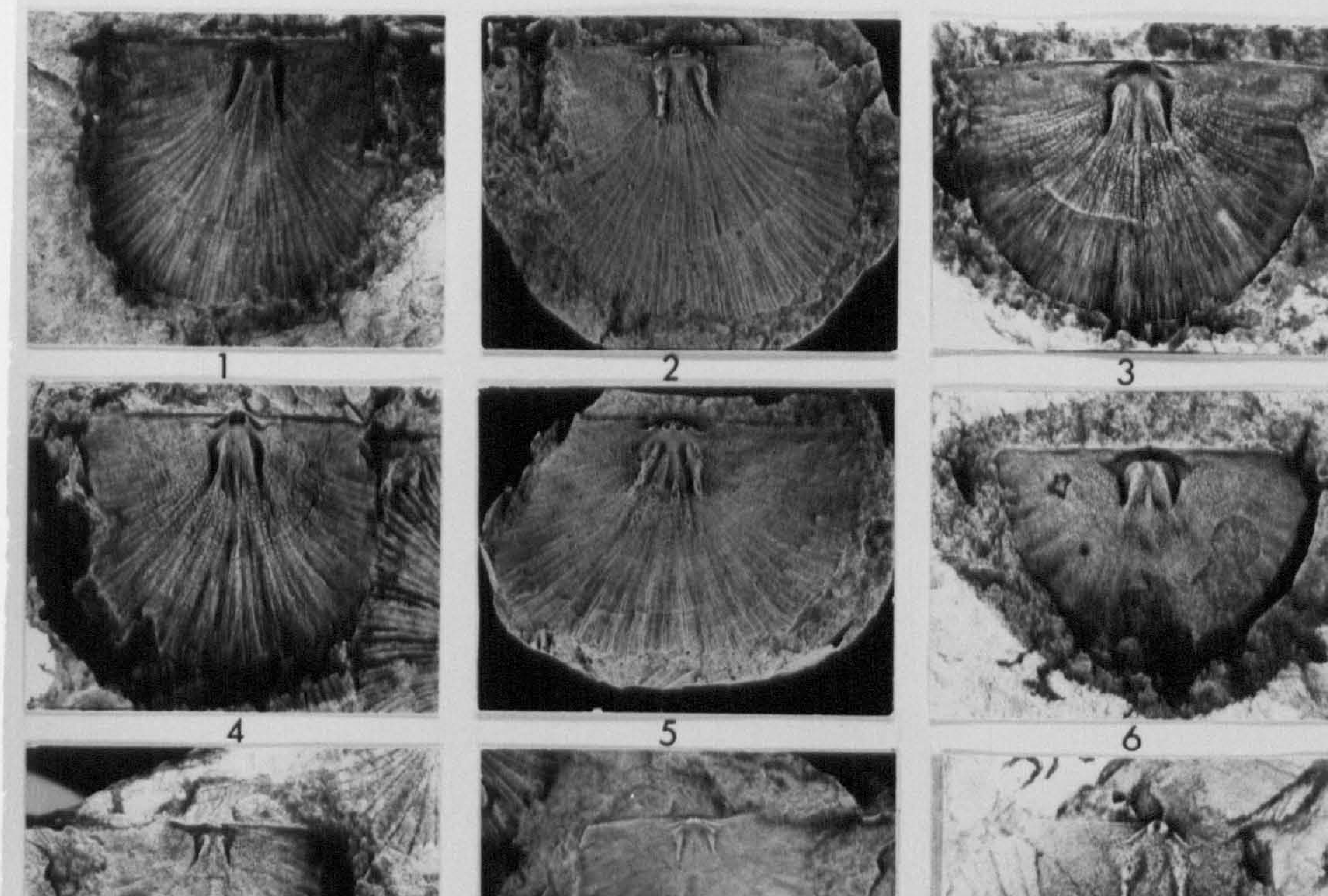
Figs.7,8, NMW84.42G.10a & b/1, internal mould and latex cast of a brachial valve showing the double and short bladed socket plates, from Upper Leintwardine Formation, Whitcliffe (Shropshire), x 1.6 and 1.7.respectively.

Fig.9. LC-NMW84.42G.5/33, internal of brachial valve showing the bladed socket plates, from uppermost Hemse Groups, Nyan 2 of Gotland; x 2.1.

Figs.10,11. AC-NMW84.42G.10a & b/2, internal moulds of brachial valves on the same bedding plane showing well impressed socket plates,both from Upper Leintwardine Formation, Whitcliffe (Shropshire); x 1.9.

Fig.12. LC-NMW84.42G.6, internal of a brachial valve showing well preserved cardinal process, socket plates and muscle bounding ridges, from uppermost Hemse Groups, locality Hällsarve in Gotland (Sweden); x 3.7.

PLATE 2



EXPLANATION OF PLATE 3

External valve morphology and ornamentation of *S. ornatella* (Davidson, 1871)

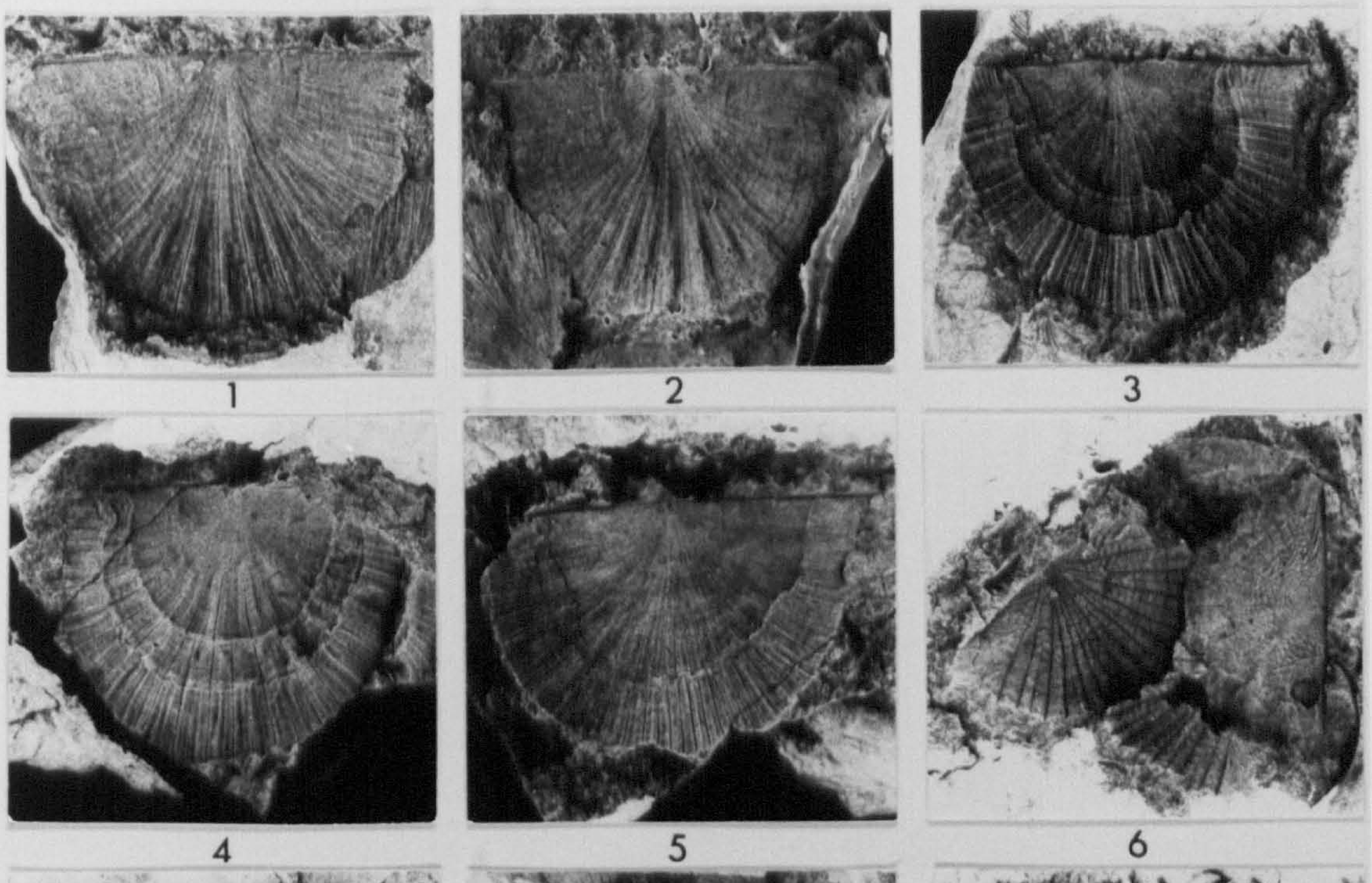
Figs.1,2,5. All from Upper Leintwardine Formation, locality Wt in Usk inlier. 1,2, AC-NMW84.42G.26a & b, external mould and latex cast of a brachial valve, x 2.6 and 2.0 respectively. 5, AC-NMW84.42G.22, external mould of brachial valve, x 2.0.

Figs.3,4,6,7,8. All from Upper Leintwardine Formation, locality C-30 near Ludlow (Shropshire). 3,4, AC-NMW84.42G. 11a/2 and 12, external moulds of a brachial valve showing well developed growth lines and radial ornament of both costellae and capillae, x 1.8 and 2.1 respectively, 6, AC-NMW84.42G.17, external mould of a brachial valve showing corrugations between costellae, x 1.9. 7, 8, AC-NMW84.42G.16a & b, internal of brachial valve and counterpart external mould showing the presence of only one growth line, x 2.1.

Fig.9. BC-YFF9311 (BGS), external mould of a brachial valve showing a well-developed pattern of broken rugae (corrugations) interrupted by radial ornament, from Upper Leintwardine Formation, locality C-30 near Ludlow (Shropshire); x 2.4.

Figs.10-12. 10,11, AC-NMW84.42G.3 & 7, externals of brachial valves showing numerous fine capillae between the coarser costellae, interrupted by faint corrugations (rugae), x 1.7 and 2.1 respectively. 12, LC-NMW84.42G.4, external mould of a brachial valve, x 2.2. All from topmost Hemse Groups; 10, 12, are from Nyan 2 and 11 is from Hallsarve 1, Gotland (Sweden).

PLATE 3



EXPLANATION OF PLATE 4

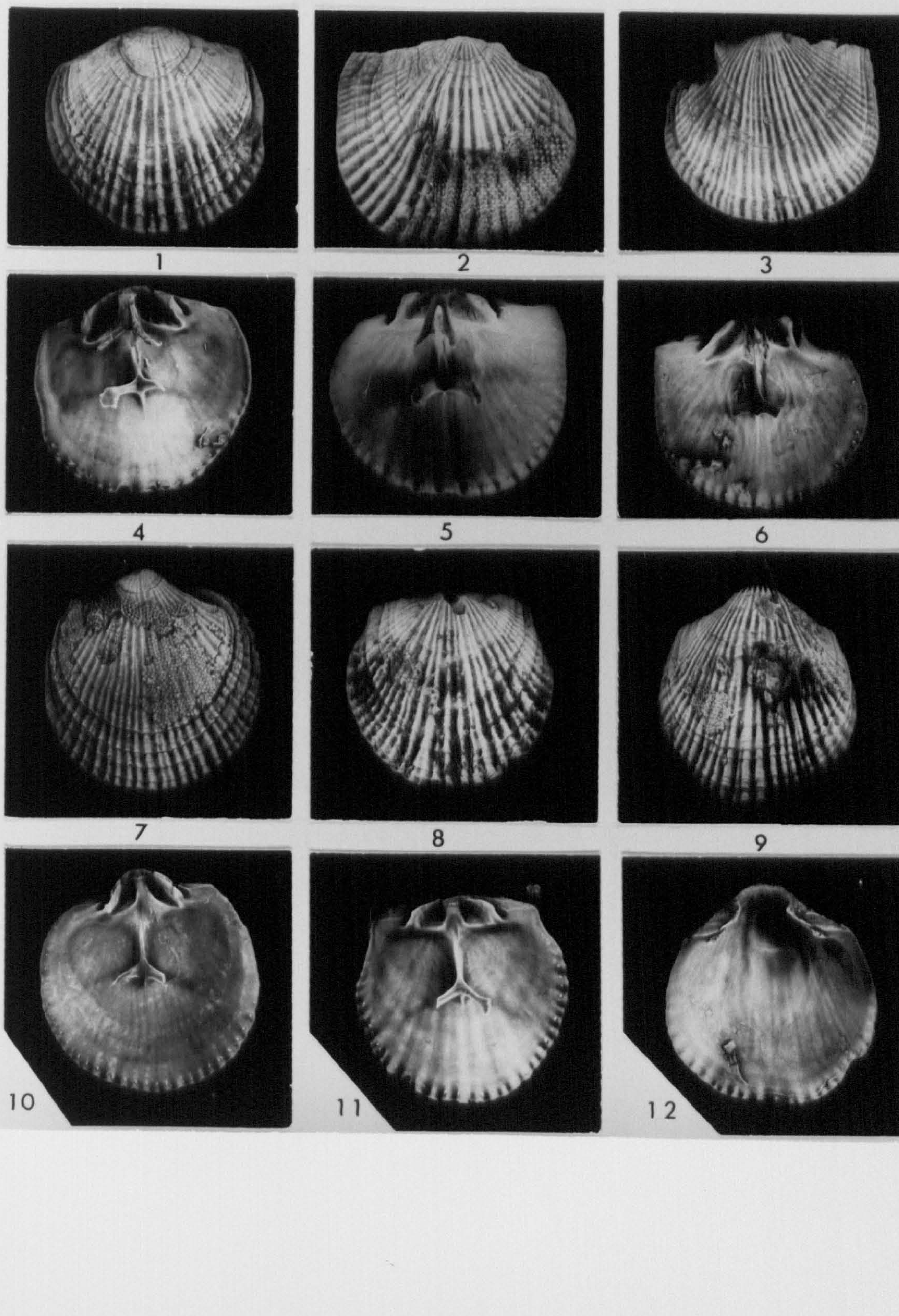
External and internal shell morphology of living brachiopod *K. rubra* (Pallas, 1776).

Figs. 1,2,3,7,8. Cc-L14737, L14738, L14739, L14740, L14741, external of brachial valves demonstrating the development of the growth fila (lines) and radial ornament (ribs) and also to show the variations in the shell shape, x 1.6, x 2.4, x 1.9, x 1.6 and x 1.6 respectively.

Figs. 4,5,6,10,11. Cc-L14737, L14738, L14739, L14740, L14741, internal of brachial valves illustrating the variations in the shape and angle of divergence of the socket plates and the ventral muscle, x 1.6, x 2.5, x 1.9, x 1.6 and x 1.7.

Figs. 9,12. Cc-L14742, external and internal of the pedicle valve, x 1.6.

PLATE 4



EXPLANATION OF PLATE 5

Paired photographs and drawings showing variation in the socket plates and pedicle valve muscle field in S. ornatella from various localities.

Figs. 1-3. Internal moulds of brachial valve illustrating the variations in the shape of the socket plates. 1, 3, AC-NMW84.42G. 24 and 18, from locality C-30 near Ludlow (Shropshire, 2, AC-NMW84.42G.28, from locality Wt in the Usk inlier; all from the Upper Leintwardine Formation; x 3.9, x 4.5 and x 5.3.

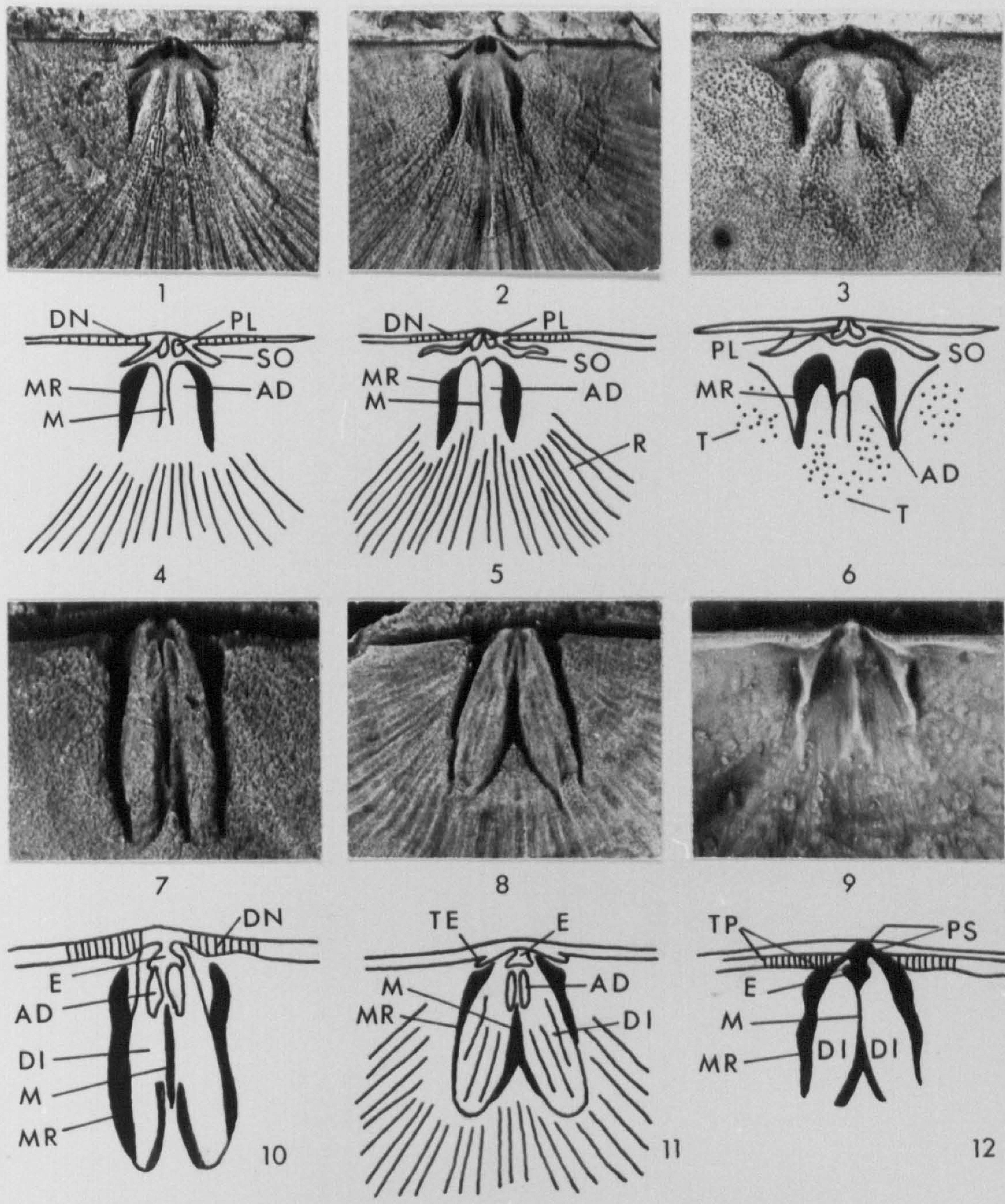
Figs. 4-6. Sketch diagrams for figs. 1, 2 and 3 respectively.

Figs. 7-9. Internal moulds of pedicle valve demonstrating the variations in the shape and angle of the pedicle valve muscle field, 7, AC-NMW84.42G.20, from locality C-30 near Ludlow, 8, AC-NMW84.42G.25, from locality Wt in the Usk inlier, 9, LC-NMW84.42G.2, from uppermost Hemse Groups, Nyan 2 in Gotland, 7 and 8 from Upper Leintwardine Formation, x 5.6, x 4 and 6.3 respectively.

Figs. 10-12. Sketch diagrams for figs. 7, 8 and 9 respectively.

In the sketched diagrams (Figs. 4-6 and Figs. 10-12): Ad. adductor muscle scars, DI. diductor muscle scars, DN. denticles, E. ventral process, M. myophragm, MR. muscle bounding ridges, PL. cardinal process lobe, PS. pseudodeltidium, R. ribs, SO. socket plates, T. tubercles and TE. teeth.

PLATE 5



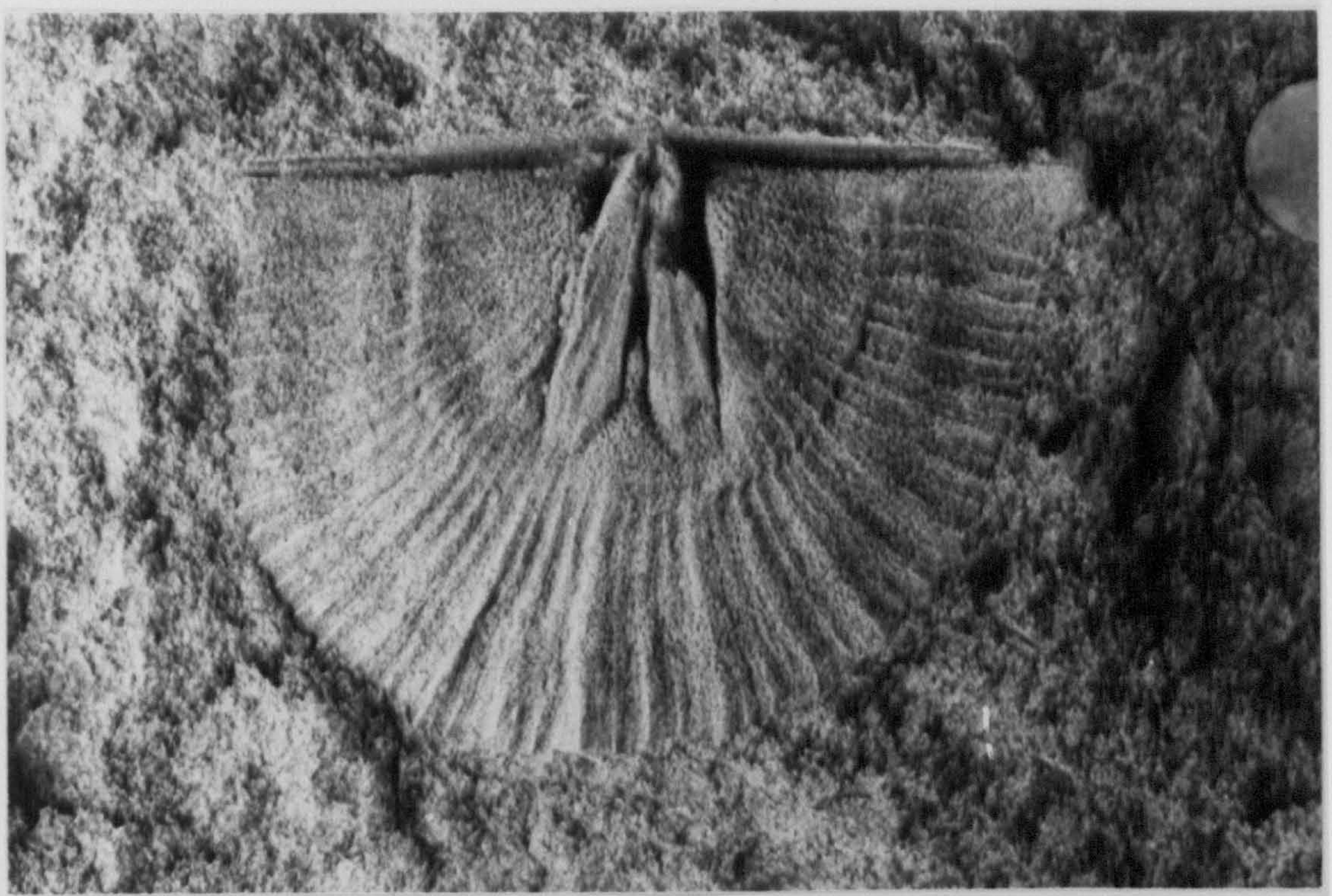
EXPLANATION OF PLATE 6

Pedicle valve morphology of the type specimen of S. ornatella (Davidson,1871).

Enlargement views of the mould and cast of the S. ornatella type specimen made to illustrate its internal shell features.

Figs. 1,2. GSM (Geological Society collection) BC13397, internal mould of pedicle valve and latex cast showing straight hinge line, ventral interarea, ventral process, myophragm, weakly developed adductor muscle scars, triangular diductor muscle scars and muscle bounding ridges, well impressed radial ribs and one concentric growth line present; from Upper Ludlow Formations, Whitcliffe, Ludlow, Salop; x 5.5 and 4.3 respectively.

PLATE 6



1

2

EXPLANATION OF PLATE 7

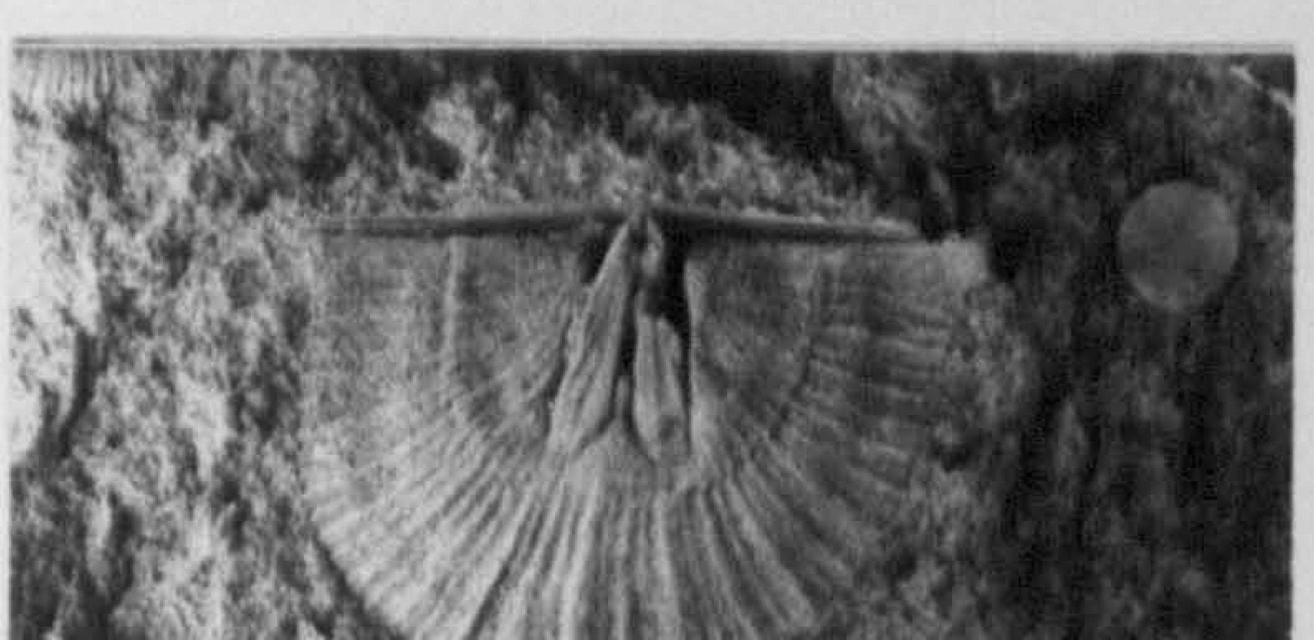
Brachial and pedicle valve morphology of S. ornatella (Davidson,1871).

Fig.1. AC1631/3, enlarged view of the internal mould of brachial valve illustrating the cardinal process lobes, recurved socket plates, well developed denticles along the hinge line, S-shaped muscle bounding ridges and the radial ornamentation; from Upper Leintwardine Formation; Walnut Tree Farm, (Wt) in the Usk inlier; x 3.4.

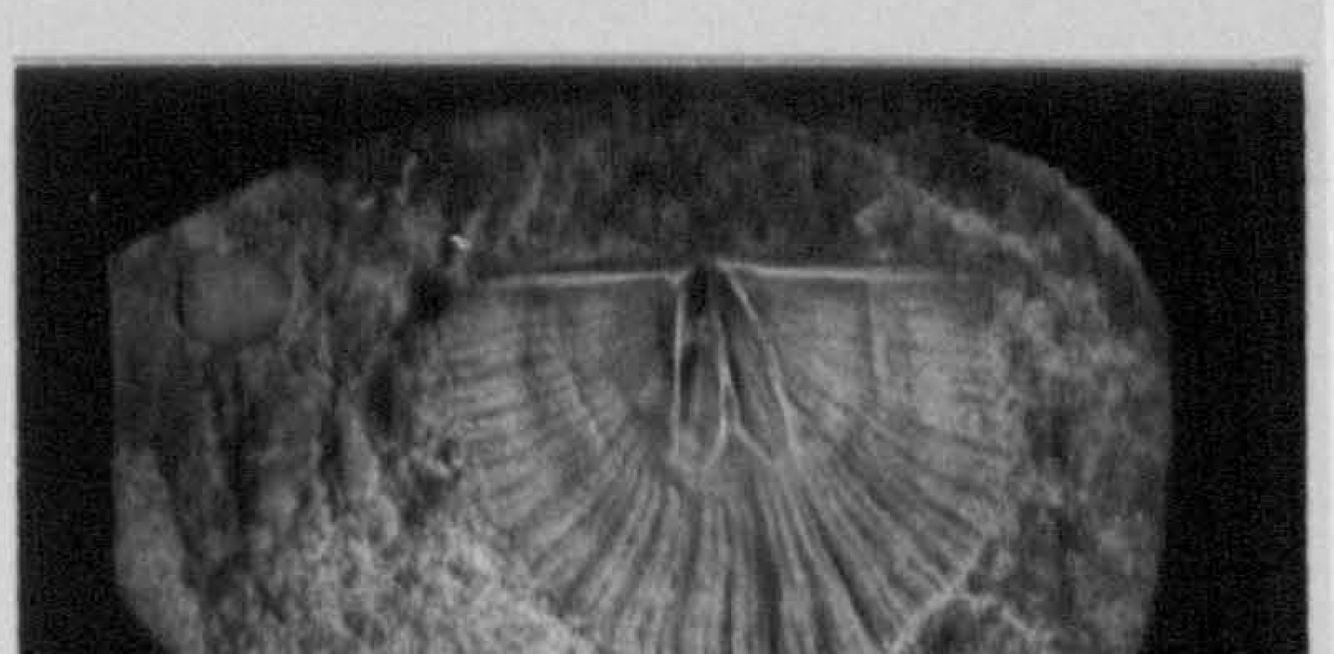
Figs.2,3. GSM (Geological Society collection) BC13397, internal mould of pedicle valve and latex cast demonstrating the ventral process, myophragm, triangular diductor muscle scar and muscle bounding ridges, well developed radial ornament and concentric growth lines, from Upper Ludlow Formation, Whitcliffe, Ludlow, Salop; x 2 and x 1.7 respectively.

PLATE 7

1



2



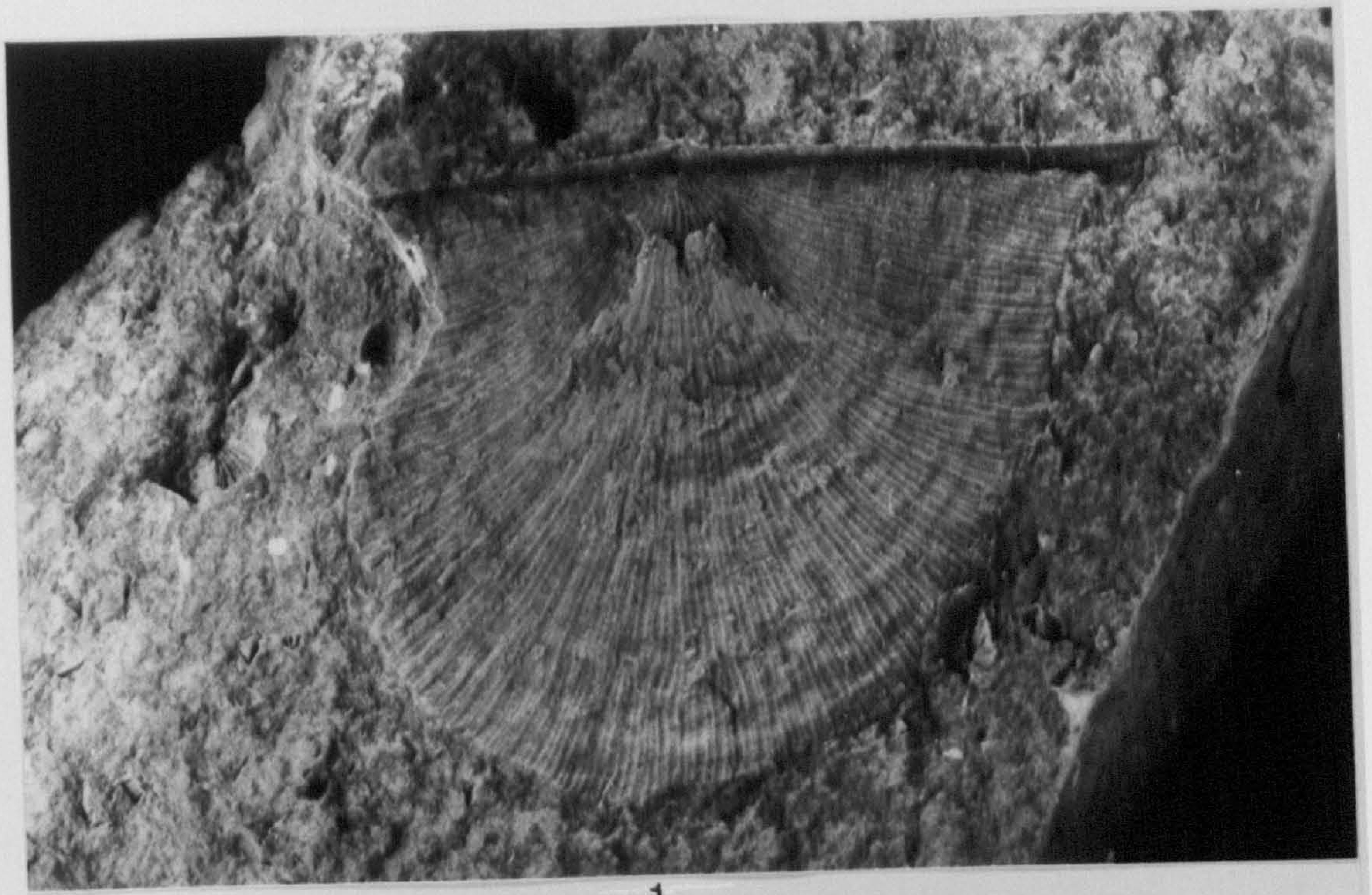
3

EXPLANATION OF PLATE 8

Brachial valve morphology of the refigured type specimen of *L.* (*L.*) *filosa* (J. de C. Sowerby,1839)

FIGS. 1,2,3. GSM (Geological Society collection) Bc6644, external moulds of brachial valve (figs.1 & 2) and latex cast (fig.3) illustrate the straight hinge line, mucronate ends of the hinge line which form the hinge ears (particularly well seen on the right hand side of the hinge line), convex chilidium and a well developed parvicostellate radial ornament; from the Coalbrookdale Formation (Wenlock Shale), Oldcastle, Malvern Hills, Worcestershire; X4, X1.5 and X 1.4 respectively.

PLATE 8



1

2

3

EXPLANATION OF PLATE 9

Pedicle valve morphology of L.(L.) filosa (J. de C. Sowerby,1839)

FIGS. 1,2,3. 1a and b, Ac-1529a and b, internal mould of pedicle valve and its counterpart impression showing triangular muscle and muscle bounding ridges, ventral process, myophragm and partitioned muscle ridges; 2a and b, Ac-1505a and b, internal mould of pedicle valve and latex cast showing the same structural features as fig.1; 3a and b, Ac-1435/7a and b, internal mould of pedicle valve and its counterpart external mould showing weakly impressed muscle, muscle bounding ridges and faintly developed growth lines in the counterpart specimen; all are from Lower Bringewood Formation; Llandegveth reservoir locality (LR) in the Usk inlier; x 1.1, x 1.3, x 1.6, x 1.5, x 1.3 and x 1.2 for figs. 1a,1b,2a,2b,3a and 3b respectively.

FIGS.4,8. 4, Ac-507, 8, Ac-1436, internal moulds of pedicle valve showing lanceolate adductor scars, triangular diductor scars, straight muscle bounding ridges and partitioned muscle ridges; from Lower Bringewood Formation; Llandegveth reservoir locality (LR) in Usk inlier; x 1.5 for both of them.

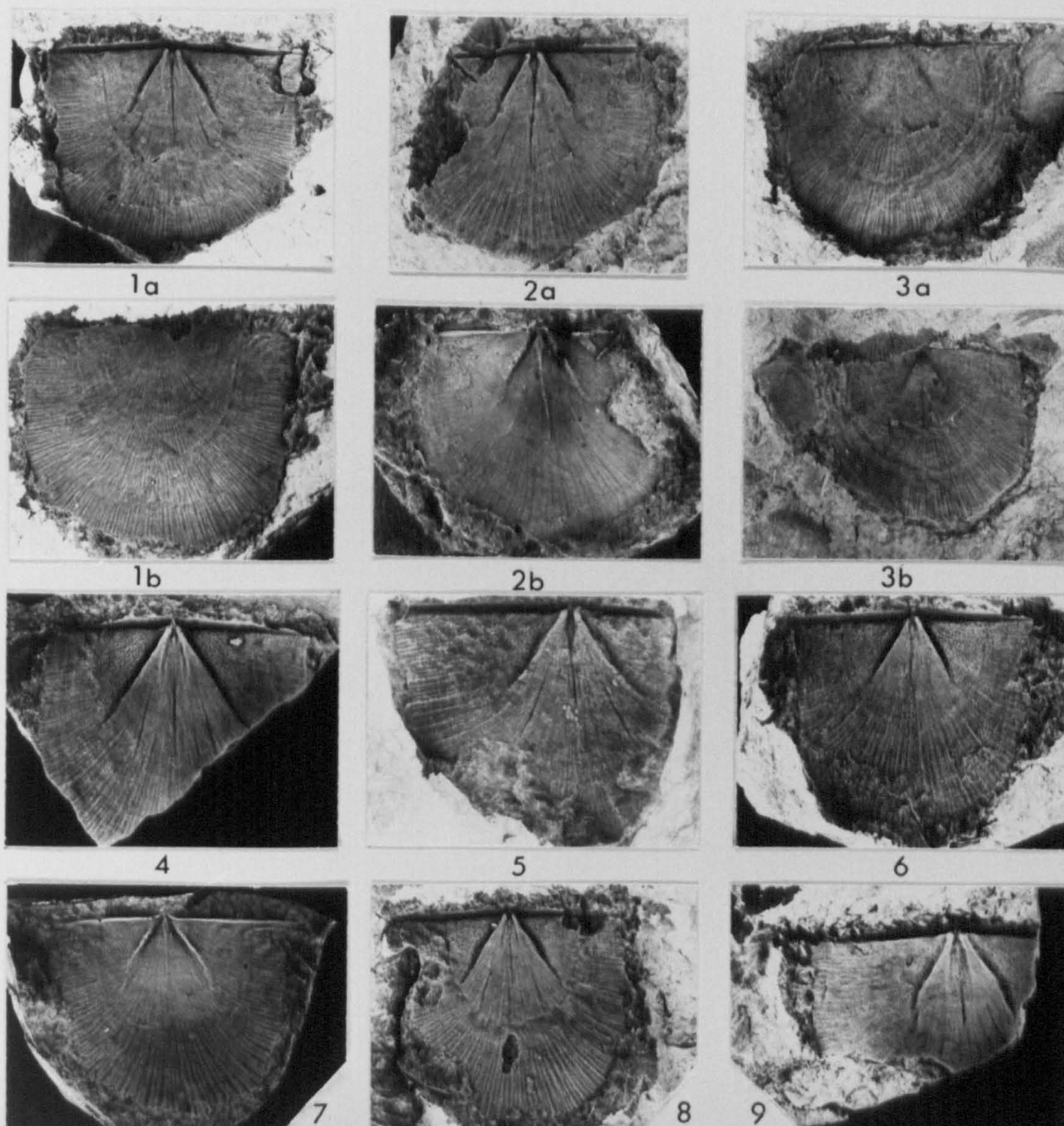
FIG.5. Ac-345/1, internal mould of pedicle valve showing a well developed ventral process and muscle bounding ridges which are very gently curved laterally (towards the lateral margin of the valve) before dying out anteriorly; from Lower Bringewood Formation; locality 31 near Ludlow area (Shropshire); x 2.4.

FIG.6. Ac-1535, internal mould of pedicle valve illustrating the triangular muscle field and the prolonged hinge line which forms the short, rounded ears; from Lower Bringewood Formation, Llandegveth reservoir locality (LR) in Usk inlier; x 2

FIG.7. Ac-220/1, latex cast of the internal mould of pedicle valve; from Lower Bringewood Formation, locality 31 near Ludlow area (Shropshire); x 1.6.

FIG.9. Ac-1477, internal mould of pedicle valve showing the triangular shape of the muscle bounding ridges which become nearly parallel after diverging at about 55°; from Lower Bringewood Formation; Llandegveth reservoir locality (LR) in Usk inlier; x 2.3.

PLATE 9



EXPLANATION OF PLATE 10

Brachial valve morphology of L.(L.) filosa (J. de C. Sowerby,1839).

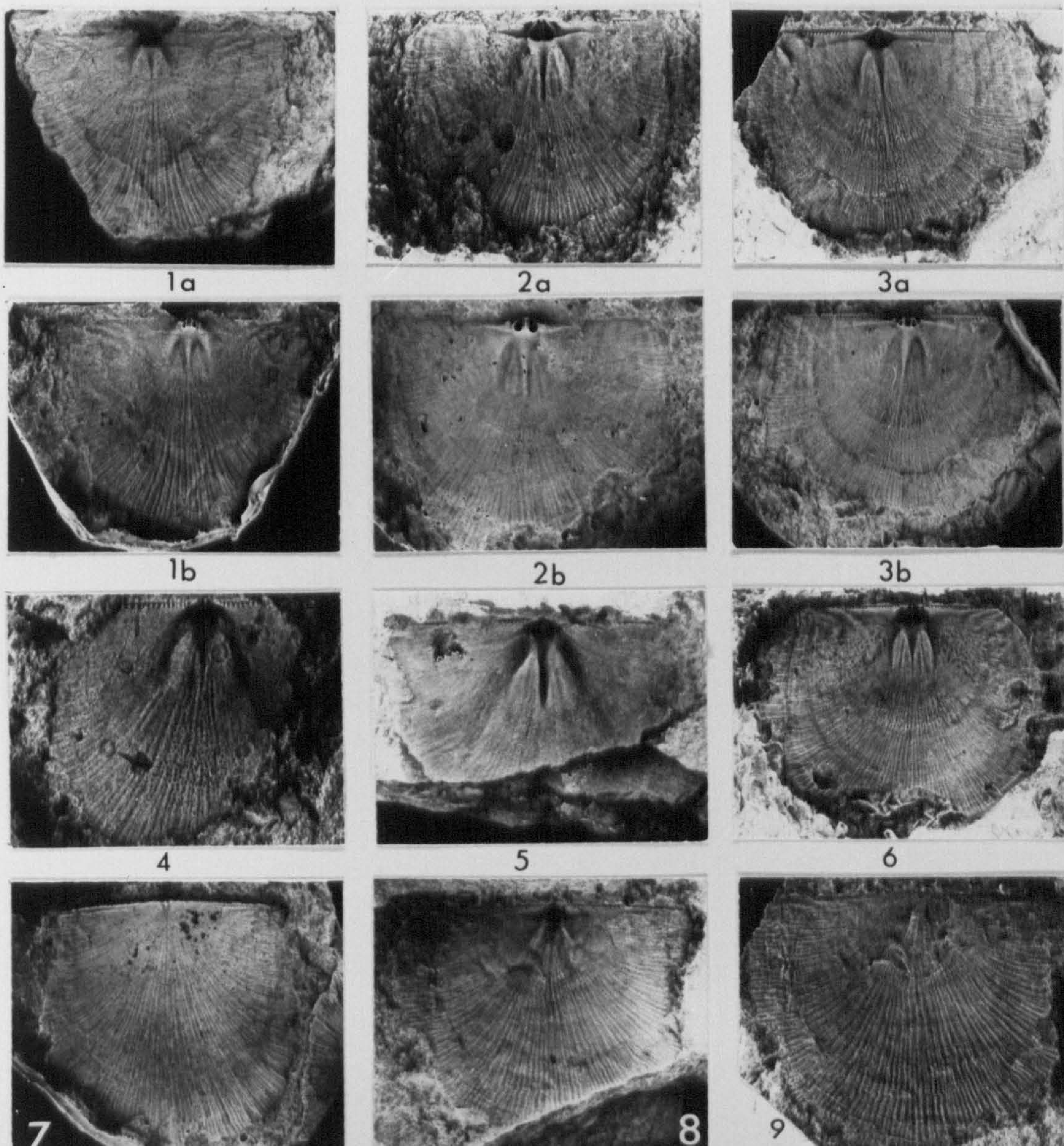
FIGS.1,8,9. 1a and b, Ac-336a and b, internal mould of brachial valve and its latex cast showing cardinal process lobes, adductor muscle scars, muscle bounding ridges, weakly developed auxiliary ridges extend laterally from the socket plates; short and rounded crenulations are weakly impressed at the antero-lateral sides of the hinge line which are directed towards and die out towards the muscle field; 8, Ac-205, internal mould of brachial valve showing the auxiliary ridges which are parallel to the hinge line and extend laterally for less than ½ the valve width; 9, Ac-175, external mould of brachial valve illustrating the equally and finely well developed radial ornament; all are from Lower Bringewood Formation; locality 31 (see text-fig.2.4) near Ludlow, (Shropshire); x 1.9,x 2.0, x 2.1 and x 2.3 respectively.

