LLANDEILO AND CARADOC (ORDOVICIAN) BEYRICHIOCOPE OSTRACODA
FROM ENGLAND AND WALES

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VOLUME 1
FRONTISPICE

Rubber cast of many palaeocope ostracode external moulds from the Spywood Member, Rorrington, Shropshire, x3.
ABSTRACT

LLANDEILO AND CARADOC (ORDOVICIAN) BEYRICHIOCOPE OSTRACODA
FROM ENGLAND AND WALES

C.R. Jones

Llandeilo and Caradoc beyrichiocene Ostracoda are described from England and Wales. They are referred to 3 suborders (Palaeocopa, Binodicopa, Eridostraca), 8 families (Eurychilinidae, Ctenonotellidae, Tetradosellidae (with 1 new subfamily); Bolliidae, Aechminidae, Circulinidae and Spinigeritidae; Eridoconchidae), 38 genera (7 new and 2 new subgenera) and 52 named species (35 new). Thirteen other forms are referred mainly to the Palaeocopa under open nomenclature, or are simply recorded.

Sampling was concentrated on the sandstone/limestone sequences of Llandeilo and Caradoc age of South Wales. Superbly preserved silicified faunas were extracted using acid techniques. Casting methods extended sampling into the predominantly sandy facies of Caradoc age of the Welsh Borderland, North Wales and northern England. Largely neglected, these ostracode mould faunas have provided an excellent source of material. Scanning electron microscopy has been extensively employed to illustrate the ostracodes recovered.

The biostratigraphy of Llandeilo and Caradoc beyrichiocopes from England and Wales is documented. They are useful in local stratigraphic correlation and may prove helpful in defining the base of the Caradoc Series in South Wales. Their potential for inter-regional correlation is limited.

British Ordovician ostracodes support other biogeographic evidence that during Llandeilo to Ashgill times, southern Britain moved closer to the Baltic and North American plates, as indicated by a breakdown in the provinciality of the British faunas.
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INTRODUCTION

The Order Beyrichiocopa Pokorný, 1953 (sensu Schallreuter 1968b, 1978) comprises Palaeozoic straight-hinged Ostracoda. Two suborders, the Palaeocopa Henningsmoen, 1953 and Binodicopa Schallreuter, 1972 are present in the British Ordovician, where they make up some ninety percent of the known ostracode species. The remainder belong mainly to the Order Podocopa Sars, 1866 and are forms similar to Medianella Neckaja, 1966. A single species of the platycope Ordovizona Schallreuter, 1969 is also present (Schallreuter & Jones 1984).

Palaeocopes are characterised by distinct velar dimorphism, usually of two basic types, antral and cruminal. Ordovician forms only develop the antral type of dimorphism, represented by ostracodes of the group Hollinomorpha Henningsmoen, 1965. Binodicopes on the other hand, have a non-dimorphic velar structure (= pseudovelum) and possess a node(s) on either side of the adductorial sulcus.

Ordovician beyrichiocope ostracodes are known mainly from Europe and North America; they have also been described from Asia, South America and Australia. Beyrichiocope species are often the most important elements in many Ordovician ostracode faunas and can be extremely abundant (see frontispiece). The usefulness of such faunas for biostratigraphy has been demonstrated, but their potential for international correlation remains to be realised.

OUTLINE OF PAST AND PRESENT RESEARCH

Siveter's (1978a, pp. 41-3) comprehensive history of research on British Ordovician ostracodes mentions nearly all the studies relevant to the present work. One publication was overlooked, that of Wade (1911) who re-assessed the taxa described by Jones (1890a) and erected the genus Melanella (= Vogdesella Baker, 1924) from the 'black shales of
Gwern-y-brain' (= Pen-y-Garnedd Shales & Phosphorite), Welshpool, Powys.

The period 1900-1978 has seen the publication of only four papers describing new ostracodes from the British Ordovician. Only recently has interest in the British faunas been revived, with the subsequent publications of Jones (1984), Jones & Siveter (1983), Schallreuter & Siveter (1983) and Siveter (1978a, 1982b, 1982c, 1983) who have described and illustrated British Llandeilo and Caradoc palaeocopae species.

The many detailed publications by Schallreuter (for example 1973, 1975, 1976, 1980b, 1982c, 1983b) on Baltoscandian ostracode faunas have greatly influenced our present knowledge of beyrichiocope taxonomy, and indeed highlighted the neglect of contemporaneous British Ordovician faunas.

The aim of this thesis is to monograph Beyrichiocopa from the Llandeilo and Caradoc series of England and Wales. Certain faunal elements that occur in the underlying Llanvirn Series are included for completeness. British museum collections of Ordovician ostracodes have been revised by the present author. However, much of the material treated herein has been obtained by extensive field collecting at many of the classical sections (Text-fig. 1) in the Ordovician of South Wales (Abereddy Bay and along the outcrop of the Towy anticline to Llandeilo and Builth), North Wales (Berwyn Hills and Welshpool area), the Welsh Borderland (Caradoc and Shelve areas) and northern England (Cross Fell Inlier and Lake District). Fieldwork was concentrated in Dyfed, South Wales because of its superbly preserved and abundant silicified ostracode fauna.

More than twenty five additional species have been extracted from silicified limestones of Ashgill age near Llandeilo, Dyfed (see Appendix). Time did not permit full taxonomic treatment of this fauna, the results of which will be published elsewhere (eg. Schallreuter &

Numbered locations refer to areas where Ordovician ostracodes are known to be present.
STRATIGRAPHY AND LOCALITIES

STRATIGRAPHY

Stratigraphical terminology and correlation essentially follows that of Williams et al. 1972, but with subsequent revisions of the following successions: Lake District (McNamara 1979), Cross Fell (Arthurton & Wadge 1981, Burgess & Holliday 1979), North Wales (Lockley 1980a, 1980b), Berwyn Hills (Brenchley 1978, Pickerhill & Brenchley 1979), Shropshire (Hurst 1979a, 1979b, Whittard 1979) and Dyfed (Addison 1974, Bassett et al. 1974, Wilcox & Lockley 1981). Text-fig. 2 shows a correlation of selected Ordovician successions in Wales and the Welsh Borderland. Chronostratigraphic classification of the Ordovician follows that of Barnes et al. (1981), Jaanusson (1979, 1982) and Paris (1981). Correlation of the British, Baltic and North American series with the Atlantic graptolite and conodont zones is outlined in Text-fig. 3. Pending international agreement as to whether the Ordovician System should be subdivided into Lower and Upper (Whittington & Williams 1964) or Lower, Middle and Upper (Jaanusson 1960), the present author has used the latter subdivisions informally (they correspond to the Baltic Ontikan, Viruan and Harjuan series respectively) or, wherever possible, the British Series have been used when correlating and comparing ostracode occurrences.

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<td></td>
<td></td>
<td></td>
<td>Oepikodus evae</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P.elegans</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P.proteus</td>
</tr>
</tbody>
</table>

TEXT-FIG. 3  Correlation of the British, Baltic and North American series with the Atlantic graptolite and conodont zones. (Modified from Bruton 1984).
10 and 13 were collected by Mr. P. Sheldon, 18 and 20 by Mr. S. Morris, and 50a-c by Dr. R. Cave. Many localities sampled and processed by the author lacked ostracodes and receive no further attention.

1. Ffairfach I: Railway cutting near Ffairfach station, Ffairfach, Llandeilo, Dyfed. The following localities are limestone bands in various units that comprise the Ffairfach Group; upper Llanvirn Series. Bassett 1982, p. 282. 1a. 32 m SU of level crossing. 1b. 95 m SW of crossing. Both at SN 6282 2113 in the 'Flags & Grits'. 1c. SN 6278 2106 in the 'Conglomerates'. Silicified material.

2. Ffairfach II: As loc.1, but in small quarry W of railway line; 2a. centre of quarry, 207 m SW of crossing. 2b. SW corner of quarry 210 m SW of crossing. Both at SN 6276 2104. Close to top of 'Lloydil Flags', Lower Llandeilo 'Flags', lower Llandeilo Series. Reference as loc. 1. Silicified material.


4. Cwm-Twrch: Small quarry 275 m SSW of Penllwyni, N of Nantgaredig, 8 km E of Carmarthen, Dyfed. 4a. SW face and 4b. NW face of quarry, both at SN 4956 2222; Llandeilo 'Flags', lower Llandeilo Series. Addison 1974, pp. 30-2. Silicified material.


6. Mincop Farm: 15 m W (104°) of Mincop Farm, outcrop at base of hedge, Meadowtown, Shropshire. SJ 3138 0186. Horizon and reference as loc. 5. Mould material.

7. Pant-y-hendre: Outcrop at E end of high northern subsidiary quarry of main Pant-y-hendre quarry, 500 m SE of Pant-y-hendre Farm. 550 m


9. Cefndyrys Lodge: Stream section opposite the lodge (= formerly Wellfield Lodge) above where stream is piped below road, 1.5km NE of Builth Hospital, Builth Wells, Powys. SD 044 528. Horizon and reference as loc. 8. Mould material.


11. Dynevor Park: The following localities are found within Dynevor Park, Llandeilo, Dyfed. SN 615 225. References pertaining to localities and horizons sampled are Williams 1953, p. 189; Bassett et al. 1974, p. 9; Wilcox & Lockley 1981. All the localities yielded silicified material.


11b. Small quarry 50m SW along track (leads to Towi floodplain) from mill at SW corner of 'fish pond', 520m WSW of Dynevor Castle (mansion). SN 6092 2216. 'Sandy Flags', Lower Llandeilo 'Flags', lower Llandeilo Series.

11c. as loc. 11b but on E side of track, 55m NW of the mill. SN 6088 2223. 'Sowerbyella Limestones'. Lower Llandeilo 'Flags', lower Llandeilo Series.
11d. as 11c but 80m NW of Mill. SN 6085 2220. Horizon as 11c.

11e. as 11c but 80m NW of Mill. SN 6084 2232. Horizon as 11c.

11f. N end of small cutting formed by sunken track. 50m NW of Keepers Lodge. SN 6135 2215. Middle Llandeilo "Flags", middle Llandeilo Series.

11g. exposure in Deer Park, 350m NW of Dynevor Castle (mansion). SN 6118 2273. Horizon as 11f.

11h. W face of quarry 95m NW of Keepers Lodge. SN 6133 2218. Horizon as 11f.

12. Kincoed: Quarry WSW of Kincoed Farm, 9km E of Carmarthen, Dyfed. Addison 1974, p. 35. 12a. 500m WSW of farm at SW end of quarry. 12b. 495m WSW of farm at extreme SW end of quarry. Both SN 5052 2113. Llandeilo "Limestone", middle Llandeilo Series. Silicified material.


16. Clog-y-frân: Old quarry 45m NE of small bridge over river Taf. 800m NW of Clog-y-frân Farm, 4km E of Whitland, Dyfed. SN 2385 1613. Llandeilo "Limestone", according to Strahan et al. (1909, p. 41) and Dr. R. Fortey (pers. comm.) the limestones are of Llandeilo age.
(based on trilobites). Ostracodes suggest an upper Llandeilo age. Rare silicified material.

17. Cwm Agol: Old quarry 600m NW of Pentre Davies Farm and 300m S of Cwm Agol Farm, Dryslwyn, 6.5km W of Llandeilo, Oyfed. SN 5655 2070. Llandeilo 'Flags'. Addison (1974, p. 36) and Owens (1973, p. 43) record a Llandeilo age (based on trilobites). Ostracodes indicate an upper Llandeilo age. Abundant silicified material.


20. Llangwm: Outcrops 280m S of Llangwm Farm, 0.75km NW of Llandeilo, Oyfed. SN 6084 2386. Williams (1953, pp. 194-5) considered the limestones to be of late Caradoc age. Ostracodes indicate an upper Llandeilo age. Silicified material.

21. Lampeter Velfrey I: Stream section S of bridge at E end of Lampeter Velfrey village, 4.5km E of Narberth, Oyfed. SN 156 144. Addison 1974, text-fig. 28. The following localities are from the Bryn-glas Limestone Member, Lampeter Velfrey Formation, Narberth Group of Addison 1974. Probably of upper Llandeilo age. 21a, E bank of stream 75m S of bridge, SN 1560 1435 (top of Bryn-glas Limestone). 21b, as 21a but 100m S of bridge, SN 1573 1433 (middle of limestone). 21c, W bank of stream 125m S of bridge, SN 1592 1428 (base of limestone). Silicified material.

22. Llan-mill: Small hillside quarry 200m NW of Llan-mill Farm,
Llan-mill, 3km E of Narberth, SN 1393 1439. Horizon as for loc. 21. Silicified material.

23. Lower Court: Overgrown quarry 400m NNE of Lower Court Farm, 2km SE of St. Clears, Dyfed. SN 3047 1510. Llandeilo 'Limestone'. Addison (1974, p.54) suggested an upper Llandeilo age (based on macrofauna), which the ostracodes confirm. Silicified material.

24. Ty-newydd: Thin limestone beneath black (Hydrim?) shales on E face of quarry, 90m N of Ty-newydd Farm, 180m SE of Nantgaredig Post Office, Nantgaredig, 8km E of Carmarthen, Dyfed. SN 4948 2160. Llandeilo 'Flags'. Strahan et al. 1909, p. 50. Addison (1974, p.34) records a middle or upper Llandeilo age, ostracodes indicate a horizon in the upper Llandeilo Series. Silicified material.

25. Llanfawr: S face of middle quarry. NE of Llandrindod Wells Hospital, Llandrindod Wells, Powys. SD 066 617. M. gracilis Shales beneath laccolithic intrusion. Baker & Hughes (1979, p. 69) suggested a "high Llandeilo age" or even lowest Caradoc. Mould material.

26. Bryn banc: Large quarry 500m SSE of Oyffryn Farm, Llan-mill, 3km E of Narberth, Dyfed. SN 1415 1450. The following come from the Bryn-banc Limestone Member, Llan-mill Formation, Narberth Group of Addison 1974 (p. 44, text-fig. 29). Probably of Costonian age (= basal Caradoc Series). 26a, NE face of quarry, SN 1415 1444. 26b, SE face, SN 1415 1442. Silicified material.

27. Henllan: Quarry in Old Garden, 825m SSW of Henllan Lodge, Llanddewi-Velfrey, 2.3km NE of Narberth, Dyfed. SN 1313 1600. 27a, N end of E face of quarry, SN 1313 1600. 28b, S end of E face, SN 1311 1597. Horizon for both samples as loc. 26. Addison 1974, p. 51. Silicified material.

28. Lampeter Velfrey II: Quarry 245m N of Bighouse, Lampeter Velfrey village, 4.5km E of Narberth, Dyfed. SN 152 145. 28a, S face of quarry, SN 1525 1456. 28b, centre of quarry, SN 1525 1457. Horizon
for both samples as loc.26. Addison 1974, p. 44. Silicified material.


31. Rorrington: 92m S of Rorrington Hall, inside gate on footpath to Kinton, Rorrington, Shropshire. SJ 2984 0062. Spywood Member, Chirbury Formation, upper part of Costonian Stage, Caradoc Series. Mould material and hydrofluoric acid residues.

32. Spywood: Stream bed, 137m NE of Spy Wood Cottage and 610m WNW (94°) of Upper Aldress, 6km ESE of Montgomery, Shropshire. SO 9581 2822. Horizon as loc.31. Mould material.


34. Cwms Cottage: 155m E of the cottage in bank at side of Caer Caradoc hill track and 1.12km WSW (72°) of Willstone, 2.5km NE of Church Stretton, Shropshire. SO 4016 9493. Horizon as loc.33. Greig et al. 1968, Harper 1947. Mould material.


36. Hazler Hill: Neptunian dyke entrenched in Uriconian (Precambrian) volcanics, small quarry W of hill track 0.5km SW of Hazler Barn, Hazler Hill, Church Stretton, Shropshire. SO 4635 9248. Harnagian
Stage, Caradoc Series. Strachan et al. 1948. Mould material.

37. Hope Bowdler: Exposure S of road (8 43771), 180m WNW (110°) of Hope Bowdler Church, Shropshire. SO 4739 9244. Horizon as loc. 33. Dean 1956, Greig et al. 1968, p. 329. Mould material.


42. Onny Valley I: Road section on N side of A489, 70m W of New House and 1500m W (100°) of Wistanstow Church, 3.5km N of Craven Arms, Shropshire. SO 4173 8586. Chatwell Sandstone Formation, Longvillian Stage, Caradoc Series. Hurst 1979b, p. 199. Mould material.

43. Onny Valley II: Base of quarry N side of A489 road section, 400m W of New House and 1.75km W (104°) of Wistanstow church, 3.5km N of Church Stretton, Shropshire. SO 4153 8601. Horizon, reference and material as loc.42.

44. Melmerby: Section on E side of A686 road, 1km NE of Melmerby.

45. Pus Gill: Mid-way up S side of Pus Gill stream gully, about 850m NE of Pusgill House, 1.3km NE of Dufton, Cumbria. 45a, NY 7036 2600. 45b, NY 7041 2601. They equate with localities 'P8' and 'P7' of Burgess & Holliday (1979, p. 12, fig. 8) respectively. Oufton Shales Longvillian Stage, Caradoc Series. Mould material.

46. Harthwaite Sike: Outcrops in N bank of stream about 1km E of Wharleycroft, 1km SE of Dufton, Cumbria. NY 7072 2476 (= locality 'H6' of Burgess & Holliday 1979, p.11, fig. 6). Oufton Shales, Longvillian Stage, Caradoc Series. Mould material.

47. Soudley: 2.05m above top of scree slope on E face of quarry, 600m S (168°) of Hope Bowdler church, Shropshire. S0 4772 9182. Glynboro Member, Cheney Longville Formation, Woolstonian Stage, Caradoc Series. Mould material.


49. Onny River: River section 0.75km NE of Cheney Longville, Shropshire. S0 4257 8543. The following are from the revised Acton Scott Formation of Dr. A. W. Owen in the type Onnian section (= Onnian Stage, Caradoc Series). 49a, 4.6m above base of Onnian (= middle of Onnia superba cobboldi Local Range Zone). 49b, 21.4m above base (= top of O. gracilis Biozone). 49c, 22.9m above base (= base of O.
superba superba Local Range Zone). All calcite material.

50. Gwern-y-brain: Stream section ~ 5km NW of Welshpool, Powys. SJ 2181

1266 (= base) to SJ 2186 1262 (= top). 50a, 1.9m above base of
Pen-y-Garnedd Phosphorite Member. 50b, 1 - 1.5m above base of
Pen-y-Garnedd Shale Member. 50c, 0.45 - 1.6m above loc. 50b. Mod
Glas Formation, Onnian Stage. Caradoc Series. Cave (1965, cf. fig. 3
for locality map and details) and Cave & Price (1978, p. 190) state
the Mod Glas to be of mid-Onnian age (= O. gracile Biozone). Mould
and calcite material, often compressed and distorted.

TERMINOLOGY

The terminology adopted herein for the description of the
beyrichiocopecarapace is essentially that outlined by Schallreuter
(1973), itself largely based on the fundamental works of Henningsmoen
(1965), Jaanusson (1957, 1966), Kesling (1951) and Martinsson (1962)
(Text-fig. 4).

The terms heteromorph and female are synonymous; both are used in the
text. Tecnomorph refers to the male and/or larval forms.

MEASUREMENTS

Five measurements in millimetres are used in describing valves
(Text-fig. 5), except when measuring rubber casts where only the
external dimensions could be taken. The measurements are tabulated as
follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>V LV</th>
<th>HV LV:HV</th>
<th>LD HD</th>
<th>LD:HD</th>
<th>HL PL</th>
<th>1.40 loc</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM</td>
<td>ZY ZY/Z</td>
<td>q-r</td>
<td>1.45 0.89 1.63 1.33 0.68 1.96 1.05 1.3-5</td>
<td>28b</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations used in tables of dimensions

No. = museum abbreviation plus number
V = valve, left (l) or right (r)
LV = greatest length of valve; excluding marginal sculpture
TEXT-FIG. 4. Terminology of the palaeocope and binodicope valve.

TEXT-FIG. 5. Measurements.
HV = greatest height of valve; measured up to hingeline
LD = greatest length of domicilium
HD = greatest height of domicilium
LV:HV = valve length : valve height
LD:HD = domicilial length : domicilial height
HL = length of hingeline
Pl. = Plate number with figure number(s) of specimen listed beneath
loc = locality number
♀ = female (heteromorph)
♂ = male (adult tecnomorph)
t = tecnomorph

Superscripted characters
* = more than
* = estimated value
HoL = holotype or lectotype

LV:HV and LD:HD are classifications of form of the valve and domicilium respectively (Schallreuter 1967a, 1968c), where:

<table>
<thead>
<tr>
<th>Value of LV:HV or LD:HD</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.45</td>
<td>very high</td>
</tr>
<tr>
<td>1.45 - 1.55</td>
<td>high</td>
</tr>
<tr>
<td>1.55 - 1.65</td>
<td>rather high</td>
</tr>
<tr>
<td>1.65 - 1.75</td>
<td>moderately high</td>
</tr>
<tr>
<td>1.75 - 1.85</td>
<td>moderately long</td>
</tr>
<tr>
<td>1.85 - 1.95</td>
<td>rather long</td>
</tr>
<tr>
<td>1.95 - 2.05</td>
<td>long</td>
</tr>
<tr>
<td>2.05 &gt;</td>
<td>very long</td>
</tr>
</tbody>
</table>

A similar procedure has been used to quantify length of hingeline (HL) where:

\[
\text{HL} \times 100 = \text{L} \quad \uparrow = \text{or best estimate}
\]
such that:

\[
\begin{array}{c|c}
\text{Resultant I} & \text{Length of hingeline} \\
45 < & \text{very short} \\
45 - 60 & \text{short} \\
60 - 70 & \text{moderately short} \\
70 - 80 & \text{moderately long} \\
80 - 95 & \text{long} \\
95 - 100 & \text{very long} \\
\end{array}
\]

In the text, figures in parentheses that follow taxonomic names represent the length of the largest valve measured (usually a female) for that particular taxon.

**MATERIAL STUDIED AND MUSEUM ABBREVIATIONS**

The majority of the material described in this thesis was obtained from the author's collections and from the following institutions (repository abbreviations in brackets):

- British Geological Survey, Keyworth (BGSK)
- British Geological Survey and Museum, London (GSM)
- British Museum (Natural History), London (BM)
- Clive R. Jones, personal collections (CRJ)
- David J. Siveter, personal collections (DJS)
- Ludlow Museum, Shropshire (LM)
- National Museum of Wales, Cardiff (NMW)
- Sedgwick Museum, Cambridge University (SM)

All the new material figured and recorded herein will be donated mainly to the British Museum and also the Sedgwick Museum and National Museum of Wales, upon publication of this work.
METHODS OF STUDY

Three types of material were used in this study:

1. Silicified material formed the greatest proportion of new material treated herein, virtually all of which was collected in South Wales.

To gain such material, limestone slabs are treated with acid which releases the silicified valves and carapaces from the carbonate matrix. The ideal target lithologies for this purpose proved to be unweathered biosparites and biomicrites. Calcareous siltstones were collected if abundantly fossiliferous, although many did not breakdown during processing. Trinucleid trilobites (often visible on weathered surfaces) proved good markers of horizons rich in ostracodes.

Bulk sampling was used throughout because ostracodes are rarely visible in the type of lithology collected. Samples were usually taken from considerably less than 0.5m$^2$ of strata to avoid 'bag' stratigraphy (Jaanusson 1982), which provides less useful results for faunal analysis. Sample weights ranged from 2-5kgm. The number of samples collected and etched from each locality varied from one to over five because some samples were barren, poorly silicified or repeated to obtain a particular heteromorph or species. Obtaining a good yield of silicified fossils was dependent on the degree of silicification of the fauna and purity of the carbonate matrix. Silicification in the Ordovician of South Wales is patchy, often varying within a quarry. Text-fig. 6 tabulates which British Ordovician limestones produced a silicified ostracode fauna.

A sample weight of 0.5-1kgm was optimum for processing. Each sample was reduced to limestone pieces of walnut size using a jaw crusher and washed to remove carbonate dust. Samples were then placed on plastic screens in plastic containers and covered with 3 litres of acid solution. A variety of acids were used with varying effect. Text-fig. 7 tabulates the results. Processing time for samples varied from two weeks
<table>
<thead>
<tr>
<th>LIMESTONE OR FORMATION CONTAINING CARBONATE HORIZON</th>
<th>SILICIFIED OSTRACODE FAUNA</th>
<th>MOULD FAUNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashgill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swindale Limestone</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Keisley Limestone</td>
<td>X(S)</td>
<td>-</td>
</tr>
<tr>
<td>Cystoid Limestone</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cautley Mudstones</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Rhiwlas Limestone</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>Sholeshook Limestone</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Robeston Wathen Limestone</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Birdshill Limestone</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Crug Limestone</td>
<td>X(S)</td>
<td>-</td>
</tr>
<tr>
<td>Caramoc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nod Glas</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Dolhir Limestone</td>
<td>X(S)</td>
<td>-</td>
</tr>
<tr>
<td>Cymerig Limestone</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>Derfel Limestone</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Acton Scott Formation</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Chatwell Sandstone Formation</td>
<td>-</td>
<td>X(S)</td>
</tr>
<tr>
<td>Harnage Shales</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Hoar Edge Grit</td>
<td>-</td>
<td>X(S)</td>
</tr>
<tr>
<td>Spywood Member</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Mydrim Limestone</td>
<td>X(S)</td>
<td>-</td>
</tr>
<tr>
<td>Narberth Group</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Llanello</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narberth Group</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Castell Limestone</td>
<td>X(P)</td>
<td>-</td>
</tr>
<tr>
<td>Llanello Limestones</td>
<td>X</td>
<td>X(S)</td>
</tr>
<tr>
<td>Llanvirn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ffairfach Group</td>
<td>X</td>
<td>X(S)</td>
</tr>
<tr>
<td>Durness Group</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arenig</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durness Group</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aberfoyle Limestone</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>

**TEXT-FIG. 6.** Table listing British Ordovician limestones or formations with carbonate units and showing which horizons yield a silicified and/or mould fauna. X = ostracodes present. (S) = sparsely present. (P) = poorly preserved. ? = possibly present.

<table>
<thead>
<tr>
<th>Acid</th>
<th>Strength</th>
<th>Results</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCL</td>
<td>10%</td>
<td>Fast. 'Clean' residues. Cheap.</td>
<td>Destroys phosphatic elements (eg. conodonts)</td>
</tr>
</tbody>
</table>

**TEXT-FIG. 7.** Table showing acids used and results obtained.
to several months depending on concentration and temperature of acid solution, size of limestone pieces and their resistance to dissolution. Spent acid solution was decanted off and any insoluble residue collected. The plastic screens suspend the sample while it is etched, thus allowing fragile valves to drop to the base of the container and help to avoid fragmentation of partially etched samples during acid replacement. Undissolved limestone was returned to the acid bath.

The washed residues were dried and then sieved (causing less fragmentation of valves) using mesh sizes of 1200, 800, 420, 250 and 125 microns and picked initially using the alcohol method (Martinsson 1962, pp. 39-40). Saliva was found to have better adhesive properties for lifting large specimens. The 1200 and 800 micron mesh fractions yielded most adult palaeocopae valves. Finer mesh sizes (250 and 125) were checked because they occasionally contained binodicoses and palaeocopae larvae. Beyrichiocopes formed about 90% of total ostracode species extracted. The relatively few non-beyrichiocope species were, however, often extremely abundant in certain samples. Yields were sometimes over 3000 ostracodes per sample.

Valves were mounted directly on SEM stubs for cleaning using fine needles and brushes. The specimens are so delicate that the cleaning techniques devised by Martinsson (1962, pp. 40-2) and Siveter (1980, p. 17) could not be used.

2. Calcite material was comparatively rare, comprising two types.
   i) Calcite valves recovered mainly from shales and siltstones by excavating the specimens using fine needles and prising them from the slab surface.
   ii) Etching sand and siltstones containing calcite ostracodes with 35% hydrofluoric acid (HF). HF dissolves silica, thereby releasing the microfossil pseudomorphs that consist of amorphous CaF₂. The methodology
of Schallreuter (1982a, 1983a) was employed. The technique gave poor results, since most of the sandstones processed were very resistant to acid corrosion. Best results have been obtained using cherts and cherty limestones (cf. Schallreuter 1982a, p. 171). Cherts of Llandeilo age from the Southern Uplands, Scotland, failed to yield a fauna when treated with HF.

3. Mould material formed most of the museum material studied, supplemented by the present author's collections.

After cleaning out the matrix from each mould to be cast, using fine brushes, poorly cemented slabs were impregnated with a dilute solution of 'Butvar B98' (manufactured by F. W. Joel, Downham Market, Norfolk), then left to dry at room temperature. Prior to casting, slabs of moulds were coated with a liquid detergent releasing agent such as 'Teepol' or 'Quadralene'. The methodology of Kelly & McLachlan (1980) and Siveter (1980, 1982a) was subsequently employed, using 'Silcoset 105' silicone rubber (manufactured by Imperial Chemical Industries) as the casting medium.

The technique gave superb results with full replication of fine detail, often less than five microns across (Pl. 19, figs 3, 4). Siveter (1982a) has described and illustrated similar types of fine ornament in Silurian beyrichiacean species from Britain.

PHOTOGRAPHY

Scanning electron microscopy (SEM) and stereophotography were used exclusively to illustrate the fauna. All specimens photographed using SEM were mounted on bevelled aluminium stubs (rivets) which eliminates foreground interference on 90° views (Siveter 1980).

Three types of adhesive were used for mounting specimens. 'Durofix' (Rawlplug Co. Ltd., London) holds large specimens securely. 'Kodaflat
500' (Kodak Ltd.) is easily absorbed by silicified valves and was used exclusively for mounting rubber casts. Siveter (1980, p.18) has described the applications of both mounting mediums. Double sided 'Sellotape' was used for mounting several specimens on a single stub. If the tape is left for several hours after attachment to the stub, a smooth surface develops as the glue settles. This ensures an aesthetically pleasing, even black background on SEM photographs. All three adhesives are soluble in acetone.

All specimens were coated with gold. Multiple coatings of gold were occasionally applied to specimens suffering build-ups of static electricity, in order to reduce the effect of 'charging'. Gold coating was used in preference to aluminium, because the latter is thought to have a detrimental effect on silicified specimens. Unfortunately the gold coating is not removable from these specimens.
SYSTEMATIC PALAEONTOLOGY

CHAPTER 1

ORDOVICIAN PALAEOCOPA FROM ENGLAND AND WALES

Subclass OSTRACODA Latreille, 1802 (nom. correct. Latreille, 1806)

Order BEYRICHIOCOPA Pokorný, 1953


Infraorder HOLLINOMORPHA Henningsmoen, 1965

Superfamily EURYCHILINACEA Ulrich & Bassler, 1925

(nom. transl. Jaanusson, 1957)

Family EURYCHILINIDAE Ulrich & Bassler, 1923

(nom. transl. Henningsmoen, 1953)

Diagnosis. (After Schallreuter 1975, p. 161). Unisulcate. Sulcus usually well developed, short to fairly long. Tubulose velum present in both sexes. Marginal sculpture is a row of spines.

Subfamily PIRETELLINAE Öpik, 1937

(nom. transl. Kay, 1940)


Diagnosis. (After Schallreuter 1975, p. 162). Trough-like sulcus. Preadductorial node distinct, more or less strongly developed. Lateral surface usually with a crista developed around ventral part of sulcus and node. Velar frill virtually entire or shortened. Dolon strongly convex, occasionally with a weak torus.

Discussion. Schallreuter (1964a, 1975) has discussed the taxonomy of the Piretellinae. Apart from *Duringia*, only two other piretellines are known: Hesperidella Öpik, 1937 and Piretella Öpik, 1937.
Occurrence. Middle and upper Ordovician of Baltoscandia and middle Ordovician of North America. In Britain, known from the Llandeilo and Caradoc series of South Wales and the Caradoc Series of the Welsh Borderland.

Genus DURINGIA Schallreuter, 1984

Type species. Original designation; Schallreuter 1984b, p. 9; Eurychilina spinosa Knüpfer, 1968, p. 9, pl. 4, fig. 1a,b; Upper Ore Horizon, Grafenthal Series (= uppermost Caradoc Series), middle Ordovician of Thuringia.

Other species. D. mackenziensis (Copeland, 1982); D. triformosa Jones, 1984; D? multipustulosa (Swain, 1962).

Diagnosis. (Slightly modified from Schallreuter 1984b). Medium sized questionable genus of Piretellinae. S2 long and sigmoidal. Preadductorial node rounded and distinct. Tecnomorphic velum developed as a flange or row of spines. Females with convex tubulose dolon, usually with a row of spines at the border of its lateral/ventral surface. Lateral surface spinose and/or granulose.

Discussion. Duringia has been discussed recently by Schallreuter (1984b) and Jones (1984). Its subfamilial assignment is based on the similarity of its dolon with that of Piretella Opik, 1937. However, the dolonal spines of D. spinosa and D. mackenziensis are not found in piretellids. The sigmoidal S2 of Duringia is opikiid-like and the remnant S3 of D. mackenziensis and D. triformosa may indicate quadrilobate ancestry. The familial assignment of Duringia remains uncertain.

D. mackenziensis, from the Chazyan Stage (= approximately Llandeilo age) of Canada, is the first record of the genus outside Britain and the Baltic. Copeland's (1982, pl. 1, figs 20-26) figured specimens of D.
mackenziensis are silicified; the fine structure of the dolon is indistinct (= tubulose ?) but its gross morphology is that of Duringia.

Both D. mackenziensis and D. spinosa have dolonal spines and more convex dolons than D. triformosa, and may represent a different lineage to the British species. The occurrence of a remnant S3 in the two oldest species, D. mackenziensis and D. triformosa, must represent a feature common to the ancestral stock which eventually became obsolete. A detailed phylogeny of Duringia awaits the description of additional species.

Swain (1962, pl. 109, figs 6a,b) figured two teconomorphic valves of D? multipustulosa which are morphologically similar to the larvae of Duringia species. Females of D? multipustulosa are not known and the species is thus included in Duringia with uncertainty.

Occurrence. Middle Ordovician of England and Wales, Thuringia, Canada, and possibly USA (Swain 1962).

Duringia triformosa Jones, 1984 Pl. 1, figs 1-6, 8, 9, 11, 15

1984 Duringia triformosa Jones sp. nov.; Jones, pp. 13, 15, pl. 11:14, 11:16.

Holotype. BM OS12261, female left valve; Pl. 1, fig. 4. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. More than 60 complete silicified valves and ten moulds of both dimorphs and teconmorphs.

Diagnosis. (After Jones 1984, p. 15). Duringia with diminutive preadductorional node. Narrow depression (= remnant S3) from posterovelbral region to dorsum. Dolon convex, tubulose and serrated distally. Tecnomorphic velum developed as a row of spines or ventral flange (males). Lateral surface spinose and granulose.

Diminutive preadductorial node. S2 long and sigmoidal, ventrally curved towards anterior, terminating close to velum. Shallow, narrow depression (= remnant S3) from posteroentral region to dorsum. Deep infravelar antrum in anterior and anteroventral regions. Dolon bends close to free margin posteroventrally. Post-dolonal velum ridge-like, dissolved into spines which terminate mid-posteriorly. Velum of both dimorphs clearly tubulose and distally serrated. Marginal sculpture is a row of spines. Lateral surface granulose and spinose.

Larvae have the velum developed as a row of spines, and in males it forms a ventral flange that is dissolved into spines anteriorly and posteriorly. Larvae occasionally have a calcarine spine.

Measurements.

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Discussion. The only complete female valve of D. spinosa (1.19mm) falls within the size variation displayed by females of D. triformosa (1.1-1.65mm). But for the presence of dolonal spines, a more convex dolon and a lack of a remnant S3, the type species quite closely resembles D. triformosa.

Females of D. triformosa show considerable size variation, especially between localities (Text-fig. 8). The youngest specimens from the Harnage Shales, Shropshire, are clearly larger than older individuals.
TEXT-FIG. 8. Size dispersion of *Duringia* triformosa.
from the Llandeilo 'Limestones' of Dyfed. However, the form, outline and morphology of both populations are closely similar. Tecnomorphic valves from the type locality show size overlap between presumed males and larvae. This, coupled with the size variation of concomitant females, maybe due to post-mortem transport of different populations and/or sampling across chronodeme boundaries. Size dispersion diagrams of Vittella fecunda Siveter, 1983 from the same locality also lack discrete instar groupings.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 2a, 3, 4, 11d, 17, 18, 20, 22, 26a, 27b, 28a,b) and Harnagian Stage, Caradoc Series of Shropshire (locs 37, 38).

Superfamily HOLLINACEA Swartz, 1936
(nom. transl. Jaanusson, 1957)

Family CTENONOTELLIDAE Schmidt, 1941

**Diagnosis.** (Slightly modified from Schallreuter 1976, p. 165). Quadrilobate to unisulcate. S2 usually moderately long to long, occasionally clearly sigmoidal, running oblique to hingeline and is directed anteroventrally. Commonly with cristae that show the present or former quadrilobate condition. Velar dimorphism commonly occurring, usually well developed but can be missing. Botulate (= non-loculate) antrum. Velar flange commonly undulate or occasionally forming a frill.

**Discussion.** The concept of this family has been redefined by Schallreuter (1976), who has also discussed its phylogeny (1966a, 1976, pp. 162, 163).
Subfamily TALLINSELLINAE Schallreuter, 1976


**Diagnosis.** (After Schallreuter 1976, p. 165). Usually clearly quadrilobate, more rarely bi- or unisulcate. Lobes sometimes dissolved into nodes. Cristae rare. Dimorphism strong to weak, or even absent. Dolon simple.

**Discussion.** Tallinnellinae are predominantly quadrilobate, usually with simple dolonate antra. The characteristic phylogenetic trend appears to be the dissolution of lobes, especially to form nodes (Schallreuter 1966a). However, this form of lobal reduction is not restricted to the Tallinnellinae. The sigmoopsine Kiesowia Ulrich & Bassler, 1908, for example, clearly shows dissolution of its lobes into nodes.

**Occurrence.** Tallinnellinae are found predominantly in the Ordovician of northern Europe (Henningsmoen 1953b, Jaanusson 1957, Neckaja in Abushik et al. 1958, Opik 1937, Sarv 1959, Schallreuter 1966a, 1976), Czechoslovakia (Príbyl 1966) and France (Vannier 1984). Copeland (1965) has recorded Tallinnella from the middle Ordovician of Canada.

In Britain, tallinnellines are known from the middle Ordovician of England and Wales.

**Genus BREPHOCHARIEIS** Siveter, 1985

**Type species.** Original designation: Siveter 1985 (in press); Bevrichia complicata Salter, 1848, pp. 234 (pars), 352 (pars), pl. 8, figs 16, 16a; from Llandeilo 'Flags', Llandeilo Series, near Llan-mill, 3km E of Narberth, Dyfed.

**Discussion.** *Brephocharieis* is readily distinguished from other tallinnellines, mainly by its more clearly differentiated quadrilobation and connecting lobe. See Siveter (1985) for further discussion.

**Occurrence.** Upper Llanvirn, Llandeilo and Caradoc series of Dyfed, Wales.

*Brephocharieis complicata* (Salter, 1848) Pl. 1, figs 7, 10, 12-14, 16

1848 *Bevrichia complicata*, Salter; Salter, p. 234, (para), 352 (para), pl. 8, figs 16, 16a.

1851 *Bevrichia complicata* (Salt.); McCoy, p. 136, (para), non pl. 1E, figs 3, 3a (= Harperopsia scripta).

1852 *Bevrichia complicata*; Salter, non p. ii, appendix A, pl. 1E, figs 3, 3a.

1855 *Bevrichia complicata*, Salter; Jones, p. 163-5 (para), pl. 6, figs 1-4, non fig. 5 (= larva of Harperopsia scripta).

1865 *Bevrichia complicata*; Huxley & Etheridge, p. 16, non pp. 7, 18.

1865 *Bevrichia complicata* Salter; Salter & Woodward, p. 19, non pl. 1, fig. 45.

1868 *Bevrichia complicata*, Salter; Jones & Holl, p. 59 (para).

1869 B. complicata, Salter; Jones, p. 15, fig. 22, non p. 11.
1881 *Bevrichia complicata*, Salter; Salter & Etheridge, p. 487
  *(par)*, pl. 19, fig. 9, *non* pp. 106, 397.

1890 *Tetradella complicata*, Salter; Ulrich, p. 112.

1900 *Tetradella complicata* (Salter); Ulrich & Bassler, p. 306.

1934 *Tetradella complicata* (Salter); Bassler & Kellett, p. 480 *(par)*.

1938 *Bevrichia complicata* Salter; Stubblefield, p. 35.

1947 *Tetradella complicata* (Salter); Harper, p. 346-7, pl. 10, fig. 3.

1963 *Tallinnella complicata* (Salter); Spjeldnaes, p. 255, pl. 36, figs 9-13, text-fig. 1.

1966c *Gunnaropsis complicata*; Schallreuter, p. 853.

1966 *Cerninella* (Cerninella) *comolicata* (Salter, 1848); Pribyl, pp. 206, 207 *(par)*, *non* pl. 2, figs 4-9, text-figs 4a-c.

1977 *Tetradella complicata* Salter; Swain, p. 29, fig. 3, no. 34.

1978a *Tallinnella* *comolicata* (Salter, 1848); Siveter, pp. 41, 43, 45, 48, pl. 1, figs 7, 8.

1979 *Cerninella complicata* (Salter, 1848); Pribyl, pp. 67, 68 *(par)*, pl. 3, figs 1, 2, *non* pl. 3, figs 3-7, text-figs 3 *(noe)* 3-4), 10 *(no.)* 1, 16 *(no.)* 2.

1985 *Brevoharleit complicata* (Salter, 1848); Siveter (in press).

**Lectotype.** Designated Siveter 1985 *(in press)*; GSM 24525 and GSM 24526 *(= part and counterpart)*, tecnomorphic left valve internal and external moulds; Llandilo 'Flags' *(= probably the Narberth Group)*, Llandilo Series; Llan-mill, 3km E of Narberth, Dyfed, Wales. Precise locality and horizon unknown.

**Material.** About 300 silicified valves and several internal and external moulds of heteromorphs and tecnomorphs.

**Diagnosis.** As for the genus.

**Description.** (Slightly modified from Siveter 1985). Lobes stout,
equally elevated except for depressed dorsal half of L4, confluent with an evenly curved, rounded connecting lobe, located very close to velum in lateral view; supravelar furrow virtually absent. L2 short, straight, pointing towards the end of the posteriorly reflexed, dorsal part of L1. L1, L3 and to a lesser extent L4, have dorsal cusps. Sulci deep; S2 and S3 broad. Dolon moderately wide, extends from near anterior cardinal corner to below S2. Narrow velum continues posteriorly as a fine ridge along ventral part of valve. Antrum anteroventral. Marginal sculpture is a row of tubercles. Valve surface very finely granulose.

**Measurements.**

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All valves from loc. 17

**Discussion.** Bevrichia complicata Salter, 1848 was the first ostracode species erected from the British Ordovician (Siveter 1978a). For a full discussion see Siveter (1985).

**Occurrence.** Upper Llanvirn and Llandeilo series (locs 1b, 3, 11a, 11d, 11e, 17) and Costonian Stage, Caradoc Series (loc. 26b) of Dyfed, Wales.
Genus HOMEOCERATOPSIS gen. nov.

Name. Greek 'homeo', resembling, and the generic name Ceratopsis Ulrich, 1894; referring to the homeomorphy between these genera. Gender feminine.

Type species. Homeoceratopsis jubata sp. nov.; from the Llandeilo Series of Dyfed, Wales.

Other species. H? sp. nov. 1.


Discussion. The fimbriate L1 and lobes L2-L4 of Homeoceratopsis resemble those of the homeomorph Ceratopsis, which belongs to the Tetradedllinae, because it develops a histial flange. A fimbriate speral process is also present in the tetradeellid Hastatellina Pribyl, 1975. This specialised development of L1 is clearly a homeomorphic feature of no special taxonomic significance.

The quadrilobate Homeoceratopsis lacks a histium and possesses a ventral connecting lobe, broad anterior to anteroventral dolon and supravelar furrow; these features are common to many Tallinnellinae. Homeoceratopsis is unique amongst tallinnellines in having a fimbriate speral process and fimbriate crest, or crista developed on L4. Other characteristic features of the genus include distinct cardinal corners; the posterior corner angle is just less than $90^\circ$, whereas the anterior angle is slightly greater than $90^\circ$. In lateral view, free margin hidden by velum in anterior and ventral regions where the marginal surface is epicline. Posteroventrally marginal surface narrow, more or less orthocline. Marginal sculpture is a row of spines.
Occurrence. Llandeilo Series and Costonian Stage, basal Caradoc Series, Dyfed, Wales.

1. *Homeoceratopsis jubata* sp. nov. Pl. 2, figs 1-12, 14-17.

**Name.** Latin 'juba', crest; referring to the fimbriate process of L4.

**Holotype.** CRJ SW023, female right valve; Pl. 2, figs 2-4, 10, 11, 17. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

**Material.** 12 heteromorphic and 80 tecnomorphic valves, all silicified.

**Diagnosis.** *Homeoceratopsis* with speral process having a fimbriate shaft. L2 reduced, forming a dorsal and ventral node. L3 obsolete dorsally. L4 flat and broad, ventrally elevated into fimbriate crest that merges with the rounded connecting lobe.

**Description.** Females moderately high to moderately long, tecnomorphs are rather long, all valves are distinctly preplete. HV and HD anterior of mid-length, LV and LD about mid-height. Domicilium moderately long to long and preplete. Transverse convexity of domicilium greatest ventrally, longitudinally it is greatest about mid-length. Hingeline long to very long.

L1 forming fimbriate speral process which projects beyond dorsum. Shaft of L1 and anterior part of connecting lobe up to base of L2 is fimbriate. L2 dissolved into dorsal and ventral nodes. L3 broad ventrally, constricted and obsolete dorsally, and not reaching the dorsum. L4 broadest, flattened; ventrally an elevated fimbriate crest merges posteroventrally with the rounded connecting lobe that joins lobes L1, L3, L4 and ventral node of L2.

S1 is virtually absent. S2 is 'comma'-shaped and deepest anteroventrally. S3 broad and shallow.
Velar flange entire, from posterior to anterior cardinal corner. In ventral view, contact between velum and domicilium is highest anteroventrally and runs close to free margin posteriorly. Dolon broad and most convex in anteroventral region.

Larvae are more preplete than dimorphs and have a posterior cardinal angle much less than $90^\circ$. S3 of larvae is very narrow and increases in width through ontogeny. Text-fig. 9 illustrates ontogenetic growth changes.

**Measurements.**

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</table>

All valves from the type locality.

**Discussion.** The fimbriate crest on L4 is a particularly diagnostic feature of *H. jubata*. No other tallinnelline possesses fimbriate lobes. *Bilobatia serralobata* Schallreuter, 1982 has posteriorly fimbriate lobes L1+L2, but it develops a special kind of antral dimorphism restricted to the Wehrliinae (see below) and is unrelated to *H. jubata*.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed (locs 3, 11d, 14, 17, 20, 26a).
2. Homeoceratopsis? sp. nov.  Pl. 2, fig. 13

**Material.** Seven complete and ten fragmentary tecnomorphic valves.

**Description.** Like *H. iubata*, except for the following: shaft of L1 depressed and cristate, fimbriation restricted to the sperral process. Ventral node of L2 less swollen than *H. iubata* and provided with a crest. L3 has a crest, just reaching dorsum. L4 with crista on anterior edge, not reaching dorsum. Connecting lobe ridge-like, more elevated than *H. iubata*, and extending posteriorly to dorsal margin. Sulci a little broader than *H. iubata*.

**Measurements.**

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</table>

All valves from loc. 17.

**Discussion.** Apart from the difference in lobar morphology mentioned above, *H?* sp. nov. 1 is similar to *H. iubata*. However, as the morphology of the female is unknown this species is left un-named and its generic position treated with caution.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed (loc. 11d, 17, 26a, 27b).
Genus HOMEOKIESOWIA Schallreuter, 1979

Type species. Original designation: Schallreuter 1979a, p. 75;
Kiesowia frigida Sarv, 1959, p. 79, pl. 12, figs 7, 8; from the Viru Series of Estonia.

Other species. H. epicopa Siveter, 1982; H. pernodosa (Opik, 1937)

Diagnosis. (After Schallreuter 1979a, p. 75). Medium-sized, quadrilobate Tallinnellinae. Lobes dissolved into single nodes. Three nodes in front of S2 and four behind. Node occupying site of ventral part of L3 (= 'posteroventral lobe') is strongest. Posteroventral-most node (L4, ventral part) is smallest, sometimes (especially in larvae) developed as a tubercle, can be fused with posterodorsal node (L4, dorsal part). At the dorsal border above L1 and L2 two small node- or spine-like tubercles may occur. Marginal sculpture is a row of spines.

Discussion. Homeokiesowia differs from other genera of Tallinnellinae by having lobes dissolved into single nodes (Schallreuter 1979a).

Occurrence. Middle Ordovician (Viru Series) of Estonia (Sarv 1959), Lithuania and Podolia, and from Backsteinkalk erratic boulders of northern Germany and the Isle of Gotland, Baltic Sea (Schallreuter 1979a).

In Britain, Homeokiesowia is restricted to the Llandeilo Series of Dyfed, Wales.

1. Homeokiesowia epicopa Siveter, 1982       Pl. 3, figs 1-9

1978a Tallinnella sp. nov. 1; Siveter, p. 48, pl. 1, figs 9, 10.

Holotype. BM OS6695, female left valve; Pl. 3, fig. 4; Llandeilo 'Flags', upper Llandeilo Series; old quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).
Material. More than 50 silicified valves of heteromorphs and
tecnomorphs.

Diagnosis. (Modified after Siveter 1982b, p. 89). Large species of
Homeokesowia (females c. 2.13mm), having small nodes on moderately
developed lobes. Dolon anterior to anteroventral.

Description. (Expanded from diagnosis of Siveter 1982b).
Homeokesowia with small nodes on moderately developed lobes L1-L4.
Dorsal parts of L1, L3 and L4 are bulbous, extending above dorsum. L2
consists of dorsal and ventral nodes connected by weak ridge. L4 and the
more prominent L3 are ridge-like centrally and each has a ventral node.
Sulci shallow. S1 very narrow, S2 and S3 equally broad. Marginal surface
orthocline.Velar ridge well developed, terminating just dorsal of
mid-height posteriorly. Dolon in lateral view extends from posterodorsal
region to below posterior base of L3. Valve surface granulose.

Measurements.

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Discussion. The lobal morphology of the stratigraphically younger H.
frigida and H. pernodosa represents a more advanced condition than in H.
epicopa, which shows incipient dissolution of its lobes into nodes
(Siveter 1982b). H. frigida (♀ 1.05-1.45mm) is smaller than H. epicopa,
it has a longer dolon covered with tubercles, and small dorsal spines
above L1 and L2. Furthermore, the lobes of H. frigida are dissolved into
more isolated single nodes than those of H. epicopa.

Occurrence. Llandeilo Series of the Carmarthen and Llandeilo areas,
Dyfed (locs 3, 11a, 17). Also on slabs SM A33368, SM A33370, SM A6353-4 from a quarry 270m W of Ysgubor Wen Farm, 2km E of Llandeilo, Dyfed, precise locality unknown. Basal sands, lower Llandeilo Series.

Genus TALLINNELLA Öpik, 1937

Type species. Original designation; Öpik 1937, pp. 88, 89, pl. 2, fig. 2a,b; Tallinella dimorpha Öpik, 1937; from the Uhaku Stage (= Llandeilo) of Uhaku, Estonia.

Other species. I. angustata (Krause, 1891); I. lata (Krause, 1891); I. marchica (Krause, 1889); I. modulata Sarv, 1959; I. panda Copeland, 1965; I. reticulata Sarv, 1963; I. sebvensis Jaanusson, 1957; I. trident Henningsmoen, 1953; I. tumida Henningsmoen, 1953; I? pachydactyla Jaanusson, 1957; I? tomacina sp. nov.

Diagnosis. (Modified from Jaanusson 1957, p. 340). Large, quadrilobate Tallinnellinae. L1 and L4 can be parallel-sided, bulbous or obsolete dorsally. L1 sometimes swollen ventrally. L2 shortest, merges with connecting lobe or developed as separate node. L3 usually bulbous dorsally. Velar ridge thick, terminating abruptly short of posterior cardinal corner. Dolon long, convex and from anterior to anteroventral regions. Valves smooth, finely granulose, or punctate.

Discussion. Tallinella is a broadly defined taxon in need of revision. Lobation is particularly variable between species. Dimorphism has yet to be proven in I. lata, I. panda, I. sebvensis, I. trident, I. tumida and I? pachydactyla. The latter is included with uncertainty because it is poorly known and has very narrow sulci and more inflated lobes than any other Tallinella species.

Occurrence. Lower and middle Ordovician of Baltoscandia, erratic boulders of northern Germany (Jaanusson 1957), north western European Russia (= Estonia and Byelorussia, see Sarv 1963, Ivanova 1979) and
middle Ordovician of Canada (Copeland 1965).

