THE BRITISH LOWER PALAEOZOIC CRINOIDEA

By

W. H. C. Ramsbottom

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CONTENTS

ABSTRACT.

A full survey is given of all known Crinoidea from the Lower Palaeozoic rocks in Britain (including Ireland), but consideration of crinoid stem fragments is omitted, with a few exceptions.

In the Ordovician 28 species are described or referred to, 16 being named as new; 5 species were previously known, the remainder are too inadequately preserved for detailed naming. The Ordovician species belong to 17 genera, two of which are new. It is found that there are two faunal provinces - one covering the Anglo-Welsh area, and the other the Scots-Irish area. Crinoids of pre middle Caradoc age in the Scots-Irish area are closely related to contemporary forms in North America, while those in the Anglo-Welsh area belong to different genera, some being related to forms found in Bohemia. In the upper Caradoc and Ashgill the faunas are more uniform, nearly all being of American affinities, and there appears to have been a mixing of forms from both faunal provinces. An especially noteworthy occurrence of crinoids is in the Ashgill Starfish Bed near Girvan, where nine genera (one new) are found, none of which has previously been recorded in Britain.

In the Silurian 88 species are described or referred to; 10 of these are too inadequately known for detailed naming, but 11 others are described as new species. The Silurian species belong to 42 genera. No faunal provinces have been detected, the fauna being more or less uniform over the British area, so far as the records permit such a generalisation. This uniformity seems to be world wide. The Llandovery has 7 new species (2 named), only 1 having been previously recorded. 16 species (3 named as new) are present in the Wenlock Shale, though they are often poorly preserved. Reef conditions in the Wenlock Limestone favoured both crinoid growth and preservation and some 65 species are recorded from this horizon, mainly at Dudley. 10 species are recorded from the Ludlow formation (3 new), but only one of these is found in the Upper Ludlow. In general it is considered that the faunas of the different Silurian formations are distinct enough to be recognised individually.

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I INTRODUCTION

The Lower Palaeozoic crinoids of Britain have been much neglected during the last fifty years. In fact the last paper dealing with them which was published in England appeared in 1896 (Bather 1896). Since then, until 1950, such studies as have been published have been the work of foreign authors.

The early history of the study of Palaeozoic crinoids in Britain was summarised by Bather (1890a), who, at that time set himself the task of describing the extensive material already collected, but this ideal did not materialise beyond the description of a few species of Silurian Inadunata. In 1890 Bather was able to write:-

> "Delay is no longer excusable. The chief fossiliferous localities all over the country have been well ransacked, and many are now no longer worked; a few more species may be found no doubt, but a vast mass of material in museums and private collections awaits description".

As far as the Lower Palaeozoic crinoids are concerned the same remains as true today, and it has been the aim of the present investigation to remedy this defect, and to draw conclusions regarding distribution and relationships of the Lower Palaeozoic crinoids generally.

Although details have been given in this thesis as to the occurrence of every known British species of crinoid from the Silurian and Ordovician rocks, it has been the primary aim to describe any new material and to redescribe those species which need revision. Full descriptions are thus only given of species inadequately revised by previous authors. Moreover the present study is concerned only with those more or less complete cups or crowns of crinoids, which give evidence as to their generic relationships, though details of stems are given where possible.

Up to now no stratigraphical use has been made of the abundant material of crinoid stems and loose columnals in Lower Palaeozoic rocks mainly because little work has been done on them. From the palaeontological viewpoint crinoid stems are not usually informative as to the relationships of species and any future work based on stems will have to be largely empirical, making use of "form species".

The systematic portion of the thesis is divided into two parts dealing respectively with Ordovician and Silurian crinoids.

(a) Material.- Owing to the rarity and localised occurrence of fossil crinoids, and to the fact that many of the most famous localities are now no longer available, this study has of necessity been concerned mainly with material in the collections of museums and institutions. Most of the specimens collected during the investigation have been placed in the Geological Survey Museum.

The principal collections which have been examined are the following, given here together with the symbols which are prefixed to registration numbers when specimens are cited.

BM - British Museum (Natural History).

GSM - Geological Survey Museum.

SM - Sedgwick Museum, Cambridge.

OM - Oxford University Museum.

BUH - Holcroft Collection, Birmingham University.

BUK - Ketley Collection, Birmingham University.

DM - Dudley Museum.

MM - Manchester Museum.

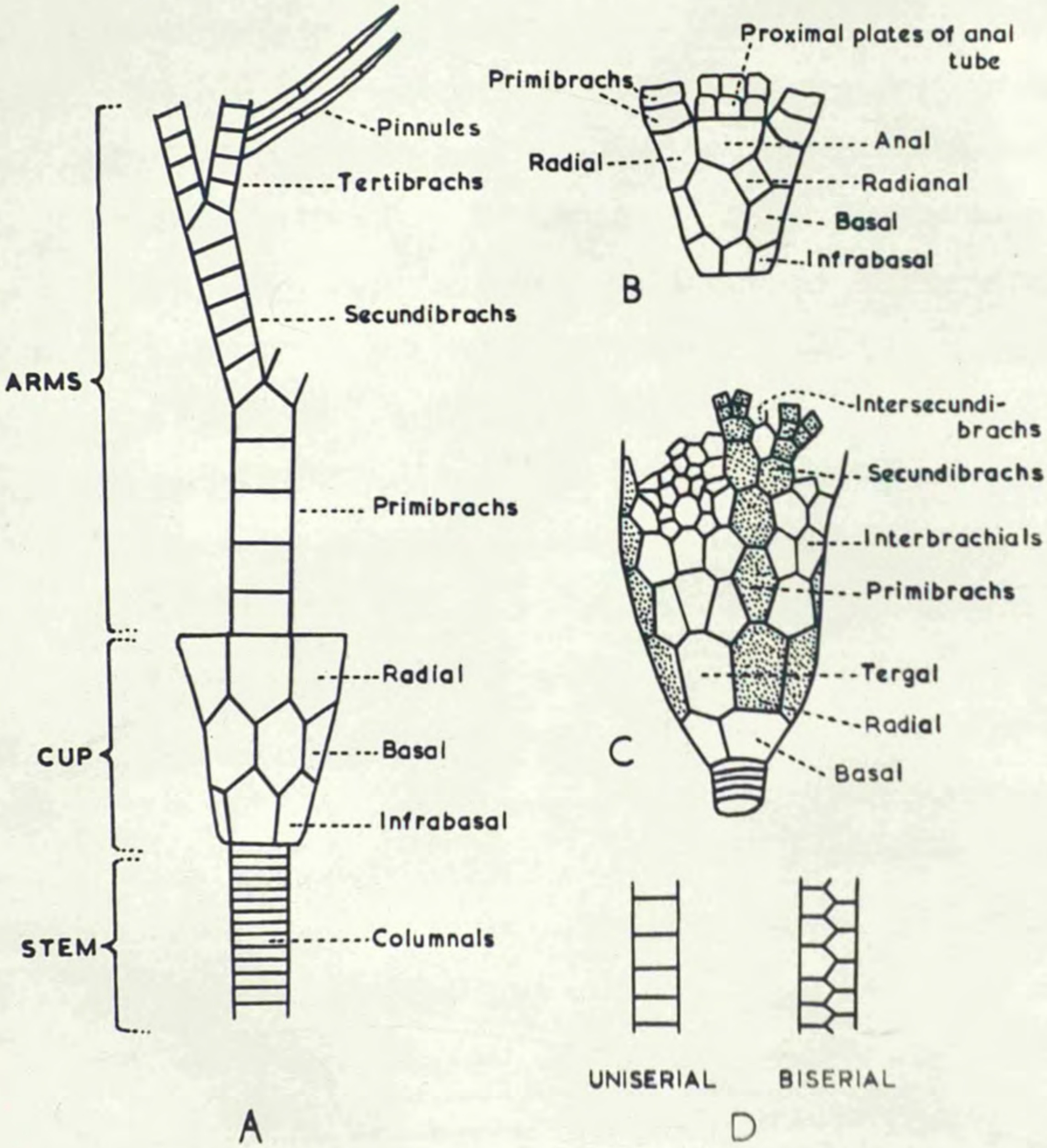
HM - Hunterian Museum, Glasgow.

JW - Mr. James Wright's private collection.

(b) Techniques.- In general few of the specimens available required elaborate development. A fine needle, constructed by inserting a small sewing needle in a stick of sealing wax, and used under a binocular microscope, has usually been sufficient. Such a needle is far finer than most other developing tools and it has the advantage that when the point has worn it is easily replaced. Specimens embedded in a coarse crystalline limestone cannot usually be developed at all, but when shale surrounds a specimen it has sometimes been softened by the use of a strong solution of Hydrogen Peroxide, and then removed with a needle.

Many crinoids occur as internal and external moulds. This is almost general in the Ordovician crinoids examined and usual in the Ludlow specimens, but rare in the Wenlock. In such cases, the finest details are usually preserved, and such specimens often yield a surprising amount of information. In these cases an impression has been taken of the external mould by means of a prevulcanised rubber latex compound, Revultex, supplied by Revertex Ltd., London. Thin layers of latex are put onto the specimen allowing time for drying between each layer until sufficient thickness is obtained; this is usually after some four or five applications. The greatest difficulty is to avoid air bubbles between the first layer of latex and the specimen, and this has been overcome by careful wetting of the specimen with water or alcohol, and examination, to confirm the absence of bubbles, under the microscope. The latex mixes completely with the water (or alcohol) and thus reaches all points on the specimen. The latex impression thus obtained is semi-transparent, and must be whitened with a thin sublimate of Ammonium Chloride by the method described by Teichert (1948) in order to be photographed and studied. Late in the investigation it was discovered that a black latex impression gave better results when photographed. The latex was made black by mixing Indian ink with the liquid latex before application.

Most of the photography was done with a Leica camera using a Leitz Rotating Stage Plate. In a few cases photographs were supplied by the British Museum (Natural History) for this museum does not loan type specimens. In some cases the photographs have been retouched especially by the inking in of the sutures between plates. This has been done in the belief that it is better to be subjective than obscure, and it may be stated that no suture line has been put on a photograph without some evidence for its existence being found in the specimen. The retouching of photographs has been kept to the minimum consistent with clarity; and where any retouching has taken place this fact is stated in the explanation of the plate.



TEXT-FIGURE 1. Terminology.

A. An imaginary Inadunate crinoid.

B. An Inadunate crinoid (Botryocrinus) seen from the posterior posterior side

C. A Camerate crinoid (Periechocrinus) from the posterior.

D. Two types of arm structure.

(c) Terminology.- The terminology in current general use for crinoids has been applied. This is mainly based on the work of Bather (1892a). Text-figure 1 illustrates the use of certain terms. Lately R. C. Moore (1950) has coined some new terms, such as 'cup-primibrachial' and 'cup-primaxil', but these are considered unnecessary, sometimes misleading, and even at times erroneous, masking homologies, and they are not used. Moore's term 'Tergal' (1950, p. 30) has been adopted, however, for the plate formerly called 'anal' in Camerate crinoids, for as was shown long ago by Bather (1899a, p. 40) this plate is not homologous with any of the anal plates in Inadunates and Flexibilia, and hence should receive a different name.

(d) Classification.- Wachsmuth & Springer (1885) divided the crinoids into three orders Camerata, Inadunata and Articulata distinguished largely on characters of the tegmen. The name Flexibilia Zittel 1895 later replaced the Articulata. Bather (1899b) divided the crinoids on the basis of the presence of absence of infrabasals into two orders Monocyclica without infrabasals and Dicyclica with infrabasals but retained the Flexibilia distinct.

The classification proposed by Moore & Laudon (1943) which has been adopted here is mainly a return to that of Wachsmuth & Springer; but within each of the groups Camerata and Inadunata (which Moore and Laudon term sub-classes) a further division is made into Orders based on the monocyclic or dicyclic nature of the base of the cup. The classification used here may thus be summarised

Class	Sub-classes	Orders
Crinoidea	Inadunata	Disparata
		Cladoidea
	Flexibilia	Taxocrinoidea
		Sagenocrinoidea
	Camerata	Monobathra
		Diplobathra

(e) Diagnoses and Synonymies.- Most of the family diagnoses given here are based on those given by Moore and Laudon (1943). In a number of cases, however, necessary amendments have been made. The generic diagnoses are original, in the form in which they are given, incorporating usually only the main diagnostic characters.

The synonymies do not include every reference in the literature to a particular species, and usually only references which for some reason are known to refer to authenticated specimens are given. Very many of the scattered references to Lower Palaeozoic crinoids in British literature refer to stems, which cannot as a rule be specifically identified with confidence, and so these are excluded. It is believed that most of the available records have been searched, and unless such a record is given here the specimens are either not available or are known to refer to stems.

II ORDOVICIAN CRINOIDEA

(a) History of Research

Up to the present time only five species of British Ordovician crinoids have been described.

(1) In 1843 Portlock described and figured a single fragmentary specimen as Trochocrinites laevis from the Caradoc at Desertcreight, Co. Tyrone.

(2) M'Coy (1852) described and figured Glyptocrinus basalis from Caradoc beds near Meifod, Montgomeryshire.

(3) In 1873, Dendrocrinus cambriensis was described by Hicks from beds now known to be of Arenig age.

(4) Nicholson and Etheridge (1881) figured and described Glyptocrinus globularis from Craighead Quarry, near Girvan.

(5) In 1896 Bather described and figured Merocrinus salopiae from Llandeilo beds in Shropshire.

In addition Salter (1866) had proposed the generic name Coelocrinus for M'Coy's species Glyptocrinus basalis. This name, being preoccupied, is only now being replaced, for in 1897 Wachsmuth & Springer referred G. basalis to their genus Rhaphanocrinus which is based on an American species. Earlier Wachsmuth & Springer (1881) had transferred G. globularis to Archaeocrinus and incorrectly placed Trochocrinites in synonymy with Periechocrinus.

Outside Britain most described Ordovician crinoids are from North America, and these were first described in a classic memoir by Billings (1859 also 1857). Many other works on Canadian and American material have been published, and these will often be referred to in the present account.

The few known crinoids from the Baltic area were mostly very inadequately described by Jaekel (1918). He also described a few forms from Bohemia, while Waagen & Jahn (1899) described a single Ordovician genus Caleidocrinus from Bohemia.

In the present account the Scottish crinoids are mainly from a fine collection made by Mr. J. L. Begg, but specimens collected by Mrs. Gray and Dr. Lamont have also been used.

(b) Systematic Descriptions

Class CRINOIDEA J. S. Miller 1821

Sub-class INADUNATA Wachsmuth & Springer 1881

Diagnosis.- Crinoidea with a rigid cup in which the brachials are free (or sometimes loosely connected) above the radials. Plates of cup united by close suture. Mouth subtegminal, food grooves suprategminal, but may be closed by fixed ambulacral plates. Arms pinnulate or non-pinnulate.

Order DISPARATA Moore & Laudon 1943

Diagnosis.- Inadunata without infrabasals

Discussion.- Crinoids of this order are characterised by a tendency towards dissimilarity of structures in the different rays. The cup contains only basals, radials and usually an anal plate and radianal (or inferradianal and superradianal). Compound radials, which are divided transversely into inferradial and superradial, are found only in this order, and, in general, the fewer the number of compound radials the more evolutionarily advanced is the genus.

Family IOCRINIDAE Moore & Laudon 1943

Diagnosis.- Monocyclic Inadunata with a usually conical cup with five basals. Radial circlet with five equal plates of which that in the right posterior is identified as the inferradianal. Superradianal above this and not included in cup, axillary, bearing on left an unbranched arm-like anal tube, and on the right an arm. Arms branch isotomously several times.

Range.- Ordovician and Silurian.

Discussion.- The genus Ammonicrinus Springer (1926a), which was included in this family by Moore & Laudon (1943), is wrongly placed here, since the cup has lately been shown to have the structure of a flexible crinoid (Ubaghs, 1952). Caleidocrinus, included by Moore & Laudon in the Heterocrinidae, should, however, be referred to this family.

Iocrinus Hall 1866

Text-figure 2

Type species by monotypy: Heterocrinus? (Iocrinus) polyxo Hall 1866, which is a subjective synonym of Heterocrinus subcrassus Meek & Worthen 1865, Richmond Series, Ohio.

Diagnosis.- A genus of Iocrinidae with a pentagonal, subpentagonal or stellate uncoiled stem. Primibrachs 4-8 or more.

Iocrinus shelvensis sp. nov.

Plate 1, figs. 3-8

Holotype.- GSM 92145 and 92145a (counterparts).

Paratypes.- GSM 92143, 92144, 92146, 92146a, 92147, 92147a.

Occurrence.- Llanvirn, Weston Stage, *Didymograptus bifidus* zone (see Whittard, 1952, p. 159); 630 feet E. 33° S. of road crossing Betton Dingle at Lyde, Shropshire.

Diagnosis.- A species of *Iocrinus* with the radials higher than wide; primibrachs seven, not more than twice as wide as high.

Description.- Cup higher than wide, widely cone-shaped; surface of cup plates smooth. Basals half the height of the radials; radials higher than wide, and widening slightly upwards. Facet occupies the whole width of radial, but a sigmoid shaped re-entrant at the distal end of the plate occupies about one third of the width of the plate. Primibrachs seven, not more than twice as wide as high; secundibrachs six in the single case seen. Arms divide about four times. Brachials always wider than high, and with a deep ventral groove.

Superradianal five sided, wider than high, bearing on its left side the anal tube. The proximal plates of the median rib of the tube are higher than wide, or as high as wide. More distally the side plates of the tube are strongly folded transversely.

Tegmen not seen.

Stem formed of columnals of varying length, proximally pentagonal and with sharp angles, becoming sub-pentagonal more distally, and eventually nearly round. Alternating columnals moniliform in the distal region.

Discussion.- The material on which this account is based was collected by Professor W. F. Whittard, who has kindly presented the type specimens to the Geological Survey Museum. It is the species which was referred to as "cf. Caleidocrinus" by Whittard (1931, p. 330). I. shelvensis has been studied by means of Revultex impressions, since all specimens are preserved as internal and external moulds. The species differs from all others described in the relatively great height of the cup.

Iocrinus whitteryi sp. nov.

Plate 1, fig. 9

Holotype.- BM E 49603.

Paratypes.- BM E 1365, E 49604, E 49605; GSM 85720.

Occurrence.- Caradoc, Whittery Beds; large quarries east of Marrington Dingle, near Chirbury, Montgomeryshire.

Diagnosis.- A species of Iocrinus with the radials wider than high; primibrachs seven, more than twice as wide as high.

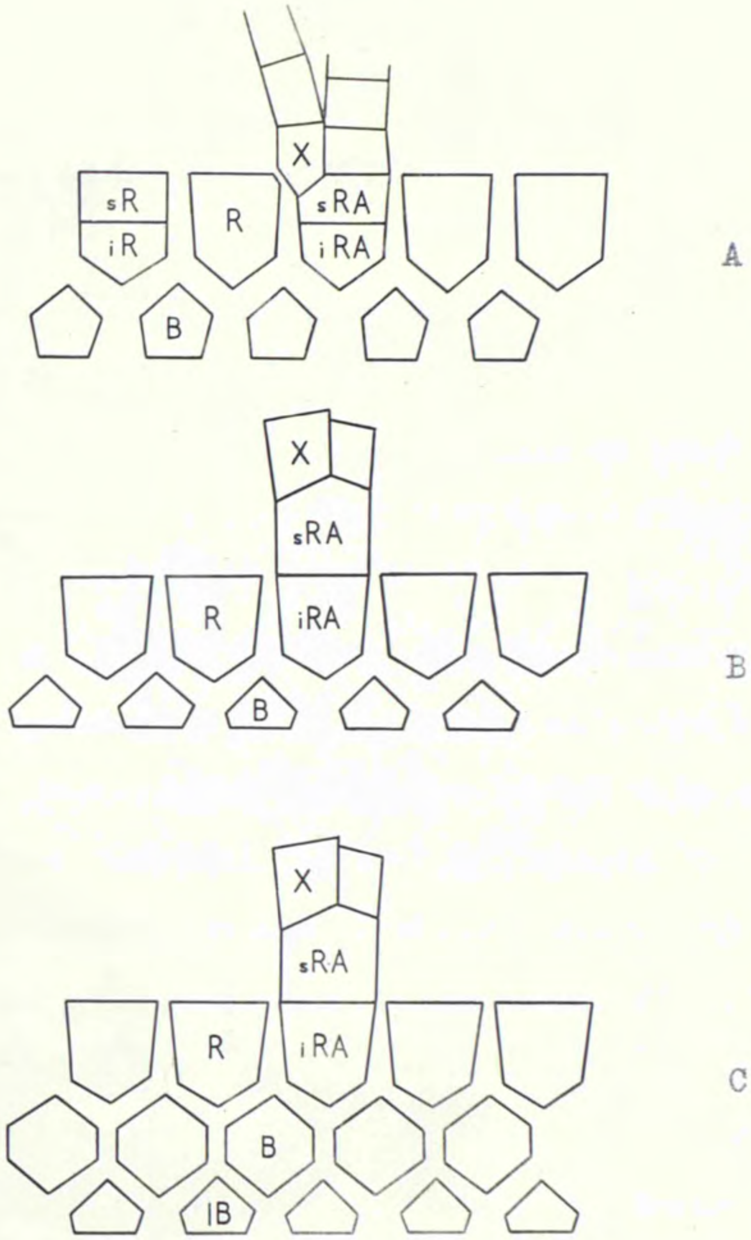
Description.- Cup, so far as seen, conical, about as wide as high. Cup plates smooth. Basals two thirds of the height of the radials. Radials wider than high, with slightly sigmoid facets occupying the whole width of the plates. Primibrachs seven, more than twice as wide as high. Secundibrachs four in the only case seen (BME 1365). Arms beyond the secundibrachs only represented by fragments in the available material, but brachials always substantially wider than high.

Anal side of cup not seen, but anal tube long, of the type usual in *Iocrinus* with a strong central rib formed of plates which are only a little wider than high.

Stem not seen.

Discussion.- The material of this species is all somewhat fragmentary, but there is enough to show without doubt that a distinct species of *Iocrinus* is present in the Caradocian of the Shelve area.

I. whitteryi differs from *I. crassus* (Meek & Worthen) in lacking the depressed area on the basiradial suture; and from both *I. crassus* and *I. subcrassus* (Meek & Worthen) in the shape of the radials and in the number of primibrachs. From *I. shelvensis* sp. nov. this species is distinguished by the shape of the radials and by the extreme breadth of the primibrachs. "*Cyathocrinus* sp." cited by Morton (1869, p. 19) refers to *I. whitteryi*, the record being based on GSM 85720-21.



TEXT-FIGURE 2. A. Heterocrinus.

B. Iocrinus (and Myelodactylus).

C. Merocrinus.

Iocrinus? cambriensis (Hicks)

Plate 2, figs. 2-4

Dendocrinus cambriensis Hicks, 1873, p. 50, pl. iv, figs. 17-20

Syntypes.- An unknown number of specimens, but including the four figured by Hicks. Of these the original of fig. 17 is SM A 16739 (gutta percha impression GSM 82819). A gutta percha impression of the original of fig. 20 is GSM 59428, but the originals of figs. 18-20 have not been traced.

Occurrence.- Hicks (1873, p. 52) stated that the figured syntypes all came from Ramsay Island, but gives Ramsay Island and St. David's as localities for the species. The Ramsay Island occurrences are now known to be from the Lower Arenig. Porth Gain Beds, Bay Ogof Hên (Pringle, 1930, p. 12). Cox (1916, p. 286) records the species as being abundant in the Port Gain beds near Llanveran Farm, west of Pen Berry, Pembrokeshire, but specimens have not been seen from this locality.

Diagnosis.- A species (possibly of Iocrinus) characterised by having 9 or more primibrachs, and a petaloid stem in which the columnals are of very irregular thickness.

Description.- Cup low, slightly wider than high, surface of cup plates smooth, though they are usually convex. Basals occupy about three sevenths of the height of the cup, and radials about four sevenths. All cup plates wider than high. Primibrachs 9-12, wider than high; secundibrachs 13-15, slightly higher than wide; tertibrachs 10-13, higher than wide. Arms divide three, or possibly four times. Brachials with evenly rounded dorsal sides and deep ventral grooves. Anal side of cup, and tube not seen.

Stem wide, five lobed, petaloid, composed of short columnals of uneven length. Alternate columnals are thickest at the outer edge of the petaloid projections.

Discussion.- All the specimens available of this species are in a cleaved mudstone, and they are more or less distorted and fragmentary. None of the syntypes shows the cup clearly, but the stem has highly characteristic features by which the species can be recognised. SM A 16739 also shows the primibrachs. The specimen on which the above description is largely based is BM E 3 (Plate 2, fig. 4), but even here the anal side of the cup is not seen, and the species is referred to Iocrinus with considerable doubt. Superficially, and except for the stem, the species has resemblances to Eustenocrinus Ulrich, but the question cannot be settled without better material.

This uncertainty is particularly unfortunate for I.? cambriensis is almost certainly the oldest known crinoid. Hicks(1873) believed that the beds containing this species were of Tremadoc age, but it was shown by Pringle (1911) that the age is really lower Arenig.

Caleidocrinus Waagen & Jahn 1899

Type species by subsequent designation of Bassler (1938, p. 56) C. multiramus Waagen & Jahn, Ordovician, Bohemia.

Diagnosis.- A genus of Iocrinidae in which the stem is round and uncoiled. More or less irregular interbrachial elements are present. Primibrachs usually two (? sometimes three).

Discussion.- Jaekel (1902, p. 175) considered that Caleidocrinus was close to Iocrinus, while Springer (1920, pp. 442-3) placed the two genera in synonymy. When first described Caleidocrinus was inaccurately figured, as was admitted by Waagen & Jahn, and arguments as to its affinities have been frequent. The original figures show interbrachial plates, of which Springer denies the existence. The anal structures, as figured by Springer, are undoubtedly similar to those in Iocrinus, but there is always the possibility that more than one species is present in the Bohemian material.

As described and figured by both Waagen & Jahn and Springer, Caleidocrinus differs from Iocrinus in having a round stem and in having only two (? sometimes three) primibrachs. It is assumed here that interbrachial elements are present in Caleidocrinus, since the species here described shows structures basically similar to those figured by Waagen & Jahn.

Caleidocrinus turgidulus sp. nov.

Plate 1, figs. 1-2

Holotype.- GSM 85719

Occurrence.- The unique holotype comes from Carneddau Hill, Builth. I am indebted to Dr. W. J. Pugh for the information that from its lithology the

the specimen probably comes from the "Red Agglomerate and Ash" of Jones & Pugh (1949, p. 66), the age thus being Llanvirn, Didymograptus murchisoni zone.

Diagnosis.- A species of Caleidocrinus with a low basin-shaped cup, all the plates being strongly convex; radials twice as wide as high.

Description.- The specimen is preserved as an internal and external mould. Cup low, bowl shaped, over twice as wide as high. Surface of cup plates smooth. Basals forming flattened base to cup and must, in life, have been almost covered by stem. Radials twice as wide as high, with a slightly indented radial facet occupying just over half the width of the plate. Depressions occur at the most distal point on the basiradial suture. Primibrachs two, twice as wide as high; secundibrachs three; arms dividing about four times. The brachials gradually lengthen distawards until they are about as wide as high. The two adjacent brachials distal to any division are in lateral contact. All brachials strongly convex; at the sutures between many of the brachials a double crescentic depression is seen, which may have a median ridge along it. These depressions are probably due to musculature.

Superradianal resembling a normal primibrach, but axillary, bearing on the left a stout anal tube formed of a single row of convex plates which are higher than wide, and on the right a normal arm.

Interbrachial areas with strongly convex small plates, irregularly arranged, but the proximal interbrachial plates are larger than the distal ones, and there is usually a single large plate resting on the shoulders of adjacent radials.

Tegmen and stem not seen, but a stem on the same slab of rock as the holotype could well have belonged to this species. It is large, round, and formed of thin alternating large and small columnals.

Discussion.- The present species is distinguished from the two Bohemian species, as figured by Waagen & Jahn, in the lowness of the cup and radials, the narrowness of the radial facets and in the small number of secundibrachs.

There is no doubt in the present specimen but that interradial elements are present, and the structure shown in very similar to that figured by Waagen & Jahn as Caleidocrinus. Springer (1920) has denied the existence of interbrachial plates in Caleidocrinus, but the discovery of the present specimen which undoubtedly shows them seems to indicate that a further re-examination of the Bohemian material would be useful.

The specific name is derived from the latin turgidulus = somewhat swollen, in reference to the strongly convex brachials. The specimen was collected about 1850, possibly by Sir Henry De la Beche. It was recorded as Cyathocrinus sp. in Huxley & Etheridge (1878, p. 25).

Family CALCEOCRINIDAE Meek & Worthen 1873

Diagnosis.- Monocyclic Inadunata with the crown bent on the stem, in which bilateral symmetry along the left anterior radius and the right posterior interradius is progressively established. Basals connected by a musculure articulation (the hinge) with the radials, of which three are compound. Three or four arms bearing radials, and the anal plate becomes shifted over the right posterior radius eventually into the right posterior interradius, and supports a massive tube.

Range.- Ordovician to Lower Carboniferous.

Anulocrinus gen. nov.

Text-fig. 3

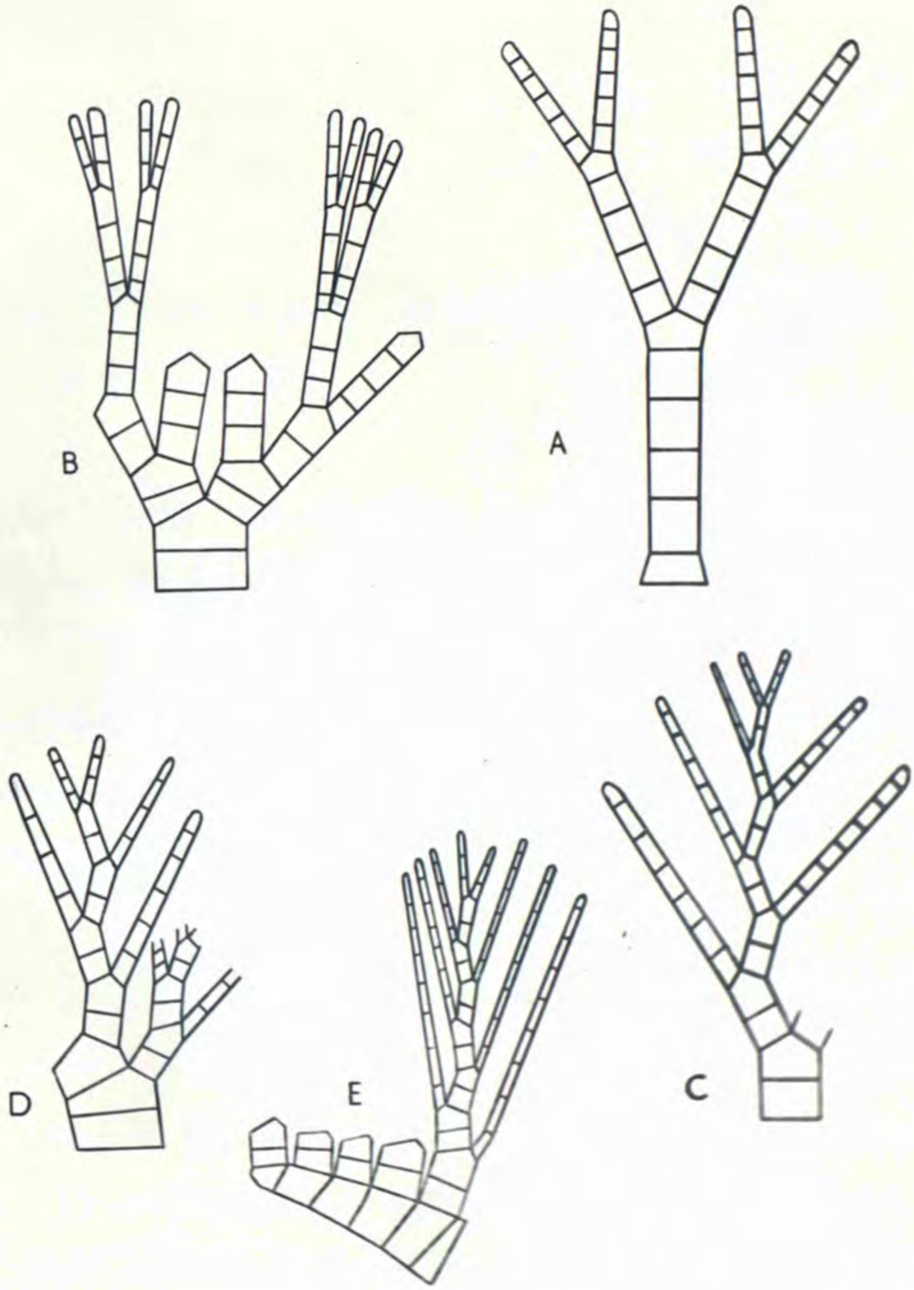
Type species.- A. thraivensis sp. nov.

Diagnosis.- A genus of Calceocrinidae in which there are four arm-bearing radials, the anterior, right anterior, and left posterior arms being isotomously branched; the left anterior arm may be isotomously branched or unbranched.

Discussion.- This new genus shows the mode of arm branching found in Eucheirocrinus, but it has four arms as in Cremacrinus instead of three as in Eucheirocrinus. It thus forms an intermediate stage between these two genera. The generic name is derived from the latin anulus = link (of a chain) in order to emphasise that a further stage in the evolution of the Calceocrinidae has now been recognised.

Cremacrinus simplex Springer (1926b, pp. 107-8, pl. 28, figs. 8, 8a) also shows this same structure and is here referred to Anulocrinus. Springer, in describing C. simplex, which was based on a single small specimen from the Bounsport formation, remarked that the type of arm structure shown in that species might well warrant its reference to a new genus, and the change has been made here. Diagrams illustrating the differences in arm structure between certain genera of Calceocrinidae are given in text-fig. 3.

Two species of Anulocrinus are described from the Starfish bed in Thraive Glen, near Girvan. This position, near the top of the Ordovician, corresponds with its expected position stratigraphically, for Cremacrinus first appears in the Trenton group, while Eucheirocrinus is Silurian. Anulocrinus, as the intermediate, form, appears between these two levels.



TEXT-FIGURE 3. Arm branching in Calceocrinidae.

A. The left anterior arm in Anulocrinus thraivensis sp. nov.

B. The other arms in Anulocrinus thraivensis sp. nov.

C. The lateral arms in Cremacrinus.

D. The lateral arms in an early species of Calceocrinus.

E. The lateral arms in a late species of Calceocrinus.

Anulocrinus thraivensis sp. nov.

Plate 8, figs. 1-8

Syntypes.- HM E 3496, E 3524, E 3581; BM E 47310, E 47311, E 47323, E 47324, E 47324 a and b, E 47319b.

Occurrence.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of _Anulocrinus_ with the left anterior arm dividing on the 5th-7th primibrach, and dividing once more again. Other arms dividing up to five times isotomously.

Description.- Details of the plating of the triangular basal circlet and hinge not seen. Upper part of cup as wide as high, (slightly) constricted laterally. All plates of the crown have a prominent pustulose ornament. Two halves of the left anterior radial only just in contact, and with sigmoid lateral margins; left anterior inferradial a little higher than superradial. Left anterior arm dividing twice; 5-7 primibrachs, slightly wider than high, first primibrach narrowing distally. 4-6 secundibrachs; up to 6 tertibrachs; branching is isotomous. Branching in other arms also isotomous; usually 2 (sometimes 3) primibrachs, wider than high; arms branch up to 5 times. Proximal brachials wider than high, distal brachials higher than wide. Axillaries in all arms nodose. Subanal plate wide and low; succeeding plates of the anal tube becoming higher, so that the 4th or 5th plate is almost as high as wide.

Stem round, proximal columnals short, increasing in length distally; from about the tenth columnal the length is greater than the width.

Discussion.- The available material of this species, though relatively plentiful, is all somewhat fragmentary, so that no one specimen has been designated as holotype. The description is thus a composite one compiled from the evidence of all the syntypes.

This species differs from A. drummuckensis and A. simplex in the division of the left anterior arm.

Anulocrinus drummuckensis sp. nov.

Plate 8, figs. 9-10

Holotype.- HM E 3508a and b (counterparts).

Occurrence.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of Anulocrinus with an unbranched left anterior arm. Brachials (except primibrachs) about as wide as high.

Description.- The unique holotype is preserved in counterpart in the form of external moulds. Form of cup not seen, and the disposition of the cup plates not clearly displayed. All cup and arm plates with a prominent pustulose ornament. The left anterior arm is stout and unbranched, composed of 16 brachials each about as wide as high. Left posterior arm with three primibrachs (wider than high) the more anterior of the first pair of branches divides unequally, the right hand branch again dividing. The more posterior of the two main branches in this arm divides twice isotomously. There are thus seven finials in this arm. Anterior and right anterior arm of similar structure, each with three primibrachs (wider than high) and branching isotomously three times. Right anterior arm only slightly smaller than the anterior and left posterior arms. In all arms in any pair of branches, that branch furthest from the left anterior arm divides first. The axillary brachials are usually slightly nodose. Traces of the anal tube are seen, but the details are obscure.

Proximal part of stem round and with very short columnals.

Discussion.- Although only known from a single specimen, and in that the cup is obscure, the arms structure of this species is quite characteristic. It differs from A. simplex Springer in the shortness of the brachials, and from A. thraivensis sp. nov. in the undivided left anterior arm. While the holotype is a small specimen it shows none of the juvenile characters found in young examples of other members of the Calceocrinidae - namely the great lengthening of the brachials and columnals (cf. Eucheirocrinus anglicus Springer - Ramsbottom, 1952, p. 44). A. simplex, however, may well be a young form.

Family HETEROCRINIDAE Zittel 1879

Diagnosis.- Monocyclic Inadunata with a small steeply conical cup, left anterior and right anterior radials compound. Right posterior radial consists of inter and super- radianal the latter being axillary and bearing on the left an unbranched anal tube and on the right an arm. One or more fixed brachials may be in the cup. Arms long, variously branched, non-pinnulate.

Range.- Ordovician.

Discussion.- Following the brief revision of the Ordovician Heterocrinidae given by Ulrich (1924) it is now difficult to determine generically many species which would formerly have been assigned to Heterocrinus. s.l. (text fig. 2). The British material available is not adequate for a full study, but some details are given here of all the known specimens.

(1) HM E 3613 (Plate 10, fig. 7) and BM E 47316a, b, which are probably conspecific, come from the Ashgill, Starfish Bed, Thraive Glen. The basals are here about two thirds of the height of the large radials (only one side of the cup is seen), there are five primibrachs, and there are signs that the second divison of the arms is heterotomous.

(2) GSM Pr 374 (Plate 2, fig. 5) and Pr 378 from the Ashgill, Slade Stage, roadside E. of Cnyciau Farm, 2 miles W.S.W. of Llandowror, St. Clears, Carmarthenshire; referred to as Heterocrinus? in Strahan and others

(1909, p. 61). In this species the structure of the cup is imperfectly seen, though at least one radial is compound, and the arm divisions, after the first, are heterotomous.

Associated with this heterocrinid are other crinoid fragments including two types of pinnulate arms, but these are as yet undetermined.

(3) A specimen collected by Mr. J. Murphy of Liverpool University and to be deposited in the National Museum in Dublin is from 38 feet above the base of the Tramore Limestone (Nemagraptus gracilis zone) Tramore, Ireland. It is preserved in a very coarse grained matrix as an external mould, and is chiefly distinguished by having the proximal brachials of at least two of the arms swollen.

Order CLADOIDEA Moore & Laudon 1943

Diagnosis.- Inadunata with infrabasals.

Family MEROCRINIDAE S. A. Miller 1889

Diagnosis.- Dicyclic Inadunata with a conical cup with five infrabasals. Radial circlet with five equal plates of which that in the right posterior is identified as an inferradianal. Superradianal above this, axillary and bearing the anal plate and anal tube on the left, and an arm on the right. Arms branching isotomously, non-pinnulate.

Range.- Ordovician.

Merocrinus Walcott 1884

Text-fig. 2

Type species by original designation *M. typus* Walcott, Trenton, New York

Diagnosis.- as for the family, only one genus being known.

Discussion.- *Merocrinus* may be described as a dicyclic *Iocrinus*, since in basic posterior structures it agrees exactly with that genus.

Merocrinus salopiae Bather

Plate 2 fig. 1

Merocrinus salopiae Bather, 1896, pp. 71-4, figs. A, a.

Holotype.- BM E 14938, and its wax squeeze B M E 6484.

Occurrence.- The unique holotype comes from the Llandeilo, Meadowtown Beds; small quarry (now filled in) near Mincop Farm, 6 miles S.E. of Welshpool, Montgomeryshire.

Diagnosis.- A species of Merocrinus in which the radials are as wide as high.

Description.- Cup low, relatively wide. Surface of cup plates smooth, but the sutures appear to be sunken. Infrabasals very low, half the height of the basals, which are wider than high and about two thirds of the height of the radials. Radials about as high as wide, the facets occupying the total width of the plate. Primibrachs four or five; secundibrachs seven or eight. Tertibrachs seven in the single case seen. Arms divide three times. All brachials about as high as wide, with evenly rounded dorsal sides, and deep ventral grooves. Superradianal axillary, a little higher than wide. Anal tube formed of plates higher than wide.

Tegmen and stem not seen.

Discussion.- Bather's description and figure of the specimen on which this species is based are inaccurate in several important respects. He stated, for example, that the infrabasals could not be seen; this is true in the wax squeeze he studied but in the Revultex impression used here, and in the specimen, they are clearly visible. The shape of the basals and the relationships of adjacent radials are also wrongly shown by Bather, and these characters are correctly shown in the new figure given here. It has also been possible to do some development, especially of the right posterior arm.

M. salopiae differs from all the three described American species of Merocrinus in the extreme lowness of the cup. M. corroboratus Walcott from the Trenton is apparently the nearest related species, and this differs also in the proximal region of the arms being rather stouter than in M. salopiae. "Glyptocrinus basalis" cited by Morton (1869, p. 19) refers in part to M. salopiae, but also includes the associated Pandoracrinus sp. nov.

Family CUPULOCRINIDAE Moore & Laudon 1943

Diagnosis.- Dicyclic Inadunata with a conical cup and 5 infrabasals; radial facets occupying full width of radials; radianal below righ posterior radial; anal in line with radials; anal sac well developed, with a vertical series of plates resting on anal. Arms branching isotomously, non-pinnulate, formed of wide brachials, often with gaping sutures.

Range.- Ordovician.

Discussion.- The wide radial facets are the main feature in which this family differs from the Dendrocrinidae.

Cupulocrinus d'Orbigny 1849

Text-fig. 4

Synonym.- Scyphocrinus Hall 1847, non d'Orbigny 1849 et auctorum.

Type species by subsequent designation of Springer (1911, p. 31) Scyphocrinus heterocostalis Hall, 1847, Trenton group, New York.

Diagnosis.- As for the family, only one genus being known.

Discussion.- According to the International Rules of Nomenclature the correct name of this genus should be Scyphocrinus Hall 1847. However, in 1833 Zenker had erected the genus Scyphocrinites for a now well-known and widespread melocrinitid, and this was subsequently corrupted to Scyphocrinus, though apparently it was not printed in that form until after the publication of Hall's name. Much confusion would be caused through having two different crinoid genera Scyphocrinus and Scyphocrinites, and this is a case where the International Commission on Zoological Nomenclature should be asked to waive the rules in favour of Cupulocrinus. Bassler (1938, p. 169) attributes Scyphocrinus (= Scyphocrinites Zenker) to Roemer 1855, but the name was used before this by D'Orbigny (1849).

The species here attributed to Cupulocrinus appear more closely related to the imperfectly known type species C. heterocostalis (Hall) than do the species (C. humilis etc.) referred to the genus by Springer (1911) in his revision of the group.

Cupulocrinus heterobrachialis sp. nov.

Plate 9, figs. 1-5

Holotype.- HM E 3614, 3614a.

Paratypes.- JW 1850, HM E 3484, E 3485.

Occurrence.- Ashgill, Upper Drummuck Group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of Cupulocrinus with a stellate stem, infrabasals, basals and radials of approximately equal height. Primibrachs normally five. Arms branching heterotomously after the first division. Brachials wider than high.

Description.- Cup higher than wide, surface of cup plates smooth, but there are traces of an axial ridge structure, especially on the infrabasals, and there are usually depressions along the sutures between the plates which latter are slightly convex. Infrabasals, basals and radials all of about equal height, all higher than wide. Radial facets occupy whole width of radials. Primibrachs usually five, wider than high, but not more than twice as wide as high. Secundibrachs four to seven. First arm division isotomous, but after this the divisions are heterotomous with the branching being on the heterocrinid plan. Arms branch four or five times. Brachials with evenly rounded dorsal sides, but distally there is a slight cornice at the distal end of the brachials. Radianal rather more than half the height of the adjacent radials in contact with right anterior radial beneath right posterior radial which is smaller than other radials. Anal plate higher than wide, and giving rise to a median ridge of plates, which are wider than high, in the anal tube. Slight longitudinal folding is seen in the side plates of the anal tube.

Tegmen not seen.

Stem stellate in cross section with alternating larger and smaller columnals; not tapering markedly proximally.

Discussion.- This is the most abundant species among the crinoids from the Starfish bed in Thraive Glen. Its closest relations seem to be with the little known C. heterocostalis (Hall), from which it differs in having larger infrabasals. It differs from C. gracilis in the position of the infrabasal, and the stellate stem, and from C. sepulchrum in the shape of the brachials. The other American species are characterised by extremely wide brachials.

Cupulocrinus gracilis sp. nov.

Plate 9, figs. 6-7

Holotype.- BM E 47313 a and b (counterparts).

Occurrence.- Ashgill, Upper Drummuck Group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis,- A species of Cupulocrinus with a round stem. Primibrachs three or four, arms branching isotomously. Radianal obliquely to lower left of right posterior radial.

Description.- Cup higher than wide, surface of cup plates smooth, radials convex. Infrabasals two thirds of the height of the basals, which are as high as wide. Basals and radials of equal height. Radial facets occupy the whole width of the radials; primibrachs three or four as wide as high, or higher than wide; secundibrachs four or five. Arms divide three times isotomously, all distal brachials with smoothly rounded dorsal sides, higher than wide.

Radianal, obliquely to the lower left of right posterior radial, and not in contact with right anterior radial. Anal plate small, not rising in height above level of radials, and giving rise to a stout median ridge in the anal tube formed of plates which are wider than high. The plates on either side of the tube are indistinct in the available material.

Tegmen not seen.

Stem round, formed of alternating larger and smaller columnals, and confluent with the base of the cup due to a slight tapering at the proximal end.

Discussion.- It is with some hesitation that this species is placed in *Cupulocrinus* because of the position of the radianal slightly to one side of the right posterior radial. It seems to bear, however, the same relation to *Cupulocrinus heterocostalis* Hall as *Dendrocrinus casei* Meek does to *D. longidactylus* Hall, the type species of *Dendrocrinus*, and so may conveniently be retained here for the present.

Its differences from other species are given in the diagnosis, and it may easily be distinguished from the other British species of *Cupulocrinus* by its round stem.

Cupulocrinus sepulchrum sp. nov.

Plate 3, figs. 6-7

Holotype.- GSM 59380.

Paratype.- GSM 59379 and its counterpart GSM 59381.

Occurrence.- Caradoc, Gaerfawr Group (of Wade, 1911), Quakers Burial Ground, 150 yds. N.W. of Cloddiau Farm, $1\frac{1}{2}$ miles N.W. of Welshpool, Montgomeryshire.

Diagnosis.- A species of Cupulocrinus with a five sided stem. All brachials (except in extreme distal region) higher than wide. Arm branching heterotomous after the first division.

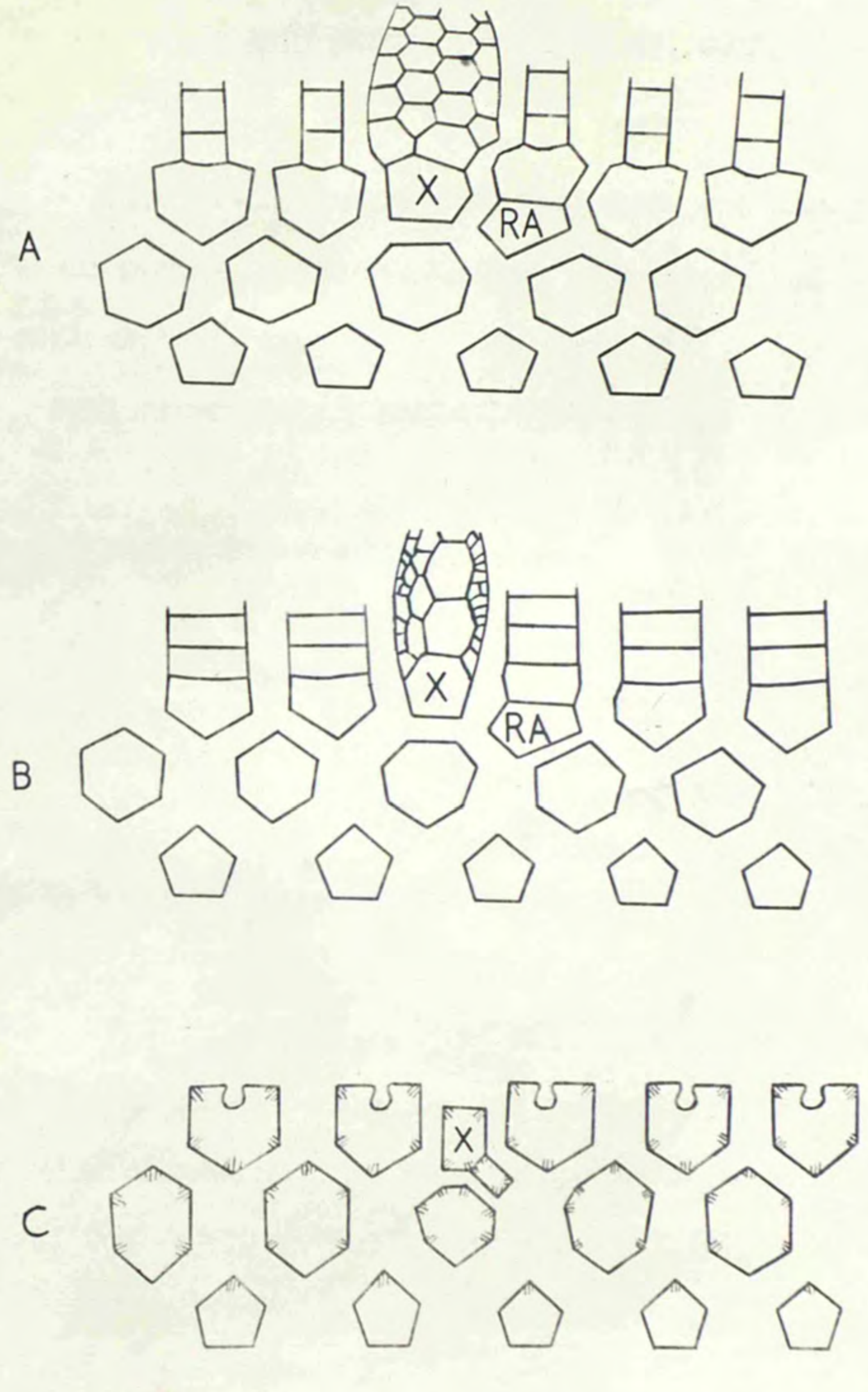
Description.- Cup conical, considerably wider than high, surface of cup plates smooth. Infrabasals, basals and radials of approximately equal height; all higher than wide. Radial facet occupies whole width of plate. Four or five primibrachs, confluent with the radials, all higher than wide, with evenly rounded backs. Arms branch about five times; proximal division isotomous, subsequent divisions heterotomous. Brachials with rounded backs, becoming shorter distally, but, except in extreme distal branches, always higher than wide. Anal plate five sided, its distal edge is distal to that of the left posterior radial, and about equal to that of the right posterior radial.

Radianal below right posterior radial. Anal plate supports two plates in second row, these having radiating ridges. Tube without prominent median ridge, but having two ridges formed of transversely folded plates. Tube plates roughly quadrangular, wider than high.

Tegmen not seen. Stem, five sided, slightly nodose at the angles, formed of columnals of equal thickness.

Discussion.- This species differs from the two Scottish species here described in having a five sided stem, and from all the described species in the extreme length of the brachials. It is also distinct in the details of the anal tube for in place of the single median ridge usual in *Cupulocrinus* there are two ridges, neither of which is as strong as the median ridge in *C. heterobrachialis*. *C. sepulchrum* has a more slender appearance than the other described species of *Cupulocrinus*, owing to its high cup and high brachials.

The type specimens, which are preserved as external moulds, have been in the Geological Survey collections for many years, and were recorded as *Heterocrinus*? by Huxley & Etheridge (1878). The starfish *Salteraster asperrimus* (Salter) comes from the same locality.



TEXT-FIGURE 4. B. Cupulocrinus (after Springer)

A. Dendrocrinus (after Springer)

C. Porocrinus (after Bather)

X - anal; RA - radianal.

Family DENDROCRINIDAE S. A. Miller 1889

Diagnosis.- Dicyclic Inadunata with a conical cup with five infrabasals; radial facets narrow, horseshoe-shaped; radianal, anal and sometimes another anal plate in cup; anal tube prominent, formed of thin plicated plates. Arms isotomously branched, slender, non-pinnulate.

Range.- Ordovician to Devonian.

Dendocrinus Hall 1852

Text-fig. 4

Type species by monotypy D. longidactylus Hall, 1852. Niagaran, Lockport, New York.

Diagnosis.- A genus of Dendrocrinidae in which the anal tube is elongated and vertically disposed.

<u>Dendrocrinus</u> <u>granditubus</u> sp. nov.

Plate 11, figs. 1-7

<u>Holotype</u>.- BM E 47332 a and b (counterparts)

<u>Paratypes</u>.- HM E 3509, E 3516, E 3518, E 3603, E 3605.

<u>Occurrence</u>.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

<u>Diagnosis</u>.- A species of <u>Dendrocrinus</u> with an enlarged anal tube formed of many rows of small equal-sized plates with a stellate pattern of ridges on each plate. Strong axial ridges on cup and surface of cup plates rugose.

<u>Description</u>.- Cup about as wide as high with extremely strong and prominent axial ridges and a rugose exterior ornament. Infrabasals form a quarter of the height of the cup. Basals, about as wide as high, form half the height of the cup. Radials wider than high, forming one third of the height of the cup, and with the facets occupying about three fifths of the width of the plates. Primibrachs usually four, sometimes five, as high as wide or wider than high, and with a rugose ornament on their dorsal sides. Arms branch six or seven times at short intervals with about six brachials between axillaries. Some divisions distally appear to be heterotomous, but proximally they are isotomous. Brachials with a fairly sharp dorsal median ridge and distal cornice-like expansion. Proximally the brachials are as high as wide or slightly wider than high, but distally they may be a little higher than

wide. Anal plate about as wide as high; radianal wider than high, beneath right posterior radial which is small and considerably wider than high. Tube prominent, formed of many (about 20) rows of small rectangular plates, each plate having a stellate pattern of small ridges. Tube always flattened in available material.

Tegmen not seen. Stem stellate and nodose, formed of alternately thick and thin columnals.

Discussion.- The most prominent feature of this species is, as the name implies, the anal tube. Indeed in splitting the rock specimens always split along the flattened tube, so that details of the arms are difficult to ascertain, except by elaborate development, and this means sacrificing the tube in part, as has been done with HM 3603 (Plate 11, fig. 2). The cup characters are difficult to decipher for another reason, namely that the strong axial ridges and rugose ornament tend to mask the sutures. Enough has been seen, however, to make the reference of the species to *Dendrocrinus* certain. No other species of *Dendrocrinus* has a tube such as is here figured and described.

Dr. W. K. Spencer (1950) records the presence of the cystid *Lingulocystis* Thoral (1935) which was first described from Languedoc, in the Girvan Starfish Bed. He tells me that this record was based on specimens of the anal tube of *D. granditubus*, and hence is erroneous.

Dendrocrinus rugocyathus sp. nov.

Plate 3, figs. 1-5

Holotype.- SM A 30745 a and b (counterparts).

Paratype.- SM A 30744 a and b (counterparts).

Occurrence.- Ashgill, Slade beds; near West Lambston, roadside, where the road to Black Patch and Frogs Hole joins the road to Nolton, Pembrokeshire.

Diagnosis.- A species of Dendrocrinus with strong axial ridges in the cup, but a smooth surface between the ridges. Anal tube with median row of larger plates; tube plates with stellate ridge pattern.

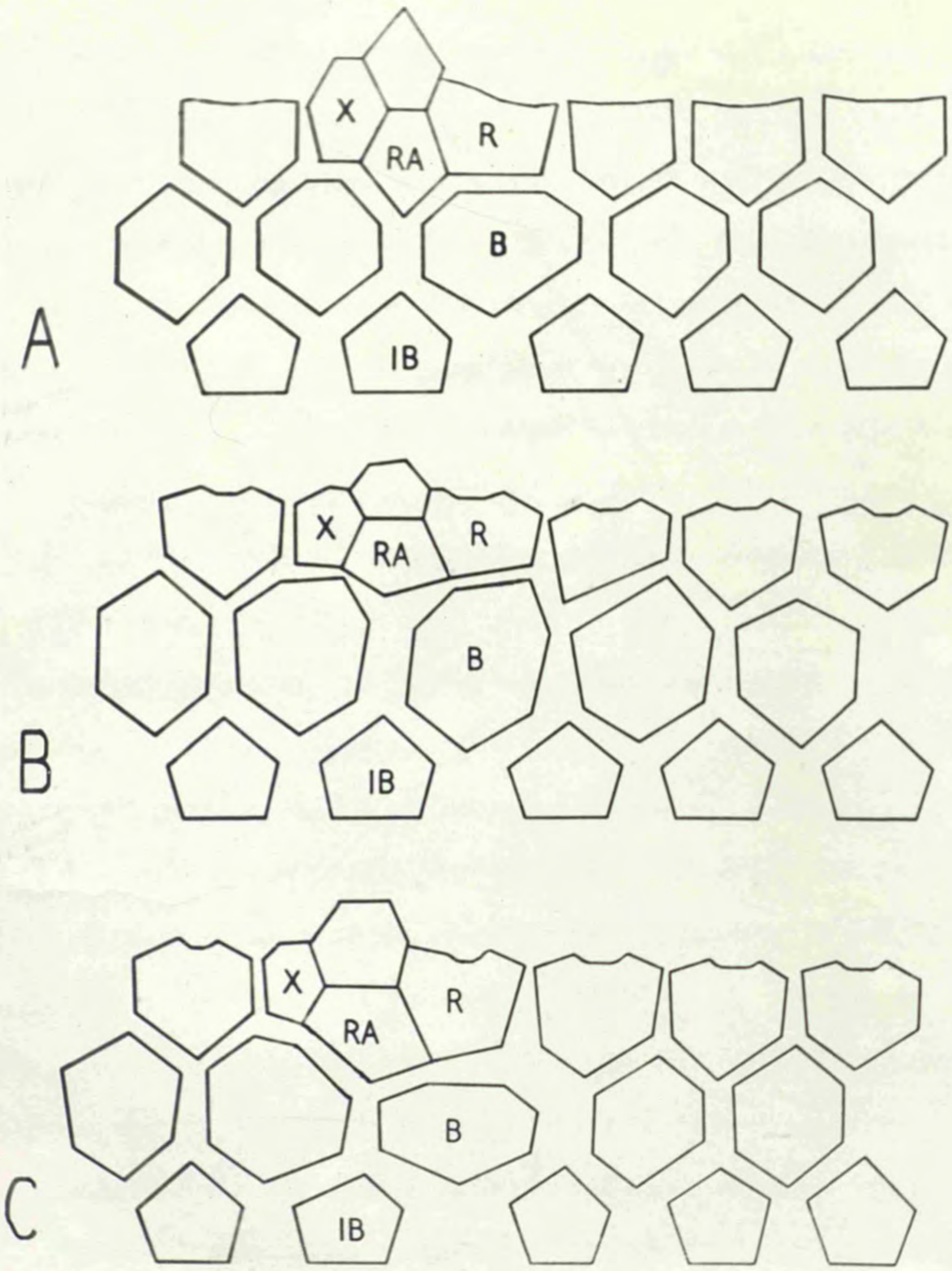
Description.- Cup conical with strongly raised axial ridges which leave deep depressions at the angles of the cup plates; surface of cup plates smooth between the axial ridges. Infrabasals about half the height of the basals, which are about as wide as high. Radials (as wide as high) about equal in height to the basals. Facet narrow rounded, occupying one third of the width of the plate, and directed outwards from the cup at an angle of about 45°. Primibrachs four or five, about as wide as high, smoothly rounded. Secundibrachs five or six. Arms divide isotomously five times. Brachials, except the primibrachs all higher than wide, and becoming higher and narrower distally. A suspicion of angularity is seen on their dorsal sides and a similar trace of distal expansion is present.

Radianal below right posterior radial, which is consequently raised above other radials, and in contact with right anterior radial. Anal plate a little smaller than its subjacent basal and both radianal and anal plates bear axial ridges. Three plates of the anal tube rest on the anal, the central of these being the largest and giving rise to a more or less prominent ridge on the tube. The plates of the tube, above the proximal three median ridge plates have a stellate ornament of ridges.

Stem stellate with alternating thin and thick columnals, the thick columnals often being slightly enlarged at the apices of the stellate angles.

Discussion.- This species is represented by the finely preserved external moulds of two crowns on the same slab, in the Turnbull Collection at the Sedgwick Museum. The photographs are taken of Revultex impressions. A third specimen (BM E 1484) in which the plates are dissociated,from the Robeston Wathen Limestone, Narberth, Carmarthenshire, is referred here only with some doubt.

The species is distinguished especially by the characters of the cup, with its prominent axial ridges and deep depressions at the corners of the plates combined with a smooth surface between the axial ridges.



TEXT-FIGURE 5. Euspirocrinus.

A. E. spiralis Angelin (after Bather).

B. E. obconicus Billings (after Billings)

C. E. girvanensis sp. nov.
X - anal; R - radial; B - basal; IB - infrabasal; RA - radianal.

Family EUSPIROCRINIDAE Bather 1899b

Diagnosis.- Dicyclic Inadunata with a conical or bowl-shaped cup. Infrabasals 3-5. Radianal, anal and a third anal plate in cup; anal tube stout, thick plated; arms branching several times isotomously.

Range.- Ordovician to Lower Carboniferous.

Discussion.- Moore and Laudon (1943, p. 51) use the family name Ampheristocrinidae S. A. Miller, 1889, for this family, but Euspirocrinidae is preferred here, since the structure of *Ampheristocrinus* Hall is imperfectly known.

Euspirocrinus Angelin 1878

Text-fig. 5

Type species by monotypy: *E. spiralis* Angelin 1878, Silurian, Gotland.

Diagnosis.- A genus of Euspirocrinidae with five infrabasals, radial facets occupying one third or more of the width of the radials.

Euspirocrinus girvanensis sp. nov.

Plate 10, fig. 5; text-fig. 5

Holotype.- HM E 3499.

Occurrence.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of Euspirocrinus with a bowl-shaped cup constricted at the base; the left anal plate is smaller than either of the other two anal plates in the cup.

Description.- Cup bowl-shaped, with sub-parallel sides above, and constricted at the base; about 7 mm. in height and maximum width, which occurs at the level of the top of the radials; External surface of plates not seen.

Infrabasals slightly greater than half the height of the basals, reflexed to form the basal constricted portion of the cup. Basals about as wide as high, hexagonal except for the posterior basal which is heptagonal. Radials about as wide as high, with the facet occupying about one third of the total width of the plate. Two quadrangular primibrachs are seen in one ray, but no further plates of the arms are seen.

Three anal plates in the cup. The lowest, which is pentagonal, rests between the posterior and right posterior basals, indenting the former plate. The upper right of the three anal plates is hexagonal, the upper left is small and pentagonal. Several rows, each formed of three small plates, of tube plates are seen resting on the upper right of the three anal plates.

Tegmen and stem not seen.

Discussion.- The unique specimen which is made the holotype of this new species is an internal cast, but it has such distinctive characters as to warrant description and naming. It differs from both the two other described species of the genus, *E. obconicus* W. R. Billings from the Trenton formation of Ottawa and *E. spiralis* from Gotland, (text-fig. 5) especially in the details of the posterior side of the cup. The small size of the left anal plate, and the shape of the cup are the main features which characterise *E. girvanensis*.

Family PALAEOCRINIDAE Bather 1899b

Diagnosis.- Dicyclic Inadunata with a usually conical cup. Radianal obliquely to the lower left of the right posterior radial. One other anal plate in cup. Orals large, anus opening directly on tegmen. Arms simple or isotomously branching.

Range.- Ordovician to Devonian.

Porocrinus Billings 1857

Text-fig. 4

Type species by monotypy P. conicus Billings 1857, Trenton, Formation, Ontario, Canada.

Diagnosis.- A genus of Palaeocrinidae with unbranched arms, and with deep folds at the angles of the plates of the cup directed towards the angles of the plates.

Discussion.- This genus is unfortunately named in that there are no actual pores in the cup. The folded areas at the corners of the plates are possibly connected with respiration, and analogous with similar structures in certain blastoids such as Codaster. In blastoids, however, the folds of the hydrospires always pass at right angles across the middle of the sutures, while in Porocrinus the folds pass towards the corners of the plates.

Porocrinus scoticus sp. nov.

Plate 10, fig. 8

Holotype.- BM E 47331.

Occurrence.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of Porocrinus with strong axial ridges on the cup: infrabasals two-thirds the height of the basals; folded areas at corners of plates small. Stem with reticulate ornament.

Description.- Cup conical with strong axial ridges on the cup plates joining the centres of each of the basal and radial plates (and presumably the analia if these were seen) and passing onto the infrabasals. Infrabasals two-thirds of the height of the basals which are as wide as high. Radials as high as wide or a little wider than high; facets narrow, directed outwards and distalwards, occupying one-third of total width of radial. Depressions occur at the corners of each plate, except between adjacent infrabasals. These are roughly triangular and have on each side 3-5 folds of the plate forming each side of the depression. The folds meet in the centre of each depression, and this is the deepest part of the depression.

Depressions also occur at the shoulders of each radial, where the third plate of the trio is an oral. Tegmen compoased of oral plates surrounding an open mouth, and separated by covering plates of the ambulacra. Six brachials are preserved in one arm of the holotype; they are slightly higher than wide; covering plates about three per brachial.

Stem round, enlarging slightly towards the cup, but not tapering sharply. In the holotype 13 mm. of stem are preserved, composed of very short slightly ridged columnals with occasional columnals a little larger than others, marked by longitudinal lines which give a reticulate appearance to the stem.

Discussion.- The above description is based on one specimen, the holotype, but it is supported by a wax cast of another (BM E 24652) the original of which cannot be found. One other wax cast of this species is also at the British Museum. This new species is mainly distinguished by the small size of the folded areas at the corners of the plates. In most North American species these areas are considerably larger. The stem ornament seems also to be unique.

Family PANDORACRINIDAE Jaekel 1918

Diagnosis.- Dicyclic Inadunata characterised by the imperfectly known structures termed parapinnules by Jaekel.

Range.- Ordovician.

Discussion.- Parapinnules (Jaekel, 1918, p. 57) may be described as having the appearance of pinnules but being apparently laterally joined; and also they are more numerous than the brachials and not regularly disposed towards them. Their true nature is unknown.

Pandoracrinus Jaekel 1918

Type species by original designation *P. pinnulatus* Jaekel, Ordovician, Bohemia.

Diagnosis.- As for the family, only one genus being known.

Pandoracrinus sp. nov.

Plate 2, fig. 6

Material.- BM E 14939 with its wax squeeze E 6485.

Occurrence.- The unique specimen comes from the Llandeilo, Meadowtown Beds; small quarry (now filled in) near Mincop Farm, 6 miles S.E. of Welshpool, Montgomeryshire.

Description.- Cup low, widely cone-shaped, surface of cup plates smooth. Infrabasals very low; basals wider than high; radials irregular in shape. Primibrachs four, secundibrachs seven in the single case seen. Arms divide at least twice. Brachials wider than high. Parapinnules are seen on various parts of all series of brachials, about two flutings on them going to each brachial.

Tegmen not seen. Stem round, ridged.

Discussion.- Bather (1896, pp. 74-5) has given a brief description of the single specimen available, which he referred to as an indeterminate crinoid. The subsequent description by Jaekel (1918) of a similar crinoid in the Ordovician rocks of Bohemia enables a name to be applied to the British specimen. The present specimen differs from P. pinnulatus Jaekel in that in the latter species the brachials are higher than wide, there are only 2 or 3 primibrachs and 3 to 4 secundibrachs.

Sub class FLEXIBILIA Zittel 1879

Diagnosis.- Dicyclic crinoidea with a flexible cup in which the lower brachials are incorporated either by lateral union with each other or by means of interbrachials or of perisome. All plates distal to radials united by loose suture and more or less movable. Mouth and food grooves exposed. Arms non-pinnulate. Infrabasals three, two large and one small.

Discussion.- Only one specimen in the Ordovician collections examined belongs to this sub class. This is HM E 3606 (Plate 10, fig. 6) from the Ashgill Starfish Bed, Thraive Glen. The specimen is a complete crown, preserved as a mould from which a Revultex impression has been taken. The upper part of the crown, above the basal, consists entirely of dissociated plates and a detailed description would be superfluous. Enough is preserved to show that this is a flexible crinoid, and since *Protaxocrinus* is the only flexible crinoid known from the Ordovician its reference to that genus seems likely, especially since the form of the crown conforms to that found in *Protaxocrinus*.

Sub class CAMERATA Wachsmuth & Springer 1885

Diagnosis.- Crinoidea with a rigid cup in which the lower brachials are to a varying extent firmly incorporated, being rendered fixed and immovable by union with either dorsal or ventral structures. Cup plates united by close suture. Mouth and food grooves chiefly subtegminal. Arms pinnulate.

Order MONOBATHRA Moore & Laudon 1943

Diagnosis.- Camerata without infrabasals.

Family PATELLIOCRINIDAE Angelin 1878

Diagnosis.- Monocyclic Camerata with three to five unequal basals; radials in contact all round; posterior side not usually differentiated by extra plates; interbrachials few; first primibrach quadrangular; few plates in cup.

Range.- Upper Ordovician to Lower Devonian.

Macrostylocrinus Hall 1852

Text-fig. 12

Type species.- By monotypy M. ornatus Hall 1852, Niagaran, Lockport, New York.

Diagnosis.- A genus of Patelliocrinidae with three unequal basals. Cup conical, posterior interradius wider than others, with 3-5 plates above the tergal plate. Arms ten, simple, biserial.

Macrostylocrinus cirrifer sp. nov.

Plate 7 figs. 1-8

Holotype.- HM E 3585, E 3585a (counterparts).

Paratypes.- JW 1857, HM E 3584, E 3586, E 3587, E 3588, E 3599.

Occurrence.- Ashgill, Upper Drummuck Group, Starfish Bed; Thraive Glen, 5 miles N. E. of Girvan, Ayrshire.

Diagnosis.- A small species of Macrostylocrinus with a coarsely pustulose ornament on the cup plates, and with a stem which bears frequent cirri at intervals in five vertical rows.

Description.- Cup cup-shaped, higher than wide, the surface of the plates bearing a pustulose ornament. Cup plates thin. Basals three, two large and one small, the latter being in the right anterior, about half the height of the radials. Radials heptagonal, about as high as wide. Narrow delicate axial ridges are seen on the cup plates, especially on the radials, from which they pass on to the arms. Primibrachs two, wider than high or as high as wide. Three or four secundibrachs follow. Arms 10, biserial, each brachial bearing a fairly long pinnule. Interradial areas depressed. First interradial plate not much bigger than the two succeeding plates in the second tow. Three or four smaller plates follow in the third row. Posterior interradial large, heptagonal, and followed by three plates in the second row. Smaller plates follow upwards to the anus which probably opens on the tegmen.

Plating of the tegmen not seen, but certainly incorporating the covering plates of the food grooves (E 3585a).

Stem round, formed of alternating large and smaller columnals. Cirri are given off at intervals and are deflected upwards towards the cup. They are in five vertical rows, but not in whorls. Six cirri occur in each vertical row in the proximal 12 mm. of stem. Distally the cirri become less numerous.

Discussion.- This species, of which about a dozen specimens are available, occurs in the form of internal and external moulds. Interpretation of the specimens from the Starfish bed was made possible by the good series of specimens (HM E 3584-3588) collected by Dr. A. Lamont; the stem and arms are best seen, however, in Mr. Begg's specimens.

This is the first species of Macrostylocrinus to be described from the Ordovician, the other described species being Middle Silurian, with one species in the Devonian.

The most characteristic feature of the species is the stem, with its cirri given off at intervals. The cup itself does not show characters which stamp it as a primitive species of the genus.

Family XENOCRINIDAE S. A. Miller 1889

Diagnosis.- Monocyclic Camerata with four basals; radials not in lateral contact except sometimes proximally. Interbrachials irregular, depressed, with many small plates. Posterior interradial with conspicuous median ridge. Stem four sided.

Range.- Ordovician (Richmond - Ashgillian).

Xenocrinus S. A. Miller 1881

Text-fig. 6

NON Xenocrinus Jahn 1893.

Type species by original designation X. penicillus S. A. Miller, 1881, Richmond Series, Ohio.

Diagnosis.- As for the family, only one genus being recognised.

Discussion.- This is the only genus yet described from the Ordovician which has four sided or "square" columnals. A species is here described from the Starfish Bed in the Ashgill, near Girvan. Although the crowns have not been found elsewhere in Britain it is noteworthy that four sided columnals are found in the Ashgillian in both the Lake District and South Wales.

Reed (1897a, pp. 82-3) described a series of crinoid stems from the Keisley Limestone of which that called "γ" (SM A 12084) is square and resembles that of Xenocrinus. The writer has collected square columnals from the Slade beds at the roadside 100 yds. S.E. of Cnyciau Farm, Llandowror, near St. Clears.

<u>Xenocrinus</u> <u>multiramus</u> sp. nov.

Plate 10, figs. 1-4

<u>Holotype</u>.- BM E 47328a and b (counterparts).

<u>Paratypes</u>.- BM E 47329 a and b, E 47320 a and b, E 47321a and b.

<u>Occurrence</u>.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

<u>Diagnosis</u>.- A species of <u>Xenocrinus</u> in which the arms branch twice, the radials and basals are of equal height, and the radials are not in lateral contact except proximally.

<u>Description</u>.- Cup conical, higher than wide, Surface of cup plates smooth, but the ray plates and the median row of plates of the posterior interradius are convex. Radials and basals of equal height. Radials higher than wide, only in lateral contact proximally, and distally separated by interradial plates. Primibrachs two, higher than wide. Secundibrachs two; these,

and the proximal three or four tertibrachs are higher than wide. Pinnulate cuneate uniserial arms follow in which the brachials are wider than high. Arms branch twice. Interradial and interbrachial areas depressed, filled with many small irregularly arranged convex plates. Posterior side of cup with radial-like tergal plate and a median vertical row of prominent convex, round-edged plates, all higher than wide, becoming more slender distally.

Stem four-sided, nodose, formed of alternating larger and smaller columnals.

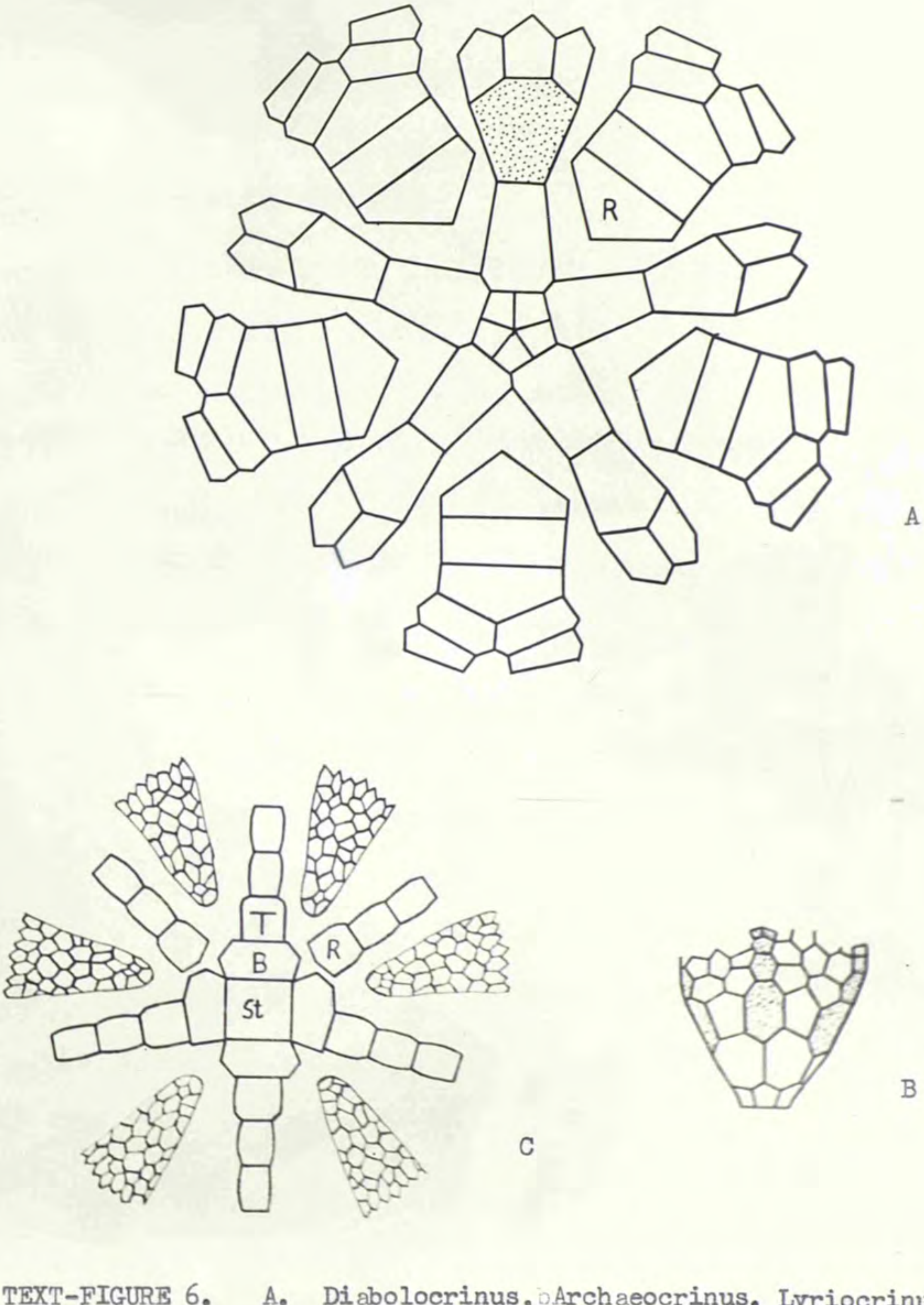
Discussion.- This clearly defined species differs from the two described American species in the large size of the basals, and in the fact that the arms divide twice instead of once. A more noticeable feature, however, is that the radials are in lateral contact proximally, whereas in the American species they are usually not in contact at all. Wachsmuth & Springer (1897, p. 184) mention an unusual specimen of *X. penicillus* in which the interradial plates do not touch the basals, which is just the condition in *X. multiramus*. This tendency to strengthen the basal elements in the cup is an evolutionary advance, but probably it is of less taxonomic importance than has been assigned to it by Moore & Laudon (1943). *X. multiramus* has been referred to *Xenocrinus* rather than to *Compsocrinus* S. A. Miller (which genus has the radials in lateral contact) because it is believed that the irregular arrangement of the interbrachial plates is of greater significance than the lateral contact of the radials. In *Compsocrinus* the interbrachial plates are regularly arranged.

Xenocrinus sp.

Material.- BM E 47312a.

Occurrence.- Ashgill, Upper Drummuck group, Starfish Bed; Thraive Glen, 5 miles N.E. of Girvan, Ayrshire.

Discussion.- One specimen of a species of *Xenocrinus* in which the arms divide only once is present in the collections from the Girvan Starfish Bed. The details of the cup plating are obscure, and a detailed description is deferred, pending the collection of better material.



TEXT-FIGURE 6. A. Diabolocrinus, Archaeocrinus, Lyriocrinus. The tergal plate is stippled.

B. Restoration of Archaeocrinus erectus sp. nov.

C. Xenocrinus. T - tergal; R - radial; B - basal; St - stem lumen.

Order DIPLOBATHRA Moore & Laudon 1943

Diagnosis.- Camerata with infrabasals.

Family ARCHAEOCRINIDAE Moore & Laudon 1943

Diagnosis.- Dicyclic Camerata with a high cup; radials separated all round, median ray ridges usually present in Ordovician genera; interbrachials regular, usually depressed; posterior interradius not markedly depressed, median ridge usually absent.

Range.- Ordovician to Devonian.

Archaeocrinus Wachsmuth & Springer 1881

Text-fig. 6

Type species by orginal designation: Glyptocrinus lacunosus Billings 1857, Trenton formation, Ottawa, Canada.

Diagnosis.- A genus of Archaeocrinidae with biserial arms, interbrachials 1-2, posterior interbrachials 1+3.

Discussion.- Not all the species referred to Archaeocrinus by Bassler & Moodey (1943) are correctly so placed. Such are a group of species with a low, bowl shaped cup, including A. parvus Miller & Gurley, A. peculiaris Miller & Gurley, A. knoxensis Miller & Gurley and A. globularis (Nicholson and Etheridge) which are probably more properly included in Diabolocrinus. A. delicatus Hudson certainly does not belong here, but is incompletely known. A. depressus Weller is almost certainly a Lyriocrinus, somewhat resembling L. britannicus Ramsbottom.

When so restricted Archaeocrinus is a relatively compact genus with the diagnostic characters given above.

Archaeocrinus elevatus sp. nov.

Plate 6, figs. 2-5; text-fig. 6

Syntypes.- HM E 3487a, E 3488a, E 3488e, E 3513, E 3529.

Occurrence.- Caradoc, Stinchar Limestone group, Orthis confinis beds; the syntypes come from Minuntion, c. $4\frac{1}{2}$ miles S.S.E. of Girvan. Specimens collected by the writer at this locality occur at about 10 ft. below the baze of the Stinchar Limestone (GSM Zi 4974-5) and examples were also collected at a similar horizon in Benan Burn (GSM Zi 4971).

Diagnosis.- A species of Archaeocrinus with a cone-shaped cup with large infrabasals, the second row of interbrachial plates being in contact with the radials.

Description.- Cup conical, average sized specimens being about 25 mm. in height, about 20 mm. in maximum width, which is at the level of the arm bases, and narrowing evenly to 3 mm. in width at the base. Surface of plates smooth. Infrabasals large, visible in side view, about half the height of the basals. Basals about as wide as high, heptagonal, truncated above. Radials higher than wide, heptagonal. Two primibrachs, each about as wide as high, the first hexagonal, the second pentagonal and axillary. Two quadrangular secundibrachs have been seen, but no further plates of the arms are preserved in the available material. Slight axial ridges pass from the infrabasals on to the basals, and then divide and pass on to the radials in the usual plan. On the upper parts of the radials and on the primibrachs and upwards on the arms these ridges become more marked, so that the secundibrachs are raised above the level of the interbrachial plates. Interbrachial areas not depressed. Interradial plates pentagonal and resting on the truncated tops of the basals, slightly higher than wide. There are two plates in the second row of interbrachials, both hexagonal; three plates in the third row, and four in the fourth, the plates becoming smaller upwards. The interbrachial areas are widest at the level of the third row of interbrachial plates. Anal interradius not markedly different in plate arrangement, nor in width, from the other interradii, but at the level of the secundibrachs, a median anal ridge occurs (E 3438e).

Tegmen and stem not seen, but the stem facet is round, and about 3 mm. in diameter.

Discussion.- This species is based on a series of not too well-preserved specimens from Minuntion, and is from the lowest level from which crinoids are recorded at Girvan. In many of the specimens the actual plates are present but the sutures are very difficult to detect. In other cases the specimens are internal moulds. The species belongs to a group of species of Archaeocrinus of which the best known member is A. pyriformis (Billings), but to which A. obconicus Slocum also belongs. The three species in this group differ from the remainder of the species of Archaeocrinus in the possession of large infrabasals clearly visible in side view. In the more typical species, such as A. lacunosus (Billings), the type species, the infrabasals are very small and are normally concealed either by the stem or owing to their presence at the base of a small basal concavity.

