LLANVIRN TRILOBITES FROM SOUTH WALES

by

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SUMMARY

The Llanvirn trilobites of South Wales are described, together with faunas of probable Arenig and Llandeilo age from outcrops whose stratigraphical relationship to the Llanvirn is poorly understood.

Twenty eight named species and subspecies are described and an additional thirty four forms are described under open nomenclature. Thirty seven genera are represented in total, and the following new species are erected: *Merlinia contracta*, *Cyclopyge torquata*, *Degamella gladiata*, *Cnemidopyge pentirvinense* and *Cnemidopyge tenuis*. *Eoharpes primus?* and *Protostygina* are recorded from Britain for the first time. Ontogenic stages of *Barrandia homfrayi* and complete material of *Platycalymene tasgarensis simulata*, *Gastropolus obtusicaudatus* and *Cremastoglottos occipitalis* is figured for the first time. This has enabled the cyclopyginine affinities of *Gastropolus* to be demonstrated, and has provided criteria for the separation of Bohemian *Cremastoglottos* from the type species.

An historical review of previous stratigraphical and faunal studies is included, along with a summary of the Llanvirn in outcrop, and discussion on prevailing problems in biostratigraphy and series definition in the region. Important fossiliferous sections of early Arenig and Upper Llanvirn age are logged, potentially important sections demonstrating biozone or series transition are summarised and regional correlation and faunal distribution charts are provided.

Llanvirn, Wales, Stratigraphy, Trilobites, Systematics.

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INTRODUCTION AND ACKNOWLEDGEMENTS

The trilobites described in this study are largely from sediments of Llanvirn age that occupy broad tracts of gently undulating land in south west Wales between Roch and the Fishguard district in the west of the region, and Llandeilo to the east (Fig 1). Most localities studied and sampled occur between Carmarthen and Narberth, where Llanvirn sediments are particularly well developed and are locally richly fossiliferous. A number of outcrops sampled have proven to be of Arenig or probable Llandeilo age as presently defined, but their trilobite faunas are included in this account because of their proximity to proven Llanvirn outcrops, with which their structural and stratigraphical relationship is sometimes poorly understood, or because they have previously been attributed to the Llanvirn series (eg. Williams 1934:55).

Regional strike and dip trends of Arenig and Llanvirn rocks are remarkably consistent and endorse the broadly east-west trending anticline-syncline structures mapped by Evans (1906) and Strahan et al. (1909; 1914). Fold structures are complexly faulted and tectonically disturbed in many places and there is widespread pyroclastic influence in the upper part of the Lower Llanvirn, and throughout most of the upper Llanvirn. Turbidite sequences are also present towards the top of the Lower Llanvin, for example north of Llanboidy (approx SN 190 250).

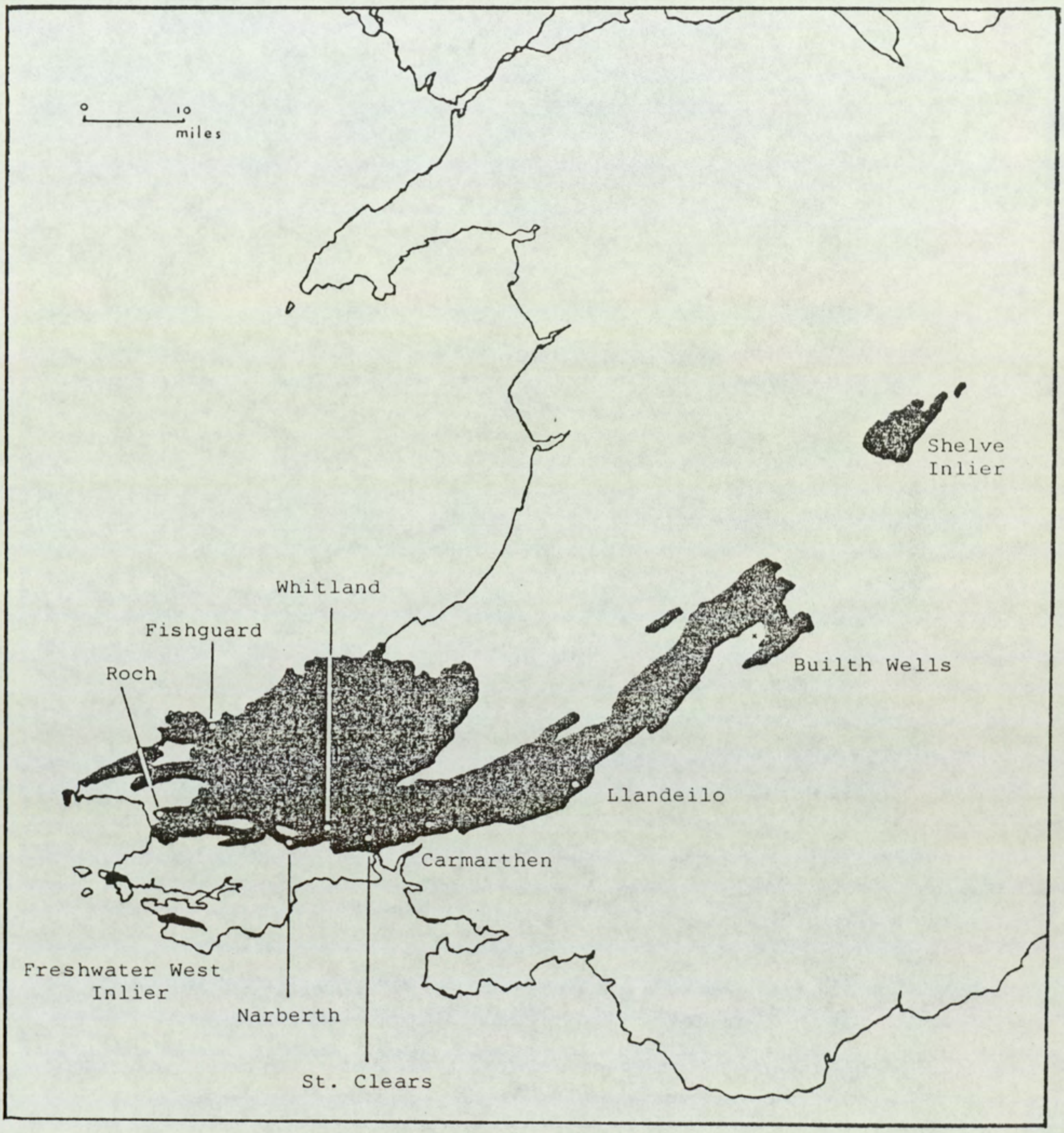

Fig 1 Generalised outcrop of Ordovician rocks in South Wales and the Borderlands, with main towns and place names referred to in the text.

The Llanvirn rocks of south west Wales are separated from coeval sediments of the Builth inlier (Elles 1940; Hughes 1969, 1971, 1979) where the faunas are more restricted, by a narrow northeast-southwest trending strip of upper Ordovician rocks, and from faunistically similar Llanvirn rocks of the Shelve Inlier, Shropshire (Whittard 1931, 1940a, 1940b, 1955-67) by Silurian and younger rocks that generally give rise to low relief topography.

Despite considerable thickness of Llanvirn rocks in the region, exposures are generally poor or isolated, this due to the recessive nature of the rocks and to the heavy drift cover which is rarely penetrated in stream sections.

Early Ordovician and upper Cambrian sequences are extensively exposed along the north Dyfed coast between the Llanvirn type area near Abereiddy Bay (Hicks 1875, 1881) and the Fishguard district, but any continuous successions that may exist in the early Ordovician are complicated by wide-spread thrust faulting and igneous intrusion (Cornelius pers. comm.).

The bulk of the material for this research was collected during two years postgraduate study funded by City of Birmingham Education Department. I thank the curators of the following institutions for the loan of specimens in their care (abbreviated prefixes of institutions used in the main text are given in brackets): Birmingham University (BU), Bristol University (BR), British Geolocial

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HISTORIAL REVIEW

The Llanvirn Series was established by Hicks in 1881, founded upon a rich fauna of trilobites (Hicks, 1875) and graptolites (Hopkinson & Lapworth 1875, Elles 1904), occurring in a slate quarry 500 metres north of Llanvirn-y-frân (now Llanfern-y-frân) Farm, near Abereiddy Bay. Hicks concluded that the slates at the quarry, containing trilobites associated with pendant didymograptids of '*bifidus*'-type, and the overlying sequence of rocks exposed to the north that includes a thick ash band and slates with abundant didymograptids of *murchisoni*-type, were characteristic of a faunistically distinct intervening series between the "Upper Arenig" and the "Lower Llandeilo" already recognised in the area. He proposed the term Llanvirn Series to accommodate this sequence, deriving the name from the nearby farm.

Since this original description of trilobites from the type area, Llanvirn trilobites of south-west Wales have received only scant attention. Rich faunas have long been recognised from several localities within the region, for example from the collecting of Turnbull from the Long Plantation railway cutting at Scolton, and several national collections contain representative Llanvirn trilobites.

The Turnbull Collection (SM) was important to Whittington (1952) in describing Dionide species, to Whittard (1955-67 pp. 11, 39, 98, 136, 175, 181, 213) in his account of the comparable trilobites of the topmost Arenig and early Llanvirn series of the Shelve Inlier, Shropshire, and to Dean (in Whittard 1979 pp. 308-320) in discussing the faunal affinities and stratigraphical implications of the Shelve faunas.

The importance of trilobites and graptolites in the correlation of the Llanvirn Volcanic suites of the Fishguard and Strumble Head districts has long been appreciated (Reed 1895, Evans 1945, Thomas & Thomas 1956) and their use in structural interpretation has more recently been stressed in renewed research into the problematical structure of the northern end of Abereiddy Bay north of the Llanvirn type area (Waltham 1971, Black _et al_. 1971).

With the exception of a small number of genera and species dealt with by Reed (1912) and Williams (1948) and more recently by Fortey & Owens (in press) in their account of the Arenig-Llanvirn transition in Dyfed, no modern redescription and revision of the Llanvirn trilobites of South Wales has been undertaken. Faunal lists have been provided however from collections made in several localised areas of the region, most comprehensively by Strahan _et al_. for the memoirs of the Geological Survey of Great Britain, The South Wales Coalfield: for Ammanford (1907), Carmarthen (1909) and Haverfordwest (1914), and by Cantrill _et al_. (1916) for Milford Haven and Dixon, (1921) for Pembroke and Tenby.

Similar lists have been provided for regions north of the memoir sheets, notably by Evans (1906) in dealing with the Ordovician of western Carmarthenshire, Cantrill & Thomas (1906) for the Llangynog district, west of Carmarthen, Evans W D (1945) for the Prescelly Hills, east of Fishguard, Cox _et al_. (1930, 1930a) for the St. Davids area and Ramsay Island, and Williams (1934) for the eastern end of the St. Davids Pre-cambrian area.

The stratigraphy and faunas of the underlying Arenig, Tremadoc and upper Cambrian in the Carmarthen district have recently been revised by Fortey & Owens (1978, 1978a), Fortey et al. (1982) and Cope & Rushton (in press), and in the Whitland district to the west by Fortey & Owens (in press). The Arenig-Llanvirn boundary has been confirmed to occur within the Llanfallteg Formation of the type area, around Llanfallteg West 6 Km north-west of Whitland, where a candidate boundary stratotype section has been proposed (Rushton et al. 1979). The upper part of the Llanfallteg Formation lies within the Lowest Llanvirn, and contains a rich fauna of trilobites resembling that of the coeval Upper Tankerville Flags and Hope Shale members of the Shelve Formation in Shropshire (Whittard 1955-66).

R A Fortey & R M Owens (in press) have introduced a biozone scheme for the Arenig series largely based on trilobites. Their scheme (Fig. 5 p 29)is more precise and satisfactory than the graptolite zones proposed by Elles (1904, 1933), to which the correlation of their new stage names is necessarily tentative. The Arenig-Llanvirn boundary is recognised entirely on faunal grounds, the base of Llanvirn Series being marked by an influx of pendant didymograptids of which Didymograptus artus Elles & Wood is characteristic.

BIOSTRATIGRAPHY AND CORRELATION PROBLEMS

Although the series of the Ordovician System as recognised in Britain are used internationally, none of them has boundary stratotype sections designated to date. Thus the present distinction between series is not founded on definition, but is deduced from the occurrence of particular biozones or characteristic assemblages of fossils. The provincial nature of such biozones or characteristic faunas, and lateral facies variations further complicate our understanding of Ordovician stratigraphy.

The Llanvirn series has been classically divided into Lower and Upper divisions (after Hicks 1881) based on graptolite faunas and a marked lithofacies change in the Upper division. The Lower Llanvirn is characterised by great thicknesses of shales and mudstones containing graptolites including didymograptids previously attributed to Didymograptus bifidus Hall, and a fauna of trilobites, gastropods, bivalves, hyolithids, cephalopods, conulariids and rare echinoderms. The Upper Llanvirn is characterised by a widespread pyroclastic influence, producing ashes associated with granulestones and shales containing few trilobites and brachiopods with didymograptids of murchisoni-type. These typically underlie shallow water, shelly-facies sediments characteristic of the Llandeilo series as developed in the type area (Williams 1953, Wilcox & Lockley 1981). This division has proven unsatisfactory in practice, due partly to the confusion which currently surrounds the taxonomy of pendant didymograptids, particularly bifidus itself. D. bifidus (Hall) is a Canadian species from the Quebec Group of Arenig age, and British forms identified with bifidus by Elles & Wood (1901) are not conspecific (Cooper & Fortey 1982, Jenkins 1983). Clearly a new name for the Lower Llanvirn biozone in Britain is necessary, and that of D.artus proposed by Fortey & Owens (in press) is accepted here. artus is a common and distinctive species widely recorded in the Lower Llanvirn. Jenkins (in Ross et al. 1982) has used G.dentatus for this purpose, but Fortey & Owens (in press) have shown this species to range down well into the Arenig in South Wales.

A number of Didymograptus species have been utilised to define subzones within the Lower Llanvirn; eg. D. speciosus (Whittard 1956: 67.67; Hughes 1971: 158) and D.acutidens (Thomas in Strahan et al. 1914: 24), but there has been little debate as to their usefulness in practice, and they have not received wide acceptance.

The problems of precise age correlation of Llanvirn rocks on faunal evidence have recently been highlighted by Rushton & Hughes (1981) who were unable to confidently assign subsurface Llanvirn rocks in eastern England to either of Hicks' biozones, despite their rich fauna of graptolites which were considered by Skevington (1973) to be of Upper Llanvirn age, but challenged subsequently by Jenkins (1983) who attributed them to the Lower Llanvirn.

Similar difficulties arise with the continued use of murchisoni to define the Upper Llanvirn. Members of this species group have long been recognised at horizons low in the artus Biozone in South Wales (eg. Evans 1906:

619, item 3) and more recently didymograptids of murchisoni type have been recognised from the mid-Arenig of Arkansas (Berry 1970) and the early Arenig of China (Mu *et al*. 1979).

Equally acute are the problems of defining the overlying Llandeilo Series. In the type area, the complete Series consists of non-graptolitic shelly facies with characteristic faunas of trilobites and brachiopods, many of which are strongly facies controlled and of restricted lateral distribution, and correlation with continuous graptolitic sequences elsewhere in Britain in poorly understood. For discussion, see Toghill 1970, Skevington 1970, Ross *et al*. 1982.

THE LLANVIRN SERIES IN SOUTH WALES

The problems of distinguishing Arenig from Llanvirn sediments on faunal evidence are highlighted by the conclusions of Williams (1934: 55) who recognised the Llanvirn Series within the northern margin of his research area east of St. Davids and inferred the presence of the 'bifidus' Biozone near Mathry on the evidence of a trilobite fauna from a single outcrop at Trehale quarry (locality 69 herein). Renewed collecting from this locality suggests that his identification of the trilobites (op cit. :56) is erroneous, and that the horizon is of probable Arenig age.

Trehale quarry (SM 8878 2870; Fig 3) exposes over twenty metres of massive rhyolitic and feldspathic ashes, ashy sandstones and banded laminated tuffs that strike almost E-W at 88° E of N, and dip at 60° S with slight rotation evident. The tuffs at the base of the section are distinctive in that thin but persistent orange, buff and white ashes are interclated with contrasting dark grey or black micaceous layers, reflecting normal clastic deposition with regular pyroclastic influence. These banded ashes are richly fossiliferous and contain an autochthonous fauna of trilobites with rarer brachiopods and dendroid graptolites. The following have been recovered during this research: Porterfieldia cf. punctata Crosfield & Skeat, Merlinia contracta sp. nov. Degamella gladiata sp. nov. Cyclopyge torquata sp. nov. Furcalithus sp. Protostygina sp., Leiagnostus cf bohemicus (Novák), Segmentagnostus Mccoyii (Salter), Callograptus sp. and an indeterminate orthid brachiopod (Cocks pers. comm.).

The precise age of these beds is problematical. Further exposures have not been located in the immediate area, which is drift covered, and structural relationships with the Arenig further north and west is not understood.

Faunistically, the abundance of Porterfieldia cf. punctata in association with Merlinia and cyclopygids invites comparison with faunas from the Cwm-ffrŵd Member of the Carmarthen Formation (Middle Lower Arenig) as recognised by Fortey & Owens (in press; see Fig 5). Furcalithus is not recognised from this member in the Carmarthen district, but Furcalithus radix sp. nov. (Fortey & Owens in press; Pl. 11, Fig 1 herein) has been utilised as a zone fossil for the overlying Cwm-yr-Abbey member in that region. Owens (pers. comm) approximates the F. radix Biozone to the arenaceous facies of the Blaencedlw and Abercastle Formations to the West of Carmarthen. The Blaencediw Formation incorporates the "Brunel Beds" horizon of Williams (1934: 49) which have yielded a varied fauna, including trilobites, at a number of localities approximately 6 km southwest of Trehale, near Tremanhir (SN 827263: see Williams 1934: 50,51). The fossils reported by Williams have not been traced, but it may be that the Arenig rocks exposed within the Tremanhir syncline of this region represent the upper part of the Moridunian stage or the base of the Whitlandian Stage as recognised in the Carmarthen district (Fortey & Owens in press) and the Trehale Beds represent the upper limit of the range of Porterfieldia punctata Crosfield & Skeat.

LOWER LLANVIRN; ARTUS BIOZONE

In the Llanvirn type area, the base of the Series is regarded as the junction of the Aber-mawr Shales and the Pen-maen-dewi Shale Formation (Jenkins in Hughes, Jenkins & Rickards in Bassett 1982; fig 2.) where the passage is apparently conformable. The Pen-maen-dewi Shale (= Upper Arenig of Hicks 1875) is here poorly fossiliferous, and no faunal evidence exists for an upper Arenig age for these beds. A fauna of dendroid graptolites of uncertain age has been recovered nearby (Jenkins unpublished; see Whittington *et al*. 1984:22) and the horizon has been approximated to the 'Tetragraptus Beds' at Whitesands Bay, southwest of Abereiddy. This horizon has been recognised for over a century (Salter 1866) without its true stratigraphic position being understood.

In the Whitland district to the east, Fortey & Owens (in press) have demonstrated that the 'Tetragraptus Beds' of Salter are overlain by a considerable thickness of mudstones containing a sparse but diverse fauna of trilobites, graptolites, calcichordates, bivalve molluscs, hyolithids and ostracods which have been attributed to the *D. hirundo* Biozone of Elles. The passage of these upper Arenig beds into the base of the Llanvirn is continuous at the disused Llanfallteg railway cutting.

The characteristic Llanfallteg Formation lithofacies consists of grey shales and mudstones that are much lighter in appearance than the underlying shales and mudstones of the Pontifenni Formation, and take on a whitish or buff-yellow appearance when weathered, with vermillion and brown oxides on bedding surfaces. This formation occupies broad tracts of land, with an approximately east-west strike to the north and north west of Whitland, and a narrower band in the Whitland and St. Clears districts. Regional dip trends confirm the anticlinal structure mapped by Evans (1906: Pl. 46). Characteristic lithogies and faunas have been located as far west as Scolton, near Haverfordwest, and in the Llangynog district southwest of Carmarthen. Thick ash bands are characteristic of the upper part of the Formation and are extensively exposed along the northern limb of the anticline north of Whitland and St Clears, where they form prominent topographical features that are useful for mapping.

In the type area, the Llanfallteg Formation grades upwards into black slaty mudstones and thin fissile shales that contain pendent didymograptids including D. artus. These beds are well exposed in the lane crossing the Afon Rhyd-y-bil (SN 1090 2300). To the north these beds are associated with turbidites and grade upwards into a considerable thickness of monotonous grey micaceous shales and mudstones which occupy a broad belt of land approximately 5 km wide, extending as far north as Maenchlocog, and continue the east-west strike of the underlying Llanfallteg Formation with regional dip trends to the north. These beds, mapped by Evans (1906) as 'blue grey mudstones etc' of unknown age, are very poorly fossiliferous, and have afforded only two fragmentary didymograptids that are cautiously attributed to D. artus? (Rickards pers. comm.) from near Ffynnon-gain Farm (0738 2300). Continuous exposures dipping uniformly at approximately 40° N occur along the shores of Llys-y-Frân Reservoir and in the bed and banks of several southerly flowing streams between the reservoir and the Eastern Cleddau to the east. Their transition into the more slaty mudstones with thin feldspathic ash bands of the Rosebush and Maenchlocog area can be seen in the northern section of a disused railway cutting south of Maenchlocog, and in the bed of the Afon Syfynwy north of Llys-y-Frân Reservoir. The slates of Maenchlocog and Rosebush are very sparsely fossiliferous and are included within the Lower Llanvirn '*bifidus* zone' by Evans (1945:94).

In the Carmarthen district, the Lower Llanvirn consists of a monotonous thickness of dark grey or black micaceous shales and mudstones which are generally poorly fossiliferous. These beds, mapped as '*bifidus* shales' by the Survey (Strahan *et al*. 1909) have been extensively exposed during the construction of the main A40 Carmarthen By-Pass to the west of Carmarthen, and have yielded a small fauna of well preserved trilobites including *Ogyginus corndensis* Murchisoni, *Ogyginus* cf *porcatus* Whittard, *Cnemidopyge* sp. and *Dindymene didymograpti* Whittard. This fauna more closely resembles that of the *artus* Biozone of Shropshire than the Llanfallteg Formation of the type area.

UPPER LLANVIRN: *MURCHISONI* BIOZONE

Although graptolites of the *D. murchisoni* species-group are undeniably abundant in rocks above the *artus* Biozone and beneath rocks of 'Llandeilo' character in the region, they are also locally abundant at horizons that yield trilobite faunas closely similar to those of the basal Llanvirn as recognised within the Llanfallteg

Formation of the type area, for example at Scolton (localities 58-60) where all graptolites collected during this research, along with specimens previously identified as D. artus (Thomas in Strahan et al. 1914: 30) have been attributed to D. murchisoni (s.l.) (Rickards pers. comm.).

In the Llanvirn type area, the murchisoni Biozone is represented by the highly fossiliferous Caerheys Shale containing the celebrated faunas of murchisoni-type graptolites with rarer trilobites including Protolloydolithus sp. and Platycalymene sp. The base of the Biozone is taken at the so-called "Murchisoni Ash" which follows the Pen-maen-dewi Shales (artus Biozone) conformably. The structural relationship of the Caerhys Shale with the 'Dicranograptus Shales' (Cox 1916) that occupy the centre of Abereiddy Bay is not understood (Bassett in Bassett et al. 1976:38) but the sequence at the northern end of the bay outlined by Black et al. (1971) endorses the suggestion of Jones (1940) that the upper Llanvirn-Llandeilo junction is represented by a non-sequence or an unconformity.

Further east in the Llanfallteg type area, no fossiliferous section demonstrating the passage from the artus Biozone into the murchisoni Biozone has been identified with certainty during this research, and Strahan et al. (1914:24) reported the absence of the murchisoni Biozone in the area covered by the Haverfordwest memoir. However, poor exposures in a lane leading north from Crosshands to Cefn-y-pant; north east of Llanboidy (approximately SN 193 245) and immediately east in the bed of the westerly flowing stream north of Fro-wen have provided D. artus Elles, D. murchisoni Boeck, and D. denshabitus Jenkins, indicating the low murchisoni Biozone (Rickards: pers. comm.).

In the Narberth district fossiliferous black shales with a mixed graptolite-trilobite fauna with rarer gastropods, brachiopods and ostracods indicative of the low murchisoni Biozone (Rickards pers. comm.) are exposed within a WSW trending anticline-syncline structure and have regional dip trends to the north. Overlying beds have been attributed to the 'Llandeilo Flag Series' of Llandeilo age (Cantrill, Thomas & Jones in Strahan et al. 1914: 31-36 see also Spjeldnaes 1963 : 262). Addison (unpub. Ph.D. thesis see Bassett in Bassett et al. 1976: 36) regards the shelly faunas at Llan Mill to represent the Upper Llandeilo, marrolithus favus Biozone and basal Caradoc; the latter indicated by rich shelly faunas from Bryn-Banc quarry northeast of Llan Mill (SN 142 144). This sequence above the Llanvirn Shales is termed here the Bryn-glâs Beds.
The Llanvirn shales at Narberth are remarkable in preserving a mixed trilobite and graptolite fauna including species more commonly associated with the Llandeilo Series elsewhere (eg. Ogygiocarella debuchi Brongniart). This horizon has been compared to similar lithologies and faunas at Cuffern near Roch, where a probable representative of

the 'Llandeilo Flags' horizon succeeds the 'Murchisoni zone' (Cantrill & Thomas in Cantrill et al. 1916:43)and to subsurface shales in the St. Clears district, near Lower Court (Evans 1906: 619). Similar soft shales underlie more arenaceous beds of the Murchisoni Biozone in the Llandeilo district (Williams 1953: 179) and a similar fauna of pendant didymograptids including D. artus and D. murchisoni sensu lato, associated with Basilicus tyrannus and Dalmanella prototypa is recorded from ashy beds beneath the basal grits of the Fairfach Group of possible Upper Llanvirn age at Llandeilo (Williams 1953: 179-180; see also Bassett in Bassett et al. 1976: 32-33). Some exposures near Llan Mill reported by the survey (eg. locality 48 of Strahan et al 1914) are no longer accessible, and no section demonstrating the continuous passage of the shales into the Bryn-glâs Beds has been discovered during this research. Jones (in Strahan et al. 1914: 26) described an ashy development above the shales that includes beds of coarse ash 18 - 20 feet thick, alternating with shales and fine grained ashes, exposed for a distance of 180 yards in a dingle east of Llan Mill. Although no faunas are reported, beds of this lithological character with Flexicalymene cf. cambrensis, and Basilicus tyrannus in a tributary of the Afon Marlais (locality 23) are presumably those described by Jones, which he included within the 'bifidis zone'. They are included here within the Bryn-glâs Beds, at an horizon near their base, and therefore presumably close to their junction with the underlying murchisoni shales recorded immediately to the west. The best exposure of the Llan Mill Shales is that south of Whitehouse Mill (SN 16431465; locality 19, Fig 2).

In the east of the region at Cuffern, near Roch, soft soot-black shales with didymograptids of murchisoni-type and ill preserved ostracods probably attributable to Graquina sp. (Siveter pers. comm.) immediately underlie ashy and slaty mudstones with Ogyginus corndensis Murchison and rarer brachiopods attributable to Tessinita prototypa (Williams). These mudstones grade upwards into slates with prolific faunas of murchisoni-type didymograptids that are very poorly exposed in the bed of a tributary of Camrose Brook, and have been ploughed up in abundance in fields immediately north of the tributary (localities 73 and 75). These slates resemble the Caerhys Shales of the Llanvirn type area both faunistically and lithologically. The soft shales at the base of this exposed sequence at Roch have been attributed to the upper 'bifidus zone ' (Thomas in Cantrill et al. 1916:41). Llandeilo rocks have provided a fauna of trilobites, brachiopods and graptolites from a quarry nearby (Op cit: 43; locality 9) where the relationship with the murchisoni Biozone would repay further investigation. Paleontological results of BGS boreholes near Roch are not yet published.

Further north, the murchisoni Biozone is well exposed at several localities between Fishguard and the Prescelly Hills, but has provided only rare, generically indeterminate trinucleid fragments during this research. The more varied faunas recorded by Evans (1945) have not been traced. At Fishguard, renewed collecting from exposures and disused quarries at Tower Hill reported by Reed (1895) has provided a varied fauna of graptolites, brachiopods, cephalopods and rare trilobites indicative of the low murchisoni Biozone (Rickards pers. comm.). The Glyptograptus teretiusculus Biozone has been identified within the beds that are extensively exposed between Fishguard and Goodwick (Rickards pers. comm.) and may provide a candidate stratotype section to define the base of the Llandeilo Series in this area. A similar graptolitic sequence at Builth has been utilized for fission track dating (Ross et al. 1982: 142).

In the Llandeilo type area the base of the series is taken as the onset of the shallow water shelly facies that overlies the Fairfach Grits unconformably (Williams 1953: 190). It has been common practice in the past to equate this horizon with the base of the teretiusculus Biozone (Williams in Bassett et al. :5) but Addison (see Ross et al. 1982: 142) and Bergström (1971, 1973) have questioned this correlation. Conodonts described by Rhodes (1953) from the earliest Llandeilo of the type area are considered by Bergstrom (1971: fig 7) to represent the lower Pygodus anserinus Biozone, recognised in Sweden. Subsequent research into Swedish middle Ordovician successions led Bergström (1973) to place the base of the teretiusculus Biozone beneath the earliest Llandeilo, implying a Llanvirn age for at least part of that biozone, and correlating the flags and grits of the Fairfach Group and the Lower Llandeilo

Flags with part of the Gymnograptus linnarssoni Biozone, and 'C. putillus' Biozone interval in Sweden. (see Skevington 1970: 202 for further discussion).

In the Whitland area, Evans (1906) indicated the 'murchisoni zone' at several places within the faulted northern limb of the anticline north and northeast of Llanfallteg. Ashy shales and slaty mudstones with tuffs and ash beds attributable to the murchisoni Biozone also occur further east between St. Clears and Carmarthen (Cantrill & Thomas in Strahan et al. 1909: 36-38) and are particularly well exposed in the Abergwili district east and northeast of Carmarthen, where pyroclastic beds are conspicuously absent. Faunas recovered during this research include D. murchisoni (Boeck), D. cf. murchisoni, and Pseudoclimograptus confertus (Lapworth), with rare trinucleid fragments probably attributable to Protolloydolithius sp.

The junction of these hard laminated beds with the softer micaceous shales of the underlying artus Biozone with D. artus Elles & Wood and D. acutidens Lapworth is exposed:-
(i) in the lane immediately east and southeast of the corn mill at Felin-wen (SN 4630 2160) 5.5 Km east of Carmarthen, and murchisoni-bearing beds are almost continuously exposed along the northerly trending lane leading to Pen-y-cnwe, where they can be traced almost to a disused quarry in beds attributed to the Llandeilo Series (SN 4650 2240; Strahan et al. 1909: 30, 40).
(ii) in a disused roadside quarry 45 metres NNW of Ricketts

Mill, 250 metres north of the confluence of the Afon Cywyn and the Afon Cynnen (SN. 3345,2140).

(iii) in the laneside west of Pant-y-hendre Quarry, near Meidrim (Toghill 1970).

The junction of the murchisoni Biozone with the overlying Llandeilo Series is also exposed at several localities near Carmarthen. Initial reconnai ance has revealed a number of sections in which the transition is apparently continuous and fossiliferous throughout. These sections would repay further detailed study and may provide candidate stratotype sections to define the base of the Llandeilo Series west of the type area.

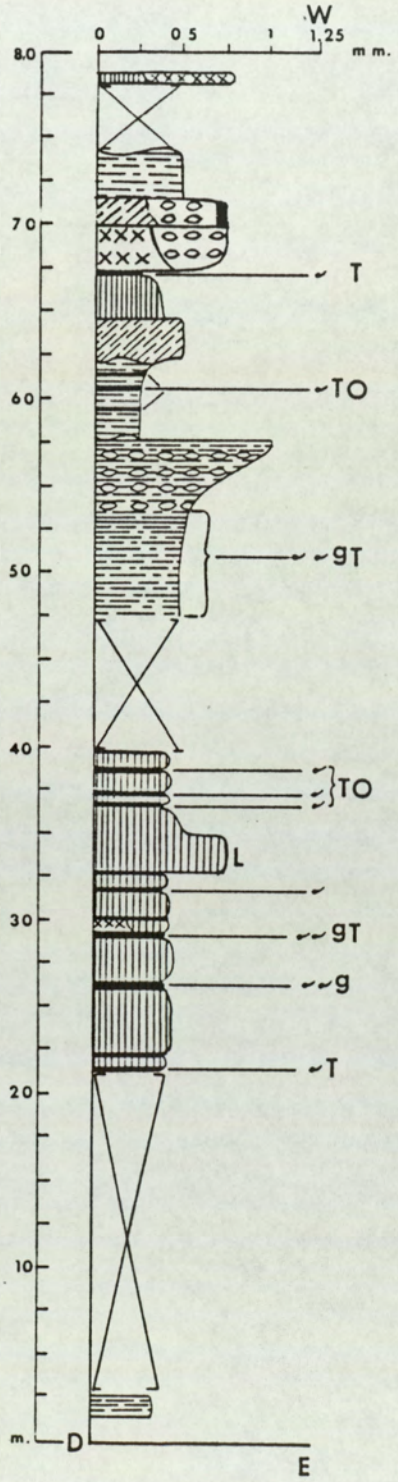
(i) Western end of Merlin's Hill 4.5 Km ENE of Carmarthen; new trackway which circumscribes the north and western flanks of the hill commencing immediately south of Allt-y-fyrddyn-uchaf (SN 4520 21.58). Slaty mudstones striking approximately NW-SE are almost vertically bedded with conjugate sets of cleavage planes developed at between 70° -90° to bedding, at 1-2.5 cm intervals near the base of the trackway; 3 - 6 cm intervals higher in the sequence near the summit. Graptolites are abundant and include D. murchisoni (Boeck) D. cf. murchisoni, cf. Diplograptus priscus (Elles & Wood) and an indeterminate biserial form (Rickards pers. comm.). Protolloydolithus ramsayi Hicks (Pl. 10, Fig. 10) from an untraced quarry at the western end of Merlin's Hill is preserved in an identical lithology, with characteristic bedding cleavage relationships suggesting that it originated at a similar horizon to that exposed in the trackway. Near the summit of the hill the dark slates with murchisoni grade into coarse, rubbly arenites and iron rich siltstones with a sparse fauna of bryozoans and brachiopods, that have been attributed to the Llandeilo (Strahan et al. 1909).

(ii) Exposures 400 metres north of Dolgwili bridge (SN 4315 2220) and exposures on the southern and eastern slopes of Allt-castell-pigyn. Characteristic striped shales with didymograptids of murchisoni-type are immediately succeeded by a thick agglomeritic ash bed equated to the 'Asaphus Ash' (Strahan et al. 1909: 37).

(iii) Disused quarry above the wooded hillslope on the eastern side of Cywyn Valley, 350 metres ESE of Rickett's Mill (SN 3325 2120). Pale coloured murchisoni shales with much ashy material are overlain by hard sandy beds with a basal coarse breccia, which are equated to the 'Asaphus Ash' (Thomas in Strahan et al. 1909:37).

(iv) Temporary exposures during excavation of trackway north of the disused quarry on the eastern flank of Penybigwern, 45 metres west of Cefn-crwth farm (SN 3090 2030). Dark shales with murchisoni underlying coarse flagstones with brachiopods and bryozoans of Llandeilo affinity.

The most southerly expression of the Llanvirn Series in the region is a small faulted inlier, poorly exposed within the Freshwater East and Castlemartin Corse-anticlines south of Milford Haven (Dixon 1921: 10-11). The precise extent of the inlier is not known, but faunas recorded include D. artus Elles & Wood, D. murchisoni (s.l), D. 'bifidus' and trinucleid trilobites (BGS. E.D. 1054, 1064-67; Pg. 4048, 4114-17, 4138-51, 4355) and both the Lower and Upper Llanvirn may be present. The lithology of specimens Pg.4150-51; ED. 1064-65,1216 and1220 invites comparison with the Llanfallteg Formation.



LITHOLOGY

= massive rhyolitic ash
= grit
= arenite
= siltstone
= mudstones
= shales
= slaty mudstones
= tuffs
= laminated tuffs
= concretions
= pyritous
= carbonaceous
= iron rich (limonitic)
= fossiliferous
= very fossiliferous

BEDDING INTERFACE
sharp
gradational
diffuse

FAUNAS
T = trilobites
g = graptolites
O = ostracods
b = brachiopods

Key for Figs 2 and 3.

Fig 2. Log of exposed section at locality 19, Upper Llanvirn; low murchisoni Biozone. Datum point (D) taken at culvert for northerly flowing tributary of Afon Cwm SN.1662 1462.

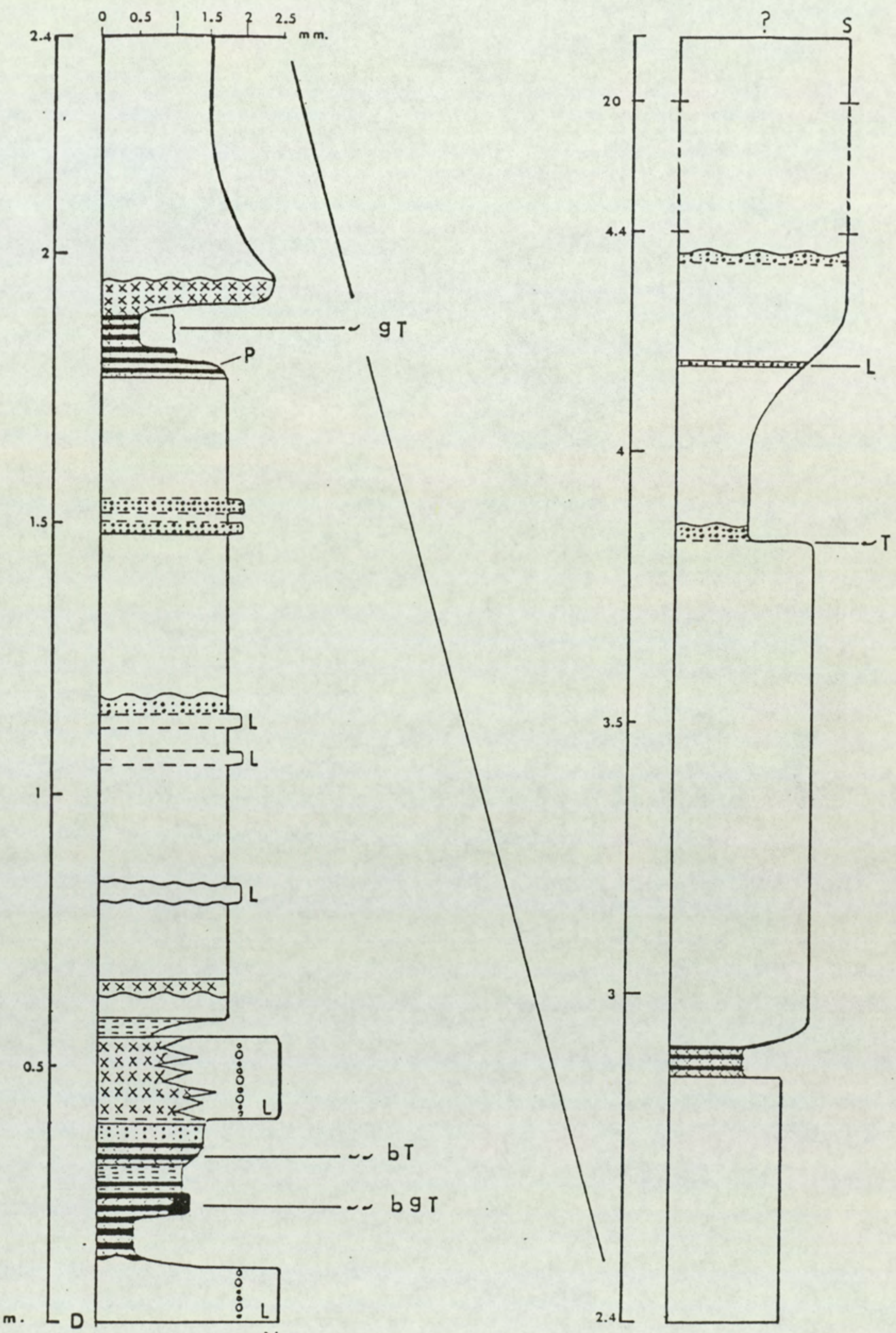


Fig 3 Log of exposed section at Trehale quarry; locality 69, of probable early Arenig (Moridunian) age. Datum point (D) taken at first exposure at north-western end of quarry.

		LLANVIRN TYPE AREA		MATHRY	WESTERN CARMARTHEN	MEIDRIM AREA	LLANDEILO TYPE AREA	
		HICKS 1881	JENKINS IN BASSETT 1982	WILLIAMS T G 1934	EVANS 1906	SKEVINGTON 1970	WILLIAMS et al. 1972	BERGSTROM 1973
		GRAPTOLITES	GRAPTOLITES	GRAPTOLITES/ TRILOBITES	GRAPTOLITES	GRAPTOLITES	GRAPTOLITES	CONODONTS
LLANDEILO		LOWER LLANDEILO	CASTELL LIMESTONE	base not seen ?	Asaphus tyrannus beds	Asaphus Ash ?	L LLANDEILO FLAGS = teretiusculus zone ?	gracilis Biozone teretiusculus Biozone
LLANVIRN	UPPER	murchisoni beds	CAERHYS SHALE LLANRIAN VOLCANICS	TY-NEWYDD GRUG SLATES MURCHISONI ASH	murchisoni beds	Murchisoni Shales	FAIRFACH GROUP	Murchisoni biozone
		murchisoni ash						
	LOWER	bifidus beds	ABER-MAWR SHALES	COED-BACH SLATES F F PEN-YR-ALLT ASHES TREHALE BEDS	bifidus beds	bifidus Shales	bifidus Shales	
ARENIG		UPPER ARENIG	— ?— ?— — PEN-MAEN-DEWI SHALE	? base not seen	"Tetragraptus Beds" sensu Salter 1866		? base not seen	
							Lithostrati-graphic Units	biozones

Fig 4. Correlation Schemes of various authors for the Upper Arenig Llanvirn and basal Llandeilo in South-West Wales.

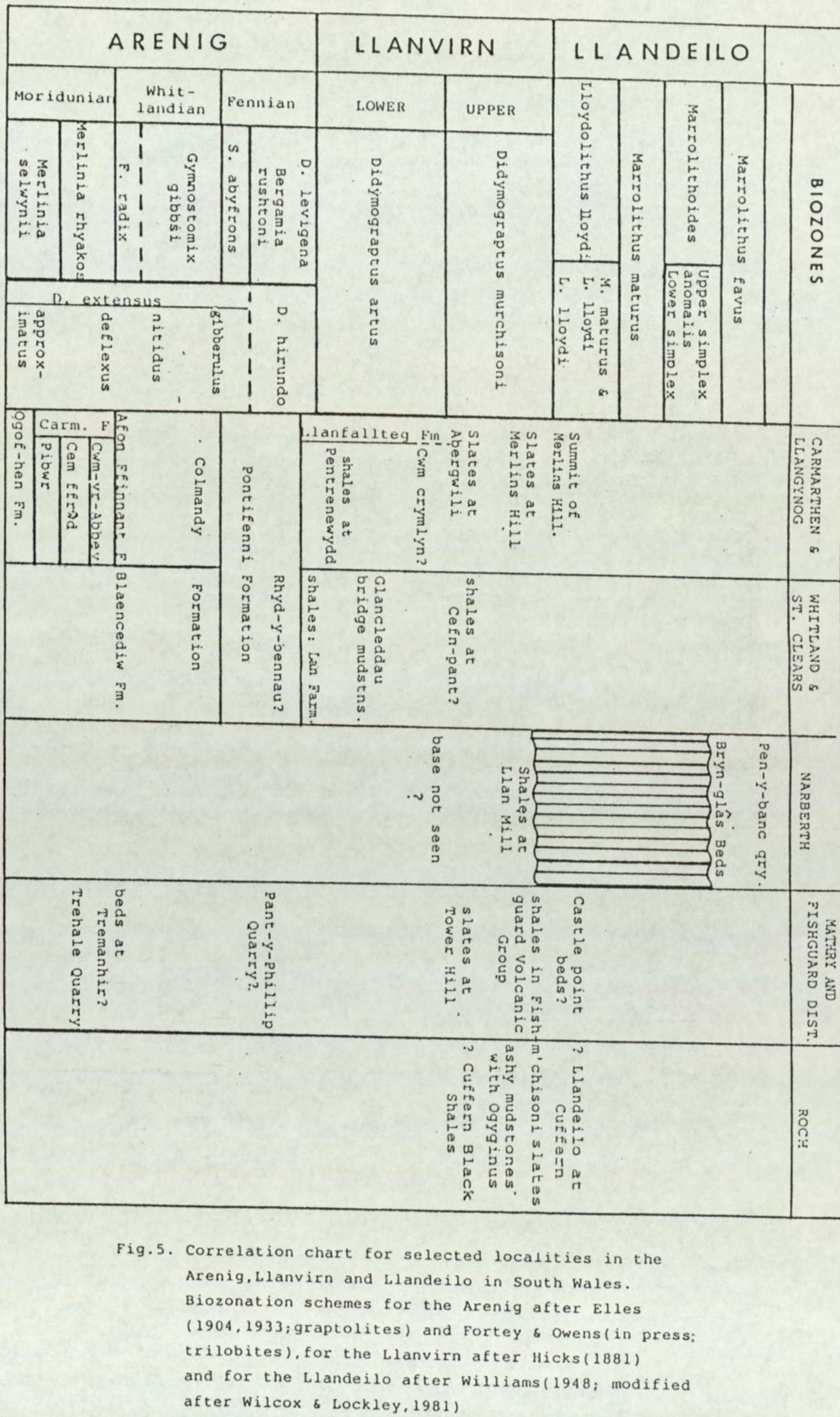


Fig.5. Correlation chart for selected localities in the Arenig, Llanvirn and Llandeilo in South Wales. Biozonation schemes for the Arenig after Elles (1904, 1933; graptolites) and Fortey & Owens (in press; trilobites), for the Llanvirn after Hicks (1881) and for the Llandeilo after Williams (1948; modified after Wilcox & Lockley, 1981)

SYSTEMATIC DESCRIPTIONS

Terminology. Descriptive terms employed here follow the Treatise Part O (Harrington et al. in Moore 1959: O117-126) with the following exceptions and additions:-

(1) Trinucleid fringe notation follows Hughes et al. (1975:543; text figs 3,4). This is an adoption of Bancroft's (1929: 69)original scheme subsequently modified by Williams (1948: 49), Whittard (1955:28) and Ingham (1970:40).

(2) The glabella is considered to include the occipital ring.

(3) L (lobe) and S (sulcus) are used to describe glabellar lobes and furrows.

(4) The course of the facial sutures in Asaphidae is described using the angular notation of R & E Richter (see Owens 1973: 4, Fig 1A).

(5) Parathoracic segment (Hughes 1979: 110) is applied to the region of the transitory pygidium having the appearance of a thoracic segment, but remaining fused into the pygidium.

(6) Young holaspis (Hughes 1979: 110) is applied to individuals with the full number of thoracic segments, but not possessing all other holaspid characters.

(7) Posterior indentation is applied to the small postaxial indentation of the posterior margin in the transitory pygidium in asaphids (see Henningsmoen 1960: 230: Hughes 1979: 110).

The orientation of the ctillaenine exoskeleton for photography follows that of Whittard (1939: 276) and Jaanusson (1957:82).

<u>SYNONYMY</u> The symbols proposed by Richter (1948) and explained by Matthews (1973) are employed here.

<u>PRESERVATION</u> Fortey & Owens (1978: 242) have outlined problems in trilobite taxonomy that arise from variability in the state of preservation within Arenig faunas from South Wales. Such problems are generally applicable here, as the majority of Llanvirn and Arenig specimens examined are preserved in shale or slate and have suffered some degree of compression and distortion.

Family METAGNOSTIDAE Jaekel, 1909

Genus SEGMENTAGNOSTUS Pek, 1977

TYPE SPECIES. Agnostus caducus Barrande, 1872, from the Dobrotivá Formation (Llandeilo) of Bohemia, by original designation.

REMARKS. Taxonomy and interpretation of this genus follows that of Fortey (1980: 27).

Segmentagnostus mccoyii (Salter in Murchison, 1854)

(Pl. 1, Figs. 1-3)

V * 1839 Agnostus pisiformis; Murchison: 650, 664, 704. pl. 25, Fig. 6a-b.

1851 Diplorhina triplicata; M'Coy in Sedgewick and M'Coy: 142, pl. IE, Fig. II.

1854 Agnostus McCoyii; Salter in Murchison: pl. 3, Fig. 8.

1859 Agnostus maccoyii; Salter in Murchison: pl. 3, Fig. 7, 8, Foss. 10, fig. 5.

1939 Geragnostus (Corrugatagnostus) maccoyi; Kobayashi: 173.

V 1955 Geragnostus maccoyi; Whittard: 8, pl. I, Figs. 5, 6.

V 1966 Geragnostus maccoyii; Whittard: 265-6, pl. 46, Fig. 2 (with full synonomy)

V 1969 Geragnostus mccoyii; Hughes: 56-60, pl. I, Fig. I -12.

LECTOTYPE. BGS 8710 (Stokes Coll.) Internal mould of cephalon, original of Murchison 1839, pl. 25, Fig. 6b; refigured and selected by Whittard (1955: 8 pl. I, Fig. 5).

TYPE LOCALITY AND HORIZON: With question , topmost Llandeilo, small quarry at south-western end of Pencerrig lake, north of Builth Wells, Powys (see Hughes 1969:56).

MATERIAL, HORIZONS AND LOCALITIES: Two complete exoskeletons (internal moulds), and one cephalon and thorax from locality 69; tuffs of probable lower Arenig;(Moridunian) age.

DISCUSSION. This species has been described by Elles (1940) and Hughes (1969) from the Builth district, where it is recorded from the teretiusculus and gracilis biozones, and Whittard (1966: 266; Pl. 46, Fig. 2) has recorded one example from the Llandeilo of the Shelve Inlier, Shropshire.

The only difference observed between this new south Wales material and type material of mccoyii from Builth, is a more evenly transverse furrow on the glabella, which is not considered to be taxonomically significant.

These new examples represent the earliest occurence of this species in Britain. The only other member of the genus known from the Arenig in Britain is S. hirundo Hicks, from the "middle Arenig" of Whitesands Bay, Dyfed, and the topmost Arenig (Mytton Flags) of Shelve, Shropshire (= Geragnostus hirundo of Whittard 1955: 7, 8; Pl. I, Figs. I-4). S. hirundo is closely similar to mccoyii, but it is distinguished by having a more rounded cephalic outline, and a transverse glabellar furrow which is almost straight, compared with the distinctly chevron-shaped course of this furrow in mccoyii. Also, S. hirundo lacks a median tubercle immediately posterior to the transverse glabellar furrow, which is clearly evident in mccoyii. The presence of this tubercle was used by Whittard (1966:266) to distinguish S. scoltonensis from the Lower Llanvirn of South Wales, from mccoyii, which lacks the tubercle. In contradiction to Whittard, Hughes (1969: 56) included this tubercle in his diagnosis of mccoyii, and it is present in the lectotype and figured examples from the type area (Hughes 1969 Pl. I, Figs.1, 2, 3, 7, 11). In S. hirundo, the pygidial axis has a transverse furrow at about the mid-point of the sagittal line, whereas in mccoyii this furrow is situated at about a third of the axial length, measured backwards from the anterior margin.

S. scoltonensis (Whittard 1966: 266; Pl. 46, Figs. 3 - 5) differs from the new specimens in lacking posterolateral pygidial spines, by having larger anterolateral lobes on the pygidial axis, and by having larger, more distinct median tubercles on the pygidial axis and the glabella. S. caducus Barrande, from the artus Biozone of Shropshire, and the Llanvirn to Llandeilo of Bohemia (Whittard 1955:9) is also similar to the new material, but is distinguished by having two transverse glabellar furrows, and a wider (tr.) pygidial axis with two transverse furrows and a larger median tubercle.

Segmentagnostus aff. mccoyii

(Pl. 1, Fig. 5)

A single cephalon of Segmentagnostus from locality 78;

slates of probable Llandeilo age, is too distorted for confident identification as species level, but resembles mccoyii in having a distinctly chevron-shaped transverse glabellar furrow, rather than a straight furrow which is diagnostic of S. hirundo. There is also an indication of a median tubercle just posterior to the transverse furrow, that is lacking in hirundo. This tubercle is smaller than that of scoltonesis (compare Pl. 1, Fig.4 with Whittard 1966: Pl. 46, Figs. 4, 5).

Genus CORRUGATAGNOSTUS Kobayashi, 1939

DIAGNOSIS. See Kobayashi (1939a: 173)

TYPE SPECIES: Agnostus perrugatus Barrande, 1872, from the Dd_1 beds (Llandeilo) of Sancta Benigna, Bohemia.

Corrugatagnostus morea Salter, 1864a

(Pl. 1, Figs. 6, 7)

V 1864a Agnostus morea; Salter: 7, Pl. I, Fig. 13.

1866 Agnostus morei; Salter: 487, Figs. a, b.

1872 Agnostus perrugatus; Barrande: 143, Pl. 14, Figs. 14-16.

1886 Agnostus morei; Postlethwaite & Goodchild: 458, Figs. 7, 8.

1939(a) Geragnostus (Corrugatagnostus) morei; Kobayashi: 173, 187.

1939(a) Geragnostus (Corrugatagnostus) perrugatus; Kobayashi: 76, 77, 79, 173, 188.

V 1940(a) Agnostus morei: Whittard: 155-7, Pl. 5, Figs 1-3.

V 1955 Corrugatagnostus morea; Whittard: 10-12, Pl. I, Figs 9-11, text-figs. 2b-c (with full synonymy).

HOLOTYPE: BGS. 8699 cephalon (refigured Whittard 1940, Pl. 5, Fig. 2).

TYPE LOCALITY AND HORIZON: Hope Shales (artus Biozone), Cefn Gwynll, near Linley, Shropshire.

MATERIAL HORIZON AND LOCALITY: Internal and external moulds of a complete pygidium from locality 59(d). Lower Llanvirn; artus Biozone. The species is also known from the artus Biozone of Shropshire (Whittard 1955) and from the Skiddaw Slates of Ellergill, Westmoreland (Postlethwaite

& Goodchild, 1886).

DISCUSSION: C. morea is an uncommon species which has been adequately described by Whittard (1940, 1955), and nothing can be added here. In his species remarks, Whittard (1955:12) proposed the new species C. sol to accommodate a closely similar, but stratigraphically younger agnostid described from the Ashgill of Ayrshire by Reed (1903,as Agnostus perrugatus, a synonym of C. morea, P. 6, Pl. I, Figs.5-7). The cephalon of C. sol is easily distinguished from morea in that it has a single elongated glabellar tubercle, rather than two discrete tubercles, and has three subparallel furrows anterior to the glabella. The pygidia of these two species are however exceedingly difficult to distinguish. Whittard (1955: 12) has noted that C. sol has a slightly larger tubercle, a relatively shorter (sag.) axis and a more regular arrangement of furrows.