Figs.2,3,6. 2a and b, Ac-1422a and b, internal mould of brachial valve and its latex cast demonstrating the internal structural features of the brachial valve with well impressed extension ridges from the socket plates which are parallel to the hinge line; 3a and b, Ac-1444/1a and b, internal mould of brachial valve and its latex cast illustrating the auxiliary ridges which extend laterally from the socket plates for about ½ the valve width, diverging antero-laterally at a very low angle (about 10°-15°) to the hinge line, well developed denticles along the hinge line and about three faintly developed growth lines present; 6, Ac-1512, internal mould of brachial valve showing denticulations, crenulation, cardinal process lobes, recurved socket plates and well impressed muscle field; all from Lower Bringewood Formation; Llandegveth reservoir locality (LR) in Usk inlier; x 1.8, x 1.8, x 1.4, x 1.5 and 1.5x respectively for figs.2a,2b,3a,3b and 6.

FIGS.4,5. Ac-624, 599, internal mould of brachial valve showing the triangular muscle field, myophragm, short bladed shape socket plates, denticulations and cardinal process lobes; from Lower Bringewood Formation; localities B6 and B4 (section B) along the Deer Park Road of Mortimer Forest (text-fig. 2.1), south west of Ludlow; x 3 and 2.4 respectively.

FIG.7. Ac-1194/1, latex cast of the external of brachial valve showing the equally and finely parvicostellae radial ornament, from Lower Bringewood Formation; Woodbury Quarry in the Abberley Hills; x 1.6.

PLATE 10



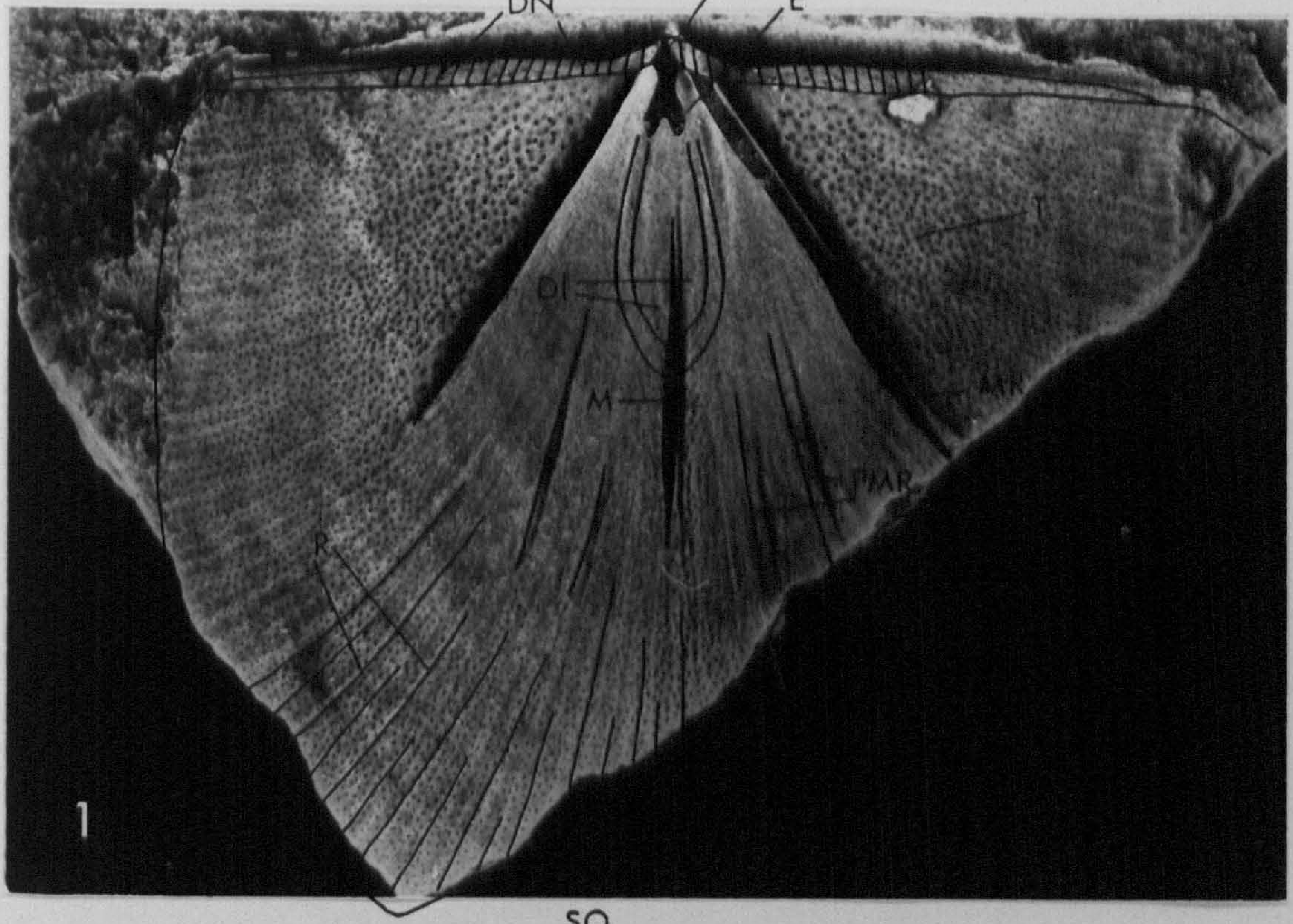
EXPLANATION OF PLATE 11

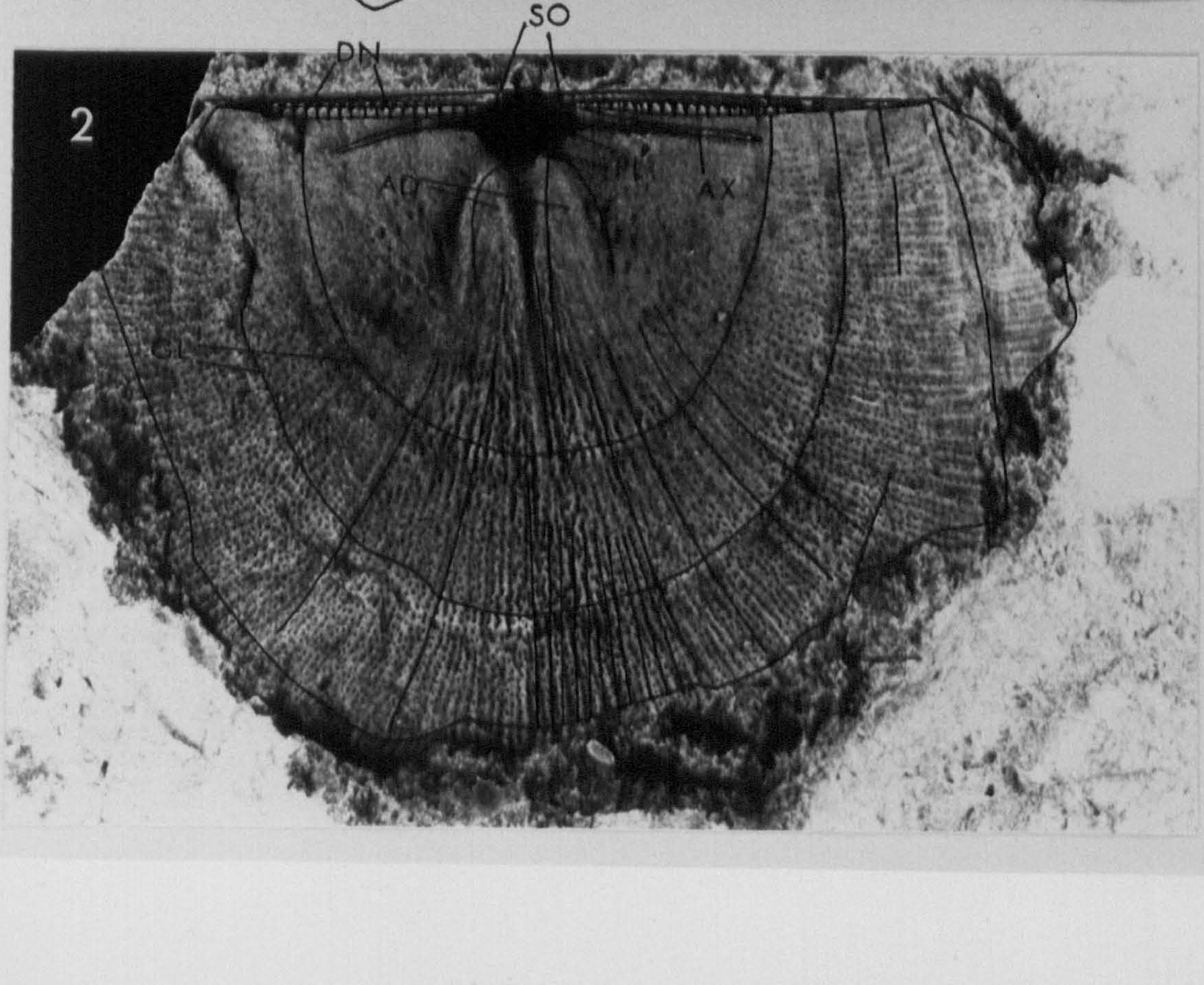
Pedicle and brachial valve morphology of _L_.(_L_.) _filosa_
(J. de C. Sowerby, 1839)

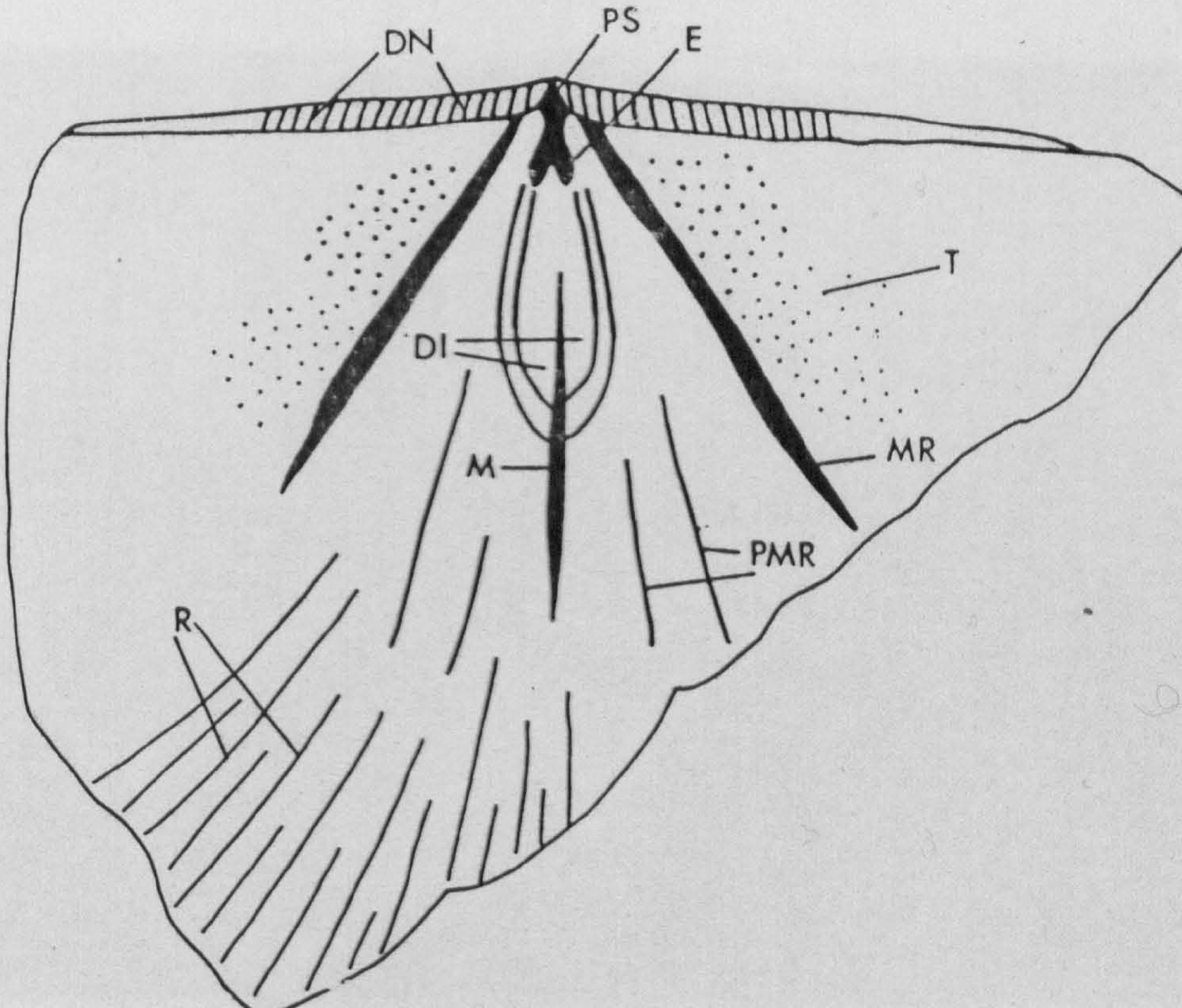
FIG.1. Ac-1507, internal mould of pedicle valve showing denticulations, pseudodeltidium, ventral process, lanceolate adductor and triangular diductor muscle scars, myophragm, muscle bounding ridges and additional partitioned muscle ridges, from Lower Bringewood Formation; locality LR Landegveth reservoir, in the Usk inlier; x 4.8.

FIG.2. Ac1444/1, internal mould of brachial valve showing denticulations, cardinal process lobes separated by a short rounded groove, short bladed socket plates which extend laterally like an auxiliary ridge for about ½ the valve width, adductor muscle and muscle bounding ridges, myophragm and three faintly developed growth lines, from Lower Bringewood Formation; Llandegveth reservoir (locality LR) in the Usk inlier; x 4.1.

PLATE 11






DN
PS
E
T
DI
M
MR
PMR
R

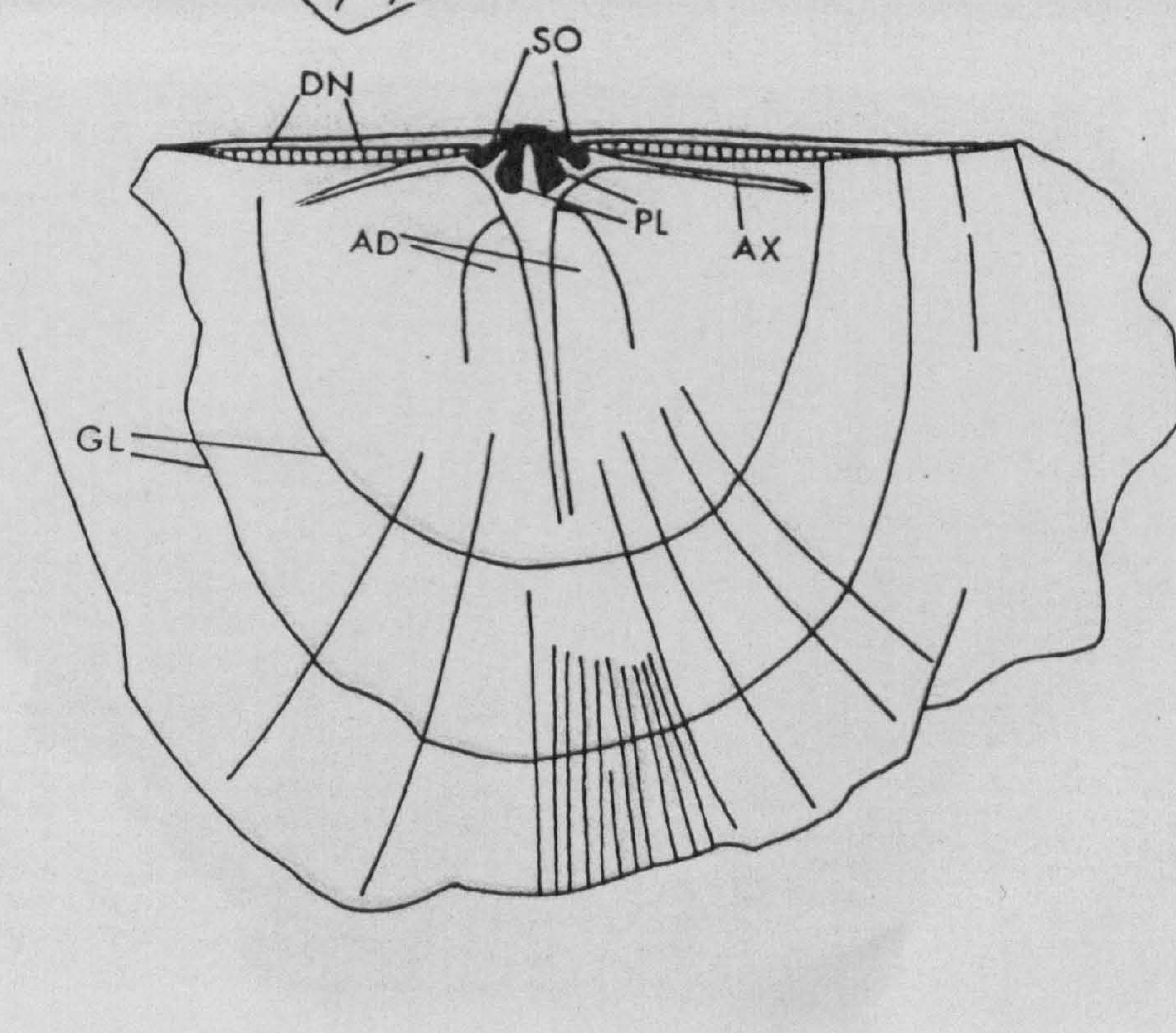
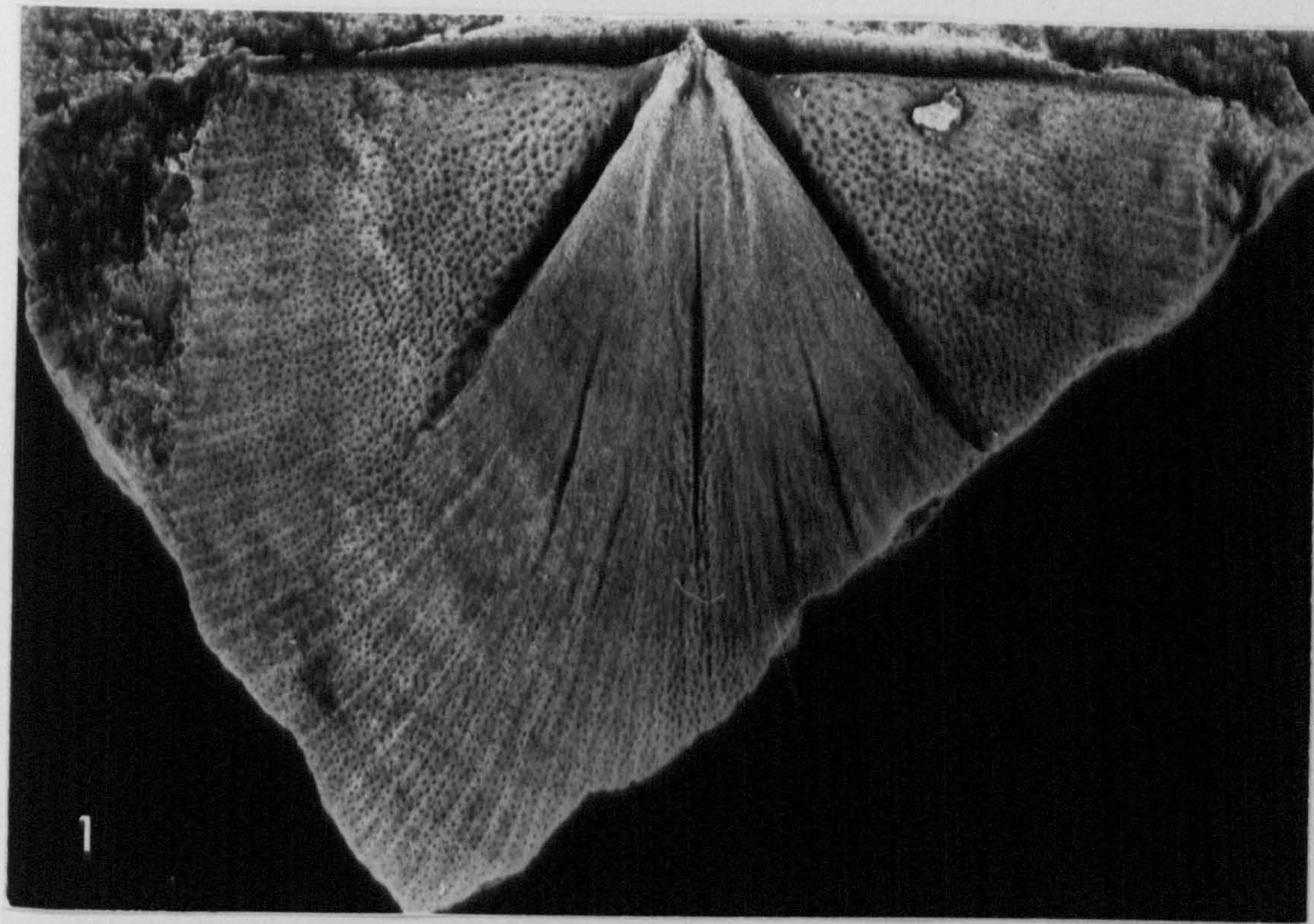
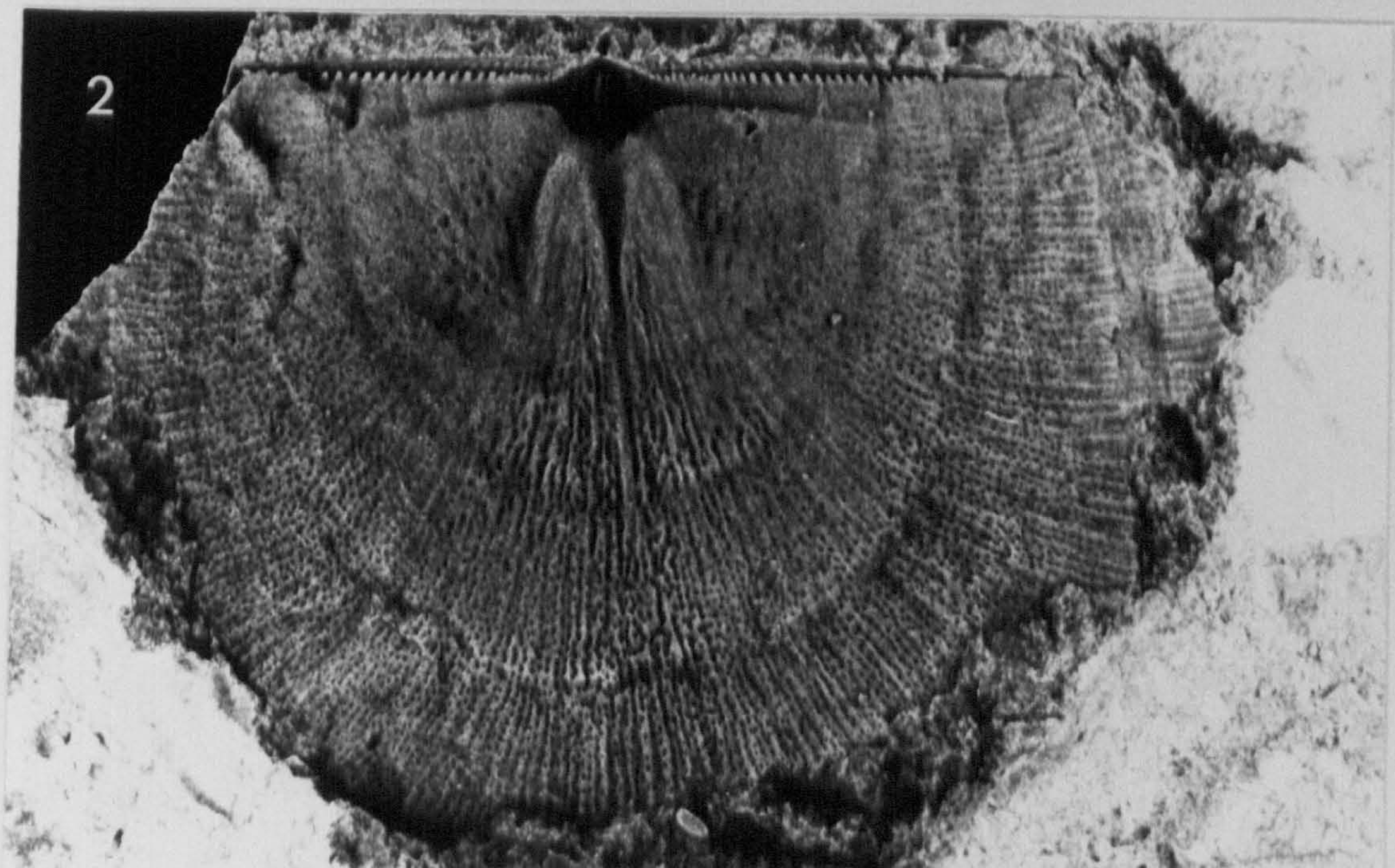

SO
DN
PL
AX
AD
GL

PLATE 11





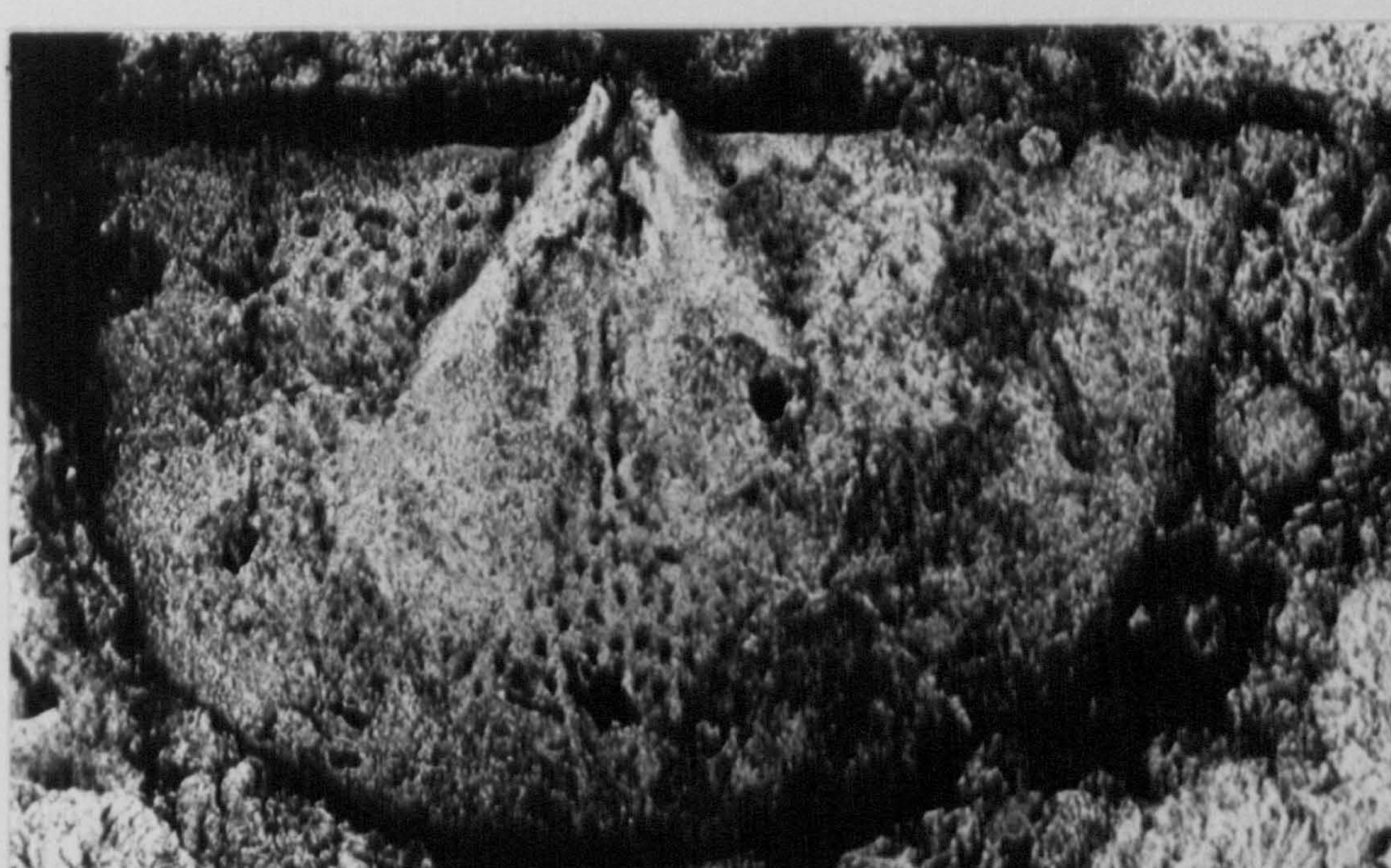
EXPLANATION OF PLATE 12

Pedicle valve morphology of P.(M.) lepisma (J. de C. Sowerby, 1839).

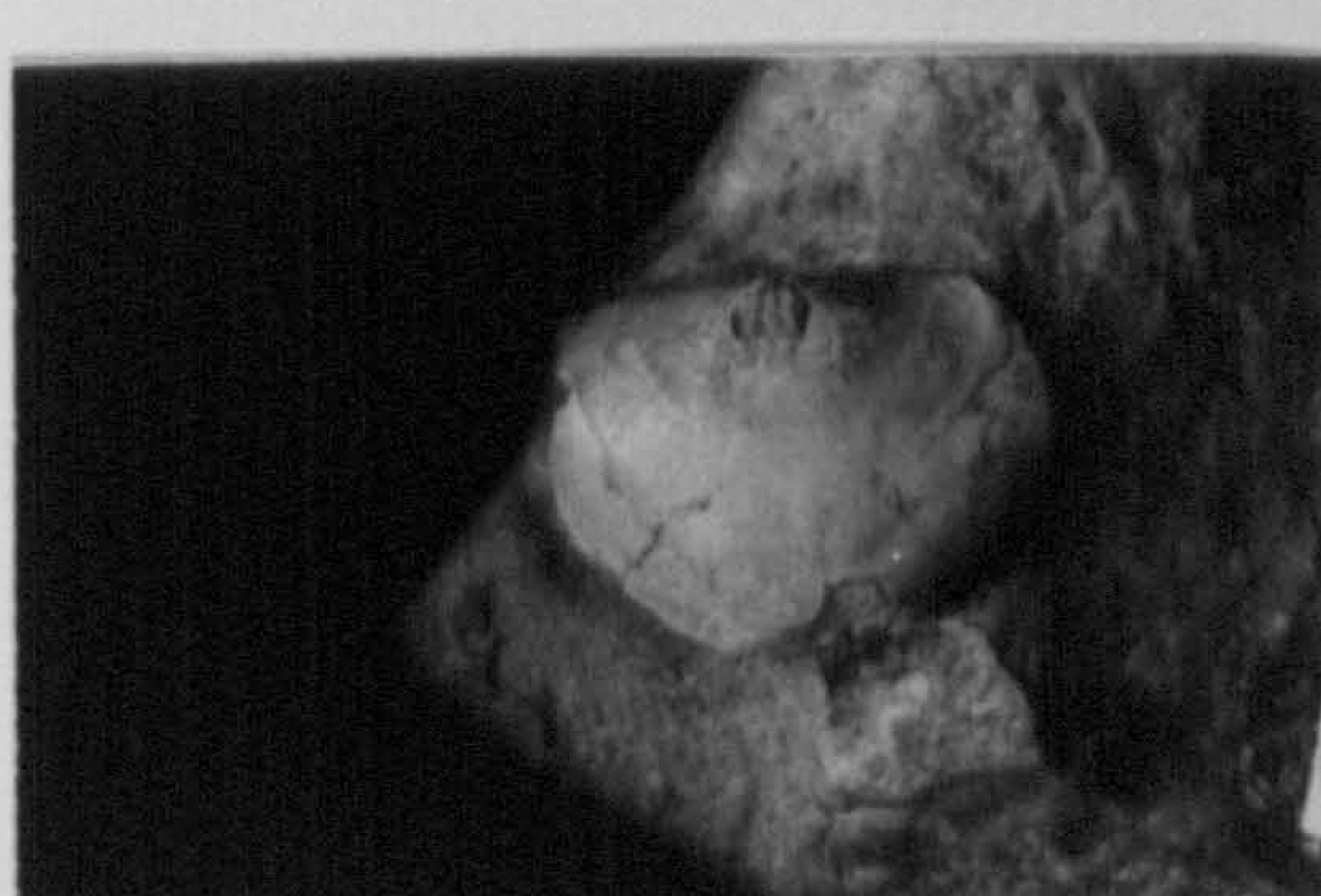
Fig.1. Ac-860b/3, internal mould of pedicle valve showing the posterior part of the adductor muscle scar, the triangular muscle and muscle bounding ridges, ventral process, myophragm, ventral interarea and denticulation, from Lower Bringewood Formation, locality 7a near Ludlow (Shropshire), x 10.7.

Figs.2,3. GSM (Geological Society collection) Bc-6638, external of pedicle valve and latex cast of the lectotype specimen showing the nacreous shell with numerous very fine and weakly developed radial fila, from the Lower Ludlow (probably Elton Formation) at Garden House Quarry, Aymestrey, Herefordshire (near Clungunford), x 2.8 and x 2.5 respectively.

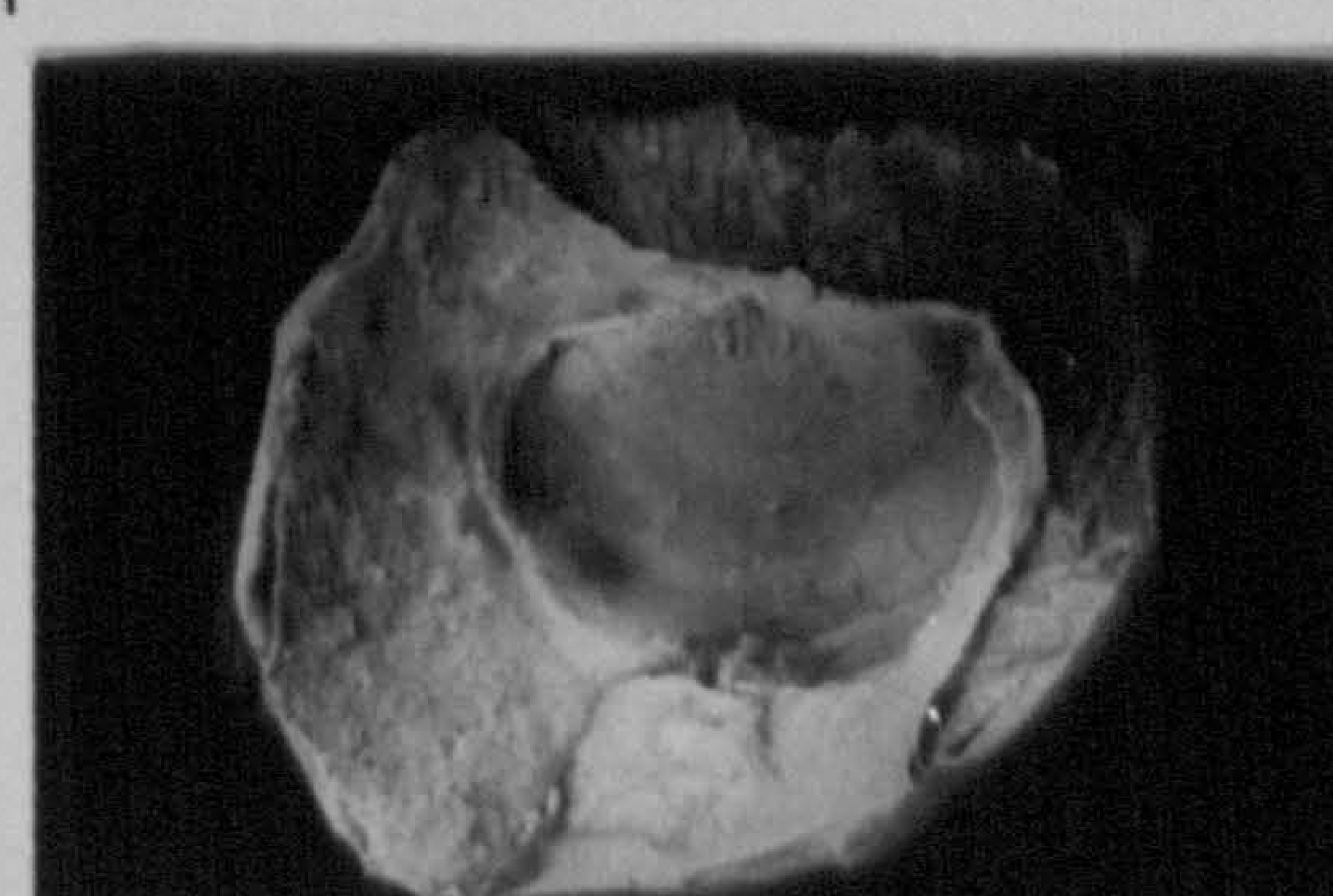
PLATE 12



1



2



3

EXPLANATION OF PLATE 13

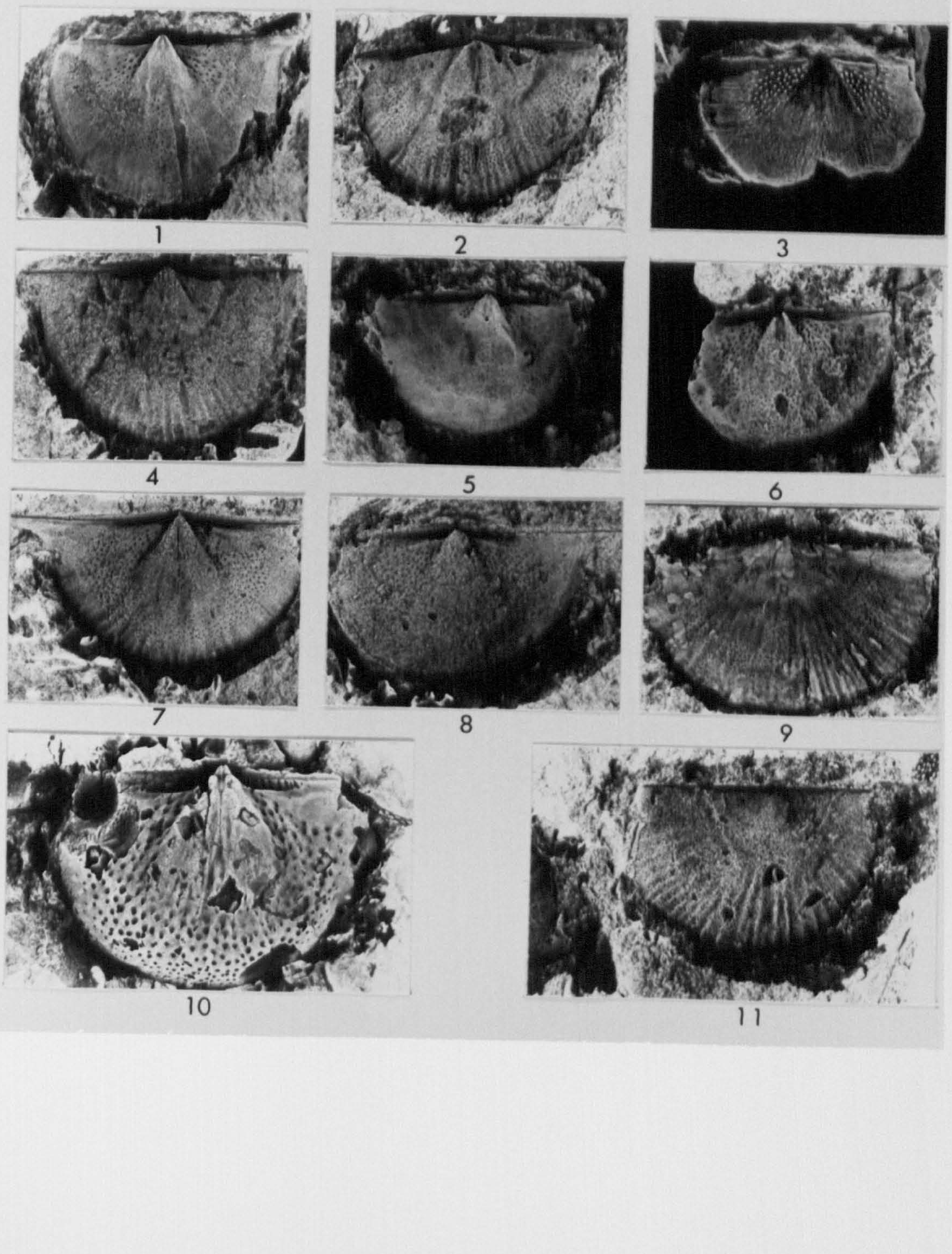
Pedicle and brachial valve morphology of P.(M.) lepisma (J. de C. Sowerby, 1839).

Figs.1,3,5,6. 1, Ac-1375; 5, Ac-1224; 6, Ac-350/3, internal moulds of pedicle valve showing the denticular plates, moderately to strongly impressed triangular muscle field and the development of the pits, particularly around the muscle field; 3, Ac-1344, internal of pedicle valve illustrates the triangular muscle and muscle bounding ridges, all from Lower Bringewood Formation; Woodbury Quarry (WQ) in the Abberley Hills; x 3.2, x 3.1, x 3.5 and 2.8 respectively.

Figs.2,4,9,11. 2, Ac-249/3; 4, Ac-207/2, internal moulds of pedicle valve demonstrate the weakly to moderately impressed muscle field and muscle bounding ridges and faintly developed radial ornament particularly near the valve margins; 9, Ac-202, external mould of pedicle valve showing radial ribs which become well developed around the valve margin; 11, Ac-239, external mould of brachial valve showing the radial ribs and the chilidium, all are from Lower Bringewood Formation, locality 31 near Ludlow (Shropshire); x 2.9, x 3.1, x 3.2 and x 3.7 respectively.

Figs.7,8,10. 7, Ac-439; 8, Ac-439; 8, Ac-537, internal moulds of pedicle valve showing the triangular muscle field and the mucronated sides of the hinge line which form the hinge ears; 10, Ac-418, internal mould of pedicle valve demonstrating the development of the denticulations along the denticular plates, ventral process, myophragm, the lanceolate adductor and the triangular diductor muscle scars; 7 and 10 are from Lower Elton Formation (locality A3 and A2 respectively); 8, is from Lower Bringewood Formation (locality A6); all from Mortimer Forest track, Section A which is on the south western slopes of High Vinnals Hill; x 3.9, x 3.4 and x 4.4 respectively.

PLATE 13



EXPLANATION OF PLATE 14

Brachial and pedicle valve morphology of P.(M.) lepisma (J. de C. Sowerby, 1839).