The cup in *A. pyriformis*, is more globular than in *A. elevatus* sp. nov., while in *A. obconicus* the radials, which are heptagonal in *A. elevatus*, are pentagonal. The second row of interbrachial plates is in contact with the radials in *A. elevatus*, while this is not the case in *A. obconicus*.

Balacrinus nom. nov.

Synonym.- *Coelocrinus* Salter 1866, *non* Meek & Worthen 1865

Type species.- *Glyptocrinus basalis* M'Coy

Diagnosis.- A genus of Archaeocrinidae in which the posterior side of the cup is not distinguishable by the presence of extra plates. All interbrachial areas usually have three plates in the second row of plates; arms uniserial, each brachial bearing a pinnule which come off on each side alternately.

Discussion.- Salter (1866, p. 283) proposed to separate *Glyptocrinus basalis* from *Glyptocrinus* under the name *Coelocrinus*, owing to its possession of infrabasals. The name *Coelocrinus* had, however, been used in the previous year by Meek & Worthen (1865, p. 273) for another crinoid. Wachsmuth & Springer (1897) referred *G. basalis* to their genus *Rhaphanocrinus*, but it differs from this genus in the arrangement of the plates of the interbrachial areas. *Rhaphanocrinus* has two interbrachial plates resting on each interradial - with three plates above the tergal, and *Balacrinus* normally has three plates resting on each interradial, and it is thus not possible to distinguish the posterior interradius. A new name is therefore proposed here to replace Coelocrinus Salter. The genus is named after Bala in Merioneth - the type species occurring in several places near the town.

Balacrinus basalis (M'Coy)

Plate 4, figs. 1-7

Glyptocrinus basalis M'Coy, 1850, p. 289.
Glyptocrinus basalis M'Coy, 1851, p. 57, pl. 1D, fig. 4.
Glyptocrinus basalis M'Coy, 1852, p. 177.
Glyptocrinus (Coelocrinus) basalis Salter, 1866, pp. 283-4, pl. 23, figs. 4, a, b, c,

Syntypes.- SM A 36529-30-31-32a-32b. Of these SM A 36532 a, b, is here selected as the lectotype. SM A 36529 is the specimen originally figured by M'Coy.

Occurrence.- The syntypes came from Caradoc beds at Gallt-yr-Ancr (= Alt-yr-Anker of M'Coy) Meifod, Montgomeryshire. The horizon within the Caradoc is probably bed C_2 of King (1928, p. 676 for remarks on the type horizon). Other specimens examined come from: Hafod Garden, Meifod (SM A 14348); Gwrelddian, Llanwddyn, 5 miles S.W. of Llangynog, Montgomeryshire (GSM 7389 - figd. Salter, 1866, pl. 23, fig. 4b); Guilsfield, 4 m. E.S.E. of Meifod (GSM 7388); Moel-y-Garnedd, $1\frac{1}{2}$ m. W. by S. of Bala (GSM 85261-6); Pen-y-rhiw, W. of Bala (GSM 85186-7); Bryn Cut, $1\frac{1}{2}$ m. S.E. of Bala (GSM 85259); Marshbrook, Shropshire (GSM 85267-69);

/roadside

roadside, 60 yds. W. of Chatwall Farm, $1\frac{3}{4}$ m. W.S.W. of Church Preen, Shropshire (GSM RT 574-5, 577, 582-3).

It seems probable so far as can be checked from the literature, that all these authenticated occurrences of the species, are within the zone of Dicranograptus clingani.

Diagnosis.- As for the genus, only one species being recognised.

Description.- Cup subglobular to conical, higher or as high as wide. Surface of cup plates usually smooth externally, but internal casts may show stellate ridges emanating from the centre of each plate. Axial ridges occur on the ray plates, becoming especially prominent on the radials. Infra-basals 5, about $\frac{1}{3}$-$\frac{1}{4}$ as high as the basals. Basals seven sided truncate above. Radials usually five sided, about as high and as wide as the basals, separated from each other laterally. Primibrachs two, secundibrachs two or three, followed by uniserial brachials, which are usually slightly cuneate. Arms branch once only and are unbranched after leaving the cup. Brachials short, each bearing a pinnule coming off on each side alternately from the thick side of the cuneate brachials. Interbrachial areas with one large interradial plate which separates the radials and rests on the truncate tops of the basals. The shape of this plate is variable and it may or may not be in contact with the primibrachs. Three plates usually follow in the second row, and these again are rather variable in arrangement. In three observed cases only two interbrachial plates are in immediate contact with the interradial. Further rows of smaller plates follow upwards. Posterior side not distinguishable by the presence of extra plates. The second primibrach seems to give rise to a fixed pinnule, but the material available does not allow this to be well studied.

Tegmen not seen. Stem round, formed of alternating nodals and internodals. Central lumen round and large.

Discussion.- All the material of this species consists of internal and external moulds, and in some cases latex impressions have been used for its study. This species is the '*Glyptocrinus*' of the *Glyptocrinus* flags of the Caradoc of Shropshire, though in that rock the crinoid is usually found as columnals and cups are rare. The only cups so far seen from Shropshire are somewhat smaller than the types, but are otherwise normal. Specimens from near Chatwall Farm were recorded as *Rhaphanocrinus* aff. *basalis* by Pocock & others (1938).

Family RHODOCRINITIDAE Bassler 1938

Diagnosis.- Dicyclic Camerata with a normally subglobular cup; radials separated all round; median ray ridges weak or absent; interbrachials regular, not depressed; posterior interbrachial with few extra plates and lacking a median ridge.

Range.- Ordovician to Lower Carboniferous.

Diabolocrinus Wachsmuth & Springer

Type species by original designation Diabolocrinus perplexus Wachsmuth & Springer, Trenton group, Tennessee.

Diagnosis.- Rhodocrinitidae with a depressed globular cup with a wide and deep basal concavity. Interradial plates sometimes surrounded by small supplementary plates which may separate them from the basals. Interbrachial areas usually 1+2, posterior interradius 1+3. Anus central at end of small tube.

Discussion.- It must be confessed that the diagnosis of the Ordovician Rhodocrinitid genera needs a thorough revision. In erecting the genus Diabolocrinus, Wachsmuth & Springer stressed the presence of a 'strong' anal tube, the tegmen being formed of fairly large plates. Neither of these features are notably present in the figures given by these authors of the species included by them in the genus. The other important character was the presence of supplementary plates in the interbrachial areas, though this is not always seen.

The species included in the genus here are perhaps not close to the type species, but no other genus can receive them. A likely solution to present difficulties might be the widening of the scope of the genus *Lyriocrinus*, but all discussion is hampered by the lack of knowledge concerning the arms of most of the species here assigned to *Diabolocrinus*. Bather (1917) suggested that *Atactocrinus* Weller was probably an unusual *Lyriocrinus* and the same might be said of *Maquoketocrinus* Slocum.

This question can not be settled by a mere examination of the literature, and a final revision must await the opportunity for study of specimens.

Diabolocrinus craigheadensis sp. nov.

Plate 6; figs. 6-10

Holotype.- BM E 46905.

Paratypes.- BM E 46906, E 46909.

Occurrence.- Craighead Limestone (Caradoc), Craighead Quarry, 4½ miles N.E. of Girvan, Ayrshire.

Diagnosis.- A species of Diabolocrinus with rays branching twice within the cup; supplementary interbrachials absent; cup extremely low, radials not seen in side view.

Description.- Cup low, bowl shaped, widest at the level of the tertibrachs, the main curve in the wall of the cup being at the level of the primibrachs and secundibrachs. It has a wide and deep basal concavity - depth 8 mm., width 9 mm. in E 46906 where the cup is about 32 mm. in width. Surface of cup plates smooth, but they are rounded and with sunken sutures. Infrabasals forming about half of the height of the walls of the basal concavity (E 46909), entirely hidden in side view, as are the basals, the upper part of which form part of the turn over of the concavity. Radials also hidden in side view, also forming part of the turn over of the concavity. Slight axial ridges are seen on the basals and radials, but these do not pass on to any other plates. Primibrachs two, secundibrachs usually two, but in one case only one. Up to four tertibrachs have been seen, but further plates of the arms are missing. There were twenty arm bases at this level. The sutures between certain of the ray plates in E 46906 are crenellate, particularly in the primibrachs and secundibrachs. Owing to the state of preservation it cannot be stated whether this character is universal.

Interradial areas slightly depressed. First interradial plates large, resting on the truncated tops of the basals; followed usually by two smaller plates and these by two further small plates. Three plates follow the large interradial in the posterior interradius. There is, however, as can be seen in the plates, considerable irregularity in the arrangement of the plates in the interradii. A single row of up to three intersecundibrachs is present, the first being usually larger than the others. A single row of two intertertibrachs is also found.

Arms, tegmen and stem not seen.

Discussion.- The most notable and characteristic feature of this species is the way in which the basals and radials are both hidden in side view, this being due to the extremely low flat cup. This character which could be taken as specialised, is combined with the unspecialised variability in the arrangement of the interradial plates, which is often found in the primitive Rhodocrinitidae (Hudson 1907, pp. 121-9).

Besides the types two other specimens probably belong here - BM E 46908 - the base of the cup seen internally, and BM E 46910 - a poorly preserved portion of a cup. All the known specimens are in Mrs. Gray's collection.

Although the specimens are labelled as being from the Craighead Limestone, it is likely that they actually came in one of the shale bands within the limestone.

Diabolocrinus globularis (Nicholson & Etheridge)

Plate 5; figs. 1-11

Glyptocrinus globularis Nicholson & Etheridge, 1880, pp. 329-30, pl. xxii, figs. 9-11.
Archaeocrinus? globularis Wachsmuth & Springer, 1885, p. 320.

Syntypes.- An unknown number of specimens, certainly included in BM E 46891-46904. The three figured syntypes cannot be definitely identified but are known to be included in the same group of specimens. Not all the specimens quoted, however, can be syntypes (see below).

Occurrence.- All known specimens come from the Craighead Limestone (Caradoc) Quarry. Specimens collected by the writer and Dr. Alwyn Williams occur at horizon 5 of Anderson & Pringle (1946, p. 175).

Diagnosis.- A species of Diabolocrinus with a thickened pentagonal lip around the basal concavity. No supplementary interbrachials. Arms ten, biserial, probably unbranched. Axial ridges usually developed.

Description.- Cup bowl shaped, about twice as wide as high and with a deep basal concavity. Surface of cup plates usually smooth, but they have sunken sutures, giving a tumid appearance to each plate. Usually an axial ridge system is developed and the ridges cross the sunken sutures; rarely these are coarse radiating ridges (BM E 46895). Infrabasals recurved, entirely within basal concavity and forming about half of the sides of the concavity (BM E 46908). Basals hexagonal, truncate, bent almost at right angles and forming subpentagonal lip of basal concavity. Edges of concavity frequently thickened, and this tends to mask sutures, giving the appearance of a continuous ring of plates. Radials separated all round, five sided, wider than high. Primibrachs two, wider than high. Secundibrachs four or five followed by biserial arms which are probably unbranched, but rarely preserved (BM E 46900). Interradial plates large, seven sided. Rarely the interradial (sometimes the tergal) plate is divided medially and then two plates are in contact with the basals. Two interbrachial plates occur in the second row, and usually two in the third row. Posterior interradius with a large tergal followed by three plates in the second row.

Tegmen formed of many small plates and without a tube. Stem not seen attached to a cup, but many associated stems are strongly nodose.

Discussion.- The above description is based on a series of good specimens in the Gray Collection at the British Museum (Natural History). When these were first seen they were in a box together with a cardboard tablet with the spaces where the three original figured specimens had been attached. It is assumed that these had got mixed with the remainder in the box, and that the original figures are somewhat generalised, for they cannot be recognised with certainty. Not all the specimens available can be syntypes, since Nicholson & Etheridge state that none of their specimens showed the tegmen, whereas in the present collection two examples show it. In the circumstances it seems impossible to select a lectotype with any certainty that it was among the original syntypes.

Only one specimens shows the arms and this is only a fragment (Plate 5, fig. 6). They are strikingly similar to those of Lyriocrinus as is the species as a whole, and were it not for the axial ridges and the relatively common irregularities of the plating of the interradial area, D. globularis might well have been referred to Lyriocrinus.

Diabolocrinus spp.

Discussion.- A number of specimens of Diabolocrinus are either not well enough preserved or not numerous enough to be described in detail.

(1) HM 3504a-b (Pl. 6, fig. 1) from the Starfish Bed, Girvan, is a large bowl shaped cup with basal concavity and a strong ornament on the plates. It is certainly specifically distinct from any of the other described species of the genus, but the inadequate material prevents its description.

(2) HM E 3616, also from the Starfish Bed, may be conspecific with the previous species, but only the internal mould is available, and this is not well enough preserved to be certain.

(3) Specimens in the collection of Mr. R. Tripp (Nos. 2136a-b, 2218a-b, 2222a-b) from the Craighead Mudstone, Craighead Quarry, Horizon 3 of

Anderson & Pringle (1946, table p. 175). These are close to D. globularis (Nicholson & Etheridge), but are internal moulds, and the tegmen (2222a) appears to differ in the ambulacra from that species. The plating, however, cannot be clearly seen.

INCERTAE SEDIS

Trochocrinites Portlock 1843

Type species by monotypy Trochocrinites laevis Portlock.

Discussion.- This genus was founded on a single fragmentary specimen (GSM 7391 Plate 9. fig. 8) from the Caradocian schists at Desertcreight, Tyrone, Northern Ireland.

The specimen is an internal mould of the base of the cup. It shows axial ridges, but no sutures can be seen between plates. Even the axial ridge system does not allow it to be ascertained whether the crinoid is monocyclic or dicyclic, though the former seems the most likely. It is certainly Camerate.

Another specimen, belonging to the collections of the Irish Geological Survey, and from the same locality, has also been examined, with equally negative results. The preservation is strikingly similar in both cases.

In view of this evidence the genus Trochocrinites must be left in abeyance until more material is found. It is in any case unlikely to be synonymous with Periechocrinus as was stated by Wachsmuth & Springer (1881).

(c) Ordovician Crinoid stems

A number of records of crinoids which occur in the literature refer to stems only. Very few of these can now be confirmed, but the following is a list of those which have been traced during the course of the present study.

(1) "Heterocrinus?" from Chair of Kildare (Reynolds & Gardner 1896, p. 593). Stem only - SM A 13835.

(2) "Crinoid" from Chair of Kildare (Reynolds & Gardner 1896, p. 592). Stem only - SM A 13835.

(3) "Glyptocrinus" Quillia, near Tramore (Reed 1897b, p. 505). Stem columnals only - SM A 16080.

(4) Crinoid stem sp. 1. Dufton Shales, Alston Road, Melmerby (Reed 1910, p. 212). Round stems - SM A 29644-8.

(5) Crinoid stem sp. 2. Dufton Shales, Alston Road, Melmerby (Reed 1910, p. 212). Pentagonal stems - SM A 29649-51.

(6) A series of crinoid stems from Keisley Limestone, Keisley, were mentioned by (Reed 1897a, pp. 82-3). These are now in the Sedgwick Museum and are registered as follows:

α - A 12077-8; β - A 12079-83; γ - A 12084; δ - A 12085; ε - A 12086; ζ - A 12087; η - A 12088.

(7) "Auxilliary side arm of a crinoid" from Caradoc Schists at Desertcreight, Tyrone (Portlock 1843, p. 346, pl. xv, fig. 3). Coiled stem - GSM 7390.

(8) "Rhodocrinites quinquangularis (Miller)". Llandeilo Flags. Phillips 1839, pl. 18, fig. 5. Pentagonal columnal - GSM Geol. Soc. Coll. p. 25.

(9) "Crinoidal column" (Portlock 1843, p. 345, pl. xv, fig. 2). Caradoc Schists, Desertcreight, Tyrone. Stem - GSM 7392.

(10) "Encrinite stem (the oldest known)" Murchison 1859, p. 50, woodcut fossils 8, fig. 9; Arenig, Mytton Dingle, Shelve, Shropshire - GSM 82820.

(11) Marr (1892a, p. 110; 1913, p. 5) records Myelodactylus from near the top of the Ashgill Shales, at Backside Beck, Cautley. Specimens which have been preserved in the Sedgwick Museum bear no relation to Myelodactylus. One (SM A 33302) is part of the cup of an unidentified dicyclic Inadunate crinoid; another is a coiled stem (SM A 33303) fragment from Spengill, Cautley, possibly belonging to some Camerate crinoid.

(12) Nicholson & Etheridge (1880, pp. 332-3, pl. xxi, fig. 12) figure a fragment of coiled stem, without cirri which is stated to have come from

Balclatchie, near Girvan (Caradoc), and which they refer to _Myelodactylus_. The original specimen cannot be found in the Mrs. Gray collection at the British Museum (Natural History), but the figure certainly suggests _Myelodactylus_. Nicholson & Etheridge group the Balclatchie specimen with another from the Upper Llandovery Beds at Penkill, and it is here suggested that the locality of the supposed Ordovician specimen was wrongly given, and that it too came from Penkill. Extensive collections of crinoid stems from Balclatchie in the Mrs. Gray collection, do not include any _Myelodactylus_, which is unknown in the Ordovician.

III SILURIAN CRINOIDS

(a) HISTORY OF RESEARCH

The history of research on British Silurian Crinoids is virtually a history of the discovery and description of crinoids from one locality and horizon - the Wenlock Limestone at Dudley, for very few species have hitherto been studied from other places.

Although a number of early writers such as Robert Plot (1686) figured crinoid columnals from Dudley, the principal worker at this early period was J. Parkinson (1808) who figured and gave a minute description of the root of Crotalocrinites verucosus; unfortunately Parkinson did not use binominal nomenclature and this species has to be based on Schlotheim's later (1820) specific name. J. S. Miller (1821), who established the outlines of crinoid classification, described four Wenlock species, but these are not all now recognised, and in one case (Temnocrinus tuberculatus) he figured the arms of one species on the cup of another. Cumberland (1826) gave a careful description and good figures of Crotalocrinites verucosus (Schlotheim) from Fownhope in Herefordshire.

It was not until the work of J. Phillips appeared in Murchison's 'Silurian System' (1839) that there was any extensive knowledge of Silurian crinoid life, and at this time fourteen species were known. It is fortunate that all the species figured and described by Phillips are common at Dudley, for of the nineteen specimens figured, only two have definitely been traced:

viz. pl. 17, fig. 1 Gissocrinus goniodactylus which is in the Northampton Museum; and pl. 18, fig. 7 Temnocrinus tuberculatus which is in the Birmingham University Type Collection. It is of interest to note that J. de C. Sowerby selected and drew the specimens to be figured before they were seen by Phillips (Murchison 1839, p. 702, footnote). An interesting account (Anon. 1843) of specimens in the museum of the Dudley Geological Society, repeated in Garner (1844), did not materially increase the knowledge then available, but Garner's account (1844) was accompanied by the earliest illustrations of sections of the crown of Eucalyptocrinites.

Individual species of crinoids were described in short papers by W. A. Lewis (1847), M'Coy (1849), and de Koninck (1858), while Salter (1854, 1859) gave further details of species already known. In the Geological Survey Memoir on the South Staffordshire Coalfield (1859) Salter gave a list of crinoid species then known from Dudley, but a much more complete work with many new species was Salter's posthumous catalogue of the Cambridge collection (1873). It is unfortunate that the descriptions given in that catalogue are often insufficient to validate the species, while in some other cases later authors have since described the species under another name. Angelin (1878) figured nearly two hundred crinoid species from the Silurian of Gotland, probably not more than half of which are good species, but not many of these have been found in England. Before any complete account of the English Silurian crinoids could be attempted it was realised by Bather that the nomenclatorial tangle left by Angelin's work must be removed by study of the Swedish material, and Bather (1893) undertook this task but it was never finished, except for a few Inadunate genera. Bather (1890-92) also began the modern study of the British Silurian crinoids, but again only dealt with a small number of Inadunates, though a few other species were figured in his text-book of 1900.

After Bather's work only Springer and Jaekel have made original studies on British Silurian crinoids, and Springer (1920, 1926a, 1926b) and Jaekel (1918) are the latest contributions until in 1950 the first paper of the present writer's was published.

(b) SYSTEMATIC DESCRIPTIONS.

Class CRINOIDEA J. S. Miller 1821

Subclass Inadunata Wachsmuth & Springer 1881

Diagnosis.- Crinoidea with a rigid cup in which the brachials are free (or sometimes loosely connected) above the radials. Plates of cup united by close suture. Mouth subtegminal, food grooves suprategminal, but may be closed by fixed ambulacral plates. Arms pinnulate or non-pinnulate.

Order Disparata Moore & Laudon 1943

Diagnosis.- Inadunata without infrabasals.

Discussion.- See page 10.

Family IOCRINIDAE Moore & Laudon 1943

Diagnosis.- Monocyclic Inadunata with a usually conical cup with five basals. Radial circlet with five equal plates of which that in the right posterior in identified as the inferradianal. Superradianal above this and not included in cup, axillary, bearing on left an unbranched arm-like anal tube, and on right an arm. Arms branch isotomously several times.

Range.- Ordovician and Silurian.

Myelodactylus Hall 1852

Synonyms.- *Brachiocrinus* Hall 1859; *Ophiocrinus* Charlesworth *non* Salter 1856; Herpetocrinus Salter 1873; *Eomyelodactylus* Foerste 1919.

Type species by monotypy: *M. convolutus* Hall 1852, Niagaran, America.

Diagnosis.- A genus of Iocrinidae with a coiled stem which is compressed or crescent-shaped in cross section in the distal region and bears two rows of cirri.

Discussion.- The cup in this genus is rarely seen, since it is enveloped in the coils of the stem. Indeed the cup is so degenerate in some species (*M. fletcheri*) that it has only four radials in some specimens, though possibly five in others. The structure of the cup can be interpreted as corresponding to the basic structures shown by *Iocrinus* (text-figure 2). As a consequence of the rarity of the cup in preserved specimens, specific discrimination is based on stem features, particularly the arrangement of the cirri and the nature of the cirrus plates.

Myelodactylus fletcheri (Salter)

Plate 16, figs. 12-13

Herpetocrinus Fletcheri Salter, 1873, p. 118, woodcut
Myelodactylus heterocrinus Angelin, 1878, p. 11, pl. x, figs. 24-25
Herpetocrinus Fletcheri Bather, 1893, p. 46, pl. ii, figs. 24-49
Myelodactylus fletcheri Springer, 1926a, p. 10, pl. 1, figs. 10-12c
Myelodactylus fletcheri Springer, 1926b, p. 86, pl. 27, figs. 10-10b

Syntypes.- The specimens quoted by Salter have now been reregistered as SM A 12609-24. SM A 12609 was designated [lecto]type by Springer (1926a, p. 10). Of the remaining syntypes only SM A 12610, A 12611 and A 12613 belong to M. fletcheri, the others being either M. ammonis or M. ammonis var. extensus. SM A 12614 is figured here as M. ammonis; A 12612 is M. ammonis var extensus; A 12616-24 are stem fragments showing columnals of either the bijugicirrus or alternicirrus type.

Occurrence.- All the syntypes are from the Wenlock Limestone, Dudley. The species is known from both the Wren's Nest (BM E 22581) and Tividale (BM E 22590), Dudley. A doubtful specimen is from the Wenlock? Shale, Sedgley, Staffordshire (BUH 551). In Gotland Bather (1893) records the species from Follongbo, Burgen, E. of Stjernafue and several localities near Farö.

Diagnosis.- Stem long, coil open, cirri fairly short, regularly paired on successive columnals. Cirrus ossicles short, about as long as wide, moniliform.

Discussion.- Although the anatomy of this species has been very adequately made known by Bather working on Swedish material, the original syntypes have never been described, except by Springer (1926a) who figured the lectotype from a cast in which certain details are obscure. A better photograph of the lectotype is given here (plate 16, fig. 12). Its structure proves to be almost identical with that of the principal specimen figured by Bather (1893, pl. i, fig. 10 - reproduced here as text-figure 7), but it has been crudely cleaned by an earlier worker and all the finer details have been obscured. None of the remaining syntypes is sufficiently well preserved to yield new information about the anatomy of the species.

Springer showed that in one specimen, in which the cup could be seen all round, only four radials occur (1926a, pl. 1, fig. 12c). This is probably an abnormality, since other specimens, which cannot be seen all round however, appear to have five radials as is usual.

Myelodactylus ammonis (Bather)

Plate 16, figs. 6-10

Herpetocrinus Ammonis Bather, 1893, p. 49, pl. ii, figs. 54-63
Myelodactylus ammonis Springer, 1926a, p. 10, pl. 2, figs. 1-9
Myelodactylus ammonis Springer, 1926b, p. 86, pl. 27, figs. 1-5a

Syntypes.- Two specimens from Gotland and ten specimens from England nos. BM 338, E 323, E 355, E 356, E 415, E 1326, E 1410a and b, 57091, 57207.

Occurrence.- The English syntypes come from the Wenlock Limestone, Dudley. Also known in England from the Wenlock Limestone, Wenlock Edge (GSM 91777), and from old quarries, 100 yards S. of Brawn's works canal bridge, Daw End, Walsall (GSM Pl 3684); Wenlock Shale, Ledbury (BM E 6660). In America the species is known from the Brownsport Formation, Decatur County, Tennessee; Waldron Shale, Mewsom, Tennessee; Laurel Formation, St. Paul, Indiana. Also known in Gotland.

Diagnosis.- Stem short, tapering, coil very close; cirri short, either of the bijugicirrus or alternicirrus type, cirrus ossicles longer than wide in proximal part of the cirrus, becoming shorter distally.

Discussion.- Bather (1893) pointed out that in this species the cirri are arranged in one of two ways, but in some cases both patterns occur in different parts of the same specimen. In the _bijugicirrus_ variety the cirri are regularly paired on alternate columnals (BM e 323, E 356; see plate 16, fig. 7). In the _alternicirrus_ variety, on the other hand, the cirri are regularly alternating, one on each columnal, and come off on each side of the stem alternately (BM 57091, 57207; see plate 16, figs. 6, 8). The cup of this species has not been seen.

Myelodactylus ammonis var. _extensus_ Springer

Plate 16, fig. 11

Myelodactylus extensus Springer, 1926a, p. 14, pl. 3, figs. 1-13a
Myelodactylus extensus Springer, 1926b, p. 87, pl. 27, figs. 11-18

Syntypes.- An unspecified number of specimens described by Springer, now in the United States National Museum. In the absence of definite designation of type specimens the syntypes must include all the specimens mentioned by Springer in hid original description. These include several English specimens from Dudley, one of which was figured (1926a, pl. 3, fig. 13).

Occurrence.- Wenlock Limestone, Dudley. Niagaran, Brownsport Formation, Decatur County, Tennessee; ?Laurel Formation, St. Paul, Indiana.

Diagnosis.- Like M. ammonis, except that the coil of the stem is open beyond the proximal region, and the stem is extended for a considerable distance in a broad curve towards the distal end.

Discussion.- There is only one character in which this variety differs from M. ammonis, nemely the mode of coiling and length of the stem. Springer treated it as a separate species, and Ehrenberg (1930, p. 322) although doing the same, was not fully convinced as to its specific identity. It is here considered that no more than varietal rank should be accorded to it. The cup has not been seen.

Myelodactylus convolutus Hall

Myelodactylus convolutus Hall, 1852, p. 191, pl. 45, figs. 5-6
Myelodactylus convolutus Bather, 1893, p. 48, pl. ii, figs.50-53
Myelodactylus convolutus Springer, 1926a, p. 8, pl. 1, figs.1-8
Myelodactylus convolutus Springer, 1926b, p. 86, pl. 27, figs. 6-8

Syntypes.- The specimens described by Hall, present whereabouts unknown.

Occurrence.- The syntypes came from Lockport. Specimens are known from the Rochester Shale and Clinton Group, Lockport, New York; Brassfield Limestone, Xenia, Ohio; Racine Dolomite, Chicago; Laurel Limestone, St. Paul, Indiana. Also recorded from Tofta, Gotland. Springer (1926a, p. 10) and Ehrenberg (1930, table opposite p. 324) record the species from England.

Diagnosis.- Stem long, coil open, columnals short, quadrangular, uniform. Cirri flat, regularly paired on successive columnals, cirrus ossicles much longer than wide.

Discussion.- No specimens of this species have been seen in the principal British collections.

Myelodactylus spp.

(1) Upper Llandovery. Nicholson & Etheridge (1880, pp. 332-3, pl. xxi, fig. 11) figure a fragment of a coiled stem from the Upper Llandovery, Penkill, near Girvan, Aryshire (horizon fide Lapworth, 1882, p. 648). The specimen, which was in Mrs. Gray's collection, cannot be found in that collection at the British Museum (Natural History). It is clear, however, that the specimen figured belongs to *Myelodactylus*, and that the genus does occur at so low a horizon as the Upper Llandovery. The figured specimen is without cirri, so that the species cannot be determined.

<u>(2) Upper Llandovery.</u> A poorly preserved specimen, here determined as <u>Myelodactylus?</u> (SM A 34050) occurs from the Upper Llandovery, Canaston Beds, Millim Stage, west bank of Eastern Cleddau River, ½ mile S. E. of Skebech Hall, 5 miles E. of Haverfordwest, Pembrokeshire.

<u>(3) Wenlock Shale.</u> Evidence of the presence of a species of <u>Myelodactylus</u> near the base of the Wenlock Shale is seen in three loose, thin, kidney-shaped columnals (GSM 85585) from the Buildwas Beds, in stream 80 yards S. of Harley Bridge, Harley, Shropshire; and also in a stem fragment from the Buildwas Beds at Buildwas, Shropshire, which has 14 columnals (BM E 14931). Neither of these specimens has cirri, so that it is not possible to determine the species.

Family PISOCRINIDAE Angelin 1878

Diagnosis.- Small monocyclic crinoids with a conical or globose cup. Basals three to five. Left and right anterior radials much smaller than left posterior and anterior radials. Super-radianal like a small radial, obliquely to left of large infer-radianal. Arms unbranched or isotomously branched, pinnulate or non-pinnulate.

Range.- Silurian and Devonian.

Pisocrinus de Koninck 1858

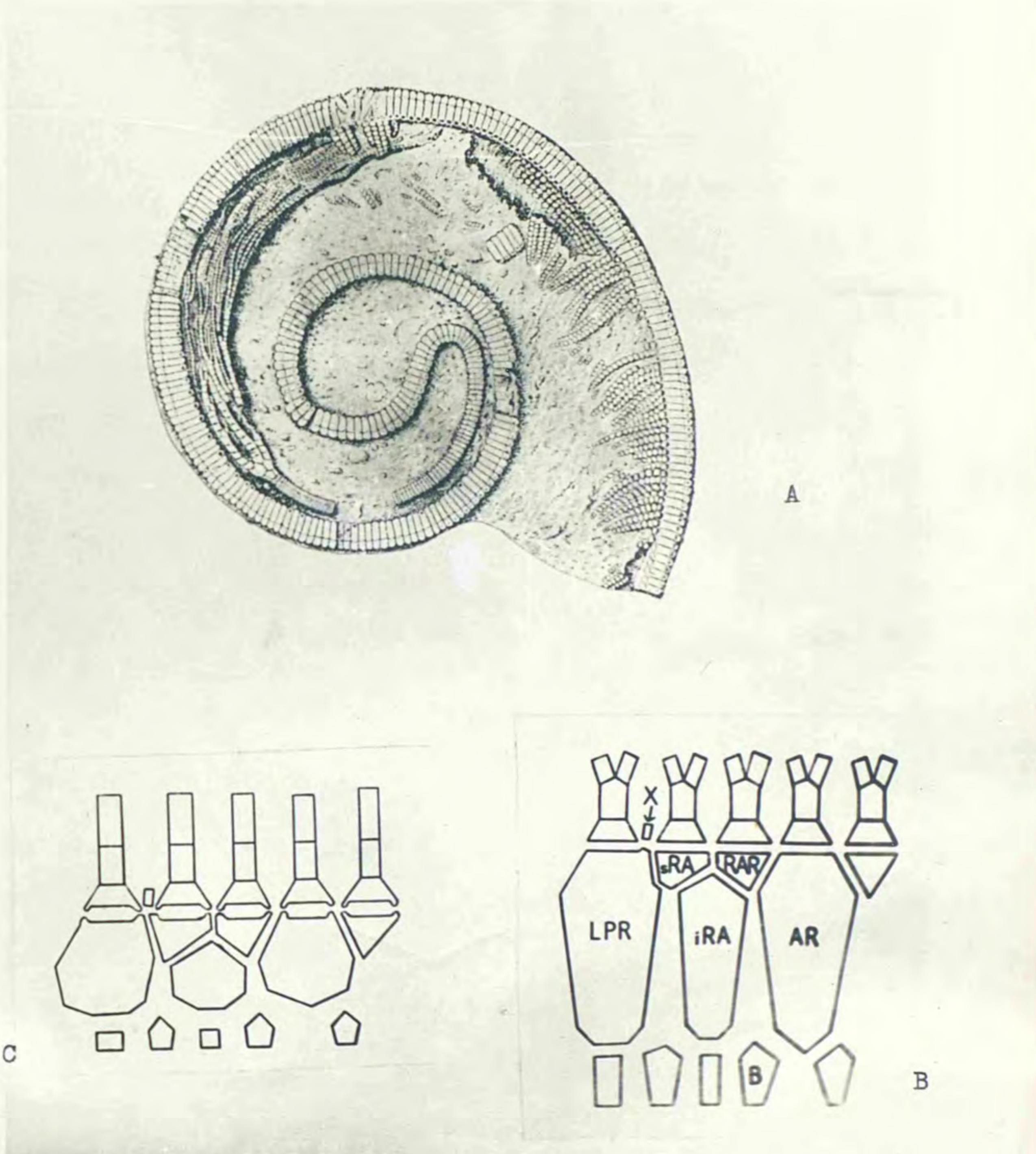
Text-figure 7

Synonym.- *Triacrinus* Ringueberg 1884 *non* Munster 1839.

Diagnosis.- A genus of Pisocrinidae with five basals and non-pinnulate, unbranched arms, the radials having lateral processes.

Type species by subsequent designation of S. A. Miller 1889, p. 269: *Pisocrinus pilula* de Koninck 1858, Wenlock Limestone, Dudley.

Discussion.- It has not proved possible to make an adequate study of the British members of this genus owing to lack of material. Bather (1893) made a detailed study of the Swedish



TEXT-FIGURE 7.

A. Myelodactylus fletcheri (Salter), reproduced from Bather (1893).

B. Cicerocrinus. B - basal; X - anal plate; LPR - left posterior radial; RAR - right anterior radial; AR - anterior radial; iRA - inferradianal; sRA - superradianal.

C. Pisocrinus. The plates are the same as those in Cicerocrinus.

species from Gotland, and these include P. pilula, the principal English species. Bather made several references to English specimens in the British Museum (Natural History) in that work, but unfortunately the once extensive Pisocrinus material in that museum is now missing (with one exception), and all efforts by Mr. L. Bairstow and Mr. E. R. Bush to find it have been unavailing.

Pisocrinus pilula de Koninck

Plate 16, figs. 1-5

Pisocrinus pilula de Koninck, 1858, p. 106, pl. ii, figs. 8-11
Pisocrinus ornatus de Koninck, 1858, p. 107, pl. ii, figs. 12-13
Pisocrinus pilula Salter, 1873, p. 128
Pisocrinus pilula Angelin, 1878, p. 21, pl. iv, figs. 4, 4a, 4b?
Pisocrinus flagellifer Angelin, 1878, p. 21, pl. iy, figs. la-e
Pisocrinus pilula Bather, 1893, p. 27, pl. i, figs. 1-11

Syntypes.- De Koninck had two specimens, one of which was in the Gray collection, now at the British Museum (Natural History), but this was stated by Bather (p. 23) to be missing in 1893. The other specimen was said by de Koninck to be in his own collection.

Occurrence.- De Koninck's original syntypes came from Dudley. The species is known from the Wenlock Limestone, Dudley and

Malvern (SM A 12694). Wenlock Shale, Malvern (GSM 89635) and Wenlock? Shale, Sedgley (BUH 262, 281). Lower Ludlow, Ledbury Tunnel (BM 6665).

Diagnosis.- A species of Pisocrinus with a globose, ovoid or conical cup, basals visible in side view. Radial facet wide at exterior of cup, with straight sides sloping inwards towards the centre of the cup.

Description.- Cup of very variable shape - globose, ovoid or conical, but the height (to base of radial facet) rarely exceeds the width. Surface of cup plates usually smooth, but is finely granular when well preserved; occasionally the surface is rugose (e. g. in the holotype of P. ornatus de Koninck). Basals of varying height, but always visible in side view, and never completely covered by the stem; basals also irregular in relative size and arrangement, but usually forming a triangular area with the three largest basals at the apices. Radials vary in size and shape as the shape of the cup varies. Radial facets deeply excavated, usually occupying over two thirds of the width of the radials, and bounded by straight sided lateral processes. These processes, usually of even width, may be distally enlarged. Adjoining processes usually form equal proportions of the area between adjacent facets. Arms undivided. First brachial short and usually confined to height of facet. More distal brachials long - height from twice to six times the width, round backed or slightly angular, and with a deep ventral groove. Covering plates three per millimetre.

Tegmen not seen. Stem proximally enlarged, formed of columnals which are slightly moniliform and which are either wider than long or as wide as long.

Discussion.- The above description is based on specimens from both Wenlock Limestone and Wenlock Shale localities. The species as here defined, following Bather (1893), is so variable that it includes all the variants so far seen, with the exception of one from the Coalbrookdale Beds of the Wenlock Shale at a stream near Sheinwood, Shropshire (GSM RT 475) which possibly belongs to the undescribed species mentioned by Bather (1893, p. 27) as having an "almost hemispherical shape". This specimen was referred to as Pisocrinus sp. in Pocock and others (1938, p. 262, loc. 39). Some other specimens (Geol. Surv. Edinburgh JS 21607-10) are the "small perfect crinoids" from a losely defined locality - railway cutting, Coalbrookdale - referred to by Smith (1881, p. 87). These do not belong to P. pilula and are probably to be referred to P. quinquelobus Bather, since they show traces of a pentalobate outline and have narrower facets than P. pilula. P. quinquelobus was first erected in a footnote (Bather, 1893, p. 27), and although there is a diagnosis no specimens are mentioned which could be the types: all that is stated is that the species comes from West

Tennessee. Springer (1926b) has figured several specimens of P. quinquelobus, as has Amsden (1949), and these allow a close comparison to be made between the American and Coalbrookdale species. They are here determined as P. cf. quinquelobus, but there is not enough material for an adequate study of these highly variable forms.

Pisocrinus spp.

(1) Lower Llandovery. A large slab and its counterpart (SM A 32134a and b) from the Lower Llandovery, Gasworks Mudstones, opposite entrance to gasworks, Haverfordwest, Pembrokeshire, shows remains of external moulds of several crowns of a species of Pisocrinus. All the remains are extremely dissociated, but the small right anterior radial, bounded on each side by a larger radial, and associated with long unbranched arms, can be seen. The cup is evidently considerably higher than wide. The brachials are about twice as long as wide, as is usual in this genus. This is the earliest record of a species of Pisocrinus in Europe, and it is a pity that the remaind are too dissociated to figure and name.

(2) Lower Ludlow. A single almost complete specimen is figured here (Reading University collection E 299 - plate 36, fig. 3) from the Lower Ludlow (*Monograptus leintwardinensis* zone) at Church Hill Quarry, Leintwardine. It was collected by Professor H. L. Hawkins during excavations in the quarry in 1926 (Hawkins & Hampton, 1927). It has a small globular cup, a stem formed of columnals of equal length, and very short arms composed of only four brachials, the first of which is very short. The arms are possibly incomplete. The basals appear to be hidden by the stem, so that this specimen cannot belong to *P. pilula*. It recalls *P. sphericus* Rowley from the Brownsport Formation of Tennessee.

Cicerocrinus Sollas 1900

Text-figure 7

Synonym.- Lagarocrinus Jaekel 1900.

Type species by monotypy: C. elegans Sollas, Upper Ludlow, Welsh Borderland.

Diagnosis.- A genus of Pisocrinidae with an elongate cup which is confluent with the stem, branched pinnulate arms, and radials without pronounced lateral processes.

Cicerocrinus elegans Sollas

Plate 35, figs. 1-3, plate 36, fig. 4

Cicerocrinus elegans Sollas, 1900, p. 267, pl. xvi, figs. 3-4
Lagarocrinus tenuis Jaekel, 1900, p. 487

Holotype.- OM c 80.

Occurrence.- The holotype is unlocalised. Sollas suggested that it was Wenlock in age, but its mode of preservation is unlike that of any other Wenlock crinoid examined. It is here suggested that its age is more probably Upper Ludlow on account of the matrix and mode of preservation, which accords well with that of other Upper Ludlow crinoids, and because all other examples of the same species are of Upper Ludlow age.

Specimens have been examined from the Upper Ludlow, Whitcliffe, Ludlow, Shropshire (BM E 26071a); quarry near old bridge, Ludlow (BM E 5726 - holotype of *C. tenuis* - here figured plate 35, fig. 1); small roadside quarry, 150 yards N. of Stapleton Castle, Stapleton, near Presteigne, Radnorshire (GSM 85405); old quarry 150 yards E.N.E. of Warren House Farm, c. 2 miles from Knighton on the Knighton - Penybont road, (GSM 85406).

Diagnosis.- A species of *Cicerocrinus* in which the cup is about twice as ~~wide~~ high as ~~high~~ wide; pinnules are borne on every fourth brachial usually.

Description.- Cup conical, about twice as wide as high, surface of cup plates smooth. Basals half the height of the radials. Radials without marked lateral processes, facet occupying the whole width of the plate. Primibrachs two, the first being abont twice as wide as high, the second usually higher than wide. Secundibrachs up to twenty observed; tertibrachs up to twenty-eight observed. In adult (i. e. large) specimens the arms branch twice, but in small specimens only once; all brachials variable in height, being up to twice as wide as high or twice as high as wide. Pinnules are borne on secundibrachs and tertibrachs usually occurring on every fourth brachial, but sometimes three and sometimes five brachials occur between divisions. Sutures of the pinnule-bearing brachials are at an angle with the sides of the arm. Pinnulars longer than wide, tapering sharply, and with a relatively wide proximal end. Small anal plate, but no tube has been seen in the available material.

Tegmen not seen. Stem round, smooth, expanding proximally and confluent with the base of the cup.

Discussion.- The specimen described by Sollas is unique in being so well preserved, and all the other specimens are more or less fragmentary. It is thought, however, that all the English Upper Ludlow Cicerocrinus specimens are conspecific with this fine specimen. C. anglicus (Jaekel) may be an exception (see below). In the case of C. tenuis (Jaekel), the holotype is a young specimen in which the arms divide only once, but it otherwise shows no differences which would suggest that it would not have grown up into a typical C. elegans. The suggestion of an Upper Ludlow age for the holotype of C. elegans seems unavoidable.

Cicerocrinus anglicus (Jaekel)

Lagarocrinus anglicus Jaekel, 1900, p. 486

Jaekel's original description. "Oberes Obersilur (Low. Ludlow beds). Gomey Quarry, Presteigh, Radnorshire in Sud Wales, England. Hohe des Kelches etwa 20 mm., Länge der Arme etwa 34 mm. Arme zunächst in 10 gleichwerthige Hauptäste getheilt, diese mit zahlreichen (etwa 24), aber anscheinend ziemlich kurzen Ramulis versehen. Stiel oben beträchtlich erweitert, namentlich in die Dicke des Kelches übergehend. 1 Orig.-Ex. Museum f. Naturkunde Berlin."

Discussion.- I am informed by Dr. W. Gross that the holotype of this species has disappeared from the Museum fur Naturkunde in Berlin. Since no topotype material has been available it has not been possible to make proper study of this species, for there is no figure. The description would suggest a distinct species characterised by many pinnules.

The horizon and locality of the holotype is in doubt. There is no place in Radnorshire with the name 'Presteigh' as given by Jaekel, and it is probable that Presteigne was intended. Modern maps do not mark any place called 'Gomey', and the nearest to this is a farm called 'Gumma', 1½ miles W. of Presteigne. The old Geological Survey map, dated 1850, however, calles this farm Gomey. There is doubt, moreover, as to which is 'Gomey Quarry', for locally no quarry is known by this name. There is an old, but still sporadically worked quarry near the road $\frac{1}{4}$ mile N. E. of Gumma Farm, now called Rock Bridge Quarry, and this seems to be the most likely place from which the holotype of C. anglicus came. Collecting in this quarry by the writer yielded no specimens of Cicerocrinus, but this is not surprising when the rarity of this genus is considered.

With regard to the horizon, Mr. C. H. Holland, who is studying the stratigraphy of the Presteigne area, tells me that the whole of the rocks surrounding Gumma Farm for some distance, and including Rock Bridge Quarry, belong to the upper part of the Upper Ludlow, and not to the Lower Ludlow as was stated by Jaekel.

Summarising the above, it appears that the holotype of C. anglicus is of Upper Ludlow age, and that it probably came from Rock Bridge Quarry, c. $1\frac{1}{2}$ miles W. of Presteigne, Radnorshire.

Family CALCEOCRINIDAE Meek & Worthen 1873

Diagnosis.- Monocyclic Inadunata with the crown bent on the stem, in which bilateral symmetry along the left anterior radius and the right posterior interradius is progressively established. Basals connected by a muscular articulation (the hinge) with the radials, of which three are compound. Three or four arm-bearing radials, and the anal plate becomes shifted over the right posterior radius eventually into the right posterior interradius, and supports a massive tube.

Range.- Ordovician to Lower Carboniferous.

Discussion.- The British Silurian members of this family have been described in a published paper which properly forms a part of this thesis (Ramsbottom, 1952). A copy of this paper is in the pocket inside the back cover.

The species described, all from the Wenlock Limestone, Dudley, are the following: Calceocrinus fletcheri (Salter),
Calceocrinus pugil Bather,
Calceocrinus inclinus Ramsbottom,
Calceocrinus serialis (Austin MS., Salter),
Calceocrinus gradatus (Salter), and
Eucheirocrinus anglicus Springer.

Order <u>CLADOIDEA</u> Moore & Laudon 1943

<u>Diagnosis</u>.- Inadunata with infrabasals.

Family CYATHOCRINITIDAE Bassler 1938

<u>Diagnosis</u>.- Dicyclic Inadunata with a bowl-shaped or low, conical cup, 3 or 5 infrabasals; single anal plate, in line with radials and resting on the posterior basal. Arms branching isotomously several times, non-pinnulate. Tegmen composed of five large oral plates, separated by ambulacral plates.

<u>Range</u>.- Silurian to Lower Carboniferous.

<u>Discusion</u>.- The genus <u>Ceratocrinus</u> Wanner, from the Permian of Timor, which was included in this family by Moore & Laudon (1943), shows a type of tegmen, with many small plates, which is quite alien to the Cyathocrinitidae, and it should be referred elsewhere.

Cyathocrinites J. S. Miller 1821

Text-figure 8

Synonyms.- Cyathocrinus Agassiz 1834; Atocrinus M'Coy 1844; Saccosomopsis Meek & Worthen 1870.

Type species by subsequent designation of Wachsmuth & Springer (1879, p. 87): Cyathocrinites planus J. S. Miller 1821, Carboniferous Limestone, England.

Diagnosis.- A genus of Cyathocrinitidae with five infrabasals.

Discussion.- This long ranging genus is represented by three species in the British Silurian. Bather (1893) divided the European Silurian species into three groups. The two British species described by Bather (1892d) both belong to the group with a stem of moderate width with rather low and alternately ridged columnals and a more or lass conical cup.

Cyathocrinites acinotubus (Angelin)

Plate 17, fig. 6

Cyathocrinus (sp. 6) monile Salter, 1873, p. 123 (nom. nud.)
Cyathocrinus acinotubus Angelin, 1878, p. 22, pl. xx, fig. 5
Cyathocrinus alutaceus Angelin, 1878, pl. iv, fig. 6a
Cyathocrinus acinotubus Bather, 1892d, p. 213, pl. xiii, figs.1-13
Cyathocrinus acinotubus Bather, 1893, p. 133, pl. vii, figs. 207-1?
Cyathocrinus alutaceus Wachsmuth & Springer, 1897, p. 98, pl. iv, figs. 6-7

Syntypes.- Two specimens in the Riksmuseum, Stockholm, were labelled by Angelin as belonging to this species, but only one of these was figured. This figured specimen was selected as lectotype by Bather (1893, p. 133).

Occurrence.- The lectotype comes from Follingbo, Gotland. Bather also records the species from Klinteberg and Visby. In England specimens have been examined from the Wenlock Limestone, Dudley, including Wren's Nest and Tividale; Malvern (in OUM); Gleedon Hill, Wenlock Edge (BM E 7001); Benthall Edge, 3 miles N. E. of Much Wenlock (GSM 91773-6); ?Dormington, near Woolhope (BM E 5654).

Diagnosis.- A species of Cyathocrinites with a nodose stem, conical cup with concavo-convex sides; smooth tumid cup plates and stout arms with rounded brachials. Radial facet with axial canal and food groove distinct.

Discussion.- This species has been described in detail by Bather (1892d, 1893). Although the type specimens have not been seen during the present study, all the English specimens mentioned by Bather have been examined, together with a few others.

Cyathocrinites vallatus (Bather)

Plate 17, fig. 5

Cyathocrinus vallatus Bather, 1892d, p. 221, pl. xiii, figs.14-18

Syntypes.- BM E 6005, E 6006; BUK 170. Of these BUK 170 is here designated lectotype. A cast of this specimen is BM E 6009.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Cyathocrinites with a conical cup with convexly rounded sides; smooth or concentrically ornamented plates. Radial facets with food groove and axial canal confluent. Arms and stem unknown, but stem lumen pentalobate.

Discussion.- No specimens other than the three original syntypes of this species have been seen during the present investigation. Bather's description cannot be improved in any particular.

Cyathocrinites sp. nov.

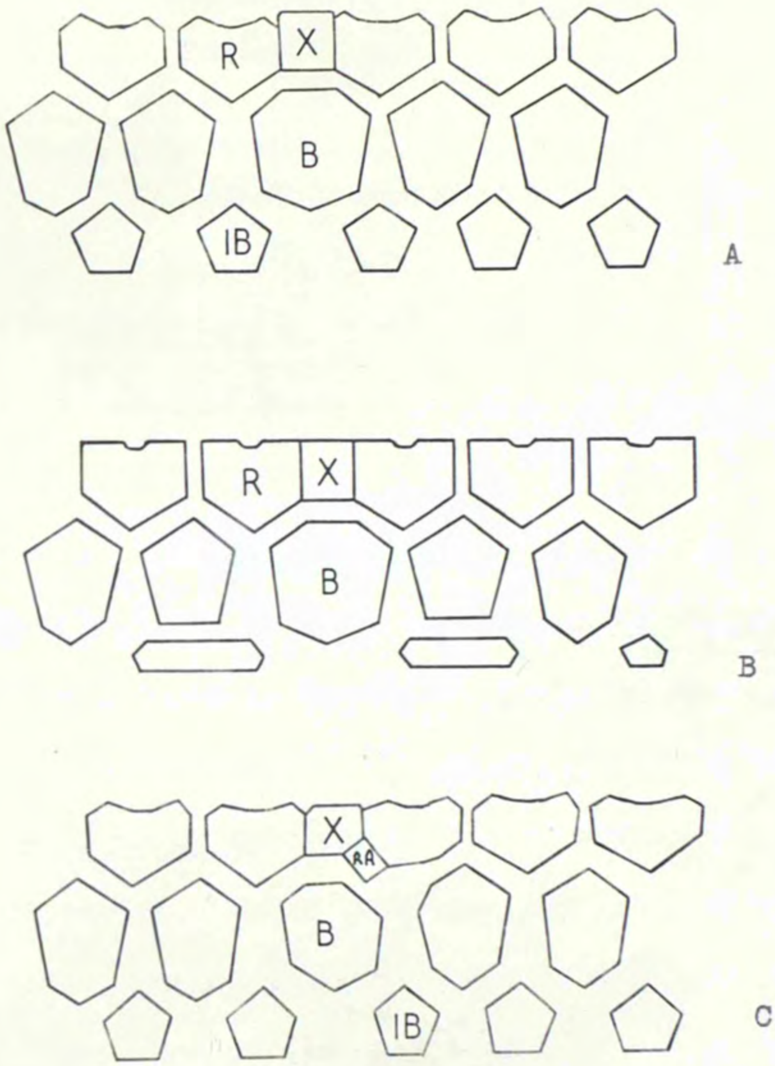
Plate 17, figs. 3-4

Material.- BM 40041.

Occurrence.- Wenlock Limestone, Dudley.

Description.- Cup basin-shaped, the plates with a non-radiating pustulose ornament. Infrabasals half the height of the basals and with a small raised flange surrounding the large pentalobate stem lumen. Basals large, concave and bending outwards at their upper edges. Radials two thirds the height of the basals, indented at their upper edges by a round facet which occupies one third of the width of the plates. Food groove probably confluent with axial canal. Tegmen not seen. Arms and stem missing.

Discussion.- The unique specimen described above was found among the *Crotalocrinites* at the British Museum (Natural History). It is chiefly notable for the unusual shape of the cup, which is due to the concave basals. The nature of the facet has led to its reference to *Cyathocrinites* rather than to *Crotalocrinites*, and the non-radiating ornament and pentalobate stem lumen confirm this assignation. It differs from other species of *Cyathocrinites* in the ornament and shape of the cup.



TEXT-FIGURE 8. A. *Cyathocrinites*, *Mastigocrinus*.

B. *Gissocrinus*.

C. *Botryocrinus*, *Dictenocrinus*.

Gissocrinus Angelin 1878

Text-figure 8

Type species by subsequent designation of Ramsbottom (1951a): Actinocrinites? arthriticus Phillips, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Cyathocrinitidae with three infrabasals.

Discussion.- A few irregular specimens of various species of Gissocrinus are known in which the fusion of the original five infrabasals into three is incomplete (e.g. G. companulatus Bather, 1893). But in spite of this Gissocrinus is very readily distinguished from Cyathocrinites by other features not so easily described in words. Among these are the axial ridges on the cup plates, a distal enlargements of the brachials and strong transverse folding of the plates of the anal tube, but few species of Gissocrinus possess all these characters.

Gissocrinus is probably the most abundant of all the crinoid genera at Dudley.

Gissocrinus arthriticus (Phillips)

Plate 18, figs. 1-2

Actinocrinites? arthriticus Phillips, 1839, p. 674, pl. 17, fig. 8
Cyathocrinus arthriticus Salter, 1859, p. 535
Gissocrinus arthriticus Wachsmuth & Springer, 1879, p. 314
Gissocrinus arthriticus Bather, 1900, p. 127, fig. xli
Non Gissocrinus arthriticus Angelin, 1878

Lectotype.- The specimen figured by Phillips. It has not been traced, though Murchison (1839, p. 702) stated that it was in Mrs. Downing's collection. It is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips.

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Gissocrinus with a fairly low cup without axial ridges; arms and anal tube horizontal; brachials round backed, with a strong distal expansion which passes all round their dorsal dides.

Description.- Cup fairly wide, low, cone-shaped, its plates without axial ridges, but bearing a pustulose or granular ornament. Infrabasals a little more than half the height of the basals which are about as high as wide. Radials wider than high, the facet occupying about $\frac{3}{4}$ of the total width of the plate. One primibrach; one secundibrach; arms branch five times. Brachials about as high as wide, round backed and with a strong rugulose distal expansion passing all round their dorsal sides. Four or five covering plates per brachial. The proximal parts of the arms and tha anal tube are horizontally disposed, the tube formed of roughly oblong plates, strongly folded transversely.

Tegmen with the five oral plates separated by ambulacra, the madreporite being enlarged and slightly folded. Stem round, formed of very short alternating columnals - nodals and internodals, usually with each alternate nodal again enlarged.

Discussion.- The above description is based largely on BM 57420, BM 57293 and BM E 26874. The species is very close to G. typus Bather (= G. arthriticus Angelin pars), but is distinguished by the slightly larger infrabasals and by the horizontal anal tube and proximal parts of the arms. This latter character accounts for the usual mode of occurrence of the species, for it is usually splayed out on the rock with either the ventral or dorsla sides exposed, and specimens showing the crown in side view are exceedingly rare. It is unfortunate that the finer details of the ventral side are usually poorly preserved.

<u>Gissocrinus capillaris</u> (Phillips)

Plate 20, figs. 1-6

<u>Cyathocrinites capillaris</u> Phillips, 1839, p. 671, pl. 17, fig. 2
<u>Gissocrinus capillaris</u> Bather, 1892d, p. 207

<u>Lectotype</u>.- The specimen figured by Phillips. It has not been traced, though Murchison stated that it was in either the Bright, Inward or Murchison collections. It is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips.

<u>Occurrence</u>.- Known only from the Wenlock Limestone, Dudley.

<u>Diagnosis</u>.- A species of <u>Gissocrinus</u> with a cone-shaped cup ornamented with rugose ridges. Brachials with round backs and a distal expansion of knob-like form on the ventral side. Stem nodose.

<u>Description</u>.- Cup almost as high as wide, narrowly cone-shaped, its plates strongly ornamented by a pattern of rugose rounded ridges. Infrabasals about half the height of the basals, which are about as high as wide. Radials wider than high, with the facet occupying about two thirds of the total width of the plate. Two primibrachs; two secundibrachs; arms branch five times.

Brachials rather variable in size but usually about as high as wide, bearing a distal expansion or knob on the ventral surface, and with evenly rounded backs. Anal tube vertical, formed of roughly oblong plates, strongly folded transversely, but this folding is on a relatively fine scale. Tube often longer than the arms.

Tegmen not seen. Stem round, formed of very short columnals, alternating nodals and internodals, with each alternate nodal again enlarged.

Discussion.- This is not a common species at Dudley. The characteristically ornamented cup combined with the knob-like ventral distal expansion on the brachials, make the species easy to recognise. Though normally of moderate size, this species can grow large - BM 57246 for example has a crown over 150 mm. in height.

Gissocrinus scoparius (Salter)

Plate 20, figs. 7-8

Cyathocrinus (sp. 7) scoparius Salter, 1873, p. 125
Gissocrinus scoparius Bather, 1892d, p. 207
Gissocrinus scoparius Ramsbottom, 1951a, p. 490

Holotype.- SM A 10168.

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Gissocrinus with a cone-shaped cup with strong axial ridges; round backed brachials higher than wide, all plates bearing a granular or pustulose ornament.

Description.- Cup cone-shaped, with a strong axial ridge system; cup plates with a finely granular or pustulose ornament. Infrabasals not seen; basals estimated to be about the same height as the radials, which are about as wide as high. Facet occupying a little less than one third of the total width of the plate. Primibrachs two; secundibrachs two or three; arms branch about five times. Brachials a little higher than wide, and increasing in height distalwards, with evenly rounded backs. Three or four covering plates per brachial. Brachials with a fine pustulose ornament. Axial canal and food grrove confluent. Anal tube, tegmen and stem not seen.

Discussion.- The holotype is the only specimen which can definitely be assigned to this species, and even this is not very well preserved, being in a very hard, slightly yellow sandy matrix which is difficult to develop. As was mentioned in Ramsbottom (1951a, p. 490) there is no doubt, however, about the specific distinctness of G. scoparius, though its relationships with the other British Silurian species of Gissocrinus are uncertain. The granular plate ornament and the characteristic rounded brachials testify to this distinctness. Bather's statement (1892d, p. 207) that this species has three infrabasals cannot be based on any evidence, since these plates are absent in the holotype. It is referred to Gissocrinus largely on account of the features of the cup, with its strong axial ridges.

One other specimen compares in its brachials with the holotype of G. scoparius (GSM 89673). The granular ornament is absent, however, and this specimen (plate 20, fig. 8) is determined as G. cf. scoparius. Here the short length of stem visible (6 mm.) is strongly nodose.

Gissocrinus goniodactylus (Phillips)

Plate 18, figs 3-6

Cyathocrinites goniodactylus Phillips, 1839, p. 671, pl. 17, fig. 1
Cyathocrinus goniodactylus Salter, 1859, p. 535
Cf. Gissocrinus goniodactylus Bather, 1893, p. 166
Gissocrinus goniodactylus Bather, 1900, p. 101, fig. viii.

Lectotype (here designated).- The specimen figured by Phillips, now in the Northampton Museum. It is designated lectotype in the absence of evidence as to how many specimens were used by Phillips in his original description.

Occurrence.- Only definitely recognised from the Wenlock Limestone, Dudley. Possibly also at Klinteberg, Gotland (Bather, 1893).

Diagnosis.- A species of Gissocrinus with the cup wider than high, and with strong axial ridges. Brachials slightly higher than wide, with median axial ridge and wing-like extensions at each side. Stem nodose in proximal region.

Description.- Cup cone-shaped, wider than high and with strong axial ridges. Infrabasals about half the height of the basals, which are about as wide as high. Radials wider than high, the facet occupying between three fifths and two thirds of the total width of the plate. Primibrachs one or two, but in either case the total length is the same; secundibrachs two; arms branch six times. Brachials a little higher than wide, with a fairly well marked median axial ridge and a flattened wing-like extension on each side. Occasionally, especially in old age, there may be a slight distal expansion. 6-7 cOvering plates per brachial. Anal tube vertical, coposed of approximately oblong plates with coarse and strong transverse folding.

Tegmen (BM 57071) composed of small plates betwen the food grooves, with a larger pustulose madreporite which is slightly elevated, in the posterior interradius (figured Bather, 1900, p. 101, fig.viii). Stem round, formed of very short columnals. In the proximal region there are alternating nodals and inter - nodals usually with each alternate nodal again enlarged. In the middle region the nodals are much less prominent, while distally the stem is smooth. The stem may reach considerable lengths (300 mm. in BM E 26881).

Discussion.- The features of the brachials and tube easily distinguish this species from others present at Dudley. It forms the first of a series of species and varieties which can be arranged in a morphological series to show a tendency towards the broadening of the brachials. G. goniodactylus var. of Bather (1893), which is the same as "Cyathocrinus (sp. 1)" of Salter (1873) is the next in the series; it is here figured on plate 18, fig. 7. G. squamiferus (Salter) follows as the ultimate member of this series, which is also notable for the tendency towards the increase in the massivemess. G. crassus Bouška is probably not closely related to this series, though it too shows very broad brachials, in this case lacking the massiveness.

Gissocrinus squamiferus (Salter)

Plate 19, figs. 1-4

Cyathocrinus (sp. 4) squamiferus Salter, 1873, p. 124
Gissocrinus squamiferus Bather, 1892d, p. 207
Gissocrinus squamifer Bather, 1900, p. 102, fig. ix(2)
Gissocrinus sqamiferus Ramsbottom, 1951a, p. 491, pl. ix, figs. 1-4

Syntypes.- The registration number quoted by Salter covered ten syntypes since reregistered as SM A 10138, A 10142-49, A 35175. Of these SM A 10149 belongs to G. goniodactylus (Phillips), while SM A 10138 was selected as lectotype by Ramsbottom (1951a, p. 492).

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Gissocrinus with a moderately low cup with axial ridges, broad and massive fairly flat brachials, and the anal tube and proximal parts of the arms more or less horizontally disposed.

<u>Description</u>.- Cup bowl-shaped, wider than high, bearing strong sometimes discontinuous, axial ridges. Infabasals very small; between them the basals may appear to be in contact with the proximal columnal. Basals pentagonal or haxagonal, about as wide as high, but posterior basal truncate with the anal plate resting on its upper surface. Radials considerably wider than high, lunate in shape, the facet occupying nearly the whole width of the plate. Primibrachs one or two; usually two secundibrachs, sometimes only one. Arms dividing five times. Brachials broad and massive, though relatively thin, usually with a marked axial ridge and wing-like extensions on each side. 8-10 covering plates per brachial (Bather, 1900, fig. ix, based on BM E 45290). Axial canal sometimes confluent with food groove and sometimes distinct, and there are intermediate stages (Ramsbottom, 1951a, text-figs. 2-4) Proximal brachials leave cup in almost horizontal position, and arms curve round to give crown its maximum width distally. Anal tube horizontal, formed of roughly four sided plates, with coarse transverse folds. Tube round and slender, probably reached almost the full length of the arms.

Tegmen not seen. Stem (only seen to a length of 8 mm. in BM 40262) formed of very short columnals with crennelate boundaries, but without conspicuous nodals. Lumen about one third of the diameter of the stem.

<u>Discussion</u>.- This species shares with <u>G. arthriticus</u> the horizontal anal tube, but it is more closely related to <u>G. goniodactylus</u>. Indeed there is a variety in the Wenlock Limestone and in Gotland (Bather, 1893, p. 167, pl. ix, figs. 326-34 - Riksmuseum, Stockholm Ec 9259) intermediate between <u>G. squamiferus</u> and <u>G. goniodactylus</u> to which the "<u>Cyathocrinus</u> (sp. 1)" of Salter (1873, p. 123) belongs (SM A 10169 - figured here plate 18, fig. 7). This variety and <u>G. goniodactylus</u> both have larger infrabasals than <u>G. squamiferus</u>.

Through the courtesy of Professor Stensiö I have been able to reexamine the Gotland specimen, referred by Bather (1893) to <u>G. squamifer</u>. The brachials do not seem to be as broad as in the types, and the specimen, which is not well preserved, is here determined as <u>G.</u> cf. <u>squamiferus</u>.

The above desription is based, in additaon to the types on BM 40337, BM E 420 and BUH 28.

Gissocrinus crassus Bouška

Plate 14, figs. 1-7

Gissocrinus crassus Bouška, 1944, p. 5, pl. ii, figs. 1-4

Holotype.- The specimen figured on pl. ii, fig. 1 of Bouška (1944).

Occurrence.- The holotype comes from the $e\alpha_2$ (Wenlock Shale, fide Kettner & Boucek, 1936, pl.i) of Amerika Quarry, near Budnian, Bohemia. English specimens are known from the Wenlock Shale at Malvern (BM E 1358), and from the Wenlock? Shale, Sedgley (BUH).

Diagnosis.- A species of Gissocrinus with broad flat brachials as wide as high, with a prominent, but narrow, axial ridges. Cup smooth or with faint axial ridges.

Description.- Cup bowl-shaped, a little wider than high; surface of cup and arm plates smooth or faintly granular. Infrabasals very small, imperfectly seen in the available material. Basals and radials of equal height, but radials twice as wide as high, lunate with the facet occupying three fifths of the width of the plate. One primibrach, slightly higher than wide; usually only secundibrach, though up to three have been observed.

Arms branch three times. Brachials broad and thin, with a narrow rounded axial ridge, and wing-like extensions on either side; almost square in ventral view (dorsal side not seen), but the more distal brachials are shorter than the more proximal ones; lateral margins usually gently curved. Anal side of cup not clearly seen, but tube short, vertical, composed of small unfolded plates which are four sided.

Tegmen not seen. Stem slender, tapering slowly distally, nodose proximally, but the nodes become further apart distally.

Discussion.- The above description is based on all the English specimens available; these seem to agree closely with the Bohemian specimens figured by Bouška. It is unfortunate that the structure of the cup is not satisfactorily seen and the plates are usually somewhat dissociated. Yet the matrix is a soft shale, and the environment must have been quiet and lagoonal (cf. Leintwardine, Hawkins & Hampton, 1927) for nearly all the specimens have their stem attached, and are more or less complete crowns. The slenderness of the stems and the broad leaf-like brachials suggest that this species may perhaps have been free swimming for a part of its life. In young specimens (BUH 228) the brachials are of almost the same size as those of more adult specimens.

Gissocrinus luculentus Ramsbottom

Plate 19, figs. 5-8

Gissocrinus arthriticus Edmunds & Oakley, 1936, pl. iii, fig.1
Gissocrinus luculentus Ramsbottom, 1951a, p. 494, pl. ix, figs. 5-8
Non Gissocrinus arthriticus Angelin (nec Phillips)

Holotype.- The complete specimen on BM E 45528.

Paratypes.- BM 57280, 57285, E 6370, E 21904.

Occurrence.- The type and most other specimens are from the Wenlock Limestone, Dudley. Also known from the Wenlock Limestone, Malvern (BM 38689).

Diagnosis.- A species of Gissocrinus with a bowl-shaped cup with strong axial ridges, the brachials bearing three knob-like distal expansions, two lateral and one dorsal. Stem smooth.

Description.- Cup bowl-shaped usually a little wider than high and with strong axial ridges, but the surface is otherwide smooth. Infrabasals about half the height of the basals; basals about as high as wide, hexagonal or pentagonal; radials wider than high, the facet occupying half the width of the plate, axial canal food groove distinct in the radials (Ramsbottom, 1951a, text-fig. 6). Primibrachs one or two, but in either case the total length of primibrach is the same indicating that fusion has taken place in some cases; secundibrachs two, but rarely only one; arms divide six times. Brachials, except in the young, about as high as wide, typically bearing three distal expansions, two lateral and one dorsal, usually round backed but there may be an axial ridge. In old age the distal expansions may extend all round the brachials. Covering plates 5-7 per brachial. Anal tube vertical, formed of roughly quadrangular plates, strongly folded transversely, of about the same length as the arms.

Tegmen not seen. Stem formed of very low columnals without conspicuous nodals, usually being very smooth and with no cirri until the root is reached. Stem usually about as long as the crown it supports.

Discussion.- The cup of this species is hardly distinguishable from that of *G. goniodactylus*, but the features of the brachials easily differentiate it. The species is probably more closely related to *G. arthriticus*, differing from it in the vertical anal tube, smooth stem and details of the brachials. The colour of this species is light brown, while *G. goniodactylus*, *G. squamiferus*, *G. capillaris* and *G. crassus* are dark brown. *G. arthriticus* and *G. scoparius* are also light brown. The specimen figured by Edmunds & Oakley (1936) is entirely typical of this species (GSM 53722).

Gissocrinus ludensis (Sollas MS.) sp. nov.

Plate 36, figs. 1-2

Holotype.- BM E 26573.

Paratype.- BM E 26577.

Occurrence.- All the known specimens come from the Lower Ludlow beds (Monograptus leintwardinensis zone) at Leintwardine, Herefordshire. The British Museum specimens come from Church Hill Quarry, Leintwardine.

Diagnosis.- A species of Gissocrinus in which the cup is cone-shaped with strong axial ridges. Infrabasals about the same height as the basals; brachials round backed; stem nodose.

Description.- Cup narrow, cone-shaped, higher than wide, with strong axial ridges. Infrabasals about as high as the basals, which are about as high as wide. Radials about as high as wide, the facet occupying about one third of the width of the plate. Primibrachs three; arms branch about five times, the brachials being being round backed and usually higher than wide and without distal expansion or ornament of any kind. Four covering plates per brachial. Anal tube formed of squareish plates with fine but deep transverse folds; tube about the same length as the arms. Tegmen not seen.

Stem, seen to a length of 60 mm., round in the proximal few millimeters, afterwards subpentagonal; formed of alternating nodals and internodals, with larger nodals situated at intervals.

Discussion.- Among the species of Gissocrinus from Dudley it is only with G. scoparius (Salter) that this species shows any close relationships. The features of the brachials, the shape of the cup and the large size of the infrabasals distinguish this species. The subpentagonal stem is also characteristic. The specimen to which Sollas attached the MS. name ludensis on a museum label (OM c 85) is a young specimen the crown being only 12 mm. in height. In view of this a more adult example has been chosen as the holotype, and in this the crown has a height of 50 mm. All the specimens are preserved as external moulds, as is usual at Leintwardine, and the species has been studied with the aid of Revultex impressions.

Family CROTALOCRINITIDAE Bassler 1938

Diagnosis.- Dicyclic Inadunata with a bowl-shaped cup. Infrabasals five; single anal plate in cup, in line with radials. Primibrachs small, resting in rounded facet, flanked by succeding brachials which are also in contact with the radials. Arm branches more or less laterally united.

Range.- Silurian.

Crotalocrinites Austin & Austin 1842

Text-figure 9

Synonyms.- Crotalocrinus Morris 1843; Anthocrinus Müller 1853.

Type species by monotypy: Cyathocrinites rugosus Miller 1821, which is a subjective synonym of Encrinites verucosa Schlotheim 1820, Silurian, Gotland and England.

Diagnosis.- A genus of Crotalocrinitidae in which the brachials are united by lateral processes throughout the full length of the arms.

<u>Crotalocrinites verucosus</u> (Schlotheim)

Plate 21, figs. 1-11; text-fig. 9.

Turban or Shropshire Encrinite - Parkinson, 1808, p. 203, pl. xv, figs. 4-9
<u>Encrinites verucosa</u> var. <u>verucosa</u> Schlotheim, 1820, p. 333
<u>Encrinites verucosa</u> var. <u>punctata</u> Schlotheim, 1820, p. 334
<u>Cyathocrinites rugosus</u> Miller, 1821, pl. opp. p. 90, figs. 1-4
<u>Encrinites verrucosus</u> Schlotheim, 1823, p. 98, pl. 27, figs. 1a-c
Tortoise Encrinite - Cumberland, 1826, pp. 17-19, figs. 38-39
<u>Cyathocrinites rugosus</u> Hisinger, 1837, p. 89, pl. xxv, figs. 3a-f
<u>Cyathocrinites rugosus</u> Phillips, 1839, p. 672, pl. 18, fig. 1
<u>Crotalocrinites rugosus</u> Austin & Austin, 1843, p. 198
<u>Cyathocrinites globosus</u> Garner, 1844, p. 456, pl. a, fig. 6
<u>Crotalocrinus rugosus</u> Salter, 1859, p. 247, figs. 4-7
<u>Crotalocrinus rugosus</u> Salter, 1871, pp. 481-3, pl. i
<u>Crotalocrinus rugosus</u> Angelin, 1878, p. 26, pl. vii, fig. 4, pl. xvii, figs. 8-8a (only)
<u>Crotalocrinus rugosus</u> Carpenter, 1886, pp. 399-400
<u>Crotalocrinus rugosus</u> Wachsmuth & Springer, 1889, pp. 364-87, pl. xix, figs. 1-6, pl. xx, figs. 2-3
<u>Crotalocrinus verrucosus</u> Bather, 1892d, p. 202
<u>Crotalocrinus rugosus</u> Springer, 1926b, p. 129, pl. 26, figs.18-20
<u>Crotalocrinites rugosus</u> Bouška, 1946, p. 5, pl. i, figs. 1-5

<u>Syntypes</u>.- The nine specimens mentioned by Schlotheim (1820), the present whereabout of which is unknown.

<u>Occurrence</u>.- The syntypes came from Gotland. Angelin records the species from Hoburg and Klinteberg, Gotland. English specimens are known from the Wenlock Limestone, Dudley, including Wren's Nest and Tividale; Wenlock Limestone, Fownhope, Herefordshire (MM L 10032a, b, c - figured Cumberland, 1826, figs. 36-38); Rock Farm, May Hill (GSM 25544); near Longhope, Herefordshire

(GSM 85588); Wenlock Edge (GSM 92729); Benthall Edge (GSM 92731); Gleedon Hill (GSM 92727) - see Cros#field & Johnston, 1914, p. 208; Also from the Lower Wenlock Limestone, Upper part of Basement Beds (i.e. between 5' 3" and 10' 6" above top of Wenlock Shale), north side of Daw End railway cutting, Walsall, E. of Rushall aqueduct, Staffordshire (GSM 83886).

Diagnosis.- A species of Crotalocrinites in which the five arms are united laterally all round the cup in a reticulated network in the form of a funnel. Cup plates with a radiating and sometimes pustulode ridged ornament.

Description.- Cup globular, widest at the lowest points of the basi-radial sutures. Surface of cup plates with radiating and sometimes pustulose ornament of ridges which cross all the sutures, except those between adjacent infrabasals, at right angles. Infrabasals half the height of the basals, no trace of chambered organ seen. Stem lumen round and large. Basals large, convex, occupying nearly half the total height of the cup. Radials a little over half the height of the basals, and with two lateral extensions on either side of the facet, which curve inwards on a level with the tegmen. Facet, when seen, occupying in adult specimens (over 25 mm. width of cup) about one third of the width of the radial; in young specimens (e.g. BM E 45557) about half the width of the radial. Radials usually thickened internally (see below). Anal plate square shaped, within the radial circlet. A small plate is sometimes seen resting on top of the anal. Tube not seen in specimens examined.

Tegmen with a large central plate, often tuberculate, and usually (e.g. SM A 12945) seven other plates surrounding it; two plates in each interradius between the ambulacra. Radially there are the simple alternating covering plates of the arms, which begin branching very soon after their origin, so that near the edges of the cup in adult specimens the ends of up to ten or more branches rest on the thickened upper edges of the radials. There may be traces of small plates between the radials and the arm facets and these are the proximal brachials. The most lateral of the brachials in each ray are enlarged. Arms repeatedly branched, the brachials with lateral processes which unite laterally to form a network continuously round the cup in the form of a funnel. Stem round, large, formed of uniform ridged columnals, and with a large round lumen. Root encrusting, with many branching cirri coming off from the thickened end of the stem. Pores occur passing through the columnals to the cirri, these being best seen at the cirrus scars in the proximal part of the root.

Discussion.- There appears to be no doubt but that this species, well known under the name Crotalocrinus rugosus (Miller), should really be called C. verucosus. Schlotheim (1820), although giving no figures, refers under his variety punctata tp Parkinson's figures of 1808. Miller gives the same bibliographic reference in 1821 and moreover states (1821, p. 120) that Schlotheim's Encrinites verrucosus is the same as his own Cyathocrinites rugosus. It is true that Parkinson figured only the root, but this is so characteristic a part ofthe species that no misidentification seems possible. Schlotheim figured the stem root and cup under the name Encrinites verrucosus in 1823. The only modern author to use this specific name was Bather (1892d, 1893).

The changing of the specific name of the species also means a change in the syntypes. Miller's specimens are in any case missing from the Bristol Museum (Bather, 1892d) where they were apparently available to the Austins (1843, pp. 198-9). Schlotheim's collection, formerly at Berlin, is alleged to have been taken to Russia (personal communication from Dr. O. Schindewolf) and in the circumstances it seems inadvisable to choose a neotype.

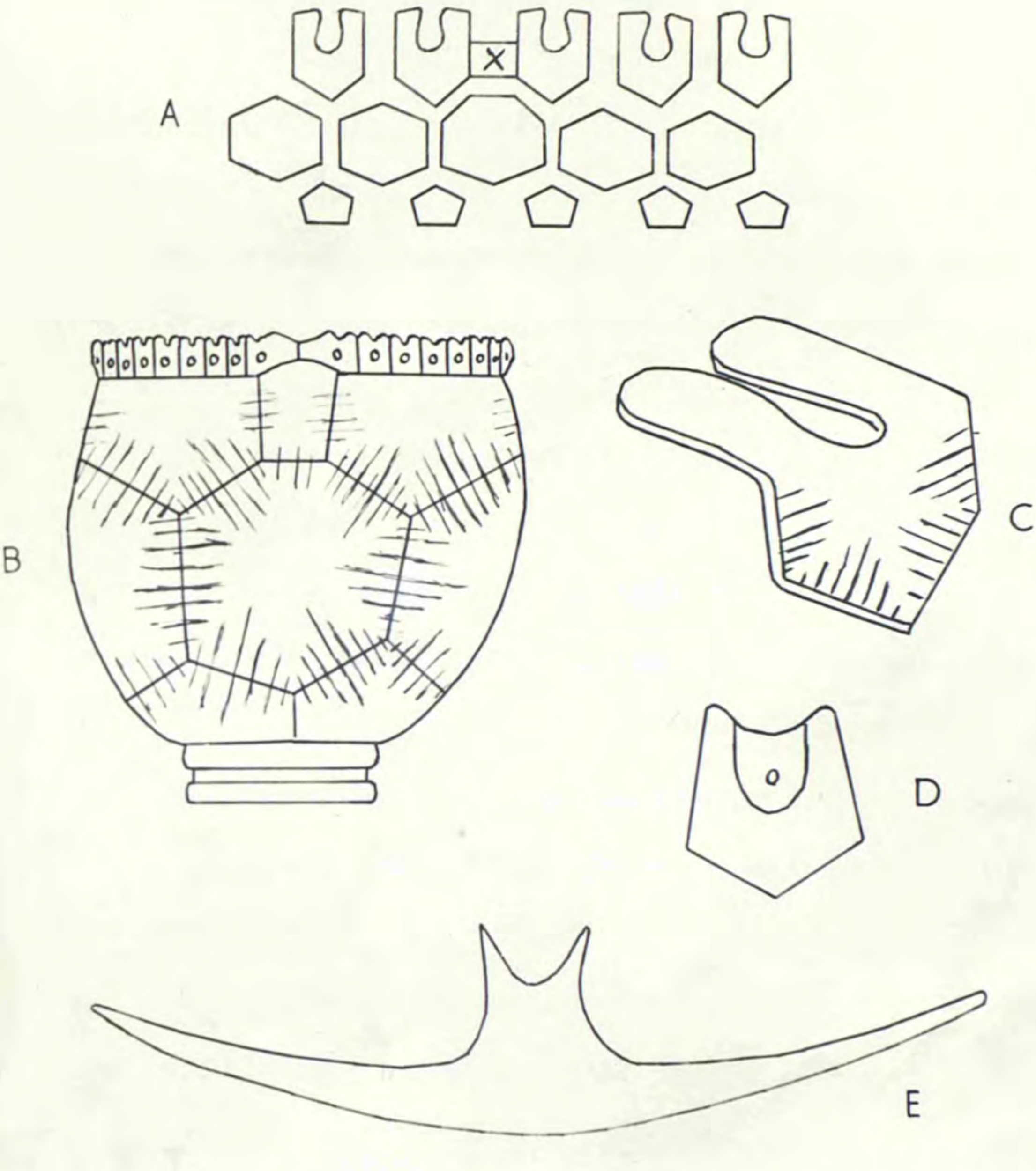
The description above, which supplements the monographs of Salter (1871) and Wachsmuth & Springer (1889) in a few points is based largely on the many good specimens available in the principal British Museums. Salter (1854, 1859, p. 247) was the first to interpret correctly the structure of this extraordinary species, and his account was supplemented in 1871. Wachsmuth & Springer, who evidently did not know of Salter's 1871 paper, after a spirited exchange with Carpenter (1886), gave a considerably more detailed account in 1889. There still remain, however, a number of points in which the anatomy of this species can be extended, and these concern particularly the structure of the radials.

(1) Lateral extension of the radials on to the ventral surface. Wachsmuth & Springer (1889, pl. xx, fig. 4) figure a specimen from Sweden which has the upper lateral ends of the radials curving inwards towards the centre of the tegmen. They refer this specimen to an undescribed species, although Angelin (1878) had referred it to *C. rugosus* (= *verucosus*). An examination of numerous specimens from Dudley has shown that such a feature of the radials, far from being unusual, is probably normal in *C. verucosus*, but that the lateral extensions are usually covered by the large lateral proximal brachials of the arms. This is well seen in DM 522 and BM E 15373 (plate 19). In very large specimens (SM A 12937, plate 19, fig.) these brachials are not big enough to cover completely the lateral extensions of the radials, which thus remain visible in part, while when the arms are completely absent the ventral surface of the cup has an appearance substantially similar to that of the specimen figured by Wachsmuth & Springer (e.g. BM E 6352). Text-figure 9 shows the suggested structure of the radial in adult specimens.

(2) The interior of the radial plates. A number of radials of this species, which are free of matrix thus allowing the interior surface of the plates to be seen, show a central thickening in the upper part of the plate. Two types of structures are found:

(a) In BM E 45550 there is a central ridge which bifurcates at about one third of the distance down the plate (plate ~~23~~ 21, fig. 7).

(b) In BM E 45549 and probably SM A 12986 the central ridge is



TEXT-FIGURE 9. Crotalocrinites verucosus (Schlotheim).

A. Analysis of the cup plates.

B. Posterior view of cup showing the facets resting on the radials.

C. Suggested structure of the radials (see page 129).

D. Structure of the facet in the young (based on BUH 417).

E. Transverse section low down in the radial (GSM 89637).

represented only by a thickening, but the bifurcation is clearly seen to direct the course of the axial nerves from the arms towards the nervous centre which is at the centre of the radial plate. It is not clear why such differences should occur, but it seems most likely that the differences are due to the varying amount of secondary thickening in the different individuals, and it is also probably related to the amount of strengthening of the upper part of the radials needed to support the arms. The strengthening ridge probably functions as a support for the arms, and in some cases there may be actual fusion between the brachials and the top of the radial, or at least no suture can be made out (BM E 45549). A number of complete cups show evidence of median thickening of the radials (e.g. BUH 276), and in other cases (GSM 89639 and the small specimen BM E 1314) the thickening is divided by a sulcus, probably to accomodate the axial nerve cord (structure b above). Text-figure 9 shows such a radial in section.