The pygidium from South Wales is attributed here to the stratigraphically older species on morphological grounds as it compares very closely with a pygidium from the coeval Hope Shales (artus Biozone) of Brithdir, near Old Churchstoke (Whittard 1955: Pl. 1, Figs.10-11) and to a new specimen from the same horizon at Whitsburn Dingle, Leigh, Shropshire (SJ 33300255; Pl. 1, Fig.7).

Family LEIAGNOSTIDAE Jaekel, 1909

Genus LEIAGNOSTUS Jaekel, 1909

REMARKS. The emended concept of this genus of Howell (1935: 236) is accepted here.

TYPE SPECIES: Leiagnostus erraticus Jaekel, known from a glacial erratic originating, with question, from the Echinosphaerites Limestone of middle Ordovician age, by original designation.

Leiagnostus cf. bohemicus (Novák, 1918)

(Pl. 1, Fig.4)

MATERIAL HORIZON AND LOCALITY: Internal and external mould of a complete exoskeleton, in which the cephalon has been diagonally bisected by a natural joint, from locality 69, tuffs of probable lower Arenig age. The specimen is on the same slab as the holotype of Merlinia contracta sp. nov. (qv.).

DISCUSSION: Whittard (1955) cautiously referred a pygidium from the Hope Shales (artus Biozone) of Shropshire to this species, originally described from the $D_1\gamma$ beds (Llanvirn) of Bohemia (Novák and Perner 1918).

Although somewhat distorted, the new specimen compares well with Whittard's Shropshire specimen, but has a slightly wider posterolateral border or flange, and a rather deeper border furrow. In both the holotype of bohemicus (Novák and Perner 1918: Pl. 1, Fig. 7 a-c) and in the Shropshire specimen, the border becomes narrower (tr.) laterally. This is not apparent in the new specimen, where the border is of constant width. In this respect the new example invites comparison with both the type species *L. erraticus* and with *L. foulonensis* Howell (1935: 236-7, Pl. 23, Figs. 17, 18) from the lower Ordovician (Arenig) grey *Calymene* Shales of Herault, France. Both of these species however have nodes developed on the thoracic axis which are not seen in the new specimen. Absence of thoracic axial nodes is consistent with *bohemicus*, and it is preferred to provisionally attribute this specimen to that species, until a range of better preserved examples is available.

The cephalon of *bohemicus* is unknown, but that of the new specimen is too fragmentary and distorted to permit detailed description here. The cephalon appears to be strongly convex (sag., tr.), without furrows, and with a narrow lateral border and border furrow. At least one of the thoracic segments appears to have a transverse furrow across the axial lobe. Latter is about a third of pygidial width across the anterior margin. The axial furrows appear to be rather weak.

Family OLENIDAE Burmeister, 1843

Subfamily TRIARTHRINAE Ulrich, 1930

GENERIC ASSIGNMENT OF TRIARTHRINES. The problematical taxonomy of three closely related Ordovician genera Triarthrus Green, 1832, Porterfieldia Cooper, 1953 and Bienvillia Clark, 1924, has recently received considerable attention (Fortey 1974: 65-76; Fortey & Owens 1978: 242-250; Ludvigsen & Tuffnell 1983). Together, these genera span the whole of the Ordovician Period, and are recorded from five continents.

Cephalic morphology has provided the basis for generic distinction. Fortey & Owens (1978: 243) suggested that the presence of a sutural ridge (ie. a furrow running parallel to the postocular facial suture of the fixigena) in the adult cranidium is diagnostic of Porterfieldia (s.s.) and remarked that this feature is commonly developed in small growth stages of other olenid genera. Its retention in the adult cranidium of Porterfieldia spp. provides evidence that this genus was derived neotenously from a Bienvillia species in an evolutionary trend that successively reduced the length (sag.) of the preglabellar field. This trend culminated in the late Ordovician with Triarthrus, in which the preglabellar field is absent.

Ludvigsen & Tuffnell (1983), although in agreement with the generic grouping of Porterfieldia species of Fortey & Owens (1978: 243), shifted the emphasis from the sutural ridge of the adult cranidium to the medially constricted or confluent preglabellar and anterior border furrows as the major diagnostic feature of the genus, and demonstrated that Fortey's (1974: 67) presumed homology between the anterior border of Porterfieldia and the frontal area of Triarthrus is incorrect. The presence or absence of a preglabellar field is not therefore an important criterion to distinguish Triarthrus from related genera, and Porterfieldia cannot be regarded as an intermediate between Bienvillia and Triarthrus.

Following the diagnosis of Ludvigsen & Tuffnell (1983: 572-3; Figs. 2-3) abundant new triarthrine material from locality 69; tuffs of probable early Arenig (Moridunian) age is attributed to Porterfieldia (s.s.).

Genus PORTERFIELDIA Cooper, 1953.

DIAGNOSIS. A genus of Olenidae with a subquadrate or subcircular glabella, with strong, backwardly curving 1S and 2S; 3S and 4S either absent or faint. Preglabellar field short (sag.) or absent; anterior border short, convex (sag.), border furrow distinct, generally pitted. Anterior border furrow and preglabellar furrow (when present) medially confluent. Palpebral lobe anteriorly placed, small. Postocular facial suture with parallel furrow on fixigena. Thorax of 11-13 segments, pygidium small, transverse, without well-defined border or border furrow.

TYPE SPECIES. Triarthrus caecigenus Raymond 1920, from the Athens Shale (middle Ordovician) of Virginia, USA, by original designation.

Porterfieldia cf. punctata (Crosfield & Skeat, 1896).
(Pl. 1, Figs. 8-12, Pl. 2, Fig. 13)

LECTOTYPE. SM.A3099: dorsal exoskeleton lacking librigenae (original of Crosfield & Skeat 1896) selected Henningsmoen (1957: 149) from the Lower Arenig, Carmarthen Formation (locality 3A of Fortey & Owens 1978).

MATERIAL HORIZON AND LOCALITY. All new material has been collected from locality 69; articulated exoskeletons: 19 specimens, of which 7 are external moulds; Cephala with articulated thorax: 3; isolated cranidia: 11, of which three are external moulds; thorax and pygidia: 7, one of which is an external mould.

The species is otherwise known from the early Arenig of the Carmarthen district, where it is recorded from the Cwmffrŵd Member of the Carmarthen Formation; Moridunian Stage to the base of the Whitlandian Stage (Fortey & Owens; in press).

DISCUSSION. This species has been adequately described by Lake (1919) and more recently, by Fortey & Owens (1978), from the Carmarthen district including the type locality at Nant-y-Glasdwr (locality 3A of Fortey & Owens 1978).

Although the new material from Dyfed agrees closely with the lectotype (selected Henningsmoen 1957: 149) and topotype material, it is generally more compressed and less well preserved than is typical of specimens from the type area. Flattened examples figured by Fortey & Owens (1978), in which the cephalic furrows are accentuated, bear the greatest similarity to the bulk of the new specimens (compare Fortey & Owens 1978: Pl. 1, Figs 3, 6 to Pl. 1 Figs. 9, 12 herein)

Of the twelve species assigned to the genus by Ludvigsen & Tuffnell (1983), the following are also similar to the new specimens; the type species P. caeciegena, from the Llandeilo of Alabama (Raymond 1920) P. papulosus, P. thor and P. parapunctatus from the Arenig of Spitzbergen (Fortey 1974), P. contayaensis from the Llanvirn of Peru (Hughes in Hughes, Rickards & Williams 1980), P. convergens from the Llanvirn of Shropshire (Whittard 1961), and P. cf. convergens from the subsurface Llanvirn of Cambridgeshire (Rushton & Hughes 1981). The type species differs from the Dyfed material in having a distinct occipital furrow, and in having a diagonal furrow crossing the outer anterior portion of the fixigena, linking the anterolateral corner of the axial furrow to the lateral border furrow. P. papulosus Fortey (1974: 70; Pl. 23 Figs. 1-11) differs in having larger palpebral lobes and deeper palpebral furrows, a wider (sag.) and more convex anterior border, and a distinct continuous occipital furrow and median occipital node. P. thor Fortey (1974:

72; Pl. 23, Figs. 12 - 23) also has larger palpebral lobes and a much more distinct occipital furrow. The fixigena is also relatively wider (tr.) in this species. P. parapunctatus Fortey (1974: 74; Pl. 24, Figs. 1 - 4) differs in having almost effaced glabellar furrows, a distinct occipital furrow and a highly convex occipital ring that is widest (sag.) medially. The palpebral lobe is also longer (exsag.) in this species.

P. convergens is rather poorly known from incomplete type material (Whittard 1961: Pl. 24, Figs. 16 - 18). Further material is necessary before an adequate diagnosis of this species is given. P. cf. convergens of Rushton & Hughes (1981: 640; Pl. 6, Figs. 5 - 9) differs from the new material in having a more rounded glabella, and a strongly developed median tubercle on the axial ring of each thoracic segment. P. contayaensis Hughes et al. 1980; Pl. 2, Figs. 4, 7, 10 -12, 14) differs in having a sub-oval cranidium with a wider (tr.) and more rounded fixigena, and a distinct, straight occipital furrow. The glabellar furrows of the holotype (op cit.: Pl. 2, Fig. 7) differ in being almost straight and transversely trending, with only the adaxial tips of IS and 2S deflected posteriorly. 3S is positioned at about mid-glabellar length, whereas in the new material, 3S originates at about three quarters of glabellar length, measured forwards from the posterior margin. The thoracic axis is also wider than that of the new specimens.

The following observations, from the full range of new material from Dyfed, serve only to highlight slight differences between this material and type and figured examples of *P. punctata*, which may not be of taxonomic importance. It may be that some of these differences are due entirely to contrasts in the mode of preservation:-

(i) the transverse width of the fixigena varies between 0.45 - 0.53 maximum glabellar width, compared to 0.33 - 0.41 given by Fortey & Owens (1978: 244) for type and topotype materials. Their lower values are derived from uncrushed specimens.

(ii) internal moulds are not caecate.

(iii) corrugation of the preglabellar field is not seen.

(iv) anterior cephalic border furrow lacks distinct row of 25 - 30 pits, although pitting is vaguely indicated in a small number of cranidia (eg. Pl. 2, Fig. 13). Such indistinct pitting is noted in poorly preserved cranidia from the Carmarthen district (Fortey & Owens 1978: 244).

(v) axial tubercles on thorax segments not seen (cf. Pl. 1, Fig. 3 of Fortey & Owens 1978, representing a stratigraphically late occurence of the species in the Carmarthen district).

Many of the examples from Dyfed have the librigena displaced backwards, and connected together by the narrow, strip-like ventral doublure (eg. Pl. 1, Figs. 8, 11). A single example of the ventral doublure from the type locality (Fortey & Owens 1978: Pl. 2, Fig. 3) shows elevated nodes corresponding to pits in the overlying anterior border furrow. Such nodes are not seen on any example from Dyfed.

The hypostome is preserved in only four of the new specimens, and all examples are rather ill-preserved and distorted (eg Pl. 1, Figs. 8, 10 - 11). In common with hypostomata of P. punctata figured by Fortey & Owens (1978: Pl. 2, Figs. 1, 2) the middle body is elliptical, and is divided into two lobes by a transverse furrow. The anterior lobe is pointed posteriorly, and the posterior lobe is constricted medially. There is some indication that anterior wings are developed in a few examples.

Olenid gen. et sp. indet.

(Pl. 2, Fig. 12)

DISCUSSION. A single imperfect exoskeleton of small size (9 mm.) from locality 69; early Arenig, belongs to an olenid genus with long genal spines that extend backwards almost the full length of the thorax and pygidium. The cephalon is too ill-preserved for confident generic determination, but the morphology of the thorax and pygidium suggest affinity to the Triarthrinae.

Four species of Triarthrus from the Caradoc and Ashgill of North America possess genal spines (Ludvigsen & Tuffnell (1983: 57). Of these, T. roughensis Parks, 1921 and T. spinosus Billings, 1857, have genal spines which extend backwards at least as far as the mid-length of the thorax.

Even allowing for the considerable distortion of the new specimen however, the genal spines are longer than in either of these Triarthrus species, both of which also have a long thoracic axial spine that is not seen in the Welsh specimen.

The balnibariinine Cloacaspis (Fortey 1974: 36) from the early Arenig of Spitzbergen is also similar, and in at least two species, has genal spines which extend beyond the tip of the pygidium (Fortey 1974: Pl. 10, Fig. 12; Pl. 12, Fig. I). The pygidium of Cloacaspis, however, differs from that of the Welsh specimen in being more elliptical in outline, with shorter pleural furrows, and a wider lateral and posterior border. Also the pleural furrows of the thorax and pygidium of balnibariinine genera branch dichotomously near the axial furrow, to form pleural nodes (Fortey 1974: 14), which are not seen in the new specimen, and the thorax of members of this subfamily, where known, carries an axial spine on the penultimate segment.

This specimen probably represents a new species to Britain, but further comments must await the recovery of more material.

Family REMOPLEURIDIDAE Hawle & Corda, 1847

1976 Gamopsidae Snajdr.

Genus CREMASTOGLOTTOS Whittard, 1961

DIAGNOSIS. Cephalon subpentagonal in outline; glabella wide, strongly convex (tr.). Two pairs of straight horizontal glabellar furrows that die out adaxially; posterior transverse glabellar furrow continuous; partly occipital and partly axial in origin. Librigena narrow (tr.), short postocular cheek, eyes strip-like, synopthalmic; anteriorly placed. Thorax almost parallel sided, axis broad. Thoracic segments subrectangular with diagonal pleural furrows; posterior segment with pleural tips drawn into long backward spines. Pygidium with maximum width at posterior margin; axis short, tapered with long terminal piece. Pleural fields with up to 5 ribs.

REMARKS. Interpretation of the posterior glabellar furrow follows that of Fortey (1981: 609). His consequent inclusion of the genus in the Remopleurididae rather than the Ellipsotaphridae (see Marek 1977) is accepted here.

TYPE SPECIES. Cremastoglottos occipitalis Whittard, 1940, from the lower Llanvirn; artus Biozone, Ladyhouse dingle, near Hope, Shropshire, by monotypy.

Cremastoglottos sp.

(Pl. 2, Fig. 14)

V. 1909 Ogygia sp. Thomas in Strahan et al.: 32.

MATERIAL HORIZON AND LOCALITY. A single external mould of a pygidium and two (?) thoracic segments (BGS. HT. 358) from the lower Llanvirn; artus Biozone, ditch 200 yds WSW of Wern ddu, 1½ miles southwest of Llanllwch, Carmarthen (approx. SN. 374179, locality 84 of Strahan et al. 1909).

DISCUSSION. The type species is described from cranidia only (Whittard 1940: 136; Pl. 5, Fig. II; 1961: 187; Pl. 25, Figs. 1-5). Marek (1977: 71; Pls. I - 2) first described complete Cremastoglottos, from the Dobrotivá Formation (Llandeilo) of Bohemia, which he assigned to C. aff. occipitalis.

A new specimen from the Hope Shales (artus Biozone) of the type area consists of a thorax and articulated pygidium, and a disarticulated cranidium (Pl. 2, Fig. II). The cranidium compares very closely with that of the type species, to which this specimen is attributed. The pygidium has an axis with four complete rings and a terminal piece (= postaxial ridge of Marek 1977: 71) that reaches the posterior margin. The terminal piece appears to widen (tr.) towards the posterior margin in a latex mould, which may be a vagary of preservation. There are five pleural ribs defined by strong interpleural furrows, and each rib has a pleural furrow along its entire length. There is a narrow border of constant width which is approximately one sixth pygidial length. This border is not invaded by the interpleural furrows. A well defined border furrow is seen in a latex mould, but this may represent the inner margin of the doublure impressed onto the dorsal surface by compression.

The pygidium of C. aff. occipitalis (Marek 1977: 71; Pls. 1 - 2) differs from that of the type species in having only four pleural ribs defined by shorter (tr.)

interpleural furrows, in having a broader (sag., tr.) ill-defined border, and in having only three axial rings and a shorter (sag.) terminal piece. Also, in the type species, the backward directed spines of the posterior thoracic segment extend well beyond the tip of the pygidium (Pl. 2, Fig. II). In Marek's (1977) figured examples of C. aff. occipitalis, this feature is difficult to interpret, but his diagrammatic reconstruction (P. 71; Fig. I) shows the spines to be only marginally longer than the pygidium.

The pygidial differences between the type species and the Bohemian form justify separation at the species level, and the name C. bohemicus is proposed for the latter.

The Welsh pygidium and posterior thoracic segment is ill-preserved, but is clearly distinct from both the type species and bohemicus. There are five pleural ribs, defined by interpleural furrows that extend almost to the margin, and there are no pleural furrows. The border is narrower than in the type species, and a border furrow is not seen in a latex mould. The axis and terminal piece are too ill-preserved to compare, but the posterior thorax segment is very similar to that of the type species.

Although a new species is probably represented, it is not named here on the strength of a single poor example. Fortey (pers. comm.) has identified single examples of pygidia attributable to Cremastoglottos spp. from the

Arenig of South Wales, that are also distinct from the type species, but they cannot be named until further examples are recovered.

Family ASAPHIDAE Burmeister, 1843

Generic assignment of asaphids follows that of Fortey & Owens (1978: 260-62). Ogygiocarella Harrington and Leanza (1957: 161) is retained herein as distinct from Ogygiocaris (s.s.) Angelin, 1854, despite the poorly qualified distinction between these closely related genera (see Whittard 1966: 222, Hughes 1973, and Fortey & Owens 1978: 260-61).

Subfamily ASAPHINAE Burmeister, 1843

Genus BASILICUS Salter, 1849

DIAGNOSIS. See Salter 1866a

TYPE SPECIES. Asaphus tyrannus Murchison, 1839, from the Llandeilo Series of Llandeilo by original designation.

Basilicus tyrannus (Murchison 1839)

(Pl. 4, Figs.1-3)

SYNONOMY - see Whittard (1964: 229).

REMARKS. Fortey (1980: 262-63) has provided valid reasons why B. peltastes Salter 1866 may be a subjective synonym of tyrannus. Although confident synonymy must await population studies of precisely localized collections, new material is here provisionally attributed to tyrannus.

LECTOTYPE: BGS (Geol. Soc. coll.) 6827; thorax and pygidium from the Llandeilo series of Llandeilo.

MATERIAL HORIZONS AND LOCALITIES: NMW 33.18 9G. 202: complete exoskeleton, unlocalised specimen from near Lampeter Velfrey (D.C. Evans coll.), probably from Bryn-glâs Beds. 23.06 external and internal moulds of essentially complete exoskeleton of an immature specimen and one pygidium from locality 23, near the exposed base of the Bryn-glâs Beds, of probable Llandeilo age. This species is largely confined to shallow water facies, and is abundant in the 'Llandeilo Flags' of the type area and in their development further west near St. Clears and Narberth. Elsewhere it is a rarity being known from a few fragments from the Llandeilo (Meadowtown Beds) of Shropshire (Whittard 1964) and, with question, from the Llandeilo of the Berwyn Hills (MacGregor 1963).

Williams (1953) provides a stratigraphic range from the Upper Llanvirn to the Lower Llandeilo for tyrannus in the type area, but common occurrence in the Bryn-glâs Beds near Llan Mill extends its range into the Upper Llandeilo after Addison (unpub. Ph. D. thesis; see Bassett in Bassett et al. 1976: 36).

DISCUSSION: Salter (1866:149) has provided a good account of this species, and Fortey (1980: 259, 262) has selected lectotypes for tyrannus and peltastes from the type area, and figured an additional specimen of tyrannus from near Llan Mill, west of Lampter Velfrey.

The newly collected examples (Pl. 4, Figs 2,3) are from silty and ashy mudstones near the exposed base of the Bryn-glâs Beds, and presumably close to the junction with the underlying Upper Llanvirn shales. Jones (in Strahan et al. 1914: 26) has placed these beds in the Lower Llanvirn 'Bifidus Zone'.

23.06 measures 36 mm, and has only five thoracic segments, but the cephalon is probably displaced backwards. The librigena of this specimen, in common with the immature librigena of tyrannus figured by Fortey (1980: Fig. 9) from the Lower Llandeilo of Dynevor Park, has a well defined border that is convex in profile, and a well formed border furrow that is deepest and distinctly concave anteriorly. The genal spine is considerably longer than in typical adult tyrannus (cf. Fortey 1980, Fig. 10; Pl. 4 Fig. 1 herein). The cranidium has been crushed over the site of the hypostoma, and cannot be compared to cranidia of tyrannus or to the lectotype of peltastes.

The hypostoma is imperfect, but is sufficiently well preserved to compare closely with hypostomata attributed to Basilicus sp. indet. from the Llandeilo of Shropshire (Whittard 1964: 230; Pl. 34 Figs. 4-6) and with that of peltastes from Llandeilo (op cit: Pl 34, Fig. 2). The median body is almost quadrangular, and there is a single pair of protruberant maculae at the posterolateral corners. The posterior margin is prolonged into two lanceolate wings and deeply invaginated medially.

The pygidium has at least ten complete axial rings and up to five faint transverse furrows are evident posteriorly. There are eleven pairs of pleural ribs; the posterior pair only very weakly developed. Axial furrows, axial ring furrows and interpleural furrows are more clearly incised on internal moulds (compare Pl. 4, Figs. 2 and 3) but Fortey (1980: 263) has noted that the number and definition of pygidial furrows may be affected both by lithology and by presence or absence of cuticle.

NMW 33.189G.202 is an adult exoskeleton and has a librigena that is much broader (tr.) than that of 23.06, with a shorter genal spine that extends only as far backwards as the anterior edge of the third thoracic segment. Fortey (1980: Fig. 10) has figured a similar librigena from Dynevor Park. The pygidium is imperfect but has at least ten axial rings and ten pairs of pleural ribs. The cranidium of this specimen is too imperfect to compare with figured examples or to interpret the development or otherwise of bacculae or axial furrows, which Fortey (1980: 262) suggests are lost during ontogcny. Interpretation of such changes, however, is unlikely to be reliable in populations preserved in non-calcareous lithologies.

Subfamily OGYGIOCARIDINAE Raymond, 1937

Genus MERLINIA Fortey & Owens, 1978

DIAGNOSIS: See Fortey & Owens (1978: 262).

TYPE SPECIES: Merlinia rhyakos Fortey & Owens, 1978 from the lower Arenig, Moridundian Stage; Cwmffrŵd Member of Carmarthen Formation, Cwm-yr-abbey, by original designation.

Merlinia contracta sp. nov.

(Pl. 2, Figs. 1-10, Pl. 3, Figs. 1-5)

.1934 Ogygiocaris selwyni; Williams: 56

NAME: Latin: contracta, narrow, referring to the pygidial border and doublure.

DIAGNOSIS: Merlinia species with distinct cephalic axial furrows, frontal glabellar lobe weakly inflated, preglabellar furrow almost effaced, fixigena relatively wide (exsag.) with well developed posterior border and furrow. Eye and palpebral lobe relatively long (exsag.), librigena narrow (tr.). Preocular facial sutures divergent at about 35° - 40° ; line $\epsilon/\zeta - \epsilon/\zeta$ at 3.4-3.6 cranidial length. Hypostoma bluntly rounded posteriorly with anterolateral wings. Thoracic axis about one fifth thorax width. Pygidium with relatively narrow (tr.) axis and narrow border and doublure.

TYPE MATERIAL HORIZON AND LOCALITY: holotype: 69.102 a-b complete exoskeleton with displaced hypostoma. Figured paratypes: 69.103; complete exoskeleton 69.107; librigena 69.104; thorax and pygidium, 69.105; pygidium and fragmentary thorax, ontogenetic stages: 69.131, 134-136 a - b 140; 151-153. Additional paratypes: one near complete internal mould, one complete external mould, 5 pygidia with articulated thoracic segments, 5 cranidia, 2 cephala with articulated thorax; 3 external moulds of pygidia, 1 librigena; 3 articulated thorax segments. Ontogenetic stages: about 20 specimens representing degrees 1-7.

All material from locality 69; tuffs of probable early Arenig age.

DESCRIPTION: Cranidium depressed and devoid of distinct furrows other than well developed axial and anterolateral border furrows. Total width across posterior margin of cranidium slightly less than cranidial length in the least distorted examples. The glabella in the largest specimens (eg. Pl 2, Fig. 5) is elongate, subparallel sided, with a weakly expanded and slightly inflated frontal lobe. Width across posterior margin of glabella about one third glabellar length. Cephalic axial furrows well developed, deepest anterior to the palpebral regions, and merge anteriorly with the shallow, open preglabellar furrow. Latter is ill defined in the largest specimens, and is invaded by the frontal glabellar lobe, which occupies about one third of its length medially.

Occipital lobes and furrows, muscle impressions and median glabellar node not seen on latex moulds or internal moulds. Absence of such features, however, may be due to the restricted size of available cranidia (see remarks below). Occipital ring narrow (sag.), defined by a very weak furrow which meets the posterior margin at the axial furrow. Eye crescentic, length about a quarter cranidial length.

Preocular facial sutures divergent at 30° - 40° from an exsagittal line through γ. Postocular suture abaxially defines broad (exsag.) subtriangular postocular fixigena. Palpebral lobe distant from axial furrow; distance from latter to ϵ/ζ about a quarter of glabellar width, distance from axial furrow to γ about one eighth glabellar width. Librigena narrow (tr.) elongated. Genal spine very narrow (tr.) at its base, and almost straight, reaching as far back as the fifth thorax segment.

Eye is separated from the lateral border furrow by a minimum distance about equal to the border width at that point. Border narrowest (tr.) abaxial of ϵ/ζ where width is about a quarter of the maximum width of the librigena. Border becomes slightly wider and concave towards the genal angle, widening and flattening anteriorly. Border furrow distinct, but does not extend on to preocular fixigena. Lateral border furrow continuous with the posterior border furrow at the genal angle. Posterior border distinct; length (exsag.) about one tenth cranidial length. Posterior border furrow shallow, and continuous from the axial furrow to the genal region.

Hypostoma imperfectly known from three examples (eg. Pl 2, Figs. 1, 6). Outline ovate, approximately as wide as long, tapering rather strongly backwards to a bluntly acuminate posterior margin. Median body ovoid, defined by deep anterolateral and posterior border furrows. Lateral border flattened; extended into bluntly rounded wings anterolaterally. Maximum width of hypostoma across wings at about a third of its length, measured backwards from the anterior margin. Here, the width is about seven eighths of the maximum length. Posterior border narrow (sag., tr.) crescentic. A pair of weakly defined maculae appears to be developed on the lateral regions of the median body, about three quarters of the way back from the anterior margin.

Thorax subparallel sided, narrowing backwards only very slightly. Axis weakly convex, very slightly tapering. Maximum width of axis slightly greater than one fifth thoracic width. Axial furrow moderately deep, and follows a zig-zag pattern. Each segment with an oblique transverse furrow that is narrow and shallow at its origin opposite the anterolateral corner of the adjacent axial ring. Furrow deepens and widens (exsag.) at the fulcrum, forming transversly elongated triangular notches, which shallow and die out before reaching the pleural tips. Anterolateral corner of pleura rounded; posterior margin drawn backwards into a very short, blunt spine, particularly in the anterior three segments.

Pygidium parabolic in outline, wider than long; in the least distorted examples (eg. Pl. 2 Figs. 1, 2), length is about 0.7 anterior width. Axial furrows rather weak, axis narrow (tr.) tapering moderately for about half of its length. Posterior half of axis almost parallel sided, and rounded posteriorly. Maximum width of axis slightly less than one fifth pygidial width across the anterior margin. Five or six axial rings usually evident, but one paratype (Pl 2, Fig. 7) has at least eight. Ring furrows faint in all but the anterior three or four rings. Pygidial border flat, and of constant width (sag., tr.), which is about one tenth pygidial width. Border furrow distinct, formed by a change in slope between the border and the pleural fields. Posterior termination of axis reaches the border furrow, but does not invade the border. Pleural field with up to eight ribs. Interpleural furrows adaxially weak, particularly posteriorly. Abaxial tips of interpleural furrows are curved backwards very slightly in one paratype (Pl. 2, Fig. 7) but not significantly so in the bulk of specimens. The tips of the furrows do not invade the border. Doublure about as wide as border, with up to fifteen distinct terrace lines that follow an irregular course subparallel to the pygidial margin. Terrace lines anastomise and bifurcate antero-laterally (Pl. 2, Fig. 4).

DESCRIPTION OF ONTOGENY: A range of meraspides from degree I to degree 7 is represented. Cranidial length remains constant at about one third of the total length of the exoskeleton in all stages, and the pygidial and cranidial length are approximately equal at least until degree 7. Cephalic axial furrows are strong in all stages, particularly degrees I-5, and the glabella is strongly convex (tr.) and expanded anteriorly. In degrees I-3 the anterior cephalic outline is subquadrate, with a depressed, near horizontal, trench-like margin anterior to the glabella. This may be attributed to compression, and has not been observed in later meraspides.

The glabella in degrees I and 2 is simple with very weak posterolateral swellings, and the occipital ring and posterior cephalic border are weakly developed. In degrees 3-5, IL and IS are well developed; IL ovoid, almost isolated by backward directed IS, and a short median occipital spine is developed. Occipital ring furrow and posterior border furrow more distinct than in degree 2.

The eye and palpebral lobe and furrow are crescentic in all stages; in degrees I and 2 the eye occupies slightly more than one third cranidial length; slightly less in later stages.

Facial suture clearly opisthoparian in all stages. Librigena is convex (tr.) with a well developed very narrow peripheral border and furrow. Width of the librigena is wider than in the adult, and the genal spine extends just beyond the tip of the pygidium in degree 2, becoming shorter with successive stages. Librigena in degrees I-5 has a short (tr.) posterior margin adaxial to the base of the genal spine. This margin is directed slightly forwards where the librigena extends beyond the width of the thorax. This appearance may be accentuated by compression.

The transitory pygidium is semi-elliptical in outline, with a narrow, convex (tr.) axis, strong axial furrows and a well developed posterolateral border and furrow. Axis clearly segmented in all stages, particularly in degrees 3-5, where at least eight axial rings are defined. Anterior ring furrows arch forwards medially in degree 3, simpler in later stages. Pleural fields with strong interpleural furrows until degree 6. Up to six pleural ribs developed; interpleural furrows reach the border furrow abaxially. Border and border furrow narrow (sag., tr.) and distinct in degrees 1-3, border furrow less distinct in degree 5 and in later meraspides.

DISCUSSION. This species compares closely with those previously assigned to Merlinia. In particular it possesses an entire inner margin to the pygidial doublure (Pl. 2, Fig 4; Pl. 3, Fig 5) an important diagnostic character which distinguishes Merlinia from Ogygiocaris Angelin (1854) in which the inner margin of the pygidial doublure is scalloped (Henningsmoen 1960: 214). At the species level, the nature of the terracing on the anterior cephalic border, frontal glabella lobe and hypostoma is important (Fortey & Owens 1978, Fig 10). Such delicate terracing is not seen on any of the new specimens, but this may be entirely related to the coarse nature of the enclosing sediment.

All four Anglo-Welsh species assigned to Merlinia by Fortey & Owens (1978) are morphologically similar. Of these, M. selwyni is closest to contracta, but is distinguished by having a wider pygidial border and doublure, shorter (sag.) eyes and palpebral lobes, a wider (tr.) librigena and a distinct preglabellar furrow. The preocular facial sutures in selwyni diverge at about 50° ; the precise angle of divergence of the preocular sutures in contracta cannot confidently be determined due to distortion, but the angle is certainly less than 50°, and may be as little as 35°. Fortey & Owens (1978) have shown that in typical specimens of selwyni from the Carmarthen district, I-3S are developed on the glabella of larger cranidia, (eg Pl. 7, Figs. I, 2) but absent on a smaller cranidium of comparable preservation (Pl. 7, Fig. 6). The largest cranidium available for the new species (Pl. 2 Fig. 5) is of comparable size to the larger, furrowed selwyni cranidia, and it is assumed that glabellar furrows did not develop with maturity in contracta. The contrast in available size ranges however makes comparison of the cranidia of these two species difficult.

The type species, M. rhyakos differs from contracta in having the glabella very weakly defined by shallow, open axial furrows, in having the preocular facial sutures divergent at a greater angle, and by having a wider pygidial border and doublure. The hypostoma of rhyakos is also more acuminate posteriorly. M. major and M. murchisoni possess a wider pygidial border and doublure than the new species. M. major also has a wider librigena, smaller eyes and a narrower (exsag.) fixigena. The hypostoma of M. murchisoni is also less acuminate posteriorly than that of the new species (compare Fortey & Owens 1978, Pl. 10, Figs. 8, 10 ; text Fig. 10, with Pl. 2 Fig. 1 here)

M. anaxia (Rushton and Hughes 1981: 637, Pl. 5, Figs. I-9) from the subsurface Llanvirn of Cambridgeshire, differs from the new species in having a narrower (exsag.) fixigena, with both the pre- and postocular facial sutures divergent at greater angles, and in possessing a narrow (sag.) anterior border. M. megacantha (Leanza 1941: 532, Pl. I, Fig. I; Harrington and Leanza 1957: 179-80, Fig. 89, 1-4) from the Llanvirn of Catamarca, Argentina, is easily distinguished from the new species by having a much shorter (tr.) posterior cranidial margin with strongly oblique postocular facial sutures, and a wider pygidial axis which constitutes a quarter of anterior pygidial width.

Genus OGYGIOCARELLA Harrington & Leanza, 1957

DIAGNOSIS: See Hughes (1979: 140)

TYPE SPECIES: Asaphus debuchi Brongniart, 1822 . By original designation of Harrington & Leanza (1957: 160-61) as Asaphus debuchianus (Brongniart, 1822) (sic.). For discussion see Whittard (1964: 255-56).

Ogygiocarella debuchii (Brongniart, 1822)

(Pl. 3 Figs. 6 - 9, 14; Pl. 4 Fig. 5)

1822 Asaphus debuchii: Brongniart: 20, 21, 143, 144; Pl. 2, Figs. 2A-C.

1839 Trinucleus Asaphoides: Murchison: 648, 660, 662; Pl. 15, Fig. 2; Pl. 23, Fig. 6.

1843 Ogygia Buchi: Burmeister: 69-71; Pl. 1, Fig. 2.

1846 Ogygia Buchi: Burmeister: 59-61; Pl. 1, Fig. 2.

1847 Ogygia Buchi; Hawle & Corda: 67, 68; Pl. 4, Fig. 39.

1849 Ogygia Buchi; Salter: 1-4; Pl. 6, Figs. 1-6.

1859 Ogygia (Asaphus) Buchii: Salter in Murchison: 53, 55; Pl. 3, Fig. 1.

1865 Ogygia Buchi; Salter: 125; Pl. 14, Figs. 1-3, 8, 9; Pl. 15, Figs. 1, 6.

1865 Ogygia Buchi var. tuberculata; Salter: 127; Pl. 15, Fig. 5.

1884 Ogygia buchii; La Touche: 56, Pl. 2, Fig. 39.

1931 Ogygicaris buchi: Reed: 458.

1931 Ogygiocaris buchi var. angustissima; Reed : 459.

1940 Ogygia buchi; Elles: 406-421.

1957 Ogygiocarella buchii; Harrington & Leanza: 160-1.

1961 cf. Spirantyx calvarina: Whittard: 193; Pl. 25, Fig. 13.

1963 Ogygiocarella debuchii; MacGregor: 792; Pl. 116, Fig. 14.

V 1964 Ogygiocarella debuchii var. angustissima; Whittard: 261; Pl. 45 Fig 9; Pl. 26, Fig. 1.

V 1964 Ogygiocarella debuchi; Whittard; 257; Pl. 44, Figs. 1-11; Pl. 45, Figs. 1-8 (with full early synonymy).

V 1964 Ogygiocaris seavilli Whittard: 243.

1964 Ogygiocaris sp.; Whittard: pars 244.

1966 Ogygiocarella debuchi var. angustissima; Whittard: 302.

V 1970 Ogygiocarella debuchi; Toghill: 122.

V 1979 Ogygiocarella debuchi; Hughes: 142; Figs.67, 69-70, 74, 76-86, 88-89, 91-92, 97.

V 1979 Ogygiocarella angustissima; Hughes: 150; Figs.87, 90, 94-96, 98-100, 102, 108, 110.

1981 cf. Ogygiocarella debuchi angustissima: Black et al.: 546.

LECTOTYPE. Whittard (1964: 261) selected the original of Brongniart (1822: Pl. 2, Fig. 2A) from Dynevor Park, Llandeilo, as lectotype; a specimen which is apparently lost. For discussion see Whittard (1964: 256) and Hughes (1979: 142).

DIAGNOSIS: Ogygiocarella with between 10-14 pairs of pygidial pleural ribs; the majority of morphs with 11 or 13 ribs.

MATERIAL HORIZONS AND LOCALITIES. New material consists of 1 nearly complete exoskeleton, 2 pygidia, 1 cranidium and 1 fragmentary pygidial doublure from locality 19, Upper Llanvirn; murchisoni Biozone, and 3 pygidia from locality 78, slates of probable Llandeilo age. Additional material examined: BGS Pr. 2732; pygidium, Pr. 2730-31; cephalon and four thoracic segments, from locality 21, and SM. A54672-54674; pygidium and thorax from Abereiddy Bay, probably locality 78. (See Whittard 1963: 244).

O. debuchii is among the common trilobites of the Llandeilo Series of the type area (Williams 1953) and is widely recorded from the Llandeilo Series further west (eg. Strahan et al. 1907, 1909; Evans 1906: 624-26, 630). Elsewhere in Britain it is abundant in Shropshire, ranging from the middle Llandeilo Series to the Rorrington Beds (Caradoc? Series; gracilis Biozone; Whittard 1964: 260), and occurs in the Builth district from near the top of the Upper Llanvirn into the Middle and Upper Llandeilo (Hughes 1979: 151). The record of this species from lower in the Llanvirn of the Builth district (De La Beche 1846: 31) and from the Lower Llanvirn 'Bifidus Shales' near Crogenen Lake, Arthog (Cox in Cox & Lewis 1945: 67) have not been substantiated. Outside Britain, O. cf. debuchii is known from the lower Llanvirn of Peru (Hughes in Hughes, Rickards & Williams 1980: 5; Pl. 1, Figs. 9-13, Pl. 2, Figs. 1-3, 5-6, 8-9, 13).

Material figured herein, 19.04, 19,05; BGS Pr 2730, Pr 2732, is of stratigraphic significance, occuring at loc 21 in beds attributed to the 'bifidus' Biozone by Strahan et al. (1914: 26), but here placed low in the murchisoni Biozone.

DISCUSSION. O. debuchii has been fully described by Whittard (1966: 257) from Shropshire, and by Hughes (1979: 142) from Builth, and nothing can be added from south Wales material examined. Salter (1866: Addenda & Corregenda), Reed (1931: 459) and Whittard (1964: 261) separated the variety angustissima from debuchii (ss.) in which up to fourteen pairs of pleural ribs are developed on the pygidium. Hughes (1979: 150) elevated angustissima to species rank, and selected a lectotype (BM. 59198; op cit.; Fig. 94).

According to Hughes (1979: 142) 10-12 ribs is diagnostic of debuchii, whereas in angustissima (Op cit.: 151) 12-14 ribs are diagnostic. Although it is stressed that the majority of debuchii specimens have 11 ribs, and the majority of angustissima specimens have 13 ribs (Hughes 1979, Fig. 93), there exists an overlap with 12 ribbed morphs which cannot be reliably allocated to either of Hughes's species.

Variation in local stratigraphic distribution between populations of 10-12 and 12-14 ribbed morphs in Shropshire and at Builth, and the additional minor differences in cephalic and pygidial morphology outlined by Hughes (1979: 151) are not considered sufficient to uphold the separation of two species, and angustissima is regarded here as a subjective junior synonym of debuchii.

Hughes (1979: 152) concluded that in the case of debuchii/ angustissima, sharp distinctions between emergent species is blurred as an ancestral stock undergoes speciation. Such a conclusion may prove valid when detailed systematic studies of the large populations of debuchii in the Llandeilo of the type area and elsewhere are undertaken. Toghill (1970: 122) has collected Ogygiocarella with pygidial morphs of both species sensu Hughes (1979) from the Llandeilo of the Mydrim area, Carmarthenshire. Williams's (1953) record of Ogygia from the Llanvirn of the Llandeilo district has not been substantiated during this research.

The figured specimens BGS. Pr. 2730, 2732 (Pl. 3, Figs.

6, 7) are registered as Ogygiocaris seavilli Whittard (1964: 241). Whittard (op. cit.: 243) stated that Ogygiocaris seavilli "occurs commonly in the Bifidus Shales of the road section south of Lampeter Velfrey and west of Llan Mill bridge, Pembrokeshire, and is well represented in the collections of the Geological Survey, but has not yet been recognised elsewhere". These specimens are presumably the source of Whittard's claim.

Ogygiocaris seavilli is almost identical to Ogygiocarella debuchii and differs in having only 10 pygidial pleural ribs, slightly fewer pygidial axial rings; 10-12 compared to 13 in debuchii (see Hughes 1979: 146), a slightly wider pygidial doublure, a slightly narrower frontal glabellar lobe, and an intramarginal preocular facial suture. The latter feature alone excludes seavilli from Ogygiocarella as presently diagnosed (Whittard 1964: 261), although no undistorted examples of seavilli are known that are of comparable preservation to Swedish specimens of Ogy-lgiocaris spp. preserved in full relief. It may therefore be that this feature is related to compression.

BGS. Pr. 2732 has 11 pairs of distinct pleural ribs, with an obscure twelfth pair in evidence, at least 13 clearly defined axial rings, and a doublure that occupies about one fifth pygidial width across the anterior margin. This specimen must therefore be attributed to O. debuchii. Whittard (1966: 243) also states that in Ogygiocaris seavilli, all but the most posterior pygidial pleurae carries a shallow and somewhat indefinite pleural furrow. However the holotype (Whittard 1966; Pl. 39, Fig.I) and at least one of the paratypes (op cit: Pl. 39, Fig.7) clearly have a pleural furrow on the tenth pair of pleurae. The absence of pleural furrows in the posterior pleurae cannot therefore be used as a reliable character to distinguish between pygidia of Ogygiocarella debuchii and Ogygiocaris seavilli.

BGS. pr. 2730-31; internal and external moulds of a damaged cephalon and four thorax segments, is attributed to O. debuchii as it has deep convergent posterior band furrows and occipital ring furrows that form a distinct pattern likened by Whittard (1966: 258) to a "foreshortened maltese cross", and the occipital ring has a distinct median tubercle, that is not developed in Ogygiocaris seavilli. Also, unlike seavilli, the glabella is somewhat expanded anteriorly, and the fragment of the posterior lobe of the hypostoma which is evident in situ in BGS pr. 2731, is swollen medially, and there are indications of oval maculae. The outline of the posterior margin of the hypostome is rather more accuminate than that of seavilli (compare Whittard 1964: Pl. 44, Fig. 3 with Pl. 3, Fig.6 here).The course of the preocular facial suture in this specimen is intramarginal.

Although of rare occurence, Hughes (1979: Fig. 93) records 10 ribbed morphs of Ogygiocarella which he includes in debuchii. It may be that an evolutionary series seavilli-debuchii-angustissima exists in which the number of pygidial ribs and axial rings increases with time, culminating in gracilis times with 13-14 ribbed forms dominant.

Contrary to Whittards' (1964: 244) statement, distorted specimens from the northern end of Abereiddy Bay (locality 78) do possess a scalloped inner margin to the pygidial doublure (eg Pl. 3, Fig. 14) and are attributed here to debuchii.

Genus OGYGIOCARIS Angelin, 1854

DIAGNOSIS. See Henningsmoen (1960: 211).

TYPE SPECIES. Trilobus dilatatus Brunnich, 1789 from the Ogygiocaris Series; Stage 4aα (Llanvirn-Llandeilo) of the Oslo region, Norway.

Ogygiocaris seavilli? Whittard, 1964

(Pl. 5, Figs. 4,5)

DISCUSSION. An almost complete exoskeleton and a pygidium from the Lower Llanvirn artus Biozone, Locality 5 are closely similar to Ogygiocaris seavilli, otherwise only known with certainty from the artus Biozone of Shropshire, where it is most abundant in the upper part of the biozone (Whittard 1964: 241; Pl. 39, Figs. 1-10; Pl. 40, Figs. 1-4).

Pygidial morphology provides the most reliable basis for distinguishing O. seavilli from Ogygiocarella as presently diagnosed (see P. 67). The new South Wales specimens have ten pygidial pleural ribs with weak pleural furrows. The axis of 5.03 has at least eight axial rings, and the anterior width (tr.) and shape are consistent with that of the holotype of seavilli (Whittard 1964: Pl. 39, Fig.

1). The axis of 5.04 is too damaged to compare with type material. In both Welsh specimens the inner margin of the pygidial doublure is scalloped, and carries at least 12 terrace lines subparallel to the outer pygidial margin. The width (tr.) of the doublure is slightly wider than that of Ogygiocarella debuchii, but does not constitute a quarter of pygidial width across the anterior margin as described by Whittard (1964: 243). In the holotype and figured paratypes of seavilli (op cit. Pl. 39, Figs. 6, 7) the width of the doublure is also less than a quarter pygidial width, and cannot be considered a reliable character to distinguish seavilli from Ogygiocarella debuchii.

Genus OGYGINUS Raymond, 1912.

DIAGNOSIS: See Whittard (1964: 245).

TYPE SPECIES: Asaphus corndensis Murchison, 1839. By original designation.

Ogyginus corndensis (Murchison, 1839)

(Pl. 3, Figs. 10-12)

1839 Asaphus corndensis; Murchison: 663, Pl. 25, Fig.4.

1859 Ogygia (Asaphus) corndensis; Salter in Murchison: Pl. 3, Fig.4.

1866 Ogygia (Ptychopyge) corndensis; Salter: 130-32, 149, 159-60, Pl. 16.

1885 Ogygia corndensis; Novák: 219, 221, 223, Pl. I, Fig. 15.

1940 Ogyginus corndensis (Murchison) mut. intermedius; Elles (pars) 406, 428-29, 432; Pl. 31, Fig.II only.

V 1964 Ogyginus corndensis; Whittard: 250-54, Pl. 42, Figs. 2-8; Pl. 43, Fig. I (includes full synonymy)

1964 Ogyginus intermedius; Whittard (pars): Pl. 41, Fig. 2 only.

V 1964 Ogyginus corndensis var. septenarius; Whittard: 254; Pl. 43; Figs. 2-4.

V 1964 Ogyginus corndensis var. novenarius; Whittard: 254: Pl. 43, Figs. 5-11.

1966 Ogyginus corndensis; Whittard: 302.

1966 Ogyginus corndensis var. septenarius; Whittard: 302.

1973 Ogyginus corndensis; Hughes: 13-15; Fig. 6.

1979 Ogyginus corndensis; Hughes: 126-136; Figs. 21-61, 66.

HOLOTYPE: BGS. GSb 4094 (Geol. Soc. Coll.); damaged complete exoskeleton, figd. Hughes 1979: Fig. 49. Low murchisoni Biozone, Weston Beds, near Middleton, Shropshire.

MATERIAL, HORIZON AND LOCALITY: Three complete pygidia; internal and external moulds, and one incomplete pygidium from locality 72; Upper Llanvirn; murchisoni Biozone. One complete meraspid of degree 4, from temporary exposures in shales attributed to the 'bifidus' Biozone by Strahan et al. (1909), 4.5 Km west of Johnstown, Carmarthen.

DISCUSSION: This species has been fully described by Whittard (1966; 250) from Shropshire, and by Hughes (1979: 126) from the Builth district, and nothing can be added from new material from Dyfed.

The earliest occurrence of the species is from the upper part of the Lower Llanvirn; artus Biozone of the Builth district (Hughes 1979: 126), and in Shropshire it is confined to the Upper Llanvirn murchisoni Biozone, and the overlying Meadowtown Beds (Llandeilo) (ie.as the var. novenarius sensu Whittard 1964; here synonymised). Contrary to Hughes' statement (1979: 126) O. corndensis is also recorded from the Dolgellau district (Cox & Lewis 1945: 73) from mudstones attributed to the Lower Llanvirn 'bifidus' Biozone.

The new specimens from ashy shales immediately above the Black Cuffern Shales at locality 72 represent the only record of the species in Dyfed.

In addition to the typical O. corndensis with eight pygidial pleural ribs, Whittard (1966) recognised two varieties, or subspecies, of corndensis in Shropshire; septenarius with seven ribs, confined to the Upper Llanvirn (murchisoni Biozone) and novenarius, with nine ribs, ranging from the Upper Llanvirn (Betton Beds) into the low Llandeilo (Meadowtown Beds). Hughes (1979: 136) disputed the formal recognition of three subspecies, whilst acknowledging that the proportion of seven, eight and nine ribbed forms within assemblages at Builth has similar stratigraphic significance to that apparent in Shropshire, assuming that present correlation between the Llanvirn and Llandeilo of the two regions is correct. It is preferred to follow Hughes initiative and include Whittard's varieties within the synonomy of corndensis. The new specimens have eight distinct pleural ribs, and there is no indication of a ninth pair on a latex mould of the best preserved specimen (Pl. 3 Fig. 10). The new specimens are distinct from O. intermedius Elles, 1940, in lacking pleural furrows, and from O. grandis Whittard 1964 and O.porcatus Whittard 1964, in having a semicircular rather than subtriangular outline, and a simple pygidial border which is wider than that of grandis, and lacks the intermarginal ridges of porcatus.

The single meraspid of degree 4 (Pl. 3, Fig.12) is cautiously attributed to this species, and agrees well with the degree 4 meraspides of corndensis figured by Hughes (1979: Figs 26, 30) from the Lower Llanvirn and from the Llandeilo of Builth. In particular, the new specimen has a well differentiated glabella with a single pair of short glabellar furrows, a well developed eye that occupies about a third of cephalic length, and a pronounced posterior border and border furrow. The pygidium is semi-circular with a pronounced flat border and deep border furrow, and, like the transitory pygidia of meraspides of unknown degree figured by Hughes (1979: Figs. 24, 25, 28) and like his degree 4 (Fig. 26), there is a distinct postaxial narrowing of the border and a shallow posterior indentation developed. The axis is ill-preserved in the new specimen, and the number of axial rings cannot be determined. Hughes (1979: 132) records at least four pleural ribs in degree 4, and his Fig. 26 has vague indication of a fifth pair. The specimen from South Wales has at least six pleural ribs, and in this respect is similar to degree 5 of O.corndensis (Hughes 1979: Figs. 31, 32).

Meraspides of other British Ogyginus are undescribed. Hughes

(1979: 148, Fig. 82) described a degree 4 meraspis of Ogygiocarella debuchi from the Llandeilo of Builth. This specimen differs from the South Wales meraspid in having a much larger eye that occupies about half cephalic length, a wider and shorter pygidium with seven pleural ribs, and in lacking a postaxial indentation of the pygidial border.

Ogyginus aff. porcatus Whittard, 1964.

(Pl. 3, Fig. 13; Pl. 4, Fig. 4)

HOLOTYPE: BM In 54953 dorsal exoskeleton lacking librigenae, from the Lower Llanvirn, Hope Shales of Ritton Castle, Shropshire.

DISCUSSION. A single fragmentary exoskeleton from temporary exposures in shales attributed to the 'bifidus' Biozone by Strahan et al. (1909) 4.5 km west of Johnstown, Carmarthen, has a number of morphological similarities to this species, otherwise known only from the artus Biozone of Shropshire (Whittard 1964: 248-9).

Only the right genal region of the cephalon is intact in the new specimen. The anterolateral border is strongly developed, with distinct terracing subparallel to the outer margin, the border furrow is deep and the librigena, which is not described from type material, is apparently convex (tr.) in profile. The genal spine is almost straight and strongly convex or tubular in profile (Pl. 4 Fig. 4). Spine reaches as far back as the fourth thorax segment.

The subparallel terracing of the border is continuous along the base of the spine.

Thorax fragmentary; pleurae ill-preserved, but with distinct pleural furrows developed. Axis typical of Ogyginus. The pygidium is also fragmentary and ill-preserved posteriorly, but in common with the holotype and paratype of O. porcatus (Whittard 1964: Pl. 40, Figs.7, 8) it has a strongly triangular outline, and a distinctive border and border furrow , consisting of an intramarginal ridge bounded on either side by furrows. This intramarginal ridge is diagnostic, and distinguishes porcatus from the closely related intermedius, (Elles 1940: Pl. 31, Fig. 10) and from the type species corndensis, in which the border and border furrow are simpler.

Asaphid gen. et sp. nov.

(Pl. 5, Figs. 1-3)

MATERIAL HORIZON AND LOCALITY. Internal and external moulds of a cranidium and a pygidium and one thoracic segment from locality 53, artus Biozone, and one external mould of a large cranidium from the lowest Llanvirn; artus Biozone, of the Llanfallteg Formation, locality 25.

REMARKS. This species is imperfectly known from three disarticulated specimens. The largest cranidium (Pl. 5, Fig. 1) may have belonged to an individual in excess of 20 cm in length by comparison with other asaphids.

Both available cranidia certainly represent one species, but the pygidium and thoracic segment are only provisionally associated with them on the basis of co-occurence.

DESCRIPTION. Cranidium slightly wider than long, with an ill-defined glabella which constitutes at least two thirds of cranidial length. Glabella is slightly swollen anteriorly in the least distorted specimen. Cephalic axial furrows almost effaced. Preglabellar region wide (sag.; exsag.), flattened and without border or border furrow. Postoccular fixigena triangular, rounded postero-laterally. Posterior border narrow (exsag.), slightly wider at genal region, border furrow deep, trench-like, effaced adaxially. Occipital ring ill defined, but in one specimen (Pl. 5, Fig. 2) with distinct medial convergence of occipital lobe furrows and posterior band furrows, to produce a pattern similar to that described for Ogygiocarella by Whittard (1966: 258).

Preocular and postocular facial sutures diverge at a point about half cranidial length, and enclose an angle slightly greater than 90°. There are no eyes, palpebral lobes or furrows.

Thoracic segment with axial ring which constitutes at least half the total width of the segment. Axial ring with distinct terracing that arches forwards medially. A deep transverse furrow separates a narrow (sag., exsag.) articulating half ring. Pleurae appear to be simple, with a distinct oblique pleural furrow.

The pygidium is sub-triangular, at least twice as wide as long, with a strongly tapering axis. Axis is about two thirds of pygidial length, and is divided into at least six axial rings and a terminal piece that is posteriorly ill defined. Posterolateral border almost a quarter of pygidial length postaxially, slightly narrower laterally. Strong subparallel terracing, which anastomises anterolaterally, is developed on the border. As with other asaphid groups, the terracing may be superimposed from the ventral doublure due to compression. Pleural fields convex (tr.) and divided into at least four flat topped pleural ribs, with very weak abaxial pleural furrows.

DISCUSSION. The absence of eyes and associated palpebral structures, the weakly defined glabella and the broad flattened preglabellar region distinguish this species from any previously described asaphid. A new genus is likely to be represented, but is not named here because the available material is inadequate.

