PALÆONTOGRAPHICAL SOCIETY.

VOL. LXXIII.

THE PLIOCENE MOLLUSCA.

VOL. II, PART II.

PAGES 653—704; PLATES LIII—LVI.

ORDOVICIAN AND SILURIAN BELLEROPHONTACEA.

PART II.

PAGES 49—92; PLATES IX—XIII.
Title-page and Index.

THE CARBONIFEROUS INSECTS.

PART I.

PAGES 1—80; PLATES I—IV.

ISSUED FOR 1919.

PALÆONTOGRAPHICAL SOCIETY.

VOLUME LXXIII.

CONTAINING

ISSUED FOR 1919.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

AGENTS FOR THE SOCIETY
DULAU AND CO., LTD., 34-36, MARGARET STREET, CAVENDISH SQUARE, W. 1.

JULY, 1921.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

Each person subscribing ONE GUINEA *is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates. The price of the Volume to Non-subscribers is* TWENTY-FIVE SHILLINGS NET.

Subscriptions are considered to be due on the 1st of January in each year.

The Annual Volumes are now issued in *two forms of Binding:* 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope. Members wishing to obtain the Volume arranged in the LATTER FORM are requested to communicate with the Secretary.

Most of the *back volumes* are in stock. Monographs or parts of Monographs already published can be obtained, apart from the annual volumes, from Messrs. DULAU AND CO., LTD., 34–36, Margaret Street, London, W. 1, who will forward a complete price list on application.

Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. SMITH WOODWARD, British Museum (Nat. Hist.), South Kensington, London, S.W. 7.

The following Monographs are in course of preparation and publication:

The Cambrian Trilobites, by Mr. Philip Lake.

The Carboniferous Insects, by Mr. Herbert Bolton.

The Palæozoic Asterozoa, by Dr. W. K. Spencer.

The Pliocene Mollusca, by Mr. F. W. Harmer.

The Pleistocene Mammalia, by Prof. S. H. Reynolds.

Owing to scarcity of paper, the Council has decided to omit from the present volume the usual lists of members and publications. Full particulars can be obtained from the Secretary.

Member deceased during 1919: Mr. H. H. Trafford.

New members: Prof. P. G. H. Boswell, Prof. H. de Dorlodot, Dr. Jonquei S. Lee, Mr. Frank Morey, Mr. E. W. Tunbridge, Dr. Wyatt Wingrave, and the Geological Survey of China.

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31ST DECEMBER, 1918.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE,

25TH APRIL, 1919,

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

THE Council, in presenting its Seventy-Second Annual Report, regrets that, owing to the circumstances of the time, its publications are still in arrear; but since the last Annual Meeting a whole volume, No. LXXI, for the year 1917, has been prepared, and it will now soon be distributed. This comprises the completion of the Monograph of Wealden and Purbeck Fishes, with six plates, the title-page and index to Volume I of the Pliocene Mollusca, and instalments of the Monographs of Cambrian Trilobites and Palæozoic Asterozoa, illustrated respectively with four plates and with numerous text-figures. Much matter is in hand for the next volume, with which comparatively rapid progress may be expected.

The expenditure during the year has again exceeded the income, but to the unusually small balance of £34 3*s.* 5*d.* should be added the sum of £30 11*s.* 1*d.* due from Messrs. Dulau on account of sales, not received until after December 31st. It should also be remembered that the total sum of £610 10*s.* 6*d.* was temporarily invested in War Loan and Exchequer Bonds, and will be available to pay for the volume in arrear when it can be overtaken. The high cost of labour and materials, however, necessarily reduces the amount of the Society's publications, and there is no prospect of a return to former conditions.

Since the last Annual Meeting five members of the Society have died, namely, the Duke of Northumberland, Mr. W. E. Balston, Mr. C. H. Cunnington, Dr. John Foulerton, and Mr. H. R. Knipe. All were valuable supporters, interested in the progress of palæontological science; Mr. Cunnington had just been elected a Member of Council, while Mr. Balston and Mr. Knipe had served in former years. New members are urgently needed to replace these and other losses, and the Council would welcome help in making the work and needs of the Society more widely known.

The thanks of the Society are due to the Council of the Geological Society for permission both to store the stock of back volumes, and to hold the Council Meetings and Annual General Meeting in their apartments.

In conclusion, it is proposed that the retiring members of Council be Mr. Ernest Gibson, Rev. H. N. Hutchinson, and Mr. A. W. Oke; that the new members be Mr. Henry Dewey, Dr. F. L. Kitchin, Mr. W. P. D. Stebbing, and Mr. Henry Woods; that the President be Dr. Henry Woodward; the Treasurer, Mr. Robert S. Herries; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance-sheet.

THE PALÆONTOGRAPHICAL SOCIETY IN ACCOUNT WITH ROBERT S. HERRIES, ESQ., M.A., F.G.S., TREASURER.

Cr. — *From January 1st, 1918, to December 31st, 1918.* — *Dr.*

			£	s.	d.	£	s.	d.
Balance from last Account :—								
Deposit Account			300	0	0			
Less due to Bank on Current Account			96	8	9			
						203	11	3
Members' Subscriptions—1914–17	164		172	4	0			
,, ,, 1918	117		122	17	0			
,, ,, 1919	5		5	5	0			
	286					300	6	0
Carriage paid by Members						1	6	2
Sales of back stock to Members						4	5	4
Repaid Income Tax (1 year)						10	11	1
Dividends :								
£500 Natal 3 per cent. Stock (less tax)			10	17	6			
£210 10*s.* 6*d.* of 5 per cent. War Loan			10	10	6			
£400 of 6 per cent. Exchequer Bonds (less tax)			17	8	0			
						38	16	0
Interest on Deposit						3	2	7
						£561	18	5

	£	s.	d.	£	s.	d.
Printing, paper, etc., Vol. LXX (balance)				186	1	10
Binding, packing and distribution, Vol. LXX				89	11	8
Printing, etc., Vol. LXXI (on account)				100	0	0
Drawing illustrations and making blocks				90	16	3
Secretary's honorarium				52	10	0
Postage and stationery				5	0	9
Premium, Fire Insurance, back stock				0	15	0
,, Anti-aircraft insurance				0	10	0
,, Fire and Anti-aircraft insurance, stock temporarily at printers				0	14	3
Petty charges—Porter		15	0			
,, ,, Bank	0	2	3			
				0	17	3
Dulau & Co., second-hand volume				0	18	0
Balance at Bank	64	8	5			
Less 3 cheques not cashed	30	5	0			
				34	3	5
				£561	18	5

To the receipts should also be added £30 11*s.* 1*d.* due from Messrs. Dulau & Co. (for sales during the year) received by the Treasurer after *December* 31*st*.

We have examined the above account, compared it with the vouchers, and find it to be correct; we have also seen the receipts for £500 Natal 3 per cent. Consolidated Stock, and for the £210 10*s.* 6*d.* 5 per cent. War Loan and £400 6 per cent. Exchequer Bonds.

ROBERT S. HERRIES,
Treasurer.

April 24th, 1919.

HENRY DEWEY.
WALCOT GIBSON.
E. T. NEWTON.
W. P. D. STEBBING. } *Auditors.*

Council and Officers elected April, 1919.

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Palæontographical Society, 1919.

THE PLIOCENE MOLLUSCA OF GREAT BRITAIN,

BEING SUPPLEMENTARY TO

S. V. WOOD'S MONOGRAPH OF THE CRAG MOLLUSCA.

BY

F. W. HARMER, Hon. M.A.Cantab., F.G.S., F.R.Met.S.,

MEMBRE HONORAIRE DE LA SOCIÉTÉ BELGE DE GÉOLOGIE ET DE PALÉONTOLOGIE.

VOL. II. PART II.

Pages 653—704; Plates LIII—LVI.

LONDON:

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Remarks.—Looks like a deformed form of var. *angulata*, having a truncated spire, coloured bands and a distorted outer lip.

Littorina rudis (Maton). Plate LIII, figs. 1, 2.

1797. *Turbo rudis*, Maton, Nat. Hist. West Count. Engl., vol. i, p. 277.
1804. *Turbo rudis*, Donovan, Nat. Hist. Brit. Shells, vol. i, pl. xxxiii, fig. 3.
1807. *Turbo rudis*, Maton and Racket, Trans. Linn. Soc., vol. viii, p. 159, pl. iv, figs. 12, 13.
1833. *Turbo rudis*, S. Woodward, Geol. of Norfolk, p. 44.
1853. *Littorina rudis*, Forbes and Hanley, Brit. Moll., vol. iii, p. 32, pl. lxxxiii, figs. 1—3, 5—7.
1859. *Littorina rudis*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 12.
1863—71. *Littorina rudis*, Jeffreys, Rep. Brit. Assoc. (Newcastle-on-Tyne), p. 77, 1863; Brit. Conch., vol. iii, p. 364, 1865; vol. v, p. 206, pl. lxv, fig. 3, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1871.
1841—70. *Littorina rudis*, Gould, Rep. Inv. Mass., 1st ed., p. 257, fig. 165, 1841; 2nd ed., p. 305, fig. 575, 1870.
1870. *Littorina rudis*, S. V. Wood, Jr., and F. W. Harmer, Rep. Brit. Assoc. (Liverpool), Sections, p. 90.
1872. *Littorina rudis*, S. V. Wood, Mon. Crag Moll., 1st Suppl., pt. i, p. 79, pl. v, fig. 9.
1872. *Littorina rudis*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 214.
1878. *Littorina rudis*, G. O. Sars, Moll. Reg. arct. Norv., pp. 165, 358.
1888—93. *Littorina rudis*, A. Bell, Rep. Brit. Assoc. (Bath), p. 136, 1888; (Leeds), pp. 413, 417, 419, 420, 1890; Proc. Roy. Irish Acad. [3], vol. ii, p. 258, 1892; Rep. Yorks. Phil. Soc., p. 63, 1893.
1892. *Littorina rudis*, Locard, Coq. mar. Côtes de France, p. 188, fig. 164.
1894. *Littorina rudis*, Munthe, Bull. Geol. Inst. Univ. Upsala, vol. ii, p. 2.
1901. *Littorina rudis*, Brøgger, Norges geol. Undersøgelse, No. 31, pp. 384, 657, pl. ix, fig. 13, pl. xii, fig. 9.
1908. *Littorina saxatilis*, var. *rudis*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 59, pl. cx, figs. 6, 9, 10.
1910—15. *Littorina rudis*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. ii, pp. 8, 23, pl. i, figs. 1—4, 1910; *L. saxatilis*, K. Svensk. Vet.-Akad. Handl., vol. liv, p. 170, 1915.
1912. *Littorina saxatilis*, sub-sp. *rudissima*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii, p. 197, pl. x, figs. 5—20.
1913. *Littorina rudis*, Gignoux, Ann. de l'Univ. de Lyon (N.S.), vol. i, pt. i, 36, p. 557.
1915. *Littorina rudis*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Fauna of New England, No. 13, p. 121.

Specific Characters.—Shell solid, ovato-turreted, smaller than the typical *L. littorea*; whorls convex, somewhat compressed or flattened below the suture, the last being much the largest, about three-fourths the total length; ornamented in the type by flattened ridges, by minute and wavy spiral striæ and by slight and irregular lines of growth; suture distinct, deeper than in *L. littorea*; spire short, rapidly diminishing in size upwards, moderately pointed; mouth angulated and slightly channelled above; outer lip thin, a little reflected, incurved towards the pillar; inner lip united to the upper lip, forming a thin glaze on the upper part of the mouth; pillar short but thick and broad, shelving inwards.

Dimensions.—L. 15 mm. B. 13 mm.

Distribution.—Recent: British coasts, abundant. West Atlantic, Mediterranean, Adriatic. Norwegian coast—Finmark and Lofoten Islands to the Christiania fiord. Circumpolar—Spitzbergen, White Sea, Iceland, Massachusetts, Behring Strait, Vancouver Island.

Fossil: Iceland Crag. Butleyan: Butley, Hollesley. Icenian: Norwich zone—Bramerton, Thorpe, Postwick, Brundall, Horstead, Beccles, Yarn Hill, Ditchingham, Dunwich, Aldeburgh. Weybourne zone—Belaugh, North Walsham, Bacton, Mundesley, East Runton, Weybourne. Isle of Man. Wexford. Pleistocene: Billockby, Speeton, Kelsey Hill, Bridlington, March, Nar Valley, Portland, Selsey, and other localities in Great Britain and Ireland. Uddevalla, Littorina Sea, Christiania fiord—*Cyprina* beds to *Tapes*-banks (Brøgger), Trondhjem (Øyen).

Remarks.—It is with many apologies to my good friend M. Dautzenberg that I retain the specific name of *rudis* for the present shell rather than *saxatilis*, Olivi, recently adopted by himself and the late Dr. Kobelt. *L. rudis* seems to me such a well-established specific name, having been widely and generally in use for more than a hundred years, that I fear the suggested alteration might lead to considerable confusion among English geologists.[1]

Forbes and Hanley expressed the opinion in 1853 (*op. cit.*, vol. iii, p. 43) that Olivi did not define his *L. saxatilis* with sufficient clearness to secure its positive identification and that the latter may have been *L. neritoides*. In the meantime Maton's older specific name *rudis* (1797) has been adopted by Jeffreys and generally in other scientific works, including the list published by the Conchological Society of Great Britain in 1902.[1]

The *L. rudis* of English waters with its varieties is fairly abundant in the Icenian deposits, especially at Bramerton near Norwich, where we seem to be approaching the shore line of the Crag sea of that period. Specimens of it differ considerably in size, form, colour and sculpture, some of them being here given under the varietal names adopted by Jeffreys and other authorities. In colour most of them are of a light yellowish-grey, while a few are deeply ferruginous. In size they vary from the minute var. *saxatilis* of Olivi to the large and solid var. *globosa*. Most of the recognised varieties of this species have now been found at Bramerton or Thorpe near Norwich.

As a recent shell *L. rudis* is distinctly littoral, occurring on beaches within the reach of the tide, or in some cases above high-water mark. It has a wide range in the eastern hemisphere, mainly northern, but it is also reported from the eastern and western coasts of North America. M. Gignoux considers that the typical *L. rudis* has not at any period penetrated into the Mediterranean (*op. cit.*, p. 557).

[1] The *L. rudis* of the Crag is a different shell from that for which I have adopted the varietal name *saxatilis*.

Var. **saxatilis** (Olivi).

1792. *Turbo saxatilis*, Olivi, Zool. Adr., p. 172, pl. v, figs. 3 *a*—3 *d*.
1841. *Littorina saxatilis*, Johnston, Proc. Berwicksh. Nat. Club, vol. i, p. 268.
1853. *Littorina saxatilis*, Forbes and Hanley, Brit. Moll., vol. iii, p. 43, pl. lxxxvi, figs. 4, 5.
1859. *Littorina saxatilis*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 19.
1867. *Littorina rudis*, var. *saxatilis*, Jeffreys, Brit. Conch., vol. iii, p. 365.
1892. *Littorina saxatilis*, Locard, Coq. mar. Côtes de France, p. 189.
1908. *Littorina saxatilis*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 57, pl. cxii, figs. 1—4.
1912. *Littorina saxatilis*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 192, pl. ix, figs. 1—6.

Varietal Characters.—Shell minute, smooth or spirally ridged, smaller than the typical *L. rudis*, nearly globular; mouth sub-orbicular; outer lip arcuated making nearly a right angle with the body whorl; colour greyish with a white base.

Dimensions.—L. 4—5 mm. B. 3·5—4 mm.

Distribution.—*Recent:* British and French coasts. Adriatic (Dautzenberg).

Fossil: Pleistocene: Bridlington, Cranstal (Isle of Man), Selsey.

Remarks.—There seems to be considerable difference of opinion as to the correct identification of the *Turbo saxatilis* of Olivi. The Rev. Dr. A. H. Cooke and Mr. J. R. Le B. Tomlin have been kind enough to examine some minute specimens of *Littorina* from the Bramerton Crag which I thought might be referred to it but they express a decided opinion that this is a mistake. They consider that this form is "always smooth and not ribbed at all." On the other hand I have received others from Venice through M. Dautzenberg which he considers Olivi's typical shell. They are distinctly ridged, corresponding closely with recent examples under this name in the Holmes collection at the Norwich Castle Museum. Those represented by Forbes and Hanley, G. B. Sowerby and Kobelt, moreover, are also spirally ornamented. Jeffreys, who unfortunately did not always figure his varietal forms, says that the var. *saxatilis*, though usually smooth, is sometimes finely ribbed. I have no evidence that Olivi's shell occurs in the English Crag, but Mr. Bell has found it in Mr. Headley's collection of fossils from Bridlington. Whether this group of molluscs should bear the varietal name of *rudis* or of *saxatilis* seems to me comparatively unimportant. The point is that the *rudis* of the Crag and the *saxatilis* of Bridlington are different, the one being characteristically Pliocene, the other Pleistocene.

Var. **lævis**, Jeffreys. Plate LIII, figs. 3, 4.

1865. *Littorina rudis*, var. *lævis*, Jeffreys, Brit. Conch., vol. iii, p. 365.
1901. *Littorina rudis*, var. *lævis*, Conch. Soc. List, Journ of Conch., vol. x, p. 17.

Varietal Characters.—Oval, solid and smooth (Jeffreys).

Dimensions.—L. 15 mm. B. 12 mm.

Distribution.—Recent: British Seas—Channel islands to Shetland.

Fossil: Bramerton, probably at other localities in the Icenian Crag.

Remarks.—The fossil specimen figured under this name, one of several in my cabinet from Bramerton, seems to correspond with Jeffreys' description of var. *lævis*, and with some recent specimens under the same name in the Norwich Museum, one of which is given with it for comparison.

Var. **jugosa** (Montagu). Plate LIII, fig. 5.

1803. *Turbo jugosus*, Montagu, Test. Brit., pt. ii, p. 586, pl. xx, fig. 2.
1867. *Littorina rudis*, var. *jugosa*, Jeffreys, Brit. Conch., vol. iii, p. 365.
1892. *Littorina jugosa*, Locard, Coq. mar. Côtes de France, p. 189.
1901. *Littorina rudis*, var. *jugosa*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17.
1912. *Littorina saxatilis*, var. *jugosa*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 195, pl. ix, figs. 18—27.

Varietal Characters.—Shell small, ornamented by strong and sharp spiral ridges, variable in number; spire short, pointed; last whorl much the largest.

Dimensions.—L. 8—12 mm. B. 8—10 mm.

Distribution.—Recent: British coasts—Shetland to the English Channel. West European.

Fossil: Icenian Crag: Bramerton. Pleistocene: Portland.

Remarks.—By some authors this form has been grouped with the var. *patula*. It differs from the latter, however, in its sharp and distinct spiral sculpture. Messrs. Dautzenberg and Fischer give several sub-varieties of it, distinguished by the strength or otherwise of their spiral ribs.

Var. **globosa,** Jeffreys. Plate LIII, figs. 6—8.

1827—44. *Turbo rudis*, Brown, Ill. Rec. Conch. Gt. Brit., ed. 1, pl. xlvi, figs. 10, 11, 1827; *Littorina rudis*, ed. 2, p. 128, pl. x, figs. 10, 11, 1844.
1865. *Littorina rudis*, var. *globosa*, Jeffreys, Brit. Conch., vol. iii, p. 365.
1901. *Littorina rudis*, var. *globosa*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17.
1912. *Littorina saxatilis*, subsp. *rudis*, var. *globosa*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 197, pl. x, fig. 3.

Dimensions.—L. 26 mm. B. 22 mm.

Distribution.—Recent: Oban, Dublin Bay, Isle of Man.

Fossil: Icenian Crag: Bramerton.

Remarks.—The shells here figured are from my own collection and were found at Bramerton. They are larger than our typical *L. rudis* which is so common at

that place, but correspond both in size and form with a recent one from the Isle of Man sent me by M. Dautzenberg under the present name, as well as with some given in Brown's 'Illustrated Conchology' as a variety of *L. rudis*. Jeffreys' description is that it is "large, globular, thick and nearly smooth." He states it has been found at Oban and in Dublin Bay, and that specimens of it are sometimes nearly an inch in length.

Var. **nigrolineata** (Gray). Plate LIII, fig. 9.

1839. *Littorina nigrolineata*, Gray, Zool. of Beechey's Voy., p. 140.
1846. *Litorina nigrolineata*, Philippi, Abbild., vol. ii, p. 104, pl. i, figs. 17—19.
1853. *Littorina rudis*, var. *nigrolineata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 34.
1859. *Littorina rudis*, var. *nigrolineata*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 13.
1912. *Littorina saxatilis*, var. *nigrolineata*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 196, pl. ix, figs. 28, 32.

Varietal Characters.—Shell ovate, suborbicular, pale and whitish with dark, impressed spiral lines; spire short; whorls convex; suture distinct; mouth ovate; inner lip dilated in front (Gray); outer lip sharply incurved.

Dimensions.—L. 14—18 mm. B. 10—14 mm.

Distribution.—*Recent:* British seas.

Fossil: Icenian Crag (not uncommon).

Pleistocene: Selsey, probably elsewhere.

Remarks.—A fair number of the Crag Littorinas are ornamented conspicuously with reddish or dark-coloured spiral bands. Some of these are distinctly of the *rudis* type, with convex whorls, an incurved lip and a deep suture, as are those here figured under the present name, the coloured bands varying in number. Others, for which I adopt Wood's name of *vulgaris* (see p. 647), group themselves with *L. littorea*, having flattened whorls, a shallow suture and a straight lip, agreeing with that species in form, but being smaller in size than the type.

Var. **rudissima** (Bean). Plate LIII, figs. 10, 11.

1844. *Littorina rudissima*, Bean in Suppl. to Thorpe's Brit. Mar. Conch., p. 266.
1912. *Littorina saxatilis*, var. *rudissima*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 198, pl. x, figs. 4—20.

Varietal Characters.—Shell of medium size, strong and solid, turreted, with a pointed and projecting spire; whorls 5 or 6, convex, well defined by the suture, the last ventricose; ornamented by numerous spiral and prominent lines.

Dimensions.—L. 10—18 mm. B. 8—15 mm.

Distribution.—*Recent:* coasts of Great Britain and of Western Europe.

Fossil: Icenian Crag: Bramerton.

Remarks.—MM. Dautzenberg and Fischer have revived the disused name *rudissima*, Bean, for some varietal forms of the present group of which they have represented a number, varying in size and spiral ornamentation. M. Dautzenberg has kindly sent me a recent specimen which he considers typical of this shell and has allowed me to figure it. I have occasionally met with examples in the Icenian Crag at Bramerton corresponding closely with it, approaching the northern var. *grœnlandica*, but differing distinctly from the general character of the other Crag varieties.

The shells for which Bean's name *rudissima* was originally used were found abundantly on rocks near high-water mark at Scarborough. That author specially distinguishes them from the typical *L. rudis* by their raised spiral markings and their patulous mouth and body-whorl.

Var. **grœnlandica** (Menke), Möller. Plate LIII, figs. 12, 13.

1842. *Littorina grœnlandica*, Möller, Ind. Moll. Grœnl., p. 9.
1846. *Littorina grœnlandica*, Philippi, Abbild., p. 103, pl. i, figs. 11–13.
1871. *Littorina grœnlandica*, Mörch, Geol. Mag. [1], vol. viii, p. 396.
1878. *Littorina rudis*, var. *grœnlandica*, G. O. Sars, Moll. Reg. arct. Norv., p. 165, pl. ix, fig. 10.
1898. *Littorina rudis*, var. *grœnlandica*, Posselt, Medd. om Grönl., vol. xxiii, p. 231.
1908. *Littorina saxatilis*, var. *grœnlandica*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 62, pl. cx, figs. 19, 20.
1912. *Littorina saxatilis*, var. *grœnlandica*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 198, pl. x, figs. 21, 28.
1917. *Littorina rudis*, var. *grœnlandica*, Schlesch, Hull Mus. publications, no. 110, p. 280.

Varietal Characters.—Shell ovate, tumid, generally larger than the typical *L. rudis*, fairly solid; whorls 5 or 6, decidedly convex, the last much the largest; suture deep, subcanaliculate; spire short, rapidly diminishing in size towards an acute apex; ornamented by spiral ridges, more or less prominent and distinct; mouth large, oval, patulous, somewhat expanded; outer lip thin.

Dimensions.—L. 15—20 mm. B. 12—15 mm.

Distribution.—*Recent:* northern coasts of Norway, Finmark, Lofoten Islands, Iceland, Greenland.

Fossil: Icenian Crag: Bramerton.

Remarks.—Of this decidedly Arctic species, found as fossil at present in the Icenian Crag only, there are one or two specimens from Bramerton in the Norwich Museum which correspond very closely with some recent shells I have received from Finmark. Prof. G. O. Sars states that they sometimes reach 20 mm. in length; the Crag forms, however, are somewhat smaller. It seems a distinct form which may be easily recognised by its general appearance and its rounded and ventricose whorls.

Var. **Reevei,** nov. Plate LIII, fig. 15.

1857. *Littorina littorea*, Reeve, Conch. Icon., vol. x, pl. iv, fig. 18 *a*.

Varietal Characters.—Oval, compressed, spiral lines delicate, impressed, body-whorl much the largest, squarely angulate above; spire narrow, short.

Dimensions.—L. 15 mm. B. 15 mm.

Distribution.—Recent: British seas, Atlantic shores of western Europe.

Fossil: Icenian Crag: Thorpe, near Norwich.

Remarks.—The fossil here given comes from the Crowfoot Collection (now in the Norwich Museum) and was found at Thorpe. It corresponds almost exactly with one of those figured by Reeve and to some extent with that figured by MM. Dautzenberg and Fischer (*op. cit.*, pl. ix, figs. 29, 30) under the subvarietal name of *canaliculatum*, but it is not the same as the latter. It is a very beautiful shell—the only one I have seen from the Crag—and seems to deserve a distinctive name. It differs from the var. *compressa* in the square and angulated shelf of the body-whorl below the suture, and in its much finer sculpture.

Var. **similis,** Jeffreys. Plate LIII, fig. 20.

1865. *Littorina rudis*, var. *similis*, Jeffreys, Brit. Conch., vol. iii, p. 365.

1901. *Littorina rudis*, var. *similis*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17.

1912. *Littorina saxatilis*, sub-sp. *tenebrosa*, var. *similis*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 194, pl. ix, figs. 16, 17.

Varietal Characters.—Resembling var. *tenebrosa* in size and shape, but is more distinctly ribbed (Jeffreys).

Dimensions.—L. 10 mm. B. 6 mm.

Distribution.—Recent: British coasts—Cornwall, S. Wales, Shetland, Aberdeenshire, estuary of the Alde, Suffolk. St. Malo.

Fossil: Not worked out.

Remarks.—Jeffreys' description of this variety is given above, but so far as I know it has never been figured in this country. Unless the type of a new and undescribed form is easily accessible a short verbal notice of it is useless, often leading to confusion and uncertainty. There is, however, a series of recent specimens under this name from Aldeburgh, in Suffolk, in the Norwich Museum, and the Rev. Dr. A. H. Cooke has kindly sent me some others, for the identification of which he can vouch. One of these I am permitted to figure. I have not noticed anything in the Crag which is precisely similar, but as most of the English varieties of *L. rudis* are to be found in our deposits it may turn up hereafter, and I have figured therefore a verified specimen of the present variety that I have received from Dr. Cooke for the purpose of comparison if necessary.

Var. **patula**, Thorpe. Plate LIII, fig. 16.

1844. *Littorina patula*, Thorpe, Brit. Mar. Conch., Suppl., p. 259, pl. i, fig. 7.
1853. *Littorina patula*, Forbes and Hanley, Brit. Moll., vol. iii, p. 36, pl. lxxxv, figs. 6—10.
1859. *Littorina patula*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 18.
1865. *Littorina rudis*, var. *patula*, Jeffreys, Brit. Conch., vol. iii, p. 365.
1892. *Littorina patula*, Locard, Coq. mar. Côtes de France, p. 188.
1901. *Littorina rudis*, var. *patula*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17.
1910. *Littorina patula*, Øyen, K. Norske Vid. Selsk. Skrift., no. 9, p. 170.
1912. *Littorina saxatilis*, var. *patula*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 196, pl. ix, figs. 24, 25.

Varietal Characters.—Shell small, subglobose, rather thin; whorls 4—5, the upper ones very small, the last large and expanded; ornamented by spiral ridges and by the lines of growth; spire very short with an obtuse apex, placed obliquely; mouth large, ovate, expanded; outer lip thin, forming a right angle with the columella.

Dimensions.—L. 12—15 mm. B. 10—13 mm.

Distribution.—Recent: Shetland Islands—Unst, south coast of Ireland, Penzance, north coast of France.

Fossil: Icenian Crag: Bramerton (?). *Tapes*-banks, Trondhjem.

Remarks.—I have not a satisfactory specimen of this variety from the Crag, but for reasons given in the last paragraph I figure a recent example from the south of Ireland, belonging to the Holmes Collection in the Norwich Museum, which agrees with some I have received from Dr. A. H. Cooke and from M. Dautzenberg. The latter writer remarks that the figures given by Kobelt and by Forbes and Hanley do not accurately represent the characteristic features of this shell. It may be specially recognised by its short spire, placed rather obliquely, and by its large and much-expanded mouth.

Var. **tenebrosa** (Montagu). Plate LIII, figs. 17, 18.

1803. *Turbo tenebrosus*, Montagu, Test. Brit., vol. ii, p. 303, pl. xx, fig. 4.
1819. *Turbo tenebrosus*, Turton, Conch. Dict., p. 197, figs. 36, 37.
1827—44. *Turbo tenebrosus*, Brown, Ill. Conch. Gt. Brit., ed. 1, p. 16, 1827; *Littorina tenebrosa*, ed. 2, p. 128, pl. x, figs. 18, 19, 1844.
1841—70. *Littorina tenebrosa*, Gould, Rep. Inv. Mass., ed. 1, p. 259, fig. 16 *b*, 1841; ed. 2, p. 306, fig. 576, 1870.
1853. *Littorina tenebrosa*, Forbes and Hanley, Brit. Moll., vol. iii, p. 39, pl. lxxxiv, figs. 11, 12; pl. lxxxv, figs. 1—5.
1859. *Littorina tenebrosa*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, figs. 16, 17.
1864. *Littorina tenebrosa*, S. P. Woodward in White's Hist. of Norfolk, vol. iii, p. 118.
1865—69. *Littorina rudis*, var. *tenebrosa*, Jeffreys, Brit. Conch., vol. iii, p. 365, 1865; vol. v, pl. lxv, fig. 3 *b*, 1869.
1872. *Littorina tenebrosa*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 213.
1892. *Littorina tenebrosa*, Locard, Coq. mar. Côtes de France, p. 188.

1896. *Litorina rudis*, var. *tenebrosa*, Munthe, Bull. Geol. Inst. Upsala, vol. ii, p. 3.
1908. *Littorina saxatilis*, var. *tenebrosa*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 61, pl. cx, figs. 7, 8; pl. cii, fig. 22.
1910. *Littorina rudis*, var. *tenebrosa*, Øyen, K. Norske Vid. Selsk. Skrift., No. 9, p. 33.
1912. *Littorina saxatilis*, var. *tenebrosa*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 194, pl. ix, figs. 13, 14.
1915. *Litorina rudis tenebrosa*, Johnson, Bost. Soc. Nat. Hist., vol. vii, Occ. papers, Fauna of New England, no. 13, p. 123.

Varietal Characters.—Shell ovato-conical, generally of a dark colour, not very thick; whorls 5, more or less convex; spire elevated; spiral sculpture indistinct or obsolete; apex acute; mouth ovate.

Dimensions.—L. 12—18 mm. B. 10—12 mm.

Distribution.—Recent: British coasts, estuarine (Jeffreys). French coasts, littoral (Locard), Canada, New England.

Fossil: Butleyan Crag: Butley. Icenian: Bramerton. *Litorina*-beds, Sweden. *Tapes*-banks, Christiania; Trondhjem.

Remarks.—Several forms have been described and figured under this name by the authors quoted above; in some cases the suture is deep, in others less so; in one variety (*elata*) the spire is elongate, in another, regarded by MM. Dautzenberg and Fischer as more typical, it is rather short. Locard says that in the recent shell the colour is variable, usually dark; specimens from the Crag are generally ferruginous.

Var. **tenebrosa elata**, Dautzenberg and Fischer. Plate LIII, fig. 19.

1912. *Littorina saxatilis*, sub.-sp. *tenebrosa*, var. *elata*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 194, pl. ix, fig. 15.

Specific Characters.—Agrees with what the above authorities regard as the typical var. *tenebrosa*, but it has a longer spire.

Dimensions.—L. 15 mm. B. 10 mm.

Distribution.—Recent: Iceland, south Coast.

Fossil: Icenian Crag: Bramerton, Bulchamp, Beccles, Easton Bavent, Yarn Hill.

Pleistocene: Selsey, Largo Bay, estuarine clays of Belfast.

Remarks.—The recent specimen here figured for comparison is from the Holmes Collection; in most of those described by the authors named above the spire is more or less elongate.

Littorina obtusata (Linné). Plate LII, figs. 27—29.

1758. *Turbo obtusatus*, Linné, Syst. Nat., ed. x, p. 761, no. 526.
1846. *Litorina obtusata*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, p. 94.
1853. *Littorina littoralis*, Forbes and Hanley, Brit. Moll., vol. iii, p. 45; vol. iv, pl. lxxxiv, figs. 5—7.
1859. *Littorina littoralis*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, figs. 20, 21.

1865. *Littorina littoralis*, Rose, Geol. Mag., vol. ii, p. 11.

1865—84. *Littorina obtusata*, Jeffreys, Brit. Conch., vol. iii, p. 356, 1865; vol. v, p. 205, pl. lxv, fig. 1, 1869; in Lamplugh, Quart. Journ. Geol. Soc., vol. xl, p. 319, 1884.

1878. *Littorina obtusata*, G. O. Sars, Moll. Reg. arct. Norv., pp. 167, 358.

1890—92. *Littorina obtusata*, A. Bell, Proc. Roy. Phys. Soc. Edin., vol. x, pp. 292, 296, 1890; Rep. Yorks. Phil. Soc., pp. 70, 72, 1892.

1890. *Litorina obtusata*, Carus, Prod. Faun. Medit., vol. ii, p. 350.

1892. *Littorina obtusa*, Locard, Coq. mar. Côtes de France, p. 187, fig. 163.

1899. *Littorina obtusata*, Posselt, Medd. om. Grønl., vol. xxiii, p. 229.

1901. *Littorina obtusata*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 657, pl. ix, fig. 15.

1908. *Littorina* (*Neritoides*) *obtusata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 64, pl. cx, figs. 14—18.

1910. *Littorina obtusata*, Øyen, K. Norske Vid. Selsk. Skrift., No. 9, pp. 15 *et seq.*

Specific Characters.—Shell thick and strong, ovate; spire truncate, depressed; whorls 5—6, the last embracing nearly all the spire, obliquely expanded, covered by excessively fine and hardly visible striæ and by the lines of growth; suture slight; mouth large, more than half the total length, oblique, acutely angulate above; outer and inner lip thickened, the latter spread over the pillar.

Dimensions.—L. 16 mm. B. 14 mm.

Distribution.—Recent: Among stones on the beaches of Great Britain below high-water mark, Atlantic Coasts of Europe, from Finmark southwards, Greenland, Iceland, White Sea, Mediterranean, Adriatic.

Fossil: Icenian Crag: Bramerton. Isle of Man, Wexford gravels, Bridlington, Nar Valley brickearth. Generally distributed in the Pleistocene deposits of the British Islands. Occurring also in the Pleistocene of Norway.

Remarks.—This littoral species, common as a recent shell and in our Pleistocene deposits, has not been reported hitherto from the Anglo-Belgian Crag. It has been found at Bridlington by the late C. B. Rose in the Nar Valley brickearth (Pleistocene), and by Mr. Bell in the Manxland drift and in the Wexford gravels. One of the specimens here figured is from Bramerton, another from the raised beach at Portland where it is exceedingly common, and a third from Wexford.

Littorina neritoides (Linné). Plate LIII, fig. 21.

1758. *Turbo neritoides*, Linné, Syst. Nat., ed. x, p. 761, no. 527.

1836—44. *Turbo neritoides*, Philippi, En. Moll. Sic., vol. i, p. 189, 1836; vol. ii, p. 159, 1844.

1846. *Litorina neritoides*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, p. 94, no. 161.

1853. *Littorina neritoides*, Forbes and Hanley, Brit. Moll., vol. iii, p. 26, pl. lxxxiv, figs. 1, 2.

1859. *Littorina neritoides*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 23.

1865—69. *Littorina neritoides*, Jeffreys, Brit. Conch., vol. iii, p. 361, 1865; vol. v, p. 206, pl. lxv, fig. 2, 1869.

1874—76. *Littorina neritoides*, Seguenza, Boll. R. Com. Geol. Ital., vol. v, p. 6, no. 420, 1874; vol. vii, p. 180, no. 707, 1876.

1884. *Littorina neritoides*, [Bucquoy, Dautzenberg et Dollfus, Moll. mar. Rouss., vol. i, p. 250, pl. xxvii, figs. 13—18.]

1890. *Littorina neritoides*, Carus, Prod. Faun. Medit., vol. ii, p. 350.
1892. *Littorina neritoides*, A. Bell, Rep. Yorks. Phil. Soc., no. 723, p. 63.
1892. *Littorina neritoides*, Locard, Coq. mar. Côtes de France, p. 190, fig. 166.
1908. *Littorina (Melarhaphe?) neritoides*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 67, pl. cxi, figs. 11—15; pl. cxii, figs. 24—29.

Specific Characters.—Shell varying in size; whorls slightly compressed towards the suture, overlapping, the last two-thirds the total length; spire short, sharply pointed; suture slight; mouth large, angulate above; outer lip thin, expanded; inner lip forming a wide glazed coating upon the pillar; pillar thick, bevelled to a sharp edge.

Dimensions.—L. 6—12 mm. B. 3—8 mm.

Distribution.—*Recent:* British seas, ranging also from Heligoland to the Canaries. Mediterranean, Adriatic, Ægean, Black Sea.

Fossil: Waltonian Crag: Little Oakley.

Pleistocene—Clyde beds (J. Geikie), Scotland, generally; estuarine clays, Belfast. Selsey, Garvel Park.

Holocene: Portrush.

Upper Pliocene: Altavilla.

Pleistocene: Messina, Livorno. *Tapes*-banks, Christiania.

Remarks.—I have a small and possibly immature specimen from Oakley, which closely resembles the recent form of *L. neritoides*, except that the base of the body-whorl is distinctly angulated. The late Mr. E. A. Smith, to whom I submitted it, considered it a carinated and rather abnormal variety of that species.

Mr. Bell informs me that *L. neritoides* is exceedingly common in the estuarine clays of north-east Ireland, where it is associated with a large variety of *Tapes aureus* similar to that of the post-glacial deposits of Christiania. Dr. Øyen informs me that although *L. neritoides* occurs there as a fossil it does not now live in that region. The specimen here figured, which I have received under that name, is from Garvel Park. It is much larger than the usual form, but not than some of those represented by MM. Bucquoy, Dautzenberg and Dollfus (*op. cit.*, figs. 13 and 16).

Littorina palliata (Say). Plate LIII, figs. 22, 23.

1821. *Turbo palliatus*, Say, Journ. Acad. Nat. Sci. Philad., vol. ii, p. 240.
1841—70. *Littorina palliata*, Gould, Rep. Inv. Mass., ed. i, p. 260, fig. 167, 1841; ed. ii, p. 309, fig. 578, 1870.
1842. *Litorina arctica*, Möller, Ind. Moll. Groenl., p. 9.
1846. *Litorina limata*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, no. 164, p. 94.
1853. *Littorina palliata*, Forbes and Hanley, Brit. Moll., vol. iii, p. 51, pl. lxxxiv, figs. 8—10.
1859. *Littorina palliata*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 24.