(3) Features in the ontogeny of the species. The smallest cups examined (GSM 89637, BUK 179) have a diameter of 7 mm.; these and others with a diameter of 8.5 mm. (BUH 417) and 11 mm. (BUK 179a) all show only a single simple radial facet, and are in every respect (except the rugose ornament of the plates) similar to Cyathocrinites. No arms are seen in these specimens, but the facet is typical of Silurian species of Cyathocrinites, and the axial canal is separate from the food groove. At a diameter of 14 mm. (BUH 470) there are four arm facets at the top of each radial. At

20 mm. diameter (GSM 89640) there are five arm facets per radial. At 27 mm. diameter GSM 3267 shows six arm facets and SM A 12945 shows seven arm gacets. There are 8 arm facets at a diameter of circa 28 mm. in BUH 275, and 11 facets at about 40 mm. diameter in BUH 583. These figures apply, of course, to specimens in which the multipal arm facets resulting from the branching of the arms within the tegmen are resting on the upper edges of the radials, and if they and the tegminal plates were stripped off a single radial facet would be seen as in BM E 6352 (which has an appearance similar to the specimen figured by Wachsmuth & Springer, 1889, pl. xx, fig, 4.

One other feature of these multipal arm facets may be mentioned here. This is the increase in the size of the axial canal with growth, and this is such that tha axial canal is more than 1 mm. in diameter in a brachial of width 2 mm. (GSM 89643). This increase may be explained by the extremely numerous eventual arm branches which each facet at this stage supports.

Measurement of a large number of specimens has shown that from the smallest specimens of 7 mm. diameter (BUK 179) to the largest (BM 57358), there is no change in the relative proportions of the sizes of the infrabasals, basals and radials.

Crotalocrinites pulcher (Hisinger)

Cyathocrinites pulcher Hisinger, 1840, p. 6, pl. xxxix, fig. 5
Anthocrinus loveni Muller, 1853, p. 192, pl. viii, figs. 1-11
Crotalocrinus pulcher Angelin, 1878, p. 26, pl. vii, figs. 5-7, pl. viii, figs.1-9, pl. xvii, fig.1, pl.xxv,figs. 8-20
Crotalocrinus pulcher Wachsmuth & Springer, 1889, p. 386, pl. xx, figs. 1a, b.
Crotalocrinus pulcher Bather, 1900, p. 176, fig. xcii (3)
Crotalocrinus pulcher Springer, 1926b, p. 130, pl. 26, fig. 21

Syntypes.- An unknown number of specimens including Hisinger's figured specimen, which was stated by Hisinger to be in the "Mus. Marino".

Occurrence.- The specimen figured by Hisinger (1840) came from Klinteberg, Gotland. Angelin (1878) records the species from Alnase (Farö), Follingbo, Endre and Klinteberg, all in Gotland. Wachsmuth & Springer (1889) record the species from Dudley.

Diagnosis.- A species of Crotalocrinites in which the arms are discreet entities, though all the brachials in each individual arm are laterally united. Cup with radiating ridges on each plate.

Discussion.- Wachsmuth & Springer (1889, p. 386) and Springer (1926b, p. 130) stated that this species occurs at Dudley, but no English specimen has been seen in the collections examined.

As the distinction between C. pulcher and C. verucosus rests entirely on the features of the arms, it is possible that cups not showing the arms, which are normally referred to C. verucosus, may actually belong to C. pulcher.

C. pulcher appears to be a smaller species than C. verucosus (Wachsmuth & Springer, 1889, p. 370, footnote).

<u>Enallocrinus</u> D'Orbigny 1849

<u>Type species</u> by subjective monotypy (Angelin 1878): <u>Apiocrinites? scriptus</u> Hisinger 1831, Silurian, Gotland.

<u>Diagnosis</u>.- A genus of Crotalocrinitidae in which the brachials are not united laterally and the arms are free.

<u>Discussion</u>.- Although not united laterally the brachials in this genus have lateral processes which show that the genus is closely related to <u>Crotalocrinites</u>. There is in fact an intermediate genus <u>Syndetocrinus</u> Kirk, in which the arms are united laterally as far as the tertibrachs, but are free more distally. <u>Syndetocrinus</u> is known in North America and Bohemia (Bouska, 1946), but has not yet been recognised in England.

Originally D'Orbigny included two species, <u>A? scriptus</u> and <u>A? punctatus</u> in this genus, but Angelin (1878) placed <u>punctatus</u> in the synonymy of <u>scriptus</u>, thereby in effect making the genus monotypic. The figures of <u>Enallocrinus assulosus</u> Angelin (1878, pl. xv, figs. 1-2), which according to Wachsmuth & Springer (1889, p. 381) are correctly drawn, show that that species has interbrachial plates and thus cannot be referred to <u>Enallocrinus</u>.

Enallocrinus scriptus (Hisinger)

Plate 21, figs. 12-16

Encrinites sp. Hisinger, 1827, p. 332, pl. vii, fig. 1
Cyathocrinites? Hisinger, 1828, p. 217, pl. v, fig. 9
Apiocrinites? Hisinger, 1828, p. 217, pl. vii, fig. 1
Apiocrinites? scriptus Hisinger, 1831, p. 123
Apiocrinites? punctatus Hisinger, 1831, p. 123
Apiocrinites? scriptus Hisinger, 1837, p. 89, pl. xxv, fig. 1
Apiocrinites? punctatus Hisinger, 1837, p. 89, pl. xxv, fig. 2
Enallocrinus scriptus D'Orbigny, 1849, p. 46
Enallocrinus punctatus D'Orbigny, 1849, p. 46
Cyathocrinus punctatus Salter, 1873, p. 125
Enallocrinus scriptus Angelin, 1878, p. 25, pl. vii, figs. 1-3, pl. ix, figs. 18-19, pl. xxv, figs. 1-7, pl. xxvii, figs. 17-20
Enallocrinus scriptus Wachsmuth & Springer, 1889, p. 388, pl. xx, figs. 5-6
Enallocrinus scriptus Bather, 1900, p. 176, fig. xcii(1,2)

Syntypes.- An unknown number of specimens in the Hisinger collection. As this species is founded on a bibliographic reference in Hisinger (1831) to an earlier paper (1828), the specimen figured in the 1828 paper must be included among the syntypes. This figure is also used in Hisinger (1827, 1837) and was later copied in other works (e.g. D'Orbigny, 1858).

Occurrence.- The original figured specimen came from Klinteberg, Gotland, from which locality Angelin's specimens also came. In England the species is only known from the Wenlock Limestone, Dudley.

Diagnosis.- As for the genus, only one species being recognised.

Description.- Cup cone-shaped, wider than high, with a wide base and expanding slowly distalwards. Cup plates ornamented with irregular ridges. Infrabasals low, commonly about one third of the height of the basals, but often less. Basals wider than high; radials wider than high, lower than the basals, often lunate and with the facet occupying almost the whole width of the plates. Primibrachs one, small, confined to centre of radial facet; secundibrachs two, the proximal of which is in contact with the radials. Arms long, tapering little, dividing seven or eight times isotomously at lengthening intervals. Brachials about twice as wide as high, except immediately following a division when they may be as wide as high. Distal ends of brachials with conspicuous transverse projections on each side; these are more prominent in the more distal parts of the arms. Food groove shallow, not confluent with the axial canal. Anal plate in radial circlet, small, square. Tegmen formed of many small plates. Stem wide, with extremely large round lumen and thin walls; formed of low nodose columnals.

Discussion.- Judging from the figures given by Angelin the British material of this species is not so well preserved as the Swedish. Most British material is badly crushed, and it is evident that this is due to the peculiar structure of the species. The cup plates are relatively thin, and the wall of the stem is extremely thin, the lumen being so laege as to render the stem very readily crushed. Only one cup has been seen in the principal British collections in which the plates appear to retain their probable original form. There is also another peculiar feature of this species, namely that the development of the various cup plates is variable, and also the ornament on them is variously developed; sometimes the cup appears so deformed as to be about three times as wide as high, the cup plates being correspondingly wide, though it is uncertain how much of this deformation is due to crushing. The most commonly seen specimen s of this species are fragments of the arms, and these are easily recognised because of the strongly marked lateral processes; there is a superficial resemblance to the arms of <u>Gissocrinus capillaris</u> (Phillips), but the brachials in <u>E. scriptus</u> are shorter.

Family PETALOCRINIDAE Weller & Davidson 1896

Diagnosis.- Dicyclic Inadunata with no anal plates in cup, radial facets narrow, horseshoe-shaped. Arm branches in each ray fused to form a single solid petal-like plate bearing the ambulacral grooves on the ventral side.

Range.- Silurian.

Discussion.- The peculiar specialised development of the arms in *Petalocrinus*, the only genus in this family, is probably an extension of the fusion of brachials seen in the Crotalocrinitidae, and it seems likely that both families were derived from a common ancestor. Owing to the rarity of the cup in *Petalocrinus* (only known in *P. mirabilis* Weller & Davidson and *P. bifidus* sp. nov.) specific discrimination is based on the characters of the 'petals' or fused arm systems which were termed 'arm fans' by Bather (1898) in his monograph of the genus.

Petalocrinus Weller & Davidson 1896

Type species by monotypy: *P. mirabilis* Weller & Davidson 1896, Niagaran, Iowa.

Diagnosis.- As for the family, only one genus being recognised.

Petalocrinus bifidus Bather MS. sp. nov.

Plate 12, figs, 1-4

Holotype.- SM A 40892.

Paratypes.- BM E 49625; Gsm 69866a and b, 88919, 92733.

Occurrence.- The holotype comes from 350 yards N. E. of Littlehope Farm, near Mordiford, Herefordshire (locality 1 of Pocock, 1930). All the paratypes come from the Woolhope area, from localities described by Pocock (1930). P. bifidus occurs in a thin band of limestone, called the Petalocrinus Limestone by Pocock, near the top of the Upper Llandovery betwen Malvern in the north and May Hill in the south. Specimens have been examined from the following localities outside the Woolhope area: watercourse, 400 yards N. of keepers lodge, 950 yards W. of obelisk, Eastnor Park (GSM Zi 4927); field, 100 yards W. of obelisk, Eastnor Park (GSM Zi 4928); old quarry, 200 yards N. E. of Linden House, Malvern (GSM Zi 4929); the Wych, Malvern (GSM Zi 4930); below the Wych, Malvern (GSM Zi 4931); 50 yards W. of Scaldbrain Barn in old lane, May Hill (GSM Zi 4932); gully in small coppice, 200 yards S. of Scaldbrain Barn, May Hill (GSM Zi 4933).

Diagnosis.- A species of Petalocrinus in which the arm fans are bilobed, being divided into two halves by a longitudinal ridge on the ventral side. Inlarge specimens each half fan may be bilobed.

<u>Description</u>.- Cup obscurely preserved in the only specimen available (BM E 49625). Infrabasals three, two large and one small, not in a concavity. Infrabasals relatively larger and basals relatively smaller than in <u>P. mirabilis</u>. Radials twice as wide as high, with facet occupying two thirds the width of the plate. One primibrach, low, considerably wider than high.

Angle of arm fan about 60°, but specimens vary between 50° and 70°; fan bilaterally symmetrical, clearly divided into two approximately equal halves by a median ridge, broader than t the other ridges, and a distal median notch, which may extend to half the total length of the fan. Each half fan may again have a distal notch, which may extend to one quarter the total length of the fan, but may be hardly discernable and may be absent altogether. This secondary notch may not be developed to an equal extent in each half. Finials about sixteen, but less in young and more in old specimens, and the two halves are not always quite symmetrical in growth. Ventral surface of fan gently convex transversely, scarcely convex longitudinally. Dorsal surface faintly concave, but convexly rounded at the edges. No growth lines or ornament seen. Ridges narrower than the grooves, except where the median and two lateral ridges widen at the notches. Covering plates simple, four per millimeter.

Tegmen not seen. No stem is available which is attached to a cup.

Discussion.- There is abundant material of the arm fans of this species available, but it is all so fragmentary that a completely satisfactory account of it cannot yet be given. Only one specimen shows the cup, and this is indifferently preserved. Petalocrinus was first found in England by Dr. R. W. Pocock in 1911, and he has given an account of its occurrence in the Woolhope area of Herefordshire. The specimens collected were entrusted to Dr. F. A. Bather for description, but this work was not completed before Dr. Bather's death in 1934. Through the kindness of Mr. L. Bairstow I have had the benefit of seeing such notes and diagrams as were made by Dr. Bather.

The infrabasals of this species, which are fused to three, differ from those of P. mirabilis, the only other species in which the cup is known, where they are completely fused, minute, and in life completely hidden by the stem (Springer, 1926b). Covering plates, not found in situ in Swedish and American species, are here photographed for the first time. As has been pointed out by Mu (1949) in a Chinese species, they are of the simple type, rather than the compound type predicted by Bather (1898).

The strongly marked lobation in the arm fans of P. bifidus is interpreted as being a trace of the original arm branching, and it shows that in this respect P. bifidud is more primitive than the other desdribed species. This accords with its low statigraphical position, at a horizon about equal to that of the most primitive Gotland species, P. visbycensis Bather, which comes from the "shore north of Visby, Gotland" (Bather, 1898, p. 421), a locality, which, according to the map given by Hede (1942), would be in the Visby Marl and hence of Upper Llandovery age (Hede, 1942, p. 214). Some faint traces of lobation have already been pointed out by Bather (1898, p. 413) in P. vibycensis, but this character is much more pronounced in P. bifidus. No other species shows such signs of the original arm branching.

The matrix in which P. bifidud is found contains many columnals, almost certainly including species other than Patea Petalocrinus. Many of these and the other shell and crinoid fragments in the rock show signs of rolling, or at least of deposition in unquiet conditions. This probably accounts for the raity of complete crowns of P. bifidus. Excavations, made with the aid of a grant from the G. W. Young fund of the Geologists Association, at locality 1 of Pocock (1930) showed that Petalocrinus occurs there through some nine inches of rock. Dr, Pocock gave the thickness as one inch.

Family BOTRYOCRINIDAE Bather 1899b

Diagnosis.- Dicyclic Inadunata, cup conical to bowl-shaped; radianal quadrangular, obliquely below right posterior radial, in some genera tending to disappear. Anal plate in line with radials; anal tube prominent with thin plates which are commonly plicate. Radial facets narrow, horseshoe-shaped. Arms branch isotomously into two main rami which bear armlets or consisting of a single pinnule bearing branch.

Range.- Ordovician to Lower Carboniferous.

Botryocrinus Angelin 1878

Text-figure 8

Synonyms.- Sicyocrinus Angelin 1878; Bathericrinus Jaekel 1918.

Type species by subsequent designation of Bather (1891b): Botryocrinus ramosissimus Angelin, Silurian, Gotland.

Diagnosis.- A genus of Botryocrinidae in which the radianal is not completely under the right posterior radial; arms branching into two main rami which bear armlets.

Discussion.- Four British species were referred by Bather to the genus Botryocrinus. Jaekel (1918) erected the genera Bathericrinus and Dictenocrinus, based on the differences in the arm structure for two of these, but it is not considered here that Bathericrinus is sufficiently distict from Botryocrinus to be recognised, but Dictenocrinus is distinguished by the presence of pinnules, whereas Botryocrinus has only armlets. This distinction, while admittedly only one of degree, is useful enough to be retained.

Botryocrinus ramosus Bather

Plate 17, fig. 7

Botryocrinus ramosus Bather, 1891b, p. 394, pl. xiii, figs. 1-4
Botryocrinus ramosus Bather, 1906, p. 95
Bathericrinus ramosus Jaekel, 1918, p. 58

Holotype.- BM 57217.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Botryocrinus with arms dividing into two main rami, giving off fairly long armlets at frequent, but irregular, intervals; axillaries slightly nodose. Basals slightly higher than wide.

<u>Discussion</u>.- Only one specimen of this species is known, and this was described in detail by Bather. The cup is damaged at the base, and the stem is unkown. Jaekel (1918) considered, contrary to the view advocated here, that this species, in its developments of armlets was sufficiently distinct to form the type species of the genus <u>Bathericrinus</u>.

<u>Botryocrinus quinquelobus</u> Bather

<u>Cyathocrinus quinquangularis</u> Salter, 1873, p. 123 (nom. nud.)
<u>Botryocrinus quinquelobus</u> Bather, 1892b, p. 189, pl. xi,figs.1-2
<u>Botryocrinus quinquelobus</u> Bather, 1906, p. 96
Non <u>Cyathocrinus quinquangularis</u> (J. S. Miller, 1821)

<u>Syntypes</u>.- SM A 10156, A 10157. Of these A 10156 was selected as the lectotype by Bather (1906).

<u>Occurrence</u>.- Only known from the Wenlock Limestone, Dudley.

<u>Diagnosis</u>.- A species of <u>Botryocrinus</u> with arms dividing into two main rami with short armlets given off at irregular intervals. Basals wider than high. Stem pentagonal.

<u>Discussion</u>.- Bather described in detail the two specimens which were known to him. A third specimen (GSM 85665) has been found

during the present study, but it is poorly preserved and adds nothing to a knowledge of the anatomy of the species.

This species forms the start of the morphological series of species of Botryocrinus and Dictenocrinus which leads towards the development of pinnules. The other members of the series are, in order, B. ramosus, D. decadactylus and D. pinnulatus.

Dictenocrinus Jaekel 1918

Text-figure 8

Type species by original designation: Botryocrinus decadactylus Bather, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Botryocrinidae in which the radianal is not completely under the right posterior radial. Arms branching once or twice and bearing pinnules.

Dictenocrinus decadactylus (Bather)

Plate 17, fig. 8

Cyathocrinus (sp.2) decadactylus Salter, 1873, p. 123 (nom. nud.)
Cyathocrinus (sp. 3) quindecimilis Salter, 1873, p. 124 (nom.nud.)
Botryocrinus decadactylus Bather, 1891b, p. 395, pl. xiii, figs. 5-15
Botryocrinus decadactylus Bather, 1906, p. 95
Dictenocrinus decadactylus Jaekel, 1918, p. 59

Syntypes.- BM E 5611, E 1328, E 1419, E 1412, E 5130, 57225, 48191; SM A 10155, A 10158; BUH 136, 349; BUK 149; and a specimen in the York Museum. Of these BM E 1419 was selected as lectotype by Bather (1906).

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Dictenocrinus with arms branching once and with rather stout pinnules. Basals wider than high.

Discussion.- This is a relatively common species in the collections examined, and numerous specimens, especially in the Holcroft collection at Birmingham Museum of the University, have been seen. The species has been adequately described by Bather.

Dictenocrinus pinnulatus (Bather)

Botryocrinus pinnulatus Bather, 1891b, p. 402, pl. xii, fig. 16
Botryocrinus pinnulatus Bather, 1892b, p. 192, fig. 3
Botryocrinus pinnulatus Bather, 1906, p. 96
Dictenocrinus pinnulatus Jaekel, 1918, p. 59

Holotype.- DM 531.

Occurrence.- The holotype is unlocalised, but was thought by Mr. W. Madely to have come from the shale between the Upper and Lower Wenlock Limestone, Dudley. Another specimen (BM E 14081 - figured Bather, 1892b) was thought by Mr. Madely to have come from the Upper Wenlock Limestone, Dudley.

Diagnosis.- A species of Dictenocrinus with arms branching twice (sometimes only once) and with long and slender pinnules. Basals as high as wide.

Discussion.- Only the two specimens referred to above have been encountered during the present study, and although the holotype is well preserved there still remains some doubt about the constancy of the arm branching. Bather has described both the known specimens in detail. In the original description (1891b) the measurements of the width of the cup at its summit and of the height of the cup have been interchanged in error.

Mastigocrinus Bather 1892c

Text-figure 8

Type species by monotypy: M. loreus Bather, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Botryocrinidae in which the radianal is absent. Anal plate in line with radials. Arms long, isotomously branched, non-pinnulate. Anal tube long, flattened, and with strongly folded plates. Tegmen formed of many small plates. Stem divided longitudinally into pentameres.

Discussion.- Although the analysis of the plates of the cup is the same as that of Cyathocrinites (text-figure 8), the true relationships of this genus are made clear by the characters of the anal tube. This is of the dendrocrinid type with strongly folded plates which is unknown in Cyathocrinites where the tube plates are not folded (text-figure 10). The stem is divided into pentameres longitudinally, a feature common in the Botryocrinidae, but unknown in Cyathocrinites. The tegmen is also of a type not seen in Cyathocrinites. The absence of the radianal usually present in this family is possibly due to resorption.

Mastigocrinus loreus Bather

Plate 17, fig. 9

Cyathocrinus (sp.9) *arboreus* Salter, 1873, p. 125 (nom.nud.)
Cyathocrinus (sp.11) - Salter, 1873, p. 125
Mastigocrinus loreus Bather, 1892c, p. 196, pl. xi, fig.3, pl. xii.
Mastigocrinus loreus Bather, 1900, p. 131, fig. xlviii

Syntypes.- BM 57048, BUK 133, DM 532, DM 533, SM A 10158. Of these BM 57048 is here selected as the lectotype.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of *Mastigocrinus* in which the brachials are wider than high. Primibrachs 7-11, usually 8.

Discussion.- The most characteristic feature of this species, which was fully described by Bather (1892c), is the long regularly dichotomising arms formed of short rounded brachials. The extreme length of the arms may be illustrated by a calculation of the length of the food groove in the lectotype. The arms divide eight times and have a length of food groove of over 26 metres. This may be compared with a length of 4.3 metres in *Cyathocrinites acinotubus* (Angelin).

Mastigocrinus bravonium sp. nov.

Plate 36, figs. 5-8

Holotype.- GSM 89994.

Paratype.- OM c 84.

Occurrence.- All known specimens are from the Lower Ludlow beds (Monograptus leintwardinensis zone), Church Hill Quarry , Leintwardine, Herefordshire.

Diagnosis.- A small species of Mastigocrinus in which the brachials are higher than wide. Primibrachs usually four, sometimes five.

Description.- A small species; cup conical, about as wide as high, surface of cup plates smooth or slightly granular. Infrabasals occupy a quarter of the height of the cup; basals occupy half the height of the cup and are as wide as high; posterior basal truncate and considerably wider than the others. Radials a little wider than high, occupying one third of the height of the cup; radial facets occupying the whole width of the radials. Primibrachs usually four, sometimes five, slightly higher than wide. Arms branch three or possibly four times isotomously; brachials with evenly rounded dorsal sides; axial canal and food groove confluent. Anal plate relatively large, considerably wider than high; anal tube formed of rectangular plates which are folded longitudinally, and there are in addition transverse folds arranged in the pattern of text-figure 10 and of the same type as in *M. loreus*.

Stem slightly subpentagonal, smooth, formed of alternating thin and thick columnals.

Discussion.- It was at first thought that this small species, represented by a number of external moulds from Leintwardine, belonged to *Cyathocrinites* and Sollas had so labelled the paratype in the Oxford University Museum. The posterior side and anal tube are exposed in the holotype, however, and they show that it should be referred to *Mastigocrinus*. It is easily distinguished from *M. loreus* Bather, the only other described species, by the length of the brachials, and the small size.

The specific name is derived from the Roman name for Leintwardine.

Family DENDROCRINIDAE S. A. Miller 1889

Diagnosis.- Dicyclis Inadunata with a conical cup with five infrabasals; radial facets narrow, horseshoe-shaped; radianal, anal, and sometimes another anal plate in cup; anal tube prominent, formed of thin plicated plates. Arms isotomously branched, slender, non-pinnulate.

Range.- Ordovician to Devonian.

Dendrocrinus Hall 1852

Text-figure 4

Type species by monotypy: D. longidactylus Hall, 1852, Niagaran, Lockport, New York

Diagnosis.- A genus of Dendrocrinidae in which the anal tube is elongated and vertically disposed.

Dendrocrinus brevis sp. nov.

Plate 15, fig. 3

Holotype.- BUH 347.

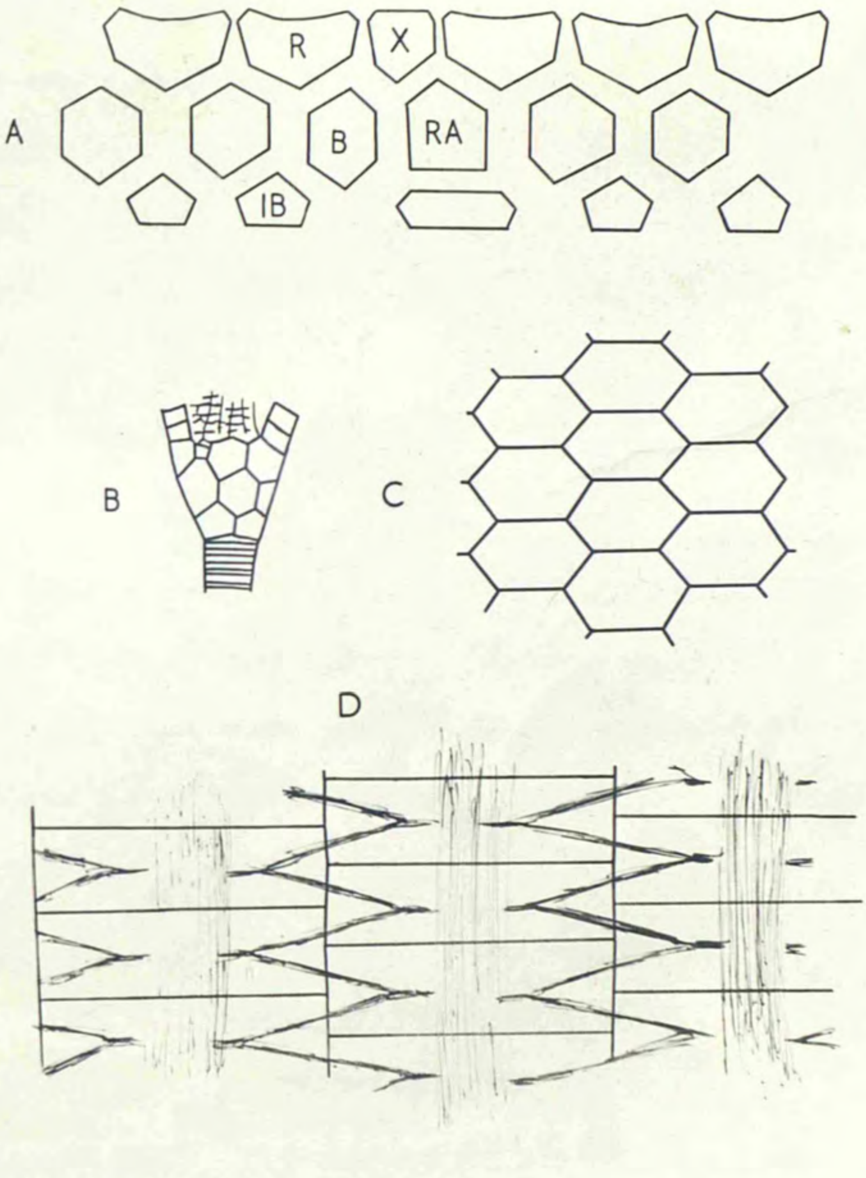
Occurrence.- Wenlock? Shale, Sedgley, Staffordshire.

Diagnosis.- A species of Dendrocrinus in which the arms are no longer than twice the height of the cup. Brachials with a sharp longitudinal dorsal ridge.

Description.- Cup conical, about as wide as high. Cup plates bear a system of axial ridges; between the ridges are small pustules in radiating rows emanating from a central knob on each plate. Infrabasals higher than wide, forming a quarter of the height of the cup. Basals higher than wide; radials about as high as wide, the radial facets occupying about one third of the total width of the radials. Primibrachs four in the one ray of the holotype which is exposed. Secundibrachs four; arms branch four times; brachials wider or as wide as high, but becoming higher distally, and with a sharp longitudinal dorsal ridge and a slight dorsal distal expansion. Arms short and slender, only as long as twice the height of the cup, their form giving the crown a somewhat squat appearance. Anal plate hexagonal, resting on truncate posterior basal; radianal wider than high, below right posterior radial, which latter is smaller than the other radials. Anal tube massive, formed of quadrangular plates with lateral folding; first tube plate resting on anal and also in contact with right posterior radial.

Tegmen not seen. Stem subpentagonal, nodose, preserved in holotype for a length of 6 mm., but the impression in the matrix shows that 22 mm. of stem were once present in this specimen.

Discussion.- This species is only known from the evidence of one specimen, the holotype. The Wenlock occurrence of the typically Ordovician genus at Dudley parallels similar occurrences in the Niagaran rocks of North America. *D. brevis* differs from both the Niagaranspecies *D. celsus* Ringueberg and *D. nodobrachialis* Ringueberg in the ornamentation of the cup plates, the squat appearance of the crown and in the details of the brachials. The same characters distinguish it from described Ordovician species of *Dendrocrinus*. The chief feature of the species, however, is the length of the arms, and it is on this character that the name of the species has been based. The squat appearance of the crown is so well marked, being a product of the short arms, that a new species is erected although only one specimen is available.



TEXT-FIGURE 10

A. Thenarocrinus callipygus Bather (after Bather).

B. Thenarocrinus gracilis Bather (after Bather).

C. The Cyathocrinitid type of tube plates.

D. The Dendrocrinid type of tube plates.

Family THENAROCRINIDAE Jaekel 1918

Diagnosis.- Dicyclic Inadunata with a conical cup; radianal wholly within the basal circlet and in contact with one or more infrabasals. Anal tube prominent, formed of horizontally folded plates; arms branching isotomously several times, non-pinnulate. Stem divided longitudinally into pentameres.

Range.- Silurian.

Discussion.- This family is usually considered to be primitive in many of its characters. The low position of the radianal, the many branched arms, and the stem divided longitudinally into pentameres are all primitive features. It is restricted to the Wenlock Limestone at Dudley.

Thenarocrinus Bather 1890c

Text-figure 10

Type species by monotypy: *T. callipygus* Bather, Wenlock Limestone, Dudley.

Diagnosis.- As for the family, only one genus being recognised.

Thenarocrinus callipygus Bather

Plate 17, figs. 1-2

Thenarocrinus callipyge Bather, 1890b, p. 334, pl. xiv, fig. 14 (nomen nudum)
Thenarocrinus callipygus Bather, 1890c, p. 222, pl. x, figs. 1-9
Thenarocrinus callipygus Bather, 1891a, p. 35, pl. i, figs. 1-3

Syntypes.- BM 48049, 57478a, 57478b; DM 523; BUK 138, 144, 153; BUH 293, 431. Of these BM 57478a is here selected as the lectotype.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Thenarocrinus in which the cup is wider th than high, the individual cup plates also being wider than high. Brachials wider than high. Radianal rests on one infrabasal.

Thenarocrinus gracilis Bather

Text-figure 10

Thenarocrinus gracilis Bather, 1891a, p. 36, pl. i, figs. 4-5

Holotype.- A specimen in the York Museum.

Occurrence.- Only known from the Wenlock Limestone, Dudley

<u>Diagnosis</u>.- A species of <u>Thenarocrinus</u> in which the cup is higher than wide. Distal brachials as high as or slightly higher than wide. Radianal rests on two infrabasals.

<u>Discussion</u>.- This species is known from the holotype alone, and it has not proved possible to examine it during the present study. Bather has, however, described it in detail.

Subclass FLEXIBILIA Zittel 1895

Diagnosis.- Dicyclic Crinoidea with a flexible cup in which the lower brachials are incorporated either by lateral union with each other or by means of interbrachials or of perisome. All plates distal to radials united by loose suture and more or less movable. Mouth and food grooves exposed. Arms non-pinnulate. Infrabasals three, two large and one small.

Discussion.- Most of the British Lower Palaeozoic species of Flexibilia have been fully described and figured in an exhaustive monograph by Springer (1920), and there remains little which may be added here. In some cases, however, better material than was available to Springer has come to light, and has yielded new information, while some species are new and were not known to Springer at the time of his work.

In this summary, where a species has been adequately described by Springer (1920), only the reference to that work is given, earlier references being found therein.

Order SAGENOCRINOIDEA Springer 1913

Family SAGENOCRINITIDAE Bassler 1938

Sagenocrinites Austin & Austin 1842

Sagenocrinites expansus (Phillips 1839)

Plate 22, fig. 1

Springer, 1920, p. 218, pl. xviii, figs. 1-9, pl. xiv, figs. 1-3.

Occurrence.- Wenlock Limestone, Dudley. Follingbo, Gotland.

Discussion.- This is the species which was erroneously taken by the Austins to be the type species of their genus Periechocrinites. The specimen used by the Austins is figured here (plate 24, fig. 3). For discussion of this subject see page here, and Ramsbottom, 1951b.

Temnocrinus Springer 1902

Temnocrinus tuberculatus (Miller 1821)

Plate 23, figs. 1-3

Springer, 1920, p. 209, pl. xvi, figs. 1-15.

Occurrence.- Only known from the Wenlock Limestone, Dudley, where it is one of the commonest of all the crinoids found.

Discussion.- The original figured specimen used by Miller has not been found, but Phillips' specimen is at Birmingham.

Meristocrinus Springer 1906

Type species by original designation: Cyathocrinus interbrachiatus Angelin, Silurian, Gotland.

Diagnosis.- A genus of Sagenocrinitidae with the radianal in the form of a radial beneath the right posterior radial. Interbrachials few or none, followed by perisome. Primibrachs three.

Meristocrinus orbignyi (M'Coy)

Plate 37, fig. 5

Taxocrinus? Orbignyi M'Coy, 1850, p. 289
Taxocrinus? Orbignyi M'Coy, 1851, p. 53, pl. 1d, fig.1
Meristocrinus orbignyi Springer, 1906, p. 519
Meristocrinus orbignyi Springer, 1920, p. 213, pl. xvii, fig. 7

Holotype.- SM A 29599

Occurrence.- Lower Ludlow, Bannisdale Slates, Monograptus leintwardinensis zone (fide, Marr, 1892b, p. 538), "Asterias Bed", High Thorns, Underbarrow, Kendal, Westmorland. The holotype is the only known specimen.

Diagnosis.- A species of Meristocrinus with the stem not expanding towards the cup, and in which the brachials have a slight distal expansion.

<u>Description</u>.- Cup bowl-shaped, with subparallel sides, surface of cup plates smooth. Infrabasals low, appearing in side view like an enlarged columnal. Basals one third the height of the radials, much wider than high, the facets occupying the whole width of the plates. Primibrachs three, wider than high; secundibrachs five. Arms dividing three times isotomously, though in the distal region the divisions are not at the same height in each branch. Proximally the brachials are wider than high, but distally becoming as high or exen higher than wide. Brachials have a slight distal expansion or cornice on their dorsal sides. Posterior side of cup not seen, but traces of the interbrachial perisome of tiny plates are seen in one interbrachial area. Tegmen not seen. Stem round, large, not expanding towards the cup, formed of uniform, ridged, short, columnals with crennellate surfaces; preserved for a length of 33 mm.

<u>Discussion</u>.- The unique holotype is preserved as an external mould in sandstone, and only the anterior side of the cup is seen. Some development of the specimen has been possible and a good Revultex impression has been made. The reference of the species to <u>Meristocrinus</u> is largely based on the presence of three primibrachs, a rare thing in Silurian Flexibilia, but also on the form of the crown.

The figure given by M'Coy (1851) and reproduced by Springer (1920) is very much restored and is inaccurate in several respects.

The basals in that figure are too big, the infrabasals are not shown, no sign of the interbrachial perisome appears, and the arm branching is too artificial and regular. The species is well characterised by the distal expansions on the brachials and the non-expanding stem.

The horizon of this species was given, in error, as Upper Ludlow by M'Coy. The stratigraphical position of the Starfish Beds in the Bannisdale Slates has been commented on by Marr (1892b, p. 539), but in which of several Starfish Beds the crinoids occur is not known.

Meristocrinus minor Springer 1920

Springer, 1920, p. 213, pl. xvii, figs. 8-9.

Occurrence.- Wenlock Shale, Dudley.

Meristocrinus nodulosus (Salter MS.) sp. nov.

Plate 21, fig. 2

Cyathocrinus nodulosus Salter, 1873, p. 124 (nomen nudum)

Holotype.- SM A 10167.

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Meristocrinus in which the axillaries are nodose, all the plates bearing a granular ornament.

Description.- Cup widely cone-shaped, wider than high. All cup plates bear a granular ornament. Infrabasals low, about half the height of the basals, which are wider than high. Radials wider than high, facet occupying the whole width of the plates. Primibrachs three, wider than high; secundibrachs three or four; arms branch three or four times. All brachials wider than high, slightly moniliform, and the axillaries are nodose. Radianal under right posterior radial, wider than high. Plates of the anal tube roughly hexagonal in shape, but there does not appear to be a ridge in the tube. Tegmen not seen. Stem wide proximally, confluent with the base of the cup, formed of columnals of even thickness.

Discussion.- This species represented only by the holotype, is distinguished from all others of the genus by the nodose axillaries. It is also notable in the absence of a ridge from the tube.

Family HOMALOCRINIDAE Angelin 1878

Homalocrinus Angelin 1878

Homalocrinus parabasalis Angelin

Plate 23, fig. 4

Springer, 1920, p. 154, pl. vi, figs. 1-12.

Occurrence.- Wenlock Limestone, Dudley; Visby, Gotland.

Discussion.- The specimens available to Springer showed only short stems, the longest of the figured stems being 28 mm. in length. A fine specimen (GSM 85436) has a stem 100 mm. in length, and is complete with the root.

Calpiocrinus Angelin 1878

Calpiocrinus intermedius Springer

Plate 21, fig. 4

Springer, 1920, pp. 156-7, pl. vii, figs. 1-3.

Occurrence.- Wenlock Limestone, Dudley; Gotland.

Ichthyocrinus pyriformis (Phillips 1839)

Plate 23, figs. 5-7

Springer, 1920, pp. 273-5, pl. xxxii, figs. 1-13.
Not Ichthyocrinus pyriformis M'Coy, 1851.

Occurrence.- Wenlock Limestone, Dudley; Hurst Hill, near Sedgley, Staffordshire (GSM 85587). The specimen figured by Ellis (1762), which is the earliest figure of any crinoid crown, is stated to have come from Pyrton Passage, but there is no Wenlock Limestone exposed at that locality at the present time. Springer records the species from Visby, Faro, Dalham and Follingbo in Gotland.

Hormocrinus Springer 1920

Hormocrinus anglicus Springer 1920

Plate 21, fig. 3

Springer, 1920, pp. 168-9, pl. xvi, figs. 6-7.

Occurrence.- Wenlock Limestone, Dudley.

Pycnosaccus Angelin 1878

Pycnosaccus bucephalus (Bather 1890a)

Plate 21, fig. 7

Springer, 1920, p. 187, pl. xii, figs. 10-11.

Occurrence.- Wenlock Limestone, Dudley.

Family LECANOCRINIDAE Springer 1913

Lecanocrinus Hall 1852

Lecanocrinus bacchus (Salter 1873)

Plate 22, figs. 5-6

Springer, 1920, pp. 138-9, pl. ii, figs. 25-28.

Occurrence.- Wenlock Limestone, Dudley.

Family ICHTHYOCRINIDAE Angelin 1878

Ichthyocrinus Conrad 1842

Ichthyocrinus intermedius Angelin 1878

Springer, 1920, pp. 282-3, pl. xxxiv, figs. 11-14.

Occurrence.- Wenlock Limestone, Dudley; Gotland.

Ichthyocrinus phillipsianus Springer 1920

Springer, 1920, p. 284, pl. xxxvi, figs. 13-14.

Occurrence.- Wenlock Limestone, Dudley.

Order TAXOCRINOIDEA Springer 1913

Family TAXOCRINIDAE Angelin 1878

Eutaxocrinus Springer 1906

Type species by original designation.- Taxocrinus affine Muller Middle Devonian, Germany.

Diagnosis.- A genus of Taxocrinidae with the rays not abutting over the interbrachials; infrabasals low; posterior basal elongate; radianal usually absent; few or no interbrachials; primibrachs two.

Eutaxocrinus maccoyanus (Salter)

Plate 37, figs. 1-4

Ichthyocrinus pyriformis M'Coy, 1851, p. 54
Ichthyocrinus McCoyanus Salter, 1873, p. 163
Taxocrinus - La Touche, 1884, pl. xvii, fig. 551
Non Ichthyocrinus pyriformis (Phillips 1839)

Holotype.- SM A 35407.

Occurrence.- The holotype is from the Lower Ludlow, Bannisdale Slates, Monograptus leintwardinensis zone (fide Marr, 1892b,

p. 538), "Asterias Bed", Light Beck, Underbarrow, Kendal, Westmorland. Two specimens are known from a similar horizon at Church Hill Quarry, Leintwardine, Herefordshire (BM E 26578, GSM 89989), and one specimen (GSM 89988) is labelled "Underbarrow" and may be from the same locality as the holotype.

Diagnosis.- A species of Eutaxocrinus without interbrachials, with three or four secundibrachs, arms branching isotomously, brachials smoothly rounded on their dorsal sides and smooth cup plates.

Description.- Cup low, wider than high, surface of cup plates smooth. Infrabasals and basals of about equal height, very low and much wider than high. Radials form half the height of the cup, slightly wider than high with the facets occupying the full width of the plates. Primibrachs two; secundibrachs three or four; arms dividing isotomously three times. All brachials wider than high, smooth and with rounded dorsal sides. Posterior side of cup not seen. Interbrachials absent. Stem widens slightly proximally and there is formed of low columnals the first twelve or thirteen being of uniform size. Distally there is an irregular alternation of longer and shorter columnals. Surface of columnals crennelate.

Discussion.- No mention of this species is made by Springer (1920). Although the posterior side of the cup has not been seen, the species is referred to Eutaxocrinus with some confidence, for the form of the crown is characteristic. This species is the earliest , stratigraphically, so far known, of the more typical members of the genus, since E. oblongatus (Angelin) from Gotland is not at all typical in its arm branching. E. maccoyanus is mainly characterised by the low cup and smooth surface of the cup plates and brachials; E. rhenanus (C. F. Roemer) from the Devonian of Germany is perhaps the species which it most resembles.

Salter (1873) spelt the specific name 'McCoyanus'. This has been altered to maccoyanus, since if the original spelling is written in lower case letters it becomes unpronouncable.

All the four known specimens are figured on the plate. One of those from Leintwardine is apparently that figured by La Touche (1884, pl. xvii, fig. 551), which was formerly in the Ludlow Museum. The other Leintwardine specimen is notable in being the only specimen examined from that locality in which the actual plates are preserved in calcite (GSM 89989), though the sutures are somewhat obscure in places.

Gnorimocrinus Wachsmuth & Springer 1879

Type species by subsequent designation of Bather (1899b, p. 923): Taxocrinus expansus Angelin, Silurian, Gotland.

Diagnosis.- A genus of Taxocrinidae with the rays not abutting above interbrachial areas. Crown rather low and rotund. Infrabasals low, posterior basal elongate. Radianal obliquely to lower left of right posterior radial. Interbrachials few or none. Arms divergent.

Gnorimocrinus sedgleyensis sp. nov.

Plate 15, fig. 2

Holotype.- BUH 188.

Occurrence.- The unique holotype comes from the Wenlock? Shale, Sedgley, Staffordshire.

Diagnosis.- A species of Gnorimocrinus with three primibrachs; arms slender.

Description.- Cup low, somewhat flareing at the level of the radials. Infrabasals low, about one third of the height of the basals. Basals about as high as wide, variable in shape. Posterior basal probably elongate, but covered in holotype by the displaced anal plate. Radials a little wider than high, the facets occupying the whole width of the plates. Radianal obliquely to the lower left of right posterior radial, a relatively large plate. Primibrachs three in all rays, wider than high. Secundibrachs usually four, but in one ray only three. Arms branch four times, rather slender for the genus, the brachials being without lateral processes and in all cases wider than high. Interbrachial areas not well preserved, but traces of perisomic plates appear in three of these areas in the holotype, the others being obscured by matrix. Posterior interradius with the anal plate and two other massive plates above it. Many dissociated perisomic plates obscure the relationships of the plates here. Perisomic plates are also seen in the intersecundibrachial, intertertibrachial and interquartibrachial areas.

Stem absent.

Discussion.- This unique specimen from Sedgley differs from all the Silurian Flexibilia, except Meristocrinus, in the possession of three primibrachs. This character is usually a feature which is to be relied on in the discrimination of the Flexibilia. The structure of the posterior side makes its reference to Meristocrinus impossible, however, and Gnorimocrinus is the only alternative genus.

Subclass CAMERATA Wachsmuth & Springer 1885

Diagnosis.- Crinoidea with a rigid cup in which the lower brachials are to a varying extent firmly incorporated, being rendered fixed and immovable by union with either dorsal or ventral structures. Cup plates united by close suture. Mouth and food grooves chiefly subtegminal. Arms pinnulate.

Discussion.- In the Camerata, as in the Inadunata, there are dicyclic forms (order Diplobathra) and monocyclic forms (order Monobathra). The main evolutionary trend in the Camerata is, according to Moore & Laudon (1943, p. 77), the upward displacement of the interbrachial elements from the cup. Combined with this the number of fixed brachials in the cup is also reduced. In the most advanced forms such as the Platycrinitidae (Lower Carboniferous) and the Hapalocrinidae (Silurian) in the Monobathra, and the Nyctocrinidae (Silurian, but not in Britain) in the Diplobathra, the cup contains no fixed brachials and few or no interbrachial plates.

Order MONOBATHRA Moore & Laudon 1943

Diagnosis.- Camerata without infrabasals.

Discussion.- The families included in the Monobathra may be divided into two groups (Moore & Laudon, 1943) which could well rank as suborders. In the first group there are six plates, five radials and the tergal, in the radial circlet; in the second group only the five radials are in the radial circlet, the tergals being raised above them. The first group (including the Xenocrinidae, Periechocrinidae and Desmidocrinidae) also has either five, four or three equal basals. Families of the second group (including the Melocrinitidae, Eucalyptocrinitidae, Clonocrinidae, Patelliocrinidae, Marsupiocrinidae and Hapalocrinidae) have five four or three unequal basals.

Family PERIECHOCRINIDAE Bather 1899b

Diagnosis.- Monocyclic Camerata with a high cup, three equal basals; radials in contact except at posterior, where they are separated by a radial-like tergal. Median ray ridges developed in primitive members, absent in advanced members; first primibrach hexagonal; tergal followed by three plates in second row.

Range.- Silurian to Lower Carboniferous.

Discussion.- *Corocrinus* Goldring, *Thamnocrinus* Goldring and *Lindstroemiocrinus* Jaekel, all included in this family by Moore & Laudon (1943) belong more properly to the Melocrinitidae.

Periechocrinus Morris 1843

Text-figure 11

Synonyms.- *Crumenaecrinites* Troost 1849; *Geocrinus* d'Orbigny 1849; *Pradocrinus* de Verneuil 1850; *Saccocrinus* Hall 1852; *Pyxidocrinus* Müller 1855; *Periechocrinites* Bassler 1938 non Austin & Austin 1843.

Type species by monotypy: *P. costatus* Austin & Austin 1843, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Periechocrinidae with a cup higher than wide, arms not branching after leaving the cup.

Discussion.- The genus *Periechocrinites* Austin & Austin 1843 was shown by Ramsbottom (1951b) to have for its type species (by original designation) *P. articulosus* Austin & Austin.

P. articulosus was in the same paper shown to belong to Sagenocrinites expansus (Phillips) and the lectotype (designated Ramsbottom, 1951b, p. 1042) is figured here (plate 24, fig. 3) in confirmation of that statement. In the 1951 paper it is stated that Periechocrinites has page priority over Sagenocrinites Austin & Austin, but this is incorrect, since by the inclusion (1842, p. 110) in Sagenocrinites of S. expansus (Phillips) the Austins validated Sagenocrinites from 1842, whereas Periechocrinites dates from 1843. It thus follows that Periechocrinites Austin & Austin 1843 becomes a synonym of Sagenocrinites Austin & Austin 1842, since their respective type species are subjective synonyms. A name is then required for the genus called Periechocrinites by the Austins, and it so happens that the earliest of several available names is Periechocrinus Morris 1843, with its type species by monotypy P. costatus (Austin & Austin).

By this happy means the need for an application to the International Commission on Zoological Nomenclature to amend the type species of Periechocrinites (as was suggested in 1951) is avoided, and a modification of a name originally suggested by the Austins is retained. The name Periechocrinites Bassler 1938 and subsequent authors is thus a synonym of Periechocrinus Morris 1843.

It may be mentioned here that Periechocrinites globosus Austin & Austin 1843 MS., stated by Wilson (1890) to come from Gleedon Hill, Wenlock Edge (lectotype, here chosen, Bristol

City Museum C 3191, shown by MS. drawings of the Austins to be the specimen used by them - figured here plate 26, fig. 3) belongs in fact to the Carboniferous Limestone species Megistocrinus globosus (Phillips).

Periechocrinus costatus (Austin & Austin)

Plate 24, figs. 1-2; plate 25, figs. 1-5

Actinocrinites moniliformis Phillips, 1839, p. 673, pl. 18, fig. 4
Periecocrinites costatus Austin & Austin, 1842, p. 110 (nom. nud.)
Periechocrinites costatus Austin & Austin, 1843, p. 204
Periechocrinus costatus Morris, 1843, p. 56
Periechocrinus interradiatus Angelin, 1878, pl. xix, fig. 15
Periechocrinus moniliformis Angelin, 1878, pl. xix, figs. 14, 14a
Periechocrinites costatus Ramsbottom, 1951b, p. 1041
Non Actinocrinites moniliformis Miller, 1821

Lectotype (designated Ramsbottom, 1951b, p. 1041) the specimen figured by Phillips, 1839, pl. 18, fig. 4, left hand figure. It has not been traced; Murchison stated that it was in either the Bright, Inwood or Murchison collection.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A large species of Periechocrinus with a cone-shaped cup of high thin plates, arm branching asymmetrical, arms biserial, dividing 3-6 times, but usually five times.

Description.- A large species, a typical crown measureing 120 mm. or more in height. Cup tall and narrow, cone-shaped. Surface of cup plates smooth or slightly granular. Basals about two thirds of the height of the radials, which are nearly twice as high as wide and contract upwards so that the facet occupies about a third of the total width of the plate. Primibrachs two, the first hexagonal and almost diamond-shaped and nearly twice as high as wide; the second axillary, but also high. Secundibrachs two. Arms divide three to six times, but normally five times giving 50 biserial rami. They remain uniserial, however, until no further arm branching takes place, and all arm branching takes place within the cup. The plan of the arm branching is asymmetrical, but constant. In the second division the inner branch divides again, in the third division the outer, and in the fourth the inner, and in the fifth the outer. Each brachial bears a pinnule, and well preserved the brachials have a slight ornament of longitudinal ridges and grooves on their dorsal sides. Crenulate sutures can be seen between the uniserial tertibrachs and quartibrachs (SM A 12851). Interradial areas with one large plate followed by further rows of two plates which become smaller upwards. In the posterior interradius the radials are separated by a radial-like tergal plate, which is followed upwards by at least two rows of three plates each, the first row being of high plates. Intersecundibrachs are arranged 1 - 2. The upper parts of the interbrachials areas are slightly depressed on account of the strong, though narrow, axial ridges on the ray plates, which extend on to the arms. These axial ridges sometimes break up on the radials and pass down on to the basals in many different strands.

Tegmen composed of many small plates, irregularly arranged, and with a short tube in the centre. The anal opening is at the end of the tube. Stem round, with prominent moniliform nodals at intervals; distally these nodals become less prominent.

Discussion.- This species was formerly well known as *Periechocrinus moniliformis* (Miller), but as that name was based on a doubtfully identifiable fragment of stem, the more appropriate and better founded name *P. costatus* was resurrected by Ramsbottom (1951b). *P. costatus* is especially characterised by the high slender cup with thin plates and by the axial ridges and the height of the cup plates. The species is the central type of a group of species of *Periechocrinus* which is more common in Europe than in America. In America the only closely related form is that figured by Springer (1926b, pl. 10, figs. 5, 5a) from the Brownsport Formation of Tennessee, as *Periechocrinus* sp. But in Gotland several species, much in need of revision, belong to this group. Indeed, judging from the figured specimens *P. scanicus* Angelin may well be synonymous with *P. costatus*. The group is also present in Bohemia, as is evidenced by the form figured by Růžička & Bouška (1944, fig. 5) as _Periechocrinus_ sp. cf. _moniliformis_.

Angelin's figures of this species (1878, pl. xix, figs. 14, 14a) from Dudley show such irregularities of plating that it may be surmised that they are inaccurate as in so many other cases (see Bather, 1893, p. 5; Wachsmuth & Springer, 1889). The only species of British crinoid among all those founded by Angelin is _P. interradiatus_, and this is certainly conspecific with _P. costatus_.

Periechocrinus simplex Salter

Plate 26, figs. 1-2

Periechocrinus simplex Salter, 1873, p. 121

Syntypes.- Two specimens, now registered as SM A 10128-9, were included in the number quoted by Salter. SM A 10128 is here selected as the lectotype.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of _Periechocrinus_ in which the arms divide twice only, giving twenty biserial rami. Cup shorter than in _P. costatus_.

<u>Description</u>.- Form of cup unknown, but shorter than in <u>P. costatus</u>. Basals two thirds as high as radials, which are as wide as high or slightly wider. Primibrachs two, only a little wider than high. Secundibrachs two. Arms biserial, each brachial bearing a pinnule. Arms normally branch twice, giving twenty rami, but in the lectotype one branch divided again. Surface of cup plates with radiating ridges and the ray plates have moderately conspicuous broadly rounded axial ridges, which cause the interbrachial areas to be depressed. Interbrachial areas with one large plate followed in the second row by two smaller ones and with three plates in the third row. Intersecudibrachs arranged 1 - 2. Posterior interradius not seen. Stem with alternating nodals and internodals, with each alternate nodal again enlarged.

<u>Discussion</u>.- The affinities of this species are not at all clear. The only known specimens are the two syntypes, and the condition of these leaves much to be desired. The species seems to belong to the P. costatus group, and to be chiefly distinguished by the relative shortness of the plates comprising the cup and the depressed interbrachial areas. Salter's description is short, and is also innaccurate as to the number of arms (he stated that there were fifteen). The woodcut given by Salter does not represent this species, as was implied by Bassler & Moodey (1943).

Periechocrinus limonium Salter

Plate 26, figs. 6-8

Periechocrinus limonium Salter, 1873, p. 121

Syntypes.- The registration number quoted by Salter covered six specimens now reregistered as SM A 10130-35. Of these A 10130 is here referred to P. costatus, A 10134-35 belong to P. bulbosus sp. nov., A 10133 is here selected as the lectotype of P. limonium, and this leaves A 10131-32 as the remaining syntypes.

Occurrence.- The syntypes are from the Wenlock Limestone, Dudley. Also known from the Wenlock Limestone, Cefn Ila, Usk (BM E 1246).

Diagnosis.- A species of Periechocrinus with an ovate cup, arms dividing within the cup to give thirty branches, six to each ray.

Description.- Cup ovate, higher than wide, surface of cup plates smooth. Basals slightly concave, half the height of the radials which are hexagonal and slightly higher than wide. Primibrachs two, the first hexagonal, slightly higher than wide, the second haxagonal and axillary. Secundibrachs two. Slight axial ridges on the ray plates. Arms divide to give thirty branches, which are biserial after leaving the cup. In each ray the inner of the two branches resulting from the first division divides again. Interbrachial areas not depressed, except slightly distally. Interbrachial plates as usual in the genus - 1 - 2, except in the posterior where three plates follow the radial-like tergal.

Tegmen formed of small irregularly arranged plates. Anal opening and tube (if any) not seen. Stem with prominent nodals at intervals.

Discussion.- This species belongs to the group of *Periechocrinus tennesseensis* (Hall & Whitfield) by reason of the ovate cup. It is very close to *P. tennesseensis* itself, but seems to differ in the narrower interbrachial areas, there being only two plates in the third row instead of three as in the American species. The only specimen showing the arms of this species is BUH 238 (plate 26, fig. 6), all the other available material being more or less indifferently preserved cups.

Periechocrinus bulbosus sp. nov.

Plate 26, figs. 4-5

Holotype.- SM A 34177.

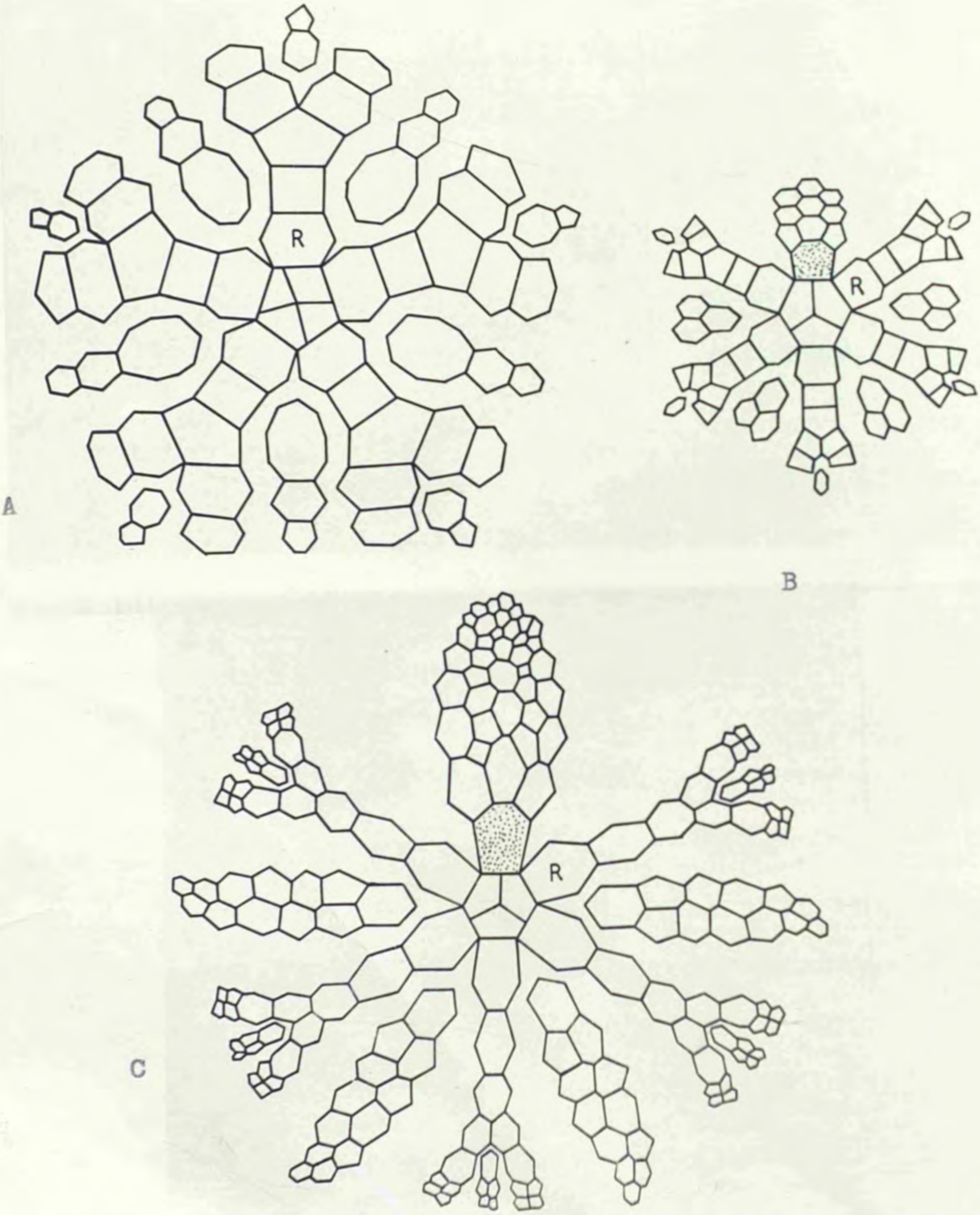
Occurrence.- The holotype comes from the Lower Wenlock Limestone, upper part of Basement beds, North side of Daw End railway cutting, Walsall, Staffordshire. One other specimen (SM A 34176) is known from this locality. Two former syntypes of P. limonium (SM A 10134-35) from the Wenlock Limestone, Dudley, also belong to the present species.

Diagnosis.- A species of Periechocrinus with a smooth plated oval cup, arms dividing twice isotomously within the cup, brachials cuneate uniserial.

Description.- Cup ovate, higher than wide, contracting a little at the level of the arm bases. Cup plates smmoth, except for the slight axial ridges on the ray plates. Basals concave, half the height of the radials which are hexagonal and wider than high. Primibrachs two; secundibrachs two; arms dividing twice, isotomously within the cup, giving twenty rami, each about twice the height of the cup in length. Brachials uniserial cuneate, about as high as wide, each bearing a pinnule. Interbrachial areas with the plates arranged 1 - 2 - 2, the lowest of which is not much larger than the others. Posterior side of cup with a radial-like tergal, followed by several rows each of three plates. A faint median vertical ridge is present in the posterior interradius.

Tegmen and stem not seen, but the lumen between the basals is subpentagonal.

Discussion.- This species, of which only four specimens have been recognised differs from the other species of the genus in its cuneate uniserial brachials, and in minor features of the cup and the relative proportions of the various plates comprising it. There is sometimes some difficulty in distinguishing between this species and young specimens of *P. limonium*, when the arms are missing as is usually the case. The presence of uniserial brachials in *Periechocrinus* is certainly unusual, and has not been reported before. *Lindstroemiocrinus* Jaekel is another genus which shows them, but, though formerly referred to the Periechocrinidae, Dr. G. Ubaghs tells me (in litt.) that it should more properly be referred to the Melocrinitidae. The presence of a tergal plates in *P. bulbosus*, however, prevents its reference to the latter family.



TEXT-FIGURE 11. A. Clonocrinus.

B. Carpocrinus.

C. Periechocrinus.

The tergal plate is stippled. R - radial.

Family DESMIDOCRINIDAE Angelin 1878

Diagnosis.- Monocyclic Camerata with three equal basals; radials in contact except at the posterior side, where they are separated by a radial-like tergal. First primibrach quadrangular; tergal followed by three plates in second row; anus opens directly through tegmen.

Range.- Silurian to Lower Carboniferous.

Discussion.- The palaeontolgy of the Swedish Silurian members of this family was left in a chaotic state as a result of the researches of Angelin (1878). Many of Angelin's species are probably invalid, and until they are revised it will not be possible to give a fully adequate account of the English specimens.

Desmidocrinus Angelin 1878

Text-figure 11

Synonym.- Leptocrinus Angelin 1878.

Type species by subsequent designation of Wachsmuth & Springer (1881, p. 282): D. pentadactylus Angelin, Silurian, Gotland.

Diagnosis.- A genus of Desmidocrinidae with uniserial arms; three to five or more arms per ray.

Desmidocrinus macrodactylus Angelin

Plate 27, figs. 9-12

Desmidocrinus macrodactylus Angelin, 1878, p. 6, pl. xvi, figs. 20-21
Desmidocrinus heterodactylus Angelin, 1878, p. 6, pl. xvi, figs. 16, 16a
Desmidocrinus tridactylus Angelin, 1878, p. 6, pl. xvi, figs. 4, 4a

Syntypes.- Two specimens figured by Angelin, now in the Riksmuseum, Stockholm.

Occurrence.- The syntypes came from Follingbo, Gotland. Only known in England from the Wenlock Limestone, Dudley.

Diagnosis.- A species of *Desmidocrinus* with three or four arms per ray; brachials wider than high.

Description.- Cup conical, about as high as wide, surface of cup plates smooth or finely granular. Basals about two thirds of the height of the radials which are as high as wide. Primibrachs two, as wide or slightly wider than high. Secundibrachs two, as wide or slightly wider than high. Arms divide once or twice, there being great irregularity, so that there are three or four arms per ray. Three to the ray is usual, but four to the ray common, even in the same specimen. Rarely two to the ray, and even unbranched arms are seen in specimens where other rays may have three or four arms per ray. Brachials short, wider than high, bearing one pinnule on each side. Interbrachial plates arranged 1 - 2 - 2. Posterior interradius with three plates in the second and third rows above the radial-like tergal. A median ridge is common in the posterior interradius.

Tegmen not seen. Stem round, proximally nodose and distally smooth.

Discussion.- It is probable that more than one species is here included under the name *D. macrodactylus*, but any further revision must await Dr. G. Ubaghs' work on the Swedish Desmidocrinids.

I am indebted to Dr. Ubaghs for the information that he considers the three species D. macrodactylus, D. heterodactylus and D. tridactylus to be synonyms.

Carpocrinus Muller 1840

Text-figure 11

Synonyms.- Phoenicocrinites Austin & Austin 1843; Carpocrinites Geinitz 1846; Abracrinus d'Orbigny 1849; Habrocrinus Angelin 1878; Pionocrinus Angelin 1878; Phoenicocrinus Springer 1913.

Type species.- (by monotypy) Actinocrinites simplex Phillips 1839, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Desmidocrinidae with two main arms per ray. The first or second secundibrach bears a pinnule rather larger than the others.

Discussion.- Carpocrinus is derived from Desmidocrinus by atrophy of one of the arms in each ray (Bather, 1900, p. 166). The larger pinnule at the base of the arms in Carpocrinus is interpreted as being the representative of this atrophied arm.

Angelin (1878) described, under the generic names Habrocrinus and Pionocrinus nineteen species from Gotland, probably not more than five or six of which are well founded. Until the revision of these Gotland crinoids, now being undertaken by Dr. G. Ubaghs of Liège, is complete, no adequate study can be made of the English specimens.

Carpocrinus simplex (Phillips)

Plate 27, figs. 2-6

Actinocrinites simplex Phillips, 1839, p. 673, pl. 18, fig. 8
Carpocrinus simplex Muller, 1840, p. 33
Phoenicocrinites simplex Austin & Austin, 1843, p. 205
Taxocrinus simplex Salter, 1873, p. 125
?Pionocrinus simplex Angelin, 1878, p. 5, pl. xv, fig. 15
Carpocrinus simplex Bather, 1900, fig. lxx(2)

Lectotype (here designated): The specimen figured by Phillips. It has not been traced. It is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips.

Occurrence.- All English specimens come from the Wenlock Limestone, Dudley. The species probably occurs in Gotland.

Diagnosis.- A species of Carpocrinus with a cone-shaped cup, about as wide as high. Interbrachial plates arranged 1 - 2 - 2; stem strongly nodose.

<u>Description</u>.- Cup cone-shaped, about as wide as high. Surface of cup plates smooth, or when very well preserved, with a fine granular ornament. Basals about two thirds of the height of the radials. Radials about as wide as high, in contact laterally except at the posterior side, facets occupying two thirds of the total width of the plates. Primibrachs two, wider than high. Arms ten, uniserial. The second or third secundibrach bears a pinnule stouter than the more distal pinnules. Each brachial has at least one pinnule coming off on each side; often two or even three pinnules may arise from one side of a brachial. Brachials about twice as wide as high, sometimes wider, with crenulate sutures. Interbrachials arranged 1 - 2 - 2, the most proximal plate being larger than the others. Posterior interradius with a tergal plate which resembles a radial but is narrower and higher. Three plates occur in the second row of plates, the most lateral of which are in contact with the adjacent radials. Several further rows of three plates occur, and there is a raised median ridge of one row of plates, larger than those lateral to the ridge.

Tegmen not seen. Stem nodose, often excessively so, with large moniliform nodals sparated by thinner internodals.

<u>Discussion</u>.- This species has been interpreted rather widely here, and it should be possible to restrict it to forms close to the lectotype, when further information about the various Gotland

species is available. One feature of the species is that it quite commonly has a gastropod, Capulus vetustus (J. de C. Sowerby) situated on the tegmen at the posterior side. This is particularly well seen in SM A 13138.

Bassler & Moodey (1943) place Actinocrinites tesseracontadactylus Hisinger (1837, pl. xxv, figs. 4a, 4b) non Goldfuss 1826 in the synonymy of this species. It is possible that Hisinger's specimen belongs here, but if so the figures must be inaccurate, for fig. 4b shows only five plates in the radial circlet instead of six. Springer (1926b) figured two specimens from Gotland which he attributed to this species, but one (plate 7, fig. 22, 1926b) appears to show infrabasals and is otherwise either deformed or inaccurately figured; while the other (1926b, pl. 7, fig. 23) is fragmentary. Angelin's specimens, described under the genus Pionocrinus (which is here considered as a synonym of Carpocrinus) could belong here, but might equally well belong to several others of Angelin's species.

<u>Carpocrinus</u> spp.

<u>Discussion</u>.- A number of specimens of Desmidocrinidae with two arms per ray have been examined which do not belong to <u>C. simplex</u> (Phillips), but which might belong to species described from Gotland by Angelin (1878). A detailed account of these is deferred pending the description by Dr. Ubaghs of Angelins species, but the following is figured here;-

(a) A species with very long arms, possibly related to <u>Carpocrinus longimanus</u> (Angelin). BUH 469 (plate 27, fig. 1), SM A 12808, SM A 35171 and BM E 5622.

Family MELOCRINITIDAE Bassler 1939

Diagnosis.- Monocyclic Camerata with four or five basals; radials in contact all round; interbrachial areas not depressed, posterior interbrachial area with few or no extra plates.

Range.- Silurian and Devonian.

Discussion.- Dr. G. Ubaghs of Liege has made a special study of the crinoids of this family, and has had many of the principal specimens on loan to him since before this study began. As a consequence of this no study has been possible of two of the named species of this family in the British Silurian.

(1) *Promelocrinus anglicus* Jaekel (1902, p. 1068, fig. 8), which is the type species of *Promelocrinus* Jaekel (by monotypy). *Proctenocrinus* Jaekel (1918, p. 32) is evidently the same genus. Holotype at Greifswald, Germany, from the Wenlock Limestone, Dudley.

(2) *Mariacrinus flabellatus* Salter (1873, p. 122) - should probably be referred to *Melocrinus* Goldfuss or to *Ctenocrinus* Bronn. Syntypes: SM A 10136 (figured here plate 28, fig. 2) SM A 12757-66, from the Wenlock Limestone, Dudley.

Scyphocrinites Zenker 1833

Text-figure 12

Synonyms.- Scyphocrinus d'Orbigny 1849 non Hall 1847; Camarocrinus Hall 1879; Lobolithus Waagen & Jahn 1899.

Type species by montypy: S. elegans Zenker, Silurian, Bohemia.

Diagnosis.- A genus of Melocrinitidae with four basals and branching uniserial arms with cuneate brachials. Some of the tertibrachs and perhaps higher plates are incorporated in the cup by means of a depressed, numerously plates network or pavement of plates in the interbrachial areas. This pavement includes fixed pinnules. Stem round, long, terminating in a large, sphereoidal chambered body having the functions of a root.

Discussion.- One of the most striking characters of this genus is the large bulbous root, which is often found spparated from the crowns. It was not in fact until 1917 that the connection between root and crown was proved (Springer 1917), though it had been suggested by Schuchert in 1904. The bulbous roots of Scyphocrinites were formerly called Camarocrinus or Lobolithus.

Scyphocrinites pulcher (M'Coy)

Plate 39, figs. 1-7

Actinocrinus pulcher M'Coy, 1851, p. 55, pl. 1d, fig. 3
Actinocrinus pulcher Salter, 1852, p. i
Actinocrinus pulcher Bolton, 1869, fronticepiece and fig. p. 164
Actinocrinus pulcher Roberts, p. 329, pl. xv
Periechocrinus pulcher Wachsmuth & Springer, 1881, p. 306
Periechocrinus pulcher Boswell, 1949, pl. xx

Syntypes.- The specimens figured by M'Coy are on a large slab containing twelve crowns now numbered SM A 16614-25, the figured crowns being SM A 16614-16. Of these SM A 16614 is selected as the lectotype.

Occurrence.- The slab containing the syntypes comes from the Lower Ludlow Beds at Nant Gwrhyd (Uchaf), S. of Llangollen, Denbighshire. This species is widespread in north and mid Wales in the Lower Ludlow, Monograptus nilssoni zone, and specimens have been examined from: Nantglyn Flags at Nantglyn Quarries, 6 miles S. of Llangollen (see Boswell, 1926, p. 563 - numerous specimens in most museums); old quarry near Gallt-y-celyn, Derwen, Denbighshife (GSM 83887 - figd. Roberts, 1870, horizon M. nilssoni zone fide Boswell, 1949, map 19.1); Rhiw Goch Slab Quarry, ½ mile N. W. of Rhewl, Llangollen (GSM 53529); stream, 300 yards W. of Little Park, Llandewi Ystradenny, Radnorshire (GSM Zi 4718); dingle, S. of Ffynnonan, 3½ miles E. of Builth, Radnorshire (GSM Zi 4725); quarry, 1150 yards N. E. of Pen Cloddian, Radnorshire (GSM Zi 4719); footpath, 500 yards E. N. E. of Builth, Radnorshire (GSM Zi 4720-24). All the last four localities are in the M. nilssoni zone according to Miss N. Kirk who collected the specimens. The species also occurs in the Lake District at: Knott Hollow Quarry (? Knottallow, a hill on which there are quarries, $1\frac{1}{2}$ miles N. W. of Ulverstone)- GSM 89997, 73997 - see Bolton, 1869, pp. 163-5 for a graphic account of the collection of these specimens; Helm Knott, Dent (Kendal Museum 207 see Aveline and others, 1888); Benson Knott, Kendal (BM 42905). The precise age of these Lake District occurrences is uncertain.

Diagnosis.- A species of Scyphocrinites with a round or sub-pentagonal stem lumen. Cup plates ornamented with radiating ridges.

Description.- Cup cone-shaped, higher than wide, the cup plates with a radiating ornament and with ridges connecting the centres of adjacent plates. Basals four, less than half the height of the radials which are as wide as high. Primibrachs two, the first wider than high; secundibrachs variable in number but usually about ten; distally the brachials become cuneate and bear fixed pinnules. Arms branch isotomously at least four times thoughout their length but with varying distances between

between the divisions in each ray. Brachials very short, cuneate uniserial, each bearing a pinnule on the thicker side. The proximal pinnules are, in the secundibrachs and tertibrachs, fixed in a depressed interbrachial integument. The first pinnulars are hexagonal in this region. More distally the first pinnular is quadrangular and short, the other pinnulars being usually longer than wide. Interbrachial areas with plates arranged 1 - 2 - 2 and merging into the depressed integument containing the fixed pinnules. Intersecundibrachs 1 - 2, also merging with the depressed integument. Posterior intbrachial area not distinguishable. Tegmen not seen.

Stem round and of great length. Proximally nodals and internodals alternate; articular surfaces striate. Lumen about one fifth of the total diameter, round or subpentagonal. Distally there are many tuberculations, possibly cirrus scars, scattered irregularly over the whole stem (plate 39, fig. 5). Bulbous root not seen.

Discussion.- This species differs from all others assigned to Scyphocrinites in the round or subpentagonal stem lumen, which in this genus is usually petaloid. Several other details of the stem including the cirrus? scars are characteristiv.

It is possible that Actinocrinus wynnei Baily (1860) is synonymous with S. pulcher, but the type specimens in the Irish Geological Survey collection have not been studied. The figures of A. wynnei certainly suggest this species, but Baily mentions several differences which cannot at present be checked.

There are many references to 'Actinocrinus pulcher' in the literature of the Upper Silurian rocks of both North Wales and the Lake District. It has not been possible to check many of these and such records (e.g. Marr, 1880, 1892b; Aveline and others 1888) should be treated with caution. Specimens of this species coming from North Wales and the Lake District are here considered to be conspecific, but further research with better material may show that forms from the two areas are distinct, though closely related.

Scyphocrinites sp.

Plate 29, figs. 1-3

Material.- Twelve slabs of rock containing fragmentary remains (GSM 85519-30) collected by C. Reid and W. G. Fearnsides in 1904.

Occurrence.- In Limestone lenticles at Catasuent Cove, Porthluney, South Cornwall. The horizon is uncertain, but is probably Silurian.

Description.- Nearly all the available material is in the form of tessellated pavements of plates which formed part of the bulbous roots formerly called Camarocrinus or Lobolithus. There are also many remains of stems, mostly single columnals, and also a few brachials; several plates may be cup plates, but they are so poorly preserved that it is impossible to be certain of this. All these remains are weathered out of the coarsly crystalline limestone matrix. The intractability of this matrix has made it impossible to do much development.

1. The bulbous roots. There is no complete bulb in the material available, but 85519 is the specimen whose form approximates most closely to that of a bulb. It is estimated to have measured about 45 mm. by about 55 mm. Specimens 85519, 85522, 85524 and 85525 are the best preserved of those showing the bulbous root.

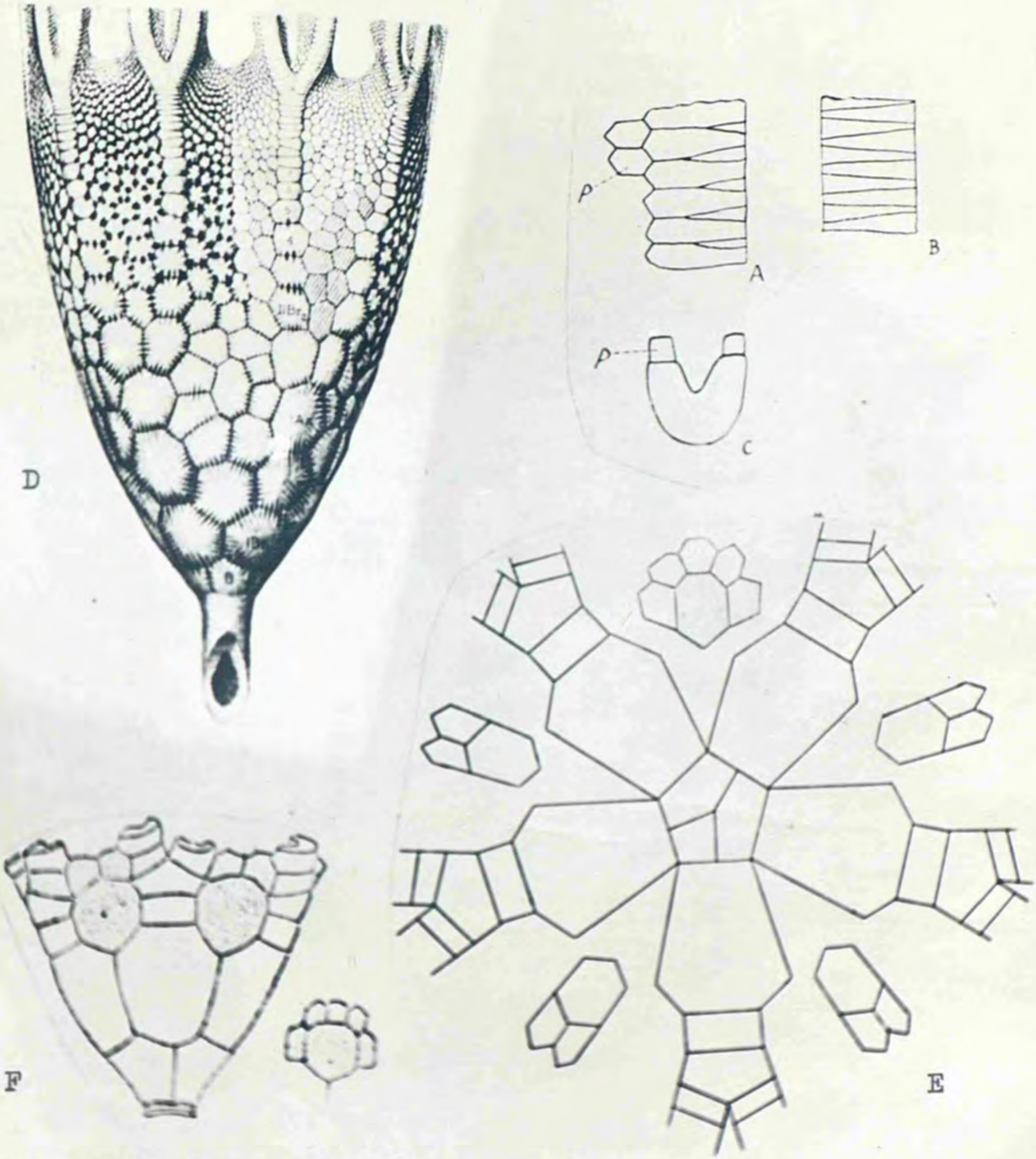
These show areas of small irregularly shaped and arranged plates in apposition to one another (plate 29, fig. 1-3). Each plate is slightly raised cantrally, and contact is made with neighbouring plates only at the corners or sometimes in the middle of the sides of the plates. In between the plates are openings which may be pores. The plates of this integument are about as thick as they are wide, but as the whole arrangement is most irregular some plates will naturally be wider or longer than their thickness. In 85525 the thickness is about 1.5 mm., whereas in 85519 it is only a little over 1 mm.

<u>2. The arms and brachials.</u> Although loose brachials, more or less broken, are shown on most of the limestone slabs, only 85520 shows a relatively well preserved portion of an arm. It is a small piece about 3.5 mm. in width and 5 mm. in length. In this length there are twelve complete brachials. It shows the peculiar alternation of wedge-shaped brachials, so characteristic of the genus. Pinnulars are given off from each brachial at its thick side, but in 85520 only two of the proximal pinnulars are still in place, and only the scars where three others have been can be seen on one side (text-figure 12). The proximal pinnular is slightly longer than wide, hexagonal in shape, the latter showing that it is a fixed pinnular. The nature of the sutures between the brachials cannot be seen in this specimen. The loose brachials are of all sizes from 0.75 mm. to 3.5 mm. in width. They show that the axial canal and food groove are separate.

3. The stem fragments. These vary in size up to 7 mm. diameter. The longest stem fragment is 43 mm. long (85520), but the articular surfaces are best seen on another specimen (85526). The stems consist of alternating nodals and internodals; each columnal, when well preserved, bears a petaloid central lumen and a radially crennellate surface.

Discussion.- The fragmentary material here described does not possess any characters which would enable the species to be determined. Nearly all the specific characters in this genus are based on features in the cup, and this has not definitely been seen in the Cornish material.

The occurrence of Scyphocrinites in Cornwall was noted by Bather (1907), who examined the specimens on which the present account is based. It was also mentioned in the Summary of Progress of the Geological Survey for 1905 and in Reid (1907, pp. 21-22). Bather came to the conclusion that the age of the lenticle in which the crinoid remains occur was Lower Wenlock in age, a view coloured by the fact that the Bohemian occurrence of this genus is of that age. Following on the work of Springer (1917) and others the range of the genus has been extended, and it is now known to range throughout the Silurian and Devonian. The associated fossils in the Cornish Limestone lenticles only indicate that the age is probably Wenlock or Ludlow.



TEXT-FIGURE 12

A-C. Scyphocrinites sp., Cornwall.
A. Lateral view of arm fragment (GSM 85520).
B. Dorsal view of arm fragment (GSM 85520).
C. Transverse section of arm (GSM 85520).

D. Scyphocrinites elegans Zenker, reproduced from Springer, 1917; the fixed pinnules are shown on the right.

E. Analysis of the plates in Macrostylocrinus.

F. Macrostylocrinus anglicus Jaekel, holotype, reproducrd from Jaekel, 1918

Family PATELLIOCRINIDAE Angelin 1878

Diagnosis.- Monocyclic Camerata with three to five basals; radials in contact all round; posterior side not differentiated by extra plates; interbrachials few; first primibrach quadrangular; few plates in cup.

Range.- Upper Ordovician to Lower Devonian.

Macrostylocrinus Hall 1852

Text-figure 12

Type species by monotypy: *M. ornatus* Hall 1852, Niagaran, North America.

Diagnosis.- A genus of Patelliocrinidae with three to five plates above the tergal in the second row. Basals three.

Macrostylocrinus anglicus Jaekel

Plate 28, figs. 5-7; text-fig. 12

Taxocrinus granulatus Salter, 1873, p. 126 (nom. nud.)
Macrostylocrinus anglicus Jaekel, 1918, p. 36, fig. 18

Holotype.- The specimen figured by Jaekel, stated by him to be at Greifswald, Germany.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Macrostylocrinus with five plates above the tergal. Arms two per ray, erect. Cup plates with a pustulose radiating ornament.

Description.- Cup conical, about as high or slightly higher than wide. Basals three, unequal, the smallest being in the right anterior, a little over half the height of the radials. Radials large, in contact all round, hexagonal or heptagonal in shape, the facet occupying about half the width of the plate. Surface of cup plates with a pustulose radiating ornament which also extends on to the arms. Primibrachs two; secundibrachs two or three, followed by erect biserial arms, two per ray. Each brachial bears a pinnule. Interradial areas depressed, with one large plate followed by two smaller ones. Posterior interradius much wider than the others, and with five plates above the tergal in the second row. The two lateral-most of these five plates ma~~t~~y or may not be in contact with the adjacent radials.