The pygidium invites comparison with that of Ogyginus Raymond 1912, and is similar to that of O. grandis (Whittard 1966: 249; Pl. 41, Figs. 5-9; Pl. 42, Fig. I) from the lower Llanvirn, Stapeley Shales (artus Biozone) of Shropshire. It is distinguished from O. grandis by having a wider (sag.; tr.) posterolateral border, a shorter and wider axis, with axial furrows more distinct, and only four rather than eight pleural ribs. The cranidium of O. grandis is easily distinguished from that of the new species in possessing distinct crescentic eyes.

Superfamily CYCLOPYGACEA Raymond, 1925

REMARKS. The definition of the Cyclopygacea given by Fortey (1981) is followed here,. to include the Nileidae of this superfamily as well as the Cyclopygidae.

Family CYCLOPYGIDAE Raymond, 1925.

Subfamily CYCLOPYGINAE Raymond, 1925.

DIAGNOSIS. Cyclopygids with five to seven thoracic segments, and without paired nodes on the third segment. Cranidium parabolic or arcuate in outline, extended anteriorly in Degamella. Glabella furrows variable; maximum of three pairs. Pygidium with or without border; axis usually short, rounded, may be effaced. Genera included: Cyclopyge Hawle & Corda, 1847; Microparia Hawle & Corda, 1847; Microparia (Heterocyclopyge) Marek, 1961; Microparia (Quadratapyge) Zhou, 1977; Aspidaeglina Holub, 1911; Segavia Koroleva, 1967; Degamella Marek 1961; Novakella Whittard, 1961; Xenocyclopyge Lu, 1962; Gastropolus Whittard, 1966.

Genus Cyclopyge Hawle & Corda, 1847.

DIAGNOSIS. See Marek (1961: 18).

TYPE SPECIES. Egle rediviva Barrande, 1846 from the Caradoc

Černín Beds of Trubin, Bohemia.

Cyclopyge torquata sp. nov.

(Pl. 6, Figs.13-15)

V ?1966 Cyclopygid D: Whittard: 228; Pl. 50, Fig.1

NAME: Latin; adorned with a necklace, referring to the occipital pits.

TYPE MATERIAL HORIZON AND LOCALITY. All specimens are from locality 69 Lower Arenig (Moridunian Stage?). Holotype: 69.28 complete exoskeleton retaining fragments of the optic surfaces. Figured Paratypes 69.29; 69.39 complete exoskeletons. Additional paratypes; one complete exoskeleton and one pygidium and fragmentary thorax.

DIAGNOSIS. Cyclopyge species with a single pair of circular pits, with raised peripheral rims, situated close to the posterior margin of the cranidium, and close to the sagittal line of the cranidium. Cephalon subelliptical with its maximum transverse width at about half sagittal length. Pygidium subtriangular with well developed border and border furrow. Axis conical, roundly terminated and divided into two axial rings and a terminal piece. Pleural field with 2 - 3 pairs of weak pleurae.

DESCRIPTION. Complete exoskeleton slightly longer than wide; outline bluntly elliptical. Total length about one and a quarter times the maximum width, which is achieved at about the mid-sagittal point of the cephalon. Cephalon accounts for about a half of the total length of the trilobite.

Cranidium consists almost entirely of a large, gently convex (sag; tr.) glabella that is slightly wider than long. Glabella widens forwards from the posterior border, and in the holotype (Pl. 6, Fig. 13) has its maximum width at approximately half of the sagittal length of the cephalon. A single pair of clearly defined circular pits occurs close to the posterior margin. The transverse distance between these pits is slightly less than one third of the width of the posterior margin of the cephalon, and they are situated opposite a point approximately one eighth cephalic length, measured forwards from the posterior margin. The peripheral rim of each pit is slightly raised and convex and merges gently into the glabella without strong definition.

Optic surfaces imperfectly known from fragments preserved, approximately in life position, in the holotype. Eyes are convex (sag; tr.) longer (sag) than wide, and occupy a median-lateral position on the cephalon, with wide anterior separation. Length (exsag.) of eye appears to be at least one third cephalic length, and there are at least thirty lenses evident.

Short (sag.) postocular area developed, with bluntly rounded posterlateral margin. Length (sag) of postocular area is slightly less than a quarter of the total length of the cephalon, and it is interpreted as a relict fixigena. Preservation of all available specimens is too poor to enable a more detailed description of fixiginal regions or cranidial surface features. Ventral doublure and hypostoma unknown.

Thoracic characters typical of the Cyclopyginae. Length of thorax slightly more than two thirds the length of the cephalon. Axis well defined by strong axial furrows. Axis tapers strongly. Width of the axial ring of the first segment about three fifths of the total segment width, width of the axial ring of the sixth segment is less than one third of the total segment width. Width of successive pleurae increases backwards so that the thorax has a subparallel outline. Pleurae simple, bluntly rounded distally.

Pygidium at least twice as wide as long and roundly subtriangular in outline. Axis short, conical and roundly terminated. Length of axis is slightly more than half pygidial length. At its widest point the axis is about a quarter of the total width of the anterior margin of the pygidium, and is divided into two complete axial rings and a terminal piece, the latter constitutes about a half of the length of the axis. Anterior and posterolateral border slightly convex and of constant width, which is slightly less than one quarter of the sagittal length of the pygidium. Border furrow narrowest and deepest postaxially, less distinct anterolaterally. Postaxial field slightly wider (sag.) than border, pleural fields with at least two pairs of very weakly impressed pleural furrows which are only evident adaxially in the least distorted specimen (Pl. 6 Fig. 13).

DISCUSSION. A number of Cyclopyge (s.s.) species which possess well defined cephalic pits and/or raised occipital areas have been described from Czechoslovakia (Marek 1961) and Scotland (Reed 1935). Of these, the type species C. rediviva Barrande, C. umbonata bohemica Marek, and C. kossleri Klouček are similar to the new species. Cyclopyge rediviva described from the Caradoc Whitehouse Group of Girvan Ayrshire (Reed 1904 Pl. 8, Figs. 2-3) and from the Caradoc of Bohemia (Marek 1966: 20; Pl. 1, Figs. 1-5; text fig 4) differs from this species in having elongated, ovate cephalic pits that diverge adaxially at about 45° from the sagittal line, a median cephalic tubercle, a short, rounded pygidial axis with a wide (sag.) postaxial field, and two pairs of distinct pleural furrows. Cyclopyge umbonata bohemica from the Llandeilo of Bohemia (Marek 1966: 22; Pl. 1, Figs. 6-9; text-Fig. 5) differs from the new species in having twin cephalic pits that are ovate, divergent adaxially and positioned further apart, and in having a shorter, roundly terminated pygidial axis, and three pleural lobes with straight terrace lines.

C. kossleri from the Llanvirn of Bohemia (Marek 1966: 17: Pl. 1, Figs. 14-17; text-Fig. 7) and the Arenig of South Wales (Fortey and Owens in press; pers. comm.) differs in having only raised circular occipital areas without associated pits, and in having a narrower (tr.) pygidial border, and longer (sag.) postaxial field.

Cyclopygid D of Whittard (1966: 288; Pl. 50, Fig. 1) from the Upper Arenig (Mytton Flags; Shelve Church Beds?) of the Shelve Inlier, is comparable with the new species, in that it possesses a similarly acuminate pygidial axis which is roundly terminated, a distinct concave border furrow and moderately wide (sag; tr.) border, and faintly segmented pleural fields. The Shropshire specimen appears to have three axial rings and a terminal piece, compared with only two clear axial rings on the axis of the new specimens. This difference may be related to the nature of the preservation and distortion of the South Wales material.

The pygidium of the new species bears a broad general similarity to that of Symphysops; type species S. armata Barrande (1872; 59; Pl. 3, Figs. 1-4; Pl. 15, Figs. 16-18; Marek 1961: 54, Pl. 5, Figs. 11-13; Pl. 7, Figs. 1, 2) but differs in having only two rather than three axial rings and an axis which tapers more rapidly than that of the type species. The pygidium of S. subarmata elongata (Kielan 1960: 90; Pl 11 Fig 14; Apollonov 1974: 28; Pl. 5, Figs. 1, 2, 4-6) also has a strongly tapering axis and differs from torquata only by having a weakly developed third axial ring preceding the terminal piece and a slightly longer (sag.) postaxial field. The cranidium in Symphysops species, however, is anteriorly extended into a spine, and there are distinct incised glabellar furrows that are not seen in the new material.

Cyclopyge cf. umbonata umbonata (Angelin, 1854)
(Pl 6, Fig. 16)

MATERIAL HORIZONS AND LOCALITIES: One pygidium, and a pygidium with five thoracic segments and fragments of a sixth segment articulated, from locality 68, Upper Arenig, hirundo Biozone of Elles (1904, 1933).

REMARKS. The nature of preservation of trilobites from locality 68, where multiple cleavage planes are developed at very low angle to bedding, does not enable confident interpretation of surface features such as shallow furrows, terracing or surface ornamentation, and linear dimensions are affected by both compression and distortion.

C. umbonata umbonata Angelin has been described by Moberg (1907) and figured by Marek (1961 Pl. 1, Fig. 10), and the following description serves to compare the new Welsh material to Swedish and Bohemian figured specimens, and to outline minor differences observed which may not be of taxonomic importance.

DESCRIPTION. Thorax sub-parallel sided, axis tapering moderately, defined by strong axial furrows. Width (tr.) of axial ring of the anterior (second) segment is marginally greater than half of the total width of the segment. Each successive axial ring is reduced in width and the axial ring of the posterior (sixth) segment is slightly less than a quarter of the total width of the segment. Oblique pleural furrows well developed, particularly abaxially, and appear to reach the pleural tips. Pleurae simple, pleural tips bluntly and abruptly truncated.

Pygidium semi-circular in outline, axis short, conical and roundly terminated. Length (sag.) of axis about half pygidial length, maximum width of axis slightly more than a quarter of the width of the anterior pygidial margin. Axis divided into a single axial ring and a terminal piece by a distinct transverse furrow. Terminal piece slightly longer (sag.) than axial ring. Posterolateral and anterior border and border furrow distinct, and constitute, post-axially, about one sixth of the total length of the pygidium.

DISCUSSION. Marek (1961 : 23) in agreement with R. and E. Richter (1954) distinguished between Swedish and Bohemian specimens (attributed previously to C. rediviva by Barrande 1872), and erected the subspecies umbonata bohemicus for Czechoslovakian material. This subspecies differs from C. umbonata umbonata Angelin in having a shorter (sag.) pygidial axis with a less distinct transverse furrow on the pygidial axis (Marek 1961: Pl. 1, Fig. 8). The new material agrees well with Moberg's (1907) illustrations of Angelin's original specimen, and with the pygidium of C. umbonata umbonata figured by Marek (1961 Pl. 1, Fig. 10) from a plaster cast of the original specimen. (Riks Museum, Stockholm ; NHRM Ar. 1953. holotype pygidium; topmost Arenig of Sweden.)

The new material also resembles Cyclopyge grandis Salter originally described by Salter (in Murchison 1859; 1864b Pl. 4,Fig.7) from the 'Tetragraptus Beds' horizon of Whitesands Bay, Dyfed, and redescribed by Fortey & Owens (1978, Pl. 4,Figs. 5, 8-9 as Microparia grandis) from Salter's type material and from the early Arenig, Carmarthen Formation; Cwm-yr-Abbey member.

The pygidium of the new material differs from that of C. grandis in having a wider (sag., tr.) more distinct border furrow, and a narrower (tr.) axis. The single axial ring is longer (sag) in the new material (compare with Fortey & Owens 1978: 259, Fig.9) Salter's type material including the holotype (Fortey & Owens 1978: Pl.4,Fig. 8) is in a comparable state of preservation to the new material.

Although confident identification of the new material requires further qualification, the recovery of a single specimen recorded as C. cf umbonata from the Upper Arenig, Pontifenni Formation; Bergamia fenniensis Biozone of Pwltrap near Carmarthen (Fortey & Owens in press) is further corroborative evidence for the occurrence of this species in the Upper Arenig of South Wales.

Genus MICROPARIA Hawle & Corda, 1847

DIAGNOSIS. Cyclopygids with five thoracic segments. Cranidium parabolic in outline, and without incised glabellar furrows; cephalic doublure short; eyes occupy almost whole length of cephalon, occasionally synopthalmic. Pygidium with weak border, doublure narrow or wide. Axis short, wide with either one or two weak axial rings (Subgenus Microparia) or with a well defined axis with three axial rings and a minute terminal piece (subgenus Heterocyclopyge).

TYPE SPECIES. Microparia speciosa Hawle & Corda, 1847, from the Upper Ordovician, Králův Dvůr Beds (Ashgill) of Bohemia, by original designation.

Subgenus Microparia (Microparia) Hawle & Corda 1847

DIAGNOSIS. Microparia with pygidial axis effaced or only weakly defined anteriorly; one or two weak axial rings.

Microparia (Microparia) broeggeri (Holub, 1912).
(Pl. 7, Figs. 4, 5; Pl 8, Fig. 14)

1912 Aeglina broggeri; Holub: 7; Pl 1, Fig. 8.
1961 Microparia (Microparia) broeggeri; Marek: 45; Pl. 3, Fig. 16.

HOLOTYPE: Thorax and pygidium with posterior part of cranidium from the Kabava Beds (Arenig?) of Bohemia. Original of Holub (1912), by monotypy.

MATERIALS, HORIZONS AND LOCALITIES. Four examples, consisting of pygidia and articulated thoracic segments, have been recovered from the artus Biozone of the Llanfallteg Formation.

of the type area, from localities 27, 29, 31 and 34. BGS Tcc 889 pygidium and 3 thoracic segments from Clôg-y-frân farmyard (close to locality 13) is also attributable to this species.

REMARKS. The new Llanvirn specimens compare very closely to a stratigraphically late example of broeggeri figured by Fortey & Owens (in press) from the Llanfallteg Formation of the type area. According to Fortey & Owens (pers. comm.), in broeggeri, which occurs commonly in the Upper Arenig in South Wales, the definition of the pygidial axis is variable, and the species forms a link between the subgenera Microparia (Microparia) and Microparia (Heterocyclopyge). Their stratigraphically late example is intermediate between M. (Microparia) broeggeri Holub, and M. (Heterocyclopyge) shelvensis Whittard.

The following description of the pygidium of the new Welsh material is based on a latex mould of the best preserved example (Pl. 7, Fig. 4) and serves only to emphasise slight differences observed from type material of broeggeri and shelvensis.

DESCRIPTION. Pygidium about two thirds as long as wide, with a broadly arcuate outline. Pygidial axis triangular; axial furrows strongest anteriorly, becoming weaker posteriorly, and then effaced terminally. Length of axis is about half pygidial length.

At its widest point the axis constitutes slightly more than one third pygidial width, and is divided into two clear axial rings and a triangular, posteriorly effaced terminal piece. The length (sag.) of both axial rings is approximately the same. In stratigraphically early examples of broeggeri from the Arenig of South Wales there is only one clear axial ring, either partly or completely defined. (Fortey pers. comm.). Pleural fields with at least three very faint interpleural furrows, in contrast to the clearly segmented nature of the pleural fields in the holotype of shelvensis (Whittard 1961; Pl. 24, Fig. 3). Rushton & Hughes (1981: 643) have attributed the more clearly incised nature of the pleural ribs in the holotype to frontal compression, which may also have affected the length to breadth ratio of the pygidium in that specimen.

Anterior pleura defined by strong inter-pleural furrow which originates close to the anterolateral corner of the first axial ring and follows a shallow 's' shaped course adaxially towards the anterolateral regions of the pygidial margin, with which it merges imperceptibly. In both the holotype and paratype of shelvensis (Whittard 1961: Pl. 24 Figs 3-4) and in M. cf shelvensis from Great Paxton (Rushton & Hughes 1981: Pl. 3, Figs. 7, 11, 14) the anterior interpleural furrow is straight for most of its length (tr.) curving backwards anterolaterally to rather abruptly merge with the pygidial margin, which in the new material is less distinct than in comparable figured materials of broeggeri, shelvensis and M. cf. shelvensis. The ventral doublure is not preserved in the new specimens.

DISCUSSION. The holotype, and only known example of Microparia broeggeri from the type locality, has been lost (Marek 1961: 45) and Holub's (1912; Pl.I, Fig. 8) figure is used to compare the species. Material from the Upper Arenig and Lower Llanvirn in South Wales cannot be justifiably separated from broeggeri, although similarities with M. (Heterocyclopyge) shelvensis Whittard in Llanvirn material may prove to be of taxonomic importance when more complete specimens are available from South Wales.

Of the Bohemian species revised by Marek (1961) the following are similar to the new Welsh specimens; M. speciosa, the type species (Marek 1961: Pl. 3, Figs. 5-10; Marek in Horny & Bastle 1970: Pl. 7, Fig. I; Kielan 1960: Pl. 10, Fig. 6) from the Ashgill, has a more transverse pygidium, with a wider and more effaced axis than the Welsh species, M. brachicephala (Klouček 1916; Marek 1961: 39; Pl. 3, Figs. 11-15) is distinguished by having a wider pygidial doublure.

M. plaisi Marek (1961: 44; Pl. 3, Figs. 22-23) is extremely close to broeggeri, from which it is distinguished only in the shape of the cranidium, which does not have its maximum width at the posterior margin, as in broeggeri, but is widest some distance forwards, and has the axial furrows and palpebral furrows bowed outwards. Cephalic muscle impressions described in plaisi from Bohemia (Marek 1961: 44) are not seen in late Arenig Welsh material attributed to broeggeri (Fortey & Owens; pers. comm.).

Rushton & Hughes (1981: 634) suggested that plaisi might prove to be a junior synonym of shelvensis from Shropshire, but the view expressed by Fortey & Owens (in press) that strong axial definition is important taxonomically is accepted here, and shelvensis is referred to M. (Heterocyclopyge). M. cf shelvensis from Great Paxton (Rushton & Hughes 1981: 633) has both pygidial and cephalic characters inseparable from plaisi, and all of Whittard's (1940) original material of shelvensis, except the designated holotype (BGS 87158; Whittard 1961: Pl. 24, Fig. 3) are similarly very close to plaisi.

Genus DEGAMELLA Marek, 1961.

DIAGNOSIS. Generally large cyclopygids, with elongated cranidium, variably extended forwards into a streamlined anterior projection. Three pairs of cephalic muscle impressions may be present, but no incised furrows. Eyes moderately large, laterally situated. Thorax of six or seven segments, Pygidium sub semicircular, border variably defined, axis long; effaced posteriorly in some species, doublure wide, or very narrow.

REMARKS. The diagnosis of Fortey & Owens (in press) is here amended to include D. gladiata sp nov. in which the pygidial border is well defined and the pygidial doublure is very narrow. The possibility that dorsal organs on the third thoracic segment are developed in one species is discussed on page 106.

TYPE SPECIES. Aeglina princeps Barrande, 1872 from the Llanvirn of Bohemia, by original designation.

Degamella gladiata sp. nov.

(Pl. 6, Figs. 6-12; Pl. 7, Figs. 12-14)

NAME: Latin; gladiata, a sword, referring to the shape of the pygidial axis.

DIAGNOSIS. Degamella with relatively short (sag.) bluntly rounded cephalon that is slightly more than one third total length of the exoskeleton. Eye moderately large, posteriorly and laterally situated. Short (sag.) fixigenae and narrow librigenae developed. Pygidium with long tapered axis and distinct narrow (sag.; tr.) border and border furrow. Pygidial doublure narrow, widest postaxially; pleural fields and axis weakly segmented.

TYPE MATERIAL HORIZON AND LOCALITY. 69.26 Holotype: complete exoskeleton with cephalon slightly displaced. Figured Paratypes: 69.05; 69.06: complete exoskeletons, 69.07 cephalon and two thoracic segments, 69.25 cranidium, 69.14 pygidium. Additional paratypes: 8 complete or near-complete exoskeletons, of which four are external moulds, 2 cephala with articulated thoracic segments, 1 cranidium, 1 thorax and pygidium, four pygidia, one of which is an external mould, and 1 example possibly representing a moulted and scattered exuvia .

All specimens are from locality 69; tuffs of probable early Arenig; (Moridunian?) age.

DESCRIPTION. Complete exoskeleton approximately twice as long as wide with a bluntly rounded, elliptical outline. Maximum transverse width of cephalon, excluding the optic surfaces, is only marginally greater than the maximum width of the thorax, which is achieved at the third segment.

Length of cephalon at least one third of the total length of the complete trilobite. Cranidium strongly convex (sag. tr.), bluntly rounded anteriorly, convexity increasing anteriorly, so that the anterior and anterolateral margin occupies a slightly ventral position. Cranidium widest at the posterior margin, which is strongly downcurved. In some specimens (eg Pl. 6, Fig. 12) marginally situated, highly effaced axial furrows are evident, formed by a localised increase in convexity of the margin at points opposite the axial furrows of the first thoracic segment.

Optic surfaces known in only five examples. In the best preserved specimens (eg. holotype: Pl. 6, Fig. 6) the eyes are convex (sag., tr.) more than twice as long (exsag.) as wide, being about two thirds cephalic length, and occupy a lateral position on the cephalon, with wide anterior separation. The posterior margin of the eye is at a point about one fifth cranidial length, measured forwards from the posterior margin. In a number of specimens (eg. Pl. 6 Fig. 11) compression has forced the optic surface into a more dorsal position than in life. There is a short (sag.) postocular area interpreted as a remnant fixigena, which has a bluntly rounded posterior and lateral margin, and a narrow lateral border and border furrow, which in at least one example (Pl. 6,Figs.7,8) can be traced forwards anterior to the eye, forming a continuous peripheral feature. In the holotype and a small number of paratypes, narrow (tr.) librigena are clearly evident with the border and furrow present. The librigena must have occupied a vertical position in life.

Cephalic doublure poorly known from two specimens that show the doublure impressed through the exfoliated anteromedial region of the cranidium. In the best preserved specimen (Pl. 6,Fig. 10) the doublure is narrow, and appears to have its maximum width (sag.) medially, becoming slightly narrower anterolaterally. At its maximum width (sag.), it is about one seventh of the sagittal length of the cranidium. There are at least twelve non-anastomising subparallel terrace lines present in the anterolateral region of the doublure. Ventral suture and hypostoma unknown.

One distorted cranidium (Pl. 7, Fig. 12) shows the posterolateral edge of the cranidium to have a series of at least seven raised areas separated by narrow notches. Similar structures have been described for Degamella nuda (= Microparia nudus; Whittard 1961: 180, 181; Pl. 24, Figs. 6, 8) from Shropshire. Whittard interpreted these notches as being functional in enrollment by acting as clamping contacts (op. cit: 180) and demonstrated that the number of notches corresponds to the number of thorax segments in the adult nudus and in a meraspid of degree 3.

The single example from South Wales is less well preserved than figured D. nuda from Shropshire, and the precise number of raised areas and notches is difficult to interpret. There may be as many as eight raised areas separated by seven notches. The more posterior raised areas are distinctly larger and sub-rectangular, those remaining are more ovoid, and do not closely resemble the angular "castellations" (sic.) described by Whittard. The seven notches, however, may include an anterior notch which articulates with the anterior pleural rib of the pygidium during enrolment in gladiata (see also Whittard 1961: 180; item 2). Thorax of six segments, not parallel sided; outline slightly bowed, with the maximum transverse width at the third segment. Axis gently tapering, defined by strong axial furrows. Width (tr) of the axial ring of the first segment is marginally greater than one third of the total width of the segment, and the width (tr.) of the axial ring of sixth segment is about a quarter of the width of the segment. Axis distinctly raised above the adjacent pleural lobes. Each pleurae is simple, bluntly truncated distally, with a strongly developed backwardly directed oblique furrow that is deepest at its origin opposite the anterolateral corners of the adjacent axial ring. Furrow shallows and broadens adaxially, disappearing before reaching the pleural tip.

Pygidium semi-circular, about as wide as long. Length of pygidium slightly less than one third of the total length of the complete exoskeleton. Axis conical, distinct. Axial furrows deepest anteriorly, axis tapers more sharply than thoracic axis, and is four fifths of the total length of the pygidium, almost reaching the posterior border furrow. At its widest point, the axis is one quarter of the total width of the pygidium. Axis weakly defined posteriorly, but not effaced, and has a sharply rounded termination. Post-axial field short (sag.) about one sixth of the total length of the pygidium. Axis and pleural fields in the least distorted specimens are devoid of distinct segmentation, but up to three axial rings and three pairs of pleurae are faintly evident in a small number of specimens that are transversely distorted (ie sagittally shortened), and one specimen has the pygidium distinctly segmented (Pl. 6, Fig. 12). Narrow (tr.) anterior and posterolateral border and border furrows developed. Anterior border furrow deepest adaxially, becoming broader and shallower abaxially, and continuous with the anterolateral furrow. This furrow is deepest anterolaterally, and becomes less distinct postaxially. Border is narrow (tr.) and of constant width, and is strongly convex (tr.). Pygidial doublure known in only two specimens (Pl. 6, Fig. 9, Pl. 7, Fig. 14) where it is about the same width (tr.) as the border anterolaterally, becoming broader postaxially to form a median forward directed prolongation, that almost reaches the sharply rounded termination of the pygidial axis.

DISCUSSION. D. gladiata is easily distinguished from other Degamella species by possessing a pygidium with a narrow, well defined border and border furrow, a narrow doublure, and a long, pointed axis that is well defined posteriorly, and which almost reaches the border furrow.

Although similar, Degamella A. (Pl.7, Figs.9-11) is distinguished from gladiata by lacking remnant fixigenae, and by having a shorter (sag) pygidial axis, a less distinct and wider border and a wider doublure. The cephalon of gladiata bears a strong general resemblance to the cephala of three Bohemian forms described by Marek (1961) including the type species D. princeps. However, princeps, princeps praecedens and bergeroni each have longer, more anteriorly pointed cephala with distinct glabellar furrows and a median tubercle, and do not retain remnant fixigenae.

Whittard (1966) has described from Shropshire a number of lower Ordovician cyclopygid pygidia of uncertain taxonomic affinity. Of these, cyclopygid D (op cit: 288, Pl 50 Fig 1) and cyclopygid E (p. 289; Pl. 49, Figs. 14, 15) are comparable with the new species. Cyclopygid D, from the middle Arenig, has a wider (tr.) border furrow and border with distinctly segmented axis, and cyclopygid E, from the lower Llanvirn artus Biozone differs from the new species in having a sub-triangular pygidium, a much wider (sag; tr.) doublure and a distinctly segmented axis.

A single specimen of a thorax and a pygidium (Pl.7, Fig.14) from the Hope Shales: artus Biozone of Overton's Rough, Leigh, Shropshire (SJ 3325 0250) may belong to the new species. The Shropshire specimen is better preserved than the South Wales material and is less distorted. The pygidium of this specimen shares many characteristics with the South Wales specimens, in that it has a well developed narrow (tr.) convex anterolateral border and a long pointed axis which almost reaches the border furrow. The axis is defined posteriorly and has at least two very weak axial rings. The pleural field is almost unfurrowed but two highly effaced furrows are vaguely evident posterior to the anterior furrow. Latter is well developed and continuous with the border anterolaterally. The pygidial doublure on the Shropshire specimen is evident postaxially as a very short (sag.) forward directed prolongation which is bluntly rounded anteriorly and is about the same length (sag.) as the border. Doublure is interpreted as being about the same width (sag.; tr.) as the border. There is parallel or sub-parallel terracing evident on exposed sections of the doublure, and similar terracing is vaguely evident in a small number of specimens from South Wales.

Degamella A

(Pl. 7, Figs. 9-11)

MATERIAL HORIZONS AND LOCALITIES. One complete exoskeleton consisting of a cranidium, lacking optic surfaces, with five articulated thoracic segments, and a slightly displaced pygidium and posterior thoracic segment, from Locality 59, Lower Llanvirn, Llanfallteg Formation; artus Biozone. A pygidium and disarticulated thorax from locality 34, low artus Biozone is probably conspecific.

DESCRIPTION. Complete exoskeleton twice as long (sag.) as wide with an overall elliptical outline. Maximum transverse width slightly forwards of the posterior margin of the cephalon, which is only marginally greater than the width of the thorax and pygidium.

Cephalon slightly wider than long; in the ratio 6:5.5, and constitutes slightly more than one third of the total length of the trilobite. Maximum width (tr.) occurs opposite a point about one eighth of the total length of the cephalon measured forward from the mid transverse point on the posterior margin. The course of the margin migrates gently forwards adaxially, then, at points opposite the adjacent axial furrows of the first thorax segment, becomes more markedly directed forwards, before resuming a near horizontal course posterolaterally. These marginal features are interpreted as highly effaced axial furrows. Optic surfaces, ventral doublure and hypostoma unknown.

Thorax sub-parallel sided, axial furrows distinct. Axis gently tapering; width (tr.) of axial ring of the first segment in slightly more than half segment width. Width of the axial ring on the sixth segment is less than one third of the total width of the segment. Axial rings convex (sag. exsag.), pleurae simple, bluntly rounded distally with well developed oblique pleural furrow which becomes weaker adaxially and does not reach the pleural tip.

Pygidium semi-circular in outline and wider than long;

length to breadth ratio 5:3.5. Axis unfurrowed and defined by moderately strong axial furrows. Length of axis is three fifths of the total length of the pygidium. Maximum width of axis is approximately one quarter of the transverse width of the anterior pygidial margin. Axis tapers less sharply than the axis of the thorax, and is bluntly rounded terminally. Pleural fields with a single straight, moderately deep anterior furrow which narrows and becomes shallower adaxially, merging with the broad, open anterolateral border furrow. Latter is ill developed and becomes effaced posteriorly; no distinct posterolateral border or border furrow developed. Doublure widest (sag.) medially, occupying the whole of the postaxial region (ie two fifths of the pygidial length) and becoming slightly narrower (tr.) laterally being about one fifth of the width of the anterior margin of the pygidium. Doublure terraced, with at least 12 sub parallel terrace lines crossing the sagittal line. Terrace lines anastomise anterolaterally.

DISCUSSION. This species differs from the type species D. princeps princeps in having a sagittaly shorter cephalon, and a shorter (sag.) and narrower (tr.) pygidial axis which in the new material is more clearly defined posteriorly.

Microparia nudus Whittard (1966: 180; Pl. 24, Figs. 5-10 = Degamella nuda sensu Fortey & Owens in press) also from the Lower Llanvirn, artus Biozone of Shropshire is similar to the new specimens but differs in having a clearly segmented axis, which is effaced posteriorly in both the holotype and two of the paratypes Whittard (1966: Pl.24, Figs.5, 7, 9). Whittard's young holaspis paratype (op cit: Pl 24, Fig.10) shows pygidial axial characters similar to the new examples but possesses a coarsely terraced ventral doublure which is not seen in the new specimens.

Fortey & Owens (in press) regard the posterior definition of moderately long pygidial axes in cyclopygids to be diagnostic of the subgenus Microparia (Heterocyclopyge); subgenotype Heterocyclopyge pachycephala Hawle and Corda 1847. However, the new species must be excluded from M. (Heterocyclopyge) in possessing six thorax segments, not five, considered by Fortey and Owens to be of greater taxonomic importance than pygidial axis definition. (Fortey; pers. comm.).

Although a new species may be represented, it is preferred not to erect a new species name here, based only on a single example.

Degamella B.

(Pl. 8, Figs.11, 12)

DESCRIPTION. A single complete but disarticulated exoskeleton, probably representing a moulted exuviae, from the Upper Llanvirn; low murchisoni Biozone of Llan Mill (close to locality here) resembles certain Degamella species, in that the cranidium is slightly longer than wide, gently convex (sag.; tr.) with the maximum width at about a third cranidial length, measured forwards from the posterior margin, and is bluntly rounded anteriorly and highly effaced. There are five thoracic segments evident, and a parathoracic segment is clearly present on the pygidium, suggesting affinity to Degamella rather than to Microparia or Microparia (Heterocyclopyge).

The Pygidium is subelliptical in outline, convex (tr) and slightly wider than long, with a very weakly defined axis which continues the even taper of the thoracic axis, and appears to be at least three quarters pygidial length and completely effaced posteriorly. There is a single shallow axial ring and interpleural furrow defining the parathoracic segment, and the pleural field is unfurrowed. There is no distinct border, but a highly effaced border furrow is weakly indicated laterally and the pygidial margin appears to be slightly convex in profile.

DISCUSSION. This specimen is significant stratigraphically and represents the only Upper Llanvirn occurrence of a cyclopyginine in the region. It is also noteworthy in that the pygidium is apparently transitory, but is considerably larger than transitory pygidia of other cyclopygids (eg. Whittard 1961: Pl. 23, Figs. 16-19; Pl. 24, Figs. 7-9). Degamella nuda Whittard (1961: 180) is similar to the new example, but has a more distinctly defined pygidial axis with up to three weak axial rings. Axial rings are more distinct in meraspides than in the adult exoskeleton (compare Whittard 1961. Pl 24

Fig.5 with Figs.7, 9).

The pygidium of Microparia (Microparia) prantli Marek (1961: 40; Pl. 3, Figs.1-4, text-Fig.13) is also similar to the new specimen, in that a single complete axial ring is defined, but it differs in having up to 3 further incomplete rings that are not seen on a latex mould of the Welsh example, and in having a more sharply defined border furrow anterolaterally.

It may be that this stratigraphically late example of Degamella represents a new species, but it is preferred not to erect a species name based on a single, possibly immature specimen.

Cyclopyginine aff. Degamella

(Pl. 7, Figs. 1-3)

MATERIAL HORIZON AND LOCALITY. One fragmentary thorax and pygidium from locality 59 (Scolton), Lower Llanvirn; artus Biozone, Llanfallteg Formation. An ill-preserved but complete specimen from the low artus Biozone of Locality 27, consists of a cranidium with five articulated thoracic segments and an inverted and displaced pygidium, and is cautiously regarded as conspecific with the Scolton specimen.

DESCRIPTION. Complete exoskeleton longer than wide; length to breadth ratio approximately 2:1. Maximum width of exoskeleton is across the posterior margin of the cranidium which is only marginally greater than the maximum width of the thorax and pygidium. Exoskeleton with an overall elliptical outline.

Cranidium slightly longer than wide and gently convex (sag. tr.); transverse convexity increasing anteriorly. Length of cranidium is slightly less than half of the total length of the exoskeleton, deduced from linear measurements of the moulted exuviae (Pl. 7, Figs. 1, 2). Cranidium widest at posterior margin, tapering gently forwards, and roundly pointed anteriorly. The poor preservation of the only available cephalon does not enable confident interpretation of surface features, but the nature and degree of fracture due to compression suggests that the cephalon is typically degamellid in that convexity (tr.) is increased anterolaterally, with the cranidium projecting forwards above the anterior cephalic margin, which is ventrally situated. Doublure, hypostoma and optic surfaces unknown.

Thorax of six segments, sub-parallel sided. Axis, defined by strong axial furrows, is gently tapering. Axial lobe of thorax moderately raised above adjacent pleural lobes, axial rings only slightly convex (tr.). Width of axial ring of first segment is slightly greater than half of the total width of the segment. Width of the axial ring of the posterior (sixth) segment is about one third of the total width of the segment. Axial ring of the third segment has a single pair of raised circular tubercles situated close to the sagittal line.

These tubercles are well preserved in the Scolton specimen, and are vaguely evident in 27.01a (Pl. 7, Fig. 1). The distance (tr.) between these tubercles is about one third of the width of the axial ring, and they are situated about mid way along the length (sag.) of the axial ring (Pl. 7 Fig. 3). Pleurae simple, rounded distally, pleural tips recurved to form short (sag.) blunt, backward directed spines. Oblique pleural furrow well developed, narrow at its origin close to the anterior extremity of the adjacent axial ring, becoming broader and deeper abaxially and strongly 's' shaped following the recurved shape of the pleural tip. Furrow disappears before reaching the pointed termination of the pleurae.

Pygidium roundly sub-triangular in outline, wider (tr) than long (sag.); width to length ratio 4:2.5. Axis, defined by strong axial furrows, tapers sharply for three quarters of its length: taper distinctly increased compared to that of the axial lobe of the thorax. Taper decreases and axis becomes almost parallel sided for posterior quarter of axial length. At its maximum width, the axis is slightly greater than a quarter of the width of the anterior margin of the pygidium. Length of axis is about four fifths of the total length of the pygidium. In both available pygidia, the termination of the axis is difficult to interpret with confidence. A latex from the external mould of the most complete pygidium, reveals a very short (sag.) postaxial field (Pl. 7, Fig.2). Axis is divided into four axial rings, and a short (sag.) rounded terminal piece. Articulating half ring of axis constitutes approximately one third of the length (sag.) of the axial ring of the posterior thorax segment. Pleural fields with at least five distinct pleural furrows which are narrowest and strongest adaxially, becoming broader and shallower towards the lateral border furrow, which is not significantly invaded by the pleural furrows. Border furrow broad, convex and of constant width (tr.) which is about one eighth of the maximum width of the pygidium at the anterior margin. Border furrow shallows and becomes less distinct post-axially. Border ill preserved and fragmentory on available material. It appears to be narrow (tr.) and slightly convex in profile in the anterolateral fragment intact on 27.01b. Doublure imperfectly known, but interpreted to be of the same width as the border and border furrow combined. Entire surface of the thorax and pygidium in 59.03 with very fine sub-parallel non-anastomising transverse terrace lines.

DISCUSSION. The new specimens differ from all other described Degamella species in possessing a pair of raised circular organs on the axial ring of the third thorax segment. In their revision of the Cyclopygacea, Fortey and Owens (in press) have provided a modified diagnosis of Degamella (s.s.) which the absence of dorsal organs on the third thorax segment is outlined. According to Fortey and Owens such organs (described as 'bulbs' or 'hollow nodes' by Whittard 1961:174) are formed entirely within the cuticle, and may have functioned as photo-phores. Their presence is restricted to a monophyletic group, which is given therein subfamily status; the Pricyclopyginae. In agreement with Fortey (pers. comm.) such dorsal organs are unlikely to have arisen more than once in separate cyclopygid groups, and it cannot be dismissed that the new material from South Wales may belong to a pricyclopygine (s.l) species with a degamellid-like morphology. Confident assignment of the new material to Degamella requires further qualification, and formal naming must await the recovery of better preserved and more complete material. It is preferred therefore at present to cautiously attribute the new material to Degamella as the most similar described genus.

The type species D. princeps (Marek 1961: 46; Pl. 4, Figs. 1-7) differs from the new species in lacking dorsal organs on the third thoracic segment, and by having a pygidial axis with three indistinct rings and unfurrowed pleural fields. The only previous record of this genus in Britain is that of Whittard (1966: 287; Pl 49, Figs. 12, 13) who described Degamella cf. princeps (as Microparia cf. princeps) from fragmentory specimens from the artus Biozone of Shropshire.

The pygidium of Degamella gigantea (Barrande) from the Upper Ordovician (Ashgillian) of Bohemia (Marek 1961: 49, Pl. 5, Fig. 3) resembles that of the new species, but differs in having a wider (tr.) axis that is one third of the total width (tr.) of the anterior pygidial margin, and only two indistinct, broad, shallow pleural furrows.

Genus Gastropolus Whittard 1966

1974 Lisogoraspis: Apollonov: 76

DIAGNOSIS. Cyclopygids with six thorax segments and a cephalon more than twice as long as the pygidium. Cranidium resembling that of Microparia but with distinct large triangular remnant fixigenal areas. Pygidium transverse with a sub-elliptical outline, a distinct convex border and a distinct, bluntly rounded axis.

TYPE SPECIES. Aeglina Obtusicaudata Hicks, 1975 from the Lower Llanvirn: artus Biozone of Llanvirn quarry (locality 76).

The genus Gastropolus was erected by Whittard (1966: 294; Pl 50, Figs. 10-12) to accommodate two distinctive pygidia and a pygidium and fragmentary thorax collected from the Hope Shales, artus Biozone of the Shelve Inlier, Shropshire. Because the cephalon was unknown with certainty at the time of publication, confident taxonomic assignment of the genus was not possible, and it was described incertae sedis.

New material, including a complete articulated exoskeleton and four cephala enable Gastropolus to be assigned to the Cyclopygidae Raymond 1925, Subfamily Cyclopyginae Raymond 1925 after Fortey & Owens (in press).

A poorly preserved complete cyclopygid attributable to Gastropolus sp. but indeterminate at species level is also known from the Early Ordovician of the Lake District (Postlethwaite 1885; Postlethwaite and Goodchild 1886) and pygidia described as Lisogoraspis (Apollonov 1974,Pl.3,Figs.13-15) from the Upper Ordovician of Kazakhstan are probably attributable to G. obtusicaudatus.

Gastropolus obtusicaudatus (Hicks, 1875)

(Pl. 6, Figs.1-5)

V. 1875 Aeglina obtusicaudata n.sp; Hicks: 185, Pl.10, Fig.3.

1885 Group A No. 2; Postlethwaite: 74-4, Pl.3, Fig.16.

1886 Aeglina obtusicaudata: Postlethwaite and Goodchild: 463; Pl. 8, Fig. 1.

V 1961 Cyclopyge obtusicaudata; Whittard: 179.

V* 1966 Gastropolus brevicaudatum gen. et. sp. nov; Whittard: 294; Pl.50, Figs.10-12.

?1974 Lisogoraspis; Apollonov: 76.

?1974 Gastropolus mirabilis; Apollonov: Pl.3, Figs.10, 11.

MATERIALS LOCALITIES AND HORIZONS. All of the new materials to date have been recovered from the Llanfellteg Formation; artus Biozone. One complete exoskeleton and part of the external mould of the left pleural lobe of the thorax and pygidium, one thorax and pygidium, one fragmentary thorax and pygidium, and one external mould of a cephalon, missing the optic surfaces; all from locality 27, one cephalon with fragmentary optic surfaces from locality 53, and two cephala from locality 35.

DESCRIPTION. Complete exoskeleton about two thirds as wide as long, maximum width (tr.) occurs near the posterior margin of the cephalon at a point about one quarter of the sagittal length of the cephalon measured from the posterior margin, and the overall outline is broadly elliptical. Cephalon, excluding the optic surfaces, is broadly sub-triangular in shape, rounded anteriorly and posterolaterally, and gently convex (sag. tr.). Forwards convexity distinctly more pronounced. Posterolateral area formed into bluntly rounded, sub-triangular lobe interpreted as a remnant fixigena above the site of the optic surface. This lobe is weakly defined anteriorly by a single, straight, backward directed shallow furrow, that originates from a ventral position at the lateral margin, opposite a point approximately half the sagittal length of the cephalon. Dorsally, this furrow becomes shallower, and disappears before isolating the lobe adaxially. Ventrally, the furrow is more distinct, and follows the anterior edge of the optic surface, then follows a course across the ventral surface of the cephalon, posterior to the protruding, strongly convex glabella, which it separates from the ventral doublure, and thus forms a continuous feature from the left dorsolateral position, to the right dorsolateral position via the vental "pre glabella" area. Ventral doublure is strongly convex (sag. exsag.) about twice the length (sag.) of the ventral furrow medially, becoming slightly wider (tr.) laterally, and is strongly terraced, with at least 12 sub-parallel terrace lines crossing the sagittal line. One of the cephala collected shows the ventral doublure to lie immediately beneath the ventral margin of the optic surface for at least one third of its sagittal length. Optic surface strongly convex (sag. tr.) about two and a half times as long as wide, with a broadly ellipsoid outline, narrowest anteriorly. One cephalon (Pl. 6,Figs.2 a,b) after laboratory preparation, shows the inner posterior margin of the optic surface to have a narrow (tr.) peripheral border and furrow, which broadens slightly, and becomes less distinct dorsally. The optic surface is likely to have occupied at least half the total length of the cephalon, and is posteriorly and partly ventrally situated.

Thoracic axis gently tapering, defined by strong axial furrows. Axial rings simple, strongly convex (sag. exsag.). Anterior three rings of equal transverse width, which is approximately one and a half times the transverse width of their pleurae, fourth and fifth rings about as wide as their pleurae, sixth ring narrower than its pleurae. All segments of equal transverse width. Pleurae simple, bluntly rounded distally, with a strongly developed oblique furrow that is broad and shallow at its origin opposite the anterolateral extremity of the axial ring. Furrow deepens abaxially, but terminates abruptly before reaching the pleural tip, dividing the pleurae into a narrow, raised anterior and lateral rim, and a broad (sag.) posterior band.

Pygidium at least three times as wide as long, and almost quadrangular in outline, with a moderately wide, strongly convex border that constitutes about a third maximum axial width laterally. Border is narrowest postaxially, so that the posterior edge of the pygidium is a double sigmoid. Border furrow deep and broad, strongest antero-laterally, and continuous with the single anterior pleural furrow. Axis strongly convex (tr.) and about one quarter the transverse width of the anterior pygidial margin, tapering gently and roundly terminated. Axis reaches to, but does not invade the posterior border, and at least one axial ring and one pair of pleural furrows is faintly evident on most specimens. One well preserved pygidium (Pl. 6, Fig. 5) has the median portion of the border absent revealing the ventral doublure. Doublure is approximately the same width (sag. exsag.) as the border with five strongly developed sub-parallel terrace lines. Anterior four terrace lines converge abruptly adaxially, at a point approximately corresponding to the anterior edge of the ventral doublure, and about one quarter of the transverse width of the pygidium, measured laterally from the sagittal line, to form a pair of ventrally situated pits on the internal mould. The posterior terrace line is continuous along the posterior margin of the doublure. Postaxial region of doublure is narrower (sag.) than lateral regions, and terracing is less distinct.

DISCUSSION. Although Whittard (1966) proposed G. brevi-caudatum as the type species, Hick's (1875) original specimen from Llanvirn quarry is here regarded as being the same species, and G. brevicaudatum Whittard, 1966 therefore becomes a subjective junior synonym of obtusicaudatus Hicks, 1875. This opinion is based largely on favourable comparison of pygidial morphology between Hicks' type specimen and that of a range of new material from several horizons within the artus Biozone of the Llanfallteg Formation in South Wales.

The new material agrees well with the figured specimens of G. brevicaudatum of Whittard (1966). Slight differences observed in the ratio of the length to width in the pygidium in Whittard's materials compared to new materials from South Wales are attributed to greater transverse distortion in Shropshire specimens (compare Whittard 1966: Pl.50, Figs.10, 12 to Pl.6, Fig.5 herein)

Subfamily PRICYCLOPYGINAE Raymond, 1925

DIAGNOSIS. Cyclopygids with six thoracic segments; third segment with a pair of hollow nodes. Cranidium round to ovoid, maximum width not at posterior margin. Glabella furrows or impressions weakly developed. Pygidium transverse, subtriangular or almost elliptical, border deeply defined. Pygidial axis distinct, not effaced posteriorly, and usually over half pygidial length. Genera included: Pricyclopyge Richter & Richter 1954; Symphysops Raymond 1925; and Emmrichops Marek 1961 (see also Hughes 1979: 113).

Genus PRICYCLOPYGE Richter & Richter, 1954

DIAGNOSIS. Pricyclopyginines with the median cephalic lobe generally subcircular, with the front margin gently rounded about the mid-line. Thoracic axial organs hollow inflated structures formed entirely within the cuticle. Pygidium subtriangular with well defined border and relatively long axis.

TYPE SPECIES. Aeglina binodosa (Salter, 1859) from the Llanvirn of Shropshire, by original designation.

Pricyclopyge binodosa binodosa (Salter 1859)

(Pl. 7, Figs. 6-8; Pl. 8, Figs. 7-10)

1859 Aeglina binodosa; Salter in Murchison: 50; Fig. 6.

V 1966 Pricyclopyge binodosa binodosa; Whittard: 172; Pl. 2, Figs 9, 11, 12. With full synonymy.

LECTOTYPE: Here selected: BGS. 35267 incompletely preserved pygidium (figd. Whittard 1940b: Pl. 4, Fig. 5), Lower Llanvirn; artus Biozone, Cefn-Gwynll, Shropshire.

MATERIAL HORIZONS AND LOCALITIES. Two fragmentary exoskeletons from locality 59 (a,c), Llanfallteg Formation ; artus Biozone, two almost complete exoskeletons, three pygidia and a pygidium and thorax from locality 60; artus Biozone, and one pygidium from locality 62, murchisoni Biozone. Abundant material including at least eleven pygidia, four cranidia, a large pygidium and thorax, and two complete exoskeletons from localities 45 and 46 (i-v), and two complete exoskeletons, three pygidia and a thorax and pygidium from locality 30 are probably of late Arenig age. A flattened and ill preserved pygidium and thorax from locality 68, late Arenig hirundo Biozone of Elles (1904, 1933) is also referred to this species.

In South Wales this species is widespread and ranges from the Middle Arenig to the Upper Llanvirn. It is also recorded from localities 1, 6, 15 and 53, and is particularly abundant at localities 30, 45 and 46 at horizons that have not been accurately defined during this research, but probably represent the Upper Arenig. Elsewhere in Britain it is known from Anglesey (Greenly 1919), Shropshire Whittard (1940b; 1961; 1966) Cambridgeshire (Rushton & Hughes 1981) and from the Skiddaw Slates and Ellergill Beds of Cumberland and Westmoreland (Postlethwaite & Goodchild 1886). It is represented at BM, BR (Whittard coll.) NMW and SM.

DISCUSSION. This species has been fully described by Whittard (1940b: 130; 1961: 172; 1966: 287) and Marek (1961: 31). All of the newly collected material agrees well with the selected type and figured material from Shropshire, and nothing can be added here.

Marek (1961:33) regarded P. prisca from the Llanvirn of Bohemia to be conspecific with binodosa from the

Llanvirn of Britain, and attributed the absence of pleural spines on the fifth and sixth thoracic segments in binodosa to differences in preservation. Whittard (1966: 287) disagreed with this view, and erected the subspecies P. b. prisca for the spinous Bohemian form. Rushton & Hughes (1981: 633) expressed doubts about the conspecific grouping of binodosa and prisca, and subsequently Hörbinger & Vaněk (1985:61) have provided valid reasons why they are justifiably separated. However, the differences outlined by Hörbinger & Vaněk are not considered here to merit their suggested subgeneric division.

According to Hörbinger & Vaněk (1985) Pricyclopyge (Bicyclopyge) is distinguished from the subgenus P. (Pricyclopyge) in having the fifth and sixth thoracic segments non- spinous, and in having a comparatively longer, narrower pygidium in which the axis is shorter (sag.) and the doublure is narrower. The lateral margin of the pygidium in P. (Pricyclopyge) is slightly sigmoidal, whereas that of P. (Bicyclopyge) is straight.

Although a number of the pygidial features outlined by Hörbinger & Vaněk (1985) may be useful at species level, pygidial morphology within binodosa populations in South Wales and elsewhere appears to be somewhat variable (eg. compare Whittard 1940b: Pl. 15, Figs. 1, 2 and 5; with Pl. 8, Figs. 7, 8 here) and may prove to be unreliable when larger populations are scrutinised. Fortey (1985: 23) has drawn attention to the paucity of well preserved binodosa in national collections, and obvious difficulties arise in any attempt to assess population variables. One example attributed to binodosa by Hörbinger & Vaněk (1983: Pl.2, Fig.5) from the Šárka Formation (Llanvirn) more closely resembles P. dolabra sp. nov. (Fortey & Owens in press) from the Upper Arenig, Bergamia fenniensis Biozone in South Wales, in which the cranidial length is equal to, or slightly exceeds maximum cranidial width, which occurs posterior to cranidial mid-length.

There can be no doubt that preservation is not responsible for the lack of thoracic spines in British binodosa populations, but Fortey (pers. comm.) has advised that the presence or absence of cephalic impressions and tubercles in binodosa material from the Arenig in South Wales can be entirely dependent on the enclosing sediment; specimens in shale preservation lack cephalic pits or tubercles except when preserved in hard concretions within the shale.

P. binodosa eurycephala (Fortey & Owens in press, see also Fortey 1985: 22-24, text-Fig. 5A) has been erected to accommodate binodosa material from the Upper Arenig Bergamia fenniensis Biozone, in which the posterior sections of the cephalic axial furrows enclose an angle of more than 65°, and the maximum cephalic width (tr.) occurs further forwards than in binodosa binodosa. None of the new cranidia collected from the Llanvirn in South Wales has cephalic morphology consistent with this early subspecies.

The remaining members of the genus are distinguished from binodosa largely by differences in cephalic morphology. P. synophthalama (Klouček, 1916; Marek 1961: 34; Pl. 2, Figs. 13-16) has a generally smaller cephalon than binodosa, with a cranidial outline that is more acutely rhomboid, with the maximum width (tr.) slightly posterior to the mid-line, and narrowing more sharply forwards and backwards. Marek (1961) figures only cephala, but reports (Op cit. 35) the thorax and pygidium of synophthalama to be almost identical to those of binodosa. Pricyclopyge? campestris is poorly known from an ill-preserved exoskeleton (Koroleva, 1967) and has been placed in P. (Bicyclopyge) by Hörbinger & Vaněk (1983: 62). Fortey & Owens (in press) have pointed out that the cranidium is similar to P. (Pricyclopyge) longicephala, but the thorax and pygidium more closely resemble binodosa.

Family NILEIDAE Angelin, 1854

1927 Symphysuridae: Poulson: 321

genus BARRANDIA M'coy, 1849

DIAGNOSIS. See Whittard (1966: 221).

TYPE SPECIES. Barrandia (Ogygia) cordai (M'coy, 1849) from the gracilis (?) Biozone ('Black Wenlock Shale' sic) of the Builth district (see Whittard 1961: 227, and notes for Fig. 8, Pl. 33). Original designation.

Barrandia homfrayi Hicks, 1875

(Pl 4, Figs. 6-8; Pl 5, Figs. 6-11)

V* 1875 Barrandia homfrayi: Hicks: 185; Pl.9, Fig.8.

1891 Barrandia homfrayi: Woods: 140.

1931 Barrandia homfrayi: Reed: 467.

1940 Barrandia homfrayi: Elles: 395, 398, 432.

V 1961 Barrandia homfrayi: Whittard: 222: Pl.31, Figs. 6-11; Pl 32, Figs.1-11.

V. 1961 Barrandia biannularis: Whittard: Pl 33, Fig. 5.

HOLOTYPE. SM A15627 (Whittard 1961: Pl 31, Fig.6) from the Lower Llanvirn; artus Biozone, Llanvirn quarry (locality 76).

MATERIAL HORIZONS AND LOCALITIES. One of the commonest and most characteristic trilobites of the Lower Llanvirn in South Wales. It is particularly abundant in the upper part of the Llanfallteg Formation, lowest Llanvirn; artus Biozone, and it occurs, though more rarely, in the topmost Arenig; Dionide levigina Biozone. Over seventy examples have been examined, mostly disarticulated pygidia and cephalic fragments, but four complete adult exoskeletons, and complete examples of meraspides of degrees 3, 4 and 7 are included. New material has been recovered from localities 2, 4, 7(iii), 8, 12, 15, 25, 28, 29, 31-33, 35, 47, 54, 56, 58, 59 (a, c, d, & f) and 60.

Elsewhere in Britain the species is common in the Lower Llanvirn of the Shelve Inlier, Shropshire, (Whittard 1961: 222) and is well represented at BM, BGS and BR (Whittard coll.).