1865—69. *Littorina obtusata*, var. *ornata*, Jeffreys, Brit. Conch., vol. iii, p. 357, 1865; vol. v, pl. lxv, fig. 1*a*, 1869.
1878. *Littorina palliata* and vars., G. O. Sars, Moll. Reg. arct. Norv., pp. 165, 358, pl. ix, fig. 9; pl. xxi, figs. 19, 20.
1892. *Littorina palliata*, Locard, Coq. mar. Côtes de France, p. 187.
1899. *Litorina palliata*, Posselt, Medd. om Grønl., vol. xxiii, pp. 230, 358.
1901. *Littorina palliata ?*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 653.
1910. *Littorina palliata*, Øyen, K. Norske Vid. Selsk. Skrift., No. 9, p. 182.
1910. *Littorina palliata*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. vii, pp. 8, 23.
1915. *Litorina obtusata palliata*, Dautzenberg et Fischer, Journ. de Conch., vol. lxii, p. 107, pl. ii, fig. 4.
1915. *Littorina obtusata palliata*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii; Fauna of New England, no. 13, Mollusca, p. 121.

Specific Characters.—Shell small, ovato-globose, not very solid; whorls 5, slightly convex, the last ventricose, much the largest, four-fifths the total length; ornamented by excessively fine and inconspicuous spiral striæ; spire very short; suture slight; mouth sub-ovate, acutely angulate above; outer lip thin, much expanded; inner lip wide, covering the pillar.

Dimensions.—L. 10—12 mm. B. 10—12 mm.

Distribution.—Recent: British coasts—Southampton, Isle of Wight; western coast of France (Locard).

Circumpolar—Finmark, Iceland, Greenland. New England coasts—Maine to Connecticut.

Fossil: Butleyan Crag: Butley.

Pleistocene: Aberdeen (Jamieson), Clyde beds, Garvel Park. Canada (Dawson). Christiania fiord? (Brøgger). Trondhjem (Øyen).

Remarks.—The American *L. palliata* of Say, a characteristically northern and circumpolar species, has been identified by most writers with the European *L. palliata* of Forbes and Hanley and with that of Locard, although Jeffreys and more recently MM. Dautzenberg and Fischer regarded it as a variety of *L. obtusata*.

The Butley fossil here represented is from the Ipswich Museum, where it is labelled *L. palliata*. It is worn and imperfect, but so far as it goes seems to correspond with Gould's figure of the American shell and with some recent specimens in the Holmes Collection at the Norwich Castle Museum found at Southampton, the locality from which those described by Forbes and Hanley were obtained. According to Prof. G. O. Sars, *L. palliata* is a very variable species, one variety figured by him (*monstr. coarctata*, *op. cit.*, pl. xxi, fig. 20) having an elongated spire, flattened whorls and a slight suture, differing from the type-form in every respect except its delicate and inconspicuous spiral sculpture. Our other specimen is from Garvel Park.

Littorina gibbosa, Etheridge and Bell. Plate LIII, fig. 24.

1893—98. *Littorina gibbosa*, A. Bell, Proc. Roy. Irish Acad. [3], vol. ii, p. 630, 1893; Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 154, pl. iii, fig. 1.

Specific Characters.—Shell minute, ovate; whorls 5, convex, the last ventricose, much the largest, three-fourths the total length, angulated at the periphery, showing oblique lines of growth, but otherwise without sculpture; spire conical, very short and small, with a compressed apex; suture fairly deep and channelled; mouth large, sub-ovate; outer lip compressed, sharply inflected above; inner lip covering the pillar, gradually becoming wider, reflected and expanded below.

Dimensions.—L. 3·5 mm. B. 2·5 mm.

Distribution.—Not known living.

Fossil: St. Erth. Waltonian Crag: Little Oakley.

Remarks.—The fossil here figured under Mr. Bell's name is the specimen he obtained some years ago at St. Erth. We are unable to refer it satisfactorily to any species known to us. It is from the Warburton Collection at the British Museum. Another was found by Mr. Bell at Oakley.

Littorina Headleyi, A. Bell. Plate LIII, fig. 14.

1884. *Littorina (?) globosa*, Jeffreys, Quart. Journ. Geol. Soc., vol. xl, p. 320, pl. xv, fig. 1.
1919. *Littorina Headleyi*, A. Bell, Yorks. Naturalist, p. 58.

Specific Characters.—Shell minute, rather thick, opaque; whorls 4, convex, without ornament, the last much the largest; spire short, regularly diminishing to a blunt point; suture slight; mouth angulate above, rounded below; pillar broad, thickened at the base, with a small umbilical chink behind it.

Dimensions.—L. 2·5 mm. B. 2·25 mm.

Distribution.—Not known living.

Fossil: Pleistocene: Bridlington.

Remarks.—The shell here represented is from the Headley Collection, where it bears Jeffreys' original name of *L. globosa*. As that had been previously used by him for a variety of *L. rudis*, Mr. Bell has suggested for it the term *Headleyi*, in which I follow him. Jeffreys states that about six specimens had been obtained at Bridlington, all so imperfect that he was doubtful as to whether they belonged to *Littorina* or *Trochus*. Neither his figure nor that here given seems to represent exactly the fossil. There is often much difficulty in getting accurate enlargements of these minute forms.

Genus **LACUNA**, Turton, 1827.

Lacuna pallidula (Da Costa). Plate LIII, fig. 25.

1778. *Nerita pallidula*, Da Costa, Brit. Conch., p. 51, pl. iv, figs. 4, 5.
1804. *Nerita pallidula*, Donovan, Brit. Shells, vol. i, pl. xvi, fig. 1.
1819. *Turbo pallidulus*, Turton, Conch. Dict., p. 192, pl. xxv, figs. 85, 86.
1853. *Lacuna pallidula*, Forbes and Hanley, Brit. Moll., vol. iii, p. 56, pl. lxxii, figs. 1, 2.

1859. *Lacuna pallidula*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 31.
1865–69. *Lacuna pallidula*, Jeffreys, Brit. Conch., vol. iii, p. 351, 1865; vol. v, p. 205, pl. lxiv, fig. 5.
1871—92. *Lacuna pallidula*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. viii, p. 49, 1871; Proc. Roy. Phys. Soc. Edin., vol. x, p. 296, 1890; vol. xii, p. 26, 1892; Rep. Yorks. Phil. Soc., p. 63, 1892.
1877. *Lacuna pallidula*, Etheridge in J. Geikie, Gt. Ice Age, ed. 2, p. 595.
1878. *Lacuna pallidula*, G. O. Sars, Moll. Reg. arct. Norv., pp. 168, 358, 390, pl. xxi, fig. 21.
1892. *Lacuna pallidula*, Locard, Coq. mar. Côtes de France, p. 192, fig. 168.
1901. *Lacuna pallidula*, Brøgger, Norges geol. Undersøgelse, No. 31, pp. 405, 657.
1901. *Lacuna pallidula*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17, no. 327.

Specific Characters.—Shell rather thin, obliquely ovate; whorls 3—4, convex, the last occupying nearly the whole length, much expanded; spire minute, excentric; suture well defined; mouth very large and wide; outer lip thin, rounded, incurved; inner lip thickened, expanded below; columella canaliculate, wide and deep.

Dimensions.—L. 6 mm. B. 5 mm.

Distribution.—Recent: British coasts, Shetland to the Channel Islands. Irish coasts. Norway—Christiania fiord to the Lofoten Islands. Iceland, Spitzbergen, Greenland. Atlantic coasts of France.

Fossil: Selsey, Portland, Dalmuir, Lochgilphead, Cumbrae, Largo, Estuarine clays of Belfast, Portrush.

Isocardia and *Tapes*-banks, Christiania fiord.

Remarks.—The specimen figured under this name is one of two obtained by Mr. Bell at Selsey. It is a species found in several Pleistocene localities in Great Britain and in Norway but is unknown from our Pliocene deposits. It is closely allied to a North American form, the *L. neritoidea* of Gould, which Jeffreys and Mr. C. W. Johnson considered to be a variety of *L. pallidula*.

Lacuna puteolus (Turton). Plate LIII, fig. 26.

1819—28. *Turbo puteolus*, Turton, Conch. Dict., p. 193, figs. 90, 91, 1819; *Lacuna puteolus*, Zool. Journ., vol. iii, p. 191, 1828.
1853. *Lacuna puteolus*, Forbes and Hanley, Brit. Moll., vol. iii, p. 58, pl. lxxii, figs. 7—9; pl. lxxiv, fig. 9.
1865—83. *Lacuna puteolus*, Jeffreys, Brit. Conch., vol. iii, p. 348, 1865; vol. v, p. 205, pl. lxiv, fig. 4, 1869; Proc. Zool. Soc., p. 110, 1883.
1871—92. *Lacuna puteolus*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. viii, p. 49, 1871; Proc. Roy. Phys. Soc. Edin., vol. x, p. 296, 1890; Rep. Yorks. Phil. Soc., no. 723, p. 63, 1892.
1877. *Lacuna puteolus*, Etheridge in J. Geikie, Gt. Ice Age, ed. 2, p. 595.
1878. *Lacuna puteolus*, G. O. Sars, Moll. Reg. arct. Norv., pp. 169, 358, 399.
1892. *Lacuna puteolina*, Locard, Coq. mar. Côtes de France, p. 192.

Specific Characters.—Shell small, globular; whorls 3—4, convex, the last three-fourths the total length; suture rather deep; spire very short with a

slightly raised and blunt but rather prominent apex; mouth large, expanded; outer lip thin, rounded, incurved.

Dimensions.—L. 5 mm. B. 5 mm.

Distribution.—*Recent:* coasts of Great Britain, Ireland, and Norway, Finmark, northern and western coasts of France. Kiel, Corunna, Vigo.

Fossil: Selsey, Portland, Torbay, Bridgewater, Southampton, Garvel Park, Clyde beds (common), Fillyside, Fort William, estuarine clays, Belfast, Portrush.

Remarks.—The specimen here figured was obtained at Garvel Park. *L. puteolus*, which has a fairly wide range as a living shell, has been reported from the Pleistocene deposits of Great Britain and Ireland. Jeffreys gives it from the Norwich Crag in the Brit. Conch. on S. P. Woodward's authority, but this may probably be a mistake. I cannot find a reference to it in any Crag list known to me.

Lacuna crassior (Montagu). Plate LIII, figs. 27—29.

1803. *Turbo crassior*, Montagu, Test. Brit., pt. ii, p. 309, pl. xx, fig. 1.
1853. *Lacuna crassior*, Forbes and Hanley, Brit. Moll., vol. iii, p. 67, pl. lxxii, figs. 5, 6.
1859. *Lacuna crassior*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xii, fig. 29.
1867—83. *Lacuna crassior*, Jeffreys, Brit. Conch., vol. iii, p. 344, 1867; vol. v, p. 205, pl. lxiv, fig. 2, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 488, 1871; Proc. Zool. Soc., p. 109, 1883.
1872. *Lacuna crassior*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 209, 213.
1878. *Lacuna crassior*, J. Reeve, Proc. Norwich Geol. Soc., vol. i, p. 70.
1892. *Lacuna crassior*, Locard, Coq. mar. Côtes de France, p. 194.
1898. *Lacuna crassior*, Posselt, Medd. om Grønl., vol. xxiii, p. 228.
1901. *Lacuna crassior*, Conch. Soc. List, Journ. of Conch., vol. x, p. 17, No. 324.
1908. *Lacuna crassior*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 74, pl. cxi, figs. 27, 28.

Specific Characters.—Shell turreted, bluntly angulated at the base, rather solid, opaque; whorls 6—7, slightly convex, somewhat angular above; suture excavated; mouth rather large, expanded below, angulated at the base; outer lip incurved; inner lip not united with the outer one.

Dimensions.—L. 12—14 mm. B. 6—8 mm.

Distribution.—*Recent:* British coasts, rather local, from low water mark to 50 fathoms, Channel Islands to Shetland, Spitzbergen, White Sea, Russian Lapland, Greenland, Gulf of St. Lawrence, Normandy.

Fossil: Icenian Crag: Bramerton. Pleistocene: Bridlington, Kelsey Hill, March gravels.

Remarks.—This northern species has been reported from Bramerton and Kelsey Hill by Jeffreys and from Bridlington by A. Bell. One of the specimens now figured (fig. 27), I found many years ago at March. Another (fig. 28) is a recent shell from the Holmes Collection at the Norwich Museum.

Lacuna divaricata (Fabricius). Plate LIII, fig. 30.

1780. *Turbo divaricatus*, Fabricius, Faun. Grœnl., p. 392.
1803. *Turbo vinctus*, Montagu, Test. Brit., pt. ii, p. 307, Suppl., pl. xx, fig. 3.
1841—70. *Lacuna vincta*, Gould, Rep. Inv. Mass., ed. 1, p. 262, fig. 169, 1841 ; ed. 2, p. 302, fig. 573, 1870.
1846. *Lacuna divaricata*, Lovén, K. Svensk. Vet.-Acad. Förh., vol. iii, p. 95.
1850—72. *Lacuna vincta*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 316, pl. xxxi, fig. 13, 1850 ; 1st Suppl., pt. i, p. 80, 1872.
1853. *Lacuna vincta*, Forbes and Hanley, Brit. Moll., vol. iii, p. 62, pl. lxxii, figs. 10—12 ; pl. lxxiv, figs. 7, 8 ; pl. lxxxvi, figs. 6—8.
1859. *Lacuna vincta*, G. B. Sowerby, Ill. Ind. Brit. Shells, p. xii, figs. 27, 28.
1863—84. *Lacuna divaricata*, Jeffreys, Rep. Brit. Assoc. (Newcastle), Trans., p. 77, 1863 ; Brit. Conch. vol. iii, p. 346, 1867 ; vol. v, p. 204, pl. lxiv, fig. 3, 1869 ; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 488, 1871 ; Proc. Zool. Soc., p. 109, 1883 ; in Lamplugh, Quart. Journ. Geol. Soc., vol. xl, p. 319, 1884.
1870—92. *Lacuna vincta*, A. Bell, Journ. de Conch., vol. xviii, p. 352, no. 401, 1870 ; *L. divaricata*, Rep. Brit. Assoc. (Leeds), pp. 413, 417, 420 ; Proc. Roy. Phys. Soc. Edin., vol. x, pp. 292, 296, 1890 ; Proc. Roy. Irish Acad. [3], vol. ii, p. 258, 1892 ; Yorkshire Naturalist, No. 723, p. 96, 1917.
1872. *Lacuna divaricata*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 213, 216.
1878. *Lacuna divaricata*, G. O. Sars, Moll. Reg. arct. Norv., pp. 169, 358, pl. xxi, fig. 22.
1892. *Lacuna divaricata*, Locard, Coq. mar. Côtes de France, p. 193, fig. 169.
1898. *Lacuna vincta*, Posselt, Medd. om. Grønl., vol. xxiii, p. 228.
1901. *Lacuna divaricata*, Brøgger, Norges geol. Undersøgelse, No. 31, pp. 380, 430, 508, 653, pl. ix, fig. 21.
1908. *Lacuna divaricata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. iv, p. 73, pl. cxi, figs. 30—34.
1910. *Lacuna divaricata*, Odhner, K. Svensk. Vet.-Akad. Handl. Stockholm, vol. vii, pp. 8, 23.
1910. *Lacuna divaricata*, de Geer, Geol. Fören. Förh., vol. xxxii, Analysis.
1915. *Lacuna vincta*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Fauna of New England, No. 13, p. 121.

Specific Characters.—Shell rather thin, semitransparent, expanded and rounded at the base ; spire elongate, ending in a blunt point ; whorls 6, compressed, the last much the largest ; suture oblique, distinct, but not deep ; mouth wide, expanded below ; outer lip thin.

Dimensions.—L. 10 mm. B. 6 mm.

Distribution.—Recent : British seas, abundant at low water mark and in the laminarian zone. Circumpolar—Iceland, Faroes, Finmark, Greenland, Canada, Alaska ; ranging also through Scandinavian coasts to Gulf of Gascony, north-eastern American coasts to New York, North Japan.

Fossil : Icenian Crag (Jas. Reeve), rare. Pleistocene beds of England, Scotland and Ireland, Clyde beds, Blackpool, Gloppa, Macclesfield, Moel Tryfaen, Aberdeenshire, Bridlington, Holderness, Kelsey Hill, March gravels, Selsey, Southampton docks and elsewhere.

Uddevalla, Christiania fiord—from upper *Arca* beds to *Tapes*-banks.

Remarks.—This shell may be distinguished from *L. crassior*, with which it is often found, by its thinner texture, its rather longer spire with an oblique suture, and its compressed and less convex whorls. Jeffreys reports it from Bridlington, Kelsey Hill and Uddevalla, while A. Bell has found it in many British Pleistocene deposits. As I cannot now lay my hands on any of these I have figured a recent one from the Norwich Museum to enable students to recognise any specimens which may turn up hereafter.

Lacuna suboperta (J. Sowerby). Plate LIII, figs. 31, 32.

1813. *Vivipara suboperta*, J. Sowerby, Min. Conch., vol. i, p. 80, pl. xxxi, fig. 6.
1844—81. *Littorina suboperta*, Nyst, Coq. foss. Belg., p. 388, pl. xxxvii, fig. 1, 1844; Conch. Terr. tert. Belg., p. 93, pl. vi, fig. 21, 1881.
1842—72. *Littorina suboperta*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 532, 1842; Mon. Crag Moll., pt. i, p. 120, pl. x, fig. 13, 1848; *Lacuna suboperta*, 1st Suppl., pt. i, p. 80, 1872.
1871. *Littorina littorea* var., Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489.
1872. *Littorina suboperta*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 209.
1874—92. *Littorina suboperta*, Van den Broeck, Ann. Soc. malac. Belg., vol. ix, p. 273, 1874; Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 133, 1892.
1912. *Littorina suboperta*, Tesch, Med. v. d. Rijks. v. Delfstoffen, No. 4, p. 62, no. 136.
1892—98. *Lacuna suboperta*, A. Bell, Proc. Roy. Irish Acad. [3], vol. ii, p. 630, 1892; *L.* (? *Littorina*) *suboperta*, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 154.

Specific Characters.—Shell thick and solid, ovato-conical; whorls 5, depressed, rounded and obtusely angulate at the base; spire short, elongate; apex acute; mouth ovate, contracted above; inner lip forming a strong and rather wide callus on the columella, covering the umbilicus, either wholly or in part.

Dimensions.—L. 12—15 mm. B. 8—10 mm.

Distribution.—Not known living.

Fossil: St. Erth.: Waltonian, Newbournian, Butleyan, at most localities of the Red Crag, sometimes in fair abundance.

Scaldisien: Belgium. Poederlien: Belgium, Holland.

Remarks.—Except that it has been found at St. Erth, this species seems to be confined to the Red Crag of East Anglia and to deposits of similar age in Belgium and Holland. In the Crag it makes its first appearance at Walton-on-Naze and Oakley where it is fairly common, and it may be found almost everywhere at other Crag horizons although more rarely. Wood pointed out that while this form is thick and strong our specimens from the Crag are generally more or less mutilated, but they are too numerous to lend any support to the view that they are derivative from some earlier deposit. *L. suboperta* has not been found in the Coralline Crag, though a smaller and less solid variety (which is also given here, fig. 31) occurs at St. Erth.

Genus **CITHNA**, A. Adams, 1863.

Cithna minima, A. Bell, MS. Plate LIII, fig. 33.

1892. *Cithna minima*, A. Bell, Rep. Yorks Phil. Soc., p. 75.

Specific Characters.—Shell minute, oval, conical; whorls 4, the last angulated, comprising nearly the whole length; upper whorls and apex depressed, suture well marked; mouth nearly circular with an expanded base; inner lip curved; basal chink long and narrow.

Dimensions.—L. 1 mm. B. 1 mm.

Distribution.—Not known living.

Fossil: Selsey.

Remarks.—The minute shell here given has been identified by Mr. Bell as the one found at Selsey and described by him under the above name. It now belongs to the Museum at York where it has been labelled *Cithna depressa*. At present it is unique, not having been recorded, so far as I know, by any other observer, or from any other locality.

Cithna incerta, A. Bell, MS. Plate LIII, fig. 34.

Specific Characters.—Shell minute, smooth, turreted; whorls 4, convex, the last ventricose, much the largest; suture deep; spire regularly diminishing in size towards a rounded and compressed apex; mouth ovate, angulate above; peristome continuous; umbilicus large, open.

Dimensions.—L. 2 mm. B. 1 mm.

Distribution.—Not recorded living.

Fossil: St. Erth.

Remarks.—The charming little shell figured under this name was found by Mr. Bell at St. Erth, and is now in the Warburton Collection at the British Museum (Nat. Hist.). It has not been recorded hitherto as a fossil from either any British or continental deposit.

Cithna has been regarded by P. Fischer as a sub-genus of *Lacuna*, to which it seems nearly allied, but Carus and the authors of the 'Marine Mollusca of Roussillon' consider it a distinct genus. A Mediterranean shell, *C. tenella* (*Hela*, Jeffreys) has been taken to represent the type.

Genus **FOSSARUS**, Philippi, 1841.

Fossarus sulcatus (S. V. Wood). Plate LIII, fig. 35.

1842—50. *Phasionema sulcata*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 535, 1842; *Fossarus sulcatus*, Mon. Crag Moll., pt. i, p. 121, pl. viii, figs. 23 *a*, 23 *b*, 1848; pt. ii, p. 317, 1850.

1871. *Fossarus clathratus*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 144; *F. costatus*, p. 495.
1872. *Fossarus costatus*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 203.
1890. *Fossarus costatus*, C. Reid, Plioc. Dep. Brit., p. 244.

Specific Characters.—Shell small, ovato-conical; whorls 3 or 4, convex, compressed above, but not angulated, the last much the largest; ornamented by rather prominent spiral ridges and by fine lines of growth in the interspaces; spire short with a pointed apex; suture depressed; umbilicus fairly large; mouth ovate, but slightly expanded, about half the total length; outer lip thin, gently rounded.

Dimensions.—L. 3 mm. B. 2 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Sutton.

Remarks.—This small shell, originally described by Wood as new, both generically and specifically, under the name of *Phasionema sulcata*, and subsequently as belonging to a recent genus, *Fossarus*, was referred by Jeffreys to a variety of a Mediterranean species, *F. clathratus*, Phil., and afterwards to *F. costatus*, Brocchi, being followed as to the latter and on his authority by the brothers Bell and by the late C. Reid. On the whole I am inclined to consider the Crag shell as distinct under Wood's name of 1848, *F. sulcatus*. Chenu figures our species as typical of the genus *Fossarus*.

Fossarus lineolatus (S. V. Wood). Plate LIII, fig. 36.

1842—74. *Phasionema lineolata*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 535, pl. v, fig. 15, 1842; *Fossarus sulcatus*, var. *lineolata*, Mon. Crag Moll., pt. i, p. 121, pl. viii, figs. 23 *c*, 23 *d*, 1848; *F. lineolatus*, 1st Suppl., p. 186, 1874.
1859. *Fossarus sulcatus*, Chenu, Man. Conch., vol. i, p. 302, fig. 2132.
1871. *Fossarus japonicus*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 495.
1872. *Fossarus japonicus*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 203.
1879. *Fossarus sulcatus*, var. *lineolata*, Cogels and Van den Broeck, Ann. Soc. malac. Belg., vol. xiv, p. 71.
1881. *Fossarus sulcatus*, var. *lineolata*, Nyst, Conch. Terr. tert. Belg., p. 91, pl. vi, fig. 20.
1892. *Fossarus lineolatus*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 121.
1895. *Fossarus* (*Phasionema*) *lineolatus*, Sacco, Moll. Terr. Terz. Piem., pt. xviii, p. 18.

Specific Characters.—Shell small, ovate; whorls 4, convex, the last much the largest; ornamented by delicate spiral ridges less numerous than in *F. costatus*, with very fine longitudinal ridges in the interspaces; spire short; mouth large, three-fourths the total length, with a small tooth on the inner lip; outer lip thin not scalloped.

Dimensions.—L. 4 mm. B. 3 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Sutton.

Casterlien, Scaldisien: Belgium.

Remarks.—Originally Wood regarded this form as a variety of *F. sulcatus*, but in his first Supplement he considered it sufficiently distinct to be considered of specific rank. Jeffreys identified it with a recent Japanese shell, *F. japonicus*, a name which was adopted on his authority for the Crag shell by the Messrs. Bell and by the late Cl. Reid. I have tried to procure a specimen of the former, but Prof. Yabe informs me there are none to be obtained either from dealers or from the public museums in that country. Prof. Sacco regarded them as distinct forms, as did Wood, who had the advantage of comparing one of his Crag specimens with a recent example from Japan.

Genus **NATICA**, Adanson, 1757.

The genus *Natica* is well represented in the English Pliocene, especially in the Waltonian division of the Red Crag. Originally proposed by Adanson for a number of closely allied forms, it has been divided of late years into several sub-genera, the principal division being between those having a calcareous and those with a corneous operculum. The former term has been for some time confined to a group of which *N. affinis* was taken as the type, the sub-generic term *Nacca* being adopted for shells having a subcentral umbilical ridge, as in the Miocene and Mediterranean species *N. millepunctata*. The use of *Nacca* has now been discontinued by some of our best authorities, *N. millepunctata* and its allies being included in the genus *Natica*, *sensu stricto*.

Another group of the Crag species—those with a non-calcareous operculum—has been known under the generic or sub-generic names of *Naticina*, Guilding (1834), or *Lunatia*, Gray (1847), the former mainly by southern, the latter by northern Conchologists, and by the Conchological Society of England in their well-known list. Recently *Naticina* has been dropped by Dautzenberg, Cossmann and other writers, most of the Crag forms hitherto comprised under that name being associated under the sub-generic term *Lunatia*, with *L. catena* as the type. A few Crag species are grouped with *Polinices*, more largely used in America, confined by P. Fischer to oval and elongated shells having the umbilicus closed by the funicular callosity.

Natica clausa, Broderip and Sowerby. Plate LVI, figs. 1—5.

1829. *Natica clausa*, Broderip and Sowerby, Zool. Journ., No. 4, p. 372.

1839. *Natica clausa*, Gray in Beechey's Voy., p. 136, pl. xxxiv, fig. 3; pl. xxxvii, fig. 6.

1842—48. *Natica clausa*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 147, pl. xvi, fig. 2, 1848.

1863—85. *Natica affinis*, Jeffreys, Rep. Brit. Assoc. (Newcastle-on-Tyne), p. 78, 1863; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1871; Proc. Zool. Soc., p. 35, 1885.

1870. *Natica clausa*, Gould, Inv. Mass., ed. 2, p. 342, no. 612.

1872. *Natica affinis*, Dawson, Canadian Nat. [N. s.], vol. vi, p. 392, pl. vi, fig. 6.

1878. *Natica clausa*, G. O. Sars, Moll. Reg. arct. Norv., pp. 159, 338, pl. xxi, figs. 12, 13.

1899. *Natica affinis*, Posselt, Medd. om Grønl., vol. xxiii, p. 142.

1901. *Natica affinis*, var. *clausa*, Brøgger, Norges geol. Undersøgelse, No. 31, pp. 42, 653, pl. vi, fig. 20; pl. xii, figs. 2, 3.

1901. *Natica affinis*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 84 (pt.), pl. liii, figs. 1—3.

1910. *Natica clausa*, Øyen, Krist. Vid. Selsk. Forh., no. 5, p. 27; Kgl. Norske Vid. Selsk. Skrift., no. 9, p. 185.

1910—13. *Natica clausa*, Odhner, Arkiv. för Zool.., vol. vii, no. 4, p. 7, 1910; K. Svensk. Vet.-Akad. Handl., vol. l, p. 14, pl. iii, figs. 1–3; 5–14; 16–17; pl. v, figs. 7–14, 1913.

1911. *Natica clausa*, Yabe, Geol. Mag. [5], vol. viii, p. 212.

1912. *Natica clausa*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxvii (Mollusques), p. 225.

1915. *Natica* (*Cryptonatica*) *clausa*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Faun. New Engl., pt. 13, p. 105.

Specific Characters.—Shell rather large, fairly strong, globose, imperforate; whorls 5, the last wide, flattened and compressed above, ventricose, much the largest, excavated below; spire very short, rapidly diminishing to a small point; suture well marked; mouth large, semilunar, obtusely angulate above, projecting below; outer lip expanded, incurved; inner lip spread over the columella, forming a semi-circular pad covering the umbilicus; operculum calcareous.

Dimensions.—L. 20—25 mm. B. 20—25 mm.

Distribution.—Recent: Circumpolar—Finmark, Lofoten Islands, Iceland, Jan Mayen, Lapland, Spitzbergen, Greenland, Banks of Newfoundland, New England coast, Melville Island, Behring Sea.

Fossil: Waltonian Crag: Little Oakley. Newbournian: Ramsholt, Sutton. Butleyan: Butley, Alderton, Hollesley.

Pliocene: Iceland. Pleistocene: Bridlington, Moel Tryfaen. Uddevalla, Christiania fiord. Trondhjem (Øyen). Greenland, Labrador. Canada—Montreal, Quebec, Rivière du Loup. Massachusetts. Siberian coast. Japan.

Remarks.—By many authorities *N. clausa* and *N. affinis* have been regarded as varieties of one species; they are evidently allied forms, but I follow Prof. G. O. Sars in considering them specifically distinct.

The shells I regard as *N. clausa* are comparatively large and strong, with a wide and expanded base and a short spire, having a northern and circumpolar habitat. Originally figured from specimens obtained in Melville Island during Beechey's voyage, they range, according to Prof. Sars, from Finmark and Spitzbergen to Greenland and the Behring Sea. *N. affinis*, on the other hand, is much smaller, narrower, and more fragile, unknown from polar seas, but extending

southwards from Norway to the Hebrides and thence, according to some authorities, to the Atlantic coast and to the Mediterranean.

Their fossil distribution seems to have been similar. The larger form, *N. clausa*, has been reported from the Pleistocene beds of Christiania under the name of *N. affinis*, one of the specimens figured by Prof. Brøgger measuring 32 mm. in height, as well as from the Post-Pliocene of Montreal and of Japan.

The specimens here figured from the last-named districts I received, one from my old friend the late Dr. G. J. Hinde, and the other from Prof. Yabe, who informed me it came from some shelly sands at Tokio which he regarded as of Pleistocene age.

The shell figured by Gould as *N. clausa* was only about 15 mm. high, but he stated he had seen a specimen from the banks of Newfoundland as large as that of Sowerby's type. Prof. Posselt mentions a *Natica* from Greenland under the name of *N. affinis*, but without figure or general description, which he says measured 30 mm. in height, and may probably have belonged to the present species. Neither the typical northern form to which I confine the name *N. clausa*, nor its closely allied *N. occlusa*, are common in the earlier horizons of the Crag, but there is a small *Natica*, described in the next paragraph as *N. affinis*, differing from it not only in size, but in form, of which I have obtained a hundred specimens from the early Red Crag of Oakley, and it is fairly abundant at many other Crag localities. There is a striking similarity in the specimens here figured from different localities as *N. clausa*, and, I think, an equally striking difference between them and the Oakley shells; the latter correspond with some I obtained some years ago from the Pleistocene deposits of Reggio in Calabria which seem identical. The one form is distinctly northern and arctic, the other boreal with a southern range.

Natica affinis (Gmelin). Plate LVI, figs. 6, 7.

1790. *Nerita affinis*, Gmelin, Syst. Nat., ed. xiii, p. 3675.

1841–70. *Natica clausa*, Gould, Rep. Inv. Mass., ed. 1, p. 238, fig. 167, 1841; ed. 2, p. 342, fig. 612, 1870.

1869–71. *Natica affinis*, Jeffreys,[1] Brit. Conch., vol. v, p. 215, pl. cii, fig. 3, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489 (pt.), 1871.

1871—1915. *Natica affinis*, A. Bell, Geol. Mag. [1], vol. viii, p. 454, 1871; Rep. Brit. Assoc. (Leeds), pp. 410, 414, 415, 1890; Proc. Roy. Phys. Soc. Edin., vol. xii, p. 22, 1892; Geol. Mag. [6], vol. ii, p. 168, 1915.

1872. *Natica affinis*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 209, 213, 216.

1878. *Natica affinis*, G. O. Sars, Moll. Reg. arct. Norv., pp. 160, 358, pl. xxi, fig. 14.

1878. *Natica affinis*, Monterosato, Enum. e Sinon. Conch. Medit. (Giorn. Sci. Nat. ed Econ. Palermo, vol. xiii), p. 36.

1890. *Natica affinis*, Carus, Prod. Faun. Medit., vol. ii, p. 302.

[1] The references by Jeffreys and some other writers to *N. affinis* may possibly include the large northern form *N. clausa*; that figured by him as *N. affinis* is undoubtedly the smaller species.

1894. *Natica clausa*, Kendall, Journ. Isle of Man Nat. Hist. Soc., vol. xii, p. 417.
1901. *Natica affinis*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 84, pl. liii, figs. 4—8.
1903. *Natica clausa*, Lamplugh, Mem. Geol. Surv. Isle of Man, p. 475.

Specific Characters.—Shell small, globose, rather thin; whorls convex, the last much the largest, inflated; spire small and short, with an obtuse and rounded apex; mouth ovate; outer lip thin, gently and regularly curved, but little expanded; inner lip forming a distinct and semicircular callus, covering the umbilicus; operculum calcareous.

Dimensions.—L. 12—15 mm. B. 10—14 mm.

Distribution.—Recent: Norwegian coast from the Lofoten Islands to the Christiania fiord, Hebrides, West Atlantic, Algiers.

Fossil: Isle of Man. Waltonian Crag: Beaumont, Little Oakley (very common). Newbournian: Newbourn, Falkenham, Shottisham, Sutton, Felixstowe. Butleyan: Bawdsey, Alderton, Butley, probably elsewhere in the Red Crag. Icenian: Bramerton.

Pleistocene: Wexford, Garvel Park, Kyles of Bute.

Remarks.—The use of the specific term *affinis* for both the shells here described has led to a certain amount of confusion which for the future should be avoided. It is not always possible to ascertain whether the large northern shell or the smaller one with a more southern range has been referred to. Though comparatively unimportant from a zoological point of view, it may be more convenient for geologists to follow Prof. Sars in using different specific names for them. On the whole the form for which I employ the present one is the more common and more generally diffused in the English Crag. So far as I know neither of them has been definitely reported from that of Belgium.

Natica pusilla, Say. Plate LV, figs. 7, 8.

1822. *Natica pusilla*, Say, Journ. Acad. Nat. Sci. Philad., vol. ii, p. 257.
1870. *Natica pusilla*, Gould and Binney, Inv. Mass., ed. 2, p. 344, fig. 613.
1872. *Natica pusilla*, S. V. Wood, Mon. Crag Moll., 1st Suppl., pt. i, p. 77, pl. iv, fig. 9.
1915. *Natica* (*Cryptonatica*) *pusilla*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Faun. New Engl., no. 13, p. 105.

Specific Characters.—Shell small, sub-globose, strong and solid; whorls 4, the last ventricose, much the largest; spire very short; apex blunt; mouth large in proportion to the size of the shell, semilunar, angulated above, rounded below; outer lip thin, expanded; inner lip forming a flattened and semicircular pad, covering the umbilicus or nearly so.

Dimensions.—L. 4 mm. B. 3·5 mm.

Distribution.—Recent: North American coast. Rare in New England, common in the south (Johnson).

Fossil: Coralline Crag: near Orford. Waltonian: Little Oakley.

Remarks.—In his 1st Supplement Wood described a minute fossil from the Coralline Crag, referring it, with some doubt, to the American shell *N. pusilla*, Say, which is grouped by some American geologists with *N. clausa*, as belonging to a new sub-genus *Cryptonatica*. I have recently received from Mr. C. W. Johnson of the Boston Society of Natural History several recent specimens, one of which is here figured, enabling me to confirm Wood's identification. I have obtained half a dozen examples of the same species from Oakley, leading me to think it may be obtained from other Crag localities if specially looked for.

Natica occlusa, S. V. Wood. Plate LVI, fig. 14.

1848—72. *Natica occlusa*, S. V. Wood, Mon. Crag Moll., pt. i, p. 146, pl. xii, fig. 4, 1848; 1st Suppl., pt. i, p. 76, pl. iv, fig. 11, 1872.

1849, *Natica clausa*, var. *elatior*, Middendorff, Mém. Acad. Imp. Sci. St. Pétersbourg, [6] vol. vi, p. 420.

1864. *Natica occlusa*, S. P. Woodward in White's Hist. of Norfolk, ed. 3, p. 118.

1870—71. *Natica occlusa*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 215, 1870; Geol. Mag. [1], vol. viii, p. 454, 1871.

1871. *Natica occlusa*, Mörch, Geol. Mag., vol. viii, p. 397, no. 6.

1872. *Natica occlusa*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 213.

1877—85. *Natica affinis*, var. *occlusa*, Jeffreys, Ann. Mag. Nat. Hist. [4], vol. xix, p. 318; in Starkie Gardner, Quart. Journ. Geol. Soc., vol. xli, p. 96.

1878. *Natica clausa*, var. *elatior*, G. O. Sars, Moll. Reg. arct. Norv., p. 160, pl. xii, fig. 1.

1901. *Natica affinis*, var. *elatior*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 721, pl. xii, fig. 1.

1912. *Natica occlusa*, Dautzenberg et P. Fischer, Camp. Scient., Prince de Monaco, vol. xxvii (Mollusques), p. 228.

Specific Characters.—Shell rather large, globose, smooth and glossy; whorls 5, convex, the last much the largest, ventricose; suture distinct, rather deep; mouth oval, one-half the total length; spire elevated, ending in an acute point; umbilicus entirely closed by the callosity of the inner lip; not so much flattened below the suture as in *N. clausa*.

Dimensions.—L. 26 mm. B. 21 mm.

Distribution.—*Recent:* Finmark. Swedish coast.

Fossil: Red Crag: Oakley, Shottisham, Butley. Pleistocene: Bridlington. Icelandic Crag (Mörch).

Remarks.—The specimen here given under the present name is the one originally figured by Wood in 1848. It is from the Leckenby Collection at the Sedgwick Museum, having been obtained from Bridlington. Another, which Wood considered to be the same, was afterwards found at Butley. Mörch identifies this species from the Crag of Iceland on the authority of Winkler.

Scandinavian authorities describe a very similar form as a variety, *elatior*, of *N. clausa*. The latter differs, however, from the typical *N. clausa* of the Crag and of circumpolar regions by its more elongate spire and its greater flatness below the

suture. The late Mr. E. A. Smith expressed an opinion to me shortly before his death that *N. occlusa* and *N. clausa* should be regarded as specifically distinct, as have MM. Dautzenberg and Fischer (*op. cit.*, p. 228).

Natica multipunctata, S. V. Wood. Plate LV, figs. 12, 13.

1842—48. *Natica multipunctata*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 148, pl. xvi, fig. 9, 1848.
1843—81. *Natica crassa*, Nyst, Coq. foss. Belg., p. 443, pl. xxxvii, fig. 33, 1843; *N. millepunctata*, Conch. Terr. tert. Belg., p. 64, pl. v, fig. 5, 1881.
1871. *Natica millepunctata*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489.
1872. *Natica millepunctata*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 203, 209.
1898. *Natica millepunctata*, var. *multipunctata*, A. Bell, Trans. R. Geol. Soc. Cornwall, vol. xii, p. 144, pl. ii, fig. 1.

Specific Characters.—Shell large, ovate, thick and coarse, compressed, slightly oblique; whorls 5, the last ventricose, much the largest; spire very short, inconspicuous; mouth large but not so much expanded as in *N. millepunctata*; umbilicus large, open, deep, traversed obliquely by a strong, coarse ridge; umbilical callosity longer, wider and thicker than in the latter; operculum calcareous.

Dimensions.—L. up to 45 or 50 mm. B. 40 mm.

Distribution.—*Fossil:* Coralline and Red Crag: all horizons, abundant. Belgian Crag.