_Tallinella? tomacina_ is from the middle Ordovician of Dyfed, Wales.

_Tallinella? tomacina_ sp. nov. Pl. 3, figs 10-19, Text-fig. 10

Name. Latin 'tomacina', a kind of sausage; alluding to the shape of the dolon.


_Material._ One tecnomorph and two female valves as external moulds and six female and nine tecnomorphic silicified valves, all are fragmentary (one complete male valve was broken prior to photography).


_Description._ Valves rather high to moderately long. Females preplete, tecnomorphs slightly preplete to sub-amplete. HV is about mid-length, LV just dorsal of mid-height. Domicilium long to very long and amplete to slightly preplete. HD is anterior, LD about mid-height. Transverse convexity of domicilium greatest ventrally, longitudinally it is about mid-length. Hingeline long to very long. Cardinal corners greater than 90°. Marginal surface in tecnomorphs is epicline in anterior to ventral regions. Lateral margin in females is steep and convex in anterior to ventral regions.

Lobes L1-L4 very narrow, ridge-like. L1 and L3 almost vertical. L2 and L4 slope towards anterior. L1 expanded dorsally, narrower and
TEXT-FIG. 10. Reconstruction of *Tallinnella? tomacina* x40

(a) tecnomorph left valve

(b) female left valve
depressed ventrally. L2 shortest, very narrow. L3 constricted ventrally, widening dorsally. L4 usually obsolete above mid-height, occasionally entire (Pl. 3, fig. 13) with swollen, parallel-sided dorsal cusp. All lobes joined by narrow bow-shaped connecting lobe which can be depressed ventrally below the sulci. S1 constricted dorsally. S2 and S3 very wide.

Velar ridge thick, running parallel with free margin except in central posterior and posteroventral regions where running higher on domicilium. Dolon from anterior cardinal corner to central ventral region, extremely convex, covering free margin in ventral view. Row of spines forms the marginal sculpture.

Valve surface finely granulose and sparsely tuberculate (mainly surrounding the L4 dorsal cusp).

**Measurements.**

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**Discussion.** I? _tomacina_ (♀ c. 2.06mm) is smaller than _T. dimorpha_ (♀ c. 2.90mm) and differs further by having narrower, ridge-like lobes, more elevated connecting lobe and a longer more convex dolon.

I? _tomacina_ possesses features characteristic of both _Tallinnella_ and _Piretopsis_ (_Protallinnella_) (Jaanusson, 1957). The dolon and thick, posteriorly elevated velar ridge of I? _tomacina_ (Text-fig. 10) is similar to _T. dimorpha_, but its ridge-like lobes and ventrally depressed, bow-shaped connecting lobe are particularly reminiscent of _P._ (P.) _ranuncula_ sp. nov. and _P._ (P.) _salopiensis_ (Harper, 1947). I? _tomacina_ is included in _Tallinnella_ with uncertainty, having more in common with _Tallinnella_ than _P._ (_Protallinnella_).
Occurrence. Apart from the type locality where SM A33369 (= left valve female) also comes from, the species is present in the upper Llanvirn, Llandeilo and basal Caradoc series (Costonian Stage) of Dyfed (locs 1b, 12a,b, 21a, 28a).

Subfamily STEUSLOFFIINAE Schallreuter, 1966

British genera. Piretopsis Henningsmoen, 1953; Varilatella gen. nov.

Diagnosis. (Slightly modified from Schallreuter 1976, p. 180).
Usually unisulcate, rarely quadrilobate. Commonly possessing cristae which delineate a former quadrilobation. Velar dimorphism; often poorly developed, sometimes absent. Dolon simple or can have a low, ridge-like torus forming the outer antral fence (= toral dimorphism of Schallreuter 1976).

Discussion. Schallreuter (1966a, 1976) has discussed the phylogenetic relationships within the Steusloffiinae. The characteristic phylogenetic trend within this subfamily is a tendency to develop lobal cristae accompanied by unisulcation and some loss of quadrilobation.

Occurrence. Steusloffiinae are restricted to the Ordovician of Baltoscandia (Henningsmoen 1953b, Jaanusson 1957, Opik 1937, Schallreuter 1966a, 1976), England and Wales.

Genus PIRETOPSIS Henningsmoen, 1953

Type species. Original designation; Henningsmoen 1953b, p. 43;
Piretopsis donsi Henningsmoen, 1953, p. 44, pl. 2, figs 7, 8; Chasmops Series (= Caradoc) of Oslo, Norway.

Diagnosis. L1-L4 developed, variously cristate and oblique to dorsum. L1, L3 normally project beyond hingeline. Sulci wide. Velum, ridge- or flange-like, typically restricted posteroventrally. Dolon narrow to
moderately broad. Antrum anteroventral to ventral, weak to moderately concave.

**Discussion.** *Piretopsis* is subdivided into three closely related subgenera based on differences in lobation (Schallreuter, Siveter & Kruta 1984). *P. (Piretopsis)* and *P. (Cerninella)* (Pribyl, 1966) are both monotypic. *P. (Piretopsis)* differs from *P. (Cerninella)* by its smaller S3 and from both *P. (Cerninella)* and *P. (Protallinnella)* (Jaanusson, 1957) by lacking the crista C2. *P. (Protallinnella)* differs from *P. (Cerninella)* by its more vertical lobes/cristae, narrower S3 and having C2 still joined with the connecting lobe.

**Occurrence.** Lower and middle Ordovician of Baltoscandia and middle Ordovician of Britain, Czechoslovakia and Morocco (see Schallreuter, Siveter & Kruta 1984).

**Subgenus PROTALLINNELLA** Jaanusson, 1957

**Type species.** Original designation; Jaanusson 1957, p. 353; Bevrichia grewingkii Bock, 1867, p. 594, from the Kunda Stage (= uppermost Arenig and lower Llanvirn), Obuchowo, Wolchow River, northwestern Russia.

**Other species.** *P. (P.) loennaensis* (Sarv, 1963); *P. (P.) ranuncula* sp.nov.; *P. (P.) salopiensis* (Harper, 1947); *P. (P.) tricostata* (Sarv, 1963); *P. (P.) quadricostata* (Sarv, 1963).

**Diagnosis.** Species of *Piretopsis* with vertical ridge-like lobes/cristae (C1-C4) and bow-shaped connecting lobe. C1, C3 usually project beyond dorsum. C4 often redundant, occasionally provided with cusp. C2 short, always connected with C1+C3. Sulci fairly wide. Anteroventral dolon. Antrum long, anterior to posterovertral. Valves granulose and/or smooth. Marginal sculpture is a row of spines.

**Discussion.** The phylogeny of *P. (Protallinnella)* has been discussed by Schallreuter, Siveter & Kruta (1984, p. 127), who suggest that the
Protallinnella species described by Sarv (1963) and P. (P.) salopiensis form a "gradual morphological transition series" between the type species of P. (Protallinnella) and P. (Cerninella). Other features characteristic of the genus include an epicline marginal surface in tecnomorphs and a velum from the anterior cardinal corner, terminating close to free edge at mid-height posteriorly but virtually entire in the type species. Females have a distinctive velar ridge or flange parallel with the free margin.

**Occurrence.** Lower Ordovician (Volkhov and Kunda stages) of Baltoscandia (Jaanusson 1957, Sarv 1963) and middle Ordovician (Llandeilo and Caradoc series) of Wales, the Welsh Borderland and Morocco (Schallreuter, Siveter & Kruta 1984).

1. **Piretopsis (Protallinnella) ranuncula** sp. nov.

   Pl. 4, figs 1-11, 14, 15

**Name.** Latin 'ranunculus', a tadpole; alluding to the shape of L1.

**Holotype.** CRJ SW013, silicified female left valve; Pl. 4, figs 4, 5, 9-11, 14. Bryn-banc Limestone Member, Narberth Group, Costonian Stage, Caradoc Series; Lampeter Velfrey quarry, 4.5km E of Narberth, Dyfed (loc. 28b).

**Material.** 225 silicified valves of both dimorphs and larvae, and one female and several tecnomorphic carapaces.

**Diagnosis.** *Piretopsis (Protallinnella)* species with slender ridge-like lobes/cristae, joined by narrow connecting lobe. Anterior lobe (L1), connected to base of large dorsal bulb. L2 very short. L4 widest, almost obsolete from mid-height to dorsum. Stout velar ridge with strong supra-velar furrow. Valve surface finely granulose. Antrum smooth.

**Description.** Females longer than males. Both dimorphs moderately
high, slightly preplete; larvae are moderately high to moderately long and preplete. HV is mid-length, LV about mid-height. Domicilium long in females, and rather long to long in tecnomorphs and distinctly preplete. HD anterior, L0 just dorsal of mid-height. Transverse convexity of domicilium greatest ventrally, longitudinally it is about mid-length.

Hingeline long, adont, with crenulated hinge groove in right valves (Pl. 4, fig. 8). Distinct posterior cardinal corner, with angle of about 90°.

Anterior corner angle is greater than 90°. Left/right valve overlap.

Lobes L1-L3 slender, ridge-like, sloping towards anterior. All lobes joined ventrally by bow-shaped connecting lobe. L1 narrow and depressed ventrally, expanded dorsally beyond central-anterior region to form large bulb, often with dorsal bifurcation. L2 very short and narrow. L3 constricted ventrally. L4 almost obsolete above mid-height, tumid ventrally. L1, L3, L4 project above dorsal margin. S2, S3 are wide. S1 much narrower and constricted dorsally.

Stout velar ridge with well developed supra-velar furrow, especially in adults. Velum rounded distally, runs more or less parallel with free edge ventrally. Female velum swollen anteriorly, forming small dolon. Marginal sculpture is an almost entire row of spines, most strongly developed antero-ventrally.

Valve surface finely granulose, slightly coarser on the velum and dorsal parts of L1, L3, L4; antrum smooth.

L1, L3 of larvae are pointed dorsally, emphasising the slight bifurcation of L1. The connecting lobe and L1-L4 become more prominent and well defined through ontogeny. L4 of larvae is less ventrally tumid than in dimorphs. The supra-velar furrow is particularly well developed in adults.
Measurements.

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Discussion. P. (P.) ranuncula differs from all other P. (Protallinnella) species by its wider lobes, ventrally tumid L4 and deep supra-velar furrow. It probably forms the ancestral stock from which P. (P.) salopiensis developed.

Occurrence. Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed and Powys (locs 3, 4a, 7, 10, 12a,b, 23, 26b, 28a,b and on slab SM A44642, from quarry 200m N of Pant-dwfn, 1.5km SE of St. Clears, Dyfed. SN 2891 1530; Llandeilo Series).

2. Piretopsis (Protallinnella) salopiensis (Harper, 1947)

Pl. 4, figs 12, 13, 16-22

1947 Tetradella salopiensis sp. nov.; Harper, p. 351, pl. 10, figs 5, 7, 9, text-fig. 1c.
1966 Cerninella (Cerninella) salopiensis (Harper, 1947); Pribyl, pp. 203, 205.
1978a Sinoopsis salopiensis (Harper, 1947); Siveter, p. 50 (para), pl. 2, figs 2-4, non pl. 2, fig. 1 (= Oomoopsis (Quadridigitalis) siveteri sp. nov.).
1979 Cerninella salopiensis (Harper, 1947); Ivanova, p. 344.
1984 Piretopsis (Protallinnella) salopiensis (Harper, 1947); Schallreuter, Siveter & Kruta, p. 135.
**Holotype.** GSM 75421C, tecnomorphic right valve external mould; Harper 1947, pl. 10, fig. 5; herein Pl. 4, fig. 18; from the Spywood Member, Middleton Formation, upper part of Costonian Stage, Caradoc Series; footpath to Kinton 92m S of Rorrington Hall, Rorrington, Shropshire (loc. 31).

**Material.** More than 50 external moulds of both dimorphs and larvae collected by the present author and cast from BM slabs 3336/A and B, 3376/B, 3397/B and C, 3585/B, 3584/B (Whittard Coll.); and nine silicified valves (four of which are fragmentary) etched from limestones collected in Dyfed.

**Diagnosis.** Species of *Piretopsis* (*Protallinnella*) with narrow ridge-like lobes/cristae joined by narrow connecting lobe which is depressed below S1, S2. Anterior lobe/crista sigmoidal, ventral part connects to posterior of dorsal bulb. C2 short. L4 with crista terminating posterior dorsocentraally, provided with dorsal crest. Velar ridge, flange-like with fairly shallow supravelar. Sulci ventrally granulose, smooth elsewhere.

**Description.** Females longer than males. Females high to rather high, males rather high to moderately high, both almost amplete. Larvae rather high to moderately long and preplete. HV about mid-length, LV dorsal of mid-height. Transverse convexity of domicilium greatest ventrally. Longitudinally, convexity is greatest about mid-length. Hingeline long. Anterior and posterior cardinal corner angles obtuse.

Lobes L1-L4 reduced to ridge-like cristae (C1-C4), joined ventrally by extremely narrow connecting lobe, bow-shaped, depressed and ventrally extended below S1, S2. C1 sigmoidal, ventral part connected to posterior of dorsal bulb. C2 short. C1, C2, C4 slope towards anterior. C3 vertical dorsal of mid-height. L4 broad and reduced, with dorsal crest and thick crista (C4) that terminates dorsocentraally. L1, C3 project beyond dorsal margin. S1-S3 long and wide. S1 widens ventrally.
Flange-like velar ridge, with weak to well developed supravelar furrow. Tecnomorphic velum distally frill-like, contact with domicilium highest in central part of ventral region. Heteromorphic velum keel-like and runs parallel with free margin. Velum terminates dorsal of mid-height in dimorphs and larvae. Dolon indistinguishable but for slight anterodorsal flexure.

Ornamentation virtually absent, possibly due to poor preservation. Scattered granules throughout S3 and ventrally in S1, S2.

Larval cristae well-developed. L1 dorsal bulb more prominent in dimorphs. Supravelar furrow often strongly developed in larvae.

Measurements.

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<td>31</td>
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Discussion. P. (P.) salopiensis differs from P. (P.) ranuncula by having narrower, more cristate lobes, a sigmoidal C1 (the ventral part of which connects posteriorly to the dorsal bulb), a vertical L3 and anteriorly sloping L4, and a shallower supravelar furrow in females. P. (P.) growingkii (9 0.1.30mm) differs from P. (P.) salopiensis in having more upright lobes/cristae, L1 lacking a dorsal bulb, S3 narrower, and a relatively broader and entire velar flange.

Lobes/cristae of Piretopsis (Protallinnella) species clearly display interspecific variation. There is also a general trend to develop lobal cristae, reduce quadrilobation and increase in size (Schallreuter, Siveter & Krūta 1984).
Harper (1947, pp. 351, 352) placed P. (P.) salopiensis in Tetradella on the basis of its lobation; the species dimorphism was not recognised. Harper considered P. (P.) salopiensis to be most similar to 'Bevrichia' complicata Salter, 1848, a species recently revised by Siveter (1985). Přibyl (1966) included P. (P.) salopiensis in his new subgenus Cerninella (Cerninella), which is now considered a monotypic subgenus of Piretopsis (Schallreuter, Siveter & Krüta 1984). Siveter (1978a) placed P. (P.) salopiensis in Sigmoopsis Henningsmoen, 1953 on the basis of heteromorphic morphology. The female left valve figured by Siveter (1978a, pl. 2, fig. 1) is herein assigned to Sigmoopsis siveteri sp. nov. Ivanova (1979) considered P. (P.) salopiensis, Harperopsis scripta (Harper, 1947) and Harperopsis bicuneiformis (Harper, 1947) as mere variations of a single species. Most recently, Schallreuter, Siveter & Krüta (1984) have assigned 'I.'salopiensis to Protallinella.

P. (P.) salopiensis is the youngest and largest known Protallinella species.

Occurrence. Coston Beds (loc. 30) and the Spywood Member, Middleton Formation (locs 31, 32), both Costonian Stage, Caradoc Series of Shropshire. Also collected from the Bryn-banc Limestone Member of the Narberth Group (loc. 28b), Costonian Stage, Caradoc of Dyfed.

Genus VARILATELLA gen. nov.

Name. Latin, 'varus', pimple and 'latus', side and the diminutive suffix -ella; referring to the fine granulation of the valve surface. Gender feminine.


Diagnosis. Medium sized, quadrilobate Steusloffiinae, having
vertical, usually cristate lobes. L1, L3, L4 reach to or beyond dorsal margin. L1 broad. L2 short, obsolete, forming elongate preadductorial node. L3 well developed to weak. L4 broadest. Cristae C1-C3 frequently present, C4 usually absent. S1 redundant. S2, S3 deep or shallow. Velar flange moderately broad, with abrupt mid-posterior termination. Valve surface granulose.

Discussion. Varilatella is related to Tallinnellina Jaanusson, 1957 and Rigidella Öpik, 1937, but differs in having an abrupt mid-posterior termination of the velum, a feature also characteristic of Tallinnella Öpik, 1937 sensu Jaanusson (1957, p. 344). However, Tallinnella species have a thick velar ridge, distinct supravelar furrow, quite strongly convex dolon, and are larger than any members of Varilatella. Forms like Tallinnellina palmata (Krause, 1889), having an entire velum, probably represent the ancestral stock which gave rise to Varilatella (Text-fig. 11). Schallreuter (1976, text-fig. 6) has illustrated a similar morphological trend in Steusloffiia Ulrich & Bassler, 1908, where ancestral forms have an entire velum and descendant species gradually develop a posterior velar termination.

In general, Steusloffiiinae illustrate trends towards reduced quadrilobation combined with replacement by cristae, both of which are manifest in Varilatella.

Subgenus VARILATELLA subgen. nov.

Name. As for the genus.

Type species. As for the genus.

Other species. V. (V.) bulbosa sp. nov.

Diagnosis. Species of Varilatella with well developed lobes (L1, L3, L4) and sulci (S2, S3). Lobes joined ventrally by bow-shaped connecting lobe.

Discussion. Apart from the posterior termination of the velum, V. (Varilatella) differs further from the related Tallinnellina by having wider, vertical lobes with a broad bow-shaped connecting lobe. Tallinnellina is a lower Ordovician genus known only from Baltoscandia. V. (Varilatella) probably arose from a Tallinnellina-like ancestral stock, at the latest by early Llandeilo times.

Occurrence. Llandeilo and basal Caradoc series of Dyfed and the Caradoc of Shropshire.

1. Varilatella (Varilatella) bulbosa sp. nov. Pl. 5, figs 1-6.

Name. Latin 'bulbosus', swollen; alluding to the dorsally prominent L3.

Holotype. CRJ M08, male right valve external mould; Pl. 5, fig. 2. Harnage Shales, Harnagian Stage, Caradoc Series; exposure S of B6371 road 180m WNW of Hope Bowdler church, Shropshire (loc. 37).

Material. Two female and five technomorphic external moulds.

Diagnosis. Varilatella (Varilatella) species with very broad L1 fused with diminutive L2. L3 constricted at mid-height, bulbous dorsally. C1, C3 well developed. C2 usually absent.

Description. Valves moderately high to moderately long. Dimorphs more
or less amplete. Larvae more preplete. HV about mid-length, LV about mid-height. Transverse convexity of domicilium greatest ventral of mid-height. Hingeline long.

Lobes L1, L3, L4 well developed and nearly vertical, perpendicular to dorsal margin. L1 very broad; fused with obsolete L2 that dorsally remains as node-like swelling in anteroventral region. L3 most elevated lobe, centrally constricted, bulbous dorsally. L4 quite broad with small, pointed dorsal cusp. Crista C3 usually more stout than C1; both fully developed, just reaching dorsal margin. C2 occasionally present as crest on dorsal node of L2. Connecting lobe broad, but narrows beneath S2. S1 absent. S2 broad, ventrally curves towards anterior. S3 usually broadest.

Velar flange from anterior cardinal corner to posteroventral region, where it terminates abruptly. Valve surface granulose, S2 sparsely granulose.

Measurements.

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<th>HL</th>
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Discussion. The ontogeny and ventral morphology of V. (V.) bulbosa is incompletely known due to the lack of suitable material and poor mould preservation. Its dolon and velum are similar to that of the older V. (V.) dissita but its lobes L1, L3 are broader and more elevated. V. (V.) bulbosa differs further from V. (V.) dissita by its larger size, more dorsally bulbous L3, and in having a fused L1-L2 that lacks the V-shaped cristae C1-C2.

Occurrence. Known only from the Harnage Shales, Harnagian Stage.
Caradoc Series of Shropshire (loc 31, 37).

2. *Varilatella (Varilatella) dissita* (Schallreuter & Siveter, 1983)

Pl. 5, figs 7-16


Holotype. BM OS6698, female right valve; Pl. 5, figs 7, 8, 12, 13; Llandeilo ‘Flags’, upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. More than 100 silicified valves of heteromorphs and tecnomorphs.

Diagnosis. Species of *Varilatella (Varilatella)* having lobes L1-L3 and sometimes ventral part of L4 cristate. L1 with prominent dorsal cusp. C1-C2 form distinct V-shape.

Description. Valves rather high to moderately high. Larvae preplete, dimorphs slightly preplete. HV is just anterior of mid-length, LV is about mid-height. Domicilium moderately long to rather long and slightly preplete. HD is about mid-length, LD just ventral of mid-height. Transverse convexity of domicilium greatest just ventral of mid-height, longitudinally it is mid-length. Hingeline long. Posterior cardinal corner rounded. Marginal surface in tecnomorphs is epicline in anterior to posteroventral regions, in females it is epicline posteroventrally. Left/right valve overlap.

Lobes L1-L4 virtually straight and perpendicular to dorsal margin. L1, L3, L4 reach dorsal margin where they are more or less weakly expanded. L1 usually with distinct dorsal cusp, but can be absent (Pl. 5, fig. 9). L4 broadest with dorsal cusp. L1-L3 and sometimes ventral part of L4 are cristate. C2-C2 form distinct V-shape. Connecting lobe
bow-shaped, slightly depressed below S2. S1 virtually obsolete, S2-S3 equally broad.

Velar flange from anterior cardinal corner, to mid-posterior where it terminates abruptly. Anteroventral dolon fairly convex. Simple antrum extends from anterior to below L3. Row of spines forms the marginal sculpture.

Valve surface granulose except for smooth antrum and presumed comma-shaped site of muscle attachment of S2.

Larvae more preplete than adults and have a more reduced connecting lobe and L1 dorsal plica.

Stratigraphically younger adult specimens (for example loc. 28a) have a poorly developed L1 plica and more elevated, robust crista on L3 (Pl. 5, fig. 9).

Measurements.

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<th>HV</th>
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<td>0.88</td>
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Discussion. The morphology and phylogenetic affinity of V. (V.) dissita (φ c. 1.47mm) have been discussed by Schallreuter & Siveter (1983, p. 3) who placed it within Tallinnellina and suggested it was closely related to the Estonian Tallinnellina rara Sarv, 1959 (largest tectomorph = 0.89mm), because like V. (V.) dissita, it too has a posterior termination of the velum. The present author considers T7 rara to be a questionable Tallinnellina species. No females of T? rara are known, but the ventrally projected connecting lobe (= histium?) of Sarv's figured tectomorphs (1959, pl. 9, figs 14, 15) resembles species
The only other possible *Tallinnellina* species with a posterior velar termination is *T? sarvi* Ivanova, 1970. It is a typical *Tallinnellina* in its large size (9.5 mm, text-fig. 62 of Ivanova 1970), narrow L1, L4, connecting lobe and punctate supravelar furrow, and is unlike any *Varilatella* species.

*V. (V.) dissita* is most closely related to *V. (V.) bulbosa* and is the earliest known descendant from the *Tallinnellina*-like ancestral stock.

**Occurrence.** Upper Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed (loc. 17, 21a,b, 22), and upper part of Costonian Stage, Shropshire (loc. 31).

Subgenus REDACTA subgen. nov.

**Name.** Latin 'redactus', reduced; referring to the obsolete lobation.

**Gender feminine.**

**Type species.** *Varilatella (Redacta) coronata* sp. nov.; from the Costonian Stage, Caradoc Series, Dyfed.

**Other species.** *V. (R.)* sp. nov. 1; *V. (R?)* sp. nov. 2.

**Diagnosis.** Species of *Varilatella* in which lobes L1-L4 are much reduced. L1 is a broad swelling. L2 obsolete but for preadductorional node. L3 is most elevated lobe. L4 broadest. S1 redundant. S2 most strongly developed. S3 weak. Cristae C1-C4 well developed or obsolete.

**Discussion.** *V. (Redacta)* differs from *V. (Varilatella)* by having more obsolete lobes and sulci.

*V. (Redacta)* probably evolved from a *V. (Varilatella) dissita*-like ancestor by lobal reduction and an increased cristal development to give *V. (R.) coronata*. Its possible descendant, *V. (R.)* sp. nov. 1, has even weaker lobes and obsolete cristae. A similar phylogenetic trend towards
lobal obsolescence and reduction of crista e has been illustrated in *Rigidella* (Schallreuter 1976, p. 182). The conservative *R. mitis* (Öpik, 1935) has a deep S2, S3 as semisulcus and C1-C4 fully developed.

*V. (Redacta)* is considered a homeomorph of *Rigidella*, which differs by having an entire velum, more reduced lobation and S3 virtually lacking. The type species, *R. mitis*, has crista e C1-C4 connected ventrally, whereas *V. (Redacta)* species have C2-C2 joined.

Other features of *V. (Redacta)* include left/right valve overlap and a row of spines forming the marginal sculpture.

**Occurrence.** Known only from the middle Ordovician of Britain, Llandeilo and basal Caradoc series of Dyfed, Wales and the Caradoc Series of Shropshire, England. A species questionably assigned to *V. (Redacta)* is described herein from the Caradoc of Cross Fell, Cumbria, England.

1. *Varilatella (Redacta) coronata* sp. nov.

   Pl. 6, figs 1-4, 6-8, 12, Text-fig. 12a

   **Name.** Latin 'corona', crown; referring to the crista e which crown the lobes.

   **Holotype.** CRJ SW162, incomplete female left valve; Pl. 6, figs 1, 4. Bryn-banc Limestone Member, Narberth Group, Costonian Stage, Caradoc Series; quarry 500m SSE of Dyffryn Farm, Llan-mill, 3km E of Narberth, Dyfed (loc. 26a).

   **Material.** More than 140 tecnomorphs and two incomplete females.

(a) female left valve, based on the holotype CRJ SW162. x58

(b) tecnomorph right valve, based on GSM RS6503. x46

TEXT-FIG. 12. Reconstruction of (a) Varilatella (Redacta) coronata and
(b) Varilatella (Redacta?) sp. nov. 2
**Description.** Female valves high to rather high and preplete, tecnomorphs high to moderately high. Males sub-amplete, larvae preplete. HV is anterior in females and larvae, but at mid-length in males. LV is about mid-height. Domicilium of females is moderately long and almost amplete, tecnomorphs moderately high to moderately long and slightly preplete. HD about mid-length, LD about mid-height. Greatest transverse convexity of domicilium is ventral of mid-height, longitudinally it is just anterior of mid-length. Hingeline long. Cardinal corners fairly distinct and obtuse; in smaller larvae posterior angles slightly exceeds 90°. Tecnomorphs have an epicline marginal surface from the anterior cardinal corner to about mid-posterior. Females have a posteroventral, epicline marginal surface.

Lobes L1-L4 fairly prominent, straight, or gently inclined towards anterior. L3 and L4 just reach dorsal margin. L1 obsolete, with dorsal cusp. L2 well developed dorsally forming elongate node. L3 constricted centrally. L4 can be slightly expanded dorsally with prominent cusp. S1 virtually obsolete. S2 deep, especially behind node of L2, and comma-shaped. S3 shallow, virtually a semisulcus. Cristae C1-C4 usually entire along lobes L1-L4, unconnected ventrally except for distinctively U-shaped C1-C2. Fifth crista sometimes developed along anterior edge of L4 (Pl. 6, fig. 12).

Velar flange from anterior cardinal corner to just dorsal of mid-posterior where it terminates abruptly. Contact between velum and domicilium is highest ventrally. Fairly broad anteroventral dolon. Valve surface, including dolon, is granulose; elliptical muscle scar region of S2 smooth (Pl. 6, figs 1, 3).

Throughout ontogeny, the posterior termination of the velum extends more dorsally, and S3 is better developed. In small larvae S3 is absent, and lobes L3, L4 have dorsal spines projecting beyond the hingeline (Pl. 6, fig. 8). The fifth crista, occasionally developed along the anterior
edge of L4, occurs in larvae usually less than 1.2mm long. Some larvae only have the ventral part of C4 developed (Pl. 6, fig. 8).

Measurements.

<table>
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<th>HV</th>
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</table>

All valves from the type locality.

Discussion. *V. (R.) coronata* (♀ 1.51mm long) differs from its smaller homeomorph *Rigidella mitis* (♀ c. 0.95mm long) in having more prominent lobes with dorsal cusps (L1, L4), U-shaped C1-C2 and in lacking a ventral connecting crista and dorsal posterior termination of the velum. The position of the dolon in *V. (R.) coronata* is similar to that of *R. mitis*; a reconstruction of which (Jaanusson 1957, text-fig. 35D) shows the dolon to be anteroventral and narrower than that of *V. (R.) coronata* (see Text-fig. 12a). The subvelar morphology of *V. (R.) coronata* females is poorly known, but may be similar to that of *V. (V.) dissita*.

Two specimens of *V. (R.) coronata* maybe pre-adult females (Pl. 6, fig. 2): anteroventrally, the distal part of the velum is slightly convex, and the associated marginal surface is more concave than the corresponding area of adult tecnomorphs.

Occurrence. Known only from limestones of Costonian age, Caradoc Series, Dyfed (locs 26a,b, 28a,b, 29).

2. *Varilatella (Redacta) sp. nov.1* Pl. 6, figs 5, 9-11, 13.

Material. 12 complete, three fragmentary tecnomorphic valves. All are
silicified.

**Description.** Valves rather high to moderately long, preplete. HV is anterior, LV about mid-height. Domicilium moderately long to rather long, slightly preplete. HD is about mid-length, LD just dorsal of mid-height. Greatest transverse convexity is ventral, longitudinally it is just posterior of mid-length. Hingeline long to very long. Cardinal corners distinct, posterior corner angle about 90° or slightly less in small larvae. Marginal surface epicline in anterior to ventral regions.

Lobes L1-L4 weakly developed, L1-L3 sometimes cristate. L1 obsolete. L2 weak, expanded dorsally into small node. L3 more prominent ventrally and inclined towards anterior. L4 redundant. L1, L3, L4 frequently have a cluster of dorsal spines projecting beyond the hingeline. Cristae occasionally present in larger tecnomorphs. C1-C2 sometimes connect ventrally, C3 ventrally prominent. Where C1-C3 absent, rows of tubercles line the crests of L1-L4. S1 virtually absent. S2 quite deep. S3 is a semisulcus.

Velar flange from anterior cardinal corner to posteriorly, terminating abruptly in larger tecnomorphs or dissolved into a row of spines.

Valve surface granulose, except for area of presumed muscle scar dorsally in S2.

**Measurements.**

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<td>0.63</td>
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<td>1.10</td>
<td>9</td>
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<tr>
<td>CRJ SW160/2</td>
<td>t-r</td>
<td>1.27</td>
<td>0.75</td>
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<td>1.13</td>
<td>0.62</td>
<td>1.82</td>
<td>1.07</td>
<td>10,13</td>
<td>26a</td>
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<tr>
<td>CRJ SW161/1</td>
<td>t-l</td>
<td>1.16</td>
<td>0.71</td>
<td>1.63</td>
<td>1.08</td>
<td>0.60</td>
<td>1.80</td>
<td>1.05</td>
<td>11</td>
<td>28a</td>
</tr>
</tbody>
</table>

**Discussion.** *V. (R.)* sp. nov. 1, considered a descendant of *V. (R.) coronata*, shows the most advanced lobal, sulcal and cristal obsolescence
of any *Varilatella* species.

Compared with *V. (R.) coronata* (d c. 1.44mm), *V. (R.)* sp. nov. 1 (d c. 1.75mm) is larger, its lobes and sulci are more reduced, and it lacks distinct dorsal cusps or a C4. C1-C3 of *V. (R.)* sp. nov. 1 are often absent and sometimes the velum is posteriorly dissolved into spines (Pl. 6, figs 5, 10), but in *V. (R.) coronata* cristae are always present and the velum is always fully developed posteriorly.

This species remains un-named until the female morphology is known.

**Occurrence.** Locs 26a and 28a,b. Costonian Stage, Caradoc Series of the Narberth area, Dyfed.

3. *Varilatella* (Redacta?) sp. nov. 2  Pl. 6, figs 14-17, Text-fig. 12b

1982c *Rigidella?* sp.; Siveter, p. 99 (= SM A9971a,b; small tecnomorph).

**Material.** Four tecnomorphic external moulds (two are incomplete).

**Description.** Valves rather high, preplete. Cardinal corners fairly distinct. Marginal surface very narrow such that contact between velum and domicilium is only just dorsal of the marginal sculpture in anterior and posteroventral regions.

Lobes L1-L4 weakly developed, cristate. L1 very broad, fused with obsolete L2. L3 broad, just reaching dorsal margin. L4 redundant.

Cristae C1-C4 usually well developed, unconnected. C4 occasionally absent. S1 absent. S2 broad, shallow. S3 obsolete.

Very broad, undulating velar frill from anterior cardinal corner to abrupt mid-posterior termination.

Valve surface granulose.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>Pl.6</th>
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</thead>
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<tr>
<td>GSM RS6503</td>
<td>d-r</td>
<td>1.91</td>
<td>1.00*</td>
<td>-</td>
<td>1.51</td>
<td>14-16</td>
</tr>
<tr>
<td>NMW 84.16G.1</td>
<td>t-r</td>
<td>1.73</td>
<td>1.06</td>
<td>1.63</td>
<td>1.27</td>
<td>17</td>
</tr>
</tbody>
</table>
SM A29971a,b  t-r  1.16 0.66* - 1.07

See Occurrence for locality details.

Discussion. The lobal and ornamental morphology of this species could be accommodated within Varilatella (Redacta). However, its velum is very broad, undulating and frill-like (Text-fig. 12b) and other Varilatella (Redacta) species have a much narrower velar flange. This species is left un-named and its generic position remains uncertain until the morphology of the female is known.

Occurrence. Known only from the Longvillian and Woolstonian stages, Caradoc Series of the Cross Fell Inlier, Cumbria. GSM RS6503 comes from the E side of the Melmerby-Alston road (A686), NE (043°) of Melmerby School and E (088.5°) of Todhills Farm, Cumbria (NY 62285 38360); Longvillian Stage, Caradoc. This locality equates approximately to loc. "N" of Arthurton & Wadge 1981, p. 19. SM A29971a, b is also from a similar horizon at the Melmerby-Alston road cutting (NY 6231 3832). The species was also collected from locs 46 (NMW 84. 16G. 1) and 45.

Subfamily WEHLRIINAE Schallreuter, 1985


Diagnosis. (Slightly modified after Schallreuter 1976, p. 202). Quadrilobate to unisulcate. Cristae well developed to absent. Velum in both sexes terminating distally in a row of spines. Dolon with a rake-like arrangement of peripheral spines.

Discussion. The Wehrliinae are typified by a special kind of antral dimorphism where a row of spines forms the outer antral fence. Schallreuter (1982b) suggests this type of brood pouch acts like a cage, holding the brood or eggs together whilst supplying them with fresh water.

Occurrence. The Wehrliinae are at present restricted to the
Ordovician of Baltoscandia and Britain (Schallreuter 1976, Siveter 1982c).

Genus SCHALLREUTERIA Siveter, 1982

Type species. Original designation; Siveter 1982c, p. 93; Bevrichia (Ctenobolbina?) superciliata Reed, 1910, p. 218, pl. 17, figs 14, 14a; Longvillian Stage, Caradoc Series of the Alston road cutting, c. 1km NE of Melmerby, Cumbria, England.

Diagnosis. (Modified from Siveter 1982c, p. 93). Quadrilobate Wehrliinae usually with non-cristate lobes. L1 and L3 can project as spine-like cusps beyond dorsal margin or be furbished with cluster of short dorsal spines. Lobes L1-L4 distinct or much reduced. Females with long convex dolon and a row of peripheral spines having a grill-like appearance. Lateral surface granulose, spinose, tuberculate or with special reticulation (net standing on pillars).

Discussion. Schallreuteria is represented in Britain by S. (Schallreuteria). The other known subgenus S. (Lippea) Schallreuter, 1984 is at present restricted to Backsteinkalk erratic boulders of northern Germany (Schallreuter 1984a). Schallreuteria and its relationships to other genera of the Wehrliinae have been previously discussed by Siveter (1982c) and Schallreuter (1984a).

S. (S.) builthensis, from the lower Llandeilo Series of Wales, is distinctly quadrilobate and presumably resembles the ancestral stock from which S. (S.) superciliata was also derived. Both species belong to the main lineage from which S. (Lippea) is separated by its loss of quadrilobation.

Occurrence. In Britain the genus is restricted to strata of Llandeilo and Caradoc age. The only other known occurrence is from drift material of upper Viruan age (= Harnagian/Soudleyan stages, Caradoc Series) from...
the Baltic coast, West Germany (Schallreuter 1984a).

Subgenus SCHALLREUTERIA Siveter, 1982

**Type species.** As for the genus.

**Other species.** *S. (S.) builthensis* sp. nov.

**Diagnosis.** (Slightly modified from Siveter 1982c, p. 93). Species of *Schallreuteria* with four distinct lobes. L1 broad. L2 diminutive. L3 slender or broad. L4 widest sometimes with low cusp. Dolon surface usually with fine radial striations. Tecnomorphic velum is a row of spines or ridge with peripheral spines. Lateral surface granulose, spinose and tuberculate.


1. *Schallreuteria (Schallreuteria) builthensis* sp. nov.

   **Pl. 7, figs 1-14**

   **Name.** From its occurrence near Builth, Powys.

   **Holotype.** CRJ M45, female right valve external mould; Pl. 7, figs 1, 2, 5. From the *Glyptograptus teretiusculus* Shales, stream section by lane leading to Newmead Farm, 3km NE of Builth, Powys (loc. 8).

   **Material.** Two females and 43 tecnomorphic external moulds.

   **Diagnosis.** *Schallreuteria (Schallreuteria)* species with spinose crista beneath S2 and S3. Females with long dolon from anterior to posterovertral regions. Tecnomorphs have velar ridge with peripheral spines. Lateral surface granulose with spinose lobes, sulci are smooth dorsally, irregularly granulose ventrally.

   **Description.** Valves moderately high to moderately long. Females
preplete, tecnomorphs preplete to subamplete. HV anterior of mid-length, LV about mid-height. Greatest transverse convexity is ventral of mid-height, longitudinally it is mid-length.

Hingeline long to moderately long. Cardinal corners distinct with angles greater than 90°.

Marginal surface steep, virtually orthocline in anterior and ventral regions.

L1 very broad. L2 very narrow with row of spines on lobal crest, which is attached ventrally to base of L1. Spinose crista of anterior ventral edge of L3 terminates beneath anterior ventral part of S2. Crista beneath S3 connects with base of broad L3 and terminates at anterior ventral edge of very broad L4, where it dissolves dorsally into a row of spines. Cristae beneath S2 and S3 are distinct or faint spinose ridges and are dissolved into spines at their edges. L1, L3, L4 have a cluster of spines forming the dorsal termination to each lobe. L4 sometimes with faint elongated dorsal crest. All lobes slope anteriorly. S1 shallow and very narrow. S2 and S3 are broad, S2 is deepest.

Tecnomorphic velum present as low ridge with distinct peripheral spines (in well preserved material) from anterior to posteroventral region, and runs parallel with free edge. Females have a long convex dolon terminating posteriorly, with fine radial striations and small peripheral spines. The subvelar morphology is poorly known.

Lateral surface granulose with spinose lobes. Discrete rows of spines run along the anterior edges of lobes L3 and particularly L4, and the crest of L2. Sulci are smooth dorsally and irregularly granulose elsewhere.

Smaller tecnomorphs are more preplete, with narrower L1, than larger tecnomorphs. Hingeline tends to decrease in proportion to LV during ontogeny.
Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
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<tr>
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<td>1.78</td>
<td>1.58</td>
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<td>1.86</td>
<td>1.00</td>
<td>1.85</td>
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<td>0.89</td>
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<td>1.47</td>
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<tr>
<td>CRJ M46/2</td>
<td>H</td>
<td>1.73</td>
<td>1.02</td>
<td>1.70</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.36</td>
<td>8,9</td>
</tr>
<tr>
<td>CRJ M46/1</td>
<td>H</td>
<td>1.62</td>
<td>0.91</td>
<td>1.78</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.38</td>
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<td>-</td>
<td>-</td>
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<td>CRJ M46/3</td>
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<td>1.62</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.07</td>
<td>6</td>
</tr>
</tbody>
</table>

All moulds from loc. 8.

Discussion. *S. (S.) builthensis* (♀ 1.86-1.93mm) is smaller than the type species (♀ 2.12-2.25mm), has a broader L3 and lacks distinctive dorsal cusps on lobes L1, L3, L4. *S. (S.) builthensis* differs further by having crista beneath S2 and S3, a more posteriorly extended dolon, a ridge-like tecnomorphic velum with peripheral spines, and an irregular pattern of spinosity.

In its general lobal morphology, radially striated dolon and velum with peripheral spines on L2, L4 *S. (S.) builthensis* is comparable with the stratigraphically younger *S. (S.) superciliata*.

Occurrence. Restricted to the *Glyptograptus teretiusculus* Shales, lower Llandeilo Series of the Builth-Llandrindod Inlier, Powys, Wales (loc. 8). The species may also occur at loc. 7 in the Mydrim area of Dyfed, but poor preservation does not allow a confident identification.
2. Schallreuteria (Schallreuteria) superciliata (Reed, 1910)

Pl. 8, figs 1-3, 6-8, 11, 12

1910 Bevrichia (Ctenobolbina?) superciliata; Reed, p. 218, pl. 17, figs 14, 14a.

1910 Bevrichia (Tetradella) turnbulli; Reed, p. 219, pl. 17, figs 12, 12a, 13, 13a.

1934 Ctenobolbina superciliata (Reed); Bassler & Kellett, pp. 53, 207.

1934 Tetradella turnbulli (Reed); Bassler & Kellett, pp. 210, 483.

1947 Tetradella superciliata (Reed); Harper, p. 350, pl. 10, fig. 6.

1978a Bevrichia superciliata Reed, 1910; Siveter, p. 52, pl. 3, figs 3, 4, 6.

1979 Tallinnella superciliata (Reed, 1910); Ivanova, p. 277, pl. 11, fig. 5.

1982c Schallreuteria superciliata (Reed); Siveter, pp. 93-100, pl. 9:94, 9:96, 9:98, 9:100.

Lectotype. Designated Siveter 1982c, p. 95, SM A103985a,b, tecnomorphic right valve, external and internal moulds; figured Reed 1910, pl. 17, figs 14, 14a; herein Pl. 8, fig. 12.

From the Melmerby Beds (= part of the Dufton Shales), Longvillian Stage, Caradoc Series; road section on E side of Melmerby-Alston road (A686), c. 1km NE of Melmerby, Cumbria, England. NY 6231 3832.

Material. Six heteromorphic and 18 tecnomorphic external moulds.

Diagnosis. (After Siveter 1982c, p. 97). Schallreuteria (Schallreuteria) with prominent single spines adjacent to adventral structure; in both dimorphs one spine occurs below S2 and one posteroventrally, male has third spine below L1. Sulci irregularly granulose to smooth. Discrete tubercles, often arranged in rows occur along lobes.

Description. As for diagnosis (see Siveter 1982c). In S. (S.)
superciliata the development of tubercles varies in adults. There can be 3 or 4 conspicuous tubercles aligned respectively along L2, the posterior part of L3 and the anterior part of L4. The full complement of tubercles is lacking in some adults.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
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<th>HV</th>
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<th>HL</th>
<th>Pl.</th>
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<td>1.36</td>
<td>1.65</td>
<td>1.82</td>
<td>1,2</td>
</tr>
<tr>
<td>SM A10984b</td>
<td>9-r</td>
<td>2.23</td>
<td>1.50</td>
<td>1.49</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>SM A10983b</td>
<td>9-r</td>
<td>2.12</td>
<td>1.18</td>
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<td>3,6,7</td>
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<tr>
<td>on SM A44639</td>
<td>9-l</td>
<td>1.93</td>
<td>1.29</td>
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<td>1.61</td>
<td>1.74</td>
<td>8,11</td>
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<tr>
<td>on SM A44639</td>
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<td>1.12</td>
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<td>SM A10985b</td>
<td>t-r</td>
<td>1.98</td>
<td>1.13</td>
<td>1.75</td>
<td>1.69</td>
<td>12</td>
</tr>
</tbody>
</table>

See Occurrence for locality details.

**Discussion.** See Siveter (1982c, p. 99) for a full discussion on the synonymy and morphology of $S$. ($S.$) superciliata.

'Brevichia' barrandiana Jones, 1855 from the "Llandeilo schist of Myndd Garw, Beddgelert, North Wales", superficially resembles tecnomorphs of $S$. ($S.$) superciliata (cf. Jones 1855, pl. 6, fig. 17, 1869, p. 15, fig. 16). The originals of 'B.' barrandiana have not been located in any British museum and the taxon should at present be considered a nomen dubium.

$S$. ($S.$) superciliata is known only from mould material. By comparison with the silicified specimens of $S$. (Schallreuteria) cf. $S$. ($S.$) superciliata, in which spines, tubercles and lobal cusps are hollow, it is likely that similar ornamental features on valves of $S$. ($S.$) superciliata were originally hollow too. The function of such ornamentation is speculative.

**Occurrence.** Soudleyan, Longvillian and Woolstonian stages, Caradoc Series of North Wales; represented by SM 25118/9 from Ynys Galed Farm,
just SE of Hendre Cennin, near Dolbenmaen, Gwynedd, (SH 4660 4385), Woolstonian Stage, Caradoc Series; SM A42729 from Pen y Parc, 2.5km E of Llanfyllin, Powys, (SJ 1681 1946), lower Caradoc Series. SM A44637, A44639 from Pont y Meibion, c. 3km SW of Glen Ceiriog, Clywd (SJ 195 352), precise locality and horizon uncertain but probably from the Pen-plaenau Siltstone Formation; Soudleyan Stage, Caradoc Series (Brenchley 1978, pp. 139-41). The lower Caradoc sediments underlying the Pen-plaenau siltstone are unfoossiliferous (Pickerhill & Brenchley 1979, p. 231) and an unlikely provenance area for these specimens. SM A42730, comes from an imprecisely known locality which the label states as "Hill N of Moel Uchlas, Montgomeryshire" (now Powys).

From England, known with certainty from loc. 44a (Woolstonian Stage) and the type locality (Longvillian Stage), Cross Fell Inlier, Cumbria where SM A29968b, SM A109790a,b, SM A10983b, SM A10984b, SM A10985b, A29970a,b come from. Tetradella cf. superciliata is recorded from the Longvillian of Harthwaite Sike of the same inlier (Dean 1959, p. 207).

3. Schallreuteria (Schallreuteria) cf. S. (S.) superciliata (Reed, 1910)

Pl. 8, figs 4, 5, 9, 10

Material. Three complete, five fragmentary, silicified tecnomorphic valves.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>Pl.8</th>
<th>loc</th>
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<tbody>
<tr>
<td>CRJ SW091</td>
<td>t-l</td>
<td>1.33</td>
<td>0.76</td>
<td>1.75</td>
<td>1.27</td>
<td>0.68</td>
<td>1.87</td>
<td>1.27</td>
<td>4, 5, 9, 10</td>
<td>12a</td>
</tr>
</tbody>
</table>

Discussion. The morphology of the three complete larval specimens is practically identical with that of S. (S.) superciliata but differs in lacking large spines below L1 and posteroventrally below L4. Because of this and the lack of female valves specific identification is uncertain.

Occurrence. Lower and middle Llandeilo Series of Dyfed (locs 4 and 12a).
Family TETRADELLIDAE Swartz, 1936

**Diagnosis.** (After Schallreuter 1982c, p. 4). Quadrilobate to almost non-sulcate. S2 usually long, and more or less sigmoidal. Some unisulcate representatives have a short to moderately long S2. Cristae rare. Velum present in both sexes, sometimes rudimentary in males. Velar dimorphism well developed; botulate or loculate. Histium; present in males of quadrilobate representatives. Females with or without histium. Histial dimorphism, where developed, is botulate. Marginal dimorphism rare. If admarginal velar dimorphism present, there is an inner antral fence. Dimensional, proportional and domiciliar types of dimorphism also known.

**Discussion.** Schallreuter (1966c, 1982c) has fully discussed the taxonomy and phylogeny of the Tetradellidae. The family is characterised by the development of a histium. However, some tetradellid genera have only a rudimentary histium, for example *Kiesowia* (*Kiesowia*) Ulrich & Bassler, 1908, or lack one altogether, as in *Vittella* Schallreuter, 1964.

Subfamily TETRADELLINAE Swartz, 1936

_(nom. transl. Kay, 1940)_

**British genera.** *Ceratopsis* Ulrich, 1894; *Omoopsis* Hessland, 1949.

**Diagnosis.** (After Schallreuter 1982c, p. 5). Unisulcate to quadrilobate. Lobes sometimes cristate or dissolved into discrete nodes. Velum and histium present in both sexes. Velar dimorphism; botulate or admarginal-locular. Histium non-dimorphic, developed as flange, keel, ridge or row of spines.

**Discussion.** Tetradellinae are characterised by having a non-dimorphic
h fistial structure and velar ( = infravelar antral) dimorphism.

Schallreuter (1966c, pp. 852, 853) has commented on the phylogeny of the subfamily.

**Occurrence.** The subfamily occurs throughout the Ordovician of North America (Copeland 1977b, 1978, 1981, Kay 1940, Warshauer & Berdan 1982) and Baltoscandia (Henningsmoen 1954a, 1954b, Hessland 1949, Jaanusson 1957, Sarv 1959, 1960) and is also known from Backsteinkalk and Ojlemyrflint erratic boulders of northern Germany (Schallreuter 1982c, 1983b) and from France (Vannier 1984). In Britain tetradeellines are found in the upper Llanvirn, Llandeilo and Caradoc series of Wales, and the Caradoc of Shropshire and Cumbria, England. An undescribed species of *Tetradella* Ulrich, 1890 is also present in the Ashgill Series of Dyfed, Wales.

**Genus CERATOPSIS Ulrich, 1894**

**Type species.** Original designation; Ulrich 1894, p. 676; *Bevrichia chambersi* Miller, 1874, p. 234, text-fig. 27; Kope Formation, Edenian Stage (= uppermost Caradoc and lowest Ashgill series), Cincinnati, Ohio.

**Other species.** *C. asymmetrica* Warshauer & Berdan, 1982; *C. britannica* Spjeldnaes, 1963; *C. coactilis* sp. nov.; *C. exaggerata* sp. nov.; *C. fimbriata* Warshauer & Berdan, 1982; *C. inflata* sp. nov.; *C. intermedia* Ulrich, 1894; *C. oculifera* (Hall, 1871); *C. quadrifida* (Jones, 1891); *C. robusta* Ulrich, 1894.

**Diagnosis.** (Modified from Warshauer 1975, p. 445). Subsquare, quadrilobate tetradeelline, with L1 modified into fimbriate spine which projects beyond the hingeline. Tumid or ridge-like histial flange which connects lobes L1-L4 ventrally. Velar frill or flange narrow and concave in tecnomorphs forming dolon in anterior and/or ventral regions. Velar (= infravelar antral) dimorphism. Valve surface usually smooth,
sometimes finely granulose or with reticulation on dolon.

**Discussion.** Of the 20 or so species that at various times have been included within *Ceratopsis* (see Warshauer & Berdan 1982), the present author considers that only the eleven species cited above belong to the genus. Warshauer & Berdan (1982, pp. 32-45) recently discussed the genus and its species at length, including seven North American species together with the British *Ceratopsis britannica* and *Bevrichia* (*Ceratopsis*) *duftonensis* Reed, 1910. The present author has followed Warshauer & Berdan (1982), except that *Bevrichia* (*Ceratopsis*) *duftonensis* is herein excluded from *Ceratopsis* and is assigned to *Sigmoopsis* (*Sigmoopsis*) Henningsmoen, 1953 (cf. p. 82 below) because it has biastral dimorphism.

*Ceratopsis* comprises quadrilobate tetradellines, having botulate, infravelar antral dimorphism with a non-dimorphic, lateromarginal histial flange. Warshauer (1975) has demonstrated the presence of this type of dimorphism in *C. chambersi*, as have Warshauer & Berdan (1982) in *C. fimbriata* and *C. intermedia*. All three species have a broad, convex dolon in anteroventral and/or ventral regions. Dimorphism has been proven in all British species but the dolon occupies a more anterior position than in the North American taxa.

Apart from velar dimorphism, Warshauer (1975, p. 445) and Warshauer & Berdan (1982, p. 33) have defined the genus as containing ostracodes with L1 modified into a characteristic fimbriate spine. However, this feature is not restricted to *Ceratopsis*; *Homeoceratopsis* gen. nov. and *Hastatellina* both possess a fimbriate L1 and the presence of a fimbriate speral process on L1 cannot be used as a diagnostic generic characteristic without consideration of the dimorphic adventral sculptures.