REMARKS. Adult B. homfrayi from South Wales are exceedingly similar to typical specimens from Shropshire figured by Whittard (1961). The holotype (Hicks 1875: Pl.9, Fig. 8; Whittard 1961: Pl 31, Fig.6) is ill-preserved, but has pygidial features consistant with the bulk of specimens from Shropshire and South Wales. Whittard's (1961) description of the adult exoskeleton is thorough, and further description is unnecessary here.

Ontogenetic stages of Barrandia species are poorly known, and are not described for B. homfrayi. Immature specimens recovered during this research, and several examples of meraspides in national collections (eg. SM A44510, A44536 Turnbull Coll.; BGS pr. 1830, pr. 1867, pr. 1997) provide a range from degree 1-7, except degrees 2 and 6. SM A44536 is ill preserved, but appears to have only a single thoracic segment, and may represent degree I. SM A44510 represents at least degree 3. Both have an almost elliptical outline, with the gently convex (tr.) anteriorly rounded cephalon equal to about half the total length of the exoskeleton. Facial sutures are vaguely evident in SM A44510. In both examples, the glabella is defined by short, marginally situated axial furrows, formed by a local increase in convexity at points on the posterior margin adjacent to the thoracic axial furrows. Librigena are clearly present, and a genal spine is developed, which reaches as far back as the anterolateral edge of the pygidium in SM A44510. Eyes, or 'nodular areas' (sic) not seen (see Whittard 1961: 223, and Hughes 1979: 156).

Width of thoracic axis is slightly more than a third of thoracic width. Axis tapers slightly; axial furrows distinct. Pleurae simple, bluntly rounded distally, with a diagonal pleural furrow that extends abaxially at least three quarter of pleural width, but disappears before reaching the pleural tip. Pleural furrow not as deep as interpleural furrow.

Pygidium about one and a half times as wide as long. Axis distinct; less than one third pygidial width across the anterior margin, and more acuminate posteriorly than in later meraspides and adult specimens. Length of axis about three quarters of pygidial length. Degree I has an unsegmented pygidium, but by degree 3 there are at least three ill defined axial rings and a terminal piece, and the pleural fields have faint indications of a single anterior rib. Postaxial field short (sag.) about a quarter of pygidial length, and there is a very narrow border and border furrow evident, which is strongest laterally, very faint posteriorly. In one example of a meraspid of at least degree 5 (Pl. 5, Fig. 8) this border and furrow can be seen, though less sharply defined, but it is apparently absent in later meraspides (eg. Pl.5, Fig.11).

Degrees 4 and 5 have a large transitory pygidium with at least two parathoracic segments. Axis remains slightly less than one third of pygidial width at the anterior margin, and is gently tapering. Although more rounded posteriorly than in degrees I or 3, the axis is still more acuminate than that of the adult. Axial length slightly more than three quarters pygidial length, and there are three weak axial rings. Degree 4, the pleural field, has two weak ribs developed; degree 5 similarly has two ribs, but has weak pleural furrows developed. In BGS. pr. 1997, the pleural furrows are truncated abaxially by the inner margin of what is interpreted as the doublure, superimposed by compression (Pl. 5, Fig. 8). Doublure is slightly less than a quarter of pygidial width anterolaterally, becoming wider (sag.) posteriorly, and terracing is very weakly evident. Such a doublure can also be seen in one example of degree 4(Pl. 5, Fig. 9). A postaxial ridge on this specimen is not interpreted as a primary feature, and is not seen on other transitory pygidia of comparable preservation.

Degree 7 retains a single parathoracic segment, but the only available example (Pl 5, Fig. 11) is too ill-preserved to further compare the pygidium with that of the adult.

Cephala are known in degrees I, 3, 4 and 7. The cephalon of degree 4 is essentially similar to that of degree 3 (qv.), with very weak, subparallel axial furrows evident posteriorly. Genal spine is slightly wider at its base than in degree 3, and extends as far back as the posterior margin of the third thorax segment. 28.05 has a wide (sag.; exsag.) cephalic doublure impressed through the anterior part of the glabella. Doublure with strong subparallel terracing (cf. Whittard 1961: Pl. 32, Fig.

4). Such a doublure is also seen in a meraspis of unknown degree from locality 53 (Pl.5,Fig.10).

The cephalon of degree 7 has well developed axial furrows, that are deepest at the posterior margin. Furrows are almost parallel for about half of cephalic length, then appear to diverge slightly forwards, but the posterior displacement of a librigena in the only available example may affect the apparent course of the axial furrow. Librigena is narrow (exsag.), elongated, with a short genal spine, that reaches no further back than the second or third thorax segment. The glabella in the single example is crushed and fractured over the site of the hypostoma (Pl. 5,Fig.11) .

Late ontogenetic degrees of B. homfrayi are remarkable in that they may measure up to 16 mm in length; considerably larger than meraspides of other nileids (Fortey 1975) or related taxa such as cyclopygids (eg. Whittard 1961: 174-5). Fortey (1975: 63) has shown that the release of the final parathoracic segment in nileids may occur at a comparatively late stage in ontogenetic development, and this is clearly the case in B. homfrayi. Hughes (1979: 158, 159; Figs. 114, 117, 119) recorded small pygidia of the type species and of B. cf cordai from the Builth district, which similarly retain a parathoracic segment apparently fused along the anterior margin of the pygidium. These specimens are attributed to meraspides of degree unspecified. Hughes (1979: 158; Fig.130) also commented on a meraspid of B. ultima with two segments developed in the anterior part of a large transitory pygidium.

In Shropshire, Whittard recognised B. biannularis in which the pygidial axis is divided into two axial rings, the posterior of which may or may not be complete, and a short terminal piece. The holotype of biannularis (Whittard 1961: Pl 33, Fig.3) has eight thorax segments and two complete axial rings on the pygidium. The pleural fields lack interpleural furrows, and therefore no parathoracic segments can be inferred. The paratypes (BGS 85328-9; Whittard 1961: Pl 33, Figs.4, 5 respectively), however, are more difficult to interpret, particularly BGS. 85329, which appears to have a parathoracic segment partly released from the left anterolateral corner, and has three axial rings evident. It may therefore be that this paratype of biannularis represents a late ontogenic degree of homfrayi.

Nileid cf. Barrandia

(Pl. 8, Figs. 4-6)

MATERIAL HORIZON AND LOCALITY. Three pygidia with articulated thoracic segments; one example with segments and two examples with five segments, and one almost complete exoskeleton which may represent a late meraspid. All specimens from locality 68, Upper Arenig; hirundo Biozone.

DESCRIPTION. All examples are severely flattened and rather ill preserved. The thorax is almost parallel sided, with a wide (tr) axis that constitutes two thirds thoracic width at the anterior segment in 68.06. Posterior width of axis less than one third segment width. In the least distorted example (Pl. 8, Fig. 4) the axis is convex (tr.) and distinctly raised above the adjacent pleurae, the axial furrow zig-zags and resembles that of B. homfrayi Hicks. Pleurae short, bluntly rounded distally with weakly developed pleural furrows which appear to be transversely longer and slightly deeper than those typical of homfrayi. In at least one example (Pl. 8, Fig. 5) the pleural furrows appear to reach the pleural tips.

Pygidium parabolic in outline and about twice as wide as long. Axis conical, rounded posteriorly, axial furrows continue taper of thoracic axis. Maximum width of axis slightly less than one third pygidial width across the anterior margin; axial length about half pygidial length. There are three axial rings and a very short (sag.) rounded terminal piece evident in the two best preserved specimens. The smallest example has an unsegmented axis (Pl 8, Fig. 6). The pleural field is unfurrowed and there is a long (sag.) postaxial field. Border and border furrow not seen in any example, but one specimen (Pl 8, Fig. 5) has the doublure superimposed onto the dorsal surface. Doublure is of constant width, which is about one fifth pygidial length, and appears to be slightly concave, with a raised, convex peripheral rim. There are at least twelve terrace lines subparallel to the margin.

DISCUSSION. Three of these ill-preserved specimens may be compared to atypical examples of B. homfrayi

Hicks in which the pygidial axis is segmented and a parathoracic segment is retained (see Pl.5, Figs. 8-11). However, no example of homfrayi of comparable size to 68.07 (Pl.8, Fig. 5) has been recovered with a segmented axis. Also the overall size and shape of the pygidium in this material is unlike that of homfrayi or other described Barrandia spp., and compares more closely to that of Prospectatrix (Fortey 1981) in which the pygidium is narrower and shorter than that of Barrandia.

The only available cranidium (Pl.8, Fig.6) is too distorted to compare with Barrandia and this example is only cautiously referred to that genus.

?Barrandia sp. indet.

(Pl.8, Fig.13)

DISCUSSION. A single well preserved but distorted pygidium from locality 60 Lower Llanvirn; artus(?) Biozone shows a number of characteristics in common with the pygidium of Barrandia cf. cordai (Hughes 1979: 158; Fig. 125) from the Llandeilo of Builth, and with a pygidium attributed to Barrandia sp. indet. from the Upper Arenig of South Wales (Fortey & Owens in press).

The new specimen is less transverse than either B. cf. cordai or Barrandia sp. indet., and in this respect resembles the pygidium of a cyclopygid, but the degree of distortion has reduced the width to length ratio. Axis is conical in outline, rather acuminate posteriorly, and does not appear to be segmented. Length of axis, excluding a short (sag.) articulating half ring, is about half pygidial length, maximum width of axis is slightly less than one fifth pygidial width across the anterior margin. The whole of the pleural fields and the postaxial field are covered with coarse subparallel terrace lines, and the testa is presumably absent from this area. Terrace lines are slightly raised and are close together postaxially, where at least fifteen cross the sagittal line. Laterally the terrace lines diverge slightly, the most posterior lines meet the posterior margin obliquely, and successive lines meet the border more laterally; the anterior five or six lines are the most strongly recurved around the tip of the axis, and join the margin anteriorly and at the rounded anterolateral corners. Presumably this distinctive terracing indicates a very wide doublure that covers the entire area of the pleural fields. There is a single short (tr) anterior furrow that dies out adaxially, and the margin appears to be slightly raised, particularly posteriorly.

B. cf. cordai differs from the new specimen in being more transverse, in having a longer axis that is divided into four faint axial rings, having a stronger anterior pleural furrow, and in having coarser terrace lines that are subparallel to the posterior margin. Barrandia sp. indet. from the Upper Arenig is very similar to the new Llanvirn specimen, and may prove to be conspecific when a range of specimens is available.

Family STYGINIDAE Vogdes, 1890.

REMARKS. The revised classification of the suborder Scutelluina Hupé, 1953 of Lane & Thomas (1983: 155) is followed here. Protostygina is not assigned to a subfamily, pending improved understanding of the relationships within the Styginidae.

Genus PROTOSTYGINA Prantl & Přibyl 1949 (a)

DIAGNOSIS. See Prantl & Přibyl 1949a: 9.

TYPE SPECIES. Protostygina bohemica (Barrande 1872) from the Šárka Formation (Llanvirn) of Rokycany, Bohemia, by original designation.

Protostygina sp.

(Pl.10,Fig.13)

DESCRIPTION. A single complete exoskeleton from locality 69, tuffs of probable Arenig (Moridunian?) age measures 4 mm in length with a maximum width across the cephalon of 7 mm. This specimen has eight thoracic segments, and probably represents a young holaspis. It is indeterminate at species level due to preservation, but like Protostygina, the cephalon is semicircular and about three times as wide as long, the glabella is defined by distinct axial furrows that are almost parallel for about half of their length, then diverge markedly forwards, to reach the cephalic margin. The width of the glabella at the posterior margin is about a third cranidial width across the posterior margin. Librigena roundly subtriangular, with a broad, flattened brim which is extended into a broad, rather bluntly acuminate genal spine. Spine reaches almost as far back as the anterolateral corners of the pygidium.

Thoracic segments narrow (sag), axial furrows deep; axis strongly convex (tr) and slightly tapered. Width of axis of anterior segment slightly less than one third segment width; axial width of posterior segment about one fifth segment width. Tips of pleurae apparently downturned.

Pygidium semi-elliptical, about twice as wide as long, with a short, blunt axis that is slightly less than a third pygidial length. There is no border or border furrow evident, and both the axis and the pleural fields are unfurrowed.

DISCUSSION. The new specimen bears a broad general resemblance to P. bohemica (Barrande, 1872; Prantl & Přibyl 1948: text fig 6) but differs in having cephalic axial furrows that reach the border anteriorly, in having larger, more crescentic eyes and in having a shorter, unfurrowed pygidial axis.

Of the eighty genera and subgenera assigned to this family by Lane & Thomas (1983), Raymondaspis Přibyl (in Prantl & Přibyl 1949a) type species R. reticulata Whittington (1965: Pl 56, Fig. 1, Přibyl & Vaněk 1971:

Pl. 1, Figs. 1a-b) is also similar to the new specimen, but is distinguished by having a distinct cephalic border and border furrow, smaller eyes and palpebral lobes, distinct 1L and 1S, and a pygidium with a longer axis and a well developed border.

The Welsh specimen also resembles Delgadoa Thadeu (1947) type species D. loredensis Thadeu (1947: Pl. 1, Fig. 8; Přibyl & Vaněk 1971: Pl. 2, Fig. 3). However, Delgadoa has a longer and narrower cephalon, a glabella that is slightly constricted (tr.) medially, with strongly curved axial furrows, ten thoracic segments and a pygidium that is distinctly segmented.

In the form of the cephalon and pygidium, and in the number of thoracic segments, the new specimen is closest to Protostygina, and represents the only record of the genus in Britain.

Family ILLAENIDAE Hawle & Corda, 1847.

REMARKS. Ectillaenus is not assigned to a subfamily here, pending improved understanding of relationships within the Illaenidae (see Lane & Thomas 1983: 156).

Genus ECTILLAENUS Salter, 1867.

1916 Wossekia; Raymond: 14.

DIAGNOSIS. Illaenid with cephalic axial furrows straight or nearly so. Eye minute or absent; postocular facial suture incurved at its posterior end. Hypostoma triangulate with anterior margin transverse or gently curved forwards medially; anterior wings long, narrow. Thorax of ten segments; axis well defined. Pygidial length about equal to cephalic length (sag.); doublure occupying c. 30-50% of pygidial length (sag.).

TYPE SPECIES. Ectillaenus perovalis (Murchison, 1839) from the Lower Llanvirn of Shropshire. Original designation.

Ectillaenus perovalis (Murchison 1839)
(Pl. 8,Figs.1-3; Pl.9,Figs.1-8)

1839 Illaenus perovalis; Murchison: 661, Pl 23, Figs 7a-b.

1854 Illaenus perovalis; Murchison: Pl.4, Figs.13-14.

1867 Illaenus (Ectillaenus) perovalis; Salter: 211; Pl.26, Figs.5-8.

V.1875 Illaenus hughesii; Hicks: 184; Pl.9, Fig.7.

1884 Illaenus perovalis; La Touche: 56; Pl.2, Fig.36.

V.1909 Illaenus perovalis; Cantrill in Strahan et al: 33.

V.1914 Illaenus perovalis; Thomas in Strahan et al.: 27, 28.

1940 Ectillaenus perovalis; Whittard: 143; Pl.7, Figs. I-2.

1940 Ectillaenus perovalis forma hughesi; Whittard: 144; Pl.7, Figs.4-9.

1957 Ectillaenus perovalis forma hughesi; Snajdr: 195.

V 1961 Ectillaenus perovalis; Whittard: 211; Pl.29, Figs. 6-13; Pl 30, Figs.I-2. (with full early synonymy).

V 1961. Ectillaenus hughesi; Whittard: 214; Pl 30, Figs. 3-7.

1984 Ectillaenus hughesi; Snajdr: 21.

LECTOTYPE. BGS. 6884; complete exoskeleton from fine grained tuff, interbedded in Hope Shales, Hope Mill Shropshire. Selected and figured by Whittard (1961: Pl 29, Figs.6,7). This specimen is now lost (Whittard 1961: 213).

MATERIALS HORIZONS AND LOCALITIES. About 30 new specimens of which four are complete exoskeletons, have been recovered from the Lower Llanvirn; artus Biozone at localities 25, 26, 27, 31, 33, 34, 53, 57, 58 and 59 (b,d.). Additional material examined: BGS 85301-5; 87213-15; 35280; BM. In. 137964; SM. A15629; A43283-4; A44539-40. The species is also well represented at BR (Whittard Collection) and complete examples BR 18058, 18060-64 have been examined.

Elsewhere in Britain the species is common in the lower Llanvirn of the Shelve Inlier (Whittard 1961), and has been recorded from the topmost Arenig; Dionide levigena Biozone of the Llanfallteg Formation of the type area (Fortey & Owens in press; Owens pers. comm.).

REMARKS. This species has been fully described by Whittard (1961) from Shropshire, and further detailed description is unnecessary here. The following notes relate to the hypostoma and doublure, and to slight differences observed in the nature of surface sculpture in material from South Wales.

DESCRIPTION. Whittard (1961: 208-11) used the nature of surface sculpture revealed on external moulds to distinguish the Arenig ectillaenine *E. bergaminus* in Shropshire. All ctillaenine material examined during this research, which includes well preserved examples from the topmost Arenig of the Whitland district (Fortey & Owens coll.) has surface ornamentation consistent with that described for *E. perovalis*. One specimen, however, (Pl 9 Figs 1-4) from the *artus* Biozone of Scolton, shows minor differences; the terrace lines on the thoracic pleurae adaxial to the fulcrum in typical *perovalis* are diagonally orientated, and converge posteriorly with the axial furrow. In this atypical example, this terracing is orientated subparallel to the axial furrow, and there is no obvious convergence posteriorly with the axial furrow (compare Whittard 1961 Pl.29, Fig. 2 with Pl.9, Fig. 3 herein). In typical specimens of *perovalis* thoracic pleural terrace lines change direction at the fulcrum, and run approximately parallel to the anterior edge of the downward directed portion of the pleura. This terracing is distinct, and consists of 6-8 deep terrace lines which converge and anastomise towards the pleural tip. In the atypical example, terracing abaxial to the fulcrum is finer, with at least 12 anastomising terrace lines which run subparallel to the pleural edge close to the fulcrum, but then turn forwards to meet the anterior margin of the pleura (Pl. 9, Fig.

4). The terracing of the librigena in this specimen is also different from that of figured perovalis in that the terrace lines are deeper in the South Wales specimen, and there is distinct dicotamous branching of terrace lines anteriorly, which is not seen in other perovalis (compare Whittard 1961 Pl 29 Fig 4, with Pl. 9, Fig. 2 herein)

Whittard (1961) gave no details of the pygidial doublure in his description of perovalis from Shropshire. In the lectotype (Whittard 1961: Pl.29, Figs. 6-7) the true width of the doublure is not revealed due to preservation. In well preserved examples from the Hope Shales (eg. BGS 87213, 87215, 85303) the doublure is widest post-axially, where it is at least half pygidial length, becoming narrower laterally. At the anterolateral corners, the width (tr.) of the doublure is about one fifth of pygidial width across the anterior margin. The bulk of material from South Wales has a doublure width consistent with Shropshire specimens, but one atypical example (Pl. 9, Fig. 8; P J Lawrance Coll.) from locality 53 shows the doublure to be less than one third of pygidial length postaxially.

One example from locality 27 shows the ventral cephalic doublure and hypostoma impressed through the dorsal surface of the cranidium. The hypostoma is not well preserved, but appears to be almost elliptical in outline, with an ill-defined, convex median body, without distinct border furrows. The posterior border is simple and bluntly rounded, and there is very fine terracing sub-parallel to the posterior margin.

Cranidial muscle scar impressions described by Whittard (1961:212) have not been observed in South Wales material.

DISCUSSION. Whittard originally regarded E. hughesi (Hicks 1875; holotype SM. A15629) as a synonym of E. perovalis (Murchison) (Whittard 1940(b): 144) but later (1961: 214) changed his opinion after comparing a wide range of ectillaenine material from Shropshire.

Whittard distinguished the two species entirely on biometrical grounds; the ratio of length to breadth in the complete exoskeleton of perovalis is given as 10: 6 (ie. I.6: I) and that for hughesi is given as 10: 7½ (ie. I.3: I). These ratios were presumably deduced from graphs, though none were published (Whittard 1961: 213). Whittard remarks that all specimens examined are preserved in shale, and have been variously compressed, but elaborates no further, and no indication is given where exactly the maximum width measurement was taken. Such considerations can be serious sources of error in biometric analysis; lateral compression in ectillaenines tends to flatten out the steeply inclined distal tips of the thoracic pleurae, and give the impression that the thorax is wider than both the cephalon and pygidium (cf. the holotype of hughesi Whittard 1961 Pl.30, Fig. 3). The apparent ratio of length to breadth is also greatly affected by distortion parallel or perpendicular to the sagittal line of the specimen. 52% of all Ectillaenus material studied from South Wales has been significantly distorted.

Type materials of E. hughesi have been re-examined and compared with a range of new material from South Wales, and to a range of perovalis specimens from Shropshire. Length and breadth measurements of 30 complete Ectillaenines from the lower Llanvirn of Shropshire and South Wales have been plotted, and the graph is presented in Fig. 6. Similar ratios between 10: 5.3-10.8 have also been deduced from over twenty isolated pygidia.

Contrary to Whittard's findings (1961: 211), a range of complete examples from South Wales and Shropshire does provide transitional size forms between the ratios given by him for perovalis and hughesi and the proven variations are attributed to distortion and compression. There is thus no valid reason for assuming two species in Shropshire or South Wales, and hughesi becomes a junior synonym of perovalis. The supplementary evidence for two species from frequency and distribution within Shropshire populations (Whittard 1961: 214) is considered to be insufficient.

E. bergaminus (Whittard 1961: 209.; syn. E. cunicularis Whittard 1961: 208; Owens pers. comm.) differs from perovalis in having a minute eye, and in having a sculpture of terrace lines with only subordinate punctae on the cranidium and pygidium.

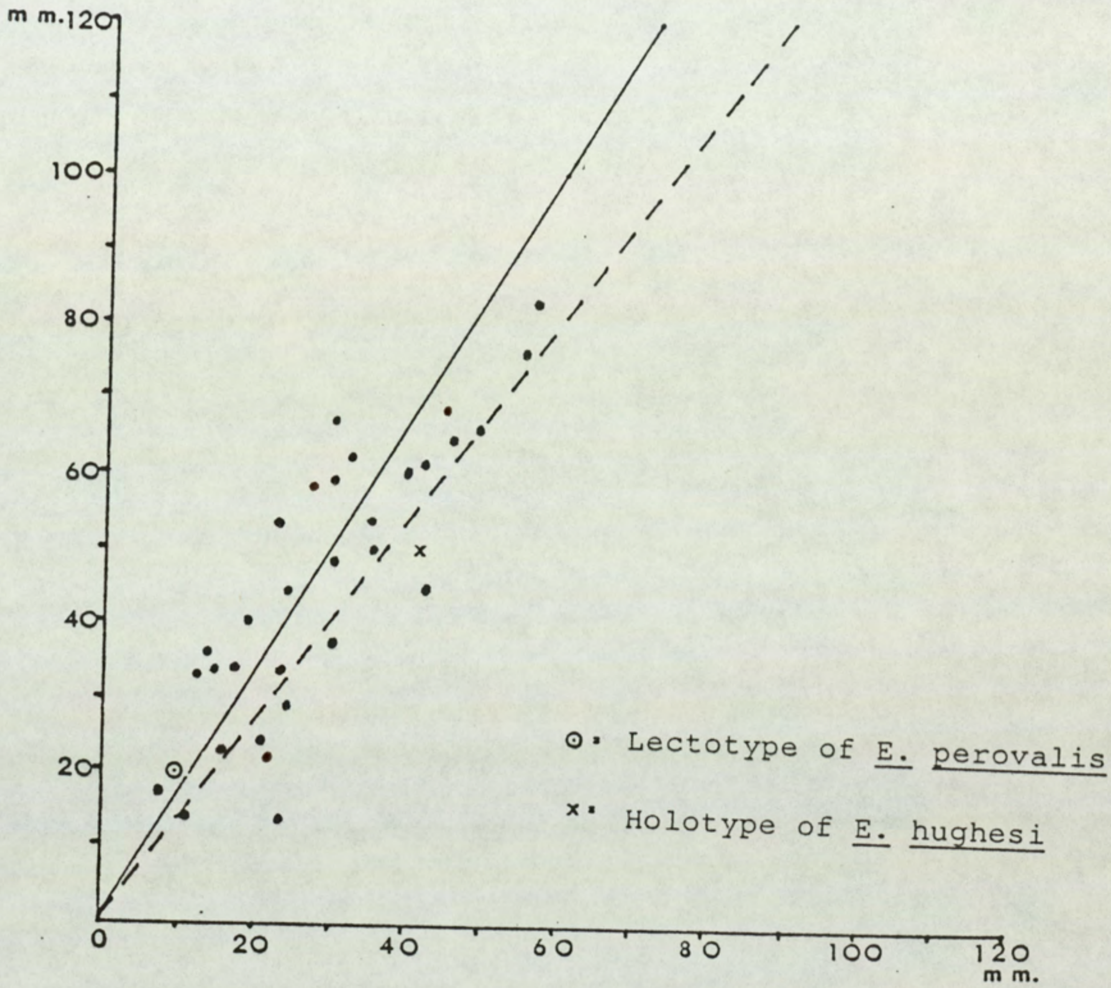


Fig 6 Plots of length/breadth measurements of 33 complete exoskeletons of Ectillaenus from the Lower Llanvirn; artus Biozone of Shropshire and South Wales.

Length-width ratios (after Whittard 1961: 214) for E. hughesi represented by a broken line, for E. perovalis by a solid line.

Family HARPEDIDAE Hawle & Corda, 1847.

Genus EOHARPES Raymond, 1905.

DIAGNOSIS. See Whittington (1948: 223).

TYPE SPECIES. Harpes primus Barrande 1856. Subsequent designation Bassler (1915: 487). From the Šárka Beds (Llanvirn) of Osek, near Rokycany, Bohemia.

Eoharpes primus? (Barrande, 1856)

(Pl.9, Fig.11; Pl.10, Fig.8)

1856 Harpes primus; Barrande: 534-5.

1872 Harpes primus; Barrande: 6; Pl 4, Figs.13-15; Pl 7, Figs II-12.

1885 Harpina prima; Novák: 213; Pl. I, Fig.5.

V 1948 Eoharpes primus; Whittington: 223; Pl. II, Figs. I-4.

LECTOTYPE. Prague, National Museum: AII86; complete exoskeleton, from the Šárka Beds of Bohemia. Selected Whittington 1948: 223.

MATERIAL HORIZON AND LOCALITY. One external mould of a complete specimen from locality 27, low artus Biozone. Ill-preserved harpedid fragments from the same locality consist of a fringe fragment and internal and extermal moulds of a partial thorax and left fringe prolongation, and are probably attributable to this species (see discussion below).

DESCRIPTION AND DISCUSSION. E. primus has been described by Barrande (1872) from type material from Bohemia, and by Whittington (1948) from topotype material (BU.

379; complete cephalon) preserved in full relief in limestone. Whittington's description is largely based on this specimen (Pl.9, Figs.9-10) and on two incomplete Bohemian specimens in the British Museum (Natural History): BM. 42562 (Barrande Coll.) and BM. 13417. None of Barrande's (1856) original syntypes, which include the complete lectotype specimen selected, nor that of Novák (1885), who described the hypostoma, was available to Whittington at the time of publication.

The complete specimen from South Wales is preserved in shale, and is compressed, particularly in the glabella and genal cheek regions, which makes comparison with type and topotype material difficult. It is here referred to primus, which is of similar age, on morphological grounds.

Like primus, the width of the brim is constant laterally and anteriorly, and is equal to about half of glabella length, and the prolongation narrows to a rounded tip. The fringe pits are uniform in size, and spaced closely but irregularly, except towards the tips of the prolongation, where they are more widely spaced (Pl. 9, Fig. 11). Anteriorly and laterally the brim is 6-7 pits deep. The posterior border and furrow, and the occipital ring and furrow are consistent with the topotype, but the glabella and cheek lobes are too crushed for comparison. Eye tubercles, alae and hypostoma are not seen, but an eye ridge is apparent on the right genal cheek. There are 12 thoracic segments with rather prominent axial rings, and well marked articulating half-rings. The pleurae are sharply deflected downwards at the fulcrum and the tips are simple and bluntly rounded. Pleural furrows are shallow adaxially, but become deeper abaxial to the fulcrum. The tips of the posterior segments, including the outer horizontal portion and the vertical portion of the pleura are deflected backwards quite markedly; this affects the fifth and successive pleurae in the new specimen, whereas in the type material of primus, this deflection occurs only after the seventh segment (Whittington 1948: 226).

The pygidium is small and ill preserved in the new example, but like that of primus, it is transverse, about three times as wide as long, with a short, bluntly rounded axis divided into two axial rings, and at least two pairs of pleural ribs are developed.

Other observed differences between the new specimen and type material or primus are:-

(i) There are fewer outer peripheral pits to the brim; about 50, compared with 80 in the topotype.

(ii) The pits appear comparatively larger, but this may be entirely due to the fact that the Welsh specimen is an external mould of the dorsal surface (cf. Stubblefield 1928: 248-9) with the upper lamella preserved, whereas the topotype is a mould of the ventral surface of the cephalon, in which raised tubercles corresponding to upper lamellar pits are preserved.

(iii) There are fewer pits on the cheek roll and cheek roll prolongation (compare Whittington 1948: Pl. II, Figs. 3-4 with Pl. 9, Fig. 11). In the Welsh specimen, however, the area of the cheek roll and cheek roll prolongation has been reduced by crushing.

E. benignensis (Barrande 1872: 4; Pl. 2, Figs. 21, 22a-b; Novák 1885: 213; Pl. I, Fig 6; Whittington 1948: 224; Pl 12, Figs I-9) from the Dobrotivá Formation (Llandeilo) of Bohemia, is very similar to primus, but differs in having relatively larger pits flanking the girder laterally and anteriorly, with the spacing between the pits notably greater in the outer margin of the brim. The pits are 9 deep laterally and anteriorly in benignensis, and the girder is rather less distinct in topotypes which preserve the upper lamellae (Whittington 1948: Pl. 12, Figs I, 2) than in primus. In benignensis the width of the brim is proportionately wider anteriorly and laterally, and the prolongation is more pointed posteriorly. There are typically fourteen thorax segments, but fifteen are recorded (Whittington 1948: 226).

E. guichenensis Henry & Philippot (1968: 2187; Pl. I, Figs. I-3; Henry 1980: 39; Pl. 2, Figs. I-4, text-figs. 9, 82; Henry & Romano 1982: 625; Pl. 63, Figs. 7-9) from the Llandeilo of France, is morphologically very close to primus, the diagnostic differences being confined to the form of the glabella and genal cheek, the more inclined lower lamella, and the nature of surface caecae on the latter. Such features cannot be compared in the Welsh specimen which cannot, therefore, be distinguished from the French species. E. cristatus Romano (1975: 28; Pl. A, Figs. 1-4) from the Llandeilo of the Valongo area, Portugal, is distinguished from the Welsh example and from guichenensis by lacking an eye ridge and a genal ridge. E. macaoensis Henry & Romano (1982: 626; Pl 63, Figs. 1-6) from the Caradoc of Central Portugal differs from the Welsh specimen in having an almost parallel sided glabella, an ornamentation of five tubercles on the rim and approximately eighty five pits in the outermost arc of the brim.

In view of the geographical and stratigraphic distribution of guichenensis, it is preferred to attribute the Welsh specimens provisionally to the Llanvirn species from Bohemia.

Family TRINUCLEIDAE Hawle & Corda, 1847.

The criteria for generic and subfamilial status within the Trinucleidae outlined by Hughes, Ingham & Addison (1975: 550-52) are accepted here.

Subfamily TRINUCLEINAE Hawle & Corda, 1847.

Genus TRINUCLEUS Murchison, 1839.

DIAGNOSIS. See Hughes et al. (1975: 556).

TYPE SPECIES. Trinucleus fimbriatus Murchison, 1839. Designation by Vogdes (1890: 84).

LECTOTYPE. BGS (Geol. Soc. Coll.) 6836a from Gwerny-fed-fâch quarry, half a mile southeast of Builth Road Station; gracilis Biozone.

Trinucleus cf. fimbriatus Murchison, 1839.

(Pl. 12,Figs.8-10; Pl. 14,Figs.7-8)

1971 Trinucleus fimbriatus; Black et al.: 546, 547.

1971 Trinucleid spp.; Black et al.: 546.

MATERIALS HORIZON AND LOCALITY. One damaged complete exoskeleton, and associated fringe fragment, and two cephala from locality 78; gracilis? Biozone. Additional specimen examined: SM. A79234, A79236 from the same locality, and SM A79242-4 from locality 79; grey shales and mudstones stratigraphically beneath the Castell Limestone, and structurally beneath locality 78 (Black et al. 1971: 546).

Elsewhere the species is common in the gracilis Biozone of the Builth-Llandrindod district.

DISCUSSION. The new specimens are all variously distorted, but have the fringe details sufficiently well preserved to compare favourably with the lectotype, and topotypes figured by Hughes (1971: Pl. 2, Figs. 2, 7; Pl. 3, Fig. I). 78.03 is the external mould of the dorsal surface of the cephalon and upper lamella, whereas 78.04 represents the external mould of the lowerlamella. Both specimens show at least 14 radial rows developed in the half-fringe, and fall within the range of variation indicated for fimbriatus in the type area. Like fimbriatus the pits are arranged in deep radial sulci, with prominent angulate inter-radial ridges. The precise number and arrangement of pits and arcs is not discernable, due to distortion, but 78.03 shows minor deformities in the radial pattern of pits and irregularity in inter-radial ridge width, comparable with variations noted by Hughes (1979: 125-25) for this species at Builth. The radial arrangement in the new specimens does not, however, seem to persist as far as the Builth materials, and the inter-radial ridges in 78.04 appear to bifurcate laterally earlier than in most figured examples from the type area. One example figured by Hughes (1971: Pl. I, Fig. 4) also shows a rather early breakdown of the radial habit towards the genal angle, which appears to be an asymmetrical deformity in that specimen.

The pygidium of the new material from locality 78 agrees in most respects with that of fimbriatus, in particular it has a steeply declined posterior border, a distinct segmented axis, and pleural fields divided by straight interpleural furrows that become progressively posteriorly directed. The number of axial rings and pleural ribs appears to be smaller in the new specimens, with only 5 axial rings and 4 pleural ribs in evidence in 78.01 and 78.02, compared with an average of 6-9 axial ribs and 5-6 pleural ribs in Builth material (Hughes 1971: 126; tables 9-10). In this respect they more closely resemble Bergamia.

T. abruptus Hughes (1971: 132; Pl 3, Figs. 2-4, 6, 7;

text-fig 4) from the upper part of the Lower Llanvirn of the Builth district also has the fringe pits arranged in radial sulci with inter-radial ridges, that do show irregularity in their arrangement as in fimbriatus. The new specimens are however easily distinguished from abruptus by having genal prolongations to the fringe, and a relatively shorter (sag.) pygidium with more pleural ribs and a wider posterior border.

T. acutofinalis (Whittard 1956: 46; Pl 6, Figs. 5-11) and T. cf acutofinalis (Hughes 1971: 137; Pl. 3, Fig. 5; Pl 4, Figs. 4, 7, 8) from the Upper Llanvirn of Shropshire and Builth respectively are distinguished from the new specimens by having only three arcs in the I series, and in having all the pits of the same size; 78.04 clearly shows the pits in the I series becoming progressively smaller internally. acutofinalis and cf. acutofinalis, also lack genal prolongations to the fringe.

Genus FURCALITHUS gen. nov (Fortey & Owens, in press).

DIAGNOSIS. Trinucleine with radial sulci very weak or absent; E_I - E_2 complete; I_n - I_I complete; I_2 extending round most of fringe or complete, I_3 occasionally present. 4-?8 interradii present in I series. Pygidium with narrow posterior border; axis reaches border, but does not significantly invade it.

TYPE SPECIES. Furcalithus radix Fortey & Owens (in press) from the Middle Arenig; Whitlandian Stage, Furcalithus radix Biozone, 70 metres above the base of the Afon Ffinnant Formation, Cwm-yr-Abbey, 10 km ESE. of Carmarthen. Original designation.

REMARKS. Furcalithus has been erected to accommodate middle Arenig trinucleines with fringe and pygidial characters that are in many ways transitional between Myttonia (Whittard 1955: 29) and contemporanous Bergamia (Whittard 1955: 31) from the Arenig (Mytton Flags) of Shropshire (Owens, pers. comm.). Abundant, but generally ill-preserved trinucleine material from locality 69, tuffs of probable early Arenig (Moridunian?) age compare well with the type species, and are cautiously attributed to Furcalithus sp.

Furcalithus sp. indet.

(Pl. 11, Figs.2-8)

MATERIAL. Fifteen complete or near complete specimens, of which four are external moulds, five cephala, two of which are external moulds, and one enrolled specimen. All specimens from locality 69.

DESCRIPTION AND DISCUSSION. None of the available specimens has fringe details sufficiently well preserved to enable detailed comparison with the holotype of F. radix (Pl. 11, Fig.I) but there is a broad general resemblance. In particular, several of the new specimens have a well developed girder on latex moulds, with radially aligned pits that extend around the entire fringe, except for the posterolateral corners. This is an important feature distinguishing Furcalithus from Myttonia. E_I - E_2 appear to be present in most examples, and at least I_I - I_n are vaguely evident in a small number of specimens. The number and distribution of pits, and the presence or absence of sulci or inter-radii are not discernable.

In common with F. radix, the new specimens have well developed glabellar furrows; IS and 2S are clearly evident in the majority of specimens, and 3S is present in the better preserved examples (eg. Pl. 11 Fig 6); there is a broad, shallow occipital furrow, and the occipital ring is narrow (sag.) and backwardly curved. At the posterior end of the axial furrow, a weak alar lobe is evident in well preserved examples. This alar lobe is elongated, more so than in the holotype of F. radix, but distortion in the new material is more marked (compare Pl. 11 Figs 2, 8, with the holotype of F. radix; Fig 1). The genal lobe in several of the new specimens has a distinct flexture running diagonally from the genal angle to the preglabellar region which is also present in Furcalithus. This flexure is accentuated anteriorly by compression (eg. Pl. 11, Fig. 5). At the genal angle, the flexure is continuous with the posterior border. Border is widest (sag.) at the genal region and narrows adaxially. Border furrow is distinct and widest (sag.) abaxially.

The holotype of F. radix has an occipital pit, a small pit abaxial and posterior to IS, a glabellar node and a small posterior fossula. None of these features is obvious in any example from Dyfed, although a small number of examples do have weak indications of a posterior fossula at the junction of the genal lobe flexture and the posterior border furrow (eg. Pl. 11, Fig. 5). Well preserved examples from Dyfed have a fine reticulate sculpture on the glabella and genal lobes. This sculpture, as in F. radix, is absent from the axial furrows.

The thorax is composed of six segments, of typical trinucleine structure. The pygidium, like that of F. radix has a distinct narrow border, which is not significantly invaded by the axis, there are 6-7 axial rings, which are posteriorly less distinct, and the pleural fields are clearly segmented. The holotype of F. radix has five pairs of pleural ribs. Dyfed material generally shows 2-3 pairs, but at least one example (Pl. 11, Fig. 4) has four pairs defined, and differences observed are probably related to preservation. In common with F. radix from the type area, pygidial pleural ribs and axial rings are clearer on latex moulds.

The remaining Furcalithus species, F. sedgwicki (Salter 1866 = Bergamia ? sedwicki of Whittard 1955: 33; Hughes 1971: 145; Hughes et al. 1975: 558) is known from ill preserved and distorted material from the Whitlandian; Gymnostomix gibbsii Biozone of the St. Davids district. It appears to differ from F. radix only in details of the fringe, and until a range of better preserved examples from Dyfed is available, useful comparison cannot be made.

The new Dyfed material is distinct from Myttonia; type species M. confusa (Whittard 1955: 29) in having a fringe with a strong girder and radially aligned pits extending further around the fringe, and differs from Bergamia; type species B. rhodesi (Whittard 1955: 32) and Stapeleyella; type species S. inconstans (Whittard 1955: 36) by having a much narrower pygidial border that is not invaded by the axis, and a less inflated pseudofrontal lobe and smaller less distinct glabellar furrows. From Bergamia spp. the new material also differs apparently having more I arcs, but this feature requires confirmation from better preserved material.

Genus STAPELEYELLA Whittard, 1955

V .1875 Trinucleus etheridgi; Hicks: 182; Pl. 9, Fig. 6.

V*.1955 Bergamia? etheridgi; Whittard: 34; Pl 4, Figs. 4-5.

DIAGNOSIS. See Hughes et al. (1975: 559). Fortey & Owens (in press) have modified the diagnosis of Hughes et al. (1975) to accommodate the Upper Arenig species S. abyfrons (see species discussion below) in which the many bifurcating inter-radial ridges external to E_I produce interclated short sulci with E_2 or E_2 and E_3, and frontally E_4 that form a series of 'Y' shaped ridges that are irregularly disposed and fewer in number than in the type species.

TYPE SPECIES. *Stapeleyella inconstans* Whittard 1955, from the Lower Llanvirn, topmost Hope Shales, path west of Brithdir Farm, 1.6 km ENE. of Old Churchstoke, Powys, by original designation.

Stapeleyella inconstans Whittard 1955
(Pl. 12, Figs. 1-7)

V. 1909 *Trinucleus* sp.; Thomas *in* Strahan *et al.*: 30.

V. 1909 *Trinucleus gibbsi*; Thomas *in* Strahan *et al.*: 30.

V. 1914 *Trinucleus* sp.; Jones and Thomas *in* Strahan *et al.*: 27, 28, 30.

V. 1914 *Trinucleus gibbsi*: Thomas *in* Strahan *et al.*: 28, 29.

V* 1955 *Stapeleyella inconstans* Whittard: 36, Pl. 4, Figs. 7-13; Pl 5, Figs. I-6. (with full synonomy)

V 1975 *Stapeleyella inconstans*; Hughes *et al.*: 559, Pl 2, Figs. 29-31.

1980 *Stapeleyella inconstans*; Temple: 221.

LECTOTYPE. (Temple 1980: 221) BGS 92971; complete specimen on slab with a second, incomplete specimen (figd. Whittard 1955: Pl. 4, Fig. 7; Hughes *et al.* 1975: Pl. 2, Fig. 29).

MATERIAL HORIZONS AND LOCALITIES. A common and characteristic species of the topmost Arenig (highest Fennian

Stage) and lower Llanvirn; artus Biozone; Llanfallteg Formation, in South Wales. New material collected includes fourteen complete or near complete specimens and nearly fifty cephala and fringe fragments. It is recorded from localities 2, 4, 10, 12, 24, 25, 27-29, 32-36, 39, 44, 50, 53, 56-59 and 60; lower Llanvirn artus Biozone, and locality 26, topmost Arenig; Dionide levigena Biozone. A single example from locality 79, cautiously attributed to this species, extends its range into the Upper Llanvirn.

Examples from South Wales are well represented at BGS and SM (Turnbull Coll. eg. SM. A41120-44; registered as Trinucleus etheridgi, and referred to Stapeleyella inconstans by Whittard 1955: 39).

Elsewhere in Britain, the species is common in the Lower Llanvirn; artus Biozone of the Shelve Inlier, Shropshire.

DISCUSSION. Whittard (1955: 36; Pl 4, Figs. 7-13; Pl. 5, Figs.I-6) has fully described this species from Shropshire, and nothing can be added here. Newly collected material, and that examined in national collections, which includes several well preserved examples of both the upper and lower fringe lamellae, agrees closely with type and figured specimens from Shropshire.

The variable nature of the fringe details in this species has been discussed by Whittard (1955: 37), who drew attention to variations in the I_2 - I_3 (ie I_I - I_2 in current terminology), $E_3 - E_4$ and $e_3 - e_4$ series, which are successive, and characteristic of stratigraphically distinct populations within the artus Biozone of Shropshire. The bulk of specimens from the Hope Shales show E_4 and e_4 , and usually have $I_n - I_2$ developed by R3; whereas populations from the overlying Stapeley Volcanic Group seldom show E_3 and e_3 dividing, and show I_I delayed until R7-II, and I_2 delayed until R10-I4.

Most of the comparative material from South Wales is smaller and more distorted than Shropshire specimens, and identification of successive fringe modification is made difficult. Also the majority of specimens with fringe details sufficiently well preserved are from a single horizon, low in the artus Biozone of the region, and only three examples from horizons higher in the Llanvirn are suitable for comparison (eg. Pl. 12, Figs. 5, 7).

It does not appear, from the restricted material available, that such fringe modifications occur in South Wales populations, and the bulk of material examined does not agree exactly with either of Whittard's groupings. The following observations from South Wales material may provide useful data for future qualification of Whittard's findings for this species in Shropshire:-

(i) I_n only developed anteriorly in many specimens.

(ii) When present, $I_n - I_I$ appear in RI in the majority of specimens, with only few examples of I_I delayed until R8-10.

(iii) I_2 more frequently occurs after R8, with very few examples of I_2 in R3-6.

(iv) I_3 seen on few examples, and not before R10.

(v) I_4 developed only at genal flange near R12.

(vi) Majority of specimens with complete E_I - E_3 arcs, some with only E_2.

(vii) E_3 and e_3 not seen to divide with certainty.

These variations agree more closely with Whittard's Stapeley Volcanic Group population, particularly with regard to the delayed appearance of I_I - I_2, but until a range of well preserved and stratigraphically late examples from South Wales is available, it is not possible to confirm Whittard's findings. In common with Shropshire populations in general, however, there is no significant difference between the fringe formulae of the upper and lower lamellae (see Reed 1912: 386), and no specimen from South Wales has any pit developed in e_I.

There are three other British species assigned to _Stapeleyella_, one with question; _S_? _etheridgi_ (Hicks) from the Lower Llanvirn; _artus_ Biozone of Llanvirn quarry, is ill preserved and has been attributed with question, to _Bergamia_ by Whittard (1955: 34; Pl. 4, Fig. 6) and transferred to _Stapeleyella_ by Hughes _et al_. (1975: 560). Lack of better preserved topotype material precludes confident generic assignment, but _Bergamia_ (ss.) has not been recognised in the Llanvirn in South Wales, and it seems likely that _etheridgi_ is a synonym of the ubiquitous inconstans.

S. murchisoni (Salter) from the lower (?) Llanvirn of Shropshire (Whittard 1955: 39; Pl.51, Figs.7,8) is separated from inconstans by having a more elongated glabella without 2S and 3S, and without a pseudofrontal lobe, and in having the glabella and genal lobe devoid of surface sculpture, and without a median glabella node. Also, according to Whittard, the outer face of the genal lobe is more gently sloping in murchisoni, and the fringe formulae is simpler than that of inconstans, with no more than two internal series, and few auxilliary pits in the outer series. The simpler fringe pitting does justify separation from inconstans but the absence of furrows and other surface features should not be considered diagnostic when based on a small range of syntypes as with murchisoni in Shropshire. None of the South Wales Stapeleyella examined has cephalic morphology consistent with murchisoni sensu Whittard (1955).

S. abyfrons sp. nov. (Fortey & Owens; in press) from the Upper Arenig, Fennian Stage; S. abyfrons Biozone in South Wales, is the earliest representative of the genus in Britain. It is distinguished from inconstans by having the e series pits less regularly arranged to form indistinct 'Y' shaped inter-radial ridges, and by having fewer pits in both the E and I series. None of the Stapeleyella material examined during this research has fringe details consistent with abyfrons.

Subfamily MARROLITHINAE Hughes, 1971

Genus MARROLITHUS Bancroft, 1929

DIAGNOSIS. See Hughes et al. (1975: 570).

TYPE SPECIES. Trinucleus ornatus var. favus Salter, 1848. Original designation by Bancroft (1929: 77). There is some confusion surrounding the type locality, which Williams (1948: 71) concludes to be the 'Llandeilo flags' of Penblewin, Carmarthenshire. (For discussion see Williams 1948: 70; Whittard 1956: 57).

Marrolithus cf. inflatus Williams, 1948

(Pl 14, Figs.9-11)

MATERIALS HORIZONS AND LOCALITIES . One fragmentary exoskeleton probably representing an enrolled specimen from exposures near Trewern Fach (locality 84 of Strahan et al. 1914), Llandeilo Series?, one external mould of a lower fringe lamella, from locality 38, siltstones of probable Llandeilo age. Three pygidia from this locality are cautiously attributed to this species.

DISCUSSION. Neither of the available fringe specimens has the full complement of pits preserved, but their arrangement and number in the E series and in the lateral inflated area compares closely with that of M. inflatus (Williams 1948: 74 text-fig. 4, pl. 6, fig. 3) from the Lower Llandeilo Flags south of Llangadock. Like the holotype of inflatus (BGS 75217; Whittard 1956: Pl. 7, Fig. 5) the cephalic border outline is gently convex anteriorly, slightly concave laterally, the glabella is swollen, clavate, and projects marginally forwards over the posterior edge of the fringe, the genal cheeks are less inflated than the glabella and the anterior fossula evident in BGS Pr 2637 (Pl. 14 fig 9) is smaller than pits of the I series and is situated close to the posterior edge of the fringe and very slightly adaxial to a forward projected line that would continue the divergent course of the axial furrows.

Williams (1948) recognised two 'varieties' of inflatus in the type area; M. i maturus (op. cit: 75; Pl 6 Fig 4; text fig 5;Whittard 1956: Pl 7 Figs 2-4) from the Lower Llandeilo Flags, is distinct from the new specimens in having a greater area of inflated pits, and a larger number of radial pits in the I series anteriorly. M. i. incipiens (Williams 1948: 77 Pl 6 Fig 2; text fig 6) from the Upper Llanvirn and basal Llandeilo of Fairfach, is easily distinguished from the new specimens by having a pronounced and thickened peripheral rim to the fringe.

Of the nine remaining species of marrolithus described from Llandeilo and Shropshire, only two are likely to be confused with the new specimens. M. primus Williams (1948: 78 Pl 6 Fig 1; text fig 7; holotype BGS 75226; Whittard 1956: Pl 7 Fig 1) from the Upper Llanvirn of Llandeilo and Shropshire also has a fringe outline that is gently convex anteriorly, but differs in that although the fringe is angulated anterolaterally, there is no swelling of pits in that region. M. bilinearis (Whittard 1956: 61; Pl 8 Figs 10-13) from the Spy Wood Grit (Caradoc) of Shropshire has a similar fringe outline, but differs in having larger numbers of pits in I_{1-2} involved in the swollen area, which persist towards the genal region, and in having more rows of pits in the I series anteriorly than in both the holotype of inflatus and the new material.

McGregor (1963) has described M. lirellatus (op cit.: 802 Pl. 116, Figs 17-20) from the Llandeilo of the Berwyn hills, which differs from the new specimens in having fewer pits in I_2 involved in the swollen region and greater regularity of the radial rows, and M. magnificus (op cit: 801; Pl.117, Figs.1-3) which is more readily distinguished from new material by having a sub-rectangular fringe outline, with swollen pits extending deep into I_4.

The pygidium is not described for M. inflatus. Pygidia from locality 38 (eg. Pl.14, Fig.11) are subtriangular in outline, almost three times as wide (tr) as long, with a gently tapering, moderately wide axis that constitutes about one fifth pygidial width across the anterior margin. There are two complete axial rings anteriorly, and a narrow (sag) articulating half ring. Up to seven further indistinct and incomplete rings are indicated by the presence of transverse rows of slit-like, ovoid (apodemal?) pits occurring in pairs either side of the sagittal line of the axis. The outer member of each pair is largest, and lies adjacent to the axial furrow. Similar axial lobe pitting is described for a pygidium from Shropshire referred with caution to M. cf. inornatus (Whittard 1956: 58 Pl. 8, Fig. 4).

The Pleural field is very indistinctly segmented, with at least four faint ribs evident anteriorly. Interpleural furrows very faint, with some indication of pleural furrows adaxially. Posterolateral border prominent, steeply inclined and widest (sag) postaxially, where it constitutes about one fifth axial length.

Pygidia are described in relatively few marrolithus species and obvious difficulties arise when considering isolated specimens. The new material is provisionally attributed to M. cf inflatus because of co-occurrence with cephala at locality 38. The pygidium of M. cf arenareous (Whittard 1956: 60; Pl. 8, Fig. 9) differs in having a more rounded outline, a narrower axis and more pronounced segmentation of the pleural field. That of M. inornatus (Whittard 56: 58; Pl.8, Figs. 1-4) differs from the new specimens only in having a less pronounced posterolateral brim and a slightly narrower axis. Pleural field segmentation is not seen in the holotype of inornatus (Whittard 1956; Pl. 8, Fig. 1) or in a pygidium referred to that species (op. cit.: Pl. 8, Fig. 4) which also differs in having a slightly sigmoidal outline to the pleural fields. Of the pygidia attributed to M. favus from the Berwyn Hills by MacGregor (1963; Pl. 17, Figs. 10-11), his Fig 10 is similar to the new material, but the posterior margin of Fig.11 is distinctly sigmoidal in outline and is unlike any example from locality 38.

Genus PROTOLLOYDOLITHUS Williams, 1948.

DIAGNOSIS. See Hughes et al. (1975; 577).

TYPE SPECIES. Trinucleus ramsayi Hicks, 1875. Original designation by Williams (1948: 66) by monotypy. Syntypes of Hicks (1875); BGS 25401; SM.A16717 from the 'zone of Didymograptus bifidus', Porth hayog (=Porth Llauog), Ramsay Island (see Whittard 1956: 42 for discussion).

Protolloydolithus ramsayi Hicks, 1875.

(Pl. 11, Figs.10, 12).

V*	1875	Trinucleus ramsayi; Hicks: 183, Pl. 10, Figs. I, 2.
	1912a	Dionide atra; Reed pars.: 202.
V.	1909	Trinucleus sp.: Thomas in Strahan et al.: 36.
	1940	Trigryopos atra; Kobayashi pars.: 203.
	1948	Lloydolithus Protolloydolithus) ramsayi: Williams: 66, text-fig.1.
	1953	Lloydolithus (Protolloydolithus) ramsayi; Williams: 179.
V	1955	Protolloydolithus ramsayi; Whittard: 41; Pl 5, Figs.9-12. (with early synonomy).

LECTOTYPE: Here selected; BGS 25401 cephalon and fragmentary thorax, Lower Llanvirn artus Biozone, probably Porth-hayog, Ramsay Island (see Whittard 1956: 42; Pl.

5, Fig 9).

MATERIAL HORIZONS AND LOCALITIES. Internal and external moulds of a slab with three complete exoskeletons and associated thorax and pygidia (BGS. HT. 126; HT. 170) from the Upper Llanvirn; murchisoni Biozone, old quarry at the western end of Merlins Hill, 4 km ENE. of Carmarthen, one fringe fragment (SM. A86139a-b) from the 'murchisoni ash quarry'; Upper Llanvirn murchisoni Biozone, near Abereiddy Bay (vicinity of locality 76 herein), and one complete fringe (BR 12733) from an unspecified locality, south side of Abereiddy Bay, zone of 'D. bifidus'.

In Shropshire the species is common in shales interbedded in the Stapeley Volcanic Group (= upper part of the 'bifidus' zone sensu Whittard 1956) and is recorded from Hope Shales in a tip heap at Brookless Coppice, Leigh. Williams (1948: 67) has described conspecific material from Cwm Brienant, near Llandeilo (figd. Whittard 1956: Pl 5, Fig.II).