Remarks.—This fossil, which so far as I know is confined to the Pliocene deposits of England and Belgium, was from the first regarded by Wood as distinct from *N. millepunctata*, an allied southern species, both recent and fossil, of which Jeffreys considered it a variety. I figure typical specimens of each, which may be more useful to students than any verbal description. The coarseness, size and compressed form of *N. multipunctata* and of its umbilical region, with its less obliquely expanded mouth, give it a general character by which, I think, it may be easily distinguished. M. Dautzenberg informs me that he is quite prepared to consider these two shells to be different species.

Var. **consors,** S. V. Wood. Plate LV, fig. 14.

1848. *Natica multipunctata*, var. *consors*, S. V. Wood, Mon. Crag Moll., pt. i, p. 148, pl. xvi, figs. 9 *d*, 9 *e*.
1898. *Natica consors*, A. Bell, Trans. R. Geol. Soc. Cornwall, vol. xii, p. 144, pl. ii, fig. 3.

Varietal Characters.—Differs from the type in size, in its rather more distinct spire and its more prominent apex.

Dimensions.—L. 20 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: St. Erth. Coralline Crag: Gedgrave, Broom Hill, Ramsholt. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Waldringfield. Butleyan: Butley.

Remarks.—The specimen here figured corresponds with Wood's specimen of the var. *consors*. It is always smaller than the type, and shorter in proportion to the size of the shell. Wood figures one of them with an operculum *in situ*. The callus on the inside lip is not so large.

Natica millepunctata, Lamarck. Plate LV, fig. 16.

1822. *Natica millepunctata*, Lamarck, Ann. sans Vert., vol. vi, pt. ii, p. 199.
1826. *Nacca punctata*, Risso, Hist. nat. Europe merid., vol. iv, p. 148, no. 375.
1836—44. *Natica millepunctata*, Philippi, Enum. Moll. Sic., vol. i, p. 161, 1836; vol. ii, p. 139, 1844.
1856. *Natica millepunctata*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 518, pl. xlvii, fig. 1.
1870—98. *Natica millepunctata*, A. Bell, Journ. de Conch., vol. xviii, p. 349, no. 316, 1870; Proc. Roy Irish Acad. [3], vol. ii, p. 627, 1893; Trans. R. Geol. Soc. Cornwall, vol. xii, p. 144, 1898.
1873—76. *Natica millepunctata*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 252, 1873 vol. v, p. 280, no. 98, 1874; vol. vii, p. 10, no. 488, 1876.
1878. *Natica millepunctata*, de Stefani e Pantinelli, Bull. Soc. Malac. Ital., vol. iv, p. 140.
1879. *Natica millepunctata*, Fontannes, Moll. plioc. Vall. du Rhone, vol. i, p. 110.
1883. *Natica* (*Nacca*) *millepunctata*, Bucquoy, Dautzenberg et Dollfus, Moll. mar. Rouss., vol. i, p. 141, pl. xvii, figs. 3, 4.
1886. *Natica millepunctata*, Dollfus et Dautzenberg, Feuille des Jeunes Natur., vol. xvi, p. 141.
1890. *Natica millepunctata*, Carus, Prod. Faun. Medit., vol. ii, p. 300.
1892. *Natica millepunctata*, Locard, Coq. mar. Côtes de France, p. 182, fig. 156.
1901. *Natica millepunctata*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 74, pl. li, figs. 1—9.
1913. *Natica* (*Nacca*) *millepunctata*, Gignoux, Form. mar. plioc. e quatern. de l'Italie, p. 562.

Specific Characters.—Shell variable, ovate, strongly oblique, solid, with well-marked and irregular lines of growth; whorls 4—5, convex, the last tumid, much the largest, depressed above; spire small, short, pointed, but little projecting; suture slight; mouth large, expanded below; outer lip incurved above, much expanded laterally; inner lip thickened above and below; umbilicus large, open, deep, traversed obliquely by a funicular ridge; operculum calcareous.

Dimensions.—L. 25—35 mm. B. 20—30 mm.

Distribution.—*Recent*: Mediterranean, generally diffused, Adriatic, Ægean, Morea, Syrian coast. West Atlantic as far south as the Canary Islands.

Fossil: St. Erth.

Miocene: Touraine, Vienna basin.

Pliocene: France—Rhone valley, Biot. Italy—Liguria, Piedmont, Tuscany, Calabria.

Pleistocene: Sicily, Calabria, Tuscany.

Remarks.—This species, which is widely diffused as a recent shell in the Mediterranean region, is reported from the Miocene and Pliocene deposits of different parts of Europe and by Seguenza from the Pleistocene of Tuscany, Calabria and Sicily. It appears doubtful whether the typical *N. millepunctata* is to be found as fossil in the Anglo-Belgian basin, being represented there by *N. multipunctata*.

Natica tigrina, Defrance. Plate LV, fig. 15.

1826. *Natica tigrina*, Defrance, Dict. Sci. nat., vol. xxxiv, p. 257.

1827—40. *Natica tigrina*, Grateloup, Bull. Soc. Linn. Bordeaux, vol. ii, p. 155, no. 142, 1827; Atlas, Conch. Terr. tert. Bass. de l'Adour, vol. i, pl. iv, fig. 12; pl. v, figs. 2, 3, 5, 1840.

1844. *Natica tigrina*, Philippi, Enum. Moll. Sic., vol. ii, p. 141, pl. xxiv, fig. 17.

1873—74. *Natica tigrina* (?), Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 253, 1873; vol. v, p. 280, no. 101, 1874.

1890—91. *Natica millepunctata*, var. *tigrina*, Sacco, Boll. Soc. Geol. Ital., vol. ix, p. 308, no. 4976, 1890; Moll. Terr. Terz. Piem., pt. viii, p. 49, pl. ii, fig. 11, 1891.

1891. *Natica tigrina*, Cossmann et Peyrot, Conch. neog. de l'Aquitaine, vol. iii, p. 394, pl. xi, fig. 1.

Specific Characters.—Shell ovate, slightly oblique, generally smaller than *N. multipunctata*, with a conical and more prominent spire; whorls 5, convex, the last ventricose, rounded; separated by deep but linear sutures; umbilicus large and deep with a funicular ridge; mouth semilunar, not so much expanded as in *N. millepunctata*, angulate above, rounded below; outer lip incurved; callus on inner lip narrower than in the former species.

Dimensions.—L. 32 mm. B. 25 mm.

Distribution.—Not known living.

Fossil: Red Crag, not rare but not worked out.

Miocene: France. Pliocene: Italy, France.

Remarks.—The Crag specimen here figured as *N. tigrina* seems to me to differ essentially both from the Pliocene *N. multipunctata* of Wood and the recent *N. millepunctata* of southern seas, as may be seen by comparing figs. 12—16 on my Plate LV, but it agrees almost exactly with one described as a distinct species, *N. tigrina*, from the south of France, by MM. Cossmann and Peyrot in their recent work on the 'Conchologie néogéne de l'Aquitaine.' The subject has not been carefully worked out as to the distribution of this form in the various localities or horizons of our Pliocene deposits, but it is not uncommon at Oakley, and may probably be found elsewhere if looked for; meanwhile I identify it provisionally with Defrance's shell.

Natica Beyrichi, von Koenen. Plate LVI, fig. 12.

1882. *Natica Beyrichi*, von Koenen, Norddeutsch. Miocän., vol. ii, p. 223, pl. v, figs. 1, 2, 3 *b*.
1883. *Natica millepunctata*, Nyst (non Linné), in Dewalque, Prodrôme, p. 422.
1886. *Natica (Nacca) Beyrichi*, Dollfus et Dautzenberg, Feuille des Jeunes Natur., vol. xvi, p. 141.
1893—98. *Natica Beyrichii*, A. Bell, Proc. Roy. Irish Acad. [3], vol. ii, p. 628, 1893; Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145, 1898.

Specific Characters.—Shell strong and solid, obliquely ovate; whorls 4, convex, the last much the largest, nine-tenths the total length; spire small, very short, with a pointed apex; suture slight; mouth large, semilunar, expanded, angulate above, rounded below; outer lip forming nearly a right angle with the body-whorl; umbilicus large, deep; umbilical ridge very small and narrow; inner lip with a thick callus.

Dimensions.—L. 22—34 mm. B. 22—32 mm.

Distribution.—Not known living.

Fossil: St. Erth.

Miocene: North Germany, Belgium, Touraine.

Pliocene: Albenga, Fango-nero near Siena.

Remarks.—This species is reported from the Miocene of North Germany, Belgium and Touraine, and from the Pliocene of Albenga and of the neighbourhood of Siena by von Koenen, who also identifies it in part with the *N. millepunctata* of Nyst from the Bolderien of Antwerp. It belongs to the *millepunctata* group, but the umbilical ridge is much finer than in the type of that species. Von Koenen says some of his North German fossils attain a height of 34 mm. Our specimen, which is from St. Erth, measures 22 mm.

Var. **Goodmani,** Etheridge and Bell, MS. Plate LVI, figs. 13, 18.

1882. *Natica Beyrichi* (pt.), von Koenen, Norddeutsch. Miocän., vol. ii, p. 223, pl. v, fig. 3 *a*.
1883. *Natica millepunctata* (pt.), Nyst (non Linné), in Dewalque, Prodrôme, p. 422.

Varietal Characters.—Resembles *N. Beyrichi*, but is much smaller and the spire is flatter; umbilical ridge nearly obsolete.

Dimensions.—L. 10—15 mm. B. 8—15 mm.

Distribution.—Not known living.

Fossil: Miocene: Antwerp.

Remarks.—The specimens here figured are from the Warburton Collection of St. Erth fossils at the British Museum, where they bear the MS. name of *Natica Goodmani*, Etheridge and Bell. They seem to me to agree with one of those described by von Koenen as *N. Beyrichi* (*op. cit.*), of which they may be regarded, perhaps, as a dwarf variety. I retain the name given by the authors above quoted, but as varietal.

Natica tenuis, Etheridge and Bell. Plate LV, fig. 11.

1898. *Natica tenuis*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145.

Specific Characters.—Belongs to the *N. Beyrichi* group, but is minute and of a thinner texture, with an acute and projecting apex, a smaller and rounded umbilicus, a strong and conspicuous umbilical ridge, and a narrow, more delicate and less expanded inner lip.

Dimensions.—L. 11 mm. B. 10 mm.

Distribution.—Not known living.

Fossil: St. Erth.

Remarks.—There are two specimens in the Warburton Collection at the British Museum under this name, one of which is here figured. They have been described by Mr. Bell as specifically distinct under the present name.

Sub-genus **LUNATIA**, Gray, 1847.

Natica (Lunatia) catena (Da Costa). Plate LIV, figs. 1—3.

1778. *Cochlea catena*, Da Costa, Hist. Nat. Test. Brit., p. 83, pl. v, fig. 7.

1838. *Natica monilifera*, Lamarck, Hist. Anim. sans Vert., ed. 2, vol. viii, p. 638.

1842—48. *Natica catena*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 142, pl. xvi, fig. 8, 1848.

1846. *Natica monilifera*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, p. 89.

1853. *Natica monilifera*, Forbes and Hanley, Brit. Moll., vol. iii, p. 326, pl. c, fig. 1.

1859. *Natica monilifera*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xvi, fig. 17.

1867—71. *Natica catena*, Jeffreys, Brit. Conch., vol. iv, p. 220, 1867; vol. v, p. 215, pl. lxxviii, fig. 4, 1869; Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1871.

1871. *Natica catena*, A. Bell, Geol. Mag., vol. viii, p. 454.

1872. *Natica catena*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 209, 213, 216.

1873—77. *Natica catena*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 256, 1873; vol. v, p. 280, no. 99, 1874; vol. vii, p. 10, no. 484, 1877.

1878. *Natica catena*, Monterosato, Enum. e Sinon. Conch. Medit. (Giorn. Sci. Nat. ed Econ. Palermo, vol. xiii), p. 36.

1878. *Natica catena*, J. Reeve, Proc. Norwich Nat. Soc., vol. i, p. 70.

1883. *Natica* (*Naticina*) *catena*, Bucquoy, Dautzenberg et Dollfus, Moll. mar. Rouss., vol. i, p. 146, pl. xvii, figs. 5, 6.

1890. *Natica catena*, C. Reid, Plioc. Dep. Brit., p. 248.

1890. *Natica* (*Naticina*) *catena*, Carus, Prod. Faun. Medit., vol. ii, p. 304.

1892. *Natica catena*, Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), pp. 122, 132.

1892. *Natica catenata*, Locard, Coq. mar. Côtes de France, p. 182, fig. 157.

1901. *Natica* (*Naticina*) *catena*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 89, pl. liv, figs. 5—8.

1903. *Natica monilifera*, Lamplugh, Mem. Geol. Survey—Geol. Isle of Man, p. 475.

1912. *Natica* (*Naticina*) *catena*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 229.

1912. *Natica catena*, Tesch, Med. v. d. Rijks. v. Delfstoffen, No. iv, p. 64, no. 142.

1919. *Natica* (*Lunatia*) *catena*, Cossmann et Peyrot, Conch. Néogén. de l'Aquitaine, vol. iii, p. 392.

Specific Characters.—Shell smooth, globose, moderately solid; whorls 6, tumid, slightly flattened below the suture, rapidly enlarging, the last expanded, much the largest; spire short, slightly projecting; mouth large, semilunar, angulate above, expanded below; suture well-marked, nearly straight; outer lip incurved upon the body-whorl; inner lip broad upwards, forming a ridge separating the umbilicus from the mouth; umbilicus of moderate size, deep, open; operculum horny, not calcareous. In the recent shell the upper part of the whorls is ornamented by a spiral band of prominent and oblique longitudinal streaks which, however, have been obliterated on fossil specimens.

Dimensions.—(Of Crag specimens) L. 26—30 mm. B. 24—28 mm.

Distribution.—*Recent:* British seas (sublittoral zone), common. West European from Norway to Gibraltar, Mediterranean, widely diffused.

Fossil: Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley (rare). Newbournian, Butleyan, Icenian. Weybournian: Belaugh. Middle Glacial Sands: Billockby, Hopton. Manx beds. Wexford gravels. Generally present in the Pleistocene deposits of England, Ireland and Scotland.

Scaldisien, Poederlien: Belgium. Scaldisien, Amstelien: Holland.

Upper Pliocene: Altavilla. Pleistocene: Monte Pellegrino, Ficarazzi, Nizzetti near Catania (Scalia).

Remarks.—The typical form of this well-known and common British species seems to have made a comparatively late appearance in the Crag basin. It was unknown to Wood from the Coralline horizon, and has been reported but rarely from the Waltonian, being found, however, more commonly in the upper portion of the Red Crag, as, for example, at Butley, as well as in the Icenian and in the British Pleistocene.

By some authorities *N. catena* has been identified with the *N. helicina* of Brocchi, by others the difference between the two has been regarded as varietal. The typical *N. helicina*, however, is an extinct form, characteristic of the Miocene and Lower Pliocene deposits, *N. catena* being a species still living and, as just stated, characteristic rather of the latest horizons of the Crag and of the English Pleistocene. These shells, which also differed from *N. helicina* in Crag times, can be, I think, easily distinguished. Believing, as I do, that they have an important zonal value, it seems to me desirable to treat them as specifically distinct.

Wood's figure of *N. catena* (*op. cit.*, pl. xvi, fig. 8) is typical, as is my fig. 1 of Pl. LIV; they have an expanded and flattened body-whorl.

MM. Dollfus and Dautzenberg agree with me that *N. catena*, Linn., and *N. helicina*, Sacco (Brocchi), should be considered different species.[1]

[1] The subgeneric name *Lunatia*, Gray (1847), has been adopted by Scandinavian authorities in place of *Naticina* (1834). The latter, however, being the older, has been, until lately, more generally preferred. M. Dautzenberg, however, has informed me that he now considers his reference of the present species in 1883 and in 1912 to *Naticina* was a mistake.

Natica (Lunatia) helicina (Brocchi), Sacco. Plate LIV, figs. 4, 5.

1814. *Nerita helicina*, Brocchi, Conch. foss. sub-ap., vol. ii, p. 297, pl. i, fig. 10.
1856. *Natica helicina* (pt.), Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 525, pl. xlvii, fig. 7.
1870. *Natica helicina*, A. Bell, Journ. de Conch., vol. xviii, p. 349, no. 319.
1874. *Natica catena*, Van den Broeck, Ann. Soc. malac. Belg., vol. ix, p. 120.
1878. *Natica helicina*, de Stefani e Pantinelli, Bull. Soc. Malac. Ital., vol. iv, p. 140.
1881. *Natica helicina*, Fontannes, Moll. Plioc. Vall. du Rhone, vol. i, p. 115, pl. vii, fig. 11.
1882. *Natica helicina*, von Koenen, Norddeutsch. Miocän, vol. ii, p. 231.
1886. *Natica* (*Naticina*) *catena*, Dollfus et Dautzenberg, Feuille de Jeunes Natur., vol. xvi, p. 141.
1889—91. *Natica helicina* and vars., Sacco, Boll. Soc. Geol. Ital., vol. viii, p. 355, no. 1958, 1889; *N. Naticina* (*catena*), var. *helicina*, Moll. Terr. Terz. Piem., pt. viii, p. 70, pl. ii, fig. 43, 1891.

Specific Characters.—Shell solid, ovato-conical; whorls 5 or 6, the last tumid, much the largest, not so wide in proportion as in *N. catena*; ornamented indistinctly by oblique, irregular and flexuous lines of growth; spire short, small, depressed; suture slight; mouth semilunar, angulate above, rounded below; outer lip not so much expanded as in the last species; inner lip forming a rather thick callus on the columella, which becomes narrow as it approaches the umbilicus, and partly covers it, its margin being thickened near the base of the shell; umbilicus open, deep.

Dimensions.—L. 22 mm. B. 18 mm.

Distribution.—Not known living.

Fossil: Coralline Crag: Sutton. Waltonian: Walton-on-Naze, Little Oakley.

Miocene: Touraine, North Germany, Belgium, Piedmont.

Lower Pliocene: Rhone valley, Biot, Piedmont, Tuscany.

Upper Pliocene: Astiano (rarissima, Sacco).

Remarks.—The Crag fossils figured under this name, which are not very rare at Oakley, agree with specimens I obtained some years ago from the Faluns of Touraine, and equally with others from the Italian Pliocene which I have received from my friend Prof. Issel, though not altogether with Brocchi's type figure which resembles more nearly *N. catena*. Possibly the former is incorrectly drawn. My Crag fossil of *N. helicina* (fig. 5) is very near to Prof. Issel's specimen (fig. 4), as it is to that of Prof. Sacco.

Wood's *N. helicina*[1] ('Mon. Crag Moll.,' 1st Suppl., pl. iv, fig. 8) is, I think, different, as are those given by Philippi ('Enum. Moll. Sic.,' vol. i, p. 163, pl. ix, fig. 12), and by Lorié ('Arch. Mus. Teyl.' [2], vol. ii, p. 230, pl. v, fig. 11).

For reasons given above I prefer to regard this species as specifically distinct from *N. catena*.

Hörnes figures two specimens as *N. helicina*, one of which (*op. cit.*, fig. 7) is

[1] I have not been able to discover the specimen of the present species figured by Wood, which has a very unusually formed spire. It might be called *N. incerta*.

not unlike the present form; the other (fig. 6), with a longer spire, may be equivalent to my *N. exvarians* (Pl. LIV, figs. 15 and 16). M. Dautzenberg considers that the one now generally recognised by French and Italian authorities as *N. helicina* resembles more nearly that given by Prof. Sacco (*op. cit.*) than does Brocchi's shell. My experience, however, leads me to think that it may be unwise to depend too much on the absolute correctness of the drawings of pre-photographic times.

Natica (Lunatia) exilis, A. Bell, MS. Plate LVI, fig. 29.

Specific Characters.—Medium size, allied in form to *N. occlusa*, but having the umbilicus partly closed; whorls somewhat convex, overlapping, the last much the largest; umbilicus deep, partly open; mouth rather long, expanded below, angulated above; inner lip forming a thickened and somewhat flattened callus; spire elevated; suture well marked.

Dimensions.—L. 28 mm. B. 24 mm.

Distribution.—Not reported living.

Fossil: Icenian Crag: Easton Bavent.

Remarks.—The specimen figured under this name was discovered by Mr. A. Bell many years ago and sent by him to the York Museum, where until the present it has been lost sight of. I adopt for it his undescribed name of *N. exilis*. In form it has a superficial resemblance to *N. occlusa* but it belongs to a different group. The umbilicus is deep and partly open.

Natica (Lunatia) fusca, Blainville. Plate LIV, fig. 18.

1825—30. *Natica fusca*, Blainville, Dict. Sci. Nat., vol. xxxiv, p. 249, 1825; Faun. franc., pl. xiv, fig. 3, 1830.

1844. *Natica sordida*, Philippi, Enum. Moll. Sic., vol. ii, p. 139, pl. xxiv, fig. 15.

1853. *Natica sordida*, Forbes and Hanley, Brit. Moll., vol. iii, p. 334, pl. c, figs. 5, 8.

1859. *Natica sordida*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xvi, fig. 18.

1867—85. *Natica sordida*, Jeffreys, Brit. Conch., vol. iv, p. 218, 1867; vol. v, p. 215, pl. lxxviii, fig. 3, 1869; Proc. Zool. Soc., p. 29, 1885.

1876. *Natica fusca*, Seguenza, Boll. R. Com. Geol. Ital., vol. vii, p. 12, no. 492.

1878. *Natica* (*Lunatia*) *fusca*, Monterosato, Enum. e Sinon. Conch. Medit. (Giorn. Sci. Nat. ed Econ. Palermo, vol. xiii), p. 36.

1886. *Natica sordida*, Kendall and R. Bell, Quart. Journ. Geol. Soc., vol. xlii, p. 211.

1890. *Natica* (*Naticina*) *fusca*, Carus, Prod. Faun. Medit., vol. ii, p. 304.

1892. *Natica fusca*, Locard, Coq. mar. Côtes de France, p. 184.

1897. *Natica* (*Neverita*) *sordida*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145, pl. ii, fig. 2.

1901. *Natica* (*Naticina*) *fusca*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 88, pl. liv, figs. 1—4.

1907. *Natica* (*Nacca*) *fusca*, Scalia, Atti Accad. Giorn. Sci. Nat. Catania [4], vol. xx, p. 32, no. 214.

1912. *Natica* (*Naticina*) *fusca*, Dautzenberg et Fischer, Camp., Scient. Prince de Monaco, vol. xxxvii (Mollusques), p. 238.

Specific Characters.—Shell oval, globose, thick and solid, somewhat glossy; spire very short, slightly prominent; whorls 5, tumid, compressed above, rapidly enlarging, the last much the largest, nine-tenths the total length; suture very slight; mouth twice as long as the spire, expanded; outer lip slightly incurved above; inner lip thick and broad, separated from the latter by a very narrow groove, reflected over the upper part of the umbilicus; umbilicus fairly large, deep, open.

Dimensions.—L. 20—25 mm. B. 16—22 mm.

Distribution.—Recent: English coast (south-west), Scotland, Ireland. Atlantic coasts as far south as Gibraltar. Mediterranean.—Corsica, Sicily, Algiers; Adriatic.

Fossil: Lower Pliocene: Piacentino (Brocchi).

Upper Pliocene: Messina.

Remarks.—This rare southern species, found at places in the seas of Great Britain, has not been reported from the East Anglian or the Belgian Crags. There are several specimens, however, from St. Erth in the British Museum of Natural History bearing the present name, but there seems some doubt as to whether they have been correctly identified. It seems desirable, therefore, to figure a verified recent specimen from my own collection for comparison, leaving the question of its occurrence or not as a British fossil in abeyance.

N. fusca was known to Forbes and Hanley, Jeffreys and others under Swainson's name of *N. sordida* and generally as belonging to the subgenus *Naticina*. It is now grouped with *Lunatia*. It seems to be specially characterised by the flattening or compression of the upper part of the whorls below the suture.

Natica (Lunatia) cirriformis (J. Sowerby). Plate LV, figs. 2, 3.

1825. *Natica cirriformis*, J. Sowerby, Min. Conch., vol. v, p. 125, pl. cccclxxix, fig. 1.
1842—48. *Natica cirriformis*, S. V. Wood, Ann. Mag. Nat. Hist. (1), vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 145, pl. xvi, fig. 7, 1848.
1843—81. *Natica cirriformis*, Nyst, Coq. foss. Belg., p. 444, pl. xxxix, fig. 1, 1843; Conch. Terr. tert. Belg., p. 66, pl. v, fig. 6, 1881.
1870. *Natica cirriformis*, A. Bell, Ann. Mag. Nat. Hist [4], vol. vi, p. 215.
1871. *Natica sordida*, Jeffreys, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489.
1872. *Natica cirriformis*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 203, 209.
1874—92. *Natica cirriformis*, Van den Broeck, Ann. Soc. malac. Belg., vol. ix, p. 187, 1874; Bull. Soc. Belg. Géol., vol. vi (Mémoires), pp. 122, 132, 1892.
1876. *Natica cirriformis*, Seguenza, Boll. R. Com. Geol. Ital, vol. vii, p. 10, no. 482.
1890. *Natica cirriformis*, C. Reid, Plioc. Dep. Brit., p. 249.
1903. *Natica cirriformis*, Dollfus, Cotter et Gomes, Moll. tert. du Portugal, p. 18, pl. xxxv, fig. 4.

Specific Characters.—Shell smooth, oblique, thick and solid; whorls 5, the last globose, much the largest, rounded, not excavated below; spire short, flattened, about $\frac{1}{8}$th of the total length; suture well-marked, channelled; mouth semilunar,

twice as long as the spire, sub-angulate above, rounded below; outer lip expanded; inner lip forming a nearly straight but inclined margin to the mouth, with a thick callus upon the columella; umbilicus large and very deep, in the type form (fig. 2) wholly open, in the variety *discrepans* (fig. 3) partly covered by the callus.

Dimensions.—L. 30 mm. B. 25 mm.

Distribution.—Not known living.

Fossil: (With the var. *discrepans*) Coralline Crag: Gedgrave, Ramsholt, Boyton. Waltonian: Beaumont, Little Oakley. Newbournian: Sutton, Shottisham, Waldringfield.

Casterlien, Scaldisien, Poederlien: Belgium.

Miocene: Portugal.

Remarks.—Two very different forms have been recognised from the Crag under the name of *N. cirriformis*. Whether they should be regarded as specifically distinct or only as varietal may perhaps be left an open question. As they are clearly allied it may perhaps be more convenient for the present to consider them as varieties of the same species.

The type form, that originally described by Sowerby, having a deep and open umbilicus, is here represented by a specimen from Oakley (Pl. LV, fig. 2).

The other (fig. 3), for which I propose the name var. *discrepans*, corresponds with Wood's shell (pl. xvi, fig. 7) and with those figured by Nyst, in which the umbilicus is partly covered by callus. They agree more or less closely with that given by MM. Dollfus, Cotter and Gomes from the Miocene of Portugal. The other references given above may possibly include the two, but at present I have no means of ascertaining. Both occur at Oakley.

Natica (Lunatia) catenoides (S. V. Wood). Plate LV, fig. 1.

1842—85. *Natica catenoides*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 141, pl. xvi, fig. 10, 1848; in J. Starkie Gardner, Quart. Journ. Geol. Soc., vol. xli, p. 96, 1885.

1843—81. *Natica Sowerbyi*, Nyst, Coq. foss. Belg., p. 441, no. 384, pl. xxxvii, fig. 31, 1843; *N. catenoides*, Conch. Terr. tert. Belg., p. 66, pl. v, fig. 7, 1881.

1870. *Natica catenoides*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 215.

1871–85. *Natica heros*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489, 1871; in J. Starkie Gardner, Quart. Journ. Geol. Soc., vol. xli, p. 96, 1885.

1872. *Natica catenoides*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 203, 209, 213.

1890. *Natica catenoides*, C. Reid, Plioc. Dep. Brit., p. 249.

1892. *Natica catenoides*, Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), pp. 122, 132, 147.

1897. *Natica (Neverita) catenoides*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145, pl. ii, fig. 6.

1912. *Natica catenoides*, Tesch, Med. v. Rijks. v. Delfstoffen, No. 4, p. 66, no. 143.

Specific Characters.—Shell large, solid, elliptical, slightly oblique; whorls 5 or 6, the last strongly ventricose, very large in proportion to the spire, the upper ones but little convex; marked transversely by obscure spiral lines, longitudinally by numerous inconspicuous lines of growth, and towards the mouth and the umbilicus by irregular spiral foldings which enter the latter; spire depressed, very short, about one-twelfth the total length, projecting but little beyond the body-whorl; mouth large, wide, semilunar, projecting below, angulate above, four-fifths the length of the shell; outer lip gently rounded, incurved; inner lip spread over the columella, thickened below the upper lip and in the umbilical region; umbilicus deep, open, fairly large.

Dimensions.—L. 55 mm. B. 55 mm.

Distribution.—? Known living.

Fossil: St. Erth. Coralline Crag: Sutton. Red Crag: Waltonian to Butleyan horizons, *passim*. Icenian: doubtful. Scaldisien, Poederlien: Belgium, Holland, Iceland Crag.

Remarks.—This fine and beautiful shell, which is much larger than any other of the Crag *Naticas*, seems to be confined as far as our present information goes to the Pliocene deposits of the Anglo-Belgian basin and to St. Erth. I have found it to be very common at Walton and Oakley, and it has been reported from every horizon of the Red and Coralline Crags. Considerable doubt attaches in Mr. Bell's opinion, however, to references from the Icenian of Easton Bavent.

N. catenoides was originally identified by Nyst with an Eocene species described by Sowerby as *N. glaucinoides*; but recognising this to be a mistake he afterwards called it *N. Sowerbyi*, finally adopting Wood's name (*op. cit.*), by which it has been known of late years. It seems to be very near to the American species *N. heros* of Say.

Natica (Lunatia) Alderi (Donovan). Plate LV, figs. 4—6.

1800. *Nerita nitida*, Donovan, Brit. Shells, vol. iv, pl. cxliv.
1836. *Natica intermedia*, Philippi, Enum. Moll. Sic., vol. i, p. 163, pl. ix, fig. 11.
1838. *Natica Alderi*, Forbes, Malac. Monens., p. 31, pl. ii, figs. 6, 7.
1853. *Natica nitida*, Forbes and Hanley, Brit. Moll., vol. iii, p. 330, pl. c, figs. 2—4.
1859. *Natica nitida*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xvi, fig. 16.
1865. *Natica nitida*, Rose, Geol. Mag., vol. ii, p. 11.
1867—71. *Natica Alderi* and vars., Jeffreys, Brit. Conch., vol. iv, p. 224, 1867; vol. v, p. 215, pl. lxxviii, fig. 5, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1871.
1870. *Natica Alderi*, Wood and Harmer, Rep. Brit. Assoc. (Liverpool), p. 90.
1871—93. *Natica Alderi*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vii, p. 359; vol. viii, p. 50, 1871; Rep. Brit. Assoc. (Leeds), pp. 417, 420, 1890; Rep. Yorks. Phil. Soc., p. 63, 1892; Proc. Roy. Phys. Soc. Edin., vol. xii, p. 22, 1893.
1872. *Natica Alderi*, S. V. Wood, Mon. Crag Moll., 1st Suppl., pt. i, p. 74, pl. vii, fig. 27.
1873—6. *Natica Alderi*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 258, 1873; vol. v, p. 280, no. 103, 1874; *N. intermedia*, vol. vii, p. 12, no. 494, 1876.

1878. *Natica* (*Lunatia*) *intermedia*, Monterosato, Enum. e Sinon. Conch. Medit. (Giorn. Sci. Nat. ed Econ. Palermo, vol. xiii), p. 36.
1878. *Lunatia intermedia*, G. O. Sars, Moll. Reg. arct. Norv., pp. 157, 358.
1883. *Natica* (*Naticina*) *Alderi* and vars., Bucquoy, Dautzenberg et Dollfus, Moll. mar. Rouss., vol. i, p. 143, pl. xviii, figs. 13, 14.
1890. *Natica intermedia*, Carus, Prod. Faun. Medit., vol. ii, p. 305.
1892. *Natica Alderi*, Locard, Coq. mar. Côtes de France, p. 183.
1901. *Lunatia intermedia*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 660.
1901. *Natica* (*Naticina*) *Alderi*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 93, pl. liv, figs. 12—15.
1912. *Natica Alderi*, Tesch., Med. v. Rijks. v. Delfstoffen, No. 4, p. 66, no. 149.
1912. *Natica* (*Naticina*) *nitida*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 239.
1912. *Lunatia nitida*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. l, p. 24.

Specific Characters.—Shell small, solid, smooth, globose; whorls 5, slightly convex, rapidly increasing in size, the last tumid, somewhat compressed above, much the largest, seven-eighths the total length; spire very short but prominent, ending in a blunt point; suture slight; mouth acutely angulate above, obtusely rounded below; outer lip with a blunt edge, but little expanded; inner lip broad, forming a thick callosity at the upper angle of the mouth and a thick triangular pad in the middle projecting over the upper part of the umbilicus, which is narrow and oblique. In the recent state the shell is ornamented by spiral rows of spots or streaks, but these have been removed by erosion from fossil specimens.

Dimensions.—L. 15 mm. B. 13 mm.

Distribution.—*Recent:* British seas, widely distributed. Iceland, Norwegian coast from the Lofoten Isles southward; West Atlantic, Mediterranean, Adriatic.

Fossil: Coralline Crag: Gedgrave. Waltonian: Walton-on-Naze, Beaumont, Little Oakley. Newbournian: Sutton, Ramsholt, Newbourn. Butleyan: Bawdsey, Butley. Icenian: Aldeby, Yarn Hill, Beccles. Isle of Man. Pleistocene: Mid. Glac. sands: Hopton, Billockby. March (F. W. H.), Kelsea Hill, Selsey, Nar Valley, Gloppa, Macclesfield, Moel Tryfaen, Worden. Scotland—King Edward, Largo Bay. Ireland—Wexford to Portrush. Scaldisien, Poederlien.

Upper Pliocene: Sicily—Messina, Caltabiano. Scaldisien, Poederlien, Amstelien: Holland.

Pleistocene: Christiania fiord (Brøgger), Trondhjem (Øyen). Ficarazzi, Monte Pellegrino, Reggio, Castroreale.

Remarks.—This British and southern form has been found at all horizons of the East Anglian Crag though not very commonly. It occurs also in many of our Pleistocene deposits, having been obtained formerly in great abundance by the late C. B. Rose in the Nar valley brick-earth. I found it to be fairly common also in the March gravels.

It has been obtained from the Upper Pliocene of the Dutch borings and from the Upper Pliocene as well as from the Pleistocene of Sicily. Prof. Brøgger

has included it in his list of Lusitanian species in the post-glacial (*Tapes*-banks) of the Christiania region.

The specimens of *N. Alderi* in my collection, both from the Coralline and Icenian Crags, are smaller than that figured by Wood from the Nar valley, which corresponds with the size of the typical British form.

It is the *N. intermedia* of Philippi, but has been more usually known under Forbes' specific name of *Alderi*. MM. Dautzenberg and Fischer, however, have recently revived Donovan's earlier name of *nitida*, identifying the latter with our shell. They consider, moreover, the one figured by Forbes and Hanley as *N. pusilla* (*op. cit.*, pl. c, fig. 7) to be the same.

Mr. R. B. Newton reports *N. Alderi* (*nitida*) from a Miocene block of fossiliferous limestone dredged in the North Sea ('Quart. Journ. Geol. Soc.,' vol. lxxii, pl. ii, fig. 7, 1917), but the specimen he figures does not appear to me a typical example of our British shell.

Natica (Lunatia) exvarians (Sacco). Plate LIV, figs. 15, 16.

1842—8. *Natica elevata*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; *N. varians*, Mon. Crag Moll., pt. i, p. 143, pl. xvi, fig. 6, 1848.
1843—81. *Natica hemiclausa*, Nyst, Coq. foss. Belg., p. 446, pl. xxxviii, fig. 15.
1856. *Natica helicina*, Hörnes, Foss. Moll. Tert. Wien, vol. i, p. 525, pl. xlvii, fig. 6.
1871. *Natica cirriformis*, var., Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, pp. 144, 489.
1881. *Natica varians*, Nyst, Conch. Terr. tert. Belg., p. 70, pl. v, fig. 10.
1890. *Natica varians*, C. Reid, Plioc. Dep. Brit., p. 249.
1891. *Natica* (*Naticina*) *catena*, var. *exvarians*, Sacco, Moll. Terr. Terz. Piem., pt. viii, p. 70.
1892. *Natica varians*, Van den Broeck, Bull. Soc. Belg. Géol., vol. vi (Mémoires), pp. 122, 133.
1896. *Natica varians*, Bernays, Bull. Soc. Belg. Géol., vol. x (Mémoires), p. 128.
1897. *Natica* (*Neverita*) *varians*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145, pl. ii, fig. 5.
1898. *Natica varians*, F. W. Harmer, Quart. Journ. Geol. Soc., vol. liv, p. 317.

Specific Characters.—Shell strong and solid, smooth, polished, ovato-conical, much larger than the typical Miocene *N. varians*; spire elevated, fairly long; whorls 5 or 6, convex, overlapping, the last much the largest, four-fifths the total length; wrinkled near the mouth by the lines of growth; suture well-marked but not deep; mouth large, semilunar, outer lip gently rounded, sharply incurved upon the body-whorl, one-third of which it leaves uncovered, obtusely rounded below; inner lip straight, forming a thick and rather wide callus on the columella; umbilicus large, open, deep.

Dimensions.—L. 25—28 mm. B. 20—24 mm.

Distribution.—Not known living.

Fossil: Lenham. Coralline Crag: Gedgrave, Sutton, Ramsholt.

Waltonian: Walton-on-Naze, Little Oakley. Newbournian: Bentley, Newbourn, Felixstowe, Waldringfield, Sutton.

Miocene: Belgium, Vienna basin.

Upper Pliocene: Belgium—Casterlien, Scaldisien, Poederlien.

Remarks.—As stated on p. 689, Prof. Sacco separates this shell from *Natica varians*, Duj., proposing for it the specific name *errarians*, which I adopt.

Messrs. Dollfus and Dautzenberg identify it with *N. helicina*, Hörnes (non Brocchi), one of his figures (*op. cit.*, pl. xlvii, fig. 6) being specially similar to the Belgian and Crag shells which are here described under the present name. Some of the principal features of our shell are the large proportion of the body-whorl which remains unconvered above its junction with the outer lip, and its prominent spire.

Natica (Lunatia) Montagui, Forbes. Plate LV, fig. 10.

1838. *Natica Montagui*, Forbes, Malac. Monensis, p. 32, pl. ii, figs. 3, 4.
1846. *Natica Montagui*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, p. 89.
1853. *Natica Montagui*, Forbes and Hanley, Brit. Moll., vol. iii, p. 336, pl. ci, figs. 3, 4.
1867—9. *Natica Montacuti*, Jeffreys, Brit. Conch., vol. iv, p. 227, 1867; vol. v, p. 215, pl. lxxviii, fig. 6.
1872. *Natica Montacuti*, S. V. Wood, Mon. Crag Moll., 1st Suppl., pt. i, p. 78, pl. iv, fig. 10.
1872. *Natica Montagui*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 213.
1873—6. *Natica Montacuti*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 264, 1873; vol. v, p. 280, no. 106, 1874; vol. vii, p. 12, no. 491, 1876.
1878. *Lunatia Montagui*, G. O. Sars, Moll. Reg. arct. Norv., pp. 157, 358.
1880. *Natica Montacuti*, Stewart, Proc. Belfast Nat. Field Club (appendix), p. 174.
1890—98. *Natica Montacuti*, A. Bell, Rep. Brit. Assoc. (Leeds), pp. 413, 420, 1890; Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145, 1898.
1890. *Natica Montacuti*, Carus, Prod. Faun. Medit., vol. ii, p. 306.
1899. *Natica Montagui*, Locard, Coq. mar. Côtes de France, p. 91.
1901. *Natica* (*Naticina*) *Montagui*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 99, pl. lv, figs. 14, 15.
1901. *Lunatia Montagui*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 657, pl. xviii, fig. 22.
1912. *Natica* (*Naticina*) *Montagui*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 245.
1913. *Lunatia Montagui*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. l, p. 27, pl. iv, figs. 16—18.
1913. *Natica* (*Naticina*) *Montacuti*, Gignoux, Form. mar. Plioc. et Quater. d'Ital., p. 562, pl. xiii, figs. 7, 8, 9.