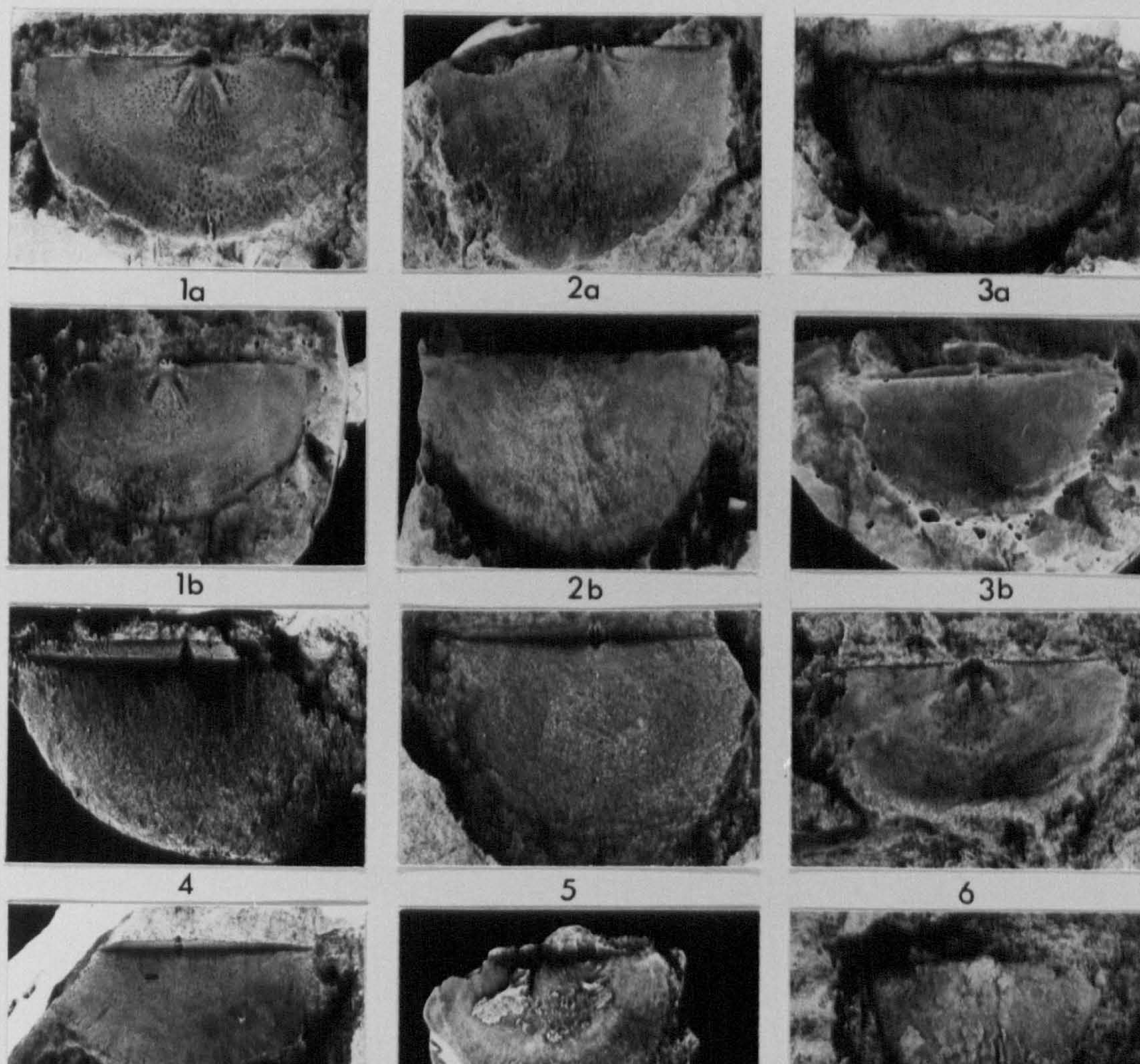
Figs.1,2,3,8. 1a and b, Ac-1170a and b, internal mould of brachial valve and latex cast showing the cardinal process lobes, the short blade-shaped socket plates, denticulations, the triangular adductor muscle and muscle bounding ridges; 2a and b, Ac-1279a and b, internal mould of brachial valve and counterpart impression illustrating the same structural features as in fig.1; 3a and b, Ac-1143/1a and b, external mould of brachial valve and latex cast showing the chilidium and the convex, triangular pseudodeltidium in the ventral interarea; 8, Ac-1410, external mould of brachial valve showing weakly developed radial ribs which can be easily overlooked; all are from Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 3.0, x 2.6, x 3.1, x 2.9, x 3.0 x 3.0 and x 2.3 for figs.1a,1b,2a,2b,3a,3b and 8 respectively.

Figs.4,6,7. 4, Ac-505; 7, Ac-527, external moulds of brachial valve demonstrating the pseudodeltidium in the ventral interarea in the pedicle valve with the triangular convex chilidium; 6, Ac-539 internal mould of brachial valve showing the same structural features as in figs.1 and 2; all are from Lower Bringewood Formation, Mortimer Forest track, Section A (localities A4-A6) near Ludlow (Shropshire); x 4.4, x 5.0 and x 2.9 respectively.

Fig.5. Ac-843/1, external mould of brachial valve showing the impression of the cardinal process lobes and the chilidium, from Lower Bringewood Formation, locality 7a near Ludlow (Shropshire); x 4.4.

Fig.9. Ac-1127, internal mould of pedicle valve showing the weakly developed muscle and muscle bounding ridges with numerous radial ribs near the anterior valve margin, from Lower Bringewood Formation, locality W1 in the Perton Lane section of the Woolhope inlier; x 3.0.

PLATE 14



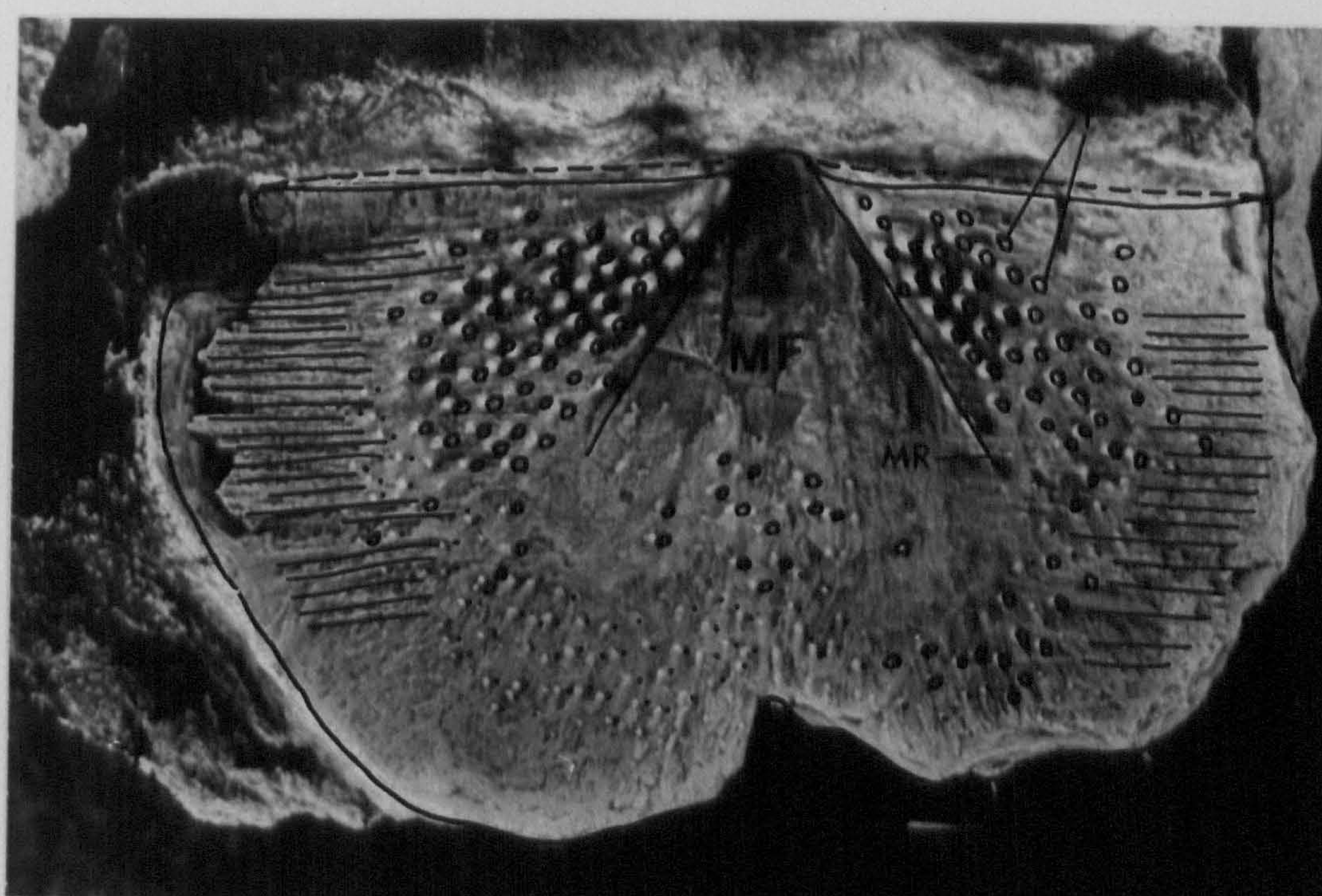
EXPLANATION OF PLATE 15

Internal of pedicle and brachial valve morphology of P.(M.) lepisma (J. de C. Sowerby,1839).

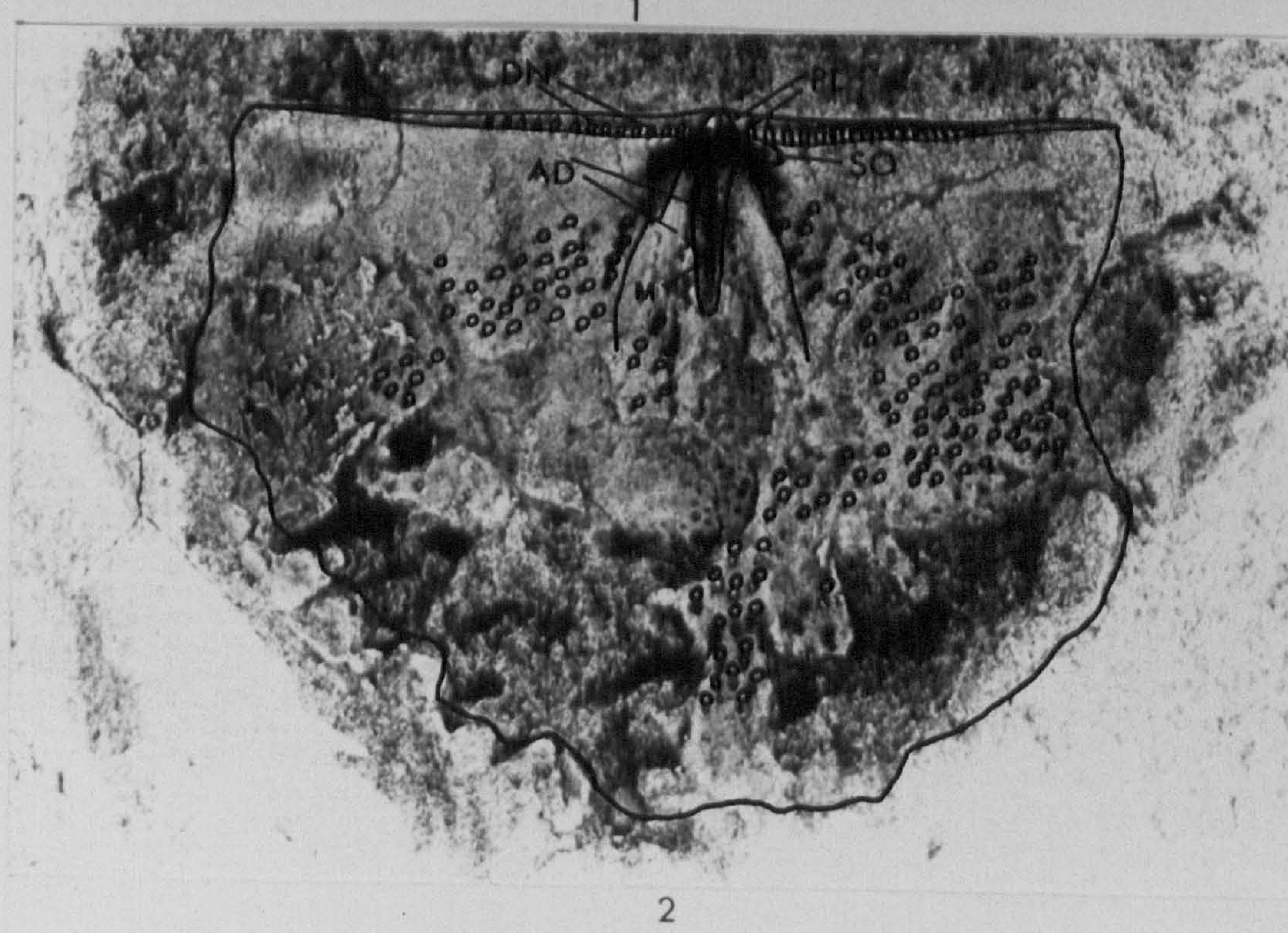
Fig.1. Ac-1344, internal of pedicle valve showing part of the shell, the muscle bounding ridges which diverge antero- laterally at about 62° from each other, and the concentration of the pits around the muscle field, from Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 9.6.

Fig.2. Ac-528, internal mould of brachial valve demonstrates the development of the denticulations along the hinge line, the chilidium, cardinal process lobes, socket plates, myophragm, the triangular muscle scars, from Lower Bringewood Formation, Mortimer Forest track, Section A (locality A5) near Ludlow (Shropshire); x 9.1.

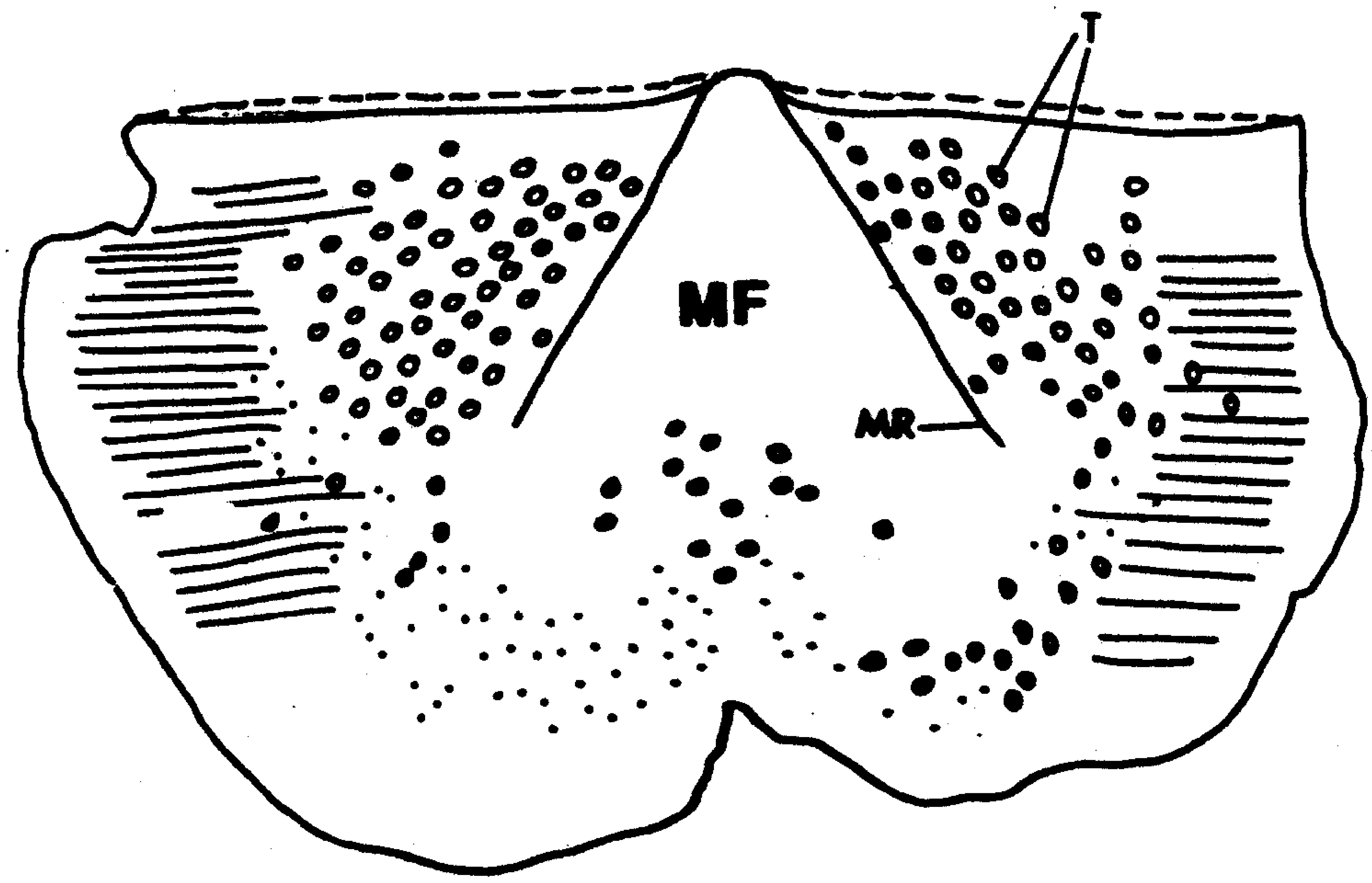
PLATE 15



1



2


T
MF
MR

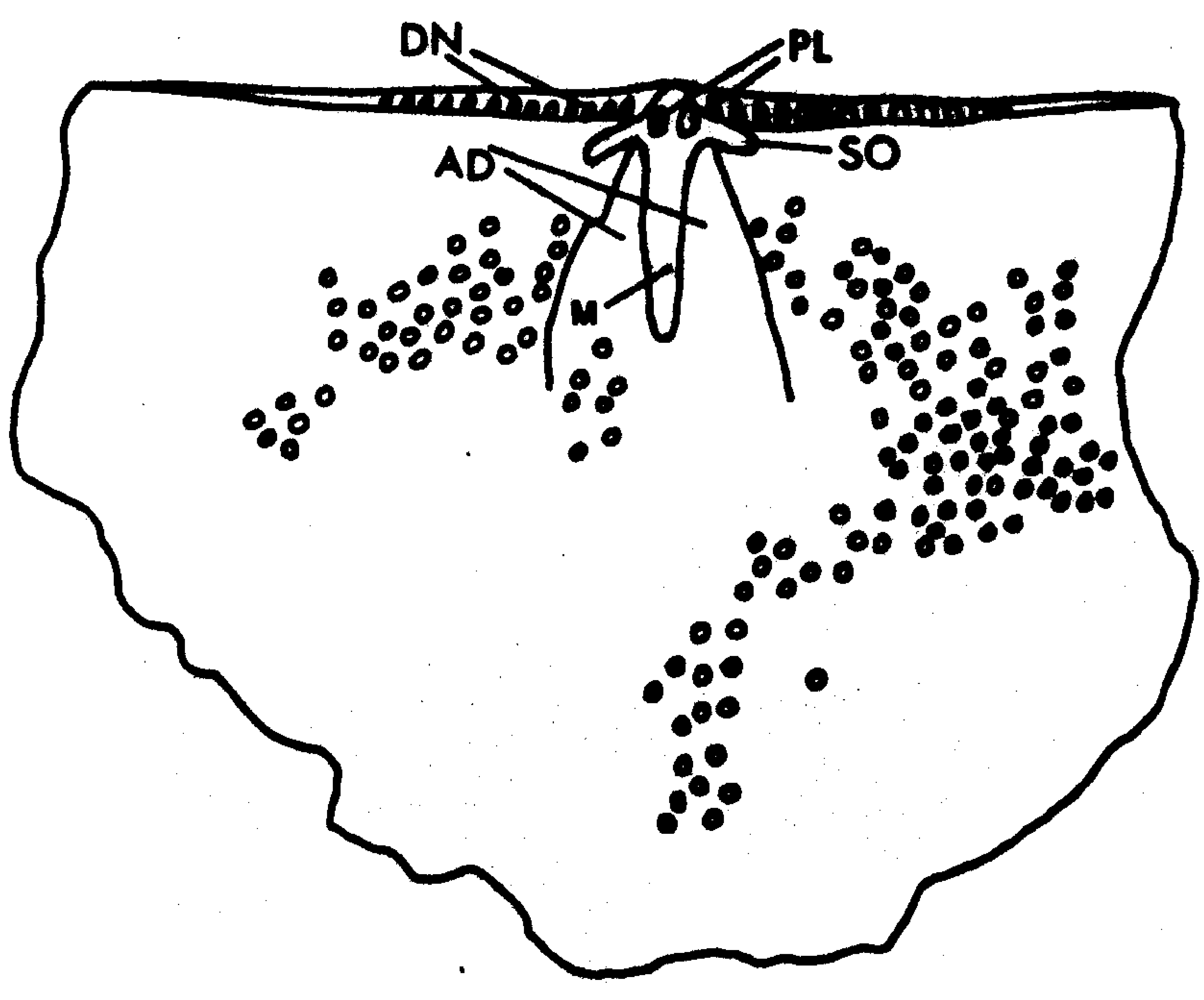
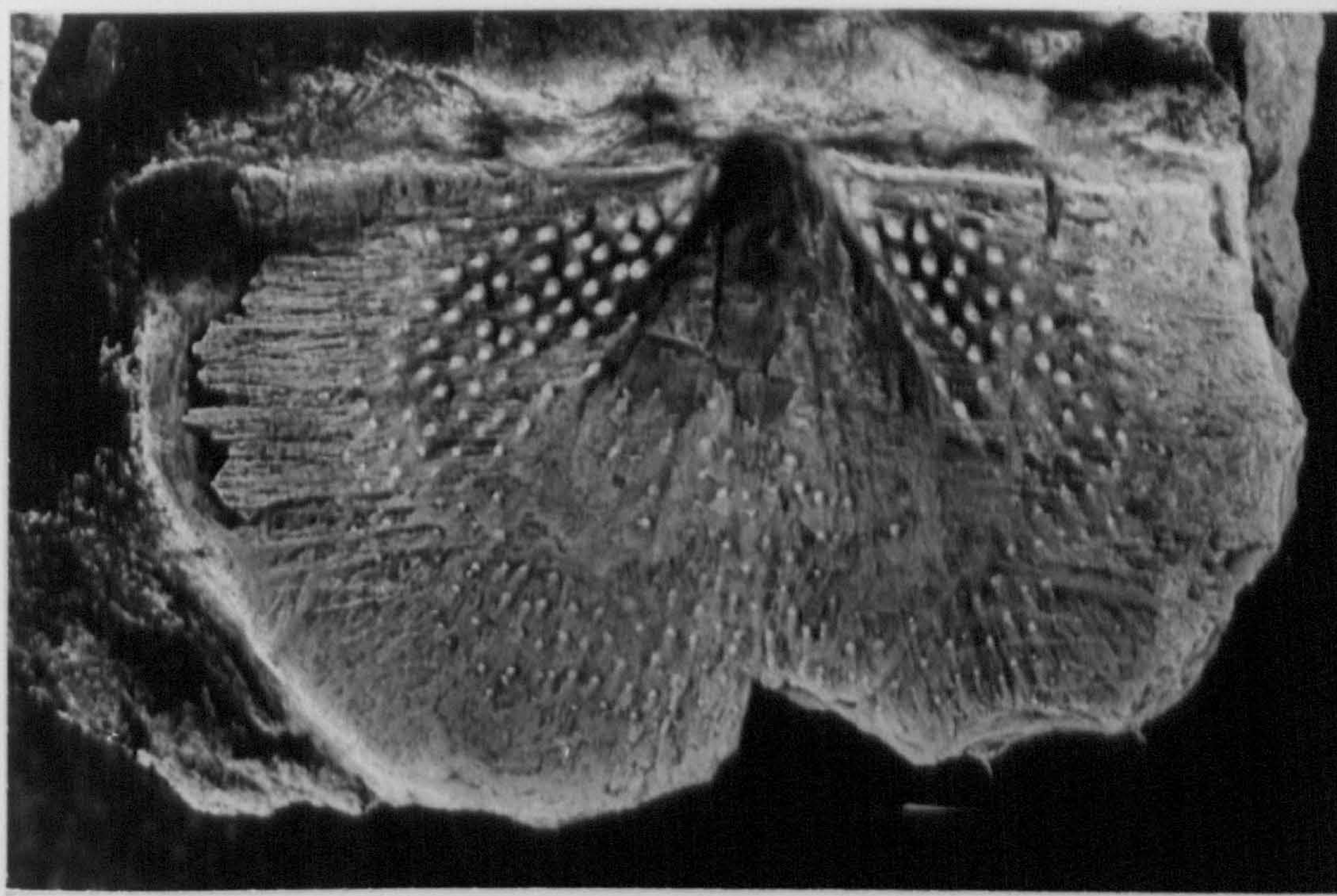

DN
PL
SO
AD
M

PLATE 15



1

2

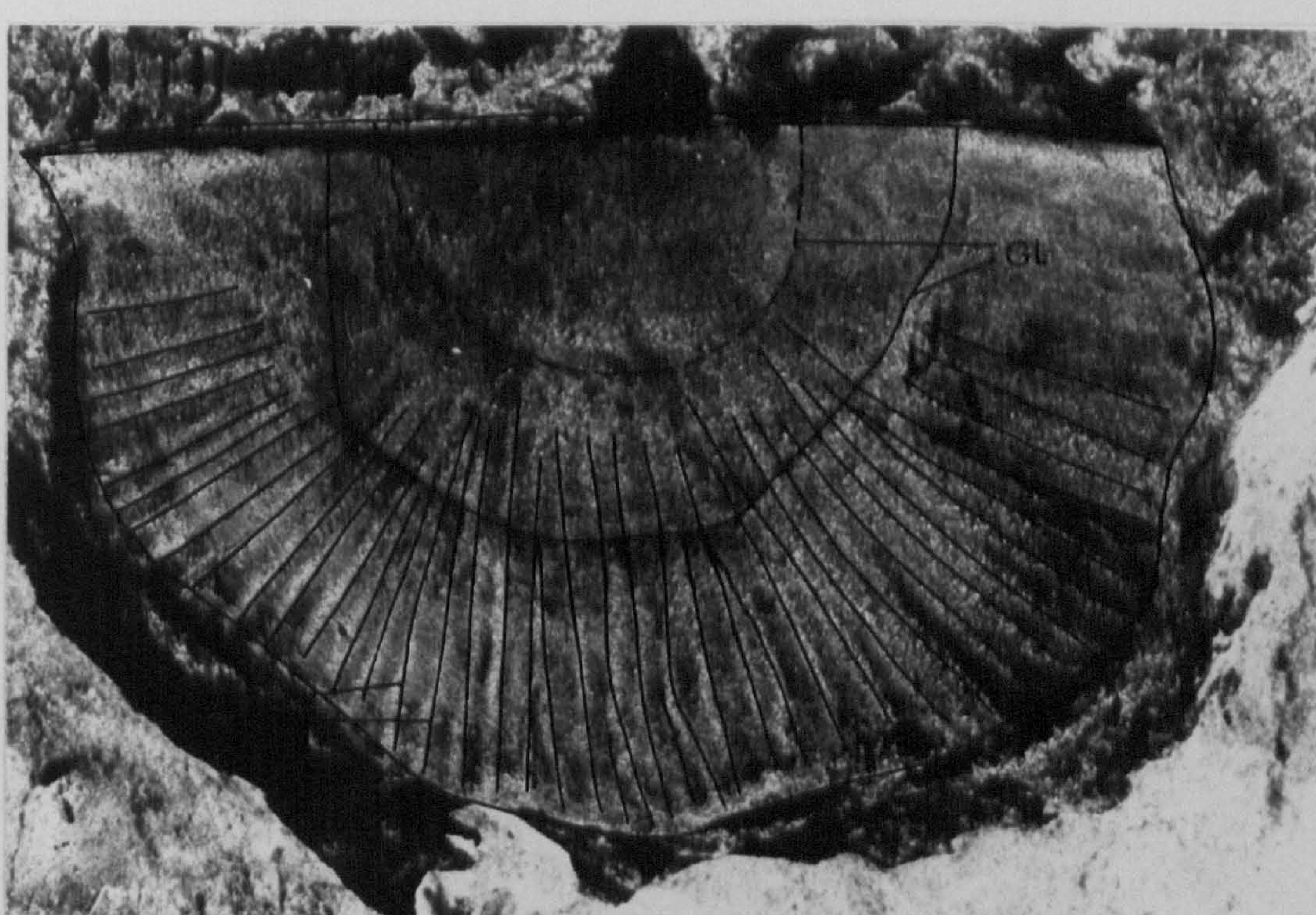
EXPLANATION OF PLATE 16

External of brachial valve morphology of *P.* (*M.*) *lepisma* (J. de C. Sowerby, 1839).

Fig.1. Ac-314, external mould of brachial valve illustrating the moderately developed radial ornaments with two concentric growth lines which are very faintly developed, from Lower Bringewood Formation, locality 31 near Ludlow (Shropshire); x 8.9.

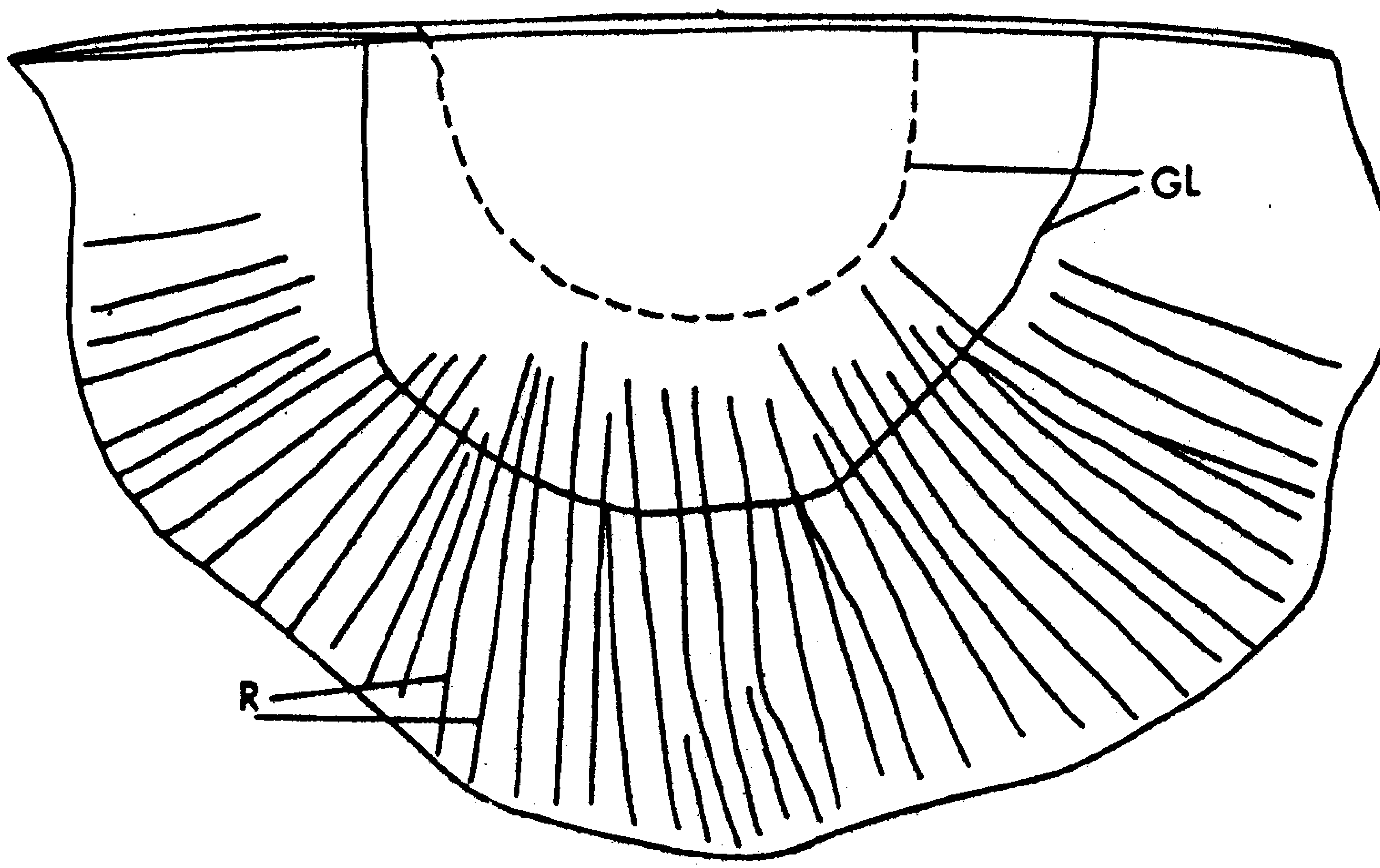
Fig.2. Ac-505, external mould of brachial valve showing a smooth shell, chilidium and the apsacline ventral interarea with the convex, triangular pseudodeltidium which appears in the posterior part of the pedicle valve, from Lower Bringewood Formation, Mortimer Forest track, Section A (locality A4) near Ludlow; x 10.4.

PLATE 16



1

2


GL
GL
R

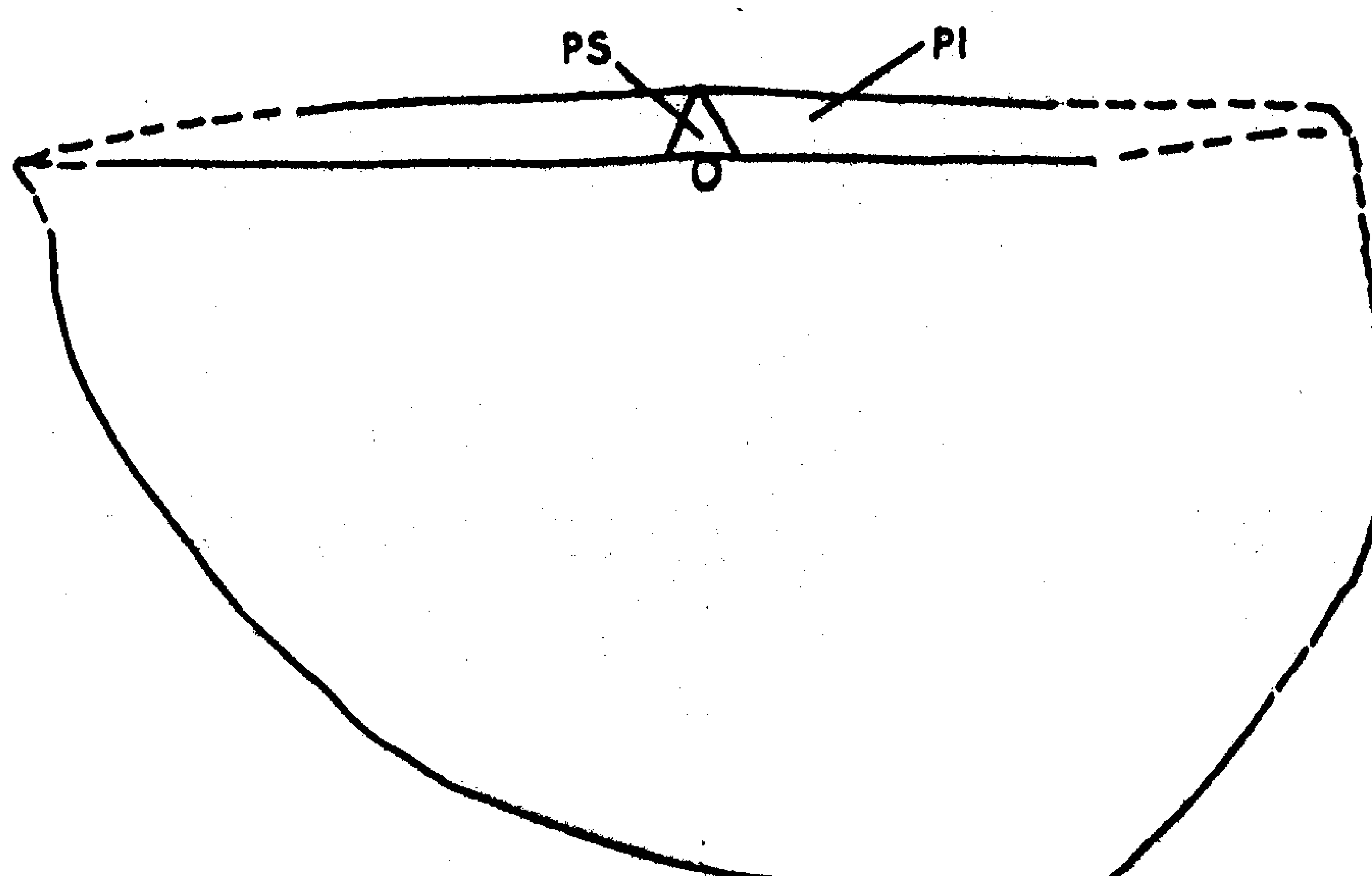
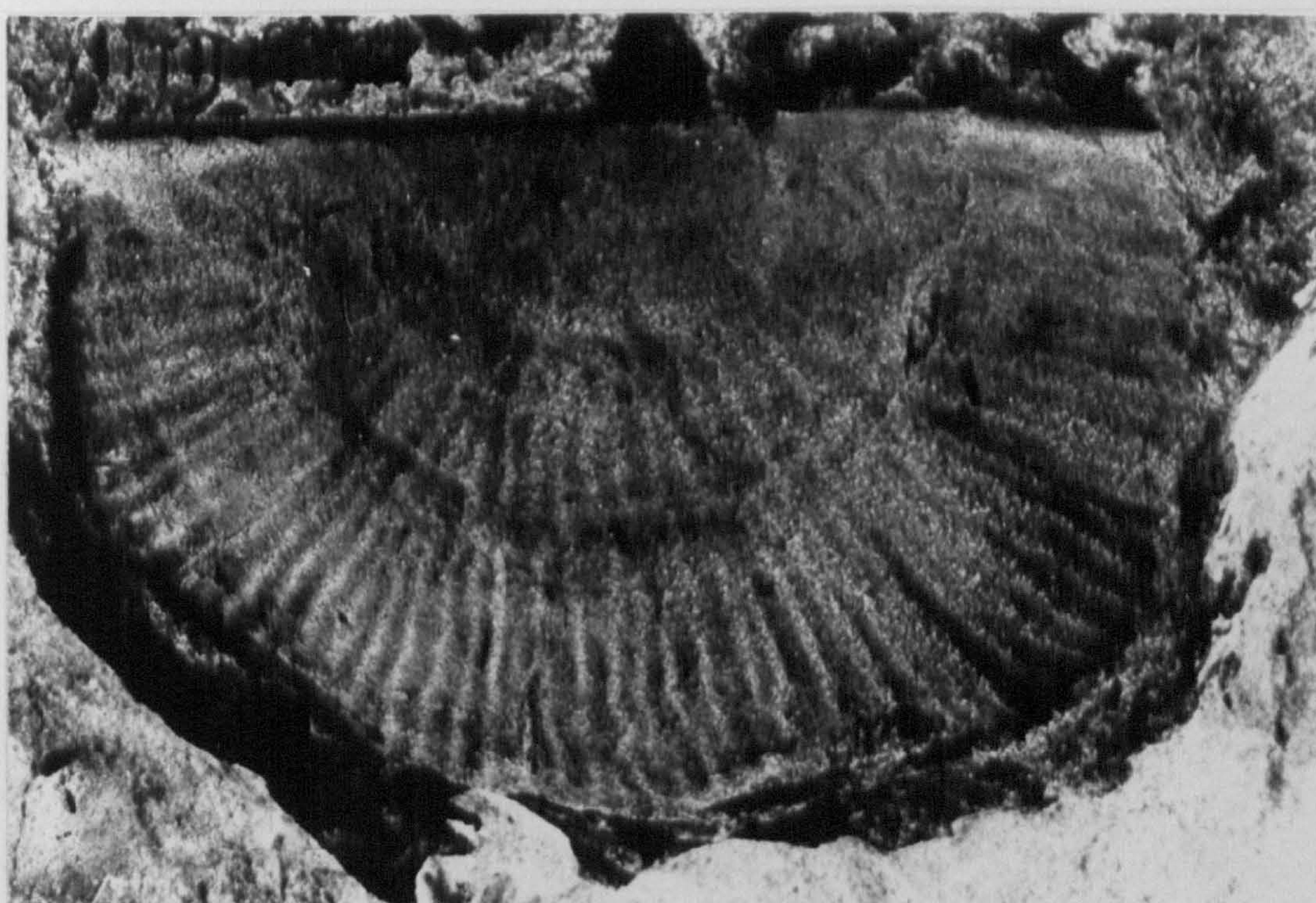

PS
PI
O

PLATE 16



1

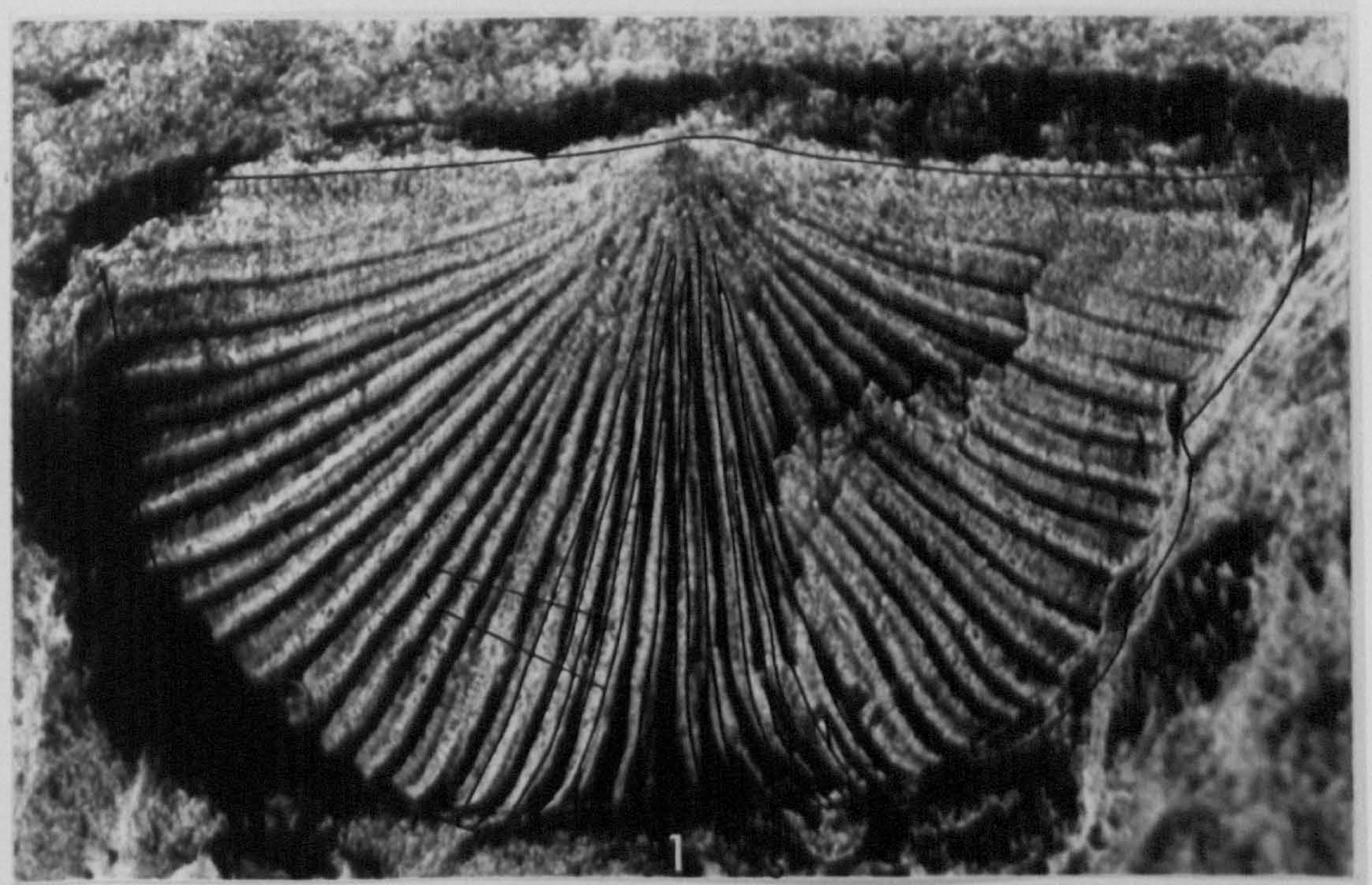
2

EXPLANATION OF PLATE 17

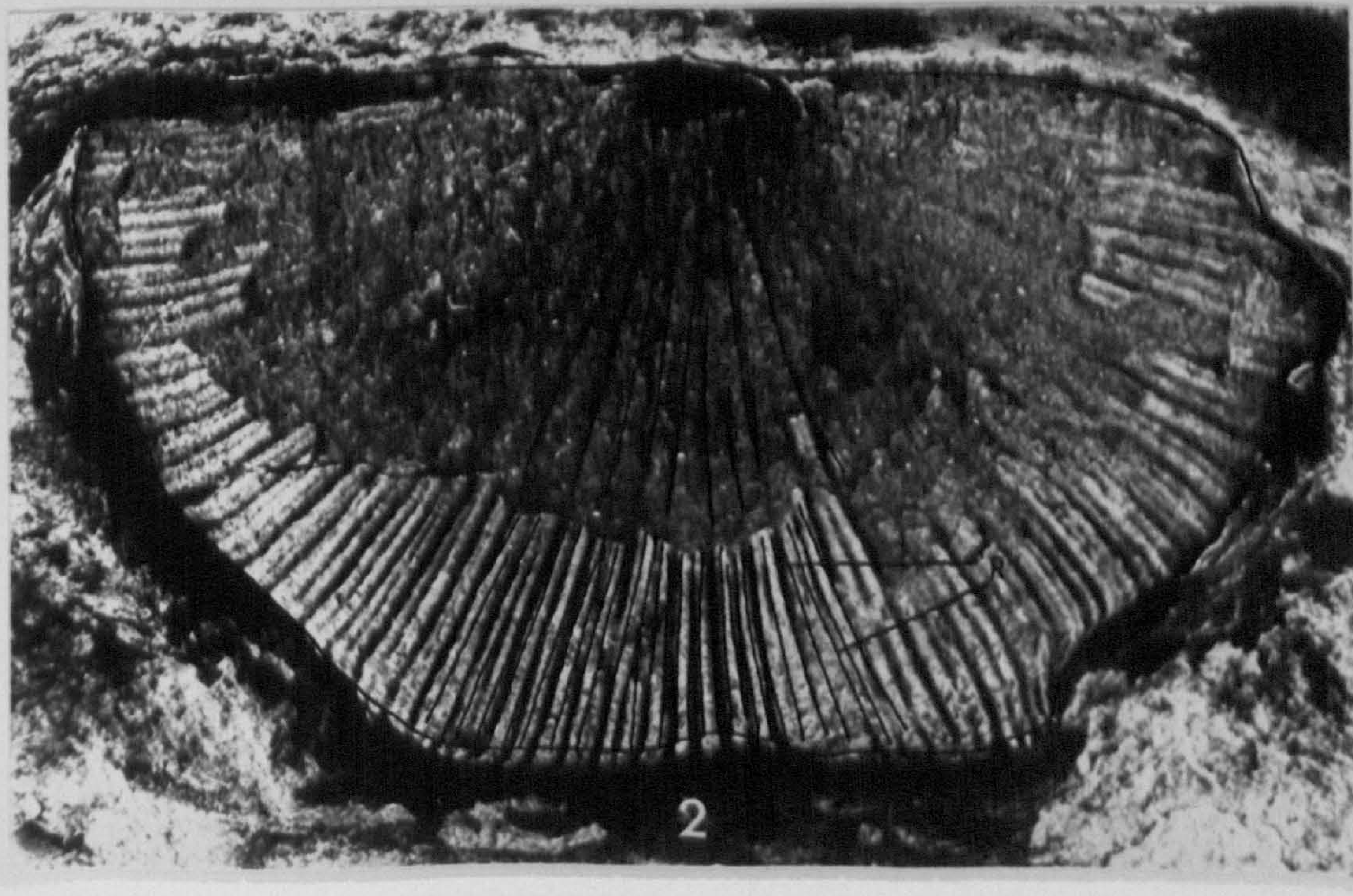
Pedicle valve morphology of _A._(_A._) _funiculata_ (McCoy,1846).