The systematic position of *Ceratopsis* within the Tetradellidae was considered uncertain by Warshauer & Berdan (1982, p. 33), because the
subfamilial classification of the taxon was "still in a state of flux", Schallreuter (1966c) and Jaanusson (1966) having independently published conflicting taxonomic revisions of the family. More recently, Schallreuter (1978, 1982c, 1983b) has refined the subfamilial classification of the Tetradellidae. The present author has followed, Schallreuter (1982c, p. 5) in placing Ceratopsis within the subfamily Tetrallinae.

**Occurrence.** Known from the middle and upper Ordovician of eastern North America (Warshauer & Berdan 1982) and the middle Ordovician of Britain, where the genus is present in strata of upper Llanvirn, Llandeilo and basal Caradoc age in Dyfed, Wales and from the Llandeilo Series of the Shelve Inlier, Shropshire, England.

1. Ceratopsis britannica Spjeldnaes, 1963 Pl. 9, figs 1-14

1963 *Ceratopsis britannica* sp. nov.; Spjeldnaes, pp. 257, 258, pl. 36, fig. 7.

1978a *Ceratopsis britannica* Spjeldnaes, 1963; Siveter, p. 48, pl. 1, figs 5, 6.


**Holotype.** GSM 85415, silicified female right valve; Spjeldnaes 1963, pl. 36, fig. 7. Llandeilo Series; Llan-mill, 3km E of Narberth, Dyfed. Precise horizon and locality unknown.

**Material.** More than 2500 silicified valves of both dimorphs and larvae.

**Diagnosis.** Moderately long to long Ceratopsis species. L1 with palmate speral process, fimbriate only on the palmate part. L2 sigmoidal or reduced. L3 curves towards anterior, does not reach dorsal margin. L4 broad, obsolete dorsally. S1 constricted dorsally or obsolete. S2, S3
equally broad, sometimes deep. Adults with acute histial flange; tumid or carinate distally. In heteromorphs, histium covers free margin in lateral view. Anterior dolon. Valves smooth.

**Description.** See Spjeldnaes 1963, p. 257. The expanded diagnosis above, portrays the salient features of the species.

Larvae have a narrow histial flange, the velum being clearly visible in lateral view.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
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<tbody>
<tr>
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<td>0.73</td>
<td>2.00</td>
<td>1.27</td>
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<td>1.89</td>
<td>1.29</td>
<td>17</td>
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</tr>
<tr>
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<td>14</td>
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<td>1.84</td>
<td>1.16</td>
<td>2-4,9,10</td>
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</tr>
<tr>
<td>GSM 85415</td>
<td>q-r</td>
<td>1.30</td>
<td>0.70</td>
<td>1.86</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
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<td>1.41</td>
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<td>17</td>
<td></td>
</tr>
<tr>
<td>CRJ SW129</td>
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<td>1.79</td>
<td>1.19</td>
<td>0.62</td>
<td>1.92</td>
<td>1.16</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion.** *C. britannica* is one of the most abundant ostracode species in the British Ordovician and displays wide intraspecific variation, especially in the development of the lobes and histium. Specimens vary from those having subdued lobes and a swollen histial flange (Pl. 9, fig. 1), to forms with a more prominent lobation and a ridge-like histium clearly connecting with the speral process of L1 (Pl. 9, figs 11, 14). In females the histium is swollen ventrally and most elevated posteriorly, giving a more subamplete outline. The anterior dolon is distinct (Pl. 9, fig. 11), or merges with the histial flange (Pl. 9, figs 1, 4). Other characteristic features of *C. britannica* include a preplete, a rather long to very long domicilium, a long to very long hingeline, with a posterior cardinal corner angle of about 90°; an almost orthocline to slightly epicline marginal surface; and left/right valve overlap.
C. intermedia (♀ 1.95mm; LV:HV = 1.5), from the Kirkfieldian-Edenian (= Caradoc) of USA, is larger and has a higher form than C. britannica (♀ 1.46mm; LV:HV = 1.8-1.95). C. intermedia differs further in having more distinct lobes, of which L1 is fimbriate to its base and L3 just projects beyond the hingeline. The velum of C. intermedia is broader than that of C. britannica and its dolon is situated more anteroventrally.

Occurrence. Middle and upper Llandeilo Series and basal Caradoc Series (Costonian Stage) of Dyfed (locs 12a, 14, 17, 18, 20, 22, 26a, 27a,b, 28b, 29).

2. Ceratopsis coactilis sp. nov. Pl. 10, figs 1-11

Name. Latin 'coactilis', made thick; alluding to the stout speral process of L1.

Holotype. CRJ SW179, silicified female left valve; Pl. 10, figs 1, 4, 5, 9. Llandeilo 'Limestone', lower Llandeilo Series; quarry 350m W of Ffynnon-Ddewi, 6km E of Carmarthen, Dyfed (loc. 3).

Material. 40 silicified valves of both dimorphs and larvae.


Description. Valves distinctly preplete. HV is anterior, LV is preplete dorsal of mid-height. Domicilium rather long to long and HD just anterior of mid-length; LD is dorsal. Transverse convexity greatest ventrally, longitudinally it is greatest anteriorly. Tecnomorphic marginal surface epicline to orthocline (small larvae). Left/right valve overlap. Hingeline very long. Posterior cardinal angle just less than 90°.
L1 broad, dorsally developed into long, stout speral process, fimbriate only at its distal end. L2 merges with base of L1, forming elongate swelling. L3 very narrow. L4 obsolete, ventrally joined with histium. L1-L3 not quite connected to histium, which is developed as a narrow, cristate flange terminating below S2. S1 redundant. S2 deepest. S3 broadest.

Velar flange virtually entire, and not covered by ventrally projected histium in lateral view. Dolon broadest anteriorly, narrowing in the anteroventral region. Marginal sculpture often developed as row of fine spines or denticles in the antero- and posteroventral regions. Lateral surface finely granulose.

Speral process of L1 is generally longer and more slender in larvae. Dimorphs have a more ventrally prominent histial flange.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
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<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>P1:10</th>
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<tr>
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<td>-</td>
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<td>1.4, 5, 9</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CRJ SW180/2</td>
<td>q-1</td>
<td>1.26</td>
<td>0.69</td>
<td>1.83</td>
<td>1.09</td>
<td>0.59</td>
<td>2.02</td>
<td>1.02</td>
<td>8</td>
<td>3</td>
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<tr>
<td>now broken</td>
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<td>1.24</td>
<td>0.69</td>
<td>1.80</td>
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<td>0.55</td>
<td>1.85</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CRJ SW180/1</td>
<td>q-r</td>
<td>1.09*</td>
<td>0.69</td>
<td>-</td>
<td>0.51</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>26b</td>
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</tr>
<tr>
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<td>0.71</td>
<td>1.77</td>
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<td>CRJ SW180/3</td>
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<td>1.20</td>
<td>0.67</td>
<td>1.79</td>
<td>1.11</td>
<td>0.57</td>
<td>1.95</td>
<td>1.07</td>
<td>3</td>
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</tr>
<tr>
<td>CRJ SW180/4</td>
<td>t-1</td>
<td>1.06</td>
<td>0.56</td>
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<td>0.97</td>
<td>0.48</td>
<td>2.02</td>
<td>0.92</td>
<td>11</td>
<td>3</td>
</tr>
</tbody>
</table>

**Discussion.** *C. coactilis* (*q* c. 1.46mm; LV:HV 1.80-1.83) has a slightly higher form and is smaller than *C. britannica*. It differs further by having a more stout speral process (fimbriate only on its distal part), a granulose valve surface, a cristate L3 and a histium that does not cover the velum in lateral view.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 3, 12a, 18, 22, 26b).
3. *Ceratopsis exaggerata* sp. nov. Pl. 11, figs 1-7

**Name.** Latin 'exaggeratus', exaggerate; referring to the broad velum and accentuated histium.

**Holotype.** CRJ SW175, silicified female right valve; Pl. 11, figs 1, 6. Llandeilo 'Flags', upper Llandeilo Series; eastern wall of quarry, 90m N of Ty-newydd Farm, 180m SE of Nantgaredig Post Office, 8km E of Carmarthen, Dyfed (loc. 24).

**Material.** Two heteromorphic valves, three complete and four fragmentary tecnomorphic valves. All are silicified.

**Diagnosis.** Very high to moderately high species of *Ceratopsis*. L1 developed as spine-like process, fimbriate to base of its shaft. L2 obsolete. L3, L4 broad and cristate. Histial flange highly elevated and cristate distally, joining L1 and L4. S2 and S3 extremely broad. Velum frill-like; very broad in heteromorphs, convex only in anterior region (= dolon).

**Description.** Heteromorphs very high to rather high and amplete. Tecnomorphs rather high to moderately high and sub-amplete. HV and HD about mid-length. LV just dorsal of mid-height. LD dorsal of mid-height, particularly in heteromorphs. Domicilium subamplete, high to moderately high in heteromorphs, moderately long to rather long in tecnomorphs. Transverse convexity greatest ventrally, longitudinally it is greatest just posterior of mid-length. Marginal surface entire and narrow in heteromorphs, orthocline in dimorphs, and epicline in larvae. Hingeline long. Cardinal corners distinct, with both corner angles greater than 90°.

L1 developed as prominent spine, distally curved towards posterior. Crest of spine fimbriate to base of its shaft. Ventral part of L2 absent, dorsally present as small node above mid-height. L3 broad, narrowing dorsally, provided with crista C3. L4 dorsally redundant,
ventrally elevated and with crista C4. S1 absent but for short semisulcus anterior of L2 dorsal node. S3 and S4 extremely broad.

Elevated histial flange is distally crista te, connecting L1 and C4. Velum frill-like, from anterior to posterior cardinal corner.

Heteromorphs with extremely broad velum in anterior to posteroventral regions becoming convex anteriorly, forming broad dolon. Marginal sculpture is a row of denticles in the ventral region. Valves smooth.

Histial flange becomes more elevated posteroventrally through ontogeny and the marginal surface becomes more orthocline in larger tecnomorphs, as opposed to the distinctly epicline marginal surface of small instars.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
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<tbody>
<tr>
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<td>♀-r</td>
<td>2.11</td>
<td>1.55</td>
<td>1.36</td>
<td>1.78</td>
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<td>1.6</td>
<td>24</td>
</tr>
<tr>
<td>CRJ SW177</td>
<td>♀-l</td>
<td>1.72</td>
<td>1.06</td>
<td>1.62</td>
<td>1.50</td>
<td>0.90</td>
<td>1.63</td>
<td>1.43</td>
<td>1b</td>
<td></td>
</tr>
<tr>
<td>CRJ SW176/2</td>
<td>d-r</td>
<td>1.36</td>
<td>0.95</td>
<td>-</td>
<td>-</td>
<td>0.73</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>CRJ SW176/1</td>
<td>t-l</td>
<td>1.29</td>
<td>0.84</td>
<td>1.54</td>
<td>1.20</td>
<td>0.68</td>
<td>1.70</td>
<td>-</td>
<td>5,7</td>
<td>1b</td>
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<tr>
<td>CRJ SW176/3</td>
<td>t-r</td>
<td>1.16</td>
<td>0.66</td>
<td>1.76</td>
<td>1.07</td>
<td>0.55</td>
<td>1.95</td>
<td>1.00</td>
<td>2,3</td>
<td>1b</td>
</tr>
</tbody>
</table>

Discussion. The spine-like L1, broad heteromorphic velum and narrow marginal surface of C. exaggerata are most similar to those of C. chambersi from the middle Ordovician of the USA. C. exaggerata (♀ c. 2.11 mm; LV:HV = 1.36-1.62) differs from C. chambersi (♀ 1.84 mm; LV:HV = 1.51) in its size and by having more crista te L3-L4 lobes, an obsolete L2, wider S2-S3 and a narrower, more highly elevated histium. The dolon of C. chambersi extends from the anterior cardinal corner to the posteroventral region and is more convex and much longer than the anterior dolon of C. exaggerata. A female of C. chambersi (Warshauer 1975, p. 448, text-fig. 1), falls within the range of form (LV:HV) shown by C. exaggerata. Both species possess a high form because of the broad, ventrally extensive velum developed in female valves.
Occurrence. Upper Llanvirn and Llandeilo series of Dyfed (locs 1a,b, 24).

4. Ceratopsis inflata sp. nov. Pl. 11, figs 8-17

Name. Latin 'inflatus', swollen; referring to the tumid, rounded histial flange.

Holotype. CRJ SW183/1, silicified female left valve; Pl. 11, figs 8-11, 15, 17. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. More than 150 silicified valves of heteromorphs and tecnomorphs.


Description. Larvae and females preplete, males slightly preplete. HV is anterior or nearer mid-length in males. LV about mid-height. Domicilium generally long and preplete, males are more amplete. HD anterior or mid-length (males). LD just dorsal of mid-height. Transverse convexity greatest ventrally, longitudinally it is greatest posteriorly. Marginal surface virtually orthocline throughout in tecnomorphs, and in ventral to posteroventral region of heteromorphs. Left/right valve overlap. Hingeline long to very long. Posterior cardinal corner angle slightly more than 90°.

L1 developed as slender speral process, palmate distally. Length of shaft of the process highly variable, often as long as the valve height (Pl. 11, fig. 13). L2 redundant but for small swelling towards its base. L3 broad, not reaching hingeline. L4 obsolete and is broadest. L2-L4 slope towards anterior. S1 virtually absent. S1 and S2 equally broad and
shallow.

Histial flange broad and tumid, forming rounded, ventrally sagged swelling in the ventral region. Velum narrow and ridge-like, from anterior cardinal corner to posterior region. Anterior dolon. Low, narrow ridge forms the marginal sculpture. The crest of the ridge is often provided with fine denticles in the posteroventral region. Valves smooth.

Histium of larvae is less swollen than in dimorphs. Marginal sculpture of small larvae represented by a row of spines.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
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<td>0.83</td>
<td>8-11,15,17</td>
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<tr>
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<td>0.95</td>
<td>0.50</td>
<td>1.90</td>
<td>0.86</td>
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<td>1.02</td>
<td>0.51</td>
<td>2.00</td>
<td>0.91</td>
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</tr>
<tr>
<td>CRJ SW169/1</td>
<td>t-l</td>
<td>0.93</td>
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<td>1.90</td>
<td>0.86</td>
<td>0.44</td>
<td>1.95</td>
<td>0.84</td>
<td>12-14,16</td>
</tr>
</tbody>
</table>

All valves from the type locality.

**Discussion.**  *C. inflata* (0.87-1.09mm; LV:HV = 1.85-1.94) resembles *C. britannica*; both are rather long. However, *C. inflata* is much smaller than *C. britannica* and has shallower sulci, a slightly broader dolon and a more anteriorly elevated histium which does not cover the free margin in lateral view. Small instars of *C. inflata* in particular can have an extremely long speral process on L1, but the palmate speral process of *C. britannica* is never longer than 50% of valve height (HV). The characteristically long speral process of *C. inflata* resembles the spine-like L1 of *Hastatellina normandiensis* Přibyl, 1975. *Hastatellina* is trilobate (Přibyl 1975, p. 12), whereas *C. inflata* is clearly quadrilobate. The rounded lobes (in longitudinal section) and the histium of *C. inflata* are similar to those of *C. intermedia*, a species which is larger, with a more triangular L1 and broader anterior to
posteroventral dolon.

**Occurrence.** Llandeilo Series of Dyfed (locs 3, 4a, 11b, 11d,e, 17, 18, 20) and Shelve Inlier, Shropshire (loc. 6).

**Genus OGMOOPSIS Hessland, 1949**

**Type species.** Original designation; Hessland 1949, pp. 295, 324; *Ogmoopsis nodulifera* Hessland, 1949, p. 324, pl. 8, figs 19a-c; lower Ordovician, Silverberg, Siljan District of Sweden.

**Diagnosis.** Small to large, quadrilobate tetradelline. Lobes L1-L4 more or less equally developed and sloping towards the anterior. All lobes connected by ventrally projected histial flange that in heteromorphs merges with the velum, covering it in lateral view. Velar flange more or less entire; from anterior to posterior cardinal corners. Narrow dolon; sometimes developed in the anterior and/or anteroventral regions. Long, botulate antrum. Valve surface smooth.

**Discussion.** The genus has only one British representative, belonging to the most commonly occurring subgenus, *O.* (*Quadridigitalis*) subgen. nov.

The generic diagnosis is redefined in the light of recent morphological nomenclature. It is considerably modified from Hessland's (1949, p. 324) original diagnosis in order to accommodate the forms within *O.* (*Quadridigitalis*).

The affinity of the genus has been discussed by Schallreuter (1966c, 1982c). More recently, Vannier (1984, p. 57) has compared species of *Ogmoopsis*. The presence of well developed, upright lobes, connected ventrally by a histial flange and botulate velar dimorphism, are the unifying generic characters. Subgenera are defined on the development of lobes and sulci.

**Occurrence.** In Britain *Ogmoopsis* is restricted to the Caradoc Series
of Shropshire, England. The other members of the genus are all European and come from the lower Ordovician of Estonia (Sarv 1959) and Sweden (Hessland 1949) and from the middle Ordovician of Czechoslovakia (undescribed material from Bohemia) and France (Vannier 1984).

Subgenus QUADRIDIGITALIS subgen. nov.

Name. Latin 'quadrifidus', split into four, and 'digitalis', of the finger; fancied resemblance of lobes to four fingers. Gender feminine.

Type species. 0. (Quadridigitalis) silvateri sp. nov.; from the Caradoc Series of Shropshire.

Other species. 0. (0.) arcadeli Vannier, 1984; 0. (0.) vesperi Sarv, 1959; 0. (?) bocki (Opik, 1935); 0. (?) ramosa Sarv, 1959.

Diagnosis. Oomooosis species with narrow, ridge-like lobes L1-L4. All lobes ventrally connected by ridge-like histium. L1 dorsally bulbous, often sigmoidal. L2 long and narrow, but not reaching dorsal margin. L3, L4 gently curved, sloping anteriorly. L1, L3, L4 project beyond dorsal margin. S1 broad, constricted dorsally. S2, S3 wide.

Discussion. Species of 0. (Quadridigitalis) differ from those of the nominate subgenus because they have more ridge-like lobes, of which all but L2 project beyond the dorsal margin. Furthermore, the sulci (S1-S3) of 0. (Quadridigitalis) are much wider than those of 0. (Oomoopsis).

0. (Oomoopsis) species have broad, equally developed lobes with flattened crests; L1 sometimes reaches the dorsal margin; L1-L3 are sigmoidal; L4 is curved towards the posterior; S1, S3 are narrow and S2 is deep and wide. Species of the nominate subgenus only occur in the lower Ordovician of Estonia and Sweden and the middle Ordovician of northern Germany (Schallreuter 1971b)

0. (0?) bocki is poorly known and is included in 0. (Quadridigitalis) with uncertainty. The lobation of this species is similar to other
members of O. (Quadridigitalis). From the description of the holotype (Opik 1935, pl. 2, fig. 2), it is unclear whether or not a histium is developed. Of the Omoopsis species erected by Sarv (1959), O. (?)(Quadridigitalis) ramosa is a questionable member of O. (Quadridigitalis) because the anterior lobe (L1) of this species has a narrow groove developed along its central part. O. (?)(Quadridigitalis) ramosa also lacks the dorsal bulb of L1, present in all other species of O. (Quadridigitalis). O. vesperi (tecnomorph 0.82mm) is a small Omoopsis species but possesses all the features characteristic of O. (Quadridigitalis). Some specimens figured by Sarv (1959, pl. 18, figs 12, 13) may not belong within O. vesperi. They have much thicker lobes and histium than the holotype (Sarv 1959, pl. 18, figs 7-9).

**Occurrence.** O. (Quadridigitalis) is found in strata of low Caradoc age, Shropshire, England. The subgenus is present in the lower Ordovician (Volkhov and Kunda stages = the upper Arenig and lower Llanvirn respectively) of Estonia (Sarv 1959) and the middle Ordovician (Llandeilo Series) of the Armorican Massif, France (Vannier 1984).

An undescribed species of O. (Quadridigitalis) is also known from the lower part of the Beroun Series (= Caradoc) of Czechoslovakia (Bohemia). It is represented by material labelled 'Tallinnella bohemica (Barr.)' in the collections of the Riks Museum, Stockholm, Sweden (specimen no. Ar 39172).
Ogmoopsis (Quadridigitalis) siveteri sp. nov. Pl. 12, figs 1-15

Name. In honour of Dr. David J. Siveter, Leicester University, England.

1978a Sigmoopsis zalkopienneae (Harper, 1947); Siveter, p. 50 (para).

pl. 2, fig. 1 (= on slab BM 3583/A, tecnomorphic left valve).

Holotype. CRJ M53, female left valve external mould; Pl. 12, figs 1, 7-10, 12. From the Harnage Shales, Harnagian Stage, Caradoc Series; outcrop in stream, Coundmoor Brook, 400m N of Little Mosterley, Cressage, Shropshire (loc. 33).

Material. More than 20 external moulds of heteromorphs and tecnomorphs.

Diagnosis. Large Ogmoopsis (Quadridigitalis) with prominent, elongated dorsal bulb on L1. L2 very narrow. L3 elevated throughout length. L4 much reduced above mid-height with dorsal cusp. Dolon from anterior cardinal corner terminating below S2.

Description. Heteromorphic valves are rather high to moderately high, tecnomorphs are moderately high to rather long. Valves more or less amplete. HV about mid-length, LV just ventral of mid-height. Transverse convexity is greatest ventrally, longitudinally it is anterior. Hingeline long to moderately long, cardinal corners indistinct. Posterior corner angle more acute than in the anterior. Males have an epicline marginal surface in anterior and ventral regions. An acute angle is formed between the contact plane and marginal surface, which in larvae is more orthoclone.

Lobes L1-L4 are ridge-like and slope towards the anterior. L1 has a prominent, elliptical, dorsal bulb. L2 shortest, very narrow, does not reach dorsal margin. L3 elevated throughout, slightly curved. L4 tumid ventrally, obsolete above mid-height, with node-like dorsal cusp. L1 and L3 can be flat topped or with a slight dorsal bifurcation, as seen in
dorsal or anterior view (Pl. 12, fig. 2). L1, L3, L4 project beyond dorsal margin. S1 broad, relatively shallow and constricted dorsally. S2, S3 wide; S2 deepest.

Lobes connected ventrally by flange-like histium that in females almost covers velum in lateral view. Velar flange from anterior cardinal corner, ending gradually in posterior region. Ventral region of tecnomorphs with deep furrow between histium and velum, absent in heteromorphs where the histium merges with the proximal part of the velum. Narrow, anterior dolon; from anterior cardinal corner, ending below S2. Antrum long and deep, admarginal in ventral and postero-ventral regions. Marginal sculpture is a narrow, rounded ridge that runs parallel with contact margin. Valves smooth.

The deep supravelar furrow developed in adult tecnomorphs is much reduced in larvae. The large dorsal bulb of L1 becomes more prominent through ontogeny. L4 dorsal of mid-height is virtually absent in larvae.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
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Discussion. Q. (Q.) siveteri (9 c. 2.54mm) is most closely related to Q. (Q.) arcadelti (9 c. 2.25mm) from the Llandeilo Series of the Armorican Massif, France. The adventral sculptures of both species are very similar (cf. Vannier 1984, text-fig. 67). Q. (Q.) arcadelti differs by having a more sigmoidal L1, narrower L3 and L4 and a shorter dolon which terminates at the base of L1.

Occurrence. Upper part of Costonian Stage and the Harnagian Stage, Caradoc Series of South Shropshire, England (locs 31, 33, 35, 37, 38).
OGMOOPSIS? subgenus undetermined

Ogmoopsis? sp. nov. 1  Pl. 12, fig. 16

1978a *Sigmoopsis galapagensis* (Harper, 1947); Siveter, p. 50 (para).

pl. 2, fig. 4 (= on slab BM 1472/B).

Material. More than 40 poorly preserved internal and external tecnomorphic moulds.

Description. Tecnomorphs more or less complete and rather long. LV dorsal of mid-height. HV mid-length or slightly anterior. Hingeline moderately long to long. Epicline marginal surface from anterior cardinal corner to mid-posterior, forming quite acute angle with contact plane. Cardinal corners subequal and slightly rounded to rounded.

Lobes L1-L4 upright and ridge-like but sloping slightly towards anterior. L1, L3, L4 more or less equally well developed and elevated. L2 narrow, terminates below dorsal margin. S1 long, very narrow. S2 deep, somewhat sigmoidal. S3 deep and broad.


Measurements.

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<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
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Discussion. The taxonomic position of the new species is uncertain since females are unknown. The upright ridge-like lobes, ventrally directed connecting lobe (= histium ?) and steeply inclined marginal surface all suggest affinity with *Ogmoopsis*. The species most resembles *O* (Quadridigitalis?) *bocki* (c. 0.75mm) except for its much larger size
and bow-shaped connecting lobe.

**Occurrence.** Spywood Member, Chirbury Formation, upper part of the Costonian Stage, Caradoc Series of Shelve Inlier, Shropshire (loc. 31).

Subfamily SIGMOOPSINAE Henningsmoen, 1953

*(nom. correct. Jaanusson, 1957)*

**British genera.** Sigmoopsis Henningsmoen, 1953.

**Diagnosis.** (After Schallreuter 1982c, p. 12). Quadrilobate to unisulcate. Some quadrilobate forms have lobes dissolved into single nodes. Histium and velum in both sexes of early, quadrilobate representatives equally well developed; biastral dimorphism. Histium and velum of other representatives only well developed in heteromorphs, where the histial (= supravelar) antrum can be absent. Later representatives can have the histium missing or rudimentary in heteromorphs, and usually absent in tecnomorphs; with velum of these forms well developed in heteromorphs, weak in tecnomorphs, with velar dimorphism strongly developed. No locular dimorphism. Marginal sculpture usually a row of spines (at least in right valve).

**Occurrence.** Middle to upper Ordovician and possibly early Silurian of Baltoscandia (Schallreuter 1966c, 1982c), and the middle Ordovician (Llandeilo Series) of France (Vannier 1984). The subfamily may also be present in the upper Ordovician of Canada (Copeland 1973, p. 15). In Britain known only from the Caradoc Series of Shropshire and Cumbria, England.
Genus SIGMOOPSIS Henningsmoen, 1953

**Type species.** Original designation; Henningsmoen 1953a, p. 204; Ceratopsia platyceras Öpik, 1937, p. 26, pl. 2, fig. 6; Uhaku, Kukruse and Idavere stages of Estonia (= Llandeilo and lower Caradoc series).

**Diagnosis.** (Modified from Schallreuter 1982c, p. 13). Quadrilobate. L1 in anterodorsal to central anterior regions, dorsal part variously developed. L2 in anterocentral to anterodorsal regions, funnel shaped and expanded ventrally. L3 kidney shaped. L4 funnel shaped, expanded dorsally. S1 weak; S2 sigmoidal, S3 arched, both well developed. Velum and histium in tecnomorphs developed as ridge or flange-like keels; in heteromorphs both developed as flanges that can unite anterodorsally. Infravelar antrum. Supravelar (= histial) antrum sometimes absent (especially in early species). Marginal sculpture is a keel, ridge, narrow flange or row of spines. Valves punctate, smooth or reticulate.

**Occurrence.** Middle and upper Ordovician of Baltoscandia (Schallreuter 1982c). Only the subgenus Sigmoopsis (Sigmoopsis) Henningsmoen, 1953 is found in Britain; from the Caradoc Series of Shropshire and Cumbria, England.

Subgenus SIGMOOPSIS Henningsmoen, 1953

**Type species.** As for the genus.

**Other species.** S. (S.) cornuta (Krause, 1897); S. (S.) duftonensis (Reed, 1910); S. (S.) granulata (Sarv, 1956); S. (S.) obliquejugata (Schmidt, 1858); S. (S.) perpunctata (Öpik, 1937); S. (S.) perpunctata ?prominens (Öpik, 1937); S. (S.) rostrata (Krause, 1892).

Discussion. Schallreuter (1982c) has recently discussed the genus. According to Schallreuter (1982c) and Jaanusson (1966, pp. 10, 11),

*Sigmoopsis* lamina Sarv, 1959 is a junior synonym of *S. (S.) rostrata*.

*Ceratopsis* Schmidti Bonnema, 1909 is almost certainly a junior synonym of *S. (S.) obliquejugata* (see Opik 1937, p. 89; Jaanusson 1957, p. 379).

*Sigmoopsis* bergsbrunnae Jaanusson, 1957 is now regarded as a junior synonym of *S. (S.) perpunctata* (Jaanusson 1963, p. 6). Sarv (1959, pp. 112, 113) considered *S. (S.) perpunctata ?orominens* to be a subspecies of *S. (S.) perpunctata*, but Schallreuter (1982c, p. 13c) has questioned the validity of Sarv's assignment.

Occurrence. As for the genus.

*Sigmoopsis* (Sigmoopsis) duftonensis (Reed, 1910) Pl. 13, figs 1-14

1910 *Evrichia (Ceratopsis) duftonensis*, sp. nov.; Reed, p. 217, pl. 17, figs 9-11, 11a.

1934 *Ceratopsis duftonensis* Reed; Bassler & Kellett, p. 243.

1941 *Ceratopsis duftonensis* Reed 1910; Schmidt, p. 46.

1978a *Ceratopsis duftonensis* (Reed, 1910); Siveter, p. 50, pl. 2, figs 1, 2.

1982 *Ceratopsis duftonensis* Reed, 1910; Warshauer & Berdan, p. 34.

1984 *Ceratopsis duftonensis* (Reed 1910); Vannier, p. 31, text-fig. 36.

Lectotype. Here designated; SM A29973a,b, female left valve external and internal moulds, figured Reed 1910, pl. 17, fig. 10 (= SM A29973a, internal mould) and Siveter 1978a, pl. 2, fig. 1 (= SM A29973b, cast of external mould); herein Pl. 13, figs 1, 2, 5, 9, 10. Melmerby Beds (= part of the Dufton Shales), Longvillian Stage, Caradoc Series; road section on E side of Melmerby – Alston road (A686), ½ km NE of Melmerby, Cumbria, England. NY 6231 3832.

Material. Known only as mould material. The other two syntypes
figured by Reed (1910) are SM A29974a,b (male left valve; Reed 1910, pl. 17, fig. 11, 11a) and probably SM A29978 (female right valve, internal mould; Reed 1910, pl. 17, fig. 9 = damaged). Other conspecific material consists of SM A29975b (female left valve), SM A29972, SM A29976 and SM A29977 (tecnomorphic right valves); all from the type locality. Slabs GSM Mi 321, 323 and 326 from the lane 820m NW (127°) of Cardington church, Cardington, Shropshire (SO 5001 9571) and GSM JD 3064 from the track 715m NE (065°) of Acton Scott church, Acton Scott, Shropshire (SO 4557 9010) are all from the Crosspipes Member, Cheney Longville Formation, (Marshbrookian Stage, Caradoc Series) of Shropshire, and have a total of 35 moulds of heteromorphs and tecnomorphs of S. (S.) duftonensis on their surfaces.

**Diagnosis.** Large *Siomoosis* (*Siomoosis*) having L1 speral process and shaft fimbriate. L2 expanded ventrally. L3 narrow. S2, S3 deep. Flange-like histium in heteromorphs, poorly defined in tecnomorphs. Supravelar (= histial) antrum broad, deeper than infravelar antrum. Valve surface smooth.

**Description.** Heteromorphs moderately long to rather long and preplete. HV mid-length to just anterior of mid-length. LV dorsal of mid-height. Transverse convexity greatest in ventral region, longitudinally it is greatest posterior of mid-length. Hingeline long. Posterior cardinal corner just greater than 90° and slightly rounded. Marginal surface of tecnomorphs is epicline and developed in the anterior to posteroventral region.

L1 speral process and shaft fimbriate to below S1, projecting beyond hingeline. L2 sigmoidal, expanded ventrally, restricted centrally with dorsal part forming small preadductorial node. L3 slightly curved, sloping towards anterior and narrow throughout. L4 broadest ventrally. S2 deeper and broader ventrally than S3.

Histium flange-like in heteromorphs connecting lobes L1-L4, but more
rounded and poorly developed in tecnomorphs. Velar flange from anterior cardinal corner to posteroverentral region, nowhere uniting with or covered (in lateral view) by histium. Supravelar (= histial) antrum in anterior and ventral regions, deep and broad, terminating below posteroverentral part of L4. Infravelar admarginal antrum shallow, developed in anterior and ventral regions. Valve surface smooth.

**Measurements.**

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See Material & Occurrence for locality details.

**Discussion.** Contrary to recent opinion (Siveter 1978a, Warshauer & Berdan 1982), (♀.)(♂.) duftonensis is assigned herein to Sigmoopsis (Sigmoopsis); this is because of its rather long form, lobal and sulcal morphology and biastral dimorphism. (♀.)(♂.) duftonensis (♀ c. 2.54mm; LV:HV = 1.85-1.92) is the largest species of Sigmoopsis (Sigmoopsis) known and the only one with a fimbriate speral process, a homeomorphic feature also developed in the unrelated tetradellids Ceratopsis, Hastatellina Přibyl, 1975 and the tallinnelline Homeoceratopsis. (♀.)(♂.) cornuta (♀ c. 1.25mm; LV:HV = 1.95) is much smaller than (♀.)(♂.) duftonensis and has broader, more subdued lobes but has a similar backward pointing spine-like L1. The lobes of (♀.)(♂.) cornuta are broader and more subdued than those of (♀.)(♂.) duftonensis. The lobes and sulci of (♀.)(♂.) duftonensis most resemble forms such as (♀.)(♂.) obliquejugata (1.35mm; LV:HV = 1.9) and (♀.)(♂.) rostrata (♀ 1.5-1.75mm; LV:HV = 1.65-1.83) which have a ventrally open S1 and S2 and well developed L2-L4 lobes. Both species differ from (♀.)(♂.) duftonensis in
having a heteromorphic velum which is hidden by the histium in lateral view. Like S. (S.) duftonensis, S. (S.) granulata (?1.3mm; LV:HV = 1.86) has the velum of both sexes clearly visible in lateral view. S. (S.) duftonensis differs from most Sigmoopsis (Sigmoopsis) species by having a poorly developed tecnomorphic histium. This is virtually absent in some tecnomorphs, with lobes L1-L4 joined instead by a broad rounded connecting lobe (Pl. 13, fig. 11). Occasionally a narrow histial ridge links L1 and L2 with the base of L3 (Pl. 13, fig. 8).

**Occurrence.** Dufton Shales, Longvillian and Woolstonian stages, Caradoc Series of the Cross Fell Inlier, Cumbria. Apart from the type locality, known from loc. 44a. Also known from the Caradoc Series of Shropshire: Harnage Shales, Harnagian Stage (loc. 37, LM 5045a); Chatwell Sandstone Formation (locs 42, 43), Longvillian Stage; Glynboro Member (loc. 47) and Crosspipes Member (see Material above) of the Cheney Longville Formation, Woolstonian and Marshbrookian stages respectively.

Subfamily GLOSSOMORPHITINAE Hessland, 1954

**Diagnosis.** (After Schallreuter 1983b, p. 129). Moderately sized (1-2mm). Quadrilobate to unisulcate, occasionally almost non-sulcate. S1 and S2 can be rudimentary, forming fissa. S2 sometimes as a cavum. Histium developed in tecnomorphs of quadrilobate representatives, only occasionally in uni- and bisulcate forms. Velum present in both sexes, and is dimorphic. Females with histiovelum. Marginal sculpture is either a ridge, keel, small flange or row of spines. Left valves frequently have a marginal flange extending over the contact plane in the posteroventral region.

**Discussion.** Schallreuter (1983b) has divided the Glossomorphitinae into three tribes on the basis of different types of velar dimorphism.
The Glossomorphitini are characterised by a velum/histiovelum, often with an inner antral fence; the Hippulini have a velum with a specialised toral sculpture. Both tribes have botulate antra. Members of the Wehrlinini have dolonate antra, usually with loculi.

Tribe GLOSSOMORPHITINI Hessland, 1954


Diagnosis. (After Schallreuter 1983b, p. 129). Velum or histiovelum forms the main adventral sculpture, and lacks a special toral sculpture. Velar dimorphism; botulate. Marginal dimorphism present, developed as an inner antral fence.

Occurrence. Middle Ordovician of Lithuania, Norway, Sweden, central Siberia, and from Backsteinkalk erratic boulders of northern Germany (Schallreuter 1983b)

From Britain, found in the upper Llanvirn, Llandeilo and Caradoc series of Dyfed, Wales and in the Caradoc of Shropshire, England.

Genus GRACQUINA Vannier, 1984

Type species. Original designation; Vannier 1984, p. 39; Bevrichia bussacensis var. hispanica Born, 1918; p. 347, pl. 26, fig. 3 (= lectotype designated Schmidt 1941, p. 42). From strata of probable Llanvirn age; Alisedas, 9km N of Almaden, Spain.

Other species. G. vannieri sp. nov.

Diagnosis. (Slightly modified from Vannier 1984, p. 39). Bisulcate. S2; long, curved, widens towards dorsal margin; S3 shorter, sloping towards anterior. Anterior lobe (L1+L2) rounded dorsally. Dorsal part of L2 forming weak preadductorional node. L3, L4 not extending beyond dorsal margin. L4 elevated about mid-height. All lobes joined ventrally by wide
connecting lobe. Velar ridge or flange in tecnomorphs. Histiovelum in heteromorphs. Long admarginal or dolonate (?) antrum. Marginal sculpture is a narrow ridge.

**Discussion.** In addition to the type species Vannier (1984, pp. 43-6) described four species, under open nomenclature. Vannier's (1984) generic diagnosis has been modified in order to include *G. vannieri*.

**Occurrence.** Llanvirn Series of France and Spain (Vannier 1984). In Britain known only from subsurface material of Llanvirn age, Huntingdon, England.

**Gracquina vannieri sp. nov.** Pl. 14, figs 1-10

**Name.** In honour of Dr. Jean Vannier, Rennes University, France.

1981 *Cerninella* sp.; Rushton & Hughes, pp. 626, 645 pl. 2, fig. 15.

**Holotype.** GSM By 8626, heteromorphic carapace, external mould (GSM By 8625 = part); Rushton & Hughes 1981, pl. 2, fig. 15; herein Pl. 14, fig. 8 (= rubber cast of left valve of carapace); from the Geological Survey's Great Paxton Borehole, 8km SW of Huntingdon, Cambridgeshire. TL 2088 6389. Silty mudstones and fine sandstones of Llanvirn age.

**Material.** Occurs as calcite valves with the corresponding external moulds. One tecnomorphic and six heteromorphic valves on slabs GSM By 8555 and By 8589 from the type locality.

**Diagnosis.** Large species of *Gracquina* with reduced, elongate preadductorial node. L4 broad. Moderately broad velar flange from anterior cardinal corner narrowing to below L4. Heteromorphs with broad histiovelum, forming dolon in anteroventral and ventral regions.

**Description.** Valves rather high to moderately long and ppreneplete. HV just anterior of mid-length, LV dorsal of mid-height. Transverse convexity of domicilium greatest ventrally. Longitudinal convexity is greatest just anterior of mid-length. Hingeline moderately long. Both
cardinal corners distinct with obtuse corner angles. Lobes L1, L3, L4 broad and rounded in longitudinal section. L1 virtually obsolete, fused with elongate L2 preadductor node. L3 broad throughout, reduced dorsally. L4 broadest, most elevated ventrally. All lobes joined by wide connecting lobe. S1 absent; S2 deepest, comma shaped; S3 virtually closed dorsal of mid-height.

Velar flange, moderately broad and concave, from the anterior cardinal corner to the posteroventral region. Histiovelum of heteromorphs concave in anteroventral and ventral regions, forming smooth dolon. Subvelar morphology unknown. Valve surface smooth.

Measurements.

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All valves from the type locality.

Discussion. The lobes and sulci of both G. vannieri (V = 1.76mm; LV:HV = 1.62-1.79) and the type species, G. hispanica (V = 1.25mm; LV:HV = 1.79), are very similar. G. hispanica has a narrower tecnomorphic velum and histiovelum, terminating more posteriorly than that of G. vannieri and differs further in having a less centrally elevated L4, a histiovelum situated higher on the domicilium and not forming a concave anteroventral to ventral dolon. The nature of preservation of the subvelar field in G. vannieri precludes comparison with the admarginal antrum of G. hispanica. However, the form of the dolon of G. vannieri suggests that it possibly has a dolonate antrum.

Occurrence. Known only from subsurface strata of Llanvirn age; the Great Paxton Borehole, Huntingdon, Cambridgeshire.

G. vannieri was the only palaeocene ostracode species recorded from
the Great Paxton Borehole (Rushton & Hughes 1981, p. 624) and provides a
generic link with the Ibero-Armorican region. The concomitant trilobite
species compare most closely with the fauna of the Hope Member, Shelve
Formation (= lower Llanvirn) of the Shelve Inlier, Shropshire (Rushton

Genus VITTELLA Schallreuter, 1964

**Type species.** Original designation; Schallreuter 1964c, p. 87, pl. 11, fig. 3; *V. vittensis* Schallreuter, 1964 from middle Ordovician
Backsteinkalk erratic boulders of northern Germany (181-type of
Schallreuter, correlated with the Skagen Formation, Vastergotland,
Sweden).

**Other species.** *V. canaliculata* (Hessland, 1949); *V. craspedota*
(Jaanusson, 1957); *V. fecunda* Siveter, 1983; *V. gullhoegensis*
Schallreuter, 1984; *V. vatia* sp. nov.; *V? iemtlandica* (Thorslund, 1940);

**Diagnosis.** (Slightly modified after Schallreuter 1983b, p. 138).
Unisulcate; sulcus usually long and sigmoidal. Preadductorional node weak,
indistinct. Posteroventral lobe prominent, sometimes bearing a
posteriorly directed spine. Flange-like velum, in females wider
anteroventrally, further from free margin than in tecnomorphs. Dolon
convex. Simple antrum, normally bordered by torus as an inner antral
fence. Marginal structure is a ridge or fused row of spines, forming a
narrow flange posteroventrally in left valve overlapping right. Lateral
surface granulose, reticulate or smooth.

**Discussion.** Phylogenetic relationships of species of *Vittella* have
been fully discussed by Schallreuter (1966c, 1983b). *V? iemtlandica* may
form the basis of a new genus because of its comma-shaped sulcus and
admarginal antrum (Schallreuter 1983b, p. 143). The inclusion of *V?
invasa Sidaravičiene within Vittella is also uncertain: the holotype (Sidaravičiene 1975, pl. 4, fig. 2) has a weak posteroventral lobe, a dorsal plica and a higher form (LV:HV = 1.5) than \textit{V. vittensis} (LV:HV = 1.77; holotype). \textit{V? rogeri} also has a high form (LV:HV = 1.49) (Ivanova & Melnikova 1977, pp. 87, 88, text-fig. 2 = holotype; incorrectly labelled as a right valve), a sigmoidal sulcus, a posteroventral lobe with a spine and a supravelar furrow and weakly convex dolon. Its tecnomorphs are unknown and it is uncertain whether females possess a dolonate or admarginal antrum (the latter is characteristic of \textit{Collibolbina} Schallreuter, 1967). Both \textit{V. fecunda} and \textit{V. vatia} possess a higher form than the type-species. Height of form does not appear to be a sound criterion for excluding taxa from \textit{Vittella}.

\textbf{Occurrence.} Upper Llanvirn and Llandeilo series and Costonian Stage, Caradoc Series of Dyfed. Also Harnagian Stage, Caradoc Series, Shropshire. Middle and upper Ordovician of the Baltic basin and Central Siberia. Lower, middle and upper Ordovician of Sweden. Middle and upper Ordovician Backsteinkalk erratic boulders of northern Germany.

1. \textit{Vittella fecunda} Siveter, 1983 Pl. 15, figs 1-13

1963 \textit{Lomatobolbina} sp.; Spjeldnaes, p. 258, pl. 36, fig. 8.
1978a \textit{Lomatobolbina} sp. nov. 1; Siveter, p. 48, pl. 1, figs 11, 12.
1983b \textit{Vittella} ? sp. nov. 1 (Siveter, 1978); Schallreuter, p. 139.
1983 \textit{Vittella fecunda} sp. nov.; Siveter, pp. 13-16, pl. 10:14, 10:16.

\textbf{Holotype.} BM OS7777, female left valve; Siveter 1983, pl. 14, fig. 1; herein Pl. 15, fig. 1. Llandeilo 'Flags', Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, Llandeilo, Dyfed (loc. 17).

\textbf{Material.} More than 1000 silicified valves of both dimorphs and larvae and several external moulds.

\textbf{Diagnosis.} (Modified from Siveter 1983, p. 15). Species of \textit{Vittella}
with narrow, sigmoidal S2, narrowing and weaker ventrally. A faint
elevation occurs above S2 near dorsum. L2 node-like. Anteroventral lobe
often elevated. Posteroventral lobe broad with variously developed
ventral node (-spine). Velum widest anteriorly and ventrally. Dolon
wide, long and convex. Perimarginal ridge (= inner antral fence) along
most of antrum.

**Description.** Females high to moderately high and preplete,
tecnomorphs rather high to moderately long and preplete. HV slightly
anteriord of mid-length. LV about mid-height. Domicilium very long to
moderately long, females preplete to slightly preplete, tecnomorphs
almost amplete. HD mid-length in males to just anterior of mid-length in
females. LD is mid-height. Transverse convexity of domicilium greatest
ventral of mid-height, longitudinally it is posterior of mid-length.

Hingeline long in dimorphs, very long to long in larvae. Cardinal
corners greater than 90°. Marginal surface hypocline in males, but
epicline ventrally in larvae. Well developed preadductorional node.
Anteroventral lobe can be node-like. Broad posteroventral lobe with
ventral node, absent to strong or spine-like.

S2 sigmoidal, narrowing and weaker ventrally with faint node-like
elevation near dorsum.

Frill-like velum, widest anteriorly and ventrally; more ridge-like in
larvae; from anterior to posterior cardinal corner, but reduced to thin
ridge dorsal of mid-posterior. Velum approximately parallel with free
margin. Supravelar furrow well developed or indistinct anteroventrally.
57% of measured females have an inner antral fence along most of antrum,
developed close to contact of dolon with domicilium. Marginal sculptures
are very similar to *V. vatia*. Valve surface generally smooth, but well
preserved specimens show fine granulosity.

Width of velum increases through ontogeny. Larvae with spinose nodes
on L3 have a proportionately larger node/spine than dimorphs.
Measurements.

<table>
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All valves from the type locality.

Discussion. \( V. \) \( \text{fecunda} \) (Q 0.96-1.45mm) is the largest known \( \text{Vittella} \) species. Apart from size, \( V. \) \( \text{fecunda} \) (x LV:HV = 1.57) has a slightly longer form than \( V. \) \( \text{vatica} \) (x LV:HV = 1.54) and differs further in having a more sigmoidal S2 with dorsal elevation, a distinct preadductor node, a variously developed antero- and posteroventral node (spine) and velum more or less parallel with the free margin. The size dispersion of females of \( V. \) \( \text{fecunda} \) and \( V. \) \( \text{vatica} \) is compared in Text-fig. 14. Like \( V. \) \( \text{vatica} \) and \( V. \) \( \text{craspedota} \), \( V. \) \( \text{fecunda} \) has an inner antral fence. Siveter (1983) has compared \( V. \) \( \text{fecunda} \) with other middle Ordovician \( \text{Vittella} \) species from Baltoscandia and Siberia. \( V. \) \( \text{rogeri} \) appears similar, but differs by its ventrally wider S2, thicker velar ridge and narrower dolon.

\( V. \) \( \text{fecunda} \) displays wide intraspecific variation. Size, particularly that of females, is extremely variable (Text-fig. 13). Other mutable features are the development of the antero- and posteroventral nodes and supra-velar furrow. There are two morphotypes: one has an anteroventral node, a spinose node developed ventrally on L3 and a well developed supravelar furrow (Pl. 15, figs 2, 3); a smoother form has no anteroventral node, its node on L3 is diminutive to absent, and its supravelar furrow much reduced anteroventrally (Pl. 15, fig. 1).

The size dispersion of both morphotypes overlap, but females of the
TEXT-FIG. 13. Size dispersion of *Vittella* *fecunda*.

TEXT-FIG. 14. Size dispersion of females of *Vittella* *fecunda* and *Vittella* *vatica*. 
smoother form are on average a little larger than the nodose form.
Intermediate forms also exist, particularly amongst smaller instars,
which cannot be segregated into distinct groups. Both forms always occur
together in samples from different localities and stratigraphic horizons
and are interpreted as intraspecific variation.

Occurrence. Upper Llanvirn and Llandeilo series and Costonian Stage,
Caradoc Series of Dyfed (locs 1a-c, 11d, 14, 17, 18, 19a, 20, 21a, 22,
23, 26a, 27a,b, 28a,b). Also found in the Harnage Shales, Harnagian
Stage, Caradoc Series of Shropshire (locs 34, 37).

2. Vittella vatia sp. nov. Pl. 16, figs 1-21

Name. Latin 'vatius', bent outward; alluding to the strong flexure of
the velum in pre-adult females.

Holotype. CRJ SW224, female left valve; Pl. 16, figs 1, 2, 5-7, 10.
Llandeilo 'Flags', Llandeilo Series; quarry 600m NW of Pentre Davies
Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. All known material is silicified; more than 500 valves of
adult and pre-adult females and tecnomorphs.

Diagnosis. Vittella species with pit-like, sigmoidal S2, weak to
absent ventrally. Preadductorional node indistinct, broad flat
posteroventral lobe, without node. Velum flared outwards
posteroventrally in females. Dolon long, terminating posteroventrally.
Inner antral fence sometimes present. Valves smooth.

Description. Female valves very high to rather high and preplete,
tecnomorphs moderately high to long and slightly preplete. HV is
anterior. LV about mid-height. Domicilium moderately long to long in
females and preplete, but rather long to long in tecnomorphs and
preplete (almost amplete in males). HD is mid-length in males, anterior
in females. LD is dorsal of mid-height. Transverse convexity of
domicilium greatest about mid-height, longitudinally it is mid-length.

Hingeline long in females, long to very long in tecnomorphs. Distinct cardinal corners greater than 90°. Marginal surface of tecnomorphs slightly epicline in ventrocentral region. Text-figs 15, 16 illustrate the claudal sculptures.

Preadductorial node weakly developed. Anteroventral lobe obsolete. Posteroverentral lobe broad and flat, slightly elevated ventrally. S2 pit-like, weak to absent ventral of mid-height. S2 appears shortened and only weakly sigmoidal because antero- and posteroverentral lobes are depressed. Velum, flange-like in females and widest anteroventrally, ridge-like in ventral region of tecnomorphs and from anterior to posterior cardinal corner. Velum reduced to indistinct ridge dorsal of mid-posterior, runs parallel with free margin. In tecnomorphs contact of velar ridge with domicilium highest centroventrally (Text-fig. 18c). Velum of adult females bends sharply towards free margin mid-posteriorly. Pre-adult females (Pl. 16, figs 3, 12, 16) have a weakly concave marginal surface antero- to centroventrally and a pronounced outward flexure of the velum posterovertrally. As a result of this flexure, the marginal surface is wider and more concave posterovertrally (Pl. 16, figs 19-21, Text-fig. 18b).

Antra (adult females) in 25% of measured valves, with inner antral fence mid-way between proximal part of dolon and marginal sculpture, running parallel with free margin along most of antrum (Text-fig. 18a). Pre-adult females in 12% of measured valves have a partially developed inner antral fence terminating mid-ventrally (Pl. 16, figs 17, 19 and Text-fig. 18b). Marginal sculptures of both valves consist of a row of fused spines (Text-fig. 15 and Pl. 16, figs 13, 14). Valves smooth.

Supravelar furrow becomes more distinct through ontogeny. Velum in large tecnomorphs is wider and more flange-like than in small larvae.

Measurements.
left valve (LV)

posteroventral marginal sculpture (PMS) of LV is a narrow flange of fused spines.

right valve (RV)

anteroventral marginal sculpture (AMS) is a row of spines.

TEXT-FIG. 15. Camera lucida drawings of internal views of Vittella vatia showing claudal and marginal sculptures. x40.

TEXT-FIG. 16. Schematic cross-sections through the contact margins of conjoined valves of Vittella vatia, showing claudal sculptures of (a) the posteroventral and (b) anteroventral regions.

Legend as for Text-fig. 15.
TEXT-FIG.17. Size dispersion of *Vittella vatica*.

Schematic diagrams of ventral views of right valves of *Vittella vatica*.
All valves from the type locality. †=pre-adult female.

Discussion. *V. vatia* (adult 9 0.88-1.02mm) is smaller than *V. vittensis* (9 1.10-1.20mm) and has a higher form. The type species has a longer, sigmoidal S2, posteroventral node and shorter dolon. *V. crasoedota* is also larger (9 1.13-1.19mm; LV:HV = 1.70) than *V. vatia* with a longer form, sigmoidal S2, more distinct preadductorial node, a posteroventral spine and shorter dolon. Like *V. vatia* and *V. fecunda*, *V. crasoedota* has an inner antral fence. The middle Ordovician *V. gullhoegensis* (9 0.98mm; LV:HV = 1.90, see Schallreuter 1984c) is most similar in size and form to *V. vatia* and has no posteroventral spine, but differs in having an indistinct supravelar furrow, a shorter dolon and no inner antral fence. The S2 of *V. vatia* bears most resemblance to the comma-shaped sulcus of *V? jemtlandica*, which differs in having an admarginal rather than dolonate antrum.