Tegmen and stem not seen.

Discussion.- This species was described by Jaekel in the following words:- "eine Art von Dudley mit viertieftem grubig radiar skulpturiertem unteren Intercostale". This, in conjunction with his figure (here reproduced as text-fig. 12), enables the species to be recognised. The above description in the absence of the holotype is based on BM 57055, BM E 1430, BM 45553 for the cup and SM A 13133 and SM A 13094 for the arms. Salter's specimens of Taxocrinus granulatus (SM A 10181-2) are poorly preserved, though they clearly belong to this species.

M. anglicus differs from all the 11 or 12 species of the genus described from the American Silurian in the presence of five plates above the tergal, only resembling in this feature the Lower Devonian M. recumbens Springer (1926a), but in the latter species the arms are four or five per ray and recumbent. The special pustulose and radiating ornament is also characteristic, and the lack of prominent axial ridges in M. anglicus is another feature in which it differs from the American species.

Macrostylocrinus sp.

Plate 12, figs. 8-9

Material.- SM A 32802.

Occurrence.- Lower Llandovery, Gasworks Mudstones, near gasworks, Haverfordwest, Pembrokeshire.

Description.- The specimen is preserved as an internal mould of the lower part of the cup. It shows three basals, five hexagonal radials, about as high as wide and in contact laterally. The first primibrachs are hexagonal, the second pentagonal and axillary. Proximal interbrachial plate hexagonal and about the same size as the first primibrachs; two plates occur in the second row of interbrachial plates.

Discussion.- Only a single specimen suggests the presence of Macrostylocrinus in the Lower Llandovery rocks, and this is imperfect in many features. The genus is already present in the Ashgill Starfish Bed near Girvan, and is also known from the Wenlock Limestone, Dudley. Further collecting must be undertaken in order to complete the account of the present species, which is probably undescribed previously.

Family CLONOCRINIDAE Bather 1899b

Diagnosis.- Monocyclic Camerata with four (exceptionally three, unequal) basals; base of cup truncate, concave; interbrachials few, first interbrachial large.

Range.- Silurian.

Discussion.- Moore & Laudon's interpretation of this family is not in accordance with the facts of morphology of the genera which they assigned to it. Culicocrinus Müller 1854 and Allocrinus Wachsmuth & Springer 1889 are better referred to the Patelliocrinidae.

Clonocrinus Quenstedt 1876

Text-figure 11

Synonyms.- Corymbocrinus Angelin 1878; Polypeltes Angelin 1878.

Type species by monotypy: Eucalyptocrinus polydactylus M'Coy 1849, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Clonocrinidae with four basals and biserial arms branching after leaving the cup.

Clonocrinus polydactylus (M'Coy)

Plate 28, fig. 4

Eucalyptrocrinus polydactylus M'Coy, 1849, p. 249
Eucalyptrocrinus polydactylus M'Coy, 1851, p. 58, pl. id, fig. 2
Hypanthocrinus polydactylus Salter, 1873, p. 120
Clonocrinus polydactylus Quenstedt, 1876, p. 638
Corymbocrinus polydactylus Angelin, 1878, p. 18, pl. ix, figs. 1, 6-12
pl. xxi, fig. 17
Clonocrinus polydactylus Bather, 1900, p. 162, fig. 76

Holotype.- BM 40257 (the cast of this specimen, which M'Coy figured, is numbered SM A 28777. Another cast is GSM 91772).

Occurrence.- Only known in Britain from the Wenlock Limestone, Dudley, and the holotype came from there. Angelin (1878) records the species from Follingbo, Gotland.

Diagnosis.- A species of Clonocrinus with a deep basal concavity, very low brachials, and in which the proximal biserial brachials are unevenly developed; the outermost brachials in each branch being larger than the innermost brachials.

Description.- Cup basin-shaped, with a deep basal concavity, which, in the holotype, is filled by the proximal columnals. Basals entirely within the basal concavity and not visible in side view. Radials hexagonal, only partly visible in side view. Primibrachs two, the first being quadrangular, the second pentagonal and axillary;

secundibrachs two, both hexagonal; two or three tertibrachs, followed by biserial arms; arms branch five times, the last three divisions taking place at irregular intervals. Biserial brachials very low, 2-3 per millimetre throughout the length of the arms. Proximally the brachials are of uneven size, the outermost brachial in any branch being wider than the adjacent innermost brachial in the same branch. This size division has disappeared by the time the third division is reached. Each biserial brachial bears a pinnule. The arms have a flattened appearance, with little space between them. Interbrachial areas filled with a vertical row of four plates, becoming smaller upwards, the lowest plate being large and in contact with the radials. Posterior interradius not distinguishable, but there are two inter-secundibrachs, one above the other and these are not in contact with the axillary primibrach.

Tegmen not seen. Stem not well seen in the available material, columnals short, smooth, stem round with large lumen.

Discussion.- M'Coy founded this species on a cast at the Sedgwick Museum at Cambridge. The original specimen has now been traced at the British Museum (Natural History); it was figured by Bather (1900). This is not a common species at Dudley, and only about a dozen specimens have been seen in the collections examined. Judging from these, and also from the specimens figured by Angelin, the holotpye is a small example of the species. It is possible that *Corymbocrinus grandis* Angelin (1878) is conspecific with the present species.

Family EUCALYPTOCRINITIDAE Bassler 1938

Diagnosis.- Monocyclic Camerata with four basals recurved from basal concavity to make part of lateral wall; radials in contact all round; first interbrachial large, no extra plates in posterior interradius. Arms between vertical partitions attached to tegmen.

Range.- Silurian and Devonian.

Eucalyptocrinites Goldfuss 1826

Text-figure 13

Synonyms.- Eucalyptocrinus Agassiz 1836; Hypanthocrinites Phillips 1839; Hypanthocrinus Morris 1843; Crinocystites Hall 1864; Crinocystis Haekel 1896.

Type species by monotypy Eucalyptocrinites rosaceus Goldfuss 1826, Devonian, Germany.

Diagnosis.- A genus of Eucalyptocrinitidae in which the partitions between the arms extend the full width of the arms.

Discussion.- Some 48 species of Eucalyptocrinites have so far been described. All have almost exactly the same arrangement of the plates of the cup, and specific discrimination has mainly been based on the shape of the crown and any excrescences of the plates or other notable peculiarities. It has been found, from an examination of the extensive literature, that the shape of the first primibrach and of the second secundibrach are often good features which can also be used in the diagnosis of species, Angelin described nine species from Gotland, but many of these are inadequately figured, and the number of good species will eventually probably not exceed four or five.

Eucalyptocrinites granulatus (Lewis)

Plate 13, figs, 1-4

Hypanthocrinites granulatus Lewis, 1847, p. 99, pl. 21
Hypanthocrinus granulatus Angelin, 1878, p. 18, pl. vi, figs. 3-4; pl. xxiv, figs. 10-12; pl. xxix, figs. 69, 70, 72.

Syntypes.- Not traced. Four specimens were figured by Lewis.

Occurrence.- The syntypes and all English specimens come from the Wenlock Shale, Walsall; Lewis (1847) states that the syntypes are from the "cutting for the Rushall canal". Angelin records the species from Visby, Gotland.

Diagnosis.- A species of Eucalyptocrinites characterised by the smooth even appearance of the cup plates; a slight elevation at base of radials. Second secundibrach five sided, first primibrach almost as high as wide.

Description.- Crown elongate-ovate, cylindrical in its middle portion, conical below and with a small basal concavity. External surface of the plates of the crown bearing a fine granular ornament, but the general appearance is smooth and even. There is a slight elevation at the base of the radials around the basal concavity. Primibrachs about as high as wide; second secundibrachs five sided axillary and almost as high as wide. Brachials short, in the middle regions of the arms 9-10 brachials occur in 5 mm. Interbrachial plates much higher than wide. Partition plates between the arms widen upwards. Plates forming uppermost part of the partitions form an even line with the lower part of the partitions, not expanded or nodose. Plates of the tegmen exposed at the distal end of the crown are smooth.

Stem not seen.

Discussion.- In the absence of the type specimens the above description is based on two specimens - BM 40255-56. This is an extremely characteristic species, easily recognised by the general shape of the crown, and the smooth appearance and relative elongation of the cup plates. It is distinguished also by the lack of distal enlargement of the partition plates between the arms.

There is evidence in the records of the Palaeontological Department of the Geological Survey that Lewis' figured specimens were purchased for the Survey Museum about 1849, but all efforts to trace them there have proved fruitless. Salter (1873, p. 120) states that the Jermyn Street Museum (now Geological Survey Museum) has good specimens. This evidently referred to the lost types, since there are no specimens of this species in the Survey Museum at present.

Eucalyptocrinites decorus (Phillips)

Plate 30, figs. 1-5

Hypanthocrinites decorus Phillips, 1839, p. 672, pl. 17, fig. 3
Hypanthocrinites decorus Garner, 1844, p. 458, pl. a, figs. 1-3
Eucalyptocrinus decorus M'Coy, 1849, p. 249

Lectotype (here designated).- The specimen figured by Phillips. It has not been traced, but was stated by Murchison to be in the collection of Mr. Cartwright of Dudley (1839, p. 673). It is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips.

<u>Occurrence</u>.- Only seen from the Wenlock Limestone, Dudley, though Garner (1844, p. 458) records the species from Hurst Hill, Sedgley (probably Wenlock Limestone).

<u>Diagnosis</u>.- A species of <u>Eucalyptocrinites</u> characterised by bulbous expansions at the distal ends of the partition plates between the arms. Convex cup plates, the first primibrach and second secundibrach are quadrangular plates much wider than high.

<u>Description</u>.- Crown evenly ovate, slightly wider above; cup plates smooth or faintly granular, convex and with sunken sutures. First primibrach much wider than high; second secundibrach, though axillary, is nearly oblong and is quadrangular in shape, being wider than high. Brachials short, in the middle portion of the arms 7 brachials occur in 5 mm. Interbrachial plates about as high as wide. Partition plates between the arms widen distally. The plates forming the upper parts of the partitions are enlarged and bulbous. Plates of the tegmen, often appearing at the distal end of the crown, convex and with sunken sutures.

Stem may be subpentagonal proximally, formed of alternating nodose and non-nodose columnals, moniliform.

<u>Discussion</u>.- This is the common species of <u>Eucalyptocrinites</u> at Dudley, and there is abundant material in the collections

examined. The finer details of the anatomy are, however, usually indifferently preserved. The species differs from all the other described species in the characteristic expansion of the distal ends of the partition plates between the arms, by the shape of the first primibrach and second secundibrach, and by the convex cup plates. Garner figured cross sections of the crown of this species as long ago as 1844.

Eucalyptocrinites spp.

Discussion.- A number of specimens labelled as being from the Wenlock Limestone, Dudley, have been examined which do not belong to either of the two species of Eucalyptocrinites just described. It is possible that they may belong to species more or less inadequately described by Angelin (1878) from the Silurian of Gotland. Until the revision of the Gotland Camerata is complete it seems unwise to assign these specimens to any of Angelin's species.

Two such specimens are DM 425 and BM E 1456 (plate 32, figs. 7-9); in these there is no enlargement of the partition plates distally, the cup is cone-shaped and the brachials longer than in E. decorus (Phillips). This species bears some resemblance to E. speciosus (Angelin).

In BM 57033 (plate 32, fig. 6) the cup plates have a coarse pustulose ornament, and this specimen possibly belongs to _E. decoratus_ (Angelin).

BM 57032 and BM 57034 may perhaps belong to _E. concinnus_ (Angelin), but both are poorly preserved.

Calliocrinus D'Orbigny 1849

Text-figure 13

Synonyms.- _Calliocrinites_ Chapman 1857; _Cryptodiscus_ Hall 1865; _Callicrinus_ Angelin 1878.

Type species by original designation: _Eugeniacrinites? costatus_ Hisinger 1837, Silurian, Gotland.

Diagnosis.- A genus of Eucalyptocrinitidae in which the partitions between the arms do not extend the full length of the arms. Plates often spinose or nodose.

Discussion.- Calliocrinus is one of the rarest genera at Dudley, only the five specimens described here having been found in the principal British collections. No species has hitherto been recorded from England, though Wachsmuth & Springer (1897) noted the presence of the genus at Dudley.

Calliocrinus rugiferus sp. nov.

Plate 31, figs. 3-4

Holotype.- BUH 420.

Paratype.- BM E 45533.

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Calliocrinus with strong ridges on the cup plates in the pattern of axial ridges. Outline of basal concavity pentagonal and with a pentagonal surrounding ridge. One primibrach.

Description.- Cup, below the level of the origin of the arms, nearly twice as wide as high, and with a broad and deep basal concavity. Depth of basal concavity in holotype 10 mm.; in paratype 13 mm. Cup plates, except basals, which are hidden from view at the base of the basal concavity, bearing strong ridges in the pattern of axial ridges, crossing the sutures at right angles, and meeting in the centres of the plates. A strong ridge forms a pentagon around the basal concavity, and at the corners of the pentagon a ridge passes down into the concavity towards the basals, but dies out before reaching them. Surface of cup plates between the ridges has a finely granular appearance. basals form the sides of the basal concavity up to about one third from the bottom. Radials hexagonal, curved and forming two thirds of the wall of the basal concavity. One primibrach (except in one ray of the paratype where there are two) pentagonal and axillary to the two secundibrachs which lead to the twenty arms. The first two brachials are uniserial, but the rest of the arms are missing in the available material. Food grooves and axial canal confluent in these uniserial brachials.

The five interbrachial plates reach as high as the first secundibrachs. They are followed by two plates side by side; above this, and forming part of the first row of plates of the tegmen, is a large plate bearing one of the short vertical partitions separating the arms. This does not extend above the level of the first row of tegmen plates. Alternating with these large interradial plates are five intersecundibrachs, also bearing vertical partitions. Ten smaller vertical partitions occur on the intertertibrachs, but none of these is complete in the available specimens. The remainder of the tegmen and also the stem have not been seen; but a pentalobate stem lumen is visible at the base of the basal concavity.

Discussion.- This species is distinguished from all others of the genus so far described by the strong ridges on the cup plates, and by the strong pentagonal ridge surrounding the basal concavity. Another distictive feature is the single primibrach, which seems to show that this is a specialised species, though it is not yet fully established since the paratype shows one ray with two primibrachs. C. beyrichianus (Angelin) from Gotland is the species with which it seems to be most closely allied.

Apart from the holotype and paratype only one specimen (BUH 421) has been seen which possibly belongs to this species.

Calliocrinus sp.

Plate 31, fig. 1

Material.- BUH 421.

Occurrence.- Wenlock Limestone, Dudley.

Discussion.- In close proximity to a starfish on this specimen are some plates which probably belong to this genus. Somewhat similar plates were figured by Angelin (1878, pl. i, figs. 1-2) in his species C. roemerianus, but it cannot be certain that BUH 421 belongs to this species, since the remains are too fragmentary.

<u>Calliocrinus</u> cf. <u>beyrichianus</u> (Angelin)

Plate 31, figs. 2, 2a

<u>Material</u>.- BM 57457.

<u>Occurrence</u>.- Wenlock Limestone, Dudley.

<u>Discussion</u>.- A single specimen examined appears to be close to this species described by Angelin (1878, p. 15, pl. li, fig. 4) from Gotland. The only figure which Angelin gives is a basal view, and it shows that the basal concavity has a pentagonal outline, and that each of the radials forming the sides of the concavity bear a number of ridges passing down towards the basals. These ridges are also present in BM 57457, where the cup plates also have a concentric series of ridges. Until <u>C. beyrichianus</u> has been redescribed from the type material it is not possible to be more precise about the British specimen.

Family MARSUPIOCRINIDAE Jaekel 1918

Diagnosis.- Monocyclic Camerata with three unequal basals; low cup with flattened base; radials in contact all round; first secundibrach resting on both the primibrach and the radial; stem round.

Range.- Silurian.

Marsupiocrinus Morris 1843

Text-figure 13

Synonyms.- *Marsupiocrinites* Phillips 1839 non de Blainville 1830; *Cupellaecrinus* Shumard 1866; *Marsipocrinus* Bather 1900.

Type species by monotypy: *Marsupiocrinites coelatus* Phillips 1839, Wenlock Limestone, Dudley.

Diagnosis.- As for the family, only one genus being recognised.

Marsupiocrinus coelatus (Phillips)

Plate 29, figs. 4-6

Marsupiocrinites coelatus Phillips, 1839, p. 672, pl. 18, fig. 3
Marsupiocrinus coelatus Morris, 1843, p. 54
Marsipocrinus - Bather, 1900, p. 157, fig. lxx
Marsipocrinus coelatus Springer, 1926b, p. 62, pl. 19, figs. 2-7

Lectotype (here designated): Phillips figured specimen. It has not been traced, though Murchison (1839, p. 702) stated that it was in Mrs. Downing's collection. It is here designated as lectotype in the absence of evidence as to how many specimens were used by Phillips.

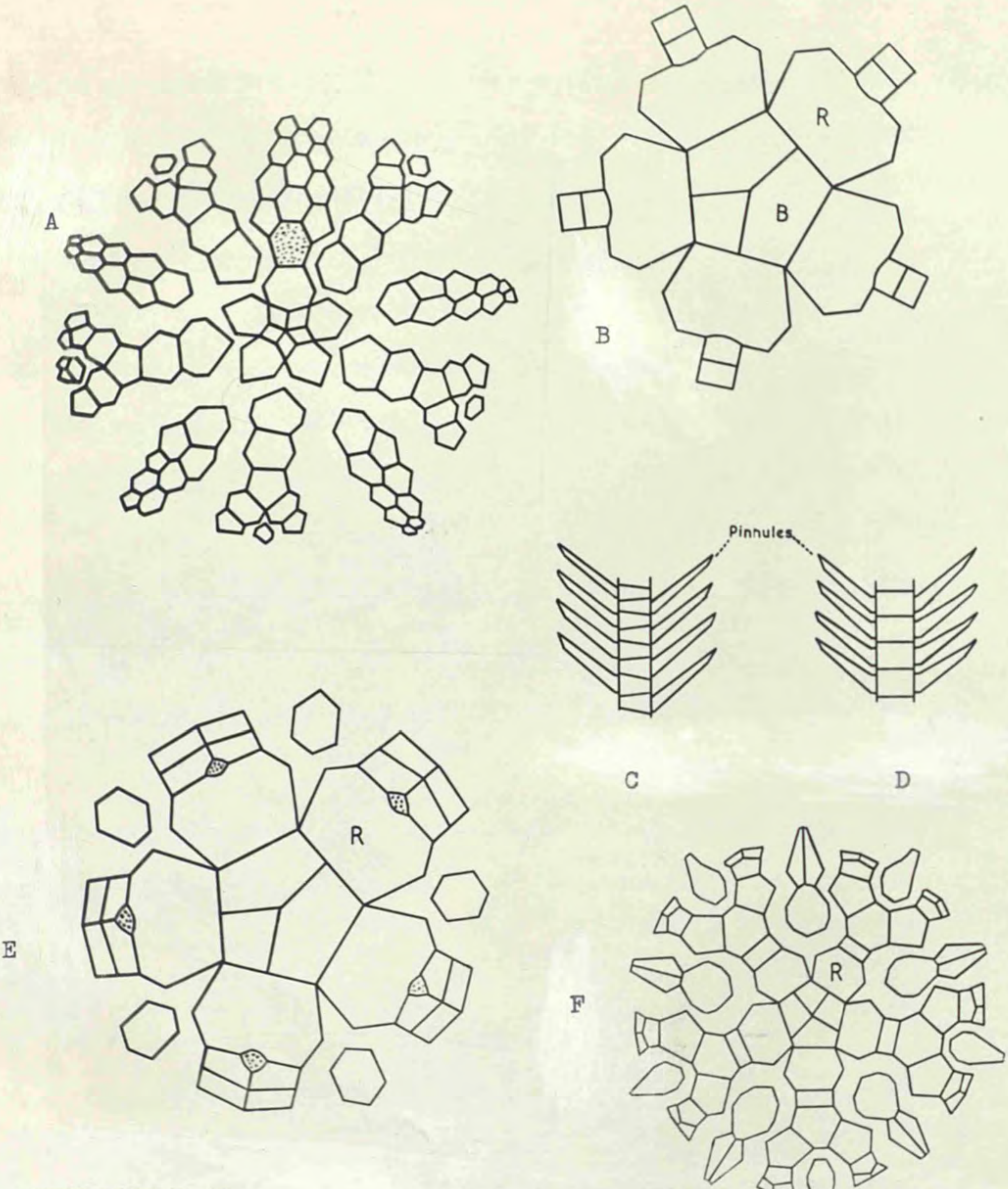
Occurrence.- Wenlock Limestone, Dudley, including Wren's Nest and Tividale; Wenlock Limestone, Gleedon Hill, Wenlock Edge (BM E 7002); Wenlock Limestone, quarry south of Gleedon Hill, west of Bench Mark 477.4 (BM E 26264).

Diagnosis.- A species of Marsupiocrinus with four arms per ray, an elongate pointed interbrachial plate, and rather coarse rugose radiating ridges on the cup plates.

Discussion.- This species has been adequately described and figured by Springer (1926b), but a few features of interest have been observed during the present investigation. Although the anus opens straight on to the surface subcentrally on the tegmen and the anal side is not normally ditinguishable in the dorsal cup, GSM 85097 has one of the interbrachial plates slightly larger than the others and an arm is missing on each side of this wide interradius. SM A 12710 shows a similar structure. More precisely there is no second arm division in the arm on each side of this interray, suggesting that this is the anal side. Unfortunately this cannot be checked since the tegmen is embedded in hard limestone.

As was mentioned by Springer, there is often a commensal gastropod, Platyceras haliotis (J. de C. Sowerby) situated over the anus. This is exceptionally well seen in BM 57241, and is figured on plate 29, fig. 6.

Young specimens of this species are relatively common in the collections examined. In these the cup is widely cone-shaped.



TEXT-FIGURE 13.

A. <u>Dimerocrinites</u> (tergal plate stippled)

B. <u>Hapalocrinus</u>, <u>Cordylocrinus</u>. C. Arms of <u>Hapalocrinus</u>

D. Arms of <u>Cordylocrinus</u>. E. <u>Marsupiocrinus</u> (primibrachs stippled). F. <u>Calliocrinus</u>, <u>Eucalyptocrinites</u>.

R - radial

Family HAPALOCRINIDAE Jaekel 1895

Diagnosis.- Monocyclic Camerata with three unequal basals; radials large, in contact all round; primibrachs, interbrachials and tergal not usually in cup; few tegminal plates, stem round.

Range.- Silurian and Devonian.

Discussion.- Moore & Laudon (1943) use the name Thallocrinidae Jaekel 1918 for this family. Since there is some doubt whether *Thallocrinus* Jaekel is not a synonym of *Hapalocrinus*, the earlier family name Hapalocrinidae is preferred here.

Cordylocrinus Angelin 1878

Text-figure 13

Type species by monotypy: *C. comtus* Angelin 1878, Silurian, Gotland.

Diagnosis.- A genus of Hapalocrinidae with two unbranched arms per ray; brachials uniserial, compound with a pinnule on each side of each brachial. Tegmen high? Interbrachials 1 - 2.

Discussion.- No species of *Cordylocrinus* has previously been described from the English Silurian, though Bather (1897) has suggested that the genus was present. The type species of *Cordylocrinus*, *C. comtus* is inadequately known.

Cordylocrinus rugobrachialis sp. nov.

Plate 15, figs. 4-6

Holotype.- BM E 418.

Paratypes.- BM E 418a (on same slab as holotype), SM A 12752a, b, c (three specimens on the same slab).

Occurrence.- The holotype is from the Wenlock Shale, Wren's Nest, Dudley, and BM E 47241 is also from the same horizon and locality. A fine slab containing the remains of 24 crowns (including 3 of the paratypes) is labelled Wenlock Limestone, Dudley (SM A 12752), the matrix however, is identical with that of the holotype, and it may be surmised that the label is inaccurate and that the slab really came from the Wenlock Shale. A single specimen is also known from the Wenlock? Shale, Sedgley (BUH 549).

Diagnosis.- A species of *Cordylocrinus* characterised by the presence of a raised ornamented area in the centre of the radials.

Brachials with a rugose longitudinal ornament of ridges and grooves.

Description.- Cup bowl-shaped, much wider than high. Basals not visible in side view, about two thirds of the height of the radials, the inner edge being sometimes thickened at the edge of the stem lumen. Radials as wide as high, hexagonal, but deeply indented by the facets which occupy nearly half the total width of the plate. Central part of the radials raised in a knob-like rugose ornamented elevation, the remainder of the radials and other cup plates being smooth. Primibrachs two, wider than high; arms divide once, i. e. two per ray, long and formed of uniserial brachials. Brachials a little wider than high, each bearing a pinnule on each side; not uncommonly two pinnules come off from one or both sides. A strongly rugose ornament of longitudinal ridges and grooves is on the brachials and they are also somewhat moniliform. Interbrachial areas with one plate resting on the shoulders of adjacent radials; the plates following this upwards are not clearly seen in the available material, and the tegmen has not been seen. Posterior interbrachial area distinguished by being slightly wider than the others, and the single plate in it is larger than that in other interbrachial areas.

Stem not well seen, but composed on the proximal area of alternating nodals and internodals, with some of the nodals again enlarged. Several whorls of cirri, composed of short bead-like cirrals, have been seen near the cup, and these may curve upwards towards the cup.

Discussion.- This species of Cordylocrinus is clearly distinguished from all others of the genus described by the curious raised area on the radials, and by the coarse longitudinal ridges on the brachials. It is from this latter feature that the specific name has been derived.

Cordylocrinus pecten (Salter MS.) sp. nov.

Plate 32, fig. 1

Platycrinus pecten Salter, 1873, p. 122 (nom. nud.)

Holotype.- SM A 10139.

Occurrence.- Wenlock Limestone, Dudley (only the holotype is known).

Diagnosis.- A species of Cordylocrinus with an obpyriform cup, the basals being visible in side view. Brachials very short, 11-12 in 5 mm.

Description.- Cup obpyriform, as wide as high, all cup plates smooth. Basals about two thirds of the height of the radials, entirely visible in side view. Radials as wide as high, the facet occupying about one third of the width of the plate and rests in a deep embayment so that the upper edge of the first primibrach is in line with the upper edge of the radial. Primibrachs two, slightly raised above the level of the radial; arms branch once only, giving ten rami. Arms uniserial, brachials very short, 11-12 in 5 mm., and without ornament on their dorsal side. The second secundibrach bears a stout pinnule on the outer side of the arms; the two or three brachials following this seem to be without pinnules, but the remaining brachials each bear a pinnule on each side. In no case was more than one pinnule seen to come from one brachial on one side. Interbrachial areas with one plate in the shoulder of the radials, followed by two plates in the second row; they appear slightly depressed owing to the raising of the primibrachs above the level of the radials. Posterior interbrachial area not seen. Tegmen not seen, but the interbrachial plates seem to rise far above the level of the arm bases. Stem absent in holotype, but traces of a cirrus can be seen curving upwards near the radial.

Discussion.- The above description is based on the specimen which was named by Salter as Platycrinus pecten, but not adequately described. It differs from C. rugobrachialis sp.

nov. in the shape of the cup, the lack of the raised area on the radial, and especially in the shortness of the brachials which are unornamented in contrast to the strong ornament shown on the brachials of the latter species.

It is possible that Cordylocrinus comtus Angelin, the type species of the genus, is close to C. pecten, but judging from the single published figure (Angelin, 1878, pl. xxiii, fig. 6), it differs in the shape of the cup and the shortness of the brachials. C. comtus needs redescription before these differences can finally be settled. C. pecten seems to show sufficient diagnostic characters for it to be described in spite of the fact that there is only one specimen.

Hapalocrinus Jaekel 1895

Text-figure 13

Synonyms.- *Agriocrinus* Jaekel 1895; *Clematocrinus* Jaekel 1897.

Type species.- (by monotypy) *H. elegans* Jaekel, Lower Devonian, Germany.

Diagnosis.- A genus of Hapalocrinidae with two to four unbranched arms in each ray; brachials cuneate uniserial, each brachial bearing one pinnule, these coming off on each side alternately; interbrachials 1 - 2.

Hapalocrinus retiarius (Phillips)

Plate 32, figs. 2-8

Actinocrinites? retiarius Phillips, 1839, p. 674, pl. 17, fig. 1
Platycrinus retiarius Salter, 1873, p. 122
Hapalocrinus retiarius Bather, 1897, p. 342
Hapalocrinus retiarius Bather, 1900, p. 156, fig. lxix

Lectotype (here designated): the specimen figured by Phillips. It has not been traced. Allen (1902) claimed that GSM 7379 was the figured specimen, but reexamination does not support this claim.

Occurrence.- Only known from the Wenlock Limestone, Dudley, many of the best slabs being labelled 'Wren's Nest'.

Diagnosis.- A species of Hapalocrinus with two or four arms per ray, smooth cup plates, the radial facets occupying about three fifths of the width of the radials.

Description.- Cup bowl-shaped, about as wide as high. Surface of cup plates smooth. Basals and radials of about equal height. Radials nearly twice as wide as high, facet occupying about three fifths of the total width. Primibrachs two, the first about twice as wide as high, the second about as wide as high and axillary. Arms divide once or twice and specimens vary in this respect even in different rays in the same specimen. Secundibrachs four, uniserial cuneate, bearing pinnules on their thick edges. Tertibrachs uniserial cuneate, also bearing pinnules on the thick side. Pinnulars longer than wide. A single interbrachial plate rests on the shoulders of the radials. Posterior side not usually distinguishable, but sometimes it may be represented by an interbrachial slightly larger than the others. Tegmen not seen, but often with a commensal gastropod, Platyceras haliotis (J. de C. Sowerby) attached. Stem formed of short columnals with nodals bearing whorls of cirri. These whorls of cirri become more widely spaced distally.

Discussion.- This species is highly gregarius and evidently occurs abundantly in bands, for the matrix in which the species occurs in such abundance is a highly characteristic yellowish sandstone which is particularly difficult to develop. The best slabs are always labelled "Wren's Nest", whenever the locality is specified beyond that of the general one of Dudley.

It is with some hesitation that the ten armed and the twenty armed forms of this species are united in the same species. This is done on account of the rather rare occurrence of specimens in which there are two, thre or four arms in different rays of the same individual. This character, combined with the small size of the species and the smooth cup plates, enables *H. retiarius* to be distinguished from the other species of *Hapalocrinus* in Britain.

Hapalocrinus dameryi sp. nov.

Plate 12, fig. 7

Holotype.- In the collection of Mr. B. K. Ellis and to be presented to the Geological Survey Museum.

Occurrence.- The unique holotype comes from the Upper Llandovery, Damery Beds; in loose blocks, about 50 yards S. of Damery Bridge, near Tortworth, Gloucestershire.

Diagnosis.- A species of Hapalocrinus characterised by having narrow axial ridges on the cup, and by longitudinal ridges on the brachials. Arms branch once.

Description.- Cup bowl-shaped, about as wide as high. Surface of cup plates smooth, but the cup has narrow rounded axial ridges leading from the region of the stem on to the arms. Plating of cup not seen, but the axial ridge system suggests small basals, and the facet probably occypies about one third of the width of the radial. Primibrachs not distinguishable; one secundibrach without a pinnule followed by pinnulate arms. Brachials wider than high, uniserial, becoming cuneate distally, and each bearing a pinnule on one side. Dorsal sides of brachials with five longitudianl ridges. Tegmen not seen, but probably fairly high. Stem not seen. On the same specimen as the holotype is a stem impression with a nodose appearance and bearing cirri in whorls. This stem probably belongs to this species.

Discussion.- The specimen on which this species is based is not well preserved as far as the details of the plating are concerned, except in the arms. The cup plating cannot be seen, but it shows axial ridges unknown in other species of Hapalocrinus. The arms are fairly well preserved and are typical of the genus, being especially characterised by the longitudinal ridges.

This is the earliest species of Hapalocrinus yet described; the earliest American species are Niagaran, and the genus is present also in the Wenlock Limestone. H. quinquepennis is described here from the Lower Ludlow, and several species are known in the Devonian.

One specimen, other than the holotype, probably belongs here (GSM 323, from the Upper Llandovery, Dursley's Cross, May Hill), but only the arms are present and they are poorly preserved.

Hapalocrinus quinquepennis (Salter MS.) sp. nov.

Plate 38, figs. 1-3

Platycrinus quinquepennis Salter, 1878, p. 116 (nom. nud.)
Crinoid sp. - La Touche, 1884, pl. xvii, fig. 550

Holotype.- BM E 26576a.

Paratypes.- BM 14900, GSM 89897.

Occurrence.- The type specimens come from the Lower Ludlow Beds (Monograptus leintwardinensis zone) at Leintwardine, Herefordshire. The British Museum specimens are from Church Hill Quarry, Leintwardine. Also known from the Lower Ludlow Beds at Ludlow (GSM 89905).

Diagnosis.- A large species of Hapalocrinus with the suface of the cup plates smooth, the radial facets occupying about two thirds of the width of the radials. Arms branch once only.

Description.- A large species, a typical crown measureing about 60 mm. in height. Cup obpyriform, tubular above, about as wide as high. Basals about half the height of the radials, which are higher than wide, the radial facets occupying about two thirds of the total width of the radials. The surface of the cup plates is smooth. Primibrachs two, with conspicuous brachial facets. Threeor four secundibrachs without pinnules, followed by uniserial or slightly cuneate brachials. Arms branch once only, giving ten rami. Each brachial bears a pinnule, these being given off on each side alternately from the thicker ends of the brachials. Brachials short, nearly twice as wide as high. Interbrachial areas with one plate, followed by two smaller ones in the second row; none of these plates reach far down into the cup. One interbrachial plate is sometimes a little larger than the others, and this is interpreted as being the posterior one.

Tegmen not seen. Stem formed of alternating nodals and internodals, the nodals becoming less prominent and less numerous distally, and the length of the columnals increases distally. No trace of cirri are seen.

Discussion.- All the available material of this species is represented by impressions, as is usual at Leintwardine, and the species has been studied with the aid of Revultex impressions. The large size of this species is the main distinguishing feature, since it is nearly twice as large as any of the other described species of *Hapalocrinus*. Salter (1878) named several speciemens at the Geological Museum as *Platycrinus quinquepennis*, but only the names appear in the Survey catalogue of 1878. La Touche figured a specimen which was formerly in the Ludlow Museum, but the figure is so generalised that the specimen has not been recognised.

Order DIPLOBATHRA Moore & Laudon 1943

Diagnosis.- Camerata with infrabasals.

Family RHODOCRINITIDAE Bassler 1938

Diagnosis.- Dicyclic Camerata with a normally subglobular cup; radials separated all round; median ray ridges weak or absent; interbrachials regular, not depressed; posterior interbrachial area with few extra plates and lacking a median ridge.

Range.- Ordovician to Lower Carboniferous.

Lyriocrinus Hall 1852

Text-figure 6

Type species by monotypy: Marsupiocrinites? dactylus Hall, 1843, Niagaran, New York.

Diagnosis.- A genus of Rhodocrinitidae with two erect, biserial arms per ray, a bowl-shaped cup, interradial and interbrachials arranged 1 - 2 - 1. Posterior interradius may have three plates in second row.

Lyriocrinus britannicus Ramsbottom

Plate 34, figs. 1-4

Lyriocrinus britannicus Ramsbottom, 1950, p. 653, pl. ix, figs.1-4

Holotype.- SM A 12715.

Paratypes.- SM A 13119, A 13120.

Occurrence.- The type specimens come from the Wenlock Limestone, Dudley. Also known from the Wenlock Limestone, Benthall Edge, 3 miles N. E. of Much Wenlock, Shropshire (GSM 88869-72).

Diagnosis.- A species of Lyriocrinus with a subpentagonal flange on the truncate basals and three plates in the second row of the posterior interradius. Surface of cup plates smooth.

Description.- Cup bowl-shaped, considerably wider than high and with a flat bottomed basal concavity. Surface of cup plates smooth. Infrabasals not seen, very small, restricted to base of basal concavity and covered by proximal columnal. Basals higher than wide, hexagonal and truncate, bearing a subpentagonal flange which surrounds the basal concavity. Radials wider than high, separated by interradial plates. Primibrachs two; secundibrachs two, followed by unbranched biserial arms. Arms stout, tapering gradually, each brachial bearing one pinnule. Interbrachial plates arranged 1 - 2 - 1 followed by two small plates; a single intersecundibrach is in contact with the axiallery primibrach. Posterior interradius with three plates in the second row and a variable number of plates in the third row.

Tegmen composed of many small plates with the anus central at the end of a small tube. Stem round, formed of alternating nodals and internodals throughout its length. The nodals become more prominent distally.

Discussion.- Three other species of *Lyriocrinus* have been described, all from the United States of America. *L. britannicus*, the first species to be described from Europe, is closest to *L. melissa* (Hall) but is smaller, there being usually no contraction of the cup at the level of the arm bases as in that species. In addition the flange on the basals is less sharply pentagonal, and the nodes at the corners of the flange are not so prominent. *L. britannicus* resembles *L. melissa* but differs from *L. dactylus* (Hall) in all the basals being truncate, and in the axiallary primibrach being in contact with the intersecundibrach. In *L. britannicus* the posterior interradius has three plates in the second row. Variation in this feature is shown by *L. melissa* (Ramsbottom, 1950, p. 652). There is rarely some irregularity in the plates in the third row of interbrachial plates, an extra plate being present (Ramsbottom, 1950, text-fig.2).

Family DIMEROCRINITIDAE Bassler 1938

Diagnosis.- Dicyclic Camerata the radials being usually just in lateral contact except at the posterior side; median ray ridges faint in primitive members, absent in advanced members; interbrachials regular, not usually depressed; posterior interradius usually lacking a median ridge, but with extra plates.

Range.- Silurian to Lower Devonian.

Dimerocrinites Phillips 1839

Text-figure 13

Synonyms.- Dimerocrinus Müller 1841; Glyptaster Hall 1852; Thysanocrinus Hall 1852; Eucrinus Angelin 1878.

Type species by subsequent designation of Wachsmuth & Springer, 1881, p. 371: D. decadactylus Phillips 1839, Wenlock Limestone, Dudley.

Diagnosis.- A genus of Dimerocrinitidae in which the arms are biserial, erect and unbranched after leaving the cup.

Dimerocrinites decadactylus Phillips

Plate 34, figs. 4-6

Dimerocrinites decadactylus Phillips, 1839, p. 674, pl. 17, fig. 1
Dimerocrinus decadactylus Bather, 1900, p. 199, fig. cxxiii

Lectotype (here designated).- The specimen figured by Phillips. It has not been traced, and is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips. Murchison (1839, p. 702) stated that the specimen was in the collection of Mrs. Downing.

Occurrence.- Known only from the Wenlock Limestone, Dudley.

Diagnosis.- A small species of Dimerocrinites with two arms per ray, cup only slightly wider than high, interradial areas slightly depressed, interradial plates large.

Description.- A small species, a typical crown measuring about 18 mm. in height. Cup bowl-shaped, slightly wider than high and with very small infrabasals not visible in side view. Surface of cup plates smooth. Basals about twice as wide as high, posterior basal truncate. Radials about the same size as the basals, just in contact laterally, except at the posterior side. Facets on the radials occupy about two thirds of the width of the plates.

Primibrachs two; two or three secundibrachs followed by biserial arms, each brachial of which bears a pinnule. Arms divide once only, giving ten rami. Interbrachial areas slightly depressed and filled by one large plate (the interradial) followed by two, but rarely only one, small plates above, situated side by side. There may follow a single plate above this. Some specimens show small intersecundibrach. Posterior interradius with a hexagonal tergal plate resting on the truncate basal, followed by three plates in the two rows which follow above this. Tegmen not seen. Stem formed of alternating nodals and internodals. A few millimetres from the proximal end some of the nodals are again enlarged. Stem commonly twice or three times the height of the crown in length, but the root has not been seen.

Discussion.- This is the first occasion on which this, the type species of the genus, has been described in detail. Phillips' brief notes are poor, but his figure, and that given by Bather (1900) are unmistakable. It is noteworthy that here the radials are just in lateral contact. Salter (1873, p. 121) stated that "this species grows large", but this mis-statement is due to the fact that the specimens seen by Salter included some examples of Lyriocrinus britannicus Ramsbottom, and in fact this species is the smallest of all the species of this genus at Dudley.

Dimerocrinites icosidactylus Phillips

Plate 34, figs. 7-12

Dimerocrinites icosidactylus Phillips, 1839, p. 674, pl. 17, fig.5

Lectotype (here designated): The specimen figured by Phillips. It has not been traced, and is here designated lectotype in the absence of evidence as to how many specimens were used by Phillips.

Occurrence.- Known with certainty only from the Wenlock Limestone, Dudley. Specimens determined as D. cf. icosidactylus are known from the Wenlock? Shale, Sedgley, Staffordshire (BUH 235, 98); and from the Wenlock (undifferentiated) at the Slate Mill, Hasguard, Pembrokeshire (GSM 89632).

Diagnosis.- A species of Dimerocrinites with four arms per ray, cup considerably wider than high, interradial areas depressed.

Description.- Medium sized, a typical crown measureing about 35 mm. in height. Cup bowl-shaped, considerably wider than high, surface of cup plates smooth or faintly granular. Infra-basals very small, not visible in side view. Radials and basals of about the same size, the radials being normally not in contact laterally or only just in contact. Radials separated by tergal in the posterior interradius. Primibrachs two; secundibrachs two; tertibrachs one or two, followed by biserial arms. Arms divide twice giving twenty rami in the normal individual. Each brachial bears a pinnule. Interbrachial areas depressed, filled by one large plate, which may be in contact with the basals in which case it is an interradial plate, followed by two smaller plates in the second row. Posterior interradius withaa large tergal plate and three plates in the second row, and with a well marked median ridge.

Tegmen not seen. Stem round, nodose, proximally with alternating internodals and rather prominent nodals. Distally the number of internodals increases and the nodals become less prominent. Length of stem about twice the height of the crown.

Discussion.- This species is well characterised by the low cup with the depressed interradial areas; it is also distinguished by the shortness of the arms relative to other species of the genus. There is some variability in the arm branching; sometimes the second arm division does not take place (plate 34, fig. 9); or the second arm division does not take place in one side of the arm (plate 34, figs. 8, 10).

The specimens determined as D. cf. icosidactylus from Sedgley are not well preserved. The horizon of the specimen from Hasguard is discussed in Cantrill and others (1916, p. 87), the specimen is figured on plate 34, fig. 13.

Dimerocrinites speciosus (Angelin)

Plate 34, figs. 1-3

Dimerocrinus multiplex Salter, 1873, p. 120 (nom. nud.)
Eucrinus speciosus Angelin, 1878, p. 25, pl. xix, fig. 2, pl. xxiii, figs. 7-7b, pl. xxvii, fig. 2

Syntypes.- Angelin figured three specimens, stated to be in the Riksmuseum, Stockholm.

Occurrence.- The syntypes came from Follingbo, Gotland.. In England only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Dimerocrinites with four arms per ray, interradial areas only slightly depressed. Cup conical, arms twice as long as the height of the cup.

Description.- Cup conical, a little higher than wide. Surface of cup plates usually smooth, but rarely shows a slight radiating ornament, tumid. Infrabasals small, hidden by the stem. Basals as high as wide; radials a little higher than the basals, wider than high, in contact laterally except at the posterior side. Facet occupies about two thirds of the total width of the radials. Primibrachs two, wider than high; secundibrachs two; two or three tertibrachs; arms divide twice, giving four arms per ray; arms biserial, twice as long as the height of the cup.

About ten brachials per 5 mm. in the middle region of the arms, each brachial bearing a pinnule. Interradial areas only slightly depressed, with one proximal plate larger than the others, and followed by two plates in the second row; two or three plates follow in the third row. Intersecundibrachs on the same plan, but smaller. Posterior interradius with the tergal plate in contact with the truncate basal. Three smaller plates follow in the second and third rows.

Tegmen not seen. Stem round, nodose, formed of alternating nodals and internodals, usually with each alternate nodal again enlarged.

Discussion.- This species is easily recognised among the British species of Dimerocrinites by the comparatively long arms and conical cup. There is little variation in the number of arms per ray. Salter's specimens of Dimerocrinus multiplex (SM A 10121-2) undoubtedly belong to this species from Gotland, which was apparently well figured by Angelin. Angelin, in addition to the figures cited in the synonymy above, also attributed to this species a section of a cup (1878, pl. xxvi, fig. 26) showing traces of the gut, but there is no evidence to show that the specimen belongs to the present species.

The plates in this species are always dark in colour.

Dimerocrinites uniformis (Salter)

Plate 33, fig. 5

Dimerocrinus uniformis Salter, 1873, p. 120

Holotype.- SM A 10123.

Occurrence.- Only known from the Wenlock Limestone, Dudley.

Diagnosis.- A species of Dimerocrinites with two arms per ray, a cone-shaped cup, interradial areas not depressedand filled with one large plate followed by two very small ones in the second row.

Description.- The holotype is the only known specimen. Cup cone-shaped, as wide as high, surface of cup plates smooth. Base damaged and the infrabasals are missing. Basals slightly higher than wide, posterior basal truncate. Radials wider than high, narrowly in contact laterally except at the posterior side. Primibrachs two; secundibrachs two, the first of which is in lateral contact with the first secundibrach of the neighbouring arm, followed by biserial arms. Arms branch once, giving ten rami. Brachials short, 8-9 in 5 mm., and each bearing a pinnule. Interradial areas not depressed, with one large plate followed by two very small ones in the second row. The large plate extends up as far as the first secundibrach. Posteroir interradius with a large tergal plate resting on the truncate basal, but the number of plates in the second row cannot be clearly seen.

Tegmen not seen. Stem missing, but the first columnal is in place, crushed into the base. It has a small lumen and a striate surface.

Discussion.- This is a most atypical species of Dimerocrinites, and it does not appear to be closely related to any described species of the genus. Its closest affinity is perhaps with D. planus (Springer) from the Brownsport formation of Tennessee, but it differs from this in the arragement of the plates in the second row of the interbrachial areas.

No specimen other than the holotype is referred to this species, and it is the only specimen of Dimerocrinites from Dudley which has been seen in which the colour is light brown, all the remainder being brown or black (compare Gissocrinus). Bather (in Woods, 1891) referred this species to Carpocrinus, but the reason for this is obscure, since the arms are biserial, a condition which is not seen in Carpocrinus.

Dimerocrinites sp. nov. A

Plate 12, fig. 6

Material.- GSM 92136.

Occurrence.- Lower Llandovery, Newlands Stage, Mulloch Hill Group; Mulloch Hill, Girvan, Ayrshire.

Discussion.- Only one specimen of this undescribed species is available, and this is imperfectly preserved. The base of the cup, of which only one interradial area is seen, is damaged and only traces of infrabasals are visible. The most characteristic feature of the specimen is the strong development of radiating ridges on each plate. Adjacent radials are separated for a short distance by the interradials which rests on the truncated top of the basal. In one ray the arms are seen to divide twice in the cup, and there are three secundibrachs.

This is a clearly distinguished specimen which shows the existence of a species of Dimerocrinites in Britian as early as any described American species, but owing to the inadequacy of the material it is not named here. D. vagans Foerste (1919) from the almost contemporary Brassfield Limestone of Ohio appears to be very similar to the present species.

Dimerocrinites sp. nov. B

Plate 12, fig. 5

Material.- SM A 32803a, b, c.

Occurrence.- Lower Llandovery, Gasworks Mudstones; opposite entrance to gasworks, Haverfordwest, Pembrokeshire.

Discussion.- The specimen is preserved as an internal and external mould. It shows the plating structure usual in the genus, but the infrabasals are very small. The radials are separated all round, the arms branch once only and there are strong axial ridges on the basals and radials passing on to the arms, which appear to be uniserial. On each interbrachial plate there is a strong central node. The stem is nodose.

This is a well defined undescribed species, and if more material were available it would have been named. A number of other specimens are almost certainly conspecific; these include SM A 32093a-d from the Lower Llandovery, quarry near Merlin's Bridge, Haverfordwest; and SM A 32425 from the Lower Llandovery, The Frolic, halfway between Higgons Well and the Powder Magazine, Haverfordwest.

INDETERMINABLE FRAGMENTS, NOMINA NUDA, etc.

The following notes collect together information about Silurian crinoids which are unidentifyable for any reason.

(1) Cyathocrinus? macrostylus Phillips (1848, p. 384). This name referrs to stems found near Stoke Edith, Herefordshire. Stubblefield (1938a, p. 30) states that the type, which possibly came from Lulow strata, has not been traced.

(2) Encrinites pennata Parkinson (1808, pp. 224-5), from Dudley. This refers to long crinoid arms, but the description, though lengthy, leaves no clue as to the identity of this species, and there is no figure.

(3) Hypanthocrinites laciniatus Salter (1873, p. 118). Nomen nudum.

(4) Poteriocrinites dudleyensis Austin and Austin (1843, p. 195). No specimen agreeing with the rather vague description given in 1843 has been seen during the present study. The type specimen, presumably from Dudley, is stated to be in the collection of J. Johnson Esq., but according to Sherborne (1940) this collection was sold by auction in 1845.

IV DISTRIBUTION

(a) Features of the Biology of Crinoids affecting their Distribution

As has been mentioned above the British Lower Palaeozoic crinoids are restricted in their occurrence to a few relatively prolific localities. There are a number of reasons why this might be expected to be so. The primary fact is that crinoids, like all echinoderms, are gregarious in their habits. This gregarious habit, notable alike in both recent and fossil crinoids, is dictated by several features in the biology of the animal which are worthy of notice here. There is no reason to suppose that the biology of palaeozoic species was substantially different from that of recent species.

Fertilisation of the eggs in recent crinoids takes place in the open water into which both eggs and spermatozoa are shed. It is thus advantageous, if a high proportion of fertilised eggs is to result, to have a high density of individuals in a limited area. The larvae of crinoids are free living and unattached in their early stages, but this pelagic stage usually only lasts 2-3 days, or at the most for 5-6 days (Regnéll, 1948b, p. 2). This short period does not allow time for any extensive migration away from the parent colony, and will thus, in itself, restrict the occurrence of one species over a very wide area. Unless the pelagic larvae are caught in a fast moving current which is able to carry them across deep water they will at least be restricted to one shelf sea area. Recent attached crinoids are nearly all restricted to deep water, but in Palaeozoic seas the crinoids lived in fairly shallow water (sometimes actually in the littoral area) as is indicated by the lithological characters of the matrix and by the associated faunas. The food of crinoids consists exclusively of small planktonic particles which fall onto the ventral disc of the animals, and are conveyed to the mouth by a subvective system of ciliary currents. A clear water environment is thus more likely to be conducive to prolific crinoid life than is a muddy one. Crinoid roots appear to be able to obtain a holding on both limestone and shaly sea bottoms, though this factor may affect the distribution of individual species and genera.

When crinoids die their calcareous skeleton soon falls apart into its constituent elements, unless something (such as rapid burial in sediment) occurs to prevent this. This is because the individual plates are, except in cases of close suture (Gislén, 1924), only held together by a thick external membrane. It has been found that in still water echinoid plates may fall apart in five or six days (K. Joysey in litt.) and there is no reason to suppose that the phenomenon is different in crinoids. Rapid burial is thus an imperative condition if any crinoid individual is to be fossilized in a more or less complete state. Such rapid burial is likely to be due to an influx of sedimentary material which may kill and bury large numbers of crinoids together. Where quick burial does not take place the individual plates are not immediately destroyed and often play a conspicuous part in rock formation, as in many palaeozoic limestones, but the present study has not been concerned with these occurrences.

It will be seen from the above that conditions suitable for both crinoid life and crinoid fossilisation will rarely be combined. This, and the small amount of rock which has yet been examined, accounts for the rarity of known British Lower Palaeozoic crinoid occurrences.

(b) Stratigraphical Survey of Crinoid Distribution

Cambrian (including Tremadoc)

No true crinoid has yet been found in the Cambrian or Tremadoc rocks. Jaekel (1918) included in the Crinoidea the Cambrian group Eocrinoidea Jaekel, but, following Regnéll (1945) these are here regarded as forming a separate class owing to their possession of non-pinnulate biserial brachioles which lack the subvective system shown by crinoid arms. Macrocystella Callaway (Tremadoc) and Protocystites Hicks (Middle Cambrian) are examples of British Eocrinoids, but they do not fall within the scope of the present study.

Ordovician

Two main faunal provinces have been recognised in the faunas of the British Ordovician - the Anglo-Welsh province and the Scots-Irish province. This is well illustrated by the trilobite faunas (Stubblefield, 1938b, 1939), but is also shown by brachiopods (Lamont, 1938, 1939), starfishes, cystids (Spencer, 1938) and, as will be shown here, crinoids.

W. K. Spencer's studies in the distribution of the Asterozoa (1938, 1950) have been based on starfish from many parts of Europe and in fact from all over the world. A similar study of crinoid distribution is precluded by lack of information about crinoids outside Britain and America. Apart from a few usually poorly-defined species from the Baltic area and Bohemia no Ordovician crinoids has been described from elsewhere in the world. Yet the reason for this is due not so much to the absence of crinoids, as to the lack of crinoid workers. Nearly every large work on European Ordovician Stratigraphy mentions the existence of crinoid remains, including cups, though they are admittedly rare. A few examples will suffice. Delgado (1908) who wrote on the Ordovician of Portugal, and who clearly distinguishes in his fossil lists between crowns and stems, mentions at least six occurrences, one (pp. 135-6) from so low a horizon as the Llanvirn. Of the Ordovician of the Baltic area, F. Schmidt (1882, p. 524) wrote:- "there are also a good many Encrinites; but the species are for the most part not yet defined". In addition the memoirs of the Geological Survey of Ireland contain a number of references to Ordovician crinoid cups, but the specimens are not available for examination. These examples are given to emphasise the fact that any conclusions reached in this account are extremely tentative and based on inadequate and incomplete information.

(1) Arenig to Caradoc of the Anglo-Welsh province

The early Ordovician crinoids in Britain in the Arenig and Llanvirn belong to the family Iocrinidae. Crinoids of this family have not been found in North America until later, namely Trenton, times. Iocrinus itself, represented here by I. cambriensis (Hicks) Arenig and I. shelvensis sp. nov. Llanvirn , has not been described elsewhere in Europe, though it is possible that certain specimens from Bohemia ascribed to Caleidocrinus may belong more

TABLE I

STRATIGRAPHICAL DISTRIBUTION OF BRITISH ORDOVICIAN CRINOIDS.

Occurrences in the Anglo-Welsh area are indicated by 'O', those in the Scots-Irish area by 'X'.

	Arenig	Llanvirn	Llandeilo	Caradoc	Ashgill
Iocrinus shelvensis sp. nov.		O			
I. whitteryi sp. nov.				O	
I? cambriensis (Hicks)	O				
Caleidocrinus turgidulus sp. n.		O			
Anulocrinus thraivensis sp. nov.					X
A. drummuckensis sp. nov.					X
Heterocrinidae				X	X O
Merocrinus salopiae Bather			O		
Porocrinus scoticus sp. nov.					X
Euspirocrinus girvanensis sp. n.					X
Dendrocrinus rugocyathus sp. n.					O
D. granditubus sp. nov.					X
Cupulocrinus gracilis sp. nov.					X
C. heterobrachialis sp. nov.					X
C. sepulchrum sp. nov.				O	
Pandoracrinus sp. nov.			O		
Protaxocrinus sp.					X
Macrostylocrinus cirrifer sp. n.					X
Xenocrinus multiramus sp. nov.					X
Xenocrinus sp.					X
Archaeocrinus elevatus sp. nov.			X		
Diabolocrinus craigheadensis sp. n.				X	
D. globularis (Nich. & Eth.)				X	
Balacrinus basalis (M'Coy)				O	
Trochocrinites laevis Portlock				X	

properly to Iocrinus (see p. 17). Caleidocrinus, known from the Llanvirn near Builth is a Bohemian genus. In the Llandeilo Merocrinus salopiae Bather and Pandoracrinus sp. occur in Shropshire. Merocrinus, like Iocrinus, has not been found in North America until Trenton times, while Pandoracrinus has only been found elsewhere in Bohemia.

It thus appears that, so far as the evidence is available there is a strong affinity between the crinoid faunas of the Anglo-Welsh area and those of Bohemia in the early Ordovician. There is no American element present, and the fauna seems to have entered North America at a later date.

Bohemian elements have also been found among the trilobites, especially in the Llanvirn (Stubblefield, 1939, p. 54; Whittard, 1931, p. 339) while the Asterozoa also show a relationship with Bohemian forms. Spencer (1950, p. 398) comments on "the continuity of an Anglo-Welsh Bohemian basin".

In the post Nemagraptus gracilis zone Caradoc the earlier present Iocrinus continues (I. whitteryi sp. nov.), but a new element enters with the incoming of Balacrinus basalis (M'Coy) and of Cupulocrinus sepulchrum sp. nov. in the North Wales and Welsh Borderland area. Balacrinus is closely related to Rhaphanocrinus, an approximately contemporaneous North American genus, while Cupulocrinus is well known in the North American Trenton. This new element of the fauna is, in fact, one which might well be an immigration from the Scots-Irish province, but records in the latter area are scarce at this time. A similar incursion at this time in North Wales of forms more generally typical of the Scots-Irish province has been noted by other workers (Stubblefield, 1939, p. 56; Elles, 1922, p. 169) in the trilobites and brachiopods.

(2) Arenig to Caradoc of the Scots-Irish province

Few opportunities have arisen to make studies on crinoids of this age in the Scots-Irish area, and only four occurrences are noted here. These, nevertheless, are of great interest. *Archaeocrinus erectus* sp. nov. is found in the *Orthis confinis* flags in the Stinchar valley; *Diabolocrinus globularis* (Nicholson and Etheridge) and *D. craigheadensis* sp. nov. both occur in the Craighead Limestone; a Heterocrinid has been seen from the Lower Caradoc Tramore Limestone in Ireland; the indeterminate *Trochocrinites laevis* Portlock is in the Caradoc at Desertcreight, Co. Tyrone.

Rhodocrinitids and Heterocrinids are among the most typical of the North American earlier Ordovician crinoids (Bassler and Moodey, 1943, pp. 27-8) but have not been recorded except in Scotland, Ireland, North America and the Baltic area. The scanty evidence indicates that a crinoid fauna of quite different type from that found in the Anglo-Welsh area is found in the Scots-Irish province and that this fauna has American affinities, which, at least until the upper part of the Caradoc, are entirely absent in the Anglo-Welsh province. Some part of the fauna of the Scots-Irish province is also found in the Baltic, as evidenced by the finding of *Carabocrinus* and Heterocrinids.

(3) Ashgillian

An extensive crinoid fauna occurs in the Ashgillian in the Starfish Bed near Girvan, and the genera present are nearly all either North American (Heterocrinids, *Porocrinus*, *Euspirocrinus*, *Cupulocrinus*, *Dendrocrinus*, *Protaxocrinus*, *Xenocrinus*, *Diabolocrinus*) or closely related to North

American genera (Anulocrinus). Macrostylocrinus is a new element, not found in America at this time.

Unfortunately nothing with this richness has been found in the Anglo-Welsh area, though further collecting in the Slade Beds should yield results in this direction (see pp. 57, 26). The Slade Beds yield a Heterocrinid, a Dendrocrinus (D. rugocyathus sp. nov.) - this genus occurs in the American Trenton and also in Scotland - as well as the four sided columnals recalling Xenocrinus (see p. 57) and many undetermined fragments. The Redhill beds also contain undetermined remains (SM A 31005, 31006a-d). These brief indications show that it is likely that the immigration of Scots-Irish province genera into the Anglo-Welsh area has become more extensive since it started in Upper Caradoc times. Indeed no indications of the continuation of an independent Anglo-Welsh crinoid fauna have been found and the provincial boundaries cannot be sustained, the whole area having been invaded by genera with American affinities.

No details have been forthcoming about contemporaneous crinoids in Bohemia, though they are known to occur (e.g. Chlupáč, 1951).

(4) Summary and Conclusions

In summary of the above it can be stated that up to the Lower Caradoc the crinoid faunas of the Scots-Irish area and the Anglo-Welsh area are distinct - the Scots-Irish crinoids being of American affinity and the Anglo-Welsh crinoids having relatives in Bohemia. In the Upper Caradoc crinoids of the Scots-Irish province invaded the Anglo-Welsh area and this invasion became more pronounced in the Ashgillian, when provincial boundaries were broken down and all the British crinoids show affinities with American forms.

The fauna of the Scots-Irish province is also found in part in the Baltic area, and the Anglo-Welsh fauna in Bohemia. These facts seem to lend support to the thesis suggested especially by J. S. Turner (1949) that the south-eastern side of the Caledonian geosyncline continues, not in Scandinavia as was supposed by Bailey (1928) but in Central Europe.

Silurian

The Silurian crinoids seem to be more or less cosmopolitan in their distribution within the British area, and no faunal provinces can be detected. The same has been observed of the brachiopods, with certain exceptions (Lamont, 1939), the trilobites especially in the lower part of the system (Stubblefield, 1939, pp. 65-7), and to a lesser extent the starfish (Spencer, 1950, p. 403).

The cosmopolitan nature of Silurian crinoid faunas extends also into North America, Gotland and Bohemia, as is shown by Table II. Each area has genera restricted to it, but a considerable anumber of genera are common to each area. Of the 41 genera described here from Britain, all except eleven are known in North America; all except twelve are known in Gotland; and fifteen of these 41 genera are found in Bohemia. All the genera found in Australia, except one, are also known in both Britain and North America.

About 16 British species are also found in Gotland (see Table III) and four are known from North America, while only two are as yet recorded from Bohemia, though this number may be increased when the fauna mentioned by Růžička and Bouška (1944) is described.

The stratigraphical distribution of the British Silurian crinoids is shown in Table III, and the different faunas are now discussed individually.

(1) Llandovery

The Llandovery crinoids are all of a distinctly Silurian type, as opposed to the definitely Ordovician facies of the preceding Ashgillian crinoid fauna.

TABLE II

DISTRIBUTION OF SILURIAN CRINOIDS

Genera found in Britain	Also occurring in			
	America	Gotland	Bohemia	Elsewhere
Myelodactylus	x	x	x	
Calceocrinus	x	x	x	
Euchirocrinus	x			
Pisocrinus	x	x	x	Australia
Cicerocrinus				South Baltic
Crotalocrinites	x	x	x	
Enallocrinus		x	x	
Petalocrinus	x	x		China
Cyathocrinites	x	x	x	
Gissocrinus	x	x	x	
Dendrocrinus	x			
Botryocrinus	x	x	x	Australia
Dictenocrinus				
Mastigocrinus				
Thenarocrinus				
Sagenocrinites	x	x		
Temnocrinus				
Gnorimocrinus	x	x		
Eutaxocrinus		x		
Meristocrinus		x		
Homalocrinus		x		
Calpiocrinus		x	x	
Hormocrinus	x	x		
Pycnosaccus	x	x	x	
Lecanocrinus	x	x		Australia
Ichthyocrinus	x	x	x	
Lyriocrinus	x			
Dimerocrinites	x	x		
Periechocrinus	x	x	x	
Carpocrinus	x	x	x	
Desmidocrinus	x	x		
Scyphocrinites	x		x	India, Spain etc.
Promelocrinus		x		
"Melocrinus"	x	x	x	
Macrostylocrinus	x			
Clonocrinus	x	x		
Calliocrinus	x	x		
Eucalytocrinus	x	x	x	
Marsupiocrinus	x	x		
Cordylocrinus	x	x		
Hapalocrinus	x			Australia

In the Lower Llandovery the earliest species of Dimerocrinites occur in Girvan and South Wales, the early occurrence of this genus being paralleled in the Brassfield Limestone in Ohio. Pisocrinus also occurs in South Wales, as also does Macrostylocrinus, a genus earlier present in the Ashgillian of the Girvan area. Regnéll (1948b) has claimed that Pisocrinus and other genera evolved in North America and only later migrated to Europe, but the earliest Pisocrinus is now shown to be European, and the same is true of Macrostylocrinus. The evidence would perhaps seem to indicate an area west of Britain in which many genera evolved, to enter either Europe or North America as opportunity permitted. There are a number of undetermined crinoid remains in the Lower Llandovery, which would seem to indicate that further species will yet be diagnosed (e.g. SM A 32128a, b).

In the Upper Llandovery the only British crinoids recorded are Myelodactylus from both the Girvan area and South Wales, Petalocrinus bifidus sp. nov. from the Welsh Borderland, and Hapalocrinus dameryi at Tortworth. P. bifidus is the most primitive species of its genus as well as being one of the earliest - the almost contemporaneous P. visbycensis occurs in Gotland. Petalocrinus is another example of the appearance of a genus in Europe before it occurs in America, for the earliest American species of the genus is Niagaran. Similarly with Hapalocrinus, the earliest American species are Niagaran.

It may be worth noting here the presence in both the Girvan area (Newlands Beds, BM E 49739-41, Plate 12, figs. 10-13) and South Wales (Gasworks Mudstones, SM A 32131-3) of a peculiar crinoid stem, characterised by large usually bifid projections situated in five vertical rows.

TABLE III

STRATIGRAPHICAL DISTRIBUTION OF BRITISH SILURIAN CRINOIDEA

	Lower Llandovery	Upper Llandovery	Wenlock Shale	Wenlock Limestone	Lower Ludlow	Upper Ludlow	Gotland
INADUNATA							
Myelodactylus ammonis Bather				X			X
- ammonis var. extensus Springer				X			
- fletcheri (Salter)			cf.	X	X		X
- convolutus Hall				X			X
- spp.		X	X				
Calceocrinus fletcheri (Salter)				X			
- pugil Bather				X			X
- inclinus Ramsbottom				X			
- serialis (Salter)				X			
- nitidus Bather				X			X
- gradatus (Salter)				X			
Eucheirocrinus anglicus Springer				X			
Pisocrinus pilula de Koninck			X	X			X
- cf. quinquelobus Bath.			X				
- spp.	X		X		X		
Cicerocrinus elegans Sollas						X	
- anglicus (Jaekel)						X	
Cyathocrinites acinotubus (Angel.)				X			X
- vallatus Bather				X			
- sp. nov.				X			
Gissocrinus arthriticus (Phill.)				X			
- capillaris (Phill.)				X			

TABLE III (continued)

	Lower Llandovery	Upper Llandovery	Wenlock Shale	Wenlock Limestone	Lower Ludlow	Upper Ludlow	Gotland
INADUNATA (continued)							
Gissocrinus goniodactylus (Phill.)				X			cf.
- squamiferus (Salter)				X			
- scoparius (Salter)				X			
- crassus Bouška			X				
- luculentus Ramsbottom				X			
- ludensis sp. nov.					X		
- spp.			X				
Crotalocrinites verucosus (Schloth.)			?	X			X
- pulcher (Hisinger)				X			X
Enallocrinus scriptus (Hisinger)				X			X
Petalocrinus bifidus sp. nov.		X					
Dendrocinus brevis sp. nov.			X				
Botryocrinus ramosus Bather				X			
- quinquelobus Bather				X			
Dictenocrinus decadactylus Bather				X			
- pinnulatus Bather				X			
Mastigocrinus loreus Bather				X			
- bravonium sp. nov.					X		
FLEXIBILIA							
Sagenocrinites expansus (Phillips)				X			X
Temnocrinus tuberculatus (Miller)				X			
Gnorimocrinus sedgleyensis sp. nov.			X				
Eutaxocrinus maccoyanus (Salter)					X		

TABLE III (continued)

	Lower Llandovery	Upper Llandovery	Wenlock Shale	Wenlock Limestone	Lower Ludlow	Upper Ludlow	Gotland
FLEXIBILIA (continued)							
Meristocrinus orbignyi (M'Coy)					X		
- minor (Springer)			X				
- nodulosus sp. nov.				X			
Homalocrinus parabasalis Angelin				X			X
Calpiocrinus intermedius Angelin				X			X
Hermocrinus anglicus Springer				X			
Pycnosaccus bucephalus (Bather)				X			
Lecanocrinus bacchus (Salter)				X			
Ichthyocrinus intermedius Springer				X			X
- phillipsianus Spring.				X			
- pyriformis (Phillips)				X			X
CAMERATA							
Periechocrinus costatus (Austin and Austin)				X			
Periechocrinus limonium Salter				X			
- simplex Salter				X			
- bulbosus sp. nov.				X			
Carpocrinus simplex (Phillips)				X			X
Desmidocrinus macrodactylus Angelin				X			X
Indeterminate Desmidocrinids			X				
Scyphocrinites pulcher (M'Coy)					X		
- sp.				?			

TABLE III (continued)

	Lower Llandovery	Upper Llandovery	Wenlock Shale	Wenlock Limestone	Lower Ludlow	Upper Ludlow	Gotland
CAMERATA (continued)							
Promelocrinus anglicus Jaekel				X			
"Melocrinus" flabellatus Salter				X			
Macrostylocrinus anglicus Jaekel				X			
- sp.	X						
Clonocrinus polydactylus (M'Coy)				X			X
Eucalyptocrinites decorus (Phillips)				X			
- granulatus (Lewis)			X				X
- spp.				X			
Calliocrinus rugiferus sp. nov.				X			
- cf. beyrichianus Ang.				X			cf.
- sp.				X			
Marsupiocrinus coelatus (Phillips)			?	X			
Cordylocrinus pecten sp. nov.				X			
- rugobrachialis sp. nov.			X				
Hapalocrinus retiarius (Phillips)				X			
- quinquepennis sp. nov.					X		
- dameryi sp. nov.		X					
Lyriocrinus britannicus Ramsbottom				X			
Dimerocrinites decadactylus Phill.				X			
- icosidactylus Phill.			cf.				
- speciosus (Angelin)				X			X
- uniformis (Salter)				X			
- sp. nov. A	X						
- sp. nov. B	X						

(2) Wenlock Shale

Conditions in Wenlock Shale times were not usually favourable for the preservation of complete crowns of crinoids, though dissociated remains of brachials, stems and cup plates, are often abundant. No crinoid cup has been seen from the Woolhope Limestone, but in the possibly equivalent rocks in Shropshire - the Buildwas Beds - stems of Myelodactylus are known together with brachials and cup plates probably belonging to (among other genera) Gissocrinus and Desmidocrinids.

Higher in the Wenlock Shale Pisocrinus cups are sometimes common, as at Malvern (Robertson, 1926) and at an untraced locality near Coalbrookdale (Smith, 1881). A few other isolated examples of complete crinoids are known, such as Gissocrinus crassus at Malvern, Cordylocrinus rugobrachialis and Meristocrinus minor at Dudley. Pisocrinus and Myelodactylus occur in the Pentland Hills (information from Mr. James Wright, specimens in Royal Scottish Museum, not examined).

The age of a quite considerable crinoid fauna from Sedgley in Staffordshire is not recorded. The fossils were collected by Mr. William Woodall about 1884, and sold to Sir Charles Holcroft, but the precise locality has not been traced. Judging from the lithology, and also from the crinoid fauna itself, it is here considered that the age is Wenlock Shale, but until the locality is traced some doubt must remain. In the material examined Pisocrinus, Myelodactylus, Dendrocrinus brevis, Cordylocrinus rugobrachialis, Gissocrinus crassus and Dimerocrinites are present. The MS. catalogue of the Holcroft collection discloses that specimens from Sedgley identified as Marsupiocrinus, Botryocrinus and "Crotalocrinus" were exchanged with F. Springer in 1888, while a "Cyathocrinus" went to Sydney Museum in 1896. If these latter identifications are correct, there is here an interesting foretaste of the prolific fauna of the Wenlock Limestone, and it is unfortunate that these irreplaceable specimens could not be examined during the present study.

It is evident that the crinoid life in the Wenlock Shale is more plentiful than has hitherto been supposed, and the sudden appearance of crinoids in the Wenlock Limestone is not now so striking as was previously thought.

(3) Wenlock Limestone

The Wenlock Limestone may be regarded as a limestone facies occurring locally within the Wenlock Series which is usually shaly. Knowledge of crinoid life at this time is almost entirely derived from crinoids occurring in the neighbourhood of Dudley, where the Wenlock Limestone consists of two beds of limestone separated by nodular beds.(Butler, 1939). Bather (1890c, p. 224), on the evidence of Mr. Madeley, a local collector, suggested that the bulk of the crinoid material came from the Upper Limestone, and this conclusion was confirmed by Butler (1939, p. 61). Hollier (1863, p. 31) in a paper on the geology of Castle Hill, Dudley, mentions a ravine opposite the railway station from which "some of the finest Encrinites have been obtained". Madeley in the MS. catalogue of the Dudley Museum, compiled in 1912, states that this ravine is in the Upper Limestone. The Upper Limestone is characterised by frequent shale partings, and it is probably fairly safe to assign those crinoids occurring in a thin shale layer on limestone to this level. Most of the finest specimens were collected between 1830 and 1850, when quarrying operations were at their peak (Chandler & Hannah 1949), and nowadays only fragmentary remains can be found.

Some 63 species of crinoids are here recorded from the Wenlock Limestone of the Dudley area. This area may be said to include Walsall, where the facies is similar (Barrow & others, 1919). The only species recorded away from Dudley are the following:- Cyathocrinites acinotubus, Crotalocrinites verucosus, Myelodactylus ammonis, Marsupiocrinus coelatus and Lyriocrinus britannicus all on Wenlock Edge; Cyathocrinites acinotubus at Dormington and Malvern; Crotalocrinites verucosus at May Hill and Fownhope; and Periechocrinus limonium at Cefn Ila, Usk. All these species also occur at Dudley. The Wenlock Limestone has abundant dissociated crinoid remains almost everywhere, however, and many other species probably occurred, for example, along Wenlock Edge, but conditions must have been too turbulent for preservation.

The horizon of the Wenlock Limestone is in the zone of Cyrtograptus lundgreni (Butler, 1939, p. 55). Some 16 species known from Dudley, also occur in Gotland, but their stratigraphical distribution there is unknown. According to Hede (1942) the main crinoid-bearing rocks in Gotland - the Slite Group - are not younger than the zone of Cyrtograptus ellesi, that is to say they are rather earlier in date than the main Wenlock Limestone. It is unlikely that there is any evidence for the migration of crinoids from England to Gotland in the Wenlock as has been claimed by Regnell (1948b) and the abundant occurrence of complete crinoids at any horizon is dictated by facies.

Four English crinoids are known in North America - viz. Myelodactylus ammonis, and M. ammonis var. extensus, M. convolutus and Pisocrinus cf. quinquelobus. In America these all occur in the Brownsport formation which was shown by Amsden (1949) to include all the subdivisions given by Springer (1926b, p. 5). The Brownsport formation is probably equivalent to the upper part of the Wenlock Series; the position assigned to it, relative to the Wenlock Limestone, in correlation tables prepared by Swartz and others (1942) would appear to be misleading.

In Bohemia the main crinoid-bearing rocks are of Wenlock Shale age (Růžička & Bouška, 1944), but the fauna is as yet for the most part undescribed.

(4) Ludlow

After the prolific world-wide outburst of crinoid life in the Wenlock the fauna of the Ludlow Series is rather meagre. Crinoids occur in Britain at two horizons in the Lower Ludlow. In the Monograptus nilssoni zone Scyphocrinites pulcher is widespread in North and Mid Wales and extends into the Lake District at what is possibly the same horizon. Scyphocrinites is known also in Bohemia in the Ludlow, though the horizon is probably higher than the nilssoni zone. The age of the Cornish occurrence of Scyphocrinites is uncertain, though possibly Ludlow; the species in this case is more closely related to the Bohemian one than to S. pulcher found in the Anglo-Welsh basin, and this fact may have palaeogeographical significance.

At the higher horizon of the Monograptus leintwardinensis zone lagoonal conditions at Leintwardine (Hawkins & Hampton, 1927) allowed the preservation of considerable numbers of specimens, though only five species are represented. Of these Eutaxocrinus maccoyanus and possibly Hapalocrinus quinquepennis are also known in Westmorland at a similar horizon, together with the unique Meristocrinus orbignyi.

The only Upper Ludlow crinoids known belong to Cicerocrinus, which is also found at a similar horizon, in Sweden and the South Baltic area, but is unknown elsewhere.

Little information is available about Ludlow crinoids on the continent of Europe, since no comprehensive studies have been made. The British evidence indicates the gradual impoverishment of the fauna due to the onset of unfavourable conditions and no Downtonian crinoids are known in Britain. But the Ludlow crinoids seem to be in part transitional to the extensive Devonian faunas, for Eutaxocrinus, Hapalocrinus and Scyphocrinites are all better represented in the Devonian than in the Silurian.

(5) Summary and Conclusions

Silurian crinoids in Britain are mostly from the Wenlock Limestone at Dudley, though a few species are known in the Llandovery, and some of the genera found in the Wenlock Limestone, when conditions favoured their growth and preservation, are also found in the Wenlock Shale. The Ludlow fauna is much impoverished, and the genera present are often better represented in the Devonian rocks. No faunal provinces can be detected in Silurian crinoids which, so far as they are described, appear to have a cosmopolitan distribution. In general it is considered that the crinoid faunas of the different Silurian Series are distinct enough to be recognised individually.

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VI Bibliography

In the following bibliography certain references in the generic synonymies are omitted. These will be found either in Bassler & Moodey (1943) or Bassler (1938).

Anon. 1843. On several new species of Encrinite and Hypanthocrinite from Dudley. From a report by the Curator of the Dudley and Midland Geological Society. Geologist ed. Moxon ii, pp. 25-31

Allen, H. A. 1902. Catalogue of Types and Figured Specimens of British Palaeozoic Echinodermata preserved in the Museum of Practical Geology. Summ. Prog. Geol. Surv. for 1901, pp. 204-11.

Amsden, T. W. 1949. The Stratigraphy and Paleontology of the Brownsport Formation (Silurian) of Western Tennessee. Yale Peabody Museum, Bulletin 5, pp. 1-138, pls. i-xxxiv.

Anderson, F. W. and J. Pringle. 1946. On a Section of the Balclatchie Beds at Craighead Quarry, near Girvan, Ayrshire. Geol. Mag. lxxiii, pp. 172-176.

Angelin, N. P. 1878. "Iconographia crinoideorum in stratis Sueciae Siluricis fossilium". Stockholm.

Austin, T. & Austin, T. 1842. Proposed Arrangement of the Echinodermata, particularly as regards the Crinoidea, and a subdivision of the class Adelostella (Echinidae). Ann. Mag. Nat. Hist., x, pp. 106-13.

Austin, T. & Austin, T. 1843. Descriptions of several new Genera and Species of Crinoidea. Ann. Mag. Nat. Hist., xi, pp. 195-207.

Aveline, W. T., T. McK. Hughes and A. Strahan. 1888. The Geology of the Country around Kendal, Sedbergh, Bowness and Tebay. Mem. Geol. Surv. Explan. Sheet 98 N.E. (Old Series).

Bailey, E. B. 1928. The Palaeozoic Mountain Systems of Europe and America. Rep. Brit. Assoc. Glasgow, 1928. pp. 57-76

Baily, W. H. 1860. In Explanations to accompany Sheet 145 of the Maps of the Geological Survey of Ireland. Mem. Geol. Surv.

Barrow, G., W. Gibson, T. C. Cantrill, E. E. L. Dixon, and C. H. Cunnington. 1919. The Geology of the Country around Lichfield. Mem. Geol. Surv. Expl. sheet 154.

Bassler, R. S. 1938. Pelmatozoa Palaeozoica. Fossilium Catalogus, I Animalia, 83.

Bassler, R.S., & Moodey, M. W. 1943. Bibliographic and Faunal Index of Paleozoic Pelmatozoan Echinoderms. Geol. Soc. America Spec. Paper 45, pp. 1-734.

Bather, F. A. 1890a. British Fossil Crinoids, I, Historical Introduction. Ann. Mag. Nat. Hist., (6), v, pp. 306-310.

Bather, F. A. 1890b, British Fossil Crinoids, II, The Classification of the Inadunata Fistulata. Ann. Mag. Nat. Hist. (6), v, pp. 310-334, 373-388, 485-486 (errata), pls. xiv, xv.

__________. 1890c. British Fossil Crinoids, III, Thenarocrinus callipygus gen. et sp. nov., Wenlock Limestone. Ann. Mag. Nat. Hist. (6), vi, pp. 222-235, pl. x.

__________.. 1891a. British Fossil Crinoids, IV, Thenarocrinus gracilis sp. nov. Wenlock Limestone, and a Note on T. callipygus. Ann. Mag. Nat. Hist., (6), VII, pp. 35-40, pl. i

__________. 1891b. British Fossil Crinoids, V, Botryocrinus, Wenlock Limestone. Ann. Mag. Nat. Hist., (6), VII, pp. 389-413, pl. xiii

__________. 1892a. Suggested Terms in Crinoid Morphology. Ann. Mag. Nat. Hist., (6) ix, pp. 51-56.

__________. 1892b. British Fossil Crinoids, VI, Botryocrinus quinquelobus sp. nov., Wenlock Limestone; and a note on Botryocrinus pinnulatus. Ann. Mag. Nat. Hist., (6), ix, pp. 189-194, pl. xi, figs. 1-2.

__________. 1892c. British Fossil Crinoids, VII, Mastigocrinus loreus nov. gen. et sp., Wenlock Limestone, Dudley. Ann. Mag. Nat. Hist. (6), ix, pp. 194-202, pl. xi, fig. 3, and pl. xii.

__________. 1892d. British Fossil Crinoids, VIII, Cyathocrinus: C. actinotubus Angelin and C. vallatus sp. nov., Wenlock Limestone. Ann. Mag. Nat. Hist., (6), ix, pp. 202-226, pl. xiii.

__________. 1893. The Crinoidea of Gotland. Kongl. Svenska Vet-Akad. Handl., 25, No. 2, pp. 1-200, pls. i-x.

Bather, F. A. 1896. Merocrinus salopiae n. sp., and another Crinoid from the Middle Ordovician of West Shropshire. Geol. Mag., (iv), iii, pp. 71-75.

__________. 1897. Hapalocrinus Victoriae n.s., Silurian, Melbourne, and its relation to the Platycrinidae. Geol. Mag., (iv), iv, pp. 337-45.

__________. 1898. Petalocrinus Weller & Davidson. Quart. Journ. Geol. Soc., liv, pp. 407-41, pls. xxv, xxvi.

__________. 1899a. Wachsmuth and Springer's Monograph on Crinoids. Fifth Notice. Geol. Mag., (iv), vi, pp. 32-44.

__________. 1899b. A Phylogenetic Classification of the Pelmatozoa. Rep. Brit. Assoc. Adv. Sci., Bristol, 1898, pp. 916-923.

__________. 1900. "The Crinoidea" in Lankester, E. R. "A Treatise on Zoology, Pt. 3". London.

__________. 1906. The Species of Botryocrinus. Ottawa Naturalist, xx, pp. 93-104.

__________. 1907. The Discovery in West Cornwall of a Silurian Crinoid characteristic of Bohemia. Trans. Roy. Geol. Soc. Cornwall, xiii, pp. 191-197.

__________. 1917. Review of 'Atactocrinus, a New Crinoid genus from the Richmond of Illinois' by Stuart Weller. Geol. Mag., (vi) iv, p. 133.

__________. 1928. The Fossil and its environment. Quart. Journ. Geol. Soc., lxxxiv, Proc. pp. lxi-xcviii.

Billings, E. 1857. New Species of Fossils from the Silurian Rocks of Canada. Geol. Surv. Canada, Report for 1856, pp. 256-345.

__________. 1859. On the Crinoideae of the Lower Silurian Rocks of Canada. Canadian Organic remains, decade iv.

Billings, W. R. 1883. Notes on, and Description of, some Fossils from the Trenton Limestone. Trans. Ottawa Field-Nat. Club, No. 4, pp. 49-52, pl.

__________. 1884. Two New Species of Crinoids. Trans. Ottawa Field-Nat. Club, No. 6, pp. 248-50, pl.

__________. 1887. A New Genus and three New Species of Crinoids from the Trenton Formation, with notes on a large specimen of Dendrocrinus proboscidiatus. Ottawa Naturalist, i, pp. 49-54, pl.

Bolton, J. 1869. "Geological Fragments collected principally from Rambles among the rocks of Furness and Cartmel". Ulverston & London.

Boswell, P. G. H. 1926. A Contribution to the Geology of the Eastern Part of the Denbighshire Moors. Quart. Journ. Geol. Soc., lxxxii, pp. 556-585, pls.