Specific Characters.—Shell small, smooth, fairly solid, globose; whorls 5—6, convex, not so rapidly enlarging as in some other species, the last tumid; spire short, a little elevated, with a blunt apex; suture distinct, slightly channelled; mouth semi-circular, obtusely rounded and expanded below; outer lip incurved upon the body-whorl; inner lip thickened, especially at the base; umbilicus small, open.

Dimensions.—L. 10 mm. B. 8 mm.

Distribution.—Recent : British coasts, mostly northern. Abroad from Finmark to the Mediterranean.

Fossil : St. Erth ? Butleyan Crag: Butley.

Pleistocene: Bridlington, Portland, Bute and Lewis, Clyde beds, Ballyrudder.

Holocene: Portrush.

Upper Pliocene: Sicily—Messina.

Pleistocene: Castroreale, Messina, Reggio, Ficarazzi, Monte Pellegrino. *Tapes*-banks—Christiania fiord.

Remarks.—N. Montagui (*N. Montacuti*, Jeffreys,[1]) is almost unknown from the Crag, but Mr. Bell has reported it from Butley, from the Antrim clays and some other British Pleistocene deposits. Possibly being a small shell it may have been overlooked. As I have not a fossil available I figure a recent specimen from Bergen for the guidance of collectors. Although mainly a northern species it has been recorded as recent from a few southern localities and as a fossil by Seguenza from the Upper Pliocene and Pleistocene of Sicily. Mr. Bell gives it, with some doubt, from St. Erth.

Natica (Lunatia) tenuistriata (Dautzenberg and Fischer). Plate LIV, figs. 11, 12.

1848. *Natica grœnlandica*, S. V. Wood, Mon. Crag Moll., pt. i, p. 146, pl. xii, fig. 5.
1911. *Lunatia tenuistriata*, Dautzenberg et Fischer, Journ. de Conch., vol. lix, p. 26, pl. i, figs. 1—3.
1913—15. *Lunatia tenuistriata*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. l, pt. v, p. 40, pl. iv, figs. 9—15 ; pl. v, fig. 19, 1913 ; vol. liv, pt. i, p. 160, 1915.

Specific Characters.—Shell fairly strong, smooth, glossy, globose ; whorls 5, finely striated, the last much the largest ; spire short, depressed ; umbilicus rather small, deep, open ; mouth ovate ; outer lip forming an obtuse angle with the body-whorl when viewed from above ; inner lip but slightly spreading.

Dimensions.—L. 20—26 mm. B. 17—21 mm.

Distribution.—Recent : Nova Zembla, Iceland, Spitzbergen, North of Siberia, Kola Peninsula, Behring Sea.

Fossil : Pleistocene: Bridlington.

Remarks.—My friend Dr. Odhner has called my attention to the Bridlington fossil described by Wood in 1848 which he thought might be the arctic species *Lunatia tenuistriata*. By the courtesy of the Curator of the York Museum I have been able to compare Wood's original shell with a recent specimen of that species from the Swedish Riks-Museum, confirming Dr. Odhner's suggestion ; the two correspond accurately, except that the latter is somewhat the larger. The characteristic feature of this species is that the outer lip joins the body-whorl at a different angle to that usual in this group of shells, as shown in my figures (11*a* and 12*a*).

[1] 'Brit. Conch.,' vol. iv, p. 227.

Natica (Lunatia) nana (Möller). Plate LIV, fig. 20; Plate LVI, fig. 19.

1842. *Natica nana*, Möller, Ind. Moll. Groenl., vol. iv, p. 80.
1878. *Lunatia nana*, G. O. Sars, Moll. Reg. arct. Norv., pp. 159, 358, pl. xxi, fig. 16.
1882. *Lunatia nana*, Verrill, Trans. Conn. Acad., vol. v, p. 516, pl. xlii, fig. 9.
1885. *Natica nana*, Jeffreys, Proc. Zool. Soc., p. 34.
1897—99. *Natica nana*, Locard, Exp. sci. Trav. et Talism., vol. i, p. 475, 1897; Coq. mar. Côtes de France, p. 92, 1899.
1899. *Natica* (*Lunatia*) *nana*, Posselt, Medd. om Grønl., vol. xxiii, p. 141.
1901. *Natica* (*Naticina*) *nana*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 100, pl. liii, figs. 15, 16.
1901. *Natica* (*Lunatia*) *nana*, Friele, Norske Nordhav. Exped. (Mollusca), pt. iii, p. 69.
1901. *Lunatia nana*, Conch. Soc. List, Journ. of Conch., vol. x, p. 19, no. 387.
1910. *Natica nana*, Odhner, Arkiv för Zool., vol. vii, no. 4, pp. 7, 23, 29, pl. i, figs. 26, 27.
1911. *Natica* (*Lunatia*) *nana*, Dautzenberg, Journ. de Conch., vol. lix, p. 301.
1915. *Polinices* (*Euspira*) *nana*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Faun. New Engl., No. 13, p. 107, Mollusca.
1919. *Natica* (*Lunatia*) *nana*, A. Bell, Yorks. Naturalist, p. 57.

Specific Characters.—Shell small, smooth, ovato-globose, imperforate, whorls $3\frac{1}{2}$, slightly convex, the last much the largest, occupying most of the shell; spire excessively short with a blunt apex; suture very slight; mouth large in proportion, obliquely expanded, angulated above; callosity of the inner lip nearly covering the umbilicus; operculum corneous.

Dimensions.—L. 5—6 mm. B. 4—5 mm.

Distribution.—Recent: British seas, north of the Hebrides, France, Gulf of Gascoigne, Nova Zembla, Spitzbergen, Finmark, Vadsö, Iceland, Greenland, New England coast, Aleutian islands, north African coast.

Fossil: Icenian Crag: Aldeby. Pleistocene: Kelsey Hill, Bridlington.

Remarks.—One of the specimens figured under this name is from Mr. Headley's collection of Bridlington shells, in which it is not rare; another is from Kelsey Hill and belongs to the Hull Museum. Its recorded distribution as a recent shell is mainly circumpolar, but it has been found as far south as to the north of the Faroes and the Hebrides in Europe, on the New England coast in America, as well as in the Gulf of Gascoigne and the Atlantic coast of north Africa. It seems possible, therefore, that it may be obtained hereafter at some other intervening localities. Jeffreys reports it, moreover, from the "Lightning" and the "Porcupine" expedition, and it has been recently noticed in Mr. Crowfoot's collection of Aldeby fossils.

Natica (Lunatia) proxima (S. V. Wood). Plate LIV, fig. 8.

1842—72.—*Natica proxima*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 530, 1842; Mon. Crag Moll., pt. 1, p. 143, pl. xvi, fig. 4, 1848; 1st Suppl., pt. i, p. 74, pl. iv, fig. 12, 1872.

1871. *Natica cirriformis*, var., Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol xxvii, p. 144.
1872. *Natica proxima*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 203, 209.
1876. *Natica proxima*, Seguenza, Boll. R. Com. Geol. Ital., vol. vii, p. 10, no. 483.
1881. *Natica proxima*, Nyst, Conch. Terr. tert. Belg., p. 69, pl. v, fig. 9.
1890. *Natica proxima*, C. Reid, Plioc. Dep. Brit., p. 249.
1892. *Natica proxima*, Van den Broeck, Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 133.
1897. *Natica (Neverita) proxima*, A. Bell, Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 145.

Specific Characters.—Shell fairly large, conical, oblique, smooth, whorls 5, the last tumid, much the largest; spire short; suture slight; mouth large, semilunar; umbilicus more or less covered by the inner lip.

Dimensions.—L. 25—30 mm. B. 20—22 mm.

Distribution.—Not known living.

Fossil: St. Erth. Coralline Crag: Ramsholt. Waltonian: Little Oakley. Butleyan: Butley, otherwise not sufficiently worked out.

Upper Pliocene (Scaldisien, Poederlien): Belgium. Sicily—Altavilla.

Remarks.—Wood has figured two specimens under this name, one in his monograph of 1848 (*op. cit.*), showing the body-whorl as slightly depressed above, and the umbilicus but partly covered by the callosity of the inner lip, the other, which I distinguish by the varietal name *Woodii* (Pl. LIV, figs. 9 and 10), that represented in his 1st Supplement, 1872 (*op. cit.*), being more strictly conical in form, with the outer lip not incurved. I have obtained both varieties at Oakley, and one or the other may be found in our public collections at various localities of the Red Crag.

N. proxima is recorded by Belgian authorities from the Antwerp Crag, and Seguenza includes it in his list of Upper Pliocene fossils from Altavilla, stating, however, that the Sicilian shell is smaller than the Crag form. Whether these are identical with ours I have no means of ascertaining. I am informed that Seguenza's grand collections were destroyed by the tidal wave consequent on the great earthquake of Messina. I was grieved to hear that his son, from whom I received much kindness during my visit to Sicily, perished at the same time.

Natica (Lunatia) pallida, Broderip and Sowerby. Plate LVI, figs. 8—11.

1829. *Natica pallida*, Broderip and Sowerby, Zool. Journ., vol. iv, p. 372.
1839. *Natica pallida*, Gray in Zool. Beechey's Voyage, p. 136, pl. xxxiv, fig. 15.
1848—72. *Natica grœnlandica*, S. V. Wood, Mon. Crag Moll., pt. i, p. 146, pl. xii, fig. 5, 1848; 1st Suppl., pt. i, p. 75, 1872.
1859. *Natica pusilla*, G. B. Sowerby, Ill. Ind. Brit. Shells, pl. xvi, fig. 19.
1867—71. *Natica grœnlandica*, Jeffreys, Brit. Conch, vol. iv, p. 216, 1867; vol. v, p. 215, pl. lxxviii, fig. 2, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1878.
1871. *Lunatia grœnlandica*, Gould and Binney, Rep. Inv. Mass., ed. 2, p. 341, fig. 611.
1872. *Lunatia grœnlandica*, Dawson, Canad. Nat. [N. S.], vol. vi, p. 88.
1872. *Natica borealis*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 213, 216.

1878. *Lunatia grœnlandica*, G. O. Sars, Moll. Reg. arct. Norv., pp. 158, 358, pl. xxi, fig. 15.
1886. *Natica* (*Lunatia*) *grönlandica*, Watson, Challenger Reports, vol. xv (Zoology), p. 447.
1890—1915. *Natica grœnlandica*, A. Bell, Rep. Brit. Assoc. (Leeds), pp. 415, 417, 1890; Geol. Mag. [6], vol. ii, p. 168, 1915.
1899. *Natica* (*Lunatia*) *grœnlandica*, Posselt, Medd. om Grönl., vol. xxiii, p. 139.
1901. *Lunatia grönlandica* and vars., Brøgger, Norges geol. Undersøgelse, No. 31, p. 653, pl. ii, figs. 7, 8.
1901. *Natica* (*Naticina*) *pallida*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 96, pl. lv, figs. 19, 20; pl. lviii, figs. 23, 24.
1910—15. *Lunatia groenlandica*, Odhner, Arkiv för Zool., Stockholm, vol. vii, no. 4, pp. 7, 23, pl. i, figs. 36—39, 1910; *L. pallida*, K. Svensk. Vet.-Akad. Handl., vol. l, p. 31, pl. iii, figs. 15, 19—37; pl. iv, figs. 1—8, 1913; vol. liv, p. 157, 1915.
1910. *Lunatia grœnlandica*, Øyen, K. Norske Vid. Selsk. Skrift., no. 9, p. 75.
1912. *Natica* (*Naticina*) *pallida*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii (Mollusques), p. 234.

Specific Characters.—Shell globose, fairly solid; whorls 4—5, the last tumid, much the largest, five-sixths the total length; spire small, short; apex minute, but slightly prominent; suture nearly straight, narrowly excavated inwards; mouth semicircular, expanded and obtusely angulate at the base; outer lip somewhat incurved above; inner lip thickened on the lower part, reflected upon the columella and nearly covering the umbilicus, which is narrow and contracted.

Dimensions.—L. 20 mm. B. 16 mm.

Distribution.—Recent: Coasts of Yorkshire, Durham and Northumberland, Dogger Bank, Shetland, Hebrides, Turbot-bank. West coast of Sweden, Norwegian coast from the Christiania fiord to Finmark, Faroe islands, Lofoten islands, Iceland, Jan Mayen, Greenland, Labrador, White Sea, Kola, Barent Sea, Kara Sea, Nova Zembla, Siberian coast, Spitzbergen, Hudson's Bay, Nova Scotia, Wellington Channel, North American coast, Banks of Newfoundland to Cape Cod, Behring Sea, Sea of Okhotsk, Japan.

Fossil: Waltonian Crag: Beaumont. Newbournian: Sutton. Butleyan: Butley, Shottisham, Hollesley, Bawdsey. Icenian: Bramerton, Thorpe (Suffolk), Chillesford, Weybourne. Wexford. Isle of Man. Iceland Crag (Mörch).

Pleistocene: Kelsey Hill, Bridlington, Scotland, Ireland.

Christiania fiord from *Yoldia*-clays to *Tapes*-banks, Trondhjem, Uddevalla. Montreal, Quebec, Rivière du Loup. Maine.

Remarks.—This northern and arctic species, which has been generally known as *N. grœnlandica*, is now identified by M. Dautzenberg and some other authorities with the *N. pallida* of Broderip and Sowerby, although Messrs. Friele and Grieg still consider these two distinct.[1] The form here described under the latter name seems to have been a comparatively late arrival in the Crag basin, most of the specimens known from our East Anglian deposits having been obtained from the

[1] Norske Nordh. Exped., pt. iii, p. 69, 1901.

Butleyan and Icenian zones, where, however, it is by no means abundant. As a recent shell it is widely diffused in circumpolar regions, ranging southwards as far as the northern coasts of Great Britain in one direction to the New England and Japanese seas in others. As a Pleistocene fossil it has been specially reported from Scotland, Ireland, Scandinavia and Canada.

Two of the specimens now figured (Pl. LVI, figs. 8 and 11) belong to the British Museum, where they bear the name of *N. borealis*, Gray, a form he and some others considered distinct from *N. pallida*. I prefer, however, to follow MM. Dautzenberg and Fischer in regarding these two, with *N. groenlandica*, as varieties of the same species.

Natica (Lunatia) Cavellii, sp. nov. Plate LIV, fig. 13.

Specific Characters.—Shell large, ovate, smooth, fairly solid, not oblique; whorls 5, convex, the last about four-fifths the total length; spire elevated, gradually decreasing in size towards a fine point; suture well marked; mouth semilunar, acutely angulate above, rounded below; outer lip gently curved, joining the body-whorl so as to leave most of the latter uncovered; inner lip spread over the upper part of the columella; umbilicus oval, partly open, rather small but deep.

Dimensions.—L. 36 mm. B. 26 mm.

Distribution.—Not known living.

Fossil: Icenian Crag: Thorpe, near Aldeburgh, Suffolk.

Remarks.—The charming specimen given under this name was observed by Mr. Bell in the Cavell Collection at Framlingham College, by the kindness of the Principal of which I am permitted to figure it. At Mr. Bell's suggestion I dedicate it to the memory of its discoverer, an enthusiastic collector of Crag fossils. It seems a distinct form, which I am unable to refer to anything hitherto described.

Natica (Lunatia) approximata, Etheridge and Bell, MS. Plate LVI, fig. 15.

Specific Characters.—Shell strong and solid with a thick callus, resembling in form the variety *Woodii* of the Crag *N. proxima*; the spire is shorter, however, and the umbilicus is larger, partly open, deeper and not so nearly covered by the inner lip as in that species.

Dimensions.—L. 27 mm. B. 21 mm.

Distribution.—Not recorded living.

Fossil: St. Erth.

Remarks.—The specimen figured under this name is another St. Erth shell

from the Warburton Collection at the British Museum which is there considered to be a new and distinct species under the MS. name of *N. approximata*, Etheridge and Bell.

Natica (Lunatia) assimilis, sp. nov. Plate LIV, fig. 17.

Specific Characters.—Shell solid, ovate; whorls 5, the last much the largest, occupying nearly the whole length; spire very short, rapidly diminishing in size to a blunt and depressed point; lines of growth very fine, indistinct; suture well marked; mouth semilunar, large; angulate above, rounded below, somewhat expanded; umbilicus open, rather large.

Dimensions.—L. 29 mm. B. 24 mm.

Distribution.—Not known living.

Fossil: St. Erth.

Remarks.—The specimen figured under this name from St. Erth belongs to the Warburton Collection at the British Museum, where it is labelled *N. varians*, Duj. For reasons given above I think this is a mistake, neither can it be referred, I consider, to the shell I have called *N. exvarians*, the mouth of which is smaller and the spire longer and more prominent. It comes nearer to *N. helicina*, especially to the *pro-helicina* of Prof. Sacco, but it is larger and on the whole, I think, deserves a distinguishing name. The St. Erth *Naticas* seem a distinct group, having no actual affinity to those of any other horizon of the British Pliocene, most of the forms that have come under notice and are here figured having a short and depressed spire.

Natica (Lunatia) varians (Dujardin, *non* Wood). Plate LIV, fig. 14.

1837. *Natica varians*, Dujardin, Bull. Soc. géol. France, vol. ii, p. 281, pl. xix, fig. 6.

1874. *Natica hemiclausa* (*N. varians*, Duj.), Van den Broeck, Ann. Soc. malac. Belg., vol. ix, pp. 134, 187.

1886. *Natica* (*Naticina*) *varians* (Duj. *non* Wood), Dollfus et Dautzenberg, Feuille des Jeunes Natur., vol. xvi, p. 141.

1890—91. *Natica catena* var. *varians*, Sacco, Boll. Soc. Geol. Ital., vol. ix, p. 311, no. 5017, 1890; Moll. Terr. Terz. Piem., pt. viii, p. 69, pl. ii, fig. 41, 1891.

Specific Characters.—Shell rather small and slender; oval, subconical; whorls 5, but slightly convex, the last much the largest, four-fifths the total length; spire very short, compressed, with a blunted point; suture slight; mouth large, acutely angulate above, rounded below; outer lip incurved; inner lip straight, thickened above by a callus which nearly covers the umbilicus.

Dimensions.—L. 20 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: Miocene: Belgium, Touraine, Bordeaux, Piedmont.

Remarks.—Two distinct shells, differing widely in form and size, have been described under the present name, the one by Dujardin being a Miocene species unknown from the Crag, the other by Wood, which has but little resemblance to it, the affinity of the first being rather with the *N. hemiclausa* of Sowerby. The difference between the two forms has been recognised by MM. Dollfus and Dautzenberg, Prof. Sacco and others. By the kindness of my friend Prof. Peyrot, of Bordeaux, who has sent me a specimen of Dujardin's shell, I am able to figure a typical example of it which corresponds accurately with that given by its author. Prof. Sacco considers *N. varians* a variety of the recent British shell *N. catena*, though he states distinctly it is not the *N. varians* of Wood. We may take it, I think, that when the specific name *varians* is mentioned by an English writer, it is Wood's shell and not Dujardin's that is referred to. We have nothing in the Crag exactly agreeing with the original *N. varians* of the French Miocene.

Sub-genus **POLINICES**, Montfort, 1810.

Natica (Polinices) triseriata (Say.). Plate LIV, figs. 6, 7.

1824. *Natica triseriata*, Say, Journ. Acad. Nat. Sci. Philad., vol. v, p. 209.
1841—70. *Lunatia triseriata*, Gould, Rep. Inv. Mass., ed. 1, p. 233, fig. 165, 1841; ed. 2, p. 340, fig. 610, 1870.
1879. *Natica triseriata ?* S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 31, pl. iii, fig. 14.
1915. *Polinices (Euspira) triseriata*, Johnson, Bost. Soc. Nat. Hist., Occ. papers, vol. vii, Fauna New Engl., No. 13, p. 206.

Specific Characters.—Shell small, ovate, globose; whorls 5, the last much the largest, not distinctly compressed below the suture; oblique lines of growth clearly marked; spire elevated, more prominent than in the species next described; suture slight; mouth rather large, expanded, angulated above, flattened below; outer lip thin, gently curved; inner lip forming a fairly wide callus but slightly covering the umbilicus; umbilicus of moderate size.

Dimensions.—L. 20 mm. B. 15 mm.

Distribution.—*Recent:* New England coast.

Fossil: Waltonian Crag: Beaumont, Little Oakley. Butleyan: Butley, probably elsewhere in the Red Crag.

Remarks.—In his 2nd Supplement Wood figured a specimen which he referred, though with some doubt, to a North American species, *N. triseriata*, regretting he had not a recent shell with which to compare it. By the kindness of Mr. C. W. Johnson, of the Massachusetts Institute of Technology, I am now able to do so. I have several doubtful examples from the English Crag, one of which I figure with the latter—they seem to belong to the present species; at any rate the American and verified specimen may be useful hereafter to students.

American conchologists have adopted the generic term *Polinices* for this group:

Fischer, however, whom as a rule I follow, adopts that name as a sub-genus of *Natica*, which he says is an oval elongate shell, having the umbilicus wholly or nearly closed by the funicular callosity.

Natica (Polinices) hemiclausa (J. Sowerby). Plate LVI, fig. 16.

1825. *Natica hemiclausa*, J. Sowerby, Min. Conch., vol. v, p. 125, pl. cccclxxix, fig. 2.
1844. *Natica macilenta*, Philippi, Enum. Moll. Sic., vol. ii, p. 140, pl. xxiv, fig. 14.
1871. *Natica hemiclausa*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489.
1872. *Natica hemiclausa*, A. Bell, Geol. Mag., vol. ix, p. 210.
1872. *Natica hemiclausa*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 209, 213, 216.
1873—6. *Natica macilenta*, Seguenza, Boll. R. Com. Geol. Ital., vol. iv, p. 352, no. 260, 1873; vol. v, p. 280, no. 105, 1874; vol. vii, p. 10, no. 485, 1876.
1874—92. *Natica hemiclausa*, Van den Broeck, Ann. Soc. malac. Belg., vol. ix, p. 134, 1874; Bull. Soc. Belge Géol., vol. vi (Mémoires), p. 133, 1892.
1881. *Natica hemiclausa*, Nyst, Conch. Terr. tert. Belg., p. 71, pl. v, fig. 11.
1890. *Natica hemiclausa*, C. Reid, Plioc. Dep. Brit., p. 249.
1890. *Natica* (*Naticina*) *macilenta*, Carus, Prod. Faun. Medit., vol. ii, p. 305.
1901. *Natica* (*Naticina*) *macilenta*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 92, pl. lii, figs. 13, 14.
1912. *Natica hemiclausa*, Tesch, Med. v. d. Rijks. v. Delfstoffen, No. 4, p. 66, no. 145.
1913. *Natica macilenta*, Gignoux, Ann. de l'Univ. de Lyons [N. S.], vol. xxxvi, p. 562.

Specific Characters.—Shell strong, smooth, oblique, subglobose, generally small; whorls 5 or 6, overlapping, the last tumid, much the largest, about four-fifths the total length; spire regularly conical, rapidly diminishing to an acute apex; suture very slight; mouth large, semilunar, angulate above, rounded and projecting below; outer lip regularly curved, not expanded; inner lip forming a rather wide callus upon the columella, which nearly and sometimes entirely covers the umbilicus.

Dimensions.—L. 12—15 mm. B. 10—12 mm.

Distribution.—Recent: As *N. macilenta*, Atlantic coasts of Spain. Mediterranean, widely diffused. Adriatic.

Fossil: Waltonian Crag: Walton-on-Naze, Beaumont, Little Oakley. Newbournian, Butleyan: *passim*. Icenian (less abundant): Aldeburgh, Bulchamp, Southwold, Yarn Hill, Easton Bavent, Bramerton. Weybourne.

Pliocene: Belgium, Holland, France, Italy.

Pleistocene: Sicily, Calabria, Tuscany.

Remarks.—N. hemiclausa, a variable shell, very characteristic of the Red Crag, and specially abundant in the Waltonian zone at Little Oakley, was originally described by Sowerby from a small specimen about 16 mm. high, which Wood was disposed to regard as immature. I have found a hundred examples or more of a similar form at Oakley. They are nearly all about the same size and appear to be full-grown. The specimen figured by Wood in 1848 as *N. hemiclausa*[1] seems to me

[1] Mon. Crag Moll., pt. i, p. 144, pl. xvi, fig. 5.

a different species. It is much larger than Sowerby's type and appears to group itself with *N. proxima*, especially with the variety *Woodii*. Philippi identifies, though doubtfully, *N. hemiclausa* with a recent Mediterranean form, *N. macilenta*, a view adopted by Seguenza but not by Wood.

Var. **oakleyensis,** nov. Plate LVI, fig. 17.

Remarks.—I have a few specimens from Oakley agreeing with the type form but larger and longer, about 18 mm. by 15 mm., which I think deserve notice. They might otherwise be taken for the Miocene species *N. varians*, described on p. 696.

Natica (Polinices) lactea, Guilding. Plate LIV, fig. 19.

1837. *Natica lactea*, Guilding, Trans. Linn. Soc., vol. xvii, p. 31.
1852. *Natica lactea*, Philippi, Martini und Chemnitz, Conch. Cab., ed. 2, vol. ii, p. 61, pl. x, fig. 2.
1885. *Natica (Mamma) lactea*, Tryon, Man. Conch. [1], vol. viii, p. 49, pl. xv, fig. 45; pl. xvi, figs. 52, 54—57, 59; pl. xvii, fig. 62; pl. xix, fig. 85.
1855. *Natica porcellanea*, Reeve, Conch. Icon., vol. ix, pl. xxiii, no. 102.
1901. *Natica (Mamma) lactea*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 107, pl. lvii, figs. 7—11.

Specific Characters.—Shell ovate, strong, smooth; whorls 6, the upper ones but slightly convex, the last ventricose, much the largest; spire very short with a small, pointed apex; suture slight; mouth oblong, semilunar, nearly half the total length of the shell, angulate above, rounded below; outer lip gently curved; umbilicus longer than wide, open, deep, partly closed by a thick callus.

Dimensions.—L. 20 mm. B. 16 mm.

Distribution.—Recent: warmer part of the N. Atlantic, Madeira, Antilles, Canaries, Isthmus of Corinth.

Fossil: Taranto, Calabria (Seguenza), St. Erth. Algiers (?).

Remarks.—The specimen here figured belongs to the British Museum and was found at St. Erth, and has been identified by M. Dautzenberg with this southern species. It agrees very nearly with a specimen of a West Indian shell from his collection which he informs me came from the Antilles. It is not the only case of the kind in the Crag fauna, as, *e. g.*, *Erato maugeriæ*, another West Indian form.

Genus **ACRYBIA,** H. and A. Adams, 1853.

Acrybia Smithii (Brown). Plate LV, fig. 9.

1838. *Bulbus Smithii*, Smith, Mem. Wern. Nat. Hist. Soc., vol. viii, p. 56, pl. i, fig. 18.
1839—49. *Globulus Smithii*, Brown, Mem. Wern. Nat. Hist. Soc., vol. viii, p. 104, pl. i, fig. 18, 1839; Ill. Foss. Conch., p. 256, pl. xxxiii, fig. 77, 1849.

1840—70. *Natica flava*, Gould, Amer. Journ. Sci. [1], vol. xxxviii, p. 196, 1840; Inv. Mass., ed. 1, p. 239, fig. 162, 1841; *Bulbus flavus*, ed. 2, p. 347, fig. 616, 1870.
1846. *Natica Smithii*, E. Forbes, Mem. Geol. Surv., vol. i, p. 429.
1850. *Natica Smithii*, S. V. Wood, Mon. Crag Moll., pt. ii, p. 321.
1877. *Acrybia flava*, Mörch and Poulsen, MS. List and Plates in Geol. Mus. Copenhagen, No. 25, pl. i, fig. 2 (unpublished).
1878. *Ampullina Smithii*, G. O. Sars, Moll. Reg. arct. Norv., pp. 155, 358, pl. xii, fig. 2; pl. xxi. fig. 18.
1901. *Ampullina Smithii*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 111, pl. lvii, figs. 12—14.
1915. *Acrybia Smithii*, Johnson, Boston Soc. Nat. Hist., Occ. papers, vol. vii, Fauna of N. England, No. 13, p. 107.

Specific Characters.—Shell thin, semipellucid, oblique, ovato-globose; whorls 4, the last inflated, occupying nearly all the length; spire minute; suture slight; mouth very large, much expanded; outer lip thin, irregularly rounded; inner lip excavated in the centre, very narrow; columella tortuous.

Dimensions.—L. 17—22 mm. B. 17—22 mm.

Distribution.—*Recent:* Finmark, Lofoten Islands, Behring Sea, New England coast.

Fossil: Pleistocene: Ardincaple, Tayport. Iceland.

Remarks.—My special thanks are due to Sir Aubrey Strahan, the Director of the Geological Survey of Great Britain, for his courtesy in entrusting me with this beautiful fossil, the one originally described by Smith having been accidentally broken some years ago. The only other fossil locality I know of is that from the Crag of Iceland, of which I have lately received a specimen from Herr Hans Schlesch.

Genus **AMAUROPSIS**, Mörch, 1857.

Amauropsis islandica (Gmelin). Plate LVI, figs. 21—23.

1790. *Nerita islandica*, Gmelin (Linné), Syst. Nat., ed. xiii, vol. i, pt. 6, no. 3675.
1835. *Natica helicoides*, Johnston, Proc. Berwick Nat. Hist. Club, vol. i, p. 69.
1841—70. *Natica canaliculata*, Gould, Rep. Inv. Mass., ed. 1, p. 235, fig. 161, 1841; *Amauropsis helicoides*, ed. 2, p. 348, fig. 617, 1870.
1842. *Natica coronea*, Möller, Ind. Moll. Groenl., p. 7.
1842—72. *Natica helicoides*, S. V. Wood, Ann. Mag. Nat. Hist. [1], vol. ix, p. 529, 1842; Mon. Crag Moll., pt. i, p. 145, pl. xvi, fig. 3, 1848; 1st Suppl., pt. i. p. 78, 1872.
1846. *Natica helicoides*, Lovén, K. Svensk. Vet.-Akad. Förh., vol. iii, p. 89.
1850. *Natica helicoides*, Forbes and Hanley, Brit. Moll., vol. iii, p. 339, pl. c, fig. 6.
1867—72. *Natica islandica*, Jeffreys, Brit. Conch., vol. iv, p. 214, 1867; vol. v, p. 215, pl. lxxviii, fig. 1, 1869; in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 489, 1871; Ann. Mag. Nat. Hist. [4], vol. x, p. 244, 1872.
1872. *Natica islandica*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, pp. 209, 213.

1878. *Amauropsis islandica*, G. O. Sars, Moll. Reg. arct. Norv., pp. 156, 358, pl. xxi, fig. 17.
1890. *Natica islandica*, A. Bell, Rep. Brit. Assoc. (Leeds), p. 415.
1899. *Amauropsis islandica*, Posselt, Medd. om Grønl., vol. xxiii, p. 138.
1901. *Amauropsis islandica*, Friele og Grieg, Norske Nordh. Exped. (Mollusca), pt. iii, p. 68.
1901. *Amauropsis islandica*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 109, pl. xvi, figs. 14—17.
1901. *Amauropsis islandica*, Brøgger, Norges geol. Undersøgelse, No. 31, p. 653, pl. xii, fig. 5.
1910—15. *Amauropsis islandica*, Odhner, K. Svensk. Vet.-Akad. Stockholm, vol. vii, p. 6, 1910; K. Svensk. Vet.-Akad. Handl., vol. liv, p. 161, 1915.
1912. *Amauropsis islandica*, Dautzenberg et Fischer, Camp. Scient., Prince de Monaco, vol. xxxvii, p. 247.
1915. *Amauropsis islandica*, Johnson, Boston Soc. Nat. Hist., Occ. papers, vol. viii, Fauna of New England, No. 13 (Mollusca), p. 107.

Specific Characters.—Shell ovato-conical, not very solid; whorls 5, convex, compressed above; spire turreted, elevated, ending in a sharp point; suture deep, oblique, channelled; mouth large, ovate, about two-thirds the total length, expanded and obtusely angulate at the base; outer lip incurved above; inner lip narrow, spread over the columella, almost concealing a small umbilicus.

Dimensions.—L. 18 mm. B. 14 mm.

Distribution.—*Recent:* North Britain, Shetland, Orkneys, Sunderland, Scarborough, Cork.

Norwegian coast, northern part, Finmark, Lofoten islands, White Sea, Iceland, Spitzbergen, Greenland, New England coast, banks of Newfoundland, Behring Sea.

Fossil: Newbournian Crag: Waldringfield, Sutton, Felixstowe, Ramsholt. Butleyan: Alderton, Butley. Icenian: *Norwich zone*—Bramerton, Thorpe, Yarn Hill, Ditchingham, Bulchamp, Aldeburgh, Dunwich, Southwold, Easton Bavent, Aldeby, Horstead. *Weybourne zone*—Belaugh, Runton, North Walsham.

Pleistocene: Middle Glacial sands—Billockby, Gorleston; Bridlington, March gravels, Kelsey Hill, Macclesfield, Moel Tryfaen, Scotland, Uddevalla, Christiania fiord, Montreal.

Remarks.—This northern species has been reported from the later part of the Red Crag and from many Icenian localities, though not as abundant. It occurs in the British and Scandinavian Pleistocene and at Montreal. One of the Crag specimens here figured is from Butley and belongs to the Ipswich Museum.

Amauropsis Øyeni, sp. nov. Plate LVI, fig. 24.

Specific Characters.—Shell rather large, ovato-conical, fairly solid; whorls 5, convex, the last five-sixths the total length; spire turreted, rapidly enlarging, ending in a small and obtuse apex; suture slightly oblique, conspicuously channelled, as in *A. islandica;* mouth long, narrow; outer lip incurved above, not expanded.

Dimensions.—L. 29 mm. B. 19 mm.

Distribution.—Not known living.

Fossil: Waltonian Crag: Little Oakley.

Remarks.—I describe provisionally and with some doubt the unique fossil here figured under the generic name of *Amauropsis*. It agrees with *A. islandica* in some respects, as in its turreted spire, its conspicuously channelled suture and its incurved upper lip.

The inner lip, however, is abnormal, leaving the umbilicus exposed, but possibly it may have been broken and have made subsequently a false growth. I have been unable to find anything, either recent or fossil, to which it may be referred; it can hardly be regarded as a variety of *A. islandica*.

Amauropsis gracilis, sp. nov. Plate LVI, fig. 25.

Specific Characters.—Shell ovato-conical; whorls 5, convex, the last much the largest; spire elongate, ending in a sharp point; suture deep; mouth angulate above, rounded and slightly produced below; outer lip thin, gently curved; inner lip oblique, straight; peristome continuous, projecting over the umbilicus, which is small and narrow.

Dimensions.—L. 22 mm. B. 16 mm.

Distribution.—Not known living.

Fossil: Icenian Crag: Easton Bavent.

Remarks.—This interesting specimen was discovered by Mr. Bell in the Cavell Collection at Framlingham College. It seems to be new, not only to the Crag, but to science.

Amauropsis Odhneri, sp. nov. Plate LVI, fig. 26.

Specific Characters.—Shell smooth, smaller than *A. islandica*, and having a very short spire, but otherwise resembling it; whorls 5; apex depressed; suture deep and canaliculate; umbilicus partly covered.

Dimensions.—L. 15 mm. B. 12 mm.

Distribution.—Not known living.

Fossil: Butleyan Crag: Hollesley.

Remarks.—The specimen here figured was found by Mr. Kennard at Hollesley. Its deep and canaliculated suture connects it with the northern genus *Amauropsis*. It is specially characterised by its short spire. Dr. Odhner, to whom I have submitted our fossil, believes it to be an unrecognised species. I describe it as new under his name.

Amauropsis japonica, A. Adams, MS. Plate LVI, fig. 27.

1879. *Natica* (*Amauropsis*) *japonica*, S. V. Wood, Mon. Crag Moll., 2nd Suppl., p. 30, pl. iii, p. 11.

Specific Characters.—Shell small, thin, fragile, ovato-conical; whorls convex, turreted, the last much the largest, three-fourths the total length; suture deep, depressed; spire short, rapidly diminishing to a blunt point; mouth ovate; outer lip thin, gently rounded; inner lip spread over the columella, which is oblique above and straight below.

Dimensions.—L. 8 mm. B. 4 mm.

Distribution.—*Recent:* Japan.

Fossil: Butleyan Crag: Butley, Hollesley.

Remarks.—The shell here figured was found by Mr. Kennard at Hollesley. It resembles the Butley specimen described by Wood except that the spire is shorter and that the umbilicus is covered by the inner lip. The latter was identified by Wood rather doubtfully with a recent species from Japan which he had not seen. I am unable to throw any further light on the subject.

Genus **AMAURA,** Möller, 1842.

Amaura candida, Möller. Plate LVI, fig. 28.

1842. *Amaura candida*, Möller, Ind. Moll. Grœnl., p. 7.
1858. *Amaura candida*, H. and A. Adams, Gen. Rec. Moll., vol. i, p. 214, pl. xxii, fig. 9.
1859. *Amaura candida*, Chenu, Man. Conch., vol. i, p. 215, fig. 1180.
1870. *Amaura candida*, A. Bell, Ann. Mag. Nat. Hist. [4], vol. vi, p. 215.
1871. *Amaura candida*, Jeffreys in Prestwich, Quart. Journ. Geol. Soc., vol. xxvii, p. 486.
1872. *Amaura candida*, S. V. Wood, Mon. Crag Moll., 1st Suppl., pt. i, p. 78, pl. i, fig. 3.
1872. *Amaura candida*, A. and R. Bell, Proc. Geol. Assoc., vol. ii, p. 213.
1890. *Amaura candida*, C. Reid, Plioc. Dep. Brit., p. 237.
1901. *Amaura candida*, Kobelt, Icon. schalentrag. europ. Meeresconch., vol. ii, p. 110, pl. lvii, fig. 15.

Specific Characters.—Shell small, ovato-oblong, imperforate; whorls 5, the last much the largest; spire produced, exserted, with a rather obtuse apex; mouth pyriform, acutely angulate above, obtusely rounded below; columella short.

Dimensions.—L. 12 mm. B. 5 mm.

Distribution.—*Recent:* Greenland.

Fossil: Waltonian Crag: Little Oakley. Butleyan: Butley.

Remarks.—This species was originally identified by Mr. A. Bell from a specimen found by him at Butley; another was afterwards obtained from the same locality by the late Mr. Crowfoot which is now figured. It seems to be a rare and distinctly arctic form.

Genus **WEXFORDIA**, nov.

Shell small, turreted, with a globose body-whorl and a short, conical, pointed spire; outer lip incurved, somewhat expanded; inner lip thickened below; umbilicus distinct.

Wexfordia Dautzenbergi, sp. nov. Plate LIV, fig. 21.

1918. *Torellia vestita*, F. W. Harmer, Plioc. Moll. Gt. Brit., vol. i, pt. iii, p. 431.

Remarks.—The specimen described in 1918 under the above name was discovered by Mr. A. Bell in some shelly material from the Wexford gravels received from Father Codd, now the Bishop of Ferns, and identified rather hastily with a rare northern species, *Torellia vestita*. It came into my hands too late, however, to be figured at that time. Submitting a photograph of it subsequently to M. Dautzenberg, the latter, having compared it with a typical example of Jeffreys' shell in his possession, considered that it was not only specifically different but belonged to another genus, having an affinity with *Trichotropis* rather than with *Torellia*. He suggested, moreover, that I should choose another generic name for it, which I have done. As *Dautzenbergia* had been previously used I propose *Wexfordia* instead, retaining M. Dautzenberg's connection with the matter by the use of the specific term *Dautzenbergi*.