*V. vatia* is the only species of *Vittella* with pre-adult sexual dimorphism (Text-fig. 18).

Sexual dimorphism in *V. vatia* is most strongly reflected in the development of the adventral sculptures. Pre-adult females have only a slightly concave marginal surface, straight velum and no dolon, whereas fertile adult females have concave, dolonate antra. Furthermore, valves and domicilia of adult females (LV:HV = x 1.5; LD:HD = x 1.93) are
higher than those of pre-adults (LV:HV = $\bar{x}$ 1.55; LD:HD = $\bar{x}$ 1.93), because the dolons of fertile females are more ventrally extended.

Pre-adult females (0.67-0.96mm) are on average 0.75mm long compared with 0.91mm for adults (0.82-0.98mm). The size dispersion of *V. vatia* (Text-fig. 17) shows some overlap between adult and pre-adult females (= A -1 instar), which are present amongst the smallest instars measured. This is unusual as one would expect to see smaller tecnomorphic instars than the smallest pre-adult females. Schallreuter (1976, pp. 167-73), in his exemplary study of the ontogeny and pre-adult sexual dimorphism of *Tetrada memorabilis* (Neckaja, 1953), showed that two tecnomorphic instars (A -6, A -5) proceeded the onset of pre-adult dimorphism, sexual maturity being reached only in the adult. Errors in sample preparation resulting in the absence of larvae less than 0.60mm long (= smallest larval instar) are not likely since fine residue fractions of 0.25mm were always picked for ostracodes. Samples from other localities also do not yield smaller larvae of *V. vatia*. Sorting due to post-mortem transport maybe an important factor controlling the size of valves available for measurement. Left valves in particular are more numerically abundant (70%) than right valves (30%) indicating preferential selection.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed (locs 11d, 17, 26a,b).
Subfamily uncertain

Genus HASTATELLINA Příbyl, 1975

Type species. Original designation; Příbyl 1975, p. 12; Bevrichia hastata Barrande, 1872, p. 499, pl. 26, figs 4a-i; from the Vinice Formation (= middle Caradoc), Trubin, near Kraluv Dvur, Czechoslovakia.

Other species. H. normandiensis Příbyl, 1975; H. posthastata Příbyl, 1975; H? trilobis (Keenan, 1951); H? sp. nov. 1.


Discussion. Příbyl (1975, pi. 1, figs 1-6, pi. 2, figs 1-3) erected the type species based on internal moulds. Thus the nature of its dimorphic adventral sculptures and subfamilial assignment is uncertain (Schallreuter 1982c). Vannier (1983b) has recently revised H. normandiensis whose adventral sculptures may be similar to those of H. hastata: in this case the ventral ridge of heteromorphs should be interpreted as a velum, not a histium (cf. Příbyl 1975). The swollen posteroventral lobe of Hastatellina could represent a subdued histium, and coupled with the known infravelar antral dimorphism of H. normandiensis would indicate an assignment to the Tetratellinae. However, if the ridge-like adventral sculpture of Hastatellina represents a histiovelum (Schallreuter 1982c), the genus should be placed in the Glossomorphitinae. Until the type species is revised the subfamilial position of Hastatellina remains uncertain.

Occurrence. Caradoc Series of Bohemia, Czechoslovakia (Příbyl 1975, 1979), the Armorican Massif, France (Vannier 1983b, 1984) and possibly the Maysvillian Stage (= Pusgillian Stage, Ashgill Series) of North
America (Warshauer & Berdan 1982). Hastatellina may also be present in the Llandeilo and basal Caradoc series of Dyfed, Wales.

Hastatellina? sp. nov.  Pl. 14, figs 11-18

**Material.** 21 silicified valves including three presumed females.

**Description.** Valves rather long to long. Slightly preplete to subamplete. HV anterior. HD mid-length. LV and LD dorsal of mid-height. Domicilium long to very long and amplete. Transverse convexity greatest ventrally, longitudinally it is greatest just anterior of mid-length. Marginal surface epicline in anterior and anteroventral regions. Left/right valve overlap. Hingeline long. Cardinal corner angles both greater than 90°.

L1 developed as fimbriate, elongate speral process directed posteriorly. L2 obsolete but for small preadductorional node. L3 and L4 fused to form very broad posteroventral lobe. S1 virtually absent. S2 shallow, V-shaped.

Presumed histium represented by sagged ventral swelling of the posteroventral lobe. Narrow flange-like velum entire, but posteriorly obsolete, represented by low ridge. Presumed heteromorphs have a wider velum anteriorly and an anterior admarginal antrum. Right valves have an anterior to anteroventral row of marginal spines, left valves with a posteroventral marginal flange. These marginal sculptures are very similar to those of Vittella. Valves smooth.

**Measurements.**

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<th>HV</th>
<th>LV:HV</th>
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</table>

Both valves from loc. 18.

**Discussion.** The fimbriate, palmate speral process (L1) of H? sp. nov.
1. (c. 1.11mm) is much shorter and less spine-like than comparable Hastatellina species. H. hastata (c. 2.4mm) and H. posthastata (c. 1.90mm) both have two sulci which are deeper than the single sulcus (S2) of H? sp. nov. 1. H. normandiensis (c. 3mm) bears most resemblance to H? sp. nov. 1 but differs by its larger size and long, spine-like L1.

The small size, palmate speral process (L1) and lack of S1 preclude a confident generic assignment of H? sp. nov. 1; the specimens may represent pre-adult instars. Until additional material becomes available, particularly heteromorphs, the species is left un-named.

**Occurrence.** Middle and upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 12a, 18, 19a, 26a).
Subfamily GUNNAROPSINAЕ subfam. nov.

Type genus. Gunnaropsis Spjeldnaes, 1963

Other genera. Harperopsis Přibyl, 1966; Histina gen. nov.; Cymabolbina gen. nov.; Latebina gen. nov.; Severopsis gen. nov.

Diagnosis. Medium to large (1.5-3mm). Weak to strongly quadrilobate. Lobes L1-L3 occasionally cristaе. Histium usually well developed uniting anteroventrally with velum; present in both sexes, or sometimes as rudiment in females. Velum usually well developed, or rarely forming a row of tubercles. Histiovelum sometimes present in heteromorphs. Velar dimorphism; botulate.

Discussion. The familial relationship of the type genus was originally uncertain because the existence of sexual dimorphism had not been proven (Spjeldnaes 1963, p. 257). Siveter (1978a, p. 47) suggested that Gunnaropsis was dimorphic but did not assign the genus further. Gunnaropsis was included in the Sigmoopsinae by Schallreuter (1966c), who interpreted the anteroventral adventral sculpture of the genus as a histial dolon. Schallreuter remarked that the genus most resembled forms such as Sigmoopsis (Sigmoopsis) rostrata (Krause, 1892). Most recently, Schallreuter (1982c, p. 13) commented that Gunnaropsis probably represents the basis of a new subfamily.

The combination of diagnostic characters mentioned above, serves to distinguish the Gunnaropsinae from any other subfamily of Tetradellidae. All gunnaropsines have botulate, velar (= infravelar antral) dimorphism and are distinguished from other tetradellid genera by a combination of (mostly) well developed quadrilobation, having an inclined histial ridge uniting anteroventrally with the velum, and dolonate antra. In more conservative gunnaropsines, for example Histina gen. nov., the histium merges with the velum anteroventrally, forming a histiovelum in
heteromorphs. Larvae of most species also have the velum reduced or absent in the subhistial part, a condition analogous to that found in *Lomatobolbina vonhactorum* Schallreuter, 1981 (cf. Schallreuter 1981a), whose heteromorphs have an anteroventral velum merging with a short histial flange in the central region, beneath which the velum is obsolete. All gunnaropsines have left/right valve overlap and a row of spines or tubercles forming the marginal sculpture. The diagnostic characters of gunnaropsine genera are summarised and illustrated in Text-figs 19 and 20.

The morphology of the adventral sculptures of the Gunnaropsinae is analogous to that of the tetradeillid subfamily Perspicillinae Schallreuter, 1967. In particular, heteromorphs of *Lomatobolbina* Jaanusson, 1957 and *Pentagona* Schallreuter, 1964 (cf. Schallreuter 1964b), have an anteroventral connection between the histium and velum. Both genera are unisulcate and biantral, and are therefore not closely related to the Gunnaropsinae. Heteromorphs of the sigmoopsine genus *Severobolbina* Schallreuter, 1974 resemble *Severopsis* gen. nov. in lateral view. However, *Severobolbina* is unisulcate and also biantral and it too is unrelated to the Gunnaropsinae. Schallreuter (1966c, p. 858) has suggested that *Gunnaropsis* may have arisen from the tetradeillid *Ogmoopsis*, the same genus which probably formed the ancestral stock for the Perspicillinae and Sigmoopsinae. The subhistial field of members of the Gunnaropsinae is not occupied by a histial (= supravelar) antrum, as in many perspicilline or sigmoopsine genera. These subfamilies could not have arisen from gunnaropsine stock. The present author believes that the Gunnaropsinae have evolved from a quadrilobate, tetradeilline ancestor. A possible precursor could have been *Polyceratella* Öpik, 1937 (lower and middle Ordovician of Baltoscandia), heteromorphs of which have a ventral histial ridge that merges with the velum to form an anteroventral dolon. However, as the tecnomorphic histium does not join
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<td>broad</td>
<td>elevated</td>
<td>cristate</td>
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**TEXT-FIG. 19. Summary of diagnostic characters of gunnaropsine genera**
the velum and both sexes have poorly developed lobes, it is unlikely that Polyceratella was ancestral to the Gunnaropsinae. The Gunnaropsinae have probably arisen from an Ommoopsis-like ancestor. The anteroventral histial/velar connection of gunnaropsine genera has presumably developed by an accretionary process, involving the anterior reduction of the histial flange and coalescence with the velum. The precise anteroventral position of this connection in the Gunnaropsinae is variable and of little phylogenetic significance (contrary to the Perspicillinae where the same anteroventral connection is more posteriorly situated in later representatives).

As with many palaeocope subfamilies, there is a general trend towards lobal obsolescence within the Gunnaropsinae. This is associated with a reduction of the histium and dominance of the velum as an outer antral fence in morphologically advanced forms (for example, Severopsis). More conservative representatives such as Histina have a histiovelum.

The earliest member of the subfamily, Gunnaropsis, forms the root stock from which other gunnaropsines evolved; the proposed phylogeny of the gunnaropsines is given in Text-fig. 21. The phylogenetic development of each genus of Gunnaropsinae is discussed more fully in each respective generic discussion.

**Occurrence.** Known only from Britain, occurring in the upper Llanvirn, Llandeilo and Caradoc series of Wales and the Caradoc of Cumbria and Shropshire, England.

**Genus GUNNAROPSIS** Spjeldnaes, 1963

**Type species.** Original designation: Spjeldnaes 1963, p. 257;
Gunnaropsis cristata Spjeldnaes, 1963, pp. 257, 258, pl. 36, fig. 6;
Llandeilo Series; Llan-mill, 3km E of Narberth, Dyfed.

**Other species.** G. narberthensis sp. nov.; G. subvexa sp. nov.; G.
Phylogeny of the Gunnaropsinae.

Diagnosis. Gunnaropsinae with vertical lobes; L1-L3 and occasionally L4 are cristate. Long histial flange or ridge, extending from below L1/L2 to L4. Velar flange terminating abruptly in central posterior region. Histium and velum unite anteroventrally forming histiovelum in heteromorphs. Anteroventral dolon.

Discussion. The phylogeny of Gunnaropsis has been discussed above. G. sp. nov. 1, although poorly known, may be the most primitive member of the genus. The species has a long histial ridge reaching the central posterior region and well developed lobes and velum. The histium of more advanced forms such as G. cristata is less posteriorly extended but still well developed. The heteromorphic histium of G. narberthensis is obsolete, forming a narrow ridge running above the velum in the central ventral region. Furthermore, the velum of G. narberthensis is frequently reduced posteroventrally and the base of cristae C1-C2 can be absent. G. narberthensis is the most advanced Gunnaropsis known.

Other generic characters include a ventrally fused anterior lobal complex (L1-L2), a distinct anterior cardinal corner, with an angle always greater than 90°, and a marginal surface in the anterior to posteroventral region which is epicline in dimorphs but usually orthocline in larvae. An almost entire row of spines forms the marginal sculpture. The spines are longest in the anteroventral region of larvae, generally shorter in males and ventrally reduced in females, forming a row of tubercles or denticles.

1. Gunnaropsis cristata Spjeldnaes, 1963  Pl. 17, figs 1-8, 10-12

1963 Gunnaropsis cristata Spjeldnaes, p. 257, pl. 36, fig. 6.

non 1978a Gunnaropsis cristata Spjeldnaes, 1963; Siveter, p. 47, pl. 1, figs 3, 4 (= Gunnaropsis narberthensis sp. nov.).

Holotype. GSM 85715, tecnomorphic left valve; Pl. 17, fig. 8. Llandeilo Series; Llan-mill, 3km E of Narberth, Dyfed. Precise horizon and locality unknown.

Material. 90 valves of both tecnomorphs and heteromorphs.

Diagnosis. Moderately high to moderately long species of Gunnaropsis. Long, straight histial flange from below S2 to base of L4. Velum terminating posteriorly just dorsal of mid-height in dimorphs. Tecnomorphic velum in subhistial part poorly developed. Histiovelum, developed anteriorly from below S2. Valve surface sparsely granulose.

Description. All valves preplete. LV just ventral of mid-height, HV is anterior. Domicilium rather long to long in heteromorphs; moderately long to rather long in tecnomorphs. LD just dorsal of mid-height. HD just anterior of mid-length in heteromorphs, but more anteriorly situated in tecnomorphs. Transverse convexity greatest ventrally, longitudinally it is greatest posteriorly. Hingeline long to very long. Posterior cardinal corner slightly rounded, with angle of about 90° in small larvae but greater in large tecnomorphs and heteromorphs. Anterior corner more distinct.

L1 slightly expanded dorsally, with a dorsal cusp. L2 quite distinct, dorsal part developed as an elongate presulcal node. L3 expanded dorsally, forming dorsal bulb in females and large tecnomorphs. L4 broadest, expanded above mid-height, with small dorsal cusp. Cristae C1-C2 V-shaped, C3 sometimes dorsally obsolete. S1 narrow and shallow. S2, S3 equally broad, but S2 deeper and more sigmoidal.
Histial flange well developed, from below L2 to base of L4, where it terminates posteriorly just dorsal of mid-height in females and large tecnomorphs, but usually below mid-height in larvae.

Tecnomorphic velum from anterior cardinal corner to below L2, where it merges with the histium; in subhistial part, velum is poorly developed, becoming more prominent posteroventrally. Heteromorphs with velum well developed throughout, uniting with histium below S2 forming histiovelum. Anteroventral dolonate antrum.

Surface ornament poorly preserved. Fine granules in supravelar furrow and scattered in ventral parts of sulci, particularly in tecnomorphs. Heteromorphs virtually smooth.

L4 most prominent in females; L1, L3 of larvae often have short, spine-like dorsal projections. C1-C2 of females occasionally U-shaped. C2 and posteroventral part of the velum are frequently absent in larvae.

Measurements.

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Discussion. The well developed lobes, velum and long histial flange of *G. cristata* constitute a basic morphological form, from which other gunnaropsine stock such as *Harpereopsis* and *Histina* could have developed.

Occurrence. Llandeilo Series of Dyfed (locs 11c-11e, 17, 20, 22).
2. *Gunnaropsis narberthensis* sp. nov. Pl. 17, figs 9, 13-23

**Name.** From its occurrence near Narberth, Dyfed.

1978a *Gunnaropsis cristata* Spjeldnaes, 1963; Siveter, p. 47, pl. 1, figs 3, 4.

**Holotype.** CRJ SW116, silicified female left valve; Pl. 17, figs 13, 17-20. Bryn-banc Limestone Member, Narberth Group; Costonian Stage, basal Caradoc Series; quarry 500m SE of Dyffryn Farm, Llan-mill, 3km E of Narberth, Dyfed (loc. 26a).

**Material.** More than 90 tecnomorphs and two heteromorphic valves.

**Diagnosis.** Moderately long to rather long *Gunnaropsis* species. C1-C2 forming a U-shape, with C1 fashioned dorsally into an inverted hook. Histial flange from beneath L1/L2 to below L4 in tecnomorphs, but reduced to short ridge running above velum in dimorphs. Velum with spinose posterior termination. Velum of larvae absent in subhistial region. Histiovelum from below L2 to L3. Valve surface finely granulose.

**Description.** Dimorphs approximately equal in size and slightly preplete. Larvae preplete. LV about mid-height in dimorphs, but dorsal in larvae. HV at mid-length in large tecnomorphs, more anterior in females and small tecnomorphs. Domicilium rather long, subamplete in dimorphs, slightly preplete to preplete in large and small larvae respectively. LD about mid-height in larvae, more dorsally situated in dimorphs. HD mid-length in dimorphs, but anterior in larvae. Transverse convexity greatest just ventral of mid-height, longitudinally greatest about mid-length. Hingeline long. Cardinal corners distinct, posterior corner slightly rounded with an angle of about 90° in dimorphs, usually slightly less in larvae.

L1-L2 fused and virtually obsolete. L3 most elevated. L4 broadest in larvae, narrower and more prominent in dimorphs. L1, L3, L4 slightly expanded dorsally, each provided with small posteriorly directed
projection, usually developed as spines in larvae. Cristae long, sloping slightly towards anterior. C1-C2 U-shaped, but frequently absent ventrally. C1 has inverted hook shape in its dorsal part. C3 virtually absent. S2, S3 equally broad. S2 deepest, constricted dorsally. S3 widest dorsally.

Histial flange well developed in tecnomorphs, from below L1/L2 to below L4, terminating as a posteriorly directed spine. Histium reduced in dimorphs, forming low narrow ridge running parallel with, and just above velum in ventral region. Flange-like velum terminates posteriorly about mid-height, as a spine-like projection. Larval velum in subhistial part obsolete, only developed in anterior and posteroventral region. In heteromorphs velum unites with histium below L2 to L3 forming histiovelum. Dolon quite broad, particularly convex in anteroventral region. Valve surface finely granulose.

In dimorphs C1-C2 are often connected to base of C3; C4 is normally present and the histium is less well developed than in larvae.

**Measurements.**

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<th>HV</th>
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<th>HD</th>
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<td>1.95</td>
<td>0.83</td>
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**Discussion.** *G. narberthensis* (♀ 1.50mm; LV:HV = 1.79-1.87) is slightly smaller and has a longer form than *G. cristata* (♀ 1.55mm; LV:HV = 1.67-1.80). *G. narberthensis* differs from *G. cristata* in having a U-shaped C1-C2 complex, C1 dorsally shaped like an inverted hook, histium reduced to a short ridge in dimorphs and velum with a spinose posterior termination. Both species have larvae in which the velum is reduced (*G. cristata*), or obsolete (*G. narberthensis*) in the subhistial
part. *G. narberthensis* presumably evolved from a *G. cristata*-like ancestor.

**Occurrence.** Upper Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed (locs 18, 24, 26a, 27, 28b).

3. *Gunnaropsis subvexa* sp. nov. Pl. 18, figs 1, 2, 5, 6

**Name.** Latin 'subvexus', sloping upward; referring to the posteroventrally directed histial ridge.

**Holotype.** CRJ SW041, large silicified tecnomorphic right valve; Pl. 18, figs 1, 5, 6. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

**Material.** More than 200 tecnomorphic valves.

**Diagnosis.** Rather high to moderately high species of *Gunnaropsis*. L4 sloping towards posterior above mid-height. Histial ridge narrow and steeply inclined, extending from beneath S2, connecting base of L3 and L4. Valve surface covered with evenly distributed granules.

**Description.** Tecnomorphs sub-amplete to preplete (small tecnomorphs). LV about mid-height. HV mid-length in large tecnomorphs, but anterior in small larvae. Domicilium rather long and preplete. LD just dorsal of mid-height. HD anterior of mid-length. Transverse convexity greatest ventrally, longitudinally it is greatest just posterior of mid-length. Hingeline long. Cardinal corners slightly rounded. Posterior corner obtuse in large tecnomorphs but equal to, or less than 90° in small tecnomorphs.

L1-L2 fused ventrally. L3, L4 have low dorsal cusps. L1 broadest dorsally with low dorsal crest. L2 forming elliptical node dorsally. L3 expanded dorsally; with small, posteriorly directed spine in small larvae. L4 broadest above mid-height where it slopes towards posterior.
C1-C2 V-shaped. C2 frequently absent in small tecnomorphs. C3 occasionally absent in large tecnomorphs. S1 narrow, shallow and absent below mid-height. S2 widest, longer than S3, which is constricted dorsally and restricted ventrally by the histium.

Histial ridge narrow and steeply inclined towards anterior, beginning beneath S2, joining with base of L3 and terminating at the posterior edge of L4. Velar flange well developed throughout in large tecnomorphs, virtually absent in ventral and posteroventral regions of small tecnomorphs. Velum terminating at or below mid-height posteriorly.

Valve surface covered with evenly distributed granules, except for oblong muscle scar of S2.

**Measurements.**

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<th>HV</th>
<th>LV:HV</th>
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<th>HD</th>
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**Discussion.** The morphology of the female of this species is unknown. The cristate lobes, long well developed histium and velum of *G. subvexa* (tecnomorphs c. 1.31mm) are all features easily accommodated within *Gunnaropsis*. Tecnomorphs of *G. subvexa* differ from those of *G. cristata* in having a higher form, more upright lobes, greater inclination of the histium, and a velum clearly developed subhistially.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 11d, 17, 21a,b, 22, 26a, 28b)

4. *Gunnaropsis* sp. nov. 1. Pl. 18, figs 3, 4

**Material.** Three damaged tecnomorphic valves.

**Description.** L1 most elevated above mid-height, provided with dorsal crest. L2 develops elongate swelling. L3 constricted centrally, swollen
ventrally. L4 broad. C1, C2 long and curved. C3 present. S1 narrow, absent ventrally. S2 deep, sigmoidal. S3 broad, restricted ventrally by histium. Histial flange long and straight; from below L1 to the central posterior region. Velar flange entire, terminating about mid-height posteriorly. Valve surface finely granulose.

**Measurements.**

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</table>

**Discussion.** The morphology of the lobes, histium and velum indicate that the species should be assigned to *Gunnaropsis*. The well developed lobation and long histium suggests the species is a rather primitive member of the genus.

The specific assignment is left open until the morphology of the female becomes known and more material is available for study.

**Occurrence.** Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 16).

**Genus HARPEROPSIS** Přibyl, 1966

**Type species.** Original designation; Přibyl 1966, pp. 201, 202; *Tetradella scripta* Harper, 1947, pp. 347, 348, pl. 10, figs 1, 2; Harnage Shales, Harnagan Stage, Caradoc Series; near Cwms Cottage, Caer Caradoc Hill, Church Stretton, Shropshire.

**Other species.** *H. bicuneiformis* (Harper, 1947); *H. decorata* (Jones, 1855).

**Diagnosis.** (Modified from Jones & Siveter 1983, p. 5). Large, amplete Gunnaropsinae, having short anteroventral connecting ridge (relict histium) between connecting lobe and velum. L1, L3, L4 well developed or elevated, projecting above hingeline. L3 with dorsal bifurcation, giving
smaller cusp nearer dorsum. Velum as well developed (-inflated) ridge, terminating abruptly mid-posteriorly. Dolon anterior. Surface of lobes, velum and dolon smooth, granulose elsewhere.

Discussion. The genus has been fully discussed by Jones & Siveter (1983). Harperopsis differs from other Gunnaropsinae because of its very large size (c. 3mm), L3 with dorsal bifurcation, unique anteroventral connecting ridge and anterior dolon. The lobes of most members of Harperopsis are well developed, and even elevated. Combined with the mid-posterior termination of the velum, these features suggest that the genus evolved from Gunnaropsis.

Harperopsis is the only gunnaropsine recorded from North Wales and Cumbria, northern England.

Other generic features include a fairly shallow anterioranteroventral antrum; orthocline to slightly epicline marginal surface in anterior to posteroventral regions of tecnomorphs, only developed in posteroventral region of females where it is epicline; marginal sculpture formed by row of short spines or tubercles.

1. Harperopsis bicuneiformis (Harper, 1947)

Pl. 18, figs 7–11, 14, 15, 17, 19, 20

1947 Tetradella bicuneiformis sp. nov.; Harper, pp. 348, 349, pl. 10, figs 4, 10, text-fig. 1b.

1966 Cerninella (Harperopsis) bicuneiformis (Harper, 1947); Pribyl, p. 204.

1978a Harperopsis bicuneiformis (Harper, 1947); Siveter, p. 50, pl. 2, figs 5–8.


Holotype. GSM 75421A, tecnomorphic left valve external mould; Pl. 18, fig. 8. Spywood Member, Chirbury Formation, upper part of Costonian.
Stage, Caradoc Series; 92m S of Rorrington Hall, just inside gate on footpath to Kinton, Rorrington, Shropshire (loc. 31).

Material. Hundreds of moulds of heteromorphs and tecnomorphs.


Description. Valves rather high to moderately long and amplete to subamplete. LV about mid-height. HV mid-length or slightly anterior. Transverse convexity greatest ventrally, longitudinally greatest just anterior of mid-length. Hingeline moderately long to long. Cardinal corners distinct to slightly rounded. Anterior corner angle more obtuse than posterior. Tecnomorphic marginal surface epicline in anterior-posteroventral region. Females have an epicline, posteroventral marginal surface.

Lobes L1-L4 slope towards anterior. L1 broad, terminates ventrally just below mid-height, where it joins base of L2 forming V-shaped L1-L2 complex. L2 short, narrow, slightly expanded dorsally. L3 elevated, expanded ventrally, often provided with posteriorly directed spine on dorsal cusp furthest from dorsum. L4 narrow ventrally, where confluent with base of L3; somewhat reduced centrally, with small dorsal cusp. S1 narrow, slightly V-shaped; S2 deep and faintly sigmoidal. S3 curved towards anterior, constricted dorsally.

Anteroventral connecting ridge inclined at acute angle, joined to base of L3 and velum. Velar ridge widest anteroventrally, often flange-like in posteroventral region. Anterior to anteroventral dolon is narrow.

Valve surface mostly smooth, possibly due to poor preservation. When present, granules restricted to antero- and posteroventral supravelar areas.
Small tecnomorphs have spinose dorsal cusps (L1, L3, L4) and more reduced L4 than females and large tecnomorphs.

**Measurements.**

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</tbody>
</table>

All moulds from the type locality.

**Discussion.** *H. bicuneiformis* differs from the type species because it is smaller, has a better defined relict histial ridge, a more inclined L3 and L4 and an isolated V-shaped L1-L2. Contrary to the opinion of Jones & Siveter (1983, p. 7), *H. bicuneiformis* is assigned herein to *Harperopsis*. Its anteroventral connecting ridge and thick velar ridge are features characteristic of the genus.

**Occurrence.** Upper part of Costonian Stage, Caradoc Series of Shropshire (locs 31, 32) and probably the Soudleyan Stage, Caradoc Series; GSM GF 8110 from the Carneddau Group, forestry road NE of Llyn Elsi, 1km SW of Betws-y-Coed, Gwynedd (SH 7879 5567).

2. *Harperopsis decorata* (Jones, 1855)

Pl. 18, figs 12, 13, 16, 18, 21-24

1855 *Bevrichia complicata*, var. *decorata*; Jones, p. 165, pl. 6, fig. 6.
1934 *Tetradella complicata decorata* (Jones); Bassler & Kellett, p. 480.
1947 *Tetradella decorata* (Jones); Harper, pp. 349, 350.
1967 *Tetradella scripta*; Dean & Binesley, p. 375.
1983 *Bevrichia decorata* Jones; Jones & Siveter, p. 7.
Lectotype. Designated Harper (1947, p. 350); GSM 35718, female right valve external mould. Wax cast figured by Jones 1855 (= BM I6324), pl. 6, fig. 6; herein Pl. 10, figs 13, 16, 18, 21. The lectotype is present with other moulds on the same slab. Harper designated “an external impression” as the lectotype but neglected to state exactly which valve. Only one complete external mould exists, and this is regarded as the lectotype. Probably from the Pen-plaenau or Cwm Rhiwarth siltstone formations of Pickerhill & Brenchley (1979, pp. 230, 231), Soudleyan Stage, Caradoc Series; Aber-marchnant village, 10.5km W of Llanfyllin, Powys (SJ 038 194). Precise locality and horizon unknown.

Material. Eight tecnomorphic moulds and two (one partly preserved) heteromorphic moulds.

Diagnosis. Species of Harperopsis having L1, L3, L4 dorsally developed into prominent bulbs. Ventral parts of L1, L2, L4 and anteroventral connecting ridge obsolete. Velar ridge inflated. Valve surface smooth but for fine scattered granules in supravelar furrow.

Description. Valves rather high to moderately high and ample. LV above mid-height. HV mid-length or just anterior. Hingeline long. Obtuse cardinal corner angles, fairly distinct.


Anteroventral connecting ridge obsolete, remains as short, thin ridge uniting base of L3 with velum. Velar ridge broad and inflated throughout. Narrow, inflated anterior dolon.

Valve surface smooth but for fine granules usually developed in
anterior and posteroventral supravelar area.

The lobes, dorsal bulbs (L1, L3, L4) and velum of small tecnomorphs are much narrower than those of females and large tecnomorphs and the ventral parts of L1, L4 are totally obsolete in larvae.

**Measurements.**

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† = type locality.

**Discussion.** *H. decorata* differs from *H. scripta* by its more inflated velum, reduced lobation, dorsal bulbs of L1, L3, L4 and the obsolescence of lobal bifurcation to L3. Because of its relatively obsolete lobation, *H. decorata* is considered a more advanced member of the genus than its probable ancestor *H. scripta*. The lobation of *H. decorata* resembles the tallinnelline *Homeokiesowia* Schallreuter, 1979, which shows incipient dissolution of its lobes to nodes. *H. decorata* is unrelated to *Homeokiesowia* because it develops a relict histium.

**Occurrence.** Soudleyan and Longvillian stages, Caradoc Series of Shropshire and North Wales.

Soudleyan Stage: loc. 39 (Shropshire) and the following (all from North Wales); specimens under accession no. NMW 79.5G from the Lockley (1980a) coll., un-numbered specimens of sample H14, loc. 958 of Lockley (1980a, pp. 174, 175, fig. 3), from the upper part of the Llaethnant Siltstone Formation (= lower Soudleyan), Afron Twrch stream section, 6km SW of Llanuwchlllyn, Gwynedd (SH 9101 2305). Also sample R20 (Lockley 1980a, pp. 179, 180, fig. 9), from the upper part of the Allt Ddu Formation (= upper Soudleyan), Rhiw March stream section, Dyfi Valley, c. 9km S of Llanuwchlllyn (SH 899 219).
Longvillian Stage, North Wales: SM A41503 is from the Gelli-grin Formation = Longvillian of Moel-y-garnedd, 2.5km ESE of Bala, Gwynedd. SM A53439 is from the Bryn Siltstone Formation (= Longvillian), near Bryn Farm, Nant Iorwerth, Glyn Ceiriog, Clwyd. SM A42731 and SM A42734 are probably of Soudleyan or Longvillian age, from the "Hill N of Moel Uchlas, Montgomeryshire" (now Powys). The precise localities of the Sedgwick Museum specimens are uncertain.

3. Harperopsis scripta (Harper, 1947) Pl. 19, figs 1-9, 11

1851 Bevrichia complicata (Salt); McCoy, p. 136, pl. 1E, fig. 3, 3a (= on SM A16696).

1852 Bevrichia complicata; Salter, p. ii, appendix A, pl. 1E, fig. 3.

1855 Bevrichia complicata; Salter; Jones, p. 164 (pars), pl. 6, fig. 1 (= larva on GSM 49449).

1856 Bevrichia complicata Salter; Salter & Woodward, p. 19, pl. 1, fig. 45.

1873 Bevrichia complicata. Salter; Salter, pp. 31 (pars), 48.

1946 Bevrichia (Tetradesella) complicata; Woods, p. 380, fig. 193.

1947 Tetradesella scripta sp. nov.; Harper, pp. 347, 348, pl. 10, figs 1, 2, 8, text-fig. 1a.

1948 Tetradesella scripta Harper; Strachan, Temple & Williams, pp. 276, 277.

1953a Tallinnella scripta (Harper, 1947); Henningsmoen, p. 214.

1964 Tallinnella scripta (Harper); British Palaeozoic Fossils, pl. 12, fig. 11.

1966 Corninella (Harperopsis) scripta (Harper, 1947); Privyl, pp. 201, 202.

1978a Harperopsis scripta (Harper, 1947); Siveter, p. 52, pl. 3, figs 7, 8.
1983 *Harporopsis scripta* (Harper, 1947); Jones & Siveter, pp. 5,
7, 9, 11, pl. 10:6, 10:8, 10:10, 10:12.

**Holotype.** GSM 74875A, male left valve external mould. Figured Harper (1947), pl. 10, figs 1 (= plasticine cast), 2 (= external mould); herein Pl. 19, figs 3-6, 11. Harnagian Stage, Caradoc Series; bank by Caer Caradoc hill track, 1125m WSW of Willstone, Caer Caradoc Hill, 2.5km NE of Church Stretton, Shropshire (loc. 34).

**Material.** More than 200 moulds of heteromorphs and tecnomorphs.

**Diagnosis.** (Modified from Jones & Siveter 1983, p. 11) Large *Harporopsis* with L1, L3, L4 developed as nearly vertical, elevated ridges. L2 diminutive to quite strong. Dolon, velar ridge, lobal crests and all but ventral-most parts of sulci smooth; granulose elsewhere.

**Description.** Female valves moderately high to moderately long, tecnomorphs rather high to moderately high. All valves amplete. LV just dorsal of mid-height. HV is mid-length. Transverse convexity greatest about mid-height in females, but ventral of this in tecnomorphs. Hingeline moderately long to long. Cardinal corners distinct with obtuse corner angles. Left valve with almost entire inner semi-groove; complementary marginal flange on right valve.

L1, L3, L4 are nearly vertical elevated ridges, can be wide or fairly narrow. Base of L1 constricted and curved towards posterior, where it joins with the anteroventral connecting ridge. L2 shortest, joined towards base of L1; diminutive to fairly strong and slightly expanded above mid-height. L3 well developed throughout, joined to top of anteroventral connecting ridge. L4 narrow to wide, sometimes tumid below mid-height. Base of L4 curved anteriorly where connected to base of L3; L4 dorsally developed as pointed cusp. S1 present above mid-height forming narrow, shallow to deep groove which opens dorsally. S2 long and comma-shaped. S2, S3 equally broad. S3 shorter than S2 and slightly constricted ventrally.
Relict histium developed as short, anteroventral connecting ridge between base of L1-L3 and velum. Thick velar ridge, well developed throughout, with deep supravelar furrow in antero- and posteroventral regions.

Valve surface smooth but for granules (0.001-0.002mm across) which cover supravelar area and ventral parts of sulci.

Larvae have posterior edge of L3 dorsally fimbriate and more cristate lobes.

Measurements

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<th>HV</th>
<th>LV:HV</th>
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♦ = valve un-numbered, on same slab as holotype.
† = see Occurrence below.

Discussion. The lobation of *H. scripta* is particularly variable. Specimens from the Harnagian Stage of South Shropshire have broad lobes (L1, L3, L4) and a diminutive L2 (Pl. 19, fig. 1). Younger specimens, from the Soudleyan and Longvillian stages of North Wales are smaller in size and have narrower lobes (L1, L3, L4) but for L2, which is often quite strongly developed (Pl. 19, fig. 9). Intermediate forms also exist. For further discussion see Jones & Siveter (1983).


Harnagian Stage, South Shropshire: locs 33, 34, 35, 36 and 37. Specimens LM 5043-5047 come from loc. 37. GSM DJ 1003-5 are from a
limestone band, c. 3m above base of section of the Harnage Shales (Harnagian Stage) in the quarry 540m WNW(110°) of the Hough, Little Stretton, 2.5km S of Church Stretton, Shropshire (SO 4454 9136). CRJ M71/1 and M72 are from the old cart-way, S end of Smeathen Wood, 1.5km S of Horderley, Shropshire, precise locality uncertain (W.T. Dean coll. in BM).

Soudleyan Stage. Clwyd: loc. 40, also specimen SM A166196 and slabs SM A44637-A44639 which come from Pont y Meibion, c. 3km SW of Glyn Ceiriog, Clwyd (SH 195352), precise locality and horizon uncertain, probably from the Pen-plaenau Siltstone Formation (=Soudleyan Stage) of Brenchley (1978, pp. 139-41).

Longvillian Stage, Clwyd: loc. 41. SM A42724 is from Bryn-Eithin, near Penmachno, 6.5km S of Betws-y-coed, Gwynedd, precise locality unknown, probably from the Carneddau Group (= Soudleyan or Longvillian age, see Howells et al. 1978). SM A42735 is from Nantyr, near Glyn Ceiriog, 4.5km S of Llangollen, Clwyd, locality and horizon uncertain. Specimen SM A40161 is distorted, but is possibly H. scripta listed by Dean (1963, p. 58) as 'Tallinnella' sp. from the Drygill Shales (Longvillian), Drygill, WSW of summit of Carrock Fell, Cumbria. Precise locality unknown.

Woolstonian Stage, Shropshire (loc. 47), and Cumbria (loc. 44a; GSM RU2546, RU2550 are from this locality).

H. scripta is one of the most commonly recorded ostracodes in British Ordovician faunal lists. Most of these records should be treated with caution as they may refer to other quadrilobate palaeocopes (Jones & Siveter 1983).
Genus **HISTINA** gen. nov.

*Name.* 'Histium' and the Latin suffix '-ina'; referring to the well developed histium. Gender feminine.

*Type species.* **Histina xanios** sp. nov.; from the Llandeilo and basal Caradoc series of Dyfed and Costonian Stage, Caradoc Series of Shropshire.

*Diagnosis.* Gunnaropsinae with well developed lobes and long, histial flange, terminating below L4 as a fimbriate spine. Heteromorphs with anteroventral histiovelum. Velar flange well developed in dimorphs but often absent in subhistial part of larvae.

*Discussion.* **Histina** has a long histium and well developed histiovelum and it is probably derived from **Gunnaropsis**. **Histina** differs from **Gunnaropsis** by having non-cristate lobes, a velum which terminates posterovertrally and by the specialised terminal structure of the histium.

Compared with **Kiesowia** (*Pseudotallinnella*) Sarv, 1959 (one of the few quadrilobate tetradeillids which also develops a histiovelum), **Histina** has a shorter anteroventral histiovelum, a more posteriorly inclined histium and well developed lobes. The histial and velar flanges of females of **K.** (*Pseudotallinnella*) do not unite anteroventrally, as in **Histina**. Tecnomorphs of **K.** (*Pseudotallinnella*) also completely lack a histium. **Histina** and **K.** (*Pseudotallinnella*) are unrelated but demonstrate that a histiovelum is not restricted to the Glossomorphitinae.
Histina xanios sp. nov. Pl. 19, figs 10, 12-23

Name. Greek 'xanion', comb for carding wool; alluding to the comblike posterior termination of the histium.

Holotype. CRJ SW032, silicified female left valve; Pl. 19, figs 15, 17, 19, 22. Llandeilo 'Limestone', middle Llandeilo Series; quarry 450m WSW of Kincoed Farm, 9km E of Carmarthen, Dyfed (loc. 12a).

Material. 315 valves of both dimorphs and larvae.

Diagnosis. As for the genus.

Description. Female valves are rather high to moderately high, tecnomorphs are moderately high to moderately long. Dimorphs are more or less amplete and larvae are preplete. LV is just ventral of mid-height. HV is just anterior of mid-length in dimorphs, but more anterior in larvae. Domicilium is rather long to long in females; tecnomorphs are long.

Transverse convexity greatest ventrally, longitudinally it is greatest just anterior of mid-length. Hingeline long to very long. Cardinal corners distinct. Posterior corner angle of dimorphs is 90° or slightly more, in larvae usually less than 90°. Obtuse anterior corner angle. Marginal surface in anterior, ventral and posterovelvar regions of males is epicline, but virtually orthocline in larvae and epicline in posterovelvar regions of females. L1, L3, L4 project beyond hingeline. L1-L2 form V-shaped complex. L1 is broadest dorsally with pointed cusp. L2 is slightly reduced at about mid-height above which it forms a round preadductorial node. L2 is joined to the base of L1, where a round node-like swelling is variously developed in dimorphs (Pl. 19, fig. 23), but rarely in larvae. L3 is most elevated lobe, constricted centrally, usually with posteriorly directed dorsal point. L4 broadest centrally, tapering dorsally, forming posteriorly pointed cusp. S1 wedge shaped, above mid-height. S2 sigmoidal, broad and deep. S3 broad, shallowest;
constricted dorsally, restricted ventrally by histium.

Long, broad histial flange extending from below S2/L3 to beneath L4, where elevated into a posteriorly directed, fimbriate spine. Broad velar flange from anterior cardinal corner to posteroventral region where it ends gradually. Velum slightly reduced in central ventral region of males, virtually absent ventrally in larvae except for slight ridge-like swelling. Anteroventral histiovelum of females forming broad, fairly convex dolon. Marginal sculpture is an almost entire row of spines. Valve surface granulose, but for smooth antrum and semi-circular muscle scar (when preserved), located behind preadductorial node.

L1 is broader, S3 is shallower in larvae. L3 of larvae, has four or five thin spines on its posterior dorsal edge (Pl. 19, fig. 10), which are much reduced or absent in adults.

Measurements.

<table>
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Discussion. The spinose posterior termination of the histium of *H. xanios* is unique. A row of four or five long tubercles is developed on the dorsal part of the main spine (Pl. 19, fig. 22), the function of which is unknown.

Occurrence. Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 3, 12a,b, 23, 24, 26b, 28a,b) and upper part of the Costonian Stage of Shropshire (loc. 31).
Genus Cymabolbina gen. nov.

Name. Greek 'kyma', swollen, and the generic name Bolbina; alluding to the prominent dolon. Gender feminine.

Type species. Cymabolbina acanthodes sp. nov.; from the lower Llandeilo Series of Powys.

Other species. C. susanae sp. nov.; C? sp. nov. 1.

Diagnosis. Gunnaropsinae with tecnomorphic histial flange usually terminating below L3 or S3. Histium of heteromorphs rudimentary or virtually absent; developed as narrow ridge in central ventral and/or posteroventral regions. Dolon broad, anteroventral to ventral. Valve surface granulose, and occasionally spinose.

Discussion. The fused L1-L2 complex, elevated L3 and broad, reduced L4 developed in all members of the genus are similar to those of Histina and Latebina. Cymabolbina differs from Latebina in having a reduced heteromorphic histium and well developed tecnomorphic velum in the posteroventral region. It differs from Histina in having a shorter tecnomorphic histium, a rudimentary heteromorphic histium and less well developed lobes. Cymabolbina differs further in lacking a histiovelum, its outer antral fence being formed entirely by the velum. Except for the histiovelum, the general morphology of Cymabolbina most closely resembles that of Histina, from which it is probably descended. C? sp. nov. 1. has features common to both genera and may be an intermediate form. Its long tecnomorphic histium is particularly reminiscent of Histina, as is the posteroventral heteromorphic histium which occupies a similar position to the specialised, histial termination of Histina.

The occurrence of a rudimentary histium in females of Cymabolbina, demonstrates that such a feature is not restricted to the Sigmoopsinae. Females of the sigmoopsine Kiesowia (Kiesowia) Ulrich & Bassler, 1908 are superficially similar to those of Cymabolbina. They differ because
the velum and histium of *Kiesowia* (*Kiesowia*) join anteriorly, the
tecnomorphic histium is absent and all lobes are dissolved into nodes,
none of which are features developed in the unrelated *Cymabolbina*.

Other generic characters include: L1 broadest at mid-height; L2
elongate and node-like; L3 most elevated and L4 broadest. S2 deep and
sigmoidal, S3 shallow. Velar flange well developed in females, but
reduced or absent in central ventral regions below the histium. Velum
terminating posteroventrally. Anteroventral antrum. Marginal surface of
tecnomorphs is developed in the anterior to posteroventral region and is
more or less orthocline. An almost entire row of marginal spines is
developed, which are longest in the anteroventral and ventral regions of
tecnomorphs.

**Occurrence.** Llandeilo Series of Dyfed and Powys, Wales.

1. *Cymabolbina acanthodes* sp. nov. Pl. 20, figs 1-5, 8-10, 14

**Name.** Greek 'akanthodes', thorny; referring to the spiny surface
ornamentation.

**Holotype.** CRJ M68, female left valve external mould; Pl. 20, figs 2,
3, 8, 9. *Glyptograptus teretiusculus* Shales; low *G. teretiusculus*
Biozone, lower Llandeilo Series; stream section by lane leading to
Newmead Farm, c. 3km NE of Builth Wells, Powys (loc. 8).

**Material.** 14 tecnomorphs and seven females, plus four fragmentary
tecnomorphs and two females.

**Diagnosis.** *Cymabolbina* species in which heteromorphs have a low,
narrow histial ridge, usually extending from the base of L3 to below S3.
Histium of tecnomorphs with spine-like posterior termination. Valve
surface finely granulose with short spines on lobes and marginal surface
of tecnomorphs.
Description. Females slightly preplete to preplete and moderately long. Tecnomorphs are preplete and rather high to moderately long. LV is at mid-height. HV just anterior of mid-length. Transverse convexity greatest ventrally, longitudinally it is greatest about mid-length. Hingeline long. Cardinal corners distinct, greater than 90°.

Lobes L1, L3, L4 are broad, reaching dorsal margin but not projecting beyond it. L2 narrow, elongate, slightly curved towards anterior, attached to posterior edge of broad L1, at about mid-height. L3 elevated, expanded ventrally with thin, posteriorly directed spine on its dorsal edge. L1, L4 provided with cusps, which are spine-like in small tecnomorphs. S1 is a narrow depression in front of L2 above mid-height. S2 deepest above mid-height. S3 fairly shallow, long and curved towards anterior.

Histial flange from below S2 to below S3 or base of L3, with posteriorly directed spine-like termination in tecnomorphs. Heteromorphic histium reduced, forming a narrow ridge from below L3 (where it reaches the velum) to anterior, ventral edge of L4. Velar flange well developed except in subhistial part of tecnomorphs. Velum terminating in posterocentral region. Broad anteroventral and ventral dolon, with faint radial striations.

Valve surface finely granulose with short spines on lobes and supravelar area and marginal surface of tecnomorphs.

S3 is deeper in large tecnomorphs and females. Larvae are generally more spinose than adults with L1, L3 dorsal spines projecting beyond hingeline.
Measurements.

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<td>CRJ M69/1 ♂</td>
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<tr>
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<tr>
<td>CRJ M69/5 ♂</td>
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<td>0.83</td>
<td>1.61</td>
<td>-</td>
<td>4,5,10</td>
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</tr>
</tbody>
</table>

All valves from the type locality (loc. 8).

**Discussion.** The surface ornament and long, radially striated dolon of *Kiesowia (Kiesowia) dissecta* (Krause, 1892) (♀ c. 2.20mm) are very similar to those of *C. acanthodes* (♀ c. 1.73mm) but the two species are otherwise dissimilar (see generic Discussion above). *C. acanthodes* and *C?* sp. nov. 1 (♀ c. 1.78*mm* are the least advanced members of the genus; both possess a distinct histial rudiment in females. *C. acanthodes* differs from *C?* sp. nov. 1 in having a shorter tecnomorphic histium, slightly broader velar flange posteroventrally, deeper S3 and spinose surface ornament.

**Occurrence.** Known only from the *Glyptograptus teretiusculus* Shales, lower Llandeilo Series of the type locality (loc. 8).

2. *Cymabolbina susanae* sp. nov. Pl. 20, figs 6, 7, 11-13, 15-21

**Name.** In honour of Susan Rigby, University of Leeds, England.

**Holotype.** CRJ SW190, silicified female left valve; Pl. 20, figs 15, 20, 21. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

**Material.** More than 100 valves of both dimorphs and larvae.

**Diagnosis.** Species of *Cymabolbina* with lobes L1, L3 projecting beyond hingeline. Histium of heteromorphs virtually absent but for short
ridge-like swelling at base of L3. Valve surface evenly granulose.

Description. Female valves are rather high to moderately high, males are rather high to moderately long, larvae are moderately long to long. Females and larvae are preplete, males are only slightly preplete. LV is about mid-height, HV is anterior. Domicilium rather long in females, rather long to long in tecnomorphs, usually preplete. LD just dorsal of mid-height, HD is anterior. Transverse convexity greatest ventrally, longitudinally it is greatest about mid-length (tecnomorphs) or anteriorly (females). Hingeline long to very long. Posterior cardinal corner very distinct, with a corner angle of about 90° or less in larvae. L1, L2 project beyond hingeline. L1 narrows dorsally, forming elongated point. L2 slightly expanded dorsally, forming rounded preadductorial node. L3 most elevated ventrally, constricted centrally, with prominent dorsal process that in larvae is fimbriate on anterior and posterior edges. L4 broad, most elevated ventrally. S1 virtually absent. S2 deepest. S3 quite shallow, deeper just behind L3.

Tecnomorphic histial flange from below L1/L2 to base of L3. Histium of females virtually obsolete but for short, ridge-like swelling that projects from base of L3. Velar flange well developed except in subhistial part of larvae, where it can be absent. Broad anteroventral dolon. Anteroventral antrum.

Valve surface evenly granulose but for smooth antrum, small circular muscle scar behind L2 and dolon with fine concentric striations.

L1 and L2 are dorsally expanded in dimorphs, and the dorsal projections on these lobes are smaller and more cusp-like, except in small females (Pl. 20, fig. 17) and larvae which have spinose dorsal projections. Lobes of dimorphs are in general broader than those of larvae. S3 is usually shallowest in larvae.
Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
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<td>1.30</td>
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<td>1.07</td>
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</tbody>
</table>

All valves from type locality (loc. 17)

Discussion. Females of C. susanae resemble specimens of the tallinnelline 'Tetradella' subquadrans Ulrich, 1890 (c. 1.36mm) figured by Burr & Swain (1965, pl. 3, figs 1-10, pl. 5, figs 24-6). The latter differs from C. susanae in having better developed lobes (especially L4), a calcarine spine, a velum from anterior to posterior cardinal corner, and in the lack of a histium.

C. susanae is similar in size and form to the type species, from which it differs by having L1 and L3 projecting beyond the hingeline, a heteromorphic histium virtually absent, a shorter dolon and in the lack of spinose surface ornament. C. susanae is considered the most advanced member of the genus because the histium of females is completely obsolete.

Occurrence. Upper Llandeilo Series of Dyfed (locs 17, 19, 20, 21a, 24).

3. Cymabolbina? sp. nov. Pl. 21, figs 1-3

Material. Two complete tecnomorphs, five fragmentary tecnomorphs and one damaged female valve.

Description. L1 obsolete, forming broad swelling. L2 reduced ventrally, dorsal part rounded or slightly elongate forming
preadductor node. L3 slightly swollen ventrally, not projecting beyond hingeline, and provided with thin spine that is directed posteriorly, outwards from valve. L1, L4 each have a small dorsal cusp. L4 broadest, obsolete. S1 developed as faint groove. S2 sigmoidal, deepest behind preadductor node. S3 broad, very shallow.

Flange-like histium of tecnomorphs extending from below S2 to base of L4. Heteromorphic histium redundant but for narrow flange from below S3 to posterior ventral edge of L4. Histium probably with spinose termination (only spine bases are preserved).

Velar flange ends gradually posteroventrally. Tecnomorphic velum narrowest posteroventrally, reduced or absent in central ventral region. Females with broad dolon anteroventrally and ventrally, with faint radial surface striations. Valve surface finely granulose.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
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<th>HD</th>
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<td>-</td>
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<td>1.02</td>
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<td>-</td>
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<td>1.46</td>
<td>0.77</td>
<td>1.90</td>
<td>1.32</td>
<td>3</td>
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</table>

All valves from loc. 23.

Discussion. C7 sp. nov. 1 differs from C. acanthodes and C. susanae mainly by its longer tecnomorphic histium and heteromorphic histium, which is developed below S3 and L4. Because of these features and the lack of material, the species is left un-named and its generic assignment remains uncertain.

Occurrence. Upper Llandeilo Series of Dyfed. Known only from loc. 23.
Genus LATEBINA gen. nov.

Name. Latin 'latebra', hiding-place, and the feminine suffix '-ina'; alluding to the much reduced velum. Gender feminine.

Type species. Latebina pseudantra sp. nov.; from the upper Llandeilo and basal Caradoc series of Dyfed.

Diagnosis. Gunnaropsinae with broad reduced lobes. Short histial flange, from below S2 to base of L3 or S3, developed in both sexes. Heteromorphs with broad anteroventral histiovelum. Velum in ventral and posteroventral region is obsolete; forms indistinct swelling, running parallel with free margin; on its crest a row of tubercles.