DISCUSSION. Hicks original two syntypes are ill preserved, but the species has been adequately described from well preserved material by Williams (1948: 66) and Whittard (1955: 41), and nothing further can be added here. BGS. HT. 126; HT. 170 shows three complete exoskeletons, but is badly distorted, and fringe details are difficult to determine. However, the largest of the complete specimens (Pl. 11, Fig. 10; lower specimen) clearly has the outer arc E_I developed, with the largest pits in this arc, and shows a prominent girder, and some indication of I_n developed at least anteriorly. In all specimens, the depth (sag.) of the fringe between the prefrontal lobe and the girder is consistent with that described for P. ramsayi (Whittard 1956: 42).

The pygidium also agrees well with that of figured examples of ramsayi from Shropshire (Whittard 1956: Pl. 5, Figs. 11, 12). The axis is divided finely into numerous axial rings, but the precise number is not discernable due to distortion. There are at least seven pleural ribs, defined by deep interpleural furrows that are straight for about three quarters of their transverse course then curve backwards slightly more markedly in the anterior three pairs. Interpleural furrows reach the posterolateral border, which is narrow (sag.) and rather weakly developed.

P. neintianus Whittard (1955: 42; Pl. 5, Figs. 13-15) from the late artus Biozone of Shropshire, has smooth pygidial pleural fields and narrower fringe anterior to the glabella and fewer pits in the E Series. P. reticulatus Elles, from the Llandeilo of the Builth district (Hughes 1971: 169; Pl. 15, Figs. I, 5-9, II; Pl. 16, Fig 2; text-Fig 12), has a much narrower anterior and lateral fringe than ramsayi, with coarser pitting in the internal series, and a coarsely reticulate surface sculpture on the glabella and genal lobes.

Protolloydolithus sp.

(Pl. 11, Fig.11)

A single distorted fringe fragment from locality 77; Upper Llanvirn; murchisoni Biozone, has characters consistent with Protolloydolithus but appears to differ from described species in that an unknown number of pits in the I series have developed a radial habit, which is apparent up to three arcs deep anteriorly. Both the pits of the E and I series are rather coarser than is typical of ramsayi, and although the precise number of pits in E_I is unknown in this specimen, it is calculated to be much less than is typical of ramsayi. The number of pits in E_I in the type species is not precisely given by Williams (1948) or Whittard (1956) but between 55-60 pits are present in the lectotype.

In this respect, the new specimen more closely resembles P. neintianus in which the fringe formula is E_I I-26; I_n I-25.

Unlike Protolloydolithus, the new specimen also seems to have a weak development of E_2 laterally, but this requires qualification from better preserved examples.

Marrolithinine aff. Bettonia (Elles 1940)

(Pl. 10, Figs.11-12)

DISCUSSION. A single almost complete cephalon, and fragment of the lower lamella of a fringe from locality

74, Upper Llanvirn; murchisoni Biozone are too poorly preserved for confident determination, but the arrangement of pits is sufficiently well preserved to show some characteristics that are shared by Bettonia Whittard (1956), type species B. frontalis Whittard (1956:66 = B. chamberlaini (Elles, 1940); see Hughes 1971: 156) now regarded as monospecific (Hughes et al. 1971: 567).

In common with Bettonia E_1 is the outermost complete arc, but there are weak indications that a few pits of E_2 are developed frontally, and the girder and first pseudo-girder are clearly evident on the lower lamella (Pl. 10, Fig 12). Whittardolithus differs from the new specimens in possessing variably developed radial sulci frontally and anterolaterally on the upper lamella, and in having at least two distinct internal pseudogirders (compare Hughes et al. 1979 Pl.7, Fig.84 with Pl. 10, Fig.12).

Trinucleinine aff. Incaia

(Pl. 12, Fig. 11)

DISCUSSION. A single complete specimen from the Upper Llanvirn; murchisoni Biozone of Cuffern near Roch is ill-preserved and has been poorly prepared, but is noteworthy in that the fringe is narrow (sag.) with distinct radial sulci, the glabella appears to be devoid of furrows, and the pygidium appears to have convex (tr.) pleural fields and a deep border furrow and distinct border. Both the axis and pleural fields are segmented.

The cephalic morphology invites comparison with Incaia Whittard 1955; type species Trinucleus nordenskioldi Bulman 1931, from the Upper Llanvirn of Peru (Hughes et al. 1975: Pl.2, Fig. 20). Whittard (1966: 274; Pl. 47, Figs. 4-12) has described I. simplicior from the Arenig of Shropshire, which bears some resemblance to the new specimen, but differs in having distinct glabellar furrows. Further comments must await the recovery of better material from South Wales.

Family ALTASPIDAE Turner, 1940

1952 Selenecemidae; Whittington: 4.

Genus SELENECEME Clark, 1924.

1940 Altaspis; Turner: 516.

DIAGNOSIS. See Whittard (1960: 117).

TYPE SPECIES. Seleneceme propinqua Clark (1924: 90; Pl 9, Fig 10; Whittington 1952: 4; Pl.2, Fig.13) from the lower Ordovician; Shumardia Limestone, Levis, Quebec, by original designation.

Seleneceme acuticaudata (Hicks 1875)

(Pl. 10, Figs. 9-10; Pl. 11, Fig. 9)

V* 1875 Illaenopsis? acuticaudata; Hicks: 184; Pl. 9, Fig. 5.

1881 Illaenopsis acuticaudata; Salter & Etheridge: 513.

1891 Illaenopsis? acuticaudata; Woods: 146.

1953 'Illaenopsis' acuticaudata; Whittard: 239.

V* 1960 Seleneceme acuticaudata; Whittard: 118; Pl. 16, Figs.1-5.

HOLOTYPE. SM. A.15628; cranidium and partial thorax, Lower Llanvirn, Llanvirn Quarry.

MATERIAL HORIZONS AND LOCALITIES. One external mould of a cranidium and thorax, and one cranidium and partial thorax from localities 58 and 59(c); artus Biozone, and one crushed cranidium and partial thorax from locality 26; topmost Arenig, Llanfallteg Formation; Dionide levigena Biozone.

The holotype is from Llanvirn Quarry (locality 76 herein) and the species is otherwise known from the lower Llanvirn of Shropshire (Whittard 1960). Fortey & Owens (in press) have also recorded this species from the Upper Arenig of the Whitland district.

DESCRIPTION AND DISCUSSION. The new material agrees closely with the holotype and with figured examples from Shropshire, which are similarly incomplete, and consist of cephala with varying numbers of articulated thorax segments. Whittard (1960) was unable to fully describe the thorax and pygidium, and he outlined the uncertainty surrounding the nature of the pygidium in other described species of Seleneceme (Whittard 1960: 119-20). A new specimen from the Hope Shales of Whitsburn dingle, 130 metres south of the culvert at Overton's Rough, Leigh, Shropshire (SJ 3320 0285) consists of a complete thorax and pygidium, with fragments of the posterior edge of the cranidium folded beneath the thorax. This specimen permits a fuller description.

Whittard (1960: 118) reported that the pygidium in Seleneceme species consists of about twelve segments, but added that the articulation of the pygidium and thorax is difficult to detect; this is true of the new Shropshire example. There is a slight dextral shift at the thirtieth segment of this specimen, which is taken as the junction, and there are therefore at least twenty nine thoracic segments.

The overall shape of the thorax and pygidium is a long, acuminate isoscales triangle. The anterior ten thoracic segments have strong pleural furrows, which are deepest at the fulcrum, and the remaining segments are unfurrowed. The axial rings are simple, and tend to be arched forwards medially after about the tenth segment. The fulcrum of each successive segment migrates adaxially from a point near the pleural tip of the fourth segment, until the fulcrum of the eleventh segment is almost at the axial furrow. This forms a distinct 'U' shaped ridge that crosses the axis at about the mid - point of the thorax. The anterior three segments do not have their pleural tips significantly downturned. The posterior nineteen segments tend to be more distinctly directed backwards, and the axial furrows have distinct(apodemal ?) pits developed at the posterolateral corner of each axial ring The new specimen is undistorted, and the posterior half of the thorax and the pygidium have the pleurae steeply inclined to provide an almost cylindrical cross section.

There are at least ten segments visible in the pygidium; the axis conforms to that of the thorax, as do the pleurae, to produce a strongly convex (tr.) cross section. Border or border furrow not seen.

A compressed specimen from locality 26 (Pl. 10, Fig.10) does not show the cranidial posterior border and furrow of acuticaudata. This may be due to slight posterior displacement of the cranidium, or simply to vagaries of preservation. Seleneceme recorded from the same locality by Fortey & Owens (in press) have been attributed to acuticaudata.

Family DIONIDIDAE Gurich, 1907.

Genus DIONIDE Barrande, 1847.

1846 Dione; Barrande: 32.

1847 Polytomurus; Hawle & Corda: 37.

1940 Trigrypos; Kobayashi: 203, 207.

DIAGNOSIS. See Whittington (1952: 2).

TYPE SPECIES. Dionide formosa (Barrande, 1846) from the middle Ordovician of Bohemia, by monotypy.

Dionide levigena Fortey & Owens (in press)

(Pl. 10, Figs. 1-5)

V. 1909 Trinucleus sp.; Cantrill in Strahan et al.: 32.

DIAGNOSIS. Dionide with a subquadrate glabella that occupies at least three quarters of cephalic length (sag.); cheek lobes devoid of genal cacea, punctae or anastomising ridges; lobes not joined in front of glabella by smooth 'preglabellar' field. Fringe about a quarter cephalic length medially; girder distinct, narrow. Pygidium with nine axial rings and eight pairs of un-furrowed pleural ribs.

HOLOTYPE. NMW 85.26G1. Almost complete specimen with posteriorly displaced cephalon; Lower Llanvirn, Llan-fallteg Formation; artus Biozone, locality 27.

MATERIAL HORIZONS AND LOCALITIES. All new material has been recovered from the lower Llanvirn; artus Biozone of localities 25, 27 and 53: 2 complete specimens (including holotype), 4 cephala and one pygidium. Additional para-types studied are SM. A54144 complete cephalon from Llanvirn Quarry (locality 76 herein); BGS. Pr. 1868; cephalon from the eastern side of Afon rhyd-bennau, 350 yards south-east of rhyd-bennau cottage (locality 61 of Strahan et al. 1914, close to locality 46 herein), BGS. TCC. 454; near complete, but crushed specimen from a brook 350 yards north-west of Gelli, Llangynog district (locality 93 of Strahan et al. 1909).

DESCRIPTION. Cephalon about twice as wide as long, and semi-circular in outline. Glabella subquadrate, gently rounded anteriorly, and highly convex (sag.; tr.). Transversely the glabella is almost pyramidal with an apical tubercle situated just posterior of the mid-point of the glabella. Latter is almost parallel sided, very slightly wider at its base. Maximum width of glabella is marginally greater than glabella length. Basal glabella furrows deep, short (tr.) axial furrows in most cephala show a very slight median invagination, and vague indication of slightly swollen posterolateral lobes, but no distinct furrows are seen. Occipital ring is narrow (sag.; exsag.) and extends transversely as far as the abaxial tips of the basal glabellar furrows. Pleuroccipital furrow narrow, distinct, posterior cephalic border broad; about one fifth cephalic length adaxially, slightly narrower at the outer edge of the cheek. Axial furrow deep and continuous anteriorly with the preglabellar furrow. Latter is also distinct, but is narrower (sag.) than the axial furrow. There is no preglabellar field, and the preglabellar furrow is confluent with the inner margin of the fringe anterolaterally. Fringe is thin and bi-lamellar in cross section, and forms a gently convex surround to the cephalon. Convexity of fringe decreases marginally, and becomes flat or slightly concave, particularly anterior to the glabella. Anteromedial length (sag.) of fringe about a quarter of cephalic length, becoming slightly wider laterally and in the genal region. Pits generally of similar size and haphazardly distributed; about six deep anteromedially. In some cephala the outermost pits, and those in the genal areas, tend to be slightly larger than the remainder. Girder narrow (tr.; sag.) and undifferentiated in the holotype (Pl. 10, Fig. 1); compressed paratypes (Pl. 10, Figs. 3, 4) show weak indications of a peripheral furrow internal to the marginal girder, which may represent a ventral doublure.

Anterior and lateral course of facial suture not seen, but it is presumed to be marginal and similar to that described for D. jubata Whittard (1958: 98). Suture appears dorsally following a strongly curved course across the genal angle, to define a posteriorly projecting lobe to the fringe. In the holotype, the suture becomes marginal once again, and follows the posterior margin for at least one fifth of its total width (tr.). The posterior margin in the holotype is damaged adaxially, but it is assumed that the marginal suture in this species can be traced almost to the occipital ring as in jubata.

Cheek lobe is gently inflated, slightly longer than wide, and lacks any surface sculpture or ornamentation. Genal cacae and cephalic nervures have not been observed on any example, and it is presumed that they are lacking in this species. The posterolateral margin of the cheek is defined by a deep pleuroccipital furrow, which widens and shallows abaxially, without significantly invading the fringe. Broad based genal spine originates from the ventral side of the cephalon, and is biconvex in cross section. In a compressed example, attributed cautiously to this species (BGS. TCC. 454; Pl. 10, Fig. 5) the genal spine extends well beyond the tip of the pygidium. Hypostoma and rostral plate unknown.

Thorax of six segments; anterior segment macropleural, divided into a broad convex (sag.) anterior band, and a narrower, gently convex (sag.) posterior band, by an oblique pleural furrow. Remaining segments are similarly divided longitudinally by pleural furrows that extend for most of their length, but the anterior band of the remaining segments is narrower (sag.) than the posterior band. Pleural tips simple, bluntly truncated distally, with the posterior edge of the pleura drawn backwards into very short, blunt spines.

Axis distinct, narrow, almost parallel sided; width about one fifth total segment width. Axial rings simple, and without the distinct anterolateral lobes and furrows diagnostic of the genus (Whittington 1952: 2). Each ring is distinctly wider anteriorly, producing a zetoidal axial furrow pattern. It cannot be precluded that the absence of axial lobes is preservational, as only three examples of the thorax are known, but a latex mould of the well preserved holotype shows no indication of lobes.

Pygidium semi-elliptical, wider than long, with a prominent axis that tapers rather more than the thoracic axis. There are nine axial rings and a minute terminal piece. Axis extends almost to the posterior margin of the pygidium, and is acuminate terminally. There are eight pairs of pleural ribs that are defined by narrow interpleural furrows, which are strongly curved backwards distally. Pleural ribs lack furrows. In BGS. TCC.454 the interpleural furrows are more distinct than in the holotype, and there is a weakly developed narrow (sag., tr.) border, which may represent a superimposed ventral doublure (Pl. 10, Fig.5).

DISCUSSION. D. levigena is a distinctive species with cheek lobes devoid of surface sculpture. Whittard (1958) described two Dionide species from the lower Llanvirn of Shropshire and Powys. Of these, D. jubata Whittard (1958: 98: 98; Pl. 14, Figs.1-5) is closest to the new species, particularly with respect to the thorax and pygidium. The cephalon of jubata differs from that of levigena by having the cheek lobes with coarse punctae separated by anastomising ridges. Also the thoracic axial rings in jubata have the characteristic lobes of the genus.

D. turnbulli Whittington (1952: 8; Pl.2, Figs.1-6, 10, 11; Whittard 1958: 96; Pl. 13, Figs 1-8) also has smooth cheek lobes, but is easily distinguished from levigena by having a smaller glabella, a wider (sag.) fringe, distinct genal cacae, and a larger pygidium with many more axial rings and pleural ribs.

Dionide sp. of Whittard (1958: 102; Pl. 13, Fig. II) from the gracilis Biozone of Shropshire is distinct from levigena in having a distinctly punctate cheek lobe.

Dionide aff turnbulli Whittington, 1952.

(Pl. 10, Fig 6)

DISCUSSION. A single compressed and ill-preserved exoskeleton, probably representing an enrolled individual, from the Lower Llanvirn; artus Biozone of Locality 5, resembles the holotype of turnbulli (SM. A16715a-b; Whittington 1952: Pl. 2 ,Figs. 1,2) in that the glabella is relatively small and occupies only about half cephalic length (sag.) and is broadly circular in outline. The shape of the glabella in turnbulli is more angular than is evident in this specimen, but this may be attributed to poor preservation. Genal cacae are clearly evident in the new specimen, and originate at about the mid-point of the axial furrow and run diagonally towards the genal region, where they are confluent with the inner margin of the genal spine. The fringe is too ill-preserved to compare in detail with type and figured turnbulli, and does not show punctae or anastomising ridges. A marginal girder is, however, weakly evident.

The thorax is fragmentary, and only four segments are seen. The pygidium appears to be flattened beneath the thorax, with the tip of the axial lobe superimposed through the base of the glabella. Little detail of the pygidium is discernable, but the external mould of the axial lobe appears to be finely segmented, like that of turnbulli.

The cephalon of both D. jubata from the artus Biozone of Shropshire and the Dobrotiva Shales (Llandeilo) of Bohemia (Whittard 1958: 98; Pl. 14, Figs. 1-5; text-Figs 5c, d) and D. quadrata var. euglypta (op. cit.: 101; Pl. 13, Fig. 9) from the Caradoc of Shropshire, differs from the new specimen by having a larger glabella that occupies about two thirds cephalic length (sag.), by having less distinct genal cacae and a prominent posterior border and border furrow.

Whittington (1953: 8) has given a full account of turnbulli from material in the Turnbull Collection (eg. SM. A16712-16) from Scolton, and has provided valid reasons why Reed (1912: Pl. 11, Figs. 2-6) was mistaken in regarding this South Wales material to be conspecific with D. atra Salter, 1866 from the Ty-obry Beds of North Wales.

?Dionide sp.

(Pl. 10 Fig 7)

DISCUSSION. A single ill-preserved but essentially complete exoskeleton from locality 69, early Arenig (Moridunian stage?) measures 6 mm (sag.) and resembles Dionide in possessing an almost semicircular cephalic outline with a distinct marginal girder, and a short (sag.) almost circular glabella defined by strong axial and preglabellar furrows. There are no eyes or definite facial sutures evident, and there is a well developed posterior border and border furrow.

The thorax also resembles that of Dionide species in that the axis is narrow (tr.) and almost parallel-sided, and the pleurae are narrow (sag.) and straight, with distinct pleural furrows. The pygidium is too ill-preserved to compare further, but appears to be semi-elliptical in outline.

Unlike described Dionide species, however, there appears to be a single pair of well defined basal glabellar lobes, and there is no indication of genal cacae or fringe ornamentation. In these features this specimen bears a broad general resemblance to the proetacean genus Aulacopleura Hawle & Corda 1847.

Family RAPHIOPHORIDAE Angelin, 1854.

Subfamily RAPHIOPHORINAE Angelin, 1854

Genus AMPYX Dalman, 1827

DIAGNOSIS. See Fortey & Owens (1978: 253).

TYPE SPECIES. Ampyx nasutus Dalman, 1827, from the Upper Arenig, Asaphus Limestone, Vastana, Ostergotland. (Selected Neotype of Whittington 1950 : 554).

Ampyx linleyensis Whittard, 1955.

(Pl. 14, Figs.4-5)

V 1940(a) Ampyx mammiillatus austini; Whittard: 157; Pl. 5, Figs.4-7.

1941 Ampyx mammillatus austini; Lamont: 463.

1953 Ampyx mammillatus austini; Lamont: 434.

V* 1955 Ampyx linleyensis; Whittard: 18; Pl 2, Figs 1, 3-8, (non Fig.2 = Cnemidopyge tenuis sp. nov.).

V. 1909 Ampyx sp.; Thomas in Strahan et al.: 28, 33.

V. 1909 Ampyx nasutus; Thomas in Strahan et al.: 30, 32.

V. 1909 Ampyx nasutus; Cantrill in Strahan et al.: 33.

V 1981 Ampyx cf. linleyensis; Rushton & Hughes: 641; Pl 6, Figs.10-19.

HOLOTYPE BGS 92943. Almost complete exoskeleton, lacking librigenae, from shales interbedded in the Stapeley Volcanic Group (artus Biozone) Tasgar quarry, Linley.

MATERIAL HORIZONS AND LOCALITIES. All new material has been collected from the Lower Llanvirn; artus Biozone, and consists of three nearly complete exoskeletons and two pygidia from locality 27, one almost complete exoskeleton and an external mould of a thorax and pygidium from locality 59(c), and one pygidium and thorax from locality 5. The species is well represented at BM, BGS, SM and BR (Whittard Coll.) and the following specimens have been examined: BGS JP 4838, HT. 497-98; artus Biozone, quarry south west of Melin-y-castell, St. Clears (locality 75 of Strahan et al. 1909, close to localities 14 and 15 here); HT. 353, Lower Llanvirn 300 yds south east of Wern-ddu, 1½ miles south west of Llan-llwch (locality 84 of Strahan et al. 1909).

DISCUSSION. A. linleyensis has been fully described by Whittard (1955: 18; Pl 2,Figs.1, 3-8) from Shropshire, where it is a common and characteristic species in the Lower Llanvirn. In South Wales it is less common, and ranges down into the late Arenig at Llanfallteg. Several specimens at BGS and in the Turnbull Collection (SM) are exceedingly similar to linleyensis in cephalic and thoracic morphology, but have pygidial pleural ribs developed to varying degrees. Such specimens are here accommodated, with question, to Cnemidopyge tenuis sp. nov. (qv.).

Re-examination of Whittard's type material reveals a considerable variation in glabellar shape and furrowing, and variation in the overall length/width ratio of complete specimens ('broad and narrow' forms of Whittard 1955: 18). Material from South Wales attributed here to A. linleyensis agrees in most respects to type and figured material from Shropshire, and the majority of well preserved examples fall within the range of variation given for this species by Whittard. Several differences in pygidial morphology in South Wales populations are noted however, and these are outlined here because changes in the pygidium are clearly sensitive within the Ampyx-Cnemidopyge phyletic groups as presently defined (see Fortey 1975b: 65-66) and are significant taxanomically. Pygidial morphs in South Wales material appear to be consistent with those outlined for A. cf. linleyensis from the subsurface Llanvirn of Cambridgeshire (Rushton & Hughes 1981: 641) in that:

(i) fewer axial rings are developed.

(ii) fewer pygidia clearly show the slightly raised rim to the pleural fields clearly seen in Shropshire specimens. In this respect they more closely resemble A. linleyoides (Fortey & Owens, in press) from the Upper Arenig; Fennian Stage (see discussion below).

(iii) The steeply inclined lateral pygidial borders on many specimens are distinctly terraced (eg. BGS HT. 353; Pl. 14, Fig. 4). Such terracing is atypical of Shropshire specimens.

Whittard (1955: 20) stated that pygidial pleural furrows disappear with growth in this species. This is consistent with his Pl. 2, Fig. 7, but not with his paratype, BGS. 92944: Pl. 2, Fig. 2, which is of average adult size, and exhibits at least three faint pleural furrows, thus excluding it from Ampyx sensu stricto (see Fortey 1975: 65-66). This specimen is accordingly referred to Cnemidopyge tenuis sp. nov. (qv).

Fortey & Owens (in press) have described A. linleyoides from the Upper Arenig, Pontifenni Formation in South Wales; this species is extremely like linleyensis and differs only in having a longer anterior cephala spine, that is 'T' shaped in cross section and carinated in appearance, and in having a pygidial border that is wider than that of linleyensis, and is not defined by an abrupt change in slope at the edge of the pleural field. In linleyoides, the border carries 8-10 raised lines that extend onto the lateral parts of the pleural field; these are atypical, albeit not unknown in linleyensis, and the pygidial axis of linleyoides is less well defined posteriorly, and comparatively wider than that of linleyensis. Axial ring definition in linleyoides is generally poor compared with linleyensis and the pygidial axial furrows are always straight, even in distorted examples of linleyoides, whereas the axis of linleyensis often appears concave when compressed. More reliable in practice, there is greater backwards curvature in the anterior pleural furrow of linleyensis.

SM. A45258 (Pl. 13, Fig. 9) from the artus Biozone at

Scolton is registered as Ampyx salteri Hicks, but differs from that species (now referred to Cnemidopyge ss.; Owens pers. comm.) in having a narrower (tr.) cranidium, with a glabella that does not expand as rapidly forwards, and in having a longer anterior frontal spine that is carinated due to compression. In this respect it more closely resembles A. linleyoides which has a 'T' shaped spine in cross section, compared with salteri which has a circular spine.

Genus CNEMIDOPYGE Whittard, 1955.

DIAGNOSIS. See Whittard (1955: 21), and Hughes (1971: 62).

TYPE SPECIES. Ampyx nudus Murchison from the uppermost LLandeilo, quarry at the south western end of Penccerig Lake, north of Builth Wells (see Hughes 1969: 64), by original designation.

DISCUSSION. Cnemidopyge was erected by Whittard (1955: 22) to accommodate fragmentary raphiophorid material of Upper Llandeilo age (sensu Williams 1969) from Shropshire, which he considered to be generically distinct from Ampyx.

In revising the raphiophorids of the Builth-Llandrindod Inlier, Hughes (1969: 63) agreed with the validity of Cnemidopyge, which clearly forms a distinct phyletic group within the teretiusculus and gracilis biozones of the Builth district, but pointed out that the generally compressed nature of British material, preserved mainly in shale, does not allow a full definition of cephalic characters, which must await completion of work on uncrushed Scandinavian material. The results of such research have not been published to date. The validity of pygidial pleural rib development to distinguish Cnemidopyge from Ampyx will ultimately be bought into question as a number of species currently assigned to Ampyx have well developed pygidial ribs (eg. A. lobatus Cooper 1953: 16; Pl.6, Figs. 3-4, A. reyesi Benedetto & Malanca, 1975: Pl. 1, Figs. 10-11; Pl. 12, Figs. 1-2, A. pallens Přibyl & Vaněk, 1980: 45; Pl. 18, Fig.6, Pl. 19, Figs. 1-6, text-Fig. 14). A. salteri Hicks from the Arenig of South Wales (see Fortey & Owens 1979: 254-255; Hughes 1969: 63) possesses weak pygidial pleural ribs and has been replaced in Cnemidopyge (Fortey & Owens in press). Arenig specimens from Shropshire attributed to A. salteri should be referred to A. cf. reyesi Benedetto & Malanca 1975 (Owens pers. comm.).

Similar difficulties in practice have been identified by Fortey (1975b: 65, 66) who has outlined pleural furrowing of the pygidium as a variable feature that excludes several Ampyx-like species from the Arenig of Spitzbergen, from sensu stricto diagnosis of Ampyx based on the type species.

In South Wales, Cnemidopyge ranges from the middle Arenig. Whitlandian stage, to the low Upper Llanvirn, murchisoni

Biozone.

Within the Llanvirn, two new species are here identified; C. pentirvinense from the artus Biozone, and C. tenuis, which ranges from the Lower Llanvirn into the lower part of the Upper Llanvirn near Llan Mill. The latter is incorporated in Cnemidopyge with question, as populations show considerable variation in pygidial rib development, and morphs with very subdued ribs are closely similar to Ampyx linleyensis Whittard (qv.).

Cnemidopyge pentirvinense sp. nov.

(Pl. 13, Figs. 6-8)

NAME. After Pentirvin Farm, close to the type locality.

HOLOTYPE. BR. M18484; almost complete exoskeleton, lacking librigenae.

TYPE LOCALITY AND HORIZON. Shales interbedded in the Stapeley Volcanic Group, Whitsburn Dingle, west of Pentirvin Farm, Northern Shropshire. Lower Llanvirn; artus Biozone.

DIAGNOSIS. Cnemidopyge with 4-5 pairs of distinct pygidial pleural ribs developed behind the anterior interpleural furrow. Interpleural furrows of anterior three ribs extend to the margin laterally; posterior furrows incomplete distally. Entire dorsal surface of exoskeleton devoid of ornamentation.

OCCURRENCE IN SOUTH WALES. Known with certainty from a single exoskeleton lacking librigenae (Pl. 13, Fig. 7) from locality 9 ; artus Biozone. A small (4mm) external mould from temporary exposures 4.5 km west of Johnstown, Carmarthen (X/C.01) may also belong to this species, and a pygidium and thorax from Pengwern Wood is tentatively regarded as conspecific (see discussion below).

REMARKS. This species is represented at BR (Whittard Coll.) and BGS (eg. RR 780/1; Surrey Coll. 1892-3 labelled as "very close to Ampyx nudus Murchison" from the 'Upper Hope Shales', stream west of south of Pentirvin). It is abundant in the east bank of Whitsburn Dingle, 200 metres west of Pentirvin, and 300 metres south east of Luckley Barn, Worthen, Shropshire (SJ. 32880185), where the lithology is identical to that of the selected holotype of pentirvinense.

DISCUSSION. A full description of this species is superfluous, as it differs from the type species C. nuda (Murchison) (Hughes 1969: 63; Pl.2, Figs.1-8, 10, 12; Pl 3, Figs.1-5) only by lacking a surface ornamentation of pustules, and by having slight dissimilarities in cephalic and pygidial morphology.

The cephalon of pentirvinense is almost identical to that of the type species, except that the facial suture invades the dorsal surface of the fixed cheek more significantly, and the maximum transverse width of the librigena is correspondingly greater. Hughes (pers. comm.) has advised caution when considering the intra-marginal course of the facial suture and width of librigena as diagnostic characters of raphiophorid material in shale preservation, when the effects of compression can greatly influence biometric data. Comparison between a range of over twenty examples of pentirvinense from Shropshire, and a similar range of C. nuda, including the lectotype and paratype, indicates that the course of the facial suture is consistently more dorsal in pentirvinense and is well demonstrated in the holotype and in the single example from South Wales (Pl. 13, Figs. 6, 7). The mode of preservation is similar in Shropshire, South Wales and Builth.

The pygidium of pentirvinense differs from that of the type species in having fewer axial furrows and pleural ribs; up to 20 distinct axial rings can be developed in nuda, whereas pentirvinense has a maximum of about 15 rings, with only the anterior 8-10 rings clearly defined. The type species typically has seven pleural ribs (with some irregularity; see Hughes 1969: 66, Pl 2, Fig 10). All except the most posterior of these ribs are defined by interpleural furrows that extend to the pygidial margin laterally. pentirvinense has only four or five ribs developed, with the interpleural furrows of the anterior three only reaching the margin. The example from South Wales has a faint but persistent pleural furrow developed on the anterior pleural rib. This furrow is very narrow (sag.) and appears to meet the margin anterolaterally. Pleural furrows have not been seen in any example from Shropshire.

C. parva Hughes (1969: 71; Pl.4, Fig.7; Pl.5, Figs.2-4, 6-8; Pl.7 Fig.4) is perhaps closest to the new species, in that it also has fewer pleural ribs than the type species; 5-6 being a typical number. It is distinguished from pentirvinense by having stronger, more complete pygidial interpleural furrows, and by having a surface ornamentation of fine pustules. Fortey (pers. comm.) has endorsed the reliability of surface ornamentation in raphiophorid taxonomy.

A pygidium and articulated thorax (BGS. pr. 1724; Pl. 13, Fig. 8) from the lower Llanvirn of a north easterly flowing tributary of the Afon Rhyd-bennau at Pengwern Wood (locality 63 of Strahan et al. 1914; probably close to locality 37 herein) has only four clear pairs of pygidial ribs, and a furrow on the anterior thoracic pleura that is arched forwards, diagnostic of Cnemidopyge (s.s.). This specimen is preserved in a rather coarse matrix which masks the original nature of the surface ornamentation, but the number of pygidial ribs indicate that pentirvinense may be represented.

Cnemidopyge tenuis sp. nov.

(Pl. 13, Figs.1-5, Pl. 14, Figs. 1-3)

V. 1884 Ampyx salteri; La Touche: 56 Pl.2, Fig.34.

V. 1909 Ampyx nudus; Cantrill in Strahan et al.: 35.

V. 1909 Ampyx cf. salteri; Cantrill in Strahan et et al.: 35.

V. 1914 Ampyx nasutus; Cantrill in Strahan et al.: 25.

NAME. *tenuis*: subtle, referring to the pygidial interpleural furrows.

DIAGNOSIS. *Cnemidipyge* species with 2-3 pairs of pygidial ribs which are moderate to very weakly defined by incomplete interpleural furrows that do not, except for the anterior furrow, reach the margin laterally. Pygidial axial rings weakly defined by furrows that are strongest medially, and which arch forwards particularly anteriorly. Pygidial border well developed; formed by abrupt change in slope. Glabella comparatively wider than that of the type species; maximum width at three quarters glabella length from the posterior margin. Dorsal exoskeleton with ornamentation of very fine pustules.

HOLOTYPE. SM. A45400 a-b; complete exoskeleton, lacking only the librigena (Turnbull Coll.).

TYPE LOCALITY AND HORIZON. The holotype is from a roadside exposure in 'Didymograptus Shales' about 1000 yards east of Lampter Velfrey Church, and is registered in the Turnbull Collection as *Ampyx nudus* Murchison. The lithology of this specimen suggests that it originated from locality 19; low *murchisoni* Biozone.

PARATYPES. SM. A44494-5; A45255-8; *artus* Biozone, Scolton (probably localities 58, 59). BGS. TCC 862; *artus* Biozone, quarry 400 yards south east of Clôg-y-frân (locality 107 of Strahan et al. 1909; close to locality 14); JP 4795 'highest *D. bifidus* shales' behind Felin Ricket (locality 69 of Strahan *et al*. 1909); Pr 2550, roadside at Whitehouse Mill (probably locality 19 herein). BR 2310-11; stream 2000 ft west, 24° south of Upper Grimmer near Worthen, Shropshire artus Biozone, 2302, 2307 Nind quarry near Linley, Shropshire, Stapeley Volcanic Group; artus Biozone; BM In. 137605-06 I.4635, Hope Shales; artus Biozone, Ritton Castle, Shropshire, and In. 37306 (figd. La Touche 1884: Pl.2, Fig. 34 as A. salteri), and In. 54949 from the Stapeley Volcanic Group; artus Biozone of Tasgar and Nind quarries respectively. In Shropshire this species appears in the Lower Llanvirn, Hope Shales and Stapeley Volcanic Group; artus Biozone, and in South Wales extends its range into the lower part of the Upper Llanvirn; murchisoni Biozone.

DISCUSSION. A full description of this species is unnecessary as it differs from the previous species pentirvinense in only minor details. The pygidium of tenuis has 2-3 pleural ribs developed, with much weaker interpleural furrows than in pentirvinense. Some morphs of tenuis (eg SM. A45257: Pl. 13, Fig. 2) have only a single, highly subdued rib evident behind the strong anterior furrow, whilst others have two well defined ribs and a third rib evident. Compressed examples show the posterior ribs more clearly (eg BGS Pr 2550; Pl. 14, Fig. 1) and latex moulds of undistorted examples reveal the ribs more clearly than internal moulds. Posterior interpleural furrows are effaced adaxially, and do not reach the pygidial margin. The holotype and at least one paratype have a very fine surface ornamentation of minute pustules distributed over the whole of the exoskeleton. The cephalon of tenuis differs from that of pentirvinense by having a glabella that is comparatively wider (tr.), and less protrubant anteriorly. Most paratypes, however, are compressed to some extent, and this has the effect of widening the glabella somewhat, but the holotype is undistorted and retains a more bulbous glabella than pentirvinense.

This new species is also remarkably similar to Ampyx linleyensis from the lower Llanvirn of Shropshire and South Wales, and differs only in the development of pygidial pleural furrows, a more weakly segmented pygidial axis and a slightly wider glabella. At least one of Whittard's (1955: Pl. 2, Fig. 7) paratypes of linleyensis should be transferred to tenuis.

tenuis is assigned to Cnemidopyge here because the pygidial pleural fields are furrowed and the cranidial morphology and forward curvature of the pleural furrow of the anterior thoracic segment are consistent with the type species.

Cnemidopyge cf. parva Hughes, 1969

(Pl. 13, Figs. 10-11)

MATERIAL HORIZON AND LOCALITY. One complete exoskeleton, one external mould of a thorax and pygidium, and two external moulds of cranidia. All specimens from locality 78, slates of probable Llandeilo or Caradoc age; gracilis Biozone (?).

DISCUSSION. All examples are distorted, and the preservation is too poor to interpret surface ornamentation, but the pygidia are sufficiently well preserved to compare favourably to the holotype of parva (Hughes 1969: Pl. 6, Fig. 1) from the teretiusculus Biozone of the Llandrindod district. In particular all the new specimens have at least five well developed pleural ribs, and a sixth pair are poorly developed in three of the four pygidia available. Like parva the interpleural furrows extend to the margin laterally, except for the posterior furrow which does not reach the margin, and there is a steeply inclined border that forms a rim to the pygidium when compressed. In well preserved examples of parva the border shows terracing subparallel to the margin (Hughes 1969: Pl 6 Fig I) which is not seen in the new material, but this is probably due to differences in preservation. Hughes (1969: 72) has demonstrated that parva has a relatively wider thoracic axis than other British Cnemidopyge. Both examples of the thorax from South Wales are, however, too distorted to make comparison.

Black et al. (1979: 546) have referred Cnemidopyge from this horizon to cf. parva, and specimens are represented in the collections at Cambridge (SM. A79233, 35, 37, 40). Cnemidopyge sp. (SM. A79245-6) from grey shales and mudstones beneath the Castell Limestone, and geometrically below locality 78, are referable to C. aff. nuda Murchison.

Raphiophorid gen. et sp. indet.

(Pl. 14, Fig. 6)

DESCRIPTION AND DISCUSSION. A single discoidally enrolled and compressed raphiophorid from locality 69; tuffs of probable lower Arenig,(Moridunian) age, is too distorted for confident generic assignment, but appears to differ from the contemporanous Ampyx cf. rayesi Benedetto & Malanca, Ampyx cetsarium Fortey & Owens, and Cnemidopyge salteri (Hicks) in having a more acuminate and protrubant glabella which tapers forwards more evenly into a long anterior spine. The pygidium is relatively short (sag), and the pleural fields are not segmented. The pygidial margin appears to fit against the inner margin of the ventral cephalic doublure, which appears to be somewhat thickened laterally and anteriorly. In this respect, and in having an elongated glabella, this specimen more closely resembles Lonchodomas Angelin, 1854.

Family ENCRINURIDAE Angelin, 1854

Subfamily DINDYMENINAE Henningsmoen

Genus DINDYMENE Hawle & Corda, 1847

DISCUSSION. Whittard (1960: 122) erected the genus cornovicia; type species by monotypy C. didymograpti from the Lower Llanvirn; artus Biozone of Shropshire, on the basis that it occupies an intermediate position, in the number of thoracic segments and in glabellar structure, between the predominately Ashgillian genus Didymene and Plasiaspis Prantl & Přibyl from the Šárka Beds (Llanvirn)of Bohemia. The affinities of this uncommon genus have subsequently been discussed by Strusz (1980: 6) who excluded both Cornovicia and Plasiaspis from the Dindymeninae, partly because both possess a rostral plate. Strusz also claimed that the rostral and connective sutures in Dindymene are ankylosed and of levisellid pattern (cf. Moore 1959: 067).

Fortey & Owens (in press) have pointed out that ventral cephalic morphology in Dindymene is very poorly understood, and dispute that ankylosed sutures are always present. They also point out that at least one species of Dindymene, D. longicaudata (Kielan 1960: Pl.28, Fig.5) appears to have a rostral plate that closely resembles that of Cornovicia didymograpti (cf. Whittard 1960: Pl. 17, Figs.1, 2). The suggestion of Strusz (1980) that cornovicia and plasiaspis may be cybelinids is therefore unlikely, and they are both retained in the Didymeninae. Fortey & Owens further suggest that the remaining similarities between Cornovicia and Dindymene warrant synonymy, a view which is upheld here.

Dindymene cf. didymograpti Whittard 1960
(Pl.18, Figs. 9-11)

HOLOTYPE. BGS 86850; almost complete exoskeleton. Lower Llanvirn; artus Biozone, Brithdir, near Old Church-stoke, Shropshire.

MATERIAL HORIZONS AND LOCALITIES. One well preserved external mould of a complete exoskeleton from temporary exposures in shales attributed to the Lower Llanvirn 'bifidus beds' (Strahan et al. 1909) 4.5 km west of Johnstown, Carmarthen. Two small and ill preserved fragmentary specimens from the low artus Biozone, Llanfalltegg Formation locality 27 (27.35, 27.57) are probably conspecific. Fortey & Owens (in press) also record rare and ill preserved Dindymene from the Fennian part of the Llanfallteg Formation at Llanfallteg which may belong to didymograpti.

DISCUSSION. This species has been described by Whittard (1960) from the topmost Hope Shales of Shropshire. The Welsh specimen from Carmarthen agrees in most respects with the type species, but is very much smaller than examples from Shropshire. The following observations serve only to highlight minor differences which may not be of taxonomic importance, and which require confirmation from a larger range of examples.

The glabella of the new specimen is fractured approximately along the sagittal line, but it appears, from a latex mould, to lack the ornamentation of fine and coarse tubercles irregularly dispersed over much of the glabella surface cf. the paratypes of didymograpti (Whittard 1960: Pl. 17, Figs. 8-10); the glabella of the holotype specimen (op. cit.: Pl. 17, Figs. 1-2) is too damaged to compare. There appears to be a somewhat swollen anterior glabellar lobe in the new specimen, but this may be preservational. The ornamentation of the fixigena is consistent with that of typical didymograpti.

The thoracic and pygidial spines of the Welsh specimen are rather longer, more sinuous and evenly tapered than is typical of didymograpti but each spine is similarly almost circular in cross section. Whittard (1960) makes no mention of the tube-like structure of the spines and pleural ridges, which is clearly evident in a latex mould of the holotype (compare Whittard 1960 Pl. 17, Fig. 2, with Pl. 18, Fig.10 here)Because the new specimen is an external mould of the dorsal, rather than the ventral surface of the exoskeleton, the arrangement of rhomboidal flanges developed distally from the ventral doublure of each pleural ridge, described by Whittard (1960: 124) are not seen, but the spines of the new specimen are devoid of the delicate ornamentation of prickly tubercles which are preserved in both dorsal and ventral surfaces in Shropshire material (Whittard 1960: Pl. 17, Figs.2, 5, 6, 9).

An ill preserved pygidium and posterior portion of a thorax from the Llanfallteg Formation of the type area (Pl. 18, Fig.11) bears a strong general resemblance to didymograpti in that the thoracic segments and pygidial pleurae are extended into spines, and are strongly deflected downwards and backwards at the fulcrum. The axial and pleural lobes of the thorax are strongly convex in profile in this specimen, and there are two pygidial pleurae and at least five axial rings evident.

Fortey & Owens (in press) have described D. saron from the Upper Arenig S. abyfrons Biozone of South Wales which is distinguished from didymograpti by having coarser reticulation of the genal cheeks, finer granulation on the glabella, longer thoracic and pygidial pleural spines, and only five or six axial rings compared with seven in didymograpti.

The Carmarthen specimen has both the glabella and pygidium damaged, which cannot therefore be compared with saron. The genal cheek reticulation is more like that of didymograpti than saron, but the longer and more sinuous pleural spines invite comparison with saron. Some examples of saron appear also to have tubular spines, but poor preservation makes it difficult to interpret this feature.

Dr. R M Owens has kindly shown me photographs of a Dindymene species from the Lower Llanvirn 'bifidus' beds of Llŷn, North Wales, which appears to be distinct from didymograpti and from the Carmarthen specimen in having much finer reticulation of the genal cheek, and an almost smooth glabella with little granulation and without glabellar furrows. Like saron, and like the Carmarthen specimen, the thoracic spines are long, but only ten thoracic segments are evident in the only complete example, which is small (5 mm) and may represent a late miraspid. The pygidial characters are ill preserved and difficult to interpret in this specimen. It may be that a third Dindymene species is present in the Arenig-Llanvirn of the Welsh basin, but further comments must await the recovery of more material.

Family CHEIRURIDAE Salter, 1864

Subfamily CYRTOMETOPINAE Öpik, 1937

Genus PLACOPARINA Whittard, 1940

DIAGNOSIS. See Hughes (1969: 78).

TYPE SPECIES. Placoparina sedgwicki (M'Coy 1849) from the Llandeilo of the Builth district (see Elles 1940: 410 and Hughes 1969: 79 for discussion). Designation by monotypy.

Placoparina sp.

(Pl. 14, Fig. 12, Pl. 15, Figs. 1-3)

MATERIAL HORIZON AND LOCALITY. One incomplete cranidium, one incomplete thorax and fragmentary cranidium and one incomplete thorax and pygidium from locality 78, slates of probable Llandeilo or basal Caradoc (gracilis Biozone) age. A complete exoskeleton, possibly a late miraspid, from the lowest Llanvirn; artus Biozone of locality 25, is also attributable to this genus. Additional material: SM.A15617-9 from the 'Llandeilo' of St. Davids and Abereiddy Bay.

The species is also recorded from highest lower Llanvirn of the Shelve Inlier, Shropshire, and may be present in the Skiddaw Slates (Whittard 1958: 115).

DESCRIPTION AND DISCUSSION. Placoparina is rare in South Wales, and all available examples are too distorted or ill preserved to compare in detail with the type species. Whittard (1958: 113-115 has provided valid reasons why Placoparina should remain distinct from Eccoptochile Hawle & Corda, 1847, and the material from South Wales more closely resembles Placoparina in that the dorsal surface of the fixed cheek is not obviously invaded by the facial suture as in the type species of Eccoptochile; E. clavigena (Beyrich 1845: 13; Figs 2-3), and the position of the eye in one of the new specimens is apparently more anterior than in E. clavigena (see Pl. 14,Fig.12).

Eccoptochile? sp. from the Lower Llanvirn of Cefn-gwynlle, Shelve, Shropshire (Lane 1971: 44 Pl, 9. Figs. 6, 7) is known from ill preserved material but differs from the new Welsh specimens in that the pleural spines of the thorax and pygidium are much wider (tr.) and occupy about half pleural width in anterior segments and about three quarters pleural width in posterior segments.

Despite the comments of Whittard (1958: 115), Hughes (1969: 81) has outlined valid morphological distinctions between Shropshire and Builth populations of placoparina, and has erected the subspecies shelvensis for stratigraphically older material from Shropshire in which the external surface of the thorax and pygidium has sunken granules, and the third pygidial pleural spine is less spatulate than in Builth material. The subspecies sedgwickii is distinguished by having a well developed terminal axial piece and spatulate terminations to the pygidial pleural spines, and is confined to the Llandeilo of the Builth district. Although the new material is not sufficiently well preserved to identify such features, Placoparina (sl.) has a wider stratigraphical range in South Wales than at Builth or in Shropshire, and both subspecies may prove to be present when a range of well preserved examples is available.

Family PLIOMERIDAE Raymond, (in Zittel) 1913

Genus PLACOPARIA Hawle & Corda, 1847

V? 1909 Sao sp.; Strahan et al.: 33 (sic).

Placoparia (Placoparia) cambrensis cambrensis Hicks, 1875
(Pl. 14 Fig 12; Pl. 15 Figs 4-6)

V* 1875 Placoparia cambrensis; Hicks: 186; Pl. 9, Figs.1-2.

V 1875 Calymene hopkinsoni; Hicks: 187; Pl. 10, Fig. 4.

1908 Placoparia zippei; Delgado: 33, 57.

V. 1909 Placoparia cambrensis; Thomas in Strahan et al.: 30.

V. 1909 Placoparia sp.; Thomas in Strahan et al.: 30.

V. 1914 Placoparia combrensis; Jones in Strahan et al.: 27.

V. 1914 Placoparia cambrensis; Thomas in Strahan et al.: 27, 28.

1940(a) Placoparia zippei ;Whittard: 165.

V 1958 Placoparia zippei; Whittard: 104; Pl. 14, Figs 6-10; text figs 6a, d-h. (non figs. b, c)

V 1958 Placoparia sp.; Whittard: 108; Pl. 14, Fig. II.

V 1966 Placoparia barrandei; Whittard: 283; Pl. 14, Figs 6-10; text figs 6a, d-h (non figs. b, c = P.(P.) zippei).

1971a Placoparia (Placoparia) cambrensis; Hammann: 58.

1971a Placoparia (Placoparia) barrandei; Hammann: 58.

1976 Placoparia (Placoparia) cambrensis cambrensis; Romano: 15, 19, 21; Pl. Ia-b.

1976 Placoparia zippei: Romano: 13.

1976 Placoparia (Placoparia) cambrensis: Romano: 13.

1976 Placoparia barrandei: Romano: 13.

LECTOTYPE. BGS 35263 selected Hammann 1971a: 58 complete exoskeleton. Original of Hicks 1875: Pl.9, Fig. 2; figd. Whittard 1940a: Pl. 6, Fig. 3). Lower Llanvirn; artus Biozone, Llanvirn quarry (locality 76).

MATERIALS HORIZONS AND LOCALITIES. In South Wales, this subspecies is common in the Llanfallteg Formation (D. levigena and artus biozones) of the type area, and over twenty examples have been examined. New material consists of 8 complete exoskeletons, 2 cephala, I thorax and pygidium, and I cephalon and thorax, from localities 25, 26, 27, 34, 58 & 59. It is also well represented in SM (eg. SM. A45265-72: Turnbull Coll.). SM. A44547 from Blean dinan, Fishguard, (probably locality 65 herein) and A 44548, from Pwllacca, Llandeilo (Elles Coll.), are indeterminate at subspecies level.

Elsewhere in Britain, this subspecies is common in the lower Llanvirn of the Shelve Inlier, and ranges down into the Upper Arenig of that district (Whittard 1958: 108-9).

DISCUSSION. British Placoparia species were first dealt with in detail by Whittard (1940(a); 1958) who referred specimens from the Arenig and Lower Llanvirn of Shropshire, Westmoreland (Elles 1898:141) and elsewhere in Britain, to the Bohemian species P. zippei (Boeck 1827: 38; Fig 26). In his synonomy of P. zippei, Whittard (1940 (a): 165; 1958: 108) included P. cambrensis Hicks (1875: 186, Pl 9, Figs. I-2) from the Llanvirn type area; the earliest record of the genus in Britain.

Following Prantl & Šnajdr's redescription of the holotype of P. zippei (1957: 500, 514; Pl. I, Figs. I-5), Whittard changed his opinion (1966: 283) and referred all Shropshire material from the Upper Arenig and Lower Llanvirn to P. barrandei Prantl & Šnajdr, adding that the records of P. zippei from Ellergill, and of P. cambrensis from South Wales were to be corrected to P. barrandei.

Since Whittard's description of Shropshire material, *Placoparia sensu lato* has been well studied in Britain and Europe, and a great deal has been learned of the taxonomy, functional morphology and coeval distribution of British, Iberian and Armorcan populations during early Ordovician (Arenig to Llandeilo) times (Hammann 1971(a), 1971(b), 1971(c); Henry & Clarkson 1975; Romano 1976). Hammann (1971a) recognised three subgenera; *Placoparia (Placoparia)*; *Placoparia (Coplacoparia)* and *Placoparia (Hawlia)*, and synonymised *Placoparia (Placoparia) barrandei* Prantl & Šnajdr 1957, with *Placoparia (Placoparia) cambrensis* Hicks 1875, a view which is supported here.

Romano (1976: 15) recognised two subspecies of *P. (Placoparia) cambrensis* based on the number of axial rings that precede the terminal piece in the pygidium; *P. (Placoparia) cambrensis armoricensis* with three axial rings, confined to the Lower Llanvirn; '*bifidus*' Biozone of France and Spain, and *P. (Placoparia) cambrensis cambrensis* from Britain, Bohemia and Portugal, with four axial rings. In Britain this subspecies ranges from the Upper Arenig; Fennian Stage, to the Lower Llanvirn; *artus* Biozone; in Bohemia it is confined to the Llanvirn Series(≏ '*bifidus*' and '*murchisoni*' biozones) and in Portugal it occurs only in the Upper Llanvirn of the Volongo Formation (Romano 1976: 13, Fig. 4; Pl. I, Figs. Ia-b).

The new material from South Wales and the representative material in national collections are attributable to the subspecies cambrensis as described and figured by Whittard (1958; as P. zippei) and Romano (1976). Hicks (1875) original syntypes from Llanvirn quarry are rather ill preserved, but the lectotype shows four clear axial rings on the pygidium.

Further description is unnecessary here, and the only observed difference in South Wales material is the apparent absence of the three medially situated tubercles on the frontal lobe of the glabella (Whittard 1958: 105; Pl. 14, Fig 6) which are not revealed on latex moulds from well preserved cranidia (eg. Pl. 14, Fig. 12; Pl. 15, Fig. 5).

Bates (1968) has recorded Placoparia sp. with three pygidial axial rings from the teretiusculus Biozone of Anglesea, which is referable to P. (Placoparia) cambrensis sensu Hammann (1971a: 58) with affinity to the continental subspecies armoricensis sensu Romano (1976: 15).

Placoparia sp.

(Pl. 15, Fig. 7)

V. 1909 Cheirurus (Cyrtometopus) primigenus; Thomas in Strahan et al.: 28.

DESCRIPTION AND DISCUSSION. A single well preserved internal and external mould of a cranidium BGS. HT. 566-7 from the lower Llanvirn artus Biozone, exposed in a lane 500 yards south west of Cwm Farm, near Merthyr village (loc. 67 of Strahan et al. 1909; probably close to locality 6 herein) and registered as Cheirurus (Cyrtemetopus) primigenus bears little resemblance to Cyrtometopus Angelin, 1854 (see Moore 1959: 0434; Fig. 337, 5a-c) and is here attributed to Placoparia sp.; distinct from Placoparia (Placoparia) cambrensis (s.l).

A full description is unnecessary as this cephalon is very similar to that of P. (Placoparia) cambrensis Hicks, but differs in having:

(i) a slightly longer (exsag.) and narrower fixed cheek.

(ii) a posterior border that does not widen (exsag.) at the genal region.

(iii) IS that is more strongly curved backwards, almost isolating IL adaxially.

(iv) coarse punctae evenly distributed over the entire glabella, occipital ring and anterior border.

This specimen also lacks an ocular ridge and furrow, which are developed in all three recognised subspecies of Placoparia (Prantl & Šnajdr 1957; Hammann 1971). Also, the three medially situated tubercles on the frontal glabella lobe of P. (Placoparia) cambrensis from Shropshire and Portugal (Whittard 1958: 105; Romano 1976; Pl. I (a) are not seen on the internal mould or on a latex of the external mould.

Although the morphological distinctions between this specimen and typical cambrensis (sl.) specimens may be sufficient to warrant separation, it is preferred not to erect a new species here, based on a single specimen.

Family CALYMENIDAE Burmeister, 1843

Subfamily METACALYMENINAE Přibyl & Vaněk, 1975

Genus PLATYCALYMENE Shirley, 1936

DIAGNOSIS. See Hughes (1969: 83)

TYPE SPECIES. Platycalymene duplicata (Murchison), from the Rorrington Beds or Spy Wood Grit (see Whittard 1960: 156); gracilis Biozone of Shropshire, by original designation.

Platycalymene tasgarensis tasgarensis Shirley, 1936

(Pl. 16 Figs 9-10; Pl. 17 Fig 11)

V* 1936 Platycalymene tasgarensis; Shirley: 394, 400, 402-3; Pl 29, Figs.14-15.