______________. 1949. "The Middle Silurian Rocks of North Wales". London.

Bouška, J. 1943. Krinoidengattung Pycnosaccus Angelin in böhmischen Silur.

________. 1944. Die Vertreter der Gattung Gissocrinus Angelin im böhmischen Silur. Bull. Internat. de l'Acad. tcheque des Sciences, xliv, pp. 584-593, pls. I-II.

________. 1946. On Crotalocrinitidae (Angelin) from the Silurian and Devonian of Bohemia. Bull. Internat. de l'Acad. tcheque des Sciences, xlvii, No. 4, pp. 1-17, pls. i-iv.

Butler, A. J. 1939. The Stratigraphy of the Wenlock Limestone of Dudley. Quart. Journ. Geol. Soc., xcv, pp. 37-74, pl. III.

Cantrill, T. C., E. E. L. Dixon, H. H. Thomas and O. T. Jones. 1916. The Geology of the South Wales Coalfield. Part xii. The Country aroud Milford. Mem. Geol. Surv.

Carpenter, P. H. 1886. Note on the structure of Crotalocrinus. Ann. Mag. Nat. Hist., (5), xviii, pp. 397-406.

Chlupáč, I. 1951. The Stratigraphy of the Králův Duůr Shales at Karlik and Zadní Třebáň (Ashgillian - Central Bohemia). Vestrik du Serv. Tchecoslovaquie, xxvi, pp. 194-211.

Cox, A. H. 1916. The Geology of the District between Abereiddy and Abercastle (Pembrokeshire). Quart. Journ. Geol. Soc., lxxi, pp. 273-342.

Crosfield, M. C. & M. S. Johnston. 1914. A Study of Ballstone and the Associated Beds in the Wenlock Limestone of Shropshire. Proc. Geol. Assoc., 25, pp. 193-224, pls. 33-37.

Cumberland, G. 1826. "Reliquiae Conservatae". Bristol and London.

Davidson, T. and G. Maw. 1881. Notes on the Physical Character and Thickness of the Upper Silurian Rocks of Shropshire, with the Brachiopoda they contain grouped in Geological Horizons. Geol. Mag. Dec. II, vol, III, pp. 100-109.

Delgado, J. F. N. 1908. Systeme Silurique du Portugal. Comm. Servica Geol. Portugal.

D'Orbigny, A. 1849. "Prodrome de Paléontologie Stratigraphique Universelle des Animaux Mollusque and Rayonnes". Vol. i. Paris.

__________. 1858. "Histoire Naturelle ...... des Crinoides vivans et fossils". Paris.

Edmunds, F. H. and K. P. Oakley. 1936 and 2nd Ed. 1947 British Regional Geology. The Central England District. Mem. Geol. Surv.

Ehrenberg, K. 1930. Die "Nebenformen" der Crinoiden, ihre Stammesgeschichtiche Entwicklung und Bedeutung. Palaeobiologica, iii, pp. 257-324, pls. XV-XVII.

Elles, G. L. 1922. The Bala Country: its Structure and Rock-Succession. Quart. Journ. Geol. Soc., lxxviii, pp. 132-175.

Ellis, J. 1762. An Account of an Encrinus, or Starfish, with a jointed stem, taken on the Coast of Barbadoes, which explains to what King of Animal those fossils belong, called Starstones, Asteriae, and Astropodia, which have been found in many parts of this Kingdom. Phil. Trans. Roy. Soc., lii, pp. 357-62, pls. xiii-xiv.

Foerste, A. F. 1919. Echinodermata of the Brassfield (Silurian) Formation of Ohio. Bull. Sci. Labs. Denison Univ., xix, pp. 3-32, pls. 1-7.

Garner, R. 1844. "The Natural History of the County of Stafford." London.

Gislén, T. 1924. Echinoderm Studies. Zoologiska Bidrag från Uppsala, ix, pp. 1-316, 351 text figs.

Goldfuss, A. 1826. "Petrefacta Germaniae", vol. i. Dusseldorf.

Hall, J. 1843. Description of the Rocks and Groups of the New York System - Niagara Group. Nat. Hist. New York, Geol., pt. iv, pp. 79-116.

______. 1852. "Palaeontology of New York, Vol. II, Containing Descriptions of the Organic Remains of the Lower Middle Division of the New York System". Albany.

Hawkins, H. L. and S. M. Hampton. 1927. The Occurrence, Structure, and Affinities of Echinocystis and Palaeodiscus. Quart. Journ. Geol. Soc., lxxxiii, pp. 574-603, pls. xliv-xlvi.

Hede, J. E. 1942. The Correlation of the Silurian of Gotland. Lunds Geol. Fältk., 1892-1942, pp. 205-229.

Hicks, H. 1873. On the Tremadoc Rocks in the Neighbourhood of St. David's South Wales and their Fossil Contents. Quart. Journ. Geol. Soc, xxix, pp. 39-52, pls. iii-v.

Hisinger, W. 1827. Gottland geognostiskt beskrifvit. Kongl. Vet.-Akad. Handl., pp. 311-37, pls. vii, viii.

__________. 1828. "Anteckningar i Physik och Geognosi under resor uti Sverige och Norrige". Fjerde Häftet. Stockholm.

__________. 1829. "Esquisse d'un Tableau des Petrifactions de la Svède, distribuées en ordre systematique". Stockholm.

__________. 1831. "Anteckningar i Physik och Geognosie under resor uti Sverige och Norrige". Femte Häftet. Stockholm.

__________. 1837. "Lethaea Suecica seu Petrificata Sueciae iconibus et characteribus illustrata". Stockholm.

__________. 1840. "Lethaea Suecica seu Petrificata Sueciae: supplementum secundum". Stockholm.

Hollier, E. 1863. Geology of the Castle Hill, with special reference to some of its peculiar fossils. Proc. Dudley and Midland Geol. and Sci. Soc. and Field Club, i, pp. 31-2.

Hudson, G. H. 1907. On Some Pelmatozoa from the Chazy Limestone of New York. New York St. Mus. Report, 60, (2), pp. 97-131, pls. 1-10.

Huxley, T. H. and R. Etheridge sen. 1878. A Catalogue of the Cambrian and Silurian fossils in the Museum of Practical Geology. Mem. Geol. Surv.

Jaekel, O. 1895. Beiträge zur Kenntriss der palaeozoichen Crinoiden Deutschlands. Palaeont. Abhandlungen, vii, pp. 1-116, pls. i-x.

__________. 1900. Veber einen neuen Pentacrinoideen-Typus aus dem Obersilur. Zeit. Deutsch. Geol. Gesellschaft, 52, pp. 480-487.

__________. 1902. Ueber verschiedene Wege phylogenetischer Entwickelung Verh. Int. Zool. Cong. Berlin, pp. 1058-1117.

__________. 1918. Phylogenie und System der Pelmatozoen. Palaeont. Zeits., III, pp. 1-128.

Jones, O. T. & W. J. Pugh. 1949. An Early Ordovician Shore-line in Radnorshire, near Builth Wells. Quart. Journ. Geol. Soc., xv, pp. 65-99.

Kettner, K. & Boucek, B. 1936. Tableaux Synoptiques des Formations du Barrandien. Trav. Inst. Geol. Pal. Univ. Charles.

King, W. B. R. 1928. The Geology of the District around Meifod (Montgomeryshire). Quart. Journ. Geol. Soc., lxxiv, pp. 671-702.

Koninck, L. G. de. 1858. Sur quelques Crinoides palaeozoiques nouveaux de l'Angleterre. Bull. Acad. Roy. Bruxelles, 2nd ser., iv, pp. 93-108, pl. ii.

________________. 1858a. On Some New Palaeozoic Crinoids from England and Scotland. Geologist, i, pp. 146-49, 178-184, pl. iv. Translation of de Koninck, 1858

Lake, P. 1895. The Denbighshire Series of South Denbighshire. Quart. Journ. Geol. Soc., li, pp. 9-23.

Lamont, A. 1935. The Drummuck Group, Girvan; A Stratigraphical Revision, with Descriptions of New Fossils from the Lower Part of the Group. Trans. Geol. Soc. Glasgow, xix, pp. 288-332, pls. vii-viii.

________. 1938. The Brachiopods. Rep. Brit. Assoc., Cambridge 1938, pp. 414-5.

________. 1939. Notes on Distribution and Migration of Brachiopoda in The British and Irish Lower Palaeozoic Faunas. Irish. Nat. Journ., vii, pp. 171-7.

Lapworth, C. 1882. The Girvan Succession. Quart. Journ. Geol. Soc., xxxviii, pp. 537-666.

La Touche, J. D. 1884. "A Handbook of the Geology of Shropshire". London and Shrewsbury.

Lewis, W. A. 1847. On a New Species of Hypanthocrinites from the Wenlock Shale of Walsall. London. Geol. Journ., pp. 99-100, pl. 21.

Marr, J. E. 1880. On the Cambrian (Sedgwick) and Silurian Beds of the Dee Valley, as compared with those of the Lake District. Quart. Journ. Geol. Soc., xxxvi, pp. 277-284.

________. 1892a. The Coniston Limestone Series. Geol. Mag., (iii), ix, pp. 97-110.

Marr, J. E. 1892b. On the Wenlock and Ludlow strata of the Lake District. Geol. Mag., (iii), ix, pp. 534-541.

________. 1913. The Lower Palaeozoic Rocks of the Cautley District (Yorkshire). Quart. Journ. Geol. Soc., lxix, pp. 1-18.

M'Coy, F. 1849. On Some New Palaeozoic Echinodermata. Ann. Mag. Nat. Hist., (2), iii, pp. 244-254.

________. 1850. On some new genera and species of Silurian Radiata in the Collection of the University of Cambridge. Ann. Mag. Nat. Hist., (2), vi, pp. 270-290.

________. 1851. "A systematic Description of the British Palaeozoic Fossils in the Geological Museum of the University of Cambridge". pp. 1-184. Cambridge.

________. 1852. "A systematic Description of the British Palaeozoic Fossils in the Geological Museum of the University of Cambridge". pp. 185-406. Cambridge.

Meek, F. B. and A. H. Worthen. 1865. Contributions to the Palaeontology of Illinois and other Western States. Proc. Acad. Nat. Sci. Philadelphia, pp. 245-273.

Miller, J. S., 1821. "A Natural History of the Crinoidea". Bristol.

Miller, S. A. 1889. "North American Geology and Palaeontology". Cincinnati.

Moore, R. C. 1950. Evolution of the Crinoidea in Relation to Major Paleogeographic changes in Earth History. Int. Geol. Cong. Rept. 18th Session, pt. xii, pp. 27-53.

________. & L. R. Laudon. 1943. The Evolution and Classification of Paleozoic Crinoids. Geol. Soc. America, Spec. Paper 46, pp. 1-153, pls. 1-14.

Morris, J. 1843. "A Catalogue of British Fossils". London. 1st Edition.

Morton, G. H. 1869. The Geology of the Country around Shelve. Proc. Liverpool Geol. Soc., 1, session x, pp. 3-22.

Mu, A. T. 1949. Petalocrinus from the Shihriulan Limestone of Wuchuan. Bull. Geol. Soc. China, xxix, pp. 93-6.

Muller, J. 1840a. Uber den Bau des Pentacrinus Caput Medusae. Verhandl. Berlin Akad., pp. 86-106.

Müller, J. 1853. Über den Bau der Echinodermen. Abhandl. Akad. Wiss. Berlin, pp. 123-219, pls. i-ix.

Murchison, R. I. 1839. "The Silurian System". London.

_____________. 1859. "Siluria" 2nd Edition. [stated on title page to be 3rd Edition] London.

Nicholson, H. A. & R. Etheridge jun. 1880. "A Monograph of the Silurian Fossils of the Girvan District in Ayrshire, with special reference to those contained in the 'Gray Collection'". Edinburgh and London.

Parkinson, J. 1808. "Organic Remains of a Former World." Vol. II. London.

Phillips, J. 1839. in Murchison, R. I., 1839.

__________. 1848. in Phillips, J. and J. W. Salter. Palaeontological Appendix to Professor John Phillips' Memoir on the Malvern Hills compared with the Palaeozoic District of Abberley, etc. Mem. Geol. Surv. Vol. ii, pt. 1.

Plot, R. 1686. "The Natural History of Stafford-shire". Oxford.

Pocock, R. W. 1930. The Petalocrinus Limestone Horizon at Woolhope (Herefordshire). Quart. Journ. Geol. Soc., lxxxvi, pp. 50-63.

___________., T. H. Whitehead, C. B. Wedd, and T. Robertson. 1938. Shrewsbury District. Mem. Geol. Surv.

Portlock, J. E. 1843. "Report on the Geology of the County of Londonderry and of parts of Tyrone and Fermanagh". Dublin.

Prestwich, J. 1840. On the Geology of Coalbrook Dale. Trans. Geol. Soc., (2), v, pp. 413-495, pls. xxxv-xli.

Pringle, J. 1911. Note on the 'Lower Tremadoc' Rocks of St. David's, Pembrokeshire. Geol. Mag., (v), viii, pp. 556-59.

_________. 1930. The Geology of Ramsay Island (Pembrokeshire). Proc. Geol. Assoc., 41, pp. 1-31.

Quenstedt, F. A. 1876. "Petrefactenkunda Deutchlands". Vol. iv, Leipzig.

Ramsbottom, W. H. C. 1950. A New Species of Lyriocrinus from the Wenlock Limestone. Ann. Mag. Nat. Hist., (12), iii, pp. 651-6, pl. ix.

Ramsbottom, W. H. C. 1951a. Two Species of Gissocrinus from the Wenlock Limestone. Ann. Mag. Nat. Hist., (12), iv, pp. 490-97, pl. ix.

__________. 1951 b. The Type Species of Periechocrinites Austin & Austin. Ann. Mag. Nat. Hist., (12), iv, pp. 1040-43.

__________. 1952. Calceocrinidae from the Wenlock Limestone of Dudley. Bull. Geol. Surv. Gt. Britain, 4, pp. 33-48, pls. iv-v.

Reed, F. R. C. 1897a. The Fauna of the Keisley Limestone.- Part II, Conclusion. Quart. Journ. Geol. Soc., liii, pp. 67-106, pl. vi.

__________. 1897b. Notes on the Geology of County Waterford. 1. The Fauna of the Ordovician Beds near Tramore. Geol. Mag., (iv), iv, pp. 502-12.

__________. 1910. New Fossils from the Dufton Shales. Geol. Mag., (v), vii, pp. 211-20.

Reid, C. 1907. The Geology of the Country around Mevagissey. Mem. Geol. Surv.

Regnéll, G. 1945. Non-crinoid Pelmatozoa from the Paleozoic of Sweden - a Taxonomic study. Medd. Lunds Geol. Min. Inst., 108, pp. 1-viii, 1-255, pls. 1-15.

__________. 1948a. Swedish Hybocrinida (Crinoidea Inadunata Disparata; Ordovician - Lower Silurian). Arkiv för Zoologi, 40 A, No. 9, pp. 1-27, pls. 1-4.

__________. 1948b. An Outline of the Succession and Migration of Non-Crinoid Pelmatozoan Faunas in the Lower Paleozoic of Scandinavia. Arkiv. för Kemi, Mineralogi och Geologi, 26 A, No. 13, pp. 1-55.

Reynolds, S. H. & C. I. Gardner. 1896. The Kildare Inlier. Quart. Journ. Geol. Soc., lii, pp. 587-605.

Ringueberg, E. N. S. 1889. The Calceocrinidae: A Revision of the Family, with Descriptions of some New Species. Ann. New York. Acad. Sci., iv, pp. 388-406, pls. x-xi.

Roberts, D. W., 1870. Notice of the occurrence of "Actinocrinus pulcher" (Salt. MSS.) in the Upper Silurian Flag of Denbighshire, North Wales, being a new locality for this Encrinite. Trans. Edinburgh Geol. Soc., i, pp. 329-330, pl xv.

Robertson, T. 1926. The Section of the New Railway Tunnel through the Malvern Hills at Colwall. Summ. Prog. Geol. Surv. for 1925, pp. 162-173.

Růžička, R. and J. Bouška. 1944. Zkameněliny z Českého Siluru z Lomů "Amerika" u vel. Mořiny. Veda Přírodný, 22, 7, pp. 1-4.

Salter, J. W. 1852. Descriptions of a few species from Wales and Westmorland, referred to in the foregoing work. Appendix to M'Coy 1852, pp. i-viii.

__________. 1854. in Murchison, R. I. "Siluria" 1st Ed. London.

__________. 1859. Appendix A in Murchison, R. I. 1859, pp. 531-552.

__________. 1866. Appendix in A. C. Ramsay. The Geology of North Wales. Mem. Geol. Surv. Vol iii.

__________. 1871. On Crotalocrinus rugosus, Miller; a remarkable Crinoid in the Woodwardian Museum. Trans. Cambridge Phil. Soc., xi, pp. 481-4.

__________. 1873. "A Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge". Cambridge.

__________. 1878. in Huxley, T. H. and R. Etheridge, 1878.

Schlotheim, E. F. Von, 1820. "Die Petrefactenkunde". Gotha.

________________. 1823. "Nachträge zur Petrefactenkune; zweyte Abtheilung". Gotha.

Schmidt, F. 1882. On the Silurian (and Cambrian) Strata of the Baltic Provinces of Russia, as compared with those of Scandinavia and the British Isles. Quart. Journ. Geol. Soc., xxxviii, pp. 514-36.

Schuchert, C. 1904. On Siluric and Devonic Cystidea and Camarocrinus. Smithsonian Misc. Coll., 1482, xlvii, pp. 201-72, pls. xxxiv-xliv.

Sherborne, C. D. 1940. "Where is the ------- Collection?". Cambridge.

Smith, J. 1881. Note on a collection of Bivalved Entomostraca and other Microzoa from the Upper Silurian strata of the Shropshire District. Geol. Mag., (ii), viii, pp. 70-75.

Sollas, W. J. 1900. On Two New Genera and Species of Crinoidea (Brahmacrinus ponderosus and Cicerocrinus elegans). Quart. Journ. Geol. Soc, lvi, pp 264-72, pl. xvi.

Spencer, W. K. 1938. The Starfishes and Cystids. Rep. Brit. Assoc. Cambridge, p. 415.

Spencer, W. K. 1950. Asterozoa and the Study of Palaeozoic Faunas. Geol. Mag., lxxxvii, pp. 393-408.

Springer, F. 1902. On the Crinoid Genera Sagenocrinus, Forbesiocrinus, and allied forms. American Geologist, xxx, pp. 88-97.

__________. 1906. Discovery of the Disk of Onychocrinus, and Further Remarks on the Crinoidea Flexibilia. Journ. Geol., xiv, pp. 467-523, pls. 4-7.

__________. 1911. On a Trenton Echinoderm Fauna at Kirkfield, Ontario. Geol. Surv. Canada Mem., 15P, pp. 1-50, pls. i-v.

__________. 1913. "The Crinoidea" in Eastman-Zittel "Text-Book of Paleontology", pp. 173-243. London.

__________. 1917. On the Crinoid Genus Scyphocrinus and its bulbous root Camarocrinus. Smithsonian Inst., Pub. 2440, pp. 1-74, pls. i-ix.

__________. 1920. The Crinoidea Flexibilia. Smithsonian Inst., Pub. 2501, pp. 1-486, pls. A-C, 1-76.

__________. 1926a. Unusual Fossil Crinoids. U.S. Nat. Mus. Proc., 67, 9, pp. 1-137, pls. 1-26.

__________. 1926b. American Silurian Crinoids. Smithsonian Inst., Pub. 2871, pp. 1-239, pls. 1-33.

Strahan, A., T. C. Cantrill, E. E. L. Dixon and H. H. Thomas. 1909. The Geology of the South Wales Coalfield, Part x. The Country around Carmarthen. Mem. Geol. Surv.

Stubblefield, C. J. 1938a. The Types and Figured Specimens in Phillips' and Salter's Palaeontological Appendix to John Phillips' Memoir on 'The Malvern Hills compared with the Palaeozoic Districts of Abberley, etc.'. Summ. Prog. Geol. Surv. for 1936, pt. ii, pp. 27-51.

______________. 1938b. The Trilobites. Rep. Brit. Assoc. Cambridge, pp. 413-4.

______________. 1939. Some Aspects of the Distribution and Migration of Trilobites in the British Lower Palaeozoic Faunas. Geol. Mag. lxxvi, pp. 49-70

Sun, Y. C. and S. S. Szetu. 1947. The Stratigraphical and Biological Position of the Species "Camarocrinus asiaticus". Bull. Geol. Soc. China, xxvii, pp. 243-52, 1 pl.

Swartz, C. K. and others. 1942. Correlation of the Silurian Formations of North America. Bull. Geol. Soc. Amer., 53, pp. 533-538, 1 pl.

Teichert, C. 1940. Cephalopods from the Drummuck Group of the Girvan District. Trans. Geol. Soc. Glasgow, xx, pp. 103-115, pls. v, vi.

__________. 1948. A simple device for coating fossils with Ammonium Chloride. Journ. Paleont., 22, pp. 102-4.

Thoral, M. 1935. "Contribution a l'Etude Paléontologique de l'Ordovicien inferieur de la Montagne Noire". Montpelier.

Turner, J. S. 1949. The Deeper Structure of Central and Northern England. Proc. Yorks. Geol. Soc., xxvii, pp. 280-97.

Ubaghs, G. 1952. Ammonicrinus Springer. Crinoidea Flexibilia du Dévonien moyen d'Allemagne. Senckenbergiana, 33, pp. 203-26, pls. 1-3.

Ulrich, E. O. 1924. New Classification of the "Heterocrinidae". In A. F. Foerste: Upper Ordovician Faunas of Ontario and Quebec. Geol. Surv. Canada Mem., 138, pp. 82-102.

Waagen W. and J. Jahn. 1899. "Systême Silurien du Centre de la Bohême par Joachim Barrande". Vol. vii, pt. 1, Prague.

Wachsmuth, C. and F. Springer. 1879. Revision of the Palaeocrinoidea, Part I, The Families Ichthyocrinidae and Cyathocrinidae. Proc. Acad. Nat. Sci. Philadelphia, pp. 226-378, pls. xv-xvii.

____________________. 1881. Revision of the Palaeocrinoidea, Part II. Family Sphaeroidocrinidae, with the sub-families Platycrinidae, Rhodocrinidae and Actinocrinidae. Proc. Acad. Nat. Sci. Philadelphia, pp. 177-411, pls. xvii-xix.

____________________. 1885. Revision of the Palaeocrinoidea, Part II, Discussion of the Classification and relations of the Brachiate Crinoids, and conclusion of the generic descriptions. First Section. Proc. Acad. Nat. Sci. Philadelphia, pp. 225-364, pls. iv-ix.

____________________. 1886. Revision of the Palaeocrinoidea, Part III, Discussion of the Classification and relations of the Brachiate Crinoids, and conclusion of the generic descriptions. Second Section. Proc. Acad. Nat. Sci. Philadelphia, pp. 64-226.

____________________. 1889. Crotalocrinus, its Structure and Zoological Position. Proc. Acad. Nat. Sci. Philadelphia, pp. 364-390, pls. xix-xx.

Wachsmuth, C. and Springer, F. 1897. The North American Crinoidea Camerata. Harvard Coll. Mus. Comp. Zool. Mem., 21-22, pp. 1-897, pls. 1-83.

Wade, A. 1911. The Llandovery and Associated Rock of North-Eastern Montgomeryshire. Quart. Journ. Geol. Soc., lxvii, pp. 415-59, pls. xxxiii-xxxvi.

Walcott, C. D. 1884. Descriptions of New Species of Fossils from the Trenton Group of New York. 35th Rept. N.Y. St. Mus., pp. 207-14. 1 pl.

Weller, S. 1900. The Paleontology of the Niagara Limestone in the Chicago Area, The Crinoidea. Chicago Acad. Sci. Bull., 4, pp. 9-153, pls. 1-15.

Weller, S. and A. D. Davidson. 1896. Petalocrinus mirabilis (n. sp.) and a New American Fauna. Journ. Geol., iv, pp. 166-73, pls. vi, vii.

Whittard, W. F. 1931. The Geology of the Ordovician and Valentian Rocks of the Shelve Country, Shropshire. Proc. Geol. Assoc., 42, pp. 322-339.

____________. 1952. A Geology of South Shropshire. Proc. Geol. Assoc., 63, pp. 143-97.

Wilson, E. 1890. Fossil Types in the Bristol Museum. Geol. Mag. (3) vii, pp. 363-72, 411-16.

Woods, H. 1891. "Catalogue of the Type Fossils in the Woodwardian Museum, Cambridge". Cambridge.

Zenker, J. C. 1833. "Beiträge zur naturgeschichte der Urwelt". Vienna.

Zittel, K. A. von. 1895. "Grundzüge der Palaeontologie (Palaeozoologie)". München.

VII EXPLANATION OF PLATES

The Ordovician Crinoidea are figured on plates 1-11. They are arranged so that crinoids occurring in the Anglo-Welsh area are on plates 1-4, and crinoids occurring in the Scots-Irish area are on plates 5-11.

The Silurian Crinoidea are figured on plates 11-39. They are arranged as far as possible stratigraphically and biologically. Thus the Llandovery crinoids are on plate 12, the Wenlock Shale crinoids are on plates 13-15, the Wenlock Limestone crinoids are on plates 16-34 and the Ludlow crinoids are on plates 35-39.

PLATE 1

PLATE 1

Figs. 1-2.	Caleidocrinus turgidulus sp. nov. GSM 85917, X 2, holotype. Revultex impressions. Llanvirn, Carneddau Hill, Builth.	Page 17
Figs. 3-8.	Iocrinus shelvensis sp. nov. X 4 Revultex impressions. Llanvirn, near Lyde, Shropshire. 3, paratype, GSM 92146a, anterior view. 4, holotype, GSM 92145a, the arms. 5, paratype, GSM 92144, the stem. 6, paratype, GSM 92147, anal tube. 7-8, holotype, GSM 92145, posterior and anterior views of cup.	Page 12
Fig. 9.	Iocrinus whitteryi sp. nov. Holotype, BM E 49603, X 4. Revultex impression. Caradoc, Whittery Beds, East of Marrington Dingle, Chirbury.	Page 13


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x2


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x2


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x4


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x4


4
x4


9
x4


6
x4


7
x4


8
x4

PLATE 2

PLATE 2

Fig. 1.	*Merocrinus salopiae* Bather Holotype, BM E 14938, X 6. Revultex impression. Llandeilo, Meadowtown Beds, Mincop, Shropshire.	Page 28
Figs. 2-5.	*Iocrinus? cambriensis* (Hicks) Revultex impressions, X 2. Arenig, Porth Gain Beds. 2, syntype, SM A 16739, St. David's. Stem showing irregular thickness of columnals. 3, MM L 12360, Ramsay Island. 4, BM E 3, St. David's.	Page 15
Fig. 5.	Undetermined Heterocrinid GSM Pr 374, X 3. Revultex impression. Ashgill, Slade Beds, E. of Cnyciau Farm, Llandowror, Carmarthenshire.	Page 25
Fig. 6.	*Pandoracrinus* sp. nov. BM E 14939, X 6. Revultex impression. Llandeilo, Meadowtown Beds, Mincop, Shropshire.	Page 50

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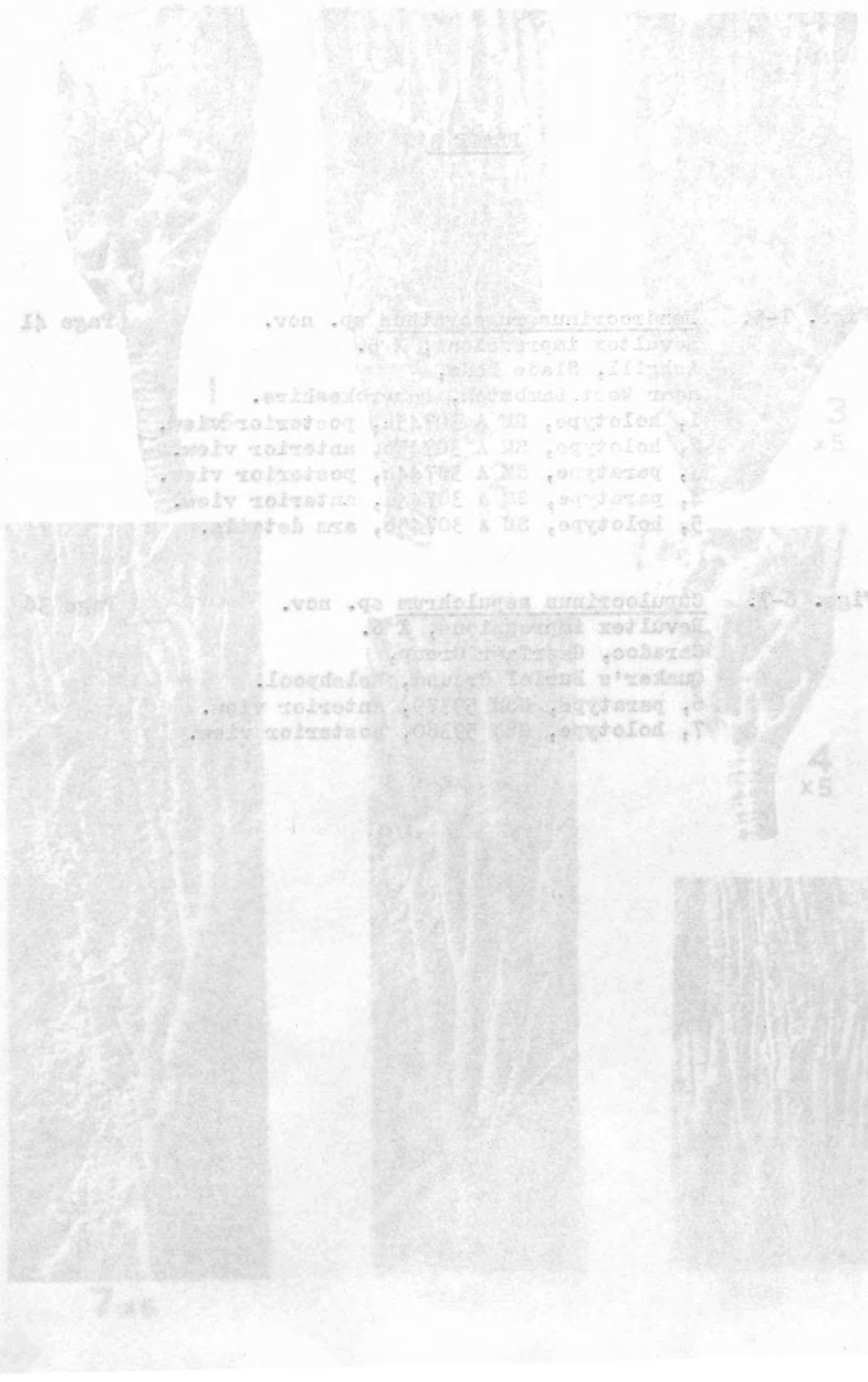
3 x2

4 x2

5 x3

6 x6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x5
4
x5
7 x6

PLATE 3

Figs. 1-5. Dendrocrinus rugocyathus sp. nov. Page 41
Revultex impressions, X 5.
Ashgill, Slade Beds,
near West Lambston, Pembrokeshire.
1, holotype, SM A 30745a, posterior view.
2, holotype, SM A 30745b, anterior view.
3, paratype, SM A 30744b, posterior view.
4, paratype, SM A 30744a, anterior view.
5, holotype, SM A 30745b, arm details.

Figs. 6-7. Cupulocrinus sepulchrum sp. nov. Page 36
Revultex impressions, X 6.
Caradoc, Gaerfawr Group,
Quaker's Burial Ground, Welshpool.
6, paratype, GSM 59379, anterior view.
7, holotype, GSM 59380, posterior view.

PLATE 3

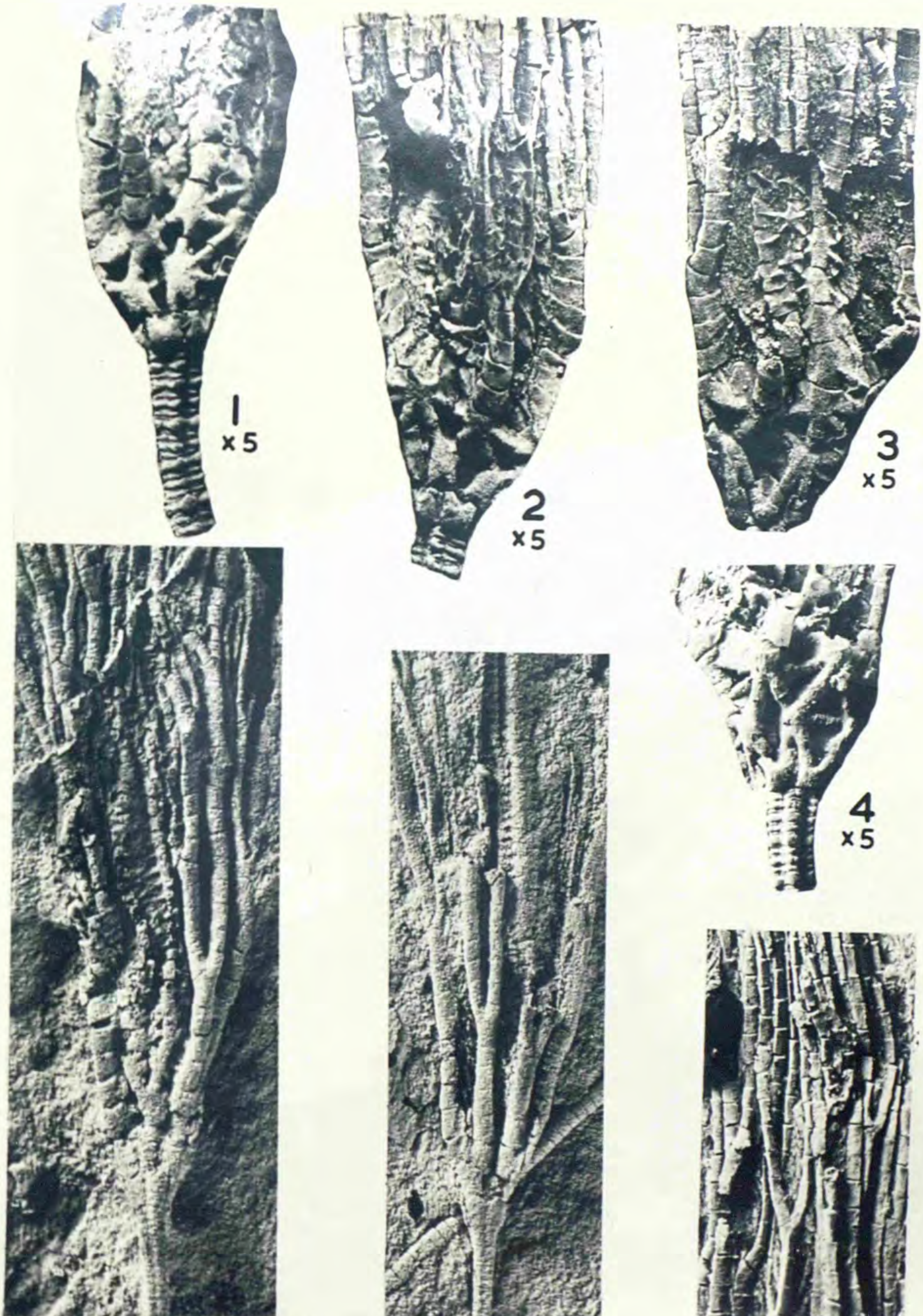


PLATE 4

PLATE 4

Figs. 1-7. <u>Balacrinus basalis</u> (M'Coy) Page 65

Caradoc.
1, GSM 7388a, Revultex impression, X 4.
2, GSM 7388b, Revultex impression, X 4, counterpart of fig. 1. Guilsfield, Meifod.
3, syntype, SM A 36530, X 4, internal mould. Alt-yr-Anker, Meifod, Montgomeryshire.
4, lectotype, SM A 36532a, X 4, internal mould, Alt-yr-Anker, Meifod, Montgomeryshire.
5, syntype, SM A 36529, X 4, internal mould. Alt-yr-Anker, Meifod, Montgomeryshire; this is the specimen figured by M'Coy, 1851.
6, GSM 85186, Revultex impression, X 4, the arms;
7, portion of the same specimen as fig. 6, enlarged to X 8. Pen-y-rhiw, W. of Bala.

In figs. 4 and 5 some of the sutures have been marked on the photograph in pencil.

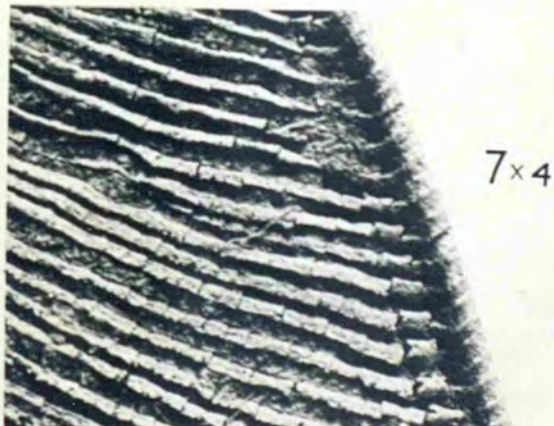
1×4

2×4

3×4

4×4

5×4



7×4

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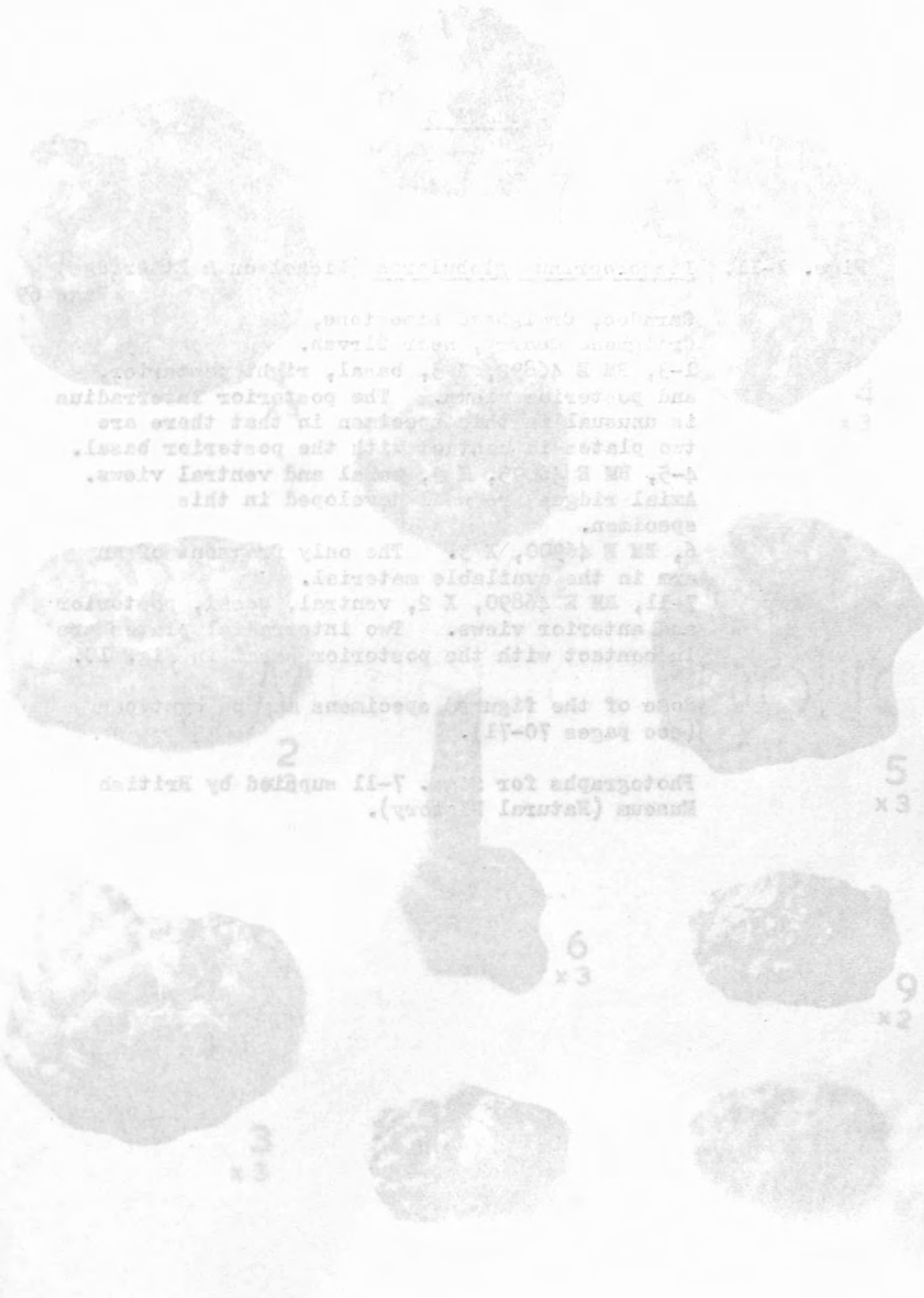
2
5
x 3
6
x 3
9
x 2
3
x 3

PLATE 5

Figs. 1-11. Diabolocrinus globularis (Nicholson & Etheridge)
Page 69

Caradoc, Craighead Limestone,
Craighead Quarry, near Girvan.
1-3, BM E 46892, X 3, basal, right posterior, and posterior views. The posterior interradius is unusual in this specimen in that there are two plates in contact with the posterior basal.
4-5, BM E 46895, X 3, basal and ventral views. Axial ridges are well developed in this specimen.
6, BM E 46900, X 3. The only fragment of an arm in the available material.
7-11, BM E 46890, X 2, ventral, basal, posterior and anterior views. Two interradial plates are in contact with the posterior basal in fig. 10.

Some of the figured specimens may be syntypes (see pages 70-71).

Photographs for figs. 7-11 suppied by British Museum (Natural History).

PLATE 5

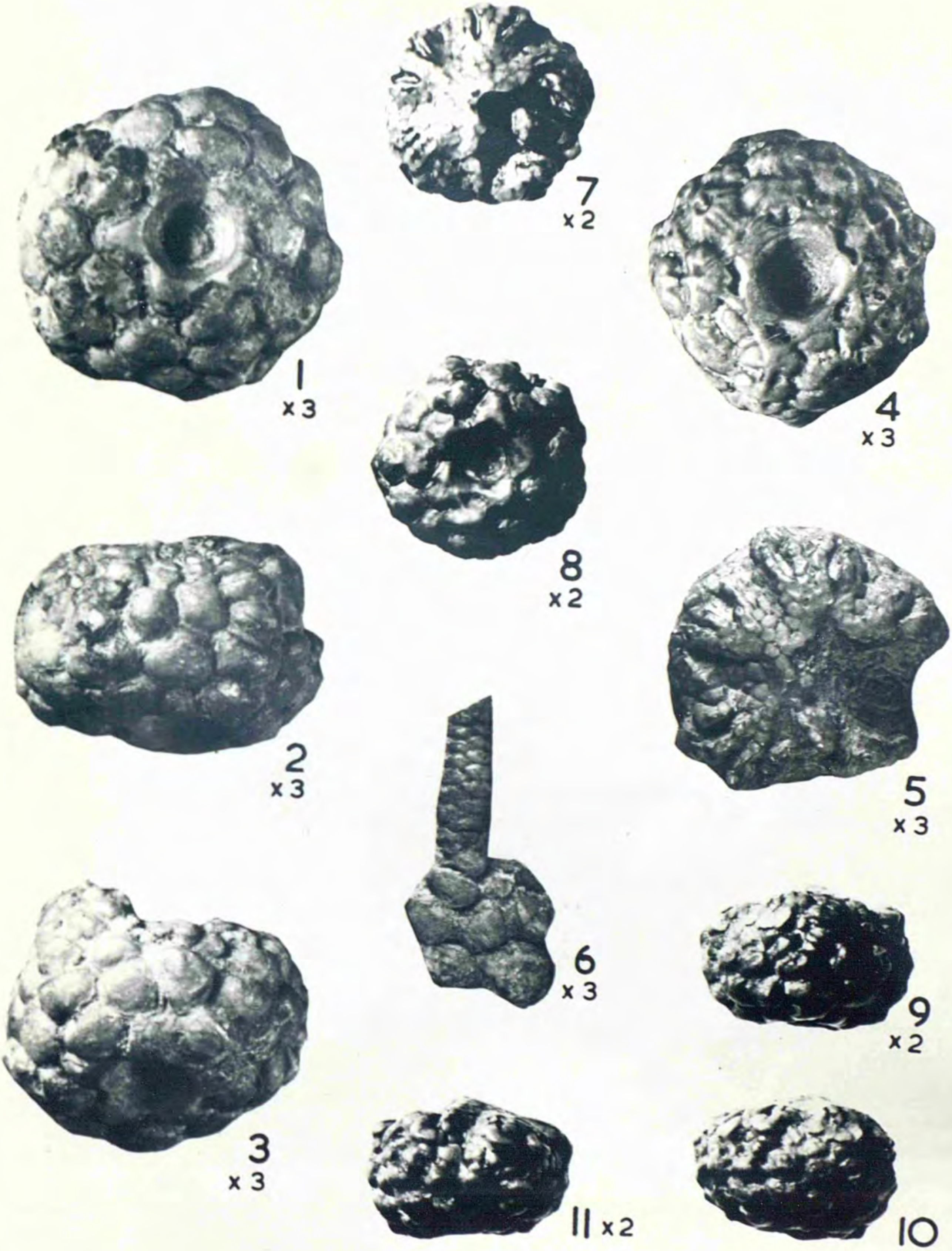

PLATE 6

PLATE 6

Fig. 1.	Diabolocrinus sp. HM E 3504, X $1\frac{1}{2}$. Ashgill, Starfish Bed, Thraive Glen, near Girvan.	Page 71
Figs. 2-5.	Archaeocrinus elevatus sp. nov. Llandeilo, Minuntion, near Girvan. 2, syntype, HM E 3488e, X $1\frac{1}{2}$. 3, syntype, HM E 3487a, X $1\frac{1}{2}$. 4, syntype, HM E 3488a, X $1\frac{1}{2}$. 5, syntype, HM E 3615, X $1\frac{1}{2}$. In figs. 2 and 4 the sutures have been marked on the specimen in pencil.	Page 62
Figs. 6-10	Diabolocrinus craigheadensis sp. nov. Caradoc, Craighead Limestone, Craighead Quarry, near Girvan. 6, paratype, BM E 46909, interior side view of basal concavity, X $1\frac{1}{2}$. 7, 8, paratype, BM E 46906, X $1\frac{1}{2}$, fig. 7 has been tilted to show the side view. 9, 10, holotype, BM E 46905, X $1\frac{1}{2}$, fig. 9 has been tilted to show the side view.	Page 67a

PLATE 6

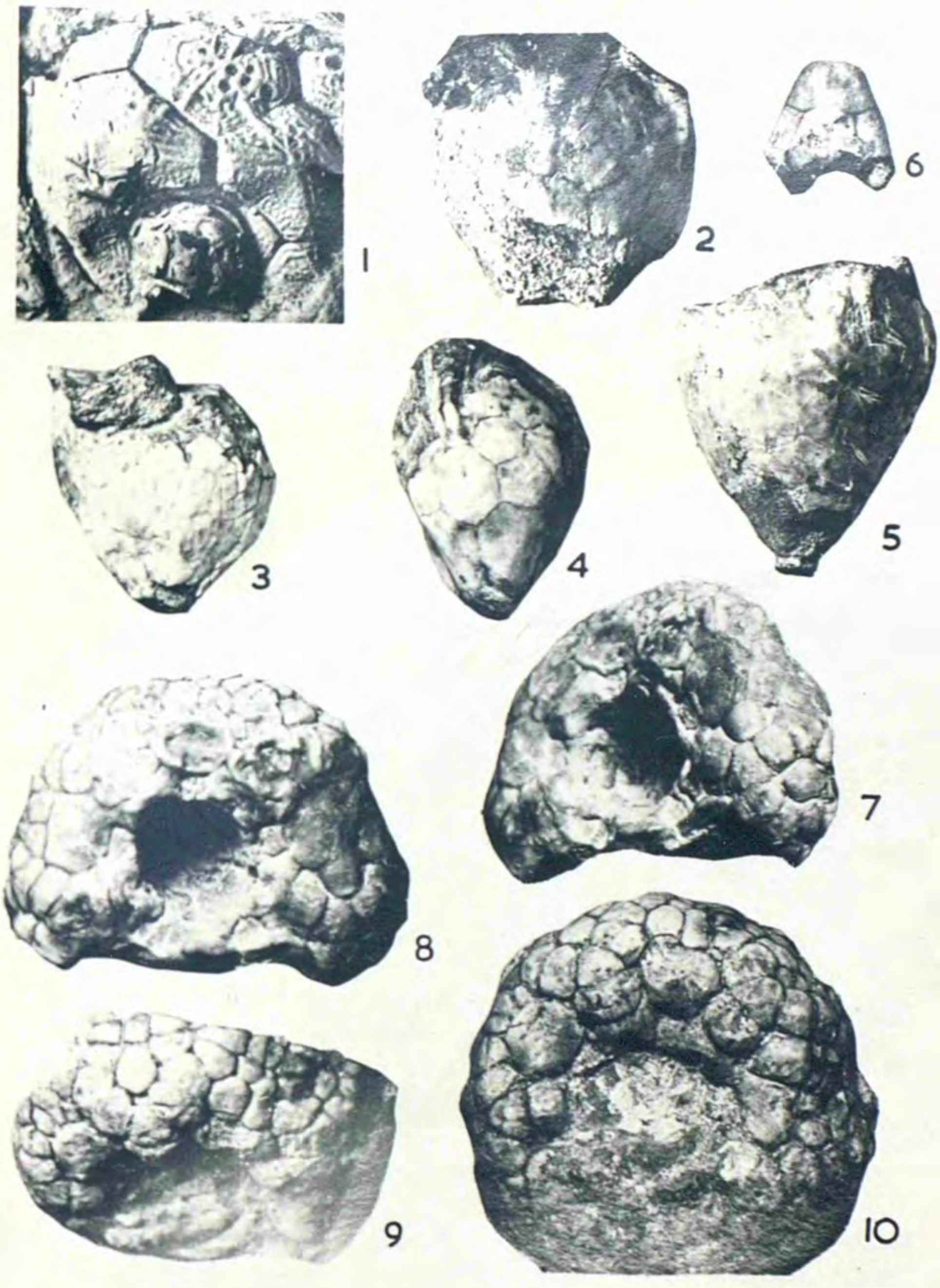

PLATE 7

PLATE 7

Figs. 1-8. Macrostylocrinus cirrifer sp. nov. Page 53

Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
1, paratype, HM E 3588, X 4, basal view, internal mould.
2-4, holotype, HM E 3585a, X 4, internal mould; right posterior, posterior and ventral views.
5, paratype, HM E 3599, X 3, external mould of crown showing cirri on stem.
6, HM E 3492, X 3, external mould of stem showing cirri.
7, paratype, HM E 3584, X 4, lateral view.
8, paratype, JW 1857, X 4, Revultex impression, to show external ornament.

PLATE 7

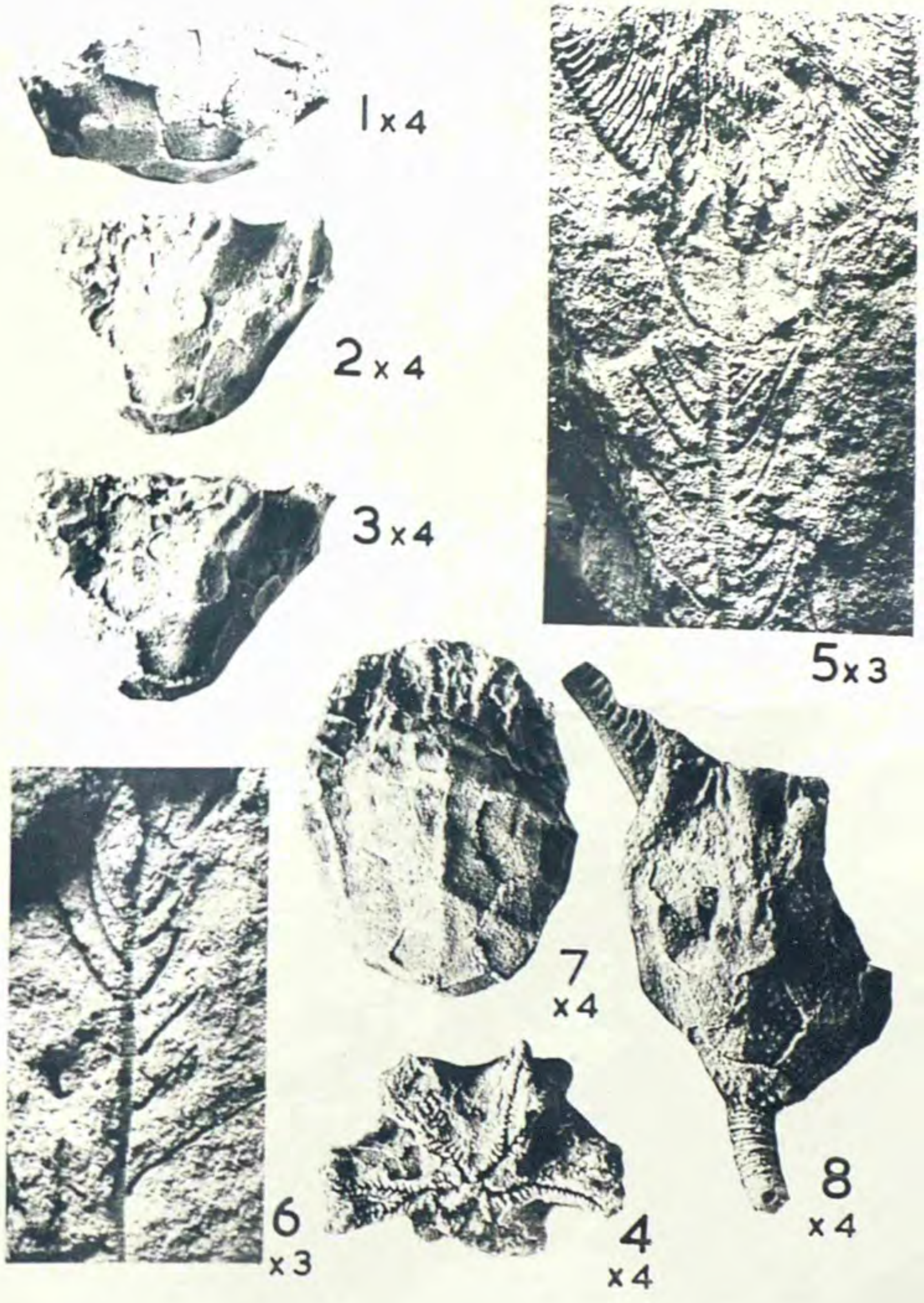

PLATE 8

PLATE 8

Figs. 1-8. Anulocrinus thraivensis sp. nov. Page 22

Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
Revultex impressions, X 4.

1, syntype, BM E 47325a, parts of the anterior and left anterior arms.
2, syntype, BM E 47322a, anterior view of crown showing also the stem.
3, syntype, BM E 47310, left anterior view of cup and proximal parts of the arms.
4, syntype, BM E 47323, left anterior view of crown.
5, syntype, BM E 47319b, right posterior view, showing parts of the on either side of the anal tube.
6, syntype, HM E 3581, left posterior view.
7, syntype, BM E 47325b, counterpart to fig. 1.
8, syntype, HM E 3524, shows the shape of the anal plate.

Figs. 9-10. Anulocrinus drummuckensis sp. nov. Page 23

Ashgill, Starfish Bed,
Thraive, near Girvan.
Revultex impressions, X 4.

9, holotype, HM E 3508b, left posterior view.
10, holotype, HM E 3508a, counterpart to fig. 9; shows the anterior and right anterior arms.

PLATE 8

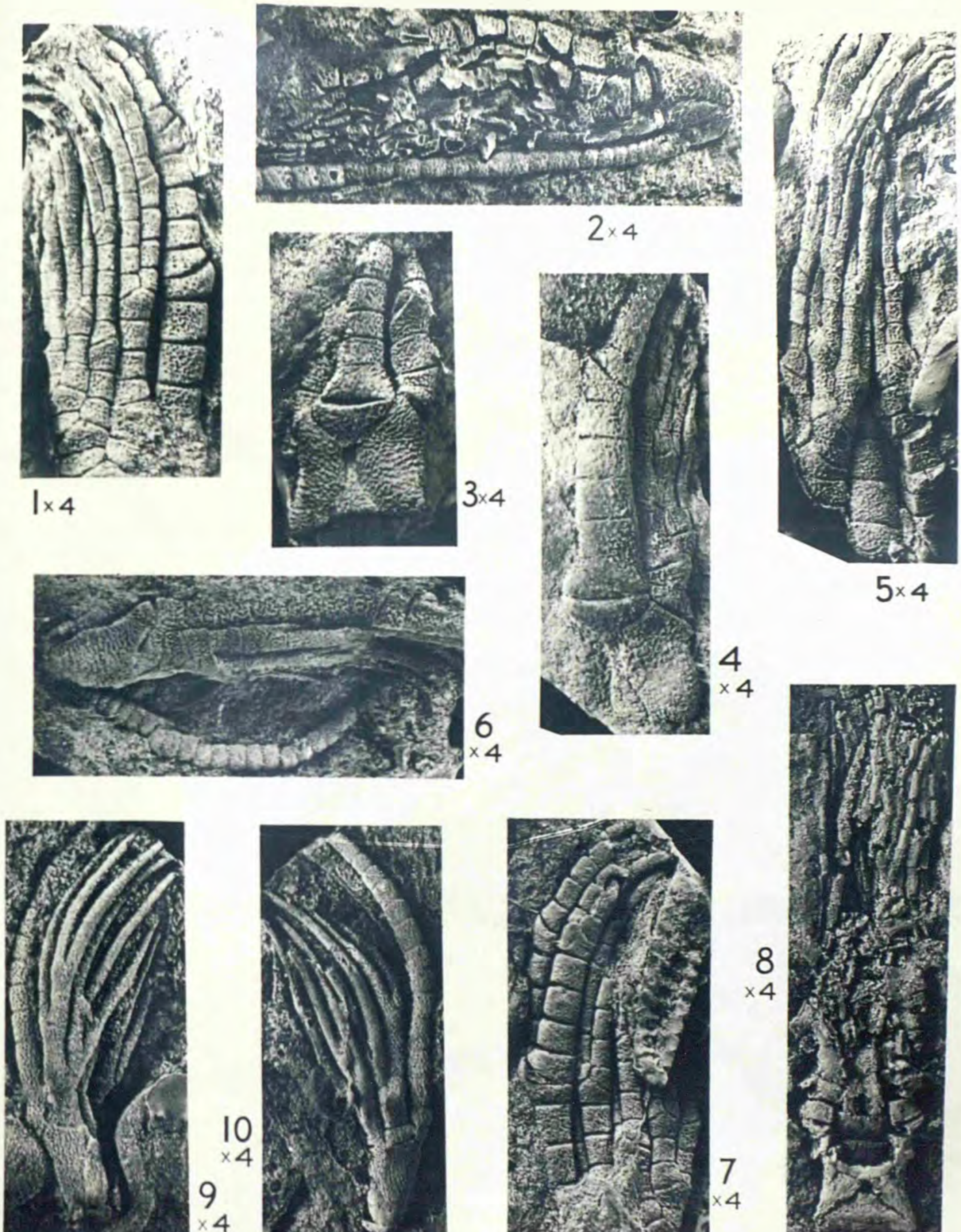

PLATE 9

Figs. 1-5. Cupulocrinus heterobrachialis sp. nov. Page 32
Revultex impressions.
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
1, holotype, HM E 3614a, X 3, right anterior view; 2, the same, X 6.
3, paratype, HM E 3484, X 3.
4, paratype, JW 1850, X 6, posterior view.
5, paratype, HM E 3485, X 6, posterior view.

Figs. 6-7. Cupulocrinus gracilis sp. nov. Page 34
Revultex impressions.
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
Holotype, BM E 47313a and b, X 4, anterior and posterior views.

Fig. 8. Trochocrinites laevis Portlock Page 73
Holotype, GSM 7379, X 1, internal mould.
Caradoc, Desertcreight, Tyrone.

PLATE 9

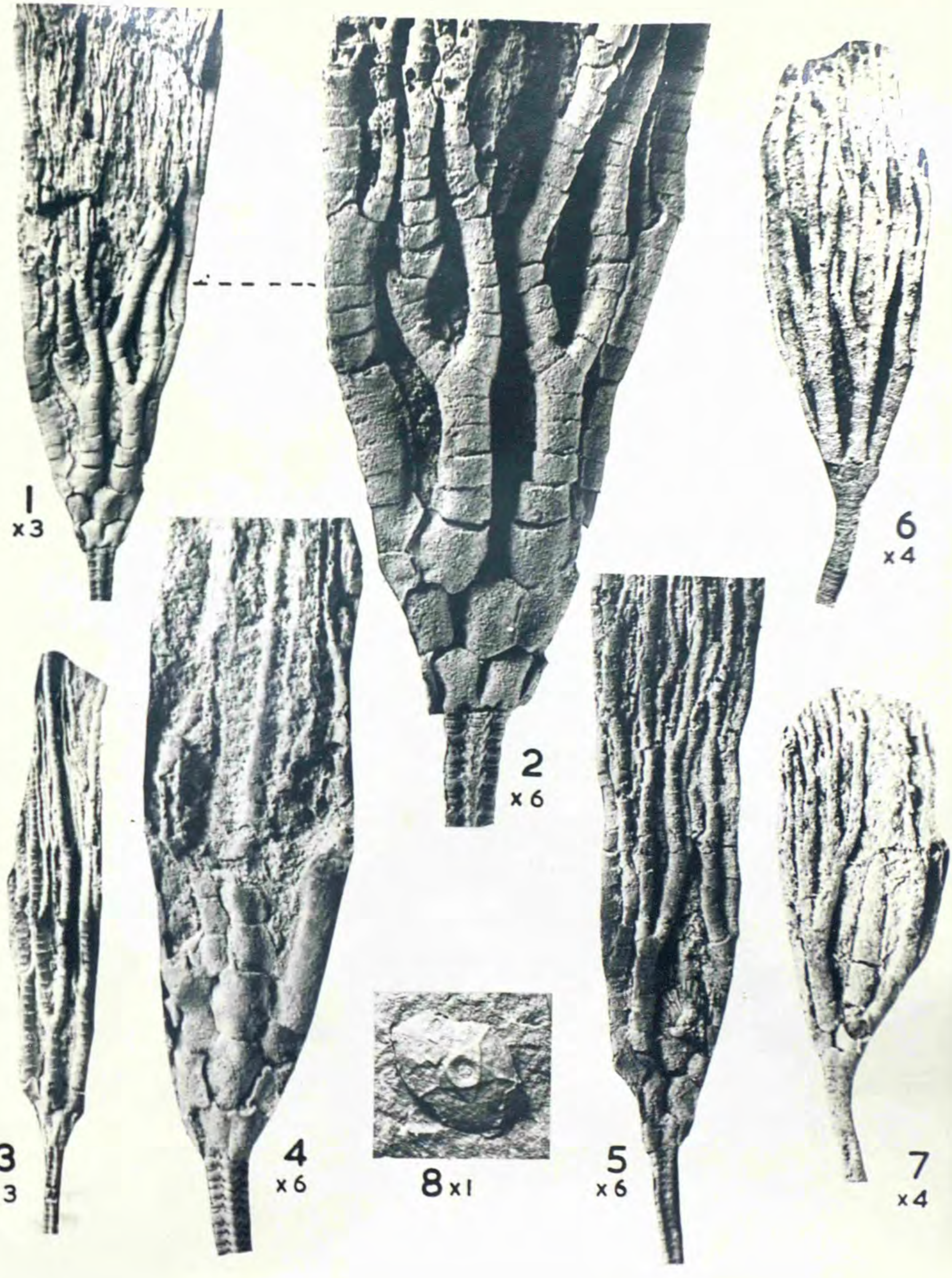

PLATE 10

PLATE 10

Figs. 1-4. *Xenocrinus multiramus* sp. nov. Page 57
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
Revultex impressions, X 4.
1, paratype, BM E 47320b.
2, holotype, BM E 47328a, posterior view.
3, holotype, BM E 47328b, counterpart of fig. 2.
4, paratype, BM E 47329, a young specimen seen from the posterior side.

Fig. 5. *Euspirocrinus girvanensis* sp. nov. Page 44
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
Holotype, HM E 3499, internal mould, posterior view.

Fig. 6. *Protaxocrinus* sp. Page 51
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
HM E 3606, X 2, Revultex impression.

Fig. 7. Undetermined Heterocrinid Page 25
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
HM E 3613, Revultex impression, X 4.

Fig. 8. *Porocrinus scoticus* sp. nov. Page 47
Ashgill, Starfish Bed.
Thraive Glen, near Girvan.
Holotype, HM E 3419, Revultex impression, X 3.

PLATE 10

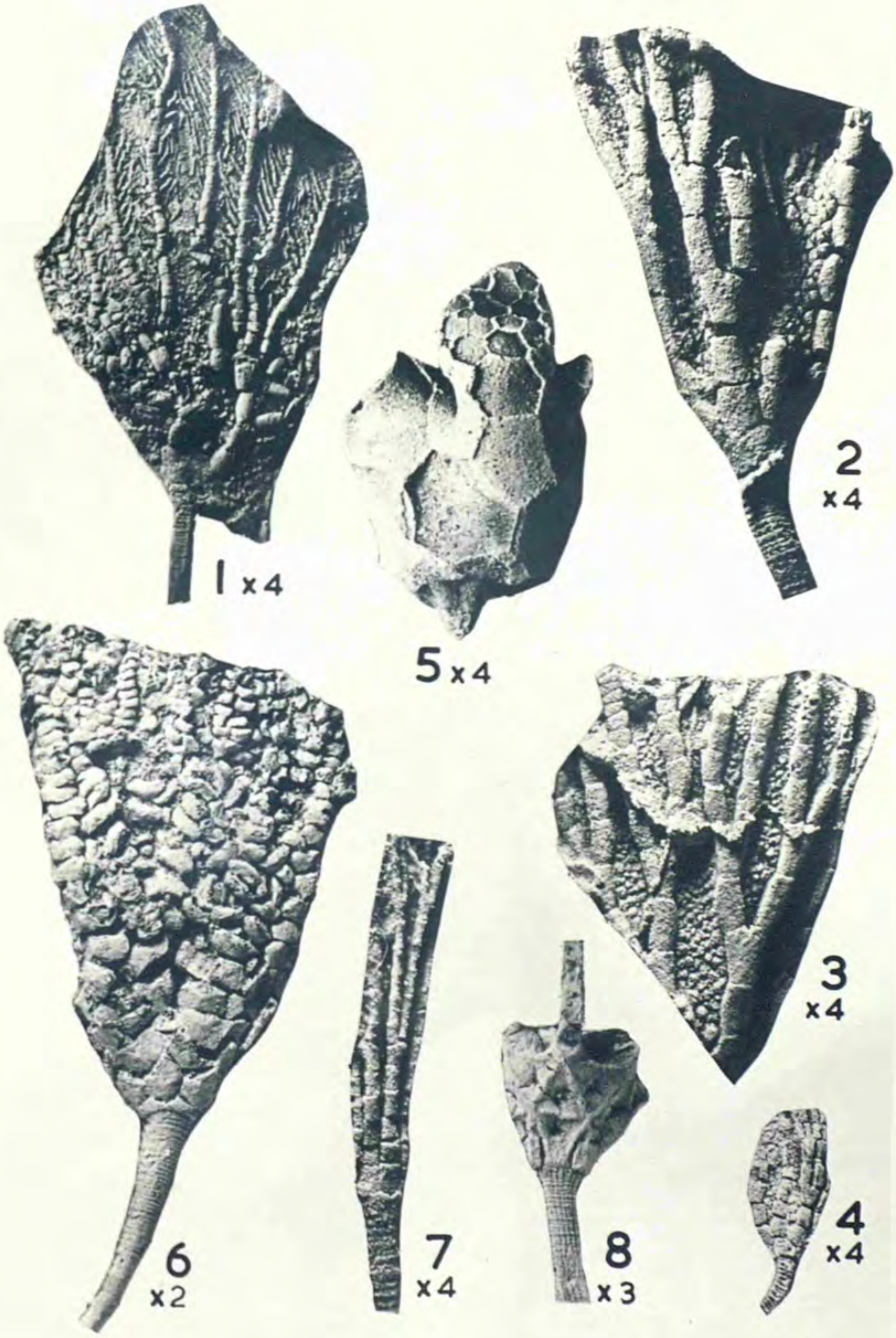

PLATE 11

PLATE 11

Figs. 1-7. *Dendrocrinus granditubus* sp. nov. Page 39
Ashgill, Starfish Bed,
Thraive Glen, near Girvan.
Revultex impressions, X 3.
1, holotype, BM E 47332a, posterior view.
2, paratype, HM E 3603, anterior view.
3, holotype, BM E 47332b, anterior view.
4, paratype, HM E 3509, posterior view.
5, paratype, HM E 3518, posterior view.
6, paratype, HM E 3605, posterior view.
7, paratype, HM E 3516, posterior view.

1 x3

2 x3

3 x3

4 x3

5 x3

6 x3

7 x3

PLATE 12

PLATE 12

Figs. 1-4. <u>Petalocrinus bifidus</u> sp. nov. Page 139
Upper Llandovery, Woolhope.
1, paratype, GSM 69866a, X 8, showing covering plates <u>in situ</u>.
2, paratype, BM E 49625, X 3; the only specimen showing the cup.
3, GSM 69866b, X 3, paratype.
4, holotype, SM A 40892, X 2, one side of the fan is divided again.

Fig. 5. <u>Dimerocrinites</u> sp. nov. B Page 251
Lower Llandovery, gasworks, Haverfordwest.
SM A 32803b, X 2, internal mould.

Fig. 6. <u>Dimerocrinites</u> sp. nov. A Page 250
Lower Llandovery, Mulloch Hill, Girvan.
GSM 92136, X 2, Revultex impression.

Fig. 7. <u>Hapalocrinus dameryi</u> sp. nov. Page 234
Upper Llandovery, Damery Beds, Tortworth.
Holotype, Revultex impression, X $1\frac{1}{2}$;
Specimen in collection of B.K. Ellis.

Figs. 8-9. <u>Macrostylocrinus</u> sp. Page 207
Lower Llandovery, gasworks, Haverfordwest.
SM A 32802, X 2, lateral and basal views.

Figs. 10-13. Undetermined crinoid stems. Page 264
Upper Llandovery, Newlands, near Girvan.
Revultex impressions, X 2. 10, BM E 49741a;
11, BM E 49739a; 12, BM E 49740a;
13, BM E 49739b.

PLATE 12

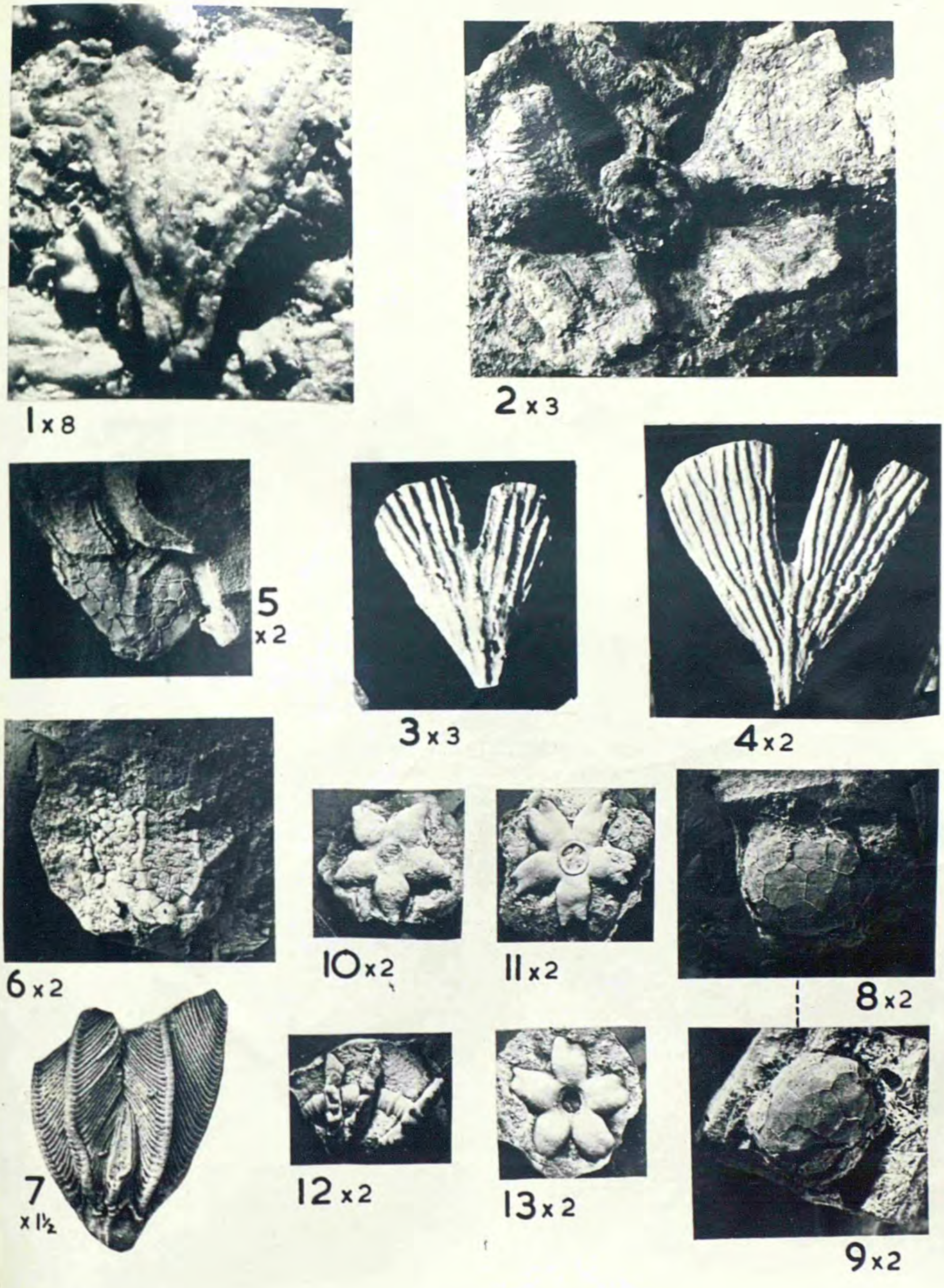

PLATE 13

PLATE 13

Figs. 1-4. Eucalyptocrinites granulatus (Lewis) Page 212
Wenlock Shale, Walsall.
1-3, BM 40256, X $1\frac{1}{2}$, two lateral views and basal view.
4, BM 40255, X $1\frac{1}{2}$.

Fig. 5. Myelodactylus cf. fletcheri (Salter) Page 82
Wenlock? Shale, Sedgley, Staffs.
BUH 551, X 3.

PLATE 13

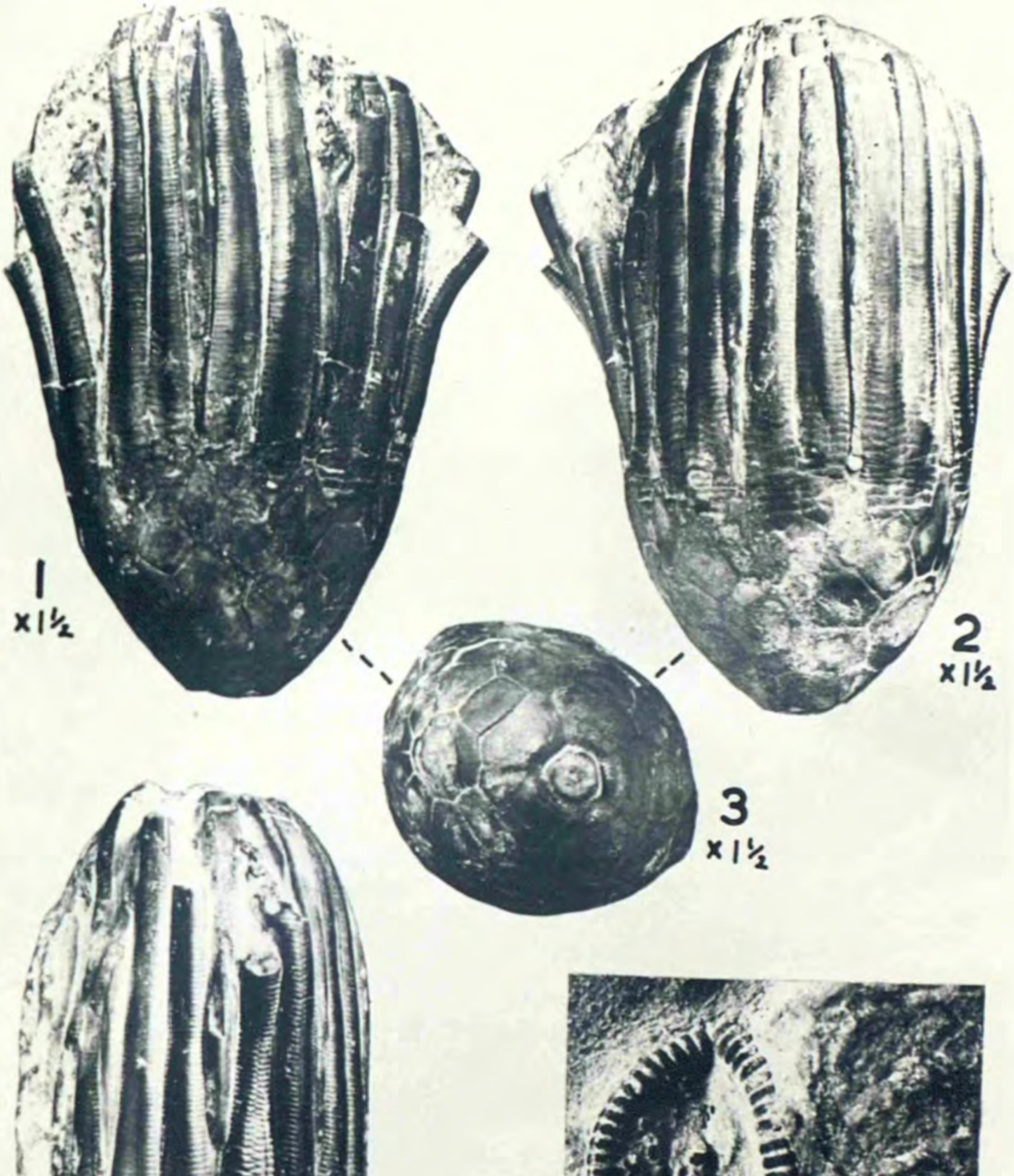

PLATE 14

PLATE 14

Figs. 1-7. Gissocrinus crassus Bouška — Page 118

Wenlock? Shale, Sedgley, Staffs.

X $1\frac{1}{2}$.

1, BUH 280.
2, BUH 228, a young specimen.
3, BUH 227.
4, BUH 272.
5, BUH 237.
6, BUH 231.
7, BUH 94.

PLATE 14

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PLATE 15

PLATE 15

Fig. 1.	Pisocrinus pilula de Koninck Wenlock? Shales, Sedgley, Staffs. BUH 262, X 3.	Page 90
Fig. 2.	Gnorimocrinus sedgleyensis sp. nov. Wenlock? Shales, Sedgley, Staffs. Holotype, BUH 188, X 3.	Page 172
Fig. 3.	Dendrocrinus brevis sp. nov. Wenlock? Shales, Sedgley, Staffs. Holotype, BUH 347, X 3.	Page 154
Figs. 4-6.	Cordylocrinus rugobrachialis sp. nov. Wenlock Shale. 4-5, holotype, BM E 418, X 3, basal and lateral views. Wren's Nest, Dudley. 6, paratype, SM A 12752, X 6. Stated on label to be from the Wenlock Limestone, Dudley, but here believed to be from the Wenlock Shale (see page 226).	Page 226

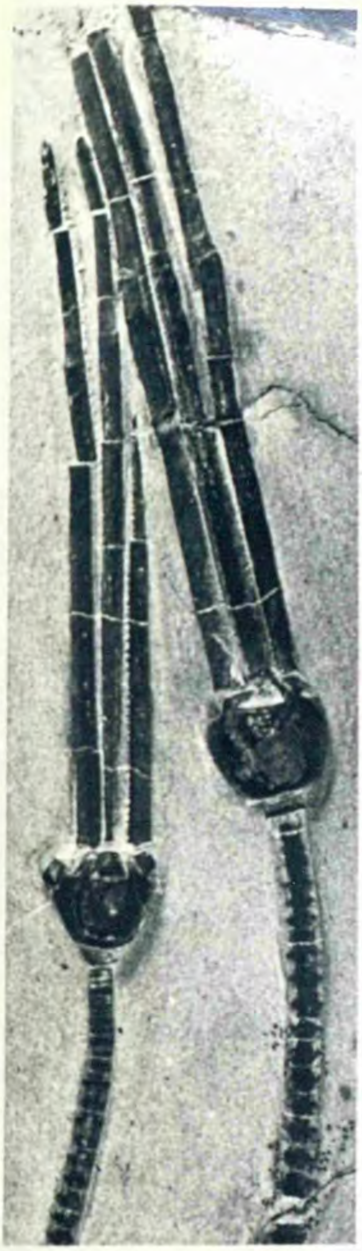

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PLATE 16

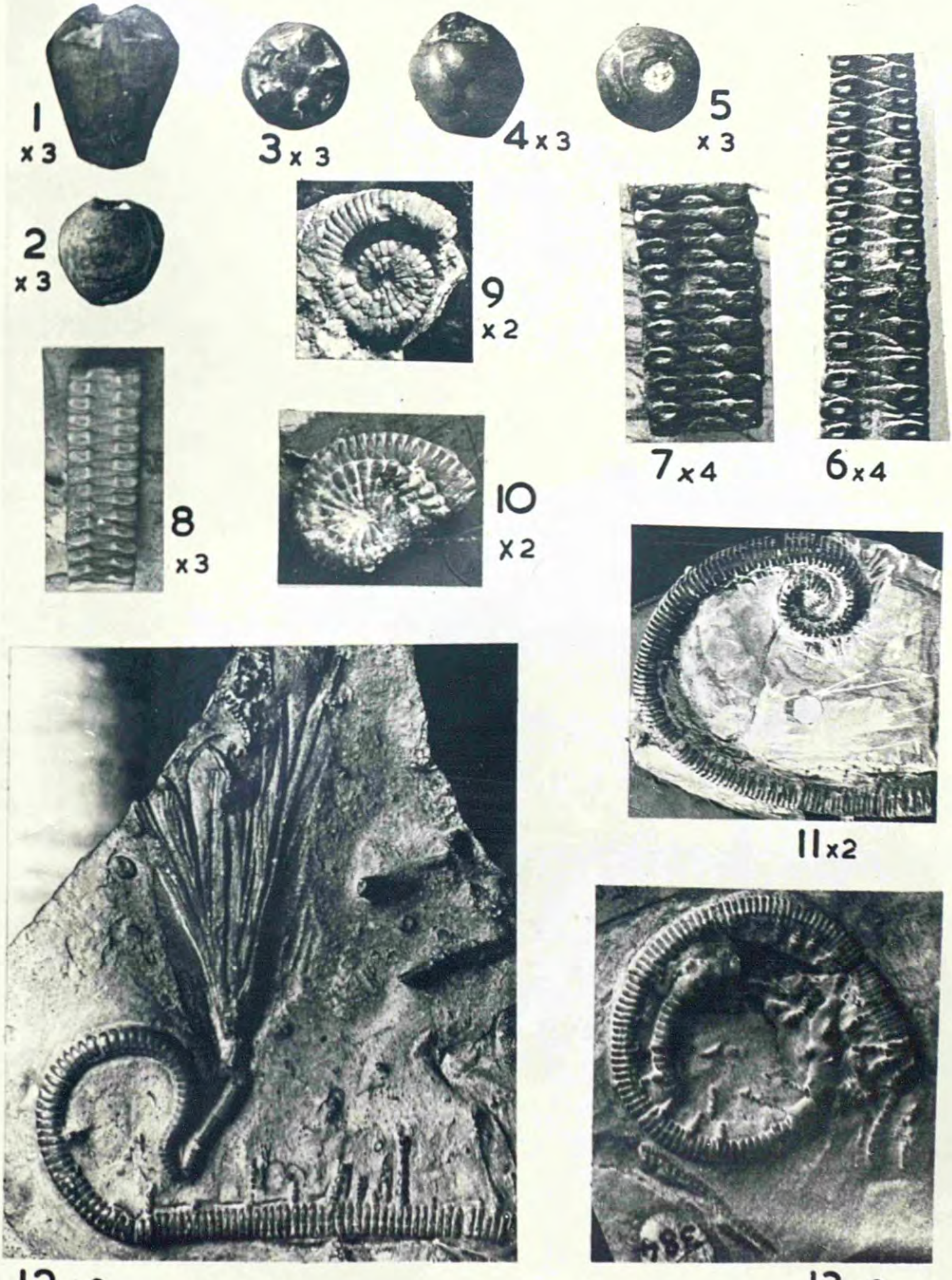
PLATE 16

Figs. 1-5. Pisocrinus pilula de Koninck Page 90
Wenlock Limestone, Dudley.
1, BM E 22600, X 3, the conical form, left posterior view.
2, GSM 89650, X 3, left posterior view.
3, GSM 89650, X 3, ventral view.
4, GSM 89648, X 3, right anterior view.
5, GSM 89648, X 3, basal view.