Discussion. The presence of a histiovelum (females), histial flange (females and tecnomorphs) and broad lobes indicate that Latebina is probably descended from Histina. Its reduced lobation and ventrally obsolete velum suggests Latebina is an advanced gunnaropsine in which the outer antral fence is formed by a histiovelum. Latebina is similar in size to, and can occur with, Severopsis from which it differs from in having better developed lobes and histium, a histiovelum, an obsolete velum and a shorter dolon.

Occurrence. The upper Llandeilo and basal Caradoc series of Dyfed.

Latebina pseudantra sp. nov. Pl. 21, figs 4-22

Name. Latin 'pseudo', false, and 'antrum', cavity; alluding to the V-shaped channel bounded by the velum and histium.

Holotype. CRJ SW034; silicified female left valve; Pl. 21, figs 4, 5, 10, 11. Llandeilo 'Flags', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).
Material. 125 tecnomorphs, two complete and five damaged heteromorphic valves.

Diagnosis. As for the genus.

Description. Female valves high to rather high, males are rather high to moderately high, larvae are moderately high to rather long. Dimorphs are slightly preplete, larvae are preplete. LV is slightly dorsal of mid-height. HV is anterior of mid-length. Domicilium moderately long to rather long and subamplete in dimorphs, preplete in larvae. LD is usually dorsal of mid-height. HD is about mid-length in dimorphs, but more anterior in larvae. Transverse convexity greatest ventrally in larvae, but just below mid-height in dimorphs; longitudinally it is greatest about mid-length in larvae, but more posteriorly situated in dimorphs. Hingeline long. Cardinal corners fairly distinct to slightly rounded. Anterior corner angle obtuse. Posterior angle slightly more than 90° in females and large tecnomorphs, usually less than 90° in small tecnomorphs. Marginal surface only well developed in anterior to anteroventral regions of tecnomorphs, where it is usually orthocline to slightly hypocline.

Lobes L1-L4 broad and reduced. L1, L3, L4 reach dorsal margin but not beyond, except for dorsal cusps (dimorphs) or spines (L1, L3 of larvae). L1 broad throughout. L2 broad and elongate, fused to base of L1, dorsal part of L2 developed into rounded preadductorial node. L3 constricted centrally, swollen and most elevated ventrally (especially in dimorphs). L4 broadest, reduced. S1 narrow and shallow, only present dorsal of mid-height. S2 very sigmoidal, deepest above mid-height. S3 shallow, developed as a semi-sulcus above mid-height.

Histial flange short, merging with velum below S2 in tecnomorphs. Histium extends posteriorly to base of L3 or S3 (usually in females). Anteroventral histiovelum well developed in females, forming broad, radially striated dolon. Velar flange developed in anterior region of
tecnomorphs and in ventral region of females, forming posterior boundary to the deep antrum. Velum obsolete in ventral and posteroventral regions; developed as narrow indistinct swelling, running parallel with free margin, surmounted by a row of more or less evenly spaced tubercles. Marginal sculpture is an entire row of spines, longest in the anteroventral and ventral regions.

Valve surface granulose. Females and large tecnomorphs have scattered tubercles on the lobes. Antrum and elliptical muscle scar (often poorly preserved behind preadductorial node) are smooth. Dimorphs often have a cluster of tubercles developed on the dorsal ends of L1, L3 and they lack the spinose terminations of larvae. Adults have generally broader and more reduced valves than larvae.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>Pl.21</th>
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<td>1.44</td>
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<td>-</td>
<td>-</td>
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<td>28b</td>
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<td>CRJ SW201/1</td>
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<td>-</td>
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<td>-</td>
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<td>16,21</td>
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<td>-</td>
<td>-</td>
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<td>0.69</td>
<td>1.87</td>
<td>1.18^*</td>
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</table>

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 17, 20, 22, 24, 26a, 28b).

Genus SEVEROPSIS gen. nov.

Name. Greek '-opsis', appearance; referring to the superficial similarity with the genus Severobolbina Schallreuter, 1974. Gender feminine.

Type species. Severopsis severopsis sp. nov.; from the upper Llandeilo and basal Caradoc series, Dyfed.
Diagnosis. Large Gunnaropsinae with lobes and sulci S1, S3 obsolete. Histial ridge narrow and reduced, from below area of L1-L2 to beneath S3 or L4. Velum developed as low ridge (larvae) or narrow flange (males) in anteroventral and ventral regions. Females with long, poorly defined dolon. Valve surface covered with minute granules.

Discussion. Severopsis differs from most other gunnaropsines because of its obsolete lobes and sulci, and reduced velum and histium, the combination of which suggests it represents an advanced gunnaropsine where the outer antral fence is formed exclusively by the velum (as in, for example Cymabolbina). The phylogeny of Severopsis is uncertain because its general morphology is not closely comparable to other gunnaropsines. The genus could have evolved from a Cymabolbina-like ancestor with a long dolon and well developed histium; however the histium of Cymabolbina is short (tecnomorphs) or obsolete (heteromorphs). Alternatively, Histina could have formed the ancestral stock, with a subsequent reduction of lobes, histium and histiovelum.


Severopsis severopsis sp. nov. Pl. 22, figs 1-6, 9, 15

Name. As for the genus.

Holotype. CRJ SW094; silicified female right valve; Pl. 22, figs 1, 4-6. Bryn-banc Limestone Member, Narberth Group; quarry 245m N of Bighouse, Lampeter-Velfrey, 4.5km E of Narberth, Dyfed (loc. 28a).

Material. One female, one male, seven larvae and 12 fragmentary tecnomorphic valves.

Diagnosis. As for the genus.

Description. Female valve high, slightly preplete. Tecnomorphic valves rather high to moderately high and amplete to subamplete. LV about mid-height to slightly dorsal of mid-length. HV is mid-length or
just anterior of this in small tecnomorphs. Domicilium moderately high in female, moderately high to moderately long in tecnomorphs; slightly preplete to amplete. LD is slightly dorsal of mid-height. HD is slightly anterior of mid-length. Transverse convexity greatest a little below mid-height, longitudinal convexity is posterior. Hingeline long to very long. Both cardinal corners distinct, with obtuse corner angles. Marginal surface in tecnomorphs usually epicline ventrally but more orthocline in anteroventral region.

All lobes obsolete, not projecting beyond dorsum. L1-L2 fused, forming broad anterior lobal complex. L2 dorsally developed into rounded preadductorional node above mid-height. L3 virtually absent dorsally, and inflated ventrally. L4 completely obsolete. L1 and L4 equally broad. S1 more or less absent. S2 extremely sigmoidal, quite deep and narrow. S3 forming a very shallow, upright semi-sulcus above mid-height.

Narrow histial ridge, developed from below L1-L2 and terminating beneath S3 or L4. Velum reduced, forming narrow flange (males) or low ridge (larvae) in anteroventral and ventral regions, which is dissolved into small tubercles anteriorly and posteriorly. Dolon anteroventral to ventral, its proximal contact with domicilium is poorly defined. Marginal sculpture in females an entire row of long tubercles; tecnomorphs have spines anteroventrally and tubercles elsewhere.

Valve surface minutely granulose, occasionally with larger, scattered granules.

Histial ridge of dimorphs does not unite with the velum anteroventrally (Pl. 22, figs 1, 2). Valves of small tecnomorphs are generally less inflated than those of adults and large tecnomorphs and have a more spinose marginal sculpture. The smallest larvae have S3 absent and the velum redundant but for a row of tubercles.
Measurements.

<table>
<thead>
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<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
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</table>

Discussion. *S. severopsis* (Ø 2.32mm) is similar in size and lateral appearance to the homeomorph *Severobolbina elliptica* (Steusloff, 1895) (Ø c. 2.30mm; LV:HV = 1.81 -1.89, cf. Schallreuter 1982c). *Severobolbina elliptica*, a sigmoopsine from the Idavere and Johvi stages (middle Ordovician) of Baltoscandia, is younger than *S. severopsis* and differs by having a longer form, and being clearly unisulcate and bialtral.

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 17, 18, 28a,b).

Hollinacean genera and species undetermined

1. Gen. et sp. nov. A. Pl. 22, figs 7, 8, 10, 11

Material. Five external moulds.

Description. Valves moderately long to rather long. Hingeline long. Entire marginal surface orthocline throughout. Contact margin and overlap condition unknown. Lobes narrow, ridge-like and rounded in cross-section. L1, L2 equally well developed, sloping towards anterior. Base of L1 joined to velum. L2 does not reach dorsum, slightly expanded ventrally. L2, L3 form U-shaped lobal complex. L3 upright but for its expanded base which is joined to L2 by narrow connecting lobe. L4 vertical, slightly constricted centrally, joined to velum in posterovertral region. L3, L4 just project beyond hingeline. S1 very
long, narrow throughout. S2 curves ventrally towards anterior. S3 broad throughout.

Velar structure forming an entire elevated ridge, rounded in cross-section. Dimorphism unknown. Valve surface smooth.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
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<th>HV</th>
<th>LV:HV</th>
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<td>CRJ H24</td>
<td>r</td>
<td>0.78</td>
<td>0.44</td>
<td>1.77</td>
<td>-</td>
<td>7,10,11</td>
</tr>
</tbody>
</table>

Both from loc. 37.

Discussion. The distinct quadrilobation suggests this species is a palaeocope. It superficially resembles Quadrijugator Kesling & Hussey, 1953, a binodicope more closely related to members of the Bolliidae Bouček, 1936 (Schallreuter 1978, pers. comm. 1983). The lobation recalls that of certain Soanelloidae Kanygin, 1971, which are tri- or quadrilobate, inequivalve palaeocopes that lack sexual dimorphism. Quadrilobella Ivanova, 1955, from the lower and middle Ordovician of Siberia, is particularly similar except for its much broader L4 which does not unite with the velum. Additional material is needed before the genus and species can be erected.

Occurrence. Harnage Shales, Harnagian Stage, Caradoc Series of South Shropshire (locs 34, 37, 38).

2. Gen. nov.? sp. nov. B Pl. 22, figs 12-14, 16, 17

Material. 135 tecnomorphic valves.

Description. Valves moderately long and amplete to subamplete. LV mid-height. HV just anterior of mid-length. Domicilium rather long, amplete in large tecnomorphs, otherwise slightly preplete. LD mid-height or slightly above. HD slightly anterior. Transverse convexity greatest ventrally, longitudinally it is anterior. Hingeline long to very long. Cardinal corners slightly rounded, anterior corner angle obtuse,
posterior greater than 90° in large tecnomorphs, otherwise less than this. Anteroventral to ventral marginal surface more or less orthocline, hypocline elsewhere. Left/right valve overlap.

Lobes well developed and upright. L1 obsolete ventrally with prominent dorsal bulb. L2 shortest, connected to base of L1 where it is swollen. L3 expanded dorsally, with posteroventrally directed calcarine spine. L2, L3 joined by low, narrow connecting lobe. L4 broad, slightly expanded dorsally provided, with pointed cusp. L1, L3 with stout, dorsal spines projecting beyond hinge. S1 narrow, restricted dorsally. S2, S3 equally broad, fairly deep, ventrally curved towards anterior.

Adventral sculptures absent but for broad, rounded swelling in anteroventral region between lateral/marginal surfaces. Large tecnomorphs have a row of anteroventral tubercles forming the marginal sculpture, but small tecnomorphs develop a virtually entire row of spines.

Valve surface granulose but for smooth sulci. L1, L3 dorsal spines and calcarine spine more pronounced in small tecnomorphs. L4 less well developed than in large tecnomorphs.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>P1.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRJ 210/1</td>
<td>l</td>
<td>1.73</td>
<td>0.98</td>
<td>1.77</td>
<td>1.60</td>
<td>0.87</td>
<td>1.84</td>
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</tr>
<tr>
<td>CRJ 210/2</td>
<td>l</td>
<td>1.60</td>
<td>0.91</td>
<td>1.76</td>
<td>1.47</td>
<td>0.78</td>
<td>1.88</td>
<td>1.35</td>
<td>17</td>
</tr>
<tr>
<td>CRJ 210/3</td>
<td>r</td>
<td>1.55</td>
<td>0.87</td>
<td>1.78</td>
<td>1.44</td>
<td>0.76</td>
<td>1.89</td>
<td>1.31</td>
<td>12</td>
</tr>
<tr>
<td>CRJ 210/4</td>
<td>l</td>
<td>1.47</td>
<td>0.82</td>
<td>1.79</td>
<td>1.37</td>
<td>0.71</td>
<td>1.93</td>
<td>1.32</td>
<td>13,14,16</td>
</tr>
</tbody>
</table>

All valves from loc. 17.

**Discussion.** As no female is available, the specific, generic and familial relationships are unsure. Tecnomorphs resemble those of Schallreuteria (Schallreuteria) but are smaller, have deeper sulci, more elevated lobes without surface ornament, and appear to lack the long, broadly rounded, male velum (= "Wulst" of Schallreuter 1979b) of that
However, most specimens possess an anteroventral swelling between lateral and marginal surfaces, which might be interpreted as a rudimentary "Wulst". In this case the species would belong within the Ctenonotellidae, since it lacks a histium. Until the morphology of the female is known further assignment remains uncertain.

Occurrence. Known from the Llandeilo Series of Dyfed (locs 11d, 17).
CHAPTER 2
ORDOVICIAN BINODICOPA FROM ENGLAND AND WALES

Suborder BINODICOPA Schallreuter, 1972

Superfamily DREPANELLACEA Ulrich & Bassler, 1923
(nom. transl. Polenova & Zanina, 1960)

Family BOLLIDAE Bouček, 1936
(nom. transl. Scott & Wainright in Moore & Pitrat 1961)


Diagnosis. (Slightly modified from Scott & Wainwright in Moore & Pitrat 1961, p. 0127). Valves subquadrate to subrectangular. Long hingeline. Hingement: by ridge and groove. Cardinal angles subequal, often well defined. Two dorsomedial nodes which are separated or joined ventrally forming a U-shaped lobe. Sulcus (= S2) developed between nodes. Pseudovelum variously developed, around all or portion of border between lateral surface and steep marginal surface. Lateral surface (other than lobes and pseudovelum) flat to inflated, smooth to coarsely reticulate, punctate to granulose. Valves subequal. Dimorphism unknown.

Discussion. See Schallreuter (1968b, 1978) for discussion and listing of Ordovician bollids and Siveter (1978b), who has recently discussed the type genus Bollia Jones & Holl, 1886.

Occurrence. Lower Ordovician to middle Devonian. Cosmopolitan geographical distribution, especially well known from Europe, North America and Russia.
Genus BULLAEFERUM Qvale, 1980


Other species. B. forneboensis Qvale, 1980; B. llandeiloensis sp. nov.

Diagnosis. (Modified from Qvale 1980, p. 99). Unisulcate, with two prominent nodes; anterior nodal complex divided by shallow furrows. Preadductorial node well developed. Posterior node bulbous. Domicilium evenly convex. Pseudovelum almost entire, developed as moderately broad flange. Lateral surface smooth or with fine granules.

Discussion. The familial position of the non-dimorphic Bullaeferum is uncertain (Qvale 1980) but is best assigned to the Bolliidae. The genus has two dorsomedial nodes, a pseudovelum and quite a steep marginal surface, all of which are typical of the Bolliidae. The nodes of Bullaeferum are particularly reminiscent of the bolliid Laterophores, except that the anterior nodal complex is usually partitioned into three or four knob-like nodes and the pseudovelum is broader and always flange-like.

Occurrence. Middle Ordovician of South Wales (= upper Llanvirn and Llandeilo series), Welsh Borderland (= middle/upper Llandeilo) and Norway (= Caradoc Series; Qvale 1980) and upper Ordovician of Estonia (= uppermost Caradoc and Ashgill series; Sarv 1959).

Bullaeferum llandeiloensis sp. nov. Pl. 23, figs 1-8

Name. Referring to its geographical occurrence in the Llandeilo area, Dyfed.

Holotype. CRJ SW221/5, silicified right valve; Pl. 23, fig. 1; Ffairfach Group, upper Llanvirn Series of the Ffairfach railway cutting,
Llandeilo, Dyfed (loc. 1a).

**Material.** 16 complete and ten fragmentary silicified valves and several external moulds.

**Diagnosis.** Valves up to 0.95mm long and amplete to subamplete. Anterior cardinal corner rounded and obtuse, posterior corner distinct with cardinal angle more or less 90°. Anterior nodal complex divided into four parts; elliptical preadductorional node, large anterocentral node and two small anterodorsal nodes. Posterior central dorsal node is elliptical, slopes towards posterior. Pseudovelum developed as quite broad flange, terminating below anterior cardinal corner.

**Description.** Valves moderately high to moderately long (small instars). Domicilium moderately long to rather long and amplete. LV dorsal. LD just dorsal of mid-height. HV and HD mid-length to slightly anterior. Hingeline long and arched in lateral view above posterior node. Posterior cardinal corner occasionally with short, acroidal spine (larvae). Marginal surface quite steeply epicline, not developed anterodorsally.

Sulcus well developed, just anterior of mid-length and above mid-height, constricted in its central part. The two anterodorsal nodes project beyond the hingeline and obscure the anterior cardinal corner in lateral view.

Pseudovelum well developed throughout, broad and concave; from posterior cardinal corner to just below anterior corner. Broad, shallow furrow between pseudovelum and domicilium. Valves smooth with scattered granules.

Anterocentral node bulb-like and elevated in large valves. Posterior node well developed in large instars, smaller and more rounded in small instars.
Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>Pl.23</th>
<th>loc</th>
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<tbody>
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<td>r</td>
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<td>0.55</td>
<td>1.73</td>
<td>0.84</td>
<td>0.47</td>
<td>1.78</td>
<td>0.73</td>
<td></td>
<td>1c</td>
</tr>
<tr>
<td>CRJ SW221/5</td>
<td>rH</td>
<td>0.89*</td>
<td>0.54</td>
<td>-</td>
<td>0.77*</td>
<td>0.44</td>
<td>1.75*</td>
<td>-</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CRJ SW221/1</td>
<td>r</td>
<td>0.82*</td>
<td>0.47</td>
<td>1.75</td>
<td>-</td>
<td>0.39</td>
<td>-</td>
<td>0.58*</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>CRJ SW221/2</td>
<td>r</td>
<td>0.78*</td>
<td>0.49</td>
<td>-</td>
<td>-</td>
<td>0.41</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>CRJ SW221/4</td>
<td>l</td>
<td>0.76</td>
<td>0.43</td>
<td>1.77</td>
<td>0.65</td>
<td>0.35</td>
<td>1.86</td>
<td>0.60</td>
<td>6</td>
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</tr>
<tr>
<td>CRJ SW221/3</td>
<td>r</td>
<td>0.71</td>
<td>0.40</td>
<td>1.78</td>
<td>0.59</td>
<td>0.32</td>
<td>1.84</td>
<td>0.55</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Discussion. *B. llandeiloensis* most closely resembles *B. tapaensis* (c. 1.08mm), the partitioning of the anterior node complex into four being very similar in both species. *B. llandeiloensis* differs in having a more prominent anterocentral node, a smaller posterior anterodorsal node and a broader pseudovelum. *B. forneboensis* (c. 1.40mm), from the Caradoc of Norway, is much larger than *B. llandeiloensis*, its anterior node complex is only partitioned into 2 or 3 nodes and its posterior node is more well defined and bulbous. Like *B. llandeiloensis*, *B. forneboensis* also possesses a posterior acroidal spine.

Occurrence. Upper Llanvirn Series (locs 1a-c) and upper Llandeilo Series (loc. 20) of Dyfed and middle/upper Llandeilo Series of Shelve Inlier, Shropshire (loc. 15; specimens on slab SM A67361-65 were collected near loc. 15).

Genus *KLIMPHORES* Schallreuter, 1966

Type species. Original designation; Schallreuter 1966b, p. 394; *Klimphores planus* Schallreuter, 1966, p. 395, pl. 1, fig. 1; from a middle Ordovician (= Caradoc) Backsteinkalk erratic boulder collected at Dornbusch, Isle of Hiddensee, Baltic Sea.

(Henningsmoen, 1948); K. minimus (Sarv, 1956); K. morgani (Jones, 1890); K. paraspinosus sp. nov.; K. pleinkalnensis Gailite, 1971; K. priekulensis Gailite, 1971; K. reticulatus (Thorslund, 1948); K. scanensis Schallreuter, 1980; K. simplex (Neckaja in Abushik et al. 1958); K. spinosus Schallreuter, 1969.

**Diagnosis.** (After Schallreuter 1980a, p. 9). Small (normally less than 1 mm long) binodicopes, more or less amplete. Two convex, oblong nodes developed in anterodorsal and posterior centrodorsal regions. Anterior node extended anteroventrally; preadductorial node almost totally incorporated into anterior node. Pseudovelum developed between lateral and marginal surface, forming simple and sometimes prominent bend, ridge-like keel or bend with row of spines. Lateral surface and nodes can be smooth, punctate or reticulate; base of lumina sometimes have sieve-pores.

**Discussion.** Schallreuter (1966b, 1969, 1980a, 1980b) and Vannier (1984) have discussed Klimphores in detail and compared its numerous species.

**Occurrence.** Middle and upper Ordovician of northern Germany (= erratic boulders), Sweden (Henningsmoen 1948), Norway (= undescribed species in Oslo Museum, nos 95862, 97644, 97661, 97665) and Latvia (Gailite 1971). An unpublished Klimphores species has also been described from the Llanvirn Series of France (Vannier 1984). In Britain Klimphores is known from the upper Llanvirn of South Wales and the uppermost Caradoc of North Wales and Shropshire, England. An undescribed species is also present in the Ashgill Series of South Wales.
1. *Klimphores morgani* (Jones, 1890) Pl. 23, figs 10-12, 14-16

1890a *Primitia morgani*, sp. nov.; Jones, pp. 5, 6, pl. 4, figs 6a,b.

1890b *P. morgani*, J.; Jones, pp. 543, 544.

1891a *P. morgani*, Jones; Jones, p. 95.

1891b *Primitia morgani*; Jones, p. 559.

1934 *Ulrichia morgani* (Jones); Bassler & Kellett, p. 490.

1965 *Ulrichia morgani* (Jones); Cave, p. 287.

1966b *Primitia morgani* Jones, 1890; Schallreuter, p. 395.

1978a *Primitia morgani* Jones 1890; Siveter, p. 45.

**Lectotype.** Here designated; BM 16056b, calcite left valve. Jones (1890a) did not name a repository for the type material, but stated that the specimens were in the "J. B. Morgan collection". Slab BM 16056 (labelled "J. B. Morgan coll.") comes from the type locality (= Pen-y-Garnedd Phosphorite & Shale, Gwern-y-Brain stream section, 5km NW of Welshpool, Powys) and was purchased from Jones in 1899. It is in all likelihood Jones's original material from which the lectotype has been selected. Jones's (1890a, pl. 4, fig. 6) original specimen was not identifiable.

**Material.** 20 calcite valves and external moulds, often poorly preserved.

**Diagnosis.** Valves up to 0.76mm long. Anterior cardinal corner more rounded and obtuse than posterior corner. Lateral surface below sulcus flattened into tear-drop shape. Anterior node elliptical, elevated anterocentrally. Posterior node forming rounded oblong, extending into ventral postero-central region and projecting further beyond hinge than anterior node. Entire pseudovelum developed as low, smooth bend. Lateral surface reticulate.

**Description.** Valves moderately high to moderately long and ample. LV dorsal of mid-height. HV about mid-length. Hingeline straight and moderately long. Marginal surface entire, orthocline to slightly
hypocline. Both nodes rather flattened and do not project a great
distance beyond hingeline.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>Pl. 23</th>
<th>loc</th>
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<td>0.57</td>
<td>11,12,15,16</td>
<td>50</td>
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<td>CRJ NW104a</td>
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<td>50b</td>
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<td>CRJ M25</td>
<td>r</td>
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<td>0.30</td>
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<td>14</td>
<td>50b</td>
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<tr>
<td>CRJ NW072</td>
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<td>0.52</td>
<td>0.30</td>
<td>1.73</td>
<td>0.39</td>
<td>14</td>
<td>50b</td>
</tr>
</tbody>
</table>

**Discussion.** *K. morgani* is similar in size and form to *K. planus* (c. 0.71mm) but differs in having less elevated nodes which do not project so far beyond the hingeline, a less prominent pseudovelum, a more convex lateral surface and slightly finer reticulation.

**Occurrence.** *Onnia gracilis* Biozone (= mid-Onnian Stage, Caradoc Series) of Welshpool, Powys (locs 50a-c; BM I5997a,b and SM A57004, A570146 are also from the vicinity of loc. 50) *O. gracilis* and *O. superba superba* biozones (= mid and uppermost Onnian Stage) of the Onny River, Shropshire (locs 49b,c).

2. *Klimphores paraspinosus* sp. nov. Pl. 23, figs 9, 13

**Name.** Greek *para*, near, and the specific name *'spinosus*'; referring to the similarity with *Klimphores spinosus* Schallreuter, 1969.


**Holotype.** BM OS6677, silicified left valve; Pl. 23, fig. 13. Also figured by Siveter (1978a, pl. 2, fig. 10). Ffairfach Group, upper Llanvirm Series of the Ffairfach railway cutting, Llandeilo, Dyfed (either loc. 1a or 1b).

**Material.** Seven partly damaged silicified valves.
Diagnosis. Valves up to 0.73mm. Cardinal corners quite distinct. Lateral surface evenly convex throughout. Large anterior node developed as upright or anteriorly sloping lobe. Smaller posterior node slopes posteriorly and does not project as far beyond hinge as anterior node. Both nodes most elevated dorsally. Row of spines developed on border of lateral and marginal surface. Valves granulose.

Description. Valves moderately high to moderately long, more or less amplete. LV and LD are dorsal. HV and HD both at mid-length. Oomicilium rather long and amplete. Hingeline long. Marginal surface entire, more or less epicline. Anterior node larger and more elevated than posterior node, which barely projects beyond hingeline. Row of spines along border of lateral surface are quite equally spaced.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
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<td>0.73</td>
<td>0.41</td>
<td>1.78</td>
<td>0.68</td>
<td>0.36</td>
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<td>0.63</td>
<td>1</td>
</tr>
<tr>
<td>CRJ</td>
<td>SW218/1</td>
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<td>0.73</td>
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<td>0.67</td>
<td>0.35</td>
<td>1.91</td>
<td></td>
<td>9 1a</td>
</tr>
<tr>
<td>BM</td>
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<td>1H</td>
<td>0.66</td>
<td>0.38</td>
<td>1.74</td>
<td>0.60</td>
<td>0.31</td>
<td>1.93</td>
<td></td>
<td>13 1</td>
</tr>
<tr>
<td>CRJ</td>
<td>SW218/2</td>
<td>1</td>
<td>0.67*</td>
<td>0.42</td>
<td>-</td>
<td>-</td>
<td>0.36</td>
<td>0.59</td>
<td></td>
<td>1b</td>
</tr>
</tbody>
</table>

Discussion. *K. paraspinosus* is older than the related *K. spinosus* (c. 0.52mm), from the Caradoc of northern Germany (= erratic boulders) and Sweden. The row of spines between the lateral and marginal surface characterises both species and is absent in other members of *Klimphores* (Siveter 1978a). *K. paraspinosus* is larger than *K. spinosus* and has longer, more elevated nodes.

Occurrence. Ffairfach Group, upper Llanvirn Series. Known only from the Ffairfach railway cutting, Llandeilo, Dyfed (locs 1a,b).
Genus LATEROPHORES Schallreuter, 1968

Type species. Original designation; Schallreuter 1968c, p. 248; Laterophores lateris Schallreuter, 1968c, p. 249, pl. 1, fig. 1; from middle Ordovician (= probably Caradoc) Backsteinkalk erratic boulders of northern Germany.

Other species. L. ansiensis (Gailite, 1971); L. elevatus sp. nov.; L. hystrix Schallreuter, 1972; L. longiposteronodus Schallreuter, 1971; L? verrucosus (Kay, 1940).

Diagnosis. (After Schallreuter 1968c, p. 248). Valves usually less than 1 mm long and more or less amplete. Two dorsal nodes, closer to anterior end than posterior. Posterior node is largest. Additionally, a central anterior node is developed and sometimes a weak preadductorial node. Pseudovelum poorly developed, flange-like or forming a row of spines. Lateral surface and nodes punctate, reticulate, granulose or smooth.

Discussion. Laterophores is morphologically similar to the related genus Klimphores, but differs mainly because of the distinct bipartition of the anterior nodal complex and the differing adventral sculptures. The anterior node of Laterophores is clearly divided into two parts and the pseudovelum is often poorly developed, in contrast to the more prominent 'bend' of Klimphores.

K? verrucosus, known only from one specimen (Kay 1940), is included with uncertainty because it has a very prominent preadductorial node and its anterodorsal node is more anteriorly situated than in any other species of Laterophores.

Schallreuter (1968c) and Vannier (1984) have discussed the genus in detail.

Occurrence. Middle and upper Ordovician of Baltoscandia (= erratic boulders from northern Germany and Gotland; Schallreuter 1968c, 1971a, 1972b), middle Ordovician of France (= unpublished species from
uppermost Llandeilo/basal Caradoc of the Armorican Massif; Vannier 1984) and possibly U.S.A. (cf. Kay 1940), and the lower and middle Ordovician of Latvia (Gailite 1971). In Britain, Laterophores is present in the middle Ordovician (= upper Llanvirn and Llandeilo series) of South Wales.

**Laterophores elevatus** sp. nov. Pl. 24, figs 1-6

**Name.** Latin 'elevatus', raised; referring to the elevated lateral surface.

**Holotype.** CRJ SW021, silicified right valve; Pl. 24, figs 1, 5, 6. Ffairfach Group, upper Llanvirn Series of the Ffairfach railway cutting, Llandeilo, Dyfed (either loc. 1a or 1b).

**Material.** Ten silicified valves and four internal and external moulds.

**Diagnosis.** Valves up to 0.69mm long. Cardinal corners fairly distinct to slightly rounded. Lateral surface quite convex centrally, forming elliptical posteroventral lobe. Anterior nodal complex clearly separated into two parts: an oval posterior anterodorsal node and a round, elevated anterocentral node. Posterior node bulbous dorsally. Pseudovelum forming narrow flange. Lateral surface and nodes finely reticulate.

**Description.** Valves rather high to moderately high, amplete to subamplete. LV more or less dorsal of mid-height. HV and HD mid-length to anterior. Domicilium moderately high to rather long; LD is mid-height. Hingeline long. Narrow, epicline marginal surface developed ventrally. Deep, tear-drop shaped sulcus between anterior and posterior nodes. Anteroventral of sulcus a furrow is developed between the anterocentral node and posteroventral lobe. Posterior node projects further beyond hingeline than anterodorsal node. Pseudovelum (where developed) is entire, very narrow and flange-like. Fine surface
reticulation usually poorly preserved.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
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<th>loc</th>
</tr>
</thead>
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<td>0.62</td>
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<td>0.67</td>
<td>0.39</td>
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<td>1.82</td>
<td>0.49</td>
<td>2</td>
<td>17</td>
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<td>CRJ SW220/2</td>
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<td>0.29</td>
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<td>3</td>
<td>1a</td>
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<tr>
<td>CRJ SW021</td>
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<td>0.64*</td>
<td>0.38</td>
<td>1.73</td>
<td>-</td>
<td>0.33</td>
<td>-</td>
<td>0.47*</td>
<td>1,5,6</td>
<td>1a</td>
</tr>
<tr>
<td>CRJ SW056</td>
<td>r</td>
<td>0.63*</td>
<td>0.40</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>on SMA67361-65</td>
<td>r</td>
<td>0.61</td>
<td>0.35</td>
<td>1.74</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.53</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion.** The posteroventral lobe of *L. elevatus* is particularly prominent in smaller specimens (Pl. 24, fig. 3). Large specimens have a more flattened lateral surface in the central region. The flange-like pseudovelum is only occasionally preserved (Pl. 24, figs 1, 2) and the fine surface reticulation is often obliterated because of silicification (Pl. 24, fig. 4).

*L. elevatus* is most similar to *L.ansiensis* (c. 1.1mm) from the Kunda Stage (= lower Llanvirn) of Latvia. Both species have distinct anterodorsal/anterocentral nodes and surface reticulation, but lack a preadductorial node. *L. elevatus* differs from *L.ansiensis* in having a narrower sulcus and an elevated posteroventral lobe. From Gailite's (1971, pl. 2, figs 1a, b) figures it is uncertain whether *L.ansiensis* possesses a pseudovelum and first hand examination of the adventral sculptures is necessary to judge how closely related the species are.

**Occurrence.** Upper Llanvirn Series (loc. 1a,b) and upper Llandeilo Series (loc. 17) of Dyfed, and middle/upper Llandeilo Series of Shelve Inlier, Shropshire (loc. 15; SMA A67361-65 is from near here).
Genus **ULRICHIA** Jones, 1890

**Type species.** Original designation; Jones 1890b, p. 543, 544; *Ulrichia conradi* Jones, 1890, p. 544, fig. 2; from the middle Devonian, Hamilton Group, Thedford, Ontario, Canada.

**Other species.** *U. pluripuncta* Swartz, 1936; *U. terminata* Swartz, 1936; *U. acricula* Kesling, 1952; *U. bicornis* (Jones, 1855); *U. crassimuralis* Bassler, 1941; *U. illinearis* Kesling, 1953.

**Diagnosis.** (Modified from Moore & Pitrat 1961, p. Q131). Small Bolliidae with coarsely punctate lateral surface. Two prominent dorsomedial nodes that do not unite ventrally and extend only slightly above dorsal margin. Pseudovelum entire and distinct. Surface of nodes, pseudovelum and marginal surface smooth.

**Discussion.** This heterogeneous genus is badly in need of revision. Of the 40 or so species assigned to *Ulrichia* at one time or another, only the species listed above could be included within the genus as presently understood. The development of two, smooth dorsomedial nodes and pseudovelum, and a coarsely punctate lateral surface appear to be unifying characters at generic level.

*Ulrichia* varionoda Blumenstengel, 1965, from the Caradoc of Thuringia, East Germany, has a granulose lateral surface and dorsal nodes, which also project beyond the dorsum. A new unpublished species from the Llandeilo/basal Caradoc of France also has granulose surface ornament (??Ulrichia of Vannier 1984, p. 80). Both species lack the coarse lateral punctuation and the smooth, dorsomedial nodes characteristic of the genus and are consequently excluded from *Ulrichia*.

**Occurrence.** Known with certainty only from the Devonian of North America, and possibly the middle Ordovician of Britain.
Ulrichia? bicornis (Jones, 1855)  Pl. 24, figs 7-9

1855 *Beyrichia bicornis*, nov. sp.; Jones, p. 173, pl. 6, fig. 23a,b.

1865 *Primitia bicornis*, Jones; Jones & Holl, pp. 416, 420.

1868 *Primitia bicornis*, Jones; Jones & Holl, p. 59.

1869 *Primitia bicornis*, Jones; Jones & Holl, p. 223.

1881 *P. bicornis*, Jones; Salter & Etheridge, p. 409.

1890b *P. bicornis*, J.; Jones, p. 543.

1934 *Primitia (Ulrichia?) bicornis* (Jones); Bassler & Kellett, p. 439.

1941 *Ulrichia bicornis* (Jones 1855); Schmidt, p. 58 (pars), non pl. 4, fig. 32.

1978a *Ulrichia bicornis* (Jones, 1855); Siveter, p.52, pl. 3, figs 9, 10.

**Lectotype.** Designated Schmidt 1941, p. 58, left valve (external mould) figured by Jones 1855, pl. 6, fig. 23 (= GSM 35731); herein Pl. 24, fig. 7. Harnage Shales, Harnagian Stage, from Harnage, c. 7km SE of Shrewsbury, Shropshire. Precise locality unknown.

**Material.** More than 30 internal and external moulds.

**Diagnosis.** (Modified from Siveter 1978a, p. 52). *Ulrichia(?)* species with subovate valves and two well developed dorsal nodes on either side of short, narrow, dorsocentral adductorial sulcus. Anterior node more centrally situated than larger posterior node. Surface of pseudovelum has fine, radial grooves.

**Description.** Valves very high and amplete. LV is mid-height. HV mid-length. Hingeline long and arched in lateral view. Both cardinal corners rounded, anterior corner angle more obtuse than posterior corner. Dorsum more or less orthocline. Marginal surface entire, steeply hypocline throughout. Anterior node is just dorsal of anterocentral region. Posterior node is slightly larger and rounded, developed in posterior part of central dorsal region and not projecting beyond dorsum. Adductorial sulcus situated between nodes in dorsocentral region; short and narrow but open ventrally and reaching dorsum. Lateral
surface flat, but for slightly elevated swelling below S2 and just posterior of posterior node. Pseudovelum most elevated ventrally, developed as an entire, rounded (in cross-section) ridge, narrowing slightly towards cardinal corners. Lateral surface distinctly punctate; everywhere else smooth but for fine, radial grooves on surface of pseudovelum.

Some specimens have a distinct dorsal bulge just behind and above the anterior node.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
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<th>HV</th>
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<tr>
<td>GSM 35731</td>
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<td>0.48</td>
<td>1.33</td>
<td>0.45</td>
<td>7</td>
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</table>

**Discussion.** *U? bicornis* is morphologically quite similar to other species of *Ulrichia*. The type species, *U. conradi* (c. 0.80mm), differs in having a longer form, more subquadrate valves, proportionally smaller dorsomedial nodes, a shallower sulcus and no radial grooves on the pseudovelum. Because of these differences and that all other likely members of the genus are of Devonian age, the species is only tentatively assigned to *Ulrichia*.

**Occurrence.** Harnage Shales, Harnagian Stage, Caradoc Series of Shropshire (locs 35, 36, 37, 38).
Genus **ROGERELLA** Vannier, 1984

**Type species.** Original designation: Vannier 1984, p. 97; *Rogierella kerfornei* Vannier, 1984, pp. 90, 99, pl. 16, fig. 4, from the Caradoc Series near Zuvinhal, Cacemes, Portugal.

**Other species.** *R. melmerbvensis* sp. nov.

**Diagnosis.** (Modified from Vannier 1984, p. 97). Valves subquadrate, anterior border more or less perpendicular to hingeline. Two dorsal nodes in anterior half of valve; anterodorsal node round or subelliptical, central dorsal node oblong or conical. Pseudovelum developed as elevated swelling on border of lateral and marginal surface in anterior to anteroventral regions. Valves smooth.

**Discussion.** The systematic position of the genus is equivocal (Vannier 1984). The presence of two dorsal nodes, pseudovelum and steep marginal surface (at least anteriorly) suggests an affinity with the Bolliidae, but the flattened ventral and posterior margins that lack a pseudovelum and the spinose posterior node of *R. melmerbvensis* are features that recall many aechminaceans. The present author follows Vannier (1984) in placing *Rogierella* within the Drepanellacea, but its familial assignment remains uncertain.

The two dorsal nodes in the anterior half of the valve and the anterior to anteroventral pseudovelum, which virtually covers the free margin in lateral view, are particularly characteristic of the genus.

**Occurrence.** Caradoc Series of the Armorican Massif, France and Portugal (Vannier 1984). In Britain known from the Caradoc of the Cross Fell Inlier, Cumbria, northern England.
Rogerella melmerbvensis sp. nov.  Pl. 24, figs 10, 11

Name. Referring to its geographical distribution in the Cross Fell Inlier north of Melmerby, Cumbria.

Holotype. On GSM RU2546, external mould of right valve; Pl. 24, fig. 11. Woolstonian Stage, Caradoc Series; road section on E side of the Melmerby - Alston road (A686), c. 1km NE of Melmerby, Cumbria (loc. 44a).

Material. One internal and six external moulds.

Diagnosis. Rather high to moderately high species of Rogerella, with central dorsal node developed as conical spine and pseudovelum in anterior and anteroventral regions.

Description. Hingeline moderately long to long. Dorsum hypocline. Cardinal corner angles subequal and greater than 90°; anterior corner rounded, posterior corner distinct. Lateral surface slightly depressed centrally, ventral and posterior lateral margin forming acute angle with contact plane. Marginal surface developed in anteroventral and anterior regions, which is steep, virtually orthocline. Central dorsal node conical, spine-like and directed posteriorly, sometimes projecting just beyond hingeline. Anterodorsal node rounded to elliptical, merging ventrally with fairly broad pseudovelum that narrows posteriorly, terminating in anterior part of ventral region. Fairly deep V-shaped sulcus developed between nodes opens dorsally.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
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<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>P1.24</th>
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<td>0.95</td>
<td>0.57</td>
<td>1.67</td>
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<tr>
<td>on GSM RU2546 r</td>
<td>0.78</td>
<td>0.50</td>
<td>1.56</td>
<td>0.55</td>
<td>10</td>
<td></td>
</tr>
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</table>

Discussion. R. melmerbvensis is slightly smaller than R. kerfornei (c. 1.20mm) and has a more conical, spine-like central dorsal node and longer pseudovelum situated in the anterior and anteroventral regions. R. melmerbvensis is also similar to 'Jonesella' gonvloba Warshauer &
Berdan, 1982, which has a more posteriorly situated central dorsal node, a more centrally developed pseudovelum and an anteroventral marginal surface forming a more acute angle with the contact plane.

**Occurrence.** Longvillian Stage (loc. 44b) and Woolstonian Stage (loc. 44a; slabs GSM RU2546, 2548, 2549 are from locality "P" of Arthurton & Wadge 1981; cf. loc. 44a), Caradoc Series near Helmerby, Cumbria.

Superfamily AECHMINACEA Bouček, 1936
(nom. transl. Grundel, 1969)

Family AECHMINIDAE Bouček, 1936
(nom. transl. Swartz, 1936)

**British genera.** Crescentilla Barrande, 1872; Pseudulricha Schmidt, 1941.

**Diagnosis.** (Modified from Moore & Pitrat 1961, p. 0127). Valves straight-hinged and subovate to subquadrate. One or two spines developed dorsally. Rounded pit or sulcus (= S2) located adjacent to base of single spine or inbetween two spines when they are developed. Pseudovelum, marginal spines or papillae sometimes present. Ventral surface usually forms acute angle with contact plane.

**Discussion.** The family is in need of revision (Schallreuter 1977b). For a list of Ordovician aechminid genera see Schallreuter (1978).

**Occurrence.** Middle Ordovician to Carboniferous of North America, Europe, Russia and Australia.
Genus **CRESCENTILLA** Barrande, 1872

**Type species.** Original designation; Barrande 1872, p. 507; **Crescentilla pugnax** Barrande, 1872, p. 507, pl. 26, figs 1d-f; middle Ordovician of Czechoslovakia (type locality and precise horizon not designated).


**Diagnosis.** Valves subovate and amplete. Cardinal corners rounded. Lateral surface most elevated and convex centrally. Two more or less equally developed, spine-like nodes in antero- and posterodorsal regions, projecting well beyond hingeline. A fairly broad dorsal sulcus is developed between the nodes at about mid-length. Valves smooth.

**Discussion.** C? baltica (0.60mm) and C? sp. of Knüpf, 1968 (0.54mm) are included with uncertainty because the nodes of both species are rounded dorsally. Schmidt (1941, pp. 68, 69, pl. 4, fig. 39) re-described the type species but figured a poorly preserved specimen. Přibyl (1979, pl. 5, figs 1, 6, text-fig. 12, no. 2) figured Barrande's (1872) original material of C. pugnax and his new species C. vaneki (text-fig. 12, no. 6) Přibyl's illustrated valves are internal moulds and the two species maybe synonymous. Until new material of the type species is described **Crescentilla** remains poorly known.

**Occurrence.** Middle and upper Ordovician of Czechoslovakia (Přibyl 1979), upper Ordovician of Thuringia (Knüpf 1968) and possibly north western Russia (Neckaja 1966). In Britain, known from the middle Ordovician (Caradoc Series) of England.

**Crescentilla** sp. nov. 1. Pl. 24, fig. 12

1978a Gen. nov. (? ) A, sp. nov. 1; Siveter, p. 52, pl. 3, fig. 5.

**Material.** One left valve external mould (= on slab GSM 49449).
**Description.** Valve moderately long, subovate and amplete. Cardinal corners rounded and obtuse. Domicilium most elevated in posterior central region. Hingeline moderately long. Entire ventral margin convex. Nodes almost equally developed, forming broad dorsal spines well beyond the hingeline. Anterior node is widest, situated in anterodorsal region, sloping towards the posterior. Posterior node located in anterior central dorsal region, sloping towards anterior. Between the nodes at about mid-length a broad, shallow, V-shaped sulcus, terminating in the dorsocentral region. Valves smooth.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>Pl.24</th>
</tr>
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<tr>
<td>on GSM 49449</td>
<td>1</td>
<td>0.92</td>
<td>0.50</td>
<td>1.84</td>
<td>0.62</td>
<td>12</td>
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</tbody>
</table>

See **Occurrence** for locality.

**Discussion.** C. sp. nov. 1. is smaller than C. puagnax (c. 1.5mm) and its nodes are longer, straighter and more centrally situated. Additional material is needed before the species can be erected.

**Occurrence.** Harnage Shales, Harnagian Stage, Caradoc Series, near Harnage, c. 7km SE of Shrewsbury, Shropshire (GSM 49449 is from here). Precise locality unknown.

**Genus PSEUDULRICHIA** Schmidt, 1941

**Type species.** Original designation; Schmidt 1941, p. 59; *Leperditia bivertex* Ulrich, 1879, p. 11, pl. 7, figs 5, 5a, from the Edenian or Shermanian stages (= upper part of Caradoc), S bank of Ohio River, W of Covington, Kentucky, U.S.A.

**Other species.** *P. bucera* (Neckaja, 1966); *P. inarguta* (Neckaja, 1966); *P. marrii* (Jones, 1893); *P. norvegica* Henningsmoen, 1954; *P. posterocerata* Blumenstengel, 1965; *P. spinata* (Burr & Swain, 1965); *P. ullehamanni* Schallreuter, 1981; *P. wilnoiensis* (Neckaja, 1966); *P? perforata* (Barrande, 1872).
**Diagnosis.** (After Schallreuter 1968c, p. 251). Valves small to medium sized (usually less than 2mm), moderately high to very high and more or less amplete. Domicilium elevated and most strongly convex anterodorsally. Two prominent rounded/conical nodes or spines in the dorsal regions. Ventral margin flattened lacking a marginal surface. Valves smooth.

**Discussion.** The genus has been been fully discussed by Schallreuter (1968c, 1981b) and Vannier (1984).

**Occurrence.** Middle Ordovician of England, Wales, France (= a new unpublished species, see Vannier 1984) and possibly Czechoslovakia (Pribyl 1979); middle and upper Ordovician of northern Germany (erratic boulders; Schallreuter 1968c, 1981b) and Russia (Gailite 1970, Neckaja 1966, Sidaraviciene 1975) and U.S.A. A new *Pseudulrichia* species is probably present in the upper Ordovician of Canada (figured Copeland 1973 as *Pseudulrichia simplex* (Ulrich 1894)', pl. 1, fig. 12).

1. *Pseudulrichia aequinoda* sp. nov.  Pl. 25, figs 1-4

**Name.** Latin 'aequalis', equal and 'nodus', swelling; referring to the equally developed nodes.

**Holotype.** CRJ SW212/4, silicified left valve; Pl. 25, fig. 1. Bryn-banc Limestone Member, Narberth Group, Costonian Stage, Caradoc Series; quarry 825m SSW of Henllan Lodge, Llanddewi-Velfrey, 2.3km NE of Narberth, Dyfed (loc. 27b).

**Material.** 20 complete valves and 40 poorly preserved specimens, all silicified.

**Diagnosis.** Anterior node developed in anterior-anterodorsal region forming stout, ventrally swollen spine. Posterior node situated in central dorsal region, developed as quite long, inclined conical spine that is directed posteriorly. Adductorial sulcus broad and shallow, U-shaped.
Description. Valves and domicilium rather high, more or less subquadrato and amplete. Hingeline straight and long. Dorsum hypocline. Cardinal corners fairly distinct, both greater than 90°; anterior corner usually concealed in lateral view by node. Ventral margin quite flat, steepest anteriorly. Anterior node forming broad spine, curved towards dorsum in anterior view. Posterior node longer, narrower, its dorsal part often curved beyond the posterior (in lateral view). Both nodes project beyond the hingeline. Domicilium most elevated just below the anterior node. Adductorial sulcus is anterior of mid-length and is slightly constricted centrally, deepest dorsally, forming a broad U-shape.

Measurements.

<table>
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<th>HD</th>
<th>LV:HV</th>
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<tr>
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<td>0.71*</td>
<td>0.46</td>
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<td>-</td>
<td>0.41</td>
<td>-</td>
<td>0.57</td>
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<td>0.53</td>
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<td>-</td>
<td>0.36</td>
<td>-</td>
<td>0.51*</td>
<td>1</td>
</tr>
</tbody>
</table>

All valves from loc. 27b.

Discussion. *P. aequinoda* is slightly larger than *P. conispina* sp. nov., from which it differs in having a broader sulcus, more equally sized, anteriorly situated spinose nodes, and a domicilium that is less elevated below the sulcus.

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 24, 27a,b, 28a).

2. *Pseudulrichia conispina* sp. nov. Pl. 25, figs 5-7, 10, 11

Name. Latin 'conus', cone and 'spina', thorn; referring to the spinose posterior node.

1978a *Pseudulrichia* cf. *P. bucera* (Neckaja, 1966); Siveter, p. 50, pl. 2, figs 11, 12.
**Holotype.** CRJ SW211/2, silicified right valve; Pl. 25, fig. 6.

Llandeilo 'Limestone', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

**Material.** 110 silicified valves.

**Diagnosis.** Anterior node elliptical, sometimes pointed, situated in posterior anterodorsal region. Posterior node developed as stout, conical spine, slightly curved and directed posteriorly; located in posterior central dorsal region. Lateral surface swollen and elevated below sulcus just anterior of mid-length.

**Description.** Valves high to rather high, subovate and amplete. Domicilium rather high to moderately high. Hingeline straight, long to moderately long. Dorsum hypocline. Cardinal corners distinct and obtuse. Ventral margin slightly convex. Anterior node is usually a prominent, elongated ellipse, occasionally pointed dorsally (Pl. 25, fig. 11) and sometimes directed posteriorly (Pl. 25, fig. 10) and projects beyond hingeline. Posterior node forms stout, conical spine, slightly curved and projecting well beyond hingeline towards posterior. Sulcus quite broad, situated anterior of mid-length. Lateral surface below sulcus and nodes somewhat swollen and elevated.

Nodes of small specimens generally more spinose than those of adults.

**Measurements.**

<table>
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<tr>
<td>CRJ SW211/4</td>
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<td>0.35</td>
<td>1.46</td>
<td>0.48</td>
<td>0.31</td>
<td>1.55</td>
<td>0.36</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
</table>

**Discussion.** *P. conispina* (g. 0.71mm) is slightly smaller than *P. bucera* (holotype = 0.75mm), from the middle Ordovician of the Baltic and north western Russia. *P. conispina* differs further because its anterior node is more elliptical and projects beyond the hingeline, it also has a
longer posterior spine and more swollen, elevated central region. The upper Ordovician *P. ullehamanni* (c. 0.58mm) is also quite similar to *P. conispina*, but differs in having smaller, more anteriorly situated nodes and less obtuse cardinal angles.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 2, 3, 11a, 11d, 12a, 17, 22, 23, 26a).

3. ?*Pseudulrichia marrii* (Jones, 1893) Pl. 25, figs 8, 9

?1893 *Ulrichia marrii* Jones; Jones, p. 294, pl. 12, fig. 16.

**Material.** About 100 poorly preserved calcite valves.

**Description.** Valves very high to high and amplete. Hingeline moderately long. Dorsum hypocline to orthocline. Cardinal corners rounded and obtuse. Lateral surface most elevated and convex in central and anterocentral regions. Ventral margin straight in cross-section. Anterodorsal node round. Posterior central dorsal node developed as a cone, curved posteriorly and just projecting beyond hingeline. Sulcus anterior of mid-length, quite broad and comma-shaped.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
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<tr>
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<td>0.58*</td>
<td>0.50</td>
<td>-</td>
<td>0.47</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

See **Occurrence** for locality details

**Discussion.** The original material of *Ulrichia marrii* has not been located. Jones's (1893, pl. 12, fig. 16) figure of *U. marrii* is very similar to the specimens of ?*P. marrii* illustrated herein, except that the anterior node of Jones's specimen projects well beyond the hingeline and contrasts with the small, round, anterior node of specimens designated ?*P. marrii*. ?*P. marrii* occurs at the same horizon (= Dufton Shales) and general location (= near Dufton, Cumbria) as *U. marrii*, and
is the only Pseudulrichia species recorded from the Cross Fell Inlier by the present author. A more definite assignment of the present material cannot be undertaken until the type material of U. marrii is located.