1949 Platycalymene tasgarensis; Lamont: 315.

1953 Platycalymene tasgarensis; Whittard: 239.

V 1960 Platycalymene tasgarensis; Whittard: 152; Pl. 21, Figs.3-12.

1969 Platycalymene tasgarensis; Hughes: 94.

HOLOTYPE. SM 5876 a-b, complete exoskeleton, Lower Llanvirn; artus Biozone, Stapeley Volcanic Group, tasgar quarry, Shropshire (Shirley 1936: Pl.29, Figs.14-15).

MATERIAL HORIZONS AND LOCALITIES. One internal and external mould of a cranidium, and one cephalon and partial thorax from shales attributed to the 'highest

Bifidus Zone' (locality 63 of Strahan *et al*. 1914) at Pengwern Wood, near Llandissilio (probably close to locality 37 herein), and one cephalon and partial thorax from temporary exposures in shales attributed to the *bifidus* Biozone (Strahan *et al*. 1909: 27) 4.5 km west of Johnstown, Carmarthen.

DISCUSSION. This subspecies has been fully described by Whittard (1960: 152) from the Lower Llanvirn of Shropshire, and no further details can be added from the new material, which agrees very closely with the holotype (Shirley 1936: Pl 29, Figs 14-15) and to figured examples from Shropshire (Whittard 1960).

tasgarensis differs from *simulata*, from the Llandeilo of Builth, and from *P.* aff *tasgarensis* *simulata*, from Abereiddy Bay (see P. 204) by having straighter cephalic axial furrows. The cephalon of the type species *P. duplicata* differs from *tasgarensis* by having more anteriorly placed eyes and palpebral lobes situated opposite 3S.

Platycalymene *tasgarensis* Shirley, 1936 *simulata* Hughes, 1969.

(Pl. 16, Figs. 11-12; Pl. 17, Figs. 9-10)

V. 1909cf. *Calymene* *brevicapita*; Cantrill *in* Strahan *et* *al*.: 35.

1940 *Platycalymene* *duplicata*; Elles: *pars* 411, 412, 432.

V* 1969 *Platycalymene* *tasgarensis* *simulata*; Hughes: 93; Pl. 12, Figs. 3, 6, 8-10; Pl. 13, Figs. 1-3.

HOLOTYPE. BM It.3013. Cranidium. Llandeilo series, Dulas Brook, 350 metres west of Maesgwynne, Builth district.

MATERIAL HORIZONS AND LOCALITIES. One external mould of a pygidium from shales exposed in Clôg-y-frân Farmyard (locality 107 of Strahan et al. 1909, locality 13 herein), one cranidium from locality 38, siltstones of probable Llandeilo age, and one cranidium from a temporary exposure 4.5 km west of Johnstown, Carmarthen; 'bifidus Zone' of Strahan et al. (1909: 27).

DISCUSSION. Hughes (1969: 93) erected the subspecies simulata for Platycalymene from the Llandeilo of the Builth district that are distinct from the type species, and from P. tasgarensis from the Lower Llanvirn of Shropshire (Whittard 1960: 152; Pl. 21, Figs.3-12), in having straight rather than curved cephalic axial furrows, and in having a pygidium with seven rather than six axial rings, and six rather than five pleural ribs.

The examples from South Wales are exceedingly similar to the types from Builth, and no further description is necessary here. BGS TCC. 874 (Pl. 16, Fig.11) has only a weakly developed sixth pair of pleural ribs, and in this respect resembles the Shropshire subspecies tasgarensis (compare with Whittard 1960: Pl. 21, Figs. 10, 12, 14).

The subspecies simulata has a more extensive stratigraphic range in South Wales than at Builth, and is also present in non-argillaceous facies, which is atypical of the genus both in Shropshire and at Builth (see Hughes 1969: 84).

Hughes (1969) was unable to describe the thorax of simulata in the absence of complete specimens from the type locality at Dulas Brook, 330 metres west of Maesgwynne, and 55 metres north of spot height 727 (SO. 058 564). A new complete external mould from the type locality (Pl. 16, Fig.12) shows the thorax to be exceedingly similar to that of the subspecies tasgarensis (see Whittard 1960: 154).

Platycalymene aff. tasgarensis simulata Hughes
(Pl. 15, Figs.8-10)

MATERIAL HORIZON AND LOCALITY. Two cranidia and a pygidium and partial thorax from locality 78; slates of probable Llandeilo or basal Caradoc age. Additional material examined: SM A79232; A44795; A54148.

DISCUSSION. All specimens are compressed and variously distorted, which precludes confident determination at species level. The cranidia agree most closely with tasgarensis Shirley simulata Hughes in that the cephalic axial furrows are straight, the anterior margin of the glabella is almost horizontal and the eyes are relatively large, with their posterior edge opposite the mid-point of 2L, and their anterior edge opposite 3S.

The effect of compression on the pygidia reduces the apparent ratio of axial width to pygidial width across the anterior margin, but there are seven clear axial rings and six pleural ribs which is consistent with simulata.

Black et al. (1971: 546) have also referred distorted Platycalymene from this locality to the subspecies simulata, with question.

Platycalymene sp. indet.

(Pl. 15, Fig. 11)

REMARKS. A single complete but ill preserved external mould (SM. A82569) from the Caerheys Shale Formation near Abereiddy Bay (approx. SM 796 310; close to locality 77 herein) is of stratigraphic importance as it is the only record of the genus within the Upper Llanvirn; murchisoni Biozone of the type area. Hughes, Jenkins and Rickards in Bassett (1982: Fig. I) have recorded Platycalymene sp. from dark shales above the 'murchisoni' Biozone near Abereiddy.

DISCUSSION. Compression and distortion preclude confident determination at species level, but the cephalic and pygidial characters are consistent for Platycalymene rather than Flexicalymene. The latter is also apparently confined to calcarenitic facies in the Anglo-Welsh region (see Hughes 1969: 84).

The cephalic axial furrows appear to be straight rather than curved, the pygidial axis is divided into at least seven rings, and the pygidial pleural fields have at least six ribs developed. The pygidial characters preclude the type species P. duplicata, which typically has 8-10 axial rings, and 8 or 9 pleural ribs, and agree more closely with P. tasgarensis simulata Hughes, otherwise only known with certainty from the teretiusculus Biozone of the Builth district. The nature of the cephalic axial furrows of this specimen are also similar to simulata. P. tasgarensis tasgarensis (Shirley 1936; Whittard 1960) differs in having curved rather than straight cephalic axial furrows, and by having fewer pygidial axial rings and pleural ribs.

Platycalymene cf. duplicata (Murchison, 1839)
(Pl. 16, Fig. 13)

V. 1914 Calymene cambrensis; Jones in Strahan et al.: 27.

DISCUSSION. A single pygidium from a roadside exposure, 120 yards west of the bridge at Llan Mill, near Lampter Velfrey (BGS. Pr. 2733; locality 48 of Strahan et al. 1914) differs in some respects from other Platycalymene pygidia from South Wales, in that it has a slightly narrower (tr.) axis with seven complete axial rings, and an obscure eighth ring preceding the terminal piece. There are seven well defined pleural ribs, each furrowed along its entire length. The width of the axis and the number of axial rings suggest affinity to the type species (holotype BGS 6847; Hughes 1969: Pl. 9, Fig. 6) but the number of pleural ribs is consistent for *P. tasgarensis simulata* (qv.). Surface ornamentation of tubercles more surpressed in this pygidium than is typical of either *duplicata* or *tasgarensis simulata*. Hughes (1969: 92; Pl. 12, Figs. 2, 7) figured a similar pygidium from the Upper Llandeilo of the Builth district, which has characteristics of both the type species and of *tasgarensis simulata*.

The type species is unknown with certainty from rocks older than the *gracilis* Biozone of Shropshire and Builth. This example from South Wales is preserved in a lithology identical to fossiliferous beds at locality 19 (see Fig 2), here placed low in the *murchisoni* Biozone (Rickards pers. comm.). The original locality of Strahan *et al.* (1914) is no longer exposed. Further examples are necessary before the range of the type species can confidently be extended into the Upper Llanvirn in South Wales.

Subfamily Flexicalymeninae Siveter

Genus FLEXICALYMENE Shirley, 1936

DIAGNOSIS. See Hughes 1969: 81.

TYPE SPECIES. *Calymene blumenbachii* var. *caractaci* Salter, 1865, from the Caradoc (Marshbrookian Stage), *Dalmanella wattsi* Biozone, Acton Scott, Shropshire. Original designation by Shirley 1936.

Flexicalymene cf. cambrensis (Salter, 1848)

(Pl. 16, Figs. 1-3)

REMARKS. Siveter (pers. comm.) has advised that populations within the cambrensis species group exhibit variation, and that this species is in need of a revision that will require the examination of a much wider range of examples from the type area at Llan Mill (eg. localities 20 & 23 here). Also, a revised diagnosis of cambrensis should be based on external moulds; the lectotype of Shirley (1931: 20; BGS 19555, Pl 2 Fig 11) is an internal mould of a fragmentary cranidium. Accordingly, new material is not given subgeneric allocation, and a synonymy is omitted here. That of Whittard (1960: 157) is the most recent dealing with cambrensis (s.l.).

MATERIAL HORIZON AND LOCALITY. All new material is from the Bryn-glâs Beds near Llan Mill, of probable Llandeilo age; two cranidia from locality 23, one cranidium from exposures 10 metres downstream of locality 23, and one pygidium from exposures 16 metres downstream from locality 23.

DISCUSSION. This species has been described by Shirley (1931: 20; Pl. 1, Figs. 11-15) from the Llandeilo of South Wales. Whittard (1960: 157; Pl. 22, Figs. 1-2) has attributed cranidia and pygidia from the Llandeilo (Meadowtown Beds) of Shropshire to cambrensis, and it is widely recorded from the Llandeilo of South Wales (eg. Strahan et al. 1909, 1914). MacGregor (1963: 808 Pl. 117, Figs. 19-24) has also described cranidia and pygidia from the Llandeilo of the Berwyn Hills.

The new cranidia are very similar to the lectotype of cambrensis, in particular IL is sub-angular in outline, particularly adaxially, and the distance between the adaxial tips of 1S is slightly greater than the maximum width (tr.) of 1L. Unlike the lectotype of cambrensis however, the new cranidia have a shorter (sag.) preglabellar area that is slightly less than a quarter cranidial length, and the anterior margin of the preglabellar area is slightly raised, (eg. Pl. 16, Fig. 2) with a faint marginal furrow. In this respect the new cranidia more closely resemble F. (Reacalymene) (s.s.) but interpretation of this observation must await examination of type locality populations.

Additional differences observed between the new specimens and the lectotype of cambrensis are that the surface pustules in the lectotype are coarser on the dorsal surface of 1L and 2L than elsewhere on the cranidium, whereas in the new material the coarsest pustules are on the frontal glabellar lobe and the raised anterior cephalic margin, and the glabella is slightly more anteriorly pointed in the lectotype. Such differences may be entirely due to preservation.

The cranidium attributed to cambrensis from Shropshire (Whittard 1960: Pl.22, Fig.1) also has a shorter preglabellar area than the lectotype, but has a shorter (tr.) distance between the adaxial tips of 1S and 2S than in the lectotype and in new material figured here, and has fine pustules of constant size distributed evenly over the dorsal surface.

The new pygidium agrees closely with that of Shirley (1931: Pl.1,Fig 11) and Whittard (1960: Pl 22, Fig.2) in that the axis is divided into six rings and a short (sag.) bluntly rounded terminal piece, and there are seven pleural ribs with distinct pleural furrows that extend almost the entire length of the rib, but disappear before reaching the margin. Pygidia from the Berwyn Hills (McGreggor 1963) have eight axial rings, and an axis that narrows rather more rapidly for the first four axial rings compared with material from Llan Mill and Shropshire. Associated cranidia depart from type material in having a more variable anterior border length, and provided morphs that are transitional between Flexicalymene and Reacalymene. Such variation, however, may be related to compression.

Cranidia attributed to F. planimarginata (Reed 1906 Pl. 17 Fig 15) from the Whittery shales (Caradoc) of Shropshire (Whittard 1960: 158, Pl. 22, Figs. 3-4) are distinct from the new cranidia in having more rounded 1L, a shorter (sag.) preglabellar area, a wider (tr.) more rounded frontal glabellar lobe and wider separation of the adaxial tips of the glabellar lobes.

Flexicalymene sp.

(Pl. 16, Fig.4)

DISCUSSION. A single pygidium from locality 20 shows a number of differences from typical pygidia attributed to cf. cambrensis from a similar horizon at locality 23. This atypical specimen has a slightly wider axis, that is more strongly tapered anteriorly (compare Pl. 16 Figs. 3, 4 with Whittard 1960; Pl 22 Fig 2) and in this respect resembles material from the Berwyn Hills (McGreggor 1963: Pl. 117, Figs. 24, 25). There are at least seven complete axial rings, with a further two incomplete rings preceding the terminal piece. There are only seven pleural ribs, and it is unlikely therefore that the observed number of axial rings includes articulated posterior thoracic segments. The nature of surface ornamentation in this specimen is very similar to cambrensis sensu Shirley (1931) and Whittard (1960).

In view of the poor understanding of the taxonomy of the cambrensis species group and of related Flexicalymene in Britain, it is preferred to provisionally attribute this pygidium to Flexicalymene sp.

Family BATHYCHEILIDAE Pribyl, 1953

1953 Pharastomidae; Hupe.

Subfamily PHARASTOMATINAE Hupe, 1953

Genus PRIONOCHEILUS Rouault, 1847

1847 Pharastoma; Hawle & Corda

DIAGNOSIS. See Roualt (1847: 309), and Bézièr (1907: 120).

TYPE SPECIES. _Calymene pulchra_ Beyrich 1846, from the Caradoc of Bohemia, by monotypy (see Siveter 1976: 339).

Prionocheilus mendax Vaněk 1965

(Pl. 16 Figs 5-8)

1846 _Calymene pulchra_; Beyrich: 26; Pl.2, Figs. 6a-b.

1855 _Calymene pulchra_; Verneuil & Barrande: 972; Pl 26, Figs.I, Ia.

1872 _Calymene pulchra_; Barrande: 36; Pl. 16, Fig.27.

1949 _Pharastoma pulchra_; Thadeu : 131; Pl. 2, Figs.3-5.

1953 _Pharastoma pulchrum_; Whittard: 239.

V 1960 _Pharastoma pulchrum_; Whittard: 134; Pl. 18, Figs 2-8.

1965 _Pharastoma pulchrum mendax_ : Vaněk: 30; Pl 3, Figs 6-7; Pl 4, Figs. 2-5.

1966 _Prionocheilus pulcher_: Whittard: 300; table 3.

1967 _Prionocheilus pulcher mendax_; Dean _in_ Whittard: 312, 313.

1976 _Prionocheilus mendax_; Přibyl & Vaněk: 38; Pl 4, Fig.1.

1983 _Prionocheilus mendax_; Hammann: 53; Pl. 2, Figs. 22-27; Pl 3, Figs. 28-33; Pl. 22, Figs. 208, 210; Pl.23, Fig. 214; text-figs. 14, 16, 18, 22. (with full synonomy).

MATERIAL HORIZON AND LOCALITY. This species is rare in South Wales and only a single cranidium and fragmentary thorax has been recovered during this research. However, there are five examples in the Turnbull Collection (SM); SM. A44511-4; A22984, from the Lower Llanvirn; artus Biozone of Scolton (probably close to localities 58 and 59 herein).

The species is otherwise known in Britain from a single locality in the topmost Hope Shales; artus Biozone, in the farmyard and path west of Brithdir farm, 1 mile ENE of Old Churchstoke, Shropshire (Whittard 1960: 136).

DISCUSSION. Whittard (1960: 134) has fully described Prionocheilus material from Shropshire, and has taken account of the Scolton material figured here. Dean in Whittard (1967: 313) concluded that Shropshire material that had previously been attributed to Pharastoma pulchrum (idem 1960: 134; Pl. 18, Figs. 2-8) and subsequently amended to Prionocheilus pulcher (idem 1966: 300; table 3) is morphologically closest to the subspecies P. pulcher mendax Vaněk (1965). Přibyl & Vaněk (1976) subsequently elevated mendax to species rank, which is accepted here.

Re-examination of South Wales material confirms that it agrees in all respects with Shropshire material, and is closely similar to type material of mendax (Vaněk 1965: Pl. 4, Fig. 4).

The cranidium of P. pulcher Barrande (1852: pars 575;

Pl. 19, Figs. 1-3, 6 non Figs. 4, 5, 7, 9 = mendax Vaněk 1965) differs from that of mendax by having a less convex frontal glabellar lobe, slightly longer (tr.) 2S and a less distinct palpebral ridge. Also in pulcher, the angle of divergence of the pre- and post-occular facial sutures is greater than that of mendax. P. vokovicense Šnajdr (1956: 54; Pl. 5, Fig. 1; Pl. 6, Fig. 1) from the Šárka Formation (Llanvirn) of Bohemia, is also similar in cranidial morphology to mendax, but can be distinguished by having a narrower (sag.) anterior border, and a proparian facial suture.

A new cranidium and thoracic segments from Scolton (Pl. 16, Fig 8) is attributed here to mendax with question as it departs from type material of mendax in having a broader (tr.) less convex glabellar lobe. It is unlike P. vokovicense Šnadjr, which is similar to mendax in its cranidial morphology, in that the anterior border is broader and more swollen sagittally. These apparent differences may, however, be entirely due to compression and further comments must await the recovery of more specimens.

Family DALMANITIDAE Vogdes, 1890

Subfamily ZELISZKELLINAE Delo, 1935

Genus ORMATHOPS Delo, 1935

DIAGNOSIS. Zeliszkelline with a broad anterior cephalic border, and a facial suture that follows a dorsal course slightly distant from the anterior margin. Eyes variable in size and anteriorly placed; reduced or absent in some species; lenses of similar size, and usually irregularly packed. Palpebral furrow deep in most species. 3S straight or sigmoidal. Librigena reduced in size and with genal spine in immature specimens. Pygidium subtriangular, often rounded posteriorly; axis with 6-10 rings; pleural fields usually with 5 or 6 ribs. Hypostoma subparallel sided or sightly constricted medially.

TYPE SPECIES. Dalmanites atavus Barrande, 1872, from the Šárka Formation (Llanvirn), near Rokycany, Bohemia, by original designation.

Ormathops llanvirnensis Hicks, 1875

(Pl. 17, Figs. 1-8)

V* 1875 Phacops llanvirnensis; Hicks: 187; Pl. 9, Figs. 3-4.

1905 Phacops llanvirnensis; Reed: 176.

1906 Phacops llanvirnensis; Evans: 616, 617.

V. 1907 Phacops llanvirnensis; Cantrill in Strahan et al.: 16.

V. 1909 Phacops llanvirnensis; Thomas in Strahan et al.: 30.

V. 1914 Placoparia llanvirnensis (sic.); Thomas in Strahan et al.: 28.

1918 Phacops llanvirnensis; Perner in Novák & Perner: 16, 42.

1940 Phacops llanvirnensis; Delo: 12.

1958 "Phacops" llanvirnensis; Struve: 184.

V 1960 Ormathops nicholsoni; Whittard: 128; Pl. 16, Fig. 7 (non Fig 6 = Ormathops nicholsoni sensu Fortey & Owens in press).

V 1960 Ormathops llanvirnensis; Whittard: 130; Pl. 16, Figs. 8, 9.

1971 Ormathops llanvirnensis; Clarkson: 52.

DIAGNOSIS. Ormathops with a minute eye composed of 12-15 lenses on a small librigena defined by preocular suture running in front of a shallow palpebral furrow, and a little distant from the anteriolateral corner of the glabella. 3S shallow, sigmoidal. Pygidium sub-parabolic with 8-9 axial rings and 6 pairs of pleural ribs, defined by deep, narrow interpleural furrows. Fixed cheek with surface ornamentation of fine pits; glabella and cephalic border with very fine punctae.

LECTOTYPE. SM.A45155; complete internal mould, selected Fortey & Owens (in press); figd. Hicks 1875: Pl 9, Fig. 4; Whittard 1960: Pl. 16, Fig. 9. From the lower Llanvirn; artus Biozone, Llanvirn Quarry (locality 76).

MATERIAL HORIZONS AND LOCALITIES. In South Wales this species is relatively common in the Llanfallteg Formation of the type area, particularly above the Llanvirn boundary within the artus Biozone; it is less frequent in the topmost Arenig Dionide levigena Biozone. Eighteen examples, including 5 complete exoskeletons, seven cephala and three pygidia with thoracic segments have been recovered from localities 27, 29, 34, 53 and 57 within the artus

Biozone, a further twenty fragmentory specimens have been recovered from localities 26 and 25; topmost Arenig (D. levigena Biozone) and lowest Llanvirn (artus Biozone) respectively, and an external mould of a partial cranidium from locality 30, late Arenig; horizon uncertain (locality 28 of Strahan et al. 1914) has been recovered.

The species is well represented at BGS (eg. BGS. Pr.2029-31 from Cefn Farchen farmyard [close to locality 34 herein]; TCC.414, 432 from Cwm Breinant, near Llandeilo; 'bifidus Shales'), and NMW (eg. NMW.33.189.G,150 yds. from Castell-gorford, St. Clears (close to locality 15 herein); 33.189.G 115 from near Whitland, and 33.189.G 15, from the D. levigena Biozone of the Llanfallteg railway cutting (locality 26 herein).

DESCRIPTION. Cephalon subelliptical in outline, slightly arcuate in some examples. Length to width ratio in the least distorted examples is about 2:1. Glabella expands anteriorly and is defined by deep axial furrows. Axial furrows defining the base of the glabella and the occipital ring are sub-parallel, width (tr.) across the base of the glabella is about a quarter of the total width across the posterior cephalic margin. Axial furrows diverge at about 50° from points adjacent to the anterior margin of the basal (1L) glabellar lobes, and follow a straight course almost to the anterolateral cephalic margin, where they converge to define rounded antero-lateral corners to the frontal lobe of glabella, and continue as the preglabellar furrow. Preglabellar furrow weaker than the axial furrows. Frontal lobe of glabella gently convex transversely, anterior outline distinctly arcuate in well preserved examples. Occipital ring strongly convex, defined by moderately deep occipital furrow that is deepest laterally at its union with the axial furrow. Three pairs of glabellar lobes and furrows developed behind frontal glabellar lobe. 1L almost elliptical, with maximum length parallel to sagittal line, and defined by a short straight deep furrow which is bifid adaxially forming two very short divergent branches. The posteriorly oriented branch is much more distinct, significantly more so than in the specimen from the Hope Shales of Shropshire figured by Whittard (196 Pl. 16, Fig. 7). 2L larger than 1L, and roundly sub-quadrate in outline, defined anteriorly by straight 2S which is not as deep as 1S and which dies out adaxially at about one third of the glabellar width at that point. 3S originates at a point about one fifth of the distance along the axial furrow measured backwards from the antero-lateral corners of the glabella, is directed diagonally backwards, and describes a sigmoidal curve. 3S dies out adaxially. Distance (tr.) between adaxial tips of 3S slightly less than the gap between adaxial tips of 2S, which is, in turn, less than the gap between the bifid adaxial tips of 1S.

Fixigena strongly convex (tr.; sag.) with posterolateral regions almost vertically orientated in uncrushed specimens. Posterior border furrow deep, less so adaxially, but becomes trench-like abaxially and reaches the postero-lateral margin. Posterior border is narrow (sag.) ad-axially; about half of the length (sag.) of the occipital ring, and expands abaxially towards the genal angle, where it is slightly longer (sag.) than the occipital ring and is strongly downcurved. Fixigena in at least three well preserved examples (Pl. 17 Figs 2, 4, 6) is covered with a random pattern of evenly distributed pits, which do not vary greatly in size, but appear to be slightly larger on the lateral and genal regions, and appear also on the lateral region of the posterior border, on the occipital ring and more rarely, on the basal glabella region.

Fixigena limited by an almost marginal facial suture which migrates dorsally, opposite a point about midway between the junctions of 2S and 3S with the cephalic axial furrow, and runs diagonally forwards for two thirds of its length, then is directed more acutely forwards, enclosing an angle slightly greater than 90° , towards the anterolateral corner of the glabella. Anterior (pre-ocular) branch of the facial suture is confluent and continuous with the axial furrow for a short distance before following a course that is almost parallel to, but slightly divergent from the preglabellar furrow, around the flattened frontal area. Librigena small sub-triangular, at least twice as long as wide but posterior extremity of librigena is not revealed on available cephala. Anterior and lateral border widest opposite palpebral lobe, and apparently gently convex in cross section. Border furrow deep and formed partly by a distinct increase in steepness between the lateral border and the small convex sub-triangular region of the librigena internal to the border. Holochroal eyes are well preserved in only one specimen (Pl. 17, Figs. 2-3). Eye is very small, sub-oval in outline, and composed of at least twelve circular, convex ommatidia. Owens (pers. comm.) records up to 15 lenses in South Wales material from the Whitland district. The post occular branch of the facial suture is not fully revealed on available specimens but is presumed to be almost gonatoparian; becoming opisthoparian just internal to the genal angle in order to join the posterior border as described by Whittard (1960: 129). Thorax of eleven segments; sub-parallel sided for about two thirds of its length, then gently tapering after the seventh segment. Axis similarly sub-parallel sided for most of its length becoming moderately tapered posteriorly, so that the width of the axial ring of each segment is about one third of total width of the segment. Axial furrows deep, axial rings convex (sag.; tr.) and rounded laterally, defined by simple transverse furrows that are slightly bowed forwards medially. Each pleura is flat topped, bluntly rounded distally, and divided transversely by a strong diagonal pleural furrow which is widest adaxially and reaches the pleural tip. The posterior margin of the anterior five segments is drawn backwards, and the anterior margin is recurved backwards distally to form very short, blunt spines.

Pygidium sub triangular, moderately rounded posteriorly and about twice as wide as long in the best preserved specimen available (Pl. 17, Fig.8). Axis is long, reaching almost to the posterolateral border furrow, gently tapering and is defined by deep axial furrows. Maximum width (tr.) of axis is about one quarter of the width of the anterior pygidial margin. At least nine simple axial rings and a short (sag.) terminal piece developed. Transverse ring furrows are not bowed forwards medially, and the terminal piece is posteriorly effaced. Narrow border area is smooth and without a border furrow. Doublure is preserved in at least one example (Pl. 17 Fig 8). Doublure is narrowest postaxially, increasing in width laterally; at maximum about half axial width.

Pleural field gently convex (tr.) with at least six pleural ribs, defined by deep narrow interpleural furrows. Furrows become shallower abaxially, and disappear before reaching the margin laterally. Each rib has a narrow and shallow pleural furrow running diagonally from the adaxial anterolateral corner of the rib, and almost reaching the tip, where it is almost confluent with the interpleural furrow.

DISCUSSION. Because of the ill preserved nature of the syntypes of both O. llanvirnensis from Llanvirn Quarry (Hicks 1875: Pl 9, Figs. 3-4; Whittard 1960: Pl. 16, Fig. 9) and O. nicholsoni (Salter 1866: 486 pars Figs. c-d [Lectotype only]; remaining syntype probably Placoparia) from the Skiddaw Slates, Whittard (1960) was unable to confidently regard llanvirnensis as a junior synonym of nicholsoni, despite their many shared characteristics, and he referred Shropshire specimens to nicholsoni.

An abundance of new Ormathops material from South Wales, has enabled Fortey & Owens (in press) to distinguish two separate species on both morphological and stratigraphic grounds. O. nicholsoni occurs commonly in the Upper

Arenig, Fennian Stage; Bergamia rushtoni Biozone, and ranges up into the Aber Mawr Formation on Ramsay Island. The base of the Llanvirn Series is drawn within this Formation (Fortey & Owens; pers. comm.). O. llanvirnensis is rare in the topmost Arenig; D. levigena Biozone of the Llanfallteg Formation, and becomes increasingly commoner within the lowest Llanvirn; artus Biozone.

O. llanvirnensis is distinguished from nicholsoni by having a glabella that is slightly narrower (tr.) across 1L, and which expands more rapidly forwards, from a point further backwards than in nicholsoni. 3S tends to be shallower compared with 1S and 2S in llanvirnensis, and the palpebral lobe is much shallower than that of nicholsoni. In ill preserved llanvirnensis specimens, the palpebral lobe cannot be seen, whereas in nicholsoni it is invariably present, even in such poorly preserved examples as the lectotype (Whittard 1960: Pl. 16, Fig. 6). The pygidium of llanvirnensis has a slightly narrower (tr.) axis, wider pleural fields, and deeper pleural furrows than that of nicholsoni.

A cephalon from the Hope Shales (Lower Llanvirn) of Shropshire attributed to nicholsoni (Whittard 1960: 129; Pl. 16, Fig. 7) clearly belongs to llanvirnensis. O. alata (Whittard 1960: 131; Pl. 16, Fig. 10) also from the Hope Shales, is distinguished from llanvirnensis in having a straight rather than sigmoidal 3S, which is deeper than in llanvirnensis. The species, however, is founded on a single, albeit well preserved, cranidium (holotype:

BGS. 86848) which is relatively small and probably represents an immature individual. Several cranidia of llanvirn-ensis examined are considerably smaller than the holotype of alatus and retain the sigmoidal 3S. It is unlikely therefore, that alatus represents an immature llanvirn-ensis as suggested by Fortey & Owens (in press).

Family ODONTOPLEURIDAE Burmeister, 1843

Subfamily SELENOPELTINAE Hawle & Corda, 1847

Genus SELENOPELTIS Hawle & Corda, 1847

1847 Polyeres; Roualt: 320.

DIAGNOSIS. See Bruton in Bruton & Henry (1978: 894).

TYPE SPECIES. Odontopleura buchi Barrande 1846, from the Letná Formation (Caradoc) of Bohemia, by monotypy.

Selenopeltis buchi buchi Barrande 1846

(Pl. 18, Figs. 1-5)

1846 Odontopleura inermis; Beyrich: 20; Pl. 3, Figs. 2a-c

1847 Selenopeltis Buchii; Hawle & Corda: 35; Pl. I, Figs. I-2.

1852 Acidaspis Buchi; Barrande: 716; Pl. 36, Figs. I-9; Pl. 37, Figs. 25-27.

1949 Selenopeltis buchi buchi; Prantl & Přibyl: 175; Pl. 3, Fig. 16, Pl. 4, Figs. I-2; Pl. 8, Figs. 5-7; Pl. 9, Fig. 2.

1956 Selenopeltis buchi buchi; Šnajdr: 501; Pl 5, Figs. 5-7.

V 1961 Selenopeltis inermis var. intermis; Whittard: 197; Pl. 26, Fig. I (with fully synonomy).

1978 Selenopeltis buchi; Bruton in Bruton & Henry: 895, 896, 897.

LECTOTYPE. Prague (National Museum): IT.700.CD714; Letná Farm (Caradoc) Bohemia. Original of Barrande 1852: Pl 37, Fig 25.

MATERIAL HORIZON AND LOCALITIES. All new material has been recovered from the upper part of the Llanfallteg Formation; artus Biozone from localities 25, 27, 34, 53, 57 and 60. Additional specimen studied: BM It.19547. thorax and pygidium (Fortey & Owens Coll.). This subspecies is also represented at BM and NMW.

REMARKS. The name buchi is used here in preference to inermis Beyrich, as used by Whittard (1961: 198), and follows Bruton in Bruton & Henry (1978). Because surface ornamentation is the only reliable criterion for separating buchi from macrophthalmus (qv.) (Bruton in Bruton & Henry 1978: 896) the latter should not merit species distinction, and should be regarded as a subspecies of buchi.

DISCUSSION. S. buchi buchi has been described by Whittard (1961: 198; Pl 26, Fig. 1) from a single example from the gracilis Biozone of Shropshire. Whittard separated buchi from macrophthalmus on pygidial morphology, and discussed the distinguishing characters previously outlined for these subspecies by Prantl & Přibyl (1949: 55, 175), many of which he regarded as invalid after examination of topotype material in comparable states of preservation

(Whittard 1961: 199). The distinguishing characters of buchi buchi after Prantl & Přibyl (1949) can be summarised as :-

(i) smaller, more posteriorly placed eyes.

(ii) stronger thoracic pleural ridges.

(iii) a longer (sag.) pygidium with pleural ridges that are less divergent, and more strongly curved.

(iv) coarser surface ornamentation, particularly on the cephalon and pygidium.

Přibyl and Vaněk (1973) have used other criteria for distinguishing between species, including shape and degree of subdivision and inflation of lateral glabella lobes. Bruton in Bruton & Henry (1978: 896) however mentions fine granulation over the entire dorsal surface as the only reliable presence or absence character to distinguish buchi and macrophthalmus, and points out that both coarse ornamentation of the pygidium, and differences in lateral glabella lobes can be misleading, and are dependent on the presence or absence of exoskeleton, degree of compression and overall size of specimen.

A range of new selenopeltis material from South Wales, including typical examples of macrophthalmus sensu Bruton in Bruton & Henry (1978) from the Upper Arenig; Bergamia rushtoni and Dionide levigena biozones (Fortey & Owens Coll.), confirms that fine surface granulation is the only reliable criterion in practice, although the pygidial pleural ribs in macrophthalmus appear to be consistently horizontal adaxially, before curving backwards, whereas the ribs of buchi do not follow such a horizontal course, and curve backwards from their origin at the axial furrow. A larger range of macrophthalmus pygidia are necessary to qualify this observation.

Selenopeltis buchi macrophthalmus Klouček, 1916

(Pl. 18, Figs. 6-8)

1896 Acidaspis buchi; Crossfield & Skeat: 528.

1931 Acidaspis (Selenopeltis) buchi; Whittard: 328.

1949 Selenopeltis macrophthalma; Prantl & Přibyl: 177; Pl. 8, Figs. 1-4.

V 1961 Selenopeltis inermis var. macrophthalmus; Whittard: 199; Pl. 26, Figs. 2-9.

1968 Selenopeltis macrophthalmus; Bruton: 65. (with full synonymy)

1978 Selenopeltis macrophthalmus; Bruton in Bruton & Henry: 895; Pl. I, Figs. 2-3, 5, 7; text-Figs. I-2.

LECTOTYPE. Prague (National Museum) L843; pygidium and fragmentary thorax, from the Šárka Fm. (Llanvirn) of Bohemia. Selected Prantl & Přibyl 1949, Figd. Bruton 1968; Pl. 11, Fig. 13.

MATERIAL HORIZONS AND LOCALITIES. This subspecies is rare in South Wales, and only a single new example has been recovered from the lower Llanvirn; artus Biozone of locality 53; 53.05 a-b disarticulated fragments, consisting of a pygidium and two associated thorax segments. Additional specimens studied are SM. A45150; external mould of partial thorax and base of cranidium, and SM.

A45151; fragmentory thorax, both from the artus Biozone of Llanvirn Quarry (locality 76).

Fortey & Owens (in press) record this subspecies from the Upper Arenig, Pontyfenni Formation; Bergamia rushtoni Biozone, into the topmost Arenig and basal Llanvirn of the Llanfallteg Formation of the type area and at Scolton. Whittard (1961: 199; Pl. 26, Fig. 9) has also figured an example from Scolton, and records the subspecies from Abergwili and St. Clears. Specimens to support the latter claim have not been located during this research.

In Shropshire this subspecies is commoner than in South Wales, and it similarly crosses the Arenig-Llanvirn Boundary.

DISCUSSION. This subspecies is reliably distinguished from buchi only in the nature of surface ornamentation. In buchi the ornamentation is much coarser on the pygidium, and variably so on the thoracic segments and cephalon (cf. Pl. 18, Figs. 2-3); in macrophthalmus fine granulation is evenly distributed over the entire dorsal surface of the exoskeleton.

The appearance of the coarsely ornamented buchi at the Arenig-Llanvirn boundary may prove to be stratigraphically important, and it may be that surface ornamentation became more pronounced in a graduated series macrophthalmus - buchi - inermis. Bruton in Bruton & Henry (1978: 895) argues that inermis and buchi from Bohemia cannot be convincingly separated, but the lectotype of inermis (Přibyl & Vaněk 1973: Pl 3, Fig.2) does have pygidial ornamentation more pronounced than in typical buchi from South Wales or Shropshire. This observation is endorsed by the findings of Fortey & Owens for selenopeltis buchi from the Arenig-Llanvirn candidate stratotype section at Llanfallteg (Fortey pers. comm.).

Family LICHIDAE Hawle & Corda, 1847

Subfamily LICHINAE Hawle & Corda, 1847

Genus METOPOLICHAS Gurich, 1901

Metopolichas sp.

(Pl. 18, Fig.12)

DISCUSSION. A single hypostoma from locality 23 closely resembles figured hypostoma of Metopolichas spp. (eg. Tripp 1957; McGreggor 1963) in that it is longitudinally and transversely convex, with a subtriangular raised middle body, large rounded posterior wings, and an indented posterior margin. The middle furrow is incomplete and consists of a backward directed almost straight furrow on each side which deepens and widens adaxially to form distinctive sulci, and there is some indication that the furrows continue, albeit faintly, and converge with the posterior furrow at the sagittal line. Lateral furrows are broad and deep, widest posteriorly, where they flatten out and merge with the posterior wings. There are a pair of small, sub-triangular anterior wings which are raised slightly above the level of the lateral furrow, and there appears to be a very constricted anterior border which is largely hidden due to compression. The posterior wings are bluntly rounded and somewhat flattened peripherally, becoming slightly convex adaxially, but remaining well below the level of the median body. The surface of the hypostoma is almost entirely covered with irregularly spaced ovoid pustules that are closely spaced and are distinctly coarser on the convex anterior region of the posterior wings, and on the lateral regions of the median body. Pustules are very fine or absent within the middle furrow sulci. The posterior margin is almost horizontal, except for a central subrectangular embayment that is about one fifth maximum width of the median body.

The hypostoma of M. contractus MacGregor (1963: 810; Pl. 118, Figs. 13, 14) from the Llandeilo of the Berwyn Hills differs from the new specimen by being less transverse; the ratio of length to width in contractus is about 2:1, compared to 3:1 in the Welsh example. As material from locality 23 is minimally distorted, this ratio is unlikely to reflect compression. The median body in contractus is also more rounded and the posterior border is much wider (sag.).

SUMMARY CHAPTER

This study confirms that the Llanvirn trilobite fauna of South Wales is typical of the *Selenopeltis* Province, and it reflects the strong provinciality of trilobites that is typical of the early part of the Ordovician. The fauna compares closely with that of the Shelve Inlier, Shropshire, particularly so in the Lower Llanvirn (*artus* Biozone), and includes a number of genera and species that are common to approximately coeval sediments in Bohemia. Most of the trilobite species from the Llanvirn of South Wales also occur in the Arenig or Llanvirn elsewhere in the Anglo-Welsh area.

The extensive faunal lists of Whittard (1955-66) for the Lower Llanvirn in Shropshire are the result of many years of intensive collecting from a number of prolific localities. Existing similarities at species level in the fauna from South Wales will no doubt increase with further collecting. The following species and subspecies occur in both areas:- *Corrugatagnostus morea*, *Segmentagnostus scoltonensis*, *Barrandia homfrayi*, *Microparia (Microparia) broeggeri*, *Gastropolus obtusicaudatus*, *Pricyclopyge binodosa bonodosa*, *Ectillaenus perovalis*, *Seleneceme acuticaudata*, *Ampyx linleyensis*, *Cnemidopyge pentirvinense*, *Cnemidopyge tenuis*, *Stapeleyella inconstans*, *Protolloydolithus ramsayi*, *Dionide turnbulli*, *Placoparia (Placoparia) cambrensis cambrensis*, *Prionochelius mendax*, *Ormathops llanvirnensis*, *Platycalymene tasgarensis tasgarensis*, *Dindymene didymograpti*, *Selenopeltis buchi buchi* and Selenopeltis buchi macrophthalmus. In addition Ogygiocaris seavilli and Ogyginus porcatus are probably present in South Wales, and the rare genera Cremastoglottos and Placoparina occur, but available material is indeterminate at species level.

Gastropolus obtusicaudatus, Ormathops llanvirnensis and Selenopeltis buchi buchi occur only rarely in Shropshire, but are relatively widespread and abundant in the low artus Biozone in South Wales.

Pricyclopyge binodosa binodosa is uncommon in the artus Biozone in South Wales, but persists into the Upper Llanvirn near Fishguard. It is however abundant, to the exclusion of most other taxa, near Llan Farm (locality 30 here; locality 28 of Strahan et al. 1914) at an horizon attributed to the Upper Arenig, and similarly at Rhyd-y-bennau (localities 45, 46) where the lithology more closely resembles the Pontifenni Formation than the Llanfallteg Formation. In Shropshire the species is rare in the Arenig, but is common in the Hope Shales;(low artus Biozone). This anomaly in vertical distribution may reflect a biofacies control. No example of Ogyginus intermedius Elles has been traced to confirm the statement of Dean (in Whittard 1967: 310) that this species is common to South Wales and Shropshire.

Of these species, M. (Microparia) broeggeri, Ectillaenus perovalis, Stapeleyella inconstans, Selenopeltis buchi

buchi and S. b. macrophthalmus also occur within the Šárka Formation of Bohemia, which approximates to the Llanvirn Series in Britain (see Dean in Whittard 1967: 319; text Fig 10). These species may prove to have zonal value when the stratigraphy and faunas of the Šárka Formation are revised.

Eoharpes primus? from the low artus Biozone near Llanfallteg provides an additional species common to Britain and Bohemia at this horizon, and Ormathops also occurs within the Šárka Formation. The appearance of O. llanvirnensis immediately beneath the Llanvirn boundary in Britain may prove to be significant when Bohemian Ormathops species are revised.

Dean (in Whittard 1967: 312) has provided an additional list of genera and species from the Llanvirn of the Anglo-Welsh region that also occur in Bohemia, but at considerably younger horizons. Dean attributed these descrepant stratigraphical ranges to migrations, but this has been questioned subsequently (Thomas et al. 1984: 26).

The Arenig-Llanvirn transition in South Wales is well defined only in the Llanfallteg district, and is poorly understood in the Llanvirn type area and to the east between St. Clears and Carmarthen. Rocks of Arenig age are unknown in the Llandeilo district. In South Wales, the following species cross the series boundary at the Llanfallteg candidate stratotype section (localities 25 & 26): Barrandia homfrayi, stapeleyella inconstans, Pricyclopyge binodosa binodosa, Placoparia (Placoparia) cambrensis cambrensis, Seleneceme acuticaudatus, Dionide levigena, Ectillaenus perovalis, Ormathops llanvirnensis, Selenopeltis buchi macrophthalamus and Ampyx linleyensis. Fortey & Owens (in press) have also recorded Ellipsotaphrus monophthalmus Klouček above and below the Llanvirn boundary at Llanfallteg, and have described three new cyclopygids that occur within the Llanvirn part of the Llanfallteg Formation, and which range down into the Arenig elsewhere in the region; Novakella copei and Microparia (Microparia) tretis, which occur below the boundary at locality 25 and Microparia (Microparia) porrecta which ranges down into the Bergamia rushtoni Biozone. Microparia broeggeri is also known from the Upper Fenni Formation; Bergamia fenniensis Biozone, but is not recorded below the Llanvirn boundary at Llanfallteg. As it is widespread in the artus Biozone of the Llanfallteg district, this probably is due to collecting failure. Segmentagnostus scoltonensis is recorded below the boundary at locality 26 (Owens pers. comm.) and from the artus Biozone at Scolton (Whittard 1966: 266 Pl. 46, Figs. 3,4).

At Shelve, only four Llanvirn species and sub-species range down into the Upper Arenig; P. (Placoparia) cambrensis cambrensis, Pricyclopyge binodosa binodosa, P. prisca Barrande and Selenopeltis buchi macrophthalmus. P. prisca has not been recorded from South Wales.

A number of localities to the east of Llanfallteg that yield faunas indicative of the artus Biozone are both lithologically and faunally distinct from the Llanfalltèg Formation and represent horizons higher in the sequence. Their transition into the typical light coloured shales of the Llanfallteg Formation can be seen in the type area and further east near St. Clears and at Llangynog.

The following species and subspecies occur, that are not known from the Llanvirn part of the Llanfallteg Formation:- Ogyginus corndensis, Ogyginus aff. porcatus, Ogygiocaris seavilli?, Cnemidopyge pentirvinense, Platycalymene tasgarensis tasgarensis, and Platycalymene tasgarensis simulata. At Shelve, Ogygiocaris seavilli and Cnemidopyge pentirvinense are also characteristic of the upper part of the artus Biozone, occuring most commonly within the shales interbedded in the Stapeley Volcanic Group, and they may prove to be useful subzone indicies. Uncharacteristic of their occurrence elsewhere in the Anglo-Welsh province, P. t. tasgarensis and P. t. simulata occur in arenaceous facies in South Wales, where P. t. simulata has a more extensive stratigraphic range than at Builth, occurring within the Lower Llanvirn near Carmarthen and in the Llandeilo at Whitland and Abereiddy.

In common with the Upper Llanvirn elsewhere in Britain, the trilobite fauna of the murchisoni Biozone in South Wales is restricted, and consists of: Ogygiocarella debuchi, Ogyginus corndensis, Pricyclopyge binodosa binodosa, Degamella sp., Protolloydolithus ramsayi, Protolloydolithus sp., cf. Bettonia sp.Platycalymene cf.duplicata, Platycalymene sp., Placoparia sp. and Cnemidopyge tenuis. Incaia Whittard (1955)may also be present. A small number of additional generically indeterminate trilobites are recorded from Tower Hill, Fishguard by Reed (1895, eg. SM.A44541, A44547).

If the trilobite fauna of the Great Paxton borehole (Rushton & Hughes 1981) is of Upper Llanvirn age as suggested by Jenkins (1983), the occurrence there of Protolloydolithus, Platycalymene and Pricyclopyge in association with raphiophorids is noteworthy, as these taxa persist into the Upper Llanvirn in South Wales, but are not known from the Upper Llanvirn in Shropshire.

Hicks (1875) recorded P. ramsayi, Neseuretus murchisoni, cyclopygids and asaphids from the Upper Llanvirn of Abereiddy Bay. No specimens to confirm these records have been traced, and Thomas et al. (1984) have regarded them as doubtful, because both of the named species were previously known only from the Lower Llanvirn elsewhere. P. ramsayi, however, ranges up into the murchisoni Biozone near Carmarthen, and is present in the Caerhys shales at Abereiddy, and both cyclopygids and asaphids do occur in the Upper Llanvirn for example at Llan Mill, Narberth. Hicks' records may, therefore, prove to be correct. The records of Trinucleus cf. lloydi and Trinucleus sp. from Llan Mill (Strahan et al. 1914: 24, 27) have not been substantiated during this research.

The Upper Llanvirn-Llandeilo boundary remains problematical in South Wales. Rich Upper Llanvirn ostracod faunas from Llan Mill have not provided any species of zonal value, and trilobites may prove to be the most sensitive indicies. At Narberth and at Pengwern Wood near Llan-dissilio the Llanvirn-Llandeilo junction is richly fossil-iferous and is demarked by contrasts in lithology and faunas that endorse the unconformable relationship suggested by Strahan et al. (1914) and Addison (see Basset et al. 1982) although the hiatus at Llan Mill may be considerably shorter than previously estimated. Elsewhere continuous sections from the Upper Llanvirn into the Llandeilo are either poorly fossiliferous or confused by complex structures, for example at Roch and Abereiddy Bay.

The Abergwili district of Carmarthen may provide useful continuous sections, although the Upper Llanvirn-Llandeilo junction is there similarly marked by a lithofacies change; the Upper Llanvirn being represented by a graptolitic facies, in which trilobites are rare, and the Llandeilo represented by a coarser and more arenitic facies. Marro-lithines, utilized to subdivide the Fairfach Group and the overlying Llandeilo in the type area, are strongly facies-controlled, and do not cross the Upper Llanvirn boundary elsewhere in Britain. Their potential usefulness at Abergwili is consequently doubtful. A continuous graptolitic sequence demonstrating the passage of the Murchisoni Biozone into the Glyptograptus teretiusculus Biozone has been recognised at Castle Point and Goodwick Bay near Fishguard (Cornelius pers. comm.) but trilobites are not yet recorded above the murchisoni Beds.

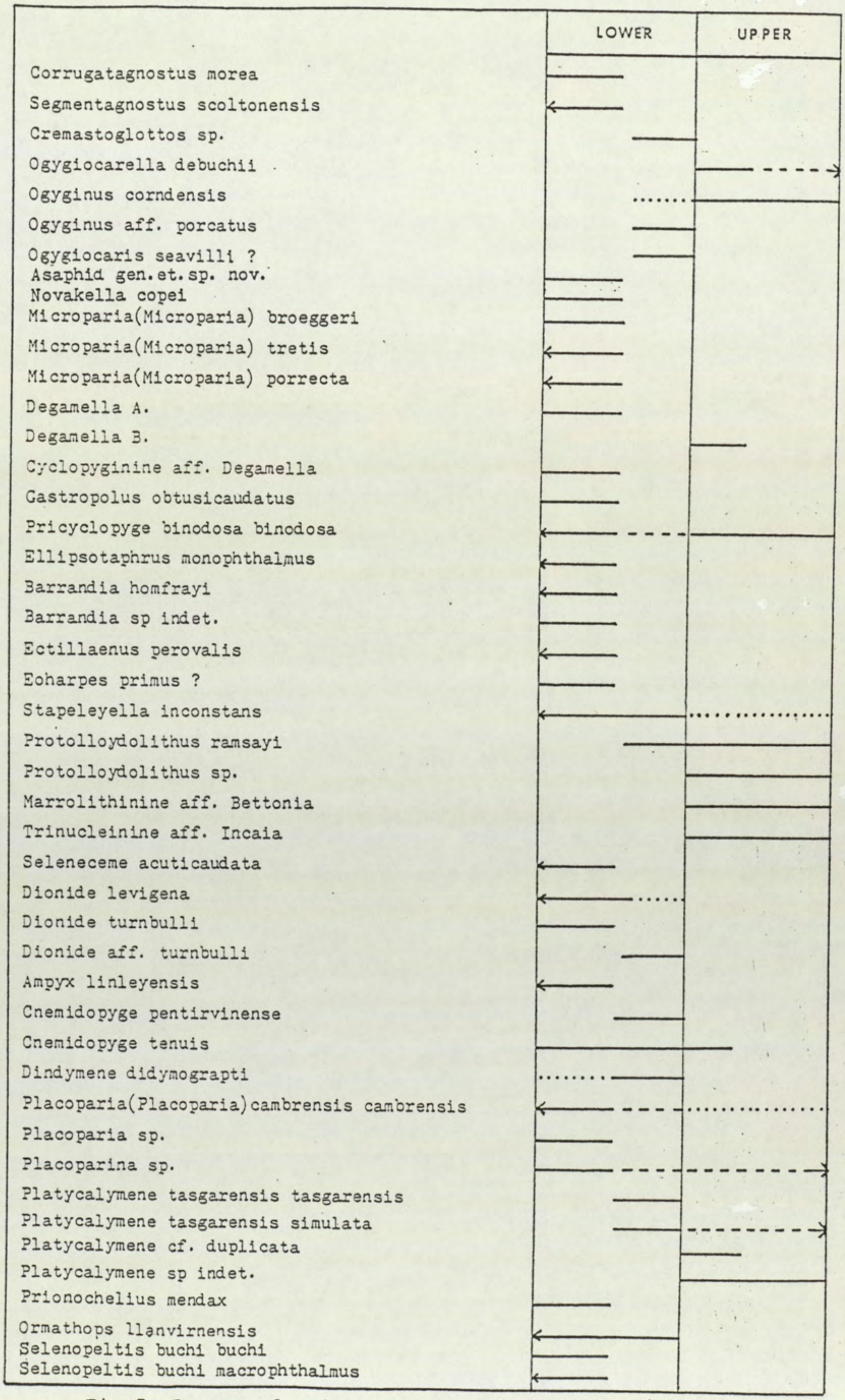


Fig.7. Ranges of trilobites in the Llanvirn in South Wales. Solid line- species present; dashed line- inferred existence, species not recorded, but occurence at younger or older horizon; dotted line- range implied by specimens of uncertain determination.

4 LOCALITIES

The localities from which specimens have been collected are listed below. The information is presented in the following order: locality number, national grid reference, topographical location (based on Ordnance Survey 1:25000 Series), stratigraphical horizon and biozone where known, and reference to previous research where applicable.

CARMARTHEN AND LLANGYNOG

1 SN 3750 2080. Loose blocks in wooded hillside, 250 metres east of Ffynnon-y-saint; 2Km WNW of St David's Hospital, Carmarthen. Llanvirn Series; artus Biozone. (Probably locality 63 of Strahan et al. 1909.)

2 SN 3250 1488. Exposures in bed of westerly flowing tributary of Afon Cynin, 300 metres downstream of the junction of an unnamed tributary flowing from the north, and 300 metres north-west of Gelli Farm. Llanvirn Series; artus Biozone. (Cantrill & Thomas 1906: 230, locality 93 of Strahan et al. 1909.)

3 SN 3238 1478. As for loc 2. but 420 metres downstream of the junction of the tributary flowing from the north. Horizon as for Locality 2.

4 SN 3188 1346. Exposures in disused cart-track adjacent to minor road between Llanybri and Ty-rhos, 400 metres south west of Pentre-newydd. Llanfallteg Formation; artus Biozone (Cantrill & Thomas 1906: 230, probably locality 95 of Strahan et al. 1909).

5 SN 3470 1756. Exposures in bed and east bank of Nant Cwm-Crymlyn, 200 metres north-east of Panteg Farm. Llanvirn Series; artus Biozone. (Cantrill & Thomas 1906: 229; Strahan et al. 1909: 32).

6 SM 3493 2140. Exposures in footpath leading north-west from Merthyr village towards Cwmduhen Farm, at a point 375 metres north west of the village church, Llanvirn Series; artus Biozone. (Locality 67 of Strahan et al. 1909).

7 As above, but (I) 387 metres NW of the church. (II) 388 metres NW of the church. (III) 450 metres NW of the church. (IV) 520 metres NW of church at junction of footpath and minor road between Bryn-bedw and Blaen-y-cwm Horizon as for locality 6.

ST CLEARS DISTRICT

8 SN 2787 1553. Exposures in northerly trending lane, 115 metres west of The Croft, and 500 metres north west of the confluence of the Afon Taf and the Afon Cynin. Lower Llanvirn; artus Biozone. (Evans 1906: 614.)

9 SN 2835 1552. Exposure in Afon Cynin, in SW-NE trending section of river 300 metres WSW of Gwafi Farm, and 300 metres north of the confluence of the Afon Taf and the Afon Cynin. Horizon as for locality 8.

10 SN 3142 1588. Exposures in the bed and banks of Afon Cywyn, 400 metres south-east of Gilfach Farm. Lower Llanvirn; artus Biozone, possibly higher in the sequence than at locality 8.

11 SN 3003 1614. Temporary exposure 30 metres south of track leading

to Asgood Farm 2.4 Km east of St Clears. Horizon as for locality 8.

12 SN 3085 1545. Loose blocks from temporary trench 150 metres SSW of Dan-yr-allt, east bank of Afon Cywyn. Horizon as for locality 8.