Genus **MÖLLERIA**, Jeffreys, 1865.

Möllеria costulata (Möller). Plate LVI, fig. 20.

1842. *Margarita ? costulata*, Möller, Ind. Moll. Grœnl., p. 8.

1863—83. *Cyclostrema costulatum*, Jeffreys, Rep. Brit. Assoc., p. 77, 1863; Brit. Conch., vol. iii, p. 291, 1865; *Mölleria costulata*, Ann. Mag. Nat. Hist. [4], vol. xix, p. 235, 1877; Proc. Zool. Soc. London, p. 89, 1883.

1870. *Adeorbis costulata*, Gould and Binney, Inv. Mass., ed. 2, p. 278, fig. 538.

1872. *Cyclostrema (Mölleria) costulata*, Dawson, Can. Nat. (n.s.), vol. vi, p. 389.

1877. *Mölleria costulata*, Etheridge in J. Geikie, Great Ice Age, ed. 2, p. 396.

1892—1917. *Mölleria costulata*, A. Bell, Proc. Roy. Irish Acad. [3], vol. ii, p. 634, 1892; Yorks. Naturalist, No. 723, p. 96, 1917.

1878. *Møllеria costulata*, G. O. Sars, Moll. Reg. arct. Norv., pp. 127, 343, 357, pl. ix, fig. 8, pl. xxxiv, fig. 5.

1898. *Moellеria costulata*, Posselt, Medd. om Grønl., vol. xxiii, p. 121.

1901. *Møllеria costulata*, Brøgger, Norges Geol. Undersøgelse, no. 31, pp. 442, 653, pl. xii, fig. 4.

1901. *Moellеria costulata*, Conch. Soc. List, Journ. of Conch., vol. x, p. 16, no. 289.

1912—15. *Moellеria costulata*, Odhner, K. Svensk. Vet.-Akad. Handl., vol. xlviii, p. 75, pl. v, figs. 43—47, 1912; vol. liv, p. 152, 1915.

1915. *Molleria costulata*, Johnson, Boston Soc. Nat. Hist., Occ. papers, vol. viii, Fauna of New England, No. 13 (Mollusca), p. 87.

PLATE LIII.

Harmer, Crag Mollusca.

PLATE LIII

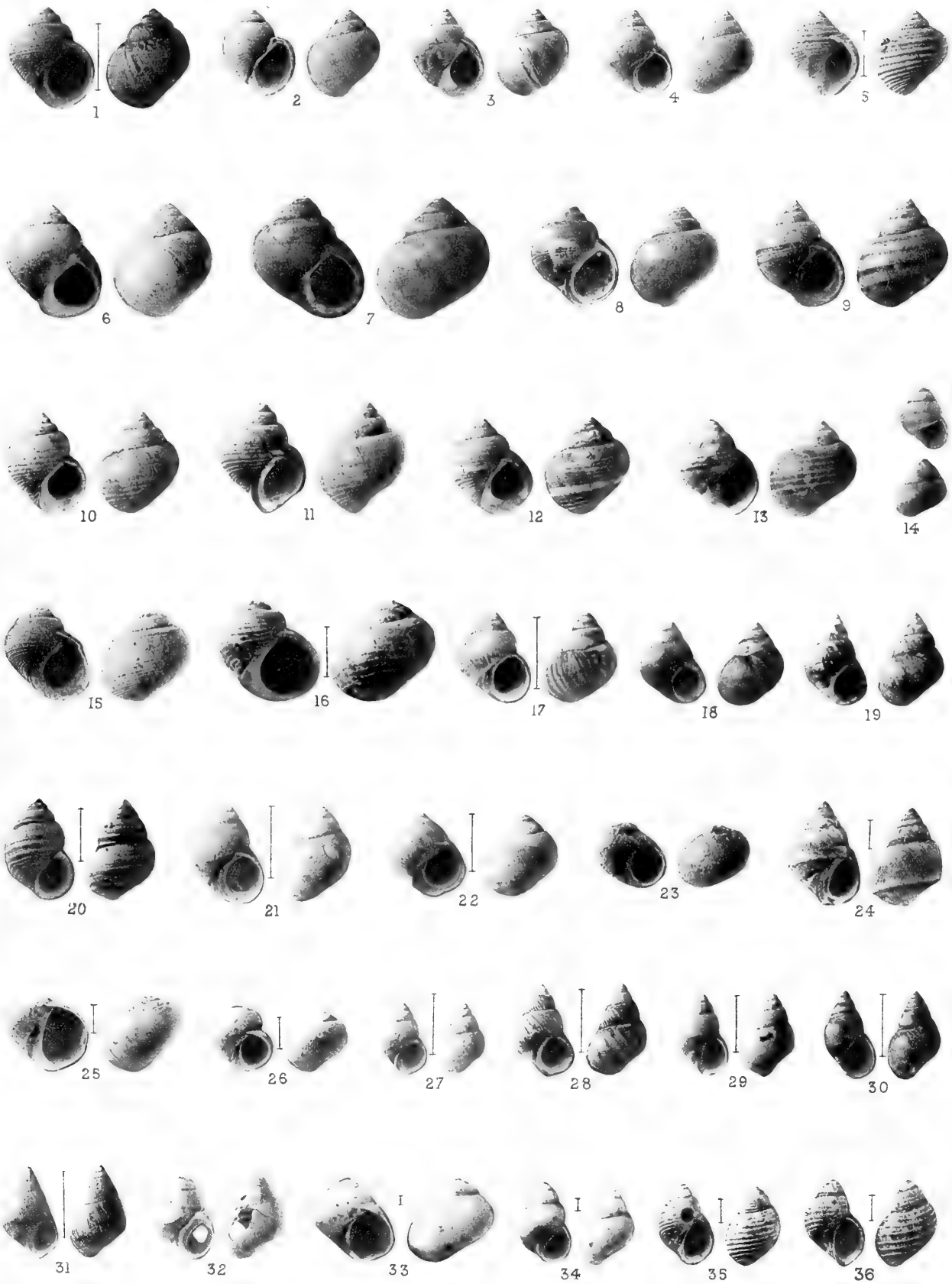

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PLATE LIV.

Harmer. Crag Mollusca.

PLATE LIV

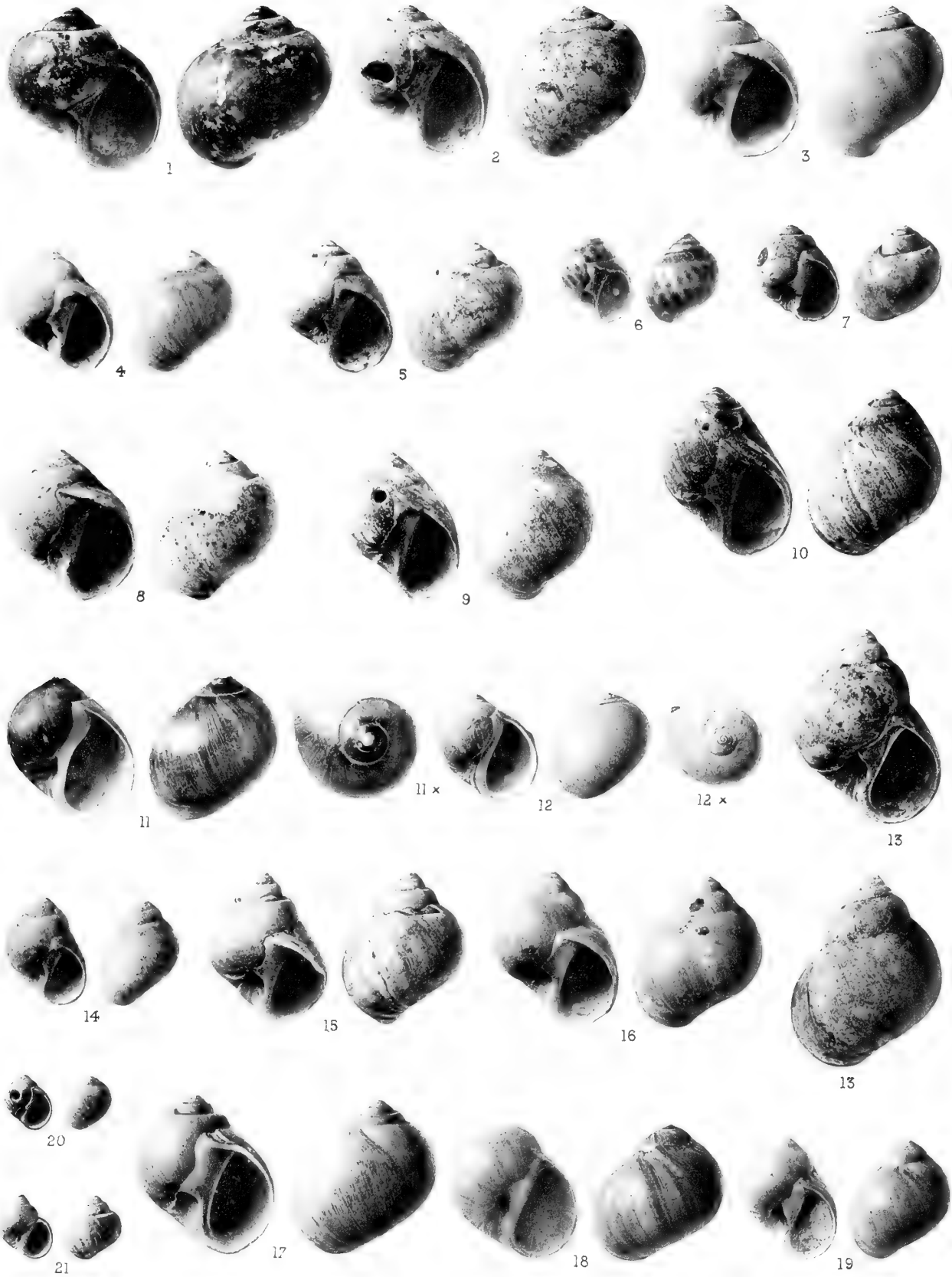

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PLATE LV.

Fig.		Page.
1.	*Natica* (*Lunatia*) *catenoides* (S. V. Wood). Little Oakley. (Harmer Collection)	686
2.	*Natica* (*Lunatia*) *cirriformis* (J. Sowerby). Shottisham. (Harmer Collection)	685
3.	Ditto. var. *discrepans*, nov. Little Oakley. (Harmer Collection)	686
4.	*Natica* (*Lunatia*) *Alderi* (Donovan). March. (Harmer Collection)	687
5.	Ditto. Little Oakley. (Harmer Collection)	687
6.	Ditto. Recent. (Harmer Collection)	687
7.	*Natica pusilla*, Say. Little Oakley. (Harmer Collection)	675
8.	Ditto. Recent. (Harmer Collection)	675
9.	*Acrybia Smithii* (Brown). Tayport. (Jermyn St. Museum)	699
10.	*Natica* (*Lunatia*) *Montagui*, Forbes. Recent, Bergen. (Harmer Collection)	690
11.	*Natica tenuis*, Etheridge and Bell. St. Erth. (British Museum)	681
12.	*Natica multipunctata*, S. V. Wood. Coralline Crag. (Jermyn St. Museum)	677
13.	Ditto. Little Oakley. (Harmer Collection)	677
14.	Ditto, var. *consors*, S. V. Wood. Walton-on-Naze. (Harmer Collection)	677
15.	*Natica tigrina*, Defrance. Little Oakley. (Harmer Collection)	679
16.	*Natica millepunctata*, Lamarck. Recent. (Harmer Collection)	678

Harmer, Crag Mollusca.

PLATE LV

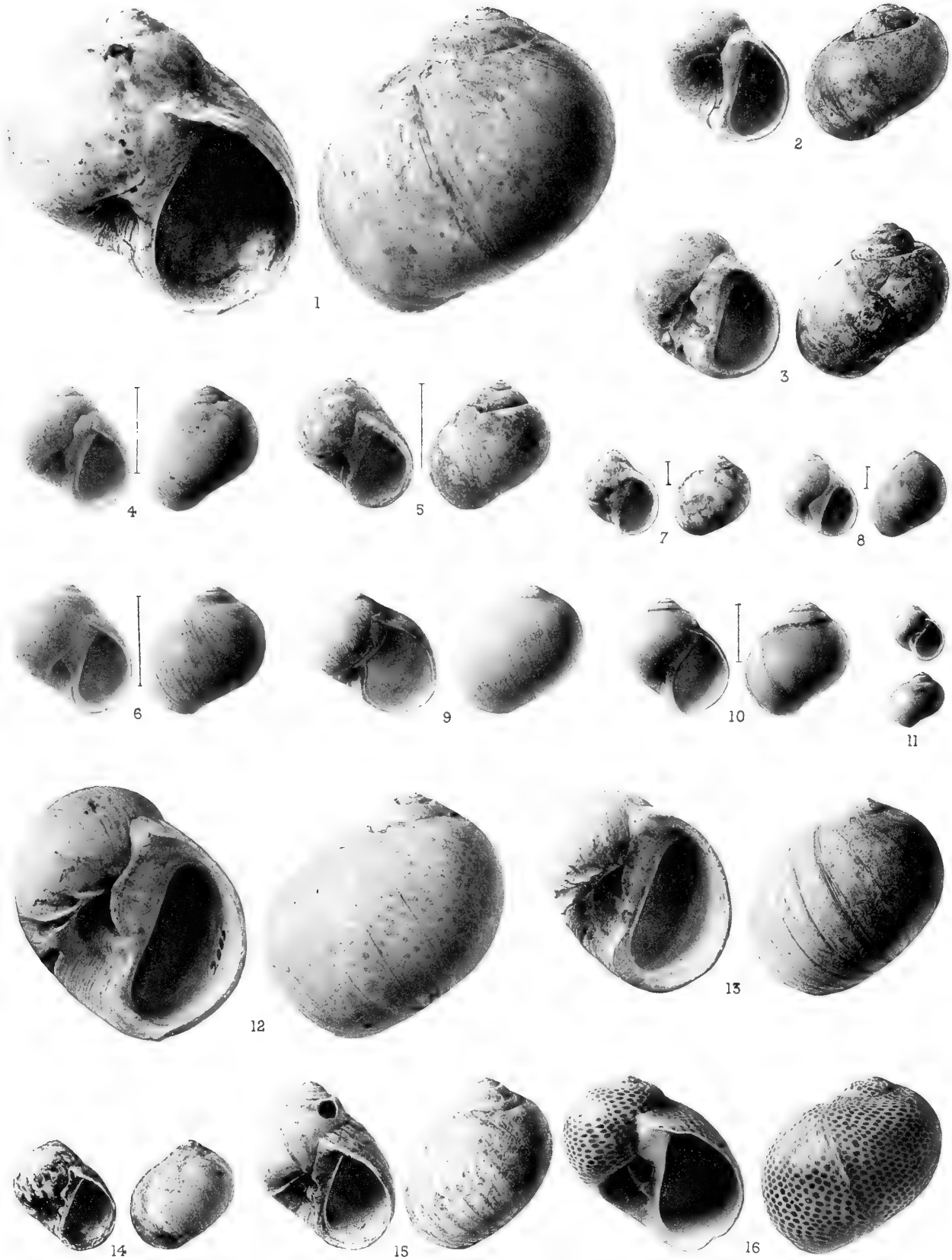

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PLATE LVI.

Harmer, Crag Mollusca.

PLATE LVI

J. Green del.

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Palæontographical Society, 1919.

A MONOGRAPH

OF THE

BRITISH ORDOVICIAN AND SILURIAN BELLEROPHONTACEA.

BY

F. R. COWPER REED, M.A., Sc.D., F.G.S.

PART II.

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SYSTEMATIC INDEX.

backwards obliquely to meet carina at 75°—60°, with their edges rising into small nodules where crossed by the strong regular contiguous revolving ridges of equal size and strength; lamellæ frequently alternate on opposite sides of whorl.

Dimensions [G. 80486].—Height of shell 10 mm.; height of mouth 6 mm.; width of mouth 4 mm.

Horizon.—Wenlock Limestone.

Locality.—Dudley.

Remarks.—The single specimen in the British Museum [G. 80486], on which the foregoing description is based, has much of the proximal part of the shell hidden by the matrix and by an attached specimen of *Orbiculoidea*. The presence of a slit-band is only visible near the mouth, and proximally its edges draw together so that it seems to be closed. The shell, however, must be referred to the genus *Temnodiscus* rather than *Cyrtolites*, and is allied to *T. lamellifer* (Lindstr.)[1] and *T. pharetra* (Lindstr.).[2]

3. **Temnodiscus murchisoni** (D'Orbigny). Plate IX, figs. 8, 9.

1839. *Bellerophon striatus*, Sowerby (*non* Bronn, 1835), in Murchison's Silurian System, p. 604, pl. iii, fig. 12 *e*.

1848. *Bellerophon murchisoni*, Férussac and D'Orbigny, Hist. Nat. Ceph., vol. i, p. 210, pl. vii, figs. 1–3.

1852. *Bellerophon murchisoni*, D'Orbigny, M'Coy, Syn, Brit. Palæoz. Foss. Woodw. Mus., fasc. ii, p. 310.

non 1842. *Bellerophon murchisoni*, D'Orbigny, D'Archiac and de Verneuil, Trans. Geol. Soc. [2], vol. vi, p. 353, pl. xxviii, figs. 7, 8.

Specific Characters.—Shell somewhat compressed, carinated, increasing very rapidly in size towards the mouth, especially in height; composed of few (1—2) whorls. Outer whorl higher than wide, subcordate, with dorsum acutely angular, becoming subangular towards mouth and finally almost rounded, the sides of the whorl becoming at the same time more convex and swollen and the whole whorl broader; carina slightly raised, with flattened top bearing slit-band [with widely separated strongly arched lunulæ]. Umbilicus situated considerably below centre of shell, small, open, perforated (?). Surface of shell ornamented with numerous closely placed, sharp, thin transverse lines or lamellæ [having finely fimbriated edges], bending back rather suddenly to meet the carina at about 30°—45°.

Dimensions.—Height about 12 mm. [6669.]

Horizon.—Upper Ludlow.

Localities.—Felindre; Horeb Chapel, Llandovery; Malvern.

Remarks.—There has been considerable confusion about this species, but the above description has been drawn up from the type-specimen in the Jermyn

[1] Lindström, *op. cit.*, p. 82, pl. vi, figs. 31—38.

[2] *Ibid.*, p. 83, pl. vi, figs. 39—51.

Street Museum [6669] from Horeb Chapel, but the details of the ornament of the slit-band and transverse lines from the specimen [28090] from Malvern.

The description of the species *B. striatus* from the Upper Ludlow Tilestones of Felindre which Sowerby gave is as follows: "Carinated, covered with sharp striæ parallel to the edge of the aperture; apex (spire?) very small, convoluted; aperture cordate (with a narrow deep sinus in the front?); keel flattened at the edge and transversely striated." McCoy described the Ludlow examples from the Tilestones of Horeb Chapel, Llandovery, as follows: "Involute, subcompressed, of about one and a-half very rapidly enlarging, completely exposed whorls; section of whorls obtusely cordate, the width slightly exceeding the length; sides tumid, very convex; circumference with an obtusely-defined, broad, prominent flattened keel; umbilicus small; surface with fine sharp striæ, transverse on the sides and keel; average diameter five lines; in proportion to diameter length of mouth $\frac{80}{100}$, width of umbilicus $\frac{15}{100}$. The greater width and tumidity of the sides, fewer and more rapidly expanding whorls, and consequently greater size of the last volution and wide obtusely flattened keel separate this species from *B. carinatus* (Sow.)."

The specimen [6669 $\frac{28}{91a}$] in the Jermyn Street Museum (formerly in the Geological Society's Museum), which is recognised as Sowerby's type, and is marked "Upper Ludlow, Horeb Chapel," consists of a well-preserved internal cast of a small shell measuring 12 mm. in height. It is composed of $1\frac{1}{2}$ or 2 whorls. The umbilicus is perforated, possibly as the result of the inner whorl being broken away. The outer whorl very rapidly increases in size, especially in height, and is somewhat compressed, being higher than wide, with a subangular dorsum and slightly raised flattened carina. The height of the outer whorl at the mouth is just over three-fourths the total height of the shell, being 8·5 mm., and its width is about 7 mm. The umbilicus is therefore far below the centre of the shell. The acuteness of the carination of the dorsum decreases somewhat towards the mouth, and the sides of the whorl become more swollen and convex. The slight flattening of the carina probably indicates the presence of a slit-band. The ornament shown on a fragment of the external impression of the shell seems to consist of fine, sharp transverse striæ bending back rather suddenly to meet the carinal edge at 30°—45°. In another specimen [28090] from Malvern in the Jermyn Street Museum labelled *B. murchisoni*, the ornamentation, which is well preserved, consists of thin transverse lamellæ with fimbriated edges as in *T. pharetra* (Lindström),[1] but the lamellæ are closer and more regular than in that species. The slit-band is well seen, and shows strongly arched, widely separated lunulæ, as in that species.

[1] Lindström, *op. cit.*, p. 83, pl. vi, figs. 39–51.

It is undoubtedly the case that this shell should be referred to the genus *Temnodiscus*, and it is allied to the Swedish species *T. pharetra* and *T. arrosus* (Lindstr.).[1]

Férussac and D'Orbigny[2] gave the following specific diagnosis of *B. murchisoni*, which was proposed by them for the pre-occupied name *striatus*: "Coquille ovale, comprimée, finement striée en travers avec quelques lignes d'acroissement sur les cotés, formant des stries en sautoir sur la partie dorsale, qui est un peu carénée. Spire croissant très rapidement, visible en entier dans l'ombilie. Bouche triangulaire, un peu cordiforme. La moule est presque lisse." Both the Devonian of Wissenbach and the Silurian localities in England quoted by Murchison are given for its occurrence, for D'Archiac and de Verneuil[3] recorded it from the Devonian of Wissenbach. The form from the Devonian of Argentina which Kayser[4] considered to be allied to *B. murchisoni* is placed by Knod[5] in his new species *B. globosus* which typically occurs in the Devonian of Bolivia. Holzapfel[6] points out that Sowerby's specific name *B. striatus* was pre-occupied by an Upper Devonian species named by Bronn in 1835, and restricts it to the latter.

4. **Temnodiscus salopiensis,** sp. nov. Plate IX, fig. 10.

Specific Characters.—Shell high, narrow, compressed, cornuate, composed of 1—1¼ whorls not in contact; umbilicus open, perforated, the proximal end of shell nearly touching the distal portion near mouth. Whorl lanceolate in cross-section, higher than wide, rapidly increasing in size; sides rounded, slightly inflated; dorsum narrow, with high, narrow, suddenly elevated and compressed keel bearing slit-band. Mouth simple (?), not expanded. Surface of whorls with sides crossed by strong narrow transverse ribs, nearly straight, mostly equidistant, sloping a little back to meet keel nearly at right angles, then bending back more strongly to cross it obliquely as thick, distant lunulæ swelling out into small nodes so as to give a serrated aspect to the keel. Interspaces between ribs smooth.

Dimensions [G. 17506].—Height of shell, 12·0 mm.; width of whorl near mouth, 4·5 mm.; height of whorl near mouth, 6·5 mm.

Horizon.—Wenlock Limestone.

Locality.—Shropshire.

[1] *Ibid.*, p. 83, pl. vi, figs. 52, 53.

[2] Férussac and D'Orbigny, 'Hist. Nat. Ceph.' (1835—1848), vol. i, p. 210, pl. vii, figs. 1—3.

[3] D'Archiac and De Verneuil, 'Trans. Geol. Soc. Lond.' [2], vol. vi (1842), p. 210, pl. xxviii, figs. 7, 8.

[4] Kayser, 'Zeitschr. deutsch. geol. Gesell.,' Bd. xlix (1897), p. 287, t. x, fig. 9.

[5] Knod, 'Neues Jahrb. f. Miner. Geol.,' Beil. Bd. xxv (1908), p. 503, pl. xxii, figs. 1, 2.

[6] Holzapfel, 'Abh. k. preuss. geol. Landesanst.,' N.F. Heft xvi (1895), p. 208.

Remarks.—Only the single specimen [G. 17506] of this species in the British Museum is known to me. It is allied to *T. lamellifer* (Lindstr.),[1] but differs in the transverse ribs not being lamellose or fimbriated and by their inclination to the keel being more at right angles, as well as by the interspaces being smooth and by the whorl increasing less rapidly in size.

5. **Temnodiscus solitarius,** sp. nov. Plate IX, fig. 11.

Specific Characters.—Shell high, narrow, compressed, cornuate, composed of $1\frac{1}{2}$ whorls in contact, but not overlapping; inner whorls absent, leaving umbilicus perforated. Whorls lanceolate in cross-section, rapidly increasing in height, more than twice as high as wide, with gently convex sides, and high compressed carina bearing narrow slit-band on summit. Mouth simple. Umbilicus small, open, perforated, situated at about one-fourth the height of shell. Surface of whorls ornamented with regular equidistant thick transverse lines, closely placed, fimbriated minutely and set with transverse granules connected with fine lines across interspaces, arched gently back on sides, but more strongly near carina, where they become finer and closer and meet slit-band at about 30°. Slit-band narrow, not clearly defined, crossed by strong lunulæ.

Dimensions.—Height of shell about 11·5 mm.

Horizon.—Upper Ludlow (Whitecliffe Group, *Sp. elevatus* Beds).

Locality.—Ludford Lane.

Remarks.—This shell, which was recorded as *Bellerophon murchisoni* by Misses Elles and Slater,[2] resembles *T. lamellifer* (Lindstr.), the type of the genus, in shape and perforated umbilicus, but in ornament is more like *T. arrosus* (Lindstr.)[3] and *T. pharetra* (Lindstr.).[4] There is no described British species like it.

Genus **BELLEROPHON,** Montfort (sens. str.).

Generic Characters.—Symmetrically involute, subglobose shells, with or without an umbilicus, the latter never very large in the typical section; whorls more or less rounded on the back; aperture generally expanded, usually with a callosity on the inner lip; dorsal lip with a more or less deep central emargination behind which there is a well-developed slit-band; surface sculpture consisting of more or less strongly-developed transverse striæ of growth. Type, *B. casulites*, Montfort.[5]

[1] Lindström, *op. cit.*, p. 82, pl. vi, figs. 31—38.

[2] Elles and Slater, 'Quart. Journ. Geol. Soc.,' vol. lxii (1906), p. 219.

[3] Lindström, *op. cit.*, p. 83, pl. vi, figs. 52—53.

[4] *Ibid.*, p. 83, pl. vi, figs. 39—51.

[5] Montfort, 'Conchyl. System.,' vol. i (1808), p. 51.

Perner[1] quoted the definition of the genus given by Ulrich and Scofield,[2] which restricts its scope to a considerable extent. But not only Ordovician and Silurian, but Devonian, Carboniferous and Permo-Carboniferous species are included by these American authors in this genus, though it seems capable of further subdivision. Perner divides the Bohemian Ordovician and Silurian representatives into three sections or subgeneric groups, their criteria being the length of the dorsal fissure behind the emargination, the size and depth of the umbilicus, the shape and direction of the lateral lips (apertural lobes) of the mouth and the character of the sculpture of the surface. These three divisions are named *Sphærocyclus*, *Cœlocyclus* and *Prosoptychus*, and are characterised as follows:

(1) *Sphærocyclus.*—Traces of spiral sculpture on surface; dorsal slit relatively long (about one-third the length of the whorl); mouth not enlarged; slit-band broad; umbilicus deep without callosity. Type *B. bohemicus*, Barr.

(2) *Cœlocyclus.*—Shell spherical; umbilicus very deep, wide, open, exposing inner whorls; slit-band broad, elevated; umbilical edge (sides of whorl) subangular to angular. Type *B. rarissimus*, Barr.

(3) *Prosoptychus.*—Last half of outer whorl ridged, more or less straightened, laterally enlarged; apertural lobes surround or conceal umbilicus.

The spiral sculpture on *Sphærocyclus* recalls *Bucaniopsis*, which seems to have a greater warrant for generic rank than *Sphærocyclus*. The genus separated off as *Cymbularia*, Koken, owing to the infolding of the apertural margins, which is not mentioned by its founder as characteristic, may otherwise be only a subgeneric group of *Bellerophon*.

It is not possible to refer all the British species to one or other of these subgeneric divisions, principally on account of our imperfect knowledge of their characters; moreover, it is possible that other new groups should be formed to receive some of them.

1. **Bellerophon globulus,** Lindström. Plate IX, figs. 12, 13.

1873. *Bellerophon dilatatus,* Sowerby, Salter, Catal. Camb. Silur. Foss. Woodw. Mus., p. 157 (*a*/877) (*non B. dilatatus*, Sowerby, 1839, in Murchison's Silur. Syst.).
1884. *Bellerophon globulus*, Lindström, Silur. Gastrop. Pterop. Gotland, p. 75, pl. v, figs. 25–34.

Specific Characters.—"Shell of somewhat variable form, globular, ovate or elliptical in outline; surface of a dark glossy hue, almost smooth, with extremely fine, densely-packed transverse striæ, which join the slit-band at an angle of 38°, bend outwards towards the sides and again converge towards the umbilicus.

[1] Perner, *op. cit.*, pp. 130, 131.
[2] Ulrich and Scofield, *op. cit.*, p. 853.

The slit-band forms an elevated keel with a flat top, on each side bordered by a fine line and wavy with the minute and delicate lines of growth. Whorls four and a-half, regularly increasing in width, twice as large as high and consequently not so narrow as in *B. sphæra*. Shell thick and as common in the genus [at] thickest around the umbilicus and at the inferior corners of the aperture. The last whorl, when seen from the side, is straight or only faintly curved, and its apertural and dorsal contours are nearly parallel. . . . The inferior corners of the aperture near the umbilicus where the shell is [at] thickest, are rounded or cylindrical, and completely hide the umbilicus, which in young specimens is open" (Lindström).

There are several shells in the Sedgwick Museum labelled by Salter *Bellerophon dilatatus* which completely agree in all essentials with Lindström's *B. globulus*. The subquadrate semi-elliptical shape of the whorls, the straightening of the last whorl, the high expanded mouth, the narrow raised slit-band flattened at the top, are just as Lindström describes and figures. The transverse striæ on the shell, though they meet the slit-band at an angle between 35° and 45° as in the Swedish form, are not always extremely fine and densely packed, for they may be rather irregular in strength, though fine on the whole. One specimen (*a*/877) from the Wenlock Limestone, Dudley, in the Sedgwick Museum, has the slit-band, shell and surface ornament well preserved, and they agree precisely with Lindström's figures and descriptions. Internal casts of the species are, however, as a rule only preserved, and these have frequently been labelled *B. wenlockensis*. But *B. globulus* is less globose in shape, the whorls are relatively higher, the cross-section is semi-elliptical and not so transverse. The sides tend to be somewhat flattened, and the dorsum is only distinctly angulated towards the mouth. The shape of the whorls, degree of convexity of the dorsum and expansion of the mouth vary somewhat in this species, as Lindström himself has pointed out.

Dimensions.—Height of shell, c. 43 mm.; width of mouth, c. 50 mm.

Horizons.—(1) Wenlock Limestone; (2) Lower Ludlow; (3) Upper Ludlow?

Localities.—(1) Dudley; Dormington Wood, Woolhope; (2) Ledbury; Dudley; (3) Kendal [28102, 28103] (Jermyn Street Museum).

2. **Bellerophon ledburiensis,** sp. nov. Plate IX, fig. 14.

1878. *Bellerophon wenlockensis*, Sowerby, Salter, Cat. Camb. Silur. Foss., Mus. Pract. Geol., p. 113.

Specific Characters.—Shell globose, involute, outer whorl completely enveloping inner whorls and slowly increasing in size to mouth. Umbilicus closed, with stout rod-like callosity projecting from it. Whorl transverse, more than twice as wide as high; dorsum broad, rounded, gently convex; sides rounded, inflated. Slit-

band narrow, slightly raised, with fine median line along it; lunulæ very delicate and numerous. Mouth with basal inner angle of lip reflected across umbilicus and recumbent on whorl. Surface of shell crossed by strongly arched fine transverse striæ meeting slit-band at about 20°, with traces of low rounded similarly arched transverse ridges; transverse lines crossed by fine somewhat broken oblique revolving lines set at rather wide equal distances apart and inclined to slit-band at about 60°.

Dimensions [28080].—Height of shell, 30 mm.; width of dorsum, 32 mm.; height of outer whorl, 15 mm.

Horizon.—Wenlock Limestone.

Locality.—Near Ledbury.

Remarks.—This shell is undoubtedly distinct from *B. wenlockensis*, and in shape and ornament more resembles *B. bohemicus*, Barr.,[1] from Stage Ff2. From the nature of the ornamentation it might seem that this species should be placed in the genus *Bucania*, but the closed umbilicus, reflected basal lip and umbilical callosity are more important, and it is preferable to place it in *Bellerophon*. Only the one specimen [28080, Mus. Pract. Geol.] is known to me.

3. **Bellerophon ruthveni** (Salter MS).

1873. *Bellerophon ruthveni*, Salter, Cat. Camb. Silur. Foss. Woodw. Mus., p. 186.
1891. *Bellerophon ruthveni*, Salter, Woods, Cat. Type Foss. Woodw. Mus., p. 96.
1901. *Bellerophon ruthveni*, Salter, Reed, Geol. Mag. [4], vol. viii, p. 358, pl. xv, figs. 5, 6.

No further details can be added to the description of this species given by me in 1901, for no better specimens are available. The species is imperfectly known and cannot be defined precisely. Salter's definition was as follows: "Smaller than *B. dilatatus* and with the band angular, and the whorls angular where the band becomes so. Very common, $1\frac{1}{4}$ inches wide." The aperture is transverse and widely expanded with rounded lateral lobes; there is a wide, sharply **V**-shaped sinus in the outer lip; the slit-band is very narrow and sunk in a groove between slightly elevated margins. The dorsum of the outer whorl near the mouth seems to be more strongly arched and carinated, but this may be due to the crushing of the specimens. There seem to be traces of one or two spiral thread-like lines running parallel and close to the slit-band and slightly diverging towards the mouth, and there are faint transverse simply arched growth-lines on the lateral lobes.

Horizon.—Kirkby Moor Flags (Up. Ludlow).

Locality.—Benson Knot, Kendal.

[1] Perner, *op. cit.*, p. 132, text-fig. 94 *e*.

4. **Bellerophon sphæra**, Lindström, var. nov. **judex.** Plate IX, fig. 15.

Varietal Characters.—Shell globose, involute, outer whorl completely enveloping inner whorls; umbilicus closed, central. Whorls rounded, wider than high; dorsum and sides convex, more or less inflated. Slit-band narrow, slightly elevated. Mouth slightly expanded, transversely semi-elliptical, with the lower lip slightly reflected and adherent. Surface of shell crossed by gently arched fine striæ of rather irregular size meeting slit-band at acute angle (30°—45°).

Dimensions.—Height of shell, 35 mm.; thickness at umbilicus c. 22 mm.; width of mouth, c. 40 mm.

Horizons.—(1) Mulloch Hill Group, Lower Llandovery. (2) Saugh Hill Group, Upper Llandovery.

Localities.—(1) Mulloch Hill, Girvan; (2) Woodland Point, Girvan.

Remarks.—The general characters of this shell seem to show that it is specifically inseparable from *B. sphæra*, Lindstr.,[1] but the less coarse and less regular ornamentation may be regarded as sufficient to put it as a variety. The absence of carination of the dorsum and the different ornamentation show that we cannot refer it to *B. wenlockensis*. As in the case of the Gotland shells there seems to be some variation in the globosity of our specimens, but the Woodland Point examples are too much crushed to determine their original shape.

5. **Bellerophon wenlockensis,** Sowerby. Plate IX, fig. 16.

1839. *Bellerophon wenlockensis*, Sowerby, in Murchison's Silurian System, p. 633, pl. xiii, fig. 21.
(*Non* 1841. *Bellerophon wenlockensis*, Sowerby ? Phillips, Palæoz. Foss. Cornw. Dev., p. 108, pl. xl, fig. 203.)
1848. *Bellerophon wenlockensis*, Sowerby, Férussac and d'Orbigny, Hist. Nat. Ceph., vol. i, p. 189, pl. viii, fig. 7.
1852. *Bellerophon wenlockensis*, Sowerby, McCoy, Syn. Brit. Pal. Foss. Woodw. Mus., p. 311.
1875. *Bellerophon wenlockensis*, Sowerby, Baily, Charact. Brit. Foss., vol. i, Palæoz., p. 65, pl. xxii, fig. 2.
1884. *Bellerophon wenlockensis*, Sowerby, J. D. La Touche, Handbook to the Geology of Shropshire, p. 73, pl. xiv, fig. 492.

Specific Characters.—Shell subglobose to globose, involute, outer whorl nearly completely embracing inner whorls. Umbilicus small, deep, nearly concealed by downward extension of lateral angles of mouth. Outer whorl slowly increasing in size, very transverse, more than twice as wide as high, sides rounded, inflated; dorsum convex, rounded, except near mouth, where a low sharp narrow keel is developed. Slit-band narrow, raised, with sharp elevated edges and numerous

[1] Lindström, *op. cit.*, p. 74, pl. iii, figs. 35–38; pl. v, fig. 1—16.

strong lunulæ. Mouth slightly expanded towards base; dorsal sinus forming very obtuse V (about 100°—110°), followed by narrow, straight, open slit which extends fully one-third the length of the whorl; lateral lobes rounded, arched forward. Surface of shell ornamented by transverse arched, strong, sublamellose squamous lines, rather closely-set, but not always equidistant or equal, somewhat undulated in places, curving back gently to meet the slit-band at about 60°, becoming coarser and less regular near the margins of mouth (with short, closely-placed fine cross lines in interspaces of some specimens).

Dimensions:	I	II (G. 15775)
Height of shell	55 mm.	50 mm.
Thickness at umbilicus	c. 37 „	c. 31 „
Height of outer whorl near mouth	c. 20 „	c. 18 „
Width of „ „	c. 50 „	c. 46 „

Horizon.—(1) Wenlock Limestone; (2) ? Llandovery Beds.

Localities.—(1) Ledbury; Wenlock; Croft, Malvern; Woolhope; Dudley. (2) The Frolic, Haverfordwest; Blaen-y-cwm.

Remarks.—Of this species Sowerby gave no specific diagnosis, but merely said: "This species differs a little from the species [*B. tenuifascia*] of the Carboniferous Limestone ('M. C.,' vol. v, p. 109, pl. ccccIxx, figs. 2, 3) figured in 'M. C.,' but it is difficult to indicate a real difference owing to the calcareous spar having taken the place of the shell. We assign it provisionally the name *B. wenlockensis*. Loc. Wenlock; Croft, Malvern."

Sowerby's figured type-specimen [6708], in the Jermyn Street Museum, is from Ledbury, and is an internal cast covered with crystalline calcite. There is a more perfect example (G. 15775) in the British Museum from the same locality; but neither of them shows any ornament or has the shell preserved. Better specimens from Dudley and Woolhope are in the Sedgwick Museum. McCoy gave the following definition: "Globose, periphery and sides obtusely rounded; umbilicus very small, mouth transversely lunate, rounded at the sides, forming a deep, obtuse V-shaped sinus in the middle, the sides of which meet at an angle of 105°, which is also the angle at which the coarse, very irregular, close, subimbricating ridges of the surface meet the keel; keel about half a line wide, strongly defined, prominent (traces in parts of very minute spiral striæ roughening the transversely arched ones). Width at mouth $2\frac{1}{2}$ inches, proportional diameter $\frac{8}{100}$, diameter of mouth $\frac{47}{100}$, diameter of umbilicus $\frac{13}{100}$. Rare in the Wenlock Limestone of Woolhope."