FIGS.1,2. 1, Ac-808 and 2, Ac-860/2 are enlargement views of the external moulds of pedicle valves showing the well developed equally and rounded parvicostellate radial ribs with the development of the sulcus at the anterior margin of the valve; from Lower Bringewood Formation, locality 7a, near Ludlow (Shropshire); x 10.7 and x 11.3 respectively.

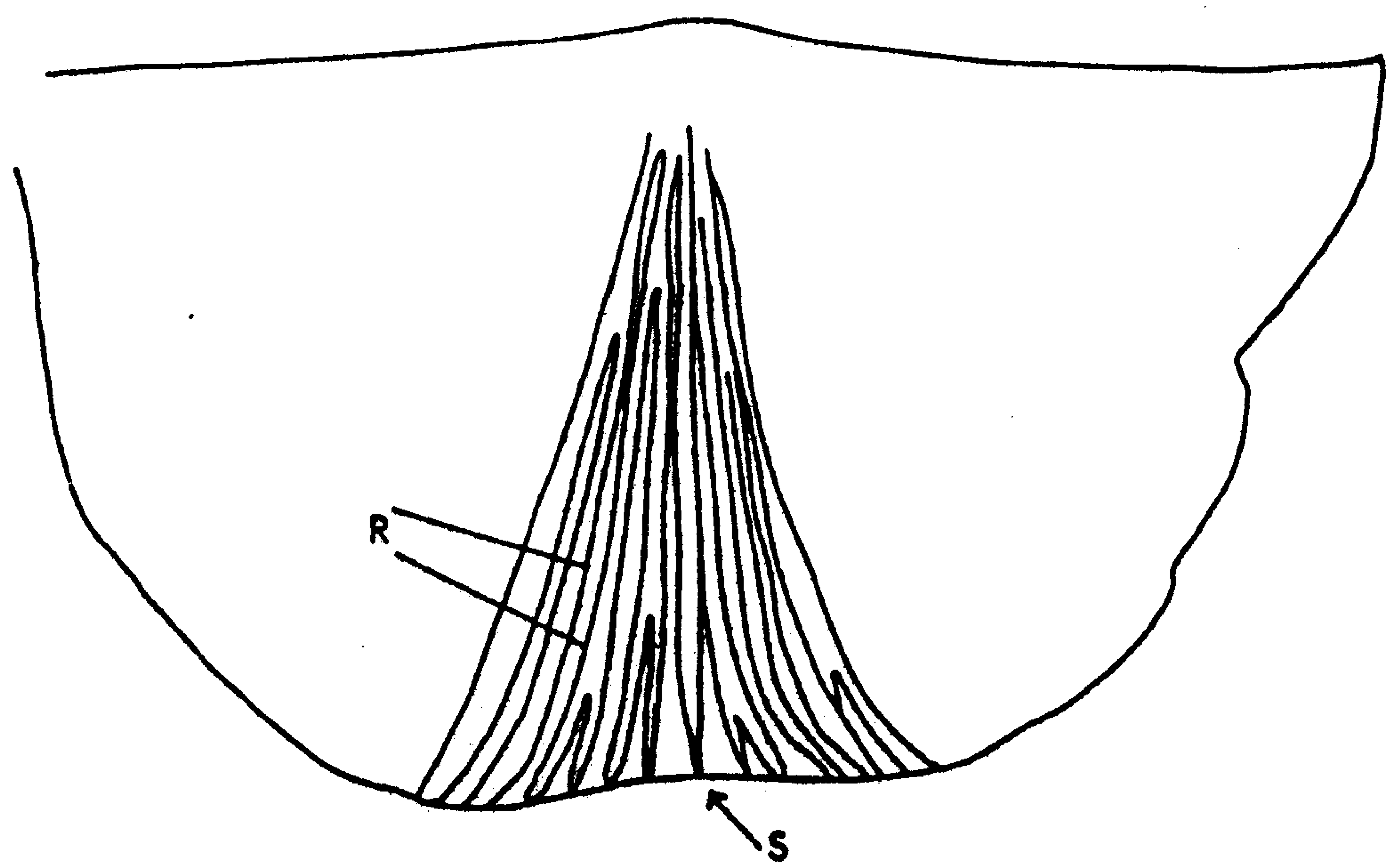
PLATE 17



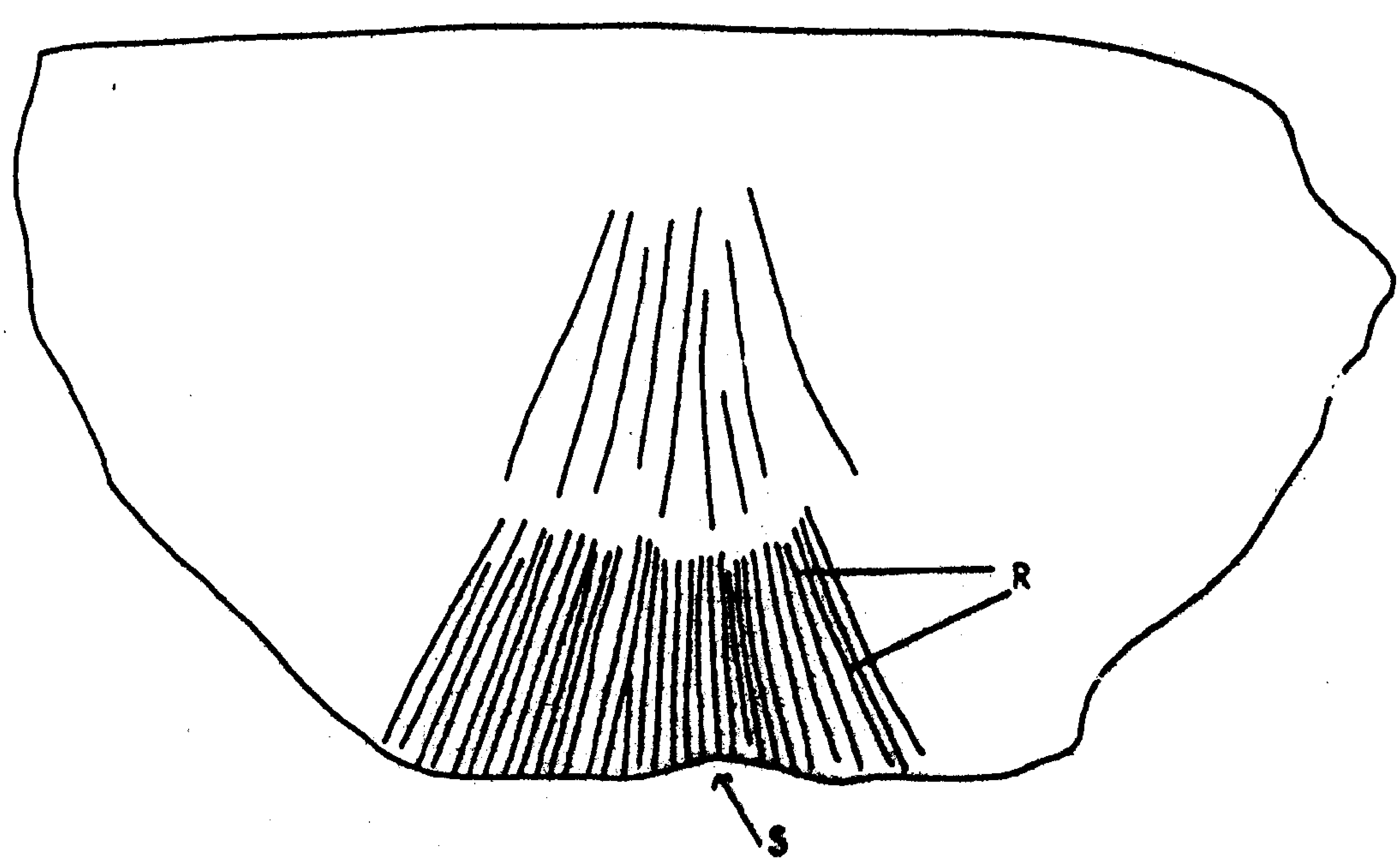
1



2

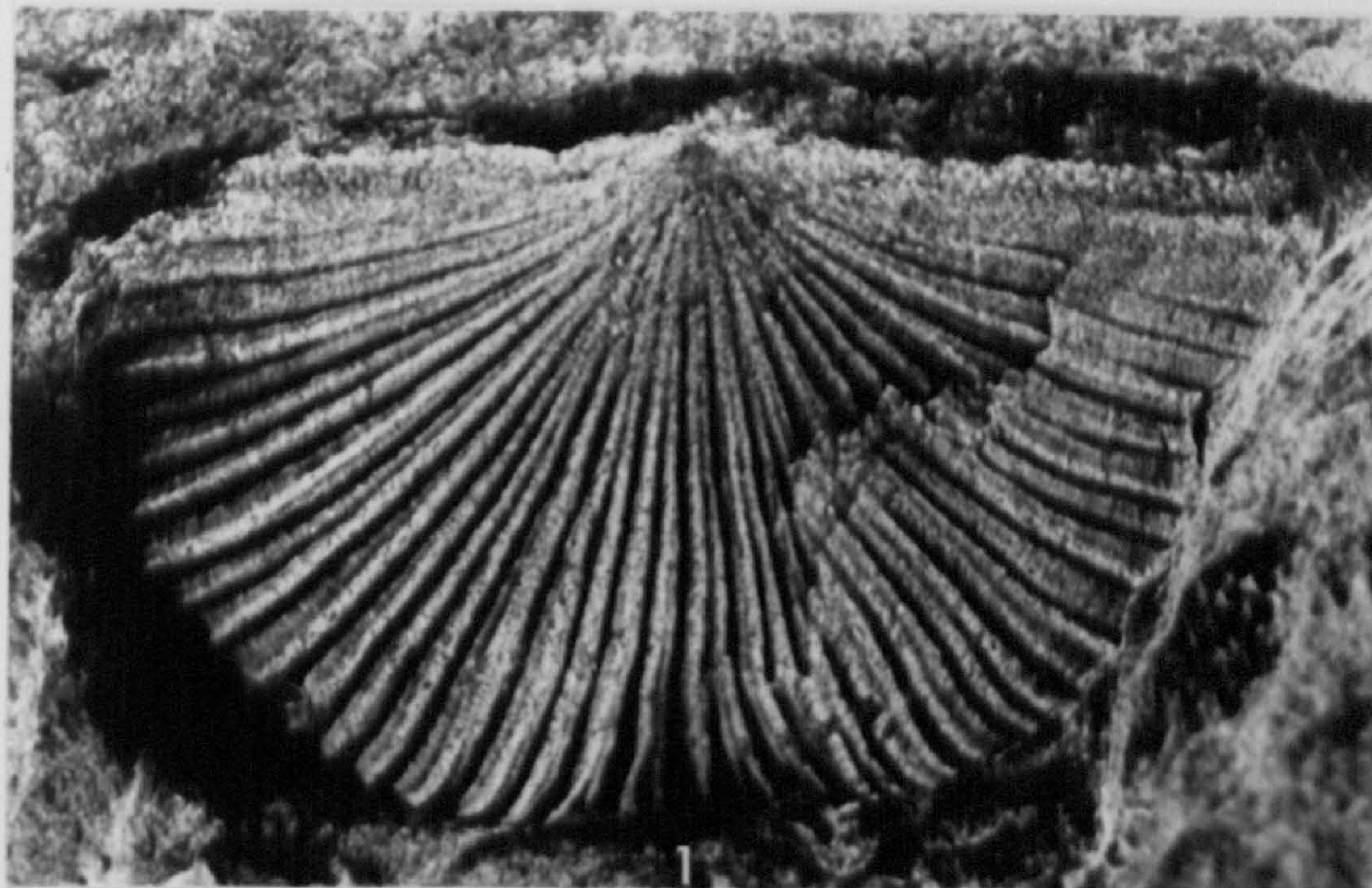


R
S

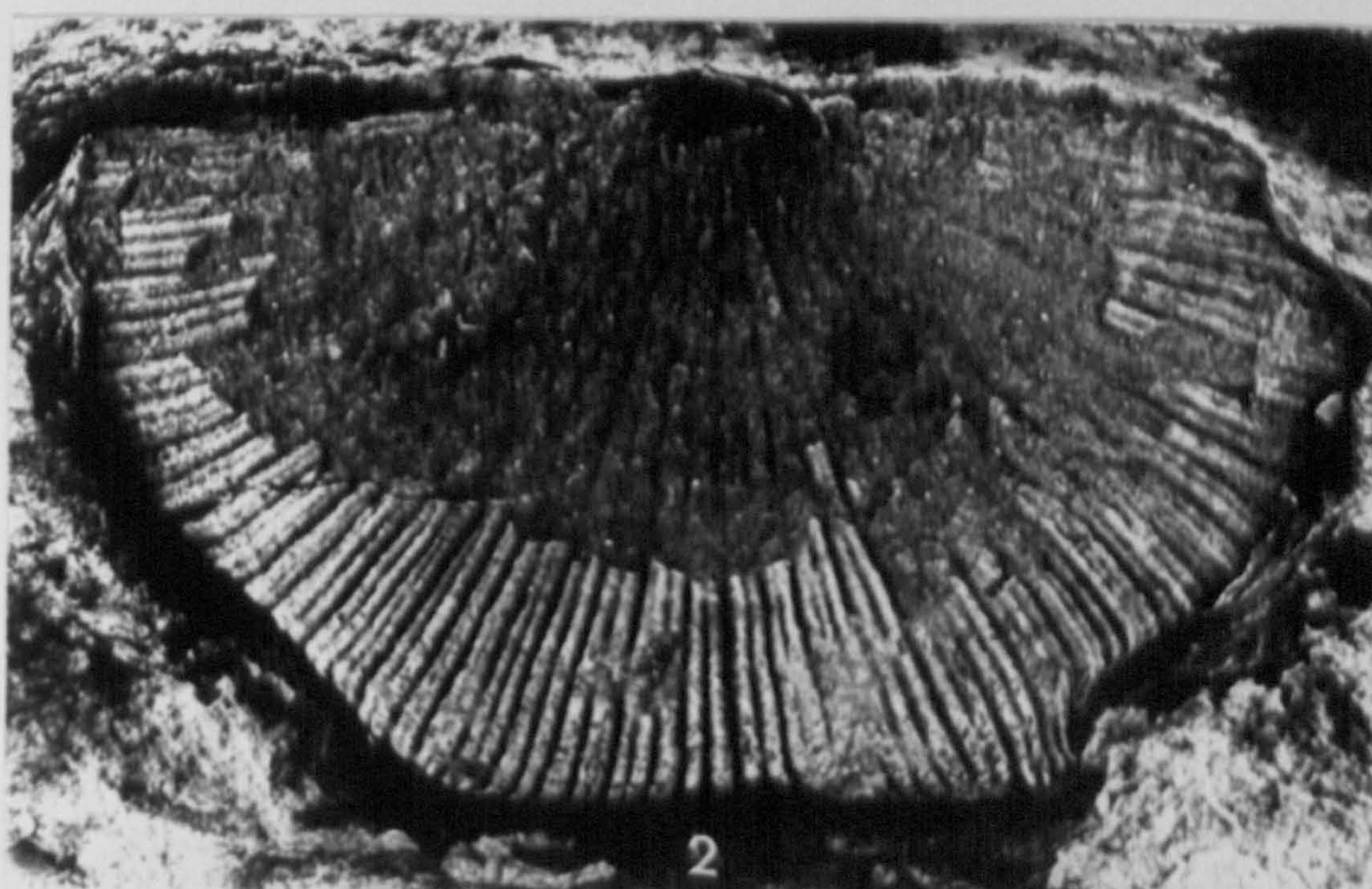


R
S

PLATE 17



1



2

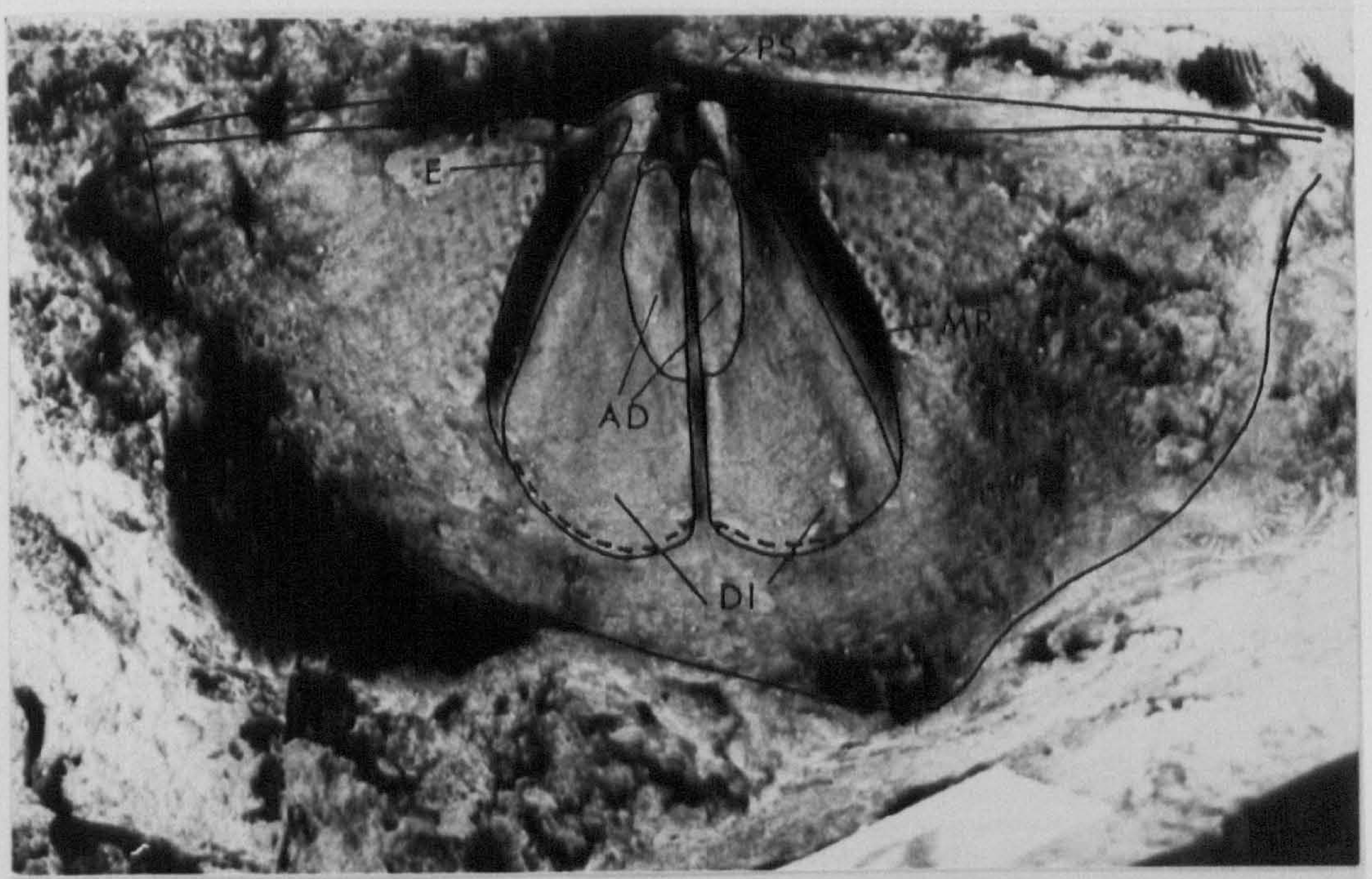
EXPLANATION OF PLATE 18

Internal of pedicle and brachial valve morphology of *A.(A.) funiculata* (McCoy, 1846).

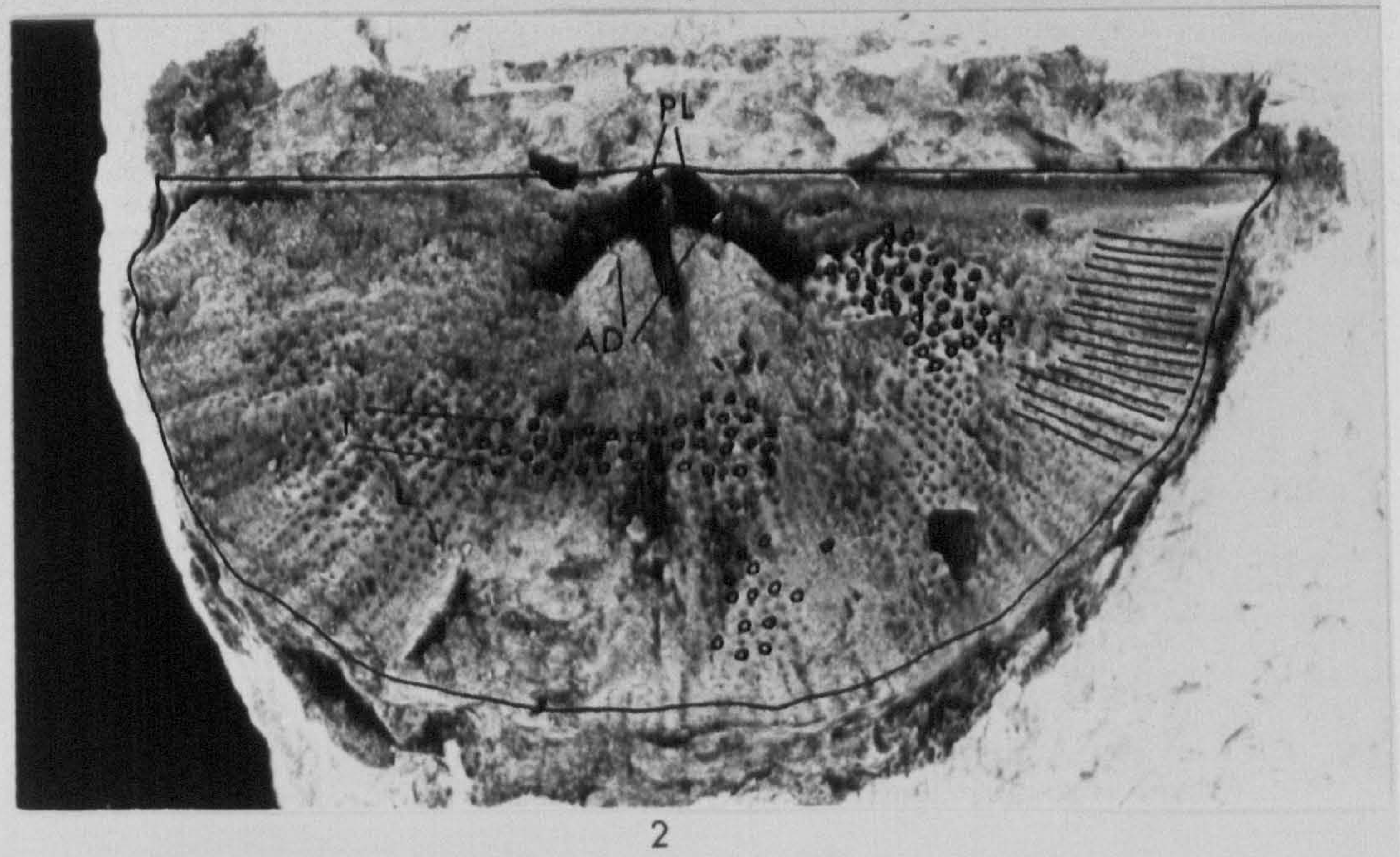
FIG.1. Ac-469, internal mould of pedicle valve illustrating the triangular shaped ventral process, myophragm, lanceolate adductor muscle scars, triangular diductor muscle and muscle bounding ridges; from the Lower Elton Formation, Mortimer Forest track, section A (L:A3); x 6.9.

FIG.2. Ac-433, internal mould of brachial valve showing cardinal process lobes, blade-shaped socket plates, triangular adductor muscle scars separated by myophragm and bounded by muscle ridges; from Lower Elton Formation, Mortimer Forest track, section A (L:A2); x 5.8.

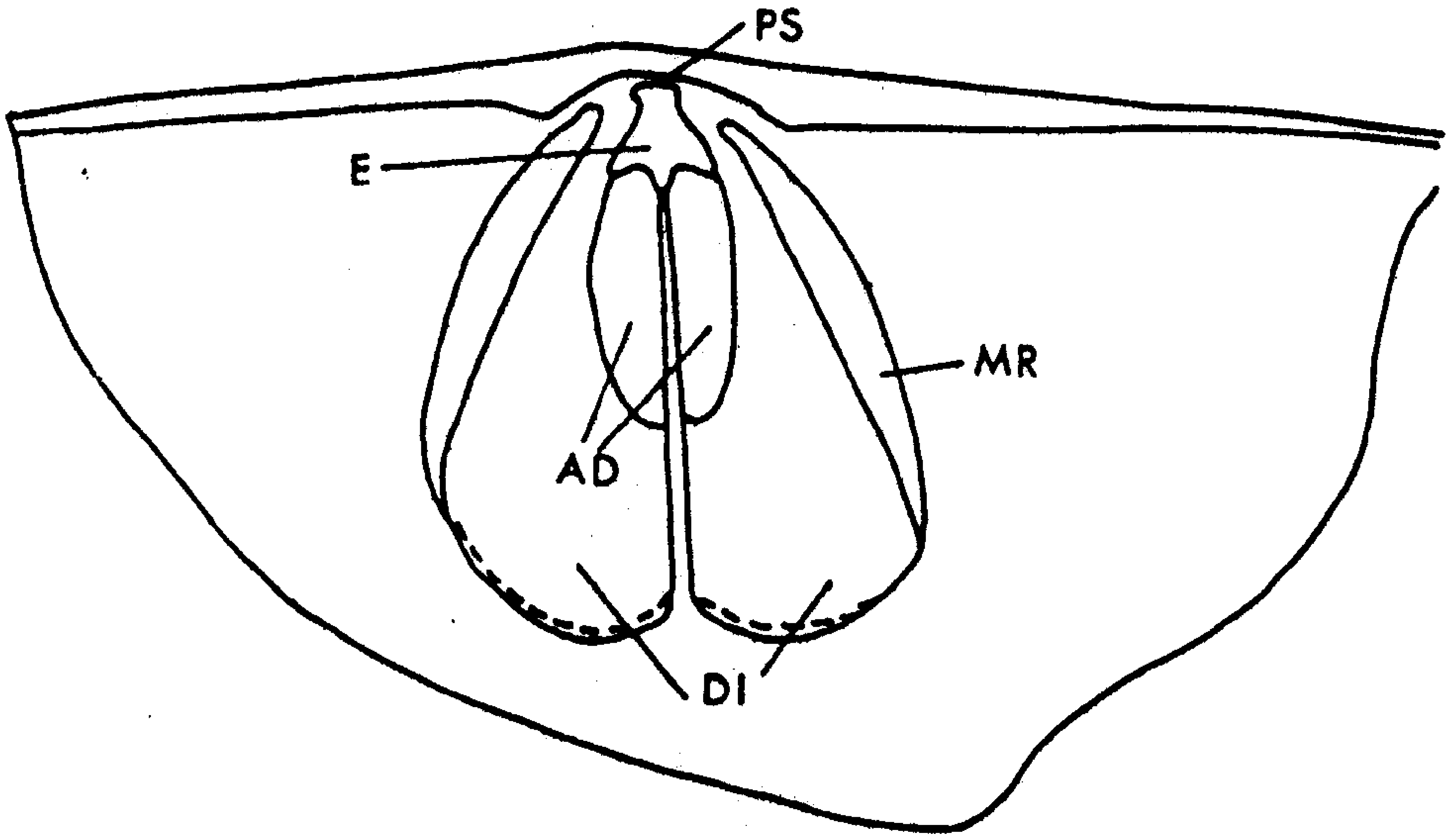
PLATE 18



1



2


PS
E
MR
AD
DI

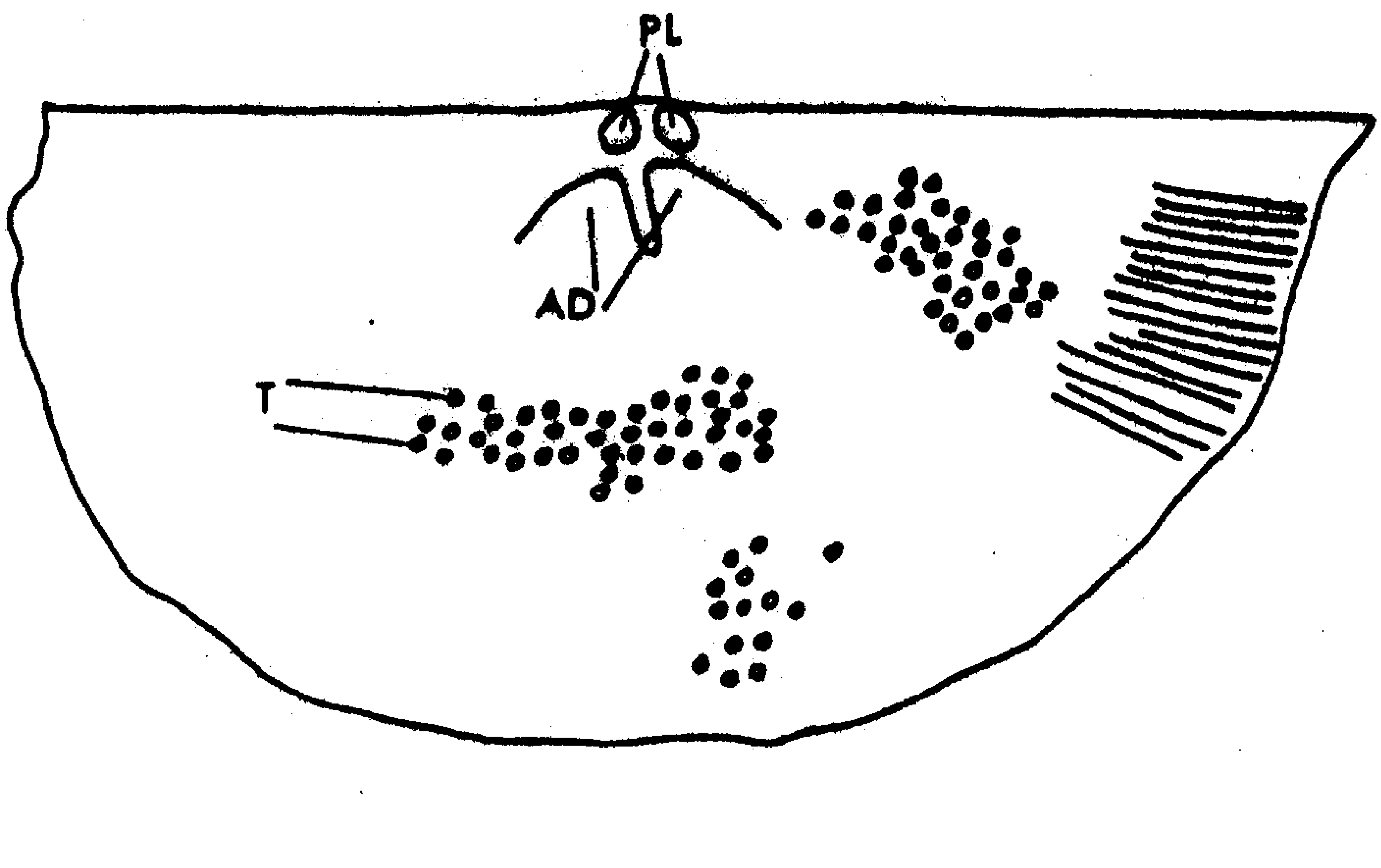
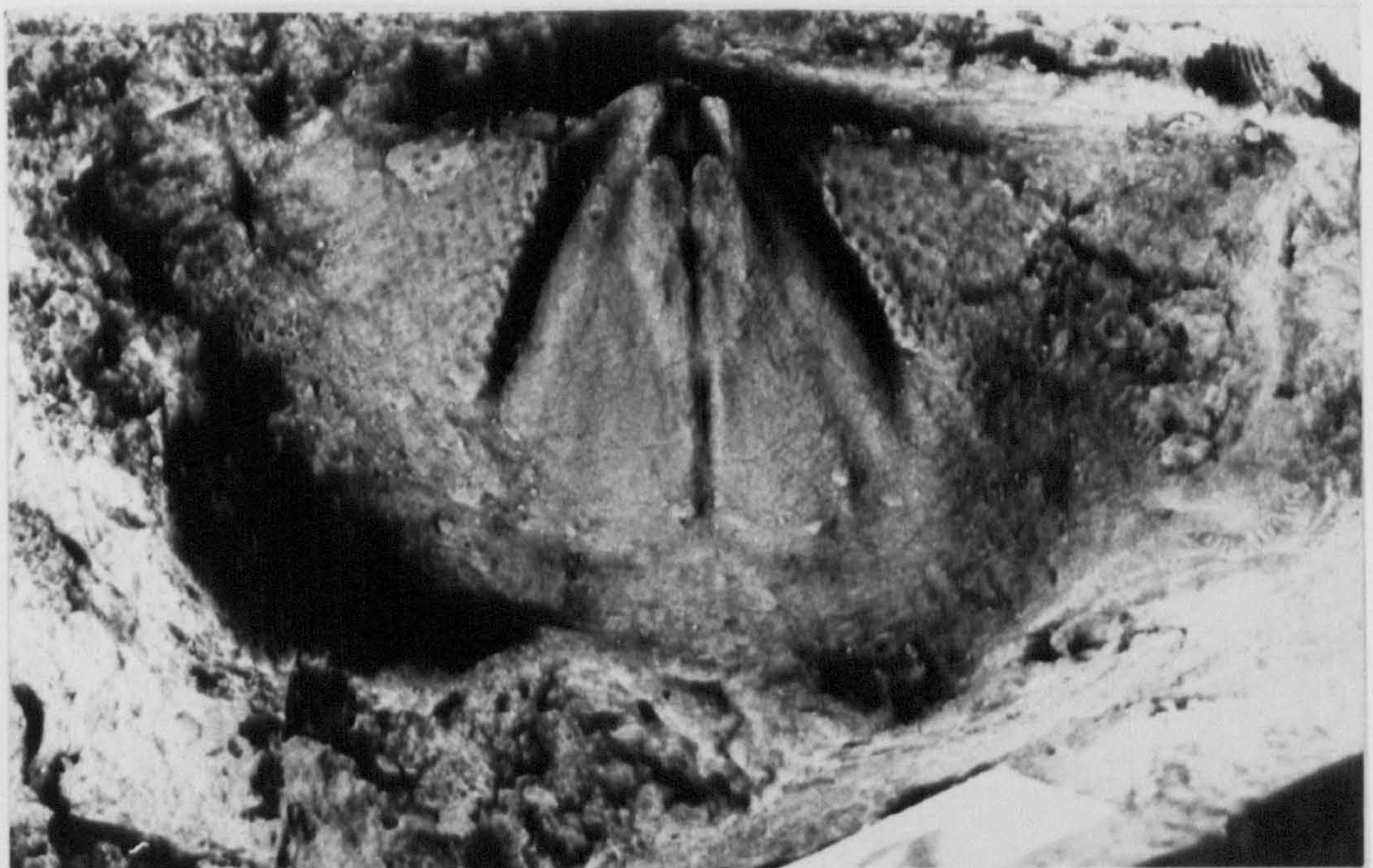
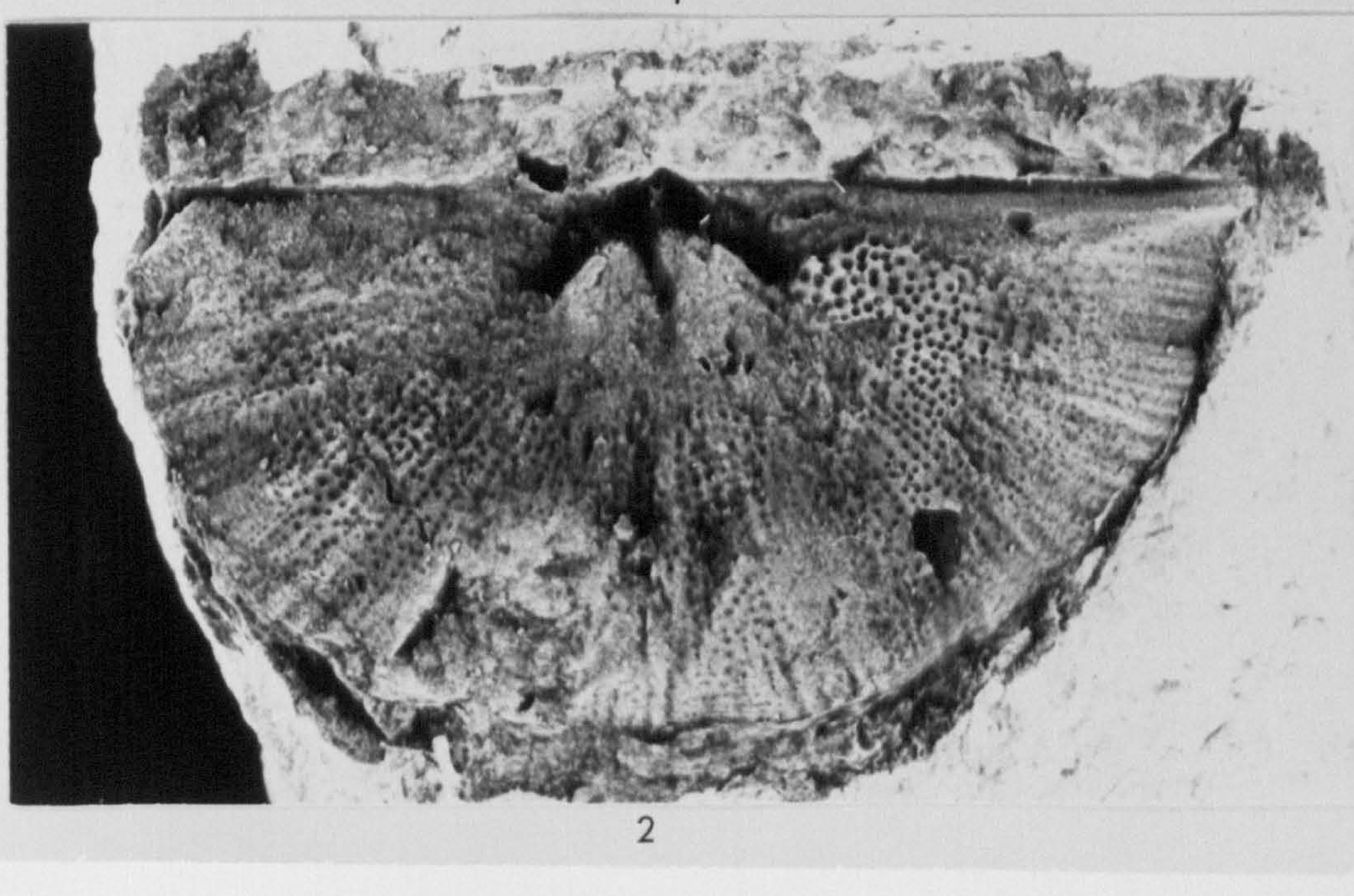

PL
AD
T

PLATE 18



1



2

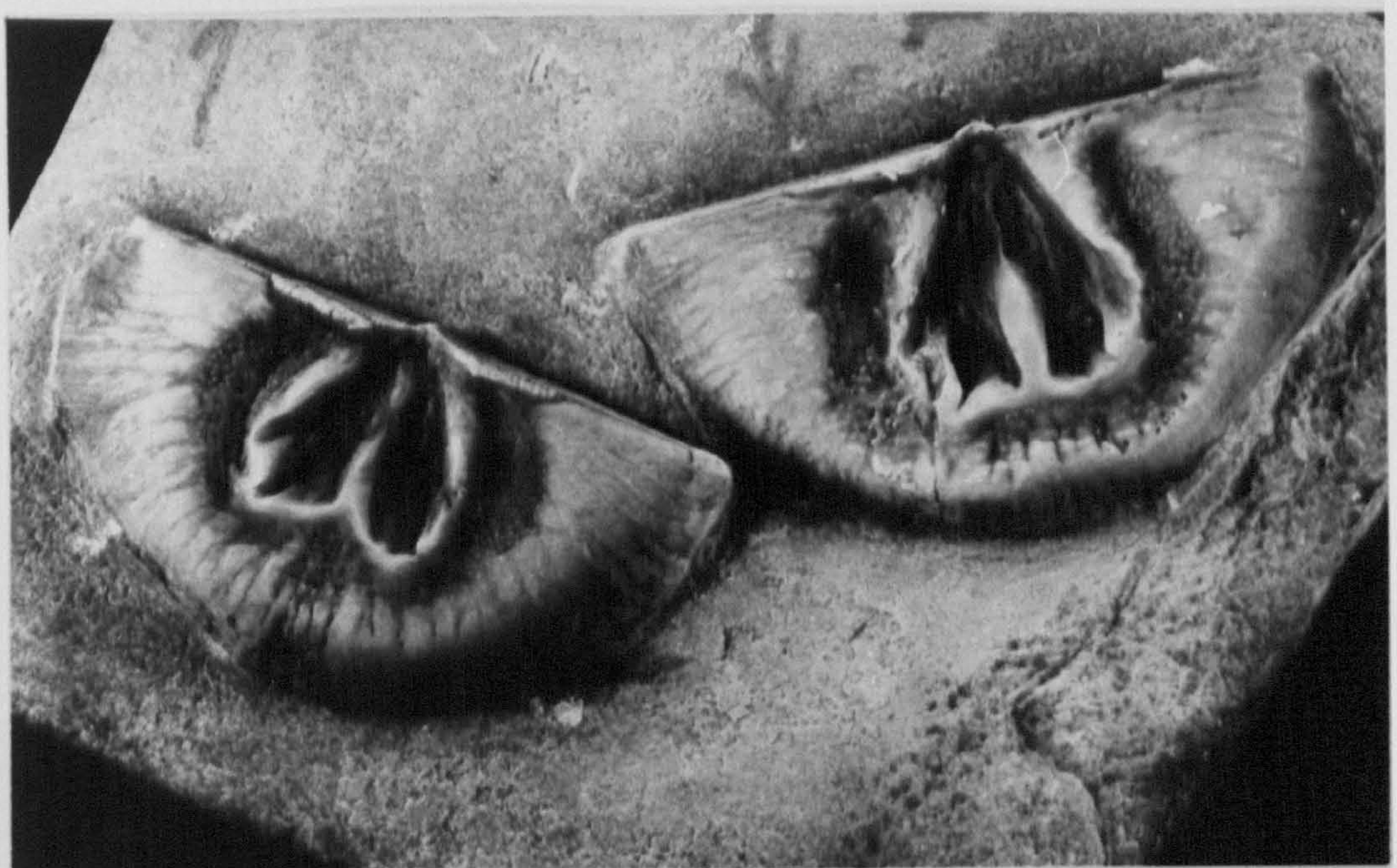
EXPLANATION OF PLATE 19

Internal of pedicle and brachial valve morphology of *A.*(*A.*) *funiculata* (McCoy,1846).