13 SN 2405 1597. Exposures in farmyard at Clog-y-frân, I.I Km SSE of the railway bridge at Pont-y-Fenni, 3 Km east of Whitland. Horizon as for locality 8 (Evans 1906: 599, 615).

14 SN 2394 1613. Loose blocks on steep wooded slopes above flood plain on the eastern bank of the Afon Taf, 250 metres north west of Clog-y-frân Farm. Horizon as for locality 8.

15 SN 2670 1988. Exposures in bed of south easterly flowing tributary of Afon Cynin 180 metres south west of Castell-Mal Farm, (previously called Mellin-y-Castell; Evans 1906: 618) immediately south of the boundary fence. Llanvirn Series; artus Biozone, Llanfallteg Formation (locality 75 of Strahan et al. 1909).

16 As above, but exposures in bed and western bank of tributary 80 metres upstream of locality 15. Horizon as for locality 15.

17 SN 2705 2010. Loose blocks in wooded hillside on

eastern slopes of Cynin Valley, 200 metres east of Castell-Mal Farm. Llanvirn Series; artus Biozone. (Possibly locality 73 of Strahan et al. 1909.)

18 N 2693 2013. Exposures in east bank of Afon Cynin, 110 metres upstream of ford and 120 metres east of Castell-Mal Farm. Horizon as for locality 17.

NARBERTH, CRINLOW AND LAMPTER VELFREY

19 SN 1643 1465. Exposures on south side of Velfrey Road from Whitland to Lampeter Velfrey at a point 200 metres south-east of Tygwyn Farm. Upper Llanvirn; low murchisoni Biozone. (Probably locality 42 of Strahan et al. 1914; see Fig 2).

20 SN 1448 1424. Exposures behind new storage building at Bryn-glâs Farm, 460 metres east of the stream culvert at Llan-mill. Llandeilo Series; Bryn-glâs Beds.

21 SN 1390 1418. Exposures in north side of Velfrey Road, 150 metres west of the bridge at Llan Mill. Lanvirn Series, Low murchisoni Biozone? (Locality 48 of Strahan et al. 1914.)

22 SN 1580 1425. Exposures in laneside and immediately adjacent in the bed of an unnamed northerly flowing tributary of the Afon marlais 400 metres south-east of Lampeter Velfrey Church and 250 metres north of Gellyrenwyn Farm. Horizon as for locality 19

23 SN 1433 1418. Exposures in bed of north-westerly flowing tributary of Afon Marlais, and immediately adjacent in disused quarry on north bank of the stream, 100 metres WSW of Bryn-glâs Farm. Calcareous siltstones and limestones of probable Llandeilo age (Bryn-glâs Beds, locality 79 of Strahan *et al*. 1914.)

WHITLAND DISTRICT

24 SN 1942. Eastern end of cliff section on south bank of Afon Taf, 225 metres north-west of All-y-bailey, 400 metres WSW of Whitland Station. Llanvirn Series; *artus* Biozone. (Evans 1906: 161, locality 41 of Strahan *et al*. 1914.)

25 SN 1560 2015. Southern end of disused railway cutting at Llanfellteg village, east bank of the Afon Taf. Basal Llanvirn Series; *artus* Biozone. (Llanfellteg Formation candidate stratotype section; Rushton *et al*. 1979; Fortey & Owens, in press, Evans 1906: 616; locality 57 of Strahan *et al*. 1914.)

26 As above, at 60 metres north of culvert, at 72 metres north of the culvert, at 87 metres north of the culvert, at 123 metres north of the culvert. Topmost Arenig Series; *Dionide levigena* Biozone (Llanfellteg Formation).

27 SN 1676 1976. Exposures immediately behind Cefn-maen-llwyd farmhouse at Rhyd-y-wrach. Llanvirn Series; *artus* Biozone, Llanfellteg Formation. (Evans 1906: 616,

617, locality 50 of Strahan et al. 1914.)

28 As above; exposures immediately south and east of the barn, and in adjacent trackway leading to field south of the farmyard.

29 SN 1684 1959. Temporary exposure in drainage ditch in field 400 metres south-east of Cefn-maen-llwyd, east of the south-westerly flowing tributary of the Afon Taf. Horizon as for locality 27.

30 SN 1705 2037. Exposure in eastern side of lane leading from Penuchadre to Lan Farm, at a point 120 metres north west of the sharp bend in the lane, and 260 metres south east of Llan Farm. Late Arenig Series, precise horizon uncertain. Locality 28 of Strahan et al. 1914.

31 N 1673 1947. Exposures in bed and eastern bank of south-westerly flowing tributary of Afon Taf, 275 metres south of Rhyd-y-wrach. Llanvirn Series; artus Biozone Llanfallteg Formation. (Strahan et al. 1914: 28)

32 SN 1657 1934. As locality 31, but 400 metres WSW of Rhyd-y-wrach. Horizon as for locality 31.

33 SN 1660 1948. Exposures in Bodau Farm yard, 130 metres north of locality 32. Llanvirn Series; artus Biozone. Llanfallteg Formation (locality 52 of Strahan et al. 1914).

34 SN 1665 1900. Recently excavated pit at northern end of disused quarry, 125 metres south-east of Cefn-Farchen Farm. Llanvirn Series; artus Biozone. Llanfallteg Formation (locality 55 of Strahan et al. 1914).

35 SN 1625 1878. Exposures and loose blocks in disused railway cutting 500 metres south-west of Cefn-Farchen Farm. Llanvirn Series; artus Biozone. Llanfallteg Formation (probably locality 56 of Strahan et al. 1914).

36 SN 1600 2010. Exposures in farmyard at Llwyn-celyn, 400 metres north-east of Llanfallteg village. Llanvirn Series; artus Biozone. Llanfallteg Formation (locality 59 of Strahan et al. 1914).

37 SN 1428 1967. Exposure in north-easterly flowing tributary of Afon Rhyd-y-bennau at Pengwern Wood, 100 metres south-east of Pengwern Farm. Llanvirn Series; artus Biozone. (Locality 63 of Strahan et al. 1914.)

38 SN 1427 1972. Temporary exposure in foundations of new silo building east of the farmyard at Pengwern Farm, 60 metres west of the spring. Arenaceous silts and sandstones of probable Llandeilo age.

39 SN 1360 2195. Exposures in farmyard at Dyffryntogyn, 1 km ENE of Cwrt. Llanfallteg Formation; precise horizon unknown. (Locality 67 of Strahan et al. 1914.)

40 SN 1274 2147. Exposure in lane leading from Llandissilio

to Cwrt, at a point opposite the lane leading south to Brynaeron. Llanvirn Series; artus Biozone. (Locality 65 of Strahan et al. 1914.)

41 SN 1284 2144. Exposure in laneside and adjacent bed of Afon rhyd-bennau, 100 metres ESE of locality 40. Llanvirn Series; artus Biozone.

42 SN 1270 2196. Temporary trench 130 metres south of Pontybrenddu Cottage, immediately opposite sharp westerly bend in footpath leading from Pontbren-ddu to Llandissilio. Llanvirn Series; artus Biozone.

43 SN 1092 2184. Exposure in south bank of Eastern Cleddau, 50 metres downstream of the sharp westerly bend in the river at Castell Gwyn. Llanvirn Series; artus Biozone.

44 SN 1087 2178. Exposure in trackway above steep wooded slope on south side of Eastern Cleddau, 100 metres south of locality 43, and 75 metres west of Castell Gwyn. Llanvirn Series; artus Biozone. (Locality 68 of Strahan et al. 1914.)

45 SN 1323 2080. Exposures in Afon Rhyd-y-bennau 150 metres north-east of Gilfachwen Farm at the point where the cattle track crosses the stream. Horizon uncertain; possibly late Arenig (Pontifenni Formation?).

46 As above, but (i) 10 metres upstream of the crossing

point. (ii) 14 metres upstream of the crossing point. (iii) 22 metres upstream of the crossing point. (iv) 70 metres upstream of the crossing point. (v) 250 metres upstream of the crossing point, and 110 metres south of the ruin of Rhyd-y-bennau cottage. Horizon as for locality 45.

47 SN 1437 2028. Exposures in Afon Rhyd-y-bennau and on adjacent wooded hillslope, south west flank of Teg-fynyydd, 250 metres south-east of College Cottage. Llanvirn Series; artus Biozone.

48 SN 1148 2163. Exposure immediately west of Pen-cnwc at 300 metre contour, 600 metres west of Llandissilio. Llanvirn Series artus Biozone. (Strahan et al. 1914: 29.)

49 SN 1162 2158 exposure in bed of south-westerly flowing tributary of Eastern Cleddau, 120 metres south-east of locality 48. Horizon as for locality 48.

50 SN 1118 2127. Exposure in bed of south westerly flowing tributary of Eastern Cleddau, 46 metres downstream of ford and 250 metres north-east of Hendre Farm. Llanvirn Series; artus Biozone.

51 SN 1104 2120. As locality 50, but 110 metres down-stream of ford due north of Hendre Farm. Horizon as for locality 50.

52 SN 1028 2125. Exposure in lane 250 metres north-west of Castell gwyn-isaf, and 45 metres west of the sharp bend in the lane. Llanvirn Series; artus Biozone (probably locality 69 of Strahan *et al*. 1914).

53 SN 0984 2124. Exposures immediately upstream of footbridge over the Eastern Cleddau at Glencleddau Farm. Llanvirn Series; artus Biozone. (Locality 72 of Strahan *et al*. 1914.)

54 SN 0988 2158. Exposure in north-south trending drainage ditch on western bank of Eastern Cleddau, 380 metres north-east of Glencleddau Farm. Horizon as for locality 53.

55 SN 0990 2164. As for locality 54, but 100 metres north. Horizon as for locality 53.

56 SN 0990 2170. Disused quarry on wooded hillside of Eastern Cleddau valley, 500 metres north of Glencleddau Farm. Horizon as for locality 53.

57 SN 0685 2205. Roadside quarry on east side of minor road leading from Claw green to Pen-ffordd, 150 metres south of culvert where road crosses Rhyd-y-brown brook. Llanvirn Series; artus Biozone. Llanfallteg Formation (locality 73 of Strahan *et al*. 1914).

58 SM 9912 2155. Exposures in northern side of railway

cutting immediately west of the roadbridge at Scolton, 500 metres west of Lower Haythog Farm. Llanvirn Series; artus Biozone.

59 As for locality 58, but continuous exposure approximately along strike, east of the roadbridge, on north side:-

(a) immediately east of bridge, 1.75 metres above ground level.

(b) 12 metres east of bridge, 2.0 metres above ground level.

(c) 45 metres east of bridge, 2.5 metres above ground level.

(d) 52 metres east of bridge, 40 cm above ground level.

(e) 200 metres east of bridge, 1.5 metres above ground level.

On south side:-

(f) 76 metres east of bridge.

(g) 140 metres east of bridge.

(h) 208 metres east of bridge.

Horizon as for locality 58. (Locality 74 of Strahan et al. 1914, "Long Plantation railway cutting" of Whittard 1955-67, pp. II, 39, 98, 136, 175, 181, 213, and Whittington 1952.)

60 SN 0080 2150 to 0090 2170. Continuous exposure, approximately perpendicular to strike, in east side of lane leading from opposite Penty-Park towards Selvedge Farm, at a point 10 metres south of Becon Hill Cottage, and north for 160 metres. Horizon as for locality 58.

61 SN 0070 2134. Exposure and loose blocks from cuvert excavation, immediately southeast of rail bridge, and north of old mill pond. Llanvirn Series; precise horizon uncertain, probably artus Biozone.

FISHGUARD DISTRICT

62 SM 9637 3687. Exposures in steep footpath leading to Blaen-dinan, eastern flank of Tower Hill, south bank of Aber Gwaun, Lower Fishguard. Llanvirn Series; murchisoni Biozone.

63 SM 9626 3692. Stream section in the second northerly flowing tributary of the Afon Gwaun, south of the road bridge, eastern flank of Tower Hill. Horizon as for loc.62.

64 SM 9636 3688. Small disused quarry alongside footpath on south bank of Afon Gwaun, opposite derelict building,and 175 metres south of the road bridge. Horizon as for loc.62.

65 SM 9629 3690. Small disused quarry on the eastern flank of Tower Hill, above the footpath leading to Blaen-dinan, at approximately the 55 metre contour, Lower Fish-guard. Horizon as for loc. 62.

66 SM 9665 3683. Pathside exposure beneath pine tree roots, 200 metres southwest of the small footbridge over the Afon Gwaun at Pwl Dyfrig, and immediately downstream of the footbridge, south bank of the Afon Gwaun, Lower Fishguard. Llanvirn Series, possibly lower in the murchisoni Biozone than at loc.62.

67 SM 9492 3688. Roadside exposure on south side of the minor road south of Bigney Hill, leading from Mill Farm to Maes-gwynne, Llanvirn Series; murchisoni Biozone (?).

68 SM 9483 3358. Pant-y-Phillip quarry, 0.7 km south of Scleddau, east side of main A40 (T), 3 km south of Fishguard. Exposures in upper level of quarry, approximately 60 metres south of the base of the scree slope at the northern end of the quarry, and exposures in the lower level, 150 metres east of the main quarry entrance. Upper Arenig Series; hirundo Biozone of Elles (1904).

ST EDRINS DISTRICT

69 SM 8878 2870. Disused quarry 250 metres west of Treggiog-Fawr Farm and 150 metres south-west of Trehale Lodge. Pyroclastic tuffs of probable early Arenig (Moridunian) age. (Williams 1934: 56; see Fig 3.)

70 SM 9265 2883. Disused quarry of south side of path leading north from Ty-newydd grûg Farm to Priskilly Forest, and exposures immediately adjacent in easterly flowing tributary of the Western Cleddau at Coed Ty-newydd grûg. Llanvirn Series: artus Biozone? (Williams. TG 1934,: 57); Coed-bach Slates of Williams T G: 1932 (unpublished fig; PhD thesis, see Fig 4).

ROCH DISTRICT

71 SM 8755 2060. Loose blocks 300 metres north of Rain-

bolts Hill Farm, and 130 metres west of the main A487; Haverfordwest to St Davids road, 0.3 km south of Roch. Llanvirn Series; beds attributed to topmost _artus_ Biozone (locality 7 of Cantrill _et al_. 1916), but of probable _murchisoni_ age.

72 SM 8860 2060. Exposure in east-west trending drainage ditch, immediately south of conifer plantation, 750 metres west of Frogs Hole, Cuffern. Upper Llanvirn; low _murchisoni_ Biozone. (Probably locality 8 of Cantrill _et al_. 1916.)

73 SM 8860 2068. Exposure in easterly flowing tributary of Camrose Brook, 60 metres north of locality 72. Horizon as for locality 72.

74 SM 8876 2055. Exposure in north-south trending drainage ditch 130 metres ESE of locality 72. Horizon as for locality 71.

75 SM 8870 2066. Loose blocks in ploughed field 40 metres north of the confluence of two easterly flowing tributaries of Camrose Brook, 150 metres north east of locality 74. Upper Llanvirn; _murchisoni_ Biozone.

ABEREIDDY BAY

76 SM 7980 3070. Disused slate quarry immediately east of path leading from Llanfern-y-frân Farm to Abereiddy Bay. Lower Llanvirn; _artus_ Biozone, Aber-mawr Shales

(after Jenkins in Bassett et al. 1982); type locality of Biozone; Hicks 1881).

77 SM 7963 3085. Roadside exposure on minor road from Caerhys Farm to Abereiddy Bay. Upper Llanvirn; murchisoni Biozone, Caerhys Shales (after Jenkins in Bassett et al. 1982).

78 SM 7956 3144. Exposures in cliff immediately south east of the flooded central region of the disused slate quarry, at the northern end of Abereiddy Bay, in beds geometrically above the Castell Limestone. Llandeilo Series or basal Caradoc? gracilis Biozone? (see Black et al. 1971; 546-8).

79 SM 7965 3140. Exposures immediately beneath the Castell Limestone at the northern end of Abereiddy Bay. Llandeilo Series gracilis Biozone? (see Black et al. 1971: 546-8).

PRESCELLY HILLS

80 SN 1224 3740. Exposures on north west bank of Afon Nefern, 200 metres WSW of Pen-cnwc-bach Farm 1,2 km south west of Eglwyswrw. Upper Llanvirn; murchisoni Biozone (Evans 1945: 98).

81 SN 1655 3430. Exposures in Afon Whitehook at the ford 120 metres south west of Fron-las-isaf, 1.7 km west of Crymmych Arms. Horizon as for locality 80 (Evans

1945: 99).

82 SN 1775 3345. Exposures in steep pathway to unnamed northerly flowing tributary of the Afon Whitehook, 100 metres north east of Blaen-y-cwm, 600 metres south west of the church at Crymmych Arms. Horizon as for locality 80 (Evans 1945: 99).

83 SN 1460 3305. Loose scree on northern flanks of Carnmelyn, approximately 400 metres south of the source of the Afon Clyn-maen. Sandy shales and mudstones attributed to the Lower Llanvirn '<u>bifidus</u> Zone' by Evans (1945: 95).

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PLATE 1 Agnostidae, Olenidae.

Segmentagnostus mccoyii (Salter in Murchison, 1854)...........31
Early Arenig (Moridunian Stage?), locality 69.

1. 69.03 .Almost complete exoskeleton. X5
2. 69.01a Complete exoskeleton. X6
3. 69.02 Cephalon and thorax of sagitally distorted specimen. X9

Segmentagnostus aff. mccoyii (Salter in Murchison 1854).......33
Llandeilo Series?, locality 78.

4. 78.06 Cephalon. X6

Leignostus cf. bohemicus (Novak 1918)..........................37
Early Arenig (Moridunian Stage?), locality 69.

5. 69.148 Almost complete exoskeleton. X4

Corrugatagnostus morea (Salter 1864)...........................35
Lower Llanvirn; artus Biozone.

6. 59.15 Pygidium. X7. Llanfallteg Formation, locality 59.
7. Sh.01 Latex mould of pygidium. X6. Shelve Formation, Hope Shales, Whitsburn dingle, Leigh, Shropshire (SJ 3330 0255)

Porterfieldia cf. punctata (Crosfield & Skeat 1896)...........41
Early Arenig (Moridunian Stage?), locality 69.

8. 69.68 Cephalon with fused libriginae and hypostoma displaced backwards. X5
9. 69.88 Cranidium. Slightly oblique dorsal view. X5.5
10. 69.57 Complete exoskeleton with hypostoma impressed through glabella. X3.5
11. 69.149 Complete exoskeleton with fused librigenae and hypostoma displaced backwards. X3
12. 69.60 Complete exoskeleton. X4

PLATE 1

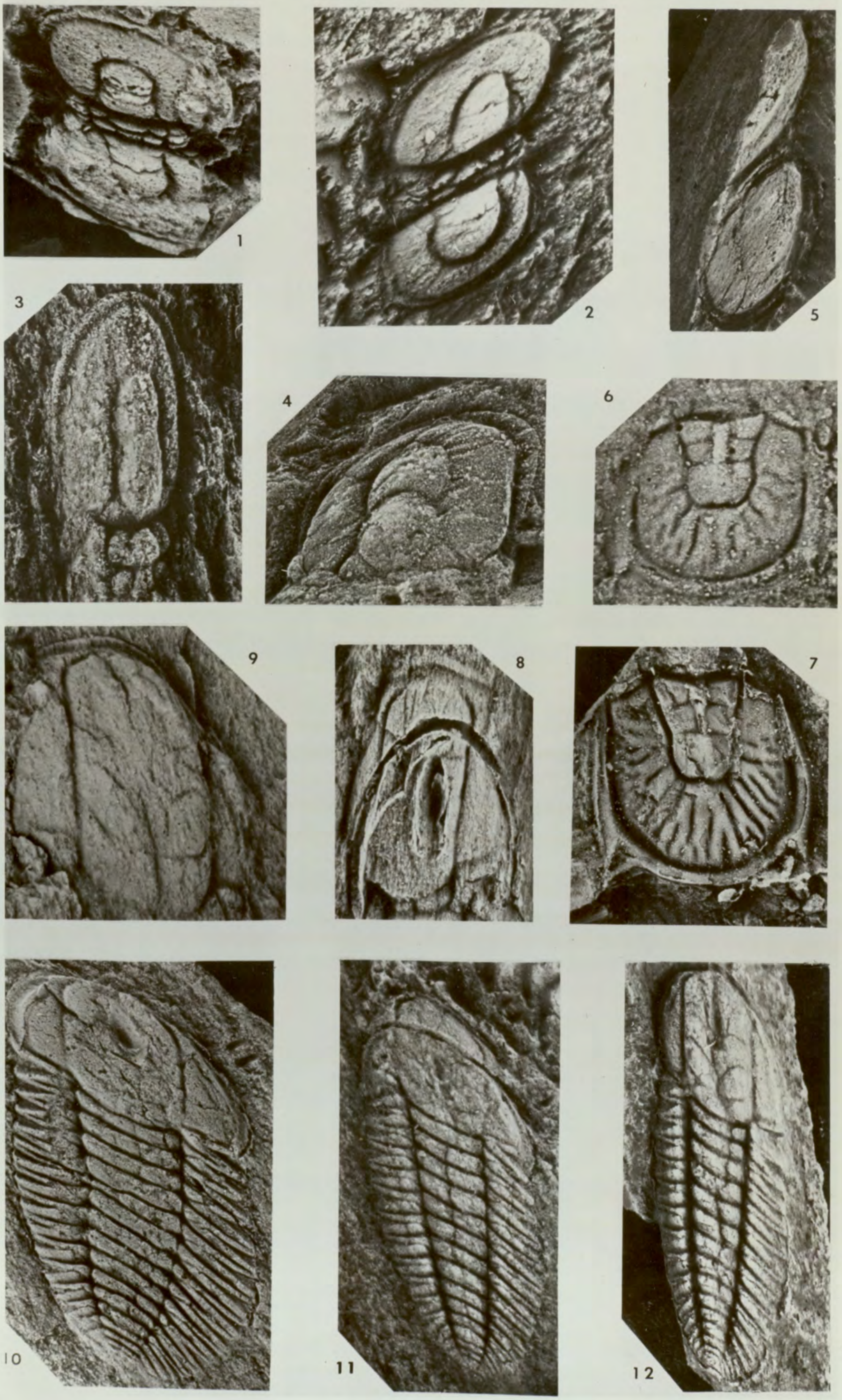


PLATE 2 Asaphidae, Olenidae, Remopleurididae

Merlinia contracta sp. nov. 54
Early Arenig (Moridunian Stage?), locality 69.

1. 69.102a Holotype, complete exoskeleton with posteriorly displaced hypostoma impressed through cranidium. X3.5
2. 69.103a Paratype: holaspis; almost complete exoskeleton, lacking librigenae. X5.5
3. 69.107 Paratype: librigena. X5.5
4. 69.101 Paratype: fragment of right pygidial pleural field and border. X2.5
5. 69.110 Paratype: cranidium. X2
6. 69.106 Paratype: cephalon and fragmentary thorax. hypostoma impressed through glabella. X3.5
7. 69.104 Paratype: pygidium and six thoracic segments. X1.5
8. 69.134 Paratype: cephalon and thorax of miraspid of at least degree 5. X10
9. 69.150 Paratype: miraspid of degree 1; complete exoskeleton. X12
10. 69.151 Paratype: miraspid of degree 2; complete exoskeleton. X18

Cremastoglottos occipitalis Whittard 1961...................48
Lower Llanvirn, Hope Shales artus Biozone, 130 metres south of the culvert at Overton's Rough, Leigh, Shropshire (SJ. 3320 0285)

11. Sh.04 Thorax and pygidium and external mould of cranidium inverted and displaced backwards. X5

Olenid gen et sp indet. 45
Early Arenig (Moridunian Stage?), locality 69.

12. 69.98 Complete exoskeleton with ill-preserved cranidium. X6.5

Porterfieldia cf. punctata (Crosfield & Skeat 1896).........41
Early Arenig (Moridunian Stage?), locality 69.

13. 69.87 Latex mould of cranidium. X4.5

Cremastoglottos sp. 45
Lower Llanvirn; artus Biozone, 200 yards WSW of Wern-ddu, 1½ miles south west of Llanllwch, Carmarthenshire.

14. BGS. TCC. 358. Latex mould of pygidium and two (?) thoracic segments. X15

PLATE 2

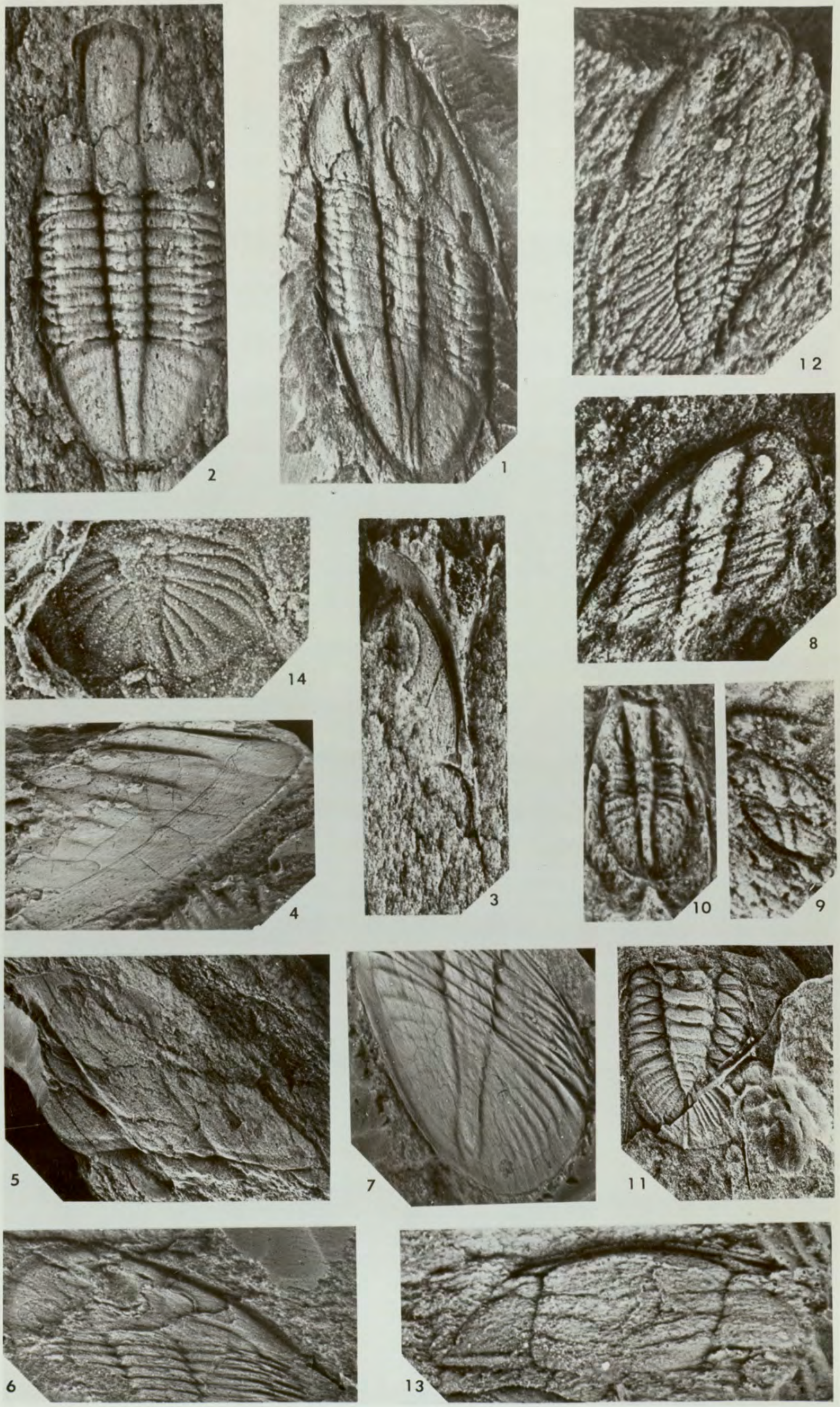


PLATE 3 Asaphidae

Merlinia contracta sp. nov. 54
Early Arenig (Moridunian Stage?), locality 69.

1. 69.136a Meraspid of degree 5; complete exoskeleton. X10
2. 69.135 Meraspid of degree 3 or 4; complete exoskeleton. X12
3. 69.132 Latex mould of miraspid of degree 5; complete exoskeleton; right librigena displaced and inverted. X5.5
4. 69.131 Meraspid of degree 6; almost complete exoskeleton lacking librigenae. X12
5. 69.105 Pygidium with doublure impressed onto dorsal surface. X1

Ogygiocarella debuchii ((Brongniart, 1822)..................62
Upper Llanvirn, low *murchisoni* Biozone.

6. BGS. Pr. 2730. Fragmentary cephalon and thorax. X1 Roadside exposures 120 yards west of the bridge at Llan Mill near Lampter Velfrey (locality 48 of Strahan *et al*. 1914, close to locality 21).
7. BGS. Pr. 2732. Pygidium. X1. Locality as for Fig 6.
8. 19.04b. Latex mould of fragmentary pygidium. X1.4. Locality 19.
9. 19.05. Latex mould of cranidium. X2. Locality 19.

Ogyginus corndensis (Murchison, 1839)......................70
Upper Llanvirn; *murchisoni* Biozone, locality 72.

10. 72.02. Pygidium. X2.3
11. 72.04. Pygidium. X1.4

Ogyginus corndensis?(Murchison 1839).......................70
Lower Llanvirn; *artus* Biozone, temporary exposure , 4.5 km west of Johnstown, Carmarthen.

12. C.07. Miraspid of degree 4; complete exoskeleton. X12.

Ogyginus aff. *porcatus* Whittard, 1964. 74
Locality and horizon as for Fig 12

13. C.06a. Fragmentary exoskeleton with genal spine *in situ*. X1

Ogygiocarella debuchii (Brongniart 1822)...................62
Llandeilo Series (?), locality 78.

14. 78.13. Latex mould of fragmentary pygidium. X1.4

PLATE 3

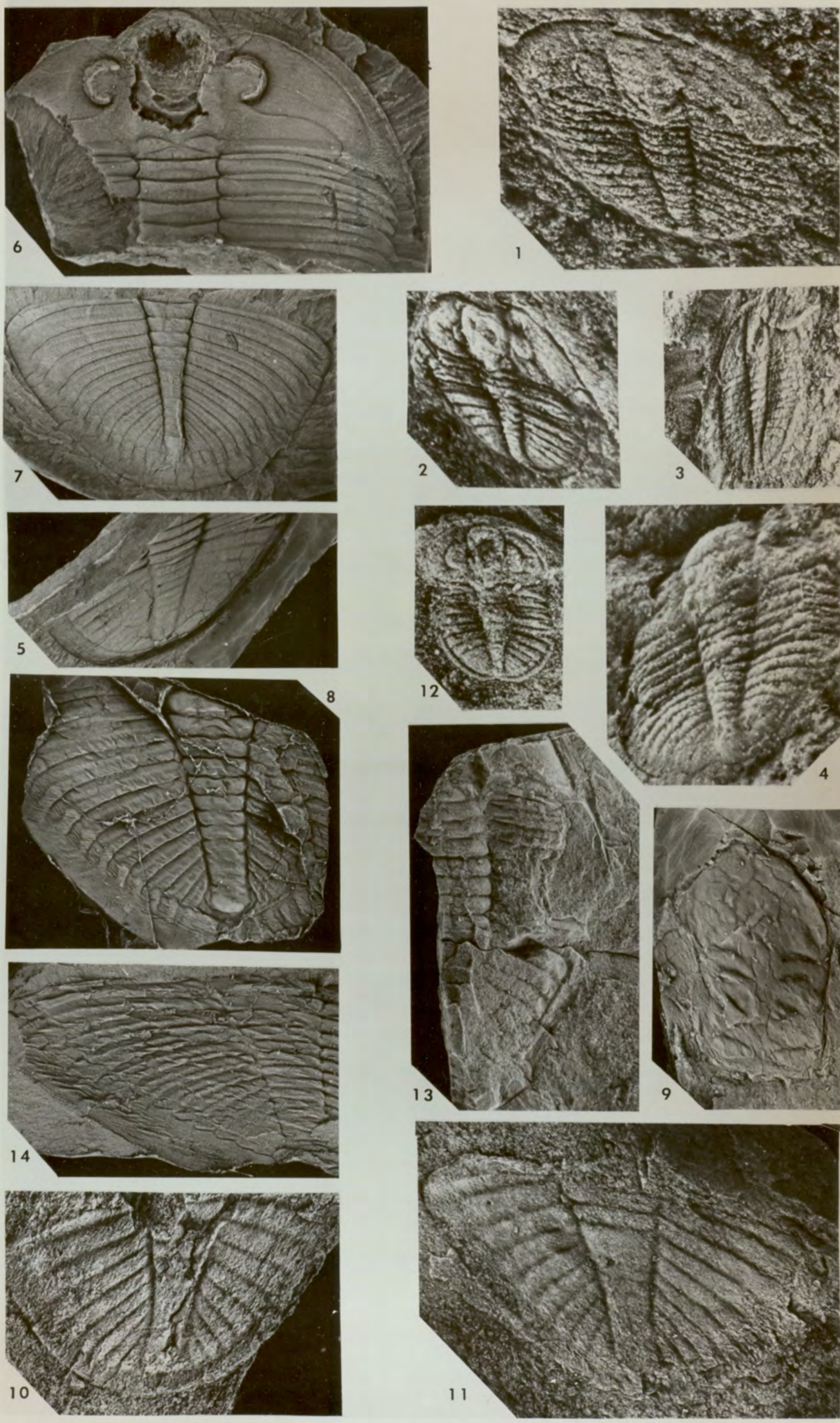


PLATE 4 Asaphidae; Nileidae

Asaphus tyrannus Murchison, 1839..............................50
Llandeilo Series, Bryn-glâs Beds, Llan Mill, Narberth.

1. NMW 33.189G.202. Almost complete exoskeleton. X1. Unlocalised specimen, probably from the Bryn glâs Beds, Lampter Velfrey (D C Evans Coll.)
2. 23.06b. Latex mould of almost complete immature exoskeleton. X2.5. Locality 23.
3. 23.06a. Internal mould of pygidium of same specimen. X3.75.

Ogyginus aff. porcatus Whittard 196 74
Lower Llanvirn; artus Biozone, temporary exposure 4.5 km west of Johnstown, Carmarthen.

4. C.06b. Detail of right genal spine. X3

Ogygiocarella debuchii (Brongniart 1822)...................62
Upper Llanvirn; low murchisoni Biozone, locality 19.

5. 19.02a. Pygidium. X1.5

Barrandia homfrayi Hicks 1875............................. 117

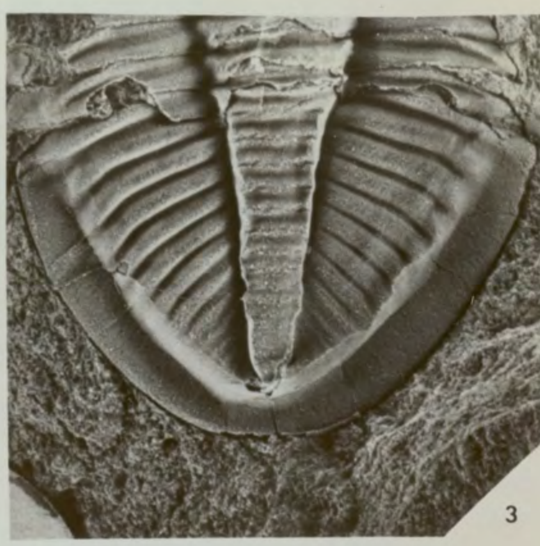
6. 47.02. Miraspid of degree 3; almost complete exoskeleton. X7.

7. SM A44510. Miraspid of degree 3; complete exoskeleton. X5.5 Long Plantation Railway Cutting, Scolton (close to localities 58 & 59; Turnbull Coll.).

8. SM A44536. Miraspid of degree 1; complete exoskeleton. X7. Locality as for Fig 7 (Turnbull Coll.).

1

2



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4

5

PLATE 5 Asaphidae, Nileidae

Asaphid gen et. sp. nov 75
Lower Llanvirn; artus Biozone.

1. 25.01 Latex mould of large cranidium. X0.6 Lowest artus Biozone, Llanfallteg Formation, locality 25.
2. 53.04a Large cranidium. X1. Locality 53.
3. 53.03 Pygidium and disarticulated thoracic segment. X1. Locality as for Fig 2.

Ogygiocaris seavilli Whittard, 1964.........................69
Lower Llanvirn; artus Biozone, locality 5.

4. 5.04 Almost complete exoskeleton. X2
5. 5.03b Latex mould of pygidium. X1.5

Barrandia homfrayi Hicks 1875 117
Lower Llanvirn; artus Biozone.

6. 27.49a Almost complete exoskeleton, lacking librigenae. X1. Locality 27.
7. 59.12a Disarticulated exoskeleton, probably representing a moulted exuviae. X1. Locality 59 (d).
8. BGS. Pr. 1997. Thorax and transitory pygidium. X6.5, Llanfallteg Formation, exposures behind cefn-maen-llwyd (locality 50 of Strahan et al 1914, probably locality 27 herein).
9. 28.05 Meraspid of degree 4; complete exoskeleton. X5.5, locality 28.
10. BGS. Pr. 1867. Latex mould of transitory pygidium and part of enrolled thorax. X6. Locality 53.
11. 53.15 Meraspid of degree 7. X5. Locality 53.

PLATE 5

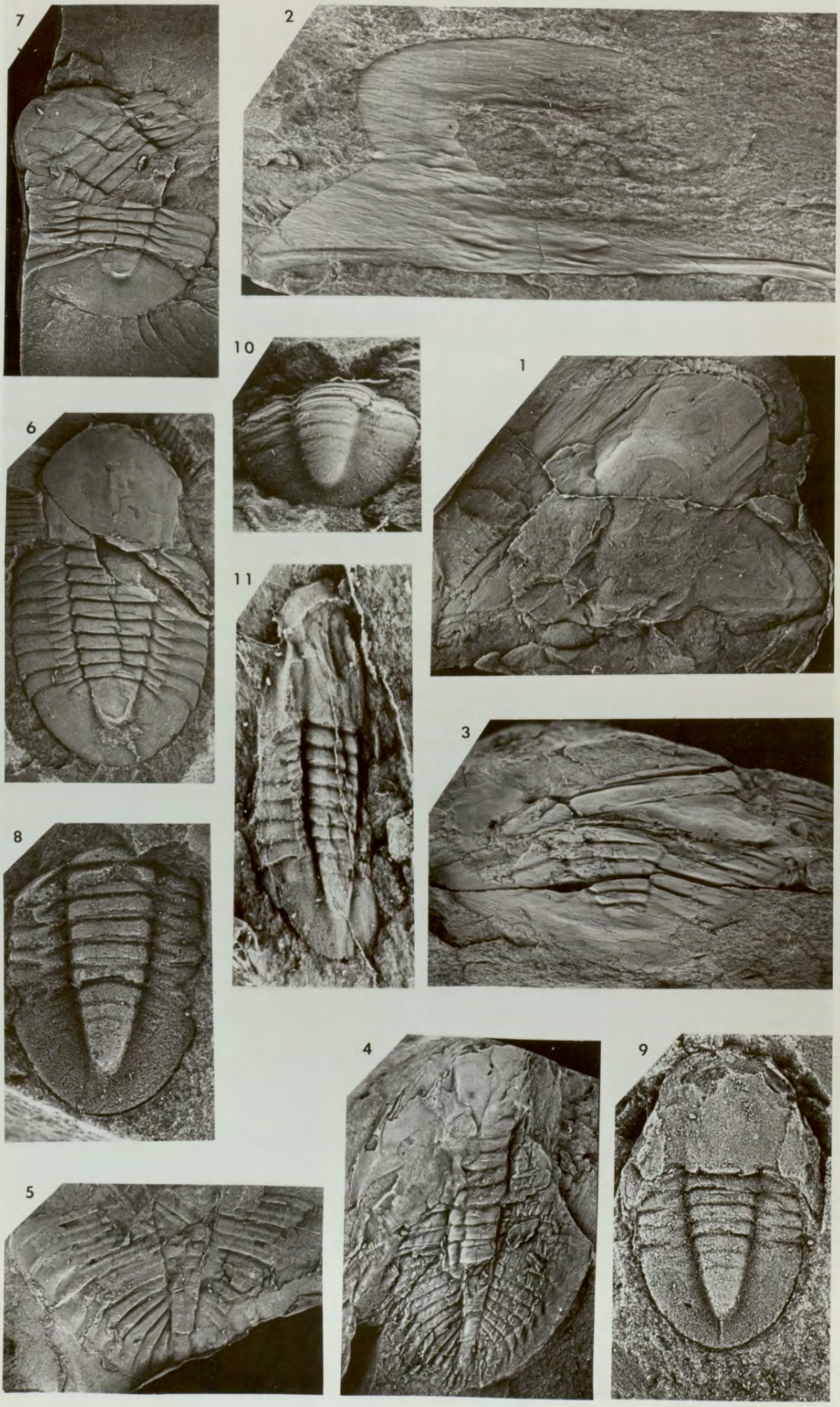


PLATE 6 Cyclopygidae

Gastropolus obtusicaudatus Hicks 1875.....................108
Lower Llanvirn; artus Biozone.

1. 27.06 Almost complete exoskeleton, with displaced optic surface. X2. Locality 27.
2a 34.01 Ventral side of flattened cephalon; oblique view showing the inner posterior rim of the optic surface. X1.5. Locality 34.
2b Same specimen, dorsal view. X1.5.
3. 27.07 Thorax and pygidium. X3. Locality 27.
4. 27.08 Fragmentary pygidium and four thoracic segments. X4. Locality 27.
5. 27.10a Pygidium. X2

Degamella gladiata sp. nov..................................92
Early Arenig (Moridunian Stage?), locality 69.

6. 69.26 Holotype: complete exoskeleton, with cephalon slightly displaced. X2.5
7. 69.06a Paratype; complete exoskeleton. X2
8. Same specimen; lateral view of cephalon. X3
9. 69.14 Paratype; pygidium. X2.5
10. 69.09 Paratype; detail of anterior margin of glabella with ventral doublure revealed by fracture. Dorsal view. X8
11. 69.07 Paratype; cephalon and four associated thoracic segments. X8
12. 69.05 Paratype; complete, transversely distorted exoskeleton. X4.5

Cyclopyge torquata sp. nov..................................79
Early Arenig (Moridunian Stage?), locality 69.

13. 69.28 Holotype; complete exoskeleton. X3.75
14. 69.29 Paratype; almost complete exoskeleton. X3
15. 69.39 Paratype; almost complete exoskeleton. X3

Cyclopyge cf. umbonata umbonata (Angelin 1854)............84
Upper Arenig hirundo Biozone, locality 68.

16. 68.01 Pygidium and five thoracic segments. X5.5

PLATE 6

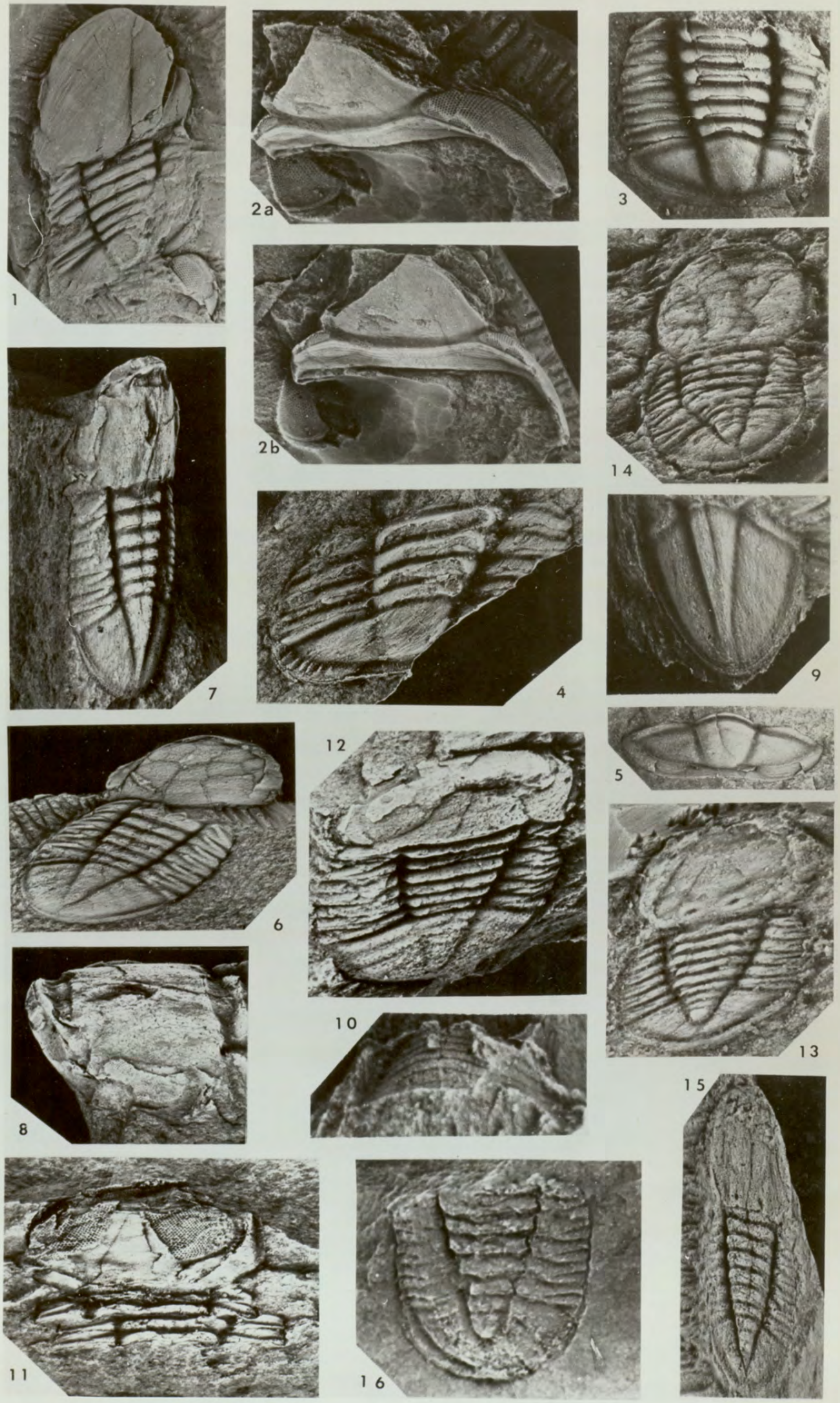


PLATE 7 Cyclopygidae

Cyclopyginine aff. Degamella 103
Lower Llanvirn; artus Biozone, Llanfallteg Formation.

1. 27.01a Cranidium and fragmentary thorax, and external mould of inverted and displaced pygidium. X1.2. Locality 27.
2. 27.01a Latex mould of pygidium. X2.5
3. 59.03 Fragmentary thorax and pygidium, showing paired organs on the third thoracic segment. X2.5. Locality 59.

Microparia (Microparia) broeggeri (Holub, 1912)............87
Lower Llanvirn, artus Biozone, Llanfallteg Formation.

4. 27.17 Latex mould of thorax and pygidium. X2. Locality 27.
5. 34.04 Thorax and pygidium. X3. Locality 34.

Pricyclopyge binodosa binodosa (Salter, 1859).............113

6. 62.01 Pygidium. X3. Upper Llanvirn; murchisoni Biozone, locality 62.
7. 27.04 Cranidium. X4. Lower Llanvirn; artus Biozone, locality 27.
8. 30.01 Latex mould of pygidium and thorax. X9. Upper Arenig?, locality 30.

Degamella A 98
Lower Llanvirn; artus Biozone, Llanfallteg Formation.

9. 58.02 Almost complete exoskeleton; pygidium and posterior thoracic segment displaced. X3.5. Locality 58.
10. Same specimen; detail of pygidium. X7
11. 27.14 Disarticulated pygidium and thorax. X3.5. Locality 27.

Degamella gladiata sp. nov.................................92
Early Arenig (Moridunian Stage?)
Locality 69.

12. 69.25 Paratype; distorted cranidium, showing detail of posterolateral rim of doublure. X6
13. 69.12 Paratype; cephalon with optic surface in situ, lateral view. X10

Degamella gladiata sp. nov.?...............................92
Lower Llanvirn; artus Biozone, Hope Shales, Overton's Rough, Leigh, Shropshire (SJ. 33250250).

14. Sh.04 Pygidium, with doublure impressed onto dorsal surface, and four thoracic segments. X3

PLATE 7

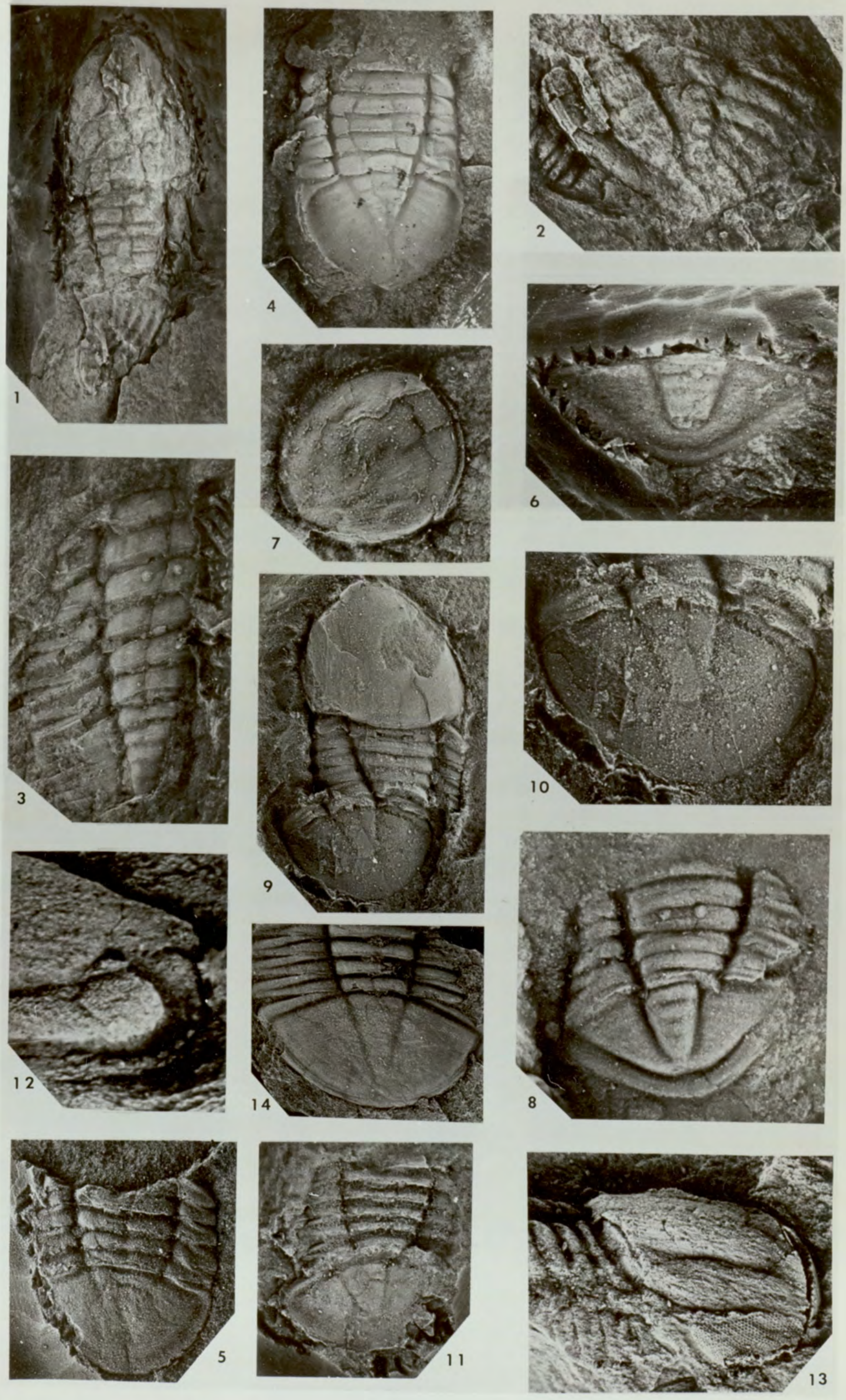


PLATE 8 Cyclopygidae Nileidae Illaenidae

Ectillaenus perovalis (Murchison, 1839)....................130
Lower Llanvirn; artus Biozone.

1. 53.11 Latex mould of complete exoskeleton. X2.5. Locality 53 (P J Lawrance Coll).
2. 27.38 Pygidium. X2.5. Locality 27.
3. 27.55b Latex mould of cephalic doublure and fragmentary hypostoma. Dorsal view. X3. Locality 27.

Nileid cf. Barrandia.....................................123
Upper Arenig hirundo Biozone, locality 68

4. 68.06a Thorax and pygidium. X3.5.
5. 68.07a Latex mould of thorax and pygidium with doublure impressed onto dorsal surface. X1.5
6. 68.05 Latex mould of almost complete exoskeleton lacking librigenae, and possibly representing a meraspid of at least degree 5. X3.5

Pricyclopyge binodosa binodosa (Salter 1859)..............113
Lower Llanvirn; artus Biozone. Locality 45.

7. 46.01 Pygidium. X5
8. 46.02 Pygidium and two thoracic segments. X5
9. SM. A44532. Ventral side of cephalon. X5.5 Long plantation railway cutting, Scolton (close to localities 58, 59; Turnbull Coll.).

Pricyclopyge binodosa binodosa?............................113
Upper Arenig; hirundo Biozone, locality 68.

10. 68.02 Thorax and pygidium. X5

Degamella B 101
Upper Llanvirn; low murchisoni Biozone.

11. SM.A44538a. Cranidium and four articulated thoracic segments. X6. Exposures 1,000 yds east of Lampter Velfrey Church (probably locality 19; Turnbull Coll.).
12. Latex mould of transitory pygidium and posterior thoracic segment associated with SM.A44538a.X7.5

Microparia (Microparia) broeggeri (Holub), 1912)...........87
Lower Llanvirn artus Biozone.

14. BGS. TCC. 889. Pygidium and three thoracic segments. X6. North side of Clog-y-frân farmyard.

? Barrandia sp. 125
Lower Llanvirn; artus Biozone, locality 60.