The specimen *a*/627 on which McCoy based this specific description is in the Sedgwick Museum, and it is from this one that I have drawn up the diagnosis of the species.

The other specimens in the same Museum are from Dudley (*b*/823, Salter's Catalogue) and are merely internal casts. The characters therefore of the slit-band and ornamentation of the surface are ascertained from the Woolhope specimen.

The species appears to be allied to *B. squamosus*, Lindstr.,[1] especially in the matter of its ornamentation, but the mouth is less expanded, and the shell is relatively broader and more globose, the dorsum also being more broadly rounded. Perner would place it in his group *Sphærocyclus*.

There are many poorly preserved specimens from the Llandovery Series of the Frolic, Haverfordwest, and one [28044] in Jermyn Street from Blaen-y-cwm, which seem inseparable specifically from *B. wenlockensis*. In the shape of the shell, characters of slit-band, partial carination of the distal portion of the outer whorl and course of striæ on the surface, they completely agree; but the striæ seem less regular in size and distribution than in typical Wenlock examples, and therein more resemble *B. squamosus*, Lindstr.

The Devonian shell from Newton referred by Phillips[2] to *B. wenlockensis*, Sow., with a query, seems to have been a very poor specimen and its specific reference quite indeterminable.

6. **Bellerophon ? solvensis**, Hicks.

1873. *Bellerophon solvensis*, Hicks, Quart. Journ. Geol. Soc., vol. xxix, p. 50, pl. iii, fig. 33.

Specific Characters.—"A small species, of three very gradually increasing whorls, about one-eighth of an inch in diameter. Surface smooth, sides inflated."

The small specimen on which Hicks founded this species is an internal cast which does not admit of precise determination, and its generic position in modern classification is doubtful. It should be added to Hicks' diagnosis that the umbilicus is open and rather deep, exposing the 2 or 3 inner whorls; and that the section of the whorls is transversely elliptical or subcircular. It may belong to the group *Cœlocyclus* of *Bellerophon* or to *Bucania*.

Horizon.—Arenig Series.

Locality.—Tremanhire, near Solva, and St. David's.

Genus **BUCANIOPSIS**, Ulrich.

Generic Characters.—Shell agreeing in all respects with *Bellerophon* except that the surface is cancellated by regular revolving and transverse striæ. Whorls enlarge rapidly, giving a broadly expanded aperture. Umbilicus of moderate size

[1] Lindström, *op. cit.*, p. 75, pl. v, figs. 25—34.

[2] Phillips, 'Palæoz. Foss.' (1841), p. 108, pl. xl, figs. 203 *a*, *b*; Whidborne, 'Mon. Brit. Devon. Fauna' (Palæont. Soc.), vol. i (1892), p. 329.

or entirely closed. Inner lip somewhat thickened. Revolving lines never oblique or wrinkled.

The type-species is *Bucaniopsis carinifera*, Ulrich,[1] of the Trenton Formation, and the definition of the genus was first given by Ulrich and Scofield in 1897 (*op. cit.*, p. 853).

Perner (*op. cit.*, p. 156) adopts this name and recognises it as a distinct genus, but I am not convinced that the presence of spiral lines is sufficient to warrant its generic separation from *Bellerophon*, for as Perner points out it agrees in all other respects with *Bellerophon*, and spiral lines (though subordinate to the transverse ones) are found in the subgenus *Sphærocyclus* belonging to the latter. However, in the present state of our knowledge it would cause unnecessary confusion to alter the customary usage of the name; but its relegation to a lower rank as a subgenus instead of a genus appears to be desirable. The name was spelt *Bucanopsis* by its author, but *Bucaniopsis* is undoubtedly the correct orthography.

1. **Bucaniopsis expansus** (Sowerby). Plate X, figs. 1—4.

1839. *Bellerophon expansus*, Sowerby in Murchison's Silurian System, p. 613, pl. v, fig. 32.
(?) 1839. *Bellerophon globatus*, Sowerby, *ibid.*, p. 604, pl. iii, fig. 15; p. 613, pl. iv, fig. 50.
1848. *Bellerophon expansus*, Férussac and D'Orbigny, Hist. Nat. Cephal., vol. i, p 185, pl. viii, fig. 1.
1852. *Bellerophon expansus*, Sowerby, McCoy (*pars*), Syn. Brit. Pal. Foss. Woodw. Mus., fasc. ii, p. 309.
1884. *Bellerophon expansus*, Sowerby, J. D. La Touche (*pars*), Handbook to the Geology of Shropshire, p. 81, pl. xix, figs. 643, 644?.
1909. *Bellerophon expansus*, Sowerby, Moberg and Grönwall, Om Fyledalens Gotlandium (Lunds), Univ. Arsskr., n.f. afd. 2, bd. 5, nr. 1, p. 41, pl. iii, figs. 5, 6, 7.

Specific Characters.—Shell involute, composed of a few transverse, rounded, convex whorls; outer whorl nearly completely enveloping inner ones, somewhat straightened and very rapidly expanding in width and height to mouth where it becomes obtusely carinate; dorsum strongly arched, convex, sides swollen. Umbilicus small, deep, with rounded edges, situated at less than one-third the height of shell. Mouth very large and high, transversely expanded, with wide rounded subcircular lateral lobes, broad reflected lower lip, and open bluntly V-shaped dorsal sinus. Slit-band of moderate width, not raised, but bordered on each side by a narrow thread-like line, and crossed by fine indistinct lunulæ and marked with 5—6 delicate revolving lines similar to but finer than those on rest of shell. Surface of shell ornamented with regular continuous rounded revolving lines, closely placed, of equal or subequal size and rarely interrupted by a few fine simply arched transverse striæ curving back to meet slit-band at about 45°.

Dimensions [28079].—Height of shell, 15·0 mm.; height of mouth, 11·5 mm.; width of mouth, 16·5 mm.

[1] Ulrich and Scofield, *op. cit.*, pp. 853, 922, 925, pl. lxii, figs. 56—61.

Horizon.—Upper Ludlow.

Localities.—Ludlow [28079]; Trewerne Hills; Castel Dinas Bran, Llangollen; Brigsteer, Kendal; Frith Farm, Malvern [28078].

Remarks.—Good specimens from Ludlow showing the ornamentation and slit-band, such as were described and figured by Moberg and Grönwall (*op. cit.*), occur in the Jermyn Street Museum [28078, 28079], and others in the Sedgwick Museum show the slit-band, but not the revolving lines on the surface. The latter are not seen in internal casts, and the type [6700] does not show them, being merely a poor impression of the apertural part of the shell.

Sowerby's description of the species was very brief: "Spire small, rounded; aperture very large, two-lobed, twice as long as broad; sinus broad and short. Length of aperture $7\frac{1}{2}$ lines; width of ditto 11 lines." Though he does not mention the slit-band, yet there is clear evidence of its presence in his figured specimen.

McCoy's definition of the species is valueless, for he combined shells of more than one type and from more than one stratigraphical horizon.

It has been believed that Sowerby's *B. globatus*[1] from the Tilestones of Felindre and Upper Ludlow Bone-bed is identical,[2] but the type-specimen cannot be found and the question must therefore be left unsettled.

2. **Bucaniopsis forbesi,** sp. nov. Plate X, figs. 5, 6.

Specific Characters.—Shell high, of few whorls, nearly involute; umbilicus very small, about one-fifth diameter of shell, deep, with centre situated at about one-fourth (?) the height of shell. Outer whorl large, rapidly expanding in height to mouth and less rapidly in width; dorsum rounded, becoming slightly carinate towards mouth. Mouth large, higher than wide, from half to two-thirds the height of shell. Slit-band rather broad, slightly depressed, inconspicuous (? bearing several closely placed revolving lines), with edges defined and raised. Surface of shell covered with fine cancellation produced by numerous fine sub-equidistant revolving lines parallel to slit-band closely decussated by equally strong gently arched transverse lines meeting slit-band at about 60°.

Dimensions.—Height of shell (distorted), c. 20 mm.; height of mouth (distorted), c. 12 mm.

Horizon.—Whitehouse Group, Middle Ordovician.

Locality.—Shalloch Mill, near Girvan.

Remarks.—Only two somewhat distorted examples of this shell in Mrs. Gray's collection have come under my notice, but they have the ornamentation well preserved in places, and in general characters they resemble *Bucaniopsis carinifera*,

[1] Sowerby in Murchison's 'Silur. Syst.,' p. 604, pl. iii, fig. 15; *ibid.*, p. 613, pl. iv, fig. 50

[2] McCoy, 'Syn. Pal. Foss. Woodw. Mus.,' fasc. ii, p. 309; Salter, 'Cat. Camb. Silur. Foss. Woodw. Mus.,' pp. 68, 192.

Ulrich,[1] and to a less extent *B. calypso*, Perner,[2] while *B. eiseni* (Lindström)[3] may also be compared.

3. **Bucaniopsis nicoli**, sp. nov. Plate X, figs. 7—9.

Specific Characters.—Shell high, of few whorls rapidly increasing in size, much expanded at mouth. Umbilicus small, deep, about one-fifth or one-sixth the height of shell. Outer whorl wider than high, rapidly increasing in size near mouth; dorsum rounded, convex in early part of whorl, but becoming decidedly carinate towards mouth, bearing narrow slightly elevated slit-band with a narrow groove along each side of it; umbilical edges subangular; umbilical slope short, steep. Mouth very large with broad open **V**-shaped sinus in outer lip; large rounded prominent apertural lobes expanded at right angles to plane of shell, and large strongly deflected inner lip reaching nearly to base of shell. Surface of shell finely cancellated by numerous regular closely-placed thread-like revolving lines of subequal size parallel to slit-band, becoming slightly sinuous and divergent on apertural lobes, crossed by much more delicate transverse arched striæ meeting slit-band at 60°—75°. Strong growth-line and ridges concentric to margin in peristome.

Dimensions.—Height of shell, 18 mm.; height of mouth, 13 mm.; width of mouth, 19 mm.

Horizons.—(1) Drummuck Group (Starfish Bed) (Upper Ordovician); (2) Bala Series.

Localities.—(1) Thraive Glen; Drummuck, Girvan; (2) Onny River, Shropshire.

Remarks.—This shell is much like the imperfectly known *B. forbesi* from Shalloch Mill, but the mouth seems larger and the whole shell broader, and it more resembles the Silurian *B. expansus*.

There is one specimen [28042] in the Jermyn Street Museum from the Bala beds of the Onny River, Shropshire, which seems inseparable from the Girvan form above described. It shows the dorsal aspect and the outline of the mouth and has the ornamentation beautifully preserved. The revolving lines show a tendency to be alternately thick and fine, but perhaps this feature may be sufficient to regard the shell as marking a variety. The dimensions of the specimen are as follows: Height of shell, 13 mm.; width of mouth, 17 mm.

4. **Bucaniopsis ?** cf. **latevittatus** (Lindström).

Some internal casts of a *Bellerophon* in the Sedgwick Museum from the Wenlock Limestone of Dudley belong to a very broad low globose shell with

[1] Ulrich and Scofield, *op. cit.*, p. 925, pl. lxii, figs. 56—61.

[2] Perner, *op. cit.*, p. 157, text-fig. 110 *a*—*c*.

[3] Lindström, *op. cit.*, p. 78, pl. vi, figs. 19—21.

unusually low transverse whorls, the width being four or five times the height, which is very small. The dorsum is broadly rounded and there is no trace of angulation. Unfortunately the shell itself is not preserved, but in *B. laterittatus*, Lindstr.,[1] and *B. pilula*, Lindstr.,[2] it is stated to possess revolving as well as transverse striæ. In shape and external characters, so far as preserved, our shell may be compared with these species. Lindström (*op. cit*, p. 74), on the strength of the ornamentation, refers these Swedish shells to the genus *Bucania* of Waagen and De Koninck, but Ulrich and Scofield[3] refer *B. laterittatus* to the genus *Bucaniopsis*.

Dimensions:	I	II
Height of shell	20 mm. .	23 mm.
Width of shell at umbilicus .	16 „ .	18 „

Horizon.—Wenlock Limestone.

Locality.—Dudley.

5. **Bucaniopsis ?** sp.

Specific Characters.—Shell of few whorls, outer whorl very rapidly expanding in size, especially in width; dorsum broadly rounded; umbilicus deep, open; umbilical edge subangular, umbilical slope steep. Whorls transverse, wider than high. Mouth very large and broad, transversely subcordate, with lateral and lower lips suddenly expanded at right angles to plane of spiral; lower lip impressed by early part of outer whorl but descending below it and somewhat reflexed; outer lip not reflexed, with large open V-shaped sinus and rounded apertural lobes.

Dimensions.—Height of mouth including lips, c. 32 mm.; width of mouth including lips, c. 50 mm.; height of shell without lips, c. 17 mm.; width of distal end of outer whorl, c. 15 mm.; height of distal end of outer whorl, c. 9 mm.

Horizon.—Llandovery Beds D.

Locality.—The Frolic, Haverfordwest.

Remarks.—There is one fair internal cast and one imperfect apertural view of another specimen in the Sedgwick Museum referable to a species which is undoubtedly distinct from other British forms. It is not possible to make out the characters of the surface or slit, but the broadly expanded mouth, the rapidly increasing size of the outer whorl and the deep open umbilicus with subangular edges resemble *B. mohri*, Miller,[4] from the Richmond Beds of Indiana and

[1] Lindström, *op. cit.*, p. 79, pl. vi, figs. 26—28.

[2] *Ibid*, p. 80, pl. vi, figs. 29, 30.

[3] Ulrich and Scofield, *op. cit.*, p. 853.

[4] Miller, 'Cincinnati Quart. Journ. Sci.,' vol. i (1874), p. 306, fig. 30; Ulrich and Scofield, *op. cit.*, p. 920, pl. lxiv, figs. 44, 45.

Kentucky, rather than any European species. The generic reference of this Welsh form is doubtful, but probably it belongs to *Bucaniopsis*.

Genus **CYMBULARIA**, Koken.

Generic Characters.—Shell involute, more or less laterally compressed; umbilicus closed on one or both sides. Outer whorl with distal portion angulated and carinated, but rest of whorl rounded. Aperture with long narrow dorsal slit and lateral lips infolded. Otherwise like *Bellerophon*.

This genus was established by Koken[1] in 1896 with *Bellerophon cultrijugatus*, Roemer,[2] from a boulder of Orthoceras Limestone, as its type. This species has apparently a closed umbilicus, though Koken says the genus has an open one, but he included *B. globulus*, Lindstr., which has it closed, and Perner has pointed out that the umbilicus may be closed only on one side by a callosity. The outer half of the last whorl is said to be characterised by a prominent keel and to be compressed, with a narrow dorsal slit reaching some distance back; but the rest of the dorsum is rounded. There is an occasional want of symmetry in the shell to which Perner calls attention. But Koken makes no mention of the infolding of the lateral edges of the mouth as shown in his figure of *C. galeata*, Koken,[3] the first member of his genus which he illustrates. This feature is also well seen in the so-called *Bellerophon* (*Oxydiscus ?*) *incola*, Barrande, as figured by Perner.[4] It is a character of some importance and is found also in the genus *Euphemus* as understood by Waagen.[5] The expanded mouth of *Bellerophon* with frequently outwardly bent margins is strikingly different. Neither in Zittel-Eastman's Textbook (2nd ed., 1913) nor in Bassler's Index (Bull. 92, U.S. Nat. Mus., 1915) is the genus mentioned. The angulation or carination of the distal part of the last whorl near the mouth is found also in Perner's *Prosoptychus*, a section of *Bellerophon*; but the umbilicus is always closed, and the lips are reflected in that section.

1. **Cymbularia alata** (Portlock). Plate X, figs. 10, 11.

1843. *Bellerophon alatus*, Portlock, Geol. Rep. Londond., p. 471, pl. xxxiii, fig. 9.

Specific Characters.—Shell involute, lenticular, thickest at umbilicus; whorls triangular, as high or rather higher than wide; outer whorl completely enveloping inner whorls, with acutely angulated dorsum; sides slightly convex or flattened

[1] Koken, 'Leitfossilien' (1896), p. 392.

[2] Roemer, 'Leth. Geogn.,' vol. i, Palæoz. (1876), Atlas, pl. v, figs. 10 *a*, *b*.

[3] Koken, 'Gastrop. Balt. Untersilur.,' Bull. Acad. Imp. Sci. St Pétersb., ser. v, vol. vii, no. 2, 1897, p. 115, fig. 2.

[4] Perner, *op. cit.*, p. 160, pl. lxxxvii, figs. 9—11.

[5] Waagen, 'Salt Range Fossils' ('Palæont. Ind.,' ser. xiii), vol. i (1887), p. 163, pl. xiv, figs. 9*a*—*d*.

and meeting at 60°—70°. Slit-band narrow, slightly elevated on carina. Umbilicus completely closed, subcentral, with callosities projecting laterally and supporting expanded basal angles of mouth. Mouth triangular, widest at base, with shallow broad open V-shaped sinus in upper lip and infolded (?) lateral lips. Surface of shell ornamented by strong widely-spaced equidistant lamellose lines arched back gently but bending back suddenly close to slit-band to meet it at about 30°.

Dimensions.—Height c. 30 mm.; thickness at base of mouth c. 35 mm.

Horizon.—Bala Beds.

Locality.—Desertcreat, Tyrone.

Remarks.—The want of symmetry noticed by Portlock may be due to the distortion of the specimen, or it may be natural, for *Cymbularia* is frequently asymmetrical, as Perner has noticed and as Lindström[1] has mentioned to be the case in his *Bellerophon* [*Cymbularia*] *fastigiatus*. The species is imperfectly known, and there are only three crushed examples for examination. The type-specimen [27998] and the paratypes [27999 and 28000] are all in the Jermyn Street Museum.

The original description is meagre and runs as follows: "Back sharply angular; aperture expanded, with flattened wing-like sides, triangular from the angularity of the back, and without a sinus; spire suddenly involute, not umbilicated. The striæ proceeding from the wings to the back are curved, and the wings have also a twisted appearance and are not quite symmetrical."

The relations of this species to *C. drummuckensis* from the Drummuck Beds (Up. Bala) of Girvan (see below) are close, but the ornamentation of the surface is different.

2. **Cymbularia carinata** (Sowerby). Plate X, fig. 12.

1839. *Bellerophon carinatus*, Sowerby, in Murchison's Silurian System, p. 604, pl. iii, fig. 4, and 1 *d*.
? 1839. *Bellerophon carinatus*, Sowerby, *ibid.*, p. 613.
1848. *Bellerophon carinatus*, Sowerby, Férussac & D'Orbigny, Hist. Nat. Cephal., vol. i, p. 209, pl. ix, fig. 12.
1852. *Bellerophon carinatus*, Sowerby, McCoy (pars), Syn. Brit. Pal. Foss. Woodw. Mus., fasc. ii, p. 309.

Specific Characters.—Shell sublenticular, of few whorls, somewhat compressed. Umbilicus open, rather deep, with a diameter of less than one-third the height of the shell, with subrectangular umbilical edge and very short steep umbilical slope. Whorls subtriangular, but rounded in cross-section; inner whorls partly exposed in umbilicus; outer whorl rather rapidly expanding in height and width, with gently convex sides and subangular dorsum bearing carina. Mouth transversely

[1] Lindström, *op. cit.* p. 77.

expanded, broadly triangular, with basal angles projecting laterally. Slit-band situated on slightly elevated compressed keel. Surface of shell smooth?

Dimensions.—Height of shell [6655] c. 8 mm.

Horizon.—Upper Ludlow (Passage Beds).

Localities.—Horeb Chapel [6655]; Bradnor Hill; S. of Trichrug, Llangadock [28097—28099]?

Remarks.—The type-specimen [6655] from Horeb Chapel in the Jermyn Street Museum is an imperfect internal cast partly embedded in matrix, but showing the umbilicus on one side. Only internal casts of the species are known. Sowerby's original description is brief and runs as follows: "Convoluted, compressed, keeled, smooth; inner whorls several, small, partly visible; aperture an equilateral triangle." He also recorded the species from the Upper Ludlow of Bradnor Hill (*op. cit.*, p. 613), but gave no figure.

It has been often recorded from the Llandovery beds, but its occurrence in them is highly doubtful, the specimens thus labelled in the Jermyn Street and British Museums from Bog Mine, Shelve, Eastnor Park and Llandovery apparently belonging to a variety or even another species (see next page).

In spite of the opinion of many palæontologists that *B. carinatus* is identical with *B. acutus*, Sowerby, Salter[1] as far back as 1854 recognised that they were distinct, saying: "*B. acutus* appears to be quite a distinct species from *B. carinatus*, [the former] having a very acute keel and flat almost excavated sides strongly striated; the umbilicus is very large and sharp-edged." We may also add that the inflation of *B. carinatus* is marked, and the mouth is transverse and broad, overhanging the umbilicus, instead of high and narrow. It is not improbable that two species from the Upper Ludlow rocks have also been associated under the name *B. carinatus*, the narrow lenticular much compressed form with the very acute angular dorsum, very small umbilicus and large outer whorl, such as Nos. 28098 and 28099 in the Jermyn Street Museum, being distinct from the type and perhaps belonging to *Zonidiscus* or another genus.

McCoy (*op. cit.*) united *B. carinatus* and *B. acutus* "with no doubt of their identity," and consequently his definition of the former applies strictly to neither species; the only localities and horizons which he mentions are the Tilestone (Ludlow) of Storm Hill, Llandeilo, and the "calcareous Upper Bala schists of Dolydd Ceiriog Waterfall, S.E. of Moel Ferna, E. of the Berwyn Mountains," the latter locality furnishing *B. acutus*.

Moberg and Grönwall[2] remark that *B. lenticularis*, Grönwall, from the Wenlock rocks of Gotland, is allied to *B. carinatus*, Sow., and to *B. acutus*, Sow. Koken[3] described a shell of Ordovician age as *Cymbularia lenticularis* which is distinct

[1] Salter, 'Quart. Journ. Geol. Soc.,' vol. x (1854), p. 74.

[2] Moberg and Grönwall, *op. cit.*, p. 43, pl. iii, figs. 12 *a*, *b*.

[3] Koken, 'Gastrop. balt. Untersilurs,' p. 116, fig. 3.

from Moberg and Grönwall's species; the shell is asymmetrical, which is often the case in *Cymbularia*, as Perner points out. But the distinguishing feature of *Cymbularia* when compared with *Bellerophon* seems to be in the mouth, the lateral edges of which are infolded instead of expanded outwards and simple, as I have already pointed out. This oral character is not determinable in *C. carinata*, hence the doubt as to its generic position.

3. **Cymbularia carinata** (Sow.), var. Plate X, figs. 13, 14.

1878. *Bellerophon carinatus*, Sowerby, Salter, Cat. Camb. Silur. Foss. Mus. Pract. Geol., p. 78.

Varietal Characters.—Shell involute, composed of 3—4 whorls, somewhat compressed, as high as wide or rather higher than wide, subtriangular in section, with gently convex sides, subangular dorsum and traces of slight keel. Umbilicus open, rather deep, about one fourth the height of the shell in diameter, partly exposing inner whorls; umbilical slopes steep. Outer whorl increasing rather rapidly in height to mouth, with long narrow dorsal median slit extending about half the length of the whorl. Slit-band and surface ornamentation unknown.

Dimensions.—Height of shell, 19 mm.; height of mouth, 10 mm.

Horizon.—Upper Llandovery.

Localities.—Bogmine, Shelve, Shropshire; Eastnor Park, W. Malvern; Cwm Dwr, Llandovery [G. 21038].

Remarks.—Only internal casts of this shell are preserved, and no external impressions show the surface characters. There are five specimens [28062, 28064—67] from Bogmine and one from Eastnor Park in the Jermyn Street Museum in this condition, and one in the British Museum [G. 21038], and it is from these that the above description has been drawn up. The shell is certainly referable to the genus *Cymbularia*, but it is not identical with Sowerby's *B. carinatus*, as it has been labelled, being more swollen and less compressed, but probably it may be regarded as a variety of it.

4. **Cymbularia drummuckensis,** sp. nov. Plate X, figs. 15—19.

Specific Characters.—Shell lenticular, somewhat inflated centrally, thickest at umbilicus, composed of few whorls, completely involute. Whorls tectiform, carinate, subtriangular in cross-section, with dorsum more or less sharply angulated and occasionally weakly trilobed towards mouth; sides gently convex, but somewhat flattened towards mouth; outer whorl completely enveloping inner whorls and very slowly increasing in height. Umbilicus subcentral, completely closed by callosities. Mouth subtriangular, not suddenly expanded,

without reflexed lateral lips, but with basal corners supported laterally by prominent thickened callosities projecting horizontally and completely filling umbilicus; outer lip with short, acutely V-shaped sinus followed by long narrow slit extending about one-third the length of whorl; lateral lips forming large gently rounded subparallel lobes with upper edges slightly folded inwards and basal portions thickened to join umbilical callosities. Slit-band narrow, slightly raised, concave between sharp margins. Surface of shell marked with fine regular transverse thread-like lines, closely placed, often minutely fimbriated, curving back rather suddenly at about two-thirds their length to meet slit-band at very acute angles (20°—30°).

Dimensions.—Height of shell, 21 mm.; thickness at umbilicus, 13 mm.

Horizon.—Drummuck Group (Upper Ordovician).

Locality.—Thraive Glen, Drummuck, Girvan.

Remarks.—The closed umbilicus and umbilical callosities projecting laterally resemble members of Perner's group *Prosoptychus*, but the last portion of the outer whorl is not straightened. The narrow sunken slit-band with raised edges is like *Cymbularia* as illustrated by Perner, and the general shape of the shell resembles *C. galeata*, Koken, and *B. fastigiatus*, Lindstr.,[1] which Koken refers to *Cymbularia*. In the latter species, judging from Lindström's figures, the ornament is closely similar, and so is also the general shape of the shell, but the umbilicus is not closed. However, *B. globulus*, Lindstr.,[2] which Koken himself placed in his genus *Cymbularia*, has a closed umbilicus, and the basal angles of the mouth are supported on umbilical callosities as in *C. drummuckensis*. The American species *B. subangularis*, Ulrich,[3] may perhaps be compared with our shell, and the imperfectly known *B. obtectus*, Phillips,[4] from Marloes Bay, of which the type-specimens [28005, 28004] are in the Jermyn Street Museum, undoubtedly bears a great resemblance to it.

Some specimens of *C. drummuckensis* from the typical locality and horizon which have a rather more subglobose shape and broader dorsum, with a tendency to trilobation of its surface, may represent a variety.

It is probable that *C. drummuckensis* is the Girvan species referred by Salter[5] to Sowerby's *B. acutus*, which is undoubtedly quite distinct.

The type-specimens of *C. drummuckensis* are in Mrs. Gray's Collection and come from Thraive Glen.

[1] Lindström, *op. cit.*, p. 76, pl. vi, figs. 1—10.

[2] Lindström, *op. cit.*, p. 75, pl. v, figs. 25—34.

[3] Ulrich and Scofield, *op. cit.*, p. 920, pl. lxiv, figs. 14—16.

[4] Phillips, 'Mem. Geol. Surv.,' vol. ii, pt. i (1848), p. 356, pl. xiv, fig. 12.

[5] Salter, 'Quart. Journ. Geol. Soc.,' vol. vii (1851), p. 172, pl. ix, figs. 18, 18 *a*.

5. **Cymbularia merita**, sp. nov. Plate X, fig. 20.

Specific Characters.—Shell involute, subglobose; whorls rounded, slowly expanding to mouth, with high, strongly-arched dorsum, slightly excavated on each side of narrow slightly-raised keel bearing flattened slit-band so as to form parallel shallow revolving depressions. Umbilicus small or closed. Mouth subtriangular, large, about one and a-half times as wide as high, rather suddenly expanded at base, the lower thickened margins being nearly at right angles to vertical plane of shell; lateral margins making a dorsal angle of about 90°; dorsal sinus V-shaped, large, wide, deep; lateral lobes prominent, angulated at corners of sinus at about 60°. Surface of whorls marked by regular fine gently-arched transverse lines, equidistant, rather closely placed, bending back sharply close to keel to meet slit-band at about 30°, with traces of very delicate and closely-placed faint revolving striæ crossing them.

Dimensions [G. 73904 *a*].—Height of shell to base of mouth, 12 mm.; height of shell including mouth, 20 mm.; width of mouth at base, 20 mm.; diameter of shell at umbilicus, 10 mm.

Horizon.—Wenlock Shale.

Locality.—Dudley.

Remarks.—This species is based on one specimen [G. 73904 *a*], in the British Museum, which was labelled *Bellerophon expansus*, Sow. Only the apertural view is seen, as the rest of the shell is imbedded in matrix, but the last whorl and the mouth are well preserved and the ornament on the surface is clearly shown. In the shape of the whorl, the narrow slightly-raised keel with a shallow revolving depression on each side of it, and the course of the transverse lines on the shell, it resembles *B. fastigiatus*, Lindström,[1] though the two species can scarcely be considered identical.

6. **Cymbularia turnbulli**, sp. nov. Plate XI, figs. 1—4.

? 1878. *Bellerophon ventriculatus*, Edgell MS., Catal. Camb. Silur. Foss. Mus. Pract. Geol., p. 67.

Specific Characters.—Shell involute, subglobose, somewhat compressed, the whorls subangular and higher than wide. Umbilicus small, deep, situated at less than half height of shell. Outer whorl nearly completely enveloping inner whorls, increasing in height rather rapidly, tectiform, subcarinate towards mouth; dorsum high, strongly-arched, subangular and weakly trilobed in outer third of whorl by broad, faint, revolving depressions, the median portion being more elevated and angulated towards mouth. Mouth widest at base with basal angles projecting; inner lip somewhat reflexed; lateral lips forming gently rounded lobes

[1] Lindström, *op. cit.*, p. 76, pl. vi, figs. 1—10.

not reflexed; upper lip with wide open V-shaped sinus followed by short narrow slit. Slit-band narrow, strongly margined. Surface of shell ornamented with fine regular equal closely-placed thread-like lines arching back suddenly near slit-band to meet it at about 20°—30°. A few low narrow rounded equidistant transverse folds are usually present on the sides near the mouth.

Dimensions.—Height of shell, c. 16 mm.; width of outer whorl behind mouth, c. 11 mm.

Horizon.—Llandovery Group.

Locality.—(1) Gas Works, Haverfordwest; The Frolic, Haverfordwest; (2) ? Blaen-y-cwm.

Remarks.—This shell resembles *B. fastigiatus*, Lindström,[1] except in the weak trilobation of the dorsum, which is also met with in some specimens of the variety of *C. drummuckensis* above mentioned. Such a feature is found in the Devonian trilobed genus *Plectonotus*, Clarke, which agrees in this respect with *Bucaniella*, but possesses a slit-band. It is possible that a callosity filled up the umbilicus. The specimens of *C. turnbulli* occur mostly as internal casts. The types are in the Sedgwick Museum.

It is probable that the poorly preserved and more or less crushed specimens [28053—56] from the Lower Llandovery of Blaen-y-Cwm, in the Jermyn Street Museum, to which the name "*Bellerophon ventriculatus*, Edgell MS.," is attached, are referable to this species, but no description or figures of specimens have ever been published under this name.

7. **Cymbularia youngi**, sp. nov. Plate XI, figs. 5—8.

Specific Characters.—Shell lenticular, more or less compressed, completely involute; whorls tectiform, carinate, subtriangular, higher than wide, few in number, with acutely angulated dorsum. Umbilicus closed, subcentral. Mouth high, triangular, much expanded, but not reflected at base, projecting laterally and supported by stout horizontal callosities arising from umbilicus; outer lip with large V-shaped sinus and broadly rounded apertural lobes. Slit-band narrow, elevated in slight carina, concave, with raised edges. Surface of shell crossed by fine closely-placed regular thread-like transverse lines of equal strength, arched back suddenly at about two-thirds the height of whorl to meet slit-band at about 45°—60°.

Dimensions.—Height of shell, c. 22 mm.; thickness at umbilicus, c. 11 mm.

Horizon.—Whitehouse Group (Middle Ordovician).

Locality.—Shalloch Mill, Girvan.

Remarks.—This shell, though closely allied to *C. drummuckensis*, is rather more compressed than that species; the slit-band is also borne on a more definite keel and

[1] Lindström, *op. cit.*, p. 76, pl. vi, figs. 1—10.

not simply on the ridge of the dorsum; the ornamentation is finer and the transverse lines meet the slit-band at a larger angle. *C. alata* (Portl.) and *B. fasciatus*, Lindstr.,[1] are related more or less closely to it. Similar laterally projecting umbilical callosities which support the basal angles of the mouth are found in *B. (Prosoptychus) plateius*, Barr., which Perner[2] considers allied to *B. globulus*, Lindstr., a species referred by Koken to his genus *Cymbularia*. The types are in Mrs. Gray's Collection.

8. **Cymbularia ? woodlandensis**, sp. nov. Plate XI, figs. 9, 10.

Specific Characters.—Shell lenticular, compressed, acutely carinate, with outer whorl almost completely enveloping inner whorls. Umbilicus very small, open, about one-sixth the diameter of the shell, and with centre situated at about two-fifths its height. Outer whorl large, rapidly increasing in height, but slowly in width, with gently convex sides and sharp acute dorsum without distinct carina, but bearing very narrow slit-band; umbilical edge abruptly rounded; umbilical slope short, steep. Mouth not expanded, nearly three times as high as wide with deep acute narrow **V**-shaped sinus in outer lip and large rounded apertural lobes. Surface of shell covered with rather coarse sublamellose transverse lines crossing umbilical edge obliquely and arching very strongly back on sides to meet dorsal edge at 30°.

Dimensions.—Height of shell, 30—34 mm.; thickness above umbilicus, 7—10 mm.

Horizon.—Saugh Hill Group, Llandovery Series.

Locality.—Woodland Point, Girvan.

Remarks.—The specimens of this shell are not usually in a good state of preservation, and the slit-band is only represented by occasional traces. The shell has the appearance of *Oxydiscus*, but has a slit-band. It is doubtful if it should be referred to *Zonidiscus* or *Cymbularia*, but its resemblance in general characters to *C. tarda* (Barr.),[3] inclines me to refer it to the latter genus. The type-specimens are in Mrs. Gray's Collection.

9. **Cymbularia** cf. **fastigiata** (Lindström). Plate XI, figs. 11, 12.

1884. *Bellerophon fastigiatus*, Lindström, Silur. Gastrop. Pterop. Gotland, p. 76, pl. vi, figs. 1—10.

Specific Characters.—"Shell rather more discoid than globular, aperture transverse and triangular in outline, the base being only slightly arched. . . .

[1] Lindström, *op. cit.*, p. 75, pl. vi, figs. 13, 14.

[2] Perner, *op. cit.*, p. 141, text-fig. 101.

[3] Perner, *op. cit.*, p. 77, pl. lxxxvii, figs. 32—34, 36, text-fig. 105 *a—c*.

Whorls five, transverse, carinated on the dorsal side. Umbilicus open and large with steep borders. The transversal striæ of the surface crowded; joining the slit-band in an acute angle of 32°, they are bent outwards and backwards to the umbilicus. In several specimens there is an indistinct carina on both sides of the slit-band and parallel to it, placed at the point where the transverse striæ are bending backwards. The slit-band is elevated, flat on its top, finely and transversely sculptured, somewhat concave along its median line and bordered on each side by two thin-edged lines" (Lindström).

Horizon.—Lower Ludlow.

Locality.—Vinnal Hill.

Remarks.—The poorly preserved examples of this species of *Cymbularia* which are in the Jermyn Street Museum [28095, 28096, 28093, 28094] and come from the Lower Ludlow of Vinnal Hill, may be compared with Lindström's species *B. fastigiatus*, the description of which as given by him is above quoted. The enrolment of the whorls, shape of the dorsum, carination, size of the umbilicus, dorsal sinus and ornamentation seem to agree most closely with that species.

Genus **ZONIDISCUS,** Spitz.

Generic Characters.—Shell compressed, sharply carinated; umbilicus open. Whorls higher than wide, more or less lanceolate in cross-section; dorsal lip with long narrow median slit followed by narrow slit-band; inner lip reflexed.

This genus was founded in 1907 by Spitz[1] for a group of compressed shells with sharp dorsal edge and slit-band and the habit of *Oxydiscus*. *Cyrtolites discus*, Lindström,[2] from the Silurian of Gotland, was chosen as the type, and a Lower Devonian species, *Oxydiscus geyeri*, Frech,[3] was also given as an example of the genus. Spitz (*op. cit.*) moreover referred Ulrich and Scofield's *Oxydiscus cristatus*, Safford, and Lindström's *Cyrtolites euryomphalus* to it.

Koken's *Temnodiscus* (= *Cyrtolitina*, Ulrich and Scofield[4]) may probably be an allied genus, but it has a different surface-sculpture, a less compressed lenticular shape and a less carinate dorsum.

1. **Zonidiscus grayi,** sp. nov. Plate XI, figs. 13—15.

Specific Characters.—Shell compressed, lenticular, thickest at umbilical edge, dorsally acute, composed of 3—4 whorls. Whorls high, narrow, lanceolate in cross-section, bearing elevated compressed prominent carina; sides gently convex,

[1] Spitz, "Gastrop. Karnischen Unterdevon," 'Beitr. Pal. Geol. Oesterr. u. Orients,' vol. xx (1907), p. 124, pl. xi (i), fig. 7 *a—c*.

[2] Lindström, 'Silur. Gastrop. Pterop. Gotland,' p. 84, pl. vii, figs. 18—21.

[3] Frech, 'Zeitschr. deutsch. geol. Gesell.,' vol. xlvi (1894), p. 463, pl. xxxiv, fig. 2.

[4] Ulrich and Scofield, *op. cit.*, pp. 847, 866.

becoming slightly concave near keel, and swelling out towards base so as to form a narrowly rounded or subangular umbilical edge; umbilical slope short, steep or vertical. Umbilicus open, rather deep, about one-fourth the diameter of shell in width, and situated at rather less than half its height. Outer whorl increasing rather rapidly in height and embracing greater part of shell, with long, narrow median open slit in lip extending back from peristome for about one-third of the whorl; remainder of outer whorl provided with narrow slit-band raised on carina having sharp edges, and crossed by thick strong subequidistant lunulæ sometimes thickened and rising above carina so as to give it a crenulated appearance. Mouth higher than wide, with reflexed inner lip. Surface of shell ornamented with rather unequal transverse fine lines directed back rather obliquely from umbilical edge and running nearly straight to base of carina, where they bend back suddenly to meet slit-band at about 45°.

Dimensions.—Height of shell, 27·0 mm.; height of outer whorl near mouth, 14·0 mm.; width of base of mouth, 11·0 mm.

Horizons.—(1) Drummuck Group (Starfish Bed), Upper Ordovician; (2) ? Redhill Beds.

Localities.—(1) Thraive Glen, Girvan; (2) ? Prendergast Place, Haverfordwest.

Remarks.—The edges of the open slit in the anterior part of the outer whorl are usually crushed together, but its posterior end is generally well marked by the sudden appearance of the carina. The slit-band is well preserved in specimens which retain the shell. Probably this is the species from Drummuck described by Salter[1] as "like *Bellerophon acutus*, but with wide umbilicus."

The reference of this species to Spitz's genus *Zonidiscus* cannot be doubted, for it combines the shape and general appearance of *Oxydiscus* with the slit-band and slit of *Cymbularia*, and it closely resembles the type of *Zonidiscus* (*Cyrtolites discus*, Lindstr.), though that species comes from a higher stratigraphical horizon.

Several specimens of this species in the Hunterian Museum are labelled *Bellerophon* (*Trematonotus*) *carinatus*, with a note stating that the specimens show "the row of close perforations on the keel." This appearance of perforations seems due to the obliquity and prominence of the equidistant thick lunulæ, which rise up in a series of little projections along the keel so as to separate slightly depressed and concave elongated areas on the slit-band, thus giving a spurious resemblance to oval foramina. A side view of the shell makes the carina appear crenulated, but after examining many specimens in various states of preservation with and without the shell, it seems certain that there are no true perforations.