Figs. 6-10. Myelodactylus ammonis (Bather) Page 84
Wenlock Limestone.
6, syntype, BM E 1410a, alternicirrus variety, Dudley, X 4.
7, syntype, BM E 1410b, bijugicirrus variety, Dudley, X 4.
8, SM A 12625, X 3, alternicirrus variety, Dudley.
9, GSM Pl 3684, X 2, old quarries, 100 yards S. of Brawn's Works canal bridge, Daw End, Walsall.
10, SM A 12614, X 2, Dudley. Formerly a syntype of M. fletcheri.

Fig. 11. Myelodactylus ammonis var. extensus Springer
Wenlock Limestone, Dudley. Page 85
BM E 22563, X 2.

Figs. 12-13. Myelodactylus fletcheri (Salter) Page 82
Wenlock Limestone, Dudley.
12, lectotype, SM A 12609, X 2.
13, syntype, SM A 12611, X 2.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8 x 3
9 x 2
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12 x 2
13 x 2

PLATE 17

PLATE 17

Figs. 1-2. *Thenarocrinus callipygus* Bather — Page 157
Wenlock Limestone, Dudley.
1, syntype, BM 57478b, X 1, shows anal tube.
2, lectotype, BM 57478a, X $1\frac{1}{4}$.

Figs. 3-4. *Cyathocrinites* sp. nov. — Page 105
Wenlock Limestone, Dudley.
BM 40041, X $1\frac{1}{2}$, lateral and basal views.

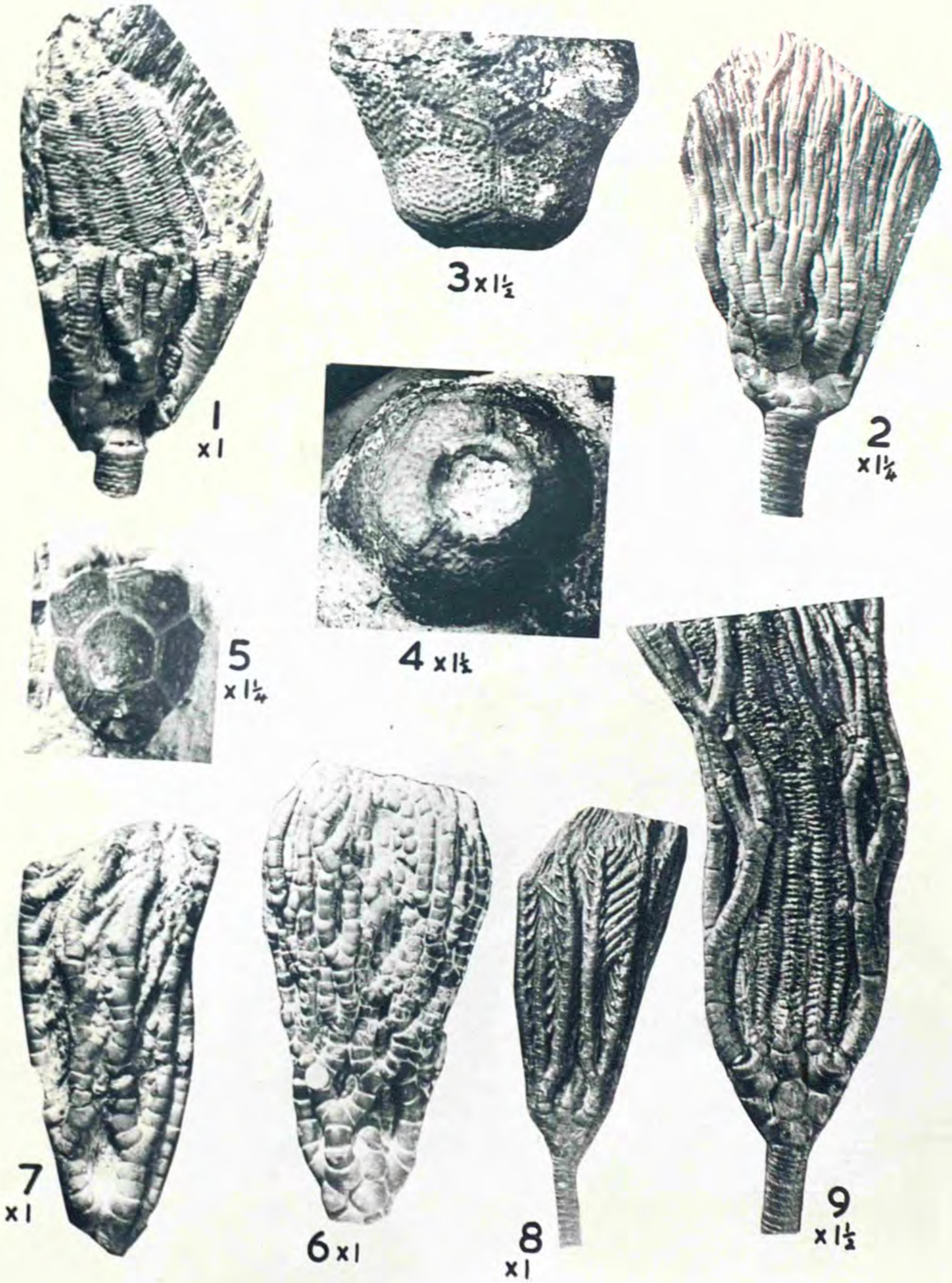
Fig. 5. *Cyathocrinites vallatus* (Bather) — Page 104
Wenlock Limestone, Dudley.
Lectotype, BUK 170, X $1\frac{1}{4}$.

Fig. 6. *Cyathocrinites acinotubus* (Angelin) — Page 103
Wenlock Limestone, Dudley.
BM E 1450, X 1, posterior view.

Fig. 7. *Botryocrinus ramosus* Bather — Page 144
Wenlock Limestone, Dudley.
Holotype, BM 57217, X 1.

Fig. 8. *Dictenocrinus decadactylus* (Bather) — Page 147
Wenlock Limestone, Dudley.
Lectotype, BM E 1419, X 1, posterior view.

Fig. 9. *Mastigocrinus loreus* Bather — Page 150
Wenlock Limestone, Dudley.
Lectotype, BM 57048, X $1\frac{1}{2}$, posterior view.


1
x1
3 x 1½
2
x 1¼
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5
x 1¼
7
x1
6 x1
8
x1
9
x 1½

PLATE 18

PLATE 18

Figs. 1-2. *Gissocrinus arthriticus* (Phillips) Page 107
Wenlock Limestone, Dudley.
1, BM 57420, X 1, dorsal,view of crown.
2, GSM 85586, X 2, details of brachials.

Figs. 3-6. *Gissocrinus goniodactylus* (Phillips) Page 113
Wenlock Limestone, Dudley.
3, lectotype, in the Northampton Museum, reproduced from Phillips, 1839, pl. 17, fig. 1.
4, BM 57481, X 1, anterior view of crown.
5, BM E 6375, X 4, details of brachials.
6, BM E 6375, X 1, shows anal tube.

Fig. 7. *Gissocrinus goniodactylus* (Phillips) var. Page 114
Wenlock Limestone, Dudley.
SM A 10169, X 1. This is "*Cyathocrinus* sp. 1" of Salter, 1873.

PLATE 18

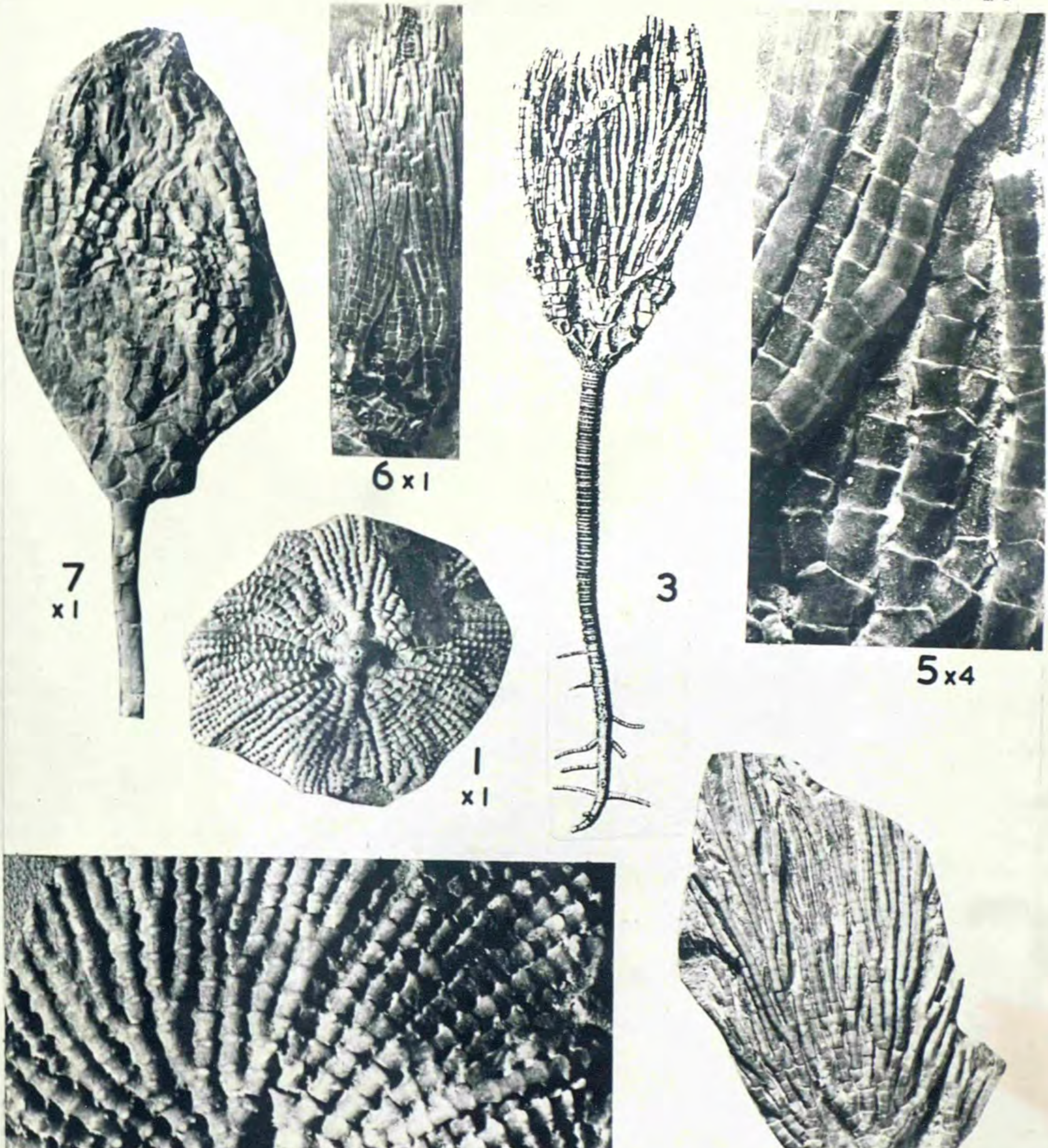

PLATE 19

PLATE 19

Figs. 1-4. Gissocrinus squamiferus (Salter) Page 115

Wenlock Limestone, Dudley.
1, BUH 28, X 2, portion of anal tube.
2, BM E 420, X 2, posterior side of cup.
3, lectotype, SM A 10138, X 1, basal view of splayed out crown, cup damaged at base.
4, BM 40337, X 1, side view.

Figs. 5-8. Gissocrinus luculentus Ramsbottom Page 120

5, paratype, BM E 6370, X 2, details of brachials; Wenlock Limestone, Dudley.
6, paratype, BM 57280, X 2, distal part of anal tube; Wenlock Limestone, Dudley.
7, BM 38689, X 1, Wenlock Limestone, Walsall.
8, holotype, BM E 45528, X 1, Wenlock Limestone, Dudley.

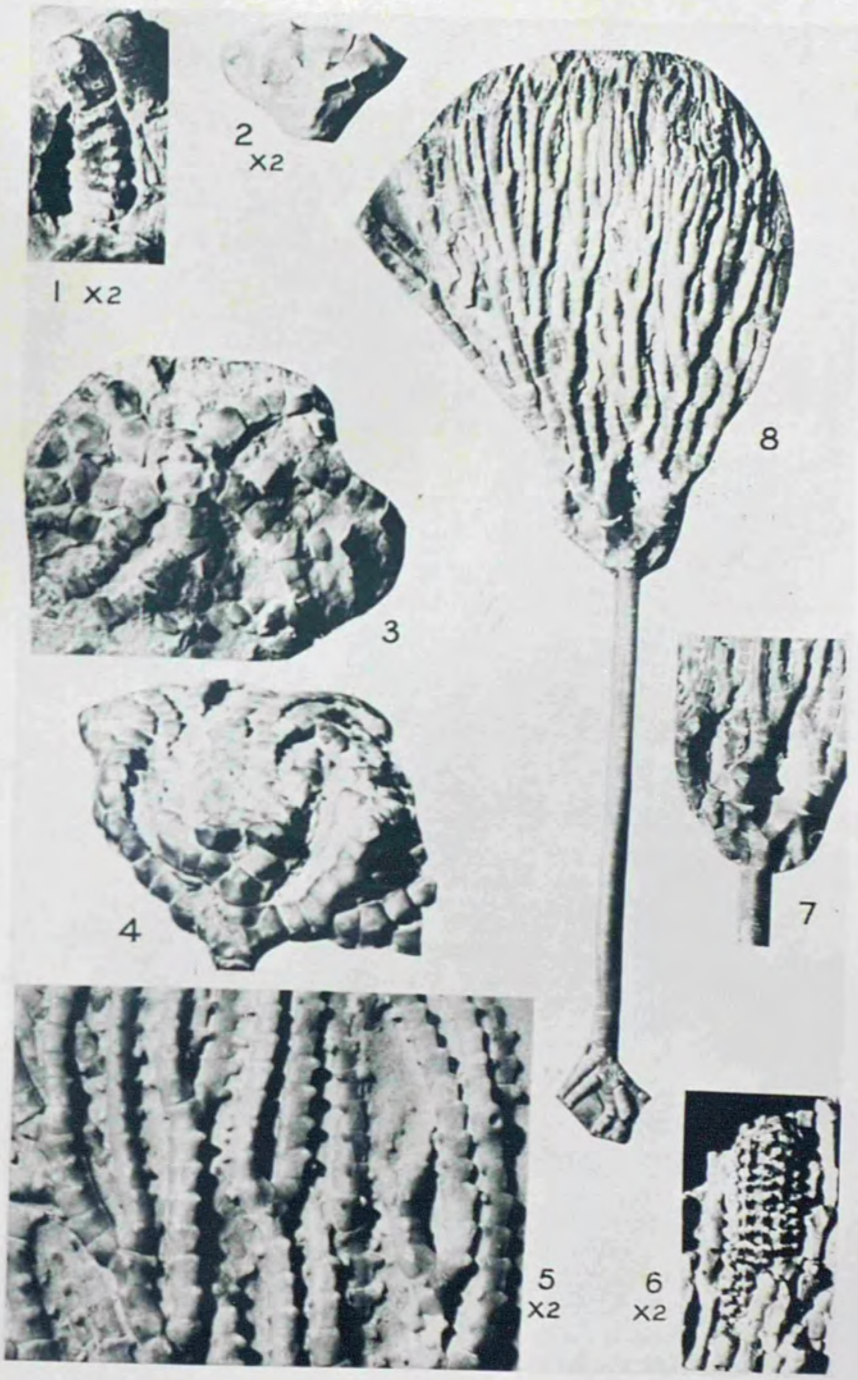
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PLATE 20

Plate 20

Figs. 1-6. Gissocrinus capillaris (Phillips) Page 109
Wenlock Limestone, Dudley.
1, SM A 12899, X 2, posterior view.
2, BM 57246, X 2, the largest crown seen.
3, BM E 22602, X 1.
4, BM E 22602, X 4, portion of tube.
5, BM E 22602, X 4, portion of arms to show details of the brachials.
6, lectotype, reproduced from Phillips, 1839, pl. 17, fig. 2, specimen untraced.

Fig. 7. Gissocrinus scoparius (Salter) Page 111
Wenlock Limestone, Dudley.
Holotype, SM A 10168, X 1.

Fig. 8. Gissocrinus cf. scoparius (Salter) Page.112
Wenlock Limestone, Dudley.
GSM 89673, X 2.

PLATE 20

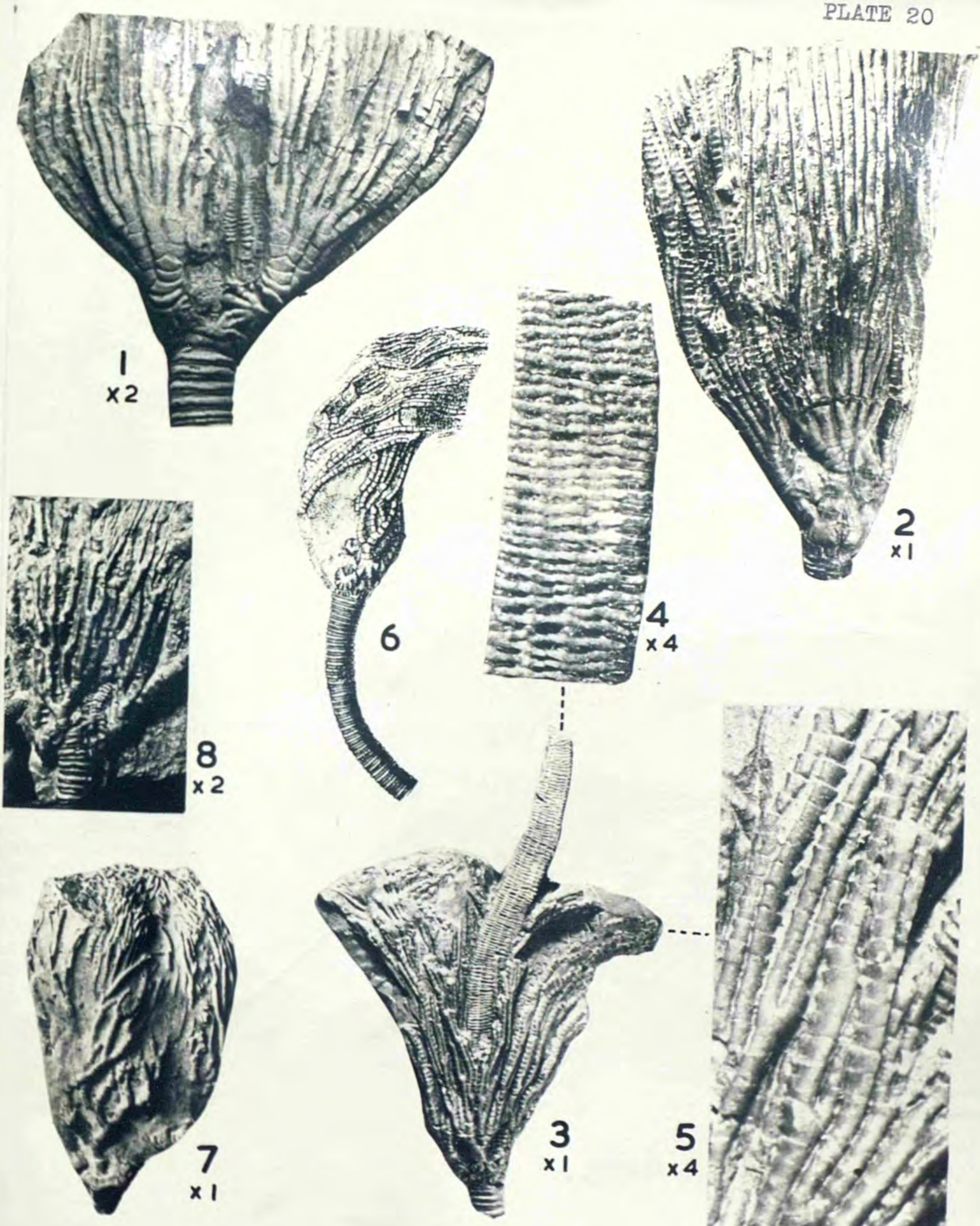


PLATE 21

PLATE 21

Figs. 1-11. Crotalocrinites verucosus (Schlotheim) Page 125

Wenlock Limestone; Dudley (except fig. 11).

1, BM 40206, X 1, showing the complete crown.

2, SM A 12958, X 6, dorsal side of the arms.

3, BUH 201, X 6, ventral side of arms.

4, BM E 45557, X $1\frac{1}{2}$; tegmen of a young specimen.

5, GSM 89637, X 2; shows the facet in the young.

6, BM E 45549, X $1\frac{1}{2}$; the interior of the radial; this is type b, see page 129.

7, BM E 45550, X $1\frac{1}{2}$; the interior of the radial, type a, see page 129.

8, SM A 12937, X 1, part of the tegmen of a large specimen.

9, SM A 12945, X $1\frac{1}{2}$, tegmen of an average size specimen.

10, SM A 12945, X 1; same specimen as in fig. 9, viewed from the side.

11, GSM 25544, X 1; this shows the small proximal brachials on top of the ~~arm facets~~ radial and underneath the ~~radial~~ facets. Rock Farm, May Hill.

Figs. 12-16. Enallocrinus scriptus (Hisinger) Page 135

Wenlock Limestone, Dudley.

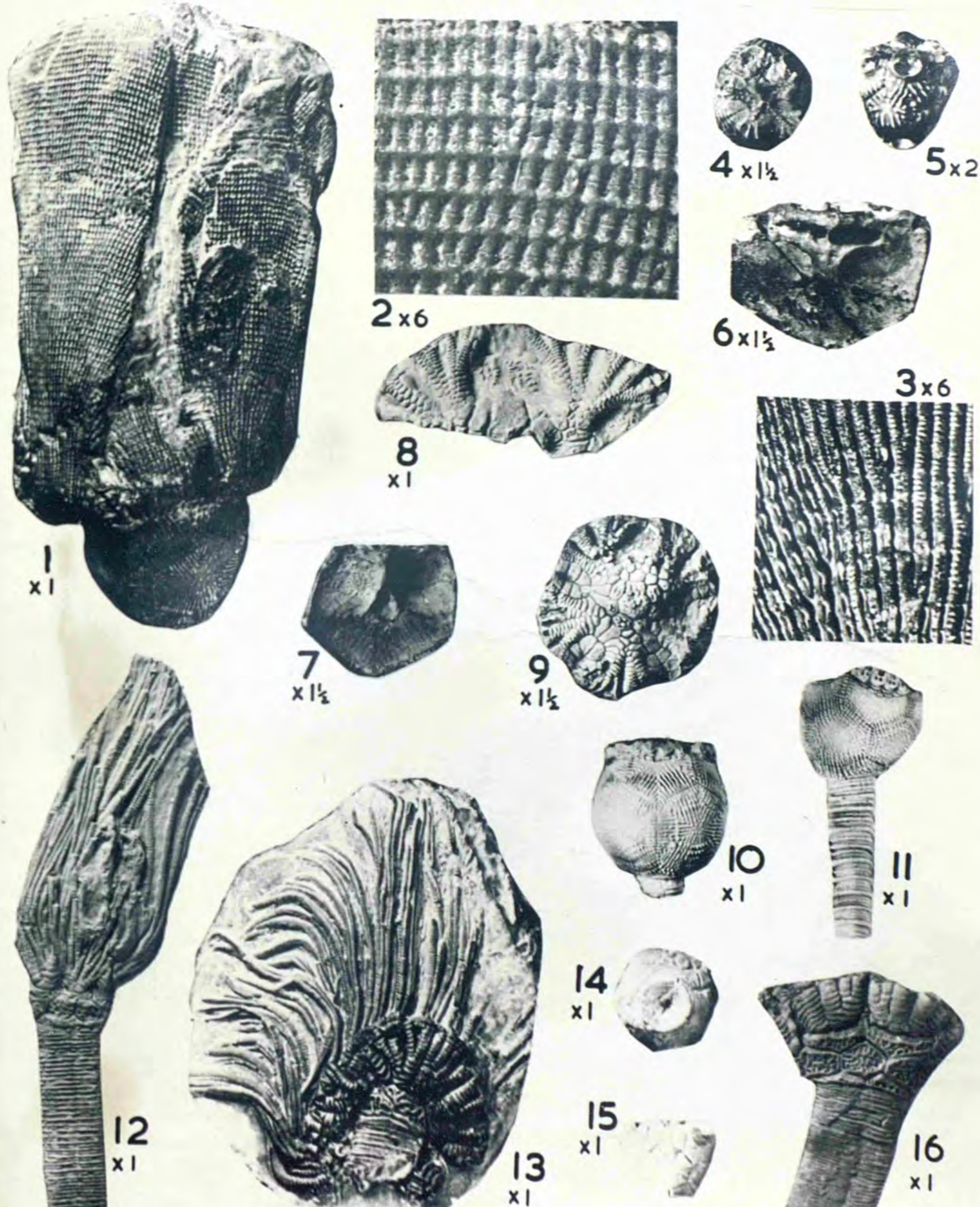
12, DM 512, X 1.

13, BM 57479, X 1.

14, 15, BM 57110, X 1, basal and posterior views.

16, DM 514, X 1.

PLATE 21



1 x1
2 x6
3 x6
4 x1½
5 x2
6 x1½
7 x1½
8 x1
9 x1½
10 x1
11 x1
12 x1
13 x1
14 x1
15 x1
16 x1

PLATE 22

Fig. 1.	<u>Sagenocrinites expansus</u> (Phillips) Wenlock Limestone, Dudley. BM 57458, X 1.	Page 160
Fig. 2.	<u>Meristocrinus nodulosus</u> sp. nov. Wenlock Limestone, Dudley. Holotype, SM A 10167, X 2.	Page 164
Fig. 3.	<u>Hormocrinus anglicus</u> Springer Wenlock Limestone, Dudley. Paratype, BM 57472, X 1½.	Page 165
Figs. 5-6.	<u>Lecanocrinus bacchus</u> (Salter) Wenlock Limestone, Dudley. Syntype, SM A 10125, X 2. Fig. 6 is tilted to show the anal plate.	Page 166
Fig. 7.	<u>Pycnosaccus bucephalus</u> (Bather) Wenlock Limestone, Dudley. Syntype, BM E 5625, X 1½.	Page 168

PLATE 22

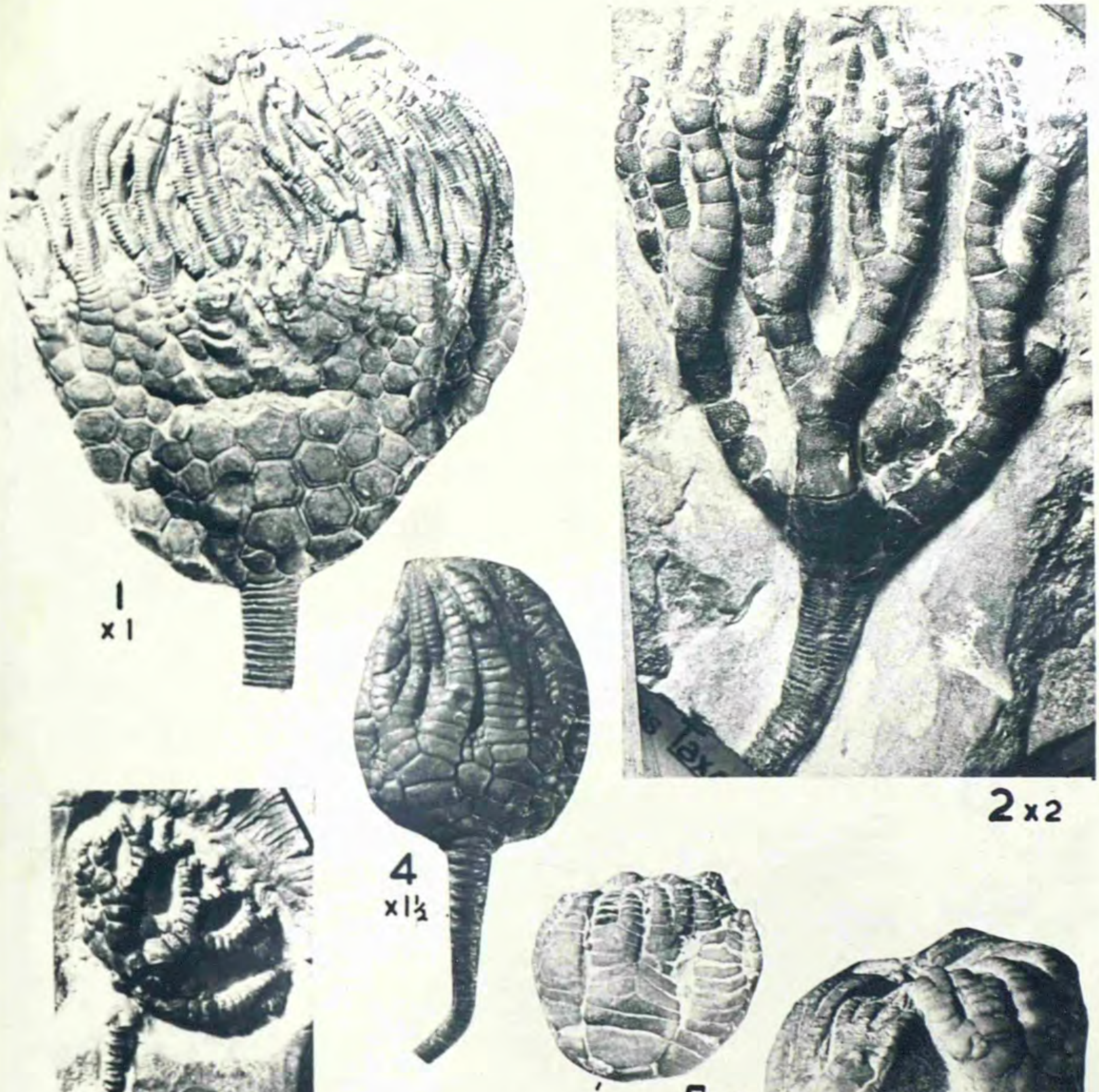


PLATE 23

Figs. 1-3.	<u>Temnocrinus tuberculatus</u> (Miller) Wenlock Limestone, Dudley. 1, SM A 13057, X 2. 2, SM A 13078, X 2. 3, SM A 13045, X 2.	Page 160
Fig. 4.	<u>Homalocrinus parabasalis</u> Angelin Wenlock Limestone, Dudley. BM 57258, X1½.	Page 165
Figs. 5-7.	<u>Ichthyocrinus pyriformis</u> (Phillips) Wenlock Limestone, Dudley. 5, BM 57936, X 2. 6, SM A 12999, X 2. 7, SM A 13001, X 2.	Page 167

PLATE 23

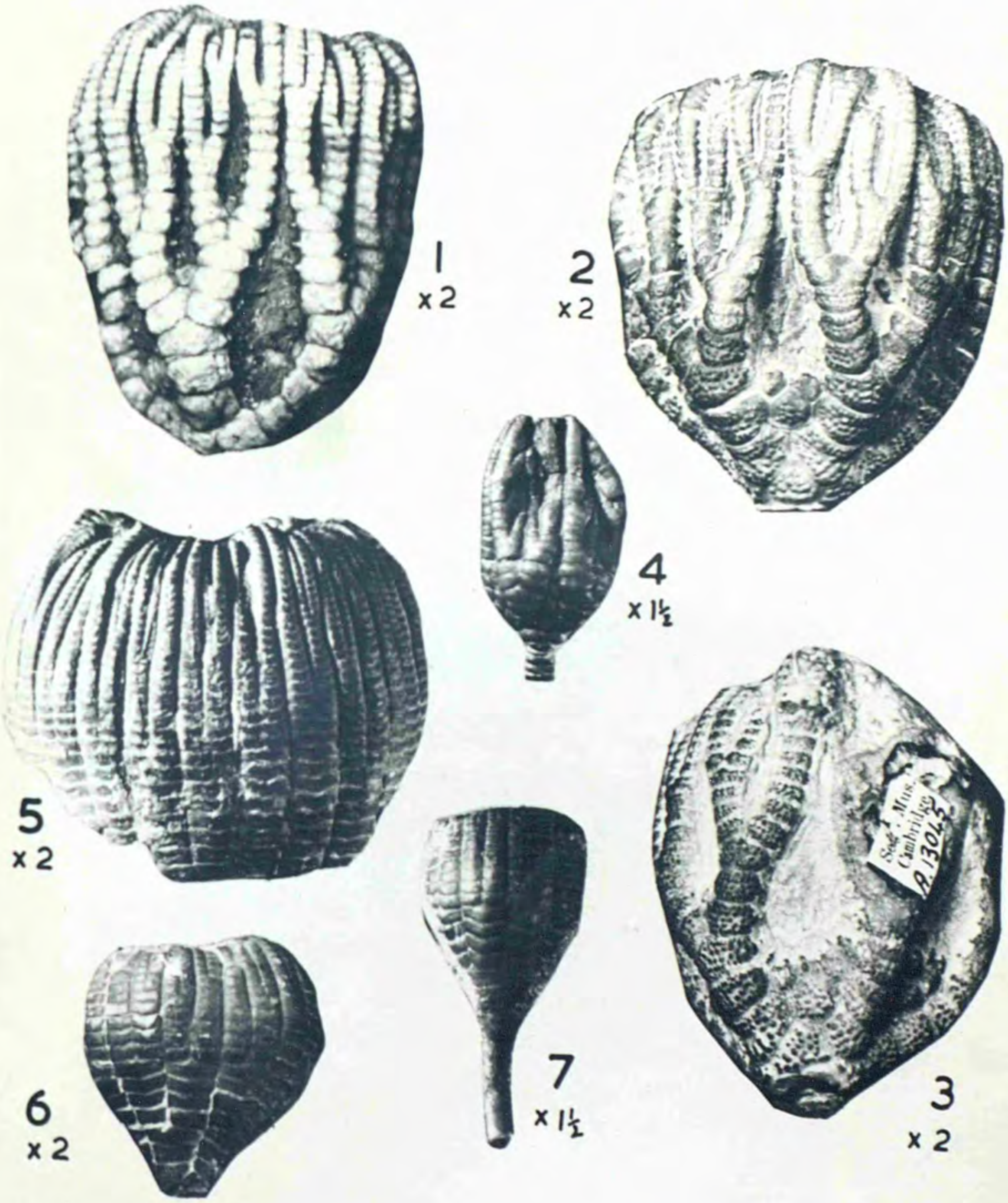


PLATE 24

PLATE 24

Figs. 1-2.	*Periechocrinus costatus* (Austin & Austin) Wenlock Limestone, Dudley. 1, BUH 343, X 1, the posterior interradius is on the left. 2, GSM 89929, X 1, the tegmen.	Page 178
Fig. 3.	*Sagenocrinites expansus* (Phillips) Wenlock Limestone, Dudley. Bristol City Museum C 3192, X 1. This is the lectotype of *Periechocrinites articulosus* Austin & Austin 1843, cited Ramsbottom, 1951b, p. 1042.	Pages 178 and 160

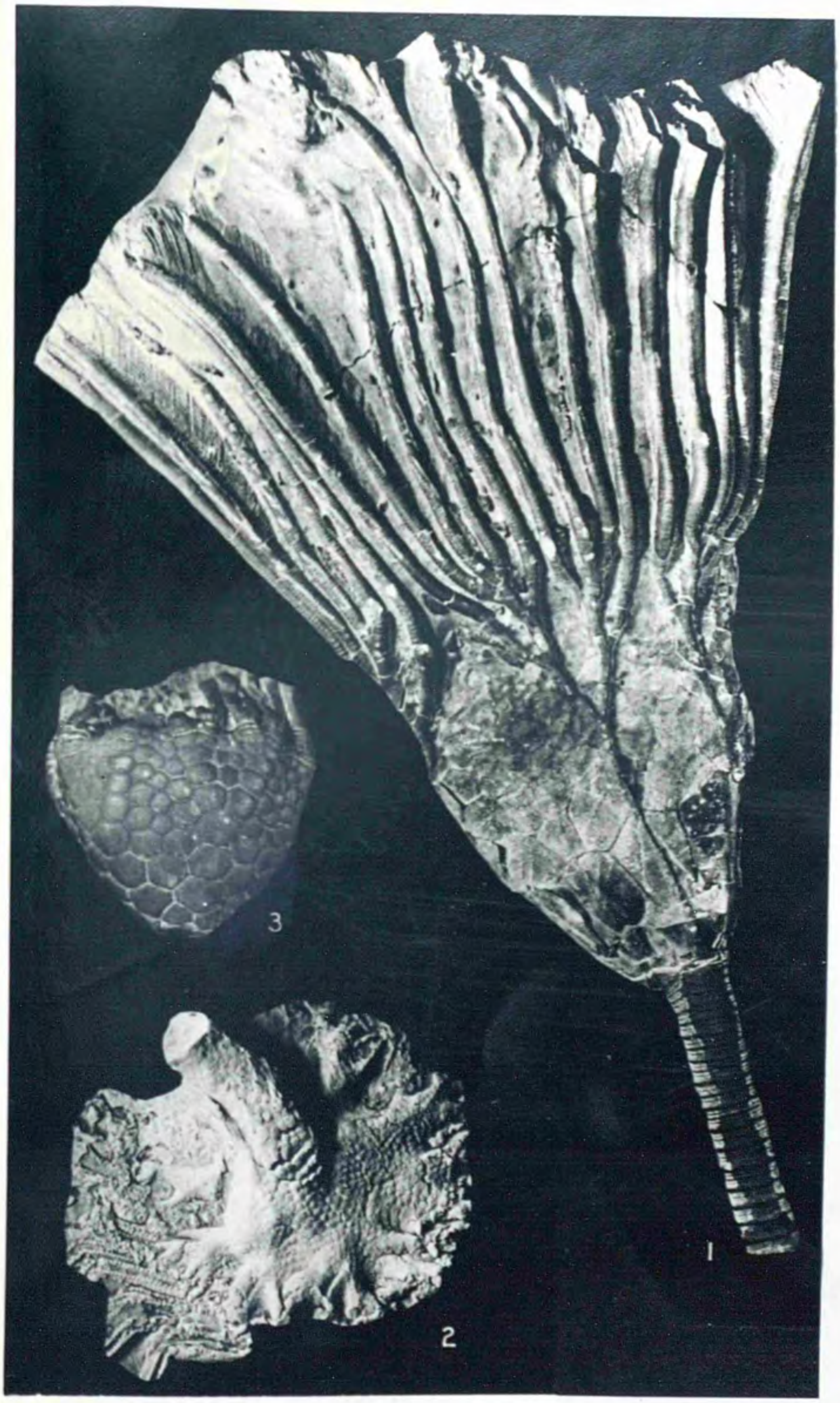

3
2
1

PLATE 25

PLATE 25

Figs. 1-5. *Periechocrinus costatus* (Austin & Austin) Page 178

Wenlock Limestone, Dudley.

1, 2, BM E 1468, X 1, posterior and anterior views.

3, SM A 12861, X 1, to show the usual mode of division of the arms.

4, SM A 30647, X 1½, shows axial nerve cords in the cup.

5, SM A 13276, X 1½, shows the granular ornament on well preserved cup plates.

PLATE 25

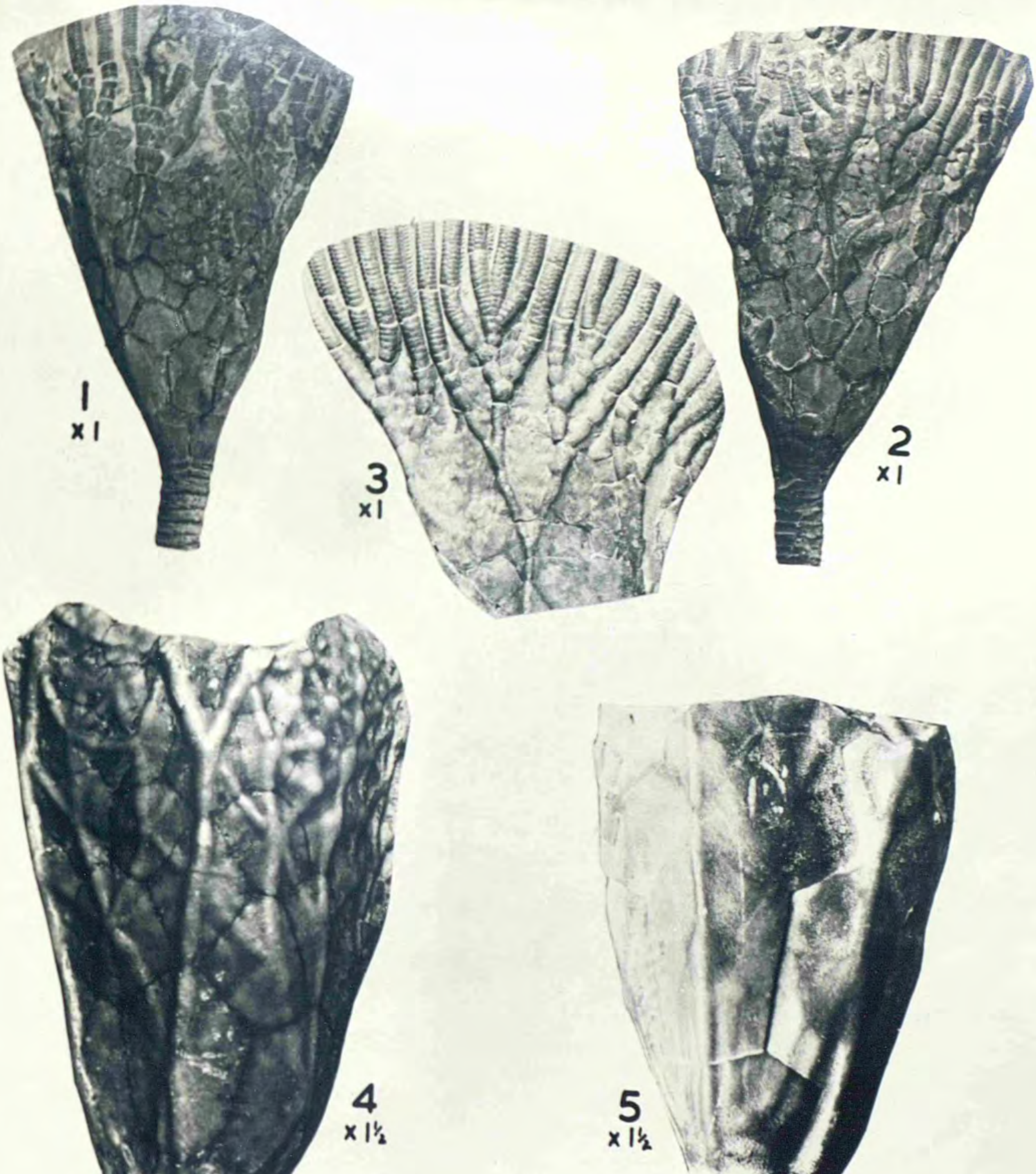


PLATE 26

PLATE 26

Figs. 1-2. Periechocrinus simplex Salter — Page 181
Wenlock Limestone, Dudley.
1, syntype, SM A 10129, X 1.
2, lectotype, SM A 10128, X 1.

Fig. 3. Megistocrinus globosus (Phillips) — Page 177
Carboniferous Limestone, but supposed to have come from Gleedon Hill, Wenlock Edge.
Bristol City Museum C 3191, X 1.
Lectotype of Periechocrinus globosus Austin & Austin.

Figs. 4-5. Periechocrinus bulbosus sp. nov. — Page 185
Lower Wenlock Limestone, Daw End railway cutting, Walsall, Staffs.
4, SM A 1o135, X 1½.
5, holotype, SM A 34177, X 1½.

Figs. 6-8. Periechocrinus limonium Salter — Page 183
Wenlock Limestone, Dudley.
6, BUH 238, X 1, the only specimen showing arms.
7, syntype, SM A 10131, X 1.
8, lectotype, SM A 10133, X 1.

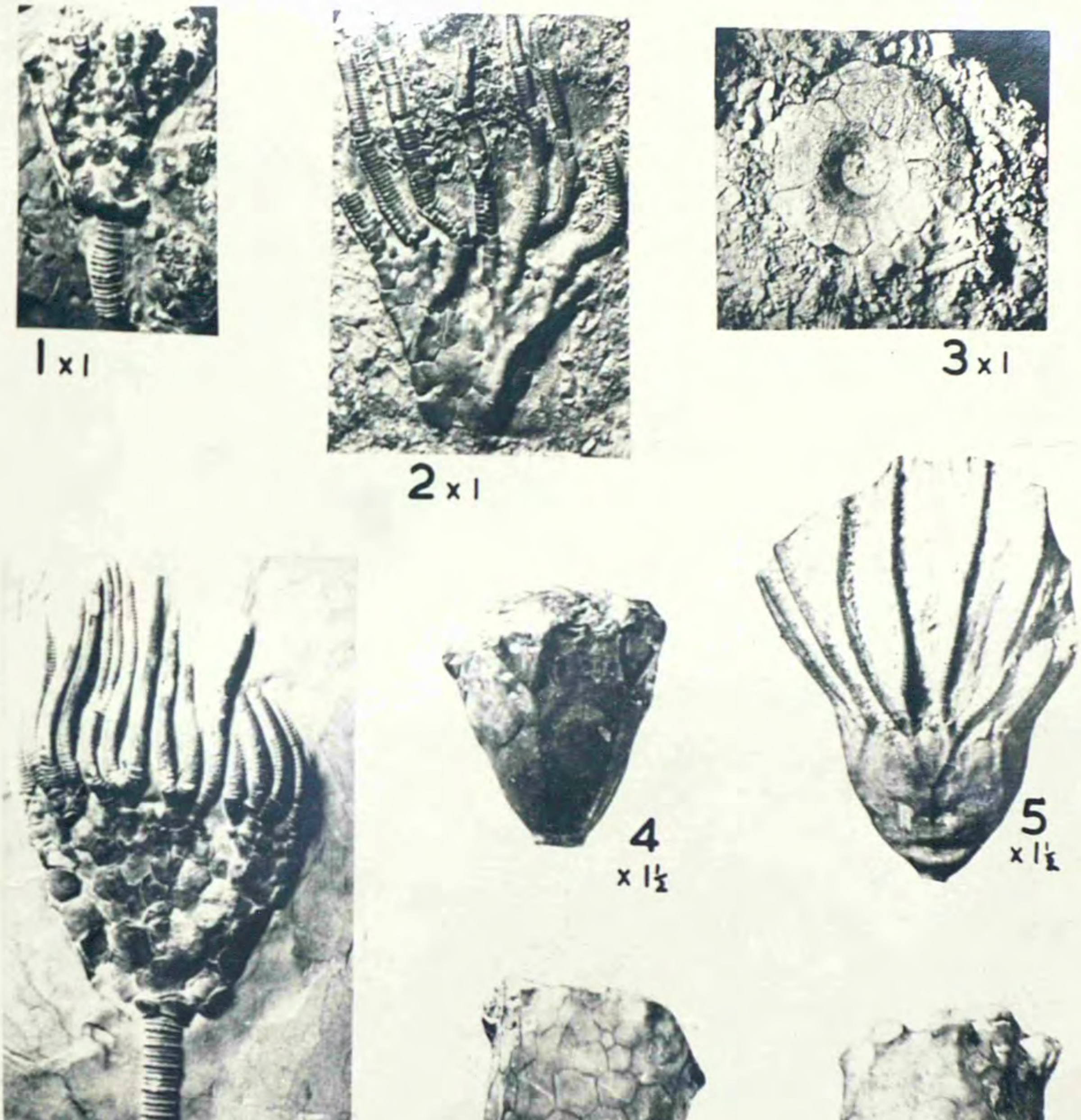

1 x 1
2 x 1
3 x 1
4 x 1½
5 x 1½
6 x 1
7 x 1
8 x 1

PLATE 27

PLATE 27

Fig. 1. <u>Carpocrinus</u> sp. Page 194
Wenlock Limestone, Dudley.
BUH 469, X 0.9.

Figs. 2-6. <u>Carpocrinus simplex</u> (Phillips) Page 191
Wenlock Limestone, Dudley.
2, lectotype, reproduced from Phillips, 1839, pl. 18, fig. 8. Specimen untraced.
3, BM E 45600, X 1.
4, BM 57123, X 1, posterior view.
5, SM A 18110, X 2; the enlarged pinnule is seen on the right.
6, BM 57360, X $1\frac{1}{2}$.

Fig. 7. <u>Carpocrinus</u> sp. juv. Page 194
Wenlock Limestone, Dudley.
SM A 12829, X 3.

Fig. 8. <u>Carpocrinus</u> sp. Page 194
Wenlock Limestone, Dudley.
SM A 18076, X 2.

Figs. 9-12. <u>Desmidocrinus macrodactylus</u> Angelin Page 188
Wenlock Limestone, Dudley.
9, BUH 285, X 1.
10, BM 57578, X 1.
11, BM 57436, X 1; one ray has an unbranched arm.
12, GSM 70204, X 1. This shows the root and the change in character of the stem throughout its length, and there are four arms per ray.

PLATE 27

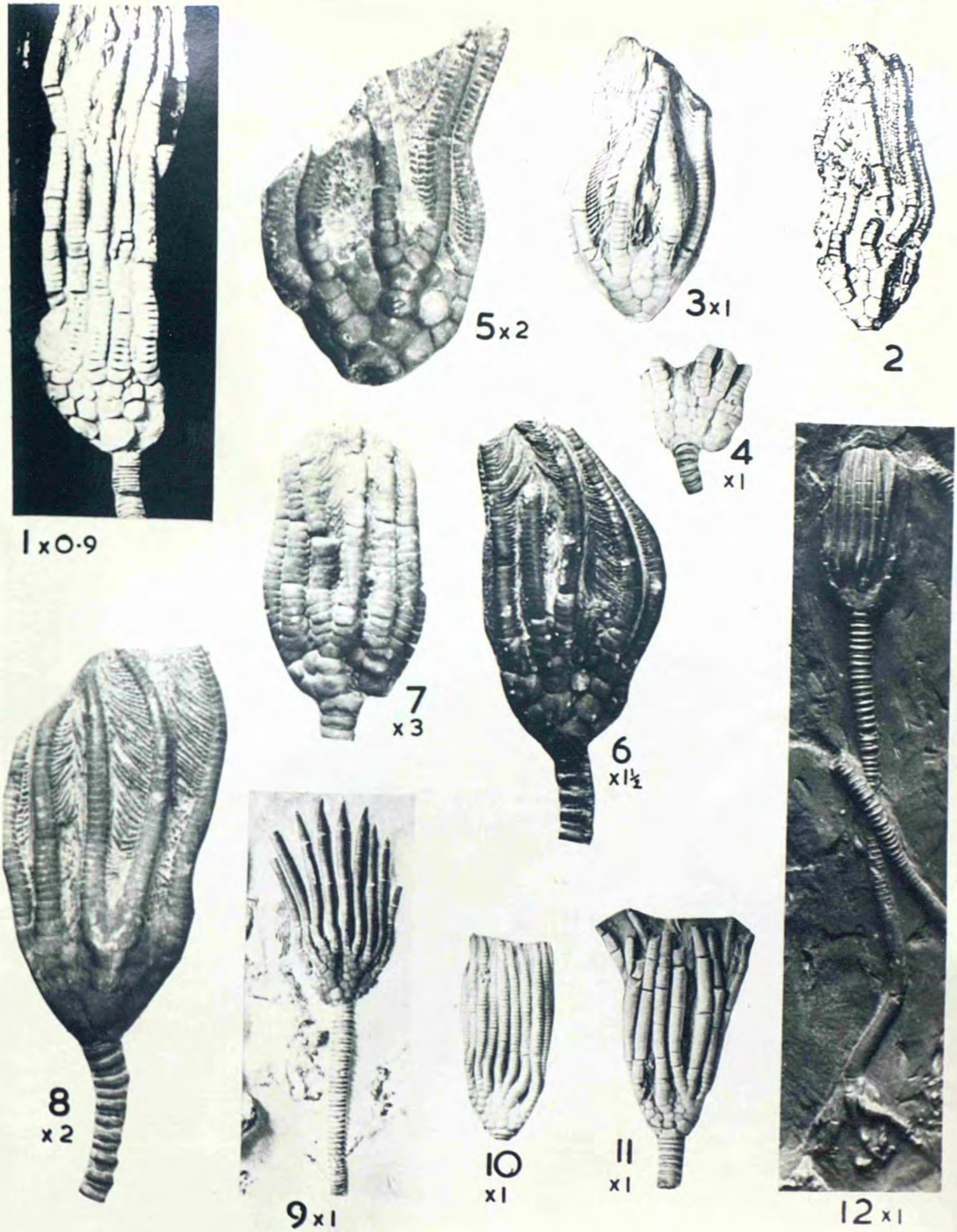


PLATE 28

PLATE 28

Figs. 1-3. "Melocrinus" flabellatus (Salter) Page 195
Wenlock Limestone, Dudley.
1, BUH 309, X $1\frac{1}{4}$.
2, syntype, SM A 10136, X 2.
3, syntype, SM A 12767, X 2.

Fig. 4. Clonocrinus polydactylus (M'Coy) Page 209
Wenlock Limestone, Dudley.
Holotype, BM 40257, X 1.

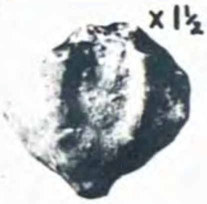
Figs. 5-7. Macrostylocrinus anglicus Jaekel Page 205
Wenlock Limestone, Dudley.
5, SM A 13133, X $1\frac{1}{2}$, posterior view.
6-7, BM 57055, X $1\frac{1}{2}$, posterior and anterior views.

PLATE 28

1 x 1¼

6 x 1½

5 x 1½



7 x 1½

2 x 2

4 x 1

3 x 2

PLATE 29

PLATE 29

Figs. 1-3. <u>Scyphocrinites</u> sp. Page 201
Limestone lenticles at Catasuent Cove, South Cornwall.
Portions of the bulbous roots.
L, GSM 85522, X 2.
2, samespecimen as fig. 1, X 4.
3, GSM 85519, X 2.

Figs. 4-6. <u>Marsupiocrinus coelatus</u> (Phillips) Page 223
Wenlock Limestone, Dudley.
4, BM E 14917, X 2, lateral view to show the small primibrachs.
5, 6, BM 57096, X $1\frac{1}{4}$, basal and lateral views.
Fig. 6 shows a gastropod on the tegmen.

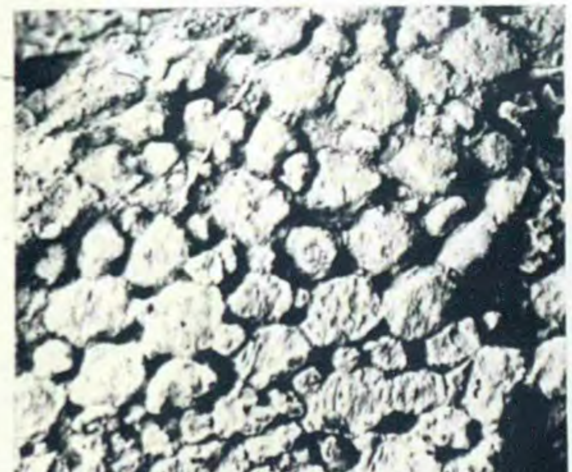
PLATE 29

1
x 2

4
x 2

5
x 1¼

6 x 1¼



2
x4

3
x 2

PLATE 30

PLATE 30

Figs. 1-5. _Eucalyptocrinites decorus_ (Phillips) Page 214
Wenlock Limestone, Dudley.
1, BM E 45563, X 2.
2, SM A 12786, X 2
3, same specimen as fig. 2, seen from the ventral side and showing the tube.
4, BM E 1736, X 2.
5, SM A 12781, X 2.

Fig. 6. _Eucalyptocrinites_ sp. Page 217
Wenlock Limestone, Dudley.
BM 57033, X 2.

Figs. 7-9. _Eucalyptocrinites_ sp. Page 216
Wenlock Limestone, Dudley.
BM E 1456, X 1. Lateral, dorsal and ventral views.

PLATE 30

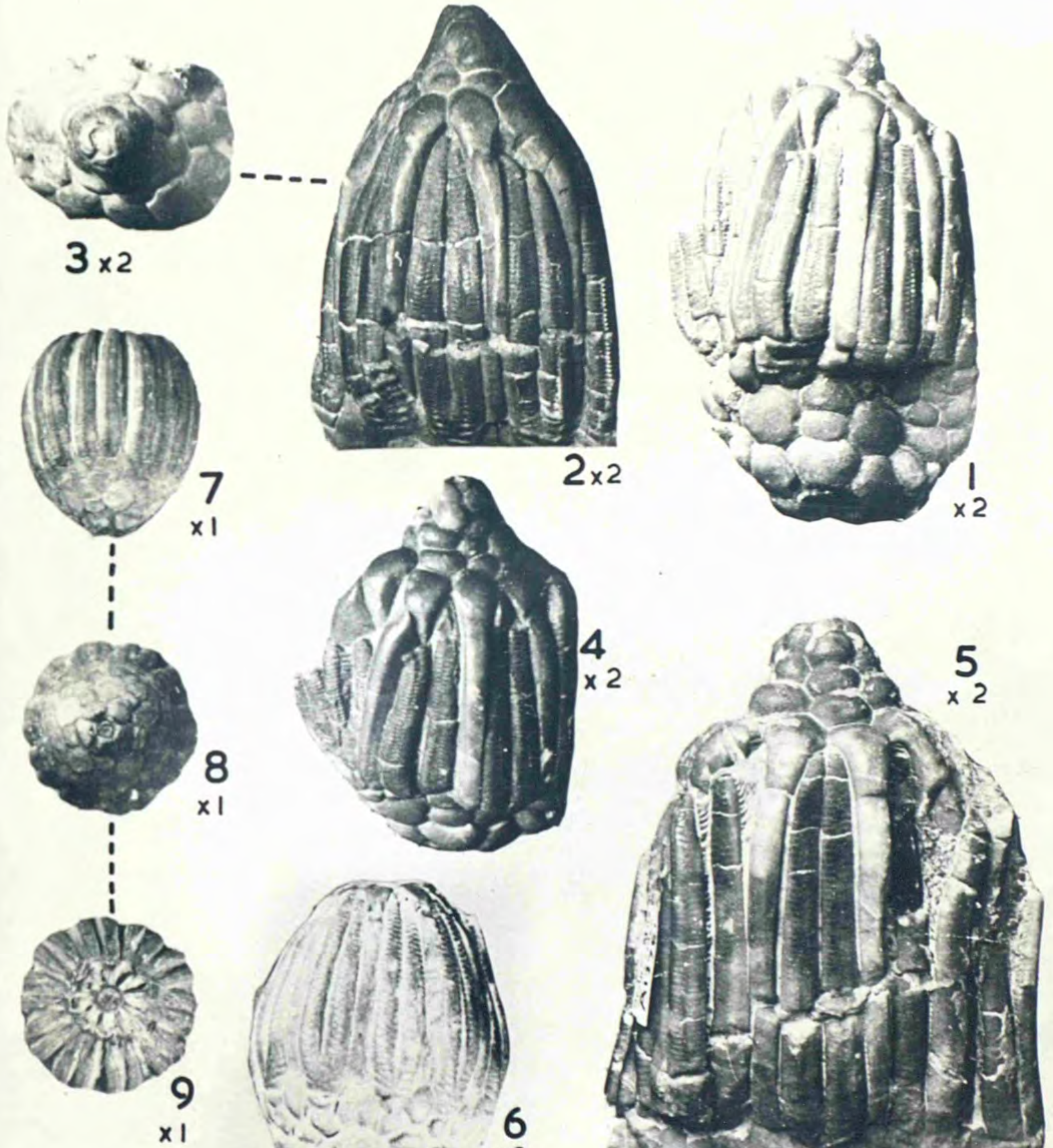


PLATE 31

PLATE 31

Fig. 1. Calliocrinus sp. — Page 220
Wenlock Limestone, Dudley.
BUH 403, X 1.

Figs. 2,2a. Calliocrinus cf. beyrichianus (Angelin) — Page 221
Wenlock Limestone, Dudley.
BM 57457, X 1, side and basal views.

Figs. 3,3a,4 Calliocrinus rugiferus sp. nov. — Page 218
Wenlock Limestone, Dudley.
3, 3a, holotype, BUH 420, basal and side views, X 1.
4, paratype, BM E 45533, X 1, with sutures marked in ink on the photograph. Basal view.

PLATE 31

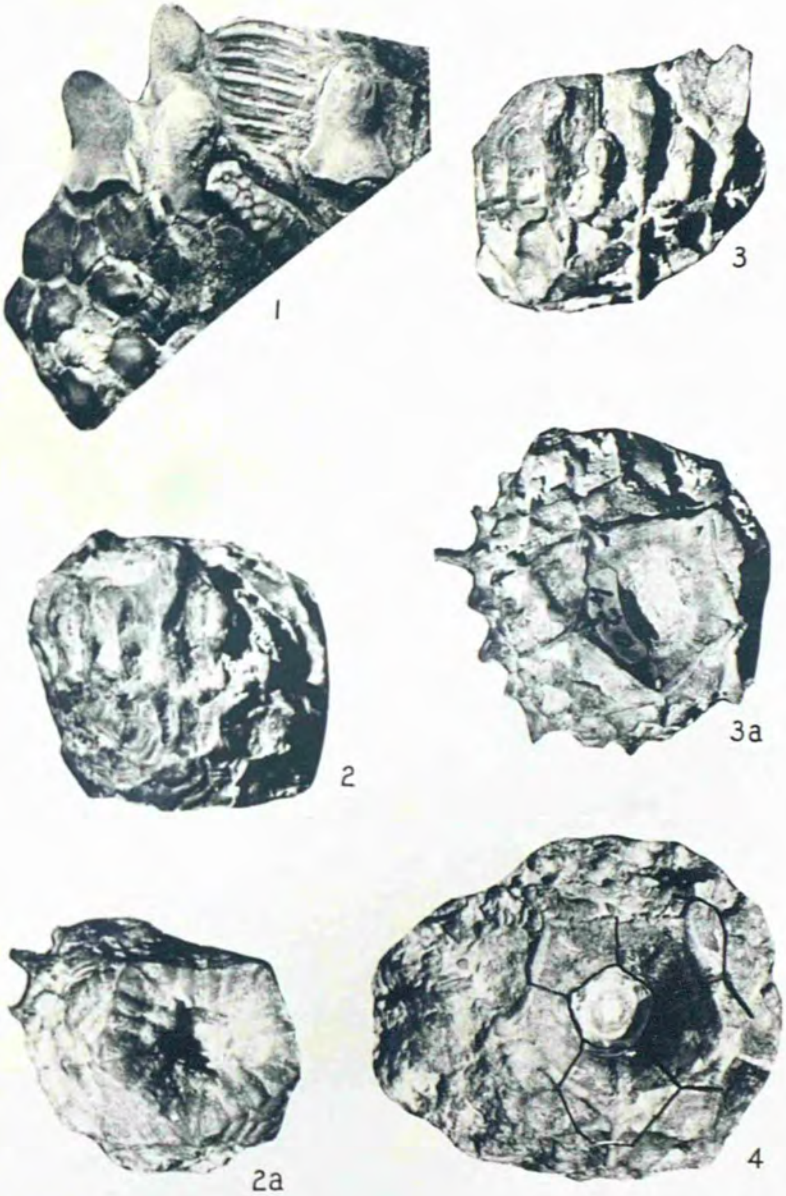


PLATE 32

PLATE 32

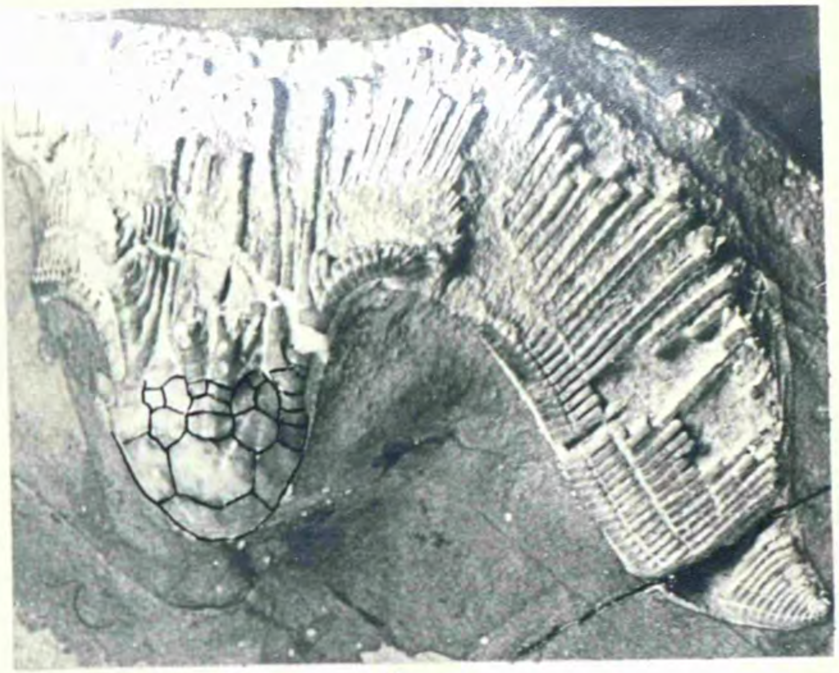
Fig. 1. *Cordylocrinus pecten* sp. nov. Page 228

Wenlock Limestone, Dudley.
Holotype, SM A 10139, X 3.
Sutures on the cup have been marked in ink on the photograph.

Figs. 2-8. *Hapalocrinus retiarius* (Phillips) Page 231

Wenlock Limestone, Dudley.
2, BM 40263, X 2, the ten armed form.
3, drawing based on BM E 5615, reproduced from Bather, 1900, fig. lxix, p. 156.
4, BM E 5615, X 2, the twenty armed form.
5, SM A 12749, X 4, shows a gastropod on the tegmen.
6, GSM 85835, X 2, shows cirri on stem.
7, BM E 5615, X 2, this shows the usual method of occurrence of this species; both ten and twenty armed forms are living gregariously together.
8, SM A 12749, a young example of the ten armed form.

2 x 2



1 x 3

3 x 3

4 x 2

5 x 4

6 x 2

7 x 2

8 x 4

PLATE 33

PLATE 33

Figs. 1-4. *Lyriocrinus britannicus* Ramsbottom — Page 239

Wenlock Limestone, Dudley.
1, paratype, SM A 13119, X 1.
2, paratype, SM A 13120, X 1.
3, holotype, SM A 12715, X 2, posterior view.
4, holotype, SM A 12715, X 2, basal view.

Fig. 5. *Dimerocrinites uniformis* (Salter) — Page 248

Wenlock Limestone, Dudley.
SM A 10123, X $1\frac{1}{4}$, anterior view.

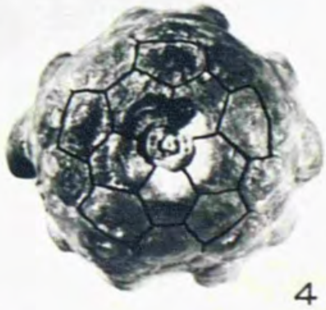
PLATE 33

1

2

5 x1¼

3 x2



4 x2

PLATE 34

PLATE 34

Figs. 1-3. *Dimerocrinites speciosus* (Angelin) Page 246
Wenlock Limestone, Dudley.
1, BM E 1445, X 1.
2, BM E 1376, X 1.
3, BM 57451, X $1\frac{1}{4}$.

Figs. 4-6. *Dimerocrinites decadactylus* Phillips Page 242
Wenlock Limestone, Dudley.
4, BUK 58, X 3, posterior interradius on right.
5, SM A 13098, X 2.
6, SM A 13097, X 2.

Figs. 7-12. *Dimerocrinites icosidactylus* Phillips Page 244
Wenlock Limestone, Dudley.
7, BM 47918, X $1\frac{1}{4}$.
8, GSM 83090, X 1. One branch is missing on the right of the interradius.
9, SM A 13099, X 2. Only two branches occur in one ray.
10, SM A 13115, X 2. One branch is missing on each side of the interradius.
11, BM 47911, X $1\frac{1}{4}$. Only two branches occur in one ray.
12, SM A 13105, X 2.

Fig. 13. *Dimerocrinites* cf. *icosidactylus* Phillips Page 244
Wenlock (undifferentiated), Slate Mill, Hasgaurd, Pembrokeshire.
Revultex impression, GSM 89632, X 2.

PLATE 34

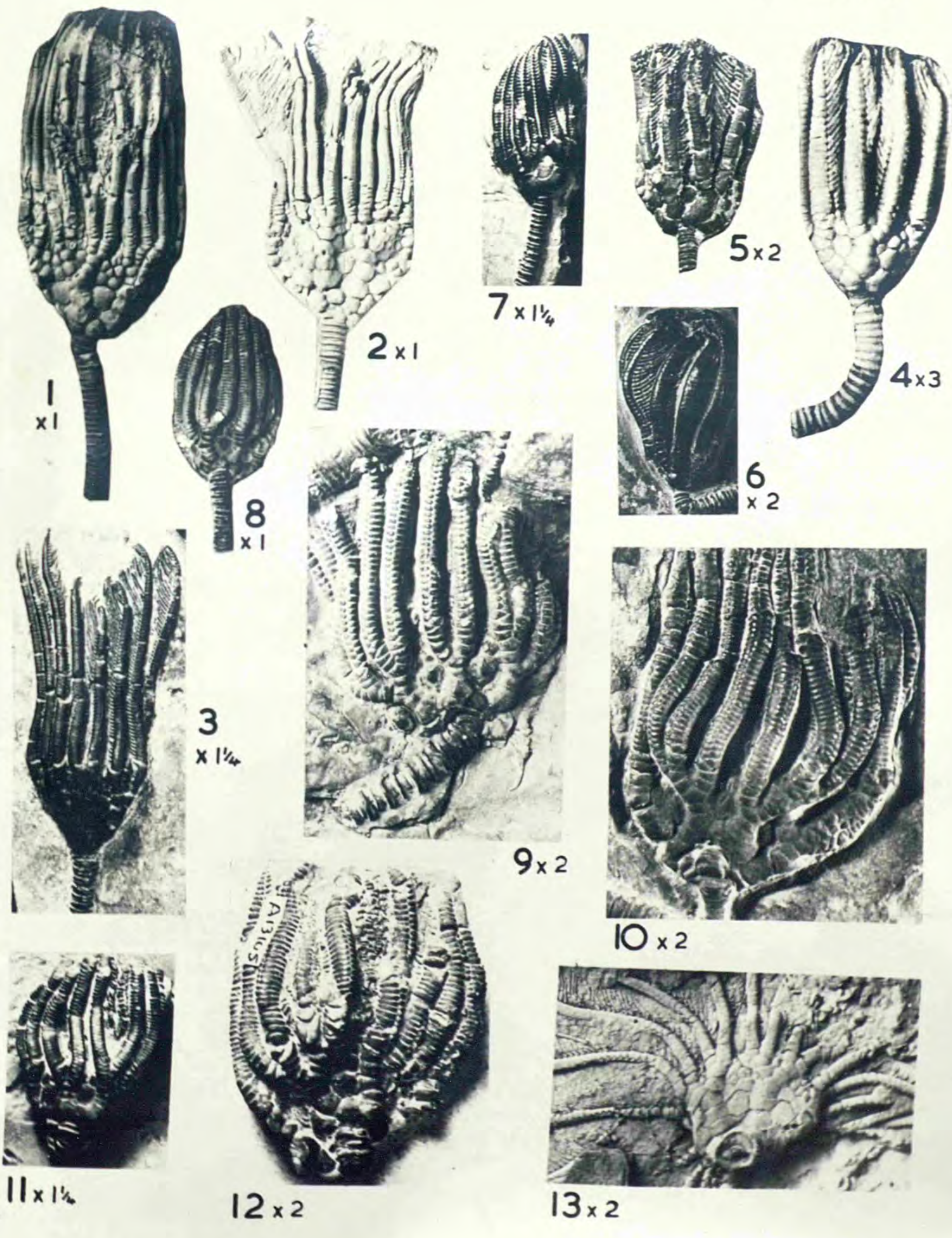


PLATE 35

PLATE 35

Figs. 1-3. *Cicerocrinus elegans* Sollas — Page 95

Upper Ludlow.
1, BM E 5726, X 4, wax squeeze of the holotype of *C. tenuis* Jaekel; quarry by old bridge, Ludlow.
2, holotype, OM c 80, X 1, unlocalised.
2a, the same, X 2.
3 , BM E 26071a, X 2, Whitcliffe, Ludlow.

PLATE 35

1 x4

2a
x2

2
x1

3
x2

PLATE 36

PLATE 36

Figs. 1-2. Gissocrinus ludensis sp. nov. Page 122
Lower Ludlow Beds,
Church Hill Quarry, Leintwardine.
1, holotype, BM E 26573, Revultex impression, X 1½.
2, paratype, BM E 26577, X 1½, shows anal tube.

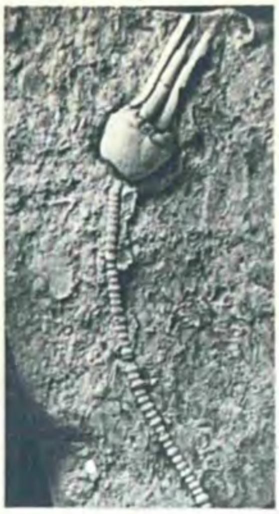
Fig. 3. Pisocrinus sp. Page 94
Lower Ludlow Beds,
Church Hill Quarry, Leintwardine.
Reading University collection E 299, X 2.

Fig. 4. Cicerocrinus elegans Sollas Page 95
Upper Ludlow, quarry 150 yards N. E. of
Stapleton Castle, near Presteigne.
GSM 85405, Revultex impression, X 2.
A young specimen.

Figs. 5-8. Mastigocrinus bravonium sp. nov. Page 151
Lower Ludlow, Leintwardine.
Revultex impressions.
5-6, paratype, OM c 84; 5, X 4; 6, X 10.
7-8, holotype, GSM 89994, posterior side of
cup showing anal tube; 7, X 4; 8, X 8.

1 x 1½

2 x 1½



3 x 2

4 x 2

5 x 4

6 x 10

7 x 4

8 x 8

PLATE 37

PLATE 37

Figs. 1-4. Eutaxocrinus maccoyanus (Salter) Page 169
Lower Ludlow.
1, GSM 89989, X 3, Leintwardine.
2, holotype, SM A 35407, Revultex impression,
X 3; Bannisdale Slates, Light Beck, Underbarrow.
3, GSM 89988, Revultex impression, X 3,
Bannisdale Slates, Underbarrow.
4, BM E 26578, Revultex impressions, X 2;
Church Hill Quarry, Leintwardine.

Fig. 5. Meristocrinus orbignyi (M'Coy) Page 161
Lower Ludlow.
Holotype, SM A 29599, Revultex impression,
X 2; Bannisdale Slates, High Thorns, Underbarrow.

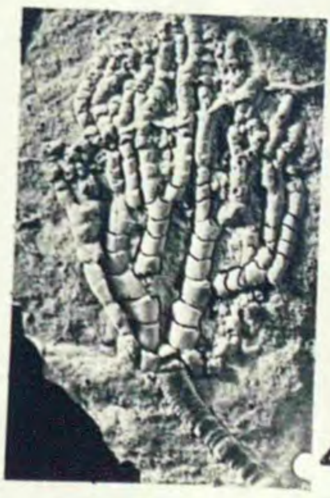
PLATE 37

1
x 3

2
x 3

5 x 2

3
x 3

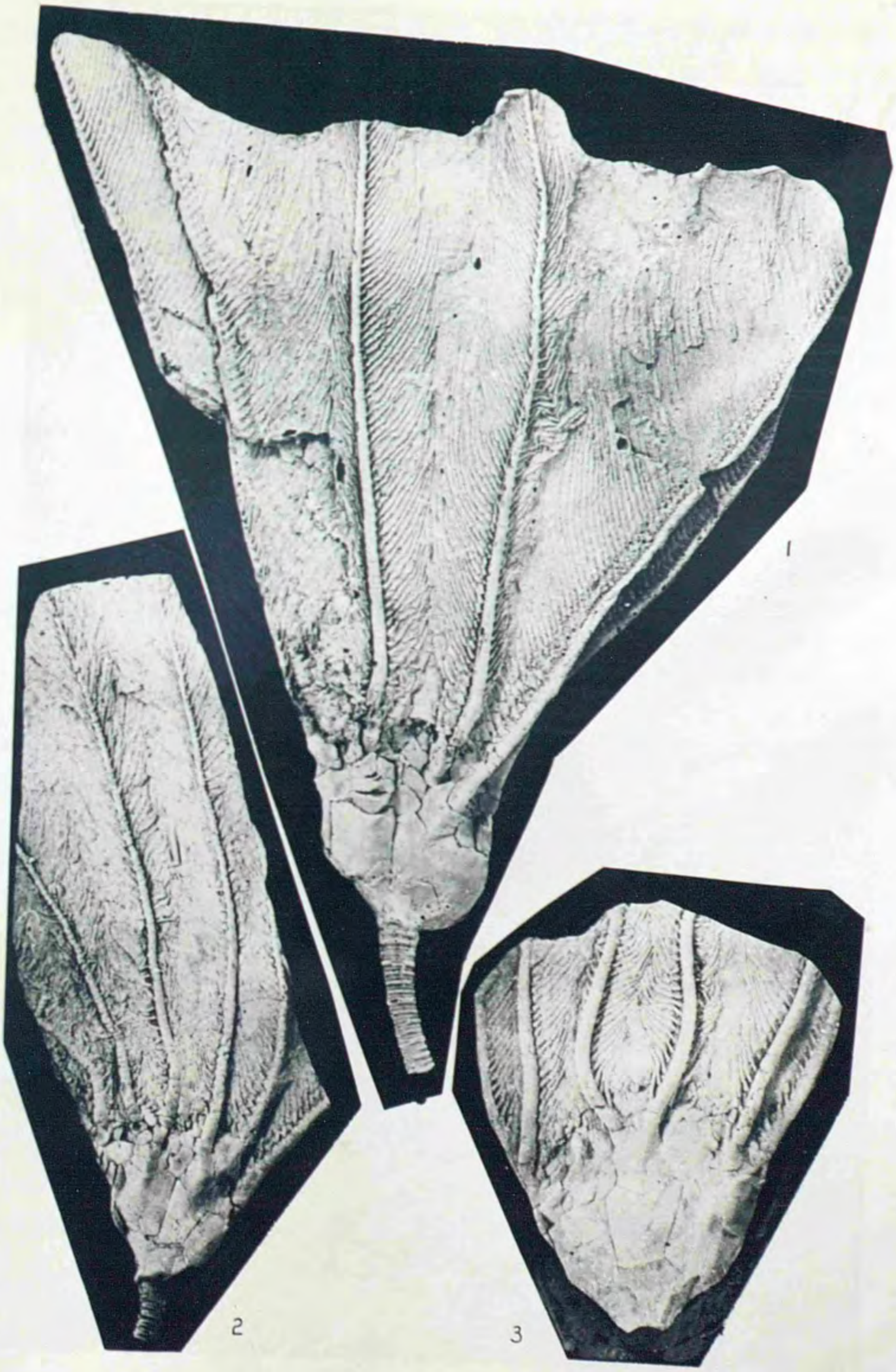


4 x 2

PLATE 38

PLATE 38

Figs. 1-3. *Hapalocrinus quinquepennis* sp. nov. Page 236
Lower Ludlow Beds.
Revultex impressions, X 2.
1, paratype, GSM 89897, Leintwardine.
2, holotype, BM E 26576a, Church Hill Quarry, Leintwardine.
3, paratype, BM E 14900, Church Hill Quarry, Leintwardine.



1

2

3

PLATE 39

PLATE 39

Figs. 1-7. Scyphocrinites pulcher (M'Coy) Page 197

Lower Ludlow.

1, GSM 89997, Revultex impression, X 2; Knott Hollow Quarry, near Ulverston, Lancs.

2, syntype, SM A 16623, Revultex impression, X 2; Nant Gwrhyd Uchaf, Llangollen.

3, syntype, SM A 16614, Revultex impression, X 2; Nant Gwrhyd Uchaf, Llangollen.

4, syntypes, SM A 16619 (upper crown) and SM A 16620 (lower crown), Revultex impressions, X 2; Nant Gwrhyd Uchaf, Llangollen.

5, GSM 90394, Revultex impression, X 1, shows cirrus scars on adult stem; Nantglyn.

6-7, Liverpool University Collection 2685, X 1, Nantglyn. Figured Boswell, 1949, pl. xx.

1 x2

2 x2

3 x2

4 x2

5 x1

6 x1

7 x1

Contents: 5 subsidiary papers.

From the Annals and Magazine of Natural History,
Ser. 12, vol. iv. p. 1040, *October* 1951.

The Type-Species of Periechocrinites *Austin & Austin*

By W. H. C. Ramsbottom.

In 1821 J. S. Miller (1821, pl. opp. p. 114, fig. 9) figured a stem fragment of a crinoid to which basal ? plates were attached, allotting the name *Actinocrinites moniliformis* to the species. No definite horizon or locality was given for the figured specimen, though it is possible that it came from Dudley. Miller stated that he had seen similar fragments at other horizons and localities including the "Mountain limestone" of Swaledale, Yorkshire, and the "transition lime" of Foulhope, the Malvern Hills, Canada, and Melville Island in the Arctic. Miller's figured specimen has not been traced. Phillips (1839, pl. xviii. fig. 4) later figured under the same name an almost complete crinoid from the Wenlock Limestone of Dudley, which had a stem and basal plates similar to those of Miller's fragment. Phillips' figured specimen has also not yet been traced, but the figure is good enough to leave no doubt as to which species is represented.

In 1843 (pp. 203–4) T. Austin and T. Austin, jun., erected the genus *Periechocrinites*, including in the genus *P. articulosus*, *P. costatus* and *P. globosus*, but the rather poor descriptions were unaccompanied by any notice of horizon or locality, and there were no figures. The locality and horizon of *P. articulosus* and *P. costatus* were given as Wenlock Limestone, Dudley, by Morris (1843, p. 56).

P. costatus was stated by the Austins to be a new name for *Actinocrinites moniliformis* Phillips *non* Miller. Authors subsequent to the Austins have accepted the identity of the species figured by Miller and Phillips under that name, and accordingly *P. costatus* has been suppressed as a synonym of *P. moniliformis* (Miller). It is here suggested that there is too little evidence to justify the opinion that the species figured by Miller and Phillips are identical ; hence the Austins were justified in giving a new name to Phillips' species. The name *P. costatus* Austin & Austin should thus replace the name *P. moniliformis* auctorum, *Actinocrinites moniliformis* Miller being left in abeyance until the original material becomes available. It is proposed that the lectotype of *P. costatus* Austin & Austin be the specimen figured by Phillips (1839, pl. xviii, fig. 4—left hand figure).

Of *P. articulosus* the Austins stated : " The perisomic plates agree with the generic description, which has, in fact, been taken from this the typical species." This statement I take to constitute a designation of the type-species for the genus. A MS. notebook, formerly belonging to the Austins and now at the British Museum (Natural History), contains an entry opposite the name *P. articulosus* : " many plated, Bristol Institution". The only specimen bearing the name *P. articulosus* at the Bristol City Museum has with it a MS. label " type ", though the writer of this label is unknown. Despite the doubt expressed by Wilson (1890, p. 413) it is clear that this specimen was considered by the Austins to be in effect the type, for in their unpublished plates at the British Museum (Natural History) it is the only specimen figured under the name *P. articulosus*. These plates were intended as the continuation of their 'Monograph on Recent and Fossil Crinoidea' (1843–47), for which their 1843 paper was preparatory. In view of this evidence the specimen at the Bristol City Museum (No. C 3192) is here designated the lectotype of *P. articulosus*. On examination it proves to be an exceptionally well-preserved example of the species now known as *Sagenocrinites expansus* (Phillips), which species is the type species of the genus *Sagenocrinites* Austin & Austin (1843, p. 205).