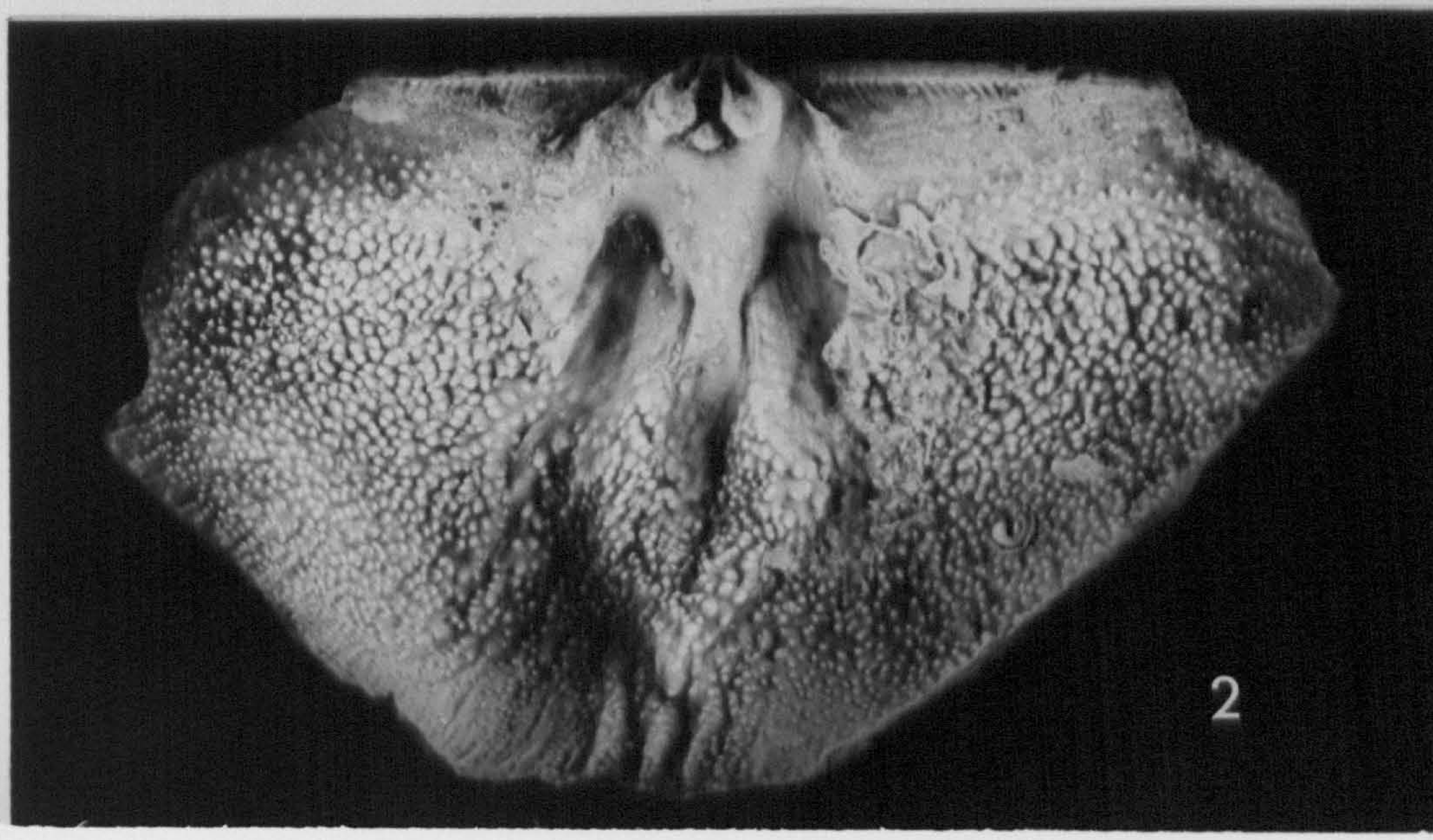
FIG.1. Bc-21032, enlargement view of the internal of pedicle valve showing well developed denticles along a pair of denticular plates, ventral process, pseudodeltidium, myophragm, lanceolated adductor muscle scars, triangular diductor muscle and muscle bounding ridges; from Wenlock Limestone, near Dudley; x 3.9 and x 3.7 for 1a and 1b respectively.

FIG.2. Bc-4363, enlargement view of the internal of brachial valve illustrating the cardinal process lobes, blade-shaped socket plates, well developed denticulation, well impressed adductor muscle scars which are bounded by muscle ridges and separated by a myophragm; from Mulde Beds, locality 11, section at Däpps, 4km NE of Fröjel, Wenlock, Gotland; x 5.4.

PLATE 19



1



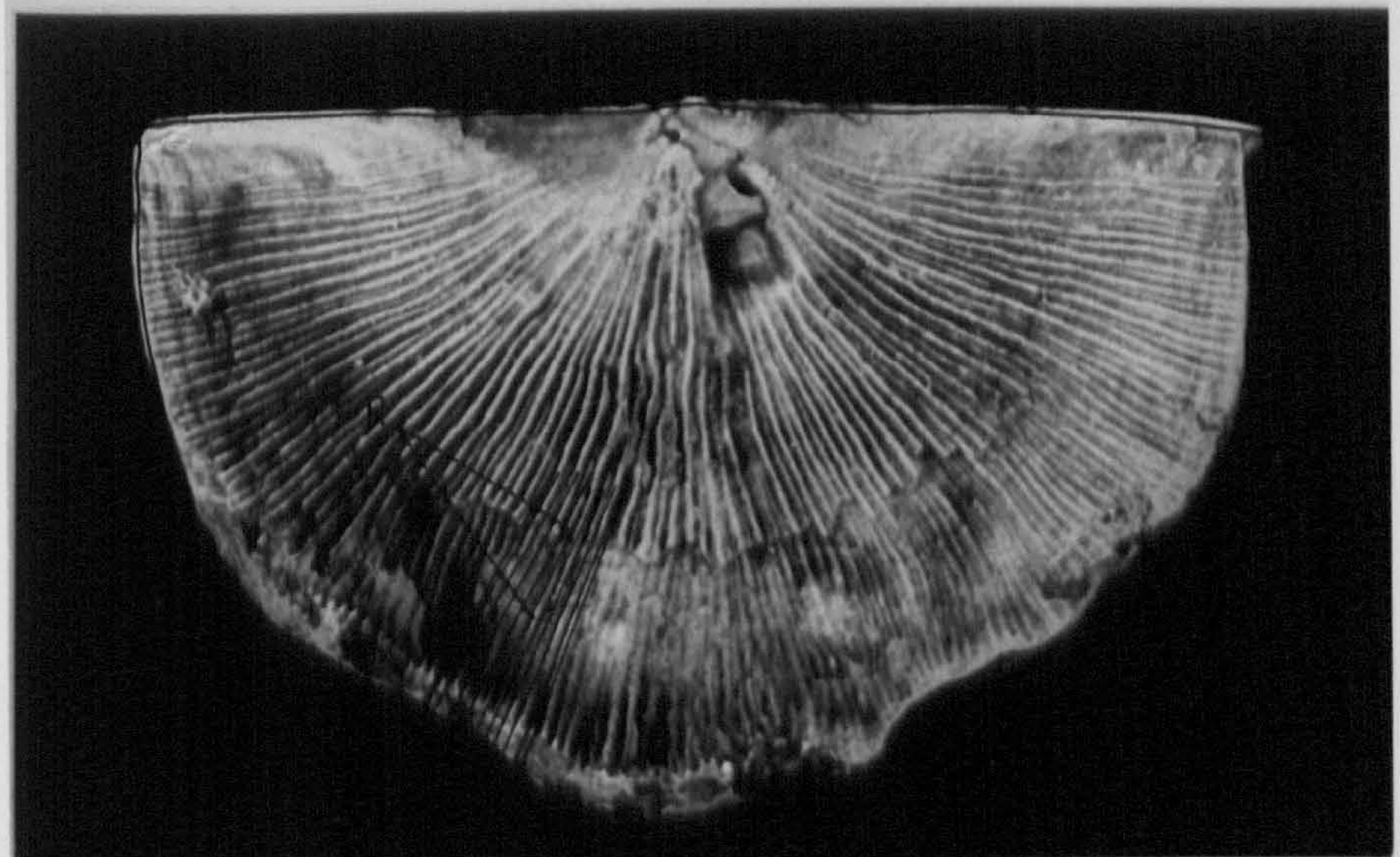
2

EXPLANATION OF PLATE 20

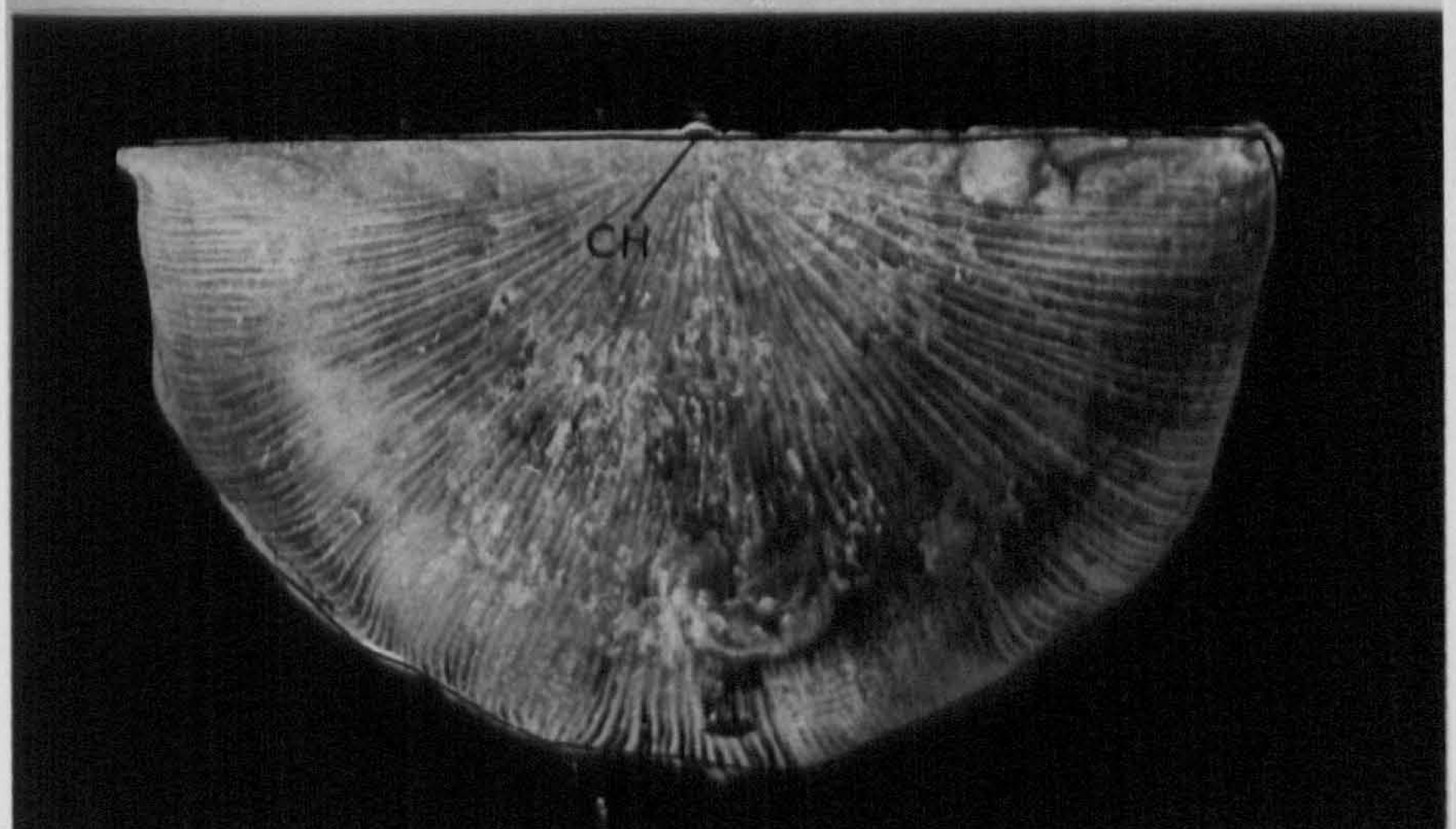
Enlargement views of the conjoined valves of _A._(_A._)
funiculata (McCoy,1846)

FIGS.1,2,3. Bc-3912/1, 1 and 2, external of pedicle and brachial valves respectively showing the rounded outline of the valves and the well developed radial ornament; 3, posterior view of the conjoined valves illustrating the small convex chilidium in the brachial valve and the larger, triangular pseudodeltidium on the opposite pedicle valve, from Wenlock Limestone, Johnson collection 1886, near Dudley; x 4.1, x 3.7 and x 4.5 respectively.

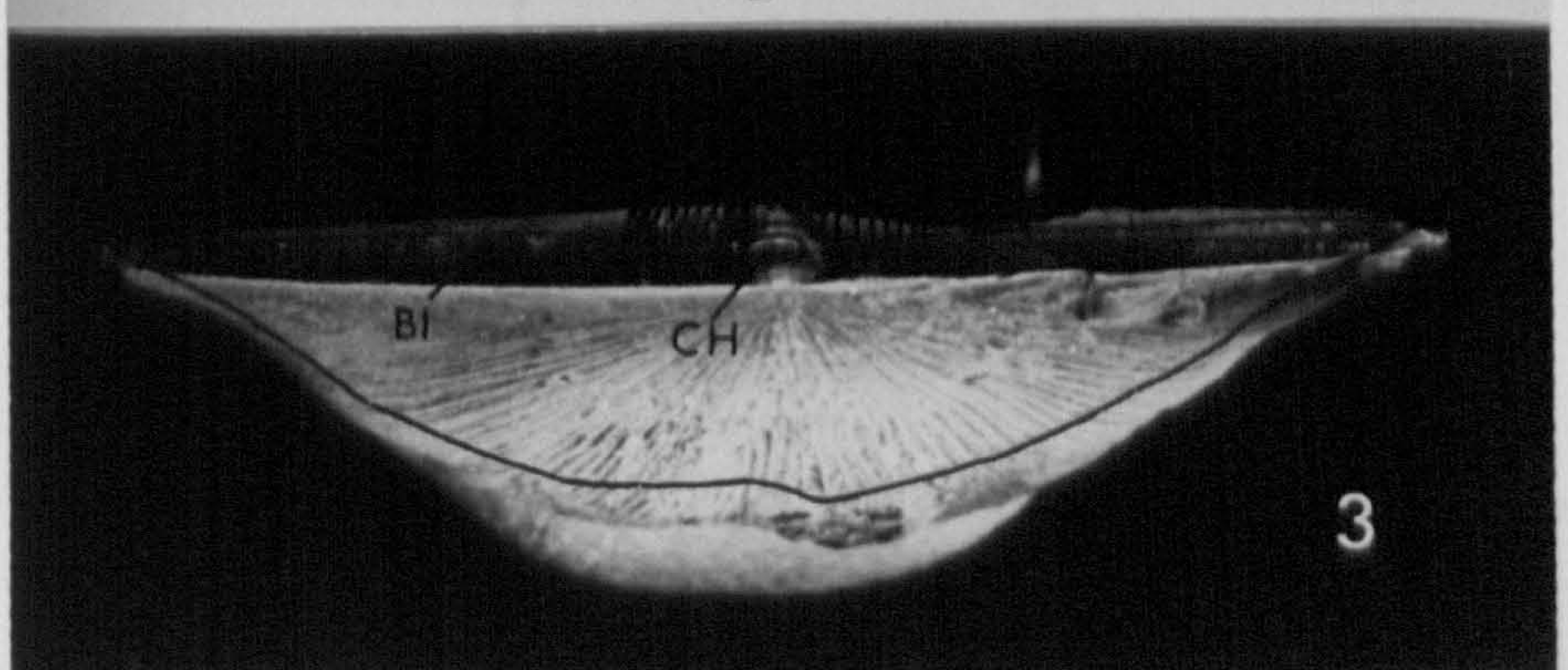
PLATE 20



1



2



3

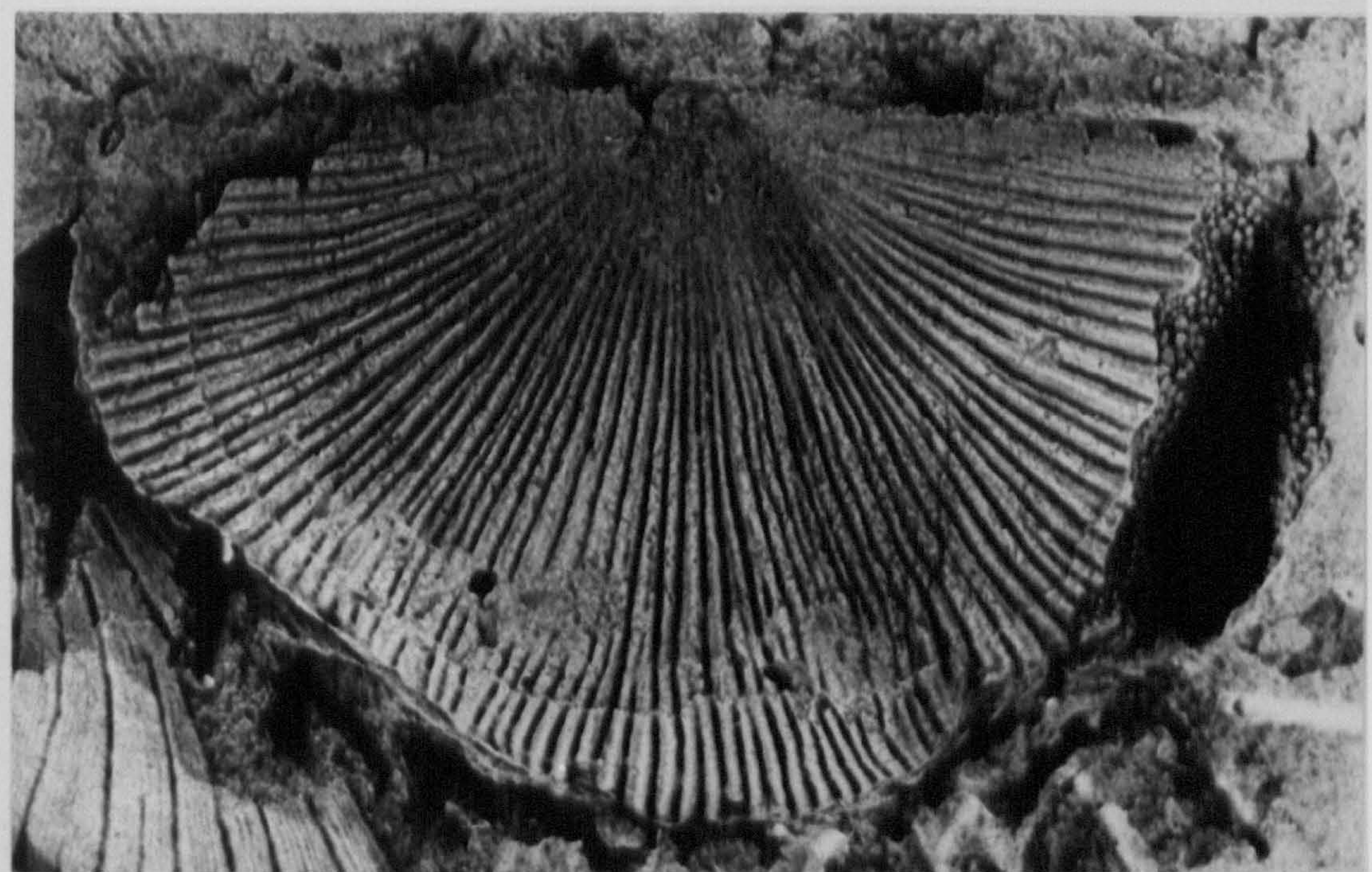
EXPLANATION OF PLATE 21

Enlargement views of the external of the pedicle and brachial valve morphology of *A.*(*A.*) *funiculata* (McCoy,1846).

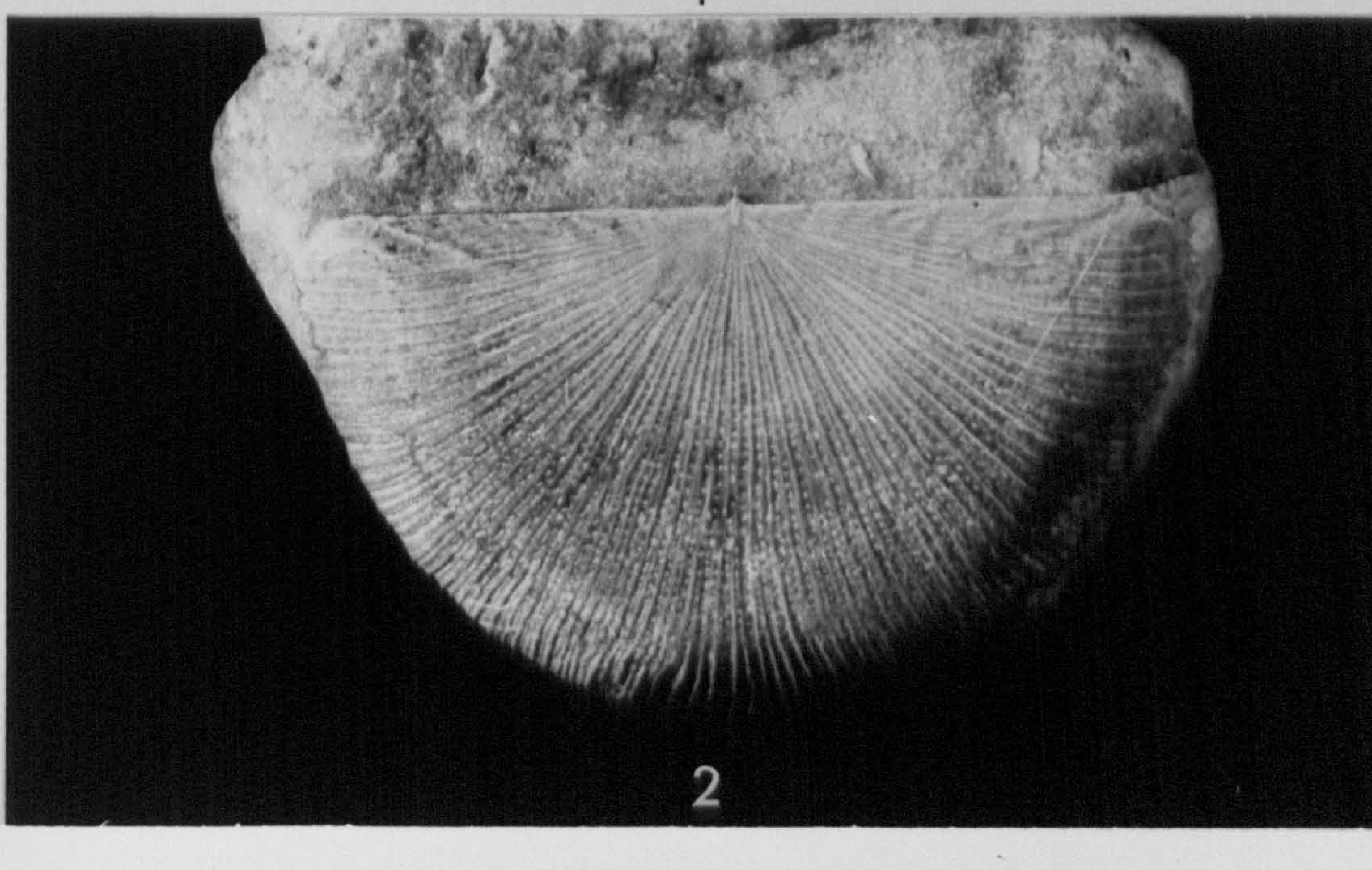
FIG.1. Ac-628, external mould of pedicle valve showing the subtriangular shell shaped and a well developed parvicostellate radial ornament; from Lower Bringewood Formation, Mortimer Forest track, section B (L:B6); x 6.

FIG.2. Bc-23161/1, external of brachial valve demonstrating the semicircular, rounded shell shape, small convex chilidium, well impressed radial ornament and faintly developed crenulation along the anterior part of the hinge line; from Wenlock Limestone, Dudley; x 4.4.

PLATE 21



1



2

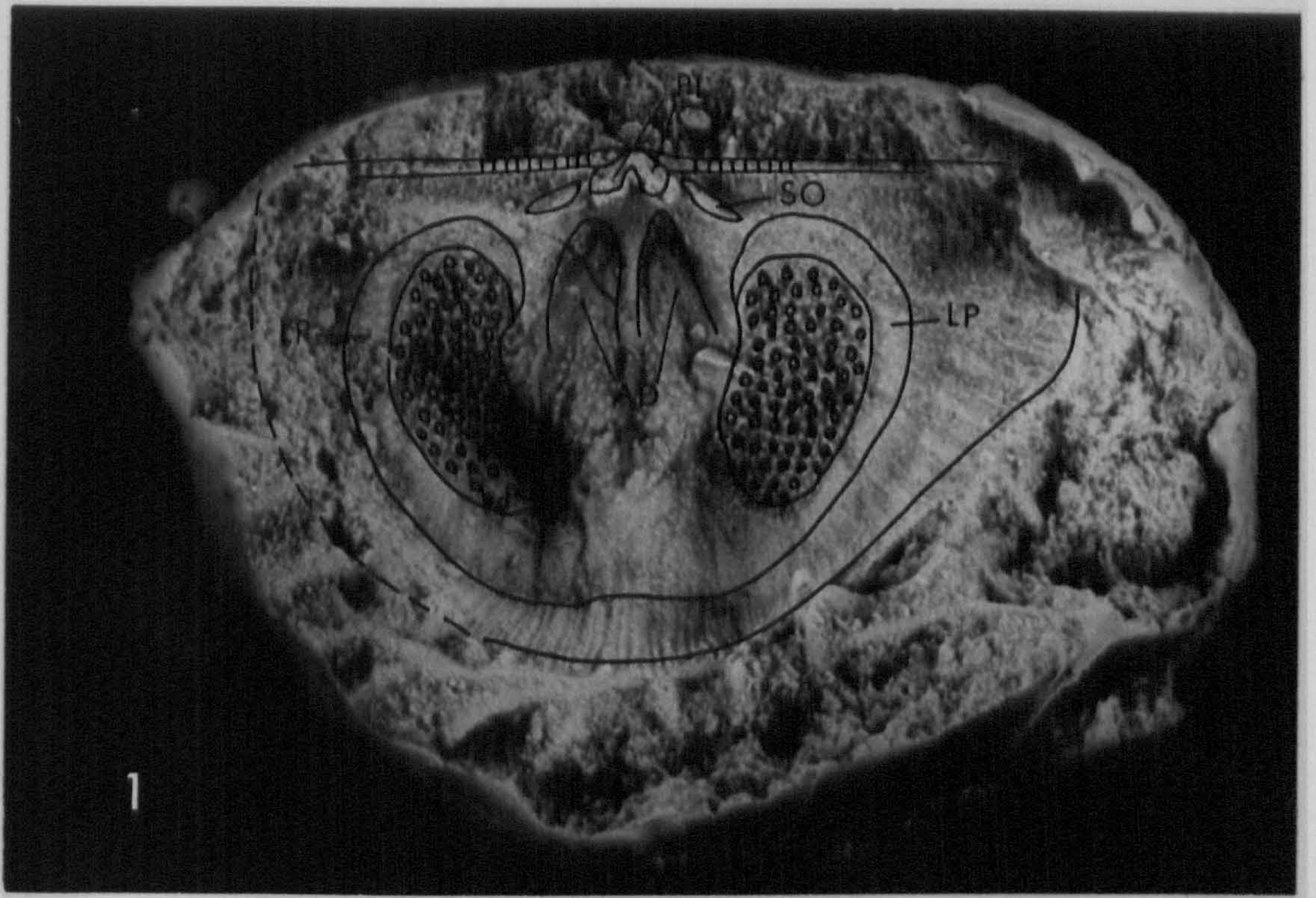
EXPLANATION OF PLATE 22

Enlargement views of the internal of the brachial and pedicle valve morphology of A.(A.) funiculata (McCoy, 1846).

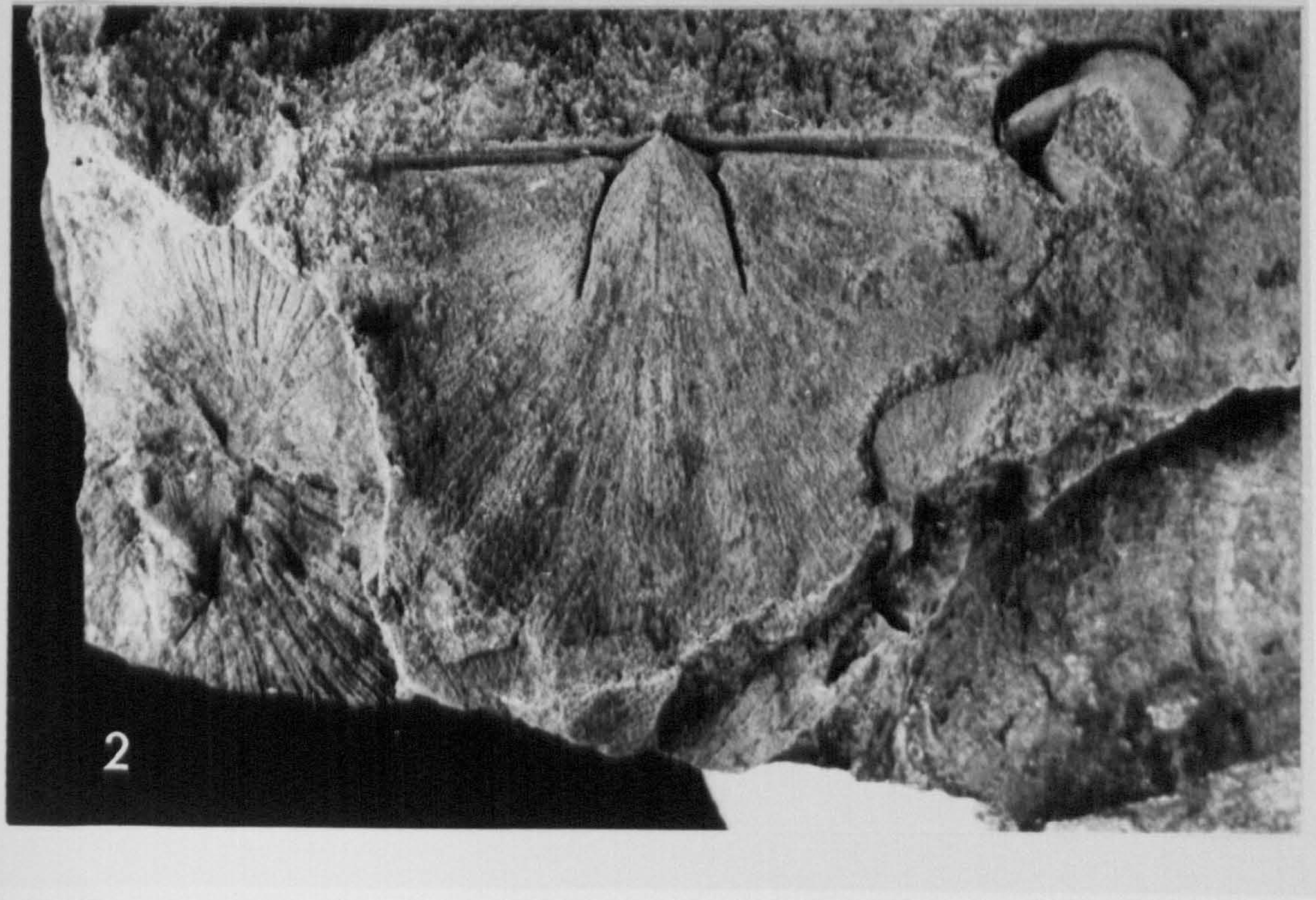
FIG.1. Bc, Wc 3, latex cast of the internal mould of brachial valve demonstrating the cardinal process lobes, the blade-shaped socket plates and a pair of kidney shaped depressions flanking the muscle scars on the floor of valve with numerous tubercles; from Upper Bringewood Formation (H.L.W.23A), Mortimer Forest track of Ludlow area; x 6.4.

FIG.2. Bc-820, internal mould of pedicle valve showing the minute teeth and the well-developed ridges which bound the muscle scars laterally only (i.e. not anteriorly); from Wenlock Shale of Dyfed area; x 4.4.

PLATE 22



1



2

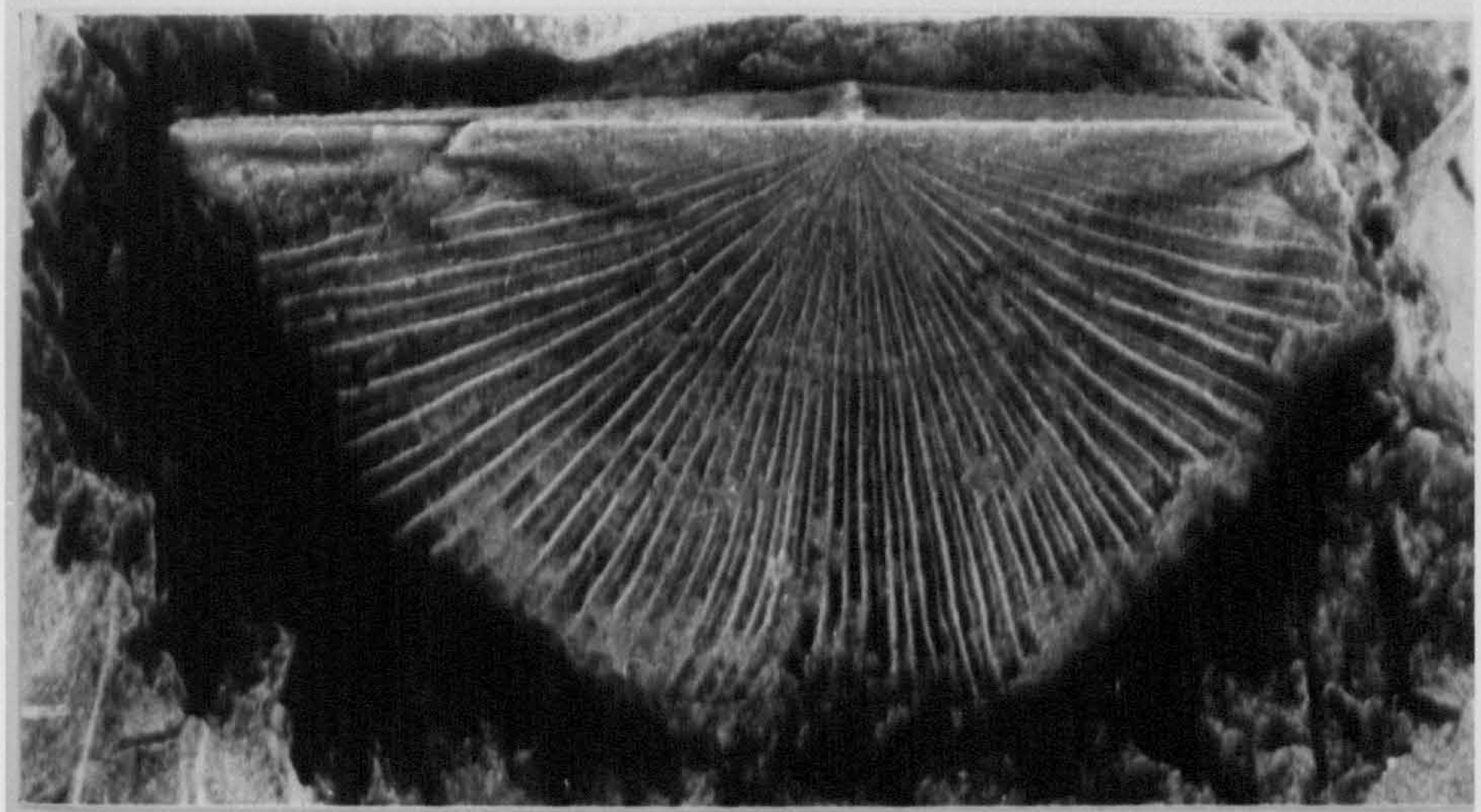
EXPLANATION OF PLATE 23

Enlargement views of the brachial and pedicle valve morphology of *A.* (*A.*) *funiculata* (McCoy, 1846).

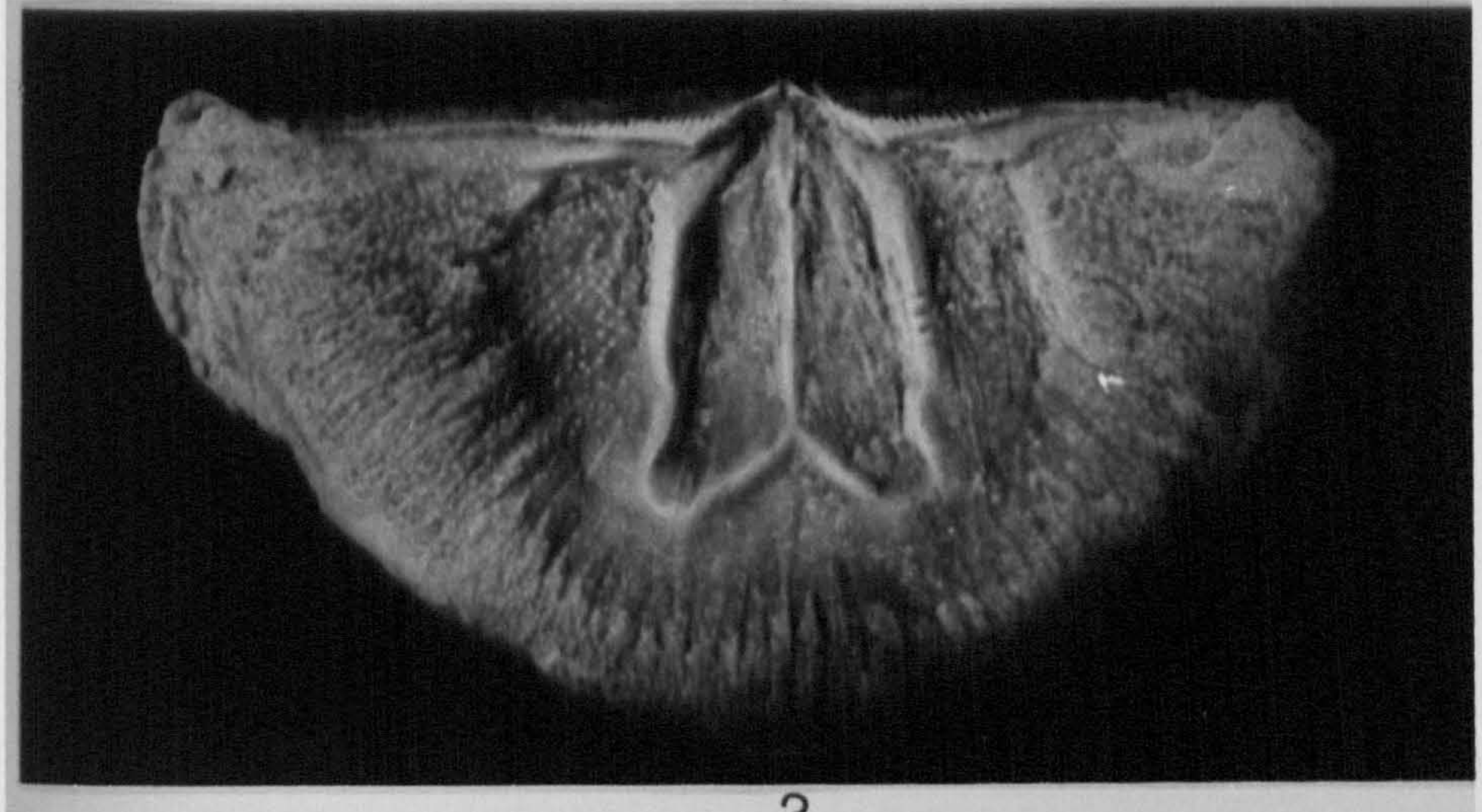
FIG.1. Ac-1161, external of the brachial valve showing the subtriangular outline of the valve, small convex chilidium which is covered by larger overslide, triangular pseudodeltidium on the opposite pedicle valve and well developed parvicostellate radial ornament; from Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 5.0.

FIGS.2,3. Bc-1570, internal of the pedicle valve and latex cast illustrating the development of the denticles along a pair of triangular denticular plates, ventral process, faintly impressed lanceolate adductor muscle scars, oval to subtriangular diductor muscle scars separated by myophragm which bifurcates anteriorly to form muscle bounding ridges; from Wenlock Limestone, Dudley area; x 3.7 and x 3.5 respectively.

PLATE 23



1



2

3

EXPLANATION OF PLATE 24

Pedicle valve morphology of A.(A.) funiculata (McCoy,1846).