The best specimens of this species are in the Hunterian Museum, Glasgow, and come from the Drummuck Group. Several examples also occur in Mrs. Gray's Collection.

The Redhill specimens which are in the Sedgwick Museum are too poor for satisfactory identification.

[1] Salter, 'Quart. Journ. Geol. Soc.,' vol. vii (1851), p. 172.

2. **Zonidiscus grayi,** var. **shallochensis,** nov. Plate XI, figs. 16, 17.

Varietal Characters.—Shell much compressed, lenticular, dorsally acute, composed of about 3 whorls, thickest on umbilical edge. Whorls high, narrow, triangular; dorsum carinated, narrow, acute; sides of whorls gently convex to flattened, somewhat swollen at base, with narrowly rounded or subangular umbilical edge; umbilical slope short, vertical. Umbilicus open, about one-fifth the diameter of the shell and with centre situated at about two-fifths its height. Mouth not expanded, with narrow median open slit in outer lip, followed by narrow slit-band (elevated on carina) with fine raised edges and strong distant lunulæ. Surface of shell ornamented by fine transverse regular sublamellose equidistant lines running obliquely back from umbilical edge to meet dorsal edge at about 75°, but scarcely curved.

Dimensions.—Height of shell, 26—27 mm.

Horizon.—Whitehouse Group, Middle Ordovician.

Locality.—Shalloch Mill, Girvan.

Remarks.—The type-specimens of this variety are in Mrs. Gray's Collection. The difference between this form and *Z. grayi* lies in the more rapid increase in height of the outer whorl, the smaller umbilicus and the ornamentation, the lamellæ being thicker and coarser; but they are undoubtedly very much alike. Unfortunately the mouth and slit are not well preserved in any of the Shalloch Mill specimens. In Mrs. Gray's list (p. 696) in the 'Survey Memoir' this variety is entered with *Z. grayi* as *B. carinatus*, Sow.

3. **Zonidiscus? transiens,** sp. nov. Plate XI, figs. 18—21.

Specific Characters.—Shell lenticular, compressed, thickest at umbilicus, completely involute, composed of few whorls; outer whorl very slowly increasing in size, tectiform, subtriangular, as high as wide or rather higher than wide, completely embracing inner whorls; dorsum narrow, flattened, occupied by flat or slightly depressed slit-band; sides of whorl gently convex or somewhat flattened, rarely a little swollen at base. Umbilicus very small, deep, central, with subangular umbilical edges. Mouth high, subtriangular, not expanded; upper lip with deep long narrow **V**-shaped sinus followed by long slit; apertural lobes rounded, large. Surface of shell ornamented with very fine closely set, slightly wavy, and somewhat interrupted revolving lines parallel to slit-band, becoming faint or obsolete near umbilicus, and crossed by fainter gently-arched delicate transverse lines, distinct near umbilicus, but scarcely visible near periphery.

Dimensions.—Height of shell, 10—12 mm.; thickness at umbilicus, 5—6 mm.

Horizon.—Balclatchie Group, Lower Ordovician.

Localities.—Balclatchie; Ardmillan; Dow Hill, Girvan.

Remarks.—The non-expanded mouth, the long narrow dorsal slit succeeded by the slit-band, the small angular umbilicus, the complete occupation of the narrow dorsum by the slit-band and the general shape of the shell seem to necessitate its reference to the genus *Zonidiscus*. The revolving lines are unusual. There is also some resemblance to some species of *Conradella* and especially of *Temnodiscus*. In many of the specimens the edges of the dorsal slit are squeezed together, so that the slit is obliterated and the dorsum seems to be acutely carinated as in *Oxydiscus*, but the narrow seam between the edges can generally be detected.

All the examples of this species are in Mrs. Gray's Collection.

4. **Zonidiscus,** sp.

Specific Characters.—Shell discoidal, coiled in flat spiral, composed of 4—5 whorls, rather slowly increasing in size to mouth, very slightly overlapping, cordate in section, higher than wide, with acutely angular dorsum, convex sides, and short steep undefined umbilical slope. Umbilicus large, shallow, open, exposing inner whorls; no definite umbilical edge. [Slit-band present, very narrow?] Ornamentation unknown.

Dimensions.—Height of shell, 23·0 mm.; height of outer whorl near mouth, 8·5 mm.

Horizon.—Lower Llandovery.

Locality.—Canilo Hill, Builth; ? Blaen-y-cwm.

Remarks.—There are three specimens [28057—59] of this shell in the Jermyn Street Museum, but none are sufficiently well preserved to allow of a full specific diagnosis. The slit-band cannot be seen in the casts or impressions, and the ornamentation is not discernible. The shell labelled *B. discus*, Edgell MS. [28045], from the Lower Llandovery of Blaen-y-cwm, may be identical, but is itself too fragmentary for a satisfactory determination. The outer whorl does not increase in size so rapidly as in *Z. grayi* or *Z. grayi* var. *shallochensis*, and more resembles the species described by Lindström as *Cyrtolites discus*, Lindstr.,[1] which is the type of the genus *Zonidiscus*.

Genus **SALPINGOSTOMA**, Roemer.

Generic Characters.—Shell symmetrically coiled in one plane; whorls numerous, enlarging gradually, scarcely embracing; umbilicus large, open. Mouth abruptly expanded at maturity, forming a trumpet-like aperture, subcircular in shape;

[1] Lindström, *op. cit.*, p. 84, pl. vii, figs. 18—21.

peristome thin, the outer portion slightly sinuate. Inner whorls with a slit-band which is replaced in outer half of last whorl by a long narrow slit not extending to apertural expansion but closed some distance behind it. Surface marked with simple or sublamellose transverse growth-lines or rugæ and with more or less oblique irregular sometimes interrupted or wavy revolving lines.

The relations of this genus and the usage of the name *Salpingostoma* are discussed by Koken,[1] Ulrich and Scofield,[2] and Perner.[3] The definition given by Ulrich and Scofield and the limitations assigned by them to the genus are here adopted. The type-species is *S. megalostoma*, Eichwald, of the Russian Ordovician, The true position of *Salpingostoma* in the scheme of classification adopted in this Memoir is somewhat doubtful, but it may be provisionally assigned to the group *Fissidorsata*.

1. **Salpingostoma asteroideum,** sp. nov. Plate XI, figs. 22, 23; Plate XII, figs. 1, 2.

Specific Characters.—Shell of 2—2½ whorls, loosely coiled, in contact but not overlapping, rapidly increasing in size (especially in height) to mouth, which is suddenly expanded at right angles to plane of shell to about three times the width of outer whorl. Outer whorl rounded, with weak dorsal carination developed especially near mouth, but elsewhere with subcircular cross-section, increasing rapidly in height near mouth. Umbilicus deep, open, exposing inner whorls, with centre at about one-fourth height of shell. Mouth immensely expanded, subcircular, rather higher than wide, with inner lip reflexed and extending below base of whorls; width of mouth about three times that of outer whorl; outer lip with small central emargination. Surface of shell covered with coarse strong, gently arched rounded rugæ regular and equidistant, meeting carina at 60°—75°, becoming weaker near mouth and dying out on expansions of peristome, with fine weak sinuous revolving spiral lines over the whole shell diverging slightly on each side from carina near aperture. Dorsal slit very narrow, usually concealed by carina.

Dimensions.—Width of mouth about 35 mm.; height of mouth about 40 mm.

Horizon.—(1) Drummuck Group (Starfish Bed), Upper Ordovician; (2) Upper Bala Beds.

Locality.—(1) Thraive Glen, Girvan; (2) ? Tyrone.

Remarks.—The types of this species come from Thraive Glen and are in Mrs. Gray's Collection. The immensely expanded mouth and the few whorls and ornamentation closely resemble *S. grande* (Barr.),[4] from stage D in Bohemia, and

[1] Koken, 'Gastrop. Balt. Untersilur.,' p. 131.

[2] Ulrich and Scofield, *op. cit.*, pp. 851, 897—900.

[3] Perner, *op. cit.*, p. 96.

[4] Perner, *op. cit.*, p. 97, pl. lxxxiv, figs. 12—14; pl. lxxxv, figs. 22—32; text-fig. 69*a*–*f*.

the species are undoubtedly closely allied. It is probable that the shell described by me as *Bellerophon ? multirugatus*[1] from the Redhill Beds (Upper Bala) of the Haverfordwest area is also closely related, but it is not well enough known to make a complete comparison; the ornamentation seems almost identical. The crushed and distorted specimen said to be from Mulloch described and figured by McCoy[2] as *B. subdecussatus*, of which his figure was an inaccurate restoration, appears to present many points of similarity; the matrix is not that of the typical Mulloch Hill Sandstone, and the mode of preservation so much resembles that of *S. asteroideum* from the Starfish Bed that I am inclined to think this is its true horizon.

The dorsal slit is not well seen in any of our specimens, but its presence can here and there be detected, though near the mouth its place is always occupied by the weak carina. One fragment [20713] of a shell from Tyrone in the British Museum probably belongs to this species.

2. **Salpingostoma buccinoideum,** sp. nov. Plate XII, fig. 3.

Specific Characters.—Shell sublenticular, somewhat compressed; composed of 3—4 whorls in contact but not overlapping, rapidly increasing in height and less rapidly in width. Whorls sublanceolate in cross-section with gently convex sides, somewhat swollen near base and acutely carinated dorsum; terminal part of outer whorl free and suddenly expanding into large trumpet-shaped mouth of subcircular shape; inner lip free. Umbilicus wide, shallow, open, exposing all the inner whorls; umbilical edge rounded. Traces of slit in dorsal carina. Surface of shell unknown.

Dimensions.—Height of shell, 27·0 mm.; height of outer whorl before becoming free, 12·0 mm.; width of ditto, 9·0 mm.; width of mouth, c. 30·0 mm.; height of mouth, c. 20·0 mm.

Horizons.—(1) Balclatchie Group (conglomerate), Lower Ordovician. (2) Stinchar Limestone Group, Lower Ordovician ?.

Localities.—(1) Balclatchie, Girvan; (2) Minuntion, near Girvan.

Remarks.—There is only one good specimen of this species from Balclatchie in Mrs. Gray's Collection, and this is chosen as the type; for the Minuntion specimen is poor and of doubtful reference. The large trumpet-shaped mouth and compressed carinate whorls are distinctive features. Perhaps *Salp. compressum* (Eichw.),[3] is allied to it, and *Salp. megalostoma*, Eichw.[4] also shows points of resemblance.

[1] Reed, 'Geol. Mag.' [5], vol. iii (1906), p. 365, pl. xx, figs. 11, 11 *a*.

[2] McCoy, 'Syn. Brit. Pal. Foss. Woodw. Mus.,' p. 311, pl. 1, L, fig. 25 (non 25*a*).

[3] Eichwald, 'Leth. Ross.,' vol. i, pt. 2, p. 1068, pl. xli, fig. 9.

[4] *Ibid.*, p. 1069, pl. xli, figs. 5 *a*—*c*.

3. **Salpingostoma etheridgei,** sp. nov. Plate XII, fig. 4.

Specific Characters.—Shell large, of 2—3 whorls in contact and slightly overlapping, rapidly increasing in height and more gradually in width, weakly carinate, subelliptical in section; sides convex, rounded, without umbilical edge. Umbilicus large, open; centre situated at less than one-third height of shell. Mouth rather suddenly expanded, more than three-fourths the height of shell; inner lip reflexed on to second whorl. Slit-band well marked, narrow, situated on low keel, with raised edges and distinct on inner portion of outer whorl, but becoming closed and represented only by sharp carination in outer three-fourths of whorl. Surface of shell smooth.

Dimensions.—Height of shell about 55·0 mm.; width of outer whorl near mouth about 28 mm.

Horizon.—Stinchar Limestone Group, Lower Ordovician.

Locality.—Craighead, Girvan.

Remarks.—The two species which most resemble it seem to be *Salp megalostoma* (Eichw.)[1] from the Russian Orthoceras Limestone and *S. compressum* (Eichw.)[2] from Stage C. Our *Salp. buccinoideum* differs by having less regularly swollen sides, a sublanceolate instead of subcircular transverse section, a decided umbilical edge, a more acute dorsal carination and a free inner lip. The type of this species is in Mrs. Gray's Collection.

4. **Salpingostoma multirugatum** (Reed).

1906. *Bellerophon ? multirugatus*, Reed, Geol. Mag. [5], vol. iii, p. 365, pl. xx, figs. 11, 11 *a*.

Specific Characters.—Shell with outer whorl rounded, rapidly enlarging towards mouth and embracing (?) inner whorls; dorsum broad, rounded, with low distinct narrow carina. Mouth transversely expanded with reflexed lip. Shell crossed by regularly arranged strong low rounded subequal broad transverse ribs, closely placed, separated by grooves of nearly equal width, curving back in a broad **V** of about 150° over the keel without interruption, but dying out on the margins of the mouth and becoming weaker on the umbilical slopes of the whorls; surface of ribs crossed by delicate fine revolving equidistant striæ parallel to the keel, but becoming sinuous, broken and irregular near the mouth.

Horizon.—Redhill Beds, Upper Ordovician.

Localities.—Prendergast Place; Mill Lane, Haverfordwest.

Remarks.—The original specimen on which this species was founded came

[1] Eichwald, 'Leth. Ross.,' vol. i, pt. 2, p. 1069, pl. xli, figs. 5 *a*—*c*; Koken, 'Neues Jahrb. f. Miner.,' Beil. Bd. vi (1889), p. 384, pl. xiii, figs. 6, 9, 9 *a*; *idem.*, 'Gastrop. Balt. Untersilur.' (1897), p. 134.

[2] Eichwald, *ibid.*, p. 1068, pl. xli, fig. 9.

from the Redhill Beds of Haverfordwest and is in the Sedgwick Museum. The position and affinities of this species were regarded as doubtful by me when I described it, but now there can be no uncertainty as to its reference to the genus *Salpingostoma* and its close affinities to the Girvan species *S. asteroideum* and to *S. grande* (Barrande),[1] from Étage D in Bohemia. The specimens are crushed, distorted and imperfect, and the species is not capable of a completely satisfactory definition. It seems to have reached a large size, the mouth of some measuring 50—70 mm. across.

5. **Salpingostoma? infundibulum** (Salter MS.). Plate XII, fig. 5.

1878. *Bellerophon infundibulum*, MS. [? Salter], Cat. Camb. Silur. Foss. Mus. Pract. Geol., p. 123.

Specific Characters.—Mouth immensely expanded, forming a large free subcircular flattened saucer; dorsal lip with small shallow open emargination followed by a narrow continuous groove on inner surface (occupied by open slit?) corresponding to keel on outer surface and continued on to dorsum of outer whorl. Ornamentation of inner surface of oral expansion composed of strong sinuous frequently broken and irregularly interrupted concentric rugæ, with fine regular concentric striæ between them. Outer whorl of shell just before expansion of mouth broadly transverse and deeply trilobed, consisting of median narrow strongly-elevated subangular portion and rounded lateral portions; lower portion of outer whorl free, not interrupting or indenting lower lip.

Dimensions.—Height of oral expansion, 43 mm.; width of ditto, 45 mm.; width of outer whorl before oral expansion, 18 mm.

Horizon.—Lower Ludlow.

Locality.—Vinnal Hill.

Remarks.—The peculiar trilobation of the outer whorl and the ornamentation of the oral expansion distinguish this imperfectly known shell, of which there is only the type specimen [28070] in Jermyn Street giving a full front view of the mouth. Its generic reference is doubtful.

6. **Salpingostoma,** sp.

In a specimen of a species of *Salpingostoma* from the Sholeshook Limestone in the Sedgwick Museum we get only a full front view of the mouth. This is sublanceolate in shape, higher than wide, pointed acutely above, but rounded below; it is widest across the middle. The lips are as usual suddenly reflected outwards at right angles to the plane of the shell, the lower lip being about one-fourth the height of the whole aperture and the upper lip about one-half the height; there

[1] Perner, *op. cit.*, p. 97, pl. lxxiv, figs. 12–14; pl. lxxxxv, figs. 22–32; text-fig. 69.

is also a small V-shaped dorsal sinus. The presence of a sharp keel on the dorsum near the mouth is indicated in the cast. Perhaps this shell is allied to *S. richmondense*, Ulrich,[1] but it is too imperfectly known for an accurate comparison.

Dimensions.—Height of mouth, c. 55 mm.; width of mouth, c. 40 mm.

Horizon.—Sholeshook Limestone, Upper Ordovician.

Locality.—Sholeshook, Haverfordwest.

Sub-Group Terebrodorsata.

Genus **TREMATONOTUS**, Hall.

Generic Characters.—Shell enrolled like *Salpingostoma*. Mouth suddenly expanded, trumpet-shaped; border entire. Umbilicus wide, open, exposing inner whorls. Dorsum of each whorl with median row of closely-placed numerous rounded openings. Sculpture of shell consisting of revolving ridges and transverse undulating lamellæ. Shell composed of three layers with a fourth external one developed in old individuals.

Without discussing here the validity of the separation of *Phragmostoma* from *Trematonotus*, into which question Perner[2] has gone at some length, we use the generic name here in the same manner as he does, which is more restricted than that adopted by Ulrich and Scofield.[3] The type is *T. alpheus*, Hall [? = *Bucania chicagoensis*, McChesney], from the Niagara Group, and the genus seems almost limited to the Upper Silurian.

Bellerophon dilatatus, Sowerby,[4] is a well-known British example, and the specimens in the British Museum described by Mr. R. B. Newton as *Trematonotus britannicus*[5] are now referred to this species (see below).

1. **Trematonotus aymestriensis** (Sowerby). Plate XII, figs. 7, 8.

1839. *Bellerophon aymestriensis*, Sowerby, in Murchison's Silurian System, p. 616, pl. vi, fig. 12.
1848. *Bellerophon aymestriensis*, Sowerby, Férussac and D'Orbigny, Hist. Nat. Ceph., vol. i, p. 216, pl. viii, fig. 15.
? 1860. *Bellerophon aymestriensis*, Sowerby, Eichwald, Leth. Ross., vol. i, Anc. Per., p. 1084.
1885. *Bellerophon dilatatus*, Sowerby, Etheridge (*pars*), Brit. Pal. Foss., p. 119.
? 1884. *Tremanotus compressus*, Lindström, Silur. Gastrop. Pterop. Gotland, p. 87, pl. iv, figs. 8—12.

Specific Characters.—Shell discoidal, of 4—5 whorls in contact but scarcely

[1] Ulrich and Scofield, *op. cit.*, p. 903, pl. lxvii, figs. 39, 40.
[2] Perner, *op. cit.*, pp. 104, 121.
[3] Ulrich and Scofield, *op. cit.*, p. 851.
[4] Murchison, 'Silur. Syst.,' p. 627, pl. xii, figs. 23, 24.
[5] Newton, 'Geol. Mag.' [3], vol. ix (1892), p. 337, pl. ix.

overlapping. Umbilicus large, shallow, open, exposing all the inner whorls. Whorls transversely elliptical, about twice as wide as high, increasing very slowly in size to near mouth where the height increases rather more rapidly; dorsum gently convex or flattened, except near mouth; umbilical edges subangular, becoming more rounded near mouth. Median line of oval foramina on narrow band on dorsum, gradually increasing in size and in distance apart towards mouth. Regular revolving thick lines on dorsum, 12—14 on each side of the row of foramina, becoming coarser and less regular on oral expansion. Mouth large, trumpet-shaped, rather suddenly expanded, subcircular, with lower lip reflected but not descending as low as centre of umbilicus.

Dimensions:

	I.	II.
Height	c. 80 mm.	c. 70 mm.
Thickness	c. 30 „	c. 35 „

Horizon.—(1) Aymestry Limestone; (2) Lower Ludlow.

Localities.—(1) Aymestry; Leintwardine; (2) Mary Knoll, Ludlow.

Remarks.—The type specimen [6709] in the Jermyn Street Museum is an imperfect internal cast, but it shows some of the foramina on the dorsum, though Sowerby did not mention them. The other specimen [28003] from Leintwardine is a more complete internal cast, and was labelled by someone *Trematonotus compressus*, Lindström, with a query, to which species it is undoubtedly closely allied. It differs from *Tr. dilatatus* in the more discoidal form of the shell, the larger and more open umbilicus, the more flattened dorsum, the sharper and more marked umbilical edges, and the oval shape of the foramina and more complete chain of them on the dorsum. The mouth also seems to have been relatively smaller, but this is doubtful.

Sowerby's description of his Aymestry form is as follows: "Thick, discoid, with a broad, rather flat margin; whorls few, their section transversely oblong and but slightly indented by the preceding whorl; aperture expanded. The greater part of the mouth is, in this specimen, broken away, but enough is left to show that it expands; is it not possible that if it were perfect it would prove to be like *B. dilatatus* (pl. xii, f. 23 and 24)? Diameter $3\frac{1}{4}$ inches, thickness 2 inches 10 lines. Loc. *Aymestry*."

Lindström (*op. cit.*, p. 88) mentions this species as apparently nearly related to his *Tr. compressus*. Of the specimens in the Jermyn Street Museum [28071, 28072] from the Lower Ludlow of Mary Knoll belonging to *T. aymestriensis* one of them [28071] shows the external ornamentation and the line of foramina.

2. **Trematonotus dilatatus** (Sowerby). Plate XIII, fig. 1.

1839. *Bellerophon dilatatus*, Sowerby, in Murchison's Silurian System, pp. 622, 627, pl. xii, figs. 23, 24.
1875. *Bellerophon dilatatus*, Sowerby, Baily (*pars*), Charact. Brit. Fossils, p. 65, pl. xxii, figs. 1 *a*, 1 *b*.

1884. *Bellerophon dilatatus*, Sowerby, J. D. La Touche, Handbook to the Geology of Shropshire, p. 79, pl. xiv, figs. 489—491.

? 1884. *Tremanotus longitudinalis*, Lindström, Silur. Gastrop. Pterop. Gotland, p. 86, pl. iv, figs. 1–7.

1892. *Trematonotus britannicus*, R. B. Newton, Geol. Mag. [3], vol. ix, p. 337, pl. ix.

Non 1843. *Bellerophon dilatatus*, Sowerby, var., Portlock, Geol. Rep. Londond., p. 398, pl. xxix, fig. 1.

Non 1852. *Bellerophon dilatatus*, McCoy, Syn. Brit. Palæoz. Foss. Woodw. Mus., fasc. ii, p. 309.

Non 1860. *Bellerophon dilatatus*, Sowerby, Eichwald, Leth. Ross., vol. i, Anc. Per., p. 1067.

Specific Characters.—Shell discoidal; whorls few, transverse, about twice as wide as high, slightly overlapping, slowly increasing in size to mouth. Umbilicus open, rather deep, more than half the diameter of the shell; umbilical edges rounded. Outer whorl with gently convex dorsum becoming more convex and even subangular towards mouth, with a narrow median ridge developed in the distal two-thirds showing along it a few large oval foramina set at subequal distances apart. Mouth large, subtriangular or cordate, higher than wide, with rather abruptly reflexed, much expanded flattened margins, having the upper lip vertical and about twice as wide as the lower lip, and the lateral lips gradually decreasing in width to the lower lip, which descends owing to its reflection as low as centre of umbilicus and is interrupted medially by the inner part of the outer whorl. Small dorsal emargination in upper lip. Exterior of shell ornamented with rather closely-set thick revolving slightly sinuous lines parallel to central ridge but diverging slightly on expanded margins of mouth, and with a few transverse growth-lines. Interior of mouth with expanded margins showing similar thick revolving lines concentrically striated and diverging outwards in a pinnate fashion on each side of the median line of the upper lip.

Dimensions:

	I (6712)	II (4597)
Height of shell with oral expansion	c. 95 mm.	c. 105 mm.
Height of shell to base of mouth	c. 38 ,,	c. 40 ,,
Width of mouth	c. 65 ,,	c. 75 ,,
Width of outer whorl at base of mouth	c. 20 ,,	c. 23 ,,

Horizons.—(1) Wenlock Limestone; (1 *a*) Wenlock Shale; (2) Lower Ludlow ?; (2 *a*) Woolhope Beds.

Localities.—(1) Burrington, near Ludlow; (1 *a*) Dudley; (2) Kingsland; ? Mary Knoll, Ludlow; (2 *a*) Worcester Railway, Malvern [28075].

Remarks.—There are two excellent specimens in the Jermyn Street Museum, of which Sowerby's original type from Burrington [6712] (Sowerby, *op. cit.*, pl. xii, fig. 23) is rather less perfect than the other [4597], the locality of which is doubtful. Sowerby's description is as follows: "Discoid, smooth; sides largely umbilicated; margin broad, slightly convex, with a central ridge; whorls few; aperture suddenly dilated to a much greater diameter than the spire and enclosing

it, orbicular. Diameter of the spire 1 inch 8 lines, thickness 1 inch, longest diameter of the aperture 3 inches, rather longer than wide. The last whorl before it expands to form the large aperture, is twice as wide as long. The edge of the aperture embraces two-thirds of the discoid spire; the front of it has no fissure, although there is a ridge upon the whorl which indicates the existence of such a fissure at an earlier period of growth. Two of our specimens show furrows inside the mouth; the one from the Lower Ludlow Rock is nearly smooth, but has slight indications of them; may not the former be impressions of the outer surface? Loc. Burrington, near Ludlow."

It will be noticed that he does not mention the foramina, but there are distinct traces of their presence in his type-specimen, though it is not as well preserved in this region as could be wished. The presence of external revolving ridges is also doubtful, as the shell is missing on the dorsum.

Lindström[1] was doubtful if his *T. longitudinalis* was identical with Sowerby's species, and remarked that neither Sowerby nor McCoy make mention of the presence of foramina in the dorsal line. McCoy's[2] description of the species was based on the Girvan specimens from Mulloch Hill, which show the revolving lines distinctly and are here regarded as a separate species referable to *Phragmostoma* (see *Phr. decipiens*).

R. B. Newton (*op. cit.*) has given a full description of certain specimens in the British Museum, from the Wenlock Beds of Dudley, which he describes as *Trematonotus britannicus*, but it does not seem possible to separate them from Sowerby's *B. dilatatus*, though they are very much better preserved than the latter's types, and show the foramina on the dorsum with great clearness as well as the ornamentation of thick sinuous revolving lines. Newton states that there is no sign of an apertural sinus and that the margin is entire, but the broad shallow open notch figured by Lindström in his *Tr. longitudinalis* appears to exist.

The specimen [27997] from the Wenlock Shale of Dudley in the Jermyn Street Museum, though distorted, may be referred to this species; it shows well the spiral lines and foramina as in Newton's figured specimens of *Tr. britannicus*, but concentric striæ seem more developed round the reflected margins of the mouth where the spiral lines have completely died out.

The difference in the appearance of the exterior of these shells seems largely due to the fact that the shell itself consists of more than one layer, the inner one bearing the revolving lines, as Perner[3] has pointed out. The Bohemian species *Tr. berannensis*, Perner,[4] from Stage Ee2, which shows the structure distinctly, is allied to our *Tr. dilatatus*.

[1] Lindström, *op. cit.*, p. 86, pl. iii, figs. 39, 40; pl. iv, figs. 1—7.

[2] McCoy, *op. cit.*, p. 309.

[3] Perner, *op. cit.*, pp. 104, 105.

[4] *Ibid.*, p. 114, pl. lxxxii, figs. 26—29; pl. lxxxvi, figs. 45, 46; text-figs. 80—82.

It is possible that several varieties are included under the specific name *Tr. dilatatus*; but the evidence is hardly sufficient to separate them satisfactorily, except in the case of the form from Woodland Point described below. The specimen [28060] from the Upper Llandovery of Bog Mine, Shelve, may belong to a distinct variety, but is too poor for description.

3. **Trematonotus dilatatus,** var. nov. **girvanensis.** Plate XIII, figs. 2, 3.

Varietal Characters.—This shell, of which the types occur in Mrs. Gray's Collection, agrees with the type-form in general characters, but the umbilical edges seem to be subangular, and the oval aperture subcircular or transversely elliptical in shape, the upper lip being less high and the lower lip especially narrower, for it only descends about one-fourth the distance from the base of the mouth to the base of the shell, and therefore does not reach the centre of the umbilicus. The foramina along the middle line of the dorsum also are smaller, but in no case are they well preserved. The whole shell seems more globose and the whorls relatively broader than in the type; but owing to crushing and distortion of the specimens this may be more apparent than real.

Dimensions.—Height of shell (with oral expansion), 67 mm.; height of ditto to base of mouth, 27 mm.; width of mouth, 64 mm.; width of outer whorl at base of mouth, 21 mm.

Horizon.—Saugh Hill Group, Llandovery Series.

Locality.—Woodland Point, Girvan.

4. **Trematonotus portlocki,** sp. nov. Plate XIII, fig. 4.

1843. *Bellerophon dilatatus*, Sowerby, var., Portlock, Geol. Rep. Londond., p. 398, pl. xxix, fig. 1.
1875. *Bellerophon dilatatus*, Sowerby, Baily (*pars*), Charact. Brit. Fossils, vol. i, Palæoz., p. 65 (*non* pl. xxii, figs. 1 *a*, 1 *b*).

Specific Characters.—Shell of few volutions; whorls low, transverse, wider than high, with broad gently convex dorsum; umbilicus large, open, exposing inner whorls (?); umbilical edges angular or subangular. Median band narrow, flattened, slightly raised, continuous, bearing small oval contiguous foramina (?). External surface of dorsum ornamented with closely-placed thick revolving lines, 20—24 on each side of slit-band, decussated by fine closely-placed transverse lines. Mouth abruptly expanded to a great size, being in height more than twice the diameter of the shell, subcircular in shape, rather higher than wide, with slight dorsal emargination and with whole margin reflexed and flattened, but not covering last whorl in front, wider dorsally than laterally, and marked with concentric striæ; whole interior of mouth ornamented with closely-placed thick revolving lines

similar to those on dorsum, curving outwards slightly on each side of a median impressed groove running up to marginal dorsal sinus.

Dimensions.—Height of shell (without oral expansion), c. 20 mm.; height of mouth, c. 47 mm.; width of mouth, c. 44 mm.

Horizon.—Upper Bala Beds.

Locality.—Desertcreat, Tyrone.

Remarks.—There is only one specimen, the type [27996] of this species, and it is in the Jermyn Street Museum; the apertural side which Portlock correctly figured is complete, but the umbilicus and dorsal parts are obscured by matrix. The raised continuous median band and the ornamentation mark it off at once from the typical *Tr. dilatatus* (Sow.), though Portlock says that Sowerby's description "exactly suits" it. The foramina on the slit-band are very indistinct, but seem to be small and contiguous. The raised band and general aspect somewhat resemble *Tr. longitudinalis*, Lindstr.,[1] but the finer and more regular ornament and the greater sharpness of the umbilical edges are distinctive features. The band, as in that species, seems to become narrower and sharper and to lose its foramina on the oral expansion.

Genus **PHRAGMOSTOMA**, Hall (*emend.* Koken).

Generic Characters.—Shell of same general shape and structure as *Trematonotus*, but with dorsum possessing only one opening or a small number of orifices. These orifices only occur on the outer whorl towards the mouth and are borne on a median ridge bordered on each side by a groove; the rest of the dorsum of the outer whorl is smooth.

The generic name is here employed in the manner followed by Perner (*op. cit.*, p. 121), who adopted Koken's[2] definition. The single species described below is doubtfully referred to this genus.

1. **Phragmostoma decipiens**, sp. nov. Plate XIII, figs. 5—7.

1852. *Bellerophon dilatatus*, Sowerby, McCoy, Syn. Brit. Pal. Foss. Woodw. Mus., fasc. ii, p. 309 (*non* Sowerby).

Specific Characters.—Shell subglobose, subdiscoidal, of 4—5 broad transverse whorls, slightly overlapping to about one-fourth or one-fifth their height; umbilicus conical, deep, rather large, being rather more than one-third the diameter of the shell, exposing all the inner whorls; umbilical edge subangular to rounded;

[1] Lindström, *op. cit.*, p. 86, pl. iv, figs. 1—7.

[2] Koken, 'Die Leitfossilien' (1896), p. 99.

umbilical slope very steep. Whorls transverse, low, about twice as wide as high, with distal third of outer whorl nearly straight, increasing slowly in height to mouth but more rapidly in height in distal third; dorsum gently rounded or slightly flattened except in distal third where it becomes carinated with a sharp median angulation. Mouth transverse, slightly expanded at sides (but not abruptly), with lower lip reflected and thickened; upper lip not reflected or thickened, but with broad open very shallow V-shaped emargination followed by long narrow median slit and then by slightly depressed band showing obscure traces of small oval foramina. Surface of shell ornamented with (1) closely-placed fine transverse striæ, becoming stronger and squamose near margins of aperture and curving back to meet median line at about 60°; and with (2) weak low rounded regular equal revolving ridges parallel to median line and becoming stronger and more distinct on umbilical slopes where they are slightly oblique to the suture-lines, and are finely cancellated by the transverse striæ.

Dimensions.—Height, c. 60 mm.; thickness, c. 20 mm.; diameter of umbilicus, c. 24 mm.

Horizon.—Mulloch Hill Group, Llandovery Series.

Locality.—Mulloch Hill, Girvan.

Remarks.—This large shell, of which the types are in Mrs. Gray's Collection, was referred by McCoy to *Tr. dilatatus* (Sow.), and in fact he only mentioned this Girvan locality for the occurrence of the species. The specimens which he thus labelled in the Sedgwick Museum and the more abundant and more illustrative material in Mrs. Gray's Collection show that it cannot be considered identical with Sowerby's form. The non-reflection of the upper lip of the mouth, the narrow median dorsal slit, the much smaller expansion of the mouth and depressed median band are sufficient to separate it, though the general shape of the shell and character of the ornamentation are on the whole closely similar. Indeed there was at first some doubt in my mind whether it was separable from the form from Woodland Point described above as *Trem. dilatatus* var. *girvanensis*, but the reduced sharpness of the umbilical edge, the presence of the median slit on the dorsum, the simple non-reflected and unthickened upper lip, the straightening of the last part of the outer whorl, the strong transverse striæ and the depressed median band are distinguishing features. The ornament of longitudinal revolving lines is almost identical. As to the genus to which this Mulloch Hill shell should be referred, *Phragmostoma* seems more suited to receive it than *Trematonotus*, and we may compare *Phr. civis* (Barr.)[1] from Stage Ee 2 for the double ridge or slit-band on the last whorl and for the ornament, and *Phr. nobile* (Barr.)[2] for the carination and foramina near the mouth.

[1] Perner, *op. cit.*, p. 125, pl. cciv, figs. 20—30; text-figs. 89, 90.

[2] *Ibid.*, p. 122, pl. lxxxii, figs. 6, 7; pl. lxxxvi, figs. 43, 44; text-figs. 87 *a—d*.

Genus **CARINAROPSIS**, Hall.

Generic Characters.—Shell composed of little more than two whorls, the inner one very small, scarcely embraced by the outer, and more or less free; outer whorl very large, rapidly expanded; dorsum sharply carinated, becoming less angular towards aperture; [slit-band occasionally distinguishable?]. Mouth very large, with everted margins; dorsal lip thin, sinuate and centrally notched; inner lip entire, reflexed [with broad thick inner plate bearing median ridge]; inner aperture to whorls covered [always ?] by triangular flat operculum.

Ulrich and Scofield[1] believe that this genus should include the genus *Pterotheca*, Salter, the Girvan representatives of which have been described by the present author[2] amongst the Pteropoda. Perner,[3] however, puts *Carinaropsis* (which he spells *Carinariopsis*) in his group Bucanioidea. In Zittel-Eastman's 'Text-book of Palæontology' (2nd edit., 1913, p. 523) the genus is put in a family by itself after the family Bellerophontidæ, but *Pterotheca* is included with the Pteropoda and placed in the family Hyolithidæ. A discussion of the characters of *Carinaropsis* and of the diverse usage of the name by various authors is given by Perner. Our British specimens do not help to clear up the difficulties connected with it. I have not seen any trace of a slit-band in any examples, and I much doubt if forms possessing this structure should be included in this genus, of which the type-species is *C. carinata*, Hall,[4] of the Trenton Group.

1. **Carinaropsis gracilis**, sp. nov. Plate XIII, figs. 8, 9.

Specific Characters.—Shell of 1—1½ whorls, scarcely embracing, acutely carinate, triangular in section; umbilicus small, situated at about one-fourth the height of shell. Outer whorl very rapidly increasing in size to about three or four times the height and width at peristome. Mouth large, much expanded laterally, transversely elliptical in shape, with broad acute shallow V-shaped sinus in outer lip; apertural lobes rounded, very large, laterally extended and flattened, inner lip somewhat deflected. Surface of shell with fine transverse striæ and growth-lines concentric to margin near peristome.

Dimensions:

	I	II
Height of shell	c. 16·5 mm.	21 mm.
Width of mouth	c. 18·5 ,,	27 ,,

Horizon.—Balclatchie Group, Lower Ordovician.

Localities.—Ardmillan; Balclatchie; Dow Hill, Girvan.

[1] Ulrich and Scofield, *op. cit.*, pp. 857, 926.

[2] Reed, 'Trans. Roy. Soc. Edinburgh,' vol. xlvii, pt. ii, no. 9 (1909), p. 215.

[3] Perner, *op. cit.*, p. 90.

[4] Hall, 'Palæont. New York,' vol. i (1847), p. 183, pl. xl, figs. 1 *a*—*c*.

Remarks.—This shell is allied to *C. carinata*, Ulr. & Scof.[1] and *C. sulcata*, Ulr.,[2] but the internal septum is not visible in any of our specimens from Girvan. The species from the Corona Beds of Roman Fell near Appleby described below bears much resemblance to this Scottish one, the type-specimens of which are in Mrs. Gray's Collection.

2. **Carinaropsis maccoyi**, sp. nov. Plate XIII. fig. 10.

1852. *Bellerophon carinatus*, Sowerby, McCoy (pars), Syn. Brit. Pal. Foss. Woodw. Mus., fasc. ii. p. 502.

Specific Characters.—Shell of few whorls, carinated; outer whorl acutely angular, wedge-shaped, rapidly increasing in height, with sharp dorsum and suddenly expanded mouth. Umbilicus small, open, partly exposing 1—2 inner whorls; umbilical edge subangular; umbilical slope very steep. Mouth transverse, wider than high, with everted margins and inner lip descending nearly to base of shell; large deep V-shaped sinus in outer lip.

Dimensions.—Height of shell, 3·50 mm.; width of mouth, 4·75 mm.

Horizons.—(1) Middle Bala; (2) Corona Beds, Bala Series.

Localities.—(1) Dolydd Ceiriog Waterfall, E. of Berwyn Mts.; (2) Roman Fell, near Appleby.

Remarks.—The two small specimens in the Sedgwick Museum from Dolydd Ceiriog which McCoy and Salter labelled respectively *Bellerophon acutus* and *B. carinatus*, are quite distinct from typical examples of these species. The very large transversely expanded and reflexed mouth, the very rapid increase in the height of the outer whorl, the small number of whorls, the small umbilicus and whole appearance of the shell at once distinguish it. But it bears a considerable resemblance to *Carinaropsis acuta*, Ulr. & Scof.,[3] from the Black River Group of Minnesota. The specimens from Roman Fell are mostly larger than those from Dolydd Ceiriog, but seem referable to the same species. The Dolydd Ceiriog shell is chosen as the type of our species.

Species of Bellerophontinæ of uncertain value.—The four very fragmentary specimens [28046—49], from the Lower Llandovery of Blaen-y-cwm, which Salter[4] named *Bellerophon latus*, but did not describe or figure, are in the Jermyn Street Museum. They are too imperfect and broken to allow of any specific description.

The same poor state of preservation likewise prevents any satisfactory determination of the solitary specimen [28045] from the same horizon and locality and

[1] Ulrich and Scofield, *op. cit.*, p. 928, pl. lxii. figs. 6—9.