It thus appears that the originally designated type-species of *Periechocrinites* is a *Sagenocrinites*, and that by page priority the name *Periechocrinites* should according to the International rules be used for the genus now known as *Sagenocrinites*. The type-species of *Periechocrinites* would then be *P. expansus* (Phillips, 1839)=*S. expansus* (Phillips, 1839)=*P. articulosus* Austin & Austin, 1843. If this course were adopted another name would be required for the genus now called *Periechocrinites*, and, in fact, the earliest available name is *Periechocrinus* Morris (1843, p. 56). Much confusion would result from having two genera called respectively *Periechocrinus* and *Periechocrinites*, the *-us* and the *-ites* endings having been considered homonymous for many years until Bassler (1938) restored the *-ites* ending for those genera in which it was originally proposed. This confusion would be avoided if the International Commission on Zoological Nomenclature were to suspend the rules in this case, and to suppress the Austins' original designation of *P. articulosus* as the type-species of *Periechocrinites*, in favour of *P. costatus* Austin & Austin (=*P. moniliformis* auctorum); thus retaining the long-established meaning of the name *Periechocrinites*. Present practice, which regards *P. moniliformis* as the type-species, ignores the Austins' original designation of *P. articulosus*. Wachsmuth & Springer (1881, p. 302) were apparently the first to claim *P. moniliformis* as the type-species.

In view of the facts outlined above it is proposed to ask the International Commission on Zoological Nomenclature to suspend the rules and to designate *Periechocrinites costatus* Austin & Austin as the type-species of *Periechocrinites* in place of *P. articulosus*.

References.

AUSTIN, T., and AUSTIN, T., junr. 1843. "Descriptions of several new Genera and Species of Crinoidea." Ann. & Mag. Nat. Hist. xi. pp. 195–207.

BASSLER, R. S. 1938. 'Pelmatozoa Palæozoica.' Fossilium Catalogus, i. Animalia, lxxxiii. pp. 1–194.

MILLER, J. S. 1821. 'A Natural History of the Crinoidea.' Bristol.

MORRIS, J. 1843. 'A Catalogue of British Fossils.' London. 1st ed.

PHILLIPS, J. 1839. *In* R. I. Murchison, 'The Silurian System,' London.

WACHSMUTH, C., and SPRINGER, F. 1881. "Revision of the Palæocrinoidea: pt. ii." Proc. Acad. Nat. Sci. Phil. pp. 177–411.

WILSON, E. 1890. "Fossil Types in the Bristol Museum." Geol. Mag. (3) vii. pp. 411–16.

From the Annals and Magazine of Natural History,
Ser. 12, vol. iv. p. 490, *May* 1951.

Two Species of Gissocrinus *from the Wenlock Limestone.* By W. H. C. Ramsbottom*.

[Plate IX.]

Summary.

G. arthriticus (Phillips) is designated as the type species of *Gissocrinus* in place of the invalidly designated *G. typus* Bather. Descriptions are given of *G. squamiferus* (Salter) and *G. luculentus*, sp. n.

The crinoid genus *Gissocrinus* is represented in the Silurian Wenlock Limestone of Dudley by the three species described and figured by Phillips (1839), *G. arthriticus, G. capillaris* and *G. goniodactylus* Phillips spp. There are also the two species *G. squamiferus* and *G. scoparius* briefly described, but not figured by Salter (1873), the former of which is dealt with more fully here. The affinities of *G. scoparius* are not apparent from the type and only known specimen (S.M. A 10168) and this species is left for future consideration, though there is no doubt of the specific individuality of this specimen. As indicated in Woods (1891), the " *Cyathocrinus* (sp. 5) " of Salter, 1873, p. 124 (S.M. A 12926) belongs to *G. goniodactylus*, while Salter's " *Cyathocrinus* (sp. 1) " is mentioned below. In museums the second species described in the present paper has usually been referred to *G. goniodactylus*.

* Published with the permission of the Director of the Geological Survey.

The material for this paper comes from the British Museum (Natural History) (B.M.), the Sedgwick Museum, Cambridge (S.M.), and the Holcroft Collection at Birmingham University (B.U.H.), and I thank the various authorities for the loan of specimens.

Subclass **INADUNATA** Wachsmuth and Springer.

Order CLADOIDEA Moore and Laudon.

Family **Cyathocrinitidæ** Bassler.

Genus Gissocrinus Angelin, 1878.

Type species (here designated).—*Actinocrinites ? arthriticus* Phillips, 1839, p. 674, pl. xvii, fig. 8, Wenlock Limestone.

Discussion.—*G. arthriticus* (Phillips) was the first of seven species named by Angelin (1878) in erecting the genus *Gissocrinus*. Bather (1893) showed that the specimens named as *G. arthriticus* by Angelin did not belong to Phillips' species, and he renamed them *G. typus* (which he took as the type species of the genus) and *G. campanula*, and he has been followed by most later authorities. Since neither of these species was named in the original description of the genus, however, they are not eligible for consideration as the type. Bouška (1943) cites *G. arthriticus* Angelin as the type species, while Moore and Laudon (1944, p. 155) cite *G. arthriticus* but do not state whether of Phillips or Angelin. In order to resolve this ambiguity *G. arthriticus* (Phillips) *non* Angelin is here designated as the type species of the genus. The main feature in which *G. arthriticus* differs from *G. typus* is in the more or less horizontal position of the anal tube and proximal parts of the arms. An analysis of the plates of the cup in *Gissocrinus* is given in fig. 1.

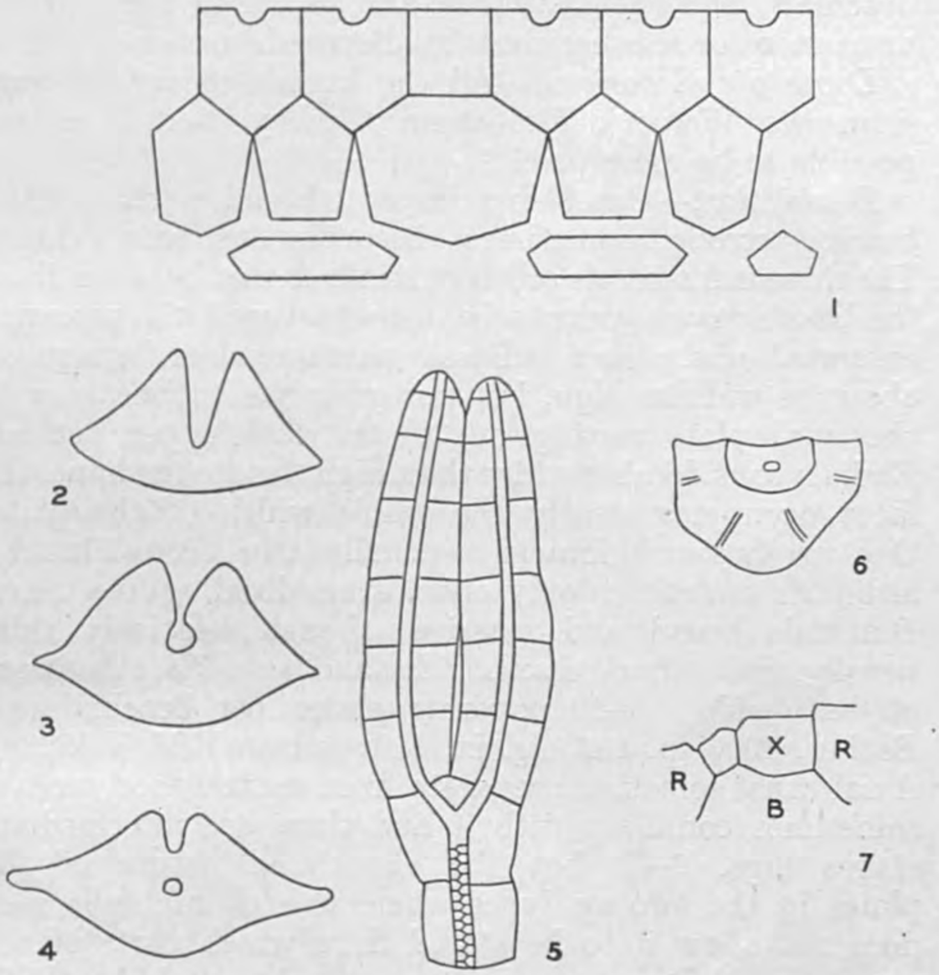
Gissocrinus squamiferus (Salter).
(Pl. IX, figs. 1–4 ; figs. 2–5.)

Cyathocrinus (sp. 4) *squamiferus* Salter, 1873, p. 124.
Gissocrinus squamiferus Bather, 1892, p. 207.
cf. *Gissocrinus squamifer* Bather, 1893, p. 167.
Gissocrinus squamifer Bather, 1900, p. 102, fig. ix (1).

Syntypes.—The registration number quoted by Salter (1873) covered ten syntypes, since re-registered as S.M.

A 10138, A 10142–9 and A 35175. Of these S.M. A 10149 belongs to *G. goniodactylus* and is thus excluded from

Figs. 1–7.



1. Analysis of the plates of the cup in *Gissocrinus* (after Bather); 2–4. Sections of the brachials showing the changing relations of the axial canal and food groove in the arms of *G. squamiferus* (figs. 2–3 from S.M. A 10145; fig. 4 from S.M. A 10143); 5. Ventral view of the distal end of an arm in *G. squamiferus*. Diagrammatized from B.U.H. 26; 6. Radial of *G. luculentus* showing the hole for the axial canal piercing the plate. B.M. E 26890; 7. Sketch of the anal side of the cup in an unusual specimen of *G. luculentus* with an extra plate to the left of the anal. B.M. 57282.

consideration, and of the remaining nine, S.M. A 10138 is here selected as the lectotype.

Other material.—The present description is based on the above types supplemented especially by B.M. 40337, B.M. E 420, and B.U.H. 28.

Diagnosis.—A species of *Gissocrinus* with a moderately low cup with axial ridges, broad and massive, fairly flat brachials, and the anal tube and proximal parts of the arms more or less horizontally disposed.

Locality and horizon.—All the known specimens come from the Wenlock Limestone, Dudley, and it is not possible to be more precise.

Description.—Cup bowl-shaped, broader than high, bearing strong, sometimes discontinuous axial ridges. The three infra-basals are very small, so that between them the basals may appear to be in contact with the proximal columnal of the stem. Basals pentagonal or hexagonal, about as wide as high, but posterior basal truncate with the anal plate resting on its truncate upper surface. Radials considerably wider than high, lunate in shape, the facet occupying nearly the whole width of the plate. One or two primibrachs; usually two secundibrachs, although sometimes only one; arms dividing five times. Brachials broad and massive, though relatively thin, usually with a marked axial ridge and wing-like extensions on each side; 7–10 covering plates per brachial (see Bather, 1900, p. 102, fig. ix, 1, based on B.M. E 45290). Axial canal sometimes separate from ventral food groove, sometimes confluent with it and there are intermediate stages (figs. 2–4), but the dissociated nature of the plates in the two syntypes where this character is seen does not allow it to be stated from which parts of the arms the different forms come. Proximal brachials leave cup in almost horizontal position, and the arms curve round to give the crown its greatest width near the top. Distally the arms are rounded off rather suddenly, the food groove continuing with the same width right to the end of the arm (fig. 5).

Anal tube also horizontally disposed and formed of roughly four-sided plates with coarse transverse folds. Tube round and slender, probably reached almost the full length of the arms. Tegmen not seen. Longest stem seen (in B.M. 40262) has a length of only 8 mm., formed of very short columnals with crenulate boundaries, but no conspicuous nodals. In this and another specimen (B.M. 40337) the round lumen is about one-third of the diameter of the stem.

Discussion.—This species shares with *G. arthriticus* the horizontal anal tube, but is more closely related to *G. goniodactylus*. Indeed, there is a variety in the Wenlock Limestone and in Gotland (see Bather, 1893, p. 167, pl. ix, figs. 326–34—Riksmuseum, Stockholm, Ec 9259) intermediate between *G. squamiferus* and *G. goniodactylus*, to which the " *Cyathocrinus* (sp. 1) " of Salter, 1873, p. 123 (S.M. A 10169) belongs. This variety, for which Bather's term " *G. goniodactylus* var." is here provisionally retained, and *G. goniodactylus* itself* both have larger infrabasals than *G. squamiferus*. The broad brachials of *G. squamiferus* are merely an expression of a trend already begun in *G. goniodactylus*, and they approach in breadth a species from the Wenlock Shales at Sedgley, Staffordshire, which is close to *G. crassus* Bouška (1943), in which the trend has gone still further.

Through the courtesy of Prof. Stensiö I have been able to examine the Gotland specimen, now numbered Ec 9324, in the Riksmuseum, Stockholm, referred by Bather (1893) to *G. squamifer*. The brachials do not seem to be as broad as in the types, and the specimen, which is not well preserved, is determined as *G.* cf. *squamiferus*.

Gissocrinus luculentus, sp. n.
(Pl. IX, figs. 5–8 ; figs. 6–7.)

Gissocrinus arthriticus Edmunds and Oakley, 1936, pl. iii, fig. 1.

Holotype.—The complete specimen on B.M. E 45528.

Paratypes.—B.M. 57280, B.M. 57285, B.M. E 6370, B.M. E 21904.

Diagnosis.—A species of *Gissocrinus* with a bowl-shaped cup with strong axial ridges, the brachials bearing three distal expansions, one dorsal and two lateral. The stem is formed of short columnals without conspicuous nodals.

Locality and horizon.—All the type specimens come from the Wenlock Limestone, Dudley. Several of the

* The figure given by Phillips (1839, pl. xvii, fig. 1) is entirely typical of *G. goniodactylus*. I am informed by the Curator of the Northampton Museum that the original figured specimen is in that institution.

other British Museum specimens come from Tividale, Dudley, but it is not possible to be more precise about the horizon, except to say that many of the specimens have a resemblance in the matrix to those known to come from the Upper Wenlock Limestone. The species is also known from the Wenlock Limestone, Walsall (B.M. 38689—Pl. IX, fig. 7).

Description.—Cup bowl-shaped, usually a little wider than high, with strong axial ridges. Infra-basals about half the height of the basals; basals about as high as wide, hexagonal or pentagonal; posterior basal truncate supporting the four-sided anal plate. Radials wider than high, the facet occupying about half the width of the plate. Several specimens show the radial pierced by the axial canal. One or two primibrachs; when there is only one, it is a long plate, while when there are two, the total length is very little greater, indicating that fusion of these two plates has taken place in some cases. The two forms occur together, even in the same specimen. Secundibrachs usually two, but sometimes only one in number, and the arms divide six times. Brachials, except in the young, about as high as wide, typically bearing three distal expansions, two lateral and one dorsal (Pl. IX, fig. 5), usually round-backed, but there may be an axial ridge. In old age the distal expansions may extend all round the dorsal side, thus simulating *G. arthriticus*. There are 5–7 covering plates per brachial.

Anal tube vertically disposed, formed of roughly quadrangular plates, strongly folded transversely (Pl. IX, fig. 6). It is about the same length as the arms, but in one of the specimens examined it emerges beyond the distal ends of the arm branches (B.M. 57285). Specimen B.M. 57282 shows an extra plate in the cup between the anal plate and the left posterior radial (fig. 7). Tegmen not seen. Stem formed of very low columnals without conspicuous nodals, usually being very smooth, with no cirri until the root is reached. The stem usually has a length about equal to that of the crown it supports.

Discussion.—The cup of this species is hardly distinguishable, except for the slightly smaller radial facets, from that of *G. goniodactylus*, but the features of the brachials and stem easily differentiate it from the latter.

It is probably more closely related to *G. arthriticus*, but is distinguished therefrom by the strong axial ridges in the cup, the vertical anal tube, the smooth stem, and the details of the brachials, which in *G. arthriticus* possess a distal expansion passing all round the dorsal side.

The colour of specimens of *G. luculentus* and *G. arthriticus* is commonly a light brown, while *G. goniodactylus* and *G. squamiferus* are usually dark brown or nearly black. According to Bather (1893, p. 151) the dark colouring in some crinoids is due to the presence of animal carbon enclosed within the stereom of the plates.

The specimen figured by Edmunds and Oakley (1936) is in the Geological Survey Museum (53722) and is typical of the species. The trivial name *luculentus* is derived from the Latin *luculentus*=bright.

References.

Angelin, N. P. 1878. 'Iconographia Crinoideorum in Stratis Sueciæ Siluricis Fossilium.' Stockholm.

Bather, F. A. 1892. "British Fossil Crinoids.—VIII. *Cyathocrinus*: *C. acinotubus*, Ang. and *C. vallatus*, sp. nov., Wenlock Limestone." Ann. & Mag. Nat. Hist. (6) ix, pp. 202–26, pl. xiii.

——. 1893. "The Crinoidea of Gotland." Kongl. Svenska Vet. Akad. Handl. xxv, No. 2, pp. 1–200, pls. i–x.

——. 1900. "The Crinoidea" in E. R. Lankester, 'A Treatise on Zoology', pt. 3. London.

Bouška, J. 1943. "Rod *Gissocrinus* Angelin a jeho druhy v českém siluru." Rozpravy II. třidy české Akademie, Praha. 53, No. 44, pp. 1–11, pls. i–ii.

Edmunds, F. H., and Oakley, K. P. 1936. "British Regional Geology. The Central England District." Mem. Geol. Surv. Gt. Britain. (Also 2nd Ed., 1947.)

Moore, R. C., and Laudon, L. R. 1944. "The Crinoidea" in H. W. Shimer and R. R. Shrock, 'Index Fossils of North America'. New York.

Phillips, J. 1839. In R. I. Murchison, 'The Silurian System'. London.

Salter, J. W. 1873. 'A Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge." Cambridge.

Woods, H. 1891. 'Catalogue of the Type Fossils in the Woodwardian Museum, Cambridge.' Cambridge.

EXPLANATION OF THE PLATE

All specimens except the original of fig. 7 are from the Wenlock Limestone, Dudley.

Fig. 1. *Gissocrinus squamiferus* (Salter). Portion of anal tube. B.U.H. 28. × 2.

Fig. 2. *G. squamiferus*. Anal side of cup. B.M. E 420. × 2.

Fig. 3. *G. squamiferus.* Lectotype. The arms are spread out, and the basal parts of the cup and the anal tube are missing. S.M. A 10138. × 1.

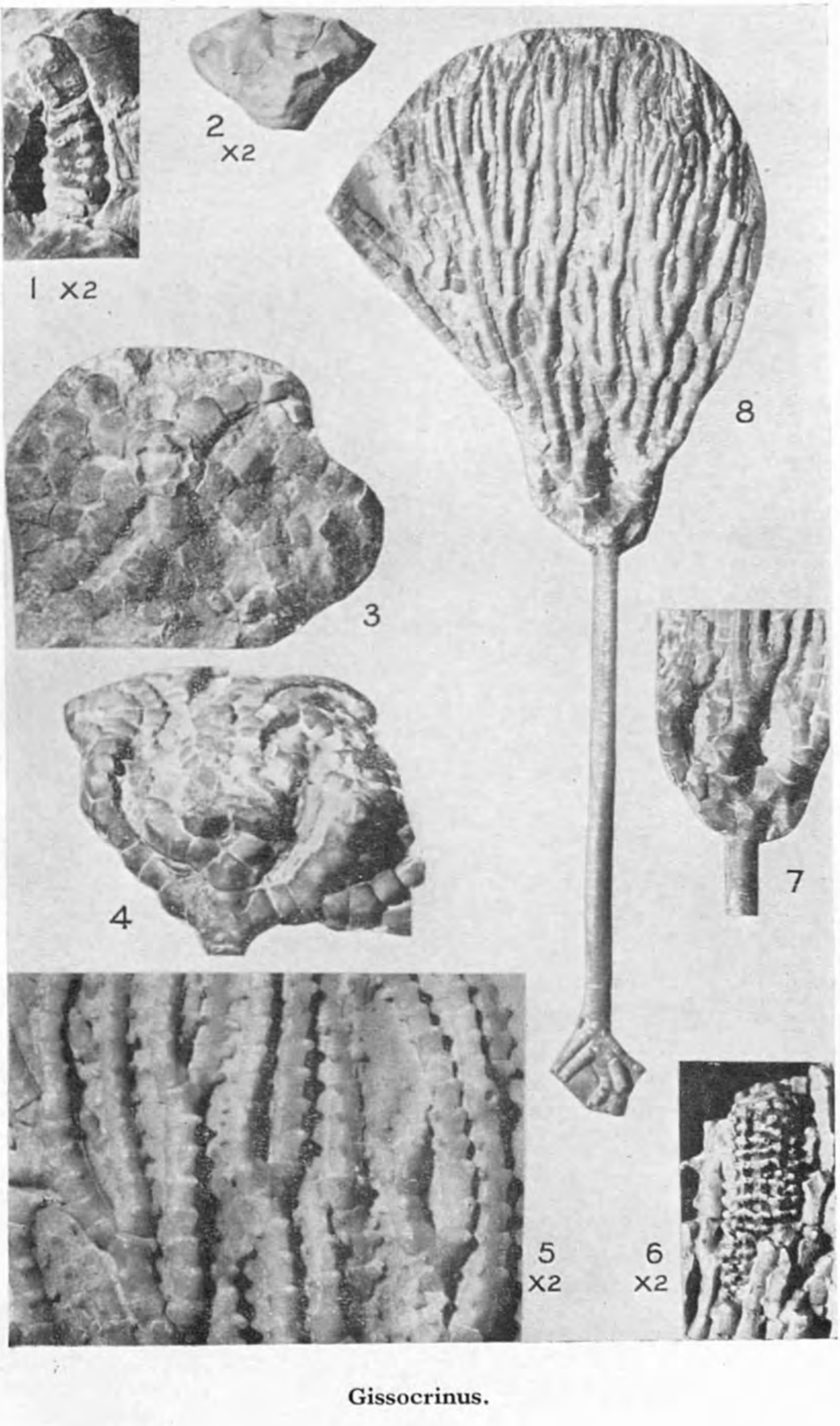
Fig. 4. *G. squamiferus.* Cup and parts of the arms. B.M. 40337. × 1.

Fig. 5. *Gissocrinus luculentus*, sp. n. Paratype. Details of the brachials. B.M. E 6370. × 2.

Fig. 6. *G. luculentus.* Paratype. Distal part of the anal tube. B.M. 57280. × 2.

Fig. 7. *G. luculentus.* Cup and proximal parts of the stem and arms. Wenlock Limestone, Walsall. B.M. 38689. × 1.

Fig. 8. *G. luculentus.* Holotype. B.M. E 45528. × 1.



Gissocrinus.

From the ANNALS AND MAGAZINE OF NATURAL HISTORY,
Ser. 12, vol. iii. p. 651, *August* 1950.

A New Species of Lyriocrinus *from the Wenlock Limestone.* By W. H. C. RAMSBOTTOM.*

[Plate IX.]

SUMMARY.

Analysis of variation in the anal inter-radius of the American species *Lyriocrinus melissa* (Hall) supports the assignment of the new English species described to the genus *Lyriocrinus*.

The first indication that the Silurian crinoid genus *Lyriocrinus* occurs in England was given by Salter as long ago as 1873 (Salter, 1873, p. 119)†. Wachsmuth and Springer (1897), Bather (1900), and Springer (1926) all mentioned the existence of English specimens, but no description has appeared until now.

The material on which the following account is based is from the Sedgwick Museum, Cambridge, the British Museum (Natural History), and the Geological Survey Museum, and I wish to thank the authorities of these museums for the loan of specimens. Mr. A. G. Brighton and Dr. C. J. Stubblefield have read the manuscript.

Symbols used in this paper follow Moore and Laudon (1941).

Subclass **CAMERATA** Wachsmuth and Springer, 1885.

Order DIPLOBATHRA Moore and Laudon, 1943.

Family **Rhodocrinitidæ** Bassler, 1938.

Genus LYRIOCRINUS Hall, 1852.

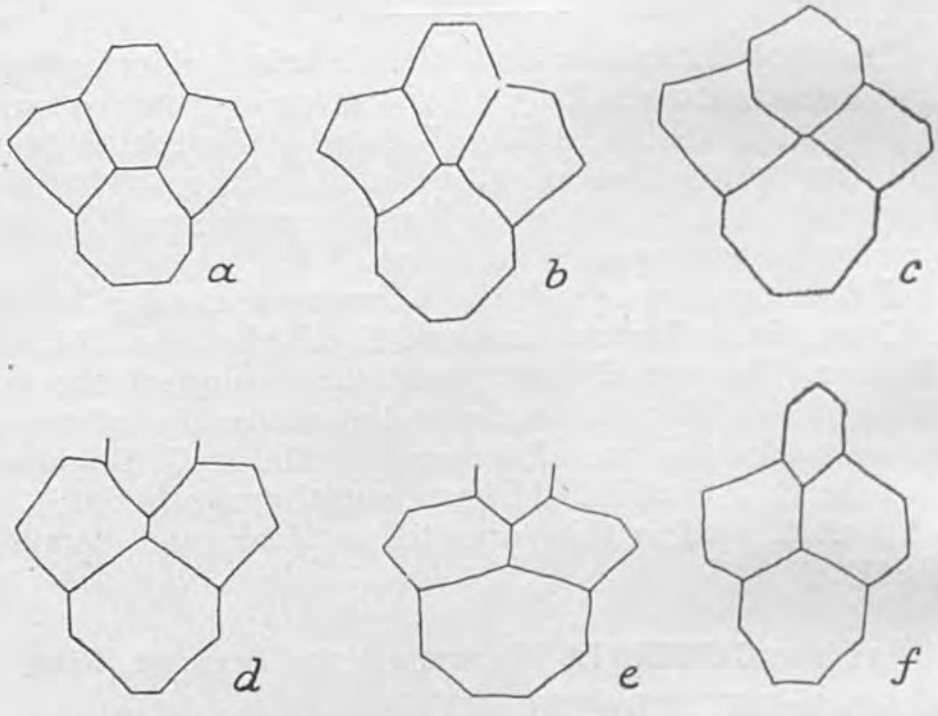
Type species by monotypy : *Marsupiocrinites ? dactylus* Hall, 1843.

Moore and Laudon (1944, p. 185) mention the " almost perfect pentamerous symmetry " of the cup, yet Wachsmuth and Springer (1897) state of the type species that " there is generally an anal plate between the interradials of the second row ", while *L. melissa* (Hall) " has exceptionally a small additional plate in the second row ". No specimens of *L. dactylus* have been available ror the present study, but the published figures bear out Wachsmuth and Springer's statement about it quoted above

* Published by permission of the Director of the Geological Survey.
† By a misprint the name appears here as '*Syriocrinus*'.

although the illustrations of the type specimens themselves do not show the extra plate. With regard to *L. melissa* no published figure has shown the presence of any extra plate in the anal inter-radius. Weller (1900) stated of specimens from the Chicago area that the cups were completely regular, the anal inter-radius being indistinguishable.

Fig. 1.



Diagrams of the inter-radial areas of *Lyriocrinus melissa* (Hall) from the Niagara Limestone, Waldron, Indiana, from specimens in the British Museum (Natural History). (*a*)–(*e*) anal inter-radii, (*f*) normal inter-radius. (*a*) E. 24139. (*b*) E. 5740. (*c*) E. 26599. (*d*) E. 24141. (*e*) and (*f*) E. 26601.

An examination of a series of nine cups of *L. melissa* from the Niagara Limestone at Waldron, Indiana, preserved in the British Museum (Natural History) has shown some interesting variations in the anal inter-radius (as fig. 1). Only eight of the specimens show the anal inter-radius clearly, and of these, one (E. 24142) is regular with the anal side not distinguishable, and three (E. 24139, E. 26600, E. 26602) have the plates of the anal inter-radius arranged substantially as in fig. 1 *a*. The remaining four can be arranged in a series (figs. 1 *b*–*e*) showing the gradual extrusion of the centre plate in the second row by movement upwards, leading to a prefectly pentamerous cup (as fig. 1*f*). There seems to be no correlation of these arrangements with the size of the cups which are all well grown with the exception of E. 26599 (fig. 1*c*) and E. 26602 (as fig. 1*a*) which are slightly smaller. None of the cups is well enough preserved to see the arrangement of the plates above the second row in the anal inter-radius.

The discovery of these structures in *L. melissa* has confirmed the assignment of the new English species to *Lyriocrinus*, for *L. britannicus*, sp. n., shows at least one extra plate in the anal inter-radius in all specimens in which the anal side has been seen.

Lyriocrinus britannicus, sp. n.
(Pl. IX; text-fig. 2.)

Diagnosis.—A species of *Lyriocrinus* with a subpentagonal flange on the truncate BB, and constantly three plates in the second row of the anal inter-radius; surface of plates smooth.

Material.—About twenty specimens are known from the Wenlock Limestone of Dudley. Only one of these (No. 369, Holcroft Collection, Birmingham University) is more accurately localized, coming from Tividale, Dudley. In museums, the Dudley crinoids are usually labelled as from "Wenlock Limestone, Dudley", but Bather (1890) has given reasons for assigning most of them to the Upper Wenlock Limestone, and this was confirmed by Butler (1939).

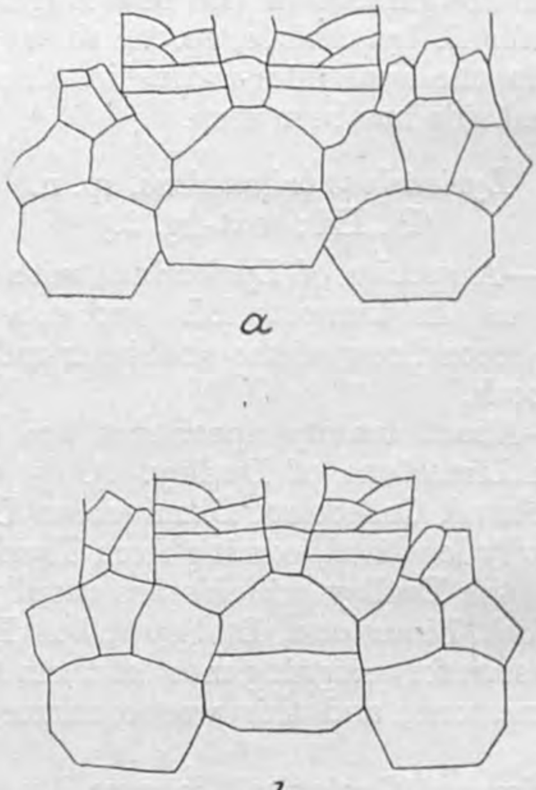
Four specimens (Geological Survey Museum 88869–88872) are known from the Wenlock Limestone at Benthall Edge, 3 miles N.E. of Much Wenlock, Shropshire.

Holotype.—Sedgwick Museum A. 12715, Dudley.

Paratypes.—Sedgwick Museum A. 13119, A. 13120, Dudley.

Description.—Cup bowl-shaped, considerably wider than high, and with a flat-bottomed basal concavity; IBB not seen, presumably five, very small, restricted to the basal concavity, and covered by the proximal columnal. BB five, equal, hexagonal and truncate, and bearing a subpentagonal flange which surrounds the basal concavity. RR five, equal, all separated by inter-radial plates. PBrBr two; SBrBr two, followed by biserial arms. Arms branch once giving ten rami which are stout, taper gradually, and bear one pinnule per brachial. Inter-radial areas formed of large plates arranged 1–2–1, followed by two small plates; the IR plates are in contact with the truncate tops of the BB. Anal inter-radius 1+3, followed by a variable number of plates in the third row. There is a single ISBr in contact with the PBr_2ax. Tegmen composed of many small plates with the anus central at the

Fig. 2.



Diagrammatic analyses of parts of the cup of *Lyriocrinus britannicus* sp. n.

(*a*) From Sedgwick Museum A. 13122, showing the irregularities in the left posterior inter-radius, and the three plates in the third row of the anal inter-radius.

(*b*) From British Museum (Natural History) E. 7156, showing irregularities in the anal inter-radius and the right posterior inter-radius.

end of a small tube. The surface of all the plates is smooth. Stem round, formed of regularly alternating nodals and internodals, throughout its length; the nodals, however, become more prominent distally.

Discussion.—Three other species of *Lyriocrinus* have been described, all from the United States of America;

L. britannicus, the first species to be described from Europe, is closest to *L. melissa* (Hall) but is smaller, there being usually no contraction of the cup at the level of the arm bases as in that species. In addition, the flange on the BB is less sharply pentagonal, and the "nodes" at the corners of the flange are not so prominent. In the specimens of *L. melissa* studied the flange is almost stellate. *L. britannicus* resembles *L. melissa* but differs from *L. dactylus* (Hall) in all the BB being truncate, and in the PBr_2ax being in contact with the single ISBr. In this latter feature, however, *L. melissa* seems to show some irregularity, even in the same specimen. In *L. britannicus* the anal inter-radius constantly has three plates in the second row, and the cup is proportionately higher than in *L. melissa.* The third American species, *L. sculptilis* (Hall), is inadequately described and has never been figured.

Wachsmuth and Springer (1897) noted the great irregularity of plate structure in the American species, and some irregularity is also seen in *L. britannicus.* In two specimens an extra plate is found in the third row of one inter-radius, but it is not found in the same position with regard to the anal side in both cases (fig. 2). This recalls the figures of *L. dactylus* given by Hall (1852, pl. 44, figs. 1 *a*, 1 *b*, 1 *d*), and was also represented in the original figures of the type specimens (Hall, 1843), but Wachsmuth and Springer (1897) in refiguring the types showed only one plate in this position. The plates above the second row in the anal inter-radius also show great irregularity (Pl. IX, fig. 3; text-fig. 2).

It seems likely that *L. britannicus* is a more primitive species than the American forms, because of the presence of the extra plate in the anal inter-radius. According to Moore and Laudon (1943) the general evolutionary tendency among the Diplobathra is towards a completely pentamerous cup. The probable mode of loss of the extra plate is seen in the series of cups of *L. melissa* figured here.

References.

Bather, F. A. 1890. "British Fossil Crinoids.—II. *Thenarocrinus callipyge*, gen. et sp. n., Wenlock Limestone." Ann. & Mag. Nat. Hist. (6) vi. pp. 222–235.

——. 1900. 'The Crinoidea' *in* Lankester, E. R., A Treatise on Zoology. Part III. London.

Butler, A. J. 1939. "The Stratigraphy of the Wenlock Limestone of Dudley." Q.J.G.S. xcv. pp. 37–74, pl. iii.
Hall, J. 1843. "Description of the Rocks and Groups of the New York System—Niagara Group," pp. 79–116. Nat. Hist. New York, Geol., pt. iv.
——. 1852. "Descriptions of the Organic Remains of the Lower Middle Division of the New York System." Pal. New York, ii. pp. 1–362, pls. i–civ.
Moore, R. C. and Laudon, L. R. 1941. "Symbols for Crinoid Parts." Journ. Pal. xv. pp. 412–423.
——. 1943. "Evolution and Classification of Paleozoic Crinoids." Geol. Soc. Am. Spec. Pap. xlvi. pp. 1–153, pls. i–xiv.
——. 1944. "The Crinoidea" *in* Shimer, H. W. and R. R. Shrock—Index Fossils of North America. New York.
Salter, J. W. 1873. "A Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge." Cambridge.
Springer, F. 1926. "American Silurian Crinoids." Smithsonian Inst. Pub. 2871, pp. 1–239, pls. i–xxxiii.
Wachsmuth, C. and Springer, F. 1897. "The North American Crinoidea Camerata." Harvard Coll. Mus. Comp. Zool. Mem. xxi.–xxii. pp. 1–897, pls. i–lxxiii.
Weller, S. 1900. "The Paleontology of the Niagara Limestone in the Chicago Area, The Crinoidea." Chicago Acad. Sci. Bull. iv. pp. 9–153, pls. i–xv.

EXPLANATION OF PLATE.

Lyriocrinus britannicus, sp. n.

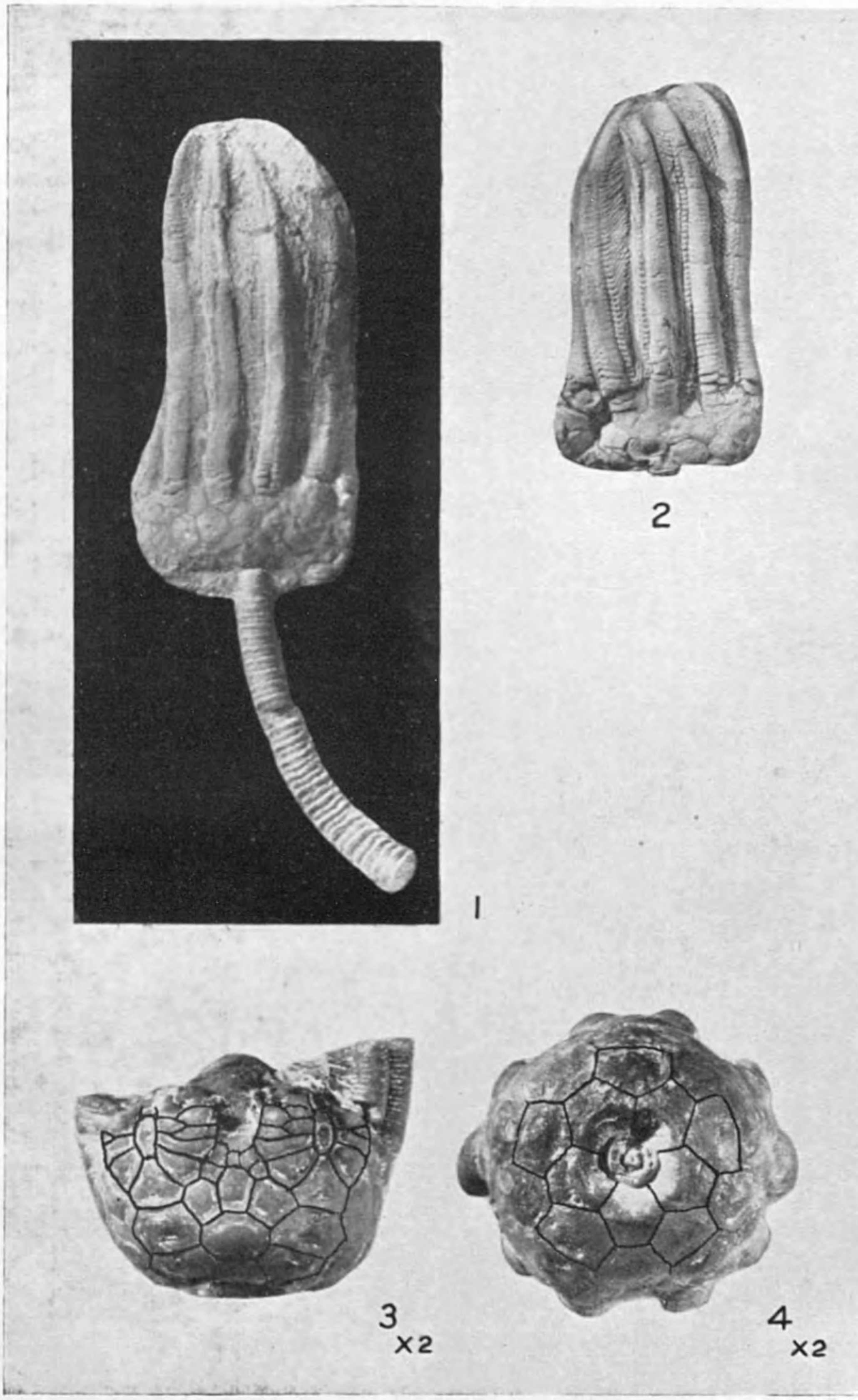
Wenlock Limestone, Dudley.

Fig. 1. Paratype, Sedgwick Museum, A. 13119. Natural size. The whole length of the stem is not shown in this figure.

Fig. 2. Paratype, Sedgwick Museum, A. 13120. Natural size. Showing details of the arms.

Fig. 3. Holotype, Sedgwick Museum, A. 12715. $\times 2$. Illustrating the structure of the anal side of the cup.

Fig. 4. Holotype. $\times 2$. View of the base of the cup showing the truncate basals bearing a flange. The proximal stem columnals are still in position and conceal the infrabasals.



Lyriocrinus britannicus, sp. n.

III.—CALCEOCRINIDAE FROM THE WENLOCK LIMESTONE OF DUDLEY

BY

W. H. C. RAMSBOTTOM, M.A.

[*From " Bulletin of the Geological Survey of Great Britain, No. 4 ", pages* 33-48

LONDON

HER MAJESTY'S STATIONERY OFFICE

1952

III.—CALCEOCRINIDAE FROM THE WENLOCK LIMESTONE OF DUDLEY

BY

W. H. C. RAMSBOTTOM, M.A.

Plates IV, V; Text-figures 1-4

Summary :—Six species of *Calceocrinus* (one new) and one of *Eucheirocrinus* are described from the Wenlock Limestone of Dudley. Some aspects of the mechanism of the hinge between the basals and radials in *Calceocrinus* are discussed, and the distribution of the Silurian species of *Calceocrinus* is tabulated. Two of the Dudley species are also known in Gotland.

INTRODUCTION

THE only British work in which any species of *Calceocrinus* has been described is that of Salter (1873, pp. 118-9), who briefly described and figured *C. fletcheri*, and gave names to three other species with very brief descriptions and citations of individual specimens by their registration numbers in the Woodwardian (now Sedgwick) Museum collection. Of these, two (*C. serialis* and *C. gradatus*), have been adopted in the present paper and credited to Salter, while the third (*C. abdominalis*) has had to be abandoned because the type specimen is a *Desmidocrinus* as reported by Woods (1891, p. 38). These species were described by Salter under the name *Cheirocrinus*, a name which, being preoccupied, has given place to *Calceocrinus* Hall.

The many early uncertainties with regard to the morphology and homologies of the various parts in this family were fully resolved by Bather (1893) in the course of his description of its Gotland representatives. In Bather's work there are several references to British material, and he wrote (p. 67) : " when the British species [of *Calceocrinus*] come to be defined, it will probably be found that, beside *C. Fletcheri*, there will be a species to which the name *C. serialis* can be applied, and perhaps two other species as yet unnamed ". In fact six species of *Calceocrinus* have now been recognized in England, including two (*C. pugil* Bather and *C. nitidus* Bather) also found in Gotland. There is also the unique specimen described by Springer (1926) as *Eucheirocrinus anglicus*. The terminology used by Bather (1893) has been largely followed here, with the exception that Springer's term " sub-anal " (Springer 1926, p. 89) has been preferred to the term " T piece " of Bather.

The collections on which this paper are based come from the British Museum (Natural History) (BM), the Sedgwick Museum, Cambridge (SM), the Geological Survey Museum (GSM), the Dudley Museum (DM), and the Holcroft (BUH) and Ketley (BUK) collections at the University of Birmingham. In all more than fifty specimens have been available, and I thank the authorities of these museums for their readiness in loaning this material. I have also, through the kindness of the authorities of the Riksmuseum in Stockholm, been able to borrow certain of the type specimens of Gotland species for comparative purposes. I am much indebted to Mr. A. G. Brighton and Dr. C. J. Stubblefield for helpful criticism of the manuscript.

Systematic Descriptions

Sub-class: INADUNATA Wachsmuth & Springer

Order: DISPARATA Moore & Laudon 1943

Family: Calceocrinidae Meek & Worthen 1873

Monocyclic Inadunata with the crown bent on the stem, in which bilateral symmetry along the left anterior radius and the right posterior interradius is progressively established. Basals connected by a muscular articulation (the hinge) with the radials, of which three are compound. Three or four arm bearing radials, and the anal plate becomes shifted over the right posterior radius eventually into the right posterior interradius, and supports a massive tube.

Calceocrinus Hall 1852

Calceocrinidae in which the right posterior and right anterior super-radials are fused to form a " sub-anal " plate which supports the anal plate and tube; basals three; left posterior and left anterior basals fused to form a single " left basal "; arms three, the left anterior being usually unbranched, end the anterior and left posterior branching on a characteristic axil arm plan.

Type species by monotypy and subsequent naming of the unnamed species *Calceocrinus halli* Ringueberg 1889.

Discussion.—An analysis of the cup and arms of the genus is given in Text-fig. 1. The evolution of this aberrant structure from the homocrinid or heterocrinid stock has been outlined by Springer (1926); see also Moore & Laudon 1943, fig. 3, p. 27. A few points in the morphology of the genus remain and may be discussed here.

With regard to the hinge between the basals and radials in the anterior part of the cup, it has long been agreed by authorities that the three pairs of fossae along the hinge line are for the reception of muscles, which were covered by a thin integument with supplementary plates, traces of which are commonly seen in the Dudley material. These muscles would pull the upper part of the cup and arms into a more upright position with regard to the stem and base, and according to Bather the original position was regained by the action of gravity. Bather (1893, p. 69) wrote that if there are muscles inside the cup which might also serve this function " it would appear from the evidence of some Dudley specimens that they were attached immediately beneath the external articular surface [of the hinge] ". The only available English specimen showing traces of possible muscular attachment in this position is a loose basal circlet of *C. serialis* numbered BM 40219b and figured on Pl. V, fig. 7. Here slight ridges run up and down the inside of the triangular left basal. Other loose basal circlets, however, show no such ridges in this position, and moreover they are usually formed of thicker plates. The specimen to which Bather probably referred is thus formed of unusually thin plates, and it is thought more likely that the ridges are strengthening struts supporting the hinge, rather than muscle attachments. This view is supported by the fact that there are also two stronger ridges on either side of the axial canal, which have a larger portion of the hinge to support. It is concluded therefore that there were no muscles inside the cup in this position.

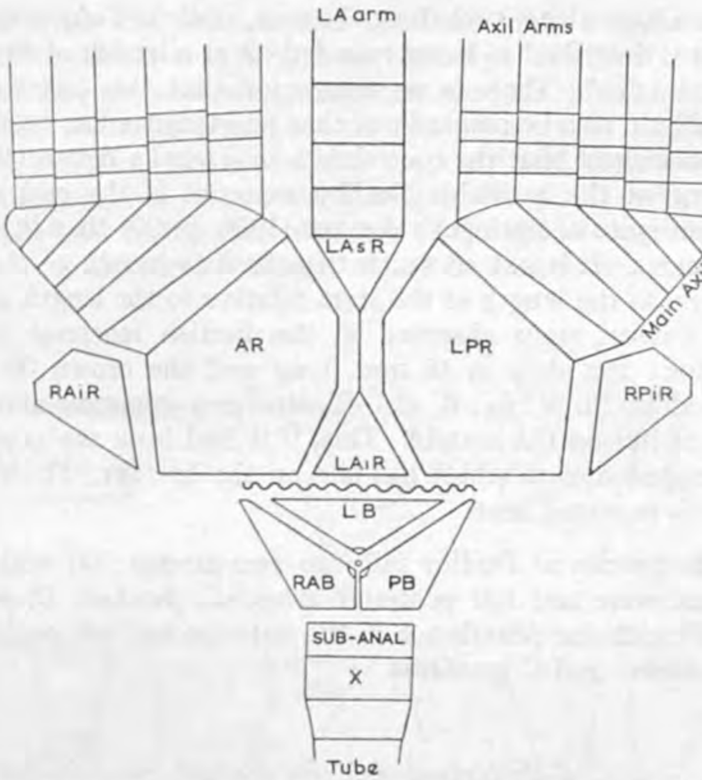


FIG. 1. Analysis of the cup and arms of *Calceocrinus*. The wavy line indicates the position of the hinge. iR=infer-radial ; sR=super-radial ; other lettering after Moore and Laudon.

The degree of movement of which the cup was capable has also been commented on by several authors. Ringueberg (1889, p. 389, pl. xi, figs. 4a, 4b) was of opinion that there was considerable movement, and that when the hinge was closed the consequent gap on the other (posterior) side of the cup was covered by an " elastic and flexible medium ". Bather (1893, p. 69) considered that there was not as much movement as Ringueberg had supposed, and that much of the movement was taken up by the stem. Springer (1926, p. 97), however, basing his conclusions largely on Lower Carboniferous specimens of *Halysiocrinus perplexus* (Shumard), suggested a muscular attachment between the basals and radials on the posterior side of the cup, and figured a specimen (pl. 30, fig. 15) in which the crown is in an almost erect position on the stem, leaving a large space in the posterior region between basals and radials. The plates bordering this space have rounded or bevelled edges with signs of muscular attachment, and are in no way suturally connected. This muscular field is also seen in some of the British material of *Calceocrinus* and the rounded edges are universal in the seven loose basal circlets examined. It is thus likely that arrangements similar to those demonstrated by Springer in the Carboniferous representatives also apply to the Silurian members of the family.

Mode of life.—The view put forward by Jaekel (1918, pp. 86-8, figs. 81, 83) that the Calceocrinidae were reef dwellers, with the stem lying recumbent on the sea bottom, was accepted by Springer (1926, p. 99). Actual stems, however, show no callus growth or similar signs of having lain on the bottom such as might have been expected according to Jaekel's theory. There has always been considerable doubt as to the length of the stem in this family and the method of attachment. Wachsmuth & Springer (1886, p. 205) have followed a stem for a distance of a foot without reaching the root, while in *Calceocrinus interpres* Bather the stem is described as being rounded off at a length of 44 mm. and as being quite unattached. There is no suggestion that this latter condition is normal, but it should also be pointed out that no evidence has been seen in the present study to suggest that the root shown in Jaekel's figure (1918, fig. 83) existed. In none of the available Dudley material is the end of the stem definitely seen, in spite of Springer's remark (1926, p. 99) that it is often seen in Dudley specimens. It is not so much the absolute length of the stem that matters, however, as the length of the stem relative to the length of the crown. The relatively longest stem observed in the British material is numbered GSM 83881, where the stem is 45 mm. long and the crown 30 mm. This specimen, figured in Pl. V, fig. 6, also illustrates a common attitude of the curved stem as it lies on the matrix. This, if it had been the position during life, does not suggest a stem which has lain on the bottom. The remainder of Jaekel's theory is accepted here.

Species.—The species at Dudley fall into two groups; (*a*) with two primibrachs in the anterior and left posterior arms—*C. fletcheri*, *C. pugil* and *C. inclinus*; and (*b*) with one primibrach in the anterior and left posterior arms—*C. serialis*, *C. nitidus* and *C. gradatus*.

Calceocrinus fletcheri (Salter)

Plate IV, fig. 1; Text-figure 2F

Cheirocrinus sp. with branched arms—Salter 1859, p. 535.
Cheirocrinus Fletcheri Salter 1873, p. 119, woodcut.
Calceocrinus Fletcheri Bather 1893, pp. 66, 74.

Holotype.—SM A 10126, Wenlock Limestone, Dudley.

Diagnosis.—A species of *Calceocrinus* with two primibrachs in the anterior and left posterior arms, a funnel shaped cup, the two portions of the left anterior radial in contact, and the axil arms repeatedly branched and with nodose axillaries.

Description of holotype.—The specimen is a complete crown with the stem incomplete, showing the left posterior side, but it has suffered considerably from early attempts at cleaning, and the proximal part of the stem and the basal part of the cup, including the hinge, have been smoothed out, thus obliterating many of the sutures. The dorsal cup, when seen from the left anterior radius, is funnel shaped, with no lateral constriction. It measures about 11 mm. in length, 12 mm. in maximum width, and about 8·5 mm. in thickness. The basals are not seen as separate plates, and the characters of the hinge are not visible except for the remains of some supplementary plates in the centre. The two portions of the left anterior radial are in contact for a distance of 2·3 mm. The infer-radial is the longer plate, and is indented below by the central muscle facet of the hinge. The large left posterior radial is seven sided, coming into contact with the first brachial of the left anterior arm. The remaining radials are not seen, and the only part of the anal structures visible are two stout plates, squarish in outline, which are probably the first plates of the anal tube. The sub-anal is not seen, but is probably small.

The left anterior arm is stout and undivided and is apparently complete, there being 29 brachials evenly tapering distally. The first brachial is broad and hexagonal, but the succeeding brachials are four sided and are wider than long. In the left posterior arm there are two primibrachs, and five main axils are seen. The axil arms are repeatedly branched and their axillary brachials are nodose in appearance due to thickening at the distal ends, the thickening being also carried on to the first brachials of the succeeding branches. In the first axil arm there are three brachials before division occurs, in the others only

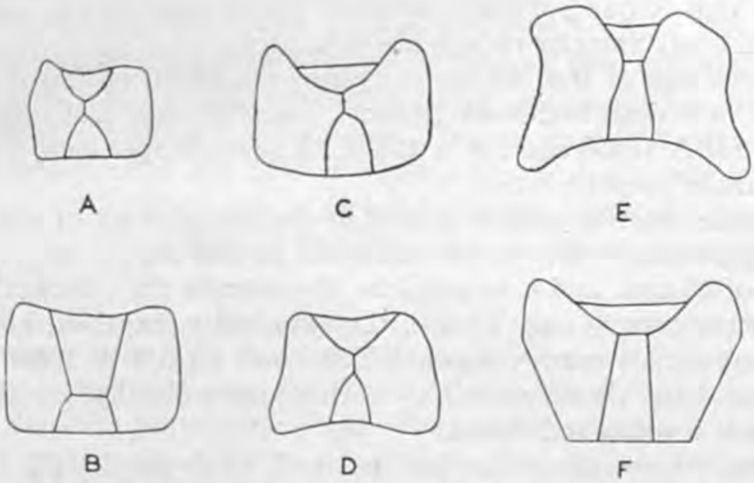


FIG. 2. Diagrams to show the shape of the upper part of the cup when seen from the left anterior radius, and the disposition of the two portions of the left anterior radial, in the English species of *Calceocrinus*, × 2. A, *C. nitidus* from the lectotype; B, *C. gradatus* from the holotype; C, *C. pugil* from the lectotype; D, *C. serialis* from the lectotype; E, *C. inclinus* from the holotype; F, *C. fletcheri* from the holotype.

two. The plan of the branching is the same throughout; the right hand branch at the first division is the one which divides again; thereafter the inner branch divides again at each division. The outer branches do not divide again. There are eight axillary brachials in the first axil arm, and thus nine finials. The second axil arm contains seven axillaries, the third six, the fourth six, whilst the fifth is partly buried in matrix. In all cases there are two brachials between successive divisions. Many of the plates have a pustulose ornament, such as has been described in *C. gotlandicus*.

The stem is incomplete but is preserved for a length of 55 mm. Proximally the columnals are not well seen, but they are probably short measuring about 1 mm. in length, whereas distally they measure 2 mm. in length.

Discussion.—The plan of the arm branching in this unique specimen follows that described by Bather in *C. gotlandicus* (Angelin), and it is with that species that *C. fletcheri* should be grouped. It differs from *C. gotlandicus* in the shape of the cup, the characters of the left anterior radials, which are separated in that species, and also in the stem.

Calceocrinus pugil Bather

Plate IV, figs. 2, 3 ; Text-figure 2c

Cheirocrinus serialis Salter 1873, p. 118, *pars*.
Calceocrinus pugil Bather 1893, pp. 82–5, pl. iii, figs. 98–104.
Calceocrinus pugil Springer 1926, p. 120, pl. 29, figs. 21, 21a.

Syntypes.—The three specimens described by Bather from Follingbo, Gotland. Of these, specimen (*b*), figured by Bather 1893, pl. iii, figs. 100-103, is here selected as the lectotype. It is numbered Ec 8938 in the Riksmuseum, Stockholm. The remaining syntypes are numbered Ec 8936 and Ec 8937 in the same collection.

Diagnosis.—A species of *Calceocrinus* in which the anterior and left posterior arms have two primibrachs, the second of which is in contact with the large radials : the cup is quadrangular, without lateral constriction, and the two portions of the left anterior radials are separated.

Discussion.—Six of the British specimens examined appear to belong to this species, first described from Gotland, viz. DM 365, DM 368, BUK 81, GSM 83885, SM A 12633 and SM A 12635. A seventh specimen, SM A 12636, is also doubtfully referred here.

This material enables several points in the morphology of the species to be resolved, particularly in regard to the stem. In DM 368 the stem is preserved for a length of 45 mm. and is incomplete. Proximally the columnals are short and the first six occupy only 3 mm.; they gradually lengthen, however, and distally six columnals occupy seven millimetres. In SM A 12635 where the stem is 27 mm. long, the columnals are rather longer distally, possibly because the specimen is a young individual.

Comparison of the specimens here referred to *C. pugil* with the original types described by Bather, shows slight differences in the arms of specimens deriving from the two areas. In particular the Gotland specimens have a very short proximal brachial in the axil arms ; and the English specimens also appear to have rather more nodose axillaries in the axil arms. Neither of these features is considered to be of specific importance, and it is to be expected that specimens of the same species from areas as far apart as England and Gotland would show slight differences.

Calceocrinus inclinus sp. nov.

Plate IV, figs. 4-7 ; Text-figure 2E

Cheirocrinus serialis Salter 1873, p. 118, *pars*.

Holotype.—SM A 12634, Wenlock Limestone, Dudley.

Paratype.—SM A 12639, Wenlock Limestone, Dudley.

Diagnosis.—A species of *Calceocrinus* with two primibrachs in the ateriorn and left posterior arms. Cup wider below, and with a marked lateral constriction ; the two portions of the left anterior radial are usually in contact ; sub-anal broad and separating the anal and radial plates. Axil arms with nodose axillaries.

Description of holotype.—The specimen (Pl. IV, figs. 5-7) is a complete cup, free of matrix, without arms, but with the main axils of the anterior and left posterior arms preserved. The cup is quadrangular, narrower upwards, and with a marked lateral constriction. It measures 12 mm. in width at the hinge line, 11 mm. in length, and 6·5 mm. in thickness. The basal circlet is sharply bent over, leaving a space of 3·5 mm. occupied by the hinge. The triangular left basal forms the whole of the hinge line, but does not enter into the formation of the stem facet. The two portions of the left anterior radial are in contact for a distance of 1·5 mm., the lateral sutures of both plates being curved and also having the appearance of having been secondarily thickened. The infer-radial is only 3 mm. wide at its base, and thus occupies only $\frac{1}{4}$ of the width of the hinge line ; it is prolonged downwards laterally to form the two dividing partitions of the hinge, which thus contains three deep pits, both above and below. At one side of the hinge line traces of supplementary plates can be seen. The large radials have straight sutures with the smaller right posterior and right anterior infer-radials, which are completely separated from the anal plate by the broad sub-anal. Two massive plates of the anal tube are preserved.

Only two brachials of the left anterior arm are present, of which the second has been displaced slightly to one side. The anterior and left posterior arms have two primibrachs, the first of which extends completely across the arm. The anterior arm has six main axils, but in the left posterior arm only three are preserved ; in a few cases the first brachials of the axil arms are seen to be about as long as wide.

Further Description.—The paratype (Pl. IV, fig. 4) is a crown with incomplete arms and stem, and the cup is damaged on the left anterior side. The left anterior arm is missing, but the axil arms have nodose axillaries, and branch on the same plan as in *C. pugil*. The brachials are about as long as broad, and the sutures of the axillaries are oblique. Two divisions occur in each axil arm—on the third and sixth brachials respectively in the first and second axil arms, and on the second and fourth in the next two arms. The divisions of the fifth and sixth axil arms cannot be seen. The main axils have " gaping " sutures, such as have been described in *C. interpres* and some other species, but there is no trace of supplementary plates covering these gapes. The stem is preserved for a length of 24 mm. and is formed of 18 columnals, the proximal three of which are very short (0·5 mm. each) and curved to meet the curvature of the stem facet. The columnals rapidly lengthen distalwards and the last three occupy 6 mm.

Discussion.—This species much resembles *C. interpres* Bather, from Gotland, in general aspect, but differs in the lateral constriction of the cup, and in the large sub-anal which separates the anal plate from the radials ; also in the normal size of the first brachials in the axil arms and in the nodosity of the axillaries. It is likely that Bather's words in reference to *C. interpres*—" it possibly occurs in England " (1893, p. 96) refer to specimens now described under the present species. The holotype was formerly a syntype of *C. serialis*. Besides the types four other specimens are assigned to this species, and also a cast numbered BM E 15327. (1) BM E 6317 is the left anterior side of a cup, and shows two portions of the left anterior radial just separated. (2) BUH 452, a cup much resembling the holotype but smaller. (3) BUH 210, a basal circlet in which the plates are extremely thick ; if this specimen is correctly assigned here, this feature, which cannot be seen on the other specimens, may account for the extreme flexing of the base on the radial parts of the cup, from which character has been derived the trivial name. (4) GSM 83884, only referred here with some doubt, for it appears to have a small sub-anal, though the other features are normal, and the specimen resembles the paratype in general aspect.

Calceocrinus serialis (Salter)

Plate V, figs. 2-7 ; Text-figure 2D

Cheirocrinus serialis Austin MS. Salter 1859, p. 535, *pars*.
Cheirocrinus serialis Salter 1873, p. 118, *pars*.
Calceocrinus serialis Bather 1893, p. 66, *pars*, p. 93.
Calceocrinus nitidus Springer 1926, p. 119, pl. 29, fig. 20.

Syntypes.—The specimens quoted by Salter (1873, p. 118) are eight in number, and as indicated by Bather (*in* Woods 1891, p. 38), they belong to more than one species. Salter (loc. cit.) mentions a " cast of Gray's specimen (Brit. Mus.) "; there is only one cast of a *Calceocrinus* in the Sedgwick Museum and this is taken from a specimen in the Gray collection in the British Museum (Natural History) numbered BM 40218, and this specimen is here selected as the lectotype. Of the other specimens quoted by Salter, SM A 12634 is the holotype of *C. inclinus* sp. nov. SM A 12633, A 12635 and possibly also A 12636 have two primibrachs and belong to *C. pugil*. SM A 12637 is not identifiable. This leaves SM A 12631 and A 12632 as the only remaining syntypes.

Diagnosis.—A species of *Calceocrinus* with one narrow stout primibrach in the anterior and left posterior arms, a quadrangular cup, contracting sharply upwards ; the right anterior and left posterior infer-radials narrow posteriorlv ; left anterior arm considerably larger than any of the axil arms ; left basal forms nearly the whole of the hinge line ; sub-anal moderately small.

Description of holotype.—The specimen (Pl. V, figs. 2, 3) is a crown and part of the stem, showing the anterior side, but with the hinge and proximal part of the left posterior side visible. The dorsal cup is low and quadrangular, with rounded corners near the hinge, and a rounded hinge base. There is no lateral constriction, but the cup is sharply narrowing above, towards the left anterior arm. It is 8 mm. in height ; 10 mm. in greatest width, which is about half way up the cup, and about 7·5 mm. in thickness. The left basal hardly enters into the formation of the stem facet, but widens sharply so as to occupy nearly the whole of the hinge line ; its sutures with the other basals are slightly curved. The posterior side of the base is hidden by the stem and no anal structures are visible. The hinge is 8·5 mm. wide and in the centre the space between the basals and radials is nearly 3 mm.; the detailed structure of the muscle facets is not discernible and two rows of supplementary plates, which are rather large, occupy the hinge area. The two portions of the left anterior radial are separated by about 1·2 mm., and the lateral sutures of the infer-radial are slightly curved. The anterior and left posterior radials are six-sided plates whose sutures with the right anterior and right posterior infer-radials are curved ; these infer-radials narrow posteriorly.

The left anterior arm is stout and undivided, being formed of 13 brachials, which are usually wider than long. It tapers sharply distally. The anterior arm has one primibrach which is narrow and stout, triangular in shape.

Probably six axil arms were present, but only five are clearly seen, being borne on the triangular main axils. The axil arms taper evenly distally and show some traces of branching the plan of which cannot be made out.

The stem is preserved for a length of 43 mm. and consists of 24 columnals. Proximally the columnals are short and curved upwards in the left anterior plane to meet the stem facet on the basal circlet. The first three columnals are short and occupy only 3 mm., but thereafter the length increases and the last three occupy 8·5 mm.

Further Description and Discussion.—The two syntypes show the essential features of the species as expressed in the diagnosis, but SM A 12632 is poorly preserved.

The structure of the posterior side is well seen in BM 40217 (Pl. V, fig. 5) in which the sub-anal is a moderately wide concavo-convex plate supporting the wide anal plate, which is in contact with the radials laterally. One further plate of the anal tube is seen, but the remainder are hidden bv the arms.

It is evident from a study of a comparatively large number of specimens in the available material that there is considerable variation in this species. In particular the degree of separation of the two portions of the left anterior radial is notable (Pl. V, figs. 3, 4). In no specimen do the two plates meet at a point ; they may be just separated, which is the more usual condition, or narrowly in contact at their apices. Some specimens show a slight nodosity of the axillaries in the axil arms, a feature which seems to have no specific importance, and is found more commonly in American and British species, than in those from Gotland.

C. serialis is closely related to *C. nitidus* Bather. The holotypes of the two species differ in the shape of the cup, which contracts more sharply towards the left anterior arm in *C. serialis*, the proportion of the right anterior and right posterior infer-radials which are thinning more towards the posterior and are longer in *C. serialis*. The brachials forming the axil arms are more slender in *C. serialis*, and the primibrachs of the anterior and left posterior arms are shorter, stouter plates. The left basal forms a larger proportion of the hinge line in *C. serialis* than in *C. nitidus*. As is explained under *C. nitidus*, however, there are some specimens intermediate between the two species in some of these features. These have usually been referred to *C. serialis* on account of the shape of the cup, which is usually a reliable specific character. *C. serialis* is much the commonest species at Dudley.

Calceocrinus nitidus Bather

Text-figure 2A

?*Chirocrinus gotlandicus* Angelin 1878, pl. xvi, figs. 10–14 (not figs. 6–9).
Calceocrinus nitidus Bather 1893, pp. 91–94, pl. iii, figs. 117–22.
Synchirocrinus anglicus Jaekel 1918, pp. 86–8, figs. 81–3.
Synchirocrinus anglicus Ehrenberg 1929, p. 65, fig. 40.
not *Calceocrinus nitidus* Springer 1926 (= *C. serialis*).

Syntypes.—Two specimens described by Bather (1893, p. 91), of which specimen (*a*) is here designated as the lectotype ; it is registered Ec 8947 in the Riksmuseum, Stockholm, and comes from Follingbo, Gotland. The other specimen from the same locality is No. Ec 8948 in the same collection.

Diagnosis.—A species of *Calceocrinus* with one wide primibrach in the anterior and left posterior arms, a quadrangular cup without lateral constriction, right anterior and right posterior infer-radials not thinning posteriorly, and the sub-anal plate very small. Left anterior arm considerably larger than any of the axil arms. Left basal forms about two thirds of the length of the hinge line.

Discussion.—Several Dudley specimens appear to agree closely with the types of this species, which were fully described by Bather (1893). The characters in which *C. nitidus* differs from *C. serialis* have been given under the latter species. There are, however, some specimens which are intermediate between the two species, and it is possible that *C. nitidus* should be considered as a variety of the older species. The only point in which the morphology of the species can be extended is in the stem, which is seen in DM 369 to be formed of small columnals throughout.

The species described by Jaekel (1918) as *Synchirocrinus anglicus* appears to be identical with *C. nitidus*. This is borne out by the shape of the cup, the small proportion of the hinge line occupied by the left basal, the shape of the primibrach and the relative stoutness of the brachials forming the axil arms.

Calceocrinus gradatus (Salter)

Plate V, fig. 1 ; Text-figure 2B

Cheirocrinus gradatus Salter 1873, p. 118.
Calceocrinus gradatus Bather 1893, pp. 66, 67.

Holotype.—SM A 10127, Wenlock Limestone, Dudley.

Diagnosis.—A species of *Calceocrinus* with one primibrach in the anterior and left posterior arms, a quadrate cup without lateral constriction, in which the left anterior super-radial is longer than and in contact with the left anterior infer-radial ; left anterior arm not much larger than the axil arms ; stem wide and formed of short columnals.

Description of Holotype.—The specimen is a crown with a portion of the stem, seen from the anterior side. The cup is quadrangular, apparently without laterial constriction, but with rounded margins. The basal region is not well seen, but probably the left basal does not form the whole of the hinge line. Posterior structures not seen, but the sub-anal is probably small, and the right anterior infer-radial narrows posteriorly. The two portions of the left anterior radial are in contact at their apices, and the super-radial is the longer plate, measuring 4 mm. in length, as against only 2·5 mm. for the infer-radial.

The left anterior arm is only slightly larger than the first axil arm, and tapers sharply distally ; its brachials are wider than long. The anterior arm has one small triangular primibrach, and there are seven main axils, whose axil arms decrease in size evenly further away from the cup. Indication that branching takes place in the axil arms is seen in the very slight nodosity of some of the brachials, but the plan of the arm branching cannot be made out.

The stem, preserved for a length of 36 mm., but incomplete, is formed throughout of very short columnals, and is comparatively wide for the size of the crown.

Discussion.—The specimen named by Salter *C. gradatus* on account of the even nature of the arms, has several other peculiarities apart from this, which have warranted retaining the species distinct from *C. serialis*. A left anterior super-radial larger than its infer-radial is known in no other described species of the genus, and the features of the stem are also characteristic.

Eucheirocrinus Meek & Worthen

Type species by the subsequent designation of Bather 1893, p. 56, *Cheirocrinus chrysalis* Hall 1860.

Discussion.—The structure of the cup in this genus is essentially the same as in *Calceocrinus*, except that here the two portions of the left anterior radial are invariably in contact, and the left posterior and left anterior basals are not yet fused. The two genera are distinguished by the arm structure, and the highly developed axil arm arrangement of *Calceocrinus* is at a much earlier stage in *Eucheirocrinus*, where the anterior and left posterior arms are branching on the normal heterocrinid plan (Text-fig. 3). Springer (1926, pp. 89-94) has already discussed the development of the axil arms of *Calceocrinus* and *Halysiocrinus* Ulrich, from the heterocrinid ancestor, and *Eucheirocrinus* forms an intermediate stage.

Eucheirocrinus anglicus Springer

Plate V, figs. 8, 9 ; Text-figure 3

Eucheirocrinus anglicus Springer 1926, p. 113, text-fig. 3a, pl. 29, fig. 6.

Holotype.—The unique specimen figured and described by Springer, now in the Springer collection at the U.S. National Museum ; Wenlock Limestone, Dudley.

Diagnosis.—A species of *Eucheirocrinus* in which all the three arms have one primibrach.

Description of holotype.—The specimen is a crown with a portion of the stem, showing the left posterior side. The cup is quadrangular, but is slightly wider towards the left anterior arm ; it measures 4·5 mm. in height, 5·0 mm. in maximum width, and 4·5 mm. in thickness. The basals and hinge are not clearly seen and the sutures have been obliterated. The two portions of the left anterior radial are in contact for a distance of about 1·5 mm.; the infer-radial is four sided and long, while the super-radial is hexagonal, short and broad. The left posterior radial is large and it has a curved sutures with the right anterior infer-radial.

The left anterior arm bifurcates on the first brachial ; of the two branches so formed the right hand one branches again on the third secundibrach, while the left hand branch divides on the second secundibrach. Two more bifurcations occur in each of the branches, and they follow the same plan as in the arms of other species such as *C. fletcheri*, in which the outer branches do not divide again. There are thus eight finials in the left anterior arm. The left posterior arm also has only one primibrach and each branch divides again on the third brachial. The plan of further branching is not seen.

The stem, which is incomplete, is preserved for a length of 12 mm., and is formed of eight columnals ; these are indistinct proximally, but distally they are nearly twice as long as wide.

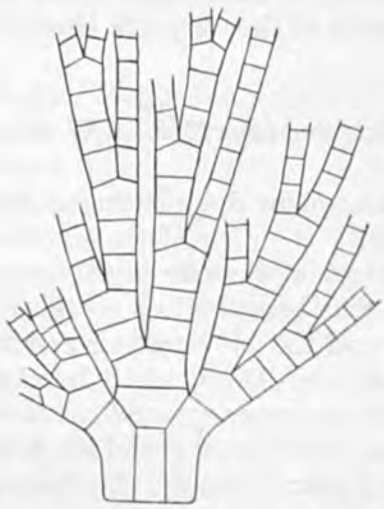


FIG. 3. Diagram to show the shape of the upper part of the cup and the arm branching in *Eucheirocrinus anglicus*. (From Springer 1926, p. 112, fig. 3c).

Discussion.—The specimen has not been available for study, but a cast of the original is numbered BM E 26841. An attempt is made here to bring the description of this species into line with that of the other species described, but several features are not well seen on the cast. Springer's original illustrations are reproduced.

This species is unique in the whole family of Calceocrinidae in that all the arms have only one primibrach. The profuse branching of the left anterior arm is also unusual. As pointed out by Springer the specimen is probably juvenile, and the length of the columnals forming the stem confirms this. It is probably the latest representative of its genus, and is evidently a specialised offshoot which left no descendants.

DISTRIBUTION

Before discussing the distribution of the Silurian species of *Calceocrinus* it would be well to establish the horizons of specimens deriving from the three areas where they are known to occur.[1] Unfortunately none of the British material from Dudley bears any indication of the horizon within the Wenlock Limestone from which it is derived. Bather (1890, p. 224) suggested, on the evidence of Mr. Madely, a local collector, that most of the crinoid material came from the Upper or Thick Wenlock Limestone, a conclusion which was confirmed by Butler (1939, p. 61). According to Butler this horizon would lie at the top of the Wenlock, within the zone of *Cyrtograptus lundgreni* (1939, p. 55).

With regard to the Gotland occurrences the correlation of Hede (1942) differs somewhat from that given by Bather (1893, p. 16), and it has been

[1] Růžička and Bouška (V'da Přírodní, vol. 22, pt. 7, 1944), record a *Calceocrinus* from e a_2 of Bohemia, but no further details are given.

followed here. According to Hede the main crinoid bearing rocks in Gotland—the Slite Group—are not younger than the zone of *Cyrtograptus ellesi*, that is to say they are rather earlier in date than the English occurrences.

The work of Amsden (1949) on the Silurian of Tennessee has shown that the divisions of the Brownsport formation outlined by Springer (1926, p. 5) do not exist and are due to facies changes. The Brownsport formation is here considered as approximately equivalent to the Upper Wenlock, the Waldron to the Middle Wenlock, the Laurel and Rochester to the Lower Wenlock, and the Medinian in a general way to the Upper Llandovery.

The accompanying table (Text-fig. 4) shows all the named species of *Calceocrinus* from their respective areas. The American species were largely described by Springer (1926) and the Gotland forms by Bather (1893). A detailed bibliography is given by Bassler & Moodey (1943). This table has been made so as to be comparable with similar diagrams compiled for other genera by Regnéll (1948), although it is likely that Regnéll's diagrams would look different if full account were taken of the stratigraphical notes given above. The inference is clear that the centre of origin of the genus lies in N. America only appearing in Europe at a much later date, though it is not likely, as claimed by Regnéll for the genera *Pisocrinus*, *Gissocrinus*, *Pycnosaccus* and *Crotalocrinites* that there is evidence of an easterly migration from England to Gotland.

	America	England	Gotland
Lower Ludlow	. .	. .	cf. 19, 21 ?
Upper Wenlock ..	9, 10	11, 12, 13, 14, 15, 16	13, 16, 17, 18, 19, 20, 21
Middle Wenlock ..	7, 8		
Lower Wenlock ..	4, 5, 6		
Upper Llandovery ..	1, 2, 3		

FIG. 4. Table showing the regional distribution and stratigraphical ranges of the Silurian species of *Calceocrinus*. 1, *alleni* Rowley ; 2, *incertus* Foerste ; 3, *centrevillensis* Foerste ; 4, *halli* Ringueberg ; 5, *typus* Ringueberg ; 6, *bidentatus* Ringueberg ; 7, *stigmatus* Hall ; 8, *bifurcatus* Springer ; 9, *bassleri* Springer ; 10, *foerstei* Springer ; 11, *fletcheri* (Salter) ; 12, *inclinus* sp. nov. ; 13, *pugil* Bather ; 14, *serialis* (Salter) ; 15, *gradatus* (Salter) ; 16, *nitidus* Bather ; 17, *gotlandicus* (Angelin) ; 18, *tucanus* Bather ; 19, *tenax* Bather ; 20, *interpres* Bather ; 21, *pinnulatus* Bather.

It is unnecessary to repeat in detail the general trends of evolution in the Calceocrinidae, as these have been discussed at some length by Bather and Springer, and a brief summary will suffice. In the cup the evolutionary later species have the two halves of the left anterior radial separated, and the subanal becomes increasingly smaller. No generalization can be made about the changes in the shape of the cup in evolution. The left anterior arm is only divided in primitive species, and the branching of the anterior and left posterior arms becomes more unequal in the more specialized species (see Springer 1926, fig. 2, p. 94). There also appears to be a tendency among the English species to have nodose axillaries in the axil arms, and this is also seen to some extent in the American species, but this is not a good specific character for it is very variable in, for example, *C. serialis*.

From general criteria and following Moore & Laudon (1943, pp. 10, 20, 27) it is clear that those species with only one primibrach are the most specialised ; it is noteworthy that these do not occur in America. As has been noted above, these are very variable and the three named species (*C. serialis*, *C. nitidus*, and *C. gradatus*) are probably only extremes of variation in a group which, although successful in point of numbers, never achieved any real degree of stability and left no descendants. Here it may be mentioned that *Eucheirocrinus anglicus* also has only one primibrach, and it is the only species of its genus known outside America. Thus it is that in these Silurian genera the latest occurrences include a high proportion of the most specialised species. Of the English species *C. pugil* and *C. inclinus* are those most related to American forms, while all the English species except perhaps *C. gradatus* have close relations in Gotland.

References

AMSDEN, T. W. 1949. The Stratigraphy and Paleontology of the Brownsport Formation (Silurian) of Western Tennessee. *Bull. Peabody Mus. Nat. Hist. Yale*, 5, pp. 1–138, pls. i–xxxiv.

ANGELIN, N. P. 1878. *Iconographia crinoideorum in stratis Sueciae Siluricis fossilium.* Stockholm.

BASSLER, R. S. and M. W. MOODEY. 1943. Bibliographic and Faunal Index of Paleozoic Pelmatozoan Echinoderms. *Spec. Papers Geol. Soc. Amer.*, 45, pp. 1–734.

BATHER, F. A. 1890. British Fossil Crinoids III, *Thenarocrinus callipygus* gen. et sp. nov., Wenlock Limestone. *Ann. Mag. Nat. Hist.* [6], vi, pp. 222–35, pl. x.

———. 1893. The Crinoidea of Gotland. *Kongl. Svenska Vet.-Akad. Handl.*, Bd. 25, No. 2, pp. 1-200, pls. i-x.

BUTLER, A. J. 1939. The Stratigraphy of the Wenlock Limestone of Dudley. *Quart. Journ. Geol. Soc.*, xcv, pp. 37-74, pl. iii.

EHRENBERG, K. 1929. Pelmatozoan Root-forms (Fixation). *Bull. Amer. Mus. Nat. Hist.*, lix, pp. 1–76.

HEDE, J. E. 1942. The Correlation of the Silurian of Gotland. *Lunds Geol. Fältk.*, 1892–1942, pp. 205–29.

JAEKEL, O. 1918. Phylogenie und System der Pelmatozoen. *Pal. Zeits.*, iii, pp. 1–128, 114 text-figs.

MOORE, R. C. and L. R. LAUDON. 1943. The Evolution and Classification of Paleozoic Crinoids. *Spec. Papers Geol. Soc. Amer.*, 46, pp. 1–153, pls. i–xiv.

REGNÉLL, G. 1948. An Outline of the Succession and Migration of Non-crinoid Pelmatozoan Faunas in the Lower Paleozoic of Scandinavia. *Arkiv för Kemi. Min. och Geol.*, Bd. 26 A, No. 13, pp. 1–55.

RINGUEBERG, E. N. S. 1889. The Calceocrinidae : A Revision of the Family, with Descriptions of some New Species. *Ann. New York. Acad. Sci.*, iv, pp. 388–406, pls. x–xi.

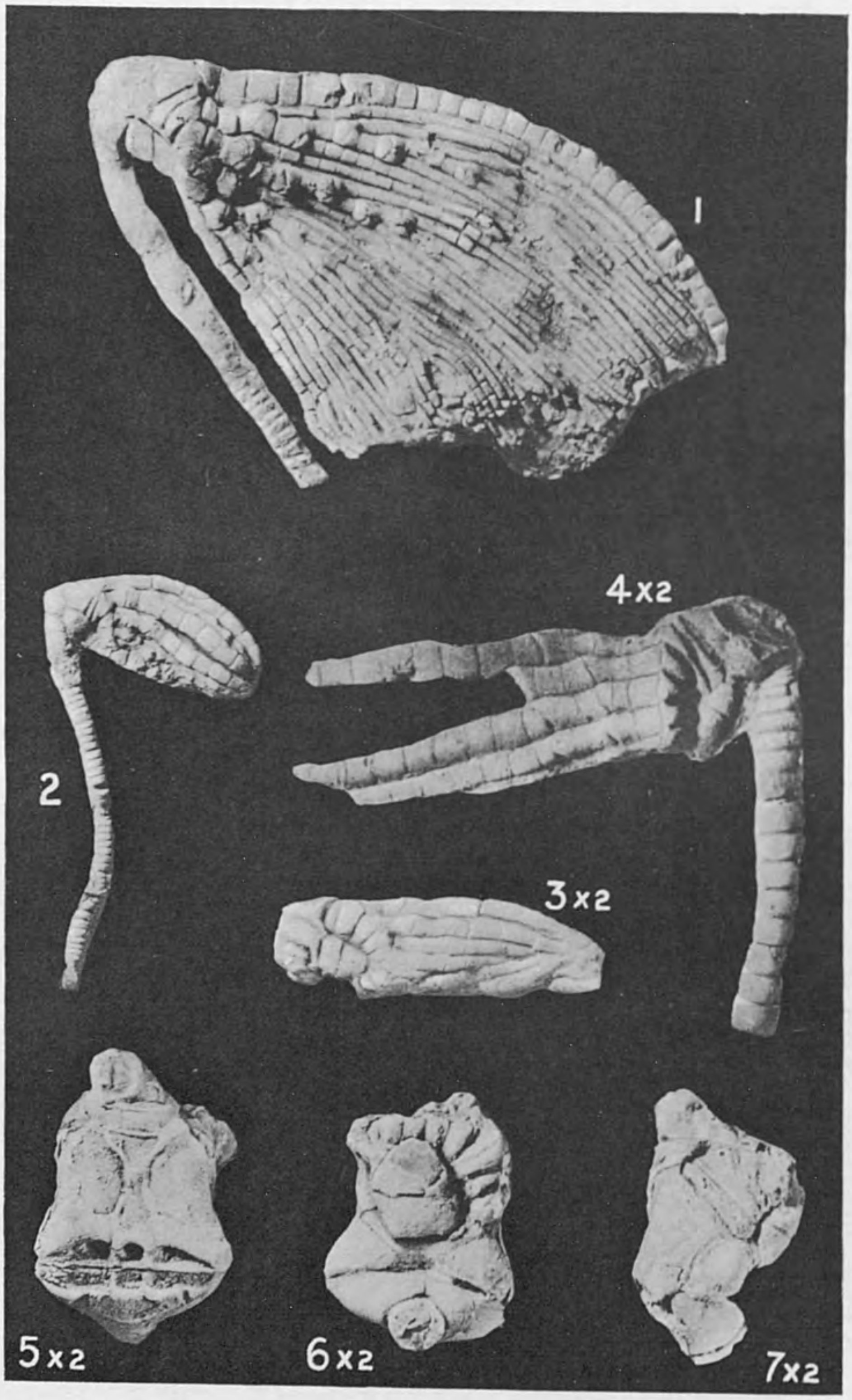
SALTER, J. W. 1859. Appendix A *in* R. I. MURCHISON, " *Siluria* ". 3rd edition (= 2nd edition), pp. 531–52. London.

———. 1873. *A Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge.* Cambridge.

SPRINGER, F. 1926. American Silurian Crinoids. *Smithsonian Inst. Pub.* 2871, pp. 1–239, pls. 1–33.

WACHSMUTH, C. and F. SPRINGER. 1886. Revision of the Palaeocrinoidea, pt. iii. *Proc. Acad. Nat. Sci. Philadelphia*, pp. 64–226.

WOODS, H. 1891. *Catalogue of the Type Fossils in the Woodwardian Museum, Cambridge.* Cambridge.



WENLOCK CALCEOCRINIDAE FROM DUDLEY

Explanation of Plate IV

All specimens come from the Wenlock Limestone, Dudley.

FIG. 1 *Calceocrinus fletcheri* (Salter), holotype, SM A 10126, natural size. (p. 36).