**Occurrence.** Longvillian and Marshbrookian stages, Caradoc Series of the Cross Fell Inlier, Cumbria. Localities as follows; Longvillian Stage; locs 45a,b and BGSK slabs on S side of Pus Gill Valley about 715m SE (143°) of Dufton Pike, Dufton, Cumbria at NY 7051 2603 (=BGSK PC 4478-81), NY 7042 2605 (=BGSK PJ 4547, NY 7041 2605 (=BGSK PJ 4560) and NY 7040 2604 (=BGSK PJ 4565). Marshbrookian Stage; BGSK PJ 3563-70 from S bank of Harthwaite Sike, 553m SE (120°) of Bow Hall, Dufton, Cumbria at NY 7073 2478.
Family CIRCULINIDAE Neckaja, 1966
(nom. transl. Schallreuter, 1968c)


Diagnosis. (Slightly modified from Schallreuter 1968c, p. 254).
Outline more or less amplete to postplete; valves rather high to very high. Hingeline relatively short. Umbonate forms with flat to triangular epicline dorsum. S2 short, usually anterior and dorsal of the central region. Greatest convexity of domicilium is central or dorsal. Marginal surface relatively flat to the contact margin, forming an acute angle with the contact plane. Swelling or bulbous adventral sculpture (=pseudovelum) on border between lateral and marginal surface. Simple contact margin.

Discussion. The concept of the Circulinidae has been redefined by Schallreuter (1968c). Differentiation at generic level within this primitive family is still obscure (Schallreuter 1977b). The taxonomic importance of variation exhibited by the pseudovelum, lobes, cristae and sulci is uncertain; its assessment and phylogenetic reconstruction await the description of additional forms.

Occurrence. Circulinidae are found dominantly in the Ordovician of northern Europe, including Norway and Sweden (Jaanusson 1957); the Baltic region (Gailite 1975, Neckaja 1966, Schallreuter 1967a, 1968c, 1972b, 1980b, Sidaravičiene 1975); and from Czechoslovakia (Přibyl 1979) and France (Vannier 1983a, 1984). Also known from Canada (Copeland 1977a, 1977b) and the USA (Kay 1934, Swain, Cornell & Hansen 1961).

Circulinids are known from the Caradoc Series of England and the upper Llanvirn, Llandoilo and Caradoc series of Wales. At least one
undescribed circulinid species is present in the Ashgill Series of Wales.

Genus CONSPICILLUM gen. nov.

Name. Latin 'conspicillum', spectacles; fancied resemblance of the lobes and sulci to a pair of spectacles. Gender neuter.

Type species. Primitia bipunctata Jones & Holl, 1869, p. 220, fig. 5; from 'Llandeilo Flagstone', Hellpool, Wyeforth, near Builth, Powys.

Other species. C. ulularum sp. nov.

Diagnosis. Large, postplete circulinid. Anterior and posterior ridge-like loops forming a figure-of-eight arrangement. Posterior loop encloses a deep depression, wider than that enclosed by anterior loop. Centrally, ridge system can be reduced. Lateral surface smooth.

Discussion. Conspicillum, unlike many Circulinidae, is distinctly postplete; this and its steep, hypoclinc dorsum, convex ventral margin and size are most reminiscent of Vogdesella Baker, 1924 and Pariconchoprimitia Schallreuter, 1980. The distinctive figure-of-eight lobal complex of Conspicillum is unlike that of any other circulinid except Rivillina Vannier, 1983, which also has a posterior ridge-like loop with sulcus but only a shallow anterior sulcus and ridge connected ventrally by a pseudovelum. The marginal surface of Rivillina is also steeper and more concave than in Conspicillum. Vannier (1984, pp. 111-3, pl. 24, figs 1-5) recently described a similar unpublished new genus from the Llanvirn of the Armorican Massif, France, being postplete with a steeply sloping marginal surface and an anterior and posterior sulcus surrounded by an incomplete pseudovelum.

The lobal complex of Conspicillum, as in typical circulininds, is produced by a thickening of the shell; thus, internal moulds do not reflect the ridge-like loops of the lateral surface. Other features characteristic of Conspicillum include an anterior cardinal corner angle
greater and much less distinct than that of the posterior corner, a hypocene marginal surface and a steep dorsum forming a flattened central area into which the sulci are depressed and encircled by the ridge-like loops.

**Occurrence.** Llandeilo Series and possibly lowest Caradoc Series of Powys, Wales.

1. *Conspicillum bipunctatum* (Jones & Holl, 1869)

   Pl. 26, figs 1-4, 7-10, 14, 15, Text-fig. 22

1865 *Bevrichia bipunctata*; Huxley & Etheridge, p. 16.
1869 *Primitia bipunctata*, Salter, sp.; Jones & Holl p.220, fig. 5.
1872 *Primitia bipunctata* Salt.; Barrande, pp. 540, 542.
1881 *Primitia bipunctata*, Salt.; Salter & Etheridge, p. 390.
1893 *P. bipunctata*, J. & H.; Jones, p. 293.
1934 *Ulrichia bipunctata*, Jones & Holl; Bassler & Kellett, p. 409.
1941 *Pseudulrichia bipunctata*; Schmidt, pp. 62, 77.
1977 *Ulrichia bipunctata* (Jones & Holl); Swain, p.29.
1978a *Bevrichia bipunctata* (Salter MS); Siveter, p. 42.

**Holotype.** BM Int18507, damaged external mould of right valve; sealing-wax cast figured Jones & Holl 1869, p. 220, fig. 5; herein Pl. 26, fig. 1 (= rubber cast). 'Llandeilo Flagstone', Hellpool, Wyeforth, near Builth, Powys. Precise locality and horizon uncertain. The locality is very probably at that part of the River Wye which is referred to as 'Hellhole', although not marked as such, on the 6" OS map (N.G.R. S0 0313 5213). The 'Hellhole' is an erosional feature in dolerite. Outcropping in the immediate vicinity is the top of the *Glyptagnostus teretiusculus* Shale (latest lower Llandeilo). However, *Nemagraptus gracilis* shales are exposed upstream, giving a possible middle or upper Llandeilo age (Mr. P. Sheldon, pers. comm.).

**Material.** 40 external moulds and a few calcite valves.
TEXT-FIG. 22. Reconstructions of right valve of *Conspicillum bipunctatum* X60.

TEXT-FIG. 23. Reconstructions of right valve of *Conspicillum ulularum* X80.
**Diagnosis.** *Conspicillum* with lobal complex forming distinct figure-of-eight pattern. Anterior and posterior ridge-like loops joined centrally by broader ridge dividing two deep sulci. Dorsum almost orthocline.

**Description.** Valves very high to high, distinctly postplete. HV posterior of mid-length, LV about mid-height. Transverse convexity greatest dorsal of mid-height, longitudinally it is anterior of mid-length. Hingeline short to moderately short. Angle between contact plane and marginal surface about 45°, at the dorsum it is about 70°.

Lobal complex forms distinct figure-of-eight pattern. Posterior loop is larger than anterior loop, and more elevated centrodorsally. Both loops joined centrally by a broad slightly elevated ridge, dividing two deep, circular sulci. The ridge-like loops are variously developed, being prominent to obsolete, though this may in part be due to preservation. A weak depression is usually present anterodorsally below the cardinal corner.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
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<th>HV</th>
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<th>HL</th>
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<td>13</td>
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<td>13</td>
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<td>13</td>
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<tr>
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<td>1.18</td>
<td>0.86</td>
<td>1.37</td>
<td>0.80</td>
<td>1</td>
<td>†</td>
</tr>
</tbody>
</table>

† = see Holotype.

**Discussion.** The distinctive lobal complex of *C. bipunctatum* resembles that found in *Octonaria* Jones, 1887, particularly the Silurian type-species *Octonaria octoformis* Jones, 1887 (see Siveter 1978b) in which two ridge-like loops are arranged in a figure-of-eight pattern. *Q. octoformis* differs from *C. bipunctatum* by having HV anterior of mid-length, a larger left valve overlapping the right valve and outline
tapering towards posterior and anterior. *Octonaria* is a thlipsurid and a
homeomorph of *Conspicillum*.

Jones & Holl (1869, p. 220) credit *C. bipunctatum* to Salter who
supplied the original specimens. However, as Jones & Holl (1869) first
described and figured the species it should be credited to them
(I.C.Z.N., p. 16, Article 12) because Salter was only responsible for
the name.

**Occurrence.** *Glyptograptus teretiusculus* Shales, lower and middle
Llandeilo Series, and *Nemagraptus gracilis* Shales, upper Llandeilo
Series of the Builth-Llandrindod Inlier, Powys (locs 9, 13). Also
collected from black shales, possibly of lowest Caradoc age (Baker &
Hughes 1979, p. 69) in the middle Llanfawr quarry, Llandrindod Wells,
Powys (loc. 25).

2. *Conspicillum ulularum* sp. nov.

   Pl. 26, figs 5, 6, 11-13, Text-fig. 23

   **Name.** Latin 'ulula', an owl; fancied resemblance of lateral surface
to the face of an owl.

   **Holotype.** CRJ M41, right valve; Pl.26, fig. 13. *Glyptograptus*
teretiusculus Shales, lower Llandeilo Series; stream section opposite
Cefndyrys Lodge, 1.5km N of Builth Hospital, Builth, Powys (loc. 9).

   **Material.** Two valves, one carapace and an external mould.

   **Diagnosis.** Species of *Conspicillum* with two weak, ridge-like loops;
posterior sulcus much broader than, and joined centrally to, anterior
sulcus.

   **Description.** Valves very high to high, preplete. HV posterior, LV
just ventral of mid-height. Transverse convexity greatest dorsally,
longitudinally it is anterior. Hingeline short. Angle between contact
plane and marginal surface about 35°, at the dorsum it is 45°.

Lobal complex indistinct; ridge-like loops encircling sulci are
reduced, almost obsolete in posterior and anterior. Posterior sulcus very broad and joined centrally to the deeper anterior sulcus by narrow furrow.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>Pl.26</th>
<th>loc</th>
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</thead>
<tbody>
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<td>H</td>
<td>1.08</td>
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<td>1.32</td>
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<td>9</td>
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<tr>
<td>-</td>
<td>R</td>
<td>1.06</td>
<td>0.72</td>
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<td>-</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>CRJ 40 R</td>
<td>1.04</td>
<td>0.74</td>
<td>1.41</td>
<td>0.50</td>
<td>5,6,11,12</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>R</td>
<td>0.95</td>
<td>0.64</td>
<td>1.48</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
</tbody>
</table>

**Discussion.** *C. ulularum* (c. 1.08mm) differs from *C. bipunctatum* (c. 1.37mm) in being smaller, having more reduced lobation, broader centrally positioned sulci, lacking a central dividing ridge and by its more acute angle between contact plane and marginal/dorsal surface. The lateral surface of *C. ulularum* compares with that of *Ballardina millersburgia* Warshauer & Berdan, 1982 (c. 0.65mm), which also has an anterior and posterior sulcus surrounded by vague swollen ridges, but differs in that the sulci are divided by an anterocentral node. *B. millersburgia* differs further in possessing an almost entire pseudovelum, a relatively long hinge and an inflated dorsum.

**Occurrence.** *Glyptograpthus teretiusculus* Shales; lower Llandeilo Series, Powys (locs 8, 9, 10).

**Genus EASCHMIDTELLA** Schallreuter, 1967

**Type species.** Original designation; Schallreuter 1967a, p. 627, fig. 7: *Easchmidtella crassiumbonata* Schallreuter, 1967; from an uppermost middle Ordovician Rollensteinkalk erratic boulder near Greifswald, East Germany.

**Other species.** *E. fragosa* (Neckaja in Abushik et al. 1960); *E. lata* (Neckaja in Abushik et al. 1960); *E? abnormis* (Sidaravičiune, 1975).

**Diagnosis.** (Slightly modified from Schallreuter 1967a, p. 626).
Small, usually less than 1 mm long. Outline amplete to weakly postplete. Form fairly high to very high. Dorsum distinct and strongly epicline to indistinct and orthocline. Dorsal margin straight or convex outwards. S2 as a sulcament. Hump shaped umbo sometimes present at border of lateral and dorsal areas. Valve surface smooth.

**Discussion.** For a full discussion of *Easchmidtella* and its relation to other circulinids see Schallreuter (1967a). Schallreuter (1967a, p. 626) considers part of the material figured under the following Schmidtella species to probably represent new *Easchmidtella* species; *S. incompta* Swain, Cornell & Hansen, 1961 (p. 359, pl. 48, fig. 3); *S. brevis* Swain, Cornell & Hansen, 1961 (pl. 48, figs 5b, 5d; not fig. 5c); *S. brevis* Kay, 1940 (comparative material in Schallreuter's collection) and *Primitiella anterorotunda* Kraft, 1962 (pl. 5, figs 8, 9).

*E? abnormis*, described by Sidaraviciene (1975, p. 32, pl. 5, figs 2, 3) from the middle and upper Ordovician of the Baltic basin, is included with uncertainty. Originally described as *Parapyxion*, this species has well developed umbones and an epicline dorsum characteristic of *Easchmidtella*. Re-description of the type material is necessary to allow a more definite assignment.

**Occurrence.** Middle and upper Ordovician of Baltoscandia, Britain (South Wales), north eastern Russia and U.S.A. (cf. Schallreuter 1967a).

*Easchmidtella elementa* sp. nov. Pl. 27, figs 1-7.

**Name.** Latin, "elementum", rudiment; alluding to the featureless lateral surface.

**Holotype.** CRJ SW151, right valve; Pl. 27, figs 1, 2, 7. Llandeilo 'Flags', upper Llandeilo Series; old quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

**Material.** More than 75 silicified valves.

**Diagnosis.** Subamplete species of *Easchmidtella* with umbones absent
and very flattened lateral surface. S2 represented by small, V-shaped sulcament internally.

**Description.** Valves very high. Outline of valves and domicilium amplete to postplete. LV and L0 about mid-height, HV and HD about mid-length. Domicilium very high to high. Transverse convexity greatest dorsally, longitudinally it is greatest towards anterior.

Hingeline moderately short to moderately long. Cardinal corners distinct with approximately equal angles. Dorsum hypocline and slopes steeply to hingeline. Marginal surface hypocline, convex and sloping steeply from flat lateral surface to the free margin; very steep anteriorly. S2 barely distinguishable, anterior and slightly dorsal of central region. Anterodorsally an indistinct swelling can be present. Short V-shaped sulcament poorly developed internally. Valves smooth.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.73</td>
<td>0.53</td>
<td>1.39</td>
<td>0.66</td>
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<td>1.44</td>
<td>0.47</td>
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</tr>
<tr>
<td>CRJ SW152/1</td>
<td>r</td>
<td>0.71</td>
<td>0.49</td>
<td>1.44</td>
<td>0.64</td>
<td>0.44</td>
<td>1.46</td>
<td>0.47</td>
<td>5</td>
</tr>
<tr>
<td>CRJ SW151</td>
<td>r</td>
<td>0.70</td>
<td>0.48</td>
<td>1.46</td>
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<td>0.46</td>
<td>1,2,7</td>
</tr>
<tr>
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<td>l</td>
<td>0.69</td>
<td>0.49</td>
<td>1.41</td>
<td>0.63</td>
<td>0.42</td>
<td>1.50</td>
<td>0.38</td>
<td>6</td>
</tr>
<tr>
<td>CRJ SW152/2</td>
<td>r</td>
<td>0.53</td>
<td>0.37</td>
<td>1.42</td>
<td>0.47</td>
<td>0.31</td>
<td>1.53</td>
<td>0.31</td>
<td>3</td>
</tr>
</tbody>
</table>

All valves from loc. 17.

**Discussion.** *F. elementa* (c. 0.73mm) is larger than *F. crassiumbonata* (c. 0.60mm) and also lacks its distinctively developed umbones. *F. elementa* most resembles the smaller *F. fragosa* (c. 0.63mm), from the middle Ordovician of the Russian Platform, which similarly has a subamplete outline and poorly developed umbones.

**Occurrence.** Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 3, 4, 12, 17, 20, 21a, 22, 23, 26b, 27, 28a,b).
Genus PARICONCHOPRIMITIA Schallreuter, 1980

Type species. Original designation; Schallreuter 1980b, *Primitia conchoides* Hadding, 1913, pl. 6, fig. 15 (= lectotype); from the middle Ordovician (*Nemagraptus gracilis* Biozone) of Rostanga, Scania, Sweden.

Other species. *P. improba* sp. nov.; *P. incompta* (Burr & Swain, 1965); *P. oscillata* sp. nov.

Diagnosis. (After Schallreuter 1980b, p. 10). Small to medium size, non-sulcate, non-lobate; sulcus at most a weak depression; internally a weak sulcament infront and dorsal of central region. Equivalve, contact margin without sculptures, valves simply lie against each other.

Discussion. Schallreuter (1980b, pp. 10-14) has fully described the genus and its phylogeny. Differentiation of species within *Pariconchoprimitia* and the related genus *Vogdesella* Baker, 1924 is difficult as there are few features for comparison. Valve outline is an important feature for distinguishing species within *Pariconchoprimitia*.


1. *Pariconchoprimitia improba* sp. nov. Pl. 27, figs 15, 17-21.

Name. Latin 'improbos', not to standard; alluding to the poor preservation of the lateral surface.

Holotype. CRJ SW152, left valve; Pl. 27, figs 15, 19, 20. Ffairfach Group, upper Llanvirn Series; railway cutting 95m SW of level crossing, Ffairfach, Llandeilo, Dyfed (loc. 1b).

Material. 75 silicified valves, only four well preserved.

Diagnosis. Amplete species of *Pariconchoprimitia* with greatest convexity in anterocentral region. Dorsum and anterior ventral surface
steeply hypocline. S2 absent, faint sulcament internally.

**Description.** Valves and domicilium very high to high. Outline of valves more or less amplete. LV and LD mid-length, HV and HD about mid-height. Transverse convexity greatest dorsally, longitudinally it is anterior.

Hingeline moderately long to moderately short. Both cardinal corners indistinct, posterior corner angle more obtuse than anterior corner. Dorsum steeply hypocline. Ventral surface hypocline and slopes steeply to free margin anteriorly; much shallower posteriorly and in ventral region. Lateral surface is most elevated in anterocentral region. S2 is absent and only a faint sulcament is preserved internally.

Larvae have a shorter hingeline and slightly longer form than adults.

**Measurements.**

<table>
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<th>No.</th>
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<th>HV</th>
<th>LV:HV</th>
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<th>HD</th>
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<td>21 1b</td>
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<td>1.44</td>
<td>0.36</td>
<td>17 12b</td>
<td></td>
</tr>
</tbody>
</table>

**Discussion.** Most valves of *P. improba* (c. 1.10mm) are poorly preserved, the external shell being present only rarely. A few specimens occasionally show valve retention, which also occurs in the larger *P. conchoideS* (c. 1.44mm). *P. improba* differs from *P. oscillata* (c. 1.31mm) in being less postplete, by having a longer hinge and more acute cardinal angles with greatest elevation of valves in the anterocentral region, rather than the posterior region.

**Occurrence.** Upper Llanvirn and Llandeilo series, and Costonian Stage, Caradoc Series, Dyfed (locs 1b, 3, 4, 12, 23, 24, 26a,b, 28b).
2. Pariconchoprimitia oscillata sp. nov. Pl. 27, figs 8-14, 16.

Name. Latin, 'oscillum', swing; alluding to the posterior swing of the valves.

Holotype. CRJ SW149, right valve; Pl. 27, figs 11, 12, 16. Llandeilo 'Flags', upper Llandeilo Series; old quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. More than 200 silicified valves.

Diagnosis. Pariconchoprimitia with short hingeline and distinct posterior swing to the valves. Non-sulcate, but faint sulcament internally.

Description. Valves very high to high. Outline of valves and domicilium postplete to distinctly postplete. Extent of the posterior swing is quite variable. LV and LD just ventral of mid-height, HV and HD are posterior. Domicilium high. Transverse convexity greatest just dorsal of mid-height, longitudinally it is just posterior of mid-length.


S2 indistinguishable, sometimes a slight flattening of valve surface in anterior dorsocentral region. Very faint sulcament internally, but usually not preserved. Valves smooth.

Larvae have a slightly longer form than adults.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
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All valves from loc. 17.

Discussion. *P. conchoides*, from the middle Ordovician of Baltoscandia, differs from *P. oscillata* by having greater transverse and longitudinal convexity, a longer hingeline, less posterior swing to the valves, a more distinct sulcament and in showing retention of moults.

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc Series, Dyfed, Wales (locs 17, 20, 26a, 27b) and middle/upper Llandeilo Series of Shelve Inlier, Shropshire, England (= SM A67366-70, from near loc. 15, precise locality unknown).

Genus PEDOMPHALELLA Swain & Cornell in Swain, Cornell & Hansen, 1961

Type species. Original designation; Swain & Cornell in Swain, Cornell & Hansen, 1961, *P. intermedia* Swain & Cornell, p. 362, pl. 48, figs 7a-c; from middle Ordovician (lower Trenton) Decorah Shale, Minnesota, U.S.A.

Other species. *P. cruda* (Neckaja, 1966); *P. enregia* (Sarv, 1963); *P. expraeputia* sp. nov.; *P. fimbriata* (Neckaja, 1966); *P. jonesii* (Krause, 1897); *P. subovata* Swain & Cornell in Swain, Cornell & Hansen, 1961; *P? mica* Sidaravičienė, 1971.

Diagnosis. (Slightly modified from Schallreuter 1968c, p. 255). Small (less than 1mm long). Valves rather high to very high and amplete. Dorsum strongly epicline. S2 short and V-shaped between anterocentral and dorsal regions. Preadductorial node round, flat, elliptical or hook shaped. Pseudovelum at border of lateral and marginal surface; either broad, swollen or elevated, dorsally extending beyond hingeline, parallel with free margin. Pseudovelum can be absent ventrally; in most species divided by furrow dorsal of S2. Valves smooth.

Discussion. The concept of Pedomphalella and its phylogeny are discussed by Schallreuter (1968c, pp. 255-58). Pedomphalella and Circulina Neckaja, 1966 are congeneric.
P. jonesii and P. egregia may be conspecific (Schallreuter 1968c). P? mica from lowermost upper Ordovician of Lithuania, is included in Pedomphalella with uncertainty because the holotype (Sidaraviciene 1971, pl. 1, figs 6a,b) lacks the steep flat marginal surface characteristic of Pedomphalella, and its pseudovelum is inflated and lies more central on the lateral surface than in any other congeneric species. Furthermore, P? mica only has a reduced central depression rather than the much broader central region typical of the genus. 'Pedomphalella' germanica Schallreuter, 1972 (cf. Schallreuter 1972b) lacks a pseudovelum and should be assigned to Vogdesella (Schallreuter, pers. comm.).

Occurrence. Middle Ordovician of the eastern Baltic (Lithuania and Estonia; Sarv 1963, Schallreuter 1968c); erratic boulders of northern Germany and Gotland (Schallreuter 1968c); Minnesota, U.S.A. (Swain, Cornell & Hansen 1961). In Britain, known from the upper Llandeilo and Caradoc series of Dyfed, Wales.

Pedomphalella expraeputia sp. nov. Pl. 28, figs 1-4, 6, 7, 10, 11.

Name. Latin, 'praeputis', prepuce; referring to the reduced pseudovelum.

Holotype. CRJ SW058, left valve; Pl. 28, figs 2, 3, 6, 7. Bryn-banc Limestone Member, Narberth Group, Costonian Stage, Caradoc Series; quarry 245m N of Bighouse, Lampeter-Velfrey, 245km E of Narberth, Dyfed (loc. 28b).

Material. More than 90 silicified valves.

Diagnosis. Pedomphalella species with pseudovelum much reduced, only just extending beyond central dorsal margin; cardinal corners thus distinct. Lateral surface markedly convex centrally.

Description. Valves very high to high. Outline of valves and domicilium more or less ample. LV and LO just dorsal of mid-height, HV
and HD just posterior of mid-length. Domicilium high to rather high. Transverse convexity greatest about mid-height, longitudinally it is anterior of mid-length.

Hingeline moderately long to long. Posterior cardinal corner angle just greater than 90°, with acroidal projection; anterior angle much greater than 90°. Dorsum epicline centrally, orthocline elsewhere. Marginal surface straight and hypocline posteriorly but more orthocline in anterior and ventral regions. Simple contact margin.

S2 tear-drop shaped, preadductorial node faintly hook-shaped. Swollen ridge (= pseudovelum) between marginal and lateral surface is entire, often obsolete anteroventrally and usually posterovertrally, occasionally well developed. Pseudovelum continues dorsally and projects beyond central part of hingeline, but is divided by narrow dorsal furrow (above S2) which does not quite reach the hingeline. Lateral surface quite arched, centrally convex, especially below S2. Valves smooth.

Larvae have a slightly longer form than adults, with a more antero- and posterovertrally reduced pseudovelum. Dorsally, pseudovelum projects just past hingeline.

Measurements.

<table>
<thead>
<tr>
<th></th>
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<td>0.57</td>
<td>0.35</td>
<td>1.61</td>
<td>0.45</td>
<td>10</td>
</tr>
</tbody>
</table>

All valves from loc. 28b.

Discussion. The middle Ordovician (upper Viruan) P. eoreoia (C. 0.78mm) is larger than P. exoraeputia and differs further by its more swollen pseudovelum which is reduced ventrally. The preadductorial node of P. eoreoia is more distinct and its large dorsal plica extends beyond the hingeline. P. intermedia (C. 0.45mm) is much smaller than P.
P. exoraeputia and its pseudovelum is more swollen, extending well onto the lateral surface. The holotype of the type species is damaged but appears to have a much stronger furrow above S2 than P. exoraeputia.

P. exoraeputia most closely resembles the middle Ordovician (Viruan) P. fimbriata (c. 0.47mm) from the Baltic. P. fimbriata differs by having a less convex central region and a prominent, entire pseudovelum projecting beyond the hinge and obscuring it in lateral view. The considerable morphological similarities between these species suggests they are closely related.

Occurrence. Upper Llandoilo Series and Costonian Stage, Caradoc Series, Dyfed, Wales (loc 21a,b, 22, 24, 26a, 27a,b, 28a,b).

Genus PSEUDBOLLIA Schallreuter, 1968

Type species. Original designation; Schallreuter 1968c, Bollia subaequata Ulrich, 1894, p. 669, pl. 46, figs 26-29; from the middle Ordovician (Trenton) Prosser Formation, Cannon Falls, Goodhue County, Minnesota, U.S.A.

Other species. P. obsolete sp. nov.; P. semilunata (Jones, 1890); P. aff. P. subaequata (Ulrich, 1894); P? biplicata (Troedsson, 1918).

Diagnosis. (Slightly modified from Schallreuter 1968c, p. 258). Small to medium sized (less than 1.5mm long). Valves high to very high, amplete to weakly postplete. Hingeline short. Dorsum can be strongly epicline. Adventral sculptures developed as swollen to angular supramarginal ridge (= pseudovelum) between lateral surface and flat, steep marginal surface. Pseudovelum runs parallel with, and not extending beyond, free margin. Two ridge-like parallel lobes on either side of S2 join with each other ventrally and the pseudovelum in antero- and posterodorsal regions. Valves smooth.

Discussion. Schallreuter (1968c, p. 259) considered Pseudbollia to be most similar to Pedomphalella and Vogdesella, but clearly different
because of its two ventrally extended ridge-like nodes. *Pseudbollia* bears a superficial resemblance to *Bollia* Jones & Holl, 1886. Schallreuter (1968c) included *Bollia unguuloidea* Ulrich, 1894 within *Pseudbollia*, but from Ulrich’s illustration (1894, pl. 46, figs 23-25) the present author considers this species to be more reminiscent of *Bollia sensu stricto* (see Siveter 1978b, p. 72). Schallreuter (1968c) also included *'Bollia' biplicata* Troedsson, 1918 and *'Bollia' semilunata* Jones, 1890b within *Pseudbollia*. As the original material of *'Bollia' biplicata* has not been examined the species is herein only tentatively assigned to within *Pseudbollia*.


1. *Pseudbollia obsolete* sp. nov. Pl. 28, figs 5, 8, 9, 12, 13, 17.

Name. Latin, 'obsoletus', referring to the reduced nodes and pseudovelum of the lateral surface.

Holotype. CRJ SW147/3, left valve; Pl. 28, fig. 5. Llandeilo 'Flags', Llandeilo Series; old quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo (loc. 17).

Material. More than 30 silicified valves.

Diagnosis. Species of *Pseudbollia* with pseudovelum obsolete ventrally and usually well developed posterodorsally, where it joins to the top of the anteriorly sloping posterior node.

Description. Valves very high to high. Outline of valves and domicilium more or less amplete. LV and LD about mid-height, HV and HD are just posterior of mid-length. Domicilium high to rather high. Transverse convexity greatest dorsal of mid-height, longitudinally it is mid-length.
Hingeline moderately short to moderately long. Cardinal corner angles equal, both greater than 90°. Dorsum hypocline. Marginal surface hypocline ventrally becoming steeper to anterior and posterior. Contact margin simple.

Two elongated nodes either side of narrow S2, merge into indistinct swollen central area.

Anterodorsal node vertical and swollen dorsally; posterodorsal node slopes anteriorly and is more restricted dorsally where it joins to the posterior branch of the ridge-like pseudovelum close to the dorsal margin. Ventrally the pseudovelum is represented by a central swelling, anteriorly it is more ridge-like. Valves smooth.

Nodes and pseudovelum of larvae appear more distinct than those of adults.

**Measurements.**

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<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>0.41</td>
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<td>0.33</td>
<td>1.50</td>
<td>0.35</td>
<td>17</td>
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**Discussion.** *P. obsoleta* (c. 0.75mm) is related to the stratigraphically younger *P. subaequata* (c. 0.63mm) from the Trenton of Minnesota, U.S.A. The ventral development of the pseudovelum in *P. subaequata* (Ulrich 1894, pl. 46, figs 26-29; Kay 1934, pl. 44, figs 6-14) is much greater than in *P. obsoleta* which also has more reduced nodes, a hypocline dorsum and a more acute angle between the marginal surface and contact plane. The upper Ordovician *P. semilunata* (c. 0.80mm), from Anticosti Island, Canada, is slightly larger than *P. obsoleta*, is more postplete and its anterior node is completely fused with the anterodorsal extension of the pseudovelum. In *P. obsoleta* the
anterior node does not merge with the pseudovelum and the posterior node
dorsally joins with the prominent posterodorsal part of the pseudovelum.

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc
Series, Dyfed, Wales (locs 17, 21a,b, 22, 23, 24, 28a) and the Harnagian
Stage, Caradoc Series of Shropshire, England (loc. 38).


Material. One complete well preserved valve, three complete poorly
preserved valves.

Measurements.

<table>
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<th>HV</th>
<th>LV:HV</th>
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<th>HD</th>
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<td>0.37</td>
<td>1.57</td>
<td>0.41</td>
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<td>27b</td>
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<td>0.36</td>
<td>1.57</td>
<td>0.40</td>
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<td>27b</td>
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Discussion. P. aff. P. subaequata is significant in that it may
provide the first link at specific level between middle Ordovician
ostracodes from North America and Britain. The reduced development of
its pseudovelum ventrally is the main difference between this species
and the type material of P. subaequata from the U.S.A. Kay (1934, pp.
336, 337) recorded that P. subaequata displayed considerable variation
between localities and horizons but did not erect a new species to
account for the different varieties he observed. The type material of P.
subaequata (Ulrich 1894, pl. 46, figs 26-29) and the specimen figured by
Kay (1934, pl. 44, figs 6-8) have a well developed, ridge-like
pseudovelum and distinct, elongate nodes. Specimens figured by Kay
(1934, pl. 44, figs 15, 16) as P. subaequata (LV:HV = c. 1.35), from the
Decorah Formation of Iowa, have indistinct nodes and a reduced
pseudovelum and are similar to P. aff. P. subaequata (LV:HV = c. 1.50)
in morphology and size (the only apparent difference being their lower
form). *P. aff. P. subaequata* and specimens of *P. subaequata* (Kay 1934, pl. 44, figs 15, 16) appear conspecific and may represent a new species but available material precludes a firm assignment.

**Occurrence.** Upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 22, 26a, 27b).

**Genus VOGDESELLA** Baker, 1924

- **Type species.** Original designation; Baker 1924, p. 188, *Jonesella obscura* Ulrich, 1894, p. 668, pl. 44, figs 17-19, from the middle Ordovician (Trenton), Prosser Formation, Cannon Falls, Minnesota, U.S.A.

- **Other species.** *V. dizrunoensis* (Gailite, 1975); *V. germanica* (Schallreuter, 1972); *V. hemidiscus* (Wade, 1911); *V. obesa* (Thorslund, 1948); *V. subovata* (Thorslund, 1948); *V. melvillensis* (Copeland, 1977); V? pragense (Pribyl, 1979).

**Diagnosis.** (Slightly modified from Schallreuter 1980b, p. 14). Small to medium size, valves quite high to very high. Dorsum hypocline. S2 more or less distinct, developed dorsally and anterior of central region; ventral part can be tear-drop shaped sometimes with distinct circular muscle scar. Internally a sulcament. Two flat, round or oblong nodes on either side of S2; posterior node usually more dorsal. Indistinct horseshoe-shaped swelling dorsocentrally sometimes connecting the nodes.

**Discussion.** The present author follows Schallreuter (1967a, 1972b, 1980b) in using the generic name *Vogdesella*, which is a senior subjective synonym of *Parapyxion* Jaanusson, 1957. Wade (1911, p. 451) erected the new genus *Melanella*, in which he included *Jonesella obscura* and *Melanella hemidiscus*. Baker (1924) found the name *Melanella* preoccupied and introduced the new generic name *Vogdesella*. Wade (1911) did not designate a type species for *Melanella*. Baker (1924, p. 188) chose "the species first mentioned by Wade, as the type", namely
Jonesella obscura. This contradicts I.C.Z.N. Article 68a(i), in which case *V. hemidiscus* should have been type species. However, since Baker (1924) subsequently designated *Jonesella obscura* as type species his choice must stand (I.C.Z.N. Article 69a(iii)).

Schallreuter (1980b, p. 14-16) has discussed *Vogdesella* and compared *V. obesa* (c. 0.75mm), *V. obscura* (c. 0.68mm) and *V. subovata* (c. 1.44mm). He considers some of the valves figured by Burr & Swain (1965) under *Primitia tumidula* Ulrich, 1894 from the Maquoketa Formation, Iowa, to represent a new *Vogdesella* species but the material remains unrevised. *V? melvillensis* (c. 2.1mm), from the late middle Ordovician of the Franklin District, Canada, is included with uncertainty because of its pit-like S2, flattened lateral surface and subamplete outline. The inclusion of *V? praege* (c. 2.07mm) is also questionable. Pribyl's figured specimens (text-fig. 13, nos 1 (= holotype) and 3) appear to be internal moulds, and thus the external morphology of the species is poorly known although its outline, form and S2 are very like *Vogdesella dizrunensis* (0.95mm). *V. dizrunensis* spans the middle and upper Ordovician boundary in western Latvia, it has a flattened central area, S2 between the antero- and central dorsal regions, and is most similar to *V. germanica* (c. 0.67mm).

**Occurrence.** Middle Ordovician of Sweden (Jaanusson 1957, Schallreuter 1980b), northern Germany (= erratic boulders, Schallreuter (1972b), Latvia (Gailite 1975) and possibly North America (Copeland 1977b). An unpublished species is also present in the middle Ordovician of France (Vannier 1984).

In Britain, known from the Caradoc Series of Powys, Wales and Shropshire, England.
Vogdesella hemidiscus (Wade, 1911)  Pl. 29, figs 2-4, 6-9, 12.

1890a *Primitia mundula*, Jones, var. *cambrica*; Jones p. 5, pl. 4, fig. 7.

1911 *Melanella hemidiscus*; Wade, pp. 451, 452, figs 9a, 9b.


1934 *Jonesella hemidiscus* (Wade); Bassler & Kellett, p. 343.

**Holotype.** The location of the holotype is unknown and there may be a senior synonym. Jones (1890a, p. 5, fig. 7) described "*Primitia mundula var. cambrica*" from material sent to him by Mr. J. Bickerton Morgan, which he had collected from "dark shales of Bala age at Gwern-y-brain, Welshpool". Jones's figure (1890a, pl. 4, fig. 7) is like *Vogdesella* but his type material is untraceable. Wade (1911, p. 451) subsequently re-described the ostracodes from the Gwern-y-brain section and erected *Melanella hemidiscus*. The present author has not located Wade's material, which he possibly gave to the Powysland Museum, Welshpool (Dr. R. Cave, pers. comm.). A neotype was not selected as Wade's type material may yet be located.

**Material.** More than 100 calcite valves and external moulds. Much of the material is poorly preserved due to compaction.

**Diagnosis.** *Vogdesella* species with S2 indistinct and tear-drop shaped in anterior dorsocentral region, constricted dorsally sometimes into narrow furrow bisecting the two indistinct nodes; posterior node largest, elongated posteriorly.

**Description.** Valves very high. Outline postplete. LV about mid-height, HV posterior. Transverse convexity greatest dorsally, longitudinally about mid-length. Short hingeline. Cardinal corners fairly distinct, angles about equal.

Dorsum orthocline to hypocline and very steeply sloping to hinge. Marginal surface hypocline; steepest in the anterior. S2 usually faint but distinctly tear-drop shaped in anterior dorsocentral regions.
restricted dorsally forming indistinct furrow that bisects the two obsolete nodes; in lateral view they appear close to the hingeline. Node behind S2 is usually elongated posteriorly, but both join ventrally sometimes into indistinct swollen central area. Internally distinct sulcament developed. Valves smooth.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
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<th>HV</th>
<th>LV:HV</th>
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<td>0.47</td>
<td>6</td>
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<tr>
<td>NW 105</td>
<td>r</td>
<td>0.95</td>
<td>0.69</td>
<td>1.37</td>
<td>0.51</td>
<td></td>
<td>50b</td>
</tr>
<tr>
<td>NW 158/3</td>
<td>l</td>
<td>0.91</td>
<td>0.66</td>
<td>1.38</td>
<td>0.51</td>
<td>7,8,9,12</td>
<td>49c</td>
</tr>
<tr>
<td>NW 158/2</td>
<td>l</td>
<td>0.89</td>
<td>0.67</td>
<td>1.32</td>
<td>0.45</td>
<td>4</td>
<td>49c</td>
</tr>
</tbody>
</table>

**Discussion.** *V. hemidiscus* (c. 1.02mm) is smaller but otherwise similar to *V. subovata* (c. 1.44mm) from Sweden. The sulcus and nodes of *V. subovata* are more distinct, particularly the node behind S2 which is more posteriorly extended. *V. obscura* (c. 0.68mm) is smaller than *V. hemidiscus*, its outline subamplete, its S2 more distinct and open dorsally and its nodes are rounder.

**Occurrence.** *Onnia gracilis* and *O. superba superba* biozones (= mid and uppermost Onnian Stage, Caradoc Series) of Shropshire (locs 49b,c, 749a). Also from the *O. gracilis* Biozone (mid-Onnian) of the Welshpool District, Powys (locs 50a-c), including specimens collected by Cave (1965, fig. 3) from his locality 77: BGSK: A604, A605b, A605e, A608, A613, A614, A624, A625, A628, all from 1-1.5m above base of Pen-y-Garnedd Shale Member, Nod Glas Formation; mid-Onnian Stage (Caradoc) of the Gwern-y-Brain stream section (see loc. 50b). Also from the Nod Glas of Gwern-y-Brain are slabs SM A57004-5, SM A57014a,b, SM A5701 and BM I6056 on which *V. hemidiscus* is present.
Family SPINIGERITIDAE Schallreuter, 1980

**British genera.** Conchoprimitiella Schallreuter, 1980 and Spinigerites Schallreuter, 1980.


**Discussion.** The Spinigeritidae has been fully discussed by Schallreuter (1980b, p. 18). A flattened marginal surface and simple contact margin are features common to both the Spinigeritidae and Circulinidae. The main difference between these families is in valve form, spinigeritids being elongate (LV:HV = greater than 1.65), whilst circulinids are moderately high to very high (LV:HV = less than 1.65). The contact margin of spinigeritids lacks claudal sculptures and there is no overlap between the valves which simply lie against each other.

Retention of valves is unknown in spinigeritids (Schallreuter 1980b, p. 17).

**Occurrence.** Middle and upper Ordovician of Baltoscandia and North America (Schallreuter 1980b). In Britain Spinigeritidae are known from the Llandeilo, Caradoc and Ashgill series of Dyfed, South Wales and uppermost Caradoc of Powys, North Wales.
Genus CONCHOPRIMITIELLA Schallreuter, 1980

Type species. Original designation; Schallreuter 1980b, p. 21;
Conchoorimitiella eremita Schallreuter, 1980b, p. 21, pl. 4, fig. 4;
from the Sularp Shale, Diplograptus multidens Biozone, middle Ordovician
of Scania, Sweden.

Other species. C. dyfedensis sp. nov.; C. papilalata sp. nov.; C.
paucisulcata (Burr & Swain, 1965).

Diagnosis. Valves postplete and flattened in cross section. Ventral
and dorsal margins form acute angle with contact plane. Lateral surface
lacking sculptures but for weak sulcal depressions sometimes developed
anterior of mid-length. Valves smooth or with fingerprint-like surface
ornament.

Discussion. Conchoorimitiella has few distinguishing features and its
species are difficult to define. However, the virtual total lack of
valve sculpture enables the genus to be easily distinguished from other
Spinigeritidae (Schallreuter 1980b, p. 21). In both British species
sexual dimorphism can be detected from measurements of form (LV:HV).
Contrary to the condition in the related genus Spinigerites, where
heteromorphs are more elongate than tectomorphs (Schallreuter 1980b, pp.
19-20), heteromorphs of C. dyfedensis and C. papilalata have a higher
form than the elongate tectomorphs. The sex of the heteromorph is
unknown.

Occurrence. Middle and upper Ordovician of Baltoscandia (Schallreuter
1980b), upper Ordovician of Iowa, U.S.A. (Burr & Swain 1965) and upper
Llanvirn, Llandeilo and basal Caradoc series of Dyfed, Wales.
Conchoprimitiella dyfedensis sp. nov.

Pl. 29, figs 1, 5, 10, 11, 13, 15

Name. From the county of Dyfed, Wales; referring to its widespread distribution.


Holotype. CRJ SW214/1, teconomorphic left valve; Pl. 29, fig 11. Llandeilo 'Limestone', upper Llandeilo Series; quarry 600m NW of Pentre Davies Farm, Dryslwyn, 6.5km W of Llandeilo, Dyfed (loc. 17).

Material. Many hundreds of silicified valves.

Diagnosis. Valves up to 1.69mm long, rather high to moderately high and strongly postplete. Cardinal corners slightly rounded. Hingeline moderately short. Valves quite convex dorsally and without surface sculpture or ornament.

Description. LV and LD below mid-height. HV and HD posterior. Domicilium rather high to moderately high. Cardinal corners slightly rounded, both much greater than 90° anterior angle usually more obtuse than posterior. Valves most convex along dorsal margin. Lateral margin most convex in antero- and posterodorsal regions, becoming flatter ventrally where forming acute angle with contact plane. Valves smooth and flattened centrally.

Small instars tend to have a longer form than in adults.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
<th>Pl.29</th>
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<tbody>
<tr>
<td>CRJ SW054</td>
<td>h-r</td>
<td>1.69</td>
<td>1.09</td>
<td>1.55</td>
<td>1.60</td>
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<td>10,15</td>
</tr>
<tr>
<td>CRJ SW214/1</td>
<td>t-l</td>
<td>1.36</td>
<td>0.81</td>
<td>1.68</td>
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<td>1.35</td>
<td>0.86</td>
<td>1.57</td>
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<td>1.59</td>
<td>0.89</td>
<td>13</td>
</tr>
<tr>
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<td>t-r</td>
<td>1.31</td>
<td>0.80</td>
<td>1.64</td>
<td>1.26</td>
<td>0.73</td>
<td>1.73</td>
<td>0.84</td>
<td>1</td>
</tr>
<tr>
<td>CRJ SW214/2</td>
<td>t-l</td>
<td>1.26</td>
<td>0.76</td>
<td>1.66</td>
<td>1.18</td>
<td>0.69</td>
<td>1.71</td>
<td>0.73</td>
<td>5</td>
</tr>
</tbody>
</table>

All valves from the type locality (loc. 17).

Discussion. C. dyfedensis differs further from C. eremita (c. 0.82mm).
in being larger, having a slightly higher form, a much flatter central region and more convex dorsal margin.

Occurrence. *C. dyfedensis* is one of the most geographically widespread middle Ordovician British beyrichiopode species, occurring in the upper Llanvirn and Llandeilo series and Costonian Stage, Caradoc Series throughout Dyfed (locs 1b,c, 2a,b, 3, 4, 11a, 11c-h, 12a, 17, 18, 19, 20, 21a,b, 22, 24, 26b 28a,b).

2. *Conchoprimitiella papilalata* sp. nov. Pl. 29, figs 14, 16-20

Name. Latin 'papilio', butterfly and 'ala', wing; fancied resemblance of surface ornament to the veins of a butterfly's wing.

Holotype. CRJ SW057, tecnomorphic left valve; Pl. 29, figs 17, 18. Bryn-banc Limestone Member, Narberth Group, Costonian Stage, Caradoc Series; quarry 825m SSW of Henllan Lodge, Llandewi-Velfrey, 2.3km NE of Narberth, Dyfed (loc. 27b).

Material. 25 silicified valves.

Diagnosis. Valves upto 1.33mm long, moderately high to moderately long and slightly postplete. Cardinal corners quite distinct, posterior corner angle extremely obtuse, greater than anterior. Hingeline moderately long to moderately short. Valves most convex centrally above mid-height. Sulcal depression in anterior dorsocentral region, often with low, rounded presulcal node. Valve surface with fingerprint-like ornament.

Description. LV and LD about mid-height, HV and HD posterior. Domicilium moderately high to long. Valves most convex in central and anterocentral regions. Dorsal margin steepest in central dorsal region. Lateral margin forms very acute angle with contact plane in ventral and posterior regions. Sulcus shallow, does not reach hingeline, terminates above mid-height ventrally. Fingerprint-like surface ornament well developed.
**Measurements.**

<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>CRJ SW215/1</td>
<td>h-r</td>
<td>1.33</td>
<td>0.80</td>
<td>1.66</td>
<td>1.24</td>
<td>0.75</td>
<td>1.65</td>
<td>0.97</td>
<td>16 26a</td>
</tr>
<tr>
<td>CRJ SW215/2</td>
<td>t-r</td>
<td>1.31</td>
<td>0.69</td>
<td>-</td>
<td>-</td>
<td>0.64</td>
<td>-</td>
<td>0.73</td>
<td>27</td>
</tr>
<tr>
<td>CRJ SW215/3</td>
<td>t-l</td>
<td>1.15 *</td>
<td>0.60</td>
<td>-</td>
<td>-</td>
<td>0.55</td>
<td>-</td>
<td>-</td>
<td>20 27</td>
</tr>
<tr>
<td>CRJ SW057</td>
<td>t-lH</td>
<td>1.11</td>
<td>0.60</td>
<td>1.85</td>
<td>1.04</td>
<td>0.54</td>
<td>1.93</td>
<td>0.71</td>
<td>17 18 27</td>
</tr>
<tr>
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<td>t-r</td>
<td>1.00</td>
<td>0.56</td>
<td>1.17</td>
<td>0.95</td>
<td>0.51</td>
<td>1.86</td>
<td>0.69</td>
<td>14 26a</td>
</tr>
<tr>
<td>CRJ SW215/5</td>
<td>t-r</td>
<td>0.98</td>
<td>0.53</td>
<td>1.85</td>
<td>0.91</td>
<td>0.46</td>
<td>1.98</td>
<td>0.71</td>
<td>19 26a</td>
</tr>
</tbody>
</table>

**Discussion.** *C. papilalata* is similar to *C. paucisulcata* (c. 0.94mm), from the Maquoketa Formation (= Ashgill) of Iowa, U.S.A., in size and form, but *C. paucisulcata* is smooth. Burr & Swain (1965, p.22, pl. 2, fig. 20), figure a valve as *C. paucisulcata* which shows fingerprint-like surface ornament, but remark that this feature is rare. The specimen in question is similar to *C. papilalata* but has a greater anterior corner angle, weaker sulcus and is more postplete; it may form the basis of a closely related, new species.

**Occurrence.** Costonian Stage, Caradoc Series of Dyfed (loc. 26a,b, 27a,b, 28).

**Genus SPINIGERITES** Schallreuter, 1980

**Type species.** Original designation; Schallreuter 1980b, p. 18;
*Primitiella spiniger* Lindstrom, 1953, pp. 141-3, pl. 1, fig. 9; from the Sularp Shale, *Diplograptus multidens* Biozone, middle Ordovician of Fagelsang, Scania, Sweden.

**Other species.** *S. bellevuensis* Schallreuter, 1980; *S. hadros* sp. nov.

**Diagnosis.** (Slightly modified from Schallreuter 1980b, p. 18). Small to medium sized. Valves elongate and more or less postplete. Heteromorphic valves flattened, slightly postplete with a longer form than tecnomorphs. Sulcal depression weak and unclear with internal sulcament, situated in dorsal anterocentral region. Elongate swelling
occasionally developed anteriorly, between lateral and ventral surface. Short, posteriorly directed spine developed posteriorly. Valves smooth or punctate.

Discussion. The monotiopleurid *Spinopleura* Schallreuter, 1968 has a short posteroventral spine but differs from *Spinigerites* because it is weakly postplete, has a well developed sulcus, posteroventral lobe and steep marginal surface. *Spinigerites* differs from the closely related *Conchoprimitiella* by having valves which are more convex in cross-section, an anterior swelling between lateral and ventral surfaces, an anterocentral sulcus, a posterior spine and usually a sulcament.

For additional discussion of the genus see Schallreuter (1980b, pp. 18, 19).

Occurrence. Caradoc Series of Sweden (Schallreuter 1980b) and Ashgill Series of U.S.A. (Burr & Swain 1965). In Britain, found only in the uppermost Caradoc of Powys, Wales and Shropshire, England.

*Spinigerites hadros* sp. nov. Pl. 30, figs 1-10.

Name. Greek, 'hadros', well-developed; referring to the relatively large size attained by adults.

1890a *Primitia unicornis* (Ulrich); Jones, p. 7, pl. 4, figs 8-13.

1911 *Primitiella unicornis* Ulrich; Wade, p. 452, pl. 36, figs 4, 5.

1965 *Primitiella?* sp. (aff. *tenera* Linnarson); Cave, p. 287, (= SM A S7005, A 57014a,b, A 57027, A 59188).

Holotype. On BM 16056, heteromorphic left valve (calcite). Pen-y-Garnedd Shale Member, Nod Glas Formation (= *Onnia gracilis* Biozone, Onnian Stage, Cardoc Series), Gwern-y-Brain, c. 5km NW of Welshpool, Powys. Precise locality unknown.

The holotype was selected from numerous specimens on slab BM 16056, which is thought to represent Jones's (1890a) original material (see
Klimphores morgani for fuller discussion).

**Material.** About 100 calcite valves and external moulds of both dimorphs, some of which are distorted and compressed within the black shales.

**Diagnosis.** Valves up to 1.68 mm long, postplete, most convex centrally, most elevated posteriorly. No sulcus. Spine short and stout, situated in central posterior region. No anterior swelling. Valves smooth.

**Description.** Form of valves varies considerably (Text-fig. 24); heteromorphs rather long to very long, tecnomorhs high to moderately long. LV just ventral of mid-height. HV posterior. Hingeline moderately short to short. Anterior cardinal corner fairly distinct to slightly rounded, cardinal angle extremely obtuse, greater than the rounded posterior corner. In cross-section, valves most convex through mid-height. Angle between contact plane and dorsal and ventral margins more or less acute and equal throughout. Short, stocky spine developed about mid-height in central posterior region never projects beyond free margin in lateral view. Valves smooth, apparently lacking surface sculptures.

**Measurements.**

<table>
<thead>
<tr>
<th>No.</th>
<th>V</th>
<th>LV</th>
<th>HV</th>
<th>LV:HV</th>
<th>HL</th>
<th>Pl.30 loc</th>
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<tbody>
<tr>
<td>CRJ NW216</td>
<td>h-l</td>
<td>1.68</td>
<td>0.87</td>
<td>1.93</td>
<td>0.96</td>
<td>50b</td>
</tr>
<tr>
<td>BM I6056</td>
<td>h-l</td>
<td>1.51</td>
<td>0.78</td>
<td>1.94</td>
<td>0.93</td>
<td>7 50?</td>
</tr>
<tr>
<td>CRJ NW112</td>
<td>h-l</td>
<td>1.46</td>
<td>0.76</td>
<td>1.92</td>
<td>0.72</td>
<td>2 50b</td>
</tr>
<tr>
<td>CRJ NW114</td>
<td>t-r</td>
<td>1.40</td>
<td>0.84</td>
<td>1.67</td>
<td>0.66</td>
<td>1 50b</td>
</tr>
<tr>
<td>CRJ NW107</td>
<td>h-l</td>
<td>1.36</td>
<td>0.71</td>
<td>1.92</td>
<td>0.80</td>
<td>50b</td>
</tr>
<tr>
<td>CRJ NW111</td>
<td>t-l</td>
<td>1.29</td>
<td>0.80</td>
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<td>0.78</td>
<td>3-6 50b</td>
</tr>
<tr>
<td>on BM I6056</td>
<td>t-l</td>
<td>1.04</td>
<td>0.60</td>
<td>1.73</td>
<td>0.58</td>
<td>10 50?</td>
</tr>
</tbody>
</table>

**Discussion.** The sexual dimorphism of *S. hadros* is similar to that of *S. spiniger* (c. 1.17 mm) as outlined by Schallreuter (1980b); heteromorphs possess a longer form than tecnomorphs. Like *S. spiniger*,

O = Holotype

Gwern-y-Brain stream section (loc. 50b);
Onnian Stage, Caradoc Series of
Powys, Wales.

n = 104
the moult stages of ′S. hadros′ appear to overlap (Text-fig. 24) but possibly represent different ′populations′. ′S. hadros′ differs from the type species in size, by having a thicker, less elevated spine and lacking an anterior swelling between the lateral surface and ventral margin.