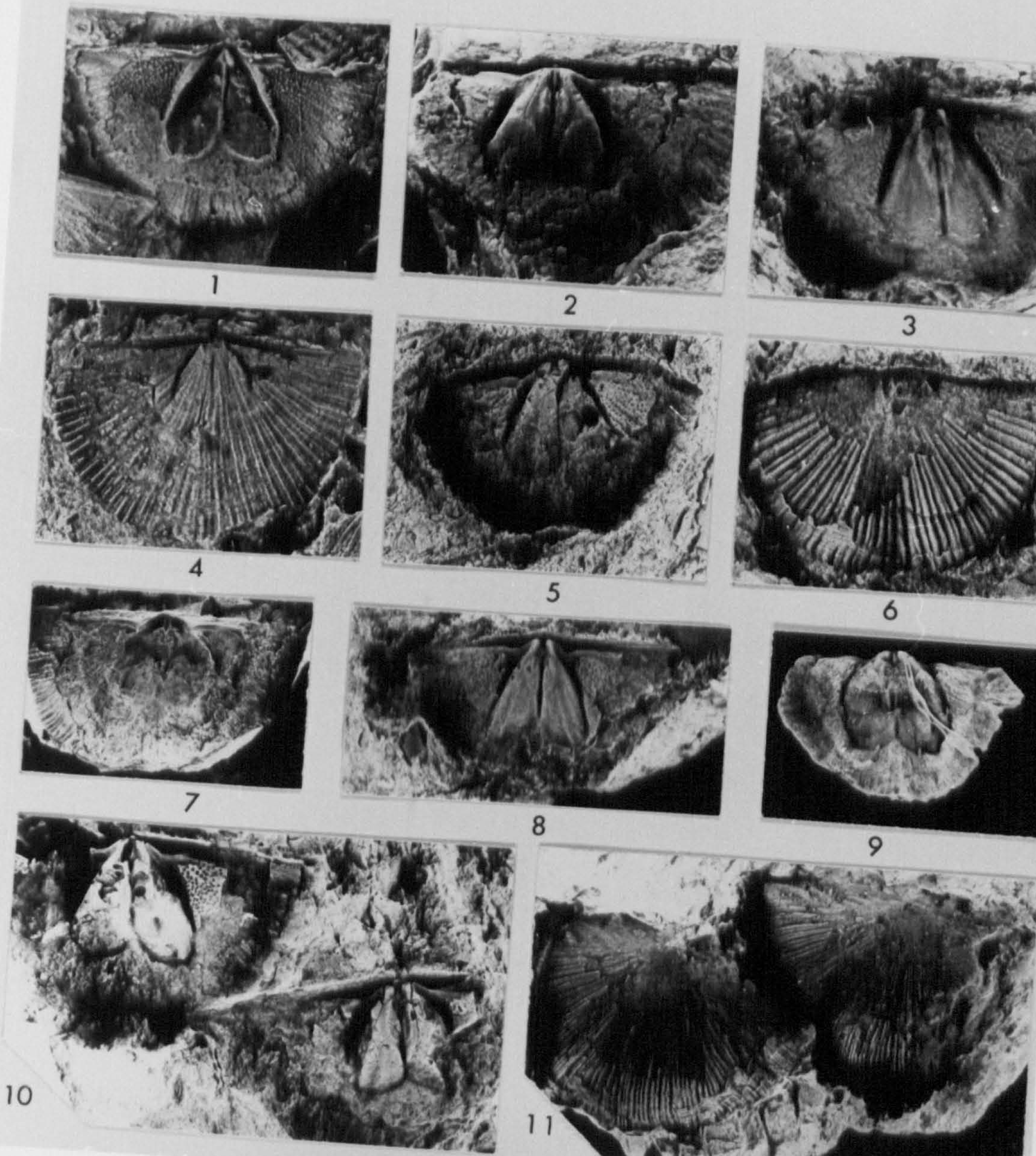
FIGS.1,2,3,4,10,11. 1, Ac-457; 2, Ac-449, internal moulds of pedicle valve showing the development of the denticles along the denticular plates, ventral process, myophragm, lanceolate adductor muscle, triangular diductor muscle and muscle bounding ridges; 3, Ac-469, internal mould of pedicle valve illustrating the same structural features as in figs.1 and 2 except that the muscle bounding ridges are very faintly impressed to enclose the diductor muscle anteriorly; 4, Ac-464/3, internal mould of pedicle valve with weakly developed muscle and muscle bounding ridges; 10,11, Ac-455 and 457a and b, internal moulds of pedicle valve and counterpart external moulds demonstrating the same structural features as figs.1 and 2; all from the Lower Elton Formation, Mortimer Forest track, section A(L:A3); x 2.5, x 2.5, x 2.7, x 3.5, x 2.4 and x 2.5 respectively.

FIGS.5,6. 5, Ac-860b/1, internal mould of pedicle valve showing the triangular muscle field; 6, Ac-860b/2, external mould of pedicle valve illustrating the equally and rounded parvicostellate radial ornament; from Lower Bringewood Formation, locality 7a near Ludlow (Shropshire); x 2.8 and x 4.1 respectively.

FIGS.7,9. Ac-1104a and b, internal of pedicle valve and counterpart internal mould showing the ventral process, lanceolate adductor and oval diductor muscle scars separated by a myophragm and bounded by muscle ridges; from Upper Bringewood Formation, Shucknall Quarry (L: SH) in the Woolhope inlier; x 2.2 and x 2.1 respectively.

FIG.8. Ac-1453, internal mould of pedicle valve demonstrating the same structural features as figs.1 & 2; from Lower Bringewood Formation, Llandegveth reservoir (L: LR) in the Usk inlier; x 3.0.

PLATE 24



EXPLANATION OF PLATE 25

External and internal brachial valve morphology of A.(A.) funiculata (McCoy, 1846).

FIGS.1,8,14. 1, Ac-466/1, internal mould of brachial valve showing the cardinal process lobes, socket plates, denticulation, adductor muscle scars bounded laterally by ridges and separated by myophragm; 8, Ac-434; 14, Ac-412, external moulds of brachial valve demonstrating the subtriangular and triangular shape of the valve, well developed parvicostellate radial ornament and the development of the sulcus in the anterior part of the valve; all are from Lower Bringewood Formation, Mortimer Forest track, section A (L:A3 & A2), near Ludlow, Shropshire; x 2.3, x 3.2 and x 2.5 respectively.

FIGS.2,3,4,5,10. 2 and 3, Ac-1547a and b, internal mould of brachial valve and counterpart impression demonstrating the same structural features as in fig.1; 4, Ac-1546; 5, Ac-1509, internal moulds of brachial valve illustrating the cardinal process lobes, the triangular muscle field, sulcus which was strongly developed in fig.5; 10, Ac-1526, external mould of brachial valve showing the rounded radial ribs with the sulcus impression; all are from Lower Bringewood Formation, Llandegveth reservoir (L: LR) in the Usk inlier; x 2.3, x 2.3, x 2, x 2.3 and x 2 respectively.

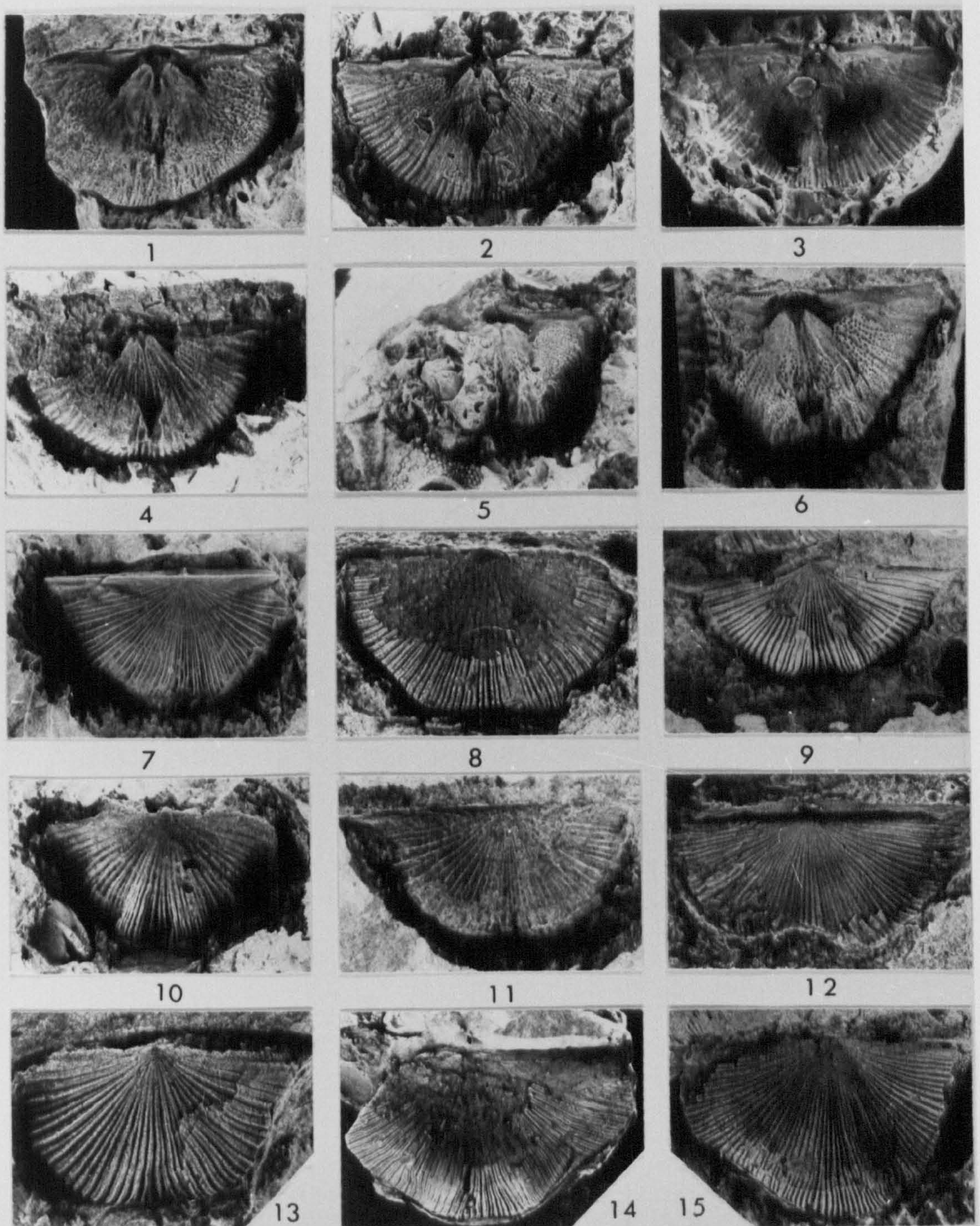
FIGS.6,9. 6, Bc, Wc 5, internal mould of brachial valve showing the development of the denticulations along a pair of denticular plates, cardinal process, socket plates and triangular muscle field with strongly sulcate impression on the anterior part of the valve; 9, Bc, Wc 6, latex cast of the external mould of the brachial valve illustrating the rounded parvicostellate radial ornament with the sulcate impression in the antero-median part of the valve; Lower Bringewood Formation, locality 35 in Perton Lane, north of Capgrove Farm in the Woolhope inlier; x 3.4 and x 2 respectively.

FIGS.7,11. 7, Ac-1161, external of brachial valve illustrating the well impressed equally, rounded parvicostellate radial ornament, small convex chilidium and the ventral interarea with the development of the pseudo-deltidium in the opposite pedicle valve; 11, Ac-1357, external mould of brachial valve showing the radial ribs, sulcus, faintly developed crenulations along the anterior part of the hinge line and the mucronated left end of the hinge line which forms the hinge ear; from Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 1.9 and x 2.4 respectively.

FIGS.12,15. Ac-577b and 628, external moulds of brachial valve showing well developed radial ornaments, fig.12, illustrating the ventral apsacline interarea with the pseudodeltidium, fig.15, demonstrating the triangular shape of the valve; from Lower Bringewood Formation, Mortimer Forest track section B (L: B1 and B6); x 2.1 for both of them.

FIG.13. Ac-808, external mould of brachial valve illustrating the equally parvicostellate radial ornament with the sulcus impression in the anterior valve margin; from Lower Bringewood Formation, locality 7a near Ludlow; x 3.5.

PLATE 25



EXPLANATION OF PLATE 26

Pedicle and brachial valve morphology of *A.* (*A.*) *funiculata* (McCoy,1846)

FIGS.1,2,11,13. 1 and 2, Bc-1570 and Bc-21032/2, internals of pedicle valve illustrating the development of the denticles along a pair of denticular plates, ventral process, lanceolate adductor and triangular diductor muscle scars separated medianly by myophragm and bounded laterally and anteriorly by muscle ridges, both figures show the semi-circular and rounded shell shape; 11 and 12, Bc-80430a and b, external of brachial valve and its posterior view demonstrating the rounded shell shape, equally parvicostellate radial ornaments, small convex chilidium covered by an overslide larger convex and triangular pseudodeltidium on the opposite pedicle valve; 13, Bc-13316, external of brachial valve showing the rounded shell shape; all are from Wenlock Limestone, Dudley area; x 1.6, x 1.9, x 2, x 2 and x 1.8 respectively.

FIG.3. Bc, Wc 10, internal of pedicle valve showing the muscle bounding ridges and the wide hinge line which is mucronate at both ends to form the hinge ears; from Mulde Marl Beds (W.G.12), spoil heaps at Mulde Brickyard, 3.3km SW of Klinte (CJ313.606; sheet 61SO), Gotland, Sweden; x 1.7.

FIGS.4,5. Bc, Wc 3a and b, internal mould of brachial valve and latex cast illustrating the cardinal process lobes, socket plates, triangular muscle bounding ridges and a pair of kidney-shaped depressions which flank the muscle scars on the floor of valve with numerous tubercles; from Upper Bringewood Formation (H.L.W. 23A), Mortimer Forest track at Ludlow area (Shropshire); x 2.1 and 2.2 respectively.

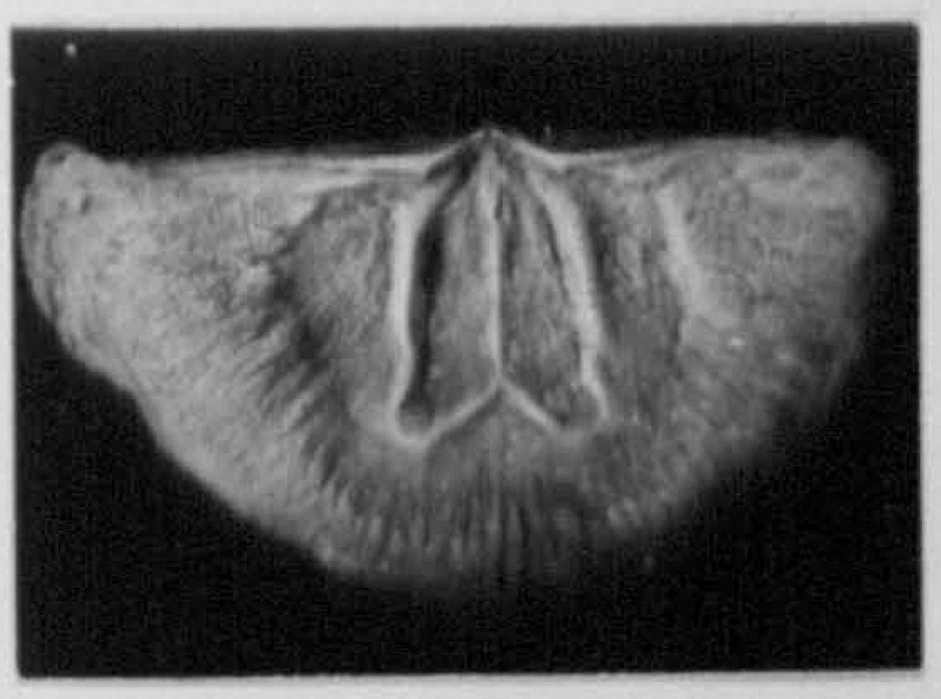
FIG.6. Bc-4363, internal of brachial valve showing the cardinal process lobes with the blade shaped socket plates, truncated adductor muscle scars separated by median rounded and tapering ridges; from Mulde Beds, Wenlock, locality 11 in Däpps section, 4km NE of Fröjel, Gotland (Sweden); x 1.9.

FIGS.7,8,9. Bc-3912/1, external views of pedicle, brachial and posterior view respectively showing rounded shell shape (figs.7 & 8); fig.9 illustrating the development of a small convex chilidium and a large convex and triangular pseudodeltidium in the pedicle apsacline interarea; from Wenlock Limestone, Dudley area; x 1.9, x 1.6 and x 2 respectively.

FIG.10. Ac-1710, external of brachial valve demonstrating the rounded shell shape and the equally parvicostellate radial ornament; from Lower Ludlow, May Hill (MH); x 1.5.

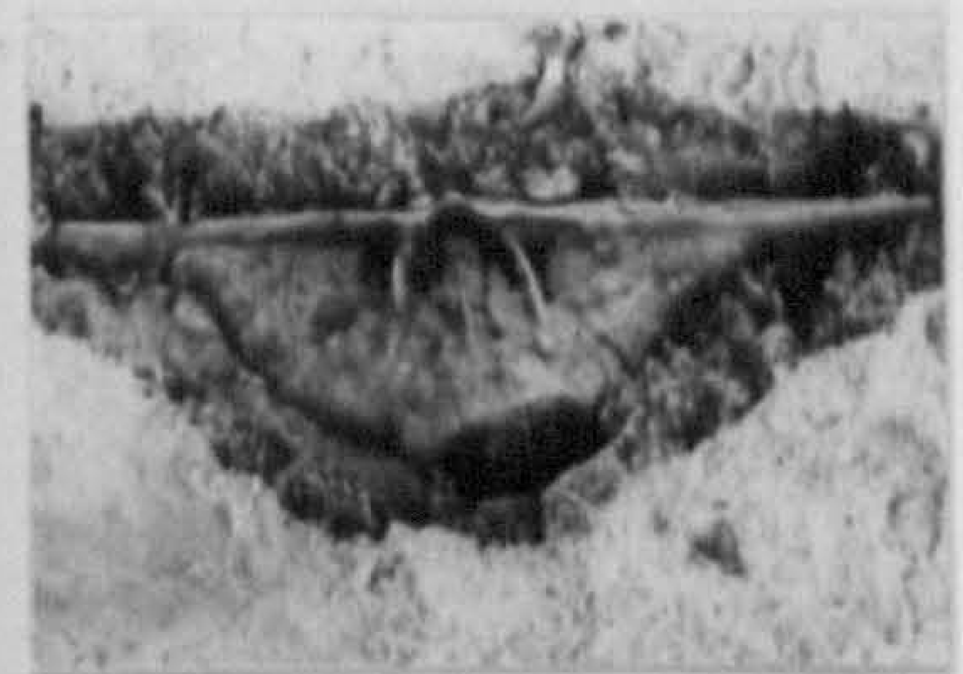
FIGS.14,15. Bc, Wc 4a and b, external of brachial valve and latex cast illustrating the rounded outline of the shell, equally, rounded radial ribs and faintly developed crenulations along the anterior part of the hinge line; from Shelly Limestone (W.G.14) in old railway cutting by road, 1.8km SSW of Klinte (C.J.329.616; sheet 61 SO), Gotland (Sweden); x 2.3 and x 1.8 respectively.

PLATE 26

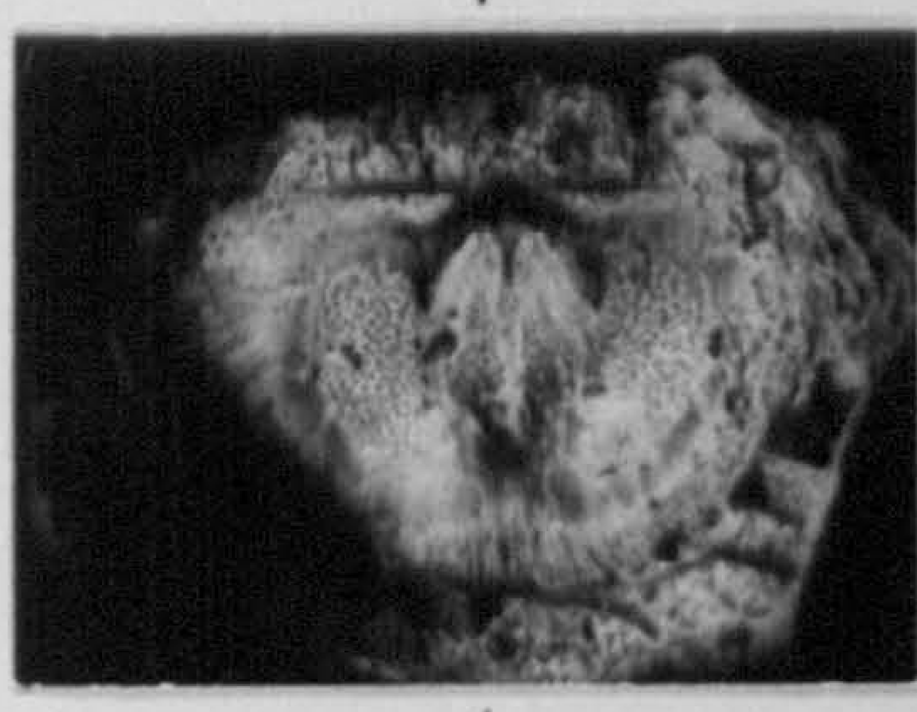


1

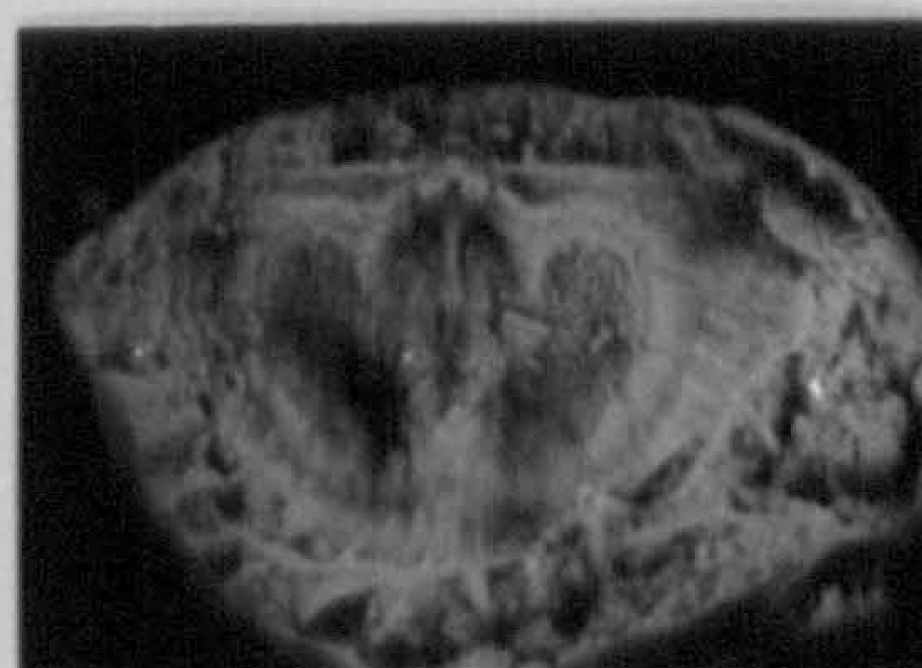
2



3

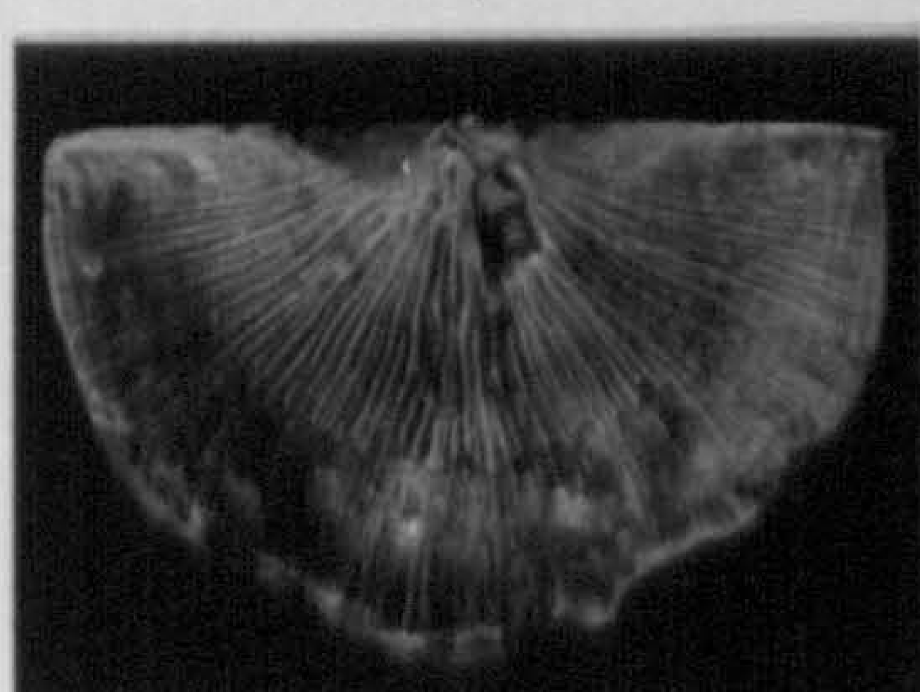


4

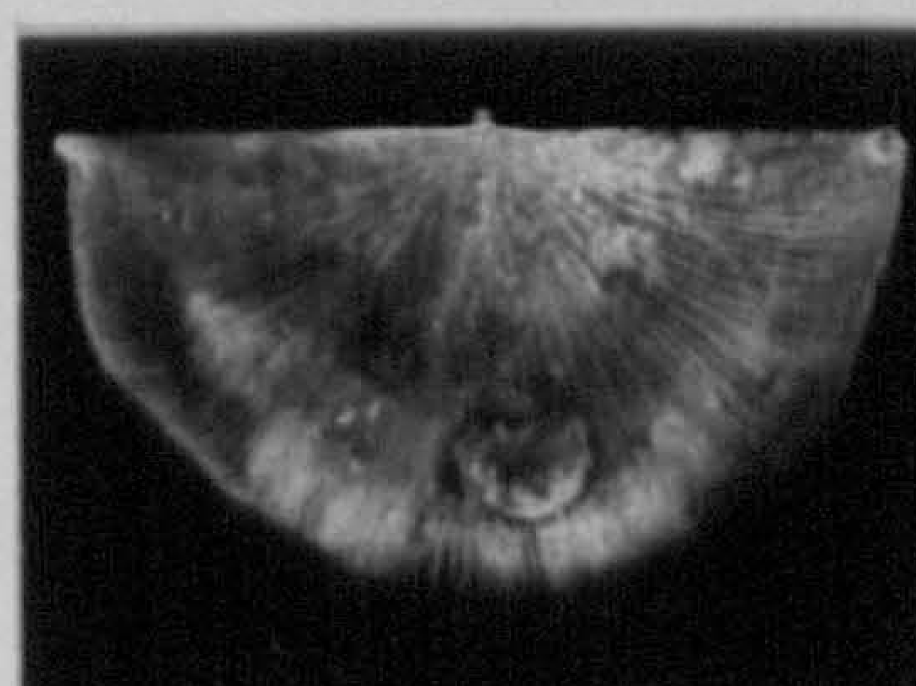


5

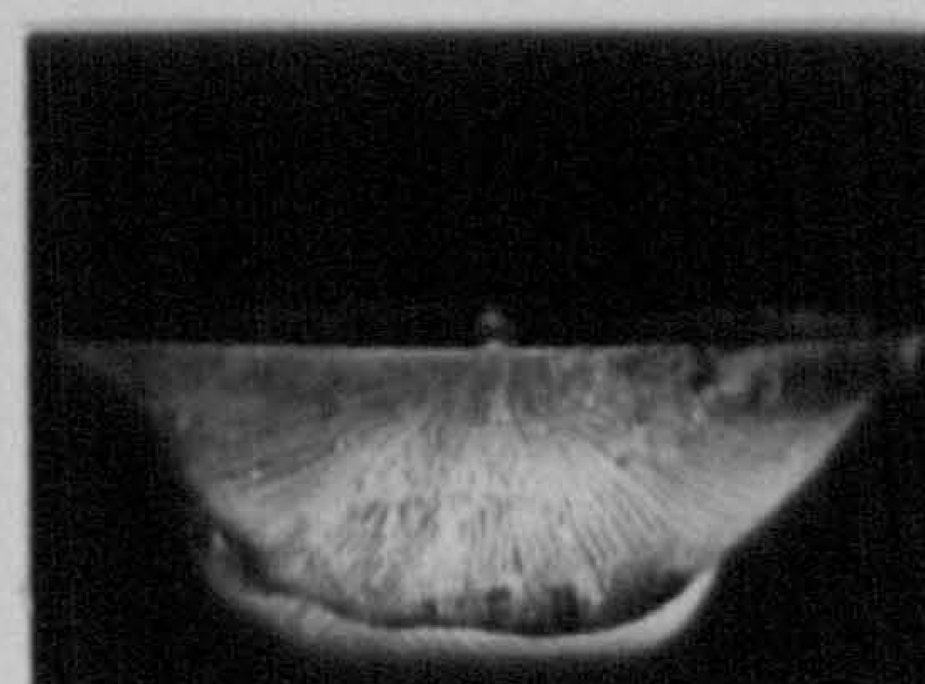
6



7

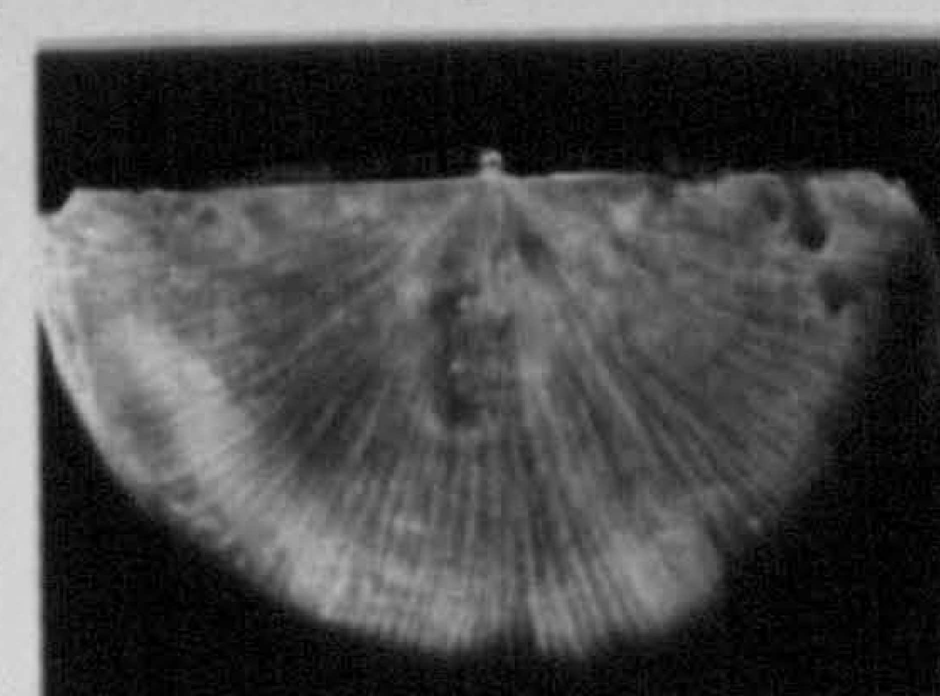


8

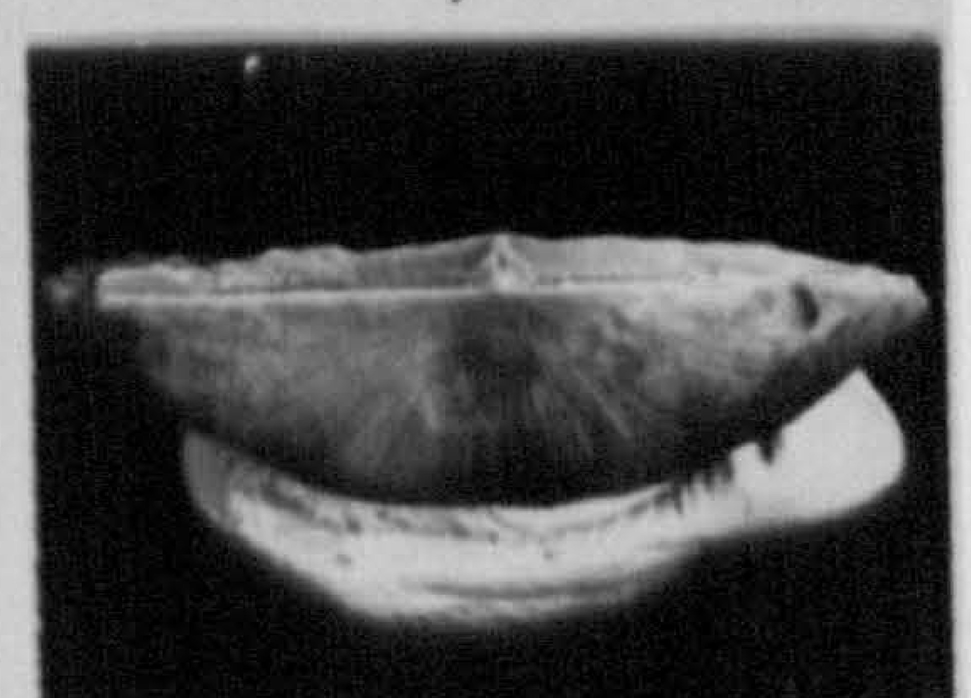


9

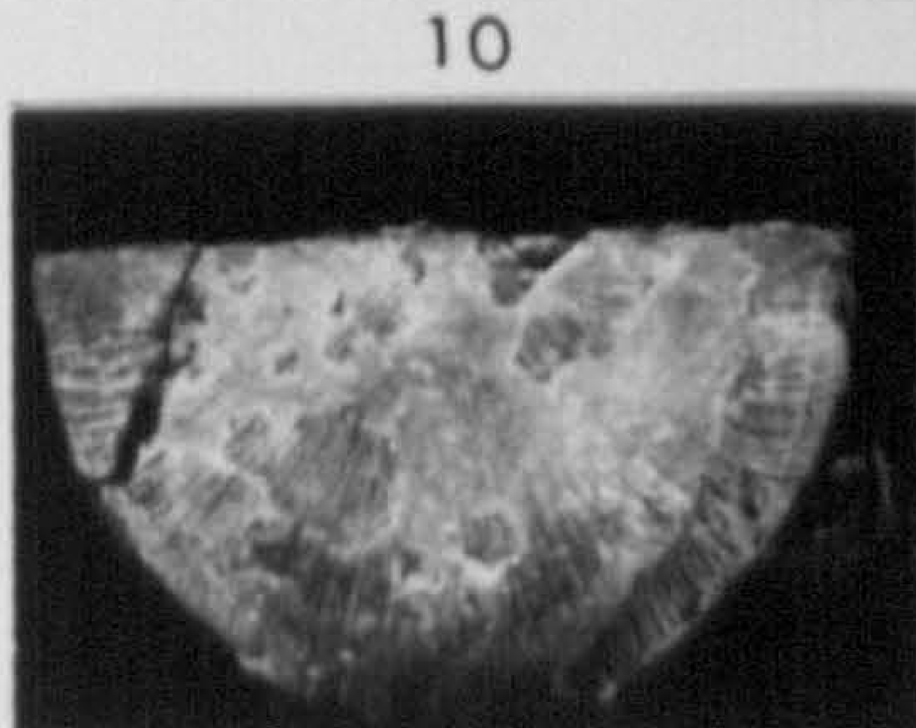
10



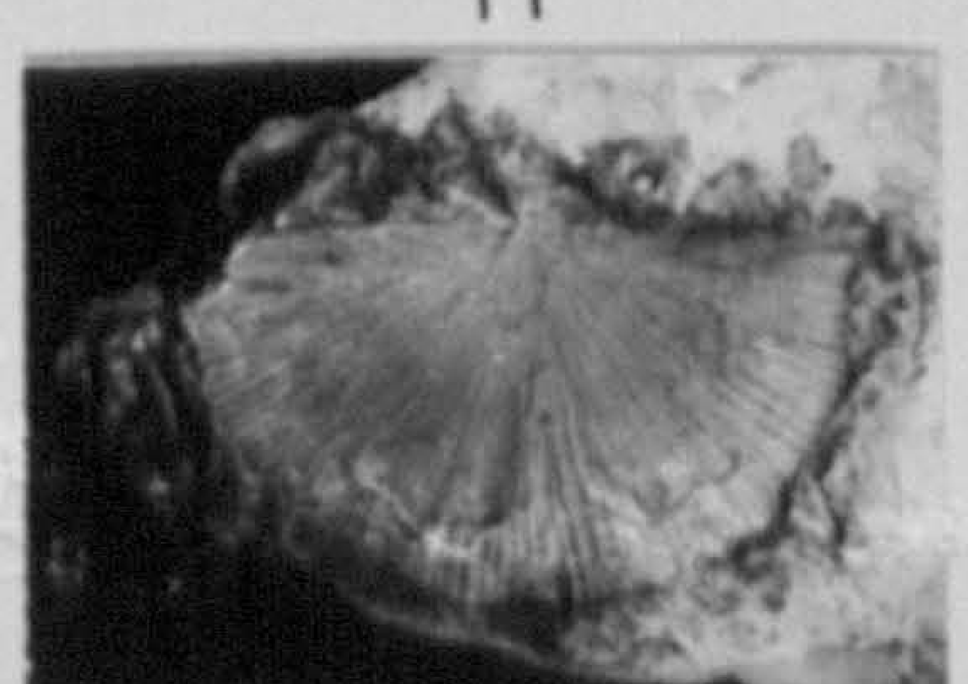
11



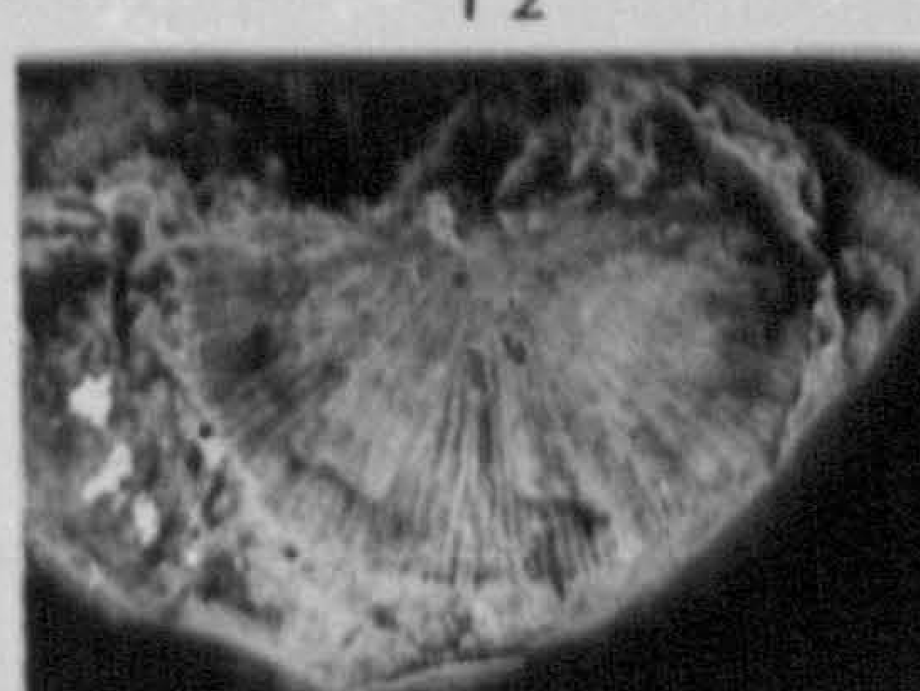
12



13



14



15

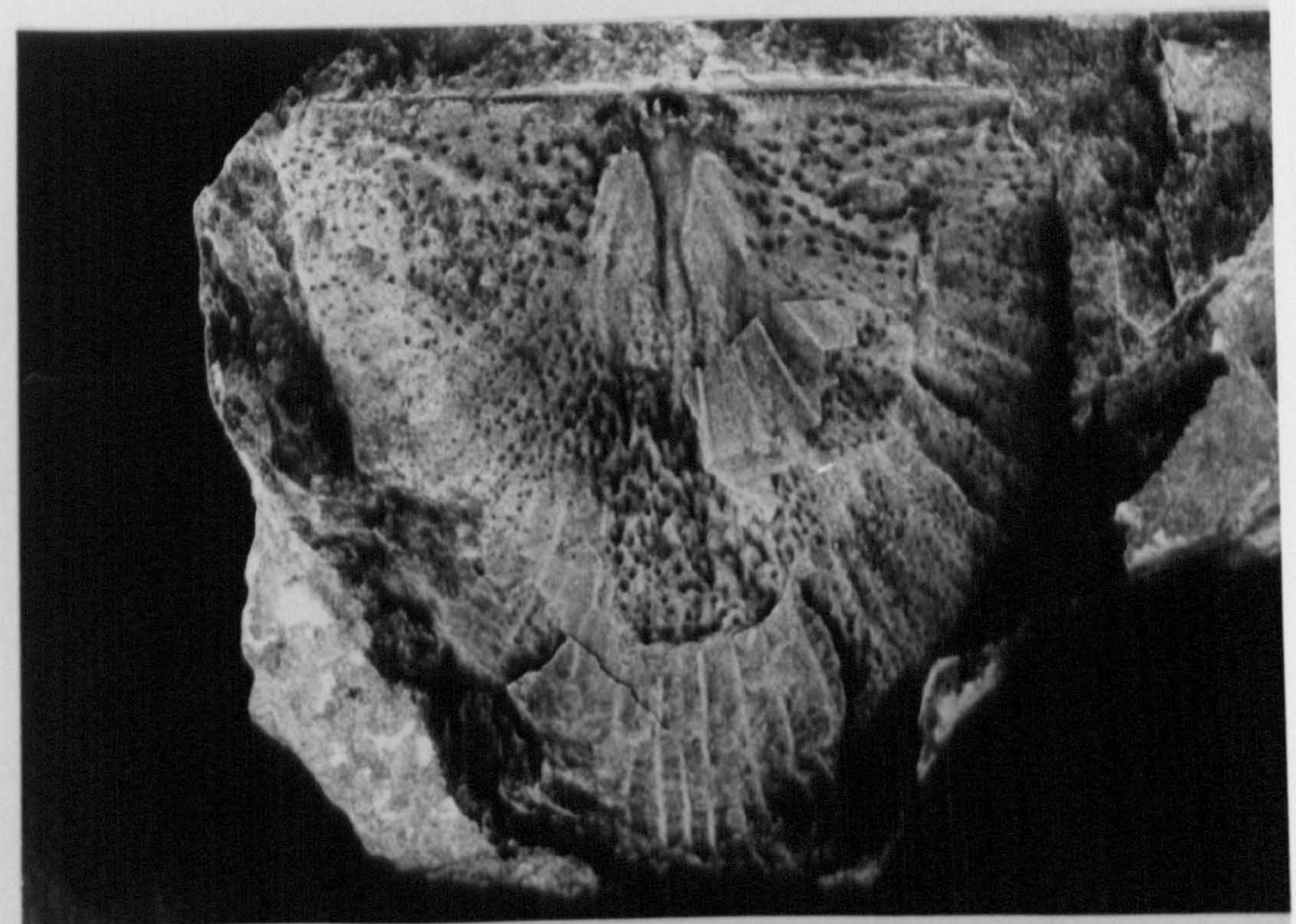
EXPLANATION OF PLATE 27

Internal of brachial valve morphology of S.(S.) euglypha (Dalman, 1828).

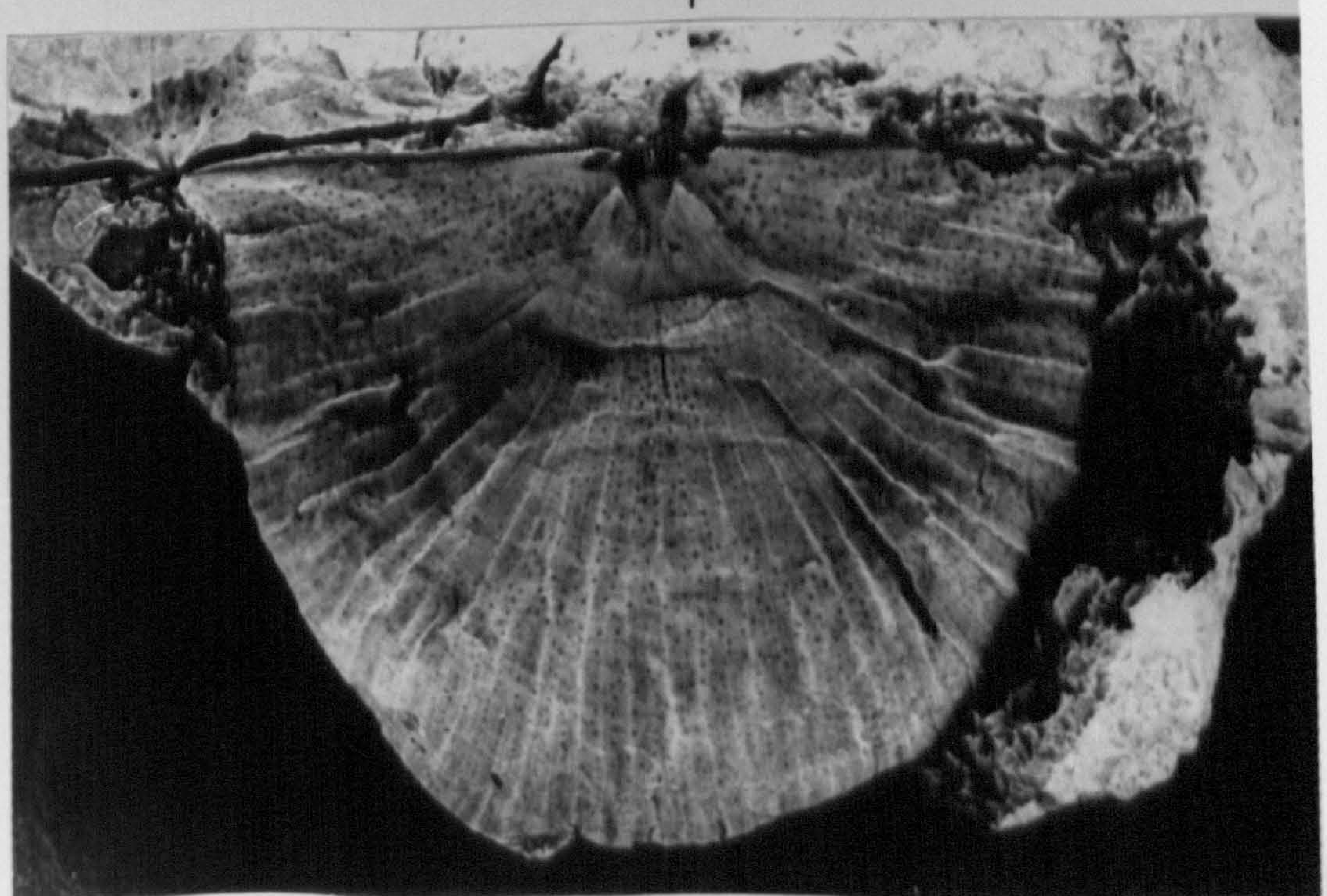
FIG.1. Ac-1150, internal mould of brachial valve showing the triangular shape of the valve, cardinal process lobes, short-bladed socket plates, denticulation along the hinge line, truncated, oval adductor muscle scars separated by median ridge and bounded laterally by a pair of ridges which diverge at a low angle, fine to coarse tuberculation on the internal valve surface; from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 3.1.