FIG. 2 *Calceocrinus pugil* Bather, DM 368, natural size. In this specimen the crown is more erect on the stem than any other among the English material. (p. 38).

FIG. 3 *C. pugil*, SM A 12633, × 2. Showing the sub-anal plate. (p. 38).

FIG. 4 *Calceocrinus inclinus* sp. nov., paratype, SM A 12639, × 2. (p. 38).

FIGS. 5–7 *C. inclinus*, three views of the holotype, SM A 12634, × 2. Fig. 5, the hinge and left anterior side of the cup. Fig. 6, the posterior side of the cup showing the broad sub-anal. Fig.7, left posterior view of the cup, showing the two primibrachs in the left posterior arm. (p. 38).

Explanation of Plate V

All specimens come from the Wenlock Limestone, Dudley.

Fig. 1	*Calceocrinus gradatus* (Salter), holotype, SM A 10127, natural size. (p. 42).
Figs. 2, 3	*Calceocrinus serialis* (Salter), lectotype, BM 40218, natural size. (p. 40).
Fig. 4	*C. serialis*, BM E 5599, natural size. The two halves of the left anterior radial are here just in contact at their apices. (p. 40).
Fig. 5	*C. serialis*, BM. 40217, natural size, showing the structure of the posterior side of the cup. (p. 40).
Fig. 6	*C. serialis*, GSM 83881, × 2. Shows nodose axillaries in the axil arms. (p. 40).
Fig. 7	*C. serialis*, BM 40219b, × 4. Internal view of the basal circlet showing the strengthening ridges on the left basal. (p. 34).
Figs. 8, 9	*Eucheirocrinus anglicus* (Springer), holotype, Original in the Springer Collection at the U.S. National Museum, × 2. Reproduced from Springer 1926, pl. 29, figs. 6, 6a. (p. 43).

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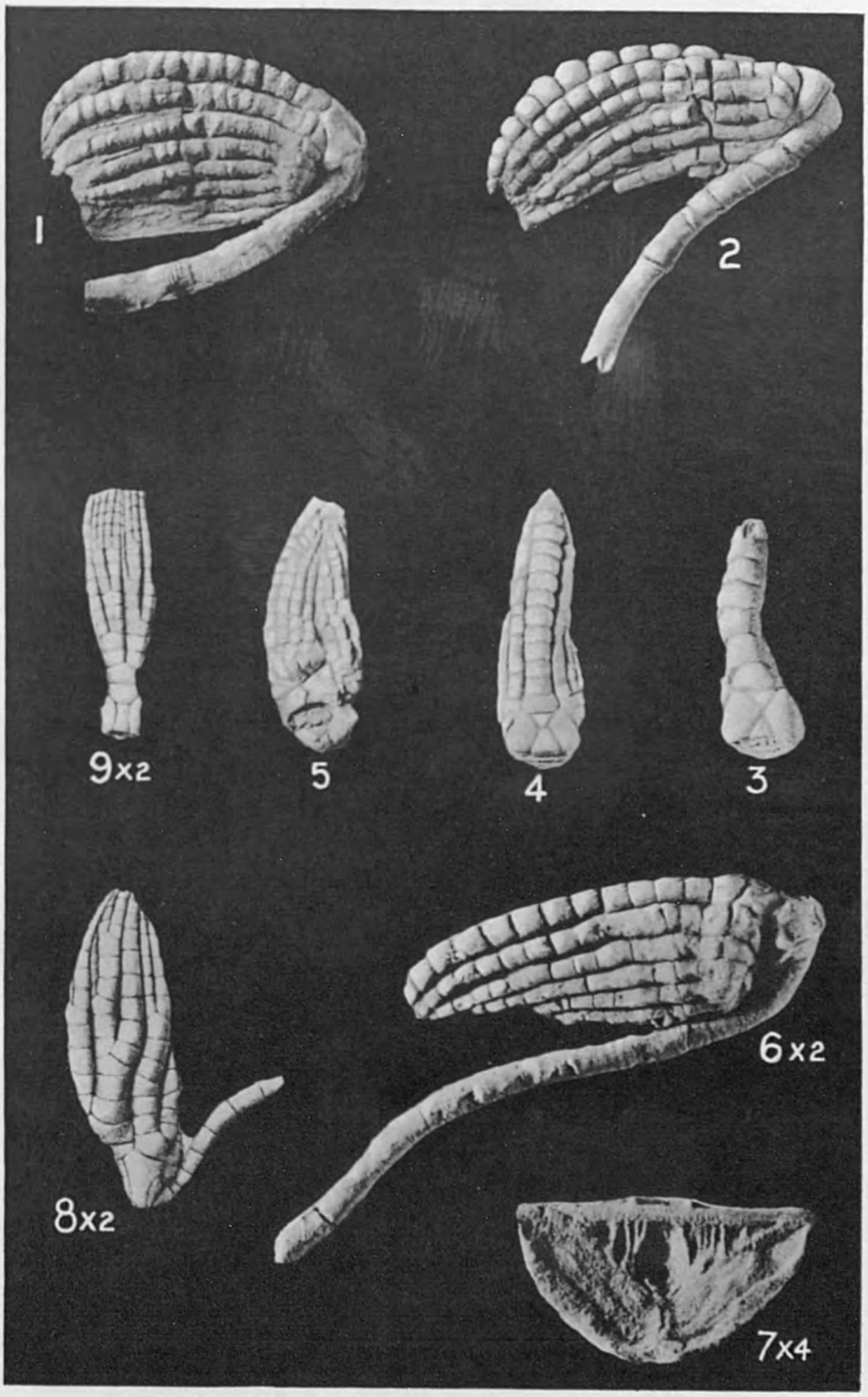

WENLOCK CALCEOCRINIDAE FROM DUDLEY

II.—THE FAUNA OF THE CEFN COED MARINE BAND IN THE COAL MEASURES AT ABERBAIDEN, NEAR TONDU, GLAMORGAN.

BY

W. H. C. RAMSBOTTOM, M.A.

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W. H. C. RAMSBOTTOM, M.A.

Plates II, III

Summary :—This fauna was discovered by Dr. A. W. Woodland in 1948 during field mapping of the South Wales coalfield. It is the richest yet found in any Coal Measures Marine Band in Britain, and some 80 species are recorded from shales 5½" in thickness. Several forms new to the British Coal Measures and considered to be of American affinity are described, and among them are new species of kirkbyan ostracods and of *Productus* (*Marginifera*). Attention to the internal characters of some chonetids has necessitated the erection of a new subgenus of *Chonetes* and the restriction of *Lissochonetes* and *Tornquistia* to species resembling their respective type species. A new species of *Limipecten* is described, and a new, but unnamed species of *Straparolus* is discussed. The affinities of this fauna in relation to the British Coal Measures marine fauna as a whole are briefly mentioned.

INTRODUCTION

DURING six-inch field mapping in 1948, Dr. A. W. Woodland discovered a very fossiliferous exposure of the Cefn Coed Marine Band in a stream section near the middle of the South crop of the South Wales coalfield. The peculiarly rich fauna of this Similis-Pulchra zone marine band is listed here, and some of the fossils are described. The paper is based on two collections, one by Dr. Woodland and numbered in the Geological Survey collections AW 3297-3444, and the other by Dr. Woodland, Dr. C. J. Stubblefield and W. H. C. Ramsbottom, numbered HR 1-588. The section in the stream-bank, 720 yards E.S.E. of Aberbaiden Farm, near Tondu, Glamorgan, is as follows :—

		Inches
	Soft grey shale, much weathered	15 seen
	Canneloid shale	1¼
D.	Hard grey shale	8
C.	Dark grey shale	
B.	Very soft grey shale	8
A.	Hard dark grey-blue shale	5½
	Soft grey shale	2
	Coal	5
	Soft grey planty shale or seatearth much weathered.	

The beds marked A B C D are those in which marine fossils were found, and the total thickness of the marine band is thus 21½ inches. No fossils were found in the other beds. Lists of the fossils found in the four beds are given below :—

Bed A

Calamites sp.; Boring sponge, cf. *Clionoides*; *Zaphrentoides postuma* (S. Smith); Crinoid columnals; *Archaeocidaris* aff. *acanthifera* Trautschold [spines, plates and teeth]; *Eunicites sp.*; Athyrid brachiopod, *Chonetes granulifer* Owen [see p. 12], *C.* cf. *granulifer*, *C. granulifer* aff. *transversalis* Dunbar and Condra [see p. 12], *C. skipseyi* Currie [see p. 12], *C.* cf. *skipseyi* [see p. 13], *C.* aff. *skipseyi* [see Pl. II., fig. 10, p. 13], *C. sp.* [smooth], *C.* (*Chonetinella*) cf. *flemingi* var. *crassiradiatus* Dunbar and Condra [see Pl. II, figs. 8, 9, p. 14], *Crurithyris carbonaria* (Hind), *Lingula mytiloides* J. Sowerby, *Martinia ?*, *Orbiculoidea* cf. *nitida* (Phillips), *Productus* (*Productus*) *carbonarius* de Koninck, *P.* (*Dictyoclostus*) *craigmarkensis* Muir-Wood, *P.* (*D.*) cf. *craigmarkensis*, *P.* (*D.*) cf. *americanus*

Dunbar and Condra *non* Swallow, *P.* (*Echinoconchus*) cf. *elegans* McCoy [see Pl. II, fig. 5, p. 20], *P.* (*E.*) cf. *semipunctatus* Shepherd var. *knighti* Dunbar and Condra [see p. 19], *P.* (*Marginifera*) *aberbaidenensis* sp. nov. [see Pl. II, figs. 1-4, p. 17], *P.* (*Linoproductus*) sp. [=Demanet 1943, pl. ii, fig. 19,=*P.* (*L.*) cf. *tortilis* McCoy of Stubblefield 1933, p. 77, and Stubblefield & Trueman, 1946, p. 276], *P.* ("*Pustula*") *rimberti* Waterlot, *Punctospirifer ?* sp. nov. [see Pl. II, fig. 7, p. 20], *Spirifer sp.*, *Rhipidomella* cf. *carbonaria* (Swallow), *Schizophoria* sp. nov.? (cf. *S. hudsoni* George), *Schuchertella* cf. *pratteni* (McChesney) [see Pl. II, fig. 6, p. 20], *Tornquistia diminuta* (Demanet) [see Pl. II, figs. 11, 12, p. 16], *T. gibbosa* (Dorsman), cf. *Wellerella tetrahedra* Dunbar and Condra ; *Aviculopecten* cf. *culpini* Hind, *Dunbarella ?*, cf. *Edmondia laminata* Hind, *Edmondia ?*, *Euchondria sp.*, *Limipecten nitidus* sp. nov. [see Pl. III, figs. 20, 21, p. 21], *Myalina compressa* Hind, *Palaeoneilo ?*, *Pseudamusium fibrillosum* (Salter), *Posidonia sulcata* (Hind) ; *Straparolus* (*Straparolus*) sp. nov. [see Pl. III, figs. 17-19, p. 22]; *Conularia sp.*; cf. *Coelogasteroceras dubium* (Bisat), *Metacoceras* aff. *cornutum* Girty, *Metacoceras sp.*, Orthocone nautiloids including *Pseudorthoceras sp.*, *Anthracoceras aegiranum* H. Schmidt, *A.* cf. *aegiranum*, *Homoceratoides ?*; *Brachymetopus* sp. nov., *Ditomopyge* sp. nov.; *Dithyrocaris ?*; *Amphissites celticus* sp. nov. [see Pl. III, figs. 6-11, p. 25], *A. humerosus* sp. nov. [see Pl. III, figs. 1-5, p. 24], *Amphissites* sp. nov. [=*A.* sp. nov. of Stubblefield *in* Mitchell & Stubblefield, 1945, p. 47; see also p. 24 here], *Cornigella ?*, cf. *Cypridina phillipsi* Corsin, *Hollinella* cf. *bassleri* (Knight), *H. sp.*, *Kirkbya ?*, *Knightina morganuga* sp. nov. [see Pl. III, figs. 14-16, p. 26], *Paraparchites sp.*, *Roundyella* spp. nov. [see Pl. III, figs. 12, 13, p. 27], Ostracods indet.; Distacodid cusps, *Hindeodella spp.*, *Idiognathodus* cf. *tersus* Ellison, *Ozarkodina* cf. *delicatula* (Stauffer and Plummer), *Polygnathodella ?*, Prioniodid conodont fragments, *Streptognathodus sp.*, Platformed conodonts indet., *Listracanthus sp.*, *Rhadinichthys sp.*, Palaeoniscid scales indet., Fish bones indet.

Bed B

Crinoid columnals and brachials ; Athyrid ?, *Chonetes* cf. *skipseyi* Currie, *Productus ?*; Pectinid fragment ; *Straparolus* (*Straparolus*) sp. nov. ; *Hollinella* cf. *bassleri* (Knight), *H.* sp., *Paraparchites ?*; Fish scales indet.

Bed C

Crinoid columnals; *Archaeocidaris* aff. *acanthifera* Trautschold [spine]; *Lingula mytiloides* J. Sowerby, *Lingula sp.* [juv. ?], *Productus sp.* [juv.]; Pectinid fragment ?, Lamellibranch indet.; *Hollinella* cf. *bassleri* (Knight), *H. sp.*, *Paraparchites sp.*; *Hindeodella sp.*; *Elonichthys sp.*, *Rhabdoderma sp.*, Fish remains indet.

Bed D

Lingula mytiloides J. Sowerby

As will be seen the richest fauna, with more than 80 species, is at the base of the band. This was also the case in the same marine band at the Cefn Coed Colliery shaft-sinkings (Ware 1930, p. 478), and Van Leckwijck (1948) has also reported similar conditions in the Belgian marine bands.

The fossils are nearly all decalcified for only the echinoderms retain any traces of original carbonate. This feature, coupled with the virtual absence of pyrites, which is so prevalent at some of the other South Welsh localities of this band, has allowed better study of the internal characters of the brachiopods. In thickness the band is comparable with that at other localities in the coalfield, for it is 13 in. thick at Cefn Coed (Ware 1930, p. 478), and reaches 30 in. in places, as at a stream section discovered by W. B. Evans near Coegnant Colliery in the Maesteg district. The Aberbaiden locality, however, is the first surface-exposure of the band giving opportunities for detailed collecting.

Whereas there is much in common in the composition of the fauna in the British and North West European marine beds of comparable age, the most notable new feature at Aberbaiden is the abundance of kirkbyan ostracods belonging to the genera *Amphissites*, *Knightina* and *Roundyella*, which have only previously been known in the British Coal Measures from a single specimen, but which are well known in the Pennsylvanian rocks of the United States. This incursion of genera and subgenera common in the American Pennsylvanian is also seen among the brachiopods by the presence of species of *Productus* (*Marginifera*), *P.* (*Echinoconchus*), *Schuchertella*, *Chonetes* (*Chonetinella*) subgen. nov. and *Punctospirifer*, which, with the exception of *Chonetinella*, were previously unknown in the British Coal Measures. Bisat (1930) was among the first to use American names for British Coal Measures fossils, in the case of some coiled nautiloids, and Bisat, Duncan and Moore (1931) noted the apparent specific identity between specimens from Britain and America in a goniatite now referred to as *Dimorphoceras politum* Shumard sp. (=*Homoceratoides jacksoni* Bisat, but see E. W. J. Moore 1939, pp. 125-7). In addition, Demanet (1943) has applied extensively American names to Belgian Coal Measures fossils. Here it may be mentioned that the collections from the Cefn Coed Marine Band at the Cefn Coed shaft-sinkings yielded two specimens of crinoid plates almost indistinguishable from those of *Cibolocrinus banioni* R. C. Moore, a species described from the Upper Pennsylvanian of Oklahoma. In general, however, the Coal Measures marine fauna is a restricted one, with a few species of wide occurrence, and, at the Cefn Coed-Mansfield horizon, some others whose distribution suggests that there were two faunal provinces—one including the northern British coalfields and the other the southern coalfields (Stubblefield 1941, and Stubblefield and Trueman 1946, pp. 276-7). Although, as has been mentioned above, the Aberbaiden fauna has some special features, it is closely related to those of the southern province, especially to those of the Bristol and Kent coalfields, but with some relationships with the South Midlands coalfields. The southern province of the coalfields on the south of the Brabant massif is also continued into Belgium, and even passes round the eastern end of the massif into Holland.

At the higher horizon of the Cwm Gorse Marine Bands, Trueman (1946, p. lxxv) has suggested the possibility of a westerly or south westerly connection with Northern Spain, due to the presence there of goniatites described from South Wales. Judging from the faunal lists and stratigraphical notes given by Delépine (1943) it seems unlikely that the horizon of the Cefn Coed Marine Band has yet been found in North Spain, but in Morocco (Delépine 1941) this level is certainly represented, and several characteristic fossils of the Cefn Coed Marine Band are recorded. This North African occurrence of Cefn Coed fossils shows that there was also a south westerly connection of the British seas at this time with those of the Mediterranean area.

Descriptions of Certain Species and Genera

BRACHIOPODA

Family: Chonetidae Hall and Clark

By far the most abundant of the brachiopods in the Aberbaiden fauna are the various forms of *Chonetes* de Koninck s.l. The forms grouping round *Chonetes* have been classified into many different genera and subgenera, one of the most recent surveys being that of Dunbar & Condra (1932, pp. 133-5). The classification given by these authors was based mainly on such external characters as the presence or absence of a ventral sinus and the smooth or radially ornamented nature of the shell. Little emphasis was placed on the internal characters which are here considered paramount in chonetid classification, and have been used to separate more distinctly the genera *Tornquistia* and *Lissochonetes*. A study of the dorsal shell-interiors has also necessitated the erection of a new subgenus for some of the species formerly referred to *Chonetina* Krotow. Still further study of internal characters will probably lead to greater clarity in the definition of the genera, although the unsatisfactory state of *Chonetes* itself is a hindrance.

Genus: *Chonetes* de Koninck 1842

Type species by the subsequent designation of de Verneuil (1845, p. 238) *Terebratulites sarcinulatus* Schlotheim 1820.

Discussion.—The name *Chonetes* was first used by Fischer de Waldheim (1830, p. 134) for some imperfect fragments to which no trivial name was applied. The figures given by Fischer (loc. cit., pl. xxvi, figs. 8, 9) are not specifically recognisable, and figure 8 may not even be a chonetid. Legally, therefore, the use of the name *Chonetes* Fischer is invalid, and the next subsequent author to use the name in a valid sense is the author of the name.

The next use of the name was by de Koninck (1842, p. 206) who reconstituted the genus on a sound footing. The species included in the genus at its first valid use were *C. buchianus* de Koninck, *C. sarcinulatus* (Schlotheim), *C. dalmanianus* de Koninck, *C. laguessianus* de Koninck and *C. papillionaceus* (Phillips), and only these species can be considered when discussing the type species. The first valid designation of a type species was that of de Verneuil (1845, p. 238) who cited "*Productus sarcinulatus*", and who incidentally placed Fischer's figures in the synonymy of that species. There is thus no doubt about the type species of the genus, although the actual characters of this species are more difficult to determine.

The confusion which has arisen about the type species of *Chonetes* probably arose from de Koninck's placing in 1847 (p. 207) of the specimens he had figured in 1842 as *C. sarcinulata* into the synonymy of *C. variolata* d'Orbigny, together with Fischer's original figures (which in 1842 he had placed in *C. dalmaniana*). It is likely that this has led to the frequent but incorrect citation of *C. variolata* as the type species (e.g. Schuchert and LeVene 1929). Under present day practice the species is quoted in citations of type species, rather than the actual specimens, whether or not these have been misidentified. *C. striatellus* (Dalman) is another species which has been cited as the type (e.g. by Paeckelmann, 1930).

The type figures of *C. sarcinulatus* given by Schlotheim (1820, pl. xxix, figs. 3a-b) are ventral valves, and both the internal and external views are shown. The true characters of this shell are difficult to assess from the figures, and the types need restudying in order to clarify the position of this species within the modern framework of chonetid classification. It is likely, judging from the description and figures given by Schnur (1853) that this Devonian species belongs to *Chonetes* s.s. as at present understood, so that no far-reaching changes need be made.

Remarks on the British Coal Measures species of Chonetes

As is apparently the case with the American Pennsylvanian species (Girty 1915, pp. 59-61 ; Dunbar and Condra 1932, p. 142) the British Coal Measures species appear to form a plexus with no clear lines of demarcation between the species. The same phenomenon was noted by Demanet (1943, p. 70) in Belgian specimens. The central type in Britain is the form described by Hind (1905, p. 530, pl. xxxv, fig. 4) as *Chonetes laguessiana* mut. Θ, and referred by Currie (1937) to *C. hardrensis* mut. Θ. This is typically about 20 mm. in width with sigmoid lateral margins, although at Aberbaiden the shells are usually only about 8 or 9 mm. in width. As has been suggested by Stubblefield (Edwards and Stubblefield 1948, p. 228) this form is probably identical with *C. granulifer* Owen from the American Pennsylvanian, and it will be so considered here. The two have the same shape, and both have about ten costae in 2 mm. along the anterior margin. There are seven or eight spines on each side of the umbo along the hinge line ; although Hind's figure (loc. cit.) shows only six spines in this position, the figured specimen, now in the British Museum (Natural History) no. B 47309 shows seven or possibly eight.

Relatively transverse forms of this species are also found at Aberbaiden, but no specimen transverse enough to agree with *C. granulifer* var. *transversalis* Dunbar and Condra has been seen. Demanet (1938, 1943) has figured specimens under this name from the Petit Buisson Marine Band in Belgium, but it seems likely that these are similar to the Aberbaiden shells, and are merely slightly transverse forms of *C. granulifer*. Apart from the difference in horizon—*C. granulifer transversalis* is a zone fossil in the Upper Pennsylvanian of America (Moore and others 1944; Dunbar and Condra 1932, pl. D, facing p. 28)—the specimens figured by Demanet are much smaller than the American forms, and that figured in 1943 (pl. i, fig. 16) shows only six cardinal spines, whereas *C. granulifer transversalis* has 8-10, on each side of the umbo.

A smaller form, normally about 11 mm. in width, but at Aberbaiden only about 8 mm. wide, and lacking the sigmoid lateral margins, has been described as *Chonetes hardrensis* mut. *skipseyi* Currie. It is likely that Hind (1905) considered that this was the young of his *C. laguessiana* mut. Θ, but it is probably distinct from *C. granulifer*, and the differences, described in detail by Currie (1937, p. 423) are thought to be sufficient to raise this mutation to specific rank as *C. skipseyi*.

There are several variations of *C. skipseyi* at Aberbaiden. One well-marked variety, represented by several specimens, has a more quadrate outline, and the radial costae are more closely spaced than in *C. skipseyi*. The width is about 7 mm. and the length about 4 mm., thus giving a width/length ratio of 0·57 as against 0·54 or less in *skipseyi*. The costae measure 10-12 in 2 mm. at the anterior margin against 8-10 in *skipseyi*. No specimen is well enough preserved, however, to serve as a suitable type for a new variety, and the name *C.* aff. *skipseyi* has been used for these shells (see Pl. II, fig. 10). Specimens rather more quadrate than *C. skipseyi*, but otherwise resembling it have been termed *C.* cf. *skipseyi*.

A notable feature of the species of *Chonetes* found at Aberbaiden is the small size of the individuals. Rarely does a shell exceed 10 mm. in width, whereas specimens of the same species in other coalfields (Somerset and Bristol, Kent, and North Staffordshire) may be twice this size. It seems likely that this is due to dwarfing, but it is not clear why this should have affected the *Chonetes* alone, for the productids and other shells seem to be of normal size. Currie (1937, p. 415) noted that in Skipsey's Marine Band in Scotland, while some of the brachiopods and other fossils were dwarfed, the chonetids were comparable in size to those from North Staffordshire. She suggested that the dwarfing may have been due to a deficiency of oxygen on the muddy sea floor. It is evident that this can only be a partial explanation, for the productids as well as the chonetids were bottom living forms.

Chonetes (*Chonetinella*) subgen. nov.

Type species.—*Chonetes flemingi* Norwood and Pratten 1855, p. 26, pl. ii, figs. 5a-e. A full description is given by Dunbar and Condra (1932, pp. 151-4). The types came from the Pennsylvanian in " beds of shale ten miles northwest of Richmond, Missouri ", and according to Dunbar and Condra this is either in the Kansas City or Lansing groups, the species as identified by them being common in both groups.

Diagnosis.—Striate chonetids with a marked single median sinus in the pedicle valve and a corresponding fold in the brachial valve; internally they resemble *Chonetes* s.s., that is to say there is a single ventral median septum, and three dorsal septa of which the median one is longer than the two lateral ones.

Discussion.—This new subgenus is proposed for the reception of those species which, in the more recent American literature have been referred to *Chonetina* Krotow 1888. As these shells have been used as zone fossils (Moore and others 1944) it is useful stratigraphically to separate them from *Chonetes* where they would otherwise belong. As will be shown they have no close relationships with *Chonetina*.

The type species of *Chonetina*, proposed to replace *Chonetella* Krotow *non* Waagen, is *Chonetella artiensis* Krotow from the Permian Artinsk Grits of Russia, which Krotow (1884) clearly described as a smooth shelled tumid species with a deep ventral sinus. The features distinguishing *Chonetina* from *Chonetes* as set forth by Krotow (1884, p. 274) are the deep ventral sinus, and the presence on the interior of the brachial valve of radial rows of papillae which are united to form radiating lamellae, two of which, bounding the sides of the dorsal fold are especially prominent. Judging from Krotow's figures there is no dorsal median septum such as is characteristic of *Chonetes*.

Dunbar and Condra (1932, p. 149) accounted for the absence of the median septum by supposing Krotow's figures to be inaccurate, and dismissed the presence of radiating lamellae as " a specific specialisation in one of the last members of the tribe ", apparently because these were not present in the American shells which they referred to the genus. They stressed only the ventral sinus as distinguishing the genus from *Chonetes* ; basing their classification as they did on the external features, Dunbar and Condra cannot have realised that the shell in *C. artiensis* is smooth. In fact the dorsal interiors of the species referred to *Chonetina* by Dunbar & Condra do not appear to differ in any important particular from those of *Chonetes* s.s.

Girty (1938, p. 283) has already questioned the use of *Chonetina* for these American Pennsylvanian shells, and King (1938, p. 257) also realised that the name was inappropriate for reasons of dissimilarity of form alone.

Dunbar and Condra's suggestion that the figures given by Krotow (1884) are inaccurate does not seem justified. *Tornquistia* also has no median septum in the brachial valve, and it also has two lateral septa dorsally combined with a gibbose appearance in the pedicle valve. Examination of pedicle valves of *C. artiensis* in the British Museum (Natural History), where the collections unfortunately do not include any brachial valves, has prompted the suggestion that *Chonetina* is more closely related to *Tornquistia* than to *Chonetes* s.s., for the shell is smooth, and the appearance of striation in some of Krotow's figures is probably due to the internal rows of papillae. Smoothness by itself, however, is not considered here to be of generic importance. It should be noted that Krotow's figures reproduced by Dunbar and Condra are enlarged to twice natural size, a fact not mentioned by those authors.

It is not claimed that *Chonetinella* is necessarily monophyletic, and it is merely a useful distinguishing name for those species of *Chonetes* which have a ventral sinus. The range of the new subgenus is apparently Upper Carboniferous and Permian, and it occurs in North and South America, Britain and India.

As has been noted by Currie (1937, p. 423) most of the British Coal Measures chonetids show only an incipient ventral sinus not definite enough to be included in *Chonetinella*. In recent years, however, several localities in Britain have yielded specimens which fall into that group of species. For example Mitchell and Stubblefield (1941) record *Chonetina flemingi* cf. var. *alata* Dunbar and Condra, from the Overseal Marine Band of South Derbyshire ; and the name cf. *Chonetina flemingi* var. *crassiradiata* Dunbar and Condra has been used by Dr. Stubblefield for shells from the Cefn Coed Marine Band at the Cefn Coed shaft-sinkings (e.g. Ba 1792). These specimens are now referred to *Chonetinella*. The genus also occurs in the Picton Point Marine Band, N.W. of Picton Point, Pembrokeshire (OTJ 1497, 1499), and from the Crofts End Marine Band in the Winterbourne borehole in the Bristol Coalfield (TCC 2192). All these identifications are based on Geological Survey collections from similar horizons.

At Aberbaiden a number of specimens agreeing with those from Cefn Coed occur (Pl. II, figs. 8, 9), but they differ from the typical *C. flemingi crassiradiatus* in their more quadrate outline, the cardinal angles being less acute than in that variety. Their detailed description is deferred pending the discovery of more material.

Tornquistia Paeckelmann 1930

Type species by original designation *Leptaena* (*Chonetes*) *polita* McCoy 1852, Carboniferous Limestone.

Licharew (1934, p. 509) replaced *Tornquistia* Paeckelmann by the name *Paeckelmannia* on the grounds that it was preoccupied by *Türnquistia* Reed 1896, a genus of trilobites. If, however, the names are spelt exactly as first proposed including diacritic marks this is clearly not the case, and *Törnquistia* Paeckelmann might well be considered valid, although Muir-Wood (1948*b*, p. 41) and some other authors have adopted *Paeckelmannia*. This is clearly a case in which a decision of the International Commission on Zoological Nomenclature is desirable, and pending this the name *Tornquistia* Paeckelmann is here retained[1].

There are three syntypes of *T. polita* preserved in the Sedgwick Museum, Cambridge, which I have been able to examine through the kindness of Mr. A. G. Brighton. The specimen figured by McCoy (1855, pl. iiiD, fig. 30) is numbered in the Sedgwick Museum E 6842 and comes from the Carboniferous Limestone at Lowick, Northumberland; it is a pedicle valve and shows a single median septum extending about a third the distance to the anterior margin. Another specimen from Lowick (E 6843) is an external mould of the brachial valve, but shows the triangular area of the pedicle valve still attached.

The third syntype (E 6844) from Mount Rath, Queens County, Ireland, is an exterior of the pedicle valve. Since the types do not show the internal features of the brachial valve, and no topotype material is available, the specimen figured by Davidson (1861, pl. xlvii, figs. 11, 11a) has been used to supply evidence on this point. It shows two narrowly diverging septa but no trace of a median septum. This specimen has been examined at the British Museum (Natural History). Paeckelmann (1930, pl. 15, figs. 11a, 12) figures brachial valves with the same features, but his fig. 13 does not show these septa, and probably does not belong to this species.

The genus *Lissochonetes* Dunbar and Condra, of which *Chonetes geinitzianus* Waagen is the type species, shows a different structure in the brachial valve. Judging from the illustrations of the type specimens given by Geinitz (1866, pl. iv, figs. 15-18) one (fig. 17) shows three septa in the dorsal interior, two lateral and one median, all about the same length. Dunbar and Condra (1932) do not mention the dorsal interior in their description of *L. geinitzianus*, but in their generic definition (p. 170) they wrote that " the dorsal median septum is almost obsolete. Otherwise the internal characters resemble those of *Chonetes* [s.s.] ". Unless Geinitz's figures are inaccurate there is thus some discrepancy, for a specimen of *L. geinitzianus* from the " Coal Measures ", Nebraska City (No. B 14235), seen at the British Museum (Natural History) shows only a short median septum. It is clear however that *Tornquistia* differs from *Lissochonetes* in the complete absence of a median septum.

It is probable that Licharew (1934) considered the presence or absence of a ventral sinus as the feature distinguishing these genera, but that a sinus can occur in *Tornquistia* is shown in *T. diminutus* (Demanet).

Judging from published data it would appear that *Tornquistia* has not yet been found in the Pennsylvanian of North America, and specimens called *Paeckelmannia* by King (1938) are either *Chonetes* or *Lissochonetes*.

[1] See Bull. Zool. Nomencl., 6, 1951, pp. 92-4.

Tornquistia diminuta (Demanet)

Plate II, figs. 11, 12

Chonetes (*Lissochonetes*) *minutus* Demanet 1943, pp. 72-3, pl. i, figs. 20–22.
Chonetes (*Lissochonetes*) *diminutus* Demanet 1949, p. 5.

The type specimens of this species from the Petit Buisson Marine Band of Belgium are said to be only 3 mm. in width, although the figures when reduced give a width of 4 mm. At Aberbaiden it often exceeds 4 mm. in width, and specimens showing the internal characters are relatively common. In the pedicle valve there is a single short median septum, while the brachial valve shows two septa diverging at an angle of about 30°, and extending about two thirds of the distance to the anterior margin. One of Demanet's figures (1943, pl. i, fig. 20) of the types also shows signs of these septa. Also seen in the brachial interior is a small cardinal process, and two widely diverging crura running almost parallel with the hinge line. In no specimen has any trace of a dorsal median septum been seen, and on this account the species has been transferred from *Lissochonetes* to *Tornquistia*.

The distribution of this species in the British Coalfields has been discussed by Stubblefield and Trueman (1946, p. 276), and in addition it has recently been found in the Cannock area of South Staffordshire.

Tornquistia gibbosa (Dorsman)

Chonetes gibbosa Dorsman 1945, p. 24, pl. 2, figs. 5–8.

This species is evidently very close to *T. diminuta* and only differs in being more gibbous and longer in proportion to its width than that species. The ventral sinus is also less well marked. Although the dorsal interiors have not been seen in the material from Aberbaiden, it is so close to *T. diminuta* that it is here considered to be congeneric with that species. The shell is evidently smooth, and the slight radiating sculpture mentioned by Dorsman is probably due to the internal rows of pustules found in all chonetids, and which have been the cause of much trouble in the past (see Weller and McGehee 1933).

In the British coalfields this species has also been found in the Gin Mine Marine Band of North Staffordshire.

Family: Productidae Gray

Productus (*Eomarginifera*) Muir-Wood and *P.* (*Marginifera*) Waagen

Eomarginifera was erected as a genus by Muir-Wood (1930), and she distinguished it from *Marginifera* "by the less-marked marginal ridges in the brachial valve, and the absence of these ridges in the pedicle valve, also by the lack of crenulations on the exterior of the marginal ridges of *Eomarginifera*. The ornament and arrangement of the spines of *Eomarginifera* are also distinct from those of *Marginifera*."

One of the main features of *Eomarginifera* is the symmetrical arrangement of the major spines on the pedicle valve, which remain constant in spite of enormous variation in the shape, size and ornament. While no mention is usually made in the descriptions of American Pennsylvanian species of *Marginifera* of these major spines, it is evident from the figures that they are present in some species (e.g. Dunbar and Condra 1932, pls. xxxv and xxxvi). Through the kindness of Dr. Muir-Wood I have been able to confirm this observation from examples of several of the common American species preserved in the British Museum (Natural History). From specimens examined of the type species of *Marginifera, M. typica* Waagen from the Salt Range, it is clear that here the spines are arranged in radial rows on the cardinal slopes more akin to the similar rows in some species of *Dictyoclostus*, and the major spines of *Eomarginifera* are not differentiated. Some American authorities (e.g. Sutton 1938) have refused to recognise *Eomarginifera* on the ground that the marginal ridges are present laterally, and in their opinion this distinction from *Marginifera* is one of degree rather than kind. The spine arrangements have not been discussed by American authors, but it is likely that the American species usually referred to *Marginifera* are more closely related to *Eomarginifera* than to *Marginifera* as typified by its type species. It is evident, however, from Muir-Wood's description of major spines in *M. himalayensis* Diener (Muir-Wood 1941, p. 20, pl. i, fig. 3) that she does not recognise this feature as being restricted to *Eomarginifera*.

Licharew (1937, p. 94) has observed that there are two pairs of adductor muscle scars in the brachial valve of *Marginifera* and neither are dendritic (Waagen 1885, p. 718, fig. 23, 1a), while in *Dictyoclostus* and *Productus* there is only one pair and this is dendritic (see Muir-Wood 1928, p. 23, fig. 8). *Eomarginifera* seems to occupy an intermediate position in which the scars are usually dendritic, but are only half divided (Muir-Wood 1928, p. 183, fig. 33). While it is not yet clear that these differences are universal, they may form a useful distinction between *Marginifera* and *Eomarginifera*.

It now seems fairly certain that *Marginifera*, as at present understood and used, is a polyphyletic form, as was noted by Chao (1927, 1928), and it probably contains the end products of several lineages of productids. The new species here described is referred to *Marginifera* for the reasons given below.

Productus (*Marginifera*) *aberbaidenensis* sp. nov.

Plate II, figs. 1-4

?*Productus* (*Eomarginifera*) *sp.* Stubblefield 1933, p. 77.
?*P.* (*E.*) cf. *longispinus* Stubblefield 1933, p. 77.
?*P.* (*E.*) cf. *longispinus* Stubblefield and Trueman 1946, p. 276.
P. (*Dictyoclostus*) *galatinensis* Demanet 1938, p. 123, pl. cix, figs. 4–5.
P. (*D.*) *galatinensis* Demanet 1943, p. 78, pl. ii, figs. 8–11.
Marginifera loczyi Dorsman 1945, p. 31, pl. 4, figs. 1–2.

Diagnosis.—A species of *Marginifera* 12-13 mm. in width and 10-11 mm. in length with small ears, pedicle valve highly convex and geniculated; venter flattened; costae 7-8 in 5 mm. at 8 mm. from the umbo; a concentric cincture crosses the pedicle valve probably opposite the marginal ridge of the brachial valve; dorsal marginal ridge developed laterally, with strong crenulations on its exterior margin along the hinge line, and usually developed anteriorly;

a transverse row of about ten strong internal pustules crosses the visceral disc of the brachial valve.

Material.—More than thirty specimens have been seen from the Cefn Coed Marine Band at the stream bed, 720 yds. E.S.E. of Aberbaiden Farm, Glamorgan.

Holotype: HR 110.

Paratypes: HR 504, AW 3304, AW 3378, AW 3434.

Description.—All the Aberbaiden shells are decalcified and only the impressions of both sides of the shell are preserved. The pedicle valves, however, are not well preserved, and their internal features have not been seen.

The *pedicle valve* is highly convex with a sharp geniculation at about 6 mm. from the umbo. Width 12-13 mm.; length 10-11 mm.; length along the curvature about 15 mm. The hinge line is the widest part of the shell and small ears are developed, the lateral margins being sinuate. The ears, however, are usually broken off and no specimen shows both ears complete. The rounded costae measure 7-8 in 5 mm. at 8 mm. from the umbo, and the spaces between the costae are rather wider than the costae themselves. About ten ribs are developed, being strongest on the lateral slopes they can be seen to cross the venter. All the ribs are on the posterior side of the geniculation. The venter is flattened with a very slight median sinus in some specimens especially developed anteriorly. About 9 mm. from the umbo (12 mm. along the curvature) a broad concentric cincture is developed and forms a groove across the shell, which is probably opposite the marginal ridge in the brachial valve. The trail in all available specimens is short and incomplete. Some traces of major spines are seen, but it is possible that these are not constant. The two on either side of the mid-line on the venter can be seen in some specimens, and one specimen (AW 3378) shows a large spine on the cardinal slope.

In the *brachial valve* the length of the visceral disc is about 8 mm., and there is a sharp geniculation (AW 3434). The valve is moderately concave, flattened medially, with reticulate ornament corresponding to that in the pedicle valve. There appear to be no spines externally in the brachial valve. No one specimen shows all the features of the interior of the brachial valve and the following is built up with the aid of several specimens. The cardinal process is bifid (AW 3304) and it continues into a short median septum which becomes prominent at about half way to the anterior margin and then dies out. At the place where the median septum dies out a transverse row of strong pustules crosses the visceral disc, about ten in number, but not always in a straight row. That these are pustules and not spines is clear from the counterparts which show no sign of spines on the external surface. A marginal ridge is present which may extend all round the anterior margin of the valve (HR 110, HR 504) or may be rather less well developed anteriorly. In all specimens, however, there are signs of definite shell thickening. Strong crenulations or denticulations are seen along the external edge of the marginal ridge along the hinge (AW 3304). There were probably about nine of these on each side of the umbo, but now only six are preserved on one side. There are strong muscle impressions on either side of the median septum in the posterior part of the valve. These are nearly divided into two and are not dendritic, but are small and compact. Brachial impressions of the type normal in *Marginifera* also occur.

Discussion.—The internal features of the brachial valve are undoubtedly those of a *Marginifera*, in spite of the fact that the marginal ridge varies in its development anteriorly, a character also found in some American species, e.g.

M. muricatina Dunbar and Condra. The well-marked single row of pustules crossing the visceral disc is also found in some species of *Marginifera*, but is so far unknown in *Eomarginifera*. It is shown for example in *M. splendens* (Norwood and Pratten) and *M. haydenensis* Girty from the American Pennsylvanian, and variation in the number of pustules in the row has been used as a specific character. *M. aberbaidenensis* has more pustules in the row than the two American species mentioned, but fewer than *M. banschangensis* Reed (1944, pl. xiv, fig. 13), an Indian species. This feature, combined with the presence of crenulations on the exterior of the marginal ridge and the non-dendritic muscle scars, has led to the reference of the species to *Marginifera* rather than to *Eomarginifera*, and it is the first species of *Marginifera* described from Britain. Here it may be mentioned that although Dunbar and Condra (1932, p. 229) refer to these pustules as spines or spine bases, this is not the case in *M. aberbaidenensis* and judging from British Museum material of *M. splendens* no spines are present externally in the brachial valve.

Delépine (1943) has recorded a species of *Marginifera*, *M. pusilla* Schellwien, from Northern Spain at a horizon higher than that of the Cefn Coed Marine Band. These specimens are unfigured, but they make a southern origin for *M. aberbaidenensis* a possibility. *M. pusilla* possesses a median sinus in the pedicle valve, which may be slight in some specimens (Schellwien 1892).

From British species of *Eomarginifera*, *M. aberbaidenensis* differs in internal characters and in the presence of the cincture in the pedicle valve. The seven specimens from the Lower Tilmanstone Marine Band of Kent (Stubblefield 1933) which are tentatively referred to the species are all pedicle valves (Geol. Surv. coll., Ba 3400a-c, 3411a-b, 3417e) except for one exterior of a brachial valve (Ba 3393), and they correspond closely in size, shape and ornament with the Aberbaiden species. Along the hinge line, however, there is a row of three spines on each side of the umbo in the pedicle valve, and owing to the state of preservation of the Aberbaiden specimens it has not been possible to say whether these are also present in *M. aberbaidenensis*. Should the Tilmanstone specimens prove to belong to *M. aberbaidenensis* it might have a bearing on the age of the Tilmanstone Marine Bands, which was discussed by Stubblefield and Trueman (1946).

It is likely that the species is also present in Belgium and Holland. In Holland it was recorded by Dorsman (1945) as *Marginifera loczyi* Chao, but the Chinese species differs in internal characters.

Productus (*Echinoconchus*) *spp.*

Plate II, fig. 5

Although well known in the Pennsylvanian rocks of the United States this genus has not hitherto been found in the British Coal Measures. The highest level in Britain where it has been recorded is in the R_1 Stage of the Millstone Grit, in the Otley Shell Bed (Stephens and others 1942, p. 356), and it is also known in the Upper Limestones of Scotland.

There are two specimens in the collections from Aberbaiden, both brachial valves, and apparently of different species. The larger specimen (HR 118) is poorly preserved but shows 2 to 3 rows of spine bases in each band, and it is compared tentatively with the Lower Pennsylvanian *E. semipunctatus* (Shepherd) var. *knighti* Dunbar and Condra, although the length of the specimen is only 15 mm. as against 50-60 mm. in that variety. From the British *E. punctatus* (Martin) it differs in having fewer rows of spines in each band.

The other specimen (AW 3383, Pl. II, fig. 5) is still smaller, the width along the hinge line being only 12 mm.: the length is incomplete. It resembles *E. elegans* (McCoy) in the prominence of the concentric bands, and also in the single row of spine bases laterally. Anteriorly there are probably at least two rows of spines, the larger of these being anterior.

Genus: *Punctospirifer* North 1920

Plate II, fig. 7

Type species by original designation *P. scabricosta* North (=*P. scabricosta* mut. *ashfellensis* North), Lower Carboniferous.

A single specimen referred with some doubt to this genus has been found at Aberbaiden, but there are also several other punctate fragments which probably belong here. Previously the highest recorded occurrence of the genus in North-west Europe was in the Assise d'Andenne (Namurian) of Belgium. Demanet (1941) figures several specimens from this horizon under the name *P. kentuckiensis* (Shumard), but judging from the figures it seems doubtful whether these are all conspecific. This occurrence was omitted in the recent survey of this genus given by Muir-Wood (1948*a*, p. 63).

The Aberbaiden specimen (Pl. II., fig. 7) is a brachial valve with a width of 18 mm. and a length of 11·5 mm. It bears 9-10 costae on each side of the unplicated median fold. In outline it is close to *P. scabricosta* mut. *redesdalensis* North, but is more quadrate and is longer in proportion to its width. In form it differs from some of the shells figured by Demanet (1941) which are alate, with a wide hinge line, and also in the same way from the American Pennsylvanian species *P. kentuckiensis*. Though the punctae are not very clearly seen, it is thought probable that the shell was punctuate. Internally the crura diverge at a wide angle and there is a shallow median septum extending about one third of the distance to the anterior margin.

These characters are typical of *Punctospirifer*, but the unique feature of this shell is that along the hinge line there is a row of denticulations, which has not hitherto been described in this genus. There are about twenty small square denticulations preserved a short distance below the hinge margin, on one side of the hinge line, the other side being damaged in this position. Should this character prove to be universal in this species it is likely that a new genus should be erected for its reception.

Genus: *Schuchertella* Girty 1904

Schuchertella cf. *pratteni* (McChesney)

Plate II, fig. 6

Description.—Outline of shell semicircular, maximum width just below the hinge line; up to 18 mm. in width and 9 mm. in length. There is usually a slight bilobation which reflects the presence of a small sinus in the brachial valve and a corresponding fold in the pedicle valve. Shell ornamented with radiating costae, which are bifurcate in the brachial valve and intercalate in the pedicle valve. Internally in the brachial valve the crura diverge at a wide angle. In the pedicle valve there is a large triangular area, but no trace of any teeth, and there does not appear to have been a median septum.

Discussion.—The species with which the Welsh shells are compared was first described by McChesney in 1859 but was not figured until 1932, when Dunbar and Condra redescribed it from the Lower Pennsylvanian Fort Scott Limestone of Missouri. Dunbar and Condra (1932, p. 119) remarked on the variability of the American shells and this is also true in the Aberbaiden specimens. The slight median sinus in the brachial valve is not always seen, and the length/width ratio varies from shell to shell. The density of the costae is also variable.

A very similar shell was collected by Dr. G. H. Mitchell from the Overseal Marine Band of South Derbyshire. The only specimen (GM 964) is a brachial valve showing the widely diverging crura, and it is considered to be conspecific with the Welsh material. This is a further link between the faunas of South Wales and the Midlands at this level.

LAMELLIBRANCHIA

Genus : *Limipecten* Girty 1904

Type species by original designation *L. texanus* Girty, Upper Pennsylvanian, Texas.

According to the work of Newell (1937) this genus differs from *Aviculopecten* McCoy in having intercalate costae in both valves, and usually in the characteristic way in which the concentric ornament swings down towards the margin in between the costae, and sometimes bears pointed projections in this position. The ligament area is like that in *Aviculopecten*; the ears are subequal in length; the left valve is convex and the right valve nearly flat.

Limipecten nitidus sp. nov.

Plate III, figs. 20, 21

Diagnosis.—A small species of *Limipecten* about 10 mm. in length and slightly less in maximum width. Costae in left valve spaced at 18 in 5 mm. at 5 mm. from the umbo. Umbonal angle about 80° in both valves. In right valve the radial ornament is weak in posterior half, the concentric ornament prominent.

Holotype.— HR 283-4, left valve.

Paratype.—HR 283-4, right valve.

Description.—*Left valve*: the length is 10 mm. and the maximum width 9·5 mm. at about half way down the shell. The width along the hinge is 7·5 mm. Ears subequal in length; shell moderately convex. The costae are intercalate, the intercalations taking place at all stages of growth. There are eight costae on the well-defined anterior ear ; the posterior ear has about nine costae, but is much less well defined. The posterior angle of the ear is acute, the anterior angle obtuse. At 5 mm. from the umbo the costae are spaced at 18 in 5 mm., and there are about 40 costae in all (excluding those in the ears). At the margin there are about 55 costae (excluding the ears). The concentric ornament is poorly developed on the main part of the shell and is only seen in faint growth lines. On the ears, however, it is prominent and swings down towards the margin in between the costae forming slight ridges. The umbonal angle is about 80°, but the details of the umbonal structures have not been seen in this valve.

Right valve: the valve is almost flat; the anterior ear is more prominent than in the left valve. The costae are intercalate, and are less prominent on the posterior half of the shell than on the anterior half. The concentric ornament is fairly well marked and is spaced about equally with the costae. There are 7 costae in the anterior ear, and about 10 in the posterior ear. Umbonal angle 80°. The ligament area is poorly preserved, but is probably long and low.

Discussion.—The above description is based on one specimen, both valves of which are preserved in counterpart. Newell (1937, p. 114) has noted six British Lower Carboniferous species which belong to *Limipecten*. *L. nitidus* differs from all these in its small size, fine ornament, and shape. Of the American species of about the same age as *L. nitidus*, *L. wewokana* Newell and *L. morsei* Newell have a different ornament and *L. konincki* (Meek & Worthen) has longer ears. There does not appear to have been described any other species of the genus in the north west European Coal Measures, although it is possible that a form described by Dorsman (1945) from the Petit Buisson Marine Band of Holland as *Aviculopecten sp.*1 belongs to the genus.

GASTROPODA

Straparolus (*Straparolus*) sp. nov.

Plate III, figs. 17-19

?*Spirorbis sp*. Hind 1905, pl. xxxvi, fig. 10.
Straparolus cf. *reedsi* Demanet 1949, pp. 9–10, pl. i, figs. 16–18.

Description.—Small almost discoidal gastropods with an apparently straight outer lip. Whorl profile rounded between the sutures, the outer whorl being flattened slightly on the upper external surface. Sutures sharp, moderately deep. Shell widely phaneromphalous; inner whorls in no case clearly seen, but four whorls can be distinguished and there were probably one or two more. Average specimens measure about 4 mm. in diameter. Ornamentation and growth lines pass nearly straight across the whorls at right angles to each suture.

Discussion.—The terms and method of description in the above follows as far as possible those used by Knight (1941). Knight (1944) has reconstituted the genus *Straparolus* de Montfort and has distributed the species into artificial subgenera, apparently on the basis of whorl outline. Under this scheme the shells now described from Aberbaiden appear to fall into *Straparolus* s.s., for there is no angulation in the whorl section. The only other alternative is *Amphiscapha* Knight 1942, in which the slight angulations are rugose, a feature which is definitely absent in our shells.

Demanet (1949) has figured and described some small gastropods which are evidently conspecific with the South Welsh specimens, under the name *Straparolus* cf. *reedsi* Knight. *S. reedsi* was made the genotype of the genus *Amphiscapha* by Knight (1942), but this name, as has been mentioned above, does not apply to our shells, although it must be agreed with Demanet that some of Knight's figures (1934, pl. 24) much resemble the European species. This is here considered to be new, but as no good specimens with the shell completely preserved are available no new name is given.

Hind (1905, pl. xxxvi, fig. 10) figured a shell from the Gin Mine Marine Band of North Staffordshire under the name *Spirorbis sp.*, which has very similar form and dimensions to the Aberbaiden material. This specimen is now preserved at the British Museum (Natural History) where it has been examined and compared with Aberbaiden specimens. It has the shell preserved, and since nearly all the Welsh material consists of internal casts, comparison is not easy, but it is thought that the two forms could be conspecific. Other material in the Geological Survey collections from North Staffordshire (Zl 931-936) is also referred to this species.

OSTRACODA

Ostracods are abundant at Aberbaiden, but they are all apparently single valves, no specimen having yet been seen with both valves attached. It is also noteworthy that the young individuals are more common than adults. As is usual they are decalcified and are found as internal and external moulds.

In addition to the Kirkbyidae here described, other types are also present, the most abundant being *Hollinella* (see Edwards and Stubblefield 1948, p. 244). The lack of well-preserved material, and in some cases the scarcity of individuals has prevented detailed studies on these.

Family: Kirkbyidae Ulrich & Bassler

Hinge line straight, with teeth in the left valve fitting into corresponding sockets in the right; valves essentially equal, but the edge of the right valve fits into the slightly rabbeted edge of the left; surface reticulate, with a subventral pit or muscle scar, and several nodes.

If the conclusions of Cooper (1945) are accepted the distinctions between the various genera in this family do not always hold good in the young stages. In *Ectodemites plummeri* Cooper, for example, he claims that all except the last three of the nine stages (eight moults) would be considered as *Amphissites* because of the characteristic mesial node, which dies away in the last three stages. The greater prominence of the nodes in young stages was also noticed in several species by Kellett (1933) and Johnson (1936), and it is seen to some extent in *Knightina morganuga* sp. nov. In the two species of *Amphissites* described here, the young stages might well be referred to Cooper's genus *Polytylites*, for they show three nodes, one of which is lost in later life, and the other two change their character as growth develops. This is described in more detail under the descriptions of the species, but the significance of these facts is that these ostracods probably underwent proterogenesis during their evolution, the young characters becoming those of the adult.

In the descriptions which follow, the valves have been orientated with the end which has the most prominent node or shoulder as anterior. In spite of arguments put forward by Geis (1932) and Bradfield (1935) for adopting the opposite orientation, it is still uncertain as to the true orientation in these fossils. The suggestion first made by Swartz (1945) for using an empirical type of orientation in which the end towards which the " swing " is directed is called plenate, the other end being antiplenate, is not always applicable in *Amphissites* where there is often no swing. Swartz and Oriel (1948) have developed this concept and it is clear that in some cases it is useful ; application to certain species of *Amphissites*, however, has suggested that the plenate end is the end normally called anterior in the older method of orientation which has been adopted here.

Genus : *Amphissites* Girty 1910

Type species by original designation *A. rugosus* Girty, Mississippian, Arkansas.

This genus, whose type species was first figured by Roundy (1926), was redefined by Knight (1928) and also revised by Roth (1929). Since that time the genus has been continually restricted by several authors. Kellett (1933) defined *Knightina* for those forms with a strong anterior shoulder, but an inconspicuous central node. Bradfield (1935) erected *Roundyella* to include forms without nodes or flanges, and Cooper (1941) separated those forms with three nodes as *Polytylites*, and those without nodes but with flanges as *Ectodemites*. Under the present framework of classification in this family the validity of the latter genus is questioned below (see under *Roundyella*). Those species that now remain in *Amphissites* have a prominent central node, and may or may not have flanges.

The genus was first recorded in the British Coal Measures by Mitchell and Stubblefield (1945) in the Charles Marine Band of South Staffordshire in the Four Ashes Borehole, where it is represented by a single specimen (Geol. Surv. Coll. Bc 2724) in which flanges are present. Only one specimen from Aberbaiden (HR 165) has been seen in which such flanges are found, and these two flanged specimens are probably conspecific, but their description is deferred pending the collection of more material. In all the other Aberbaiden material flanges appear to be absent.

Amphissites humerosus sp. nov.

Plate III, figs. 1-5

Diagnosis.—A relatively transverse species of *Amphissites* with a length/height ratio of 1·87 when adult, and with a strong anterior shoulder and an elongate central node, which is slightly behind the central point ; flanges absent.

Holotype.—HR 411, left valve.

Paratypes.—89045.6, 89045.7, 89045.15, HR 423. All types are from the stream bed, 720 yards E.S.E. of Aberbaiden Farm, Glamorgan.

Description.—Carapace moderately transverse, when fully adult measuring about 0·88 mm. in length and about 0·47 mm. in height. Hinge line straight ; cardinal angles rounded, the anterior being nearly a right angle, the posterior more obtuse. A prominent transversely elongated node occupying about one sixth of the total length of the shell is situated just posteriorly of the centre; this node is indented ventrally by the small round Kirkbyan pit or muscle scar. Anteriorly the node is connected with the rounded anterior shoulder (= anterior node), which passes steeply down to the margin. In side view the carapace is thickest at the anterior end, and, except for the central node evenly thins posteriorly.

The ornament is reticulate, the carapace being covered with small round pits in the central part, but a concrescent band of radially arranged pits each about twice as long as one of the central pits, is situated near the lateral and ventral margins. It is along this row of pits that the impression of the shell usually breaks. No hinge structures have been seen, and, due to the invariable separation of the two valves in the available material, it has not been possible to observe any overlap. Flanges are not seen on the external mould, and are probably absent.

The smallest known form of this species measures 0·47 mm. in length and 0·21 mm. in height (89045.7), and it shows a strong rounded central node and fairly well-marked anterior and posterior nodes, the anterior being the more prominent. This small form resembles Cooper's genus *Polytylites* in the presence of three nodes. A more advanced stage, 0·58 mm. in length and 0·29 mm. in height, shows strong anterior and central nodes, but the posterior nodes have almost disappeared. At this stage the central node is still rounded, and it is not until the shell measures 0·70 mm. by 0·35 mm. that the central node begins to elongate and the shell to assume the adult characters.

Amphissites celticus sp. nov.

Plate III, figs. 6-11

Diagnosis.—A species of *Amphissites* with a length/height ratio of 1·75 when adult; with a round central node just behind the central point, and an ill-defined, but moderately prominent anterior node; flanges absent.

Holotype.—HR 424, left valve.

Paratypes.—89046.6, 89046.12, 89046.13, 89046.21, 89046.32. All types are from the stream bed, 720 yards E.S.E. of Aberbaiden Farm, Glamorgan.

Description.—Carapace quadrate in outline, when adult measuring about 0·82 mm. in length and about 0·47 in height. Hinge line straight, cardinal angles rounded, the posterior more obtusely than the anterior. Longest at about half way between the dorsal and ventral margins. A prominent rounded node, occupying about one eighth of the total length is situated just posterior of the centre, clearly marked off from the obscurely humped anterior node, which is most elevated near the hinge line. The anterior slope is not steep enough for this node to be called a shoulder. No posterior node is seen and the shell thins evenly posteriorly from the anterior node, except for the central node. The kirkbyan pit or muscle scar is situated slightly in front of and below the central node.

The ornament is finely reticulate, and the carapace is covered in the central area with small pits, but near the lateral and ventral margins there is a concrescent row of radially arranged pits, each about twice as long as one of the central pits. Flanges appear to be absent. No hinge structures or overlap observed.

The smallest specimen seen (89046.32) is 0·29 mm. in length and 0·17 mm. in height, and shows three well-defined nodes—anterior, central and posterior—thus resembling *Polytylites*. In 89046.21, measuring 0·41 mm. by 0·23 mm. the posterior node is slightly less prominent, and it has disappeared almost completely at a size of 0·53 mm. by 0·29 mm. (89046.13). Thereafter the shell assumes the normal features of the adult.

Discussion.—The commonest species of *Amphissites* found at Aberbaiden is *A. celticus*. It differs from *A. humerosus* in its more quadrate outline, and in the rounded central node being clearly marked off from the anterior node, which is less shoulder-like than in *A. humerosus*.

Neither of these species appears to be closely related to any described from the American Pennsylvanian, owing to their lack of flanges. *A. humerosus* combines the central node of *Amphissites* with the anterior shoulder of *Knightina*, and in this respect it resembles *Knightina pinguoides* Croneis and Gale (1939, p. 273) from the Mississippian Golconda Formation of Illinois. In both species, however, the central node appears to be more than a " faint ridge trending obliquely toward the anterior cardinal angle " (Kellett 1933, p. 98) which is characteristic of *Knightina*, and both these species are here referred to *Amphissites*.

Genus : *Knightina* Kellett 1933

Type species by original designation *Amphissites allorismoides* Knight (1928), Lower Pennsylvanian, Missouri.

This genus is differentiated from *Amphissites* according to Kellett (1933, p. 98) by " its more elongate form and by the prominent anterior shoulder combined with the obscure configuration of the remainder of the valve " . . . " the central node being represented by a faint ridge trending obliquely toward the anterior cardinal angle ".

It is rarer than the other Kirkbyan genera at Aberbaiden.

*Knightina morganuga** sp. nov.

Plate II, figs. 14-16

Diagnosis.—A species of *Knightina* with a length/height ratio of 2·0 when adult, lacking flanges and with no notable surface features except for the anterior shoulder and kirkbyan pit.

Holotype.—89047.11, left valve.

Paratypes.—HR 393, 89047.14, 89047.4.

All types from the stream bed, 720 yards E.S.E. of Aberbaiden Farm, Glamorgan.

Description.—Outline of carapace ovate, twice as long as high, measuring when adult about 0·70 mm. long and 0·35 mm. high. Posterior end slightly higher than anterior. Hinge line straight ; cardinal angles rounded, the anterior being blunter than the posterior ; ventral margin straight. The small kirkbyan pit or muscle scar is round and centrally situated, about half way between the dorsal and ventral margins. A slight elevation on the dorsal and lateral borders

* The species name is derived from " morganwg " the Welsh root from which comes the word Glamorgan.

of the pit passes up to the strong anterior shoulder, which fall steeply to the margin. Flanges absent, hinge structures and overlap not observed.

Ornament reticulate, the surface being covered with small reticulation pits in the central area, and round the margins at the lateral and ventral sides there is a row of radially arranged pits, each about twice as long as one of the central pits.

The young shells show the normal adult features, except that in the middle stages (size 0·53 by 0·26, HR 393) the anterior shoulder is very marked. The smallest specimen seen measures 0·29 mm. in length and 0·15 mm. in height (89047.14).

Genus: *Roundyella* Bradfield 1935

Type species by original designation *Amphissites simplicimus* Knight 1928, Lower Pennsylvanian, Missouri.

Roundyella is described as having neither "nodes, costae, [n]or flanges" (Bradfield 1935, p. 66), whilst *Ectodemites* Cooper (1941) has "one or more false keels, but [is] without well-defined nodes" (Cooper 1941, p. 49). Most members of the Kirkbyidae have one false keel very near the ventral margin, and there seems to be a clear division between those which have this alone and those which have in addition another one or two flanges nearer the centre of the shell. Cooper does not appear to discriminate in any way between these two groups, and some of the species he refers to *Ectodemites* have no flanges (e.g. *E. genae* Roth sp.—Cooper 1946, pl. 15, figs. 32-33). This being so, there is then no real distinction between *Roundyella* and *Ectodemites*, and here the two genera are regarded as synonymous. If such a distinction were to be made on the basis of flanges, then *Amphissites* and *Knightina* could also be sub-divided into other genera.

Roundyella sp. nov.

Plate II, figs. 12-13

Description.—Carapace thin, flattened, only slightly convex, but with the thickest region near the centre. Length about 0·47 mm., height about 0·26 mm. Outline sub-ovate, hinge line straight, cardinal angles rounded, ventral border flattened. One end (anterior) is usually slightly higher than the other. There is a small kirkbyan pit which is slightly behind the centre, and the sides slope evenly away from the centre. Ornament finely reticulate. Hinge structures and overlap not observed.

Discussion.—A number of specimens conform with the above description, which is based on 89048, but their small size, combined with the lack of a developmental sequence has prevented their being made the types of a new species. Although there are larger forms at Aberbaiden which also probably belong to the genus *Roundyella* no form has been seen of which this small species might be the young.

References

BISAT, W. S. 1930. On the goniatite and nautiloid fauna of the Middle Coal Measures of England and Wales. *Sum. Prog. Geol. Surv.* for 1929, pt. III, pp. 75–89, pls. vii–viii.

———, C. DUNCAN and E. W. J. MOORE. 1931. On the occurrence of a British Coal Measure goniatite in Missouri, U.S.A. *Proc. Yorks. Geol. Soc.*, xxii, pp. 1–8, pl. i.

BRADFIELD, H. H. 1935. Pennsylvanian Ostracoda of the Ardmore basin, Oklahoma. *Bull. American Paleont.*, 22, No. 73, pp. 1–172, pls. 1–13.

CHAO, Y. T. 1927. Productidae of China. Part I. Producti. *Pal. Sinica* [B], v, 2, pp. 1–192, pls. i–xxvi.

———. 1928. Productidae of China. Part II. Chonetinae, Productinae and Richthofeninae. *Pal. Sinica* [B], v, 3, pp. 1–81, pls. i–vi.

COOPER, C. L. 1941. Chester Ostracodes of Illinois. *Illinois Geol. Surv. Rep. Invest.*, 77, pp. 1–101, pls. 1–14.

———. 1945. Moult stages of the Pennsylvanian ostracode Ectodemites plummeri. *Journ. Paleont.*, 19, pp. 368–75, pl. 57.

———. 1946. Pennsylvanian Ostracodes of Illinois. *Bull. Illinois Geol. Surv.*, 70, pp. 1–177, pls. 1–21.

CRONEIS, C. and A. S. GALE. 1939. New Ostracodes from the Golconda Formation. *Denison Univ. Bull., Journ. Sci. Lab.*, xxxiii, pp. 251–95, pls. v–vi.

CURRIE, E. D. 1937. *In* Currie, E. D., C. Duncan and H. M. Muir-Wood. The fauna of Skipsey's Marine Band. *Trans. Geol. Soc. Glasgow*, xix, pp. 413–52, pls. ii–iv.

DAVIDSON, T. 1861. British Fossil Brachiopoda, vol. ii. Carboniferous species. *Palaeont. Soc.*, pp. 121–210, pls. xxvii–xlvii.

DELÉPINE, G. 1941. Les goniatites du Carbonifère du Maroc. *Notes et Mém. du Service des Mines du Maroc*, Mém. 56, pp. 1–110, pls. i–viii.

———. 1943. Les faunes marines du Carbonifère des Asturies (Espagne). *Mém. Acad. Sci. Inst. France*, 66, pp. 1–122, pls. i–vi.

DEMANET, F. 1938. *In* RENIER, A. and others. *Flore et Faune Houillères de la Belgique.* Brussels.

———. 1941. Faune et Stratigraphie de l'étage Namurien de la Belgique. *Mém. Musée Roy. d'Hist. Nat. Belg.*, 97, pp. 1–327, pls. i–xviii.

———. 1943. Les horizons Marins du Westphalien de la Belgique et leurs faunes. *Mém. Musée Roy. d'Hist. Nat. Belg.*, 101, pp. 1–166, pls. i–ix.

———. 1949. Contribution a l'étude de la microfaune marine du Westphalien de la Campine. *Bull. Inst. Roy. Sci. Nat. Belge.*, xxv, 37, pp. 1–16, pls. i–ii.

DORSMAN, L. 1945. The marine fauna of the Carboniferous in the Netherlands. *Meded. Geol. Sticht.* [C], iv, 3, No. 3, pp. 1–101, pls. 1–11.

DUNBAR, C. O. and G. E. CONDRA. 1932. Brachiopoda of the Pennsylvanian system in Nebraska. *Bull. Nebraska Geol. Surv.* [2], 5, pp. 1–377, pls. i–xliv.

EDWARDS, W. and C. J. STUBBLEFIELD. 1948. Marine bands and other faunal marker-horizons in relation to the Sedimentary Cycles of the Middle Coal Measures of Nottinghamshire and Derbyshire. *Quart. Journ. Geol. Soc.*, ciii, pp. 209–60, pls. xiii–xv.

FISCHER DE WALDHEIM, G. 1830. *Oryctographie du Gouvernement de Moscou.* Moscow.

GEINITZ, H. B. 1866. *Carbonformation und Dyas in Nebraska.* Dresden.

GEIS, H. L. 1932. Some Ostracodes from the Salem Limestone, Mississippian, of Indiana. *Journ. Paleont.*, 6, pp. 149–88, pls. 22–6.

GIRTY, G. H. 1910. New genera and species of Carboniferous fossils from the Fayetteville Shale of Arkansas. *Ann. New York Acad. Sci.*, xx, pp. 189–238.

———. 1915. Fauna of the Wewoka Formation of Oklahoma. *Bull. U.S. Geol. Surv.*, 544, pp. 1–353, pls. i–xxxv.

———. 1938. Descriptions of a new genus and a new species of Carboniferous brachiopods. *Journ. Washington Acad. Sci.*, xxviii, pp. 278–84, pl.

HIND, W. 1905. Notes on the Palaeontology. Appendix to J. T. Stobbs. The marine beds in the Coal Measures of North Staffordshire. *Quart. Journ. Geol. Soc.*, lxi, pp. 527–46, pls. xxxv–xxxvi.

JOHNSON, W. R. 1936. The Ostracoda of the Missouri Series in Nebraska. *Nebraska Geol. Surv.Paper* 11, pp. 1–52, pls. i–v.

KELLETT, BETTY. 1933. Ostracodes of the Upper Pennsylvanian and the Lower Permian strata of Kansas. I. The Aparchitidae, Beyrichiidae, Glyptopleuridae Kloedenellidae, Kirkbyidae and Youngiellidae. *Journ. Paleont.*, 7, pp. 59–108, pls. 13–16.

KING, R. H. 1938. New Chonetidae and Productidae from the Pennsylvanian and Permian strata of North Central Texas. *Ibid.*, 12, pp. 257–79, pls. 36–39.

KNIGHT, J. B. 1928. Some Pennsylvanian Ostracodes from the Henrietta Formation of Eastern Missouri. *Ibid.*, 2, pp. 229–67, pls. 30–34.

———. 1934. The gastropods of the St. Louis, Missouri, Pennsylvanian outlier : VII. The Euomphalidae and Platyceratidae. *Ibid.*, 8, pp. 139–66, pls. 20–26.

———. 1941. Paleozoic Gastropod Genotypes. *Special Papers Geol. Soc. Amer.*, 32, pp. 1–510, pls. 1–96.

Knight, J. B. 1942. Four New Genera of Paleozoic Gastropoda. *Journ. Paleont.*, 16, pp. 487–8.
————. 1944. Paleozoic Gastropods *in* Shimer, H. W. & R. R. Shrock. *Index Fossils of North America.* New York.
de Koninck, L. G. 1842. *Description des animaux fossiles qui se trouvent dans le terrain Carbonifère de Belgique.* Liége.
————. 1847. *Monographie des genres Productus et Chonetes.* Liége.
Krotow, P. 1885. Artinskische Etage. *Trans. Imp. Soc. Nat. Univ. Kazan*, 13, pp. 1–314, pls. i–iv.
————. 1888. Geological Investigations in the Western Border of the Urals in the regions of Tscherdyn and Ssolikamsk. [In Russian]. *Mém. Com. Géol.*, vi. pp. 297–563, pls. i–ii.
Licharew, B. 1934. *In* K. A. von Zittel. *Grundzüge der Paläontologie* (Russian edition). Leningrad, etc.
————. 1937. Permian brachiopoda of the North Caucasus. Families Chonetidae Hall & Clarke and Productidae Gray. *Paleont. of U.S.S.R. Monographs*, xxxix, fasc. i, pp. 1–151, pls. i–xiii.
McCoy, F. 1852. Contributions to British Palaeontology: On Some new Brachiopoda from the Carboniferous Limestone. *Ann. Mag. Nat. Hist.* [2], x, pp. 421–29.
————. 1855. *Systematic Description of the British Palaeozoic Fossils in the Geological Museum of the University of Cambridge.* Fascicule iii, pp. 407–661. London.
Mitchell, G. H. and C. J. Stubblefield. 1941. The Geology of the Leicestershire and South Derbyshire Coalfield. *Geol. Surv. Wartime Pamphlet* No. 22. (2nd edition 1948).
———— – ————. 1945. The Geology of the northern part of the South Staffordshire Coalfield (Cannock Chase region). *Ibid.*, No. 43, pp. 1–48.
Moore, E. W. J. 1939. The goniatite genus *Dimorphoceras* and its development in the British Carboniferous. *Proc. Yorks. Geol. Soc.*, xxiv, pp. 103–128, pl. xv.
Moore, R. C. and others. 1944. Correlation of Pennsylvanian formations of North America. *Bull. Geol. Soc. Amer.*, 55, pp. 657–706, 1 pl.
Muir-Wood, H. M. 1928. The British Carboniferous Producti. II. *Productus* (sensu stricto) *semireticulatus* and *longispinus* groups. *Mem. Geol. Surv., Palaeont.*, iii, pp. 1–217, pls. i–xii.
————. 1930. The Classification of the British Carboniferous Brachiopod Subfamily Productinae. *Ann. Mag. Nat. Hist.* [10], v, pp. 100–08.
————. 1941. *In* Muir-Wood, H. M. and K. P. Oakley. Upper Palaeozoic faunas of North Sikkim. *Pal. Indica* [N.S.], xxxi, mem. i, pp. 1–91, pls. i–iv.
————. 1948*a*. Malayan Lower Carboniferous fossils and their bearing on the Viséan palaeogeography of Asia. *Brit. Mus.* (*Nat. Hist.*). London.
————. 1948*b*. On two species of "*Productus*" from the Namurian, E_2 zone, of County Dublin, Ireland. *Proc. Roy. Irish Acad.*, lii, B, pp. 41–8, pl. ii.
Newell, N.D. 1937. Late Paleozoic Pelecypods: Pectinacea. *Kansas Geol. Surv.*, 10, pp. 1–123, pls. 1–20.
North, F. J. 1920. On *Syringothyris* Winchell, and certain Carboniferous brachiopoda referred to *Spiriferina* D'Orbigny. *Quart. Journ. Geol. Soc.*, lxxvi, pp. 162–227, pls. xi–xiii.
Norwood, J. G. and H. Pratten. 1855. Notice of the genus *Chonetes* as found in the Western States and Territories with descriptions of eleven new species. *Journ. Acad. Nat. Sci. Philadelphia*, 3, pp. 23–32, pl. ii. (Author's copies, 1854).
Paeckelmann, W. 1930. Die Brachiopoden des deutschen Unterkarbons. I, Die Orthiden, Strophomeniden und Choneten des Mittleren und Oberen Unterkarbons. *Abh. k. Preuss. Geol. Landesanstalt* [N.F.], 123, pp. 143–326, pls. 9–24.
Reed, F. R. C. 1944. Brachiopoda and Mollusca from the Productus Limestones of the Salt Range. *Pal. Indica* [N.S.], xxiii, *Mem.* 2, pp. 1–678, pls. i–lxv.
Roth, R. 1929. A revision of the ostracod genus *Kirkbya* and subgenus *Amphissites*. *Pub. Wagner Free Inst. Sci.*, i, pp. 1–56, pls. i–iii.
Roundy, P. V. 1926. *In* Roundy, P. V., G. H. Girty and M. I. Goldman. Mississippian formations of San Saba County, Texas. *Prof. Pap. U.S. Geol. Surv.*, 146, pp. 1–59, pls. i–xxxiii.
Schellwien, E. 1892. Die Fauna des karnischen Fusulinenkalks. *Palaeontographica*, xxxix, pp. 1–56, pls.
Schlotheim, E. F. von. 1820. *Die Petrefactenkunde......* Gotha.
Schnur, J. 1853. Zusammenstellung und Beschreibung sammtlicher im Uebergangsgebirge der Eifel vorkommenden Brachiopoden. *Palaeontographica*, iii, pp. 169–254, pls. xxii–xlv.
Schuchert, C. and C. M. LeVene. 1929. *Fossilium Catalogus*: *I Animalia*, 43, *Brachiopoda*, pp. 1-140. Berlin.
Stephens, J. V., W. Edwards, C. J. Stubblefield and G. H. Mitchell. 1942. The Faunal Divisions of the Millstone Grit Series of Rombalds Moor and neighbourhood. *Proc. Yorks. Geol. Soc.*, xxiv, pp. 344–72.

STUBBLEFIELD, C. J. 1933. Contributions to the Geology of the Kent Coalfield. III, Notes on the fauna of the Coal Measures of Kent. *Sum. Prog. Geol. Surv.* for 1932, pt. II, pp. 71–7.

———. 1941. *In* discussion of E. DIX. The general Sequence of strata in the Warwickshire Coalfield. *Abs. Proc. Geol. Soc.*, 1382, pp. 11–12.

——— and A. E. TRUEMAN. 1946. The faunal Sequence in the Kent Coalfield. *Geol. Mag.*, lxxxiii, pp. 266–79.

SUTTON, A. H. 1938. Taxonomy of Mississippian Productidae. *Journ. Paleont.*, 12,pp. 537–69, pls. 62–6.

SWARTZ, F. M. 1945. Orientation, morphology and classification of Paleozoic straight-backed Ostracoda. *Bull. Geol. Soc. Amer.*, 56, p. 1205.

——— and S. S. ORIEL. 1948. Ostracoda from the Middle Devonian Windom beds in Western New York. *Journ. Paleont.*, 22, pp. 541–66, pls. 79–81.

TRUEMAN, A. E. 1946. Stratigraphical problems in the Coal Measures of Europe and North America. *Quart. Journ. Geol. Soc.*, cii, pp. xlix–xciii.

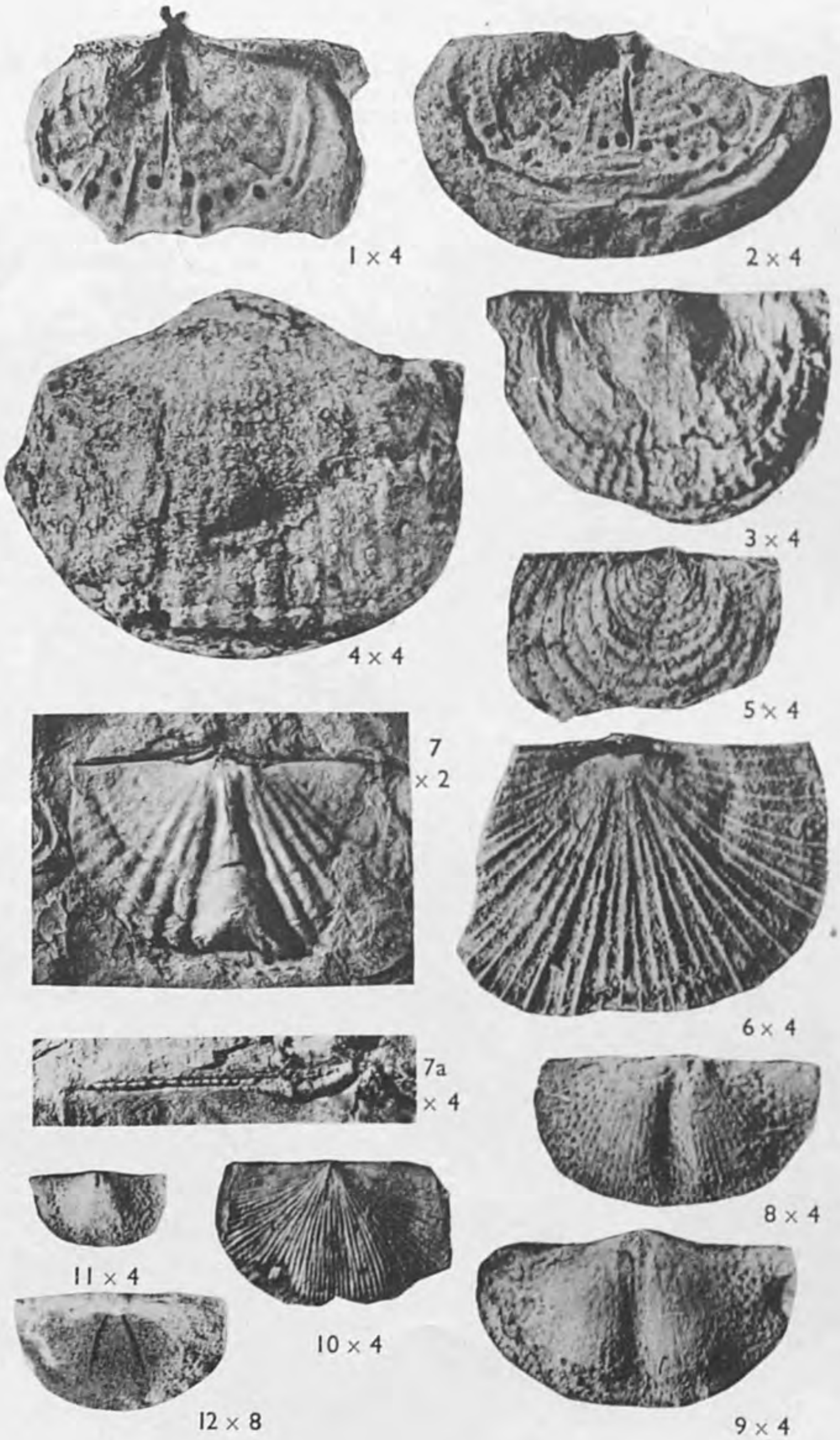
VERNEUIL, E. DE 1845. *In* MURCHISON, R. I., E. DE VERNEUIL and A. DE KEYSERLING. *Géologie de la Russie d'Europe et des Montagnes de l'Oural.* Vol. ii. London.

VAN LECKWIJCK, W. 1948. Quelques observations sur les variations verticales des charactères lithologiques et fauniques de divers horizons marins du terrain houiller de Belgique. *Annales Soc. Géol. Belge.* (*Bull.*), lxxi, pp. B 377–406.

WAAGEN, W. 1884. Productus Limestone fossils. *Pal. Indica* [xiii], i, pt. iv, fasc. 4, pp. 611–728, pls. lviii–lxxxi.

WARE, W. D. 1930. An account of the Geology of the Cefn Coed sinkings. *Proc. S. Wales Inst. Eng.*, xlvi, pp. 453–504.

WELLER, J. M. and R. MCGEHEE. 1933. Typical form and range of *Mesolobus mesolobus*. *Journ. Paleont.*, 7, pp. 109–10.



MARINE FOSSILS FROM THE COAL MEASURES OF GLAMORGAN

Explanation of Plate II

All specimens figured are from the Cefn Coed Marine Band from the stream bed, 720 yards E.S.E. of Aberbaiden Farm, Glamorgan. The fossils are in the Geological Survey Museum.

Figs. 1–4 *Productus* (*Marginifera*) *aberbaidenensis* sp. nov. × 4 ; 1, paratype, AW 3304, dorsal interior showing the cardinal process and denticulations near the hinge line. 2, holotype, HR 110, with the anterior marginal ridge. 3, paratype, AW 3335, exterior of brachial valve. 4, paratype, HR 98, exterior of pedicle valve showing the concentric cincture. (p. 17).

Fig. 5 *Productus* (*Echinoconchus*) cf. *elegans* (McCoy) × 4 ; AW 3383, brachial valve. (p. 20).

Fig. 6 *Schuchertella* cf. *pratteni* (McChesney) × 4 ; AW 3333, brachial valve. (p. 20).

Fig. 7 *Punctospirifer ?* sp. nov. × 2 ; HR 221, brachial valve. 7a, enlargement of the hinge line showing the denticulations, × 4. (p. 20).

Figs. 8, 9 *Chonetes* (*Chonetinella*) cf. *flemingi* var. *crassiradiatus* (Dunbar and Condra), pedicle valves, × 4 ; 8, AW 3435. 9, AW 3303 . (p. 14).

Fig. 10 *Chonetes* aff. *skipseyi* Currie, × 4 ; HR 184, brachial valve. (p. 13).

Figs. 11, 12 *Tornquistia diminuta* (Demanet) ; 11, HR 123, × 4, pedicle valve showing the medium septum. 12, HR 145, × 8, dorsal interior showing the lateral septa, cardinal process and diverging crura (p. 16).

Explanation of Plate III

All specimens are figured × 24 unless otherwise stated. The originals are from the Cefn Coed Marine Band, from the stream bed, 720 yards E.S.E. of Aberbaiden Farm, Glamorgan and are in the Geological Survey Museum,

Figs. 1–5 *Amphissites humerosus* sp. nov. 1, paratype, HR 423, external impression of right valve. 2, holotype, HR 411, left valve. 3, paratype, 89045.15, left valve. 4, paratype, 89045.6, right valve. 5, paratype, 89045.7, left valve. (p. 24).

Figs. 6–11 *Amphissites celticus* sp. nov. 6, paratype, HR 395, external impression of left valve. 7, holotype HR 424, left valve. 8, paratype, 89046.12, right valve. 9, paratype, 89046.13, right valve. 10, paratype, 89046.21, right valve. 11, paratype, 89046.6, left valve. (p. 25).

Figs. 12, 13 *Roundyella* sp. nov. 12, 89048a. 13, 89048b. (p. 27).

Figs. 14–16 *Knightina morganuga* sp. nov. 14, holotype, 89047.11, left valve. 15, paratype 89047.4, left valve. 16, paratype, 89047.14, right valve. (p. 26).

Figs. 17–19 *Straparolus* (*Straparolus*) sp. nov. × 4 ; 17, HR 225. 18, HR 302. 19, HR 306. (p. 22).

Figs. 20, 21 *Limipecten nitidus* sp. nov. × 4 ; HR 284. 20, holotype, left valve. 21, paratype, right valve. (p. 21).

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MARINE FOSSILS FROM THE COAL MEASURES OF GLAMORGAN