

# Lower Ordovician Brachiopoda from mid and southwest Wales

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### Synopsis

A study of Welsh Lower Ordovician Brachiopoda, especially from rocks of the Llanvirn and Llandeilo Series in the Llandeilo and Builth Wells areas, reveals the presence of 45 species and subspecies of which eight, belonging to the genera *Christiania*, *Gelidorthis*, *Glyptorthis*, *Macrocoelia*, *Monobolina*, *Paterula*, *Schizotreta* and *Trematis*, are new. Representatives of the genera *Plectoglossa*, *Porambonites*, *Schmidtites*? and *Torynelasma*, as well as *Conotreta*, *Gelidorthis* and *Murinella*, were hitherto unknown in Wales; the occurrences of *Christiania*, *Corineorthis*, *Gelidorthis*, *Kullervo*, *Mcewanella*, *Murinella*, *Oxoplecia*, *Parastrophinella*, *Paterula*, *Plectoglossa*, *Porambonites*, *Skenidioides*, *Tissintia*, *Torynelasma*, *Trematis* and *Triplesia* constitute the earliest records of these taxa in the Anglo-Welsh Province.

The fauna is reminiscent of the mainly endemic Anglo-Welsh assemblages from the Shelve area, although the indigenous taxa are supplemented by a number of Baltic stocks like *Christiania*, *Kullervo* and *Porambonites*, and a few of Bohemian affinity, notably *Gelidorthis* and *Paterula*. Correlation between the Shelve and other Anglo-Welsh successions is practicable and demonstrates the widespread distribution of distinctive fossil assemblages dominated by inarticulates in pre-Caradoc argillaceous facies. More precise local correlations based on conspecific forms can be effected between both the argillaceous and arenaceous facies of the Llandeilo and Builth Wells areas.



## Introduction

Since the identification of the 'Llandeilo Flags' as the fourth formation of the Silurian System (Murchison 1839: 222), the Ordovician successions of the Llandeilo area have been a source of much controversy. The issues involved are well known and centre on the merits of the Llandeilo Series as an internationally acceptable time-stratigraphical unit. To some extent this debate was generated by the failure of Murchison (1839: 355–357) and others to realise that fossiliferous sandstones associated with the 'Llandeilo Flags' were not Caradoc but Llanvirn or Llandovery in age. Yet even when the stratigraphical succession had been satisfactorily determined (Strahan *et al.* 1907: 12; Williams 1953: 179), the controversy remained alive. In retrospect this was the consequence of not recognizing that much of the Llandeilo Series is coeval with the lower part of the *Nemagraptus gracilis* Zone (Williams *et al.* 1972: 5). This particular shortcoming reflected the inherent difficulties of correlating what was until recently believed to be an exclusively shelly Llandeilo facies with contemporaneous graptolitic shales found in the other parts of Carmarthenshire (Dyfed) and in Shropshire. It also arose from the impoverished nature of the Llandeilo shelly assemblages, the brachiopod constituents of which especially seemed to be mainly pandemic species with wide stratigraphical ranges. Between 1866–1883, for example, Davidson (see Cocks 1978) listed several species of brachiopod from the Llandeilo Flags of Wales, some of which were founded on type specimens from post-Ordovician rocks.

In 1949, one of us (A.W.) described eleven species of Ordovician brachiopods from the Llandeilo–Llangadog area. The study and a later stratigraphical account in 1953 showed that the brachiopod faunas of the Llandeilo Flags and especially those of the varied sediments constituting the underlying Ffairfach Group are more diverse than had been generally acknowledged. The species were poorly illustrated and inadequately defined, but no revision was contemplated until two features of the distribution of Ordovician marine faunas became evident.

The first was the endemic distribution of many of the brachiopod species characteristic of the older Ordovician rocks of Wales and Shropshire. The degree to which these Anglo-Welsh species were distinguishable from contemporaneous taxa in the rocks of Scotland, North America and the Baltic had long been known. But as the Ordovician faunas of Europe and north Africa became more familiar, especially through the admirable researches of Havlíček (1967, 1971, 1977), the endemism of those from south Britain became more obvious. Indeed factor analyses of such faunas suggested that the Anglo-Welsh assemblages are diagnostic of a marine province which retained its individuality for the greater part of the Period (Williams 1969, 1973). In this context, the unexpected appearances of taxa which are more characteristic of the Baltic, Bohemian or north African successions are records of interprovincial migrations, and their occurrences are important clues to the distribution of tectonic plates during Ordovician times.

A renewed interest in the taxonomy of the older Ordovician faunas of the Builth–Llandeilo area was also prompted by a study of the brachiopod assemblages of the Shelve district in west Shropshire (Williams 1974, 1976: 38–44). These researches showed that the assemblages were relics of three associations of low to moderate diversity, each characteristic of a distinctive type of substrate as indicated by the entombing sediments. The brachiopods recovered from the Shelve successions were obviously closely related to those found in contemporaneous shelly facies in Wales. This circumstance afforded an opportunity to explore the geographic and stratigraphical distributions of the associations and the structure and evolution of their constituent communities in the manner outlined by Lockley (1978). In particular, the varied sediments and pyroclastics associated with the volcanic complexes exposed in the Towy Anticline between Llandrindod Wells and Llandeilo (Fig. 1) were known to contain a relatively diverse brachiopod fauna which may have been the Llanvirn antecedents of some of the associations found in the richly fossiliferous Caradoc Series. The community relationship, if any, between these high-diversity associations and the intercalated restricted faunas of the Llandeilo Series was equally intriguing.



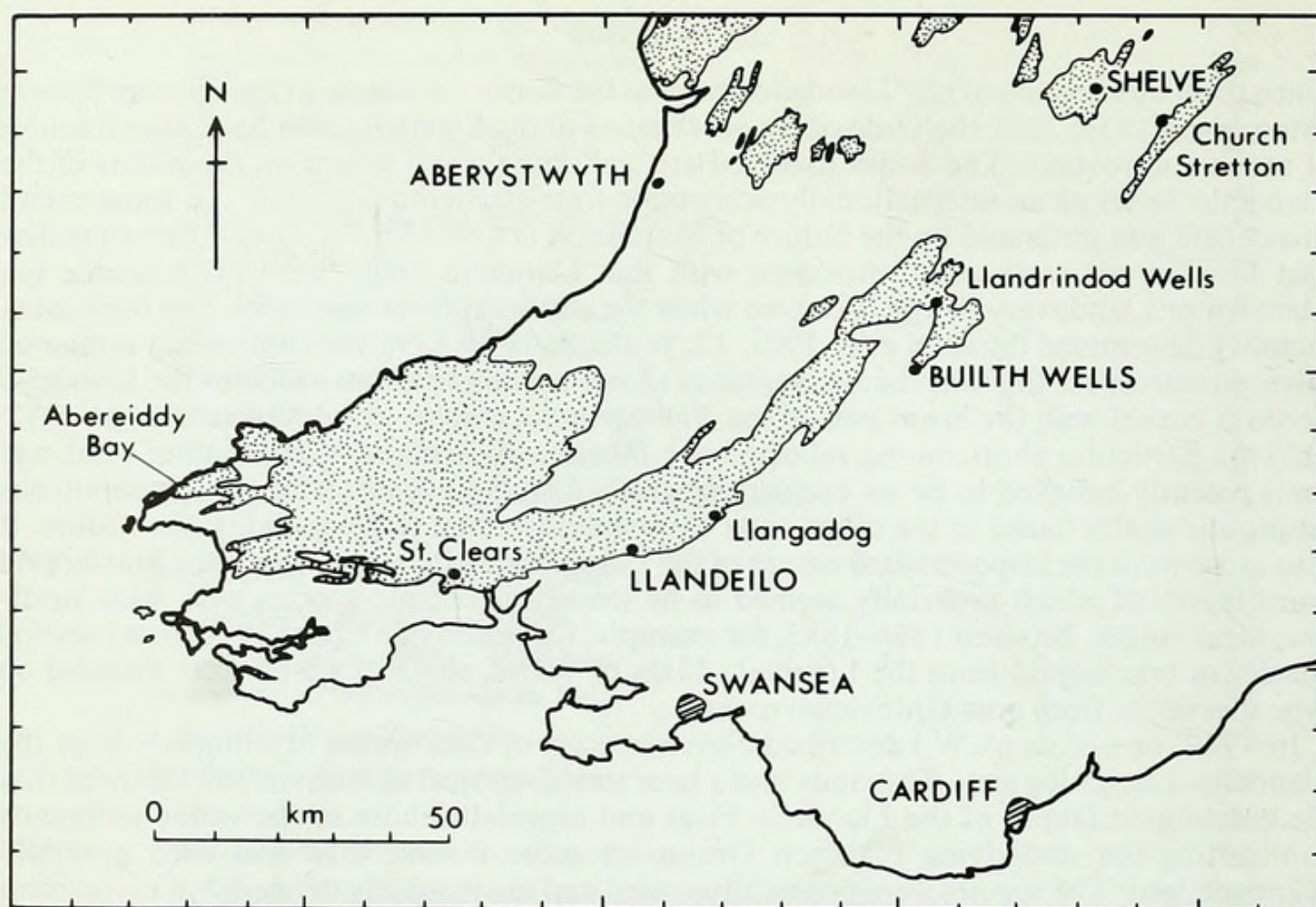


Fig. 1 Map of south Wales and the Welsh Borders, showing key localities and outcrop of Ordovician rocks (stippled).

In an attempt to unravel these relationships, collections from the Llanvirn and Llandeilo rocks of Powys and Dyfed were made by Dr J. M. Hurst and Dr C. J. Wilcox as well as the authors. Systematic sampling was limited to comparatively few, albeit the most representative and best exposed, stratigraphical sections. About 500 kg of rock were collected from the type section of the Ffairfach Group and these have yielded over 7500 brachiopods and numerous representatives of several other phyla. Another 130 kg of coeval sediments and ashes from the Coed Duon and Longwood sections, respectively about 4 km SE and SW of Llangadog, provided nearly 3000 brachiopod specimens. In contrast over 1300 kg of Llandeilo rocks, collected by Dr Wilcox especially from Dynevor Park, Pont-bren-Araeth Dingle and the type section along the Cennen, yielded fewer than 6000 brachiopods; these he kindly placed at our disposal for this study.

From the viewpoint of clarifying the relationship between the fossil faunas of the Shelve and Llandeilo areas, those occurring in the Ordovician sediments and ashes of the Builth-Llandrindod Inlier are crucial. We were fortunate to have access to brachiopods from collections made by Mr P. R. Sheldon, obtained mainly from the Carneddau Hills north of Builth Wells and sections along the Howey Brook and near Bwlch-y-cefn Banc, both within 5 km east of Llandrindod Wells, which were invaluable supplements to our own samples. In all, the impressions of over 5000 brachiopods retrieved from the Inlier were available for systematic appraisal.

The classic areas of Builth Wells and Llandeilo were, of course, well known to those indefatigable fossil collectors who provided eminent palaeontologists of the last century, like Davidson, M'Coy and J. de C. Sowerby, with so much material for study. In the course of our own researches we have examined as many relevant specimens featured in publications as we have been able to unearth. In this task, we have been aided by Dr L. R. M. Cocks' Review of British Lower Palaeozoic Brachiopods (1978). Such specimens are housed in the British



Museum (Natural History), the Geological Survey Museum, the National Museum of Wales and the Sedgwick Museum; their whereabouts are identified by the prefixes B or BB, GSM, NMW and SM respectively. New numbers assigned to specimens during this study fall within the sequences BB 92265–499, BB 94036–77 and BB 94216–48, and SMA 104410–9, SMA 104446–65 and SMA 105827–36.

**Table 1** Stratigraphical distribution of brachiopod species according to 'subseries' occurrence. L1 and L2 represent the *Didymograptus bifidus* Shales and Ffairfach Group of the Llandeilo area. L3, L4 and L5 represent the Lower, Middle and Upper Llandeilo of the Llandeilo area, respectively. B1 and B2 represent the *D. bifidus* and *D. murchisoni* Beds, and B3 and B4 the *Glyptograptus teretiusculus* and *Nemagraptus gracilis* Beds of the Builth area. Brackets denote uncertainty about the horizon at which a taxon occurs. Six of the 45 described taxa, which are not listed here, originate from isolated localities referred to in the text.

| Species                                                                  | L1 | L2 | L3  | L4 | L5  | B1 | B2 | B3 | B4 |
|--------------------------------------------------------------------------|----|----|-----|----|-----|----|----|----|----|
| <i>Christiania elusa</i> sp. nov.                                        |    |    |     |    |     |    | *  |    |    |
| <i>Corineorthis pustula</i> Williams                                     |    |    | *   |    |     |    |    |    |    |
| <i>Corineorthis</i> cf. <i>pustula</i> Williams                          |    |    |     |    |     |    |    | *  | *  |
| <i>Corineorthis</i> sp.                                                  | *  |    |     |    |     |    |    |    |    |
| <i>Dalmanella parva</i> Williams                                         | *  | *  | *   | *  | *   |    | *  | *  |    |
| <i>Gelidorthis cennenensis</i> sp. nov.                                  | *  |    |     |    |     |    |    |    |    |
| <i>Glyptorthis</i> cf. <i>viriosa</i> Williams                           |    |    | *   | *  |     |    | *  |    |    |
| <i>Glyptorthis viriosa</i> Williams <i>tumida</i> subsp. nov.            | *  |    |     |    |     |    | *  |    |    |
| <i>Hesperorthis dynevorensis</i> Williams                                | *  |    |     |    |     |    | *  |    |    |
| <i>Horderleyella convexa</i> Williams                                    | *  |    |     |    |     |    |    |    |    |
| <i>Horderleyella</i> sp.                                                 | *  | *  | *   |    |     |    |    |    |    |
| <i>Kullervo</i> sp.                                                      | *  |    |     |    |     |    |    |    |    |
| <i>Lingulella</i> cf. <i>displosa</i> Williams                           |    |    |     |    |     |    | *  | *  |    |
| <i>Macrocoelia llandeiloensis</i> (Davidson)                             | *  | *  | *   |    |     |    | *  |    |    |
| <i>Macrocoelia llandeiloensis</i> (Davidson) <i>elongata</i> subsp. nov. |    |    |     |    |     |    | *  |    |    |
| <i>Mcewanella berwynensis</i> MacGregor                                  |    |    | *   |    |     |    | *  |    |    |
| <i>Monobolina crassa</i> sp. nov.                                        |    |    |     |    |     |    |    | *  | *  |
| <i>Murinella</i> sp.                                                     | *  |    |     |    |     |    |    |    |    |
| <i>Oxoplectra</i> cf. <i>nantensis</i> MacGregor                         | *  | *  | *   |    |     |    |    |    |    |
| <i>Palaeoglossa attenuata</i> (Sowerby)                                  | *  | *  | *   |    |     |    | *  | *  | *  |
| <i>Parastrophinella</i> cf. <i>musculosa</i> Williams                    |    |    | (*) |    |     |    | *  |    |    |
| <i>Parastrophinella parva</i> MacGregor                                  |    | *  | *   |    |     |    |    |    |    |
| <i>Paterula</i> cf. <i>bohémica</i> Barrande                             | *  | *  |     |    |     |    |    |    |    |
| <i>Plectoglossa</i> sp.                                                  |    |    | (*) |    |     |    |    |    |    |
| <i>Porambonites</i> sp.                                                  |    |    |     |    |     |    | *  |    |    |
| <i>Pseudolingula granulata</i> (Phillips)                                | *  | *  |     |    |     |    | *  |    |    |
| <i>Rostricellula triangularis</i> Williams                               | *  | *  |     |    |     |    | *  |    |    |
| <i>Salopia turgida</i> (M'Coy)                                           | *  | *  |     |    |     |    | *  |    |    |
| <i>Schizocrania</i> cf. <i>salopiensis</i> Williams                      | *  | *  |     |    | *   |    | *  | *  | *  |
| <i>Schizotreta</i> cf. <i>transversa</i> Williams                        |    | *  |     |    |     |    |    |    |    |
| <i>Schizotreta transversa</i> Williams <i>ffairfachensis</i> subsp. nov. | *  |    |     |    |     |    | *  | *  | *  |
| <i>Schmidtites</i> ? <i>micula</i> (M'Coy)                               |    |    |     |    | (*) |    | *  | *  | *  |
| <i>Skenidioides</i> sp.                                                  | *  |    |     |    |     |    |    |    |    |
| <i>Sowerbyella antiqua</i> Jones                                         | *  | *  | *   |    |     |    | *  |    |    |
| <i>Tissintia immatura</i> (Williams)                                     | *  | *  | *   | *  | *   |    |    |    |    |
| <i>Tissintia plana</i> (Williams)                                        | *  | *  |     |    |     |    |    |    |    |
| <i>Tissintia prototypa</i> (Williams)                                    | *  | *  |     |    |     | *  | *  |    |    |
| <i>Tissintia</i> sp.                                                     |    | *  |     |    |     |    |    |    | *  |
| <i>Triplasia edgelliana</i> (Davidson)                                   |    | *  |     |    |     |    |    |    |    |



### Faunal distribution

In the wake of current palaeoecological studies, the traditional faunal list showing the stratigraphical range and frequency of occurrence of fossil species may be misleading. A lithostratigraphical unit as comprehensive as a Group or a Formation may contain a number of benthic associations which are more or less exclusive of one another. In the varied sediments and ashes composing the Ffairfach Group, for example, there are as many as eight distinctive faunal assemblages; and, although some of them may have been ecotones, the majority must have been fully independent associations. It may, therefore, seem pointless to present an introductory list of species recorded from, say, the Ffairfach Group. Yet there are two benefits from doing so which prompt us to continue the tradition.

The first is that if there are two or more benthic associations in a stratigraphical unit, they are likely to reflect an orderly sequence of events affecting the palaeoenvironment and will, through such facies relationships, impart a diagnostic pattern on the faunal list for the entire unit. Such sequences of associations are well seen in the Ffairfach Group and will be discussed elsewhere. Meanwhile it is noteworthy that part of the sequence identified at Ffairfach is found in the Upper Llanvirn sediments and ashes of the Builth area which, of course, accounts for the similarities in the two faunal lists.

Secondly the changing nature of fossil associations also contributes to their general usefulness when they are used to compile faunal lists. Throughout geological time, associations have evolved by replacement of their constituent taxa, by speciation and by assimilation of immigrant stocks. Since such changes commonly occurred, a particular climax association is normally diagnostic of a short segment of geological time. The exceptions appear to be some low diversity associations like those characteristic of the Middle and Upper Llandeilo successions. Even these, however, are informative if only for palaeoecological purposes.

As the list in Table 1 shows, 45 brachiopod taxa have been identified in the Llanvirn-Llandeilo rocks of mid-Wales, with 16 species belonging to the Inarticulata, 18 to the Orthida, 2 to the Triplesiidina, 5 to the Strophomenida, 3 to the Pentamerida and 1 to the Rhynchonellida. Their stratigraphical distribution is also given.

In both the Llandeilo and Builth Wells areas, the pattern of distribution is essentially the same. The Lower Llanvirn (*Didymograptus bifidus*) successions are dominated by the opportunistic articulate species *Tissintia prototypa*. Thereafter diversity dwindles from a maximum in the variable sediments and ashes of Upper Llanvirn age where articulate species may outnumber inarticulates by 6 or 7 to 1. Reduction in diversity resulted from an elimination of articulate species which although dominant in the Lower and Middle Llandeilo successions of the type area were no more numerous than the inarticulates in the Upper Llandeilo, while in the Builth area they had almost entirely disappeared by the end of Lower Llandeilo times (*Nemagraptus gracilis* Zone). As for the endemicity of the faunas, the study has confirmed the dominance of the Anglo-Welsh stocks, but sporadic immigrant genera from the Baltic province are well in evidence in late Llanvirn times when volcanic activity briefly provided shallow belts of clean-washed pyroclastics and derived sediments for colonization by *Christiania*, *Hesperorthis*, *Kullervo* and *Triplesia*.

### Stratigraphical terminology

The stratigraphical nomenclature used in the systematic section is based almost entirely on the stratigraphy proposed by Williams (1953) for the Llandeilo region and by Elles (1939) and Jones & Pugh (1941, 1948, 1949) for the Builth district. In both areas the existing nomenclature may be lithostratigraphical, biostratigraphical and chronostratigraphical and in the Builth district is complex and in some respects repetitive.

At Llandeilo the *D. bifidus* shales are overlain by the Upper Llanvirn Ffairfach Group which was divided by Williams (1953: 180) into five lithostratigraphical units, referred to



here as formations. In the overlying Llandeilo Series, which consists of a biostratigraphically based chronostratigraphical sequence of stages (Lower, Middle and Upper), the succession can be further subdivided into distinctive lithostratigraphical and biostratigraphical units (Williams 1948) which have been used in the descriptions of the range of some species.

In the Builth-Llandrindod area, the 'stratigraphical and palaeontological succession' of zones proposed by Elles (1939: 389), largely on the basis of graptolite biostratigraphy, included only one lithologically-based unit, the Main Volcanic Series. This was subsequently subdivided by Jones & Pugh (1941, 1949), who recognized four volcanic series and numerous laterally variable or impersistent lithostratigraphical units in the succession as a whole. The terminology proposed by these authors remained essentially unchanged except for minor modifications introduced by Hughes (1969) until, with the publication of the Geological Society Special Report no. 3 on the Ordovician (Williams *et al.* 1972) and the 1976 I.G.S. map of the 'Llandrindod Wells Ordovician Inlier', the stratigraphical terminology of this area was modified to conform to modern lithostratigraphical practice (e.g. Elles' *D. murchisoni* 'zone' is now the Upper and Lower *D. murchisoni* Shales). Some confusion arises in the classification adopted for the I.G.S. map, which has modified the lithostratigraphical terminology established by Jones & Pugh in such a way that the lower part of the Builth Volcanic Series becomes the 'Main tuff group' while the Grey Felspar Sands and Pyritous Felspar Sands become amalgamated equally informally into the 'Coarse felspathic sandstones'. Although the nomenclatorial modifications incorporated in the I.G.S. map have been accepted for identifying the successions from which the described taxa have been recovered, we prefer a formalized classification (i.e. Main Tuff Group) and we adhere to the chronostratigraphy proposed by Williams *et al.* (1972).

### Systematic methods

The procedure adopted in the taxonomic study of the fossil collections at our disposal has been governed by the need to define all taxa as precisely as possible in preparation for palaeoecological researches on the older Ordovician brachiopod faunas throughout Wales and the Welsh borderland. The work has necessarily involved rectifying a number of nomenclatural errors, some of which have been perpetrated by an author of this monograph. The major commitment, however, has been to conduct taxonomic surveys of large samples collected at closely-spaced intervals. Thus in the type section of the Ffairfach Group, which consists of about 100 m of nearly continuous exposures including the mainly unfossiliferous basal Grit Formation (>20 m), 77 samples, each yielding an average of almost 100 identifiable brachiopod remains, were taken from these outcrops at a mean stratigraphic interval of 85 cm. The commonest fossil was *Dalmanella parva*, which constituted more than half of all the brachiopods recorded in 36 out of the 64 samples in which it occurs. It would have been too daunting a task to subject every collection of *Dalmanella parva* to an exhaustive series of statistical tests. Instead spot checks were carried out to confirm the morphological homogeneity of the stock throughout the entire range of its occurrence, and having found this to be so, one of the better-preserved samples was chosen to represent the Ffairfach populations in statistical comparisons with *Dalmanella* from other localities. When, as was true of *Sowerbyella*, a genus appeared to be represented by morphologically distinguishable populations within a section, an appropriate number of samples were comprehensively compared so as to define the variation.

The statistical procedures adopted here conform to those outlined by one of us (Williams 1962: 69–79) and permit direct comparisons with data presented subsequently (e.g. Williams 1974) which were also derived from analyses conducted in a similar or identical manner. Economy precludes publication of the 103 statistical tables on which our systematic studies have been based. The tables, laid out according to standard format and arranged in the taxonomic sequence of this paper, have been deposited in the Palaeontology Library of the British Museum (Natural History) and are available for consultation. In addition, the means,



variances and numbers of measurements taken for all quantified characters are incorporated in the following systematic descriptions. Where a bivariate estimate of a feature had been calculated, a coefficient of correlation ( $r$ ) is also given. These parameters should prove sufficient to enable readers to carry out the standard univariate and bivariate statistical tests. In particular, they can be used for the calculations of the rate of growth ( $a$ ), the index of residual shape ( $b$ ) and even the natural logarithms of means (variances) when allometric effects of shell growth can be demonstrated (Kermack & Haldane 1950).

The abbreviations used in the text for presentation of these statistics identify certain vectors of measurement expressed in millimetres. They are:  $l$ , length;  $\bar{l}$ , mean maximum length;  $w$ , width;  $\bar{w}$ , mean maximum width;  $th$ , mean maximum depth;  $\bar{l}_{sc}$ , mean maximum length of a muscle scar;  $\bar{l}_s$ , mean maximum length of the median (or compound) septum;  $\bar{dl}$ , mean maximum length of dental lamellae;  $\bar{l}_c$ , mean maximum length of the dorsal cardinalia (brachiophore bases unless otherwise stated); and  $\bar{l}_{sr}$ , the mean maximum length of the dorsal socket ridges. The variances ( $var$ ) are always given with these statistics, as are the mean maximum length and variance of the complete valve, i.e.  $\bar{l}_{mm}$  ( $var\ l$ ), and the coefficient of correlation ( $r$ ) when the relative growth of a valve or one of its features is being described.

### Taxonomic descriptions

Under 'material' all measurements given are in mm; p.v. = pedicle valve, b.v. = brachial valve.

Lectotypes were mainly selected by Cocks (1978).

Class **INARTICULATA** Huxley, 1869

Order **LINGULIDA** Waagen, 1885

Superfamily **LINGULACEA** Menke, 1828

Family **OBOLIDAE** King, 1846

Subfamily **OBOLINAE** King, 1846

Genus **SCHMIDTITES** Schuchert & Le Vene, 1929

*Schmidtites* ? *micula* (M'Coy), emended  
(Figs 2–10)

1851 *Siphonotreta micula* M'Coy : 389

1852 *Siphonotreta micula* M'Coy; M'Coy in Sedgwick & M'Coy : 188; pl. 1H, fig. 3.

1866 *Siphonotreta micula* M'Coy; Davidson : 76; pl. 8, figs 2–6.

1974 *Schmidtites* ? *simplex* Williams : 26; pl. 1, figs 11–15.

1978 *Helmersenella* ? *micula* (M'Coy) Cocks : 29.

**DIAGNOSIS.** Subequally biconvex, circular obolids with valves almost as wide as long and 13% as deep as long ventrally, ornamented by concentric fila, fine overlapping lamellae and microscopic radial striations; pseudointerareas narrow, obscure, dorsal interior with fine median ridge.

**DESCRIPTION.** Suboval, gently biconvex obolids with obtuse posterior beaks subtending an angle of about 120° and rounded anterior margins; shells averaging between 92 and 99% as wide as long in 5 samples (e.g. 33 valves from Pen Cerrig:  $\bar{l}$  mm ( $var\ l$ ) 3.31 (0.314),  $\bar{w}$  mm ( $var\ w$ ) 3.25 (0.350),  $r$  0.967) and averaging 13% as deep as long ventrally in 2 samples (e.g. 21 valves from Pen Cerrig:  $\bar{l}$  mm ( $var\ l$ ) 3.32 (0.188),  $th$  ( $var\ th$ ) 0.43 (0.011),  $r$  0.359); ornamented by strong closely-spaced fila, finely-developed overlapping lamellae and very fine striations; valves with narrow arcuate divided pseudointerareas; brachial valve interior with a low variably-developed median ridge up to 50% of valve length.



| MATERIAL                            |             | length | width |
|-------------------------------------|-------------|--------|-------|
| Lectotype, exterior of p.v.         | SM A.45444  | 3.6    | 3.6   |
| Articulated valves                  | BB 92473    | 2.5    | 2.6   |
| "                                   | BB 92470    | 1.5    | (1.4) |
| "                                   | SM A.44903  | 4.7    | 4.5   |
| Exterior of p.v.                    | GSM 16457   | 4.1    | 4.1   |
| "                                   | GSM 16472   | 3.0    | 2.9   |
| "                                   | SM A.104456 | 5.0    | 4.4   |
| Internal and external mould of b.v. | BB 92301    | 3.0    | 2.7   |
| Internal mould of b.v.              | SM A.104419 | (5.5)  | 5.0   |

HORIZONS AND LOCALITIES. SM A.44879–90 and A.45441–57 from the black Llandeilo shales (probably high *Glyptograptus teretiusculus* or low *Nemagraptus gracilis* Zones) of Pen Cerrig, 2.5 km north of Builth Wells, (National Grid ref. SO 042540); SM A.44891–927 from the olive shales belonging to *N. gracilis* Zone exposed in Harper's Quarry, Wellfield, 2 km north of Builth Wells (SO 037534); BB 92301–6 and BB 92470–3 from Upper *Didymograptus murchisoni* Shales exposed in Howey Brook, 4 km east of Howey, NW of Builth Wells (SO 091592); GSM 16456–8 from the black Llandeilo Flags of Wyeford, Builth Wells; GSM 16469–73 from an unknown horizon and locality in the 'Upper Llandeilo of the Llandeilo area'; NMW 68.376.G.167–70 from Upper Llanvirn shales exposed in stream 600 m SW of Shaky Bridge, 2 km east of Llandrindod Wells (SO 079609); SM A.44838–9, A.44858, 104419 and 104453–6 from basal *N. gracilis* Shales exposed in Gwern-y-fed-fach quarry, 1.5 km north of Builth (SO 030526).

DISCUSSION. The observation that *Schmidtites* ? *simplex* Williams (1974) and *Siphonotreta micula* M'Coy (1851) are synonyms highlights a problem of taxonomic classification which can only be resolved by establishing whether the morphological characteristics of the samples used in this review of the species are of lingulacean or siphonotretacean affinity.

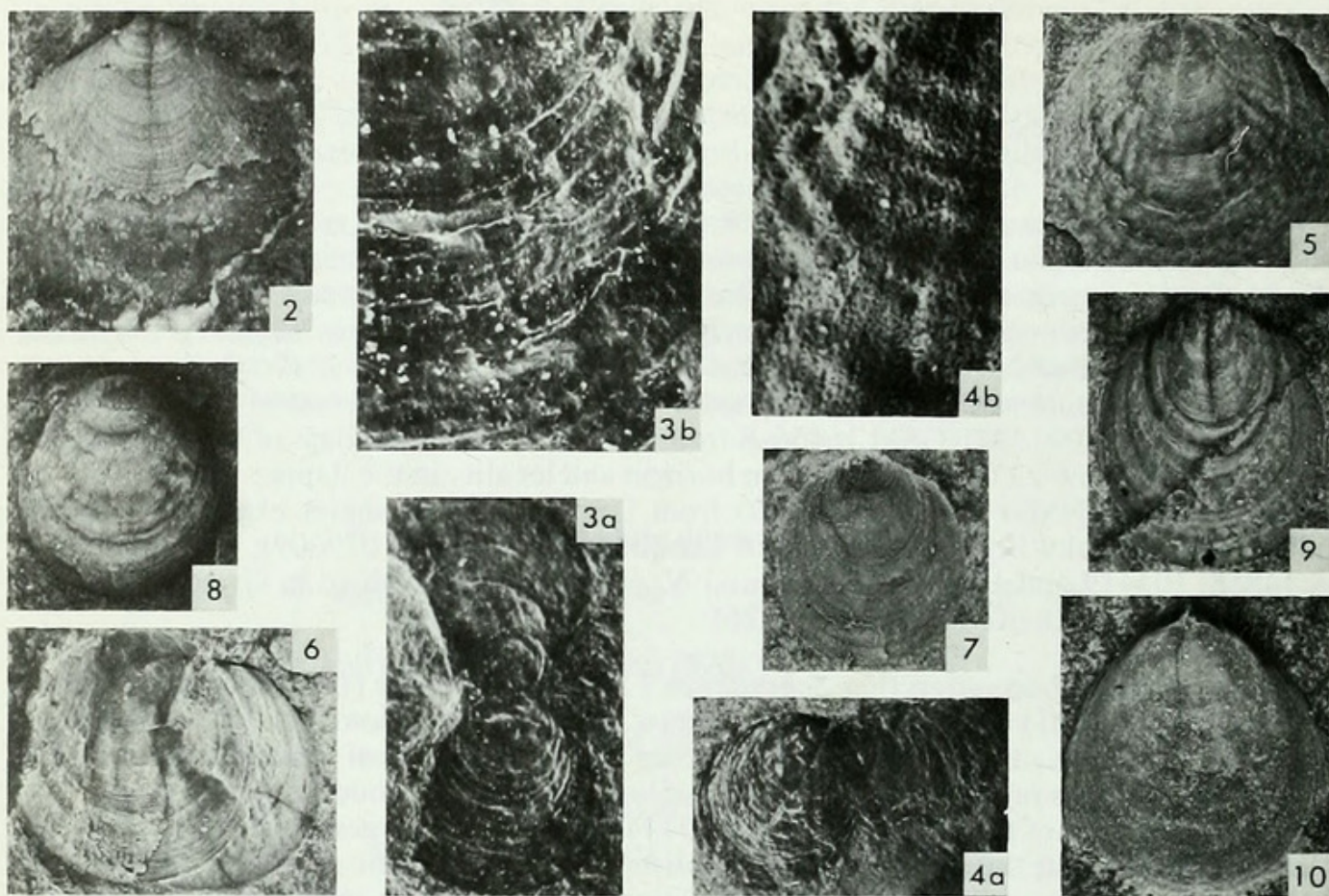
An examination of the lectotype (SM A.45444) and paralectotypes from Pen Cerrig near Builth indicates that the shell ornament consists only of concentric growth-lines devoid of spine bases, and fine microscopic radial striations which are best seen under the scanning electron microscope. Occasionally, specimens show a finely granular ornament in association with concentric growth lines. Specimens from the olive shales of Wellfield are similarly characterized by strong concentric growth lines with some individuals displaying in addition a coarsely granular to pustulose relief on both the internal and external surface of valves. This extra 'ornamentation' is attributable to a microscopic rucking of the entombing shales. The shells of all specimens are very thin and often crumpled or split peripherally, particularly posteromedially as in the lectotype. Williams (1974 : 27) noted a similar 'transverse or even radiating' wrinkling of the shells of *Schmidtites* described by him from the Shelve area. Indeed a symmetrical posteromedian splitting of the shell is such a common phenomenon, particularly in the Pen Cerrig sample, that it has almost certainly been mistaken for a pedicle groove and must account for the fanciful reconstructions of Sedgwick & M'Coy (1852: pl. 1H) and Davidson (1866: pl. 8).

The presence of an internal dorsal median ridge, divided interarea and microscopic radial striations indicates that these thin-shelled inarticulates have clear lingulacean affinities and can therefore be assigned with some confidence to the genus *Schmidtites*.

Comparisons between the Stapeley, Rorrington, Meadowtown, Pen Cerrig, Wellfield, Wyeford, Howey Brook and Shaky Brook samples reveals that the Stapeley subspecies, identified here as *Schmidtites* ? *micula subcircularis* Williams, is different from all seven other samples in being significantly more elongate ( $p > 0.05$ ,  $p > 0.05$ ,  $p > 0.001$ ,  $p > 0.001$ ,  $p > 0.01$ ,  $p > 0.05$  and  $p > 0.005$  respectively). Comparisons of the remaining samples reveal that they are all essentially identical. Only the Rorrington and Howey Brook samples differ significantly at the 5% level ( $0.05 < p < 0.04$ ). Clearly the species group *S.* ? *micula* (M'Coy) shows limited variation in space and time, a conservative evolutionary characteristic often ascribed to the lingulaceans.



GSM specimens 16469–73 represent the only specimens of *S. ? micula* (M'Coy) known from the Llandeilo of the type area; they are reported from an unknown locality in the 'Upper Llandeilo' of Llandeilo.



**Figs 2–10** *Schmidtites ? micula* (M'Coy). Fig. 2, lectotype SM A.45444, exterior of a pedicle valve  $\times 10$ , from Llandeilo shales, Pen Cerrig, Builth. Figs 3a, b, BB 92470, matching valves  $\times 15$ , with detail of growth lines  $\times 70$ ; Figs 4a, b, BB 92473, matching valves  $\times 8$ , with detail of punctae  $\times 300$ ; both from Llanvirn shales, Howey Brook, Llandrindod. Fig. 5, GSM 16457, latex impression of exterior of a pedicle valve  $\times 8$ , from Llandeilo shales, Wyeford, Builth. Fig. 6, SM A.44903, matching valves  $\times 6$ , from Llandeilo shales, Wellfield, Builth. Fig. 7, BB 92301, external mould of a pedicle valve  $\times 8$ , from Llanvirn shales, Howey Brook, Llandrindod. Fig. 8, GSM 16472, exterior of a pedicle valve  $\times 8$ , from Llandeilo shales, Llandeilo. Fig. 9, SM A.104456, exterior of a pedicle valve  $\times 6$ ; Fig. 10, SM A.104419, internal mould of a brachial valve  $\times 6$ ; both from Llandeilo shales, Gwernyfed, Builth.

### Subfamily LINGULELLINAE Schuchert, 1893

#### Genus *LINGULELLA* Salter, 1866

#### *Lingulella* cf. *displosa* Williams (Figs 11–14)

cf. 1974 *Lingulella displosa* Williams : 28; pl. 2, figs 2–8.

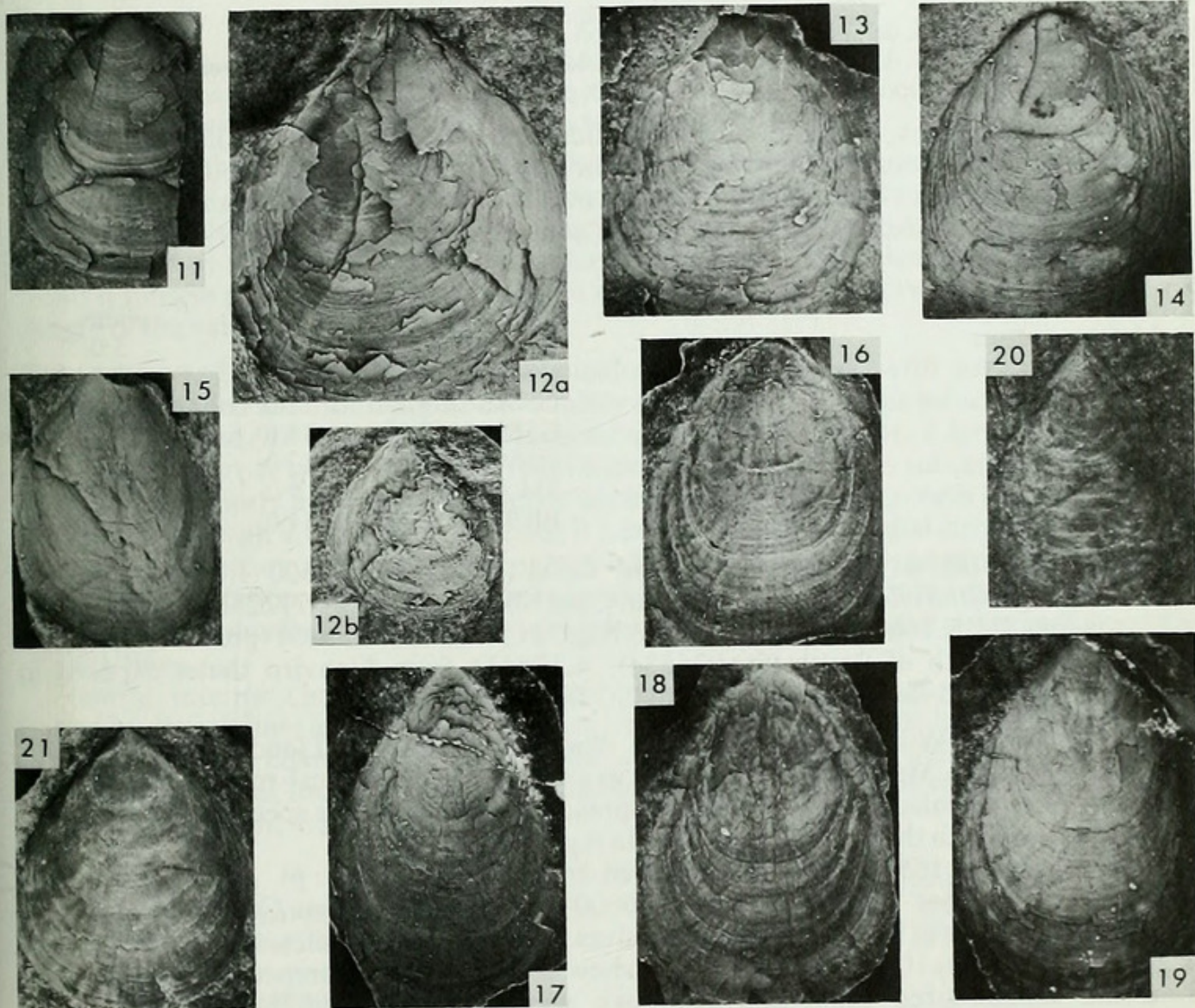
**DESCRIPTION.** Ventribiconvex, elongately oval to subtriangular lingulellinids with a pedicle valve averaging 84% as wide as long ( $\bar{l}$  mm (var l) 11.15 (5.32),  $\bar{w}$  mm (var w) 9.35 (4.16),  $r$  0.946 for 8 valves from Bach y Graig) with striated pseudointerarea divided by pedicle groove into two propleareas; exterior ornamented by slightly irregular concentrically disposed impersistent lamellae.



## FIGURED MATERIAL

|                  |             | length | width |
|------------------|-------------|--------|-------|
| Matching valves  | SM A.104460 | 11     | 9.0   |
| Exterior of p.v. | SM A.104410 | 16     | (14)  |
| "                | SM A.104465 | 8.8    | 7.7   |
| "                | SM A.104464 | 10     | 8.5   |

HORIZONS AND LOCALITIES. SM A.104410, A.104459–65 and A.46523 from uppermost *Didymograptus murchisoni* to lower *Glyptograptus teretiusculus* shales exposed in the stream section east of Bach y Graig, 1.5 km east of Llandrindod Wells (SO 072610); SM A.44862 from the 'Llandeilo Limestone' (*Nemagraptus gracilis* Zone) of Harper's Quarry, Wellfield, 2 km north of Builth (SO 037534).



**Figs 11–14** *Lingulella cf. displosa* Williams. Fig. 11, SM A.104410, exterior of a pedicle valve  $\times 2$ ; Figs 12a, b, SM A.104460, matching valves  $\times 4$  and latex impression of same  $\times 2$ ; Figs 13–14, SM A.104464–5, latex impressions of exteriors of pedicle valves, both  $\times 4$ ; all specimens from Llanvirn shales, Bach y Graig, Llandrindod.

**Figs 15–21** *Palaeoglossa attenuata* (J. de C. Sowerby). Fig. 15, BB 92265, internal part of exfoliated pedicle valve  $\times 2.5$ ; Figs 16–19, latex impressions of partially exfoliated pedicle valves GSM 16600, 16542, 16598 and 16599, respectively, all  $\times 2.5$ ; all from Lower Llandeilo Flags, Coed Shôn, Llangadog. Fig. 20, SM A.104411, dorsal view of matching valves  $\times 4$ , from Llanvirn shales, Upper Gilwern, Builth. Fig. 21, SM A.16678, latex cast of external mould of a pedicle valve  $\times 4$ , from Llandeilo Flags, Wellfield, Builth.



DISCUSSION. The material described here closely resembles the Shelve *L. displosa* Williams in its broadly triangular outline, length : width ratio ( $0.5 < p < 0.4$ ) and distinctive lamellose ornament. Where good material is available *Lingulella* can be distinguished from the closely related lingulellinid *Palaeoglossa* both by its ornament and shape. However, although *Palaeoglossa* is apparently more widespread than *Lingulella* in the successions of mid Wales and the Welsh Borderland further material is needed to establish the stratigraphical and geographical distribution of these two closely related genera more fully.

Genus *PALAEOGLOSSA* Cockerell, 1911 emended Williams (1974)

*Palaeoglossa attenuata* (J. de C. Sowerby)  
(Figs 15–21)

1839 *Lingula attenuata* J. de C. Sowerby in Murchison : 641; pl. 22, fig. 13.

1866 *Lingula attenuata* J. de C. Sowerby; Davidson : 44; pl. 3, figs 18–23, 26, 27, 33 only.

1974 *Palaeoglossa attenuata* (Sowerby) Williams : 32; pl. 3, figs 2–13.

DESCRIPTION. Biconvex, elongately oval lingulids with acute beaks subtending an angle of about  $60^\circ$  and slightly curved lateral and anterior margins; pedicle valve about two-thirds as wide as long and about 10% as deep as long and evenly convex in transverse and longitudinal profile; shell ornamented by growth lines, fine concentric fila (up to 10 per mm) and very fine radial striations.

#### FIGURED MATERIAL

|                  |             | length | width |
|------------------|-------------|--------|-------|
| Matching valves  | SM A.104411 | 8.0    | 5.0   |
| Exterior of p.v. | GSM 16599   | 11.0   | 7.5   |
| "                | GSM 16598   | 17.0   | 12.5  |
| "                | GSM 16542   | 18.0   | 11.5  |
| "                | GSM 16600   | 17.0   | 13.0  |
| "                | SM A.16678  | 9.0    | 7.5   |
| "                | BB 92265    | 14.0   | 10.0  |

HORIZONS AND LOCALITIES. BB 92265 and GSM 16542, 16598–600 from the Lower Llandeilo *Lloydolithus lloydi* Flags exposed in Coed Shôn Quarry (SN 712256), 2.5 km south of Llangadog; SM A.16678 from 'calcareous flags' exposed at Wellfield (probably Harper's Quarry), 2 km north of Builth (SO 036534); A.104411 from Llanvorn shales exposed in small quarries 550 m east of Upper Gilwern (SO 092582).

DISCUSSION. Since Williams (1974 : 31–35) described the Lower Llandeilo *P. attenuata* (Sowerby) from the Meadowtown Beds, an examination of historical records and further collecting have revealed the relatively widespread occurrence of this species in contemporaneous successions in the Builth and Llandeilo regions.

GSM specimens 16542 and 16598 figured by Davidson (1866 : pl. 3, figs 19 and 20 respectively), together with GSM 16599, 16600 and BB 92265 from Coed Shôn Quarry, average 71% as wide as long in five pedicle valves. The relevant statistics,  $\bar{l}$  mm (var l) 15.40 (8.30),  $\bar{w}$  mm (var w) 10.90 (4.925),  $r$  0.926, show no significant difference in shape ( $p < 0.9$ ) from the smaller-sized topotypes. Although specimen SM A.16678 (also figured by Davidson 1866 : pl. 3, fig. 33) is similar to the topotypes it exhibits radial striations and may prove to be a *Lingulella*.

Sporadic records of *P. attenuata* in the *Didymograptus bifidus* and lower *Didymogr. murchisoni* shales have been given by Elles (1939 : 394–403). Shales of Upper *D. murchisoni* to early *Nemagraptus gracilis* age yielded nearly all the preserved Builth specimens. This suggests that the majority of *P. attenuata* in the Builth area are found in late Upper Llanvorn to Middle Llandeilo sediments, and are therefore coeval with most of the specimens from the Llandeilo area including B 23276 and SM A.44834 from contemporaneous horizons, at Llandeilo and Ffairfach respectively, and BB 92283 from Dynevor Park (Wilcox 1979 : 177). A single poorly preserved external mould (BB 92283), from the argillaceous lower part of the



Flags and Grits Formation of the Ffairfach Group at the type section (SN 628611), is tentatively assigned to *P. attenuata* and may represent the earliest record of the species in the Llandeilo area.

The observation that shells of *Palaeoglossa* are characterized by fine radial striations serves to emphasize its close relationship to *Lingulella* and we reiterate an earlier observation (Williams 1974 : 31) that it may eventually prove to be a junior synonym of the latter.

### Subfamily GLOSSELLINAE Cooper, 1956

#### Genus *PSEUDOLINGULA* Mickwitz, 1909 emended Williams (1974)

##### *Pseudolingula granulata* (Phillips) (Figs 22–29)

1848 *Lingula granulata* Phillips in Phillips & Salter : 370; pl. 25, fig. 1.

1866 *Lingula granulata* Phillips; Davidson : 36; pl. 2, figs 15–18.

1974 *Pseudolingula spatula* Williams : 36; pl. 4, figs 6–14; pl. 5, fig. 1.

**DIAGNOSIS.** Subequally biconvex, subquadrate *Pseudolingula* with brachial valves between two-thirds and nine-tenths as wide as long in relation to increasing size and the angles subtended at the beaks changing from an acute 80° to as much as 125° in larger specimens; ornamented by strong fila laterally and anterolaterally with a wavelength of 0.2 mm; adnate ventral muscle platform and dorsal median ridge both extending forward for about half the length of the valve.

**DESCRIPTION.** Subequally biconvex, subquadrate *Pseudolingula* with parallel lateral and obtusely rounded anterior margins and slightly acute to obtuse beaks subtending an angle of between 80° and 90° in 4 smaller specimens and 115° and 125° in 2 larger adult ones; 3 pedicle valves are between 64% and 77% as wide as long; both valves subcarinate posteriorly, flattening anteriorly and laterally; exterior surface ornamented by growth lines and strongly developed fila with a wavelength of about 0.2 mm laterally, fine radial striations numbering about 20 per mm are well developed in the median sector of valves and probably represent a radial ornamentation developed on the inner layers of the shell; variably developed granules are found sporadically in large shells at the intersections between radial striae and concentric growth lines.

Ventral interior characterized by broad anteromedially protruding platform heavily rutted by growth lines and extending forward from the beak for half the length of the valve.

Dorsal interior characterized by sporadic coarse pitting and a well-developed median septum arising near the beak and extending forward for about half of valve length, to attain its maximum height at the anterior end.

#### FIGURED MATERIAL

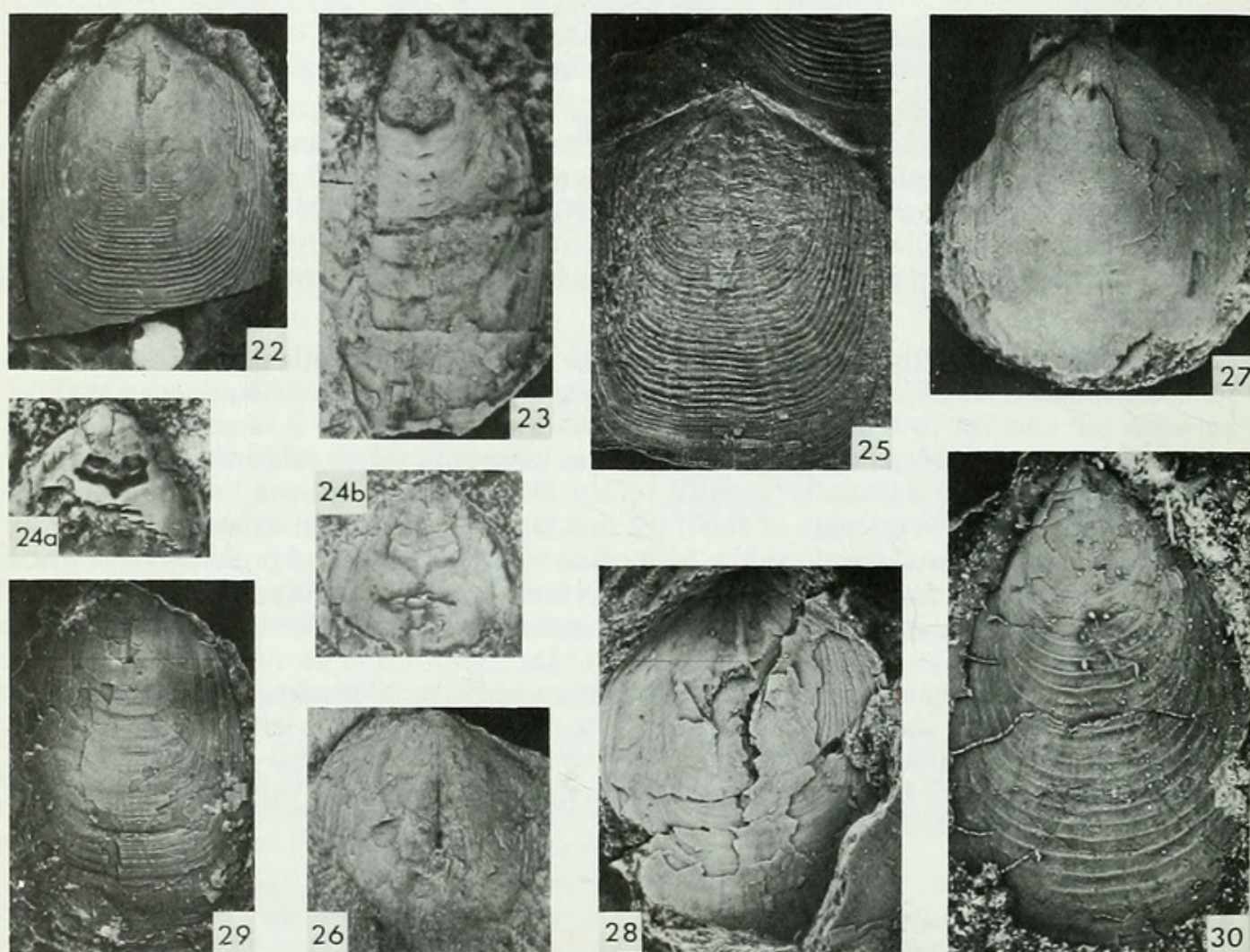
|                                                      |              | length | width |
|------------------------------------------------------|--------------|--------|-------|
| Lectotype, internal part of exfoliated b.v.          | GSM 8460     | (20)   | 15    |
| Internal part of exfoliated b.v.                     | SM A.45419   | 23.5   | 17.5  |
| "                                                    | BB 92271a    | —      | (15)  |
| Internal part of exfoliated p.v.                     | BB 92269a    | 12     | (8)   |
| Internal and external parts of exfoliated b.v.       | BB 92285a, b | 21     | 19    |
| "                                                    | SM A.104417  | 23     | 14    |
| Internal mould and external shell of matching valves | BB 92284     | 12     | 10    |
| Internal and external parts of exfoliated p.v.       | BB 92267a, b | —      | (6)   |

**HORIZONS AND LOCALITIES.** Lectotype (GSM 8460) from unknown horizon and locality in 'Llandeilo Limestone' of Dynevor Park; BB 92284–5 and 92293 from the Flags and Grits in the middle part of the Ffairfach Group, Ffairfach railway cutting (SN 628211); BB 92266–70 from Middle Llandeilo Flags exposed in old trackway 50 m NW of St Tyfei's Church, Dynevor Park, Llandeilo (SN 622233); BB 92271 from Lower Llandeilo (*Corineorthis* Beds)



in old quarry 75 m SE of St Tyfei's Church (SN 622222); SM A.45419 from an unknown locality in the 'Llandeilo Beds' of the Llandeilo area and A.44840 from an unknown horizon in the Ffairfach railway cutting south of the station; SM A.104417 from Lower Llanvirn shales exposed in Camnant Brook near The Court Farm 7 km NE of Builth (SO 088576).

**DISCUSSION.** When Williams (1974: 36) erected the species *spatula* for a distinctive *Pseudolingula* occurring sporadically throughout the Lower Ordovician successions of the Shelfe area, he overlooked the long-established but little-known *Lingula granulata* Phillips. This taxon was effectively founded on one brachial valve from the 'Llandeilo Limestone' of Dynevor Park in the type area, but there is no doubt that the species is a *Pseudolingula*. Moreover recent collecting throughout the Ffairfach Group and the Llandeilo Series in the type area yielded a sufficient number of valves assignable to *P. granulata* to provide some



**Figs 22–29** *Pseudolingula granulata* (Phillips). Fig. 22, holotype GSM 8460, exfoliated brachial valve  $\times 2$ , from Lower Llandeilo limestones, Dynevor Park, Llandeilo. Fig. 23, BB 92269, exfoliated pedicle valve  $\times 4$ ; Figs 24a, b, BB 92270, internal and external parts of exfoliated pedicle valve  $\times 4$ ; both from Middle Llandeilo Flags, Dynevor Park, Llandeilo. Fig. 25, SM A.45419, exfoliated brachial valve  $\times 2$ , from Llandeilo Limestones, Llandeilo. Fig. 26, BB 92271, internal part of an exfoliated brachial valve  $\times 2$ , Lower Llandeilo, Dynevor Park. Fig. 27, BB 92285a, internal part of an exfoliated brachial valve,  $\times 2$ ; Fig. 28, BB 92284, external part of exfoliated matching valves (view of dorsal valve)  $\times 4$ ; both from Flags and Grits, Ffairfach Group, type section. Fig. 29, SM A.104417, latex impression of an exfoliated brachial valve  $\times 2$ , from Llanvirn shales, Camnant Brook, Builth.

**Fig. 30** ? *Plectoglossa* sp. B 3474, latex cast of an exfoliated pedicle valve  $\times 8$ , from Llandeilo Beds, Llandeilo.



indication of the variability of the species. Despite the fact that the Llandeilo specimens tend to be relatively broader than those comprising the sample on which *P. spatula* was founded (Williams 1974 : 37), the difference is evidently related to the smaller size of the Shropshire shells. The Shelve species is, therefore, regarded by us as a junior synonym of *P. granulata*.

The changes in outline which the valves of *Pseudolingula* underwent during growth also complicate comparisons between samples from the Ffairfach Group and the Llandeilo Limestone. Llandeilo shells differ from the larger Ffairfach forms in being relatively longer and in exhibiting a more acute beak in smaller forms and a more variable beak generally; there are also slight differences in ornamentation. The morphological differences between the three Llanvirm specimens and the eight Llandeilo ones available for comparison are restricted to shape and ornament and are probably size-related. The three Llanvirm brachial valves are especially characterized by obtuse beaks subtending an angle of about  $110^\circ$  and are between 83% and 90% as wide as long. The inner radial striae and external fila are coarser also, but the sample is too small for the differences to warrant taxonomic recognition.

Specimen SM A.46529 from Llanvirm shales exposed at Hendy Bank, south of Llandegley Rocks 7 km ESE of Llandrindod (SO 125595 approx.), is a pedicle valve of *P. granulata* collected by Elles. She correctly identified this specimen and presumably therefore others which she assigned to the species from neighbouring localities (Elles 1939 : 394–399).

#### Genus *PLECTOGLOSSA* Cooper, 1956

##### ? *Plectoglossa* sp.

(Fig. 30)

A single specimen (B 3474) of the external part of an exfoliated pedicle valve from the 'Upper Llandeilo' of an unknown locality in the Llandeilo area is a glossellinid and is provisionally assigned to the genus *Plectoglossa*. The specimen is 7.5 mm long and 4.5 mm wide with an acute beak subtending an angle of  $70^\circ$  and evenly convex longitudinal and transverse profiles. The ornament is highly distinctive with prominent, elevated, evenly spaced, concentric growth lines numbering 4 per mm over the post-neanic surface of the valve. The specimen almost certainly comes from beds of the Llandeilo Series, since it is associated with a marrolothid. Although the Llandeilo Glossellinae are represented almost exclusively by *Pseudolingula granulata* (Phillips) it is considered improbable that this small specimen might be a juvenile representative of that species. No individuals of comparable size show such evenly curved lateral margins, the same prominent elevated growth lines, or are characterized by a lack of a ventral platform.

#### Family ELKANIIDAE Walcott & Schuchert, 1908

##### Genus *MONOBOLINA* Salter, 1865

##### *Monobolina plumbea* (Salter)

(Figs 31–34)

1859 *Lingula plumbea* Salter in Murchison : 50; foss. 8, fig. 1.

1859 *Lingula Ramsayi* Salter in Murchison : 55; foss. 10, fig. 20.

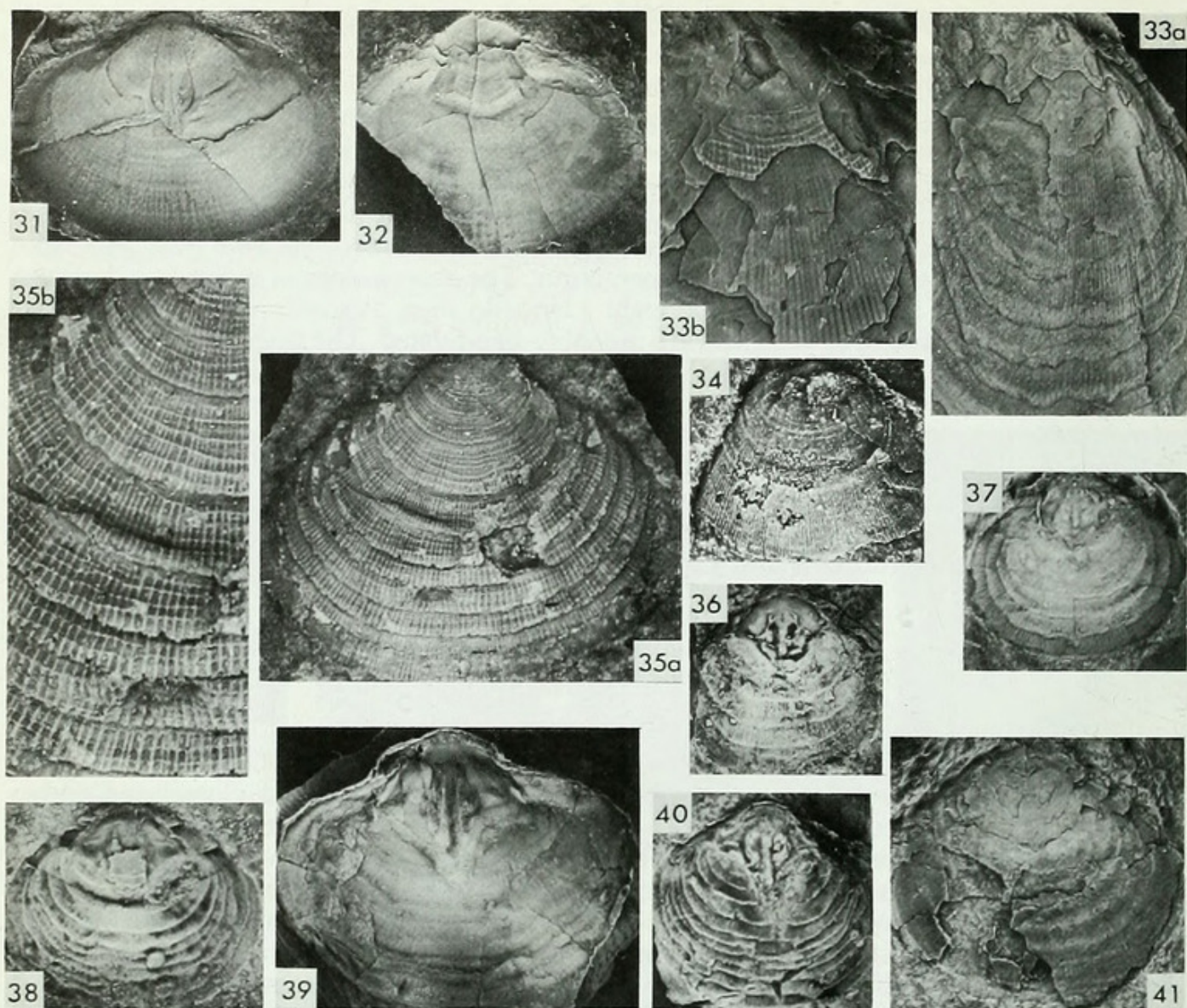
1868 *Obolus? plumbea* (Salter) var. *plicata* (Hicks MS) Davidson : 311; pl. 16, fig. 6, non fig. 7.

1875 *Dinobolus? Hicksii* Davidson in Hicks : 188; pl. 10, fig. 6.

Since the type species of *Monobolina* was redescribed by one of us (Williams 1974 : 38) we have observed a further detail of dorsal morphology in the form of socket ridges about one-quarter as long as wide and about one-sixth as long as the valve (Fig. 31).

Cocks (1978 : 19) has suggested that *Lingula ramsayi* Salter probably belongs in the genus *Monobolina* and selected lectotypes for *M. plumbea*, *M. plumbea* var. *plicata* and *M. ? ramsayi*. We agree that the lectotype (GSM 8439) and particularly the paralectotypes (GSM 8434 and B 14404) of *M. ? ramsayi* belong to the genus *Monobolina*, although there is





**Figs 31–34** *Monobolina plumbea* (Salter). Fig. 31, paralectotype B 5917, latex cast of internal part of exfoliated brachial valve  $\times 2.5$ ; Fig. 32, lectotype GSM 16909, latex cast of internal part of exfoliated pedicle valve  $\times 2.5$ ; both from Mytton Flags, White Grit Mine, Shropshire. Figs 33a, b, BB 14404, partially exfoliated valve  $\times 3$ , and detail of ornament  $\times 8$ , from Llanvirn Beds, Abereddy Bay, Dyfed. Fig. 34, B 14376, latex cast of external mould of a ? pedicle valve  $\times 4$ , from Arenig Beds, Tremamhire, St David's, Dyfed.

**Figs 35–41** *Monobolina crassa* sp. nov. Figs 35a, b, B 5918, latex cast of external mould of a pedicle valve  $\times 4$ , with detail of ornament  $\times 8$ , from Llandeilo shales, Wellfield, Builth. Figs 36–38 and 40, GSM 16902, 16918, 16901 and 16900 respectively, internal moulds of brachial valves all  $\times 2$ , from Llandeilo shales, Wyeford, Builth. Fig. 39, **holotype** SM A.104412, latex cast of internal mould of a brachial valve  $\times 2$ , from Llandeilo shales, Pen Cerrig, Builth. Fig. 41, SM A.44850, exterior of a pedicle valve  $\times 2$ , from *Nemagraptus gracilis* shales, Gwern-y-fed, Builth.

no evidence to suggest that the specimens are distinguishable from the type species. The large, thick-shelled paralectotypes are better preserved than the lectotype and exhibit 7 and 9 costellae respectively at 5 mm anteromedially of the umbones; B 14404 also exhibits the distinctive concentric fila characteristic of the type species. Indeed, having examined over 150 recognizable *Monobolina* specimens in an old Geological Survey collection from Abereddy Bay, we have selected twelve specimens (GSM Zs 6259–70) which exhibit the outline, ornament and ventral muscle platform impressions characteristic of the type species *M. plumbea*. The lectotype (B 14376) of *M. plumbea* var. *plicata* which Davidson



(1868 : 312) and Hicks suggested was 'a small variety of *O. plumbea*' has 9 costellae per mm, 5 mm anteromedially of the umbo; the internal mould figure by Davidson (1868 : pl. 16, fig. 7) is no longer known.

*Lingulella ? hicksii* (Davidson), which comes from approximately the same horizon and locality as the specimens of *M. ? ramsayi*, should be regarded as a *nomen dubium* (Cocks 1978 : 15). The holotype B 5943 (by monotypy), although poorly preserved, is large and apparently transverse in outline with distinguishable thickened growth lines and platelike shell layers, all of which indicate that it might be a *Monobolina*.

| MATERIAL                                                |           | length | width |
|---------------------------------------------------------|-----------|--------|-------|
| Lectotype, internal part of an exfoliated p.v.          |           |        |       |
| exterior . . . . .                                      | GSM 16909 | 13     | 16    |
| Paralectotype, external part of an exfoliated b.v.      | B 5917    | 12     | 17    |
| External part of a partially exfoliated valve . . . . . | B 14404   | (17.5) | (14)  |
| External mould of a valve . . . . .                     | B 14376   | 7.5    | 6.5   |

HORIZONS AND LOCALITIES. GSM 16909 and B 5917 from the Mytton Flags (Arenig), White Grit Mine, west of Stiperstones, Shropshire (c. SJ 335002); B 14404, GSM 8434, 8439, Zs 6259-70 and SM A.44841-9 and 97723 from rocks of Llanvirn age, Abereddy Bay, Dyfed (c. SM 798307); B 14376 from Arenig Beds, Tremanhire, St Davids, Dyfed (c. SM 827263).

***Monobolina crassa* sp. nov.**  
(Figs 35-41)

1866 *Obolella plumbea* (Salter); Davidson : 61 pars; pl. 4, fig. 23, *non* figs 20-22, 24-27.

1871 *Obolus? plumbeus* (Salter); Davidson : 341 pars; pl. 50, fig. 24, *non* figs 22-23.

DIAGNOSIS. Large thick-shelled *Monobolina* with well-developed anteromedian extension to the internal dorsal platform and a short ventral platform about one-fifth as long as valve.

NAME. 'Thick'.

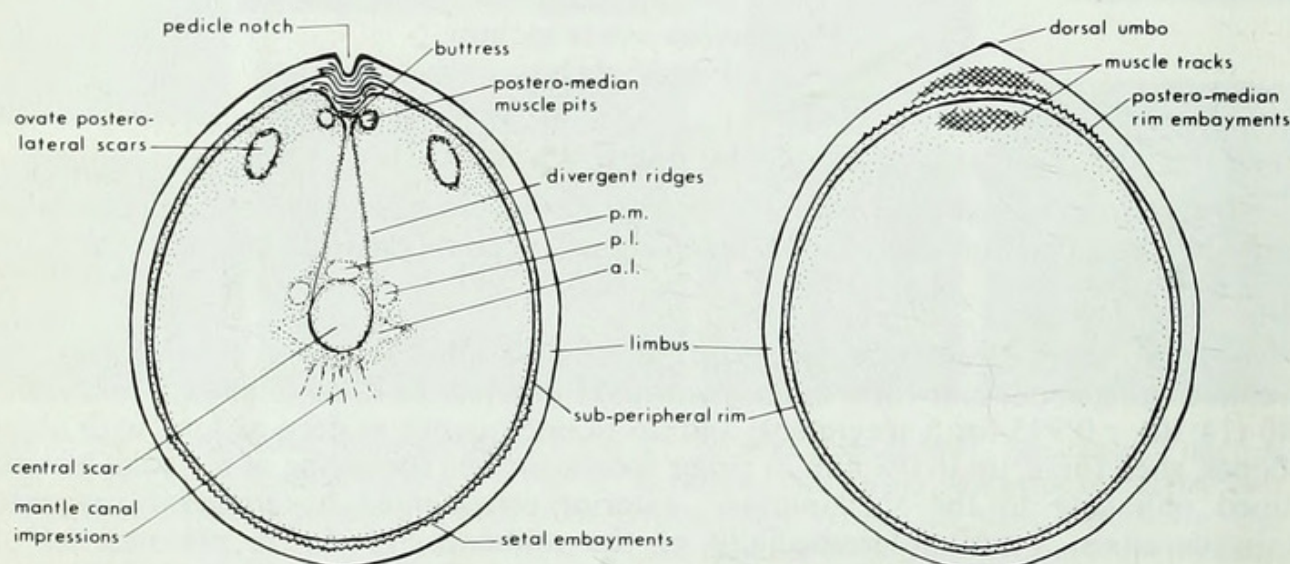
DESCRIPTION. Large, transverse, subelliptical, thick-shelled biconvex *Monobolina* with valves averaging about four-fifths as long as wide ( $\bar{l}$  mm (var l) 13.46 (6.808),  $\bar{w}$  mm (var w) 16.40 (14.30),  $r$  0.995 for 5 specimens) and up to one-quarter as deep as long with obtuse umbones; shell thick, up to 0.8 mm in larger specimens and consisting of platelike lamellae inclined obliquely to the shell surface; exterior ornamented by irregular concentric fila in densities, 5 mm anteromedially of the umbones, of 4 fila per mm in one specimen and of 6, 7, 8 and 9 costellae per mm in 1, 2, 3 and 1 valves and with low concentric rugae with a wavelength of about 1 mm on the postneanic shell; ventral interior with posterior muscle platform about one-fifth as long as valve and about as wide as long; dorsal interior with well-developed, diamond-shaped posterior platform ( $p$ ) averaging 53% as long as valve in 4 specimens ( $\bar{l}$  mm (var l) 13.58 (8.989),  $1p$  (var  $1p$ ) 7.15 (4.097),  $r$  0.984) and impressed by a pair of outside lateral and elongate, submedian muscle scars with prominent muscle tracks on either side of a longer median groove which extends forward to the pointed anterior margin of the platform and is divided anteromedially by a fine, low ridge.

| MATERIAL                                         |             | length | width |
|--------------------------------------------------|-------------|--------|-------|
| <b>Holotype</b> , internal and external parts of |             |        |       |
| exfoliated b.v. . . . .                          | SM A.104412 | 18     | 23    |
| Paratype, exterior of p.v. . . . .               | SM A.44850  | 16     | 19    |
| Paratype, internal mould of b.v. . . . .         | GSM 16918   | 11.5   | 14    |
| " . . . . .                                      | GSM 16900   | 12.8   | 15    |
| Paratype, external mould of p.v. . . . .         | B 5918      | 10.3   | 12.5  |
| Paratype, internal mould of b.v. . . . .         | GSM 16901   | 13     | 16.5  |
| " . . . . .                                      | GSM 16902   | 12     | (14)  |



**HORIZONS AND LOCALITIES.** B 5918 from 'Llandeilo Flags' (probably *Glyptograptus teretiusculus* Zone) of Wellfield, Builth; SM A.104412 and A.104451-2 from *G. teretiusculus* shales exposed in the stream section east of Pen-Cerrig, 3 km north of Builth (SO 048537); SM A.104446-8 and GSM 16547 from *G. teretiusculus* shales exposed in the Trecoed stream section, 4 km north of Builth Wells (SO 054552); SM A.104449 from *G. teretiusculus* shales exposed in Dulas Brook, 5.5 km north of Builth Wells (SO 059566); GSM 16900-2 and 16918 from Llandeilo Shales of Hellpool, Wyeford, Builth; SM A.44850 (2 specimens) from *Nemagraptus gracilis* shales exposed in Gwern-y-fed quarry, 1.5 km north of Builth (SO 030526).

**DISCUSSION.** *Monobolina crassa* sp. nov. differs from *M. plumbea* Salter in its greater biconvexity, well-developed posteromedian dorsal platform and relatively small ventral platform, and therefore must be regarded as specifically distinct from the older Shelve species. Although Davidson (1866 : 61) stated that 'in the Museum of the Geological Survey some specimens are labelled Hellpool, Wyeford Builth. This is "Upper Llandeilo" and it may be a mistake', it is now certain that *Monobolina* occurs sporadically in the Llandeilo successions of the Builth area (i.e. *G. teretiusculus* to *N. gracilis* Zones). This means that the genus, represented by the type species *M. plumbea* (Salter) in the Arenig rocks of the Shelve area and the related form described here, does not have such a restricted stratigraphical and geographical range as previously considered (Rowell in Williams *et al.* 1965 : H270, Williams 1974 : 39).



**Fig. 42** Diagrammatic views of the interiors of the brachial (right) and pedicle (left) valves of *Paterula fissura* [Addison ms] sp. nov., showing the posteromedian (p.m.), posterolateral (p.l.) and anterolateral (a.l.) components of the central muscle scar.

### Family PATERULIDAE Cooper, 1956

#### Genus *PATERULA* Barrande, 1879

#### *Paterula* cf. *bohémica* Barrande (Figs 43-45)

cf. 1879 *Paterula Bohémica* Barrande : 110; pl. 95 (1-3); pl. 152, fig. 1 (1-9A).

cf. 1974 *Paterula* cf. *bohémica* Barrande; Williams : 40; pl. 6, figs 2-11.

**DESCRIPTION.** Dorsibiconvex subcircular to suboval *Paterula* with a slightly truncated to rounded posterior margin and a rounded anterior one; brachial valve with a mean width relative to length of 90% (range 86-93% in 4 valves) and a mean depth relative to length of 16% (range 14-17% in 3 valves); limbus well-defined, about 0.1 mm wide representing 5-7% of valve length and enclosing subperipheral rim; dorsal beak situated immediately forward of posterior arc of limbus; concentric ornament fine, with up to 40 fila per mm; ventral interior



characterized by grooves diverging from beak to bound posteromedian sector of about 20° and to extend anteriorly for about one-third of valve length; dorsal interior featureless.

## FIGURED MATERIAL

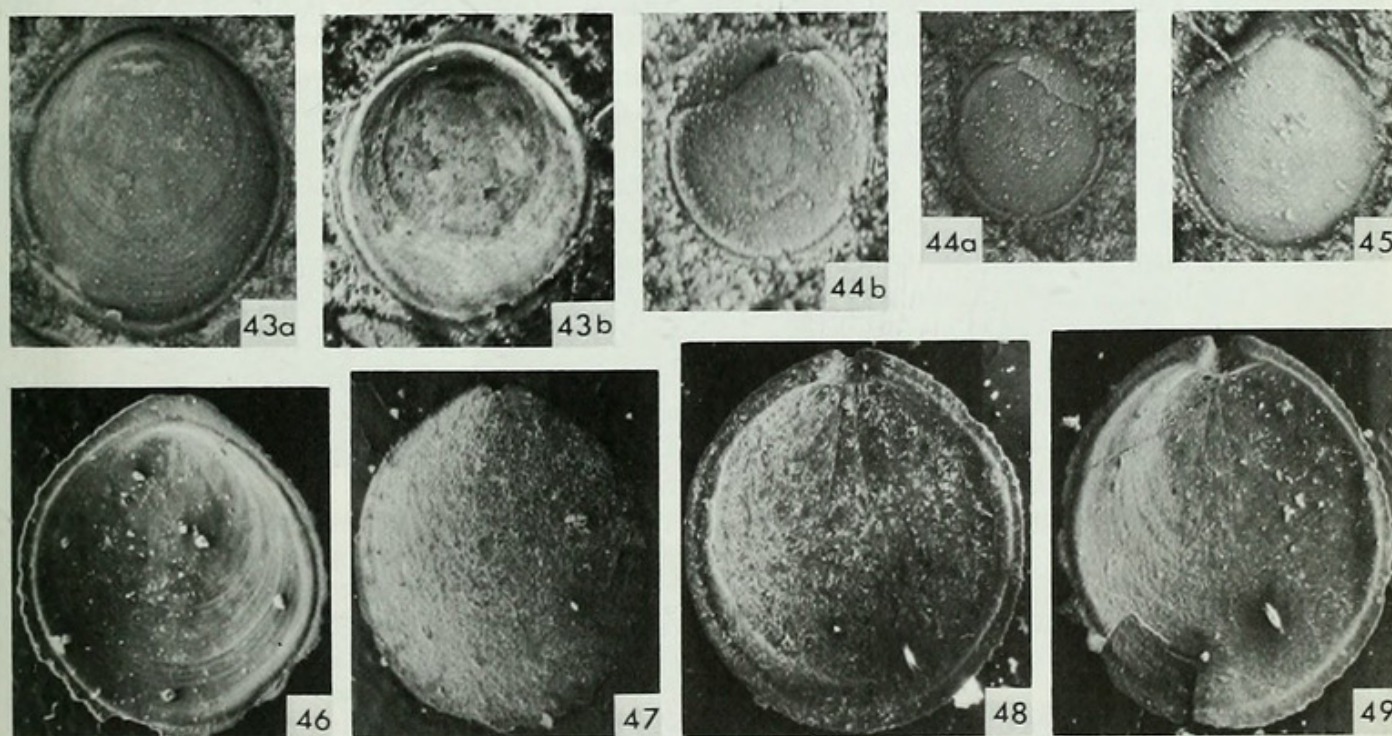
|                                                |          | length | width |
|------------------------------------------------|----------|--------|-------|
| Internal and external parts of exfoliated b.v. | BB 92286 | 1.5    | 1.4   |
| "                                              | BB 92287 | 1.5    | 1.4   |
| Internal part of exfoliated b.v.               | BB 92272 | 2.1    | 1.8   |

**HORIZON AND LOCALITIES.** BB 92286–9 from the calcareous upper part of Flags and Grits in the middle of Ffairfach Group, Ffairfach railway cutting (SN 628211); BB 92272 from the Lower Llandeilo *Marrolithus inflatus maturus* Limestones exposed 100 m downstream from waterfall in Pontbren Araeth Dingle (SN 622237); SM A.44835 from an unknown horizon and locality in the Llandeilo area.

**DISCUSSION.** *Paterula* from the Llandeilo area compares very closely with the type species *P. bohémica* Barrande from the Llanvirn Sárka Formation of Czechoslovakia, as does the contemporaneous stock from the Shelve area of Shropshire (Williams 1974 : 40). The species is especially distinguishable in the full development of the limbus around the entire margin of the shell and the submarginal location of the dorsal beak. Although the Welsh forms have a less sharply truncated margin than the Shropshire specimens, the difference does not warrant any formal recognition.

*Paterula fissura* [Addison MS] sp. nov.  
(Figs 42, 46–49)

**DIAGNOSIS.** Elongately oval *Paterula* with submarginal beaks and deep, tapering pedicle notch from which radiate grooves on interior of pedicle valve enclosing a central circular muscle scar.



**Figs 43–45** *Paterula* cf. *bohémica* Barrande. Figs 43a, b, BB 92272a, b, internal part of exfoliated brachial valve and latex cast of same, both  $\times 16$ , from Lower Llandeilo limestones, Pontbren Araeth, Llandeilo. Figs 44a, b, BB 92287, internal and external parts of an exfoliated brachial valve, both  $\times 12$ ; Fig. 45, BB 92286, internal part of an exfoliated brachial valve  $\times 16$ ; all from the Flags and Grits, Ffairfach Group type section.

**Figs 46–49** *Paterula fissura* [Addison MS] sp. nov. Fig. 46, paratype BB 36121, a brachial valve  $\times 24$ ; Fig. 47, paratype BB 36124, a pedicle valve (external view)  $\times 20$ ; Fig. 48, holotype BB 36120, a pedicle valve,  $\times 20$ ; Fig. 49, paratype BB 94065, a pedicle valve  $\times 20$ ; all from Upper Llandeilo limestones, St Clears, Dyfed.



NAME. 'A cleft or slit'.

DESCRIPTION. Small dorsibiconvex, suboval *Paterula* with both pedicle and brachial valves averaging 86% as wide as long (e.g.  $\bar{l}$  mm (var l) 1.45 (0.076),  $\bar{w}$  mm (var w) 1.24 (0.061),  $r$  0.978 for 20 brachial valves) and respectively averaging 11% and 13% as deep as long (e.g.  $\bar{l}$  mm (var l) 1.44 (0.084),  $\bar{th}$  (var th) 0.19 (0.004),  $r$  0.933 for 18 brachial valves); transverse profiles evenly convex with longitudinal profile characterized by submarginal umbonal apices attaining maximum height just anterior of the slightly pointed posterior umbones.

Ventral interior with flat marginal limbus enclosing a subperipheral rim deeply embayed by posteriorly tapering pedicle notch which is about 10% as wide as valve at the rim and 5% as wide as valve at posterior extremity of umbo; long, narrowly divergent grooves arising at posterior embayment in subperipheral rim extend anteriorly for about half of valve length to meet tangentially and enclose a central circular muscle scar which is about 10% as wide as valve.

Dorsal interior also with subperipheral rim enclosed by marginal limbus which is enlarged and slightly pointed posteromedially.

#### FIGURED MATERIAL

|                 |          | length | width |
|-----------------|----------|--------|-------|
| Holotype, p.v.  | BB 36120 | 2.0    | 1.7   |
| Paratypes, b.v. | BB 36121 | 1.6    | 1.4   |
| Paratype, p.v.  | BB 94065 | 2.0    | 1.6   |
| "               | BB 36124 | 1.6    | 1.4   |

HORIZON AND LOCALITY. BB 36120-4 and BB 94065 from the Upper Llandeilo Bryn Glas Limestone of the Narbeth succession exposed in the old quarry 400 m north of Lower Court Farm, St Clears, Dyfed (SN 307152).

DISCUSSION. This species was studied, but not formally published, by Addison (1974 : 139) with the aid of a scanning electron microscope, which allowed the observation of minute morphological detail. In addition to those features described above, he noted a small posteromedian buttress connecting the pedicle notch and the divergent grooves and recorded two sets of ventral posterolateral muscle scars and three sets of scars comprising the central scar complex (Fig. 42, p. 18). He also noted fine radiating anteromedian mantle canal markings and minute embayments which probably accommodated setae in the outer edge of the anterior part of the subperipheral rim. Both the dorsal umbonal cavity and posterior sector of the limbus were shown to be covered by a fine network of muscle tracks with small muscle pit embayments in the outer posterior sector of the subperipheral rim.

We support Addison's contention that *P. fissura* resembles *P. perfecta* Cooper in many respects. Like him, however, we regard differences, such as the configuration of the ventral muscle scar complex and the extent of the development of mantle canal markings, as indicative of specific differences between these two forms.

#### Order ACROTRETIDA Kuhn, 1949

#### Superfamily ACROTRETACEA Schuchert, 1893

#### Family ACROTRETIDAE Schuchert, 1893

#### Subfamily ACROTRETINAE Schuchert, 1893

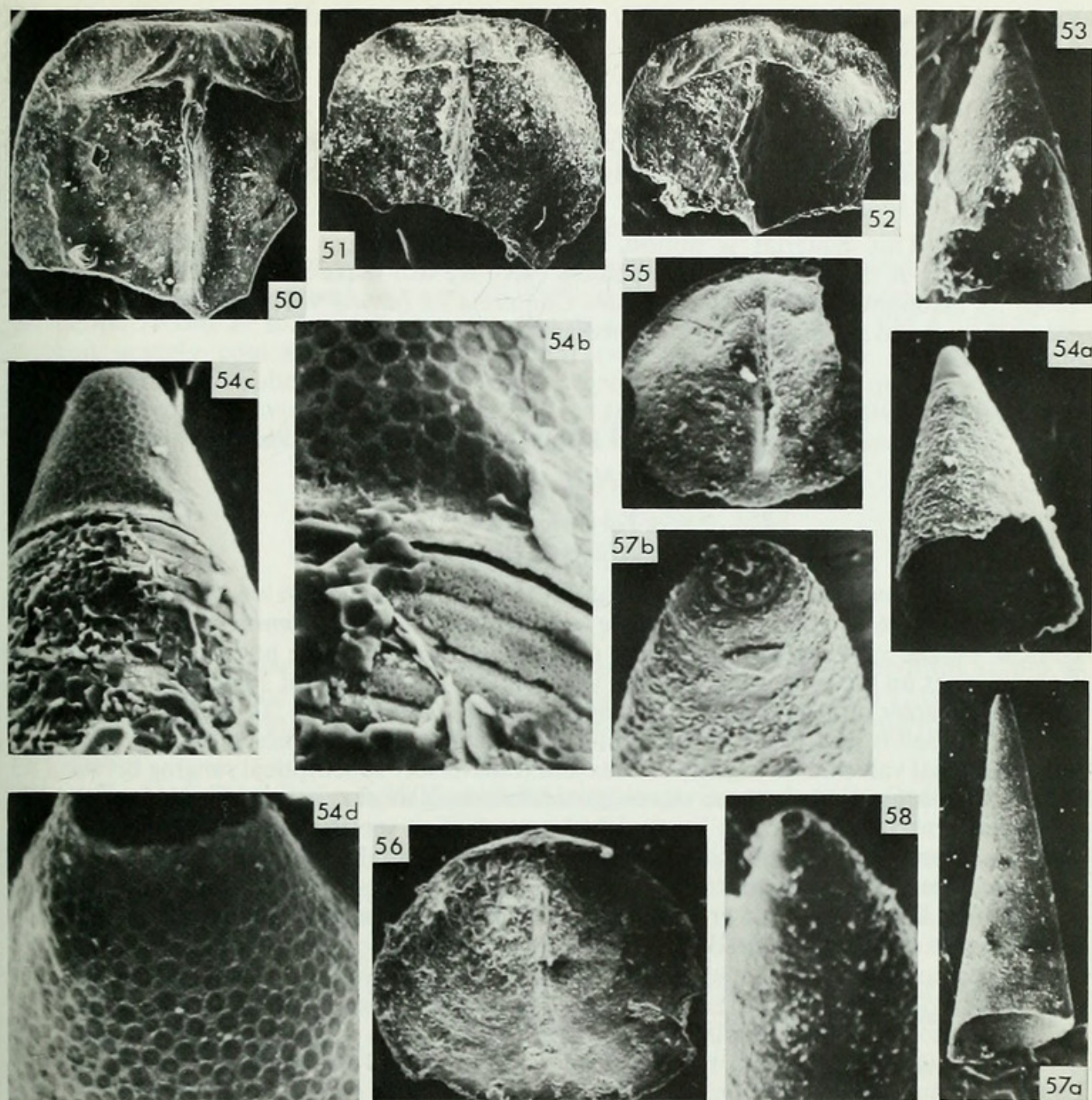
#### Genus CONOTRETA Walcott, 1889

#### ? *Conotreta* sp.

(Figs 50-52)

DESCRIPTION. Acrotretinid brachial valve with a subcircular to subquadrate outline and a convex profile, almost as long as wide with well-developed transverse proparea, one-fifth to one-quarter as long as valve, bounded anteriorly by prominent hinge line and short anacline interarea; cardinal scars divergent, developed as wide, deep grooves in propareas which are





**Figs 50–52** ? *Conotreta* sp. BB 94049, 94054 and 94052, three brachial valves  $\times 36$ ,  $\times 32$  and  $\times 24$  respectively, all from Upper Llandeilo limestones, St Clears, Dyfed.

**Figs 53–56** *Torynelasma* sp. Fig. 53, BB 94044, a pedicle valve  $\times 56$ ; Figs 54a–d, BB 94045, a pedicle valve with details of growth lines (and punctae), protegulum and foramen,  $\times 56$ ,  $\times 850$ ,  $\times 250$  and  $\times 600$  respectively; Figs 55–56, BB 94046–7, two brachial valves  $\times 40$  and  $\times 56$ ; all specimens from Upper Llandeilo limestones, St Clears, Dyfed.

**Figs 57–58** ? *Acrotretid* indet. Figs 57a, b, BB 94056, a pedicle valve  $\times 16$ , with detail of foramen  $\times 180$ ; Fig. 58, BB 94057, a pedicle valve (apical view)  $\times 95$ ; both from Upper Llandeilo limestones, St Clears, Dyfed. (See p. 23).

indented medially at the posterior margin where the thick median septum arises steeply to form a prominent triangular keel incorporating upper and lower anteroventrally projecting rods; radial lines developed sporadically on valve floor; dorsal exterior and ventral valve unknown.



| FIGURED MATERIAL |          | length | width |
|------------------|----------|--------|-------|
| Brachial valve   | BB 94049 | (1.0)  | 1.25  |
| "                | BB 94052 | (1.2)  | 1.5   |
| "                | BB 94054 | (1.1)  | 1.25  |

HORIZON AND LOCALITY. BB 94049–55 from Upper Llandeilo Bryn Glas Limestone strata of Narbeth succession exposed in old quarry 400 m north of Lower Court Farm, St Clears, Dyfed (SN 307152).

DISCUSSION. This material is almost certainly representative of a hitherto unknown acrotretinid, but in the absence of a pedicle valve we can make no conclusive statements about its taxonomic affinity. It resembles *Conotreta* in having well-developed propareas, cardinal scars and a posteriorly arising median septum.

### Subfamily **TORYNELASMATINAE** Rowell, 1965

#### Genus **TORYNELASMA** Cooper, 1956

#### *Torynelasma* sp. (Figs 53–56)

DESCRIPTION. Small torynelasmatinid with acutely conical pedicle valve at least half as long and half as wide as deep, with obscure pseudointerarea and prominent asymmetrically conical 'bubble raft' protegulum, about one-sixth as deep as valve and extending furthest from the apex on the posterior side of the valve, apical foramen about 30  $\mu$ m in diameter in 2 specimens; larger protegular pits averaging 3.46  $\mu$ m in diameter ( $n = 50$ , var 0.636); the non-protegular shell is punctate with encircling evenly-spaced growth lines between 6 and 8  $\mu$ m apart; brachial valve flat to slightly convex and transversely subelliptical ranging between 83 and 94% as long as wide in three valves, pseudointerarea short anacline bounded posteriorly by obtuse umbo and anteriorly by straight hinge, median septum long extending almost to anterior commissure, with maximum height towards anterior but no transverse plate- or rod-like structures; obscure posteromedian muscle scars occur on either side of the median septum and faint concentric growth lines mark the valve floor; dorsal exterior unknown; pedicle valve interior structurally featureless.

| FIGURED MATERIAL |          | length | width | depth |
|------------------|----------|--------|-------|-------|
| Pedicle valve    | BB 94044 | 0.4    | 0.4   | 0.75  |
| "                | BB 94045 | 0.4    | 0.4   | 0.7   |
| Brachial valve   | BB 94046 | 1.0    | 1.2   | —     |
| "                | BB 94047 | 0.65   | 0.7   | —     |

HORIZON AND LOCALITY. Upper Llandeilo Bryn Glas Limestone strata of the Narbeth succession exposed in the old quarry 400 m north of Lower Court farm, St Clears, Dyfed (SN 397152).

DISCUSSION. The ventral morphology is essentially identical to the *Torynelasma* type species *T. toryniferum* Cooper (1956 : 257), though it apparently has larger protegular pits (cf. Biernat & Williams 1970 : 494). It is also similar to the Siluro-Devonian genus *Caenotreta* (Cocks 1979 : 93). The dorsal interior of the Llandeilo *Torynelasma* does not bear the spoon-like transverse septal plate of the type species, or rods as in *Caenotreta*, but this may be because of imperfect preservation. If further suitable material becomes available it will be important to establish whether the septal development seen in specimen BB 94047 is representative of a complete undamaged structure; if this were the case, the species would be better considered representative of a new generic stock within the Torynelasmatinae.

We note that despite differences in protegular structure, *Opsiconidion* Ludvigsen (1974), Scaphalasmatinae, and *Caenotreta* are virtually identical in all other respects and also would probably be best accommodated in the Torynelasmatinae.



In addition to the acrotretaceans discussed here, the Bryn Glas Limestone residues have yielded miscellaneous faunal elements including the 'acutely conical valves' (BB 94056-7) illustrated (Figs 57-58). These exceptionally conical valves, although exhibiting no recognizable protegular ornament, show a discernible change in cone slope near the apex and a well-developed apical foramen. With our present imperfect knowledge of acrotretacean faunas we tentatively consider that these valves may also be related to the *Torynelasmatinae*.

#### Genus indet

**MATERIAL AND DISCUSSION.** An assemblage of small acrotretids recovered from basal *G. teretiusculus* shales exposed just east of Welfield Lodge (SO 044528) represents the first authentic record of this order from the Builth area. The specimens, SM A.105827-36, exhibit acutely conical pedicle valves about twice as deep (up to 3.5 mm) as long (1.5-2.0 mm) and subcircular slightly convex brachial valves with a median septum of unknown profile. They are unlike *Conotreta* or *Apsotreta* from the Shelve area (Williams 1974) and may ultimately prove to be more closely related to the *Torynelasmatinae*.

Superfamily **DISCINACEA** Gray, 1840  
Family **TREMATIDAE** Schuchert, 1893

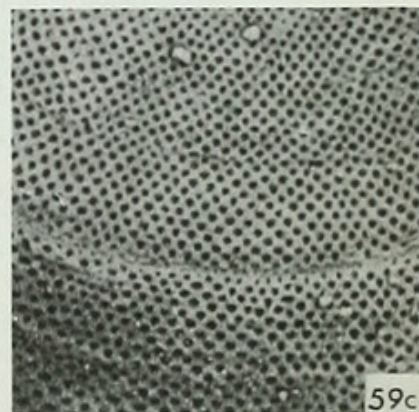
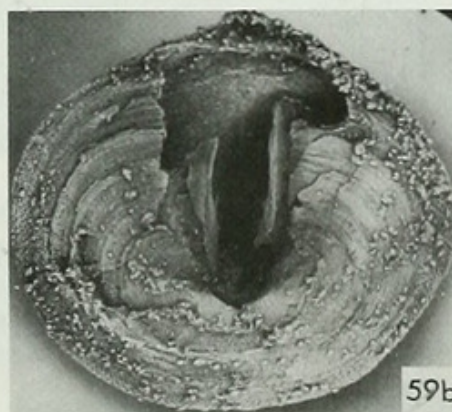
Genus **TREMATIS** Sharpe, 1848

*Trematis evansi* [Addison MS] sp. nov.  
(Figs 59a-c)

**DIAGNOSIS.** Subcircular, biconvex *Trematis* with pedicle notch about three-fifths as long as valve, situated in broad posteromedian sector; ornament quincuncial with 12 concentric pit rows between 4 and 5 mm anteromedially of dorsal umbo and 7 pits per mm in each row at this point.

**NAME.** For D. C. Evans, who in 1906 published his pioneering work on the Ordovician rocks of western Carmarthenshire.

**DESCRIPTION.** Subcircular biconvex *Trematis* with valves slightly wider than long and about one-quarter to one-fifth as deep as long; pedicle valve with broad posteromedian sulcus extending from the apex, just anterior to the mid-point where the maximum depth is observed, to the posterior margin with sides enclosing a sector of almost 90°; median pedicle notch, about three-fifths as long and one-eighth as wide as valve with sides of notch concave towards mid-line; listrum small apically but well-developed along each side of the pedicle fissure as longitudinal plates about one-third as wide as notch and characterized by fine radiating lines; brachial valve evenly convex with maximum depth just anterior of the mid-point, umbo obtuse, interarea simple, about one-tenth as long as valve. Ornament of small quincuncially arranged pits, numbering 7 per mm 5 mm anteromedially of the dorsal umbo,



**Figs 59a-c** *Trematis evansi* [Addison MS] sp. nov. **Holotype** BB 36126, dorsal view  $\times 4$ , ventral view  $\times 4$  and detail of dorsal ornament of conjoined valves  $\times 10$ , from Upper Llandeilo limestones, St Clears, Dyfed..



has 12 alternately arranged concentric pit rows between 4 and 5 mm anteromedially; pit size, pit and pit row spacing increase progressively from umbo to anterior margin with quincuncial pattern consistent over entire valve surface except where growth pauses result in minor attenuations.

Interiors of both valves incompletely known except for pair of rounded dorsal muscle scars on either side of an obscure low median ridge.

HOLOTYPE. Complete specimen, BB 36126; length 11.0 mm, width 12.3 mm.

HORIZON AND LOCALITY. Upper Llandeilo Bryn-glas Limestone, exposed in old quarry 400 m north of Lower Court Farm near St Clears (SN 307152).

DISCUSSION. Addison (1974: 144, not formally published) reviewed the affinities of *T. evansi*, showing that amongst quincuncially-ornamented *Trematis* it can only be considered to resemble *T. parva* Cooper and *T. melliflua* Reed in density and style of ornament. Both these poorly-known species, however, have sulcate brachial valves and are distinguishable from *T. evansi* at least in this respect.

### Genus *SCHIZOCRANIA* Hall & Whitfield, 1875

#### *Schizocrania* cf. *salopiensis* Williams (Figs 60–65)

1866 *Discina crassa* Hall?; Davidson *pars*: pl. 6, fig. 6, non fig. 7.  
cf. 1974 *Schizocrania salopiensis* Williams: 44; pl. 6, figs 22–26.

DIAGNOSIS. *Schizocrania* with subcircular to suboval outline and a broadly triangular pedicle opening, about one-third as deep as long dorsally with a posteriorly placed umbo and dichotomizing capillae developed with variable density; ventral ornament of concentric growth lines.

DESCRIPTION. Pedicle valve subcircular to transversely suboval with broadly triangular pedicle opening with straight sides and a well-developed listrum; brachial valve subcircular to suboval, between 85% and 91% as long as wide in 5 specimens, with an evenly convex transverse profile, longitudinal profile asymmetrically convex with posterior umbo overhanging smoothly rounded posterior margin; ventral exterior ornamented by concentric growth lines surrounding the central point at the anterior apex of the triangular pedicle opening and extending onto listrum; dorsal exterior ornamented by sporadically occurring faint growth lines and prominent capillae disposed radially from umbo and numbering 9 to 15 per mm at the anterior margin in a sample of small shells, and between 10 and 16 per mm at 5 mm anteromedially in a group of larger shells; capillae reflexed posterolaterally.

Dorsal interior with well-defined slightly divergent posterior adductor scars extending forward for about one-fifth of valve length and separated by a median ridge; radial mantle canals number 6 and 7 per mm, 5 mm anteromedially of the umbo, in 4 and 1 specimens from Penddol with each canal therefore corresponding to about two external capillae; ventral interior unknown.

#### FIGURED MATERIAL

|                                  |             | length | width |
|----------------------------------|-------------|--------|-------|
| Exfoliated exterior part of b.v. | BB 92277    | 4.1    | 4.5   |
| Internal mould of b.v.           | BB 92300    | 4.2    | 4.6   |
| External mould of b.v.           | SM A.46560  | 10.5   | 11.5  |
| "                                | SM A.44861  | 11     | 12    |
| Internal part of exfoliated b.v. | SM A.104418 | 8      | 10.5  |
| External mould of p.v.           | SM A.104413 | (6.5)  | (9.0) |

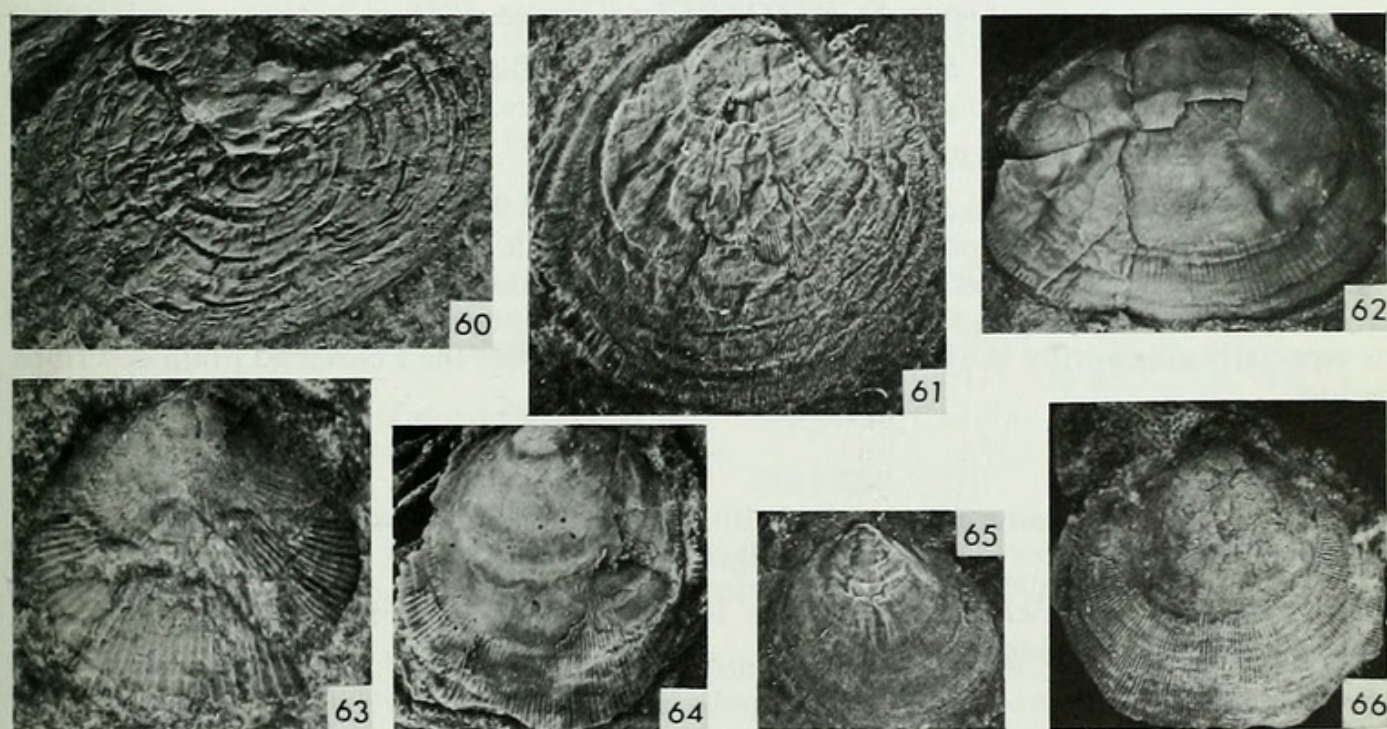
HORIZONS AND LOCALITIES. BB 92492–4 from Flags and Grits of the Ffairfach Group exposed at Coed Duon, Llangadog (SN 709256); BB 94248 from Flags and Grits, Ffairfach Group type section (SN 628211); BB 92275–7 from Upper Llandeilo Flags exposed in dingle 200 m south of Crûg, Llandeilo (SN 627229); BB 92278 from Lower Llandeilo



*Sowerbyella* Limestones exposed in old trackway SW end of Deer Park, Dynevor Park, Llandeilo (SN 609223); BB 92298–300 from the grey shelly sandstones ('Pebbly Felspar Ash' of the Main Tuff Group) 200 m SW of Carn peak, Carneddau Hills, 1.25 km ESE of Newmead Farm near Builth Wells (SO 065539); SM A.44861 from the 'Llandeilo Limestone' (*Nemagraptus gracilis* Zone) of Harper's Quarry, Wellfield, 2 km north of Builth (SO 037534); SM A.46560 from Llanvirn *Didymograptus murchisoni* shales exposed in Howey Brook (SO 090592); SM A.104418 from *Glyptograptus teretiusculus* shales exposed in the stream section east of Pen Cerrig (SO 948537). SM A.104413 from *G. teretiusculus* to *N. gracilis* Zone shales exposed at Penddol Rocks, in the Wye river section 1 km NW of Builth (SO 031522); GSM 16762 from the 'Llandeilo flags of Builth', probably the same horizon, precise locality unknown.

**DISCUSSION.** The specimens, including GSM 16762, SM A.44850, A.46560 and A.51157 from localities in the Builth region, allow us to add information on the species' ventral morphology and the variability of its dorsal ornament to the existing description (Williams 1974: 44). The small Llandeilo and the usually larger Builth specimens exhibit more variable dorsal capillae densities than apparently conspecific brachial valves from Shelve. Such pronounced variability in ornament may be indicative of specific variation in the Welsh stock.

The stratigraphical range of *Schizocrania* cf. *salopiensis* in the Builth region and in the Llandeilo area (Bassett *et al.* 1974: 9; Wilcox 1979: 42) falls within that of the Shelve stock which is known from Upper Llanvirn, Llandeilo and basal Caradoc rocks.



**Figs 60–65** *Schizocrania* cf. *salopiensis* Williams. Fig. 60, SM A.104413, internal mould of a pedicle valve  $\times 6$ , from Llandeilo shales, Penddol, Builth. Fig. 61, SM A.46560, latex cast of an external mould of a brachial valve  $\times 8$ , from Llanvirn shales in Howey Brook, Llandrindod. Fig. 62, SM A.104418, internal part of an exfoliated brachial valve  $\times 4$ , from Llandeilo shales, Pen Cerrig, Builth. Fig. 63, BB 92277, a partially exfoliated brachial valve  $\times 8$ , from Upper Llandeilo shales, Llandeilo. Fig. 64, BB 92300, exterior of a brachial valve  $\times 8$ , from Llanvirn sandstones, Newmead, Builth. Fig. 65, SM A.44861, latex cast of external mould of a brachial valve  $\times 2$ , from Llandeilo shales, Wellfield, Builth.

**Fig. 66** *Schizocrania multistriata* (Reed). Holotype SM A.34039, exterior of a brachial valve  $\times 2$ , from Lower Caradoc limestones, Lampeter Velfrey, Dyfed.



*Schizocrania multistriata* (Reed), emended  
(Fig. 66)

1905 *Trematis multistriata* Reed : 446; pl. 23, figs 1–1a.

DESCRIPTION. Subcircular to transversely suboval *Schizocrania* with brachial valve about nine-tenths as long as wide and one-fifth as deep as long, dorsal transverse profile evenly convex, longitudinal profile unevenly convex with maximum depth posterior to midline; ornament of a few indistinct concentric growth lines and prominent radial capillae numbering 10 per mm at 5 mm anteromedially of the dorsal umbo, capillae reflexed posterolaterally. Interior of brachial valve and pedicle valve unknown.

HOLOTYPE. Exterior of brachial valve, SM A.34039; length 16.5 mm, width 18.5 mm.

HORIZON AND LOCALITY. The only known specimen is from the Lower Caradoc Bryn Banc Limestone exposed in old quarry 250 m NW of Lampeter Velfrey Church (SN 153146).

DISCUSSION. This species, of which the holotype is still the only specimen known, resembles *S. salopiensis* Williams in its external dorsal morphology and may prove to be a senior synonym of the Shelve species. Meanwhile it is transferred to the genus *Schizocrania*, to which it undoubtedly belongs.

Family DISCINIDAE Gray, 1840

Subfamily ORBICULOIDEINAE Schuchert & Le Vene, 1929

Genus *SCHIZOTRETA* Kutorga, 1848

*Schizotreta* cf. *transversa* Williams  
(Fig. 70)

cf. 1974 *Schizotreta transversa* Williams : 47; pl. 7, figs 2, 3, 7.

A single external mould of a *Schizotreta* pedicle valve (BB 92274) from the Lower Llandeilo *Lloydolithus lloydi* Flags exposed in the old quarry in Castle Wood, Dynevor Park, Llandeilo (SN 615217), compares most closely with the contemporaneous Shelve species *S. transversa* Williams. The similarity in the relatively transverse outline and lack of well-developed fila is especially noteworthy in view of the distinctive form from the Ffairfach Group described below.

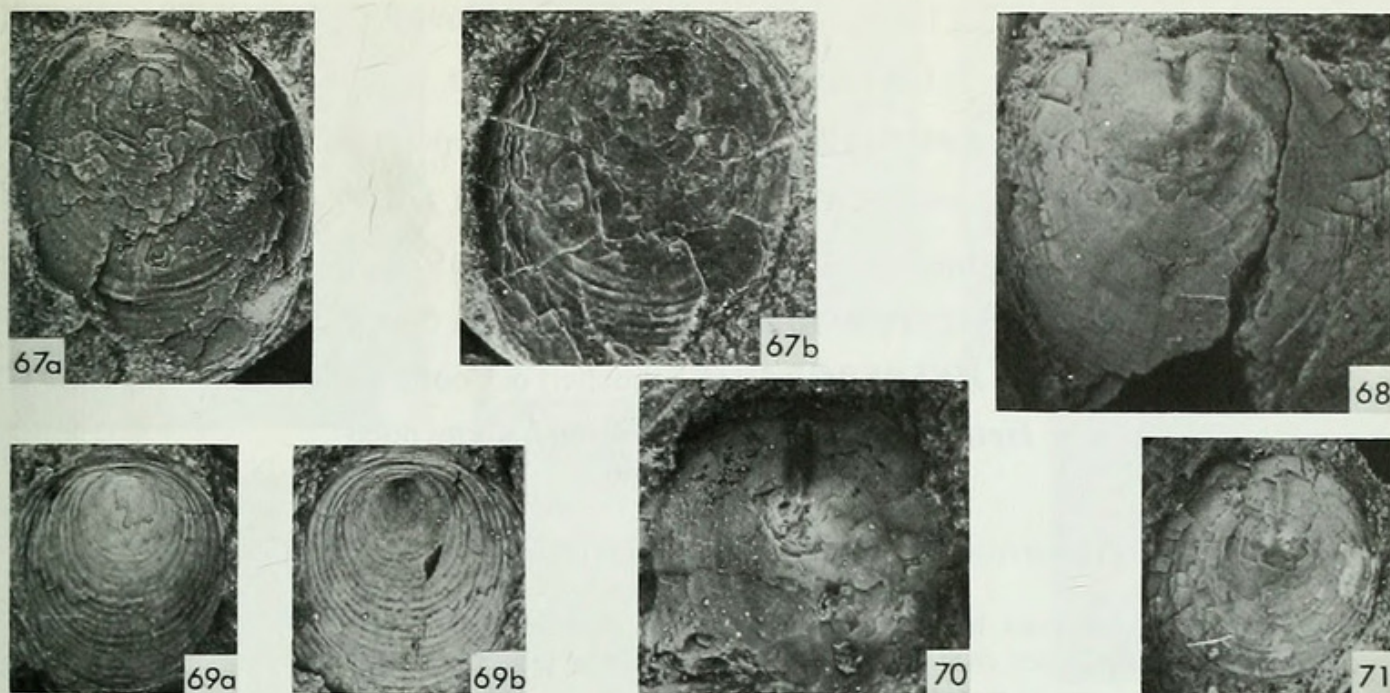
*Schizotreta transversa* Williams *ffairfachensis* subsp. nov.  
(Figs 67–69)

DIAGNOSIS. Suboval *Schizotreta* slightly longer than wide, with a surface ornament consisting of well-developed fila.

NAME. From Ffairfach.

DESCRIPTION. Subcircular to suboval *Schizotreta* with truncated posterior margin and pronounced concentric ornamentation consisting of strongly-developed fila numbering 5–6 per mm in the anterior and lateral parts of the valve and with fine, closely spaced radial striations over the whole shell; pedicle valve subconical, almost as wide as long (averaging 95% in three specimens) and 20% as deep as long in 2 valves, with a well-developed pedicle track occupying median portion of the valve posterior to apex which is situated medially 29% of valve length anterior of posterior margin; brachial valve 88% as wide as long ( $\bar{l}$  mm (var 1) 7.64 (1.413),  $\bar{w}$  mm (var w) 6.44 (4.798),  $r$  0.968 in 5 valves) and 13% as deep as long ( $\bar{l}$  mm (var 1) 7.64 (1.413),  $th$  (var th) 0.98 (0.137),  $r$  0.966 in 5 valves) with apex situated at 14% of valve length forward of the posterior margin.





**Figs 67–69** *Schizotreta transversa ffairfachensis* subsp. nov. Figs 67a, b, **holotype** BB 92290a, b, internal and external parts of an exfoliated brachial valve  $\times 4$ ; Fig. 68, paratype BB 92292, internal part of an exfoliated pedicle valve  $\times 4$ ; Figs 69a, b, paratype BB 92291a, b, internal and external parts of an exfoliated brachial valve  $\times 4$ ; all from Flags and Grits, Ffairfach Group, type section.

**Fig. 70** *Schizotreta* cf. *transversa transversa* Williams. BB 92274, exterior of a pedicle valve  $\times 8$ , from Lower Llandeilo Limestones, Dynevor Park, Llandeilo.

**Fig. 71** *Schizotreta transversa transversa* Williams. B 21766, latex cast of external mould of a pedicle valve  $\times 4$ , from Llandeilo Flags, Shelve, Shropshire.

#### TYPE MATERIAL

|                                                                          |          | length | width |
|--------------------------------------------------------------------------|----------|--------|-------|
| <b>Holotype</b> , external and internal parts of exfoliated b.v. . . . . | BB 92290 | 10.0   | 9.0   |
| Paratype, internal part of an exfoliated p.v. . . . .                    | BB 92292 | 11.0   | 10.5  |
| Paratype, internal and external parts of exfoliated b.v. . . . .         | BB 92291 | 6.5    | 5.9   |

**HORIZON AND LOCALITY.** All specimens are from the argillaceous lower part of the Flags and Grits of the Ffairfach Group, Ffairfach railway cutting, Llandeilo (SN 628211).

**DISCUSSION.** The Ffairfach *Schizotreta* differs from the smaller form *S. transversa* Williams (1974 : 47) from the Shelve area in its more elongate shape and particularly in the strong development of concentric fila. These features are considered important enough to warrant subspecific recognition of the Llanvirn form. The recognition of *Schizotreta* in the Arenig (Williams 1974 : 48) and Llanvirn Series reveals an extended stratigraphical range for the genus and indicates that the characteristic elongately suboval shape of Scottish and American stocks like *S. corrugata* (Cooper) and *S. medioradiata* (Reed) was also typical of early Anglo-Welsh forms.

An examination of specimen B 21766 (Fig. 71) from the 'Llandeilo Flags' of Shelve, referred to by Davidson (1866 : pl. 7) as *Orbiculoidea forbesi* Davidson and since referred to *Orbiculoidea* sp. by Cocks (1978 : 176), reveals that it can be assigned to *S. transversa transversa* Williams.



Class **ARTICULATA** Huxley, 1869Order **ORTHIDA** Schuchert & Cooper, 1932Suborder **ORTHIDINA** Schuchert & Cooper, 1932Superfamily **ORTHACEA** Woodward, 1852Family **DOLERORTHIDAE** Öpik, 1934Subfamily **HESPERORTHINAE** Schuchert & Cooper, 1931Genus **HESPERORTHIS** Schuchert & Cooper, 1931*Hesperorthis dynevorensis* Williams, emended  
(Figs 72–80)

1949 *Hesperorthis dynevorensis* Williams : 226; pl. 11, figs 1, 2.

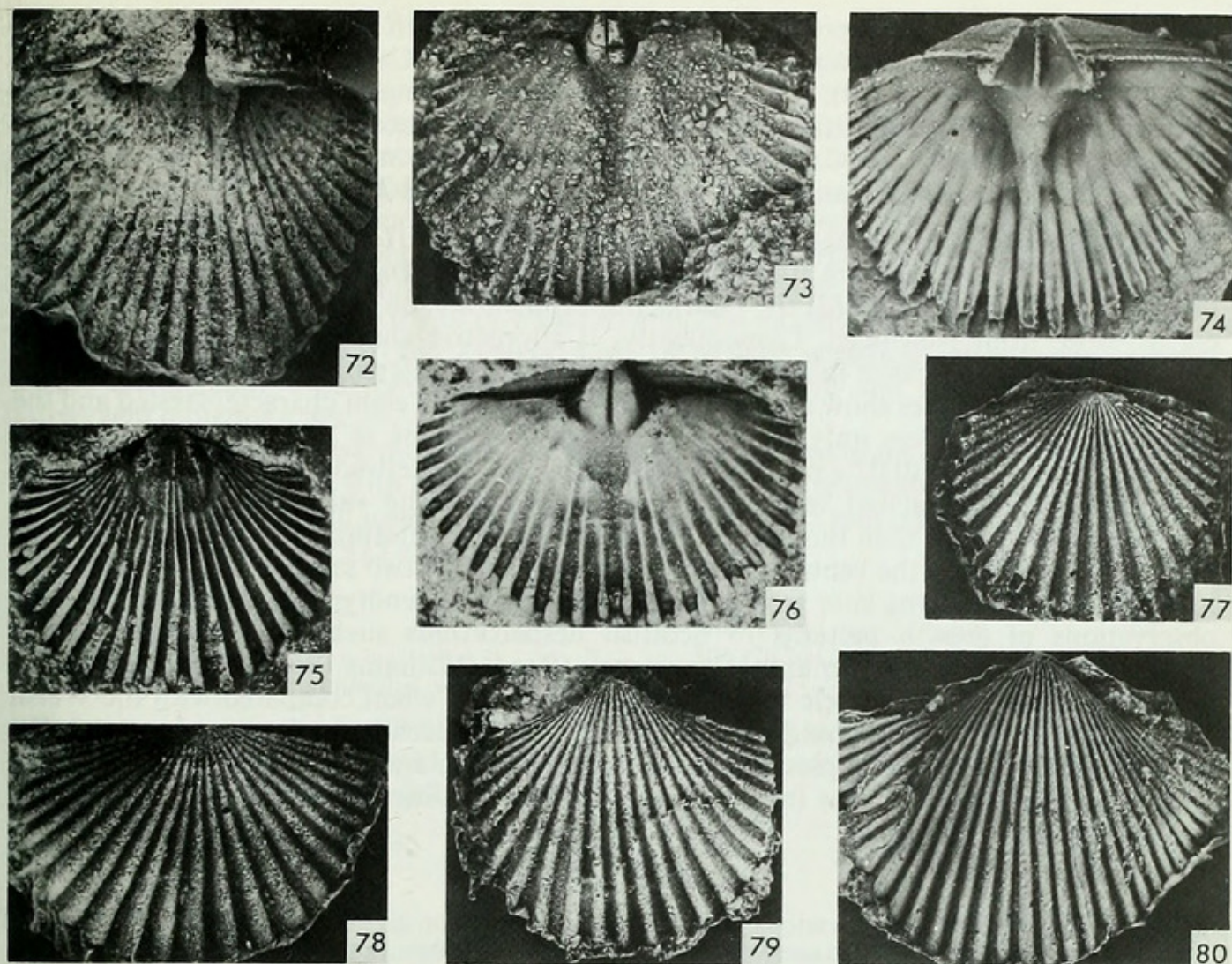
**DIAGNOSIS.** Planoconvex to ventribiconvex *Hesperorthis* with up to 34 regularly spaced costae, numbering 2 per mm at 5 mm anterior of the umbones, and a ventral muscle scar averaging 38% as long as pedicle valve.

**DESCRIPTION.** Planoconvex to ventribiconvex *Hesperorthis* with suboval outline and slightly obtuse cardinal angles; pedicle valve averaging 82 to 89% as long as wide and 24 to 28% as deep as long (e.g.  $\bar{l}$  mm (var l) 9.08 (5.778),  $\bar{t}h$  (var th) 2.18 (0.325),  $r$  0.738 in 13 valves from Newmead) in three samples; brachial valve averaging 74 to 84% as long as wide (e.g.  $\bar{l}$  mm (var l) 11.14 (18.842),  $\bar{w}$  mm (var w) 14.28 (27.855),  $r$  0.980 in 30 valves from Llanelwedd) and 14 to 17% as deep as long in same three samples (e.g.  $\bar{l}$  mm (var l) 14.75 (4.175),  $\bar{t}h$  (var th) 2.33 (0.351),  $r$  0.826 in 6 valves from Llanelwedd); ventral interarea curved apsacline and up to one-quarter as long as valve with narrow delthyrium defined by parallel to slightly divergent boundaries subtending an angle of up to 30°; dorsal interarea flat, anacline and up to 15% as long as valve with well-developed fine transverse growth lines numbering 10–15 per mm; notothyrium open with divergent boundaries forming an angle of about 60°; exterior ornamented by up to 35 regularly spaced rounded costae depending on size; mean amplitude of costae 0.5 mm at 5 mm anteromedially of umbones of 9 valves; counts of 25, 26, 27, 28, 29, 30, 31, 32, 33, 34 and 35 costae were recorded in 1, 0, 0, 1, 3, 4, 6, 4, 1, 0 and 2 valves of specimens from the type horizon at Llandeilo compared with 2, 3, 6, 7, 6, 2, 1, 0, 0 and 0 valves from the Builth area (see Table 2, p. 30).

Ventral interior with deep delthyrial cavity bounded by dental lamellae supporting small teeth about 20% as long as interarea with maximum anterior extension at lateral margins of tooth; ventral muscle scar slightly raised, averaging between 37 and 39% as long as valve (e.g.  $\bar{l}$  mm (var l) 9.65 (4.563),  $\bar{l}sc$  (var lsc) 3.54 (0.605),  $r$  0.865 in 11 valves from Newmead) and 65 to 83% as wide as long in three samples (e.g.  $\bar{l}$  mm (var l) 3.54 (0.550),  $\bar{w}$  mm (var w) 2.93 (0.424),  $r$  0.885 in 12 valves from Newmead); paired adductor scars, thin and long, represented anteriorly by fine ridges separated and bounded by fine grooves extending beyond the anterior margin of diductor scars to link with *vascula media*.

Dorsal interior with simple low, thin plate-like cardinal process narrowing posteriorly and dividing a broad, low, smooth notothyrial cavity; brachiophores short divergent about 30% as long as interarea, with bases averaging 19 to 22% as long as valve (e.g.  $\bar{l}$  mm (var l) 11.11 (17.501),  $\bar{l}c$  (var lc) 2.38 (0.791),  $r$  0.947 in 30 valves from Llanelwedd) and 78 to 86% as long as wide (e.g.  $\bar{l}$  mm (var l) 2.45 (0.738),  $\bar{w}$  mm (var w) 3.41 (1.901),  $r$  0.951 in 18 valves from Llanelwedd); sockets deep; adductor scar pattern quadripartite with anterior adductors smaller than more deeply impressed posterior pair and extending forward for about 60% of the length of the valve, entire field about two-thirds as wide as long and one-third as wide as valve.





**Figs 72–80** *Hesperorthis dynevorensis* Williams. Fig. 72, BB 92308, latex cast of the internal mould of a pedicle valve  $\times 2$ ; Fig. 73, BB 92307, internal mould of a brachial valve  $\times 2$ ; both from Pebbly Sandstones, Ffairfach Group, type section. Fig. 74, BB 92313, latex cast of internal mould of a brachial valve  $\times 4$ ; Fig. 75, BB 92314, internal mould of a pedicle valve  $\times 3$ ; Fig. 76, BB 92312, internal mould of a brachial valve  $\times 4$ ; all from Upper Llanvirn sandstones, Newmead, Builth. Figs 77–78, NMW 68.376.G.153–3, latex casts of external moulds of two brachial valves, both  $\times 2$ ; Fig. 79, NMW 68.376.G.151–1, latex cast of external mould of a pedicle valve  $\times 2$ ; all from Llanvirn Sandstones, Tan y Craig, Builth. Fig. 80, BB 92475, latex cast of external mould of a pedicle valve  $\times 2$ , from Upper Llanvirn Ashes and Lavas, Coed, Duon, Llangadog.

#### FIGURED MATERIAL

|                                              |                    | length | width |
|----------------------------------------------|--------------------|--------|-------|
| Internal mould of b.v. . . . .               | BB 92307           | 19     | 26    |
| Internal mould of b.v. . . . .               | BB 92312           | 8      | 12    |
| Latex cast of internal mould of p.v. . . . . | BB 92308           | 24     | 24    |
| Latex cast of external mould of p.v. . . . . | BB 92475           | 20     | 26    |
| Latex cast of external mould of b.v. . . . . | NMW 68.376.G.151-1 | 17     | 19    |
| Latex cast of external mould of b.v. . . . . | NMW 68.376.G.153-3 | 15     | 22    |
| Latex cast of external mould of b.v. . . . . | NMW 68.376.G.153-3 | 13     | 16    |
| Latex cast of internal mould of b.v. . . . . | BB 92313           | 11     | 13.5  |
| Internal mould of p.v. . . . .               | BB 92314           | 11     | 13.5  |

**HORIZON AND LOCALITIES.** BB 92307–11 from the upper part of the Pebbly Sands Formation of the Ffairfach Group, Ffairfach railway cutting, Ffairfach, Llandeilo (SN 628211);



BB 92312-4 from the lower to middle part of the Main Tuff Group with Lower *Didymograptus murchisoni* Shales, outcrop SW of cairn on Carneddau Hills 1 km ESE of Newmead Farm (SO 065539); BB 92474-5 from rhyolitic conglomerates in the Ashes and Lavas Formation of the Ffairfach Group exposed at Coed Duon, 3 km south of Llangadog (SN 709256); NMW 68.376.G.150-61 from tuffaceous sandstones exposed in quarry east of Tan y Grait 1 km north of Llanellwedd, north of Builth Wells (SO 047528).

DISCUSSION. Comparisons between penecontemporaneous *Hesperorthis* from Ffairfach, Newmead and Llanellwedd are affected by the restricted size range of individuals composing the samples and by the fact that the Ffairfach specimens are, on average, more than twice as big as those from Newmead. Consequently, if allometric changes had occurred during growth, tests of significance might show the samples to be different. However, the Ffairfach and Llanellwedd samples show no significant difference in the eight characters tested and the Newmead sample differs only from the Ffairfach specimens in the shape of its shorter ventral muscle scar ( $0.02 < p < 0.01$ ) and from the Llanellwedd sample in having a significantly wider brachial valve ( $0.05 < p < 0.02$ ). Since the valves from Ffairfach and Llanellwedd are bigger than those from Newmead we have interpreted the greater length of the brachial valve and the ventral muscle scars in the former two samples as an acceleration in forward growth during later growth stages rather than as genotypic differences. Certainly observations of growth patterns in Scottish hesperorthids such as *H. australis exilis* Williams, *H. australis* Cooper and *H. craigensis* (Reed) (Williams 1962: 107-9) reveal that the shape of the ventral muscle scar is quite variable. Yet when compared with the Welsh samples, the three Scottish taxa differ significantly. Differences in the density of costae in the Ffairfach and Newmead samples are directly related to size and, in the absence of sufficient specimens of comparable size from those two Welsh localities, the validity of a statistical comparison is in doubt.

**Table 2** The distribution of various patterns of rib density for given range of size in samples of *Hesperorthis dynevorensis* Williams from the Llanvirn rocks of Newmead and, in brackets, Ffairfach.

| width mm | No. of ribs |       |        |       |       |
|----------|-------------|-------|--------|-------|-------|
|          | 22-24       | 25-27 | 28-30  | 31-33 | 34-36 |
| 6-9      | 1 —         | 6 —   | 3 —    | 1 —   | — —   |
| 10-13    | — —         | 4 —   | 12 (1) | 1 (3) | — —   |
| 14-17    | — —         | 1 —   | — (1)  | 1 (3) | — (1) |
| 18-21    | — —         | — (1) | — (3)  | — (3) | — (1) |
| 22-25    | — —         | — —   | — (1)  | — (1) | — —   |
| 26-29    | — —         | — —   | — (2)  | — (1) | — —   |

Subfamily **GLYPTORTHINAE** Schuchert & Cooper, 1931

Genus **GLYPTORTHIS** Foerste, 1914

*Glyptorthis* cf. *viriosa* Williams  
(Figs 86-88)

cf. 1974 *Glyptorthis viriosa* Williams: 64; pl. 10, figs 6, 8, 9, 11, 12, 14, 15; pl. 11, figs 1, 2, 4.

DIAGNOSIS. Small biconvex *Glyptorthis* with slightly carinate pedicle valve 81% as long as wide and 34% as deep as long and a brachial valve 30% as deep as long, ventral muscle scar 82% as long as wide and 25% as long as valve.

DESCRIPTION. Small biconvex *Glyptorthis* with slightly obtuse cardinal angles; pedicle valve







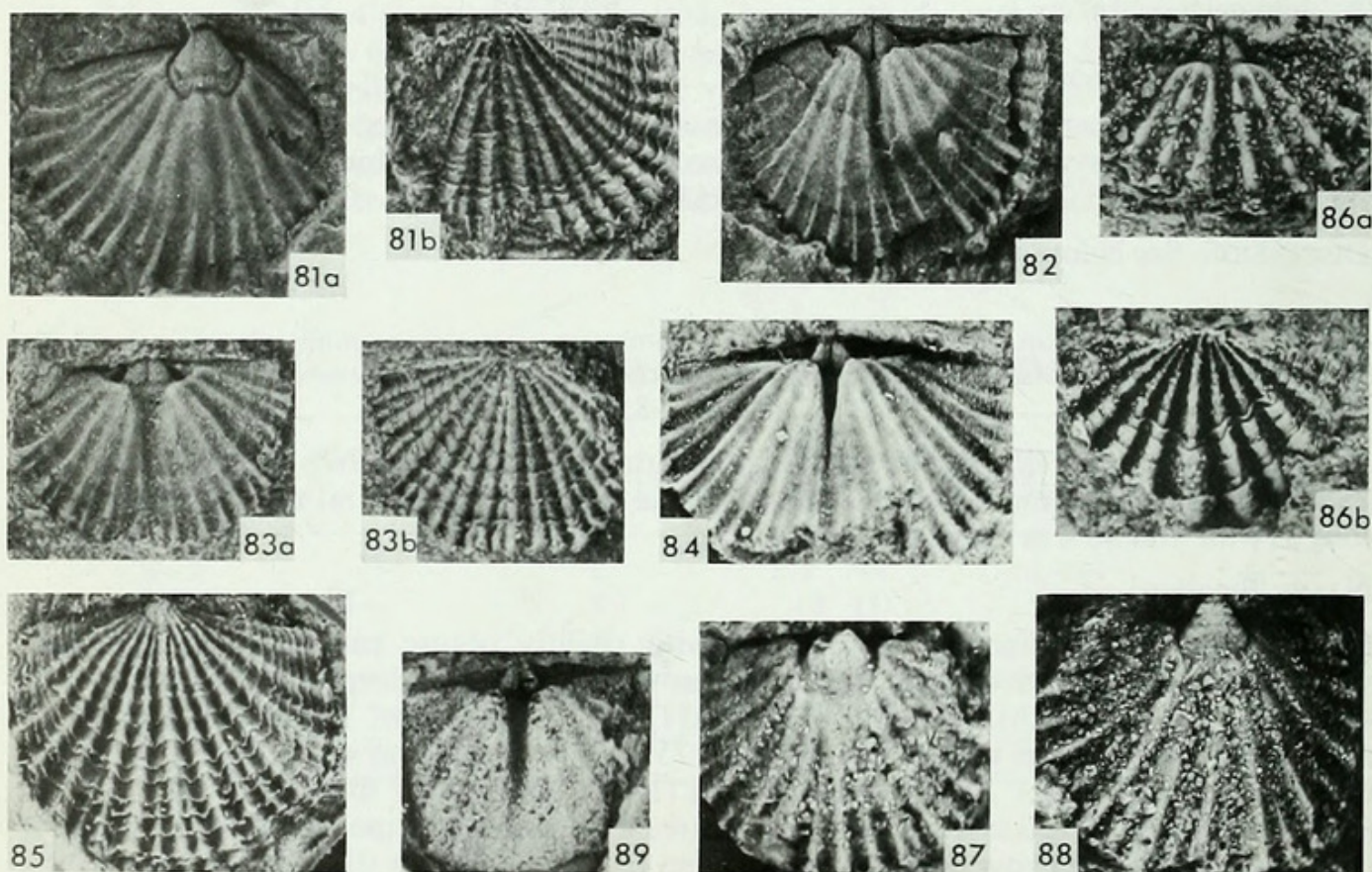
adductor scars subrectangular and about one-third as wide as muscle field, diductor scars longitudinally divergent.

Dorsal interior with simple, blade-like cardinal process and blunt divergent brachioophores defining simple sockets and with bases extending forward for 20% of length of valve and occupying 28% of valve width (i.e. 51% as long as wide:  $\bar{l}$  mm (var 1) 0.80 (0.080),  $\bar{w}$  mm (var w) 1.57 (0.087),  $r$  0.937 in 6 valves); the floor of notothyrial cavity with transverse muscle tracks is bounded anteriorly by poorly-defined notothyrial platform passing anteriorly into well-defined median ridge, adductor muscle scars obscure.

#### TYPE MATERIAL

|                                                        |          | length | width |
|--------------------------------------------------------|----------|--------|-------|
| <b>Holotype</b> , internal and external moulds of p.v. | BB 92315 | 5.0    | 7.0   |
| Paratype, internal and external moulds of b.v.         | BB 92316 | 4.9    | 6.4   |
| "                                                      | BB 92317 | 3.6    | 5.0   |
| "                                                      | BB 92318 | 4.5    | 6.0   |
| Paratype, internal mould of b.v.                       | BB 94245 | 4.8    | 6.0   |

**HORIZON AND LOCALITY.** BB 92315–8 and 94245 are from the argillaceous lower part of the Flags and Grits in the middle of the Ffairfach Group, Ffairfach railway cutting, Ffairfach, Llandeilo (SN 628211).



**Figs 81–85** *Glyptorthis viriosa tumida* subsp. nov. Figs 81a, b, **holotype** BB 92315, internal and external moulds of a pedicle valve  $\times 6$ ; Fig. 82, paratype BB 92316, internal mould of a brachial valve  $\times 6$ ; Figs 83a, b, paratype BB 92317a, b, internal and external moulds of a brachial valve  $\times 6$ ; Fig. 84, paratype BB 92318, internal mould of a brachial valve  $\times 6$ ; Fig. 85, paratype BB 94245, latex cast of external mould of a pedicle valve  $\times 6$ ; all from the Flags and Grits, Ffairfach Group, type section.

**Figs 86–88** *Glyptorthis* cf. *viriosa* Williams. Figs 86a, b, BB 92321, internal and external moulds of a brachial valve  $\times 4$ ; Figs 87–88, BB 92320 and 92319 respectively, internal moulds of two pedicle valves, both  $\times 6$ ; all from Llanvirn sandstones, Howey Brook, Llandrindod.

**Fig. 89** *Glyptorthis* sp. BB 92295, internal mould of a brachial valve  $\times 4$ , from Middle Llandeilo Limestone, Pontbren Araeth, Llandeilo. (See p. 33).



**DISCUSSION.** The two penecontemporaneous populations described here are morphologically similar. Seven characters were tested and the only significant differences were in the relative length of the ventral muscle scar and the shape of the cardinalia ( $0.02 < p < 0.01$  in both cases). Since both the ventral muscle scar and the dorsal cardinalia are known to have been affected by allometrical changes during growth, it is probable that these differences are related to the difference in mean size between the two populations. In the sample of smaller specimens both the ventral scar and the cardinalia are considerably wider than they are in the collection of larger shells. An examination of the ribbing in both populations reveals that they are virtually identical; in juvenile brachial valves up to 4 mm in width the primary costae and  $1\bar{a}$  are the only ribs noted. Large brachial valves exhibit simple internal branching with  $1\bar{a}1$  and  $4\bar{a}1$  noted in the dorsal valves of both populations;  $1\bar{b}$  occurs, only rarely, in Ffairfach dorsal valves.

Comparisons between the two samples described here and *G. viriosa* Williams (1974 : 64) from the Shelve Caradoc indicate the essential homogeneity of the Ordovician *Glyptorthis* from England and Wales, but there are differences. The ventral muscle scars of both Welsh forms are significantly different from that of the Shelve stock. If these differences are allometrically induced, variations in the relative depth of the brachial valves are more important. The average valve of the Ffairfach sample is not only deeper than its Shelve counterpart but it deepened at a significantly faster rate during growth. This difference in growth also tends to set the Ffairfach sample apart from the Howey Brook *Glyptorthis*. The brachial valves of the latter appear deeper than those of the former but not significantly so, and their rate of deepening was actually much closer to that of the Shelve specimens.

These complex differences in growth and inherent shape characteristics suggest that in the Lower Ordovician the Anglo-Welsh *Glyptorthis* was subject to an unusually high rate of speciation. The evidence is admittedly based on small samples and needs further investigation. For the time being, however, it seems reasonable to erect a new subspecies based on the Ffairfach sample and to compare the Howey Brook specimens with *G. viriosa* s.s.

Recent studies of the Llandeilo Series in the type area have revealed the sporadic occurrence of *Glyptorthis* (sp. indet.) at horizons in the *Lloydolithus lloydi* Flags, the *Marrolithus maturus* Beds and the *Marrolithoides anomalis* Limestones of the Middle Llandeilo. A brachial valve (BB 92295) from the *M. anomalis* Limestones exposed in the old quarry beside the road in Pontbren Araeth Dingle SN 659237) is figured here (Fig. 89).

#### Family PLECTORTHIDAE Schuchert & Le Vene, 1929

##### Subfamily PLECTORTHINAE Schuchert & Le Vene, 1929

##### Genus CORINEORTHIS Stubblefield, 1939

##### *Corineorthis pustula* Williams, emended (Figs 90–101)

1851 *Orthis turgida* M'Coy pars : 399–400.

1852 *Orthis turgida* M'Coy; Sedgwick & M'Coy pars : 299; pl. 1H, figs 20, 22, 24, non figs 21, 23.

1949 *Corineorthis pustula* Williams : 230.

1961 *Corineorthis biconvexa* MacGregor : 180; pl. 19, figs 1–6.

**DIAGNOSIS.** Dorsibiconvex, subcircular *Corineorthis* with brachial valve over one-quarter as deep as long and pedicle valve becoming slightly resupinate in late growth stages, multicostellate with hollow ribs numbering about 4 per mm; bilobed ventral muscle scar averaging 46% as long as valve and over three-fifths as wide as long.

**DESCRIPTION.** Dorsibiconvex, large *Corineorthis* with obtuse cardinal angles; pedicle valve with typically orthoid to subpentagonal outline and maximum depth posteromedially where a slight fold is developed, anterior part of valve flat with incipient resupination occurring sporadically in a few large valves, averaging 91% as long as wide ( $\bar{l}$  mm (var 1) 14.75 (6.351),



$\bar{w}$  mm (var w) 16.20 (9.682),  $r$  0.745 in 22 valves) and 21% as deep as long ( $\bar{l}$  mm (var l) 15.07 (7.869),  $\bar{t}h$  (var th) 2.93 (0.746),  $r$  0.801 in 7 valves); brachial valve sulcate, strongly convex with steep lateral and anterior slopes, averaging 82% as long as wide ( $\bar{l}$  mm (var l) 13.61 (11.927),  $\bar{w}$  mm (var w) 16.66 (18.231),  $r$  0.896 in 35 valves) and 28% as deep as long ( $\bar{l}$  mm (var l) 13.92 (10.091),  $\bar{t}h$  (var th) 3.84 (0.883),  $r$  0.864 in 19 valves); ventral interarea curved apsacline with narrow open delthyrium subtending an acute angle of between 30° and 40°, dorsal interarea curved anacline with narrow open notothyrium; external ornament multicostellate with ribs numbering 2, 3 and 4 per mm at 5 mm anteromedially of the umbo in respectively 1, 5 and 1 dorsal valves, commonly between 7 and 9 primary ribs with dominantly internal branching in sectors I–III and both internal and external branching in sectors IV–VII; crests of costellae perforated by regularly-spaced exopunctae numbering 3 per mm at 5 mm anteromedially of the umbones of 3 ventral valves, finely developed concentric ridges between costellae number 7, 8, 9 and 10 per mm at the same growth stages in 2, 2, 1 and 1 pedicle valves.

Teeth short, stout, triangular with well-developed crural fossettes, supported by variably-developed dental plates averaging 20% as long as valve in 13 specimens (range 13 to 31%) and averaging 80% as long as wide in 15 specimens (range 56 to 123%); ventral muscle scar bilobed, consisting of a pair of diductor impressions averaging 46% as long as valve ( $\bar{l}$  mm (var l) 14.53 (6.734),  $\bar{l}sc$  (var lsc) 6.71 (1.346),  $r$  0.875 in 17 valves) and 62% as wide as long ( $\bar{l}$  mm (var l) 6.97 (1.644),  $\bar{w}$  mm (var w) 4.36 (0.638),  $r$  0.708 in 20 valves), and separated medially by a pair of elongated adductor impressions consisting of two closely adjacent parallel ridges arising along the median line at about one-quarter of the valve length from the umbo and extending to the anterior edge of the scar complex, where they pass into a single thicker ridge representing the *vascula media* which bifurcate just forward of the muscle field to enclose the posterior part of a subtriangular anteromedian depression; the posterolateral sectors of most pedicle valves are characterized by coarse pustules which are slightly elongated along radial lines.

Cardinal process simple, bladelike and variable in length averaging 22% as long as valve in 13 specimens (range 14 to 33%), nototyril platform passing forward, beyond the anterior end of the brachiophore bases, into a median septum which extends towards the commissure for about half of valve length before subsiding rapidly to the valve floor (averaging 49% as long as valve in 6 specimens ( $\bar{l}$  mm (var l) 13.05 (22.495),  $\bar{l}s$  (var ls) 6.33 (3.567),  $r$  0.971); brachiophores stout, up to about 20% as long as valve with variably developed platelike bases averaging 17% as long as valve ( $\bar{l}$  mm (var l) 12.58 (13.546),  $\bar{l}c$  (var lc) 2.15 (0.431),  $r$  0.727 in 16 valves) and almost three-quarters as long as wide (average 72% for 17 valves; range 48 to 114%); simple deep sockets bounded anterodorsally by sporadically developed fulcral plates; quadripartite adductor scars only faintly impressed and sporadically developed, between two-thirds and half as long as valve in smaller and larger valves respectively and about three-quarters as long as wide with posterior pair of scars separated from anterior pair by transverse ridges; faint, anastomosing radial, pustular markings ornament the posterolateral sectors of a few of the larger valves.

## FIGURED MATERIAL

|                                             |             | length | width |
|---------------------------------------------|-------------|--------|-------|
| Internal mould of b.v. . . . .              | GSM 75266   | 18     | 22    |
| " . . . . .                                 | BB 94222    | (10)   | 10    |
| " . . . . .                                 | BB 94075    | 4.8    | 5.0   |
| " . . . . .                                 | GSM TCC.360 | 15     | 16    |
| Latex cast of b.v. internal mould . . . . . | GSM 75262   | 18     | 22    |
| Latex cast of b.v. external mould . . . . . | GSM 75263a  | 17     | 19    |
| " . . . . .                                 | BB 94225    | 13     | 14    |
| Internal mould of p.v. . . . .              | BB 94077    | 16     | 17    |
| " . . . . .                                 | BB 94076    | 12     | 12.5  |
| " . . . . .                                 | BB 94218    | 12     | 14    |
| " . . . . .                                 | BB 94219    | (12)   | (14)  |
| Latex cast of p.v. internal mould . . . . . | GSM TCC.357 | 18     | 20    |



**HORIZONS AND LOCALITIES.** Lectotype SM A.16679 and syntypes SM A.44972–5 from Lower Llandeilo Beds near Llandeilo, exact horizon and locality unknown; SM A.34078–81, GSM 75262–6, BB 94075–7 and BB 94216–25 from late Lower Llandeilo, *Corineorthis* Flags, exposed 70 m SW of St Tyfei's Church, Dynevor Park, Llandeilo (SN 623222); GSM TCC.357 and 360 from late Lower Llandeilo calcareous flags exposed in bank 320 m NE of Cwrt-y-Gorphwys cottage, 1 km SW of Ffairfach (SN 620207).

**DISCUSSION.** The species *C. pustula* Williams was founded on the basis of 'syntypes' from the St Tyfei's Church locality in Dynevor Park. It is therefore unfortunate that the lectotype (SM A.16679) selected by Cocks (1978 : 53), although the basis for one of Sedgwick & M'Coy's original figures (1852 : pl. H, fig. 20), originates from an unknown locality. In the Llandeilo region the species is at present known from late Lower Llandeilo strata exposed at Pontbren Araeth (Wilcox 1979 : 46) and from the Cwrt-y-Gorphwys and Dynevor Park localities noted above. Since the latter best-known locality, which is the nearest to Llandeilo, yields material entirely similar to the lectotype in its calcareous, partially orange-weathered matrix, it is possible that the lectotype originates from this locality.

A sufficient number of external moulds were available to emend the ribbing data presented by Williams (1949 : 231). Ribs  $1\bar{a}$ ,  $1\bar{b}$ ,  $1$ ,  $2\bar{a}$ ,  $2\bar{b}$ ,  $2$ ,  $3\bar{a}$ ,  $3\bar{b}$ ,  $3$ ,  $4\bar{a}$ ,  $4\bar{b}$ ,  $4$ ,  $5\bar{a}$ ,  $5\bar{b}$ ,  $5$ ,  $6\bar{a}$ ,  $6\bar{b}$ ,  $6$ ,  $7\bar{a}$  and  $7$  occurred in 3 out of 4 brachial valves between 10 and 14 mm in length, whilst  $2\bar{a}$ ,  $3\bar{b}$ ,  $3\bar{a}$ ,  $4\bar{b}$ ,  $4\bar{a}$ ,  $6\bar{a}$ ,  $6\bar{b}$ ,  $6\bar{a}$  and  $7\bar{a}$  also occurred in 2 of these 4 valves.

M'Coy (1851 : 399–400) originally included various representatives of the genera *Salopia* and *Corineorthis* in his species *Orthis turgida* and Williams (1949) and MacGregor (1961) have attempted to distinguish between representatives of these genera occurring in the Ordovician rocks of north and south Wales. In so doing MacGregor (1961 : 180) erected a new species from a locality in the Berwyn Hills 5 km SW of Llanarmon. He discussed the differences between *C. pustula* and his *C. biconvexa*, concluding that the former species had a less convex pedicle valve and more massive brachioophores. The emended description of *C. pustula*, however, indicates that the Dyfed specimens can be moderately convex ventrally and possess variably developed brachioophores. We, therefore, consider *C. biconvexa* to be a junior synonym of *C. pustula*.

With respect to the remaining specimens originally described as *O. turgida* by M'Coy, the lectotype (SM A.11100) selected by Williams is a *Salopia* (see p. 53) whilst the material from near 'Conway Falls', Gwynedd, tentatively assigned by Williams (1949 : 233–234) to *Corineorthis globosa* has since been referred to *Salopia globosa* by MacGregor (1961 : 182), Diggins & Romano (1968 : 46) and Cocks (1978 : 82).

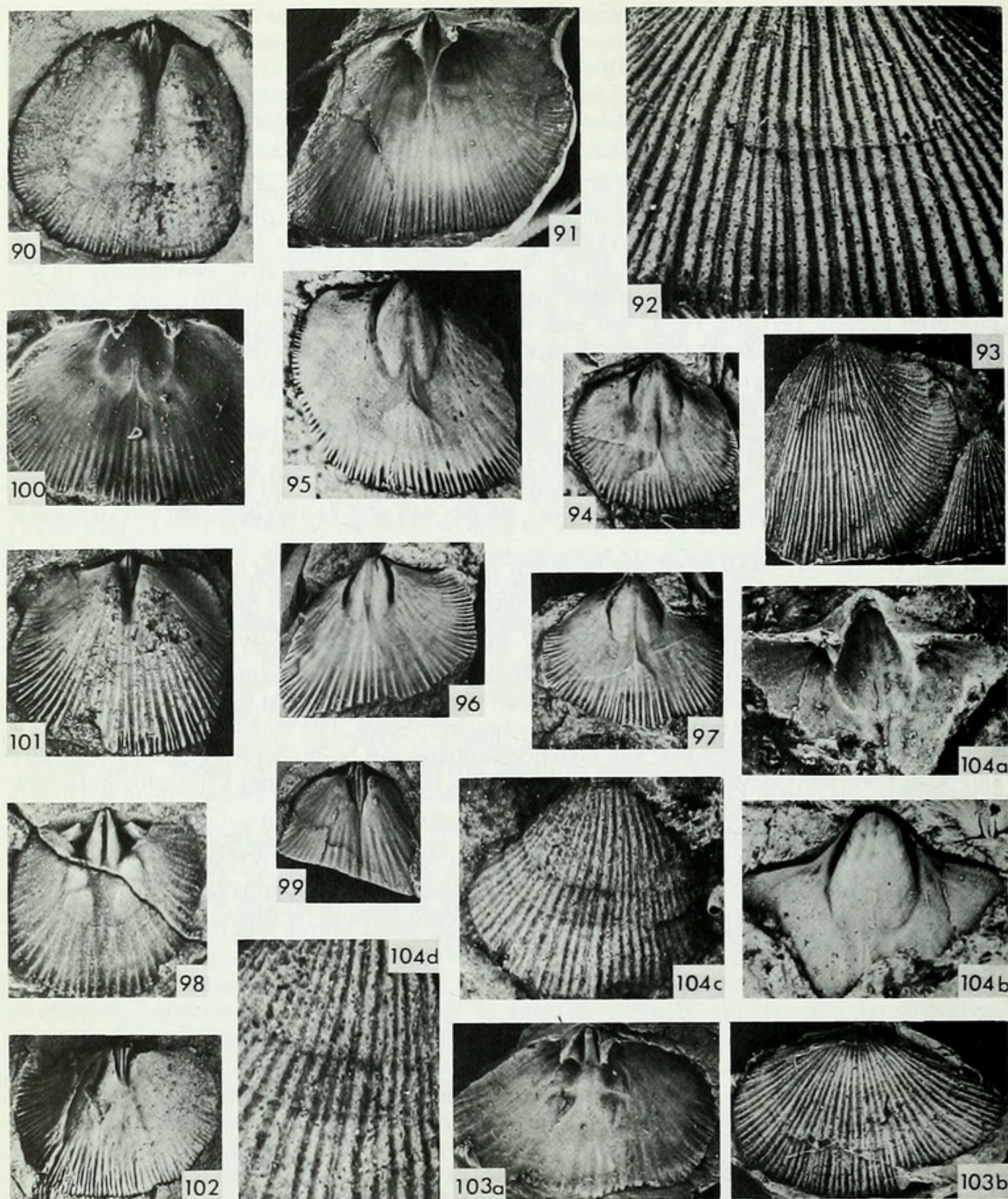
***Corineorthis* cf. *pustula* Williams**  
(Figs 102–103)

**DESCRIPTION.** *Corineorthis* with convex brachial valve two-thirds to three-quarters as long as wide and about one-seventh as deep as long; interarea anacline; multicostellate ornament consisting of  $1\bar{a}$ ,  $1\bar{b}$ ,  $1$ ,  $2\bar{a}$ ,  $2\bar{b}$ ,  $2$ ,  $3\bar{a}$ ,  $3\bar{b}$ ,  $3$ ,  $4\bar{a}$ ,  $4\bar{b}$ ,  $4$ ,  $5\bar{a}$ ,  $5\bar{b}$ ,  $5$ ,  $6\bar{a}$ ,  $6\bar{b}$ ,  $6$ ,  $7\bar{a}$ ,  $7\bar{b}$ ,  $7$ , etc., in the only known external mould; cardinal process simple, dividing notothyrial cavity and extending forward via notothyrial platform towards the median septum; brachioophores stout, up to one-quarter as long as valve and slightly more divergent than long, with bases converging anterodorsally to unite with notothyrial platform; sockets bounded anteriorly by fulcral plates; quadripartite adductor scar enclosed posterolaterally by radiating ridges; anterior pair of adductor scars triangular, separated from posterior pair by transverse ridges.

**FIGURED MATERIAL**

|                                              |             | length | width  |
|----------------------------------------------|-------------|--------|--------|
| Internal mould of b.v. . . . .               | SM A.104415 | 12     | 15     |
| Internal and external moulds of b.v. . . . . | SM A.104416 | (7.8)  | (11.5) |





**Figs 90–101** *Corineorthis pustula* Williams. Fig. 90, GSM 75266, internal mould of a brachial valve showing muscle scars  $\times 2$ ; Fig. 91, GSM 75262, latex cast of internal mould of a brachial valve  $\times 2$ ; Figs 92–93, BB 94225 and GSM 75263a respectively, latex casts of external moulds of brachial valves  $\times 6$  and  $\times 3$ ; Figs 94–97, BB 94076, 94077, 94219 and 94218 respectively, internal moulds of pedicle valves, all  $\times 2$ ; Figs 98–99, BB 94075 and 94222, internal moulds of brachial valves  $\times 6$  and  $\times 2$ ; all from Lower Llandeilo beds, St Tyfei's, Dynevor Park, Llandeilo. Fig. 100, GSM TCC.357, latex cast of internal mould of pedicle valve  $\times 1.5$ ; Fig. 101, GSM TCC.360, internal mould of brachial valve  $\times 2$ ; both from Lower Llandeilo beds, Cwrt y Gorphwys, Llandeilo.



**HORIZON AND LOCALITY.** Both specimens from *Glyptograptus teretiusculus* to *Nemagraptus gracilis* shales exposed in the River Wye section (SW bank) at Penddol, 1.5 km north of Builth Wells (SO 031522).

**DISCUSSION.** This is the first record of *Corineorthis* occurring in the Builth area.

*Corineorthis* sp.

(Figs 104a–d)

Internal and external moulds of two *Corineorthis* pedicle valves (BB 92296–7) from the lower, argillaceous part of the Flags and Grits Formation of the Ffairfach Group exposed in the type section (SN 628211) resemble *C. pustula* in style and distribution of costellae (3 to 4 per mm at the 5 mm growth stage) and exopunctae (about 3 per mm at 5 mm), and in the development of their ventral muscle scars, pedicle callist and *vascula media*. They differ from *C. pustula*, however, in being considerably more convex, with strongly-developed concentric growth lines at intervals of 1 to 2 mm. They also lack internal pustules although this is not necessarily a diagnostic feature.

The difference in profile of the pedicle valves from Ffairfach and those attributable to *C. pustula* s.s. may be because of the small size of the Ffairfach specimens, which are associated with an assemblage of relatively small individuals of other brachiopod species. In any event the Ffairfach specimens represent the earliest record of the genus yet reported.

Subfamily **ORTHOSTROPHIINAE** Schuchert & Cooper, 1931

Genus *GELIDORTHIS* Havlíček, 1968

*Gelidorthis cennenensis* sp. nov.

(Figs 105–111)

**DIAGNOSIS.** Small, mucronate, ventribiconvex *Gelidorthis* with coarse radial costellae and strongly sulcate dorsal valve.

**NAME.** From Cennen Brook, Dyfed, which flows through Ffairfach.

**DESCRIPTION.** Small, transversely subquadrate, ventribiconvex mucronate *Gelidorthis* with strongly acute cardinal angles becoming rounded and obtuse in large adults; pedicle valve carinate, averaging 75% as long as wide in 31 specimens and 25% as deep as long ( $\bar{l}$  mm (var 1) 3.62 (1.627),  $\bar{th}$  (var  $\bar{th}$ ) 0.91 (0.086),  $\bar{r}$  0.671 in 13 valves), ventral interarea apsacline; brachial valve strongly sulcate averaging 66% as long as wide ( $\bar{l}$  mm (var 1) 2.24 (0.816),  $\bar{w}$  mm (var  $\bar{w}$ ) 3.38 (1.386),  $\bar{r}$  0.934 in 41 valves) and 21% as deep as long ( $\bar{l}$  mm (var 1) 3.19 (0.796),  $\bar{th}$  (var  $\bar{th}$ ) 0.67 (0.073),  $\bar{r}$  0.898 in 13 valves); dorsal interarea flat anacline with an open notothyrium defined by divergent boundaries; radial ornamentation consisting of relatively angular costellae numbering between 4 and 5 per mm at 2 mm anterior of the umbo in 6 brachial valves, branching dominantly internal in brachial valves (e.g.  $1\bar{a}1$ ,  $1\bar{a}$ ,  $1$ ,  $2\bar{a}1$ ,  $2\bar{a}$ ,  $2$ ,  $2\bar{a}$ ,  $3\bar{a}$ ,  $3$ ,  $3\bar{a}$ ,  $4\bar{a}$ ,  $4$ ,  $5\bar{a}$ ,  $5$  etc.); concentric growth lamellae sporadically developed towards anterior commissure with fine, regularly developed growth fila, numbering at least 20 per mm, observed in larger valves.

Ventral interior with short divergent dental plates extending forward for an average of 17% of valve length ( $\bar{l}$  mm (var 1) 2.81 (1.033),  $\bar{dl}$  (var  $\bar{dl}$ ) 0.48 (0.049),  $\bar{r}$  0.869 in 14 valves) and a

**Figs 102–103** *Corineorthis* cf. *pustula* Williams. Fig. 102, SM A.104415, internal mould of a brachial valve  $\times 2$ ; Figs 103a, b, SM A.104416a, b, latex casts of internal and external moulds of a brachial valve, both  $\times 3$ ; all from Llandeilo shales, Penddol, Builth.

**Figs 104a–d** *Corineorthis* sp. BB 92297. a, latex cast  $\times 4$  of b, internal mould of pedicle valve  $\times 4$ , c, latex cast of external mould  $\times 4$  and d, detail of same  $\times 6$ , from Flags and Grits, Ffairfach Group, type section.



length to maximum lateral extension (w) ratio of 52% ( $\bar{dl}$  mm (var dl) 0.48 (0.049),  $\bar{w}$  mm (var w) 0.92 (0.050),  $r$  0.819 in 14 valves), muscle field indistinct and obscured by internal ribbing.

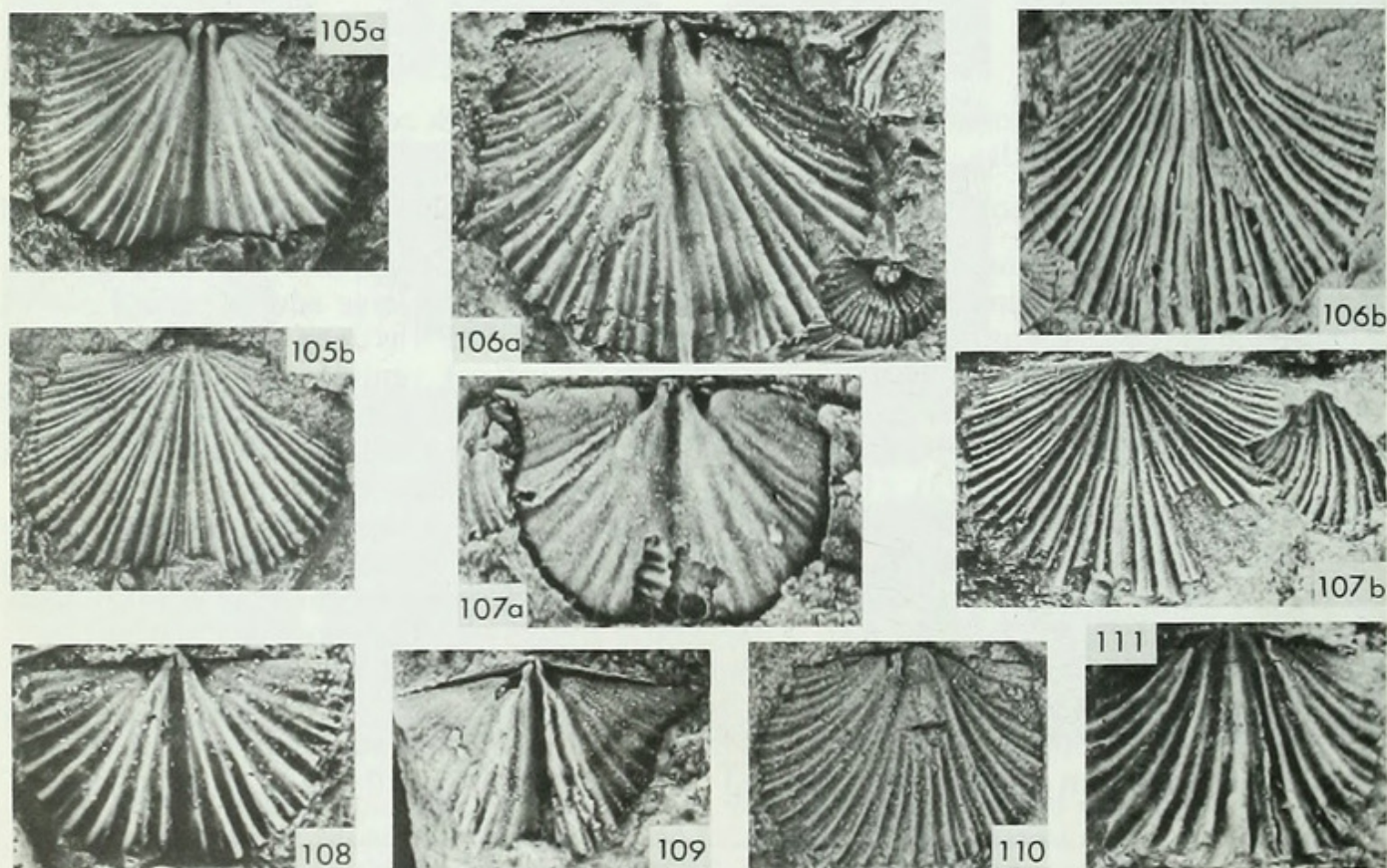
Dorsal interior with simple short brachiophores with bases extending forward for an average of 14% of valve length and averaging 47% as long as wide (l mm (var l) 0.35 (0.025), w mm (var w) 0.74 (0.030),  $r$  0.281 in 18 valves); sockets simple, frequently poorly developed; notothyrial cavity divided by a simple ridge-like cardinal process which extends forward to commissure as a high angular median septum.

#### TYPE MATERIAL

|                                                        |          | length | width |
|--------------------------------------------------------|----------|--------|-------|
| <b>Holotype</b> , internal and external moulds of b.v. | BB 92326 | 4.2    | 5.8   |
| Paratype, internal mould of p.v.                       | BB 92323 | 6.0    | 8.0   |
| „ internal and external moulds of b.v.                 | BB 92324 | 4.3    | 5.8   |
| „ „                                                    | BB 92327 | 2.8    | 4.5   |
| „ „                                                    | BB 92328 | 6.0    | 6.8   |
| „ „                                                    | BB 92329 | 2.9    | 4.4   |
| „ internal and external moulds of p.v.                 | BB 92325 | 3.5    | 4.5   |
| „ „                                                    | BB 92330 | 2.0    | 2.6   |

**HORIZON AND LOCALITY.** All specimens from the argillaceous lower part of the Flags and Grits in the middle of the Ffairfach Group, railway cutting, Ffairfach, Llandeilo (SN 628211).

**DISCUSSION.** *Gelidorthis* has recently been recognized in the Ordovician of Britain by Williams (1974: 74), who identified Upper Llandeilo specimens from Shropshire as *G.* cf.



**Figs 105–111** *Gelidorthis cennenensis* sp. nov. Figs 105a, b, holotype BB 92326a, b, internal mould and latex cast of external mould of a brachial valve  $\times 6$ ; Figs 106a, b, 107a, b, paratypes BB 92328a, b and 92324a, b respectively, internal and external moulds of brachial valves, all  $\times 6$ ; Figs 108–109, paratypes BB 92329 and 92327 respectively, internal moulds of brachial valves, both  $\times 6$ ; Figs 110–111, paratypes BB 92323 and 92325 respectively, internal moulds of pedicle valves  $\times 4$  and  $\times 6$ ; all from the Flags and Grits, Ffairfach Group, type section.



*partita* (Barrande). The Shropshire stock is similar in size outline and ventral morphology to the present species but the former lacks 'a definite sulcus...' (*op. cit.*: 74) and is immediately distinguishable from the Ffairfach shells. Since the new species is represented by a large sample, it has been possible to present a more thoroughly quantitative description of it than is available for *G. partita* and indeed for the four Caradocian species from Bohemia (Havlíček 1977: 79–84), all of which are considerably larger, and in many respects unlike the Ffairfach form.

Subfamily **PLATYSTROPHIINAE** Schuchert & Le Vene, 1929

Genus *MCEWANELLA* Foerste, 1920

*Mcewanella berwynensis* MacGregor  
(Figs 112–122)

1961 *Mcewanella berwynensis* MacGregor: 183; pl. 19, figs 9–15.

**DESCRIPTION.** Biconvex, plicate *Mcewanella* with 4 pedicle valves averaging 86% as long as wide (range 75–95%) and about one-quarter as deep as long and 6 brachial valves averaging 78% as wide as long (range 67–94%:  $\bar{x}$  mm (var l) 8.28 (3.56),  $\bar{w}$  mm (var w) 10.67 (4.67),  $r$  0.886) and about one-quarter as deep as long; ventral interarea flat apsacline, delthyrium open; dorsal interarea orthocline to slightly anacline, notothyrium open; exterior ornamented by angular costae numbering 8 and 10 in 1 and 4 brachial valves, with fine radial costellae on and between costae; dorsal fold, bearing two median costae, developed in larger valves.

Ventral interior with short, stout dental lamellae supporting simple teeth; muscle field simple diamond-shaped, over one-third as long as valve and about as wide as long.

Dorsal interior with simple blade-like cardinal process extending forward for about one-fifth of valve length and becoming thickened towards the anterior edge of the notothyrial platform, whence the median septum extends towards the commissure, subsiding to valve floor in anterior half of valve; brachiophores short, thick with bases extending forward for an average of 21% of length of 4 valves and an average of 50% of their maximum lateral extension in four specimens; sockets simple with obscure fulcral plates.

**FIGURED MATERIAL**

|                                          |          | length | width |
|------------------------------------------|----------|--------|-------|
| Internal mould of b.v. . . . .           | BB 92331 | (10)   | 12    |
| " . . . . .                              | BB 94069 | 8.2    | 11    |
| " . . . . .                              | BB 94070 | 7.5    | (8)   |
| Exterior of p.v. . . . .                 | BB 94068 | 5.8    | 7     |
| Internal part of exfoliated p.v. . . . . | BB 94067 | 8.2    | 11    |
| Internal mould of p.v. . . . .           | BB 94072 | 5.5    | 5.8   |

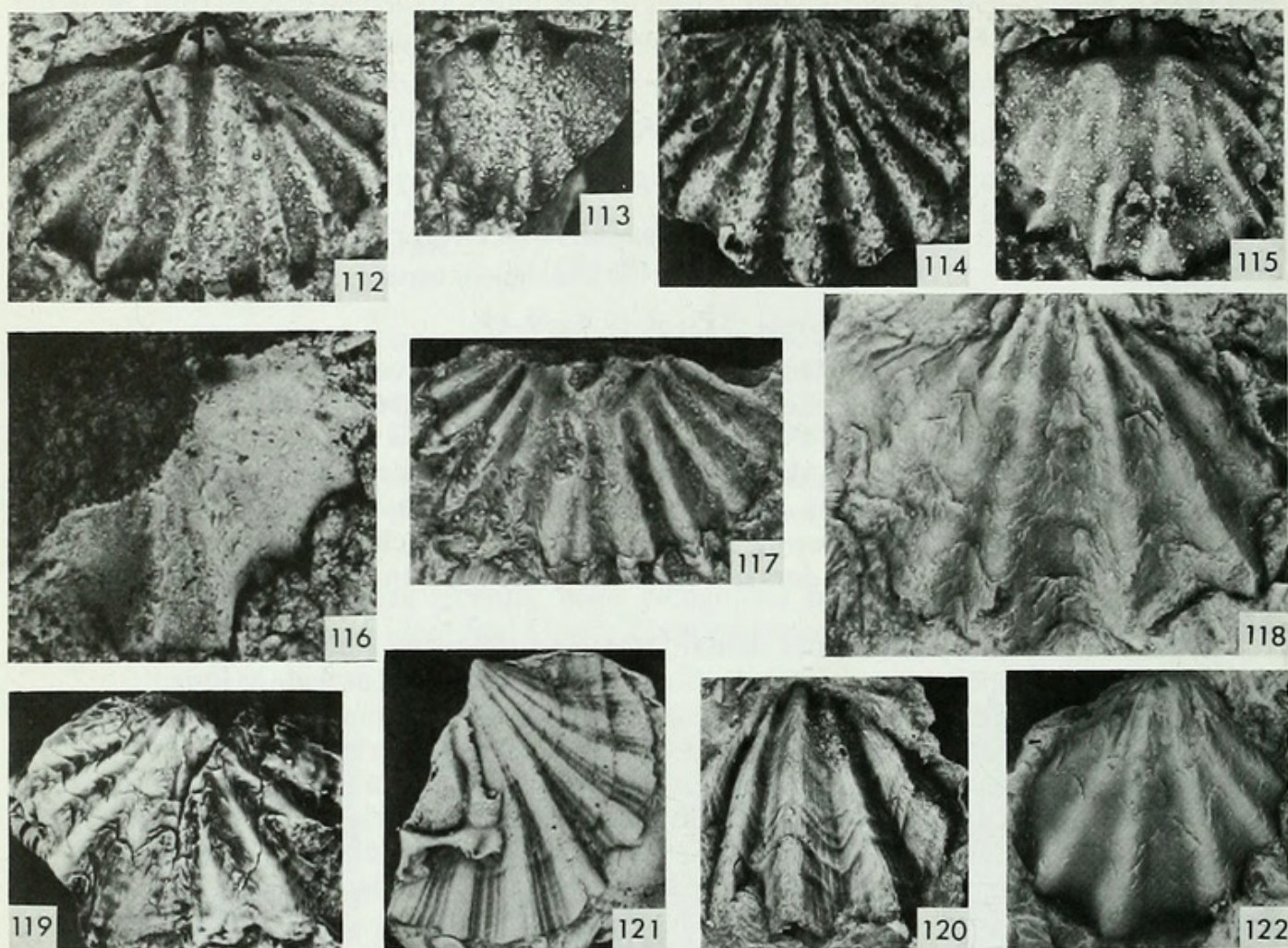
**HORIZON AND LOCALITY.** BB 92331 and BB 94066–72 from tuffaceous sandstones exposed at the top of the small hill just north of Howey Brook, 4 km east of Howey (SO 0925 5915).

**DISCUSSION.** The six brachial, four pedicle and two fragmentary *Mcewanella* valves recovered from the *Didymograptus murchisoni* sandstones of Howey Brook resemble *M. berwynensis* MacGregor (1961: 183) in all morphological features. They constitute a larger and better-preserved sample than those from the type locality and provide some information on the variability of the species. The Bult material also represents the earliest known record of the genus anywhere.

The internal and external parts of an exfoliated *Mcewanella* pedicle valve (BB 92279a, b), the external mould of a brachial valve (BB 94073) and exfoliated exteriors of two brachial valves (BB 92280 and BB 94074a, b) from the Lower Llandeilo *Sowerbyella* Beds exposed beside the old track in the Deer Park (SN 609223) also resemble *M. berwynensis* in all observed features (Figs 118–120). Moreover Addison (1974: 42) reported *Mcewanella* from the Upper Llandeilo Bryn Glas Limestones exposed at Llan Mill, west of Lampeter Velfrey. A specimen (GSM 11965) from this locality (Fig. 121) substantiates this record while GSM



specimens Pr. 652-3, the internal and external parts of an exfoliated *Mcewanella* brachial valve (Fig. 122), have been collected from 'Llandeilo' beds exposed at Clog-y-fran Farm, west of St Clears, Dyfed (SN 161238 approx.). These identifications testify to the widespread, though rare, occurrence of *Mcewanella* in the Lower to Middle Ordovician rocks of Wales.



**Figs 112-122** *Mcewanella berwynensis* MacGregor. Fig. 112, BB 94069, internal mould of a brachial valve  $\times 4$ ; Fig. 113, BB 94072, internal mould of a pedicle valve  $\times 4$ ; Fig. 114, BB 94068, latex cast of the external mould of a pedicle valve  $\times 5$ ; Figs 115-116, BB 94070 and 92331 respectively, internal moulds of brachial valves both  $\times 4$ ; Fig. 117, BB 94067, partially exfoliated pedicle valve  $\times 4$ ; all from Llanvirn sandstones, Howey Brook, Llandrindod. Figs 118-119, BB 92279 and 94074 respectively, partially exfoliated brachial valves  $\times 4$  and  $\times 2$ ; Fig. 120, BB 94073, latex cast of external mould of a pedicle valve  $\times 2.5$ ; all from Lower Llandeilo Limestones, Dynevor Park, Llandeilo. Fig. 121, GSM 11965, latex cast of external mould of a brachial valve  $\times 3$ , from Llandeilo Beds, Llan Mill, Lampeter Velfrey, Dyfed. Fig. 122, GSM Pr.652-3, partially exfoliated brachial valve  $\times 2$ , from Llandeilo Beds, Clog y fran, St Clears, Dyfed.

#### Family SKENIDIIDAE Kozłowski, 1929

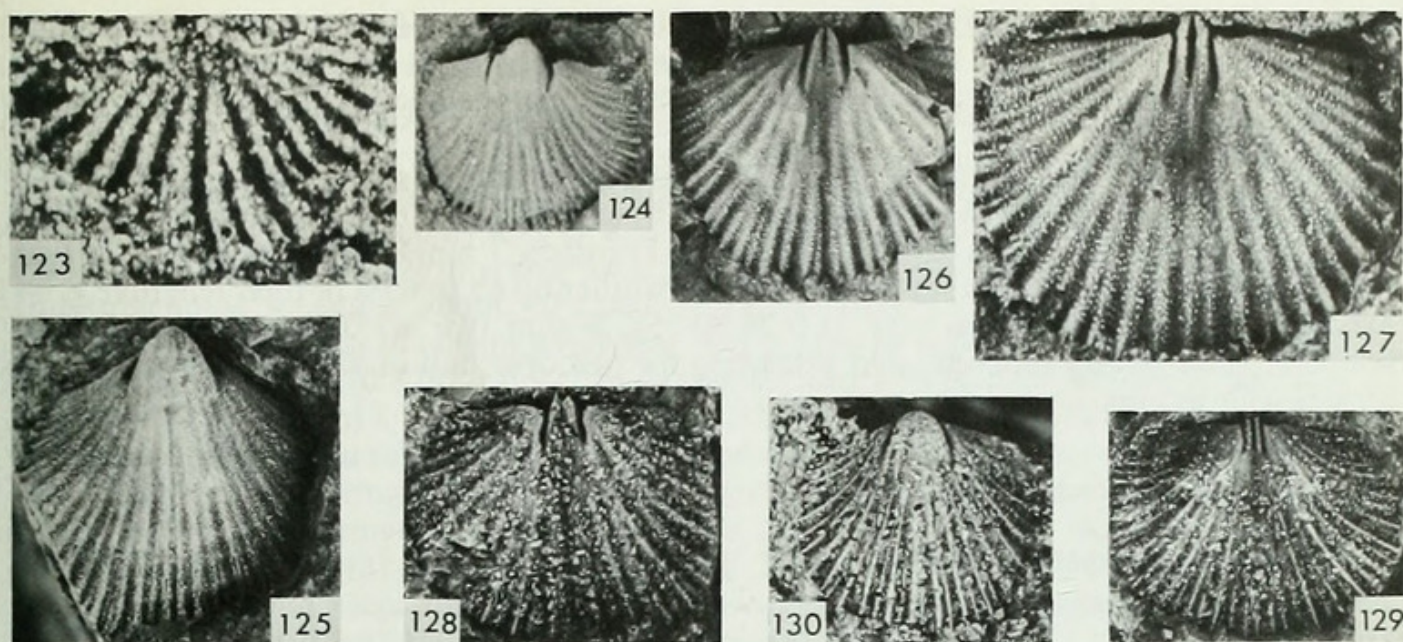
#### Genus *SKENIDIOIDES* Schuchert & Cooper, 1931

#### *Skenidioides* sp.

(Fig. 123)

Two small external moulds of transverse dorsal valves (BB 92332 and a smaller incomplete specimen) from the upper part of the Flags and Grits in the Ffairfach Group, Ffairfach, Llandeilo (SN 628211) are provisionally assigned to *Skenidioides*. The valves are planar to slightly convex and between half to two-thirds as long as wide with acute cardinal angles;





**Fig. 123** *Skenidioides* sp. BB 92332, external mould of a brachial valve  $\times 12$ , from the Flags and Grits, Ffairfach Group, type section.

**Figs 124–130** *Dalmanella parva* Williams. Figs 124–125, BB 92336 and 92333 respectively, internal moulds of pedicle valves  $\times 6$  and  $\times 8$ ; Figs 126–127, BB 92334 and 92335 respectively, internal moulds of brachial valves  $\times 6$  and  $\times 12$ ; all from the Flags and Grits, Ffairfach Group, type section. Figs 128–129, BB 92337 and 92339 respectively, internal moulds of brachial valves both  $\times 6$ ; Fig. 130, BB 92340, internal mould of a pedicle valve  $\times 6$ ; all from Llanvirn sandstones, Howey Brook, Llandrindod.

ornamentation consists of at least 10 dorsal costae with occasional costellae branching internally in the first two sectors; pedicle valve and internal features unknown.

#### Superfamily ENTELETACEA Waagen, 1884

#### Family DALMANELLIDAE Schuchert, 1913

#### Genus *DALMANELLA* Hall & Clarke, 1892

#### *Dalmanella parva* Williams (Figs 124–130)

1949 *Dalmanella parva* Williams : 169; pl. 8, figs 11–14.

1974 *Dalmanella parva* Williams; Williams : 89; pl. 15, figs 1–4, 7.

**DESCRIPTION.** Small, ventribiconvex *Dalmanella* with obtuse cardinal angles; pedicle valve carinate, 80 to 85% as wide as long and 29 to 27% as deep as long (e.g. 45 valves from Ffairfach :  $\bar{l}$  mm (var l) 2.69 (0.862),  $\bar{th}$  (var th) 0.77 (0.084),  $r$  0.912); brachial valve sulcate, 75 to 77% as wide as long (e.g. 111 valves from Ffairfach :  $\bar{l}$  mm (var l) 2.43 (0.362),  $\bar{w}$  mm (var w) 3.22 (0.472),  $r$  0.932) and 20 to 21% as deep as long (e.g. 27 valves from Ffairfach :  $\bar{l}$  mm (var l) 2.79 (0.184),  $\bar{th}$  (var th) 0.59 (0.011),  $r$  0.649); ventral interarea curved apsacline longer than anacline dorsal interarea, delthyrium and notothyrium open, pedicle callist usually conspicuous; radial ornamentation costellate with 5 or 6 ribs per mm, 2 mm anteromedially of the dorsal umbones of 20 specimens; branching simple and almost invariably internal in the brachial valve, e.g. 1, 2 $\bar{a}$ , 2, 3 $\bar{a}$ , 3, 4 $\bar{a}$ , 4, 5 $\bar{a}$ , 5, 6 $\bar{a}$  and 6 were always present in 30 brachial valves but with 4 $\bar{a}$ , 5 $\bar{a}$  and 6 $\bar{a}$  present on the surfaces of 10, 8 and 1 valves.

Ventral interior with small teeth supported by dental plates extending anteriorly for 23 to 27% of pedicle valve length (e.g. 20 valves from Howey Brook :  $\bar{l}$  mm (var l) 3.53 (0.642),  $\bar{dl}$

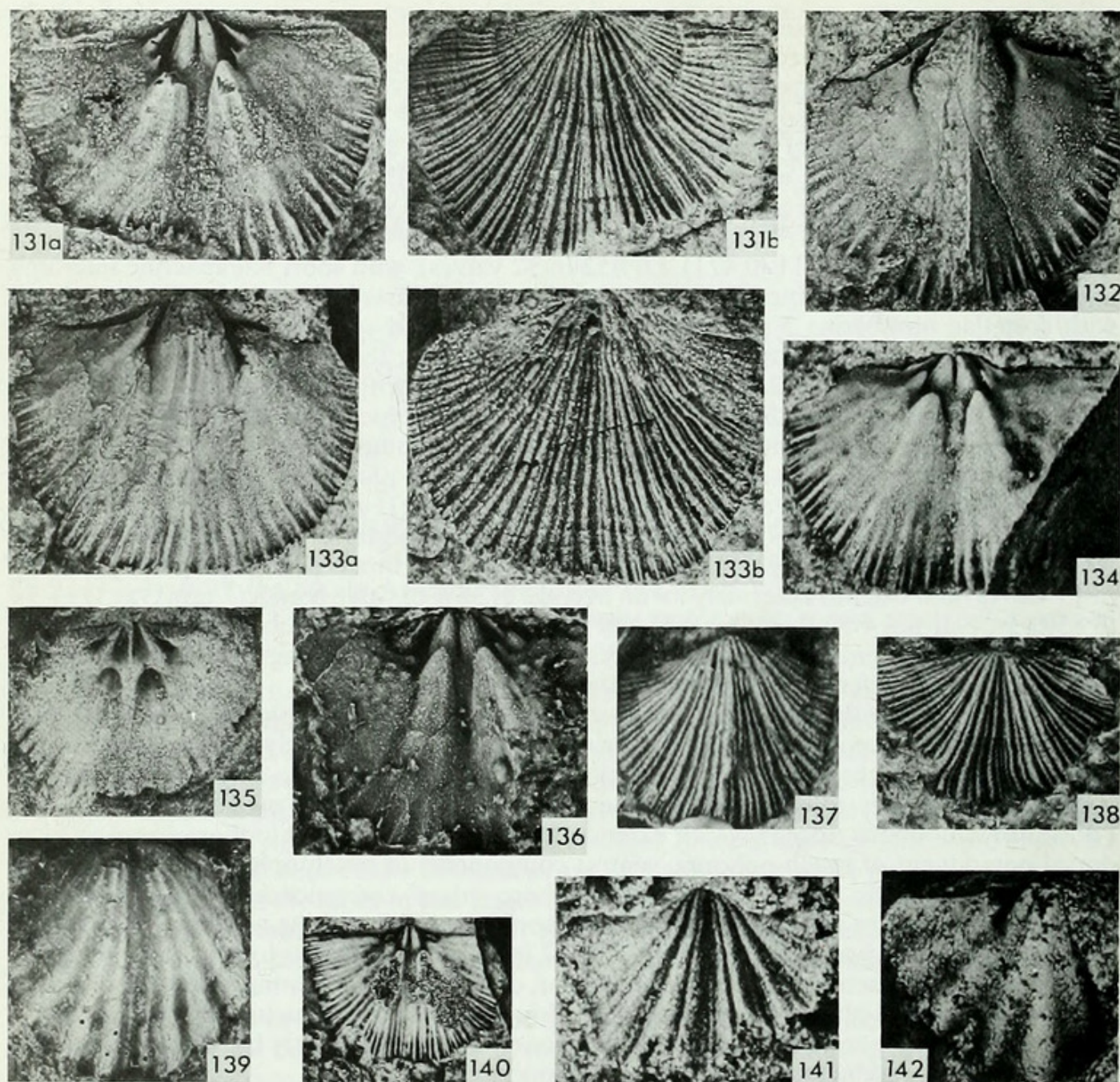


DIAGNOSIS. Ventribiconvex *Horderleyella* with obtuse cardinal angles, a normally carinate



DISCUSSION. See below, p. 45.





**Figs 131–138** *Horderleyella convexa* Williams. Figs 131a, b, BB 92344a, b, internal and external moulds of a brachial valve, both  $\times 3$ ; Fig. 132, BB 92343, internal mould of a pedicle valve  $\times 3$ ; Figs 133a, b, BB 92342a, b, internal and external moulds of a pedicle valve, both  $\times 3$ ; Fig. 134, BB 92346, internal mould of a brachial valve  $\times 4$ ; Fig. 135, BB 92345, latex cast of brachial valve  $\times 3$ ; all from Flags and Grits, Ffairfach Group, type section. Fig. 136, SM A.33345, internal mould of a brachial valve  $\times 4$ ; Figs 137–138, GSM 75247 and 75246 respectively, latex casts of the external moulds of a pedicle and a brachial valve, both  $\times 4$ ; all from Llanvirn Ashes, Bryntowy, Bethlehem.

**Figs 139–142** *Horderleyella* sp. Fig. 139, BB 92477, a brachial valve exterior  $\times 4$ , from Llanvirn beds, Coed Duon, Llanadog (p. 46). Fig. 140, GSM TCC. 362, internal mould of a brachial valve  $\times 2$ , from Lower Llandeilo beds, Cwrt-y-Gorphwys, Ffairfach (p. 46). Figs 141–142, BB 92348 and 92355 respectively, internal and external moulds of pedicle valves, both  $\times 5$ , from the Pebbly Sands, Ffairfach Group, type section.



*Horderleyella* sp.  
(Figs 141–142)

**DIAGNOSIS.** Small transverse mucronate *Horderleyella* with pedicle valve about 70% as long as wide and simple fascicostellate ornament developing from juvenile costate condition.

**DESCRIPTION.** Small ventribiconvex mucronate *Horderleyella* with carinate pedicle valve, sulcate brachial valve and strongly angular fascicostellate bundles. Pedicle valve transverse subtriangular in outline, about 70% as long as wide ( $\bar{l}$  mm (var l) 6.23 (0.934),  $\bar{w}$  mm (var w) 8.85 (1.305),  $r$  0.770 in 11 valves) and about 32% as deep as long in 6 specimens, ventral interarea apsacline; brachial valve wider than long and about 15% as deep as long with anacline interarea; external ornament essentially consisting of up to 8 coarse angular costae but exhibiting the following fasciocostellae in a few pedicle valves: 1b, 1a1a, 1, 2a2a, 3a and 3a; ribbing patterns on brachial valves poorly known; concentric growth lines fine, regularly spaced throughout.

Ventral interior with dental plates and muscle scar respectively extending anteriorly for about one-quarter and two-fifths of valve length.

Dorsal interior with open notothyrial cavity divided by simple cardinal process consisting of slightly differentiated myophore and shaft, notothyrial platform extending forward into broad median septum; brachioophores relatively short, blade-like, supported by bases which are almost as long as wide, sockets supported by fulcral plates with underlying crural pits; adductor scars deeply impressed posteriorly in region of adductor pit but poorly known anteriorly.

**FIGURED MATERIAL**

|                                      |          | length | width |
|--------------------------------------|----------|--------|-------|
| External mould of p.v.               | BB 92348 | (6.0)  | 8.0   |
| Internal and external moulds of p.v. | BB 92355 | 5.6    | 9.2   |

**OTHER MATERIAL**

|                                      |          |       |       |
|--------------------------------------|----------|-------|-------|
| Internal and external moulds of b.v. | BB 92349 | 5.0   | (6.0) |
| "                                    | BB 92352 | 7.9   | 10.0  |
| Internal and external moulds of p.v. | BB 92350 | 8.0   | 10.0  |
| "                                    | BB 92351 | (6.0) | 8.0   |
| External mould of p.v.               | BB 92353 | 7.3   | 11.0  |
| "                                    | BB 92354 | 5.0   | 8.0   |

**HORIZON AND LOCALITY.** BB 92348–55 from the upper part of the Pebbly Sands in the lower part of the Ffairfach Group, Ffairfach railway cutting, Ffairfach, Llandeilo (SN 628211).

**DISCUSSION.** Attempts to collect taxonomically useful samples of both *H. convexa* and *H. lata* from their respective type localities in Long Wood near Bethlehem (SN 693259 and 695262) have proved unsuccessful. However, a large sample of *H. convexa* from the middle part of the Ffairfach Group, which compares with the type material in every respect, has allowed us to assess the variability of this species.

Although we have examined the lectotype (GSM 75245), the paralectotypes (GSM 75246–7) and topotypes (SM A.33345–6) of *H. lata*, insufficient material is available to assess the variability of this 'species' thoroughly. Our observations suggest that, apart from differences in size, these two *Horderleyella* 'species' do not differ substantially in any fundamental morphological respect. Such differences as the differentiation of the ventral muscle scar and the prominence of internal ribbing noted by Williams (1949: 171–173) are most readily attributable to changes in size. We therefore conclude that *H. lata* should be regarded as a synonym of *H. convexa*.

The small sample of *Horderleyella* from the Pebbly Sands is particularly distinctive in that the specimens appear to be persistently coarsely costate; similar forms from the Lower Llandeilo (e.g. BB 94058) are associated with strongly fascicostellate individuals (e.g. BB 94059, see below) of the same size. Although unweathered and partially exfoliated shells, e.g. BB 92476 and 92477 (Fig. 139), appear more strongly costate than any external moulds



of comparable size, such differences are not entirely preservational as *Horderleyella* moulds from the Pebbly Sands (i.e. BB 92348–55) are undoubtedly more coarsely costate than similar-sized moulds of *H. convexa* such as GSM 75246–7 and BB 94059.

Detailed collecting throughout most of the key Upper Llanvirn and Lower to Middle Llandeilo sections of the Llandeilo area revealed the sporadic occurrence of *Horderleyella* in a variety of facies including: BB 92476–7 from loose calcareous blocks from the Flags and Grits Formation of the Ffairfach Group exposed at Coed Duon, 3 km south of Llangadog (SN 709256); BB 94058–9 from the Lower Llandeilo *Sowerbyella* Limestones exposed to the east of the Old Castle in Dynevor Park, Llandeilo (SN 612217); and GSM TCC.362 (Fig. 140) from the Late Lower Llandeilo calcareous Flags exposed 320 m NE of Cwrt-y-Gorphwys Cottage SW of Ffairfach (SN 520207). In addition *H. convexa* occurs abundantly in sandstones and tuffaceous sandstones at various horizons in the Ffairfach Group. In this respect therefore there are no indications that specific *Horderleyella* stocks are exclusively confined to particular stratigraphical horizons, although the forms assigned here to *Horderleyella* sp. cannot at present be shown to be conspecific with *H. convexa*.

Numerous harknessellid species are known from the Ordovician rocks of the Welsh Borderland (Bancroft 1945, Williams 1974), north Wales (MacGregor 1961, Williams 1963) and west Wales (Addison 1974). Until a thorough revision of the family is undertaken, however, we consider it premature to discuss the affinities of *H. convexa*.

### Family HETERORTHIDAE Schuchert & Cooper, 1932

#### Genus *TISSINTIA* Havlíček, 1970

A study of the various *Tissintia* samples recovered during the present investigation has shown that there are three distinct forms of this genus within the Llanvirn and Llandeilo successions of south and central Wales. All three were first identified by Williams in 1949. Two of them, *T. prototypa* and *T. immatura*, have already been revised (Williams 1974 : 108–114) and only the form originally designated '*Resserella immatura* var. *plana*' (Williams 1949 : 167) has to be formally emended.

#### *Tissintia prototypa* (Williams) (Figs 143–151)

1949 *Dalmanella prototypa* Williams : 168; pl. 8, figs 7–10.

1974 *Tissintia prototypa* (Williams) Williams : 108; pl. 17, figs 15–19; pl. 18, figs 1–9, 11.

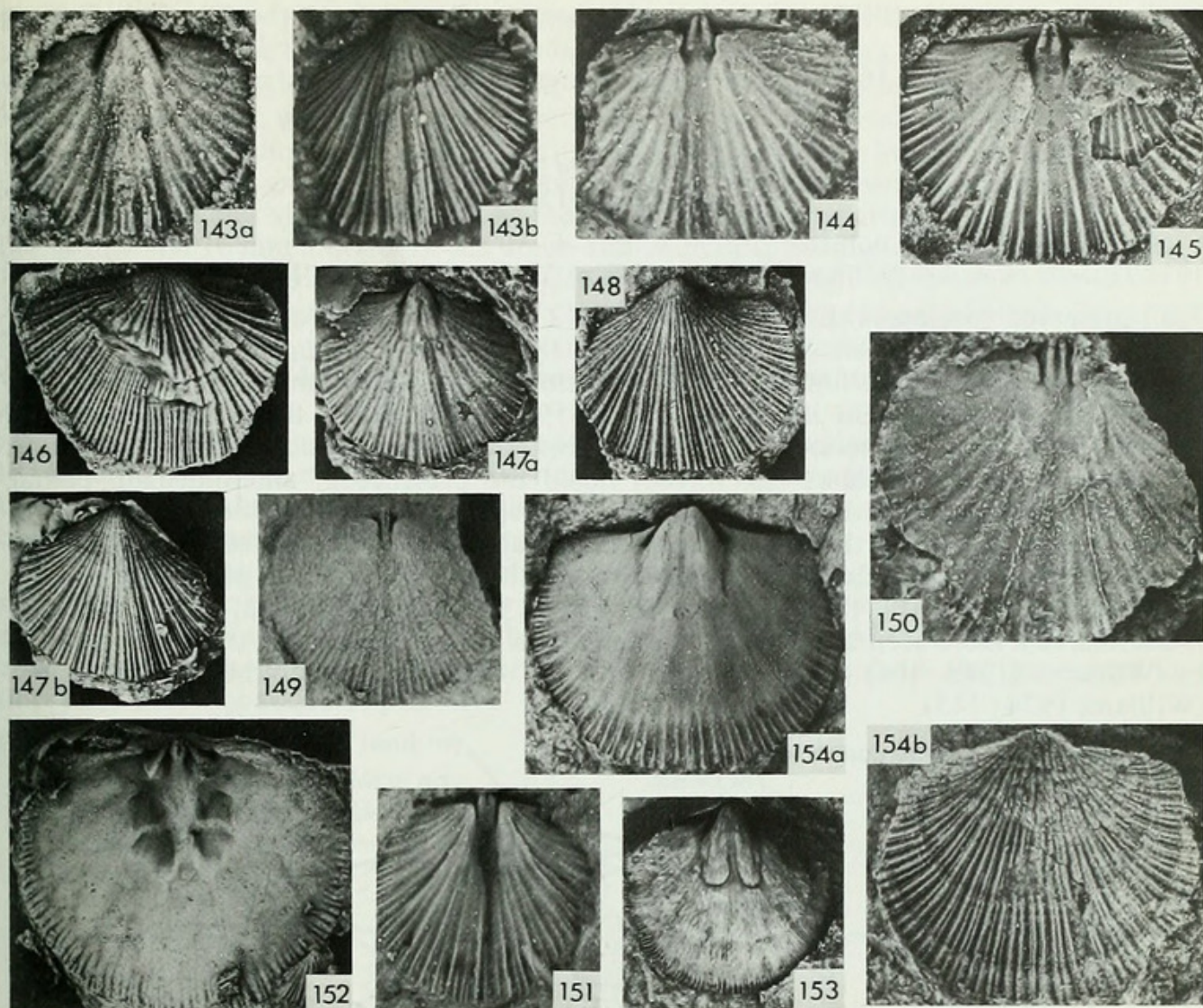
A large sample of *T. prototypa* specimens (including BB 92369, BB 94062–4 and BB 94237–40) from a bivalve-dominated coquina in the *Didymograptus bifidus* Beds exposed in the upper reaches of Camnant Brook, 8 km NE of Builth (SO 088576), resembles the samples described by Williams (1974 : 107–114) from contemporaneous horizons in the Shelve and Llandeilo areas.

Comparisons between the Builth and the Llandeilo samples reveal no significant differences although in the former sample the costellae are slightly coarser, numbering 4 and 5 per mm, 5 mm forward of the umbones in 8 and 2 brachial valves. Although the Shelve specimens also have a higher density of costellae than those from Builth, the two samples differ significantly ( $0.01 < p < 0.001$ ) only in respect of the relative length of their dental plates, which average 20% as long as the valve in the latter sample ( $\bar{l}$  mm (var 1) 6.90 (3.478),  $\bar{dl}$  (var  $dl$ ) 1.37 (0.101),  $r$  0.821 in 30 valves; cf. 14% for the Shelve sample in Williams 1974 : 108; 112, table 81).

The low density of costellae in the Builth specimens is related to the strongly developed fascicostellate style of ornament; the sample also well illustrates the sulcate nature of the brachial valve (cf. Havlíček 1977 : 114) and the variability of the cardinal process.

Numerous small specimens (e.g. BB 92556) of this species have also been recovered from the top of the Upper *Didymograptus bifidus* Beds beneath the Red Agglomerate and Ashes





**Figs 143–151** *Tissintia prototypa* (Williams). Figs 143a, b, BB 94062, internal mould and latex cast of external mould of a pedicle valve  $\times 4$ ; Figs 144–145, BB 94063 and 94064 respectively, internal moulds of brachial valves, both  $\times 4$ ; Fig. 146, BB 92369, latex cast of external mould of a brachial valve  $\times 3$ ; Figs 147a, b, BB 94237, internal mould and latex cast of the external mould of a pedicle valve  $\times 2$ ; Fig. 148, BB 94238, latex cast of the external mould of a pedicle valve  $\times 3$ ; all from Lower Llanvirn shales, Camnant Brook, Builth. Fig. 149, BB 92358, internal mould of a brachial valve  $\times 3$ , from the Llanvirn Bwlch y Cefn tuffs, Llandrindod. Fig. 150, BB 92359, internal mould of a brachial valve  $\times 4$ , from the Llanvirn, Llandegley tuffs, Llandrindod. Fig. 151, BB 92356, internal mould of a brachial valve  $\times 4$ , from Llanvirn shales at Howey Brook, Llandrindod.

**Figs 152–154** *Tissintia immatura* (Williams). Fig. 152, BB 92362, latex cast of internal mould of a brachial valve  $\times 3$ ; Fig. 153, BB 94241, internal mould of a pedicle valve  $\times 1.5$ ; Figs 154a, b, BB 92363a, b, internal and external moulds of a pedicle valve, both  $\times 3$ ; all from Flags and Grits, Ffairfach Group, type section.

(Rhyolitic Tuffs) of Howey Brook, 4 km east of Howey (SO 089592). The dorsal ribbing pattern with 1a) 1b) 1a, 2b) 2a, 2a1 = 2b, 3a1a) 3a, 3c) 3a, 3a1a) 2a, 4b) 4b, and all other observed morphological features compare in every aspect with the emended description given by Williams (1974 : 108–9). Similarly, larger specimens from penecontemporaneous horizons in the Bwlch-y-cefn Tuffs (BB 92357–8) and the Llandegley Tuffs (BB 92359) (SO 120609 and 128614 respectively) can also be assigned to this species. These observations confirm the reports of Williams (1969 : 121) of *D. prototypa* at this horizon in the Builth area.



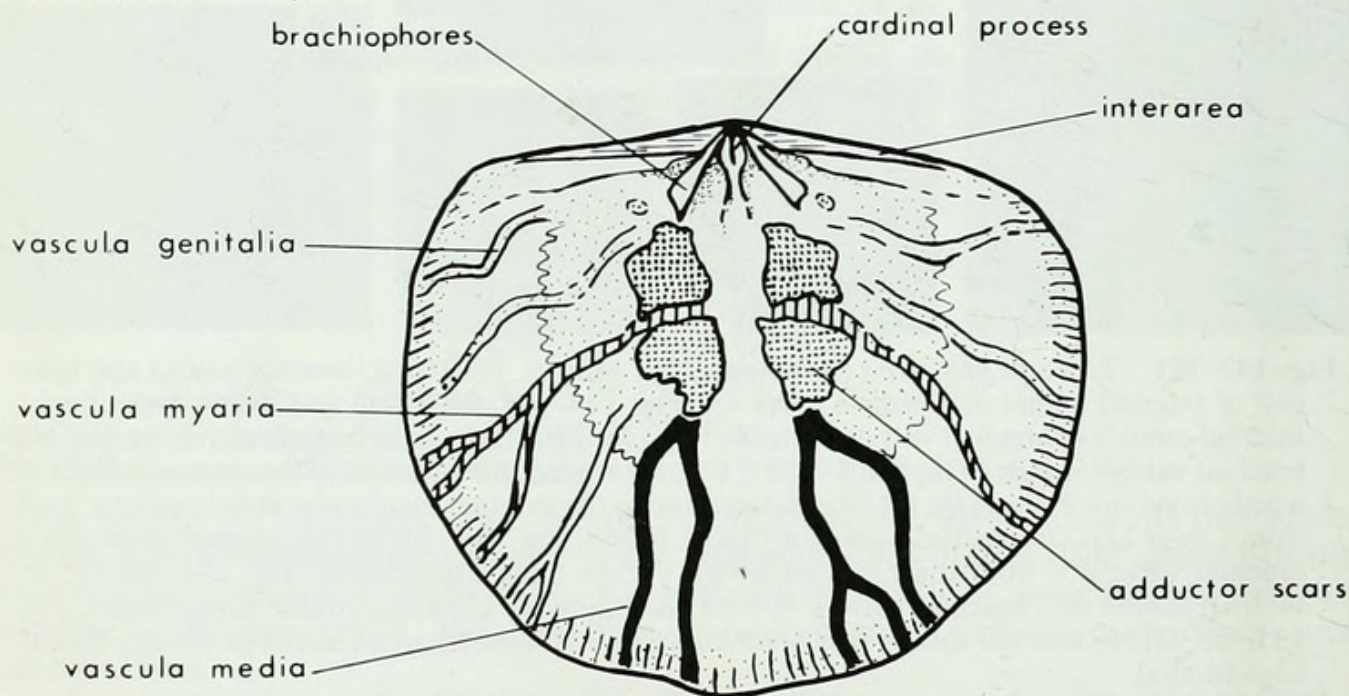
*Tissintia prototypa* (BB 92360-1) has also been recovered from the Ffairfach Grit at Ffairfach (SN 630212). Although known from the underlying Lower Llanvirn *D. bifidus* shales (Williams 1949 : 169; 1974 : 109) this represents the first record of the species in the Ffairfach Group.

***Tissintia immatura* (Williams)**  
(Figs 152-155)

1949 *Resserella immatura* Williams : 165; pl. 8, figs 1-4.

1974 *Tissintia immatura* (Williams) Williams : 109; pl. 18, figs 10, 12-15; pl. 19, figs 1-5.

Well-preserved specimens (BB 92362-3, 94241-2 and 94247) from the argillaceous lower part of the Flags and Grits in the middle of the Ffairfach Group at its type locality (SN 628211) represent the first record of this form in the Upper Llanvirn of this area. The well-preserved specimen BB 92362 (Figs 152, 155) clearly illustrates the presence of mantle canals arising from the anterior and lateral margins of the dorsal adductor scar and radiating to the commissure. Williams (1949 : 166) noted the presence of anteromedian 'pallial sinuses' in Middle Llandeilo representatives of this species but was unable to deduce from that material the extent of the lemniscate mantle canal system evident in this upper Llanvirn representative. Similarly the mainly internally branching multicostellate pattern seen in the specimen, with 1a1 = 1b1, 1b1) 1a, 2b) 2a, 2c) 2a, 2a1) 2b, 3a1a) 3a, 3c) 3a, 4b) 4b, 4a1) 4b1, is considered a more accurate reflection of the typical configuration than the example given by Williams (1949 : 166) and compares with the ribbing facies of the Shelve sample (Williams 1974 : 113).



**Fig. 155** Diagrammatic view of the dorsal interior of *Tissintia immatura* (Williams), based on specimen BB 92362.

***Tissintia plana* (Williams)**  
(Figs 156-162)

1848 *Orthis Testudinaria* Dalman in Phillips & Salter : 373.

1869 *Orthis testudinaria* Dalman; Davidson : 226 pars; pl. 28, fig. 14 only.

1949 *Resserella immatura* var. *plana* Williams : 167; pl. 8, figs 5, 6.

**DIAGNOSIS.** Large ventriconvex *Tissintia* with posteriorly reflexed, partially hollow multicostellae and elongate, subflabellate ventral muscle field averaging almost half as long as valve.



**DESCRIPTION.** Large planoconvex to ventribiconvex, subcircular *Tissintia* with pedicle valve between 69 and 91% as long as wide in 8 specimens and 15 to 21% as deep as long in 5 specimens; brachial valve 72 to 94% as long as wide in 6 specimens and 10 to 11% as deep as long in 2 specimens; ventral interarea slightly curved, apsacline about 10% as long as valve with transverse striations parallel to hinge line and an open delthyrium subtending an angle of about 70°, dorsal interarea short, flat anacline; external ornament consisting of hollow multicostellae reflexed posteriorly along the hinge line and numbering respectively 3 and 2 per mm, 5 and 10 mm anterior of the umbo and branching mainly internally with  $1\bar{a}1$  ( $1\bar{b}$ ,  $1\bar{b}$ )  $1\bar{a}$ ,  $2\bar{b}$ )  $2\bar{a}$ ,  $2\bar{c}$ )  $2\bar{a}$ ,  $2\bar{a}1 = 2\bar{b}$ ,  $3\bar{a}1\bar{a}$ )  $3\bar{a}$ ,  $3\bar{c}$ )  $3\bar{a}$ ,  $3\bar{a}1\bar{a}$ )  $2\bar{a}$ ,  $4\bar{b}$ )  $4\bar{a}1$ )  $4\bar{b}1$ .

Delthyrial cavity deep, bounded laterally by short, thick divergent dental plates extending forward for 16 to 19% of the length of 3 valves and supporting short, stout, divergent teeth with crural fossettes, denticular cavity continuous with pronounced hinge line groove; muscle field extending forward for 44 to 58% of the length of 4 valves (mean 47%) as impressed diductor scars enclosing raised adductor platform divided by fine median ridge up to one-third as wide as muscle field posteriorly but tapering anteriorly to about one-tenth of the field width; diductor scars sublabellate with component lobes separated anteromedially by strongly developed longitudinal ridges.

Cardinal process bilobed, stout, undifferentiated; notothyrial platform passing into short median septum extending forward for about one-third of valve length; sockets simple, enclosed by hinge and short divergent brachioophores with bases 57 to 64% as long as wide and 10 to 16% as long as two measured valves; dorsal muscle field obscure except for impressed posterior adductor pits.

#### FIGURED MATERIAL

|                                              |           | length | width |
|----------------------------------------------|-----------|--------|-------|
| Internal and external moulds of p.v. . . . . | BB 92364  | 23.5   | 27.0  |
| Internal and external moulds of b.v. . . . . | BB 92368  | 17.0   | 18.0  |
| Internal mould of p.v. . . . .               | BB 36164  | 19.5   | 24    |
| Internal mould of b.v. . . . .               | BB 36165  | 18     | 23    |
| " . . . . .                                  | GSM 10341 | 22     | 26    |
| External mould of b.v. . . . .               | BB 36172  | 20     | 25    |
| External mould of p.v. . . . .               | GSM 10341 | 22     | 24    |

#### OTHER MATERIAL

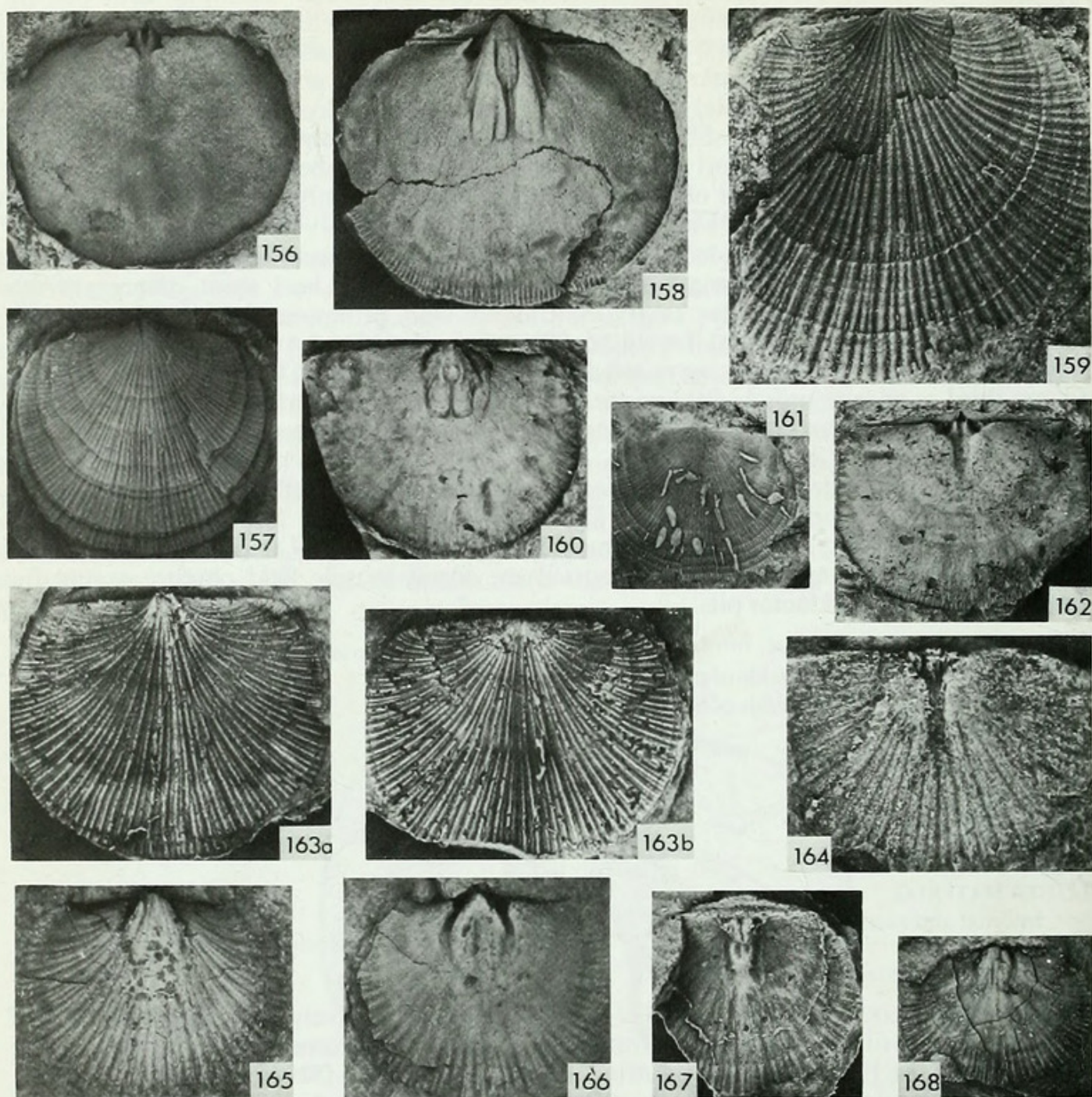
|                                              |          |      |      |
|----------------------------------------------|----------|------|------|
| Internal and external moulds of p.v. . . . . | BB 92365 | 19.5 | 22.0 |
| " . . . . .                                  | BB 92366 | 16.0 | 18.0 |
| Internal and external moulds of b.v. . . . . | BB 92367 | 17.0 | 22.0 |

**HORIZONS AND LOCALITIES.** BB 92364–7 and BB 92368 respectively from the upper part of the Flags and Grits Formation and from the Rhyolitic Conglomerates Formation of the upper part of the Ffairfach railway cutting, Ffairfach, Llandeilo (SN 627210); BB 36164–72 from the calciferous Lower Caradoc Bryn Banc Limestone exposed in old quarry 800 m SSW of Henllan Lodge, Llanddewi Velfrey, Dyfed (SN 131160). GSM 10341–3 from Llandeilo Flags, Pant-dwn 1.5 km SSE of St Clears, Dyfed (SN 289151 approx.); lectotype (selected Cocks 1978 : 74) GSM 75237 from Lower Llandeilo beds exposed in quarry 100 m NE of Pant-y-ffynon, Llandeilo, Dyfed (SN 652228).

**DISCUSSION.** *T. plana* is regarded here as a distinct species since its partially hollow ribs and large size immediately distinguish it from *T. prototypa* and *T. immatura*. Being also characterized by its larger sublabellate ventral muscle scar, it is elevated from a subspecies to a species. Specimens collected from Llanddewi Velfrey by Addison (1974), including BB 36172, also exhibit hollow ribs.

The present studies have shown that the widespread Lower Llanvirn form *T. prototypa* persisted into early Upper Llanvirn (Ffairfach Grit) times, when it was succeeded after a short stratigraphical interval by *T. immatura* and then, in the succeeding formation, by *T. plana*. Thus all three species occur within a 37 m portion of the Ffairfach Group although only the latter two are known with certainty from the Llandeilo Series of the type area.





**Figs 156–162** *Tissintia plana* (Williams). Figs 156–157, GSM 10341, internal mould of a brachial valve and latex cast of the exterior of a pedicle valve, both  $\times 1.5$ , from Llandeilo Flags, Pant-dwfn, St Clears, Dyfed. Fig. 158, BB 92364, internal mould of a pedicle valve  $\times 1.5$ , from the Flags and Grits, Ffairfach Group, type section. Fig. 159, BB 92368, external mould of a brachial valve showing moulds of hollow ribs  $\times 3$ , from the Rhyolitic Conglomerates, Ffairfach Group, type section. Fig. 160, BB 36164, internal mould of a pedicle valve  $\times 1.5$ ; Fig. 161, BB 36172, external mould of a brachial valve  $\times 1$ ; Fig. 162, BB 36165, internal mould of a brachial valve  $\times 1.5$ ; all from Lower Caradoc limestones, Llanddewi Velfrey, Dyfed.

**Figs 163–168** *Tissintia* sp. Figs 163a, b, SM A.46528, latex casts of the external moulds of respectively the pedicle and brachial valves of an articulated specimen, both  $\times 4$ ; Fig. 164, BB 94234, internal mould of a brachial valve  $\times 4$ ; Figs 165–166, SM A.46527 and BB 94233 respectively, internal moulds of pedicle valves, both  $\times 4$ ; Fig. 167, SM A.46525, latex cast of the internal mould of a brachial valve  $\times 3$ ; Fig. 168, SM A.46526, internal mould of a pedicle valve  $\times 2$ ; all from Llandeilo shales, Llanfawr quarry, Llandrindod.



*Tissintia* sp.  
(Figs 163–168)

**DESCRIPTION.** Subcircular, ventribiconvex to planoconvex *Tissintia* with obtuse cardinal angles; pedicle valve averaging 12% as deep as long ( $\bar{l}$  mm (var 1) 5.90 (2.735),  $\bar{th}$  (var th) 0.72 (0.047),  $r$  0.600 in 5 valves) and 80% as wide as long ( $\bar{l}$  mm (var 1) 6.72 (2.972),  $\bar{w}$  mm (var w) 8.58 (4.236),  $r$  0.962 in 12 valves) with slightly carinate median zone; brachial valve averaging 78% as long as wide; ventral interarea planar, apsacline, longer than anacline dorsal interarea; radial ornamentation multicostellate to fascicostellate with 5 and 6 ribs per mm, at 5 mm anteromedially of the umbones of 2 and 3 brachial valves; branching mainly internal in first 5 sectors of brachial valve with posterolateral costellae reflexed towards the hinge line.

Ventral interior with small teeth supported by dental plates which extend forward for between 12 and 25% of valve length in 3 specimens (mean 16%) and laterally for between 50 and 85% of their length in 3 specimens (mean 63%), and enclosing the posterior sector of an elongate bilobed muscle field which is between two-thirds and three-quarters as wide as long and between one-third and two-fifths as long as the valve in two specimens.

Cardinalia unknown, situated behind low median ridge which extends forward for about half of valve length; adductor scars elongate, about half as wide as long and half as long as valve.

**FIGURED MATERIAL**

|                                      |            | length | width |
|--------------------------------------|------------|--------|-------|
| External mould of articulated valves | SM A.46528 | 8.8    | 11    |
| Internal mould of b.v.               | SM A.46525 | 8.5    | 10    |
| "                                    | BB 94234   | 7.5    | 10    |
| Internal mould of p.v.               | SM A.46527 | 7.5    | 9     |
| "                                    | BB 94233   | 7.3    | 8.5   |

**HORIZON AND LOCALITY.** SM A.46525–8, BB 94233–6 and Llandrindod Wells Museum specimen No. 0357/56 from *Nemagraptus gracilis* Shales exposed in Llanfawr Quarry, 0.5 km east of Llandrindod Wells (SO 066617); UCW (Aberystwyth) specimens 23101–5 also from this locality.

**DISCUSSION.** Although the material described here exhibits the reflexed posterolateral costellae and ribbing facies typical of the genus *Tissintia*, insufficient is known of the internal morphology of this form to determine its specific affinities. Until more material is available its relationships to older and to contemporary stocks, i.e. *T. prototypa* and *T. immatura*, remain unknown.

Family **LINOPORELLIDAE** Schuchert & Cooper, 1931

Genus ***SALOPIA*** Williams, 1955

***Salopia turgida*** (M'Coy), emended  
(Figs 169–178)

1851 *Orthis turgida* M'Coy: 339 pars.

1852 *Orthis turgida* M'Coy; M'Coy in Sedgwick & M'Coy: 229 pars; pl. 1H, fig. 21, non figs 20, 22–24.

1949 *Paurorthis turgida* (M'Coy) Williams: 228; pl. 11, figs 9–11.

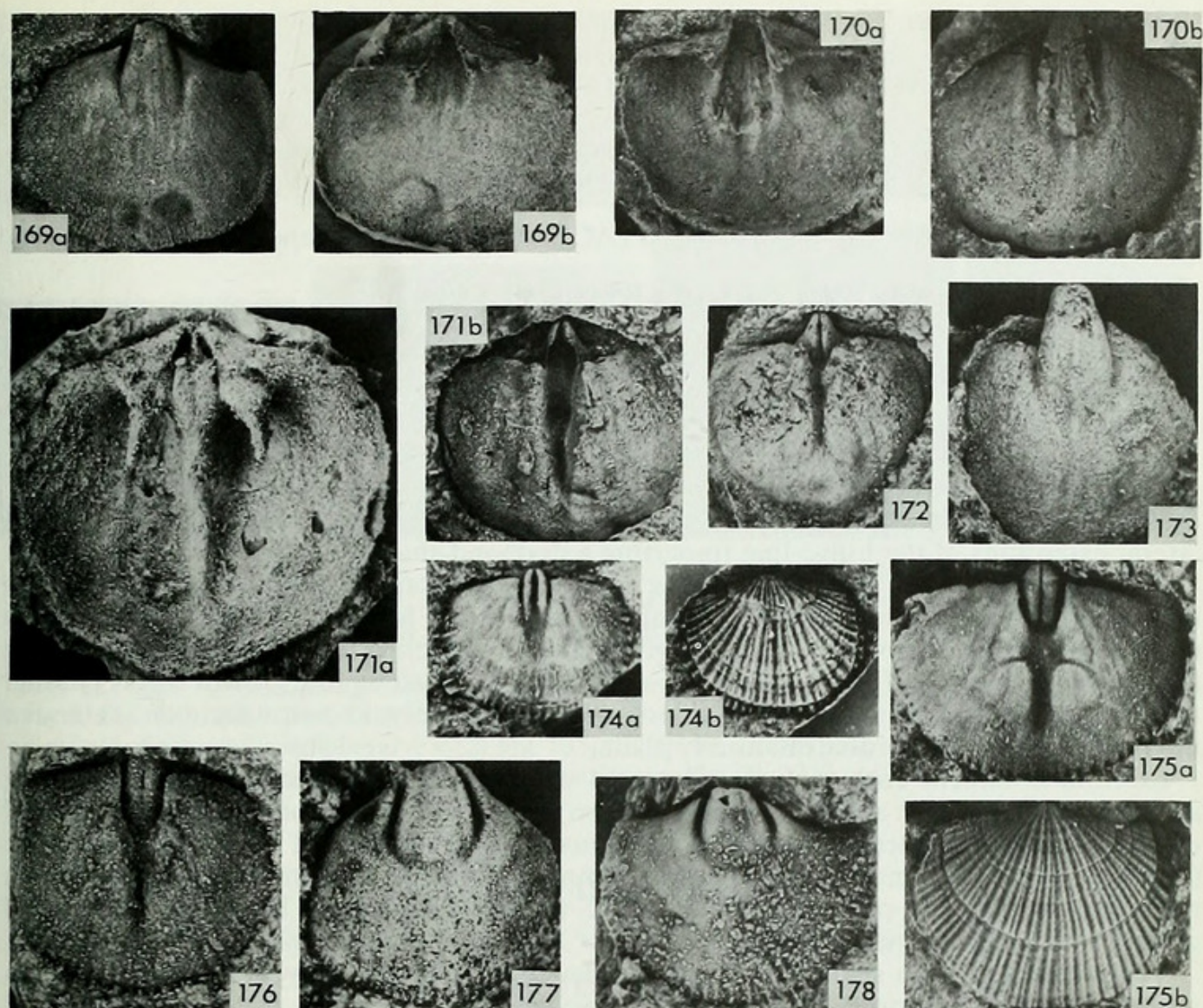
**DIAGNOSIS.** Strongly biconvex, subspherical *Salopia* with multicostellate ornament consisting of 5–6 ribs per mm at 2 mm anteriomedially of umbones; pedicle valve with elongately oval muscle scar about 43% as long as valve; brachial valve with well-developed brachioophores up to 41% as long as valve and a strong median septum extending forward for about three-quarters of the valve length.

**DESCRIPTION.** Strongly biconvex, subspherical, rectimarginate *Salopia* with adult pedicle valve averaging 99% as long as wide and 27% as deep as long ( $\bar{l}$  mm (var 1) 14.94 (5.277),  $\bar{th}$  (var th) 4.00 (0.474),  $r$  0.772 in 25 valves from Ffairfach) with rounded obtuse cardinal









**Figs 169–178** *Salopia turgida* (M'Coy). Figs 169a, b, BB 92370, internal mould and latex cast of a pedicle valve, both  $\times 2$ ; Figs 170a, b, BB 92371, latex cast and internal mould of a pedicle valve, both  $\times 2$ ; Figs 171a, b, BB 92373, latex cast  $\times 3$  and internal mould  $\times 2$  of a brachial valve; Fig. 172, BB 92374, internal mould of a brachial valve  $\times 2$ ; Fig. 173, BB 92372, internal mould of a pedicle valve  $\times 2$ ; all from Pebbly Sands, Ffairfach Group, type section. Figs 174a, b, BB 92376a, b, internal mould and latex cast of the external mould of a brachial valve, both  $\times 6$ ; Figs 175a, b, BB 92375a, b, internal mould and latex cast of the external mould of a brachial valve, both  $\times 6$ , both from Flags and Grits, Ffairfach Group, type section. Fig. 176, BB 92377, internal mould of a brachial valve  $\times 4$ ; Figs 177–178, BB 92379 and 92378 respectively, internal moulds of pedicle valves, both  $\times 4$ ; all from Llanvirn sandstones, Howey Brook, Llandrindod.

When one of us (Williams 1949 : 228) emended the original description of *O. turgida* M'Coy on the basis of a sample from the type Ffairfach section, the species was placed in the genus *Paurorthis*. Examination of the sample described here, from the same horizon and locality, clearly indicates that the species is representative of the genus *Salopia*, which is particularly characterized by well-developed, anteriorly extending brachiophores and a cardinal process which is continuous anteriorly with the median septum; the pedicle valve lacks the prominent anteromedian ridge typical of *Paurorthis*. The two genera also differ in style of ornament and configuration of muscle scars.

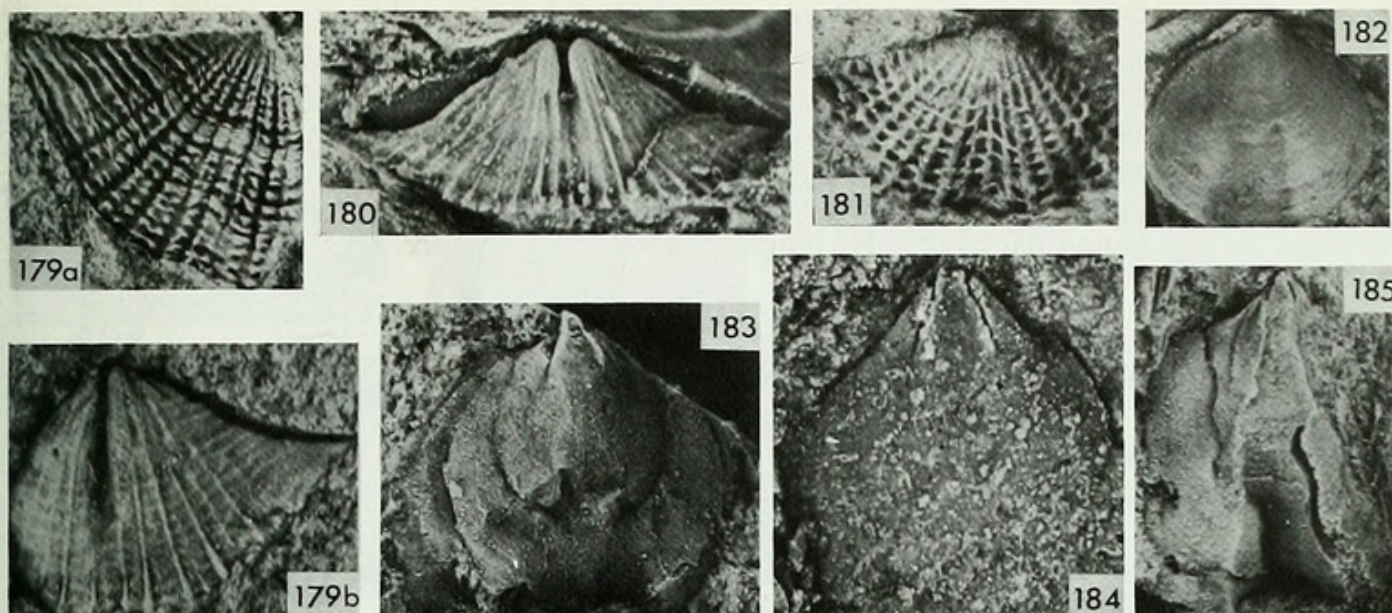
Penecontemporaneous *Salopia* from the Builth area are apparently conspecific with *S. turgida* (M'Coy) and represent the first record of the genus in this area.

Although it would be desirable to investigate the relationship of *S. turgida* (M'Coy) to penecontemporaneous species from north Wales and Shropshire (i.e. *S. globosa* (Williams),









**Figs 179–181** *Kullervo* sp. Figs 179a, b, BB 92380, external and internal moulds of a pedicle valve, both  $\times 6$ ; Fig. 180, BB 92381, internal mould of a pedicle valve  $\times 6$ ; Fig. 181, BB 92400, latex cast of external mould of a pedicle valve  $\times 6$ ; all from the Flags and Grits, Ffairfach Group, type section.

**Figs 182–185** *Triplexia edgelliana* (Davidson). Fig. 182, BB 92386, exterior of a pedicle valve  $\times 4$ ; Fig. 183, BB 92385, internal mould of a pedicle valve  $\times 5$ ; Fig. 184, BB 92399, internal mould of a juvenile pedicle valve  $\times 12$ ; Fig. 185, BB 92395, internal mould of a pedicle valve  $\times 4$ ; all from Flags and Grits, Ffairfach Group, type section. See also Figs 186–191.

Suborder **TRIPLESIIDINA** Moore, 1952

Superfamily **TRIPLECIACEA** Schuchert, 1913

Family **TRIPLECIIDAE** Schuchert, 1913

Genus **TRIPLESIA** Hall, 1859

*Triplexia edgelliana* (Davidson)  
(Figs 182–191)

1869 *Rhynchonella* ? *Edgelliana* Davidson : 190; pl. 24, figs 27, 28.

1978 *Camerella edgelliana* (Davidson) Cocks : 137.

**DIAGNOSIS.** Globular, equally biconvex, plicate *Triplexia* with pedicle and brachial valves respectively 91% and 88% as long as wide and 27% and 29% as deep as long.

**DESCRIPTION.** Globular, biconvex, plicate *Triplexia* with well-rounded obtuse cardinal angles; adult pedicle valve about 90% as long as wide and about 27% as deep as long ( $\bar{l}$  mm (var l) 5.38 (1.45),  $\bar{th}$  (var th) 1.45 (0.477),  $r$  0.761 in 8 valves); ventral umbo slightly acute with short curved apsacline interarea with pseudodeltidium; broad, gently rounded ventral sulcus originating at about the 4 mm growth stage, with boundaries diverging at about  $15^\circ$  so that anteriorly sulcus and corresponding dorsal fold are about one-third as wide as valve in average-sized specimens; brachial valve about 88% as wide as long ( $\bar{l}$  mm (var l) 5.26 (6.529),  $\bar{w}$  mm (var w) 5.97 (9.127),  $r$  0.977 in 21 valves) and about 33% as deep as long ( $\bar{l}$  mm (var l) 4.87 (5.569),  $\bar{th}$  (var th) 1.60 (1.120),  $r$  9.27 in 16 valves) with rounded incurved umbo obscuring very small interarea; external surface smooth except for fine growth lamellae numbering at least 12 per mm anteromedially and most conspicuous towards commissure.

Ventral interior with short, low, divergent dental plates about 23% as long as valve ( $\bar{l}$  mm



(var 1) 4.20 (1.773),  $\overline{dl}$  (var  $dl$ ) 0.96 (0.060),  $r$  0.386 in 9 valves) and about as divergent as long ( $\overline{l}$  mm (var 1) 0.96 (0.060),  $\overline{w}$  mm (var  $w$ ) 0.97 (0.128),  $r$  0.780 in 9 valves) and supporting widely divergent, low transverse teeth; pedicle passage and muscle scars obscure.

Dorsal interior characterized by typical forked cardinal process and widely divergent brachioophores subparallel to hinge to which they are fused except at lateral extremities; a fine, variably developed median ridge extends forward from bulbous anterior base of cardinal process for up to one-quarter of valve length; muscle scars obscure.

| TYPE MATERIAL                                 |           |   | length | width |
|-----------------------------------------------|-----------|---|--------|-------|
| Lectotype, internal mould of p.v.             | GSM 10354 | . | 11     | 13    |
| Paralectotype, internal mould of b.v.         | GSM 10356 | . | (7.5)  | (9)   |
| OTHER FIGURED MATERIAL                        |           |   |        |       |
| Internal and external moulds of p.v.          | BB 92384  | . | 8.0    | 10.0  |
| "                                             | BB 92385  | . | 6.0    | 7.5   |
| "                                             | BB 92386  | . | 5.9    | 6.2   |
| "                                             | BB 92395  | . | 10.0   | —     |
| "                                             | BB 92399  | . | 3.7    | 3.0   |
| Internal and external mould of b.v.           | BB 92387  | . | 5.5    | 6.5   |
| Internal mould of b.v.                        | BB 92393  | . | 7.5    | 8.5   |
| Articulated specimen (p.v. dimensions given). | BB 92394  | . | 6.2    | 7.4   |

**HORIZONS AND LOCALITY.** All material from the Ffairfach Group, Ffairfach railway cutting, Ffairfach, Llandeilo (SN 628211); BB 92384–5, 92389–90, 92392–3, 92395, 92399 and probably GSM 10354–7 from the argillaceous lower part of the Flags and Grits and BB 92386, 92388 and 92394 from the calcareous upper part of the same formation; BB 92387 and 92391 from argillaceous beds in the lower part of the Rhyolitic Ashes and Lavas Formation.

**DISCUSSION.** This species, variously classified by Davidson (1869:190) and Cocks (1978:137), is a triplesiid and is more properly assigned to the genus *Triplesia* because of its distinctive cardinal process and gross morphology.

Several specimens have a crumpled or collapsed appearance suggesting that this typical triplesiid was thin-shelled. Observations on its ontogeny indicate that juveniles prior to the development of plication are typically elongately lobate, averaging 114% as long as wide in 5 observed pedicle valves less than 4 mm in width.

*T. edgelliana* (Davidson) is the oldest triplesiid species known from the Ordovician rocks of Wales; it resembles *T. maccoyana* Davidson from the Lower Bala Group, north Wales except for its significantly shallower dorsal valve (Lockley 1980) and may also ultimately prove to be closely related to the Soudleyan *Triplesia* from Shropshire (Williams 1974:116). Although little is known of the internal characteristics of the Anglo-Welsh *Triplesia*, it is apparent that, despite its sporadic occurrence, the stock retained morphological homogeneity throughout much of the Ordovician.

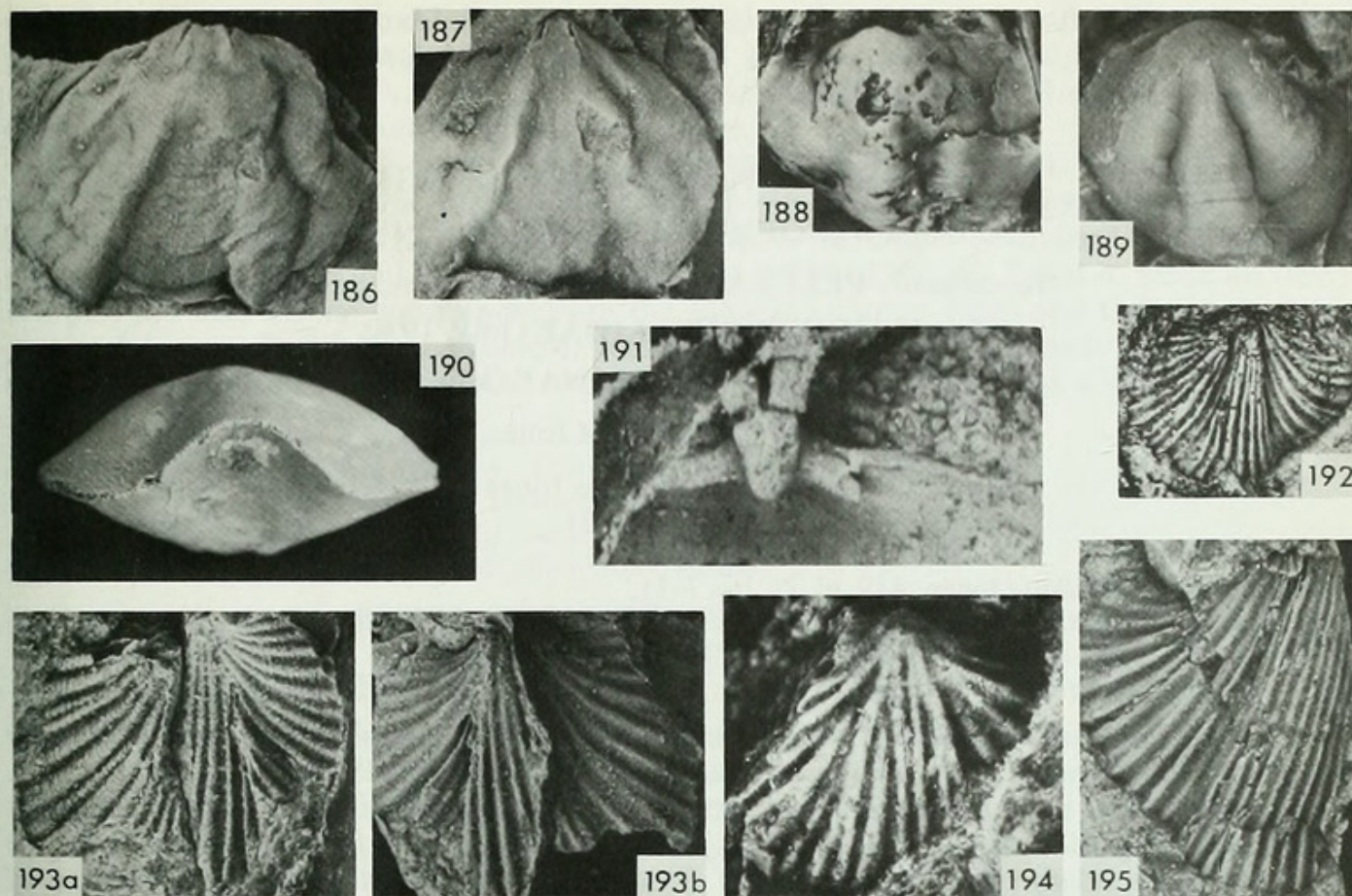
#### Genus *OXOPLECIA* Wilson, 1913

##### *Oxoplecia* cf. *nantensis* MacGregor (Figs 192–195)

cf. 1961 *Oxoplecia nantensis* MacGregor: 196; pl. 20, figs 15–19.

Three brachial valve specimens, BB 92396–8, from the uppermost Rhyolitic Conglomerates Formation of the Ffairfach Group, Ffairfach railway cutting, Ffairfach, Llandeilo (SN 627210) closely resemble *O. nantensis* MacGregor. They are about 84% as long as wide and 28% as deep as long with obtuse cardinal angles and a well-developed dorsal fold. The ornament is costellate with bifurcating ribs and internal and external secondary branches





**Figs 186–191** *Triplesia edgelliana* (Davidson). Fig. 186, BB 92383, internal mould of a pedicle valve  $\times 4$ ; Fig. 187, lectotype GSM 10354, internal mould of a pedicle valve  $\times 3$ ; Fig. 188, paralectotype GSM 10356, internal mould of a brachial valve  $\times 3$ ; Fig. 190, BB 92394, anterior view of articulated valves  $\times 6$ ; Fig. 191, BB 92393, latex cast of cardinal area of brachial valve  $\times 16$ ; all from Flags and Grits, Ffairfach Group, type section. Fig. 189, BB 92387, exterior of a brachial valve  $\times 4$ , from overlying member in same section. See also Figs 182–185.

**Figs 192–195** *Oxoplectia* cf. *nantensis* MacGregor. Fig. 192, SM A.44948 internal mould of a brachial valve  $\times 2$ , from Lower Llandeilo shales, Tre Gib, Llandeilo. Figs 193a, b, BB 92398a, b, external and internal moulds of a brachial valve  $\times 3$ ; Fig. 194, BB 92397, exterior of a brachial valve  $\times 8$ ; Fig. 195, BB 92396, internal mould of a brachial valve  $\times 4$ ; all from the Rhyolitic Conglomerates, Ffairfach Group, type section.

numbering 2–3 per mm, 5 mm anteromedially, with at least 12 costae on each lateral flank and 5 to 8 on the median fold. Concentric ornamentation consists of delicate lamellae numbering 10 and 12 per mm, between 5 and 6 mm anteriorly of the dorsal umbo, in 2 specimens. The internal moulds show only traces of ribs.

#### FIGURED MATERIAL

|                                              |          | length | width |
|----------------------------------------------|----------|--------|-------|
| Internal and external moulds of b.v. . . . . | BB 92396 | 10.5   | 12.0  |
| Exterior of b.v. " . . . . .                 | BB 92398 | 9.5    | 12.0  |
| Exterior of b.v. " . . . . .                 | BB 92397 | 4.0    | 4.5   |

**DISCUSSION.** Williams (1974 : 125) has discussed the differences between *O. nantensis* from the Berwyns and from the Shelve area. It is clear from evidence given above that the Ffairfach specimens resemble those from the Shelve more closely, being virtually identical in dorsal shape, depth and radial ornamentation and differing only in the relative coarseness of the concentric lamellae of the Shelve form. Wilcox (1979) reports *Oxoplectia* (i.e. *Cliftonia* sp. of Williams 1953 : 191 etc.) occurring sporadically throughout the Lower Llandeilo and occasionally in the Middle Llandeilo; SM A.34086–7 are recorded from lower Lower Llandeilo strata exposed at Careg-y-foel-gam farm 3 km SSE of Llangadog (SN 706249



approx.) and SM A.44948 (Fig. 192) originates from Lower Llandeilo exposures at Tregib farm 1 km SSE of Llandeilo (SN 636212). However, BB 92396–8 represent the first record of this form in the pre-Llandeilo rocks of Wales.

Order **STROPHOMENIDA** Öpik, 1934

Suborder **STROPHOMENIDINA** Öpik, 1934

Superfamily **PLECTAMBONITACEA** Jones, 1928

Family **SOWERBYELLIDAE** Öpik, 1930

Subfamily **SOWERBYELLINAE** Öpik, 1930

Genus **SOWERBYELLA** Jones, 1928

*Sowerbyella antiqua* Jones

(Figs 196–212)

1928 *Sowerbyella antiqua* Jones : 419; pl. 21, figs 7–11.

1949 *Sowerbyella antiqua* Jones, var. *llandeiloensis* Williams : 234; pl. 11, figs 12–14.

1961 *Sowerbyella antiqua* Jones; MacGregor : 201; pl. 23, figs 11–15.

1974 *Sowerbyella antiqua* Jones; Williams : 130; pl. 22, figs 4, 7–14; pl. 23, figs 1, 3, 4.

**DISCUSSION.** The taxonomic distinction between the widely distributed Welsh *S. antiqua* Jones and the 'variety' *S. antiqua* Jones *llandeiloensis* Williams (1949 : 234) is ambiguous. Spjeldnaes (1957 : 84) considered the two forms to be specifically distinct, while MacGregor (1961 : 203) regarded the latter taxon as a junior synonym of the former. To ascertain the morphological relationship, specimens of *S. antiqua* from Maes y fallen, the source of Jones' paratypes, and topotypes of *llandeiloensis* from both Dynevor Park localities cited by Williams (1949 : 235), were compared with two collections of *Sowerbyella* from the type Ffairfach succession and with another sample from Coed Duon previously taken to be representative of *S. antiqua* s.s. (Williams 1974 : tables 98, 100–104). All six samples were compared with one from the Builth area and the results are summarized in Tables 3 and 4, which illustrate the extent of statistically useful data.

The syntypes from the coarse Lower Llandeilo sandstones exposed at Maes y fallen are much less well preserved than the remaining samples. There is even some deformation of the rock fabric of the locally inverted succession which has resulted in a slight, yet perceptible,

**Table 3** *Sowerbyella antiqua* (Jones). Percent ratios of pedicle valve length/width (a), length/depth (b), length of muscle scar/valve length (c), length/width of muscle scar (d), brachial valve length/width (e), length of socket ridges/valve length (f), length/width of socket ridges (g), length of septa/valve length (h), length/width of septa (i), and ribbing counts (j) at 2 mm anteromedially of the dorsal umbo, in samples from the Lower Llandeilo at Maes y Fallen (A), Dynevor Park, Old Castle (B) and Dynevor Park boat house (C); also from the Ffairfach Group in the type section (D) and (E), at Coed Duon (F) and from Upper Llanvorn tuffaceous sandstones near Builth Wells (G).

|   | a  | b  | c  | d  | e  | f  | g  | h  | i  | j, ribs per mm |    |    |    |
|---|----|----|----|----|----|----|----|----|----|----------------|----|----|----|
|   |    |    |    |    |    |    |    |    |    | 9              | 10 | 11 | 12 |
| A | 57 | —  | —  | —  | 56 | —  | —  | —  | —  | —              | —  | —  | —  |
| B | 52 | 19 | 33 | 70 | 50 | 10 | 33 | 61 | 91 | 1              | 7  | 10 | 1  |
| C | 52 | 18 | —  | —  | 49 | —  | —  | —  | —  | 2              | 13 | 9  | 5  |
| D | 53 | 24 | —  | —  | 50 | —  | —  | —  | —  | 0              | 8  | 6  | 3  |
| E | 51 | —  | 36 | 74 | 48 | 10 | 31 | 66 | 96 | 1              | 12 | 11 | 5  |
| F | —  | —  | 32 | 74 | 51 | 12 | 36 | 56 | —  | 6              | 30 | 19 | 9  |
| G | 52 | 21 | 35 | 69 | 50 | 12 | 31 | 66 | 83 | —              | —  | —  | —  |



asymmetry in some of the examined specimens. However, sufficient undeformed and well-preserved material was obtained to examine the internal morphology of both valves and show that, although the valves are relatively less transverse than in other samples, the differences in outline are not statistically significant.

Material from the *Sowerbyella* Limestones at the two Dynevor Park localities, cited by Williams (1949 : 235) as the type localities for the *llandeiloensis* variety, are shown to be identical in all respects to the *S. antiqua* sample from the Upper Llanvirn Ffairfach Group exposed at Coed Duon and described by Williams (1974 : 130); see Table 4. Since all three samples are also similar to samples from the Ffairfach Group Flags and Grits at the type section and from Builth Wells (Table 4), it is concluded that the subjectively derived opinion of MacGregor (1961 : 204) that the two forms . . . 'should be united as a single species' is valid.

**Table 4** Distribution of significant differences between morphological characters (a to j, Table 3) in samples A to G of *Sowerbyella antiqua* (Jones).

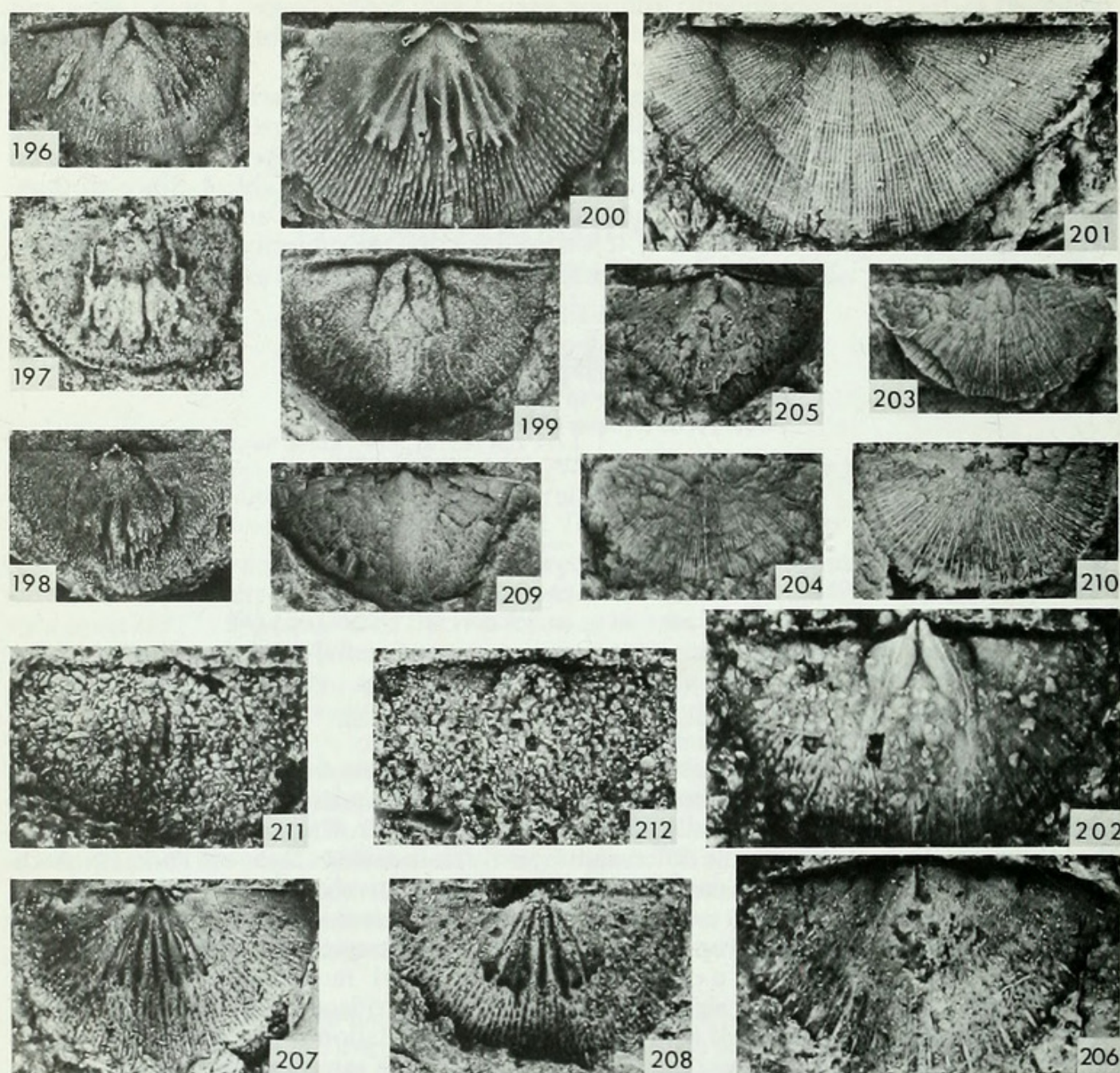
|   |   |   |   |   |       |   |
|---|---|---|---|---|-------|---|
| B | — |   |   |   |       |   |
| C | — | — |   |   |       |   |
| D | — | — | — |   |       |   |
| E | — | g | e | e |       |   |
| F | — | — | — | — | e,g,h |   |
| G | — | — | — | — | f     | — |
|   | A | B | C | D | E     | F |

Unlike the samples discussed above, which were collected from single horizons, the sample from the Rhyolitic Conglomerates Formation of the standard section of the Ffairfach Group was derived from four equally-spaced horizons between 8 and 5 m below the top of the formation. This pooled sample differs significantly from eastern Dynevor Park, Ffairfach Flags and Grits and Coed Duon samples in possessing a relatively more transverse brachial valve ( $0.01 < p < 0.001$ ,  $0.02 < p < 0.01$  and  $0.05 < p < 0.02$  respectively); it differs significantly from the western Dynevor Park and Coed Duon samples in exhibiting relatively divergent socket ridges ( $0.05 < p < 0.02$  and  $0.01 < p < 0.001$  respectively); and from the Builth Wells sample in having significantly shorter socket ridges relative to valve length ( $0.05 < p < 0.02$ ). When compared with the Coed Duon population the relative length of the dorsal septa is significantly greater than in the pooled Ffairfach sample ( $0.001 > p$ ).

These differences in the dorsal morphology of *Sowerbyella* recovered from the Rhyolitic Conglomerates seem to be of limited taxonomic significance. They have been demonstrated for a pooled sample of four collections of predominantly adult valves. The absence of young and immature valves from the shell residues preserved in the Rhyolitic Conglomerates could well account for the statistically identifiable difference in outline because large shells in all samples tend to be more mucronate than young ones. Moreover, the interiors of brachial valves undergo considerable changes during growth. In particular, secondary shell accretion on the socket ridges and septa supporting the adductor muscle bases changes the morphology of such apophyses. The ridges tend to become more stumpy and the septa become ankylosed to form a cleft platform (e.g. Figs 197–198).

The diagnosis and description of *S. antiqua* have recently been amended (Williams 1974 : 130). The revision was based on a study of well-preserved moulds of *Sowerbyella* from Coed Duon which are here shown to be indistinguishable from basal Llandeilo *Sowerbyella* from Maes y fallen where the syntypes of the species were collected. In these circumstances, no further amendment is called for and the formal diagnosis for the species and its 'variety' remains that cited above.





**Figs 196–212** *Sowerbyella antiqua* Jones. Fig. 196, BB 94060, internal mould of a pedicle valve  $\times 2.5$ ; Fig. 197, BB 92499, latex cast of internal mould of a brachial valve, showing marginal follicular embayments,  $\times 3$ ; Fig. 198, BB 92495, latex cast of internal mould of a brachial valve  $\times 3$ ; Fig. 199, BB 92496, internal mould of a pedicle valve  $\times 3$ ; all from Lower Llandeilo sandstones, Maes y fallen, Llandeilo. Fig. 200, BB 92401, latex cast of internal mould of a pedicle valve  $\times 6$ ; Fig. 201, BB 92403, external mould of a brachial valve  $\times 6$ ; Fig. 202, BB 92404, internal mould of a pedicle valve  $\times 6$ ; all from the Rhyolitic Conglomerates, Ffairfach Group, type section. Figs 203–204, BB 92408 and 92407 respectively, exteriors of a pedicle and of a brachial valve, both  $\times 3$ , both from the Flags and Grits, Ffairfach Group, type section. Figs 205–206, BB 94039 and 94037 respectively, internal moulds of pedicle valves, both  $\times 6$ ; Figs 207–208, BB 94038 and 94036 respectively, internal moulds of brachial valves, both  $\times 6$ ; all from Lower Llandeilo Limestones, Old Castle, south Dynevor Park, Llandeilo. Figs 209–210, BB 94041 and 94040 respectively, exteriors of a pedicle and of a brachial valve, both  $\times 3$ , from Lower Llandeilo Limestones, west Dynevor Park, Llandeilo. Figs 211–212, NMW 68.376.153–3, internal moulds of a brachial and of a pedicle valve, both  $\times 6$ , from Llanvirn sandstones at Tan y Graig, Builth.



**HORIZONS AND LOCALITIES.** GSM 10292 (holotype of *S. antiqua* by original designation) and SM A.11314–5 from unknown horizons and localities in the Llandeilo Limestone of Llandeilo, possibly the Lower Llandeilo *Sowerbyella* limestones of Dynevor Park. Paratypes, GSM 37533–4 from the Llandeilo Limestone in the old quarry 275 m SW of Ffynonddewi near Nantgaredig (SN 4785 2075) and GSM 32152a, 32152b<sup>2</sup> from Lower Llandeilo Basal Sandstones 275 m SW of Maes y fallen (SN 649210); SM A.34101–5, BB 942495–9 and BB 94060 also from the same Maes y fallen locality; GSM 75268<sup>3</sup> and 75270 (syntypes of the *llandeiloensis* variety, Williams 1949 : 234) and BB 94040–3 from Lower Llandeilo *Sowerbyella* Limestones in old quarry 70 m west of Boat House, western Dynevor Park (SN 609223); SM A.34094–5, GSM 75267 and GSM 75269 (also *llandeiloensis* syntypes, Williams 1949 : 235) from Lower Llandeilo *Sowerbyella* Limestones 5 m north of Old Dynevor Castle, southern Dynevor Park (SN 6115 2176); BB 94036–9 from the same horizon 50 m east of the Old Castle (SN 6123 2172); BB 92407–8 from limestones in the upper part of the Flags and Grits Formation of the Ffairfach Group in the type section (SN 628211); BB 92401–6 from the uppermost Ffairfach Rhyolitic Conglomerates Formation at the same locality; BB 35524–34 from the Flags and Grits Formation of the Ffairfach Group exposed on the western side of Coed Duon near Llangadog (SN 709256); NMW 68.376.G.150–161 from quarry east of Tan y Graig 1 km north of Llanellwedd near Builth Wells (SO 048528).

Superfamily **STROPHOMENACEA** King, 1846

Family **STROPHOMENIDAE** King, 1846

Subfamily **FURCITELLINAE** Williams, 1965

Genus **MURINELLA** Cooper, 1956

*Murinella* sp.

(Figs 213–215)

**DESCRIPTION.** Plano- to slightly biconvex *Murinella* with slightly obtuse cardinal angles and semi-elliptical outline; pedicle valve about 90% as long as wide and 14% as deep as long with apsacline interarea characterized by a narrow pseudodeltidium with a median fold; brachial valve at least 60% as long as wide and about 10% as deep as wide with anacline interarea characterized by a low, broad, medially indented chilidium extending laterally for 15–20% of hinge width; exterior of both valves ornamented by fine parvicostellae numbering 6 per mm at 5 mm anteromedially of the umbo, crossed by fine regularly developed fila (numbering about 25 per mm) and sporadically-occurring growth lines.

Ventral interior exhibiting ill-defined muscle field medially divided by indistinct low, narrow ridge marked by very fine longitudinal median striations within muscle field; muscle scar about 77% as long as wide extending anteriorly for about 32% of valve length and bounded posterolaterally by short, widely divergent dental plates extending anteriorly for about 18% of valve length and supporting simple teeth; diductor component of scar characteristically elongate and occupying the lateral sectors of the muscle field.

Dorsal interior with a bilobed cardinal process with a small undifferentiated median process flanked by well-developed subsidiary ridges acting as diductor bases, and socket ridges extending laterally, parallel to the hinge line, for about 45% of valve width; median septum broad and low extending anteriorly from the low, broad notothyrial platform for about 40% of valve length with a fine narrow median ridge continuing to commissure and dividing well-impressed, semicircular dorsal adductor scars which are further divided by a few variably developed fine, radiating ridges and grooves.

<sup>2</sup>Spjeldnaes (1957 : 84) chose this as the lectotype of *antiqua*, a choice which was also recognized by MacGregor (1961 : 201). However, since the holotype had already been designated by Jones (1928 : 419; pl. 21), this was superfluous.

<sup>3</sup>Cocks (1978 : 97) chose this as the lectotype of *llandeiloensis*.



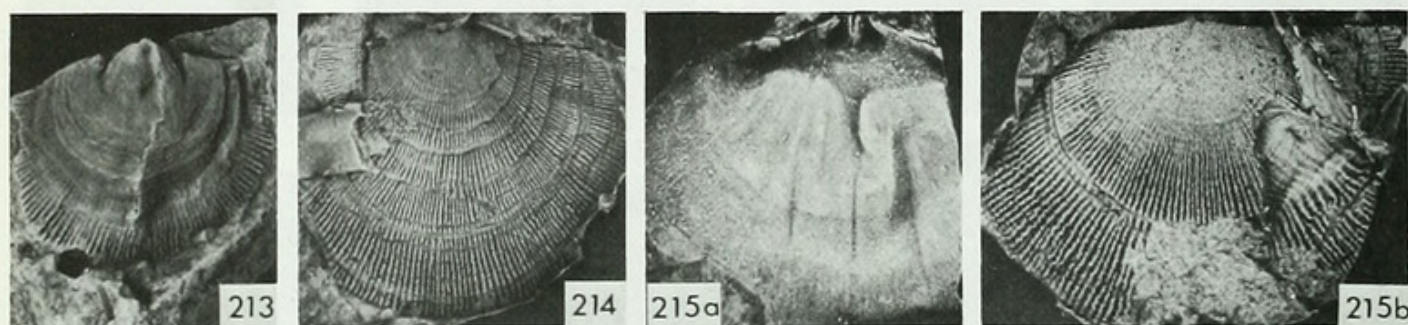
## FIGURED MATERIAL

|                                              |           | length | width |
|----------------------------------------------|-----------|--------|-------|
| Internal and external moulds of b.v. . . . . | BB 92461  | (12)   | 20    |
| Internal and external moulds of p.v. . . . . | BB 92462  | 8.5    | 9.5   |
| External mould of p.v. . . . .               | GSM 10889 | 16.5   | 18.0  |

HORIZON AND LOCALITY. BB 92461–3 from the Flags and Grits in the middle of the Ffairfach Group, Ffairfach railway cutting, Llandeilo (SN 628211); GSM 10889 probably from the same horizon and locality.

DISCUSSION. The brachial valve BB 92461 exhibits pronounced growth distortions on both anterolateral flanks; each side of the valve initially grew radially but then irregularly towards the anteromedian and anterolateral sectors of the shell.

A single pedicle valve of *Murinella* is known from the Lower Llandeilo Meadowtown Beds of the Shelfe area (Williams 1974: 141) and compares with the Ffairfach valve in the arrangement of the muscle field. In the absence of further material, however, it is not possible to do more than conclude that these penecontemporaneous forms may be closely related.



Figs 213–215 *Murinella* sp. Fig. 213, BB 92462, internal mould of a pedicle valve  $\times 3$ ; Fig. 214, GSM 10889, latex cast of the external mould of a pedicle valve,  $\times 2$ ; Figs 215a, b, BB 92461a, b, internal mould and latex cast of the external mould of a brachial valve, both  $\times 2.5$ ; all from the Flags and Grits, Ffairfach Group, type section.

## Subfamily OEPIKINAE Sokolskaya, 1960

Genus *MACROCOELIA* Cooper, 1956*Macrocoelia llandeiloensis* (Davidson)  
(Figs 216–226)

1871 *Strophomena compressa* (J. de C. Sowerby) var. *llandeiloensis* Davidson: 316; pl. 46, figs 11–14.

1959 *Rafinesquina*? *llandeiloensis* (Davidson) Spjeldnaes: 16; pl. 1, figs 1–7.

1961 *Macrocoelia llandeiloensis* (Davidson) MacGregor: 206; pl. 23, figs 1–10.

DIAGNOSIS. Planoconvex *Macrocoelia*, becoming slightly geniculate in late adult stages of growth with subperipheral rim; finely ornamented with about 8 parvicostellae per mm, 10 mm anterior of umbo, and with a flabellate ventral muscle scar over one-third as long as the adult pedicle valve.

DESCRIPTION. Planoconvex semicircular to semi-elliptical *Macrocoelia* with slightly obtuse rounded cardinal angles and maximum width at, or more commonly just anterior to, the hinge line, variably but evenly convex in transverse profile and unevenly convex in longitudinal profile with incipient geniculation developed in adult specimens; pedicle valve averaging 73% and 78% as long as wide in two samples from Ffairfach and Coed Duon respectively, with smaller and larger mean size ( $N = 35$  and  $N = 7$ ), and averaging 14% as deep as long (range 8 to 22%, e.g. 20 valves from Ffairfach:  $\bar{I}$  mm (var 1) 10.88 (5.383),  $\bar{th}$



(var th) 1.56 (0.585),  $r$  0.641); brachial valve averaging 72 to 77% as long as wide in the same two samples (e.g. 20 valves from Ffairfach:  $\bar{l}$  mm (var l) 8.87 (8.165),  $\bar{w}$  mm (var w) 12.35 (16.792),  $r$  0.974); ventral interarea long apsacline with transverse growth lines parallel to hinge and a well-developed pseudodeltidium and low chilidium, dorsal interarea short anacline; radial ornamentation unequally parvicostellate with 5, 6, 7, 8 and 9 ribs per mm at 10 mm anteromedially of the umbones of 1, 4, 5, 8 and 2 brachial valves respectively.

Ventral interior with widely divergent dental plates supporting simple teeth and extending anteriorly for an average of 14 to 21% of valve length (e.g. 20 valves from Ffairfach:  $\bar{l}$  mm (var l) 9.64 (9.343),  $\bar{dl}$  (var dl) 1.40 (0.304),  $r$  0.770) and for an average of 45 to 49% of their maximum lateral extension in the same two samples (e.g. 23 valves from Ffairfach:  $\bar{l}$  mm (var l) 1.37 (0.302),  $\bar{w}$  mm (var w) 3.05 (2.010),  $r$  0.892); muscle field poorly developed, equidimensional in small specimens with rare incipient flabellate patterns at lateral margins but with strongly-developed, flabellate paired diductor scars (in larger specimens) averaging 85% as long as wide and 38% as long as valve and enclosing narrow longitudinal adductor scars medially; pedicle tube short and narrow in small specimens but vestigial or absent in larger individuals with tendency for closure to begin anteriorly.

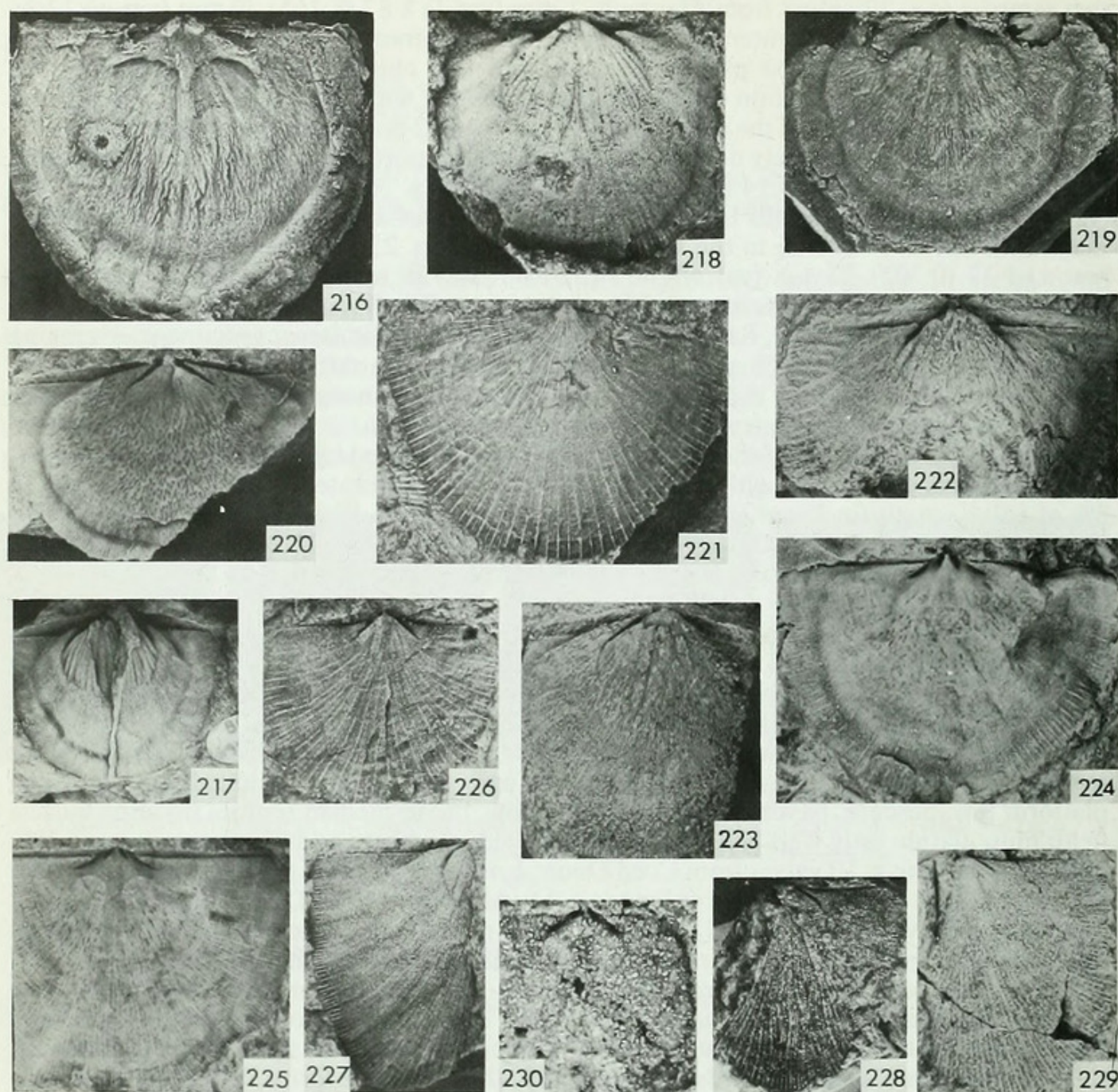
Dorsal interior with stout bifid cardinal process characterized by flattened anterior attachment platforms disposed roughly parallel to the interarea and extending anteriorly for up to 8% of valve length (in larger specimens, e.g. 13 valves from Ffairfach:  $\bar{l}$  mm (var l) 8.88 (9.048),  $\bar{lc}$  (var lc) 0.52 (0.031),  $r$  0.886) and for 63 to 73% of their maximum lateral extension in respective samples (e.g. 13 valves from Ffairfach:  $\bar{l}$  mm (var l) 0.52 (0.031),  $\bar{w}$  mm (var w) 0.83 (0.073),  $r$  0.903); processes tapering posteriorly towards umbo and ankylosed anterodorsally to widely divergent socket ridges which extend anteriorly for 10 to 14% of valve length (e.g. 12 valves from Ffairfach:  $\bar{l}$  mm (var l) 8.88 (8.778),  $\bar{lsr}$  (var lsr) 0.89 (0.055),  $r$  0.872) and for 31 to 39% of their maximum lateral extension in respective samples (e.g. 12 valves from Ffairfach:  $\bar{l}$  mm (var l) 0.89 (0.055),  $\bar{w}$  mm (var w) 2.86 (0.737),  $r$  0.862); genital markings, consisting of rounded raised pustules, are confined to socket region between socket ridges and hinge line and developed sporadically; notothyrial platform low, obscure, passing anteriorly into a low, broad median septum dividing muscle field; musculature only well-defined in adult individuals where adductor scars average 38% as long as valve (e.g. 10 valves from Coed Duon:  $\bar{l}$  mm (var l) 19.45 (8.914),  $\bar{lsc}$  (var lsc) 7.75 (2.014),  $r$  0.875) and 77% as wide as long (e.g. 11 valves from Coed Duon:  $\bar{l}$  mm (var l) 7.52 (2.404),  $\bar{w}$  mm (var w) 9.71 (4.081),  $r$  0.931); radial ridges at an angle of about 30° to median line and dividing the adductor scars into anteromedian and posterolateral sectors.

The greater parts of the posteromedian sectors of both valves are characterized by fine pustules which are strongly elongated along radial lines and tend to become thickened and amalgamated into irregular, slightly anastomosing radial ridges in some larger individuals; these markings are absent towards the periphery which in large forms invariably exhibits a pronounced subperipheral rim which is fluted, particularly dorsally, by radial mantle canals of a lemniscate system.

## FIGURED MATERIAL

|                                                                      |                    | length | width |
|----------------------------------------------------------------------|--------------------|--------|-------|
| Internal mould of b.v. . . . .                                       | BB 92421           | 22     | 25    |
| " . . . . .                                                          | BB 92445           | 21     | 28    |
| Internal and external moulds of b.v. . . . .                         | BB 92432           | 11     | 15    |
| " . . . . .                                                          | BB 92431           | 10.5   | 15    |
| Internal mould of p.v. . . . .                                       | B 13618            | 16.5   | 19    |
| " . . . . .                                                          | BB 92433           | 14.5   | 23    |
| " . . . . .                                                          | BB 69520           | 22.5   | 27    |
| " . . . . .                                                          | BB 92442           | —      | 23    |
| " . . . . .                                                          | NMW 68.376.G.176.3 | 12     | 16    |
| Internal and external moulds of p.v. . . . .                         | BB 92443           | 17     | 22    |
| Internal and external parts of exfoliated<br>p.v. exterior . . . . . | BB 92444           | 11     | 14    |





**Figs 216–226** *Macrocoelia llandeiloensis* (Davidson). Fig. 216, BB 92421, latex cast of the internal mould of a brachial valve  $\times 2$ ; Fig. 217, BB 69520, internal mould of a medially split pedicle valve  $\times 1$ ; both from Llanvirn shales, Coed Duon, Llangadog. Fig. 218, B 13618, internal mould of a pedicle valve  $\times 2$ , from the Ffairfach Group, type section. Fig. 219, BB 92445, internal mould of a brachial valve  $\times 1.5$ , from the Ashes and Lavas, Ffairfach Group type section. Fig. 220, BB 92433, internal mould of a pedicle valve  $\times 2$ ; Fig. 221, BB 92444, internal part of an exfoliated pedicle valve  $\times 3$ ; Figs 222–223, BB 92442 and 92443 respectively, internal moulds of pedicle valves, both  $\times 2$ ; Figs 224–225, BB 92432 and 92431 respectively, internal moulds of brachial valves, both  $\times 3$ ; all from the Flags and Grits, Ffairfach Group, type section. Fig. 226, NMW 68.376.G.176.3, internal mould of a pedicle valve  $\times 2$ , from Llanvirn shales at Tanlan. Builth.

**Figs 227–230** *Macrocoelia llandeiloensis elongata* subsp. nov. Fig. 227, **holotype** BB 92409, internal mould of a pedicle valve  $\times 2$ ; Fig. 228, BB 92410, internal mould of a pedicle valve  $\times 2$ ; Fig. 229, BB 92411, internal mould of a pedicle valve  $\times 3$ ; Fig. 230, BB 92418, internal mould of a brachial valve  $\times 4$ ; all from Llanvirn sandstones, Howey Brook, Llandrindod.



**HORIZONS AND LOCALITIES.** BB 92421–8 and BB 69520–5 from argillaceous shell beds in the Flags and Grits Formation on the west side of Coed Duon ridge, 3 km south of Llangadog (SN 709256); BB 92429–39 from argillaceous lower part of the Flags and Grits in the Ffairfach Railway Cutting, Ffairfach (SN 628211); BB 92441 from the uppermost part of the underlying Pebbly Sands Formation at the same locality and BB 92442–4 from the limestones in the upper part of the Flags and Grits Formation exposed immediately to the south in the railway embankment; BB 92445 from the lower ashy part of the overlying Ashes and Lavas Formation at the same locality; BB 92440 from the sandy beds of the Ffairfach Grit Formation exposed in the field beside the Longwood road 300 m NW of Beili-dyffryn Farm (SN 693257); B 13618 from an unknown horizon and locality at Ffairfach (probably from the same locality as BB 92441); NMW 68.376.G.176.2–3 from Upper Llanvirn sandstones exposed 40 m from gate on hill road from Tanlan, 4 km NNE of Builth Wells (SO 057547); SM A.34098–100 from Lower Llandeilo sandstones exposed 275 m SW of Maes y fallen, Llandeilo (SN 649210); SM A.34096–7 from Lower Llandeilo beds exposed at Dynevor Park Old Castle, Llandeilo (SN 6115 2176).

**DISCUSSION.** Comparison between the two samples described here indicate that the smaller-sized Ffairfach individuals are significantly more transverse in ventral outline than the larger individuals from Coed Duon ( $0.02 < p < 0.01$ ). Similarly the dorsal socket ridges are significantly longer relative to valve length and significantly more divergent than long in the Coed Duon sample ( $0.01 < p < 0.001$  and  $0.05 < p < 0.02$  respectively). Allometric effects, causing the relative increase in length of the pedicle valve during growth, are particularly significant in the development of the dorsal socket ridges which, whilst becoming relatively more divergent during growth, also show a marked acceleration in their forward growth relative to valve length. Since the two samples not only fail to differ significantly in any of the nine other comparative tests conducted, but also show progressive trends in the development of pustules and atrophy of the pedicle tube during growth, we conclude that no taxonomic significance should be attached to the size-related morphological differences which have been observed.

A small sample, consisting mainly of pedicle valves, from penecontemporaneous rocks in the Builth area compares closely with *M. llandeiloensis* s.s. from the Llandeilo district. Although they are significantly less transverse in ventral outline than the Ffairfach specimens, they exhibit a characteristic pedicle tube and do not differ significantly from the Ffairfach or the Coed Duon samples in any other observed respect. The relevant statistics are: for the pedicle valve outline ( $n = 10$ )  $\bar{l}$  mm (var l) 8.29 (5.388),  $\bar{w}$  mm (var w) 10.04 (7.118),  $r = 0.937$ ,  $\bar{a}$  (var a) 1.1494 (0.0202); for the relative length of the dental lamellae (dl) ( $n = 5$ )  $\bar{l}$  mm (var l) 8.60 (6.925),  $\bar{dl}$  (var dl) 1.42 (0.127),  $r = 0.784$ ; and for the length and width of the dental lamellae ( $n = 6$ )  $\bar{l}$  mm (var l) 1.38 (0.114),  $\bar{w}$  mm (var w) 2.83 (0.355),  $r = 0.820$ .

***Macrocoelia llandeiloensis* (Davidson) *elongata* subsp. nov.**  
(Figs 227–230)

**DIAGNOSIS.** Elongately semi-elliptical, planoconvex *Macrocoelia* becoming slightly geniculate in late adult stages of growth with subperipheral rim; ornamented with about 5 parvicostellae per mm, 10 mm anterior of the umbo.

**DESCRIPTION.** Planoconvex elongately semi-elliptical *Macrocoelia* with slightly rounded, normally orthogonal cardinal angles and maximum width at or near hinge line; pedicle valve averaging 80% as long as wide in 13 valves ( $\bar{l}$  mm (var l) 8.67 (17.847),  $\bar{w}$  mm (var w) 10.83 (22.711),  $r = 0.961$ ; range 63 to 100%) and 15% as deep as long ( $\bar{l}$  mm (var l) 8.67 (17.847),  $\bar{th}$  (var th) 1.27 (0.471),  $r = 0.955$  in 13 valves) with smaller valves generally transverse but larger valves almost or equally as long as wide and sporadically exhibiting incipient geniculation; brachial valve flat averaging 81% as long as wide in 3 juvenile valves (range 76 to 86%); ventral interarea apsacline with supra-apical foramen, dorsal interarea short anacline,



pseudodeltidium and chilidium unknown; radial ornamentation unequally parvicostellate with 5 ribs per mm, 10 mm anteromedially of the umbones of 3 pedicle valves.

Ventral interior with short, divergent dental plates extending anteriorly for an average of 12% of valve length ( $\bar{l}$  mm (var l) 8.67 (17.847),  $\overline{dl}$  (var dl) 1.05 (0.148),  $r$  0.895 in 13 valves) and for an average of 44% of their maximum lateral extension ( $\bar{l}$  mm (var l) 1.05 (0.148),  $\overline{w}$  mm (var w) 2.38 (1.116),  $r$  0.879 in 13 valves) and partially enclosing an obscure equidimensional muscle field with sublabellate diductors about one-quarter as long as valve developed in the largest known specimen.

Dorsal cardinal process lobes delicate, extending anteriorly for about 10% of valve length and 72% of their width with bases ankylosed to widely divergent, thin socket ridges extending anteriorly for 16% of the length of the valve and for 40% of their lateral extension ( $\bar{l}$  mm (var l) 1.08 (0.254),  $\overline{w}$  mm (var w) 2.72 (1.222),  $r$  0.834 in 6 valves), dorsal muscle scar pattern obscure.

| TYPE MATERIAL                                          |          | length | width |
|--------------------------------------------------------|----------|--------|-------|
| <b>Holotype</b> , internal and external moulds of p.v. | BB 92409 | 18     | 22    |
| Paratype, internal and external moulds of p.v.         | BB 92410 | 14     | 14    |
| " " "                                                  | BB 92411 | 11.2   | 12    |
| " " internal mould of b.v. . . . .                     | BB 92418 | (6)    | 7     |

**HORIZON AND LOCALITY.** BB 92409–20 from sandy ashes at the top of the Main Volcanic Series in the Howey Brook ('Main feeder') section 4 km east of Howey, outcrop on top of small hill on north side of brook (SO 0925 5915).

**DISCUSSION.** Although *M. llandeiloensis elongata* subsp. nov. only differs from the penecontemporaneous *M. llandeiloensis* from Tan-lan in its lack of a pedicle tube, it differs from both Llandeilo samples in having a coarser ornament. It also differs significantly from the Ffairfach sample, of virtually identical mean size, in its significantly more elongate pedicle valve ( $0.01 < p < 0.001$ ), its more elongate brachial valve ( $0.05 < p < 0.02$ ), its deeper pedicle valve ( $0.05 < p < 0.02$ ) and its relatively shorter dental lamellae ( $0.05 < p < 0.02$ ). It thus differs from the related Ffairfach specimens in the majority of compared features. Like the Builth Strophomenida generally, *Macrocoelia* from this area is relatively poorly represented, but the Howey Brook sample is sufficiently distinct to warrant systematic recognition at the subspecific level. Indeed additional material from loose tuffaceous blocks at the Howey Brook locality (including BB 94243–4) resemble the subspecies in the characteristic elongate outline.

Family **CHRISTIANIIDAE** Williams, 1953

Genus **CHRISTIANIA** Hall & Clarke, 1892

*Christiania elusa* sp. nov.

(Figs 231–240)

**DIAGNOSIS.** Small plano- to concavoconvex, transverse *Christiania* with valves averaging about two-thirds as long as wide; ventral anterior with median and lateral pair of dental lamellae.

**NAME.** 'Mocked, deceived'.

**DESCRIPTION.** Small plano- to concavoconvex, transverse, slightly plicate *Christiania* with pedicle valve averaging 69% as long as wide in 16 valves ( $\bar{l}$  mm (var l) 4.34 (0.655),  $\overline{w}$  mm (var w) 6.30 (1.475),  $r$  0.926; range 63 to 80%) and 25% as deep as long ( $\bar{l}$  mm (var l) 4.34 (0.655),  $\overline{th}$  (var th) 1.09 (0.116),  $r$  0.770 in 16 valves) with flat apsacline interarea; brachial valve averaging 64% as wide as long in 5 valves ( $\bar{l}$  mm (var l) 3.94 (0.573),  $\overline{w}$  mm (var w) 6.22 (0.602),  $r$  0.849; range 56 to 71%) with a very short anacline interarea; exterior of both valves poorly known but exhibiting obscure concentric growth lines towards anterior commissure.



Ventral interior with short, thick pedicle tube in centre of posteriorly thickened median septum which extends anteriorly for about 33% of valve length; diductor muscle field bounded posterolaterally by well-developed ridges (dental plates) arising beneath the hinge teeth and extending for about 33% of valve length ( $\bar{I}$  mm (var 1) 4.87 (0.387),  $\bar{II}$  (var dl) 1.60 (0.148),  $r$  0.811 in 6 valves) towards the anterolateral commissure; fine, slightly convergent or anteriorly extending ridges also arise beneath the triangular hinge teeth and extend forward subparallel to median septum for about 20% of valve length, presumably intervening between adductor and diductor muscle attachment areas.

Dorsal interior with simple, bilobed cardinal process and fine, sporadically developed median septum arising anterior to the hinge line and extending almost to the commissure; well-developed double pair of high, sharp, slightly curved septa extending from postero-medial part of valve to near commissure, enclosing slightly raised sector unequally bisected by diagonal septa; submedian septa diverging from median septum at about 15° initially but curving away from median line towards anteromedian margins; posterolateral septa also diverging from hinge line at about 15° to curve away towards posterolateral margins; septa, presumed to enclose adductor muscle fields, confined anteriorly by a curved row of low tubercles, aligned with commissure.

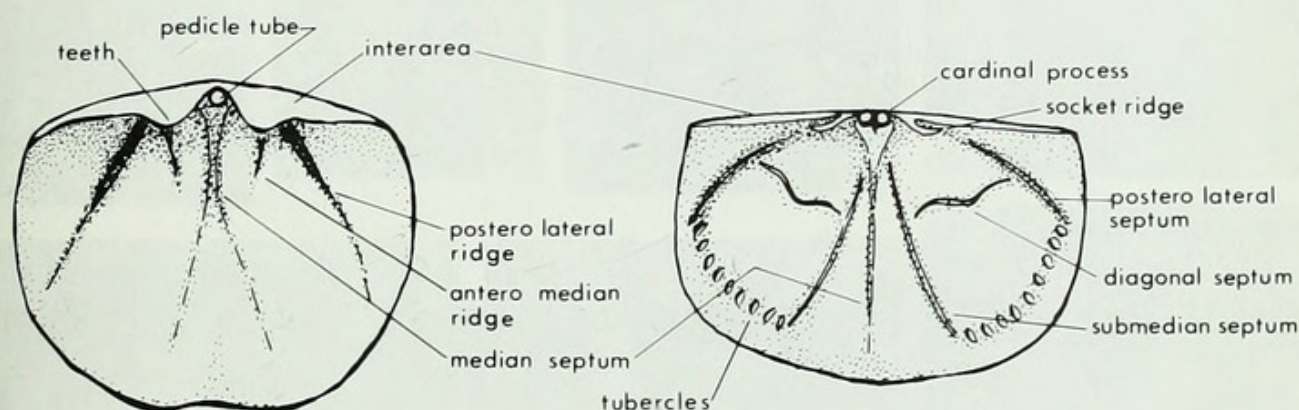


Fig. 231 Diagrammatic views of the interiors of a pedicle (left) and a brachial (right) valve of *Christiania elusa* sp. nov.

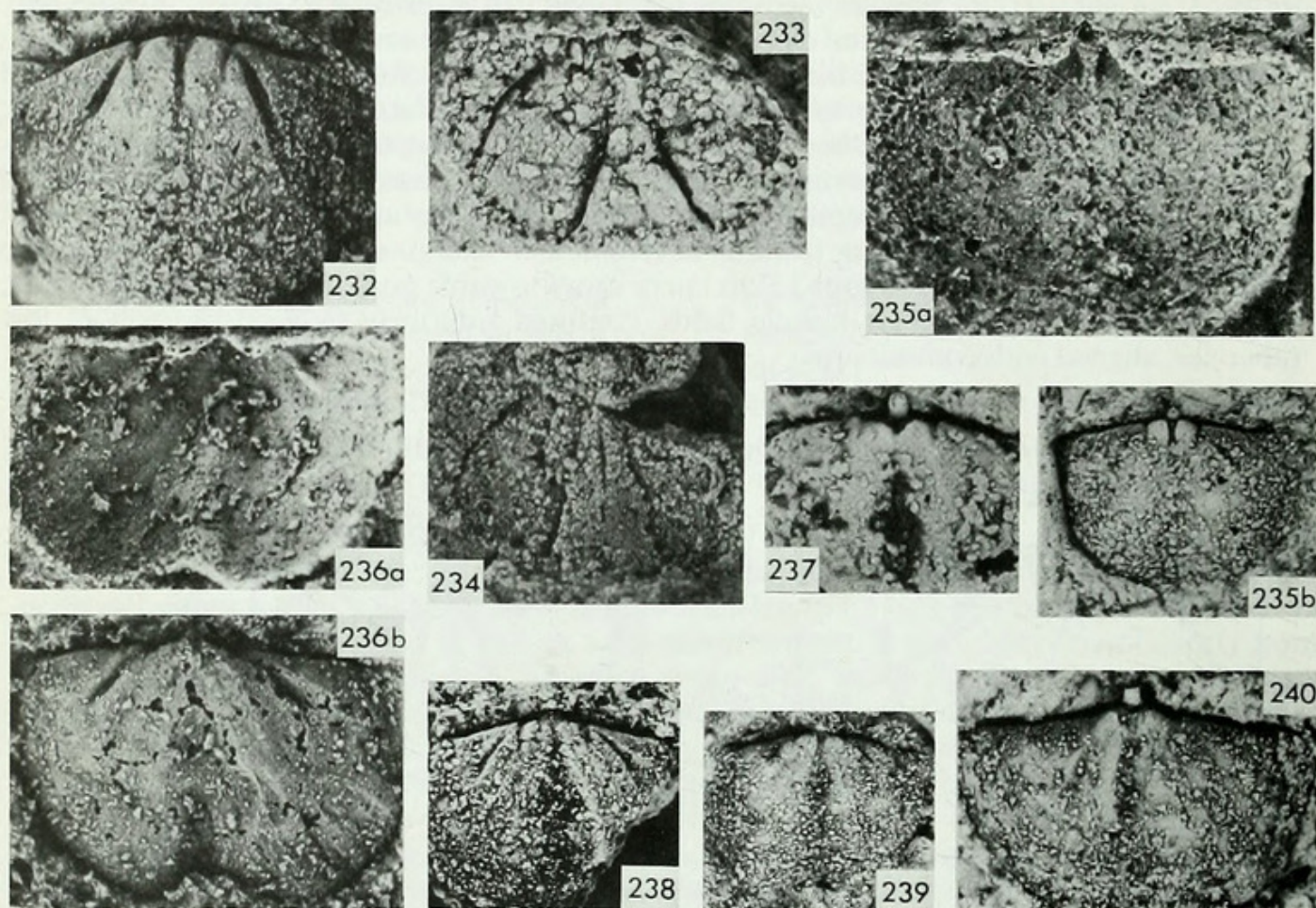
#### TYPE MATERIAL

|                                                        |                                      |          | length | width |
|--------------------------------------------------------|--------------------------------------|----------|--------|-------|
| <b>Holotype</b> , internal and external moulds of p.v. | .                                    | BB 92451 | 5.9    | 7.4   |
| <b>Paratype</b> , internal and external moulds of p.v. | .                                    | BB 92446 | 5.1    | 8.0   |
| "                                                      | "                                    | BB 92447 | 4.1    | 6.1   |
| "                                                      | "                                    | BB 92448 | 4.4    | 6.1   |
| "                                                      | "                                    | BB 92449 | 5.0    | 7.5   |
| "                                                      | "                                    | BB 92450 | 4.2    | 6.1   |
| "                                                      | "                                    | BB 92452 | 4.5    | 6.0   |
| "                                                      | internal mould of p.v.               | BB 92453 | 3.0    | 4.8   |
| "                                                      | "                                    | BB 92454 | 4.6    | 7.0   |
| "                                                      | "                                    | BB 92455 | 4.5    | 6.5   |
| "                                                      | Internal and external moulds of b.v. | BB 92456 | 4.4    | 7.0   |
| "                                                      | "                                    | BB 92457 | 3.7    | 5.4   |
| "                                                      | "                                    | BB 92458 | 5.0    | 7.0   |
| "                                                      | "                                    | BB 92459 | 3.5    | 6.2   |
| "                                                      | Internal mould of p.v.               | BB 94246 | 3.5    | 5.0   |

**HORIZON AND LOCALITY.** BB 94246 and BB 92446–60 are from the sandy ashes at the top of the Main Volcanic Series in Howey Brook ('Main Feeder') section, 4 km east of Howey, outcrop on top of small hill on north side of brook (SO 0925 5915).



DISCUSSION. Although *Christiania* is well known in the Ordovician successions of Scotland, Ireland and North America (Hall & Clarke 1892, Cooper 1956, Williams 1962, Mitchell 1977) and parts of Europe (Spjeldnaes 1957, Havlíček 1967), until recently (Cocks 1978: 123, 203; Hurst 1979) the genus was unknown from Caradoc and older rocks in the Anglo-Welsh region.



**Figs 232–240** *Christiania elusa* sp. nov. Fig. 232, holotype BB 92451, internal mould of a pedicle valve  $\times 6$ ; Fig. 233, BB 92456, internal mould of a brachial valve  $\times 6$ ; Fig. 234, BB 92457, internal mould of a brachial valve  $\times 6$ ; Figs 235a, b, BB 92449, latex cast  $\times 8$  and internal mould  $\times 4$  of a pedicle valve; Figs. 236a, b, BB 92447, latex cast and internal mould of a pedicle valve, both  $\times 8$ ; Figs 237–240, BB 92426, 92446, 92455 and 92452 respectively, internal moulds of pedicle valves  $\times 6$ ,  $\times 4$ ,  $\times 4$  and  $\times 6$  respectively; all from Llanvirn sandstones, Howey Brook, Llandrindod. Figs 233–240 are all paratypes.

The specimens described here are representative of a distinctive specific stock within the genus and constitute the first record of *Christiania* in the pre-Ashgill successions of Wales. *C. elusa* sp. nov. differs from the penecontemporaneous *C. oblonga* Pander from Norway and Russia (Spjeldnaes 1957: 113–127) in having neither a continuous ‘branchial loop’ nor diagonal septa arising forward of the cardinal process (1957: fig. 27a). Indeed the new species is more reminiscent of the younger *C. holtedahli* Spjeldnaes with its ‘branchial loop’ which is discontinuous near the anterolateral commissure and its transversely disposed, curved diagonal septa and fine median septum. Similarly *C. elusa* differs from known Scoto-Irish species, e.g. *C. bilobata* Reed, *C. perrugata* (Reed), *C. portlocki* Mitchell, *C. sulcata* Williams and *C. tenuicincta* (M’Coy), in numerous respects particularly its transverse outline and fine dorsal septa.



Order **PENTAMERIDA** Schuchert & Cooper, 1931

Suborder **SYNTROPHIIDINA** Ulrich & Cooper, 1936

Superfamily **PORAMBONITACEA** Davidson, 1853

Family **PORAMBONITIDAE** Davidson, 1853

Genus **PORAMBONITES** Pander, 1850

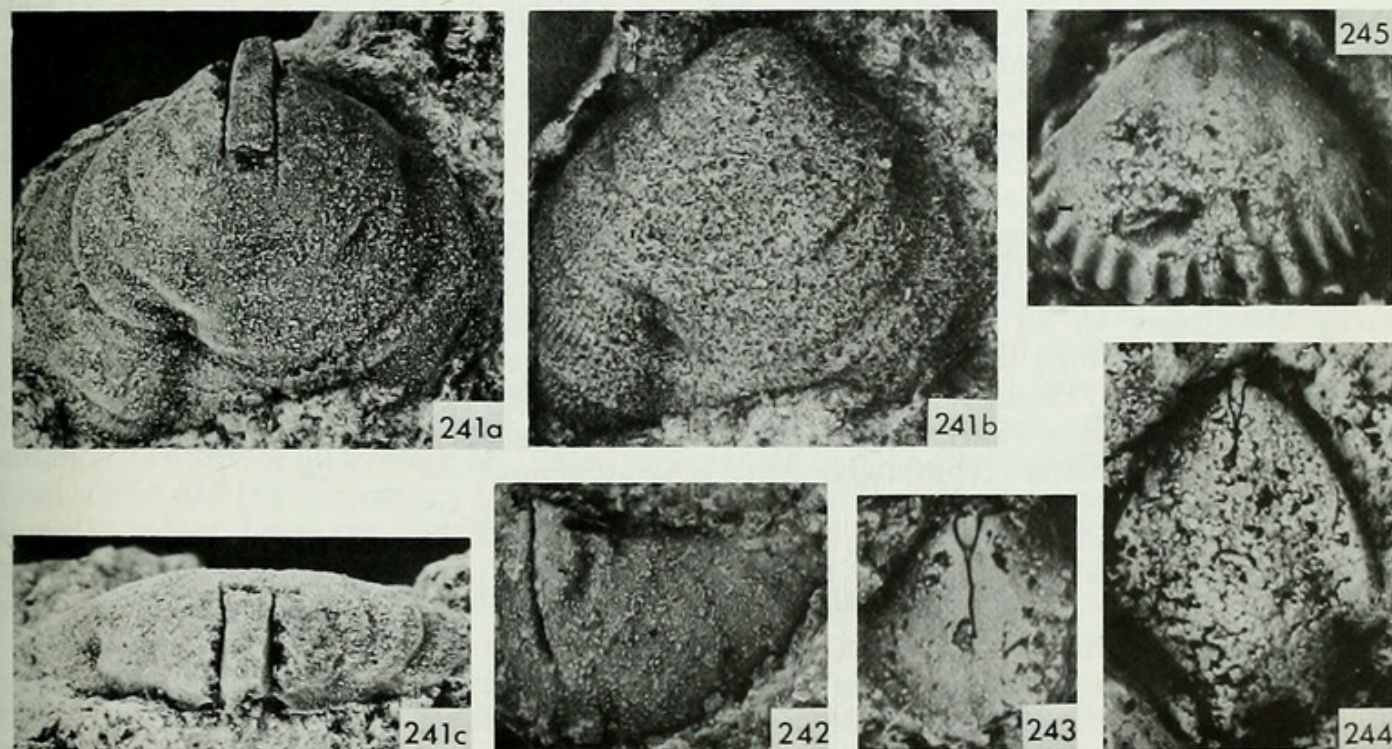
*Porambonites* sp.

(Figs 241–242)

**DESCRIPTION.** *Porambonites* with large plicate pedicle valve with subpentagonal outline, 84% as long as wide and 25% as deep as long with ventral sulcus beginning in anterior third of valve; exterior ornament poorly preserved but multicostellate with costellae numbering 3–4 per mm on the anterolateral part of the valve; strong, irregularly spaced concentric growth lines also characterize the anterior parts of the valve; interarea unknown; subparallel dental plates supporting very small teeth arise directly from valve floor and extend anteriorly for about one-third of valve length; brachial valve unknown.

**DIMENSIONS.** Internal and external moulds of p.v. BB 92464, length 16 mm, width 19 mm.

**HORIZON AND LOCALITY.** BB 92464–5 are from the sandy ashes at top of Main Volcanic Series in Howey Brook ('Main Feeder') section, 4 km east of Howey, outcrop on top of small hill on north side of brook (SO 0925 5915).



**Figs 241–242** *Porambonites* sp. Figs 241a–c, BB 92464, a, ventral view of internal mould, b, latex cast of external mould and c, posterior view of a pedicle valve, all  $\times 2.5$ ; Fig. 242, BB 92465, internal mould of posterolateral fragment of a pedicle valve  $\times 4$ ; both from Llanvirn sandstones at Howey Brook, Llandrindod.

**Figs 243–244** *Parastrophinella parva* MacGregor. Fig. 243, BB 92282, internal mould of a pedicle valve  $\times 8$ , from Lower Llandeilo beds, Ffairfach. Fig. 244, BB 92466, internal mould of a pedicle valve  $\times 6$ , from Llanvirn sandstones, Howey Brook, Llandrindod.

**Fig. 245** *Parastrophinella* cf. *musculosa* Williams. GSM 10291, internal mould of a brachial valve  $\times 8$ , from Llandeilo Beds, Llandeilo.



DISCUSSION. This is the first record of *Porambonites* in the Ordovician of the Anglo-Welsh region. Until more material is available to assess its variability, the taxonomic relationships of this form to known species from Scotland, Ireland and Scandinavia cannot be determined. The material also represents the earliest recorded occurrence of the genus in the Ordovician of Britain.

Family **PARASTROPHINIDAE** Ulrich & Cooper, 1938

Genus **PARASTROPHINELLA** Schuchert & Cooper, 1951

*Parastrophinella parva* MacGregor

(Figs 243–244)

1961 *Parastrophinella parva* MacGregor : 197; pl. 22, figs 5–10.

DESCRIPTION. Small, biconvex, subtriangular *Parastrophinella* with pedicle valve 83% as wide as long and 25% as deep as long, characterized by multiplicate anterior commissure composed of a median and two lateral rounded plications arising in the anterior half of the valve; valve surface almost smooth except for coarse concentric growth lines close to anterior commissure; interior dominated by spondylium extending forward for about one-quarter of valve length and supported anteriorly by a median septum; ventral interarea unknown; brachial valve unknown.

DIMENSIONS. Internal and external moulds of p.v. BB 92466, length 6.5 mm, width 5.4 mm.

HORIZONS AND LOCALITIES. BB 92466 from sandy ashes at top of Main Volcanic Series in the Howey Brook ('Main Feeder') section, 4 km east of Howey, outcrop on top of small hill on north side of brook (SO 0925 5915). BB 92282 from Lower Llandeilo Flags exposed in small quarry on north side (embankment) of Ffairfach railway cutting, Ffairfach, Llandeilo (SN 6376 2105).

DISCUSSION. Moulds of the pedicle valves of *Parastrophinella* have been collected from two different horizons in the Builth and Llandeilo successions. Both compare closely with *P. parva* MacGregor in all preserved morphological features. *P. parva* is fundamentally different from the three larger Anglo-Welsh *Parastrophinella* species hitherto known, *P. costata* MacGregor, *P. musculosa* Williams and *P. brenchleyi* Lockley (1980), which all bear an average of at least twelve costae. We therefore consider that ultimately *P. parva* MacGregor may be better accommodated in a separate genus.

*Parastrophinella* cf. *musculosa* Williams

(Fig. 245)

cf. 1974 *Parastrophinella musculosa* Williams : 151; pl. 28, figs 9–13, 17.

A single internal mould of a brachial valve (GSM 10291), labelled as *Camerella* (?) sp. from the 'Lower ? Llandeilo' of an unknown locality in the Llandeilo region, closely resembles *P. musculosa* Williams. The specimen is 4 mm long, 5 mm wide and about 1.4 mm deep with an incipient fold, a convex transverse profile characterized by steep lateral slopes and a convex longitudinal profile becoming anteriorly geniculate; the ornament consists of 14 slightly rounded delayed costae. The umbonal region bears the faint impression of a pair of medially situated, elongate, septalial outer plates which extend forward for at least one-quarter of valve length. *P. musculosa* itself was originally described from the Spy Wood Grit (Costonian) of Shropshire (Williams 1974).



Order **RHYNCHONELLIDA** Kuhn, 1949Superfamily **RHYNCHONELLACEA** Gray, 1849Family **TRIGONIRHYNCHIIDAE** McLaren, 1965Genus **ROSTRICELLULA** Ulrich & Cooper, 1942*Rostricellula triangularis* Williams, emended  
(Figs 245–263)

1949 *Rostricellula triangularis* Williams: 235; pl. 11, figs 15–18.

**DIAGNOSIS.** Biconvex, plicate, costate *Rostricellula* with triangular outline and pedicle valve averaging 89% as long as wide; dental plates averaging 25% as long as valve and enclosing compound ventral muscle scar; wavelength of costae averaging about 0.6 mm at 5 mm anteromedially of the dorsal umbo.

**DESCRIPTION.** Biconvex to dorsibiconvex, uniplicate, globular *Rostricellula* with triangular outline and maximum width in anterior half of valve; broad ventral sulcus complemented by dorsal fold; pedicle valve averaging 89% as long as wide (e.g. 13 valves from Coed Duon:  $\bar{l}$  mm (var l) 5.30 (1.037),  $\bar{w}$  mm (var w) 5.97 (1.436),  $r$  0.909) and 32% as deep as long (e.g. 10 valves from Coed Duon:  $\bar{l}$  mm (var l) 5.60 (0.467),  $\bar{t}h$  (var th) 1.81 (0.148),  $r$  0.652), with brachial valve 82% as long as wide (e.g. 10 valves from Coed Duon:  $\bar{l}$  mm (var l) 4.91 (0.605),  $\bar{w}$  mm (var w) 5.98 (0.877),  $r$  0.784) and 37% as deep as long (e.g. 10 valves from Coed Duon:  $\bar{l}$  mm (var l) 4.91 (0.605),  $\bar{t}h$  (var th) 1.81 (0.329),  $r$  0.853); slightly rostrate with apical angle of about 90° and a slightly elongated pedicle foramen, palintropes very depressed; exterior ornamented by an even number of dorsal primary costae, numbering 16 and 18 respectively in 6 and 5 brachial valves between 4 and 7 mm in length, complementary ventral costae uneven in number; ventral sulcus broad, containing 3 costae corresponding to 4 on the dorsal fold, which are divided medially by a relatively wide spacing between the two inner costae, averaging 0.7 mm at 5 mm anteromedially of the umbo in 7 valves compared with an average spacing of 0.6 mm for other anteromedian costae.

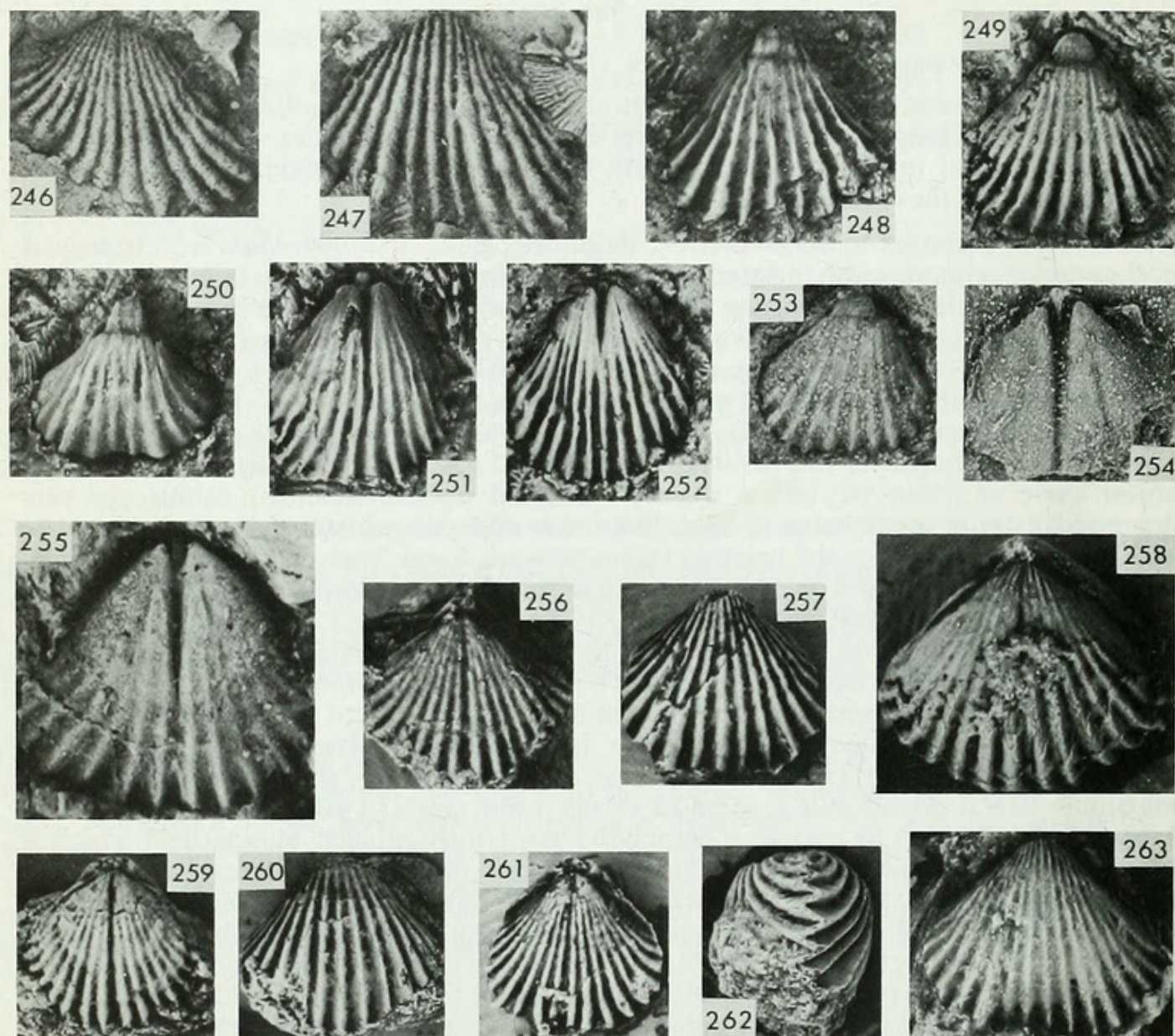
Ventral interior with small teeth supported by slightly divergent dental plates extending anteriorly for an average of 25% of the length of the valve (e.g. 25 valves from Bryntowy:  $\bar{l}$  mm (var l) 5.62 (0.893),  $\bar{d}l$  (var dl) 1.40 (0.111),  $r$  0.471) and 82% of their maximum lateral extension (e.g. same 25 valves:  $\bar{l}$  mm (var l) 1.40 (0.111),  $\bar{w}$  mm (var w) 1.70 (0.144),  $r$  0.665) to enclose a compound posteriorly-situated muscle field which is sporadically differentiated to show a median adductor impression, between one-third and half as wide as field, flanked by narrower elongate diductor scars; whole scar complex extends forward for an average of 23% of valve length (e.g. 16 valves from Bryntowy:  $\bar{l}$  mm (var l) 5.66 (0.916),  $\bar{l}sc$  (var lsc) 1.33 (0.155),  $r$  0.648) and for 86% of its maximum width (e.g. same 16 valves:  $\bar{l}$  mm (var l) 1.33 (0.155),  $\bar{w}$  mm (var w) 1.54 (0.141),  $r$  0.815), which occurs at the transverse ridge marking the anterior edge of the scar; faint transverse muscle tracks sporadically developed.

Hinge plate of dorsal interior small, divided by septalium which is buttressed by median ridge extending forward for at least half of valve length and often continuing to commissure by passing anteriorly into median internal costa corresponding to conspicuous external median groove between submedian costae; crural bases short, averaging 14% as long as valve (e.g. 16 valves from Bryntowy:  $\bar{l}$  mm (var l) 4.13 (1.804),  $\bar{l}c$  (var lc) 0.59 (0.018),  $r$  0.749) and 55% as long as their maximum width; muscle scars faint, sporadically developed as elongate posteriorly-tapering impressions extending, on either side of the median ridge, from the posterior adductor pits towards the anterior half of the valve.

**HORIZONS AND LOCALITIES.** BB 94226–32 (topotypes) from Upper Llanvirn ashes exposed in stream 200 m NW of Bryntowy Farm, 2 km SSW of Llangadog, Dyfed (SN 695262); BB 92478–89 from loose calcareous blocks from the Flags and Grits Formation of the Ffairfach Group exposed at Coed Duon, 3 km south of Llangadog (SN 709256); BB 92490



from underlying Rhyolitic Grits and Conglomerates at the same locality; BB 92491 from the calcareous upper part of the Flags and Grits Formation of the Ffairfach Group in the type section (SN 628211); BB 92467–9 from the Rhyolitic Conglomerate Member of the Ffairfach Group at the type section (SN 628211); BB 92281 from probable Upper Llanvirn sandstones exposed in the Old Pantau quarry, 1.5 km east of Llandeilo (SN 644224).



**Figs 246–263** *Rostricellula triangularis* Williams. Figs 246, 247, paralectotypes GSM 75232b, a, latex casts of the external moulds of brachial valve and of a pedicle valve, both  $\times 4$ ; Figs 248–250, topotypes BB 94227, 94226 and 94229 respectively, internal moulds of pedicle valves, all  $\times 4$ ; Figs 251–252, topotypes BB 94231 and 94228 respectively, internal moulds of brachial valves, both  $\times 4$ ; all from Llanvirn ashes, Bryntowy, Bethlehem. Fig. 253, BB 92491, internal mould of a pedicle valve  $\times 6$ ; Fig. 254, BB 92468, internal mould of the posterior part of a brachial valve  $\times 6$ ; Fig. 255, BB 92467, internal mould of a brachial valve  $\times 8$ ; all from the Rhyolitic Conglomerates, Ffairfach Group, type section. Fig. 256, BB 92489, dorsal view of a complete specimen  $\times 4$ ; Fig. 257, BB 92486, ventral view of a complete specimen  $\times 4$ ; Figs 258–259, BB 92483 and 92485 respectively, dorsal views of complete specimens  $\times 6$  and  $\times 4$ ; Fig. 260, BB 92487, ventral view of a complete specimen  $\times 4$ ; Fig. 261, BB 92480, dorsal view of a complete specimen  $\times 4$ ; Fig. 262, BB 92481, anterolateral view of a complete specimen  $\times 4$ ; Fig. 263, BB 92478, exterior of a pedicle valve  $\times 4$ ; all from calcareous Llanvirn beds, Coed Duon, Llangadog.



| FIGURED MATERIAL       |   |   |   |   |   | length     | width |        |
|------------------------|---|---|---|---|---|------------|-------|--------|
| External mould of p.v. | . | . | . | . | . | GSM 75232a | (8.0) | (10.0) |
| External mould of b.v. | . | . | . | . | . | GSM 75232b | (6.0) | (8.0)  |
| Exterior of p.v.       | . | . | . | . | . | BB 92478   | 6.0   | 7.5    |
| Complete specimen      | . | . | . | . | . | BB 92481   | 6.0   | 7.0    |
| "                      | . | . | . | . | . | BB 92483   | 5.5   | 6.5    |
| "                      | . | . | . | . | . | BB 92480   | 5.4   | 5.4    |
| "                      | . | . | . | . | . | BB 92485   | 5.5   | 5.5    |
| "                      | . | . | . | . | . | BB 92486   | 5.5   | 6.8    |
| "                      | . | . | . | . | . | BB 92487   | 5.2   | 6.2    |
| "                      | . | . | . | . | . | BB 92489   | 4.6   | 5.2    |
| Internal mould of p.v. | . | . | . | . | . | BB 92491   | 3.4   | 3.8    |
| "                      | . | . | . | . | . | BB 94227   | (6.6) | (6.5)  |
| "                      | . | . | . | . | . | BB 94229   | 5.4   | 6.0    |
| "                      | . | . | . | . | . | BB 94226   | 6.5   | 6.3    |
| Internal mould of b.v. | . | . | . | . | . | BB 92467   | 4.5   | 5.0    |
| "                      | . | . | . | . | . | BB 94231   | 6.5   | 6.0    |
| "                      | . | . | . | . | . | BB 94228   | 6.3   | 5.9    |

**DISCUSSION.** A comparison between the Bryntowy topotypes, preserved exclusively as internal and external moulds, and the smaller number of complete shells from Coed Duon suggests that the latter sample consists of less elongate individuals. However, a large proportion of the topotypes are broken or slightly distorted. The parameters of external shape derived from the smaller Coed Duon sample therefore better define the proportions of *R. triangularis*, while the topotypes provide information on the variability of the internal morphology.

Since *R. triangularis* was first described, the species has been recorded in Upper Llandeilo rocks of the Berwyn Hills (McGregor 1961 : 201) and the related species *R. sparsa* Williams has been described (Williams 1963 : 467; 1974 : 153) from Caradoc rocks of the Bala and Shelve areas. It is evident, from the description given by MacGregor and a re-examination of his material, that the Berwyn specimens resemble *R. sparsa* both in outline and density of costae. We therefore doubt whether *R. triangularis* occurs outside the Llandeilo area.

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