Occurrence. Onnia gracilis and O. superba superba biozones (= mid and uppermost Onnian Stage, Caradoc Series) of Welshpool, Powys and the Onny River, Shropshire.

O. gracilis Biozone of Welshpool: (locs 50a-c).

O. gracilis and O. superba superba biozones: BM I6056 and the material of Cave (1965, p. 287) were collected from loc. 50, Welshpool, Powys. Also known from locs 49b,c, Onny River section, Shropshire.
CHAPTER 3
ORDOVICIAN ERIDOSTRACA FROM ENGLAND AND WALES

Suborder ERIDOSTRACA Adamczak, 1961

Family ERIDOCONCHIDAE Henningsmoen, 1953
(nom. transl. Krandijevsky, 1958)


Diagnosis. (After Schallreuter 1968a, p. 113). Valves small (less than 1 mm long) or rarely medium sized (1-2 mm long), with one to eleven lamellae. Sulcus weak. Two dorsal nodes usually developed, one on either side of sulcus. Adventral sculpture situated some distance from free margin, developed as a smooth swelling with a row of spines or a swollen rib.

Discussion. Some authors have questioned the affiliation of the Eridostraca to the Ostracoda (Schmidt 1941, Hartmann 1963, Jones 1968, Langer 1973), but recent publications by Schallreuter (1977a, 1978) provide compelling evidence that eridostracans are true ostracodes, possibly related to the Podocopa Sars, 1866.

The Eridoconchidae differ from the Cryptophyllidae Adamczak, 1961 because the former possess an adventral sculpture (Schallreuter 1968a).

Occurrence. Middle Ordovician to Devonian of northern Europe, North America and possibly Australia (Jones 1968).
Genus ERIDOCONCHA Ulrich & Bassler, 1923

**Type species.** Original designation; Ulrich & Bassler 1923, p. 297; *Eridoconcha rugosa* Ulrich & Bassler, 1923, p. 296, fig. 14(9); from the Corryville Member, McMillan Formation, Maysvillian Stage (= upper part of Pusgillian Stage, Ashgill Series) of Cincinnati, Ohio, U.S.A.

**Other species.** *E. granulifera* Adamczak, 1961; *E. magna* Harris, 1931; *E. papillosa* Zagora, 1966; *E. papillosa aculeata* Poltnig, 1983; *E. plerilamella* sp. nov.; *E. simpsoni* Harris, 1931; *E. spinosa* Zagora, 1966; *E. papillosa nodosa* Poltnig, 1983; *E. sp. A* Jones, 1968.

**Diagnosis.** (Modified from Schallreuter 1968a). Usually umbonate. No distinct sulcus or nodes, internally a sulcament can be present. Seven to twelve lamellae, separated by U-shaped furrows.

**Discussion.** The upper Ordovician type species is poorly known. Schallreuter's (1968a) generic diagnosis is partly based on Zagora's (1966) description of *E. cf. rugosa* (= from the Middle Devonian of Thuringia) which possesses a sulcament. It is uncertain if *E. rugosa* develops this condition. Furthermore, Warshauer & Berdan (1982) have examined syntypes of the type species and record that they only have four lamellae and a short umbonal sulcus, whilst Ulrich & Bassler's (1923) type figure apparently shows seven lamellae. *E. plerilamella* has a maximum of twelve lamellae and the generic diagnosis has been modified accordingly. Jones (1968) regards the number of lamellae to be an unstable character on which to define a genus or species of Eridostraca. This may be so, especially as the similar genus *Cryptophyllum* may develop anything from six to thirteen or more lamellae. However, the U-shaped inter-lamella furrows and ridge-like adventral sculpture of *Eridoconcha* are particularly characteristic. A more accurate generic diagnosis awaits the re-description of the type and topotype material of *E. rugosa*.

**Occurrence.** Middle Ordovician of Wales, middle to upper Ordovician of
196

U.S.A. (Ulrich & Bassler 1923, Harris 1931), and the Devonian of Austria (Poltning 1983), Thuringia (Zagora 1966), Poland (Adamczak 1961) and possibly Australia (Jones 1968).

Eridoconcha plerilamella sp. nov. Pl. 30, figs 11-19.

Latin 'plerus', very many and 'lamella', thin plate; referring to the numerous valve lamellae.

1978a Cryptophyllus? sp. 1; Siveter, p. 47, pl. 1, figs 1, 2.

Holotype. CRJ SW223/3, silicified right valve; Pl. 30, figs 13, 17, 18; upper part of Narberth Group, Costonian Stage, Caradoc Series; quarry 245m N of Bighouse, Lampeter-Velfrey, 4.5km E of Narberth, Dyfed (loc. 28a).

Material. 70 silicified valves.

Diagnosis. Species of Eridoconcha with up to twelve ridge-like lamellae and anteriorly directed umbones which project far beyond hingeline. Valves up to 0.94mm long, complete to subamplete with cardinal corners hidden in lateral view. Surface smooth.

Description. Valves very high. LV is ventral. HV is anterior. Domicilium very high to high and amplete. LD a little ventral of mid-height. HD about mid-length. In cross-section lateral surface most elevated and convex above mid-height, ventral of umbones. Sulcus is lacking. Valves poorly preserved internally; development of sulcament undetermined. Umbones large, directed anteriorly, with the nauplioconch forming a smooth, rounded 'capping'. Hingeline straight, short and rarely preserved (Pl. 30, figs 11, 12).

Largest specimens (= presumed adults) with ten (Pl. 30, fig. 15) to twelve (Pl. 30, fig. 13) lamellae that are distally ridge-like (= adventral sculpture) at a short distance from each successive free margin. Lamellae occasionally of variable width within an individual valve. In early ontogeny, furrows between successive lamellae are
somewhat V-shaped, but become increasingly U-shaped towards adult.

Measurements.

<table>
<thead>
<tr>
<th>No.</th>
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<th>HV</th>
<th>+HH</th>
<th>LV:HV</th>
<th>LD</th>
<th>HD</th>
<th>LD:HD</th>
<th>HL</th>
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<td>0.73</td>
<td>0.61</td>
<td>1.28</td>
<td>0.87</td>
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<td>1.50</td>
<td>0.44</td>
<td>13,17,18</td>
<td>28a</td>
<td></td>
</tr>
<tr>
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<td>L</td>
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<td>0.83</td>
<td>0.63</td>
<td>1.12</td>
<td>0.85</td>
<td>0.58</td>
<td>1.47</td>
<td>0.51</td>
<td>11,12</td>
<td>28a</td>
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<tr>
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<td>r</td>
<td>0.86</td>
<td>0.73</td>
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<td>0.78</td>
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<td>-</td>
<td>1.21</td>
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<tr>
<td>CRJ SW223/4</td>
<td>r</td>
<td>0.76</td>
<td>0.66</td>
<td>0.53</td>
<td>1.15</td>
<td>0.71</td>
<td>-</td>
<td>0.35</td>
<td>14-16</td>
<td>28a</td>
<td></td>
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</tr>
</tbody>
</table>

+HH = height to hingeline.

Discussion. The mechanism of growth in *E. plerilamella* and the middle Ordovician North American *E. magna* and *E. simpsoni*, is probably similar to that outlined by Schallreuter (1977a) for *Cryptophyllus gutta*. Schallreuter, 1968. Each new valve develops a new hinge, the previous hinge becomes obsolete and migrates away from the contact plane as instars are added. Thus lamellae of juvenile instars do not extend to the contact plane.

*E. plerilamella* develops more lamellae than any other *Eridoconcha* species. *E. magna* (1.98mm; LV:HV = 1.43) has up to eleven lamellae, is larger than *E. plerilamella*, with a longer form, subquadr rate outline and central dorsal umbones. *E. simpsoni* (c. 0.60mm; LV:HV = 1.20) is similar in form to *E. plerilamella*, but develops ten lamellae, is smaller and its umbones are more centrally situated.

Occurrence. Upper Llandeilo Series and Costonian Stage, Caradoc Series of Dyfed (locs 23, 26b, 27b, 28a,b).
CHAPTER 4

STRATIGRAPHICAL DISTRIBUTION OF ORDOVICIAN BEYRICHIOCOPA
FROM ENGLAND AND WALES

Since Siveter's (1978a) pilot study on British Ordovician Ostracoda, our knowledge of these largely undescribed faunas has steadily increased (Jones 1984, Jones & Siveter 1983, Schallreuter & Jones 1984, Schallreuter & Siveter 1983, Siveter 1982b, 1982c, 1983, 1985). The Beyrichiocopa are the most significant faunal element amongst Ordovician ostracodes from England and Wales, comprising some 90% of the total fauna. They appear most geographically widespread in South Wales, which yielded diverse silicified faunas; however this may simply reflect the concentration of sampling in this area undertaken in the present study. Unlike their Silurian counterparts, whose biostratigraphy is now known in some detail (Siveter 1978b), the biostratigraphy of Ordovician beyrichiocopes from England and Wales is not as yet known in sufficient detail to be of use for accurate stratigraphic correlation. This situation largely reflects more imprecise stratigraphic control, often because numerous Ordovician localities are fault bounded and correlation with type sections is therefore difficult. Many of the ostracodes have extended stratigraphic ranges which reflect their fairly slow evolution. Never-the-less, some palaeocopae do have restricted ranges and can be used as marker species. Text-figs 25 and 26 summarise the biostratigraphy of Llanvirn-Caradoc beyrichiocopes from England and Wales. Represented are the total ranges for the species figured herein, with a concentration on the deposits of South Wales and the Welsh Borderland.
During Homoeceras S. (Schalxrauteria J. S.) superciliosa Piritepsis IRf. sp. nov., TadelliOae Ogmoopsis 0. (Quadridigitaa Sigmoposis 5. (Sigmoposis)
TEXT-FIG. 26.
Llanvirn faunas

It is significant that many ostracode assemblages come from Llandeilo-Ashgill sand and carbonate dominated sequences when the contrast between shelly and graptolitic facies was strongest (Siveter 1978a). Compared with Baltoscandian carbonate/shale successions, where beyrichioptes are abundant throughout the Ordovician, the English and Welsh ostracodes are virtually absent in the Arenig and most of the Llanvirn. The oldest known fauna of significance comes from the Ffairfach Group (= upper Llanvirn) near Llandeilo, Dyfed. It consists predominantly of the paleoconchs Brephocharitaeis complicata, Ceratopsis exaggerata, Gunnaropsis sp. nov. 1, Talinnella? tomacina and Vittella fecunda, together with the binodiconchs Bullaeferum llandeiloensis, Conchoorimithiella dyfedensis, Klimphores paraspinous, Laterophores elevatus and Pariconchoprimitia improba.

As with the concomitant trilobites and brachiopods (Whittington et al. 1984), there is little faunal changeover of ostracodes at the Llanvirn/Llandeilo series boundary; except for G. sp. nov. 1 and K. paraspinous most species range into the overlying Llandeilo. Known ostracode material from both the Arenig and Llanvirn of the Welsh Basin is thus very scarce and of little value for biostratigraphy. Gracquina vannieri is the only other known Llanvirn ostracode from southern Britain. Originally described as 'Cerninella sp.' from the BGS Great Paxton Borehole, Huntingdonshire (Rushton & Hughes 1981), it represents the only occurrence of Gracquina outside the Ibero-Armorican region.

Llandeilo faunas

The majority of known Llandeilo beyrichioptes occur as excellently preserved silicified faunas from South Wales. The carbonates in which they occur outcrop in an arcuate belt extending from the type Llandeilo area to Carmarthen, and westwards into the more shelf-margin and basin
facies, found near Haverfordwest and Aberediddy Bay. Sections in the type area only yield silicified ostracodes in the lower and middle Llandeilo, processed samples from the upper Llandeilo proving to be barren. No single ostracode species characterises either of these subdivisions in the type area, although palaeocopes such as Gunnaropsis cristata, Homeokiesowia epicopa and Gen.? et sp. nov. B are typical Llandeilo forms. Seven kilometres west of Llandeilo, near Dyfed (loc. 17), an abundant upper Llandeilo assemblage occurs, which supplements the lack of material from the upper Llandeilo Series of the type area. Numerous beyrichiocopes are present, including Ceratopsis britannica, G. cristata, Homeoceratopsis iubata, Easchmidtella elementa and Pseudurichia conispina; only the gunnaropsine Cymabolbina susanae is restricted to the upper Llandeilo Series and is thus an important marker for this horizon in Dyfed.

Further west, in the Llan-mill/Lampeter-Velfrey district near Narberth, a group of limestones and flags (= Narberth Group of Addison 1974) in part upper Llandeilo and probably basal Caradoc age (= Costonian Stage, see Addison in Williams et al. 1972) yield abundant beyrichiocopes. Typically Gunnaropsis narberthensis, Latebina pseudantra, Pedomphalella expraeputia, Pseudurichia aequinoda, Severopsis severopsis and Varilatella (Varilatella) dissita occur throughout the group. Still further west, the more basinal Castell Limestone (= middle/upper Llandeilo Series) yields a poorly silicified fauna in which, apart from the ubiquitous Vittella fecunda, ostracodes are only identifiable to generic level (Ceratopsis, Conchoprimitiella, Laterophores and Pseudurichia).

North east of the type Llandeilo area, near Builth, a geographically restricted ostracode assemblage occurs, more or less confined to the dark graptolitic shales of the low-mid Glyptograptus tertiusculus Biozone (= approximately lower Llandeilo in age). The fauna consists of
Schallreuteria (Schallreuteria) builthensis, Cymabolbina acanthodes and Conspicillum ulularum. Conspicillum bipunctatum is also present, but ranges through to the middle/upper Llandeilo and possibly into the basal Caradoc Series (= Hemagruptus gracilis Shales). Piretopsis (Protallinella) ranuncula occurs in the G. teretiusculus Shales at Builth, but is most common in the Llandeilo/basal Caradoc series of Dyfed.

Correlation between most Llandeilo sequences sampled (Text-fig. 1) should be possible when detailed logging of the sections has been undertaken. However, recognition of the lower and middle Llandeilo Series using ostracodes is problematical at the moment, since no beyrichiocope exists as a diagnostic marker for either horizon; the upper Llandeilo and basal Caradoc series are more promising in this respect. Longer ranging forms such as B. complicata, Ceratopsis coactilis, Conchoprimitiella dyfedensis, Duriogia triforsa, H. iubata, Paraconchoprimitia improba and P. (P.) ranuncula are geographically widespread but less useful for correlation. Three beyrichicopes from Dyfed also occur in the sand/silt/shale sequence of Llandeilo age in the Shelve Inlier, Shropshire. B. llandeiloensis, L. elevatus and Paraconchoprimitia oscillata occur in the Llandeilo Series of Dyfed and the middle/upper Llandeilo of Shelve.

As the majority of Llandeilo beyrichiopes are new taxa, they provide little assistance at present for international correlation. One exception exists: Pseudbollia aff. P. subaequata from Narberth (= upper Llandeilo/basal Caradoc age) is very similar to forms described as 'P. subaequata' from the Decorah Formation of Iowa, U.S.A. (= approximately Soudleyan Stage, Caradoc Series), and may provide the first link at specific level between middle Ordovician ostracodes from North America and Britain.
Caradoc faunas

The Narberth Group of Dyfed (see Addison 1974) spans the Llandeilo/Caradoc series boundary, and is apparently of Costonian age in its youngest part. The spinigeritid *Conchoprimitiella papilalata* and the ctenonotellid *Varilatella (Redacta) coronata* are useful markers for this part of the group. Furthermore, *Piretopsis (Protallinnella) salopiensis*, a form previously restricted to the Costonian Stage of Shropshire (locs 30-32), occurs at the same horizon, thus giving weight to the proposition that the Narberth sequence may reveal the base of the Costonian (Whittington et al. 1984, p. 26) (its base is unconformable in the type area of South Shropshire).

More than 20 beyrichiocene species range into the Costonian from the underlying Llandeilo in Dyfed (Text-figs 25, 26). Most are unknown above the base of the Harnagian Stage. This may be facies related as many of the sampled Llandeilo and basal Caradoc (= Costonian) sequences are overlain by dark graptolitic shales of Harnagian age, which lack ostracodes and presumably reflected a detrimental change in the environment after the early Caradoc transgression. *V. (V.) dissita* and *Histina xanios* are present in the Llandeilo of Dyfed and range into the overlying Costonian but also occur in the contemporaneous Spywood Member of the Shelve Inlier.

Beyrichiocopes of post-Costonian age are scarce in South Wales. Some of the pre-Costonian forms are found in the Harnage Shales of South Shropshire, notably *D. triformosa*, *P. conispirina* and *V. fecunda*. Other representatives characteristic of the Harnagian Stage in Shropshire include *V. (V.) bulbosa*, *Ulrichia? bicornis*, Gen. et sp. nov. A and *Crescentilla* sp. nov. 1, a genus previously restricted to the Caradoc of Bohemia. *Ommoopsis (Quadridigitalis) siveteri* is present in the same ostracode assemblage but also occurs in the older Spywood Member at Shelve.
By post-Harnagian times many palaeocope genera were extinct; notably (except for Harperopsis) members of the Gunnaropsinae are absent. Harperopsis bicuneiformis, H. decorata and H. scripta are the only gunnaropsines recorded from North Wales. H. scripta is a particularly characteristic form, found in association with U? bicornis, O.(O.) siveteri and Sigmoopsis (Sigmoopsis) duftonensis in Shropshire (= Harnagian), and with H. decorata and Schallreuteria (Schallreuteria) superciliata in North Wales (= Longvillian/Soudleyan stages). H. decorata and H. scripta are frequently confused by authors recording faunal lists (e.g. Brenchley 1978, Lockley 1980a) or are merely called 'Tallinnella' sp. H. decorata is the only ostracode recorded from the upper part of the small outcrop of Pontesford Shales (= Soudleyan) in Shropshire.

In northern England a Caradoc ostracode association is present in the Cross Fell Inlier (= Longvillian-Woolstonian). Representatives include the ubiquitous H. scripta and S. (S.) superciliata, Sigmoopsis (Sigmoopsis) duftonensis, Rogerella melmerbvensis, Varilatella (Redacta?) sp. nov. 2 and ?Pseudulrichia marrii. A species close to H. scripta is also present in the contorted Drygill Shales (= Longvillian) of the northern Lake District.

No Actonian or Onnian palaeocopes are known. The youngest ostracode fauna of importance is the binodicope assemblage of Klimphores morgani, Spinigerites hadros and Vogdesella hemidiscus, which occurs in the Pen-y-Garnedd Phosphorite and Shale at Welshpool, Powys and in the type Onnian of the Onny River section, Shropshire. Both occurrences are of mid-uppermost Onnian age.

Correlation using late Caradoc beyrichiocopes is unpromising since relatively few forms exist and they are mainly long ranging. An exception is the Onnian fauna described above. Costonian and Harnagian beyrichiocopes are more abundant with shorter ranges and have better
potential for biostratigraphy.

Ashgill faunas

Ashgill beyrichiocopes are as yet undescribed from Britain, but the present study has shown that abundant silicified faunas exist in the lower part of the Ashgill Series (e.g. Birdshill and Crug limestones, both probably of Pusgillian age, Dr. M.G. Bassett pers. comm.) in South Wales. A well preserved silicified assemblage of more than 25 ostracode species was extracted from limestones at Dryslwyn Castell, west of Llandeilo, Dyfed (see Appendix). The limestones, originally thought to belong to the Llandeilo Series (cf. Addison 1974, p. 36) are of Ashgill age based on ostracodes (herein) and also conodonts (Drs R.J. Aldridge and M.G. Bassett, pers. comm.). The beyrichiocope assemblage is most similar to that found in the Portrane Limestone (= Cautleyan Stage) near Dublin, Ireland (Mr. R. Orr, pers. comm.). The Dryslwyn Castell ostracode assemblage is almost entirely Baltic in affinity. Several of these species, such as Platvbolbina (Reticulobolbina) spongiosoreticulata Schallreuter, 1972 and Uhakiella magnifica Sarv, 1959 are conspecific with material described from northern Germany (= erratic boulders) and the Baltic respectively. The fauna awaits description (Jones & Siveter in prep.) but the Ashgill ostracodes of South Wales may have potential for correlation with regions outside Britain.

Other silicified beyrichiocope faunas from southern Britain are known from the Cautley Mudstones (Cautley Inlier) and Keisley Limestone (Cross Fell Inlier), northern England, and possibly the Rhiwlas Limestone of North Wales. Mould faunas also occur, such as Uhakiella stranulata (McCoy, 1851) from the Applethwaite and Torver formations (= Cautleyan Stage) of the Coniston Limestone Group (McNamara 1979), together with an undescribed species of Euprimites. Species of Hippula, Platvbolbina and
Quadritia are also present in mudstones of Rawtheyan age from the Cross Fell Inlier, but again await description.
Shallow-water shelf faunas, such as beyrichiocope ostracodes, are potentially sensitive indicators of provincial affinities (Cocks & Fortey 1982), since in many cases they were probably depth, temperature and possibly substrate dependant. Middle to late Ordovician beyrichiocope faunas from England and Wales are typically associated with shelf-sea benthos such as trilobites and brachiopods and should help us understand more about the palaeogeographical position of southern Britain during the Ordovician. Schallreuter & Siveter (in press) have discussed in detail the potential ostracodes have for dispersal; benthic forms have no known pelagic larval stage.

In early Ordovician times (Arenig and lower Llanvirn series), faunal and facies distributions indicate that southern Britain (Wales, Welsh Borderland and northern England) was in all likelihood part of the high latitude Gondwana plate (Cocks & Fortey 1982; see Text-fig. 27), and separated from the mid-latitude Baltic plate by an oceanic barrier (Tornquist's Sea) to faunal migration. A North American plate straddled the palaeoequator at this time, separated from Gondwana and Baltica by the Iapetus Ocean. Schallreuter & Siveter (in press) have shown that ostracode distributions support other biogeographic evidence that Tornquist's Sea had contracted by the mid to late Ordovician, and that the Baltic and North American plates may have been closer together than had hitherto been supposed.

British ostracode faunas are notably deficient in the early Ordovician. One of the oldest known faunas is that from the Great Paxton Borehole, Huntingdon, which is dominated by the palaeocopae Gracquina, an
TEXT-FIG. 27. Positions of continents and sedimentary facies of the area surrounding Britain in Arenig times (after Cocks & Fortey 1982). Gondwana = Armorica, Iberia, Bohemia, Africa, eastern Newfoundland and southern Britain. Baltica = Scandinavia (except for a slice of western Norway), the Russian Platform southwards to Poland and eastwards to the Urals. North America = most of Canada and USA (except for parts of the Atlantic seaboard), western Newfoundland, Greenland, northern Britain, a small slice of western Norway and Spitzbergen.
endemic Gondwanan genus recently described from the Llanvirn Series of France and Spain (Vannier 1984). The upper Llanvirn fauna described herein, from the Ffairfach Group of South Wales, has surprisingly few endemic genera. Bullaeferum, Laterophores and Pariconchoprimitia are all known from Gondwana (Vannier 1984) and Baltica (Schallreuter 1968c, 1969, 1980b). The distinctive genus Ceratopsis also makes its first appearance in the Welsh Basin at this time. It is particularly characteristic of mid to late Ordovician sequences in U.S.A. (Warshauer 1975, Warshauer & Berdan 1982), but is not known from the Baltic or central/southern Europe. Our knowledge of British Llanvirn ostracodes is poor; relatively few forms are present, which make their potential for biogeography difficult to assess. However, it is clear that even as early as the Llanvirn, faunal links between southern Britain and the Gondwanan and Baltic plates were already established.

By Llandeilo times about 30 ostracode genera are known to occur in the sand and carbonate dominated sequences of South Wales. Ten of these genera are endemic to the Welsh Basin and mainly belong to the Gunnaropsinae, a palaeocope subfamily restricted to southern Britain throughout the Ordovician. Other endemic forms include the ctenonotellids Brephocharieis, Homeoceratopsis, Varilatella (Varilatella) and Varilatella (Redacta), the latter two being homeomorphs of the older Baltic genera Tallinnella Jaanusson, 1957 and Rigidella Öpik, 1937 respectively. The circulinid Conspicillum is also restricted to South Wales. The remaining southern British genera have a more cosmopolitan distribution: six are of Baltic affinity (mainly palaeocopes, eg. Homeokiesowia, Vittella and Klimhores), five occur in the Baltic and North America (mainly binodicopes, eg. Conchoprimitiella, Pedomphalella and Pseudbollia), two are known from the Ibero-Armorican region and the Baltic (Laterophores and Pariconchoprimitiella), and Ceratopsis and Eridoconcha have previously been described only from the
middle and upper Ordovician of North America (Warshauer & Berdan 1982, Harris 1931). Also present in the Welsh Basin are *Duringia*, known elsewhere from Canada (Copeland 1982) and Thuringia (Schallreuter 1984b), and *Hastatellina* which also occurs in Bohemia, France and possibly the U.S.A. (Warshauer & Berdan 1982).

It is apparent that by Llandeilo times links between ostracode faunas of the Welsh Basin and those on the North American and Baltic plates were already present (herein and Schallreuter & Siveter, in press), thus dispelling the assumption made by McKerrow & Cocks (1976) and Cocks & Fortey (1982) that ostracodes were endemic across the North Atlantic region in the Ordovician. Schallreuter & Siveter (in press) have shown that numerous cosmopolitan ostracode genera are present on both the North American and 'European' sides of the Iapetus Ocean by the middle to late Ordovician.

The biogeographic affinities of Llandeilo ostracodes from South Wales are summarised in Text-fig. 28. The Welsh faunas show closest affinity with those from Baltoscandia, but faunal exchange with North America was possibly even at specific level. The binodicope *Pseudbollia* aff. *P. subaequata* (Ulrich, 1894), from the Llandeilo and basal Caradoc series of South Wales, is closely similar (possibly conspecific) to forms described as *P. subaequata* (see Kay 1934, pl. 44, figs 15, 16) from the Decorah Formation (approximately Soudleyan Stage, low Caradoc Series), Iowa, U.S.A.

According to ostracode evidence, contact between southern Britain and Gondwana was still apparent in the Llandeilo, although it is significant that nearly all the genera endemic to the Ibero-Armorican region (cf. Vannier 1984) are absent in the Llandeilo-Ashgill series of southern Britain. It would appear that even by the Llandeilo, southern Britain was no longer so closely associated with Gondwana as had been the case in the Arenig to early Llanvirn.
TEXT-FIG. 20. Diagram showing relative resemblances at generic level of beyrichiocope ostracodes from the Llandeilo Series of South Wales to those of other areas. The scale ranges from a total of eleven genera in common in Baltoscandia to only two in Bohemia/Thuringia.
Ordovician plate reconstructions by Keppie (1977, fig. 1), based on faunal and palaeomagnetic data, indicate that southern Britain was part of a microplate, the Avalon Prong, together with southern Ireland, southeast Newfoundland, the Boston seaboard and the southeast Appalachians. This was in close proximity to Gondwana in the Arenig and moved northwards (into more intermediate latitudes) approaching Baltica and North America during Llanvirn to Caradoc times. Llandeilo ostracodes from southern Britain and southeast Newfoundland (Cobbs Arm Limestone) have little in common (studies by the present author), but Welsh beyrichiocide faunas would indicate that southern Britain had moved closer to Baltica and North America during Llandeilo times than has previously been suspected.

Certainly by the Caradoc other benthos such as trilobites (Whittington & Hughes 1972) and brachiopods (Williams 1973) from southern Britain were also very similar to those of Scandinavia. The ostracodes behave similarly, becoming more cosmopolitan throughout Caradoc (Text-fig. 29) and Ashgill times. Earliest Caradoc (Costonian Stage) ostracode faunas of southern Britain are essentially the same as those present in the Llandeilo Series except for the additional occurrence of Ommoopsis, a genus known from the lower to middle Ordovician of Baltoscandia, Bohemia and the Armorican Massif. By the Harnagian Stage, breakdown of any remaining ostracode provinciality continued and was enhanced by the disappearance of most of the remaining gunnaropsines (Gunnaropsis, Latebina and Severopsis). Numerous other beyrichiocide taxa present throughout the Llandeilo and basal Caradoc series also disappear. The Baltoscandian genus Sigmoopsis appears at this time, as does the Bohemian bino dicope Crescentilla. Late Caradoc beyrichiocopes are sparse in Britain, but again, are mainly of Baltoscandian affinity (eg. Klimphores, Schallreuteria and Sigmoopsis). However, the binodicopes Pseudulrichia, Spinigerites and Vogdesella also
TEXT-FIG. 29. Diagram showing pandemic/endemic ratios for beyrichiocene ostracodes from southern Britain through Ordovician and early Silurian time; u. L.I = upper Llanvirn Series; l.L, m.L and u.L = lower, middle and upper Llandeil Series respectively. Stages of the Caradoc Series; Co = Costonian, Ha = Harnagian, So = Soudleyan, Lo = Longvillian, Wo = Woolstonian, Ma = Marshbrookian, Ac = Actonian, On = Onnian. Stages of the Ashgill Series; Pu = Pusgillian, Ca = Cautleyan, Ra = Rawtheyan, Hi = Hirnantian. Llandov. = Llandovery Series.
occur in Baltoscandia and North America. Curiously, *Rogereella*, a
binodicope previously restricted to the Caradoc Series of France and
Portugal (Vannier 1984), is present in the Longvillian-Woolstonian
stages of the Cross Fell Inlier, northern England. By late Caradoc
times, only two genera are endemic to southern Britain, *Harperopsis* and
*Varilatella*.

By early Ashgill times 90% of ostracode genera from the Welsh Basin
were pandemic in their distribution (Text-fig. 29), represented by
cosmopolitan forms such as *Brevidorsa*, *Platvbolbina*, *Pygoconcha* and
*Tetradella*, all of which are known from late Ordovician erratics of the
Baltic, and the Ashgill Ellis Bay and Vaureal formations of Anticosti
Island, Canada (Copeland 1970, 1973). At least four palaeocope species
from South Wales are conspecific with described forms from the late
Ordovician of the Baltic (*Gellensia nodoreticulata*, *Piretia rugosa*,
*Platvbolbina* (*Reticulobolbina*) *spongiosoreticulata* and *Uhakiella*
magnifica, see Appendix). *Steusloffina cuneata*, recently recorded from
late Ordovician/earliest Silurian of Anticosti Island (Copeland 1983)
and known from the Ashgill Brachiopodskiffer of Scania (Troedsson 1918)
is also present in South Wales. The majority of Ashgill ostracodes from
southern Britain are of Baltoscandian affinity and mirror the
relationships shown by trinucleid trilobites (Owen 1980) and brachiopods
(Cocks & Fortey 1982, p. 473) which were most similar, even at specific
level to those of Scandinavia.

Ostracodes support the notion of Cocks & Fortey (1982) that by mid to
late Caradoc and certainly by Ashgill times, Tornquist's Sea was
insignificant as a faunal barrier, and that southern Britain was in
relatively close proximity to the Baltic plate. The numerous
cosmopolitan ostracode genera now known to occur in North America and
the Baltic/southern Britain in mid to late Ordovician times
(Schallreuter & Siveter, in press) would also support the thesis of
Cocks & Fortey (1982, p. 472) that even by early Caradoc times the "Iapetus Ocean was no longer the barrier for faunal interchange it had been earlier". The palaeogeography of southern Britain, Baltica, North America and Gondwana during the late Ordovician was probably similar to that illustrated by Cocks & Fortey (1982; see Text-fig. 30) for earliest Silurian times. Interestingly, beyrichiacean ostracode faunas of the Llandovery/Wenlock series of southern Britain possibly show a return trend towards endemism, like those documented by Copeland (1980) and Copeland & Berdan (1977) across the areas of the Iapetus Ocean recorded in the early Silurian successions of the Appalachians.

A detailed biostratigraphic assessment of British Ordovician and Silurian ostracodes will doubtless confirm recent palaeogeographic reconstructions (Cocks & Fortey 1982) based on faunal relationships of other invertebrate groups. The details of this study will be published elsewhere (Jones & Siveter, in prep.).
TEXT-FIG. 30. Probable palaeogeography during the late Ordovician and early Silurian times (after Cocks & Fortey 1982).
GENERAL SUMMARY

This thesis monographs Llandeilo and Caradoc beyrichiocoep Ostracoda of England and Wales. The Palaeocopa (Chapter 1) and Binodicopa (Chapter 2) make up some 90% of the known ostracode fauna. A single species of eridostracan (Eridoconcha, Chapter 3) is also present. The remaining ostracodes belong mainly to the largely undescribed Podocopa (eg. Medianella) and Platycopha (eg. Ordovizona).

The British Ordovician displays markedly contrasted facies and the benthic ostracode assemblages belong to the trilobite-brachiopod shelly associations and are rare in basinal facies. It is significant therefore that many of the Welsh Basin ostracode assemblages come from the sand- and carbonate-dominated Llandeilo-Ashgill sequences, when contrast between shelly and graptolitic facies was strongest. Beyrichiocoep ostracodes are lacking in the Arenig and scarce in the Llanvirn. The oldest known fauna from the Welsh Basin is that of the Ffairfach Group (upper Llanvirn), Dyfed. In the Llandeilo, about 30 beyrichiocoep genera are present, mostly extracted from silicified limestones of South Wales. Caradoc ostracodes mainly occur as mould faunas, especially in the Welsh Borderland, North Wales and northern England (Cross Fell Inlier). Although Caradoc faunas are generally less diverse and more infrequent than in the underlying Llandeilo, palaeocophs such as Piretopsis and Harperopsis often cover entire bedding planes (see frontispiece). British Ashgill ostracodes remain poorly known, although a superb silicified assemblage is present in South Wales (see Appendix). Other Ashgill faunas also occur in the Lake District, and Cautley and Cross Fell inliers of northern England.

Llandeilo and Caradoc beyrichiocoepes have potential for local stratigraphic correlation in England and Wales (Chapter 4). Certain
ostracodes have restricted stratigraphic ranges and may, for example, prove useful in defining the base of the Costonian Stage, basal Caradoc Series in South Wales. The potential that ostracode species have for inter-regional correlation is less promising. Ashgill ostracodes may be more useful because certain species described from Baltoscandia are known to occur in South Wales.

British beyrichiocene faunas support other biogeographic evidence that during Llandeilo to Ashgill times southern Britain moved northwards into more intermediate latitudes, towards the Baltic and North American plates. This is indicated by a progressive breakdown in ostracode provinciality throughout the Ordovician. Contrary to recent opinion (McKerrow & Cocks 1976, Cocks & Fortey 1982) ostracodes were not endemic across the North Atlantic region at this time.
APPENDIX
OSTRACODA FROM THE ASHGILL SERIES OF WALES

A silicified ostracode fauna was extracted from Ashgill limestones of Dyfed, Wales. Time did not allow a comprehensive study of the fauna but a provisional list of the ostracode taxa and their distribution is presented below (Text-fig. 31).

ASHGILL LOCALITIES
1. Birdshill: Quarry 200m NW of Birdshill Farm, 2.5km WNW of Llandeilo, Dyfed, SN 6032 2297. Birdshill Limestone, Pusgillian Stage, Ashgill Series (Williams et al. 1972).
2. Crûg: Overgrown quarry 75m E of Crûg Farm, 0.5km NW of Llandeilo, Dyfed SN 6270 2304. Crûg Limestone, Pusgillian Stage, Ashgill Series (Dr. M.G. Bassett, pers. comm.).
3. Dryslwyn Castell: Overgrown quarry at base of castle mound, 400m SW of Ty-castell, Dryslwyn, 7.5km W of Llandeilo, Dyfed, SN 5546 2023.

Ostracodes indicate an Ashgill age.
<table>
<thead>
<tr>
<th>OSTRACODA</th>
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<tbody>
<tr>
<td><strong>PALAEOCOPA</strong> Henningsmoen, 1953</td>
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<tr>
<td>Cystomatochilina sp. nov. 1</td>
<td></td>
<td></td>
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<tr>
<td>Distobolbina cf. bispinata Schallreuter, 1977</td>
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<td>Gellensia nodoreticulata Schallreuter, 1982</td>
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<td>Gryphiswaldenia plicata Schallreuter, 1969</td>
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<td>Hesperidella sp. nov.</td>
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<td>Platybolbina (Platybolbina) cf. plana (Krause, 1889)</td>
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<tr>
<td>Platybolbina (Reticulobolbina) spongiosoreticulata Schallreuter, 1972</td>
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<td>Tetradella egorowi Neckaja, 1952 subsp. nov.</td>
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<tr>
<td>Uhakiella magnifica Sarv, 1959</td>
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<td><strong>BINODICOPA</strong> Schallreuter, 1972</td>
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<td>Klimphores sp.</td>
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<td>Gen. et sp. nov. (= a circulinid)</td>
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<td><strong>LEIOCOPA</strong> Schallreuter, 1972</td>
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<td>Brevidorsa sp.</td>
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<td><strong>ERIDOESTRACA</strong> Adamczak, 1961</td>
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<td>Eridoconcha sp.</td>
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<tr>
<td>Pygoconcha sp. nov.</td>
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<td><strong>PLATYCOPA</strong> Sars, 1866</td>
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<td>Gebeckeria dryslwynensis Schallreuter &amp; Jones, 1984</td>
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<td>Spinopleura sp. nov.</td>
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<tr>
<td><strong>PODOCOPA</strong> Sars, 1866</td>
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<tr>
<td>Pullvillites sp.</td>
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<td>Steusloffina cuneata (Steusloff, 1895)</td>
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<td>X</td>
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<tr>
<td>podocope gen. et sp. indet. 1</td>
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**TEXT-FIG. 31.** Provisional list of Ostracoda from the Ashgill Series of Wales. See Appendix for localities.
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edited by R. H. Bate, J. W. Neale, Lesley M. Sheppard
and David J. Siveter

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The front cover shows a male right valve and soft parts, internal view, of *Caboncypris nunkeri* De Deckker, 1982
Genus **HARPEROPSIS** Pribyl, 1966

Type-species (by original designation): **Tetradella scripta** Harper, 1947

**Diagnosis:** Large, complete, quadrilobate tetradeild; having short anteroventral connecting ridge (relict histium) between connecting lobe and velum. L2 short, connects near base of L1; L1, L3, L4 strongly developed, ridge like, nearly vertical, projecting above dorsum; L3 with dorsal bifurcation, giving smaller cusp nearer dorsum. Velum as well developed (-inflated) ridge, terminates abruptly mid-posteriorly. Infravelar, antero-anteroventral antrum; dolon smooth, extends to anterior cardinal corner. Row of spines forming marginal sculpture.

**Remarks:** Harperopsis differs from other genera by its unique connecting ridge between its velum and the connecting lobe. Its prominent, vertical lobes (L1, L3 L4) are also distinctive. The overall morphology of the type-species **Harperopsis scripta** is reminiscent of the ctenonotellid **Tallinnella dimorpha** Opiëk (Publ. Geol. Inst. Univ. Tartu, 50, 1937), type-species of the older **Tallinnella** Opiëk, 1937. Both **H. scripta** and **T. dimorpha** have a thick velar ridge terminating mid-posteriorly, and anteroventral antrum in heteromorphs. **T. dimorpha** differs by the bulbous dorsal terminations of L1, L3, L4, the swollen, granulose base of L1, and by the absence of any histial structure comparable to **H. scripta**. Such a structure (interpreted as a ventral strengthening strut) could have developed by an accretionary process, involving the velum and connecting lobe; in this case a **Tallinnella**-like ancestor could thus be postulated. However, we believe **Harperopsis** is derived from older tetradeild stock (found in the Llandeilo Series of South Wales and basal Caradoc Series of the Shelve district, Shropshire), which has a histial ridge connected anteroventrally to the velum. Thus, more likely, a reduction of this condition would give rise to the ventral connecting ridge (a relict histial structure) of **Harperopsis**. Přibyl (Cas. narod. Mus., 135 (4), 201-2, 1966) designated **T. scripta** type-species of his new subgenus **Cerninella** (**Harperopsis**). However, Přibyl's generic diagnosis excludes **H. scripta** as now known. **Beyrichia bohemica** Barrande (Système Silurien due centre de la Bohème, 1, suppl., pl. 26, fig. 13, pl. 34, figs. 19, 20, 1872), type-species of **Cerninella**, differs from **H. scripta** by the lack of a histial structure, its slender L1, L2, L3, and its dorsally reduced L4. Following Siveter (Geol. J. Spec. Issue, 8, 52, 1978), we regard **Harperopsis** as a distinct genus.

We differ with Přibyl's (204, 1966) generic assignment of **T. bicuneformis** Harper (op. cit. 348-49, pl. 10, figs. 4, 10, text-fig. 1b) to within **C. (Harperopsis)**. This species differs from **Harperopsis** in having a more well defined relict histial ridge, more inclined L3 and L4, and an isolated V-shaped L1-L2. Although **T. bicuneformis** is closely related to **Harperopsis** (cf. Siveter, 50, 1978), we consider that the species is best assigned to a new tetradeild genus (C. Jones, in prep).

Additional forms referred to **Harperopsis** include **Beyrichia decorata** Jones (Ann. Mag. nat. Hist. (2), 16, 165, pl. 6, fig. 6, 1855) and an additional, undescribed British species.

**Distribution:** **Harperopsis** is known from the Caradoc Series, middle Ordovician, of Wales and Northern England.

---

**Explanation of Plate 10, 6**

Figs. 1-6,9LV (unnumbered specimen, on same slab as holotype, 2820 μm long): fig. 1, ext. lat.; fig. 2, ext. ant.; fig. 3, obl. vent.; fig. 4, vent.; fig. 5, obl. dors.; fig. 6, dors.

Scale A (500 μm; x 20), figs. 1-6.
Harperopsis scripta (Harper, 1947)

1855 Beyrichia complicata, Salter; T. R. Jones, op. cit., 164 (pars), pl. 6, fig. 5 (= juvenile on GSM 49449).
1947 Tetradella scripta sp. nov.; J. C. Harper, Geol. Mag., 84, 347, 348 (pars), pl. 10, figs. 1, 2, 8, text-fig. 1a.
1948 Tetradella scripta Harper; I. Strachan, J. Temple & A. Williams, Geol. Mag., 85, 276, 277.
1978 Harperopsis scripta (Harper, 1947); D. J. Siveter, op. cit., 52, pl. 3, figs. 7, 8.


Type locality: 150 m E of Cwms Cottage, 0.5 km SE of Caer Caradoc Hill, Church Stretton, Shropshire (Grid Ref. SO 4816 9493); approx. lat. 52° 32' N, long. 2° 46' W. Harnage Shales, Harnagian, Caradoc Series, middle Ordovician.

Figured specimens: Institute of Geological Sciences, nos. GSM 74875A (holotype, fLV; Pl. 10, 8, figs. 1-6; Pl. 10, 12, figs. 1-4); unnumbered specimen on same slab as holotype (fLV; Pl. 10, 6, figs. 1-6; Pl. 10, 10, figs. 1-3). Both from the type locality and horizon.

The figured specimens (Siveter, 1978, pl. 3, figs. 7, 8) are ‘Silcoset’ silicone rubber casts of external moulds.

Stereo-Atlas of Ostracod Shells 10, 11

Harperopsis scripta (7 of 8)

Diagnosis: Large Harperopsis having diminutive L2. Dolon, velar ridge, lobal crests and all but ventral-most parts of sulci smooth; granulose elsewhere. Left valve with almost entire inner semi-groove; complementary marginal flange on right valve.

Remarks: Harper (347, 348, 1947) placed H. scripta in Tetradella on the basis of its lobation, but did not recognise its dimorphism. None of the six species he assigned to Tetradella would now belong within the genus.

Intraspecific variation in H. scripta consists of flattened to semi-cristate L2, and ridge-like to swollen base of L4. Juveniles have fimbriate L3, and more cristate-like lobation.

H. decorata differs from H. scripta by its inflated velum, reduced lobation but with L1, L3, L4 bulbous dorsally, and the obsolescence of lobal bifurcation to L3.


H. scripta is one of the most commonly quoted ostracodes in British Ordovician faunal lists, but undoubtedly most of these records should be treated with caution as most probably they refer to other forms of quadrilobate palaeocopids.

Explanation of Plate 10, 12

Figs. 1-4, fLV (holotype, GSM 74875A): ornament (granules with pores) at base of S2 (figs. 1, 2) and ventral supra-velar region (figs. 3, 4).
Scale A (250 μm; × 64), fig. 1; scale B (50 μm; × 200), fig. 2; scale C (250 μm; × 64), fig. 3; scale D (32 μm; × 310), fig. 4.
A Stereo-Atlas of Ostracod Shells

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The front cover shows a female left valve of Hemicythere villosa (Sars, 1866)
ON DURINGIA TRIFORMOSA JONES sp. nov.

by C. R. Jones
(University of Leicester, England)

Duringia triformosa sp. nov.

Holotype: Brit. Mus. (Nat. Hist.) no. OS 12261; 9LV.
Type locality: Old quarry about 300 m south of Cwm Agol Farm, c. 7 km west of Llandeilo, Dyfed, Wales; approx. lat. 51°51’N, long. 4°05’W (Nat. Grid. Ref. SN 56552070). Llandeilo ‘Flags’, Llandeilo Series, middle Ordovician.

Derivation of name: Latin, formosus, beautifully formed; alluding to the three distinct morphological forms.

Figured specimens: Brit. Mus. (Nat. Hist.) nos. OS 12261 (holotype, 9LV: Pl. 11, 14, fig. 5), OS 12260 (juv. LV: Pl. 11, 14, fig. 4), OS 12263 (♂? RV: Pl. 11, 16, figs. 1, 2), OS 12262 (juv. RV: Pl. 11, 16, figs. 3, 4), OS 12264 (♀LV: Pl. 11, 16, figs. 5, 6).

One specimen (♀LV: Pl. 11, 14, figs. 1–3) was broken after photography. All the figured specimens are from the type locality and horizon, except for OS 12264, which comes from Capel Dewi quarry, 350 m west of Ffynnon-Dewi, c. 15.5 km west of Llandeilo, Dyfed (N.G.R. SN 47472063); Llandeilo ‘Flags’, lower Llandeilo, middle Ordovician.

Explanation of Plate 11, 14
Figs. 1–3, 9LV (now broken, 1.30 mm long): fig. 1, ext. lat.; fig. 2, ext. ant.; fig. 3, ext. vent. Fig. 4, juv. LV, ext. lat. (OS 12260, 1.02 mm long). Fig. 5, 9LV, ext. lat. (holotype, OS 12261, 1.23 mm long).
Scale A (250/μm; x 42), figs. 1, 3; scale B (250/μm; x 47), fig. 2; scale C (250/μm; x 47), fig. 4; scale D (250/μm; x 45), fig. 5.

Stereo-Atlas of Ostracod Shells 11, 15

Diagnosis: Duringia with diminutive preadductor node. Narrow depression (= remnant S3?) from postero-central region to dorsum. Females with weakly convex tubulose dolon, serrated distally. Tecnomorphic velum as row of spines (juveniles), or ventral flange (males?). Lateral surface spinose and granulose.

Remarks: D. triformosa is only the second described species of the genus. The younger type-species, D. spinosa (Knüpf er, 1968) (see Schallreuter, Stereo-Atlas of Ostracod Shells, 11 (3), 9–12, 1984), from the uppermost Caradoc of Thuringia, closely resembles D. triformosa but for the presence of its dolonal spines, more convex dolon, and lack of a remnant S3. Only one complete female valve of D. spinosa is known (1.19 mm long), which falls within the large size variation displayed by D. triformosa (females from Llandeilo Series: 1.08–1.3+ mm long). Like the type-species, D. triformosa has a tubulose velum, justifying inclusion of the genus within the Eurychilinacea. However, the familial assignment of Duringia is questionable (Schallreuter, op. cit.). Schallreuter provisionally placed Duringia in the Piretellinae (Eurychilinidae) because the dolon of D. spinosa is similar but it also has dolonal spines not normally present in piretellines. D. triformosa would support this assignment as it too lacks dolonal spines. However, the sigmoidal S2 of Duringia remains strikingly opikiid-like. The recognition of a remnant S3 (?) in D. triformosa may indicate quadrilobate ancestry; its familial assignment is therefore still uncertain.


Explanation of Plate 11, 16
Figs. 1, 2, ♀♂RV (OS 12263, 1.27 mm long): fig. 1, ext. lat.; fig. 2, ext. post. Figs. 3, 4, juv. RV (OS 12262, 1.12 mm long): fig. 3, ext. ant.; fig. 4, ext. lat. Figs. 5, 6, large♀LV, broken posteriorly (OS 12264, 1.3+ mm long): fig. 5, ext. ant. obl.; fig. 6, serrated terminations of the tubulose dolon.
Scale A (250/μm; x 43), fig. 1; scale B (250/μm; x 45), fig. 2; scale C (250/μm; x 44), fig. 3; scale D (250/μm; x 46), fig. 4; scale E (300/μm; x 35), fig. 5; scale F (100/μm; x 80), fig. 6.
A new Ordovician kirkbyacean ostracode

By Roger E. L. Schallreuter, Hamburg and Clive R. Jones, Leicester

With 2 figures and 1 table in the text


Abstract: A new genus and species of the Kirkbyacea is described from the Upper Ordovician of Wales. The species is a more typical representative of that group than hitherto described from the Ordovician.

Key words: New taxon (Gebeckeria), Kirkbyocopina, Ashgillian, test, anatomy, phylogeny; Wales (Dryslwyn).


Introduction

The taxonomic position and origin of the Kirkbyacea is currently in debate. It is variably placed within the orders Beyrichiocopa (= Palaeocopida), Platy­copa or Podocopida. Becker (1981) recently discussed a polyphyletic origin of the Kirkbyacea. Regarding the first occurrence of the Kirkbyacea three genera have been described from the Upper Ordovician of Baltoscandia (Schallreuter 1968, 1969, 1972) and one incomplete valve was described as Kirkbya ? sp. from the Middle Ordovician Edinburgh formation of Virginia by Kraft (1962). All these forms are rather simple and their kirkbyacean nature has been questioned. Grundel (1978: 75) only considered Nonsulcozona Schallreuter, 1972 as a fairly certain representative of that superfamily. The new species described below, recently discovered (C. R. J.) from the Ashgill of Wales, is a more complex form exhibiting greater similarity to typical kirkbyaceans than hitherto known Ordovician species. It proves the taxonomic importance of the "kirkbyan pit" and other morphological features and the existence of several phylogenetic lines of the Kirkbyacea already in Ordovician times.
A new Ordovician kirkbyacean ostracode

Systematic description

**Gebeckeria** n.g.

Derivatio nominis: In honour of Dr. Gerhard Becker, Frankfurt am Main, for his extensive studies on Palaeozoic ostracodes.

Type-species: *Gebeckeria dryslwynensis* sp. nov.

Diagnos is: Small, amplete kirkbyacean. Shape rather long; two dorsal nodes, antero- and posterodorsal of diminutive but distinct “kirkbyan pit”. Elongate swelling in central regions, ventral of pit. Entire adventral sculpture as rounded, keel-like ridge. Lateral surface reticulate.

Remarks: The other Ordovician genera placed within the Kirkbyacea are *Martinssonozona* Schallreuter, 1968, *Ordovizona* Schallreuter, 1969 and *Nonsulcozona*. *Martinssonozona* bears most similarity to *Gebeckeria*, possessing a distinct “kirkbyan pit” and shell reticulation, but differing in its lack of lomal and adventral sculptures. In this respect *Gebeckeria* is comparable to *Aurikirkbya*, a Permian genus. *A. barbarae* (not type-species) also possesses two dorsal nodes, and a ridge-like elevation ventral of the pit (not ventrocentrally as in *Gebeckeria* but central-anterior and -posterior; Sohn 1950: Pl. 7, figs. 14–20). *A. barbarae* is a homeomorph of *Gebeckeria*, but illustrates the relationship and common ancestry of *Gebeckeria* with typical kirkbyaceans.

*Gebeckeria dryslwynensis* n.sp.

Derivatio nominis: From the type locality at Dryslwyn (see below).

Holotype: British Museum (Natural History) London (BMNH), no. OS 12259 – Fig. 1.2a–c.

Paratypes: BMNH nos. OS 12282–OS 12286 and Geologisch-Paläontologisches Institut und Museum, University of Hamburg (GPIMH), nos. 2798–2799.

Type locality: Dryslwyn Castell: overgrown quarry at base of castle mound, 450 m SW of Ty-castell, Dryslwyn, 7.5 km W of Llandeilo, Dyfed, South Wales, U. K. (National Grid Reference SN 55462023).

Stratum typicum: Ashgill.

Material: More than 100 silicified valves, adults and larvae.