FIG.2. Ac-1449, internal mould of brachial valve, illustrating the same structural features as fig.1, except that the angle of divergence of the muscle bounding ridges is larger and the outline valve shape is more rounded than triangular; from the Lower Bringewood Formation, Llandegveth reservoir (LR) in the Usk inlier; x 3.1.

PLATE 27



1



2

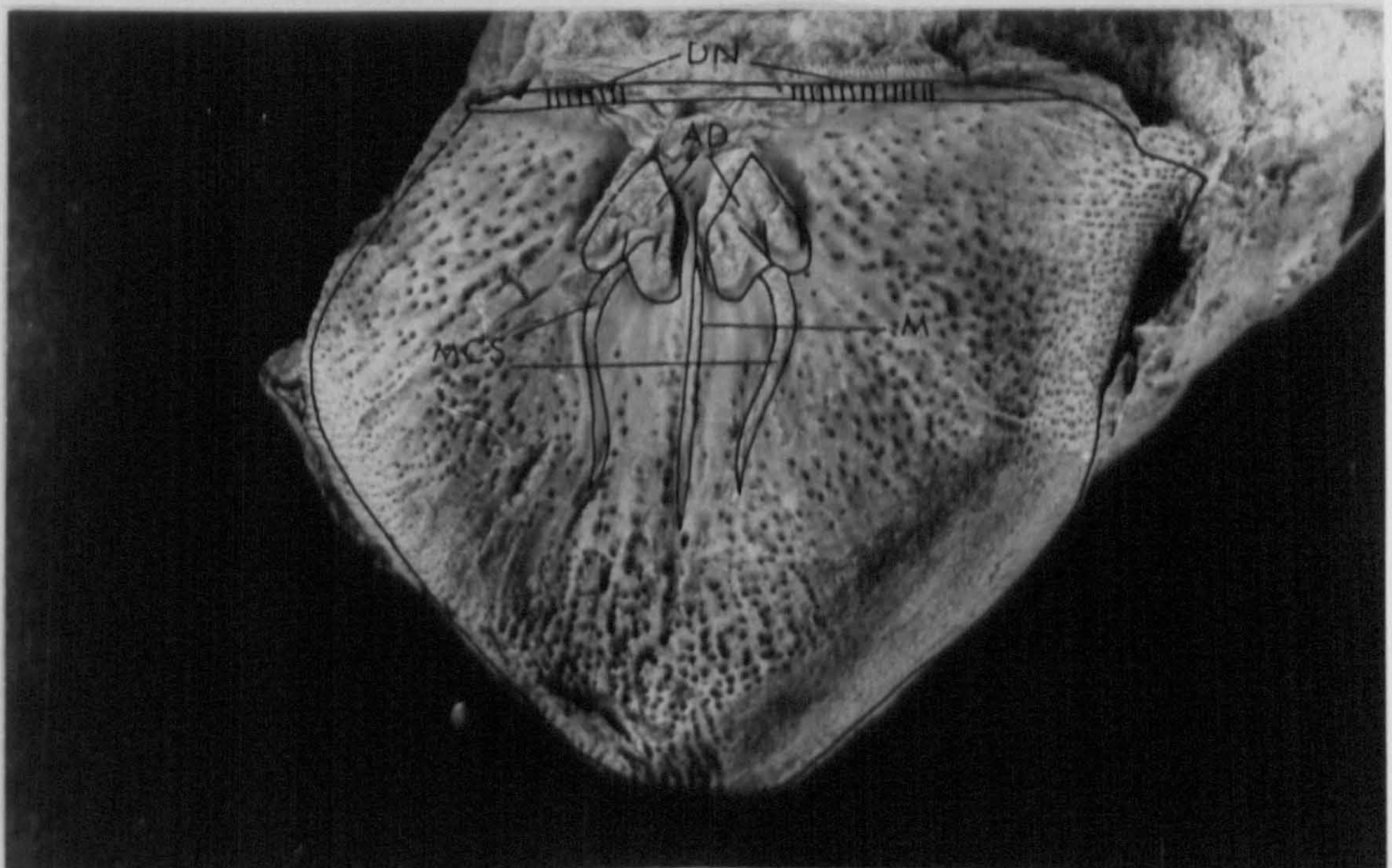
EXPLANATION OF PLATE 28

Internal of brachial valve morphology of S.(S.) euglypha (Dalman,1828).

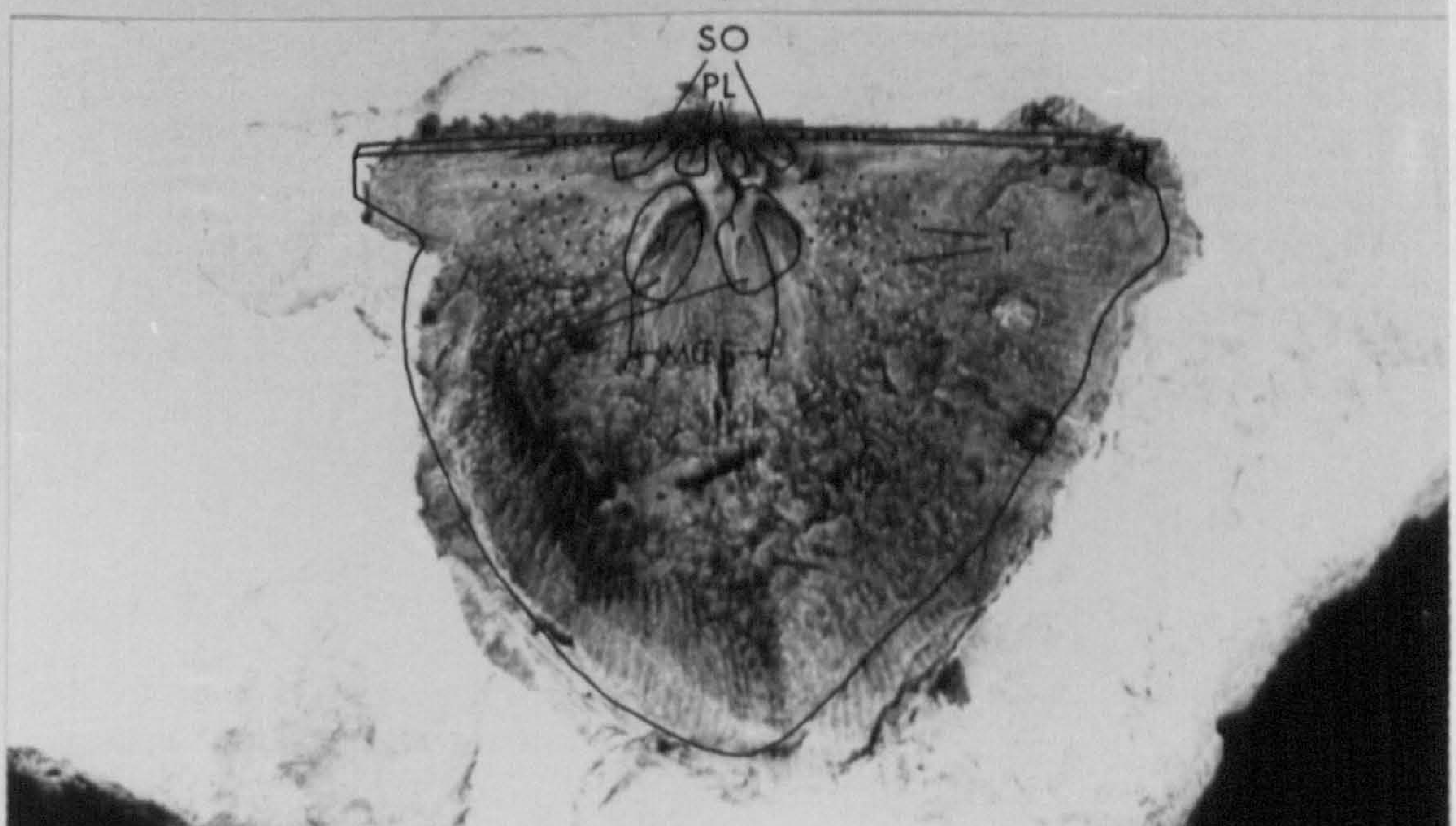
FIG.1. Ac-639, internal mould of brachial valve illustrating the triangular shape of the valve outline, well developed denticulation, subtriangular adductor muscle scars which are lobate anteriorly with a pair of extension ridges, originating within the muscle bases and widely separated posteriorly, showing the lemniscate type of mantle canal system and with tubercles on the external surface of the valve; from the Upper Bringewood Formation, Mortimer Forest track, section B (L:B7); x 2.2.

FIG.2. Ac-1228, internal of brachial valve demonstrating the triangular shell shape, the cardinal process lobes which are directed postero-ventrally, short blade-shaped socket plates, oval adductor muscle scars with a pair of extension ridges from the muscle bases to the body cavity showing the same character as that illustrated by fig.1; from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 2.5.

PLATE 28



1



2

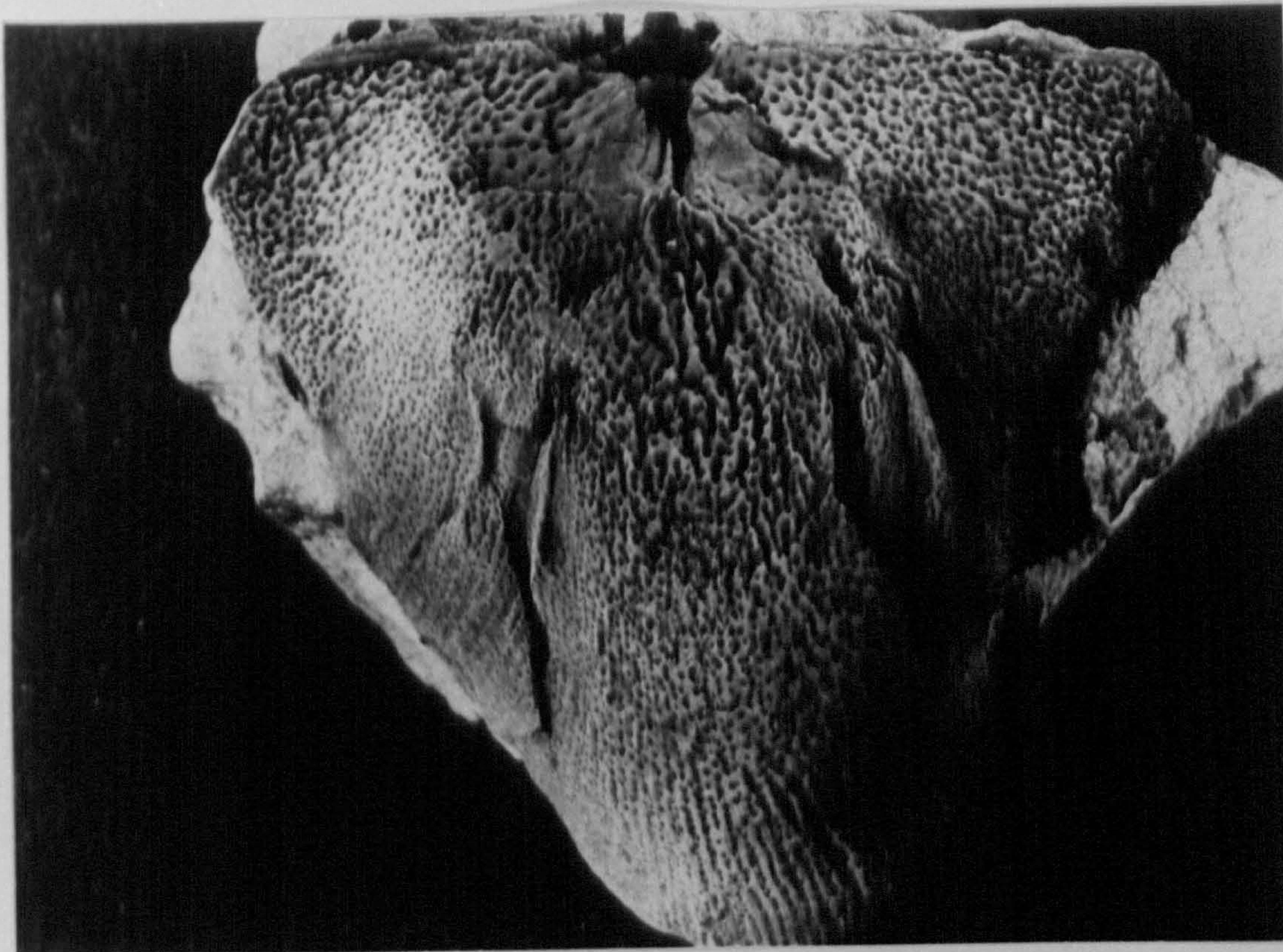
EXPLANATION OF PLATE 29

Enlargement views of the brachial and pedicle valve morphology of *S.* (*S.*) *euglypha* (Dalman, 1828).

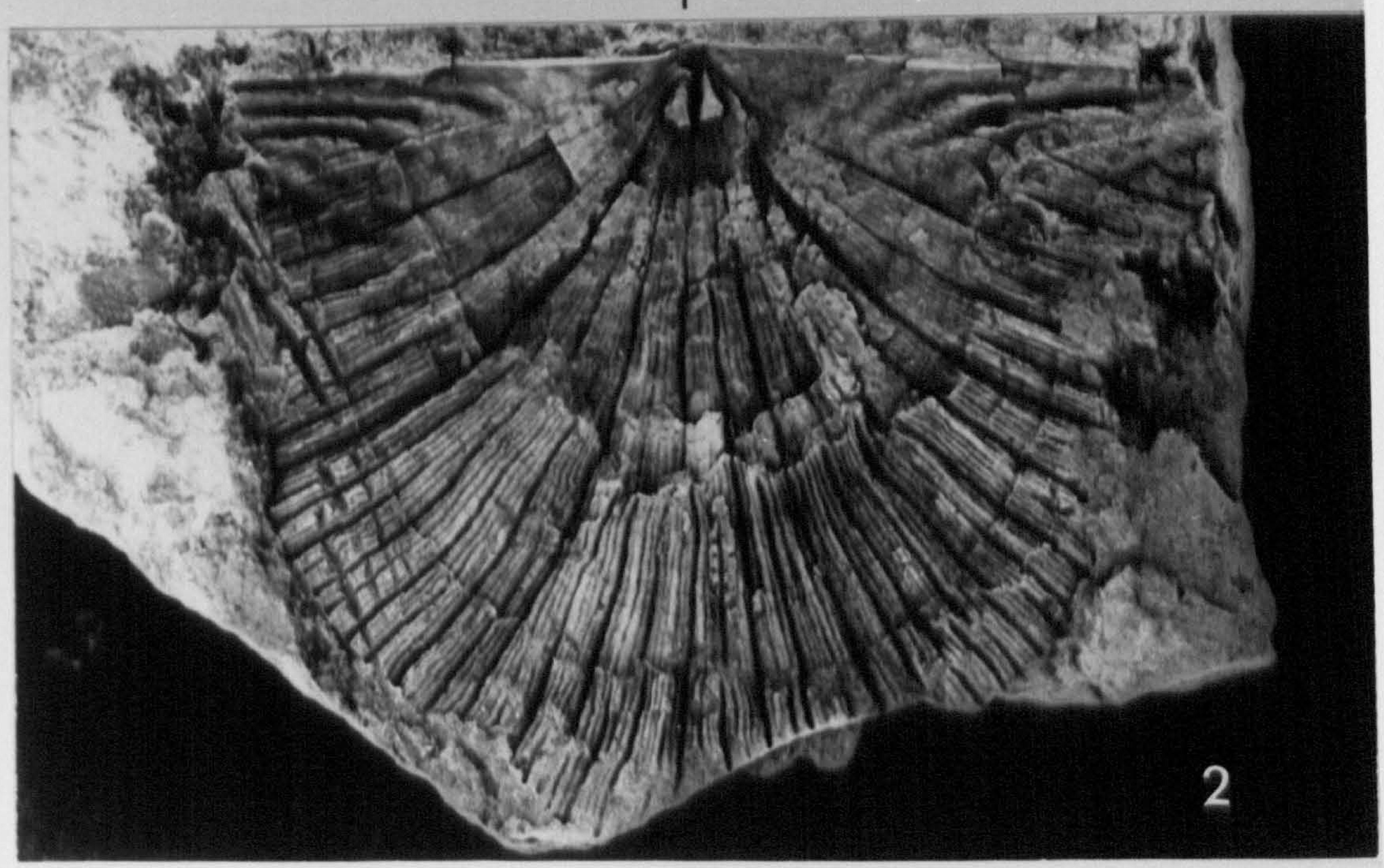
FIG.1. Ac-826, internal mould of brachial valve showing the triangular outline of the valve, the cardinal process lobes and well-impressed fine to coarse tuberculation on the whole internal valve surface; from the Lower Bringewood Formation, locality 7a near Ludlow (Shropshire); x 3.2.

FIG.2. Ac-1256, external mould of pedicle valve demonstrating the cardinal process lobes which have adhered during diagenesis to the postero-median region of the pedicle valve, well developed coarse radial ribs (costellae) leaving a wide space between them which is occupied by 4-5 finer ribs (capillae) and the well-impressed ridges or crenulations originating from the postero-lateral sides of the hinge line (i.e. ears), directed and dying out antero-medianly; from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 4.8.

PLATE 29



1



2

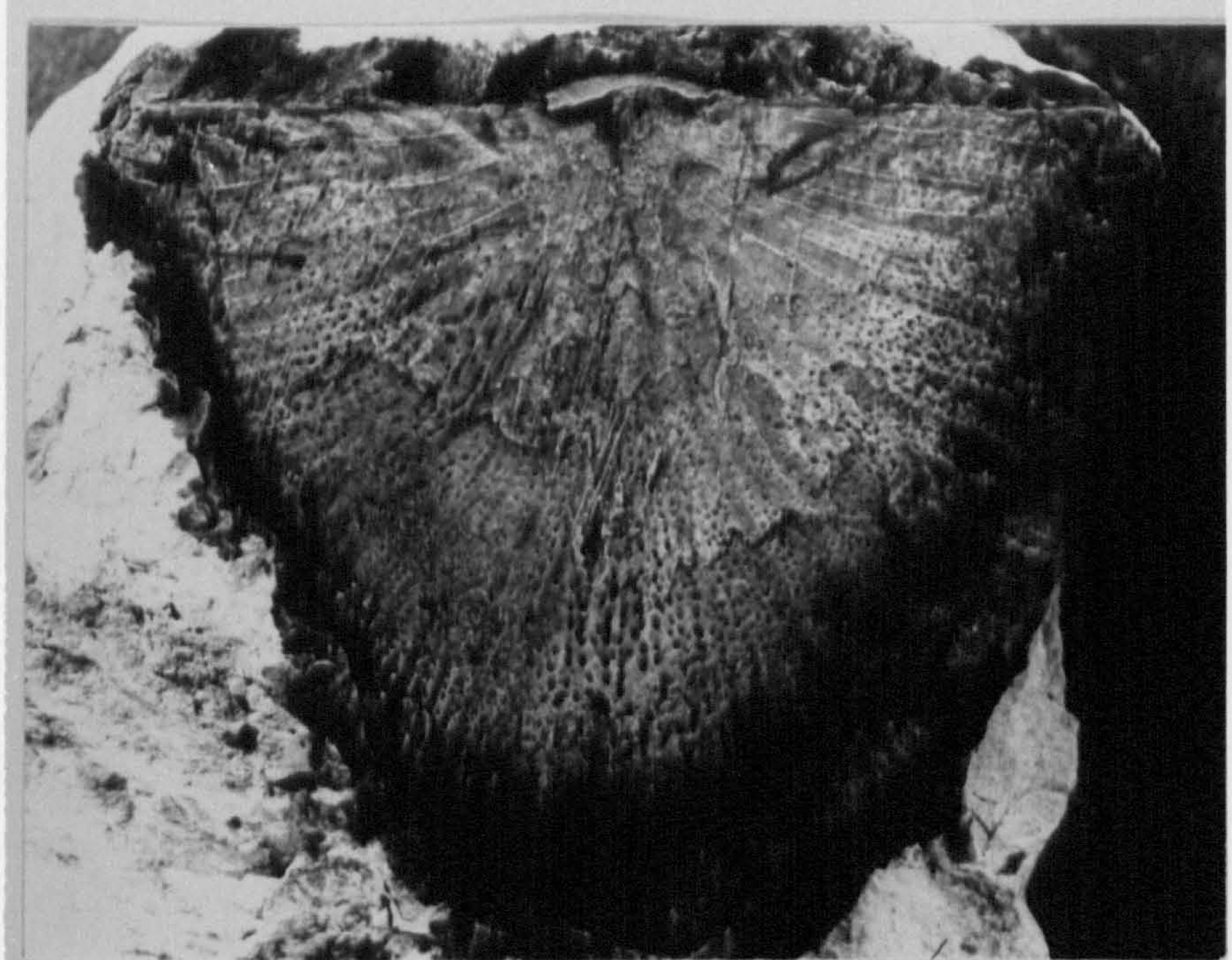
EXPLANATION OF PLATE 30

Enlargement views of the pedicle and brachial valve morphology of S.(S.) euglypha (Dalman,1828).

FIG.1. Ac-1188, external of brachial valve showing the triangular outline of the shell with numerous nearly parallel striations along the external surface of the valve; from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 2.7.

FIG.2. Ac-1439, internal mould of brachial valve illustrating the triangular valve shape, the cardinal process lobes which are separated by a short, rounded groove, short blade-shaped socket plates, denticulations, well developed coarse and fine radial ornament (costellae and capillae); from the Lower Bringewood Formation of Llandegveth reservoir locality (LR) in the Usk inlier; x 3.2.

PLATE 30



1

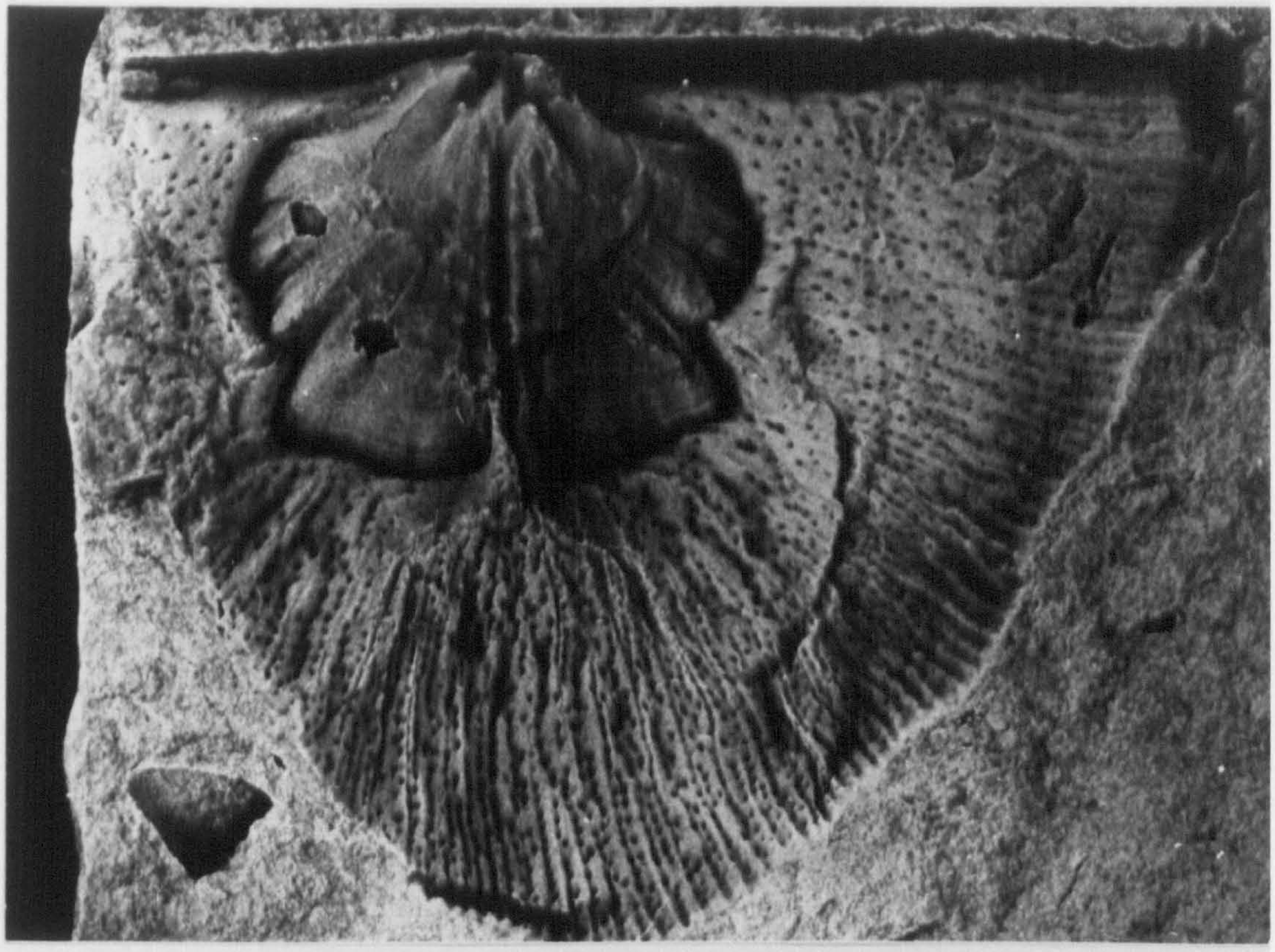
2

EXPLANATION OF PLATE 31

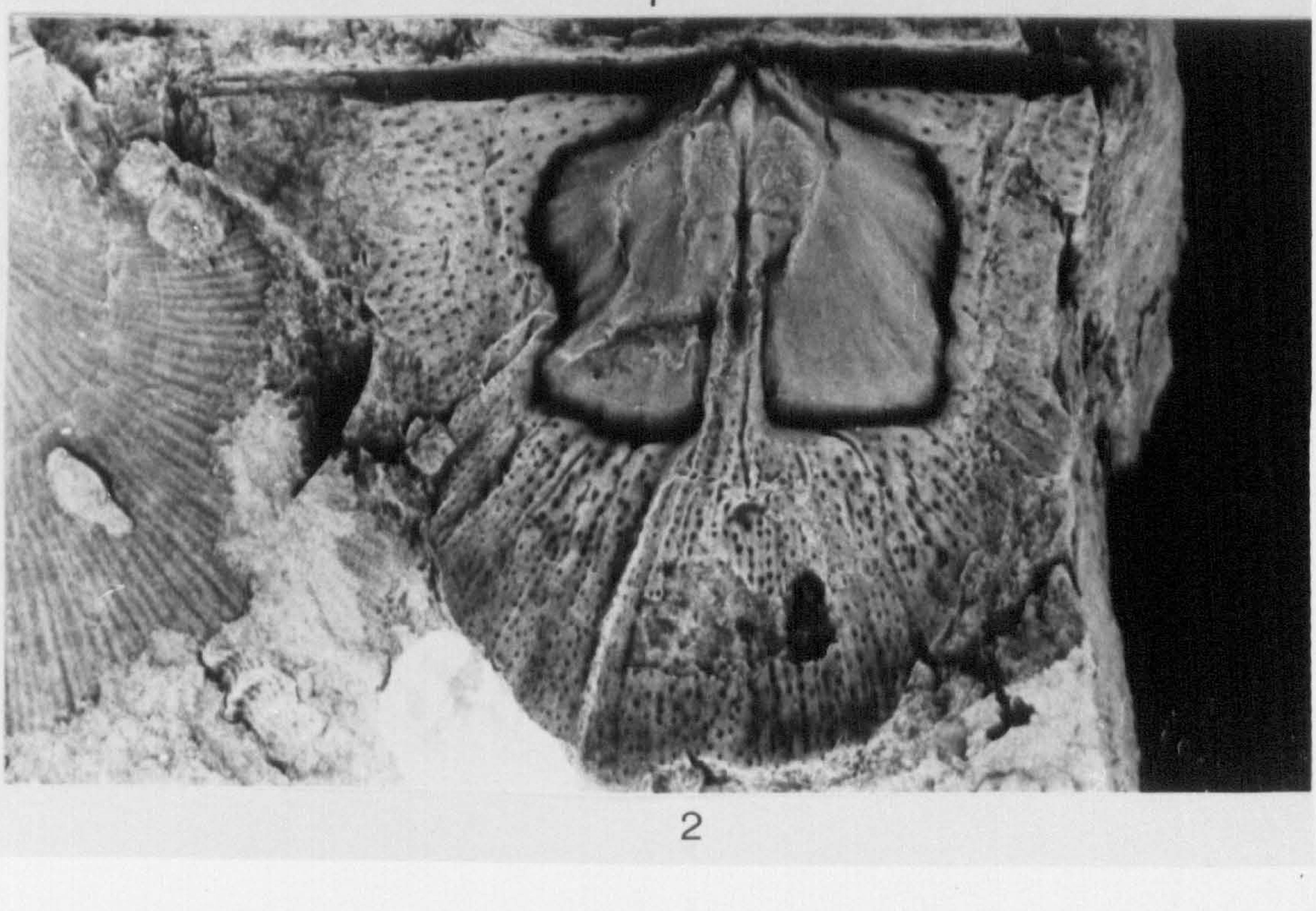
Enlargement view of pedicle valve morphology of S.(S.) euglypha (Dalman,1828).

FIGS.1, 2. 1, Ac-863/1 and 2, Ac-1436/4, internal moulds of pedicle valve illustrating the triangular shape of the valve, ventral process, lanceolate adductor and flabellate diductor muscle scars which are separated medianly by myophragm and bounded laterally and anteriorly by muscle ridges; fig.1, from the Lower Bringewood Formation, locality JS, Wenlock Edge; x 4.1. Fig.2; from the Lower Bringewood Formation, Llandegveth reservoir, locality LR in the Usk inlier; x 3.2.

PLATE 31



1



2

EXPLANATION OF PLATE 32

Pedicle and brachial valve morphology of S.(S.) euglypha (Dalman,1828)

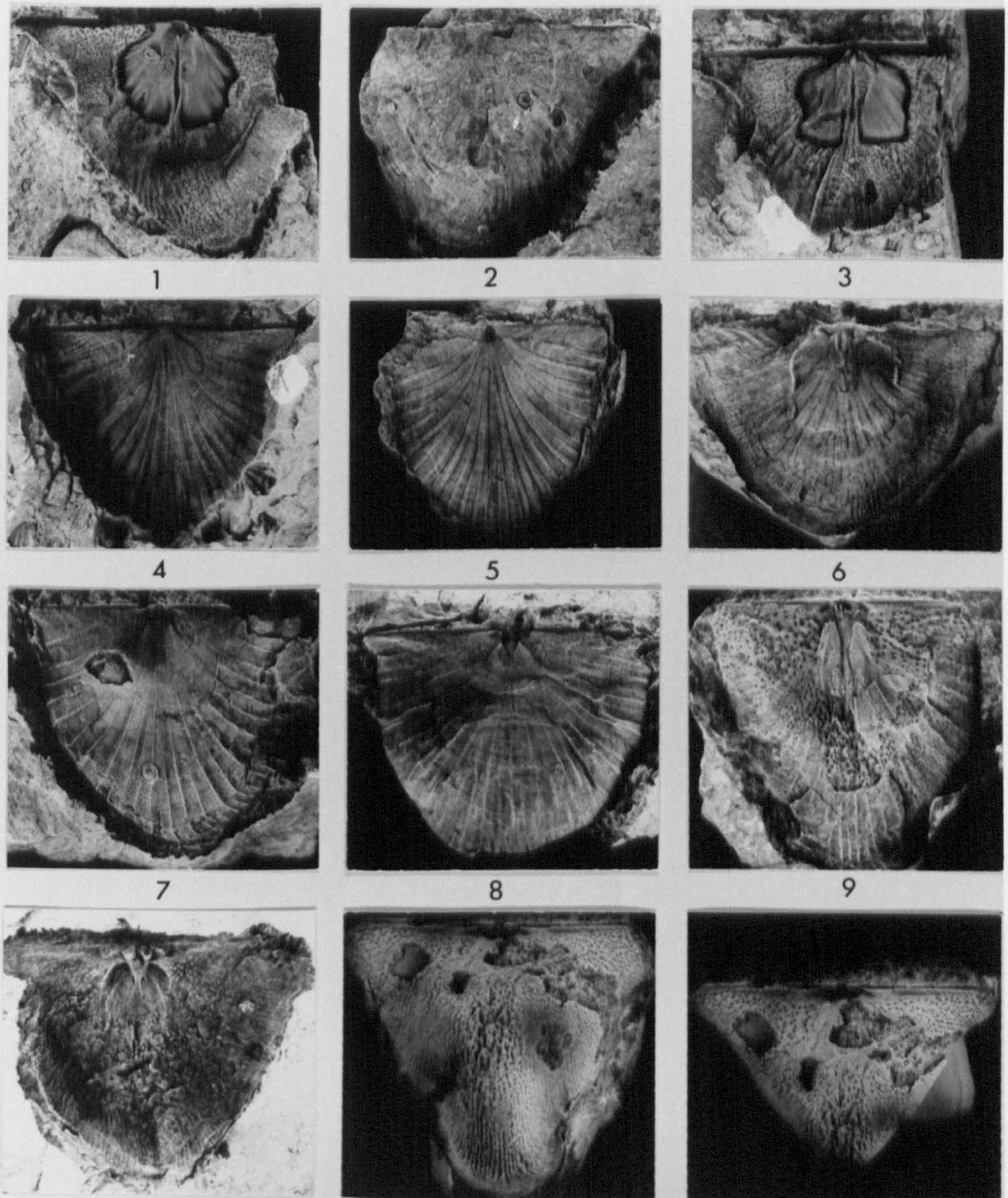
FIGS.1-5. 1 and 2, Ac-1506a and b, internal mould of pedicle valve and counterpart external mould demonstrating the triangular outline of the valve, faintly to moderately impressed lanceolate adductor muscles, strongly developed flabellate diductor muscle and muscle bounding ridges and both the (adductor and diductor muscles) separated by a rounded, narrow and tapering myophragm; 3, Ac-1436/4, internal mould of pedicle valve illustrating the same structural features as fig.1; 4,5, Ac-1563/1a and b, internal mould of pedicle valve and counterpart external mould showing the triangular outline of the valve, faintly developed muscle field, straight hinge line and well developed parvicostellate radial ornament (costellae and capillae); all are from the Lower Bringewood Formation, Llandegveth reservoir (LR) in the Usk inlier; x 1.1, x 1.1, x 1.1, x 1.2 and x 1.3 respectively.

FIGS.6,9,10. 6, Ac-1302, internal of pedicle valve illustrating the development of the crenulations along the left hand side of the hinge line, faintly and moderately developed adductor and diductor muscle scars, well developed ventral process with trace of two lobes of the cardinal process on its postero-lateral sides; 9, Ac-1150, internal mould of brachial valve showing the triangular outline shape of the valve, cardinal process lobes, denticulation, socket plates, nearly parallel, oval adductor muscle and muscle bounding ridges separated by low, median ridge; 10, Ac-1228, internal of brachial valve illustrating the cardinal process lobes which are directed postero-ventrally, short-bladed socket plates, oval, lobate adductor muscle scars with extensions from the muscle bases to the body cavity forming the lemniscate type of the mantle canal system; all are from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 1, x 1.4 and x 1.2.

FIGS.7,8. Ac-1439 and Ac-1449, internal moulds of brachial valve demonstrating the subtriangular and subrounded outline shape respectively, well developed cardinal process lobes, socket plates, denticulation and faintly impressed adductor muscle and muscle bounding ridges with well developed fine and coarse radial ribs (fig.7); from the Lower Bringewood Formation, Llandegveth reservoir (LR) in the Usk inlier; x 1.5 and x 1.3.

FIGS.11 & 12. BM, Wc-9, internal mould of brachial valve and its posterior view showing the triangular valve shape, cardinal process lobes separated by short, rounded groove, socket plates, denticulation; from Lower Bringewood Formation, Ludlow area, roadside exp. 170 yds NNE Mary Knoll House (4828.7377); x 1.1 and x 1.2 respectively.

PLATE 32



EXPLANATION OF PLATE 33

Externals of pedicle and brachial valve morphology of *S.(S.) euglypha* (Dalman,1828).

FIGS.1,2,3,4,6,10. 1 and 2, Ac-1191a and b, external of brachial valve and counterpart external mould showing very thin, broken incomplete shell, rounded shape of the valve outline, well impressed radial ornament, well preserved crenulations originating from the postero-lateral margins of the shell (hinge ears), directed and dying-out antero-medianly; 3, Ac-1134, external mould of brachial valve showing the same features as in fig.1; 4 and 6, Ac-1303 and 1306, external moulds of pedicle valve demonstrating the subtriangular valve shape with the closely spaced coarse radial ribs (costellae) occupied by 3-4 finer ribs in between (capillae), fig.6, also demonstrating the development of the concentric growth line; 10, Ac-1188, external of brachial valve showing fine, nearly parallel striations along the external surface of the shell with probably the attachment of the convex pseudodeltidium from the opposite pedicle valve; all are from the Lower Bringewood Formation, Woodbury Quarry (WQ) in the Abberley Hills; x 1.2, x 1.1, x 1.4, x 1.1, x 1.2 and x 1.3 respectively.

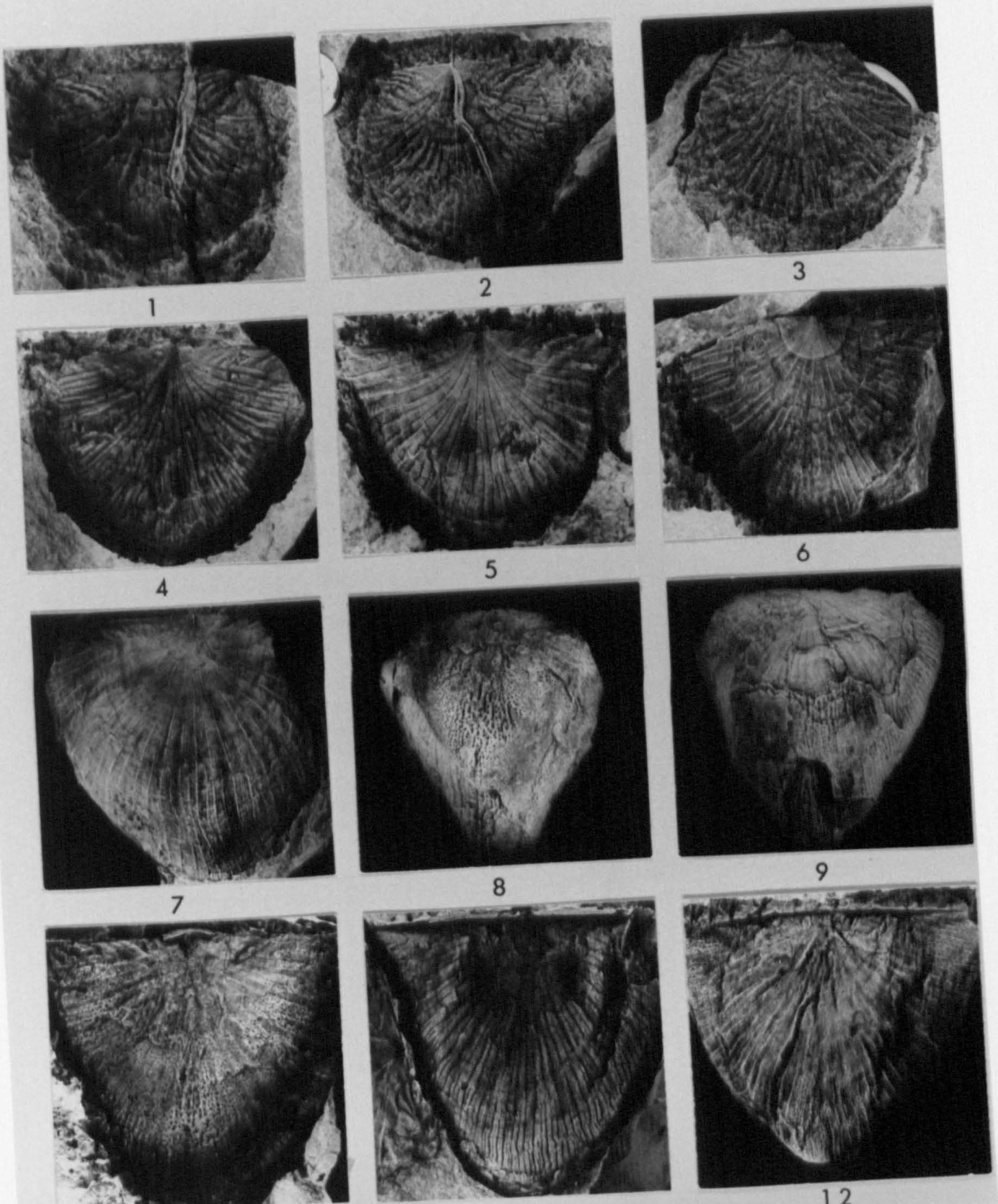
FIG.5. Ac-1458, external mould of pedicle valve demonstrating the well impressed coarse and fine radial ornamentation with faintly developed crenulations along the right hand side of the hinge line; from the Lower Bringewood Formation, Llandegveth reservoir (LR) in the Usk inlier; x 1.3.

FIG.7. Ac-862/1, external of brachial valve demonstrating the strongly convex shell and widely spaced coarse radial ribs with about six finer ribs in between; from the Lower Bringewood Formation, locality 7a, near Ludlow (Shropshire); x 1.7.

FIGS.8, 9. BM, Wc-6 and 4, externals of brachial valve illustrating part of the thin shell which was strongly convex with triangular outline shape; from the Upper Bringewood Formation, Ludlow area; x 1.1 and x 1.3 respectively.

FIGS.11,12. Ac-616/2 and 278, external moulds of brachial valve showing the triangular outline of the shell with the denticulations along the ventral interarea on the opposite valve (fig.11); both are from Lower Bringewood Formation; fig.11, from Mortimer Forest track, section B (L:B5); fig.12, from locality 31 near Ludlow area; x 1.4 for both of them.