[2] *Ibid.*, p. 929, pl. lxii. fig. 5.

[3] Ulrich and Scofield, *op. cit.*, p. 928, pl. lxii. figs. 6—9.

[4] 'Catal. Camb. Silur. Foss. Mus. Pract. Geol.' (1873), p. 67.

in the same Museum to which Wyatt Edgell[1] attached the MS. name of *Bellerophon discus*, but it probably is referable to the genus *Zonidiscus* rather than to *Oxydiscus* (see p. 74). It seems to resemble in general characters the shell called *Oxydiscus annularis*, Perner,[2] from Stage Ee 2 in Bohemia.

Addendum.

Salpingostoma shallochense, sp. nov. Plate XII, fig. 6.

Specific Characters.—Shell composed of few whorls in contact but not overlapping, slowly increasing in size to mouth, circular or subcircular in section, but with dorsum of last whorl weakly carinated towards mouth. Outer whorl ornamented with transverse rugæ set some distance apart and slightly arched back in middle so as to form a wide angle on the dorsum, which shows distinct traces of a median slit with compressed, somewhat sinuous (?) edges. Mouth suddenly and immensely expanded nearly at right angles to plane of shell, forming a trumpet-shaped subcircular peristome with flattened lips about five times the diameter of outer whorl; inner lip reflexed and descending below base of whorls; outer lip entire, without median emargination, but with faint median ridge on its outer surface in continuation of dorsal slit on last whorl. Surface of peristomal expansion marked with low concentric growth-ridges and ornamented with numerous radiating thick rounded raised lines, mostly equidistant and regularly disposed, minutely wavy on the inner and lateral portions, with the broader interspaces occupied by 4—7 much finer similarly wavy thread-like radial lines. Inner surface of peristome showing numerous fine straight radiating striæ and a few concentric growth-ridges.

Dimensions.—Height of shell before oral expansion, c. 25 mm.; width of mouth, 60–65 mm.; height of mouth, 50–55 mm.

Horizon.—Whitehouse Group.

Locality.—Shalloch Mill, Girvan.

Remarks.—The cast and impression of the huge mouth of this shell, with a portion of the coiled whorls attached, has been lately sent me by Mrs. Gray. Unfortunately there is not sufficient of this imperfectly preserved specimen to give as full a description of the specific characters as could be desired, but the species is certainly distinct from any previously described, although it is obviously allied to *S. grande* (Barr.)[3] from Stage D 5 in Bohemia, agreeing with it in the ornamentation of the peristome, the transverse ribs on the whorls, and the dorsal slit.

[1] *Ibid.*, p. 67.

[2] Perner, *op. cit.*, p. 74, pl. lxxxvi, figs. 1—3.

[3] *Ibid.*, p. 97, pl. lxxxiv, figs. 12—14; pl. lxxxv, figs. 22—32; text-fig. 69 *a—f*.

STRATIGRAPHICAL DISTRIBUTION OF THE BELLEROPHONTACEA IN ENGLAND AND WALES.

ARENIG.

Sinuites? *ramseyensis* (Hicks).
„ *discoides*, sp. nov.?
Oxydiscus? *llanvirnensis* (Hicks).
„ ? *perturbatus* (Sow.).
Tetranota hippopus (Salt.).
Bellerophon? *solvensis*, Hicks.
Budleigh Salterton { *Cyrtolites budleighensis*, sp. nov. *Bellerophon*, sp.

BALA (including LLANDEILO).

Sinuites anceps (Salt. MS.).
„ *bilobatus* (Sow.).
„ *crypticus*, Reed.
„ *pseudocompressus*, sp. nov.
„ *pusgillensis*, sp. nov.
„ *semirugosus* (Salter MS.).
„ *soudleyensis*, sp. nov.
„ sp.
Oxydiscus acutus (Sow.).
„ ? *llanvirnensis* (Hicks).
„ ? *perturbatus* (Sow.).
Cyrtolites nodosus (Salt.).
„ sp.
Bucania, sp.
Kokenospira lingualis (Salt.).
„ *latidorsata*, sp. nov.
„ *secunda* (Reed).
Bucaniopsis nicoli, sp. nov.
Conradella sladensis, Reed.
Salpingostoma multirugatum (Reed).
„ sp.
Carinaropsis maccoyi, sp. nov.

LLANDOVERY.

Cyrtolites nodosus (Salt.), var. nov. *llandoveriana*.
Bucaniella quadrisulcata, sp. nov.
„ *trilobata* (Sow.).
Kokenospira credibilis, sp. nov.
Bellerophon wenlockensis, Sow., var.
Bucaniopsis?, sp.
Cymbularia carinata (Sow.), var.
„ *turnbulli*, sp. nov.
Zonidiscus, sp.
Trematonotus dilatatus (Sow.), var.

WENLOCK.

Bucaniella trilobata (Sow.),
Kokenospira subdecussata (McCoy).
Temnodiscus fletcheri, sp. nov.
„ *monilifer*, sp. nov.
„ *salopiensis*, sp. nov.
Bellerophon globulus, Lindstr.
„ *ledburiensis*, sp. nov.
„ *wenlockensis*, Sow.
Bucaniopsis? cf. *latevittatus*, Lindstr.
Cymbularia merita, sp. nov.
Trematonotus dilatatus (Sow.).

LUDLOW.

Bucaniella trilobata (Sow.).
Bellerophon globulus, Lindstr.
„ *ruthveni*, Salt. MS.
Temnodiscus murchisoni (D'Orb.).
„ *solitarius*, sp. nov.
Bucaniopsis expansus (Sow.).
Cymbularia carinata (Sow.).
„ cf. *fastigiata* (Lindstr.).
Salpingostoma? *infundibulum*, Salt. MS.
Trematonotus aymestriensis (Sow.).
„ *dilatatus* (Sow.).

ORDOVICIAN SPECIES OF BELLEROPHONTACEA FROM TYRONE, IRELAND.

BALA.

Sinuites bilobatus (Sow.)?
„ *elongatus* (Portlock).
„ *subrectangularis*, sp. nov.?
Kokenospira lingualis (Salt.).
Cymbularia alata (Portlock).
Salpingostoma asteroideum, sp. nov.?
Trematonotus portlocki, sp. nov.

[*Note*.—The Silurian species of Bellerophontacea occurring in Ireland are not sufficiently known to give a satisfactory list.]

STRATIGRAPHICAL DISTRIBUTION OF THE BELLEROPHONTACEA IN THE GIRVAN DISTRICT, SCOTLAND.

ORDOVICIAN.

STINCHAR LIMESTONE GROUP.

Oxydiscus bougangensis, sp. nov.
„ *hunteri*, sp. nov.
Cyrtolites craigensis, sp. nov.
Bucania gravida, sp. nov.
„ cf. *punctifrons* (Emmons).
Kokenospira nicholsoni, sp. nov.
Tetranota carrickensis, sp. nov., var. *craigensis*.
Salpingostoma buccinoideum, sp. nov.?
„ *etheridgei*, sp. nov.

BALCLATCHIE GROUP.

Sinuites balclatchiensis, sp. nov.
„ *discoides*, sp. nov.
„ *maccallami*, sp. nov.
„ ? *sphæroidalis*, sp. nov.
„ ? *separatus*, sp. nov.
Sinuitopsis congruens, sp. nov.
Oxydiscus hunteri, sp. nov.
Bucania evoluta, sp. nov.
„ *gravida*, sp. nov.
Kokenospira maccullochi, sp. nov.
Tetranota carrickensis, sp. nov.
Zonidiscus transiens, sp. nov.
Salpingostoma buccinoideum, sp. nov.
Carinaropsis gracilis, sp. nov.

WHITEHOUSE GROUP.

Isospira huttoni, sp. nov.
Bucania Playfairi, sp. nov.
Conradella girvanensis, sp. nov.
„ ? *multilineata*, sp. nov.
Bucaniopsis forbesi, sp. nov.
Cymbularia youngi, sp. nov.
Zonidiscus shallochensis, sp. nov.
Salpingostoma shallochense, sp. nov.

DRUMMUCK GROUP.

Sinuites subrectangularis, sp. nov.
Cyrtolites thraivensis, sp. nov.
Kokenospira lingualis (Salt.), var. nov. *girvanensis*.
Tetranota carrickensis, sp. nov. var. *etheridgei*.
Conradella aff. *fimbriata*, Ulr. & Scof.
Bucaniopsis nicoli, sp. nov.
Cymbularia drummuckensis, sp. nov.
Zonidiscus grayi, sp. nov.
Salpingostoma asteroideum, sp. nov.

SILURIAN.

MULLOCH HILL GROUP.

Kokenospira mullochensis, sp. nov.
Bellerophon sphæra, Lindstr., var. nov. *judex*.
Phragmostoma decipiens, sp. nov.

SAUGH HILL GROUP.

Bellerophon sphæra, Lindstr., var. nov. *judex*.
Cymbularia ? *woodlandensis*, sp. nov.
Trematonotus dilatatus (Sow.), var. nov. *girvanensis*.

CAMREGAN GROUP.

Kokenospira euphemoides, sp. nov.

PENKILL GROUP.

Bellerophon, sp. ind.

INDEX.

NOTE.—The roman and arabic numerals following a semicolon refer to the plates and figures illustrating those species which are figured.

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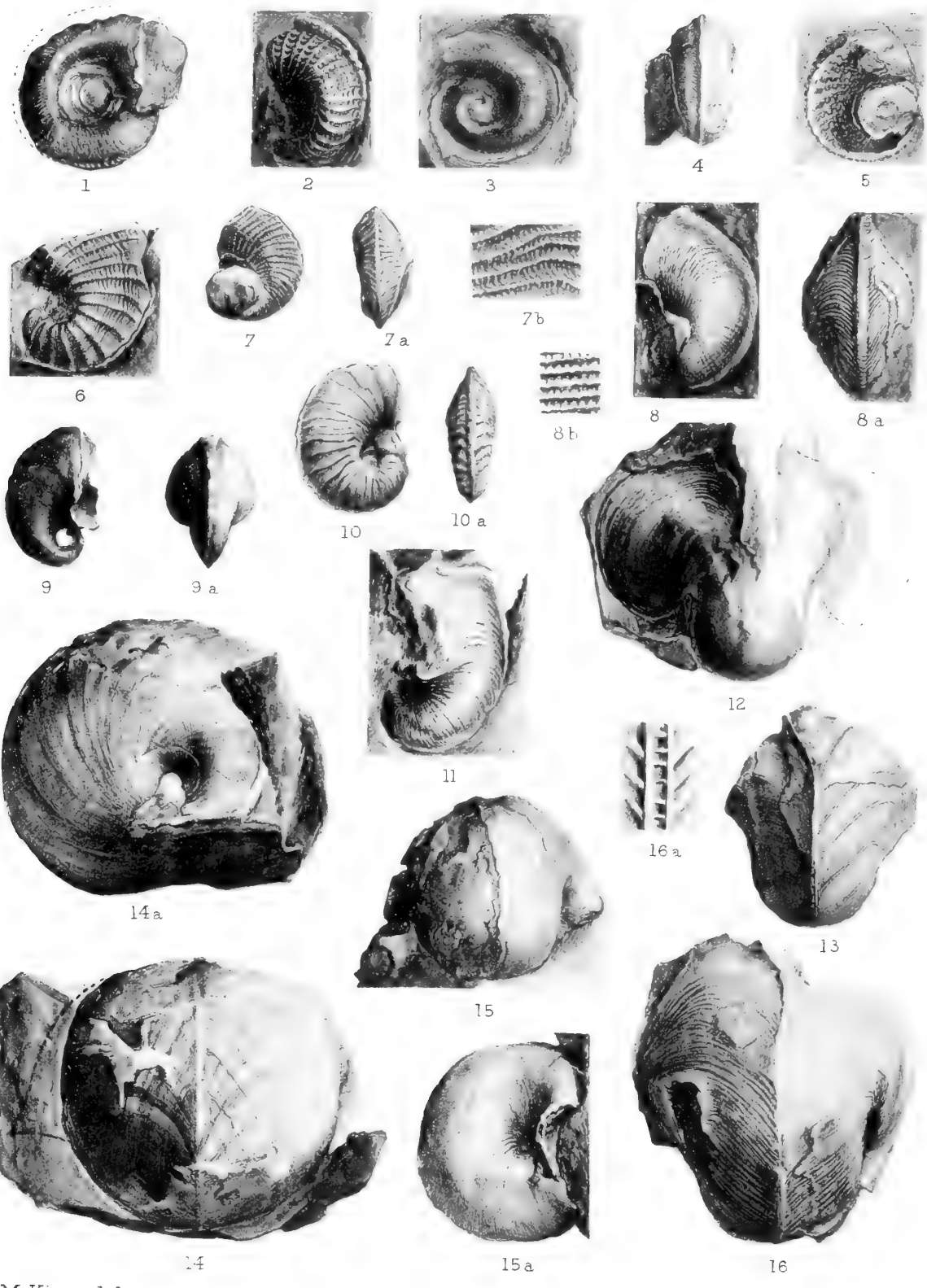
PLATE IX.

Reed. Bellerophontacea.

PLATE IX.



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1-5. CONRADELLA. 6-11. TEMNODISCUS.

12-16. BELLEROPHON.

PLATE X.

Fig. Page.

1. *Bucaniopsis expansus* (Sowerby). Dorsal view (shell preserved). × 2. Upper Ludlow, Ludlow. Mus. Pract. Geol. [28079]. 60.

1*a*. Ditto. Ornamentation of same specimen. × 10. 60.

2. Ditto. Dorsal view of another specimen. × 2. Ludlow Beds, Frith Farm, Malvern. Mus. Pract. Geol. [28078]. 60

3. Ditto. Dorsal view of internal cast. × 2. Upper Ludlow, near Ludlow. Sedgwick Mus. 60.

4. Ditto. Ditto. × 3. Upper Ludlow. Dinas Bran, Llangollen. Sedgwick Mus. 60.

5. *Bucaniopsis forbesi*, sp. nov. Front view. × 1½. Whitehouse Group, Shalloch Mill, Girvan. Mrs. Gray's Coll. 61.

5*a*. Ditto. Dorsal view of same specimen. × 2. 61.

5*b*. Ditto. Ornamentation of same specimen. × 10. 61.

6. Ditto. Side view of distorted specimen. × 2. Same horizon, locality and collection. 61.

7. *Bucaniopsis nicoli*, sp. nov. Dorsal view. × 1½. Drummuck Group, Thraive Glen, Girvan. Mrs. Gray's Coll. 61.

7*a*. Ditto. Ornamentation of same specimen. × 14. 61.

8. Ditto. Impression of exterior of apertural region of another specimen. × 1½. Same horizon, locality and collection. 61.

9. Ditto. Side view of internal cast. × 1½. Same horizon, locality and collection. 61.

10. *Cymbularia alata* (Portlock). Dorsal view. × 1½. Bala Beds, Desertcreat, Tyrone. Mus. Pract. Geol. [27998]. 63.

11. Ditto. Ditto. × 1½. Same horizon, locality and collection [28000]. 63.

12. *Cymbularia carinata* (Sowerby). Side view of internal cast. × 3. Upper Ludlow, Horeb Chapel, Llandovery. Mus. Pract. Geol. [6655]. 64.

13. Ditto. Var. Side view of internal cast. Upper Llandovery, Bogmine, Shelve. Mus. Pract. Geol. [28065]. 66.

14. Ditto. Var. Posterior view of internal cast. Same horizon, locality and collection [28062]. 66.

15. *Cymbularia drummuckensis*, sp. nov. Dorsal view. × 3. Drummuck Group, Thraive Glen, Girvan. Mrs. Gray's Coll. 66.

16. Ditto. Side view of another specimen. × 1½. Same horizon, locality and collection. 66.

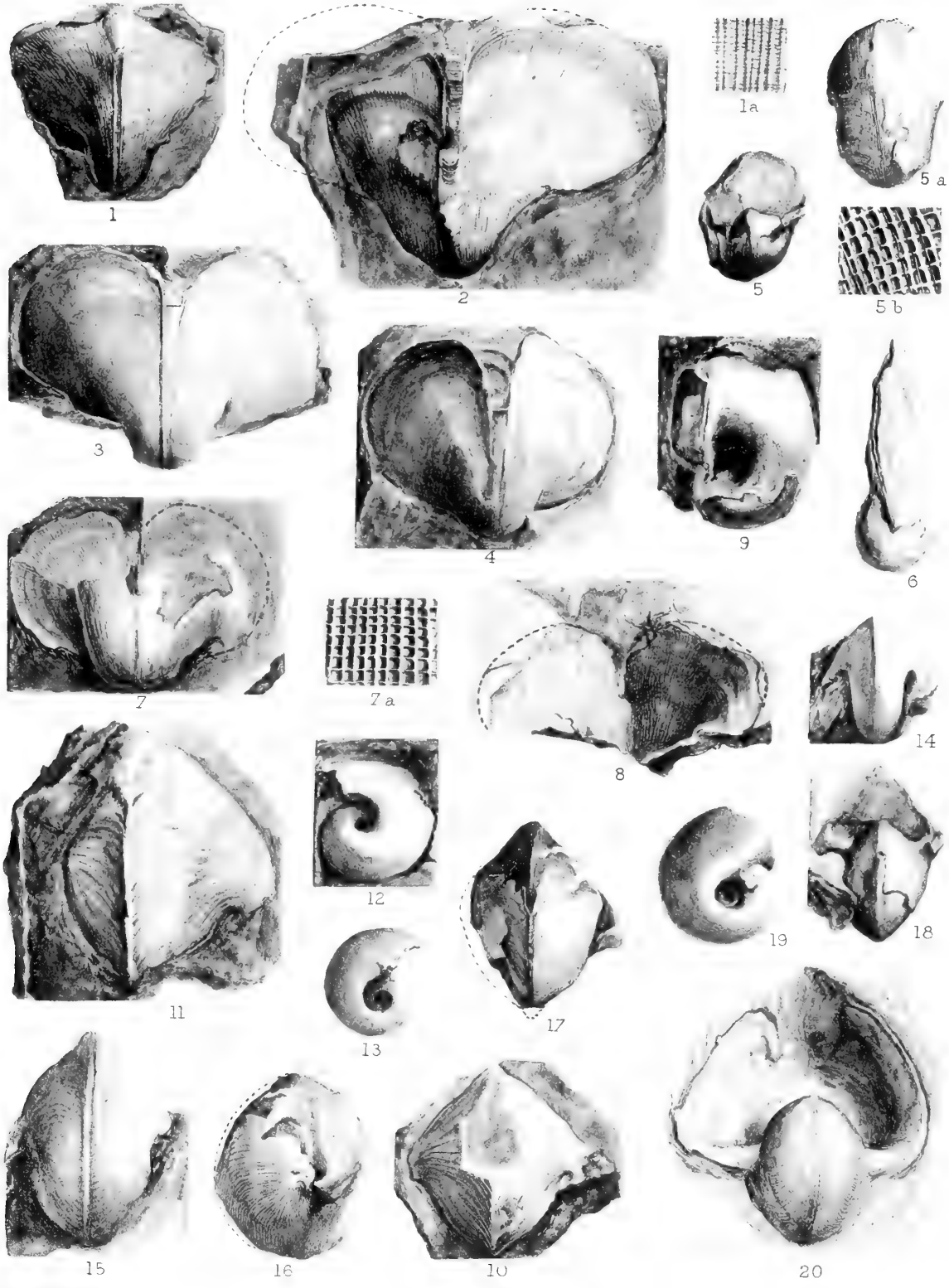
17. Ditto. Dorsal view of another specimen. × 1½. Same horizon, locality and collection. 66.

18. Ditto. Front view of another specimen. × 1½. Same horizon, locality and collection. 66.

19. Ditto. Side view of internal cast. × 1½. Same horizon, locality and collection. 66.

20. *Cymbularia merita*, sp. nov. Front view. × 2. Wenlock Shale, Dudley. Brit. Mus. [G. 73904*a*]. 68.

Reed, Bellerophontacea. PLATE X.



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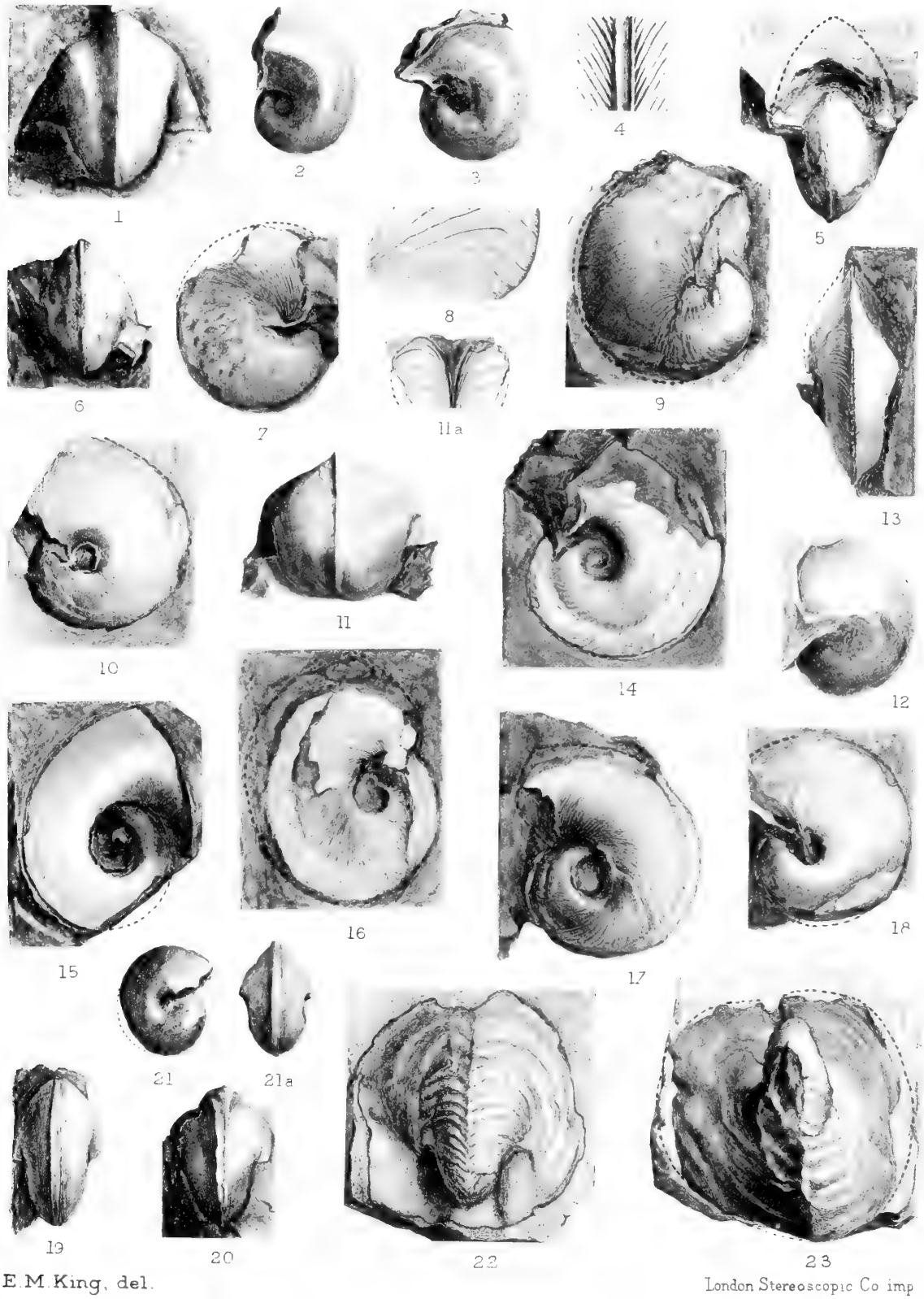
1-9. BUCANIOPSIS. 10-20. CYMBULARIA.

PLATE XI.

Reed. Bellerophontacea. PLATE X.



1-12. CYMBULARIA. 13-21. ZONIDISCUS.

22-23. SALPINGOSTOMA.

PLATE XII.

Reed, Bellerophontacea.

PLATE XII.

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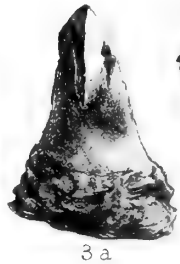

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3b

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4a

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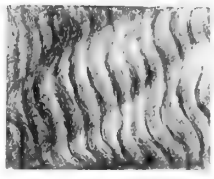

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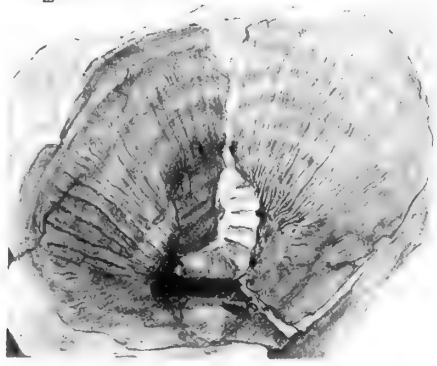

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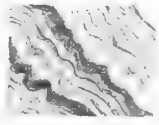

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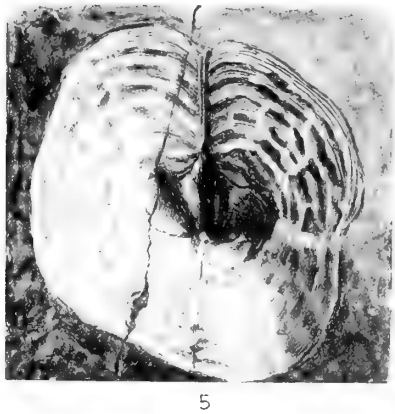

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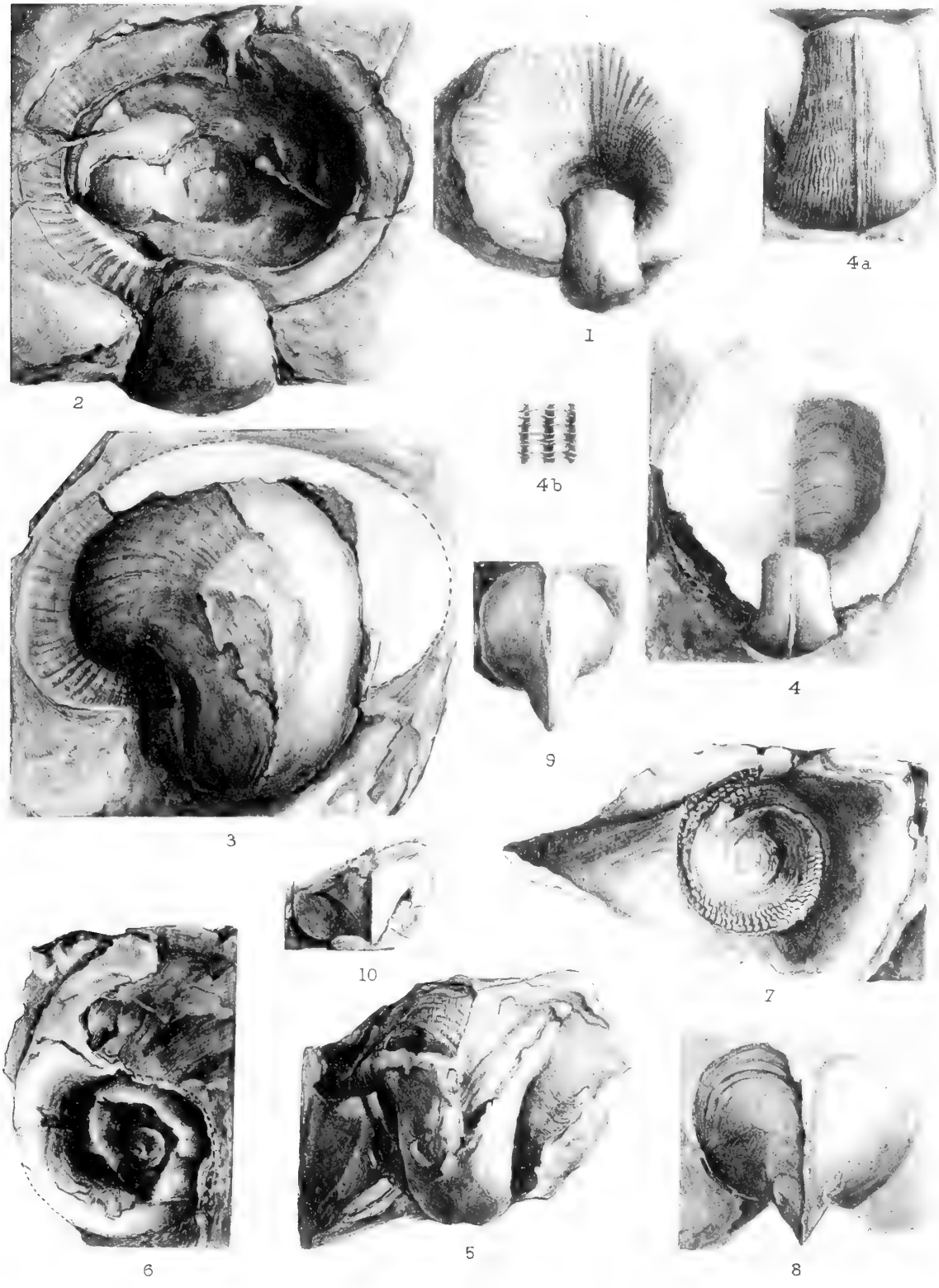
1-6. SALPINGOSTOMA. 7-8. TREMATONOTUS.

PLATE XIII.

Fig.		Page.
1.	*Trematonotus dilatatus* (Sowerby). Front view. Half nat. size. Wenlock Limestone, Burrington, near Ludlow. Mus. Pract. Geol. [6712].	80.
2.	Ditto. var. *girvanensis*, nov. Front view. Nat. size. Saugh Hill Group, Woodland Point, Girvan. Mrs. Gray's Coll.	83.
3.	Ditto. Dorsal view of another specimen. Nat. size. Same horizon, locality and collection.	83.
4.	*Trematonotus portlocki*, sp. nov. Front view. Nat. size. Upper Bala Beds, Desertcreat, Tyrone. Mus. Pract. Geol. [27996].	83.
4*a*.	Ditto. Lower portion of same specimen. × 2.	83.
4*b*.	Ditto. Ornamentation. × 10.	83.
5.	*Phragmostoma decipiens*, sp. nov. Dorsal view. × $\frac{2}{3}$. Mulloch Hill Group, Mulloch Hill, Girvan. Mrs. Gray's Coll.	84.
6.	Ditto. Side view of internal cast. Nat. size. Same horizon, locality and collection.	84.
7.	Ditto. Impression of umbilical portion, showing ornamentation. × 2. Same horizon, locality and collection.	84.
8.	*Carinaropsis gracilis*, sp. nov. Dorsal view. × 2. Balclatchie Group, Balclatchie, Girvan. Mrs. Gray's Coll.	86.
9.	Ditto. Ditto. × 2. Same horizon, locality and collection.	86.
10.	*Carinaropsis maccoyi*, sp. nov. Dorsal view. × 5. Middle Bala, Dolydd Ceiriog Waterfall, E. of Berwyn Mts. Sedgwick Mus.	87.

Reed, Bellerophontacea.

PLATE XIII



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1-4. TREMATONOTUS 5-7. PHRAGMOSTOMA.

8-10. CARINAROPSIS.

Palæontographical Society, 1919.

A MONOGRAPH

OF THE

FOSSIL INSECTS

OF THE

BRITISH COAL MEASURES.

BY

HERBERT BOLTON, M.Sc., F.R.S.E., F.G.S.,
DIRECTOR OF THE BRISTOL MUSEUM.

PART I.

Pages 1—80; Plates I—IV.

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THE FOSSIL INSECTS OF THE BRITISH COAL MEASURES.

INTRODUCTION.

The first recorded Palæozoic insect of any country appears to have been a British specimen, *Lithosialis brongniarti* (Mantell), which was discovered in the Coal Measures of Coalbrookdale in the early part of last century. It was sent by Mantell to Brongniart as a leaf impression. Brongniart in turn submitted the fossil to Mons. Audouin, who (1833, Audouin, 'Ann. Soc. Ent. France,' ii, Bull., p. 7) described it as "d'un insecte inconnu," and allied to the Hemerobiidæ, *Semblis*, and especially to *Corydalis* and *Mantis*. The specimen was afterwards figured and named by Mantell (1854, 'Medals of Creation,' vol. ii, p. 575, fig. 2).

According to Parkinson, however, Lhuyd first recognised fossil insects in the British Coal Measures. Parkinson ('Organic Remains,' vol. iii, p. 258, 1804—1811) states that Lhuyd in a postscript to a letter to Dr. Richardson wrote as follows: "Scripsi olim suspicari me Araneorum quorundam icones, una cum lithophytis, in schisto carbonario observasse; hoc jam ulteriore experientia edoctus aperte assero. Alias icones habeo, quæ ad Scarabæorum genus quam proxime accedunt. In posterum ergo non tantum Lithophyta, sed et quædam insecta in hoc lapide investigare conabimur." ('Lithophylacii,' p. 113.)

["I have formerly written that I believed I had observed certain impressions of spiders identical with Lithophytes in carbonaceous shales; this I now, taught by later experience, openly assert. I have other impressions which approach nearest to the family of beetles. For the future, therefore, we will endeavour to investigate not only Lithophyta, but also certain insects in these shales."]

Parkinson reprints four figures given by Lhuyd in his 'Iconograph,' tab. 4. Two of these figures show eight legs and must therefore represent the remains of Arachnids. None of the figures show wing-structure.

Interest in the occurrence of fossil insects was stimulated in 1837 by the publication of Dean Buckland's 'Bridgewater Treatise' on Geology, in which he described and figured two fossils found at Coalbrookdale by Mr. Anstice (1837, Buckland, 'Geology and Mineralogy,' 2nd ed., vol. ii, p. 76). He determined both specimens to be the remains of coleopterous insects—a determination since corrected by H. Woodward (1871, 'Geol. Mag.,' vol. viii, p. 386, pl. xi), by Scudder, and finally by Pocock, who referred them to the Arachnida ("Terrestrial Carboniferous Arachnida," 'Mon. Pal. Soc.,' 1911, pp. 39, 77).

Attention was afterwards diverted from the Coal Measures by the remarkable discoveries of insect-remains made by Brodie in the Purbeck and Liassic rocks, and by similar discoveries on the continent.

Mr. E. W. Binney (1867, 'Proc. Lit. and Phil. Soc. Manchester,' vol. vi, p. 59) exhibited a specimen which "bore some resemblance to the pupa state of a coleopterous insect," and had been found in the Cinderford Dyke Pit at Bradley, near Huddersfield.

A second specimen exhibited by Binney at the same time was referred to *Xylobius sigillariæ*, Dawson. Binney added: "We must expect great additions to be made to the Carboniferous fauna, as doubtless the rich and luxurious vegetation of that remote period would afford food and shelter for numerous insects."

Binney's notes on the Huddersfield specimens caused the Rev. P. B. Brodie to record (1867, 'Geol. Mag.,' vol. iv, pp. 285—286) that he had in his collection "a wing of a gigantic Neuropterous insect in ironstone from the Derbyshire Coal Measures."

The same year Kirkby (1867, 'Geol. Mag.,' vol. iv, pp. 388—390) reported the finding of clearly defined insect-remains in the Durham Coal Measures. One example consisted of "portions of the fore wing or tegmina of an orthopterous insect nearly allied to *Blatta* or Cockroach," and the other "of an orthopterous insect, apparently the abortive wing of a specimen related to the Phasmidæ." Kirkby's first specimen is the small but very fine wing described here under the name of *Phylomylacris mantidioides* (Sternberg). The second specimen is not determinable as an insect-fragment, and may prove to be a fossil fruit, referable to one of the higher plants of the Coal Measures.

From 1867 onwards the finding of fossil insects in the British Coal Measures occurred at long intervals until in 1908, the date of publication of Handlirsch's 'Fossilen Insekten,' the following had been recorded:

Phylomylacris mantidioides (Goldenberg).
olim, "allied to *Blatta*," Kirkby.
olim, "*Blattina mantidioides*," Goldenberg.
Lithosialis brongniarti (Mantell).
olim, "*Gryllacris brongniarti*," Mantell.
Lithomantis carbonarius, Woodward.
Archæoptilus ingens, Scudder.
Brodia priscotincta, Scudder.
Ædœophasma anglica, Scudder.
Aphthoroblattina johnsoni (Woodward).
olim, "*Etoblattina johnsoni*," Woodward.
(*Blattoidea*) *peachii* (Woodward).
olim, "*Etoblattina peachii*," Woodward.
Leptoblattina exilis, Woodward.
Lithomylacris kirkbyi, Woodward.
Soomylacris deanensis (Woodward).
olim, "*Etoblattina deanensis*," Woodward.
Pseudofouquea cambrensis (Allen).
olim, "*Fouquea cambrensis*," Allen.
Breyeria woodwardiana (Handlirsch).
olim, "affinity with *Lithomantis carbonarius*," Stobbs.
olim, "*Stobbsia woodwardiana*," Handlirsch.

The numerous discoveries of insect-remains in the Coal Measures of Commentry (Allier), France, and the remarkable series made known by Handlirsch from the

continent generally, and from the United States, overshadowed the limited British series, which seemed almost trivial by comparison. The present monograph shows, however, that the fossil insect-remains of the British Coal Measures are far more abundant than was supposed, and that they are by no means unimportant. About seventy specimens are known, of about sixty species, and they represent five of the great groups of fossil insects.

Palæodictyoptera are the dominant forms, and are closely followed by Blattoids, several of which are referable to genera occurring in the French and Belgian coalfields. The British examples of *Soomylacris* are represented near Lens and Liévin by *Soomylacris lievinensis*, Pr., while *Phylomylacris mantidioides* has its counterparts in *Phylomylacris godoni*, Pr., and *Phylomylacris lafittei*, Pr., from Lens. The great Protodonata of Commentry are represented in the Bristol coalfield by *Boltonites radstockensis*.

The generic identity of French and British Coal Measure insects implies that they formed part of a general and wide-spread fauna, a view which is strengthened by the fact that while *Soomylacris deanensis* and *S. stocki* occur in the Forest of Dean coalfield, to the west, *S. burri* occurs in the Kent coalfield to the east, and only separated by the Straits of Dover from the Coal Measures of Northern France, in which Pruvost finds other species of the same genus.

Pruvost has also shown that in the Coal Measures of Lens and Liévin there is present a well-defined horizon of *Anthracomya phillipsii*, in which that species passes through the same developmental changes as in the Kent coalfield.

It is extremely likely that the Kent coalfield will later yield numerous insect-remains closely allied to those of France, and that systematic search will amplify the list of forms already known from all the British coalfields.

The British Palæodictyoptera, on the whole, are more varied than the French, few forms showing the primitive condition of *Stenodictya*, while certain examples, such as *Mecynoptera tuberculata*, *Palæomantis macroptera*, and the three genera of Lithomantids, are highly specialised. A similar degree of specialisation is seen in the British examples of the Protorthoptera, while the Blattoids, by their numerous genera and species, indicate that the group had a long history and a wide geographical range in the British coal period.

The fossil insects already found in the British Coal Measures form probably but a small fraction of those which remain to be discovered when attention is more fully directed to them. The insect-fauna, however, is not usually associated with the general fauna in the Coal Measures, but occurs in beds of lighter coloured rock than the ordinary carbonaceous shales, and with abundant ironstone nodules, or in the case of the Blattoids, in association with masses of drifted vegetation in the black shales, where the neuration of the wings so closely simulates the pinnules of *Neuropteris* as to be mistaken for the latter and cast aside.

While insect-remains are usually regarded as wholly restricted to the West-

phalian and Stephanian stages of the Coal Measures, the fauna with which they are most often associated in this country may indicate a greater age, as it is known to occur as low down as the Calciferous Series of Scotland. Any statement, therefore, of the range in time of British Palæozoic insects based on the present known forms may have to be set aside by later discoveries.

The fauna with which fossil insects are usually associated in Great Britain is one in which arachnids and certain of