13. 60.09 Complete but distorted pygidium. X5

PLATE 8

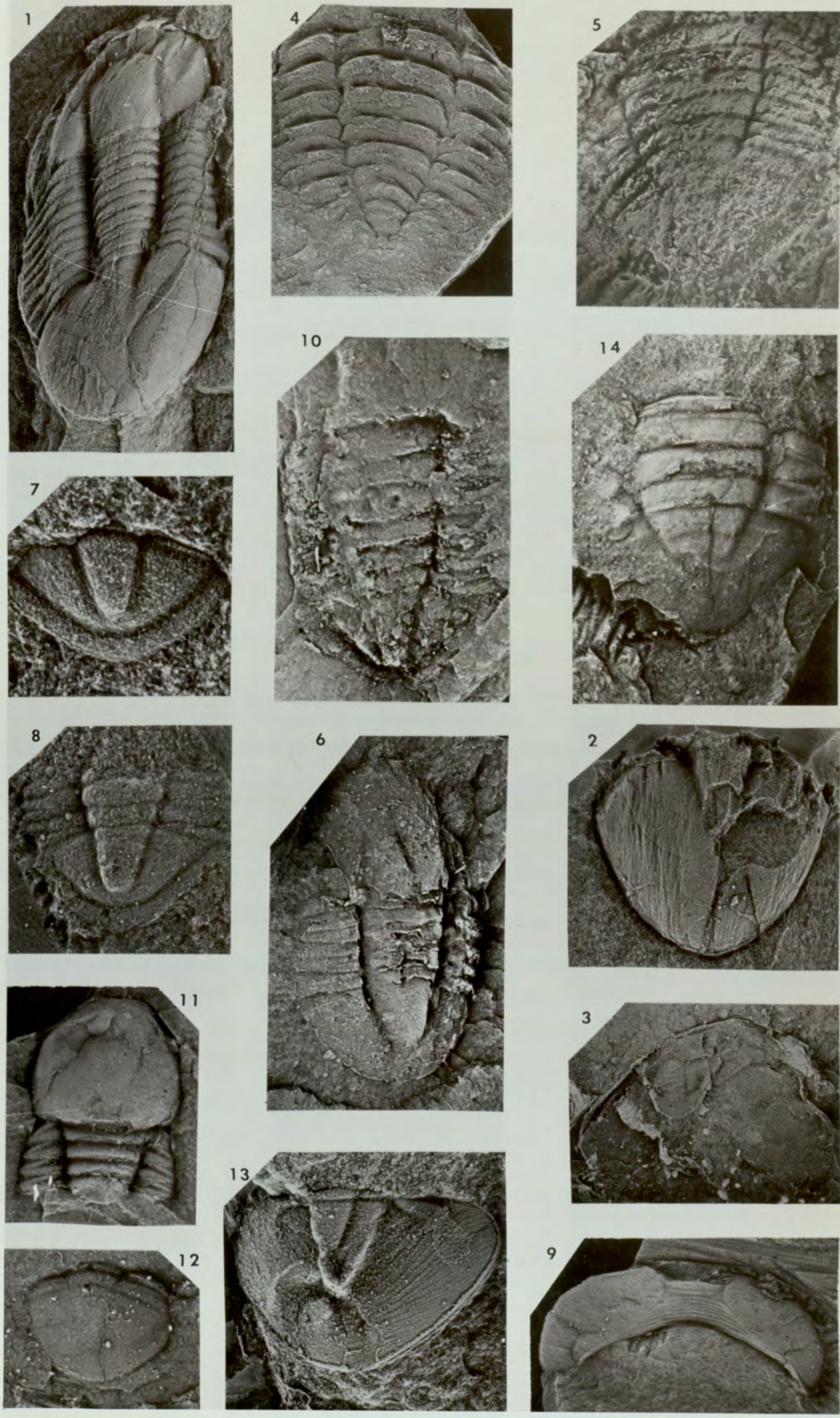


PLATE 9 Illaenidae, Harpedidae

Ectillaenus _perovalis_ Murchison 1839......................130
Lower Llanvirn; _artus_ Biozone.

1. SM A44560 Complete exoskeleton. X2.5. Long Plantation railway cutting, Scolton (probably close to localities 58 and 59, Turnbull Coll.).

2. Same specimen; detail of left librigena. X10
3. Same specimen; detail of left pleural lobe of thorax. X10
4. Same specimen; detail of pleural tip of anterior thoracic segment. X15
5. 34.09 Complete exoskeleton. X3.5.Locality 34.
6. 28.02 Complete exoskeleton. X3. Locality 28.
7. 29.05 Latex mould of almost complete exoskeleton. X5. Locality 29.
8. 53.12a Pygidium of transversely distorted specimen with doublure impressed onto dorsal surface. X3.25. Locality 53.

Eoharpes _primus_ (Barrande 1856)...........................137
Šárka Beds (Llanvirn), Osek, near Rokycany, western Bohemia.

9-10. BU. 379. Topotype; cephalon, dorsal and oblique anterodorsal views. X3.5.

Eoharpes _primus_? (Barrande 1856)..........................137
Lower Llanvirn; _artus_ Biozone. Locality 27.

11. 27.32 Latex mould of complete exoskeleton. X7.

PLATE 9

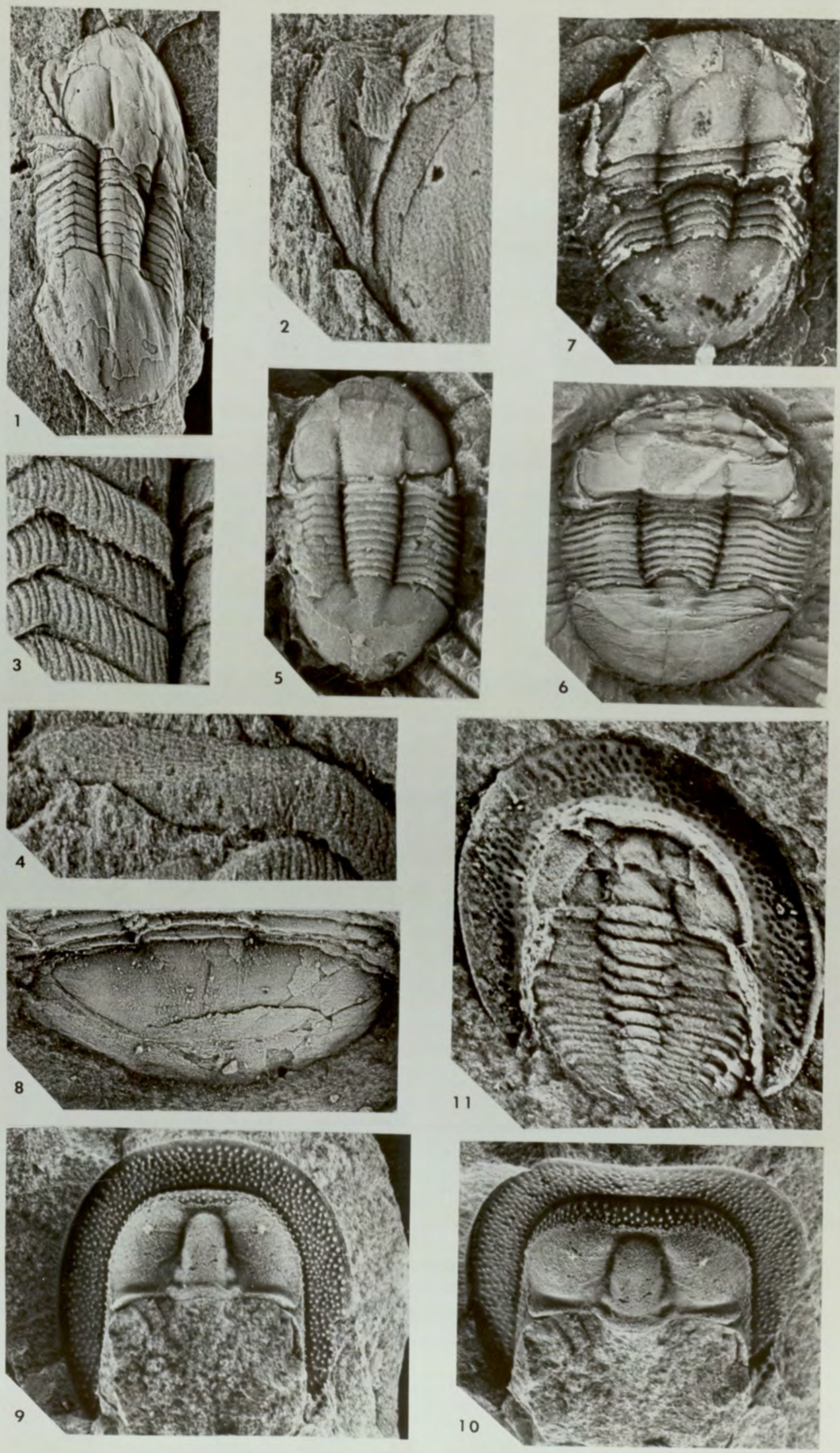


PLATE 10 Harpedidae, Dionididae, Altaspidae trinucleidae, Styginidae

Dionide levigena (Fortey & Owens, in press)..............160
Lower Llanvirn; artus Biozone.

1. NMW 85.26G1 Holotype; latex mould of almost complete exoskeleton in which the cephalon is displaced backwards over the anterior three thoracic segments. X9. Locality 27.

2. 25.01 Paratype; almost complete exoskeleton. X5.5. Lowest artus Biozone, locality 25.
3. 27.18 Paratype; cephalon and two fragmentary thorax segments. X10. Locality 27.

4. SM.A54144 Paratype. cephalon. X8. Scree at Llanvirn quarry, (locality 76): Coll. A W A Rushton, 1963.
5. BGS TCC. 454. Paratype; damaged complete exoskeleton. X6.5. Brook 350 yards northwest of Gelli, Llangynog district (close to locality 2).

Dionide aff. turnbulli Whittington 1952..................171
Lower Llanvirn; artus Biozone, locality 5.

6. 5.05a Fragmentary cephalon and thorax, with pygidium folded beneath. X5

Dionide sp.? 69
Early Arenig (Moridunian Stage?), locality 69.

7. 69.100 Almost complete exoskeleton. X6.5

Eoharpes primus? (Barrande, 1856).......................137
Lower Llanvirn; artus Biozone, locality 27

8. 27.33 Fragmentary fringe and thoracic segments. X10

Seleneceme acuticaudata (Hicks 1875)....................163

9. Sh.OB Thorax and pygidium. X4.5. Lower Llanvirn, Shelve Formation, Hope Shale Member; artus Biozone, 130 metres south of the culvert at Overton's Rough, Whitsburn dingle, Leigh, Shropshire (SJ.3320 0285).
10. 26.02a Crushed cranidium and fragmentary thorax. X2.5. Topmost Arenig, Whitlandian Stage, Llanfallteg Formation; Dionide levigena Biozone, locality 26.

Marrolithinine aff. Bettonia 161
Upper Llanvirn; murchisoni Biozone

11. 74.01 Almost complete cephalon. X6. Locality 74.
12. 72.01 Fragment of lower lamella of fringe; internal mould. X5. Locality 72.

Protostygina sp. 127
Early Arenig (Moridunian Stage?), locality 69.

13. 69.146 Complete exoskeleton. X12

PLATE 10

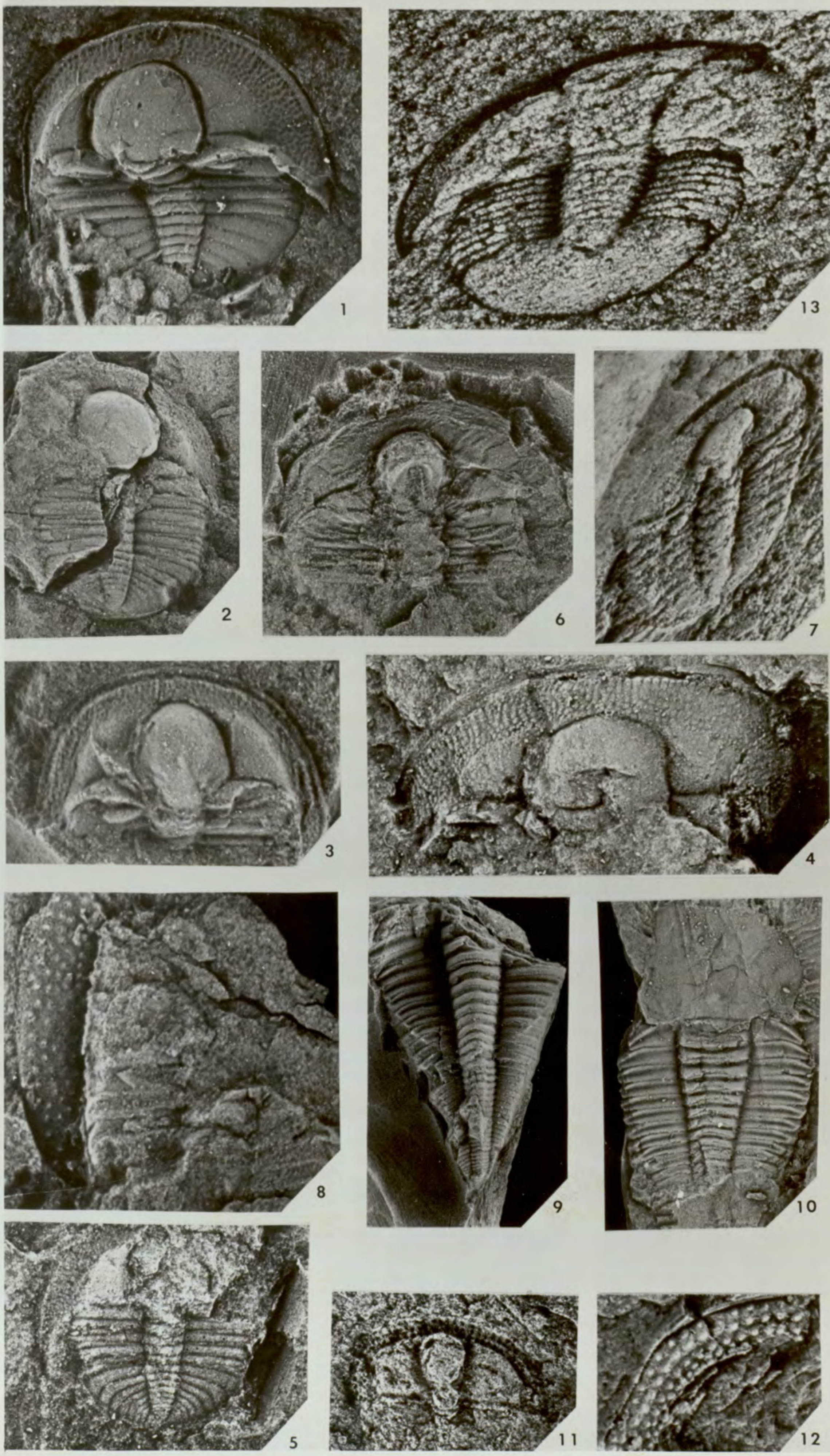


PLATE 11 Trinucleidae, Altaspidae

Furcalithus radix gen et sp. nov..........................145
(Fortey & Owens: in press)
Middle Arenig Whitlandian Stage; radix Biozone, 85 metres at 356 from the road bridge at Cwm-yr-Abbey (locality 16k of Fortey & Owens: in press).

1. BM. It.18949. Holotype; almost complete exoskeleton. X5

Furcalithus sp. indet....................................145
Early Arenig (Moridunian Stage?), locality 69.

2. 69.40 Latex mould of complete exoskeleton. X5
3. 69.43 Latex mould of cephalon and fragmentary thorax. X4
4. 69.51 Latex mould of complete exoskeleton. X7.
5. 69.48 Complete exoskeleton. X6.5
6. 69.37 Almost complete exoskeleton. X4
7. 69.49 Enrolled? exoskeleton with genal spines. X5
8. 69.36b Latex mould of complete exoskeleton. X6

Seleneceme acuticaudata (Hicks 1875).......................163
Lower Llanvirn; artus Biozone, Llanfallteg Formation, locality 58.

9. 58.03 Latex mould of cranidium and ill-preserved fragmentary thorax. X2.5

Protolloydolithus ramsayi Hicks 1875.......................158
Upper Llanvirn; murchisoni Biozone, Old Quarry at western end of Merlins Hill, 4 km east of Carmarthen.

10. BGS HT. 126. Two almost complete exoskeletons: one internal mould and one external mould. X3.75

Protolloydolithus sp.......................................161
Upper Llanvirn; murchisoni Biozone, Caerhys Shale, locality 77.

11. 77.01 Fragment of fringe; internal mould of lower lamella. X4.

Protolloydolithus ramsayi? (Hicks 1875)....................158
Upper Llanvirn; murchisoni Biozone.

12. SM.A86139a Latex mould of fragmentary fringe. X4. Murchisoni Ash quarry, south of Abereiddy Bay.

PLATE 11

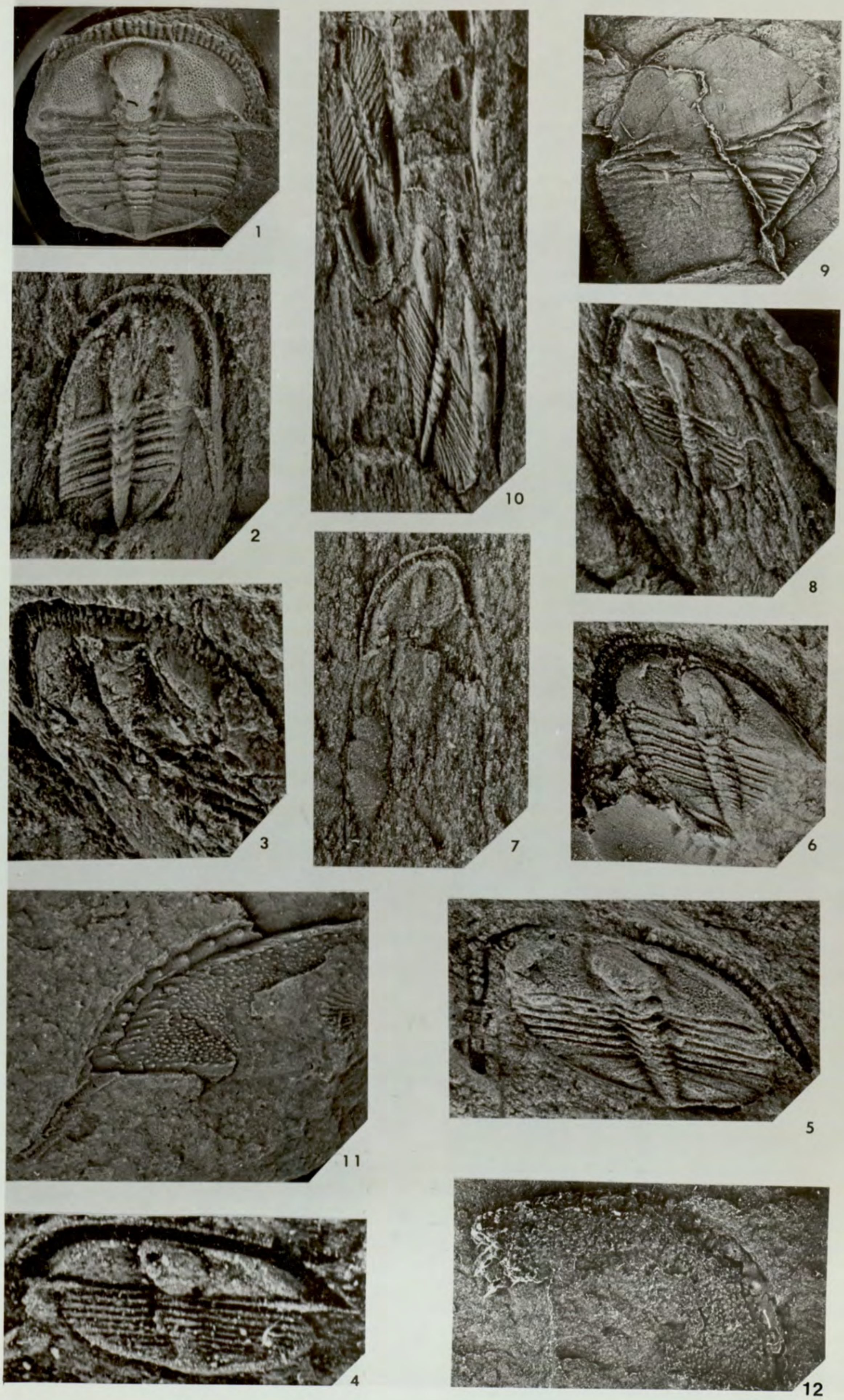


PLATE 12 Trinucleidae

Stapeleyella inconstans Whittard 1955........................149
Lower Llanvirn; artus Biozone.

1. 27.29a Two complete exoskeletons and a fragmentary fringe. X5. Locality 27.
2. SM.A41141 Almost complete exoskeleton. X6. Long plantation railway cutting, Scolton (close to localities 58 & 59; Turnbull Coll.).
3. 27.30 Latex mould of fragmentary fringe; ventral surface of lower lamella. X3. Locality 27.
4. 27.21 Damaged enrolled exoskeleton, showing details of both upper and lower fringe lamellae. X4.5. Locality 27.
5. 53.06a Fragmentary exoskeleton. X5.5. Locality 53.
6. 39.01 Latex mould of complete exoskeleton. X3. Llanfallteg Formation; precise horizon unknown, locality 39.

Stapeleyella inconstans Whittard 1955........................149
Upper Llanvirn; murchisoni Biozone (?); west side of old harbour at Fishguard, north of main road, first outcrop on north side of first gulley.

7. SM. A866598. Fragmentary fringe. X10.

Trinucleus cf. fimbriatus Murchison 1839..................142
Llandeilo Series?, locality 78.

8. 78.02a Almost complete exoskeleton, lacking fringe. X3.5
9. 78.04 Fragmentary cephalon showing details of lower lamella of fringe. X4.5
10. 78.03 Cephalon with details of upper and lower fringe lamella. X4.5

Trinucleine aff. Incaia Whittard 1955.....................162
Upper Llanvirn; murchisoni Biozone, 850 yards west of Frogs Hole, south of Cuffern, Roch district.

11. BGS JM678a. Almost complete exoskeleton. X4.5

PLATE 12

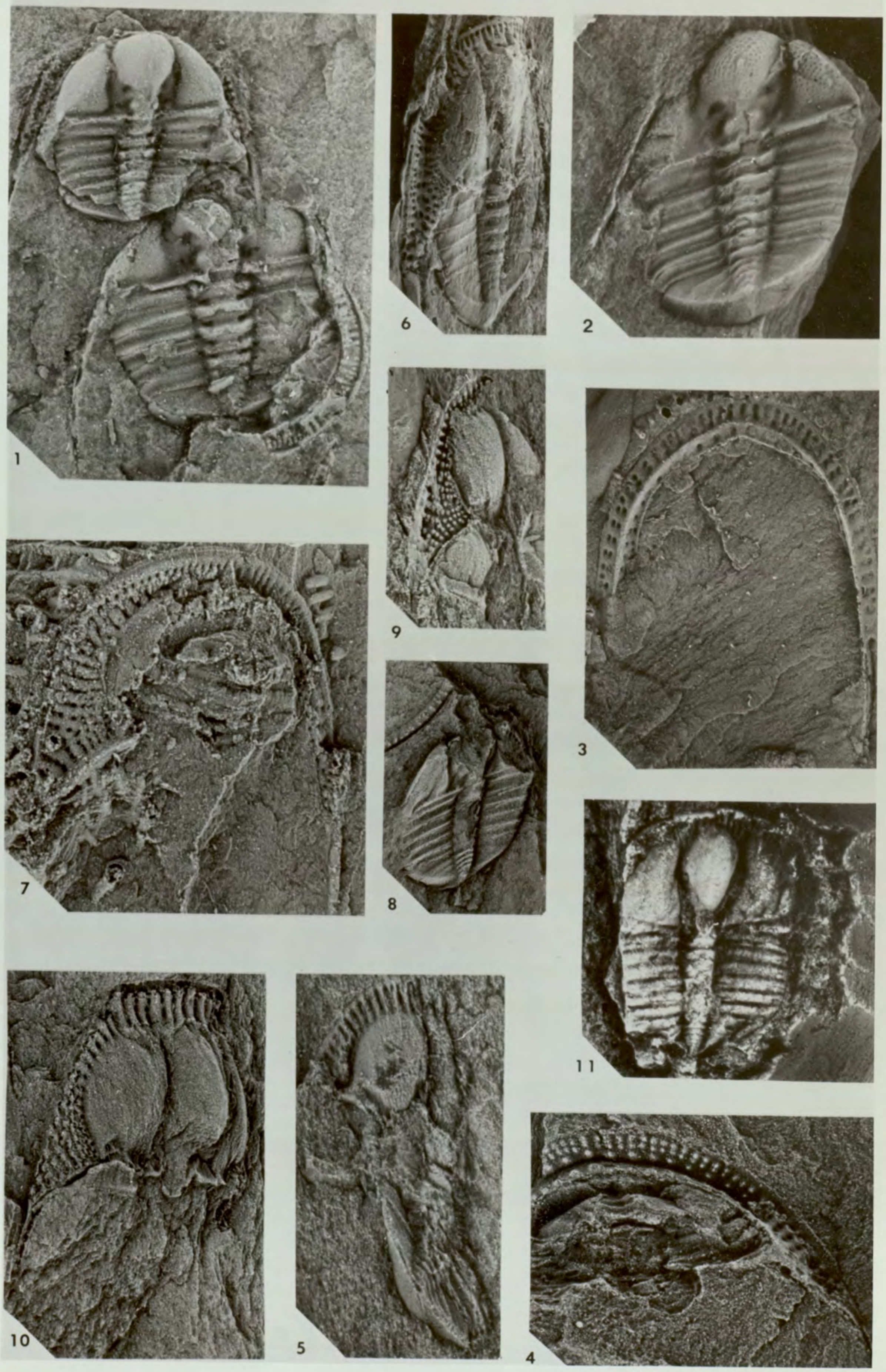


PLATE 13 Raphiophoridae

Cnemidopyge tenuis sp. nov. 183

1. SM A45400a Holotype; almost complete exoskeleton, lacking librigenae. X3. Upper Llanvirn; low *murchisoni* Biozone, roadside about 1000 yards east of Lampeter Velfrey Church (probably locality 19; Turnbull Coll.).
2. SM A45257a Paratype; almost complete exoskeleton, lacking librigenae. X2. Lower Llanvirn; *artus* Biozone, Long plantation railway cutting, Scolton (close to localities 58 & 59; Turnbull Coll.).
3. BGS TCC 862. Paratype; latex mould of almost complete exoskeleton, lacking librigenae. X3.5. Quarry 400 yards SE of Clog-y-frân farm (close to locality 14); Lower Llanvirn, *artus* Biozone.
4. BGS. Jp. 4795. Paratype; almost complete exoskeleton. X2.5. Lower Llanvirn *artus* Biozone, Llanfallteg Formation, lane 500 yards south west of Cwm Farm, Merthyr. (locality 67 of Strahan *et al* 1909)
5. SM. A45228 Paratype; pygidium. X4. Horizon and locality as for Fig 1 (Turnbull Coll.).

Cnemidopyge pentirvinense sp. nov. 180

6. BR. 18484. Holotype; almost complete exoskeleton, lacking librigenae. Lower Llanvirn, Shelve Formation, shales interbedded in the Stapeley Volcanic Group; *artus* Biozone, Whitsburn Dingle, 650 yards W, 11° S. of Lords Stone, Leigh, Shropshire.
7. 9.02 Paratype; almost complete exoskeleton, lacking librigenae. X2. Lower Llanvirn; *artus* Biozone, loose scree at locality 9.

Cnemidopyge aff. *pentirvinense* sp. nov.

8. BGS Pr 1724. Thorax and pygidium. X2.5. Shales attributed to the 'highest *bifidus* shales' (Thomas *in* Strahan *et al*. 1914: 29; locality 63) near the spring at Pengwern Wood (close to locality 37 here).

Ampyx aff. *linleyoides* sp. nov. 177
(Fortey & Owens, in press).
Lower Llanvirn; *artus* Biozone, Long plantation railway cutting, Scolton (close to localities 58 & 59, Turnbull Coll.).

9. SM. A45258 Cranidium and two fragmentary thoracic segments. X2.5

Cnemidopyge cf. *parva* Hughes 1969 186
Llandeilo Series?, locality 78.

10. 78.11 Pygidium and three disarticulated thoracic segments. X3
11. 78.20 Almost complete pygidium. X4

PLATE 13

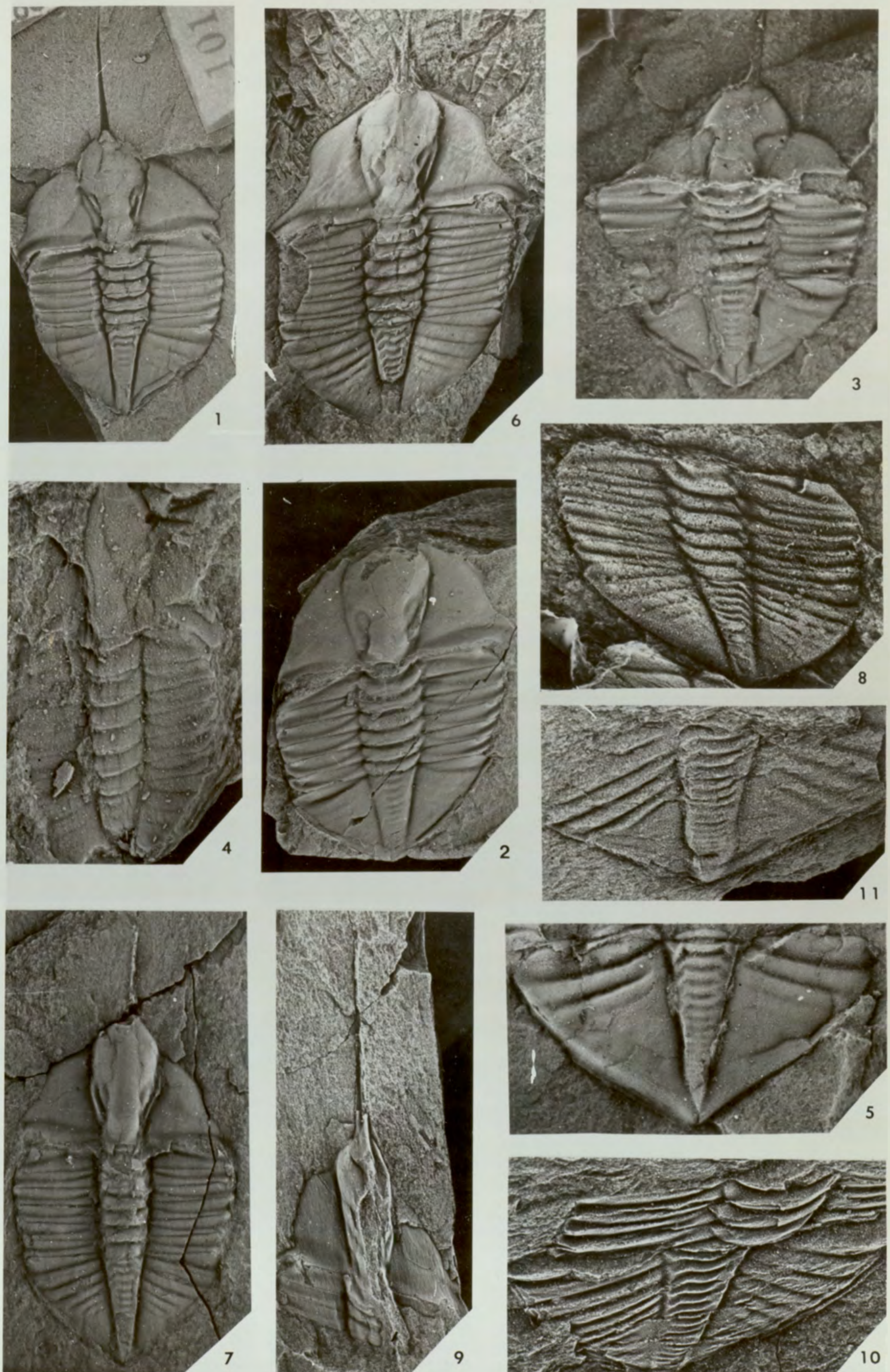


PLATE 14 Raphiophoridae, Trinucleidae, Pliomeridae, Cheiruridae.

Cnemidopyge tenuis sp. nov............................183

1. BGS .Pr.2550.Paratype,almost complete exoskeleton X2. Upper Llanvirn,murchisoni Biozone,120 yards west of the bridge at Llan Mill.
2. SM.A.44494. Paratype;latex mould of almost complete exoskeleton.X2. Lower Llanvirn;artus Biozone, Long Plantation railway cutting,Scolton(vicinity of localities 58-59;Turnbull Coll.)
3. 19.07. Paratype;almost complete exoskeleton.X2.5. Upper Llanvirn,murchisoni Biozone,locality 19.

Ampyx linleyensis Whittard,1955......................174

4. BGS.HT.353. Latex mould of articulated pygidium and thorax,and fragmentary cranidium.X4. Lower Llanvirn;artus Biozone,200 yds. wsw.of Wern-ddu (locality 84 of Strahan et al 1909)
5. 27.56 Latex mould of thorax and pygidium.X5. Lower Llanvirn;artus Biozone,locality 27.

Raphiophorid gen. et sp indet.........................187
Early Arenig(Moridunian Stage?),locality 69.

6. 69.154. Enrolled and compressed exoskeleton, ventral view.X3.

Trinucleus cf fimbriatus Murchison,1839.............142
Llandeilo Series? locality 79.

7. SM.A.79242. Fragment of upper lamella of left side of fringe,slightly oblique dorsal view.X4.
8. SM.A.79244. Fragmentary cephalon showing upper lamella of fringe.X3

Marrolithus cf inflatus Williams,1948...............154

9. BGS.Pr2637.Latex mould of enrolled and compressed exoskeleton,dorsal view.X3. Llandeilo Series? exposure 50yds. from Trewern Fach(locality 84 of Strahan et al 1914;horizon with Leptograptus sp. of a form intermediate between Didymograptus and Leptograptus.Op.cit.:34)
10. 38.03. Latex mould of ventral surface of upper lamella of fringe,dorsal view.X3. Llandeilo Series? locality 38.
11. 38.04. Latex mould of pygidium.X4.Locality as Fig 10.

Placoparina sp.....................................193
Lower Llanvirn;artus Biozone,locality 25.

12. 25.03.Latex mould of almost complete exoskeleton, possibly a late meraspid.X10.

Placoparia(Placoparia)cambrensis cambrensis

Hicks,1875...195
Lower Llanvirn; artus Biozone,locality 59(c).

13. 59.13. Almost complete exoskeleton.X5.

PLATE 14

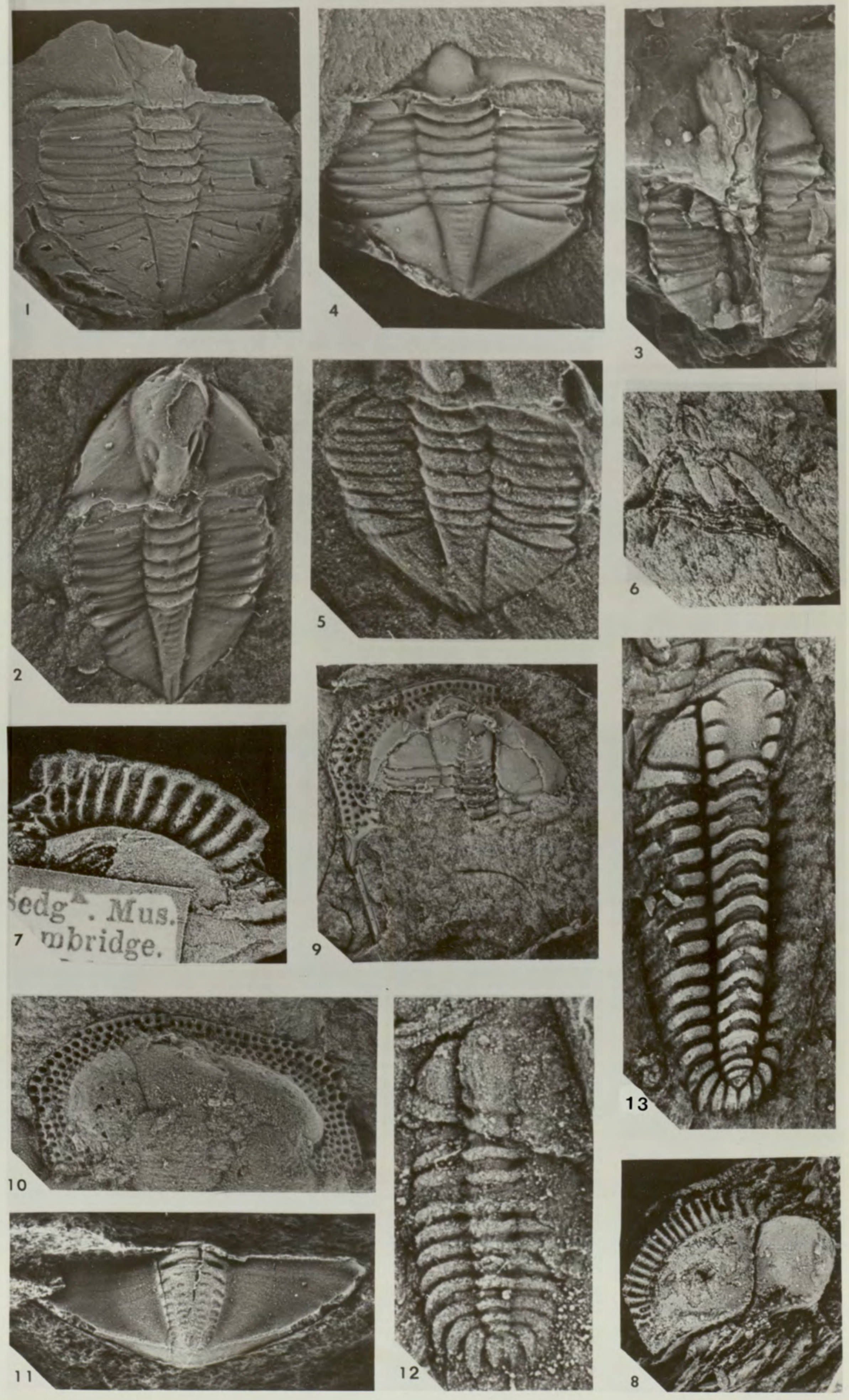


PLATE 15 Pliomeridae, Cheiruridae, Calymenidae.

Placoparina sp.......................................193
Landeilo Series? locality 78.

1. 78.08. Fragmentary thorax and pygidium;slightly oblique dorsal view.X1.5.

2. 78.05. Almost complete cranidium.X4.5.

3. 78.07. Fragmentary thorax and cranidium.X1.25.

Placoparia(Placoparia) cambrensis cambrensis Hicks,1875..195

Lower Llanvirn; artus Biozone.

4. 34.08. Almost complete exoskeleton.X4.5.locality 34.

5. 59.11b. Latex mould of almost complete cephalon. X5.5. locality 59(c).

6. 59.13b. Latex mould of cephalon.X9. locality 59(c).

Placoparia sp.......................................199
Lower Llanvirn; artus Biozone,lane 500 yds. southwest of Cwm Farm,near Merthyr village(locality 67 of Strahan et al 1909)

7. BGS.HT.567. Latex mould of complete cranidium.X4.

Platycalymene aff tasgarensis simulata Hughes,1969..204
Llandeilo Series? locality 78.

8. 78.09. Almost complete cranidium.X2.5.

9. SM.A.54147.Almost complete cranidium.X2.5.

10. 78.14. Latex m,ould of pygidium.X3.5.

Platycalymene sp.indet...............................205
Upper Llanvirn; murchisoni Biozone,Caerhys Shale,road cutting near Abereiddy Bay(approx.SM 796310)
Harper Coll.

11. SM.A.82569. Latex mould of complete but compressed exoskeleton, with displaced librigenae.X1.

PLATE 15

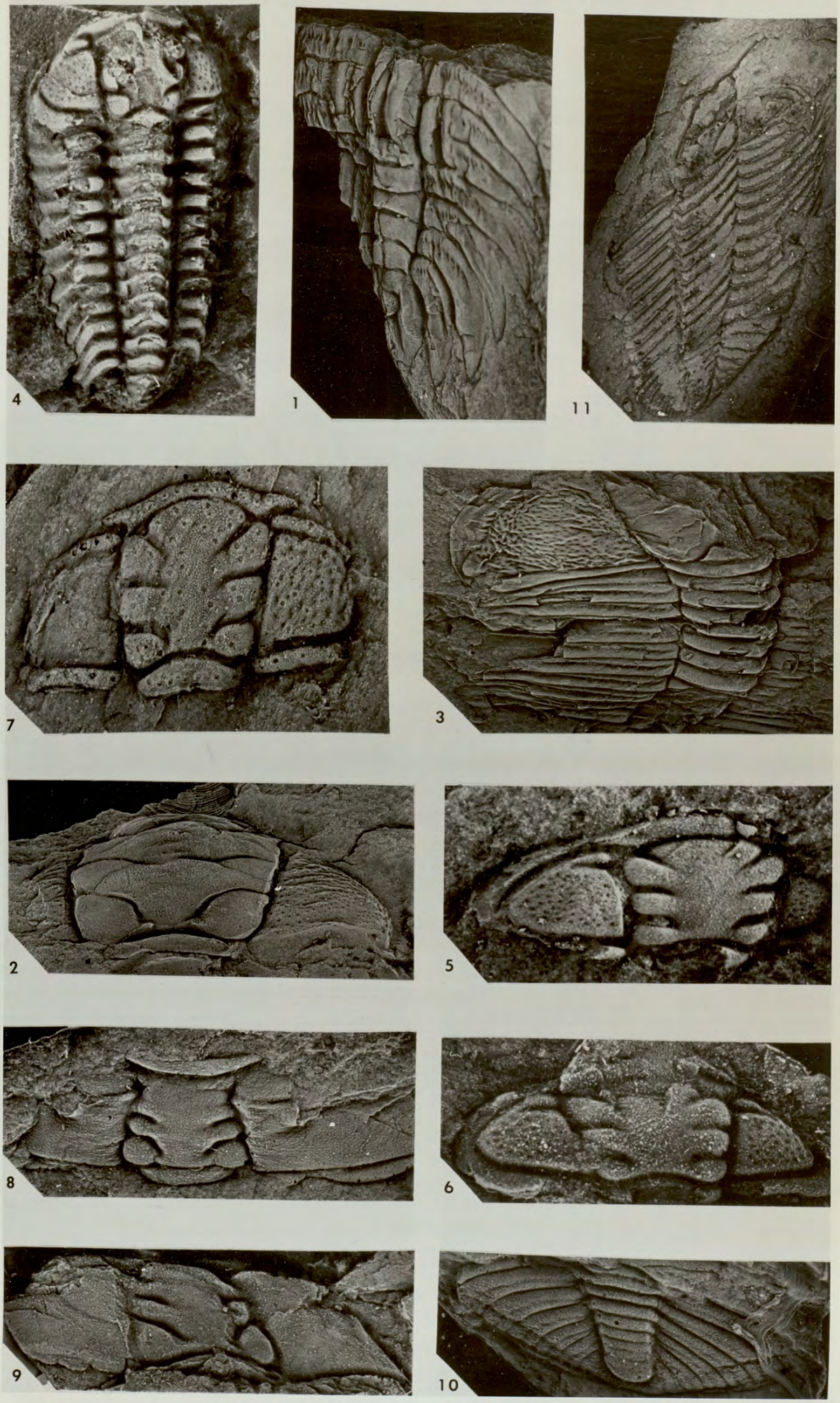


PLATE 16 Calymenidae, Bathychelidae.

Flexicalymene cf cambrensis (Salter, 1848)............207
Llandeilo Series?

1. 23.04. Latex mould of cranidium. X3.5. locality 23.
2. 23.03. Latex mould of fragmentary cranidium. X3.5 Locality as for Fig. 1, but 10 metres downstream.
3. 23.02. Pygidium. X4. Locality as for Fig. 1, but 16 metres downstream.

Flexicalymene sp......................................210
Llandeilo Series?, locality 20.

4. 20.01. Pygidium. X6.

Prionochelius mendax Vaněk, 1965......................212
Lower Llanvirn; artus Biozone, Long Plantation railway cutting, Scolton (vicinity of localities 58-59)

5. SM.A.44513. Almost complete exoskeleton, with the hypostoma impressed through the glabella. X5. (Turnbull Coll; see Whittard 1960:136)
6. SM.A.44514b. Cranidium. X3.5. (Turnbull Coll.)
7. SM.A.44512. Cranidium and fragmentary thorax. X4.5 (Turnbull Coll.)
8. 58.08. Fragmentary cranidium and four thoracic segments. X8. Locality 58.

Platycalymene tasgarensis tasgarensis
Shirley, 1936...201

9. C.04. Cephalon and fragmentary thorax. X5.5. Lower Llanvirn; artus Biozone, temporary exposure 4.5 Km. west of Johnstown, Carmarthen.
10. BGS.Pr.1726. Latex mould of cranidium. X4. Exposures attributed to the Lower Llanvirn, "highest Bifidus Shales", Pengwern Wood. (locality 63 of Strahan et al 1914, close to locality 37 here)

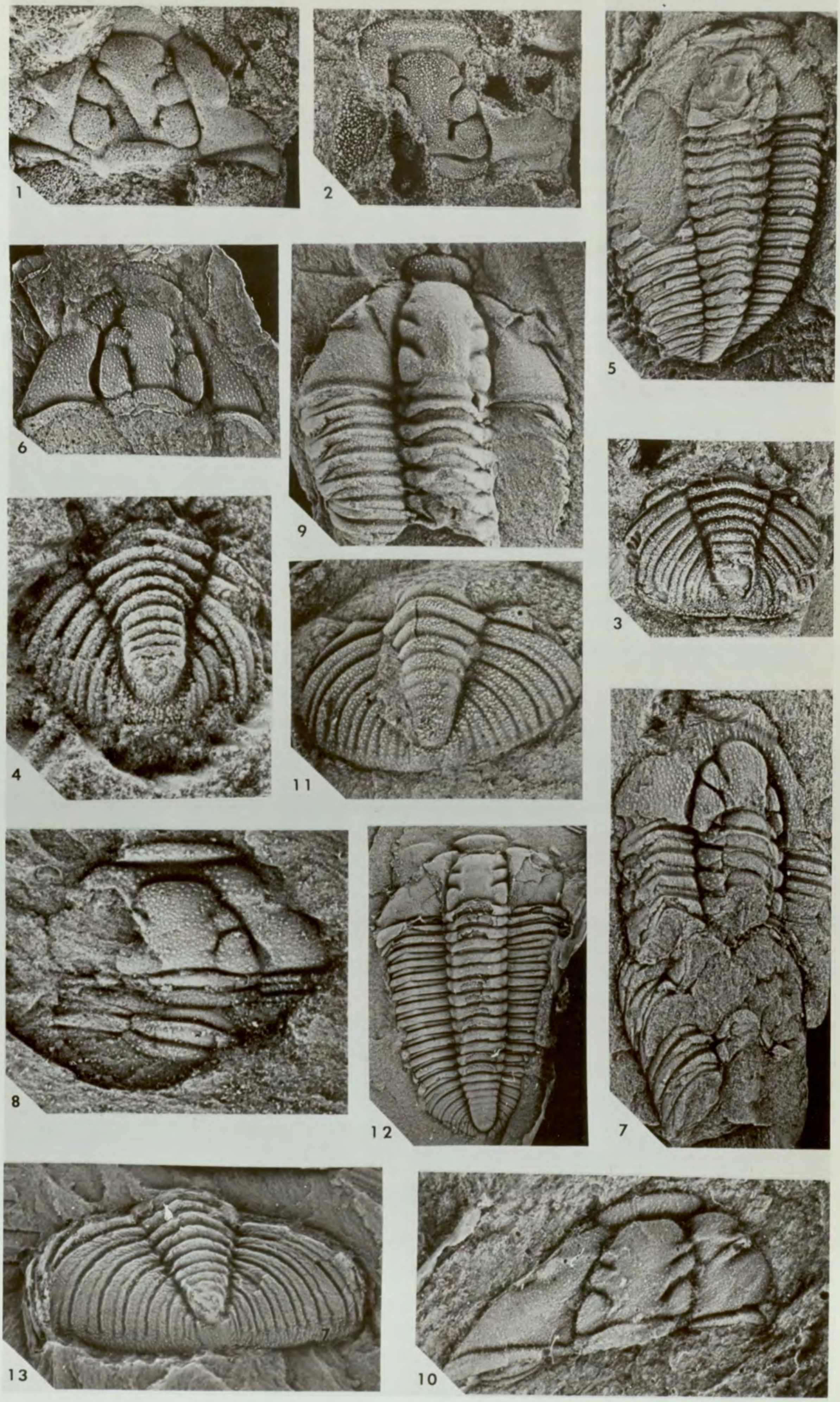
Platycalymene tasgarensis Shirley, 1936 simulata
Hughes, 1969..202

11. BGS.TCC.874. Latex mould of pygidium. X2.5. Lower Llanvirn, shales exposed in Clog-y-frân farmyard (locality 107 of Strahan et al. 1909)
12. BW.02. Latex mould of almost complete exoskeleton X2.5. Llandeilo Series, left bank of Dulas Brook, 350 yds. west of Maesgwynne (SO 058564). Probably the type locality of Hughes (1969:93)

Platycalymene cf duplicata (Murchison 1839)..........206
Upper Llanvirn, murchisoni Biozone, 120 yds. west of the bridge at Llan Mill. (locality 48 of Strahan et al 1914)

13. BGS.Pr.2733. Pygidium. X5.

PLATE 16



Ormathops llanvirnensis Hicks,1875...................215
Lower Llanvirn; artus Biozone.

1. 53.16. Cranidium.X4.5. locality 53.
2. 27.43. Cephalon; oblique anteromedial view.X4.5 locality 27.
3. Same specimen; detail of right optic surface.X12.
4. 27.42. Latex mould of cranidium and disarticulated thorax.X6. locality 27.
5. 57.07. Latex mould of almost complete exoskeleton X2.5. locality 57.
6. 27.44. Latex mould of almost complete cranidium.X6 locality 27.
7. 53.17. Pygidium.X7.5 locality 53.
8. 57.08. Pygidium and two fragmentary thoracic segments. X3. locality 57.

Platycalymene tasgarensis Shirley,1936 simulata Hughes,1969...202

9. C.02. Almost complete cranidium.X10. Lower Llanvirn; artus Biozone, temporary exposure 4.5 Km. west of Johnstown, Carmarthen.
10. 38.06. Almost complete cranidium.X5.5. Llandeilo Series? locality 38.

Platycalymene tasgarensis tasgarensis Shirley,1936...201

11. BGS.Pr.1720. Cephalon and fragmentary thorax.X5. Exposures attributed to the Lower Llanvirn,"highest Bifidus Shales", Pengwern Wood,(locality 63 of Strahan et al 1914, close to locality 37 herein)

PLATE 17

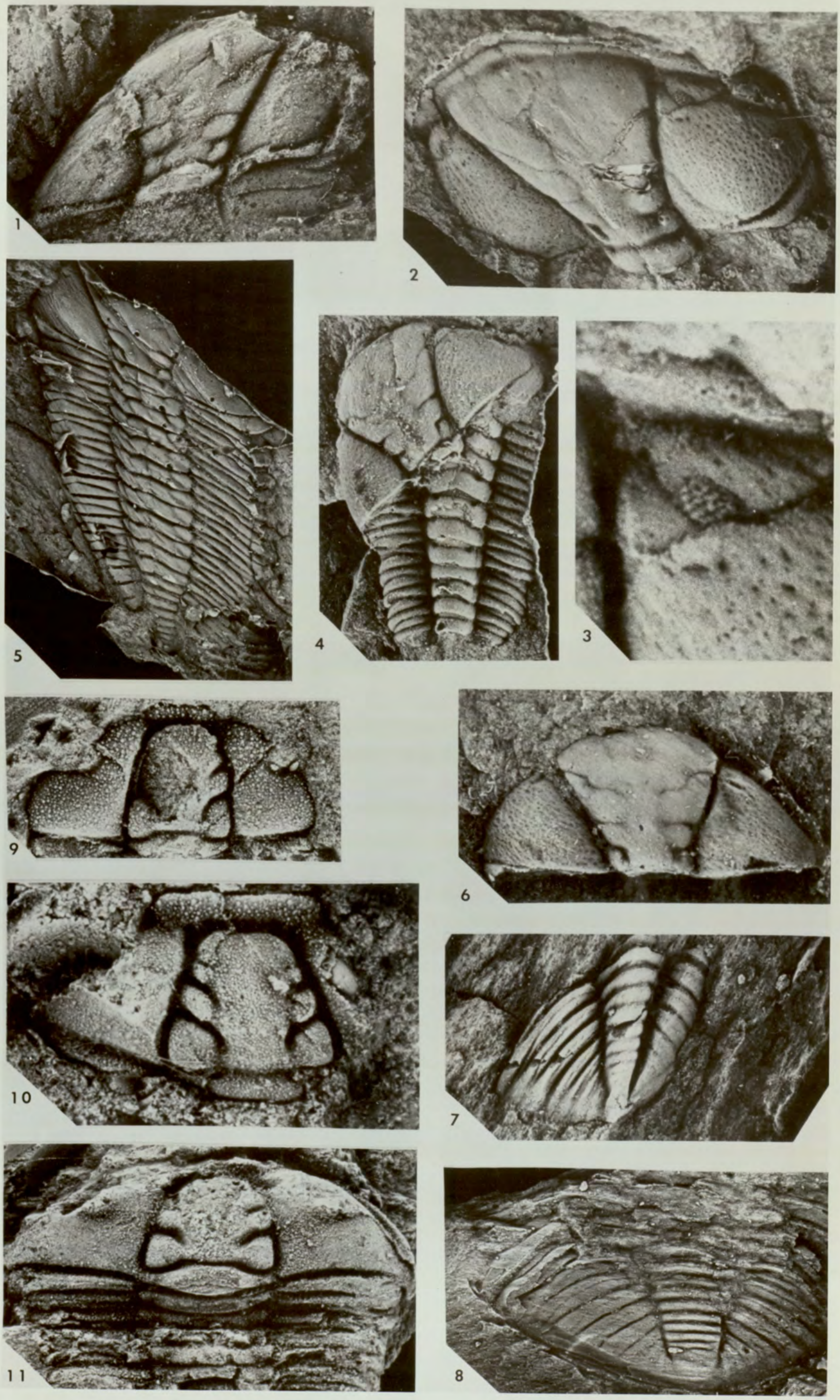


PLATE 18 Encrinuridae, Odontopleuridae, Lichidae.

Selenopeltis buchi buchi Barrande,1846...............223
Lower Llanvirn; artus Biozone.

1. 27.19. Latex mould of almost complete exoskeleton X1.5. locality 27.

2. 34.06a. Cranidium and fragmentary thorax.X2. locality 34.

3. Same specimen; detail of glabella. X3.5

4. 34.05b. Latex mould of pygidium and six thoracic segments.X4.5. locality 34.

5. 34.10. Latex mould of pygidium and thorax.X2. locality 34.

Selenopeltis buchi macrophthalmus Klouček,1916.......226

6.SM.A.45150. Latex mould of fragmentary thorax and cranidium.X3. locality 76.

7. SM.A.45151. Fragmentary thorax.X2. locality 76.

8. 53.05a. Latex mould of pygidium and two fragmentary thoracic segments.X3. locality 53.

Dindymene didymograpti Whittard,1960.................189
Lower Llanvirn; artus Biozone.

9. C.03. Latex mould of complete exoskeleton.X10. Temporary exposure 4.5 Km. west of Johnstown, Carmarthen.

10. Same specimen; detail of posterior thoracic spines of right pleural lobe of thorax.X20.

11. 27.57. Latex mould of pygidium and posterior thor thoracic segments.X10. locality 27.

Metopolichas sp.....................................228

12. 23.06. Hypostoma.X2. Exposures 15 metres downstream of locality 23; Llandeilo Series?

PLATE 18