PLATE 33

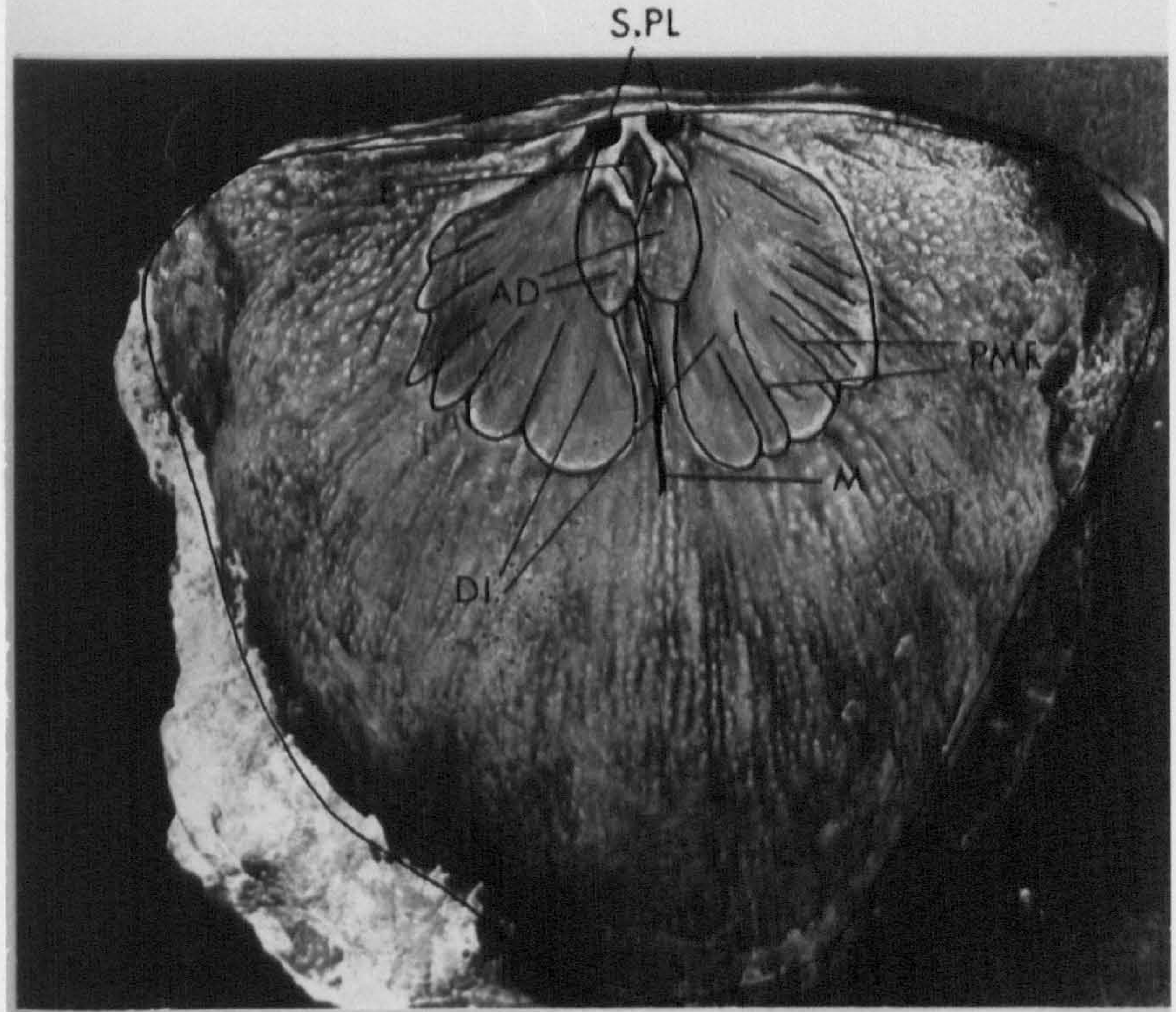


EXPLANATION OF PLATE 34

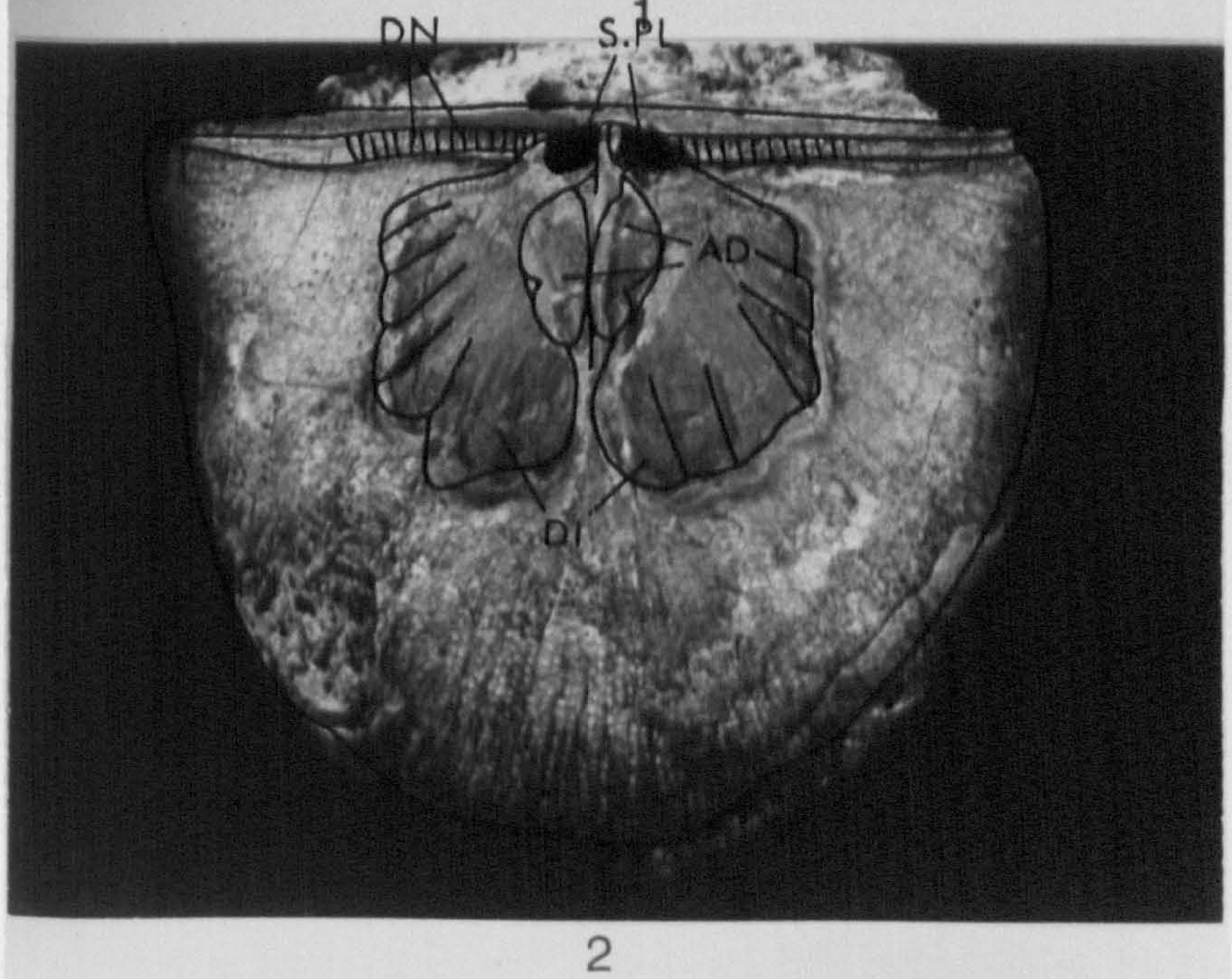
Enlargement view of the internal of pedicle valve morphology of *S*.(*S*.) *euglypha* (Dalman, 1828).

FIGS.1,2. 1, Lc-890 and 2, BM-13370, internals of pedicle valve demonstrating the well impressed ventral process, lanceolate adductor muscle scars, flabellate diductor muscle scars, myophragm, muscle bounding ridges and a trace of the two lobes of the cardinal process which fitted on the postero-lateral side of the ventral process; from the Wenlock Limestone, Dormington Quarry (L: DQ), Woolhope; x 2 for both of them.

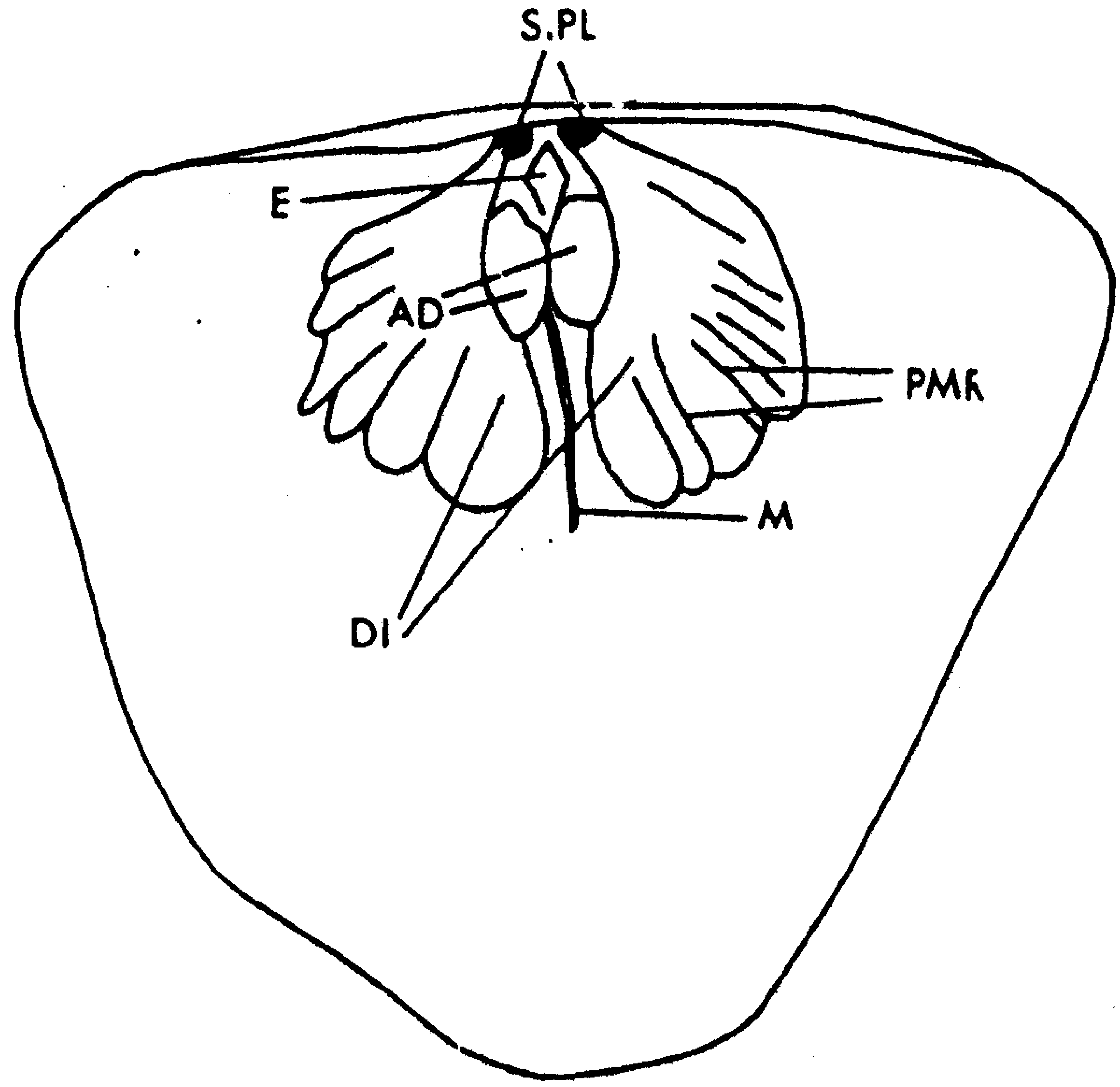
PLATE 34



1



2


S.PL
E
AD
PMR
M
DI

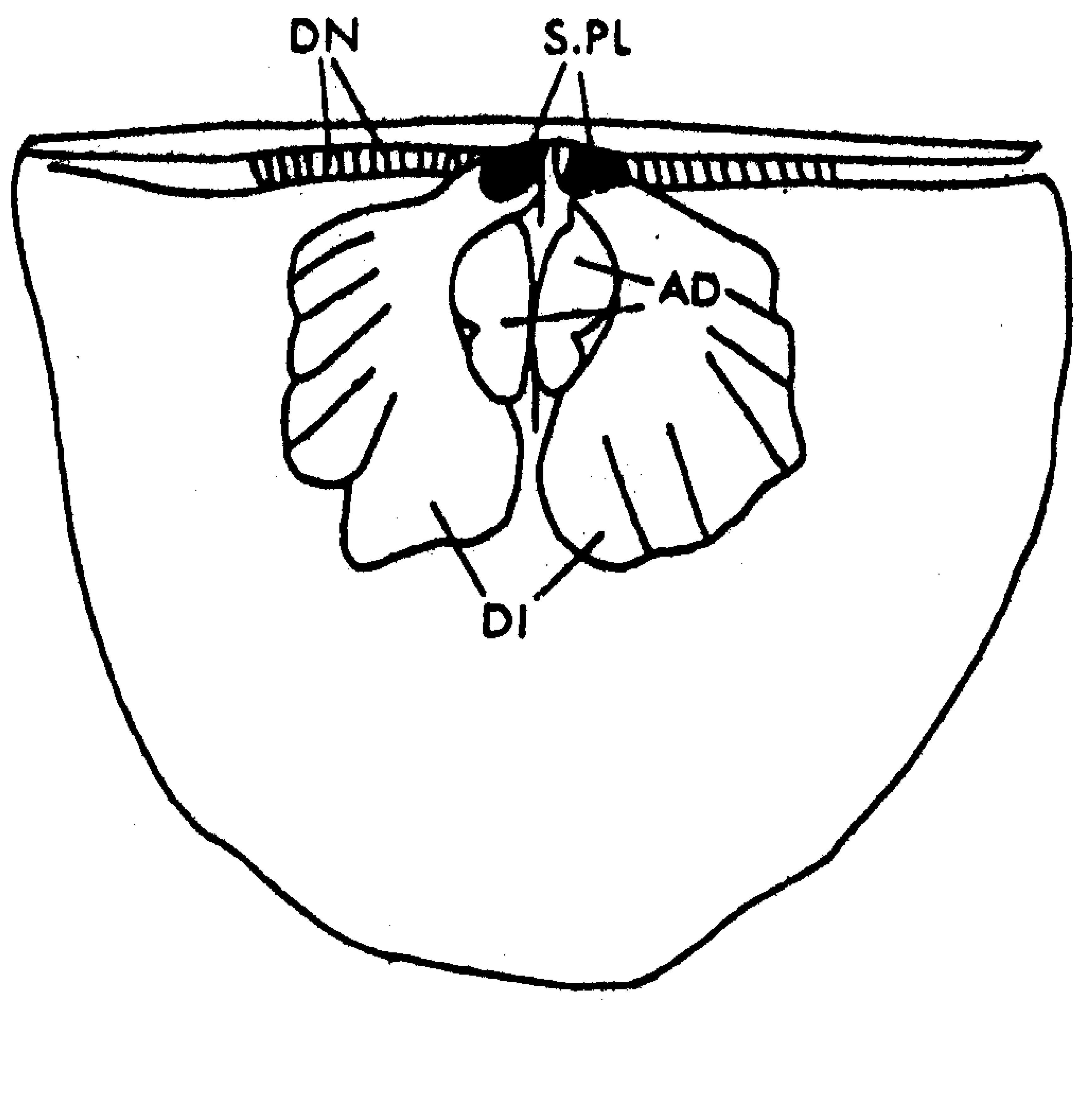
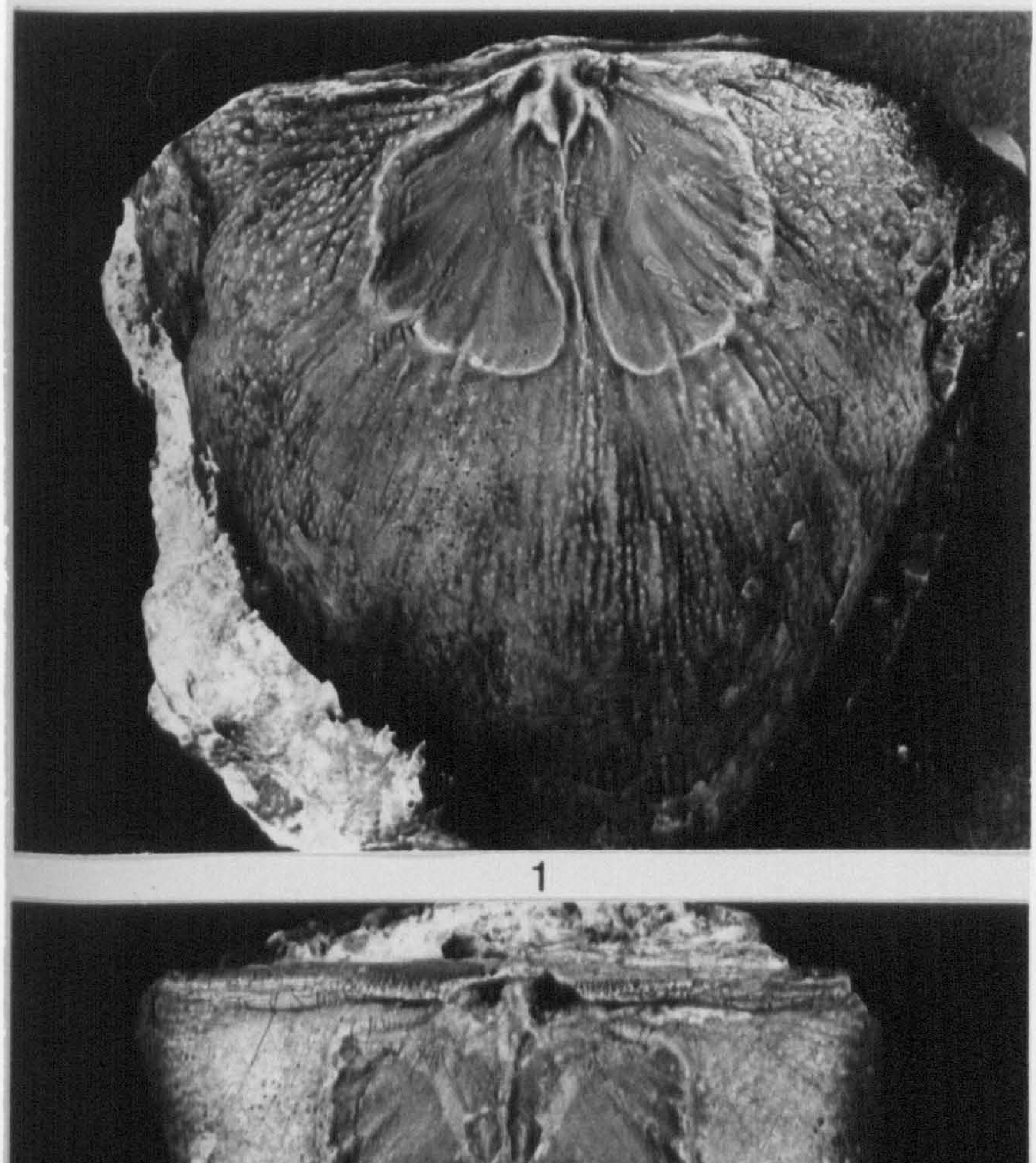

DN
S.PL
AD
DI

PLATE 34



1

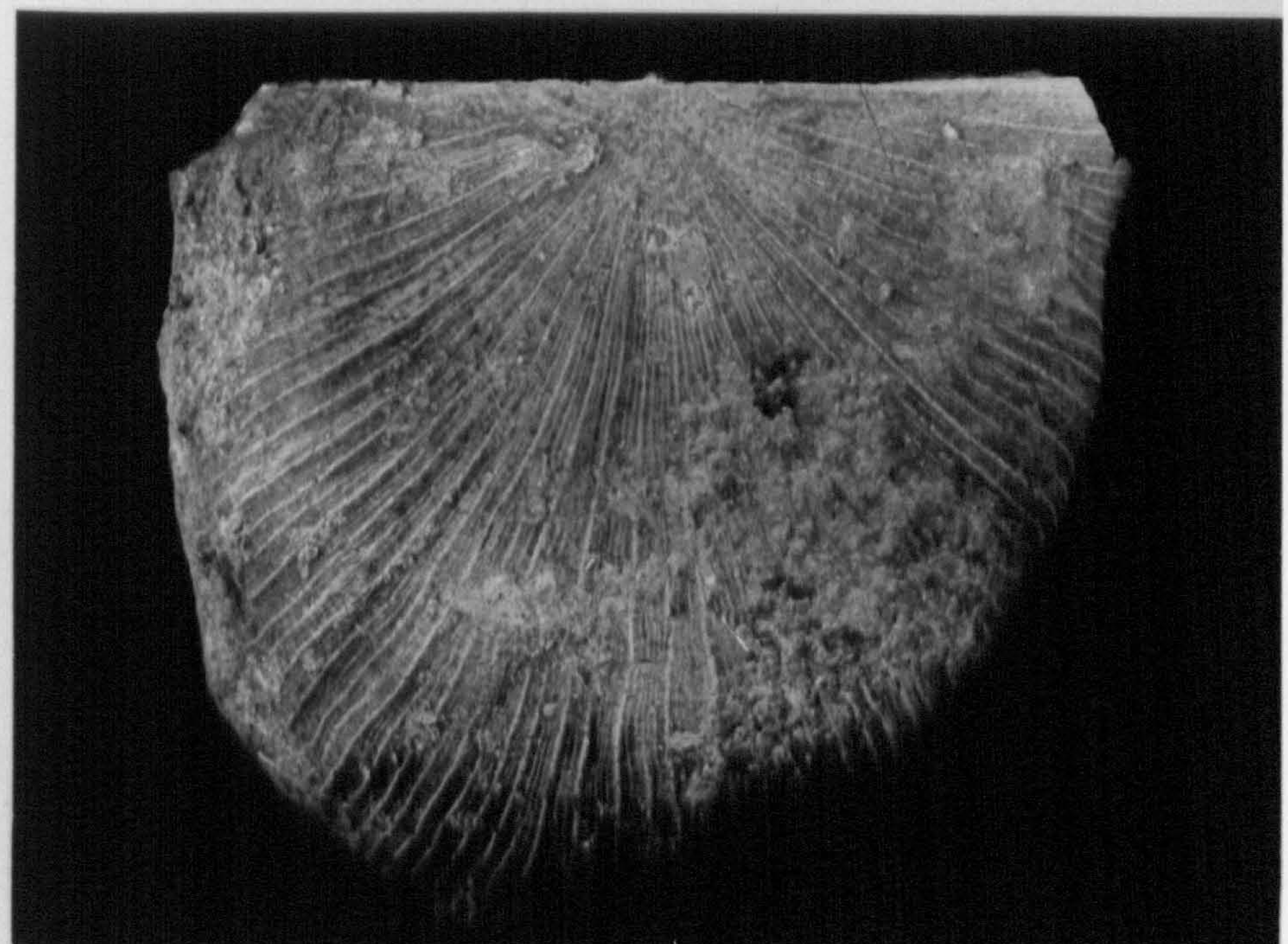
2

EXPLANATION OF PLATE 35

Enlargement view of the brachial valve morphology of S.(S.) euglypha (Dalman, 1828).

FIGS.1,2. 1, BM-13365, external of brachial valve demonstrating the rounded shell shape, the development of the chilidium and the coarse and fine radial ribs (costellae and capillae); fig.2, BM-13366, internal mould of brachial valve illustrating the rounded valve shape, well impressed denticulation along the hinge line, lobate and subtriangular adductor muscle and muscle bounding ridges with a pair of extension ridges from the muscle bases to the body cavity forming the lemniscate type of the mantle canal system; both from the Wenlock Limestone, Dormington Quarry (L: DQ), Woolhope; x 2.6.

PLATE 35



1

2

EXPLANATION OF PLATE 36

Pedicle and brachial valve morphology of S.(S.) euglypha (Dalman,1828).

FIG.1. Lc-875, internal mould of pedicle valve demonstrating the triangular valve shape, ventral process, lanceolated adductor and flabellated diductor muscle scars, separated by rounded myophragm and bounded laterally and anteriorly by muscle ridges; from Lower Bringewood Formation, locality Fc/31 near Ludlow area; x 1.

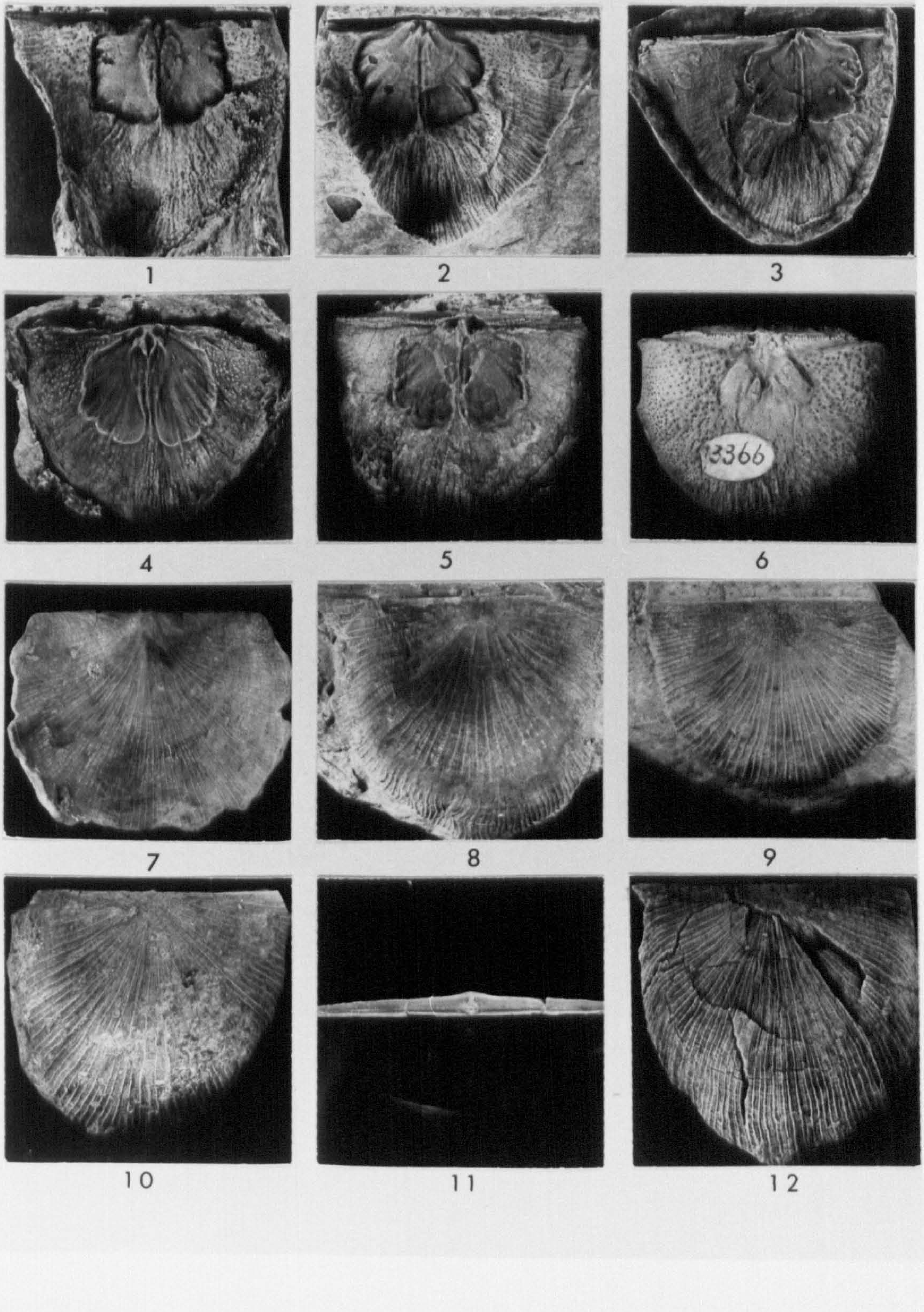
FIGS.2,3. Lc-863/1a and b, internal mould of pedicle valve and latex cast showing the same structural features as in fig.1; from the Lower Bringewood Formation, locality (JS), Wenlock Edge; x 1.4 and x 1.3 respectively.

FIGS.4,12. 4, Lc-890, internal of pedicle valve illustrating the same structural features as in fig.1, 2 and 3, and the trace of the two lobes of the cardinal process which are located on the postero-lateral sides of the ventral process; 12, Lc-870, external of brachial valve demonstrating the subtriangular shape of the shell, mucronate left hand end of the hinge line which formed the hinge ear and the well impressed fine and coarse radial ornament from the Wenlock Limestone, locality DQ, Dormington Quarry, Woolhope; x 0.8 and x 1.3 respectively.

FIGS.5,6,10. 5, BM-13370, internal of pedicle valve showing the same structural features as fig.4, in addition the specimen also illustrates the development of the denticles on the pair of denticular plates and the apsacline ventral interarea; 6, BM-13366, internal mould of brachial valve demonstrating the rounded shape of the valve, well developed denticulation, subtriangular and lobate anteriorly adductor muscle scars with a pair of extension ridges from the muscle bases to the body cavity forming the lemniscate type of mantle canal system; 10, BM- 13365, external of brachial valve showing the appearance of the small, convex chilidium and the well impressed fine and coarse radial ornament; all are from the Wenlock Limestone, Dormington wood, Woolhope; x 1, x 1.1 and x 1.1 respectively.

FIGS.7,8,9,11. 7, BM-3908/1; 8, BM-35544; 9, BM-24160, externals of brachial valve showing rounded outline shape of the shell and well impressed coarse and fine radial ornamentation; 11, BM-3908/2, posterior view of the conjoined valves illustrating the straight hinge line, the development of the small, convex chilidium on the brachial anacline interarea with the larger subtriangular pseudodeltidium on the opposite apsacline pedicle interarea; all are from the Wenlock Limestone, Dudley area; x 1.2, x 1.2, x 1.1 and x 1.3 respectively.

PLATE 36

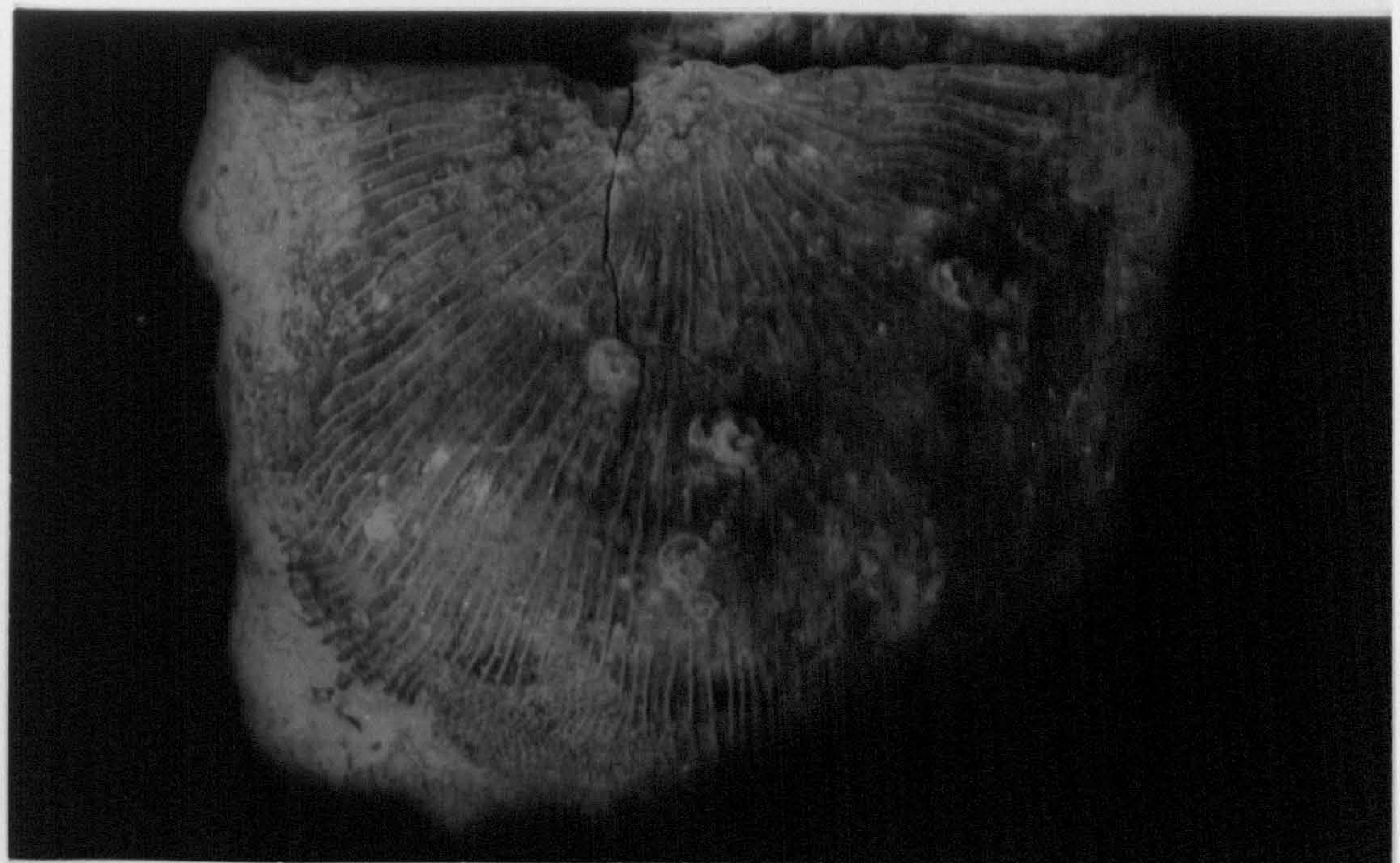


EXPLANATION OF PLATE 37

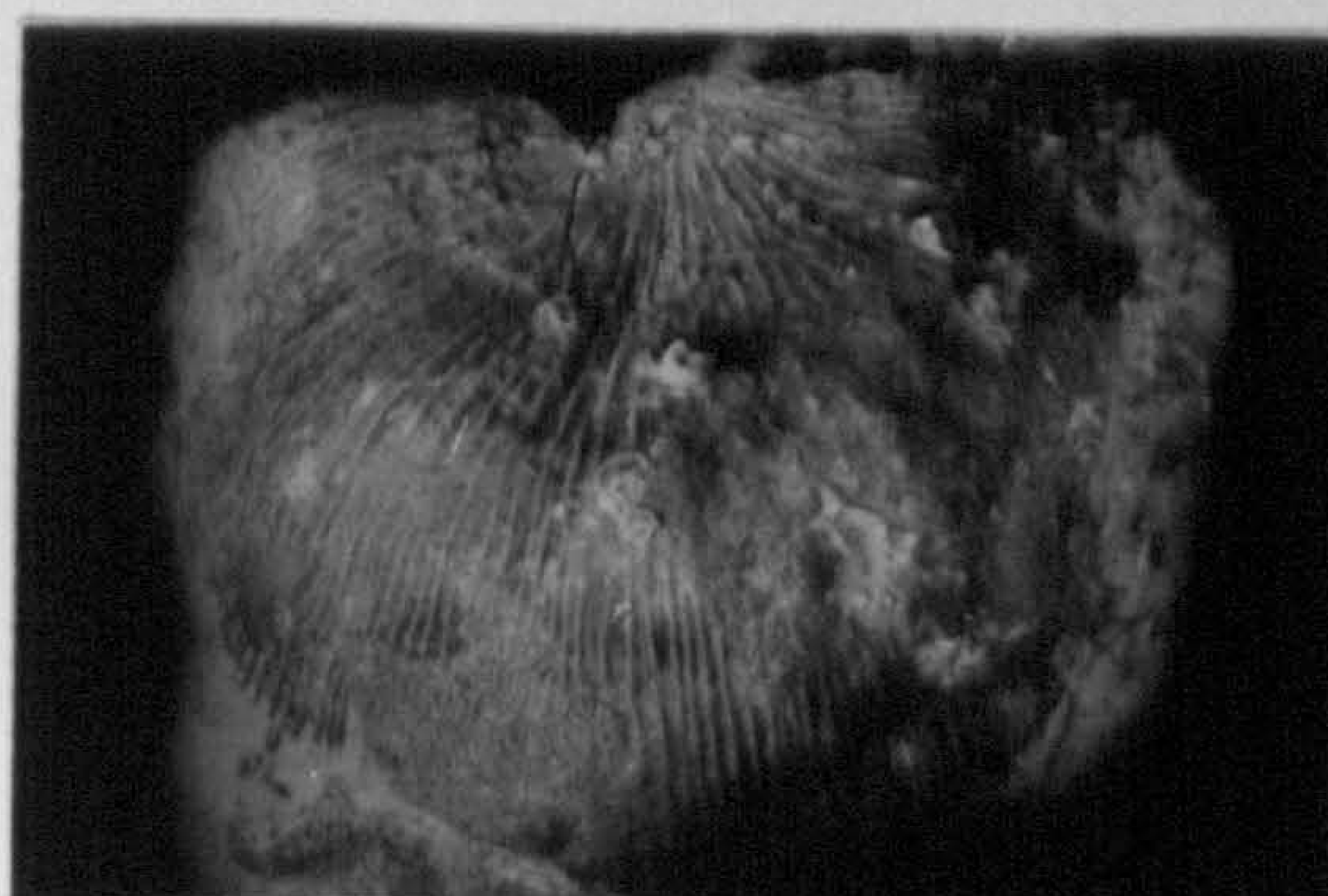
Enlargement views of external brachial valve of
S. euglypha (Dalman, 1828)

FIGS.1-5, BM-G291; illustrating the attachment of the epifauna on the external shell surface of *S. euglypha* brachial valve. The epifauna grew after the death of the animal on the hinge line interareas (e.g. *Spirorbis*; figs.3 & 4) and on the anterior part of the shell (e.g. bryozoans and worms; figs.1, 2 & 5); from Wenlock Limestone, Dudley area; x 2.6 & x 1.4 for figs. 1 & 2. respectively.

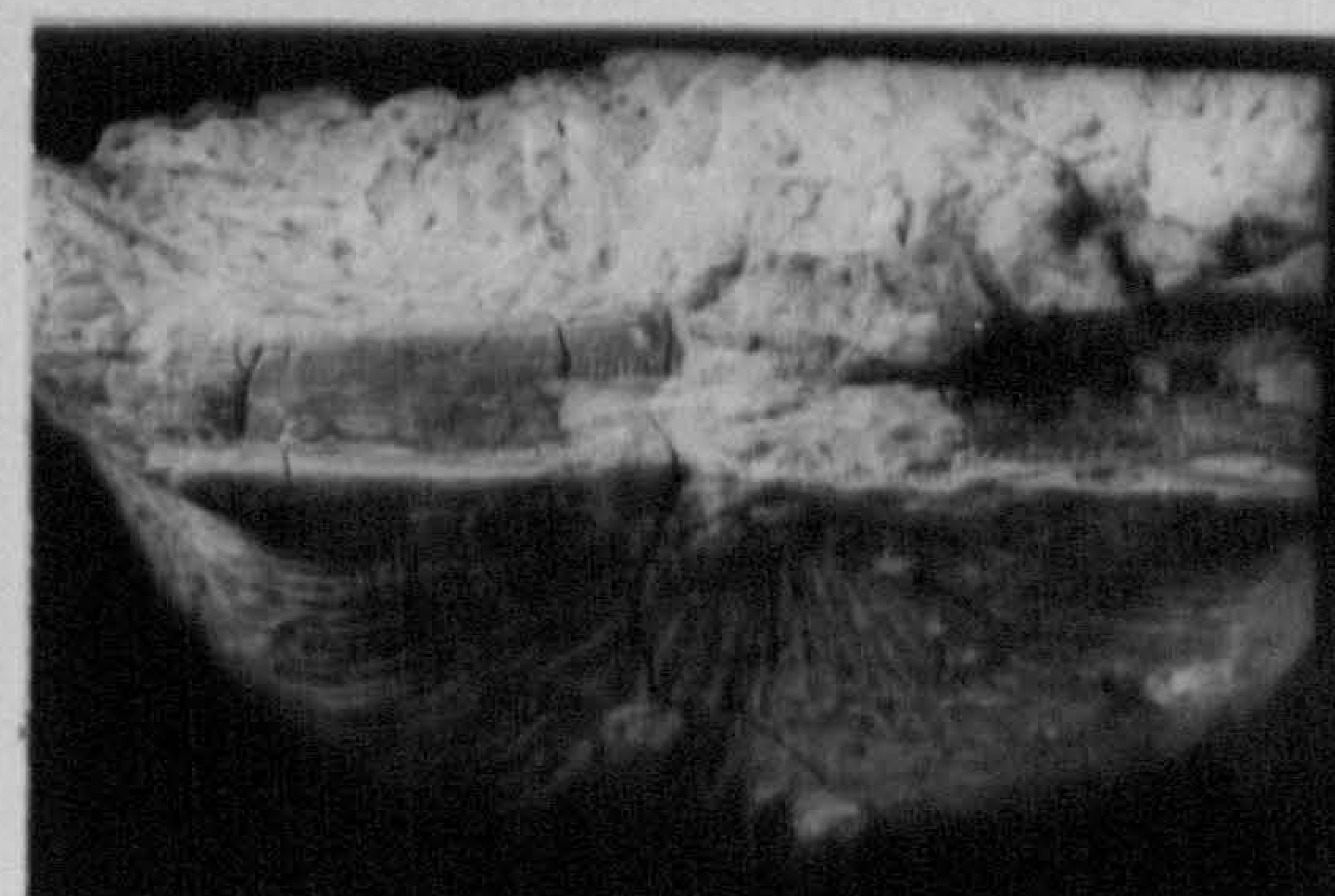
PLATE 37



1

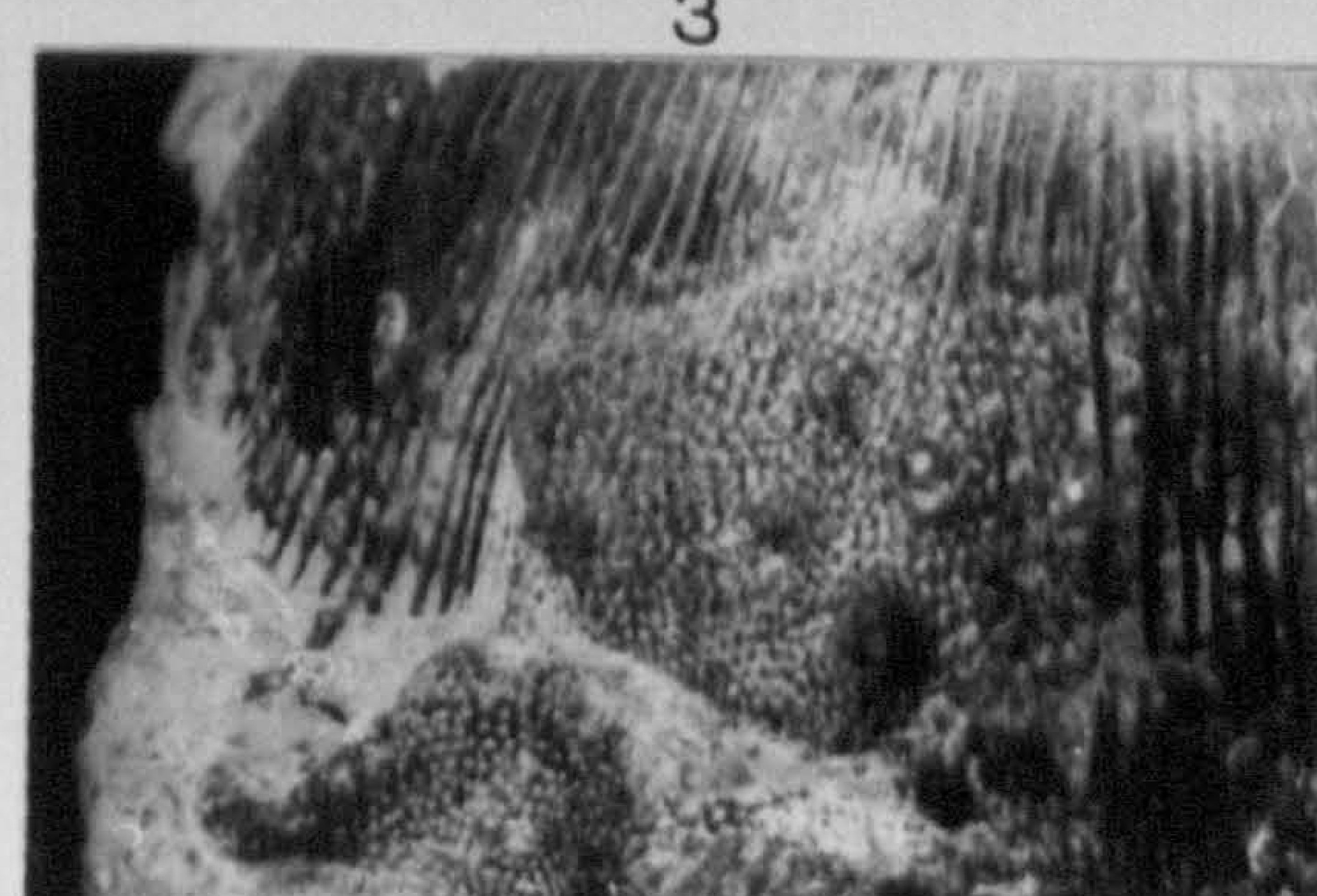


2



3

4



5