Description: Largest valve 0.91 mm (Fig. 2.1). Valve moderately long to rather long, domicilium rather long to very long (classification of shape according to Schallreuter 1967: 631). Valve subamplete to slightly postplete, domicilium amplete. Hinge-line long, at both ends slightly shorter than greatest length of domicilium (L₀), anteriorly L₀ overreaching hinge-line a little more than posteriorly. Hinge in lateral view hidden by small epicline dorsum (Fig. 2.5). Dorsal margin slightly convex. Cardinal corners distinct, posterior corner sometimes with a very short acroidal spine (Fig. 2.2). Cardinal angles slightly more than 90°, anterior angle larger. Free margin in lateral view covered by adventral sculpture. Lateral margin centroventrally straight or concave, anterior slightly more convex than posterior. Greatest height of valve (H) central to post-
A new Ordovician kirkbyacean ostracode

erocentral, and of domicilium \((H_D)\) centrally. Valves rather flat, uniformly convex.

Kirkbyan pit small, distinct lies a little before and dorsal of the central region; looks like an enlarged lumen of the reticulation (internal view shows it is a true pit: Fig. 2.5). Distinct, relatively large node anterodorsal of pit; posterodorsal of pit another node, nearly as strong (Figs. 1.2, 2.4) to weaker (Figs. 1.2, 2.1–3). In internal view anterior node the more distinct (Fig. 2.5), neither reaching the dorsal margin. Long indistinct elevation ventral of pit in ventrocentral region, does not reach beyond nodes to anterior and posterior.

Adventral sculpture at the lateral margin ridge-like, from anterior to posterior cardinal corner, anteriorly close to the free margin, strengthening and more distant posteriorly. Lateroventral furrow distinct centroventrally and to posterior, absent anteriorly.

Lateral surface including that of adventral ridge distinctly reticulate; consisting of fine ridges parallel to lateral margin, and weaker ridges perpendicular to lateral margin, resultant caverns forming the lumina. Such parallel ridges are also present ventrally on the marginal surface (Figs. 1.2c, 2.1b), they weaken towards the free margin (similar to *Aurikirkbya barbarae*, cf. SOHN 1950: Pl. 7, Fig. 20c).

Adventral ridge less strongly developed in larvae, especially in posterior half where the lateroventral furrow is absent (Fig. 1.3). The figured larva has a relatively stronger posterior node than the larger valves.

**Dimensions and proportions:** Table 1.

**Distribution:** Known with certainty only from the type locality.

### Table 1.

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\(V = \) valve, \(H' = \) maximum height, \(H = \) height without sculptures overreaching hinge-line; measurements in mm.

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Fig. 1. *Gebeckeria dryslwynensis* n.g. n.sp. a–b: Paratype BMNH OS 12282, left valve in lateral (a) and dorsal view (b); × 63. 2a–e: Holotype (BMNH OS 12259), left valve in dorsal (a), lateral (b), ventral (c), anterior (d) and posterior view (e); × 68. 3: Paratype (BMNH OS 12283), juvenile right valve in lateral view; × 78. All from type locality. Ashgill.
The taxonomic position of the Kirkbyacea is a problem. The following possibilities are discussed: that the Kirkbyacea remains in the order Beyrichiocopa (= Palaecocopida) (GRÜNDL 1965, SOHN 1975, BECKER & SANCHEZ DE POSADA 1977, BECKER 1978, OLEMSKA 1979), that it is placed in the order Platycopida (HENNINGSMOEN 1965, SCHALLREUTER 1968, BECKER in BANDEL & BECKER 1975) or in the order Podocopa (KOZUR 1972) or is included in ordo inc. (GRÜNDL 1978). In order to resolve this current uncertainty we first discuss the important taxonomic features of the superfamily.

The “kirkbyan pit”

The taxonomic significance of the “kirkbyan pit” is debatable. SOHN (1954: 8) attached great taxonomic significance to it whereas GRUNDL (1965: 50-51; 1978: 73-74) considered the “kirkbyan pit” irrelevant for taxonomy and phylogeny of the Kirkbyacea because it has no characteristic features. True, adductor-ial pits occur in many ostracodes, but in combination with other features the “kirkbyan pit” has high taxonomic/phylogenetic significance.

Major ostracod groups are sometimes characterized by one morphological feature; for example, the Beyrichiomorpha with cruminal dimorphism, and the Hollinomorpha with antral dimorphism (exceptions of course exist). In these groups sexual dimorphism, a very important feature, is expressed in the shell. In other (especially non-dimorphic) groups less important features must be used. For example, in the kirkbyaceans a combination of features (“Gesamthabitus” = overall morphology of GRUNDL, 1965: 53-54) must be considered. In this respect the “kirkbyan pit” is taxonomically and phylogenetically important, despite the fact that morphologically similar pits occur in many other ostracode taxa and that the pit does not occur in all kirkbyaceans. Assigning Gebeckeria to the Kirkbyacea indicates the existence of the pit within its main stock for over 200 million years (Ordovician–Permian).

The ventricular concavity

HENNINGSMOEN (1965: 390) and SCHALLREUTER (1968) both recognised the importance of the ventricular concavity in the higher classification of the Kirkbyacea. HENNINGSMOEN noted that “Some forms show a 'ventricular concava..."
vity, and on the whole they resemble the Kloedenellacea more than any other palaeocope group, although no kloedenellid dimorphism has been observed. A ventricular concavity is practically unknown in typical beyrichiocopes and the few exceptions (Schallreuter 1982: 9, 103) are not taxonomically significant. As in the case of the "kirkbyan pit" the ventricular concavity does not occur in all kirkbyaceans but it is present in so many cases that it cannot be considered an unimportant feature. It may be a feature of order rank.

The reticulation

"Shell reticulation" differs from "surface reticulation" (Schallreuter 1973: 63-64). Surface reticulation is an ornamental sculpture produced by thickenings of the shell, whereas shell reticulation is a so-called "diminutive sculpture" produced by excavations of shell material, represented by cavernae in the shell (cf. Adamczak 1968: fig. 23). Both kinds of reticulation can occur on one valve (for example: Schallreuter 1982: pl. 9, 104).

Reticulation is a very common feature among ostracodes and especially so in Kirkbyacea (shell reticulation) (cf. Grundel 1978: 71). In spite of this, Grundel (1978: 74) considers reticulation unimportant for taxonomic or phylogenetic assignment, even at generic level. This is valid in some cases (e.g. Klimphores; cf. Schallreuter 1983c), but not in most kirkbyaceans.

The kirkbyan "Gesamthabitus"

Typical kirkbyaceans possess an adductorial pit and "shell reticulation". Combinations of these features occur in several groups, such as the Primitiopsacea (e.g. Clavofabella and Undulirete, Martinsson 1964; fig. 9A, D, 10C), Kloedenellaceae (Monotiopleuridae: Karinmutatia, Schallreuter 1978; pl. 5, 46; Kloedenellidae: Euclamella, Adamczak 1968: pl. 40, figs. 2-4), and Eurychilinacea (e.g. Piretella, Schallreuter 1975: pl. 26 [5], fig. 5; Moebbiosa and Rimabolbina with a pit-like fissum, op. c. pl. 23 [2], figs. 1, 6, pl. 24 [3], fig. 1) 1983a: pl. 27 (13), figs. 1, 3, 5, 6). Typical kirkbyaceans differ from these forms by their pit position and/or shape and outline. Moreover the domicilium is more elongate, the straight hinge-line rather long (slightly shorter than greatest length); cardinal angles are nearly equivalent and not usually exceeding 90°; the pit is nearly central. The Middle Ordovician Karinmutatia (Schallreuter 1978: 5, 45-48), for example, at first sight appears to be a typical reticulate kirkbyacean. However, its anterior cardinal angle is much larger than that posteriorly, it possesses an antero-central pit, and kloedenellid dimorphism (unknown in kirkbyaceans).

Gebeckeria and Martinsonozona possess the typical kirkbyacean morphology or "Gesamthabitus" (see p. 417). Gebeckeria also resembles Aurikirkbya, particularly in lobation (see remarks). The affinity of Martinsonozona to the Kirkbyacea was mentioned by Schallreuter (1968: 144), but its position within the group
A new Ordovician kirkbyacean ostracode

was questioned by Gründer (1978: 74) who thought it a monotiopleurid. Martinssonozona is here still considered a kirkbyacean, the differences with the Monotiopleuridae are discussed elsewhere (Schallreuter 1968: 143, 1978: 47).

Phylogeny

To account for the few differences in Middle Devonian kirkbyids, Gründer (1965: 54) proposed that evolutionary lineages had just started their individual development from some common ancestor. We believe the roots of the Kirkbyacea lie in the Ordovician, not the Devonian. Of the three genera previously placed in the Kirkbyacea only Nonsulcozona was acknowledged by Gründer (1978: 75) as a certain representative of that group, placing the genus in his new tribe Paegniurini (recte Paegniini), subfamily Kirkbyinae. Martinssonozona and Ordovizona were included in the Monotiopleuridae, which Schallreuter (1968: 143) considered the ancestral stock of the Kirkbyacea.

The oldest known species of Kirkbyacea are the Middle Ordovician Kirkbya ? sp. of Kraft (1962), Ordovizona longa Schallreuter, 1983, and an undescribed Ordovizona species from Britain (C. R. J. in prep.). Kirkbya ? sp. is known only from one incomplete specimen. Though some important features, such as the anterocardinal corner are not visible, the species in distinctly reticulate, the pit central, and is provisionally placed in Martinssonozona. Ordovizona longa lacks shell reticulation and instead of a pit has a dorsally open graben (cf. Schallreuter 1973: fig. 7). Only its shape, outline and the posterior shoulder are reminiscent of typical kirkbyaceans. In the Upper Ordovician type-species, O. sulcata Schallreuter, 1969 characteristic longitudinal striations are developed as in O. longa, but reticulation occurs between the striae. Ordovizona was placed in the Amphissitidae. O. longa and O. sulcata possess a ridge just ventral of the sulcus, which if strengthened could have formed the distinct ventrolateral ridge of certain Amphissitidae and Arcyzonidae (for example Sohn 1954: pl. 3, figs. 15, 18, 20; Kesling & Copeland 1954: pl. 1).

Ordovizona may thus belong to the root stock of both families. The arcyzonids were considered the ancestral group of the Amphissitidae by Becker (1981: 185).

Martinssonozona in comparison with Ordovizona has a more "kirkbyid" appearance, because of the pit and distinct shell reticulation. It may originate from Ordovizona. If Kirkbya ? sp. of Kraft (1962) does belong in Martinssonozona, generic separation must have already occurred in the Lower or early Middle Ordovician. In this case Gebeckeria may originate from Martinssonozona.

Conclusions

Gebeckeria dryslwynensis n.g. n.sp. from the Ashgill of Wales is another Ordovician representative of the Kirkbyacea. Together with the taxa already described it shows that the diversification of that group was already relatively high
even in the Ordovician and that there are at least three phylogenetic lines (Arcyzonidae: Ordovizona, Paegniini: Nonsulcozona, Kirkbyidae: Martinssonozona, Gebeckeria). The taxonomic and phylogenetic significance of the main morphological features of the Kirkbyacea are discussed. The taxonomic importance of the “kirkbyan pit” is emphasized.

Now as before (Schallreuter 1968) the Kirkbyacea are placed within the order Platycopa. The discussion whether the Kirkbyacea should form a suborder of its own (Kirkbyocopa) or remain a member of the Punciocopa lies out of the scope of the present paper.

Acknowledgements

We thank David J. Siveter (University of Leicester) for reading and correcting the manuscript.

Literature


Most authors compare the Punciacea with the Eurychilinacea, suborder Palaeocopida, order Beyrichiocopa, an Ordovician group with typical velar dimorphism. Schallreuter (1968) considered the Permian/Triassic Kirkbyacea as the ancestral stock of the Punciacea and united the Punciacea and Kirkbyacea within the common suborder Punciocopa. The Punciocopa were placed within the order Platycopa together with the Kloedenellilocopa. The proof of kloedenellid dimorphism in Manataes by Nohara & Nakasone (1982) supports the inclusion of the Punciocopa within the Platycopa and not the Palaeocopida.
A new Ordovician kirkbyacean ostracode


Anschriften der Verfasser:
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LLANDEILO AND CARADOC (ORDOVICIAN) BEYRICHIOCOPE OSTRACODA
FROM ENGLAND AND WALES

A Thesis
Submitted for the Degree of
Doctor of Philosophy
in the
Faculty of Science
University of Leicester

by

Clive R. Jones

December 1984

VOLUME 2
Thesis
9.5.1985

To the Faculty of Engineering
Department of Engineering
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PLATE 2

Fig.  

Homeoceratopsis jubata gen. et sp. nov. 29

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1,16  ?Pre-adult female right valve. Lateral view (stereo-pair), x42; posteroventral oblique view of fimbriate crest on L4, x105. CRJ SW026.

2-4,10, Holotype, female right valve. Anterior oblique, anterior (stereo-pair), lateral (stereo-pair), ventral (stereo-pair), oblique dorsal, x38; anterior oblique view of fimbriate L1, x76. CRJ SW023.

5,6  Tecnomorphic left valve. Lateral and ventral views, x46. CRJ SW028.

7,12  Male right valve. Lateral (stereo-pair) and ventral oblique views, x53. CRJ SW025.

8,9  Tecnomorphic right valve. Anterior (stereo-pair) and lateral (stereo-pair) views, x46. CRJ SW027.

14,15 Female left valve. Posterior (stereo-pair) and lateral (stereo-pair) views, x44. CRJ SW024.

Homeoceratopsis? sp. nov. 1 31

13  Tecnomorphic right valve. Lateral view (stereo-pair), x37. CRJ SW154/1.
PLATE 3

Fig.  

Homeokesowia epicopa Siveter, 1982  
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1, 2, 5 Female right valve. Anterior (stereo-pair), lateral (stereo-pair) and ventral (stereo-pair) views, x29. BM OS6696.

3, 6, 8 Male right valve. Lateral (stereo-pair), dorsal and posterior views, x25. BM OS6669.

4 Holotype, female left valve. Lateral view (stereo-pair), x26. BM OS6695.

7 Female right valve. Internal ventral oblique view, x25. BM OS6697.

9 Female left valve. Lateral view, x30. BM OS6670.

Tallinnella? tomacina sp. nov.  
Middle Llandeilo Series, Kincoed Farm, Dyfed (loc. 12a).

10 Tecnomorphic right valve. Lateral view (stereo-pair), x25. CRJ SW166/3

11 Female left valve (anterior part only). Internal lateral view showing concave inside of dolon, x26. CRJ SW166/1.

12 Tecnomorphic left valve (partly broken). Lateral view x22. CRJ SW166/2.

Lower Llandeilo Series, Ysgubor Wen Farm, Llandeilo, Dyfed.


Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28a).

16, 17 Tecnomorphic left valve (posterior part only). Lateral and posterior oblique views, x31. CRJ SW166/4.
PLATE 4

Fig. 1 Piretopsis (Protallinnella) ranuncula sp. nov. Costonian Stage, Caradoc Series, Lampeter-Velfrey (loc. 28b).

1 Female carapace. Ventral view, x20. CRJ SW015.

2,3,6 Male right valve. Anterior (stereo-pair), and lateral (stereo-pair) views, x23; ventral oblique view of marginal surface and granulose ornament, x74; ventral view, x23. CRJ SW017.

4,5 Holotype, female left valve. Lateral (stereo-pair) and anterior (stereo-pair) views, x19; anterior oblique view of anterior part of dolon, x52; ventral (stereo-pair) and dorsal views, x19; anteroventral oblique view, x15. CRJ SW013.

7 Tecnomorphic right valve. Lateral view, x30. CRJ SW173.

8 Tecnomorphic right valve. Internal lateral view, x22. CRJ SW08.

Piretopsis (Protallinnella) salopiensis (Harper, 1947) Costonian Stage, Caradoc Series, Rorrington, Shropshire (loc. 31).

12,13 Cast of external mould of female left valve. Lateral (stereo-pair), anterior (stereo-pair), ventral (stereo-pair) and dorsal views, x19. CRJ M61.

16,19 Cast of external mould of tecnomorphic right valve. Lateral view, x25. GSM 75421C.

20 Cast of external mould of tecnomorphic left valve. Lateral view, x19. CRJ M63.

21,22 Cast of external mould of tecnomorphic right valve. Lateral and ventral views, x27. CRJ M62.

Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28b).

17 Female left valve. Lateral view, x21. CRJ SW182.
PLATE 5

Varilatella (Varilatella) bulbosa gen. et sp. nov.
Harnagian Stage, Caradoc Series, Hope Bowdler, Shropshire (loc. 37).

1,4,5 Cast of external mould of female right valve (anteroventral part damaged on figs 1,5). Lateral (stereo-pair) view, x34; ventral oblique and dorsal views, x35. CRJ M49/4.

2 Holotype, cast of external mould of male right valve. Lateral view (stereo-pair), x32. CRJ M08.

3 Cast of external mould of male right valve. Lateral view (stereo-pair), x38. CRJ M06.

6 Cast of external mould of tecnomorphic right valve. Lateral view, x35. CRJ M49/1.

Varilatella (Varilatella) dissita (Schallreuter & Siveter, 1983)
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

7,8,12 Holotype, female right valve. Anterior (stereo-pair), lateral (stereo-pair), ventral (stereo-pair) and ventral oblique views, x39. BM OS6698.

10,11 Male right valve. Lateral (stereo-pair), anterior and ventral views, x40. BM OS6692.

14 Male left valve. Lateral view, x40. BM OS6699.

15 Female right valve. Lateral view, x40. BM OS6693.

Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28a).

9 Male left valve. Lateral view (stereo-pair), x34. CRJ SW167.
PLATE 6

Fig.  Varilatella (Redacta) coronata subgen. et sp. nov.  Page 50

Costonian Stage, Caradoc Series, Llan-mill, Dyfed (loc. 26a).

1,4 Holotype, female left valve. Lateral (stereo-pair) and dorsal oblique views, x38. CRJ SW162.

2,7 ?Pre-adult female right valve. Lateral (stereo-pair) and ventral oblique views, x41. CRJ SW163/1.

3,6 Male left valve. Lateral (stereo-pair) and ventral (stereo-pair) views, x41. CRJ SW163/1.

8 Small tecnomorphic right valve. Lateral view, x63. CRJ SW163/5.

12 Tecnomorphic left valve. Lateral view, x50. CRJ SW163/4.

Varilatella (Redacta) sp. nov. 1  Page 53

Costonian Stage, Caradoc series, Llan-mill, Dyfed (loc. 26a).

5 Tecnomorphic left valve. Lateral view, x42. CRJ SW160/1.

10,13 Tecnomorphic right valve. Lateral (stereo-pair) and ventral views, x43. CRJ SW160/2.

Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28a).

9 Tecnomorphic right valve. Lateral view, x44. CRJ SW161/2.

11 Small tecnomorphic left valve. Lateral view, x41. CRJ SW161/1.

Varilatella (Redacta?) sp. nov. 2  Page 55

Longvillian Stage, Caradoc Series, E side of Melmerby-Alston road (A686) cutting, Cumbria. (See Occurrence, p. 56).

14-16 Cast of external mould of male right valve. View of central posterior region showing granulose ornament and crista C4, x42; anterior (stereo-pair) and lateral (stereo-pair) views, x29. GSM RS6503.

Woolstonian Stage, Caradoc Series, Harthwaite Sike, Dufton, Cumbria (loc. 46).

17 Cast of external mould of tecnomorphic right valve. Lateral view, x31. NMW 84. 166.1
Fig. 57

Schallreuteria (Schallreuteria) builthensis sp. nov.

Lower Llandeilo Series, Newmead Farm stream section, Builth, Powys (loc. 8).

1, 2, 5 Holotype, cast of external mould of female right valve. Lateral (stereo-pair), anterior oblique and dorsal oblique views, x34. CRJ M45.

3, 10, 14 Cast of external mould of tecnomorphic right valve. Anterior oblique and lateral (stereo-pair) views, x42; lateral view of ventral margin showing spinose distal termination of velum, x92. CRJ M46/4.

4, 7 Cast of external mould of tecnomorphic left valve. Lateral (stereo-pair) and ventral views, x41. CRJ M42.

6 Cast of external mould of small tecnomorphic left valve. Lateral view, x37. CRJ M46/3.

8, 9 Cast of external mould of male left valve. Lateral view, x38; lateral view of sulcus S2 and tubercular/granulose ornament, x59. CRJ M46/2.

11, 12 Cast of external mould of male left valve. Lateral and ventral views, x39. CRJ M46/1.

13 Cast of external mould of anterior part of female left valve. Lateral view showing peripheral spines of dolon, x35. CRJ M47/2.
PLATE 8

**Schallreuteria (Schallreuteria) superciliata** (Reed, 1910)

Longvillian Stage, Caradoc Series, E side of Melmerby-Alston road (A686) cutting, Melmerby, Cumbria. (See Occurrence, p. 62).

1,2 Cast of external mould of female right valve. Lateral view (stereo-pair), x31; lateral view of large tubercles on lobe L2 (stereo-pair), x86. SM A29968b.

3,6,7 Cast of external mould of female right valve. Lateral view (stereo-pair), x33; lateral view of peripheral spines on dolon (stereo-pair), x200; tubercle and granulose ornament on lobe L4, x185. SM A10983b.

8,11 Cast of external mould of male right valve. Lateral view (stereo-pair), x34; anterior oblique view of tubercular/granulose ornament of anterior margin, x100. SM A109790a.

12 Lectotype, cast of external mould of tecnomorphic right valve. Lateral view, x31. SM A10985b.

**Schallreuteria (Schallreuteria) cf. S. (S.) superciliata**

Middle Llandeilo Series, Kincoed Farm, Carmarthen, Dyfed (loc. 12a).

4,5,9 Tecnomorphic left valve. Lateral (stereo-pair), anterior (stereo-pair) and ventral views, x42; ventral oblique view of prominent tubercle below sulcus S2 and marginal spines, x75. CRJ SW091.
1, 6, 7, Female left valve. Lateral (stereo-pair), ventral oblique and ventral views, x46; lateral view of fimbriate speral process of lobe L1, x170. CRJ SW169/5.

2-4, 9, Female left valve. Posterior, anterior (stereo-pair), lateral (stereo-pair), ventral (stereo-pair) and dorsal views, x43. CRJ SW128

5 Male left valve (now broken). Posterior view, x44.

8 Female right valve. Internal anterior oblique view (stereo-pair), x45. CRJ SW170.

12 Tecnomorphic right valve. Lateral view, x46. CRJ SW129.

14 Female left valve. Lateral view, x41. CRJ SW174/1.

Costonian Stage, Caradoc Series, LLan-mill, Narberth, Dyfed (loc. 26a).

11 Female left valve. Lateral view (stereo-pair), x40. CRJ SW174/3.
PLATE 10

Fig.

_Ceratopsis coactilis_ sp. nov.

Lower Llandeilo Series, Ffynnon-Ddewi, Carmarthen, Dyfed (loc. 3).

1, 4, 5, Holotype, female left valve. Lateral (stereo-pair), dorsal and anterior views, x42; lateral view (stereo-pair) of L1 fimbriate speral process, x84. CRJ SW179.

8 Female left valve. Lateral view (stereo-pair), x48. CRJ SW180/2.

11 Tecnomorphic left valve. Lateral view, x61. CRJ SW180/4.

Costonian Stage, Caradoc Series, Llan-mill, Narberth, Dyfed (loc. 26a).

2, 3, 6, Tecnomorphic left valve. Posterior (stereo-pair), lateral (stereo-pair), anterior and ventral views, x49. CRJ SW181.

10 Female right valve. Lateral view, x51. CRJ SW180/1.
Fig. 1.6 Holotype, female right valve. Lateral (stereo-pair) and anterior (stereo-pair) views, x22. CRJ SW175.

4 Male right valve. Lateral view, x38. CRJ SW176/2.

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1b).

2,3 Tecnomorphic right valve. Lateral (stereo-pair) and ventral views, x39. CRJ SW176/3.

5,7 Tecnomorphic left valve. Lateral and ventral views, x38. CRJ SW176/1.

Fig. 8-11, Holotype, female left valve. Lateral (stereo-pair), ventral 15,17 (stereo-pair), anterior (stereo-pair), posterior, ventral oblique and anterior oblique views, x51. CRJ SW183/1.

12-14, Tecnomorphic left valve. Lateral view of rake-like speral 16 process of lobe L1, x97; lateral (stereo-pair), ventral oblique and anterior oblique views, x48. CRJ SW169/1.
PLATE 12

Fig.  

Ommoopsis (Quadridigitalis) siveteri subgen. et sp. nov. Page

Harnagian Stage, Caradoc Series, Cressage, Shropshire (loc. 33).

1, 7-10. Holotype, cast of external mould of female left valve.  
12 Lateral (stereo-pair), anterior, ventral oblique, ventral (stereo-pair), posterior oblique and dorsal views, x21. CRJ M53.

Harnagian Stage, Glenburrell, Shropshire (loc. 35).

2, 13. Cast of external mould of female left valve. Anterior (stereo-pair), anterior oblique and lateral views, x27. CRJ M54/1.

15 Cast of external mould of tecnomorphic left valve. Lateral view, x27. CRJ M54/2.

Costonian Stage, Caradoc Series, Rorrington, Shropshire (loc. 31).

3-6 Cast of external mould of male right valve. Lateral, posterior, ventral oblique and ventral views, x21. On BM 3397/B.

Harnagian Stage, Caradoc Series, Hope Bowdler, Shropshire (loc. 37).

11 Cast of external mould of male left valve. Lateral view (stereo-pair), x22. CRJ M55.

Ommoopsis? sp. nov. 1

Costonian Stage, Caradoc Series, Rorrington, Shropshire (loc. 31).

16 Cast of external mould of tecnomorphic left valve. Lateral view (stereo-pair), x19. On BM 3584/B.
PLATE 13

**Fig.**

*Sigmooopsis (Sigmooopsis) duftonensis* (Reed, 1910)

Longvillian Stage, Caradoc Series, Melmerby-Alston road (A686) cutting, Melmerby, Cumbria (near loc. 44).

1, 2, 5. Lectotype, cast of external mould of female left valve.
9, 10 Posterior (stereo-pair), lateral (stereo-pair), ventral oblique, ventral (stereo-pair) and dorsal views, x23. SM A29973b.

3, 4, 6. Cast of external mould of male left valve. Posterior (stereo-pair) and lateral (stereo-pair) views, x23; posterior oblique view of fimbriate lobe L1, x65; ventral oblique view, x23; view of fimbriate L1 showing fine surface striations, x139. SM A29974b.

Marshbrookian Stage, Caradoc Series, Cardington, Shropshire (see Material, p. 83).

8 Cast of external mould of tecnomorphic right valve. Ventral view, x32. GSM Mi323.

Harnagian Stage, Caradoc Series, Hope Bowdler, Shropshire (loc. 37).

11 Cast of external mould of tecnomorphic left valve. Lateral view (stereo-pair), x27. CRJ M17.

Marshbrookian Stage, Caradoc Series, Soudley, Shropshire (loc. 47).

12 Cast of external mould of female right valve. Lateral view, x27. GSM JD3084.

Woolstonian Stage, Caradoc Series, Soudley, Shropshire (loc. 47).

13 Cast of external mould of female right valve. Ventral view, x27. CRJ M66/2.
PLATE 14

Gracquina vannieri sp. nov.
Llanvirn Series, Great Paxton Borehole, Huntingdon, Cambridgeshire.

1-3,6. Female right valve. Lateral (stereo-pair), posterior (stereo-pair), posterior oblique, ventral (stereo-pair) and ventral oblique views, x34. GSM By 8589.

5,9,10 Tecnomorphic left valve. Lateral (stereo-pair), ventral and dorsal views, x36. GSM By 8555.

8,4 Holotype, cast of external mould of female left valve (of whole carapace). Lateral view, x30; fine granulose surface ornament posteroventrally on lobe L4, x300. GSM By 8626.

Hastatellina? sp. nov. 1
Llandeilo Series, Dryslwyn Castell, Dyfed (loc. 15).

11-13, Tecnomorphic left valve. Anterior, lateral (stereo-pair), anterior oblique and ventral views, x52; posterior oblique view of comb-like speral process of L1, x138. CRJ SW178/1.

14,15, Female left valve. Anterior (stereo-pair), lateral (stereo-pair) and ventral oblique views, x53. CRJ SW178/2.
PLATE 15

Fig.  

**Vittella fecunda** Siveter, 1983

Upper Llandeilo Series, Dryslwyn, Llandeilo (loc. 17).

1. Holotype, female left valve. Lateral view (stereo-pair), x38. BM OS7777.

2. Female left valve. Lateral view (stereo-pair), x40. BM OS6672.

3. Female left valve. Lateral view (stereo-pair), x40. BM OS7779.

4. Tecnomorphic right valve. Lateral view (stereo-pair), x50. CRJ SW138.

5, 6, 11 Small tecnomorphic right valve. Anterior (stereo-pair), lateral (stereo-pair) and ventral oblique (stereo-pair) views, x50. BM OS7782.

7, 8. Tecnomorphic left valve. Lateral and ventral views, x41. CRJ SW140.

9, 10. Male right valve. Lateral (stereo-pair) and posterior (stereo-pair) views, x40. BM OS7778.

12. Small tecnomorphic carapace. Ventral view, x71. CRJ SW143.

13. Female right valve. Internal ventral oblique view (stereo-pair) of antrum and inner antral fence, x40. BM OS7781.
Plate 16

**Vittella vatia** sp. nov.

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1, 2. Holotype, adult female left valve. Lateral (stereo-pair), anterior (stereo-pair), ventral oblique, ventral, posterior and dorsal views, x59. CRJ SW224.

3. Pre-adult female left valve. Lateral view (stereo-pair), x57. CRJ SW125/1.

4, 9. Tecnomorphic left valve. Lateral (stereo-pair) and ventral oblique views, x63. CRJ SW126/4.

8, 16. Pre-adult female left valve. Anterior oblique and lateral view, x58. CRJ SW125/6.

11, 12. Pre-adult female right valve. Anterior (stereo-pair), lateral (stereo-pair), ventral oblique and ventral views, x64. CRJ SW124.

13. Tecnomorphic right valve. Internal lateral view (stereo-pair), x51. CRJ SW144/2.

14. Tecnomorphic left valve. Internal lateral view, x53. CRJ SW144/1.

15. Adult female right valve. Lateral view, x52. CRJ SW122.

18. Tecnomorphic left valve. Lateral view, x52. CRJ SW126/3.

19. Pre-adult female left valve. Ventral oblique view, x65. CRJ SW125/2.

21. Pre-adult female right valve. Ventral view, x69. CRJ SW123.

Upper Llandeilo Series, Llan-mill, Dyfed (loc. 22).

1,5,7, Tecnomorphic left valve (anterior now broken). Lateral (stereo-pair) and ventral oblique views, x36; lateral views of crista C3 and U-shaped cristae C1-C2, x120. CRJ SW040.

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

2,3 Tecnomorphic right valve (now broken anteroventrally). Lateral and ventral oblique views, x42. CRJ SW042.

4 Female right valve. Lateral view (stereo-pair), x36. CRJ SW196/1.

6 Female left valve (now broken). Lateral view, x37. CRJ SW039.

10 Tecnomorphic left valve. Lateral view, x37. CRJ SW196/2.

11 Small tecnomorphic left valve. Lateral view, x49. CRJ SW016.

Llandeilo Series, Llan-mill, 3km E of Narberth, Dyfed. Precise horizon and locality unknown.

8 Holotype, tecnomorphic left valve. Lateral view, x32. GSM 85715.

Gunnaropsis narberthensis sp. nov.

Costonian Stage, Caradoc Series, Llan-mill, Dyfed (loc. 26a).

9 Tecnomorphic left valve. Lateral view (stereo-pair), x37. CRJ SW120.

13, Holotype, female left valve. Lateral (stereo-pair), anterior oblique (stereo-pair), posterior oblique, ventral oblique (stereo-pair) and dorsal views, x33. CRJ SW116.

14,21 Male right valve. Lateral and ventral oblique views, x32; ventral view showing coalescence of velum and histium anteroventrally, x59. CRJ SW117.

15 Tecnomorphic right valve. Lateral view, x38. CRJ SW118.

16,23 Small tecnomorphic right valve. Lateral and ventral views, x45. CRJ SW121.
**Gunnaropsis subvexa** sp. nov.

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1,5,6 Holotype, tecnomorphic right valve. Lateral (stereo-pair) and ventral oblique views, x40; lateral view of anterior lobal complex L1-L2 and sulcus S2 with presumed, smooth muscle scar area, x64. CRJ SW041.

2 Tecnomorphic right valve. Lateral view, x48. CRJ SW199/1.

**Gunnaropsis** sp. nov. 1

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1b).

3 Tecnomorphic right valve (broken anteriorly). Lateral view, x28. CRJ SW200/1.

4 Tecnomorphic left valve (anterior part only). Lateral view, x28. CRJ SW200/2.

**Haroeropsis bicuneiformis** (Harper, 1947)

Costonian Stage, Caradoc Series, Rorrington, Shropshire (loc. 31).

7,9,10 Cast of external mould of tecnomorphic right valve. Lateral view of anterior part of supravelar furrow, x52; lateral, posterior, ventral (stereo-pair) and dorsal views, x22. CRJ M76/2.

8 Holotype, cast of external mould of tecnomorphic left valve. Lateral view, x26. GSM 75421A.

11 Cast of external mould of female left valve. Lateral view (stereo-pair), x24. CRJ M76/1.

14,15 Cast of external mould of female right valve. Lateral, anterior (stereo-pair) and ventral views, x24. On BM 3376/B.

**Haroeropsis decorata** (Jones, 1855)

Souydleyan Stage, Caradoc Series, Pontesford, Shropshire (loc. 39).

12 Cast of external mould of tecnomorphic left valve. Lateral view, x20. CRJ M75.

Soudleyan Stage, Caradoc Series, Aber-marchnant, 10.5km W of Llanfyllin, Powys (see Lectotype, p. 115).

13,16 Lectotype, cast of external mould of female right valve.

18,21 Ventral (stereo-pair) and lateral (stereo-pair) views, x21; lateral view of posteroventral part of supravelar furrow, x67; anterior view (stereo-pair), x21. GSM 35718.

22 Cast of external mould of female right valve (anterior part only). Anterior oblique view, x21. CRJ M74/1.

23,24 Cast of external mould of tecnomorphic left valve. Lateral and dorsal views, x19. CRJ M74/2.
PLATE 19

Fig. 1-7, Harperopsis scripta (Harper, 1947) Harnagian Stage, Caradoc Series, Caer Caradoc Hill, Church Stretton, Shropshire (loc. 34).

1-2,7, Cast of external mould of female left valve. Lateral (stereo-pair), anterior (stereo-pair), ventral (stereo-pair) and dorsal views, x20. Un-numbered specimen on same slab as holotype (GSM 74875A).

3,4. Holotype, cast of external mould of male left valve. Lateral view of sulcus S2, x64, and granulose surface ornament within, x200; anterior (stereo-pair), lateral (stereo-pair) and ventral views, x20; GSM 74875A.

Harnagian Stage, Smeathen Wood, Horderley, Shropshire (see Occurrence, p. 119.)

9, Cast of external mould of female left valve. Lateral view, x10. CRJ M71/1.

Histina xanios gen. et sp. nov. Lower Llandeilo Series, Ffynnon-Devni, Carmarthen, Dyfed (loc. 3).

12,13, Female right valve. Anterior (stereo-pair), ventral (stereo-pair) and lateral views, x36. CRJ SW09.

20, Female left valve. Internal lateral view, x31. CRJ SW202/2.

Middle Llandeilo Series, Kincoed Farm, Carmarthen, Dyfed (loc. 12a).

15,17, Holotype, female left valve. Lateral view (stereo-pair), x35; ventral oblique view of anterioventral coalescence of velum and histium, x119; ventral oblique view, x35; lateral view of histial termination, x135. CRJ SW032.

16, Male right valve. Lateral view (stereo-pair), x37. CRJ SW033.

Middle Llandeilo Series, Kincoed Farm, Carmarthen, Dyfed (loc. 12b).

10,18, Small tecnomorphic right valve. Posterior oblique view of fimbriate spine-like process on dorsal part of lobe L3, x195; lateral view, x39. CRJ SW07.

21, Tecnomorphic left valve. Ventral oblique view, x32. CRJ SW203.

23, Female left valve. Lateral view, x30. CRJ SW202/1.
PLATE 20

Fig.  

1  Cast of external mould of tecnomorphic right valve.  
Lateral view (stereo-pair), x31. CRJ M69/3.

2,3,8, Holotype, cast of external mould of female left valve.  
9  Posterior (stereo-pair), lateral (stereo-pair), ventral  
(stereo-pair) and dorsal views, x34. CRJ M68.

4,5, Cast of external mould of tecnomorphic right valve.  
10  Lateral, ventral (stereo-pair) and ventral oblique views,  
x34. CRJ M69/5.

14  Cast of external mould of female left valve. Lateral  
view, x33. CRJ M69/2.

25  Cymabolbina susanae sp. nov.  

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

6,7, Male right valve. Lateral (stereo-pair), posterior  
11-13 (stereo-pair), ventral (stereo-pair), dorsal and anterior  
views, x31. CRJ SW191.

15,20, Holotype, female right valve. Lateral (stereo-pair), ventral  
21 (stereo-pair) and dorsal views, x30. CRJ SW190.

16,17 Female right valve. Lateral view of base of lobe L3, with  
relict histial structure and central ventral part of velum  
showing surface striations, x66; lateral view, x30.  
CRJ SW082.

18  Male right valve. Ventral view of anteroventral coalescence  
of histium and velum, x73. CRJ SW045.

19  Tecnomorphic right valve. Lateral view, x37. CRJ SW046.
PLATE 21

Cymabolbina? sp. nov. 1
Upper Llandeilo Series, Lower Court Farm, St. Clears, Dyfed (loc. 23).

1 Female right valve. Lateral view, x31. CRJ SW204/4.
2 Tecnomorphic left valve (broken anteroventrally). Lateral view, x31. CRJ SW204/1.
3 Tecnomorphic left valve. Lateral view, x36. CRJ SW204/3.

Latebina pseudantra gen. et sp. nov.
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

4,5,10 Holotype, female left valve. Lateral (stereo-pair), anterior (stereo-pair), ventral (stereo-pair) and dorsal views, x29. CRJ SW034.
6,7,8,11 Tecnomorphic left valve. Posterior oblique view of posteroventral margin and relict velum, x119; posterior (stereo-pair) and lateral (stereo-pair) views, x32; ventral view of central ventral region, x75; ventral (stereo-pair) and ventral oblique views, x32. CRJ SW084.
12 Male right valve (broken anterodorsally). Lateral view, x28. CRJ SW201/2.
15,22 Female left valve (broken posteriorly). Ventral and posteroventral oblique view, x31. CRJ SW044.
16,21 Male right valve (broken posteriorly). Lateral and ventral oblique views, x27. CRJ SW021/1.
17,20 Tecnomorphic right valve. Granulose ornament on lobe L4, x180; lateral view (stereo-pair), x30. CRJ SW085.
18,19 Small tecnomorphic left valve. Ventral (stereo-pair) and lateral views, x44. CRJ SW086.
PLATE 22

Fig. Page

Severopsis severopsis gen. et sp. nov. 134

Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28a).

1,4. Holotype, female right valve. Lateral view (stereo-pair), x 25; posterior oblique and anterior oblique views, x17; ventral oblique view, x25. CRJ SW094.

Upper Llandoilo Series, Dryslwyn, Dyfed (loc. 17).

2 Male right valve. Lateral view, x24. CRJ SW096.

3,9 Tectonomorphic left valve. Lateral (stereo-pair) and ventral oblique (stereo-pair) views, x28. CRJ SW095.

Gen. et sp. nov. A

Harnagian Stage, Caradoc Series, Hope Bowdler, Shropshire (loc. 37).

7,10. Cast of external mould of right valve. Ventral (stereo-pair), anterior (stereo-pair) and lateral (stereo-pair) views, x64. CRJ M24.

8 Cast of external mould of left valve. Lateral view, x43. On LM 5046.

Gen. nov.? et sp. nov. B 137

Upper Llandoilo Series, Dryslwyn, Dyfed (loc. 17).

12 Right valve. Lateral view, x34. CRJ SW210/3.

13,14. Left valve. Anterior, lateral (stereo-pair) and ventral views, x35. CRJ SW210/4.

17 Left valve, x33. CRJ SW210/2.
Fig.  

**Bullaferum llandeiloensis** sp. nov.  

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1b).

1  Holotype, right valve. Lateral view (stereo-pair), x60. CRJ SW221/5.

2,3,7 Right valve (broken posteriorly). Lateral (stereo-pair), posterior (stereo-pair) and anterior views, x57. CRJ SW019.

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1a).

4 Larval right valve. Lateral view (stereo-pair), x68. CRJ SW221/3.

6 Larval left valve. Lateral view, x64. CRJ SW221/4.

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 2b).

5 Right valve (broken anterodorsally). Lateral view, x63. CRJ SW221/1.

8 Right valve (broken posteriorly). Lateral view, x71. CRJ SW221/2.

**Klimphores morgani** (Jones, 1890)  

Onnian Stage, Caradoc Series, Gwern-y-brain stream section, Welshpool, Powys (loc. 50b).

10 Right valve. Lateral view (stereo-pair), x95. CRJ NW104a.

11,12, Lectotype, left valve. Posterior (stereo-pair), lateral 15,16 (stereo-pair), ventral and dorsal views, x67. On BM 16056.

14 Larval left valve. Lateral view, x94. CRJ MW072.

**Klimphores paraspinosus** sp. nov.  

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1a).

9 Left valve. Lateral view (stereo-pair), x70. CRJ SW218/1.

Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (precise locality unknown).

13 Holotype, left valve. Lateral view, x68. BM OS6677.
PLATE 24

**Laterophores elevatus** sp. nov.
Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1a).

1, 5, 6 Holotype, right valve. Lateral (stereo-pair), ventral and dorsal views, x88. CRJ SW021.

3 Right valve. Lateral view, x85. CRJ SW220/2.

4 Left valve. Lateral view (stereo-pair), x80. CRJ SW220/1.
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

2 Left valve. Lateral view, x79. CRJ SW219.

**Utrichia? bicornis** (Jones, 1855)
Harnagian Stage, Caradoc Series, Harnage, Shrewsbury, Shropshire (see Lectotype, p. 152)

7 Lectotype, cast of external mould of left valve. Lateral view (stereo-pair), x78. GSM 35731.

8 Cast of external mould of right valve. Lateral view (stereo-pair), x72. On GSM 35731.
Harnagian Stage, Caradoc Series, Hope Bowdler, Shropshire (loc. 37).

9 Cast of external mould of right valve. Lateral view, x72. BM OS6674.

**Roperella melmerbyensis** sp. nov.
Woolstonian Stage, Caradoc Series, Melmerby-Alston road (A686) cutting, Melmerby, Cumbria (loc. 44a).

10 Cast of external mould of right valve. Lateral view (stereo-pair), x63. On GSM RU2546.

11 Holotype, cast of external mould of right valve. Lateral view (stereo-pair), x55. On GSM RU2546.

**Crescentilla** sp. nov. 1
Harnagian Stage, Caradoc Series, Harnage, Shrewsbury, Shropshire (see Occurrence, p. 158).

12 Cast of external mould of left valve. Lateral view, x65. On GSM 49449.
Pseudulrichia aequinoda sp. nov.

Costonian Stage, Caradoc Series, Henllan Lodge, Llanddewi-Velfrey, Dyfed (loc. 27b).

1 Holotype, left valve. Lateral view (stereo-pair), x79. CRJ SW212/4.

2 Right valve. Lateral view, x77. CRJ SW212/3.

3 Left valve. Lateral view, x73. CRJ SW212/1.

4 Left valve. Lateral view, x76. CRJ SW212/2.

Pseudulrichia conispina sp. nov.

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

5 Larval right valve. Lateral view, x81. CRJ SW211/3.

6 Holotype, right valve. Lateral view (stereo-pair), x85. CRJ SW211/2.

7 Larval right valve. Lateral view, x100. CRJ SW211/4.

Costonian Stage, Caradoc Series, Llan-mill, Dyfed (loc. 26a).

8 Right valve. Lateral view, x77. CRJ SW211/5.

9 Left valve. Lateral view (stereo-pair), x65. On BGSK PC4480.

Pseudulrichia marrii (Jones, 1893)

Longvillian Stage, Caradoc Series, Pus Gill, Dufton, Cumbria (see Occurrence, p. 163).

8 Right valve. Lateral view, x91. On BGSK PC4480.

9 Left valve. Lateral view (stereo-pair), x65. On BGSK PC4480.
Fig. Conspicillum bipunctatum (Jones & Holl, 1869)  
Probably lower Llandeilo Series; 'Hellhole', Wyeforth, Builth, Powys (see Holotype, p. 166)

1 Holotype, cast of external mould of right valve. Lateral view (stereo-pair), x43. BM In18507.

Middle Llandeilo Series, Pen-ddôl Rocks, N bank of River Wye, Builth, Powys (loc. 13).

2 Cast of external mould of right valve. Lateral view (stereo-pair), x36. NMW 84. 16G. 3.

3,4,9, Cast of external mould of right valve. Lateral (stereo-pair), posterior (stereo-pair), ventral (stereo-pair) and dorsal views, x39. NMW 83. 16G. 6.

7 Cast of external mould of left valve. Lateral view, x37. NMW 84. 16G. 2.

8 Cast of external mould of left valve. Lateral view, x38. NMW 84. 16G. 4.

14 Cast of external mould of right valve. Lateral view, x37. NMW 84. 16G. 5.

Upper Llandeilo or lowest Caradoc Series, Llanfawr Quarry, Llandrindod Wells, Powys (loc. 25).

15 Cast of external mould of right valve. Lateral view, x40. CRJ M36.

Conspicillum ulularum sp. nov.

Lower Llandeilo Series, Cefndyrys Lodge, Builth, Powys (loc. 9).

5,6,11, Right valve of partly compressed carapace. Anterior (stereo-pair), lateral (stereo-pair), dorsal (stereo-pair) and ventral views, x43. CRJ M40.

13 Holotype, right valve. Lateral view (stereo-pair), x44. CRJ M41.
PLATE 27

Fig.  

_Faschmidtella elementa_ sp. nov.  
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1, 2, 7 Holotype, right valve. Lateral (stereo-pair), posterior (stereo-pair) and ventral (stereo-pair) views, x59. CRJ SW151.

3 Larval right valve. Lateral view (stereo-pair), x74. CRJ SW152/2.

4 Left valve. Lateral view, x50. CRJ SW152/3.

5 Right valve. Lateral view, x76. CRJ SW152/1.

6 Left valve. Internal lateral view (stereo-pair), x59. CRJ SW152/4.

_Pariconchoprimitia oscillata_ sp. nov.  
Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

8 Left valve. Internal lateral view (stereo-pair), x37. CRJ SW150/5.

9 Larval right valve. Lateral view (stereo-pair), x50. CRJ SW150/3.

10 Right valve. Lateral view (stereo-pair), x41. CRJ SW150/2.

11, 12, 16 Holotype, right valve. Lateral (stereo-pair), ventral (stereo-pair) and dorsal views, x33. CRJ SW149.


14 Right valve. Lateral view, x36. CRJ SW150/1.

_Pariconchoprimitia improba_ sp. nov.  
Upper Llanvirn Series, Ffairfach railway cutting, Llandeilo, Dyfed (loc. 1b).

15, 19, 20 Holotype, left valve. Lateral (stereo-pair), posterior (stereo-pair) and ventral (stereo-pair) views, x42. CRJ SW152.

18 Left valve. Internal lateral view (stereo-pair), x38. CRJ SW153/2.

21 Right valve (outer shell exfoliated). Lateral view, x36. CRJ SW153/3.

_Middle Llandeilo Series, Kincoed Farm, Carmarthen, Dyfed (loc. 12b).

17 Left valve. Lateral view (stereo-pair), x51. CRJ SW153/5.
PLATE 28

Fig.  

**Pedomphalella exoraeoutia** sp. nov. 176

Costonian Stage, Caradoc Series, Lampeter-Velfrey, Dyfed (loc. 28b).

1,11 Right valve. Lateral view (stereo-pair), x72; lateral view of circular ventral part of sulcus S2, x194. CRJ SW145/2.

2,3,6, Holotype, left valve. Lateral (stereo-pair), anterior (stereo-pair), dorsal (stereo-pair) and dorsal oblique views, x72. CRJ SW058.

4 Right valve. Internal lateral view (stereo-pair), x69. CRJ SW145/3.

10 Larval left valve. Lateral view, x70. CRJ SW145/1.

**Pseudbollia obsolete** sp. nov. 179

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

5 Holotype, left valve. Lateral view (stereo-pair), x64. CRJ SW147/3.

8,9,12 Left valve. Anterior (stereo-pair), lateral (stereo-pair) and dorsal (stereo-pair) views, x84. CRJ SW147/2.

13 Right valve. Internal lateral view (stereo-pair), x71. CRJ SW147/4.

Harnagian Stage, Caradoc Series, Wall under Heywood, Shropshire (loc. 38).

17 Cast of external mould of left valve. Lateral view, x77. CRJ M48.

**Pseudbollia aff. P. subaqueata** (Ulrich, 1894) 181

Upper Llandeilo Series, Llan-mill, Dyfed (loc. 22).

14-16 Right valve. Lateral (stereo-pair), posterior (stereo-pair) and dorsal views, x85. CRJ SW146.
Fig. 184

**Vogesella hemidiscus** (Wade, 1911)

Onnian Stage, Caradoc Series, Gwern-y-brain stream section, Welshpool, Powys (loc. 50b).

2 Right valve (slightly compressed dorsoventrally). Lateral view (stereo-pair), x42. CRJ NW078.

6 Left valve. Lateral view, x41. CRJ NW104b.

Onnian Stage, Caradoc Series, Gwern-y-brain stream section, Welshpool, Powys (loc. 50a).

3 Right valve (slightly distorted anteroventrally). Lateral view (stereo-pair), x42. CRJ NW158/1.

Onnian Stage, Caradoc Series, Onny River section, near Cheney Longville, Shropshire (loc. 49c).

4 Left valve. Lateral view (stereo-pair), x48. CRJ NW158/2.

7-9, 12 Left valve. Posterior, lateral, anterior oblique and dorsal views, x48. CRJ NW158/3.

**Conchoorimitiella dyfedensis** sp. nov.

Upper Llandeilo Series, Dryslwyn, Dyfed (loc. 17).

1 Tecnomorphic right valve. Lateral view (stereo-pair), x33. CRJ SW214/3.

5 Tecnomorphic left valve. Lateral view, x31. CRJ SW214/2.

10, 15 Heteromorphic right valve. Lateral (stereo-pair) and ventral (stereo-pair) views, x26. CRJ SW054.

11 Holotype, tecnomorphic left valve. Lateral view (stereo-pair), x32. CRJ SW214/1.

13 Heteromorphic right valve. Lateral view, x33. CRJ SW214/4.

**Conchoorimitiella papilalata** sp. nov.

Costonian Stage, Caradoc Series, Llan-mill, Dyfed (loc. 26a).


16 Heteromorphic right valve. Lateral view (stereo-pair), x32. CRJ SW215/1.

19 Tecnomorphic right valve. Internal lateral view (stereo-pair), x40. CRJ SW215/5.

Costonian Stage, Caradoc Series, Henllan Lodge, Llanddewi-Velfrey

17, 18 Holotype, tecnomorphic left valve. Lateral (stereo-pair) and dorsal (stereo-pair) views, x38. CRJ SW057.

20 Tecnomorphic right valve. Lateral view, x37. CRJ SW215/3.
PLATE 30

Fig. 1  Cast of external mould of tecnomorphic right valve.
Lateral view (stereo-pair), x34. CRJ MW114.

2  Cast of external mould of heteromorphic left valve.
Lateral view (stereo-pair), x33. CRJ NW112.

3-6 Cast of external mould of tecnomorphic left valve.
Posterior view, x38; posterior oblique view of posterior spine, x106; lateral (stereo-pair) and dorsal (stereo-pair)
views, x38; CRJ NW111.

8,9  Heteromorphic left valve. Lateral and posterior view, x32.
CRJ NW073.

7  Holotype, heteromorphic left valve. Lateral view
(stereo-pair), x32. On BM I6056.

10  Small tecnomorphic left valve. Lateral view, x43. On
BM I6056.

Fridoconcha plerilamella sp. nov. 196

Costonian Stage, Caradoc Series, Lampeter-Velfrey,
Dyfed (loc. 28a)

11,12  Left valve. Internal anterior oblique and lateral
(stereo-pair) views, x46. CRJ SW223/2.

13,17, Holotype, right valve. Lateral, ventral oblique and dorsal
views, x48. CRJ SW223/3.

14-16 Right valve. Posterior oblique view of postero-central
lateral surface, x243; lateral view (stereo-pair), x54; lateral view of U-shaped furrow between two successive lamellae on the central lateral surface (stereo-pair),
x194. CRJ SW223/4.

Costonian Stage, Caradoc Series, Lampeter-Velfrey,
Dyfed (loc. 28b).

19  Right valve (slightly broken posteroventrally). Lateral
view, x48. CRJ SW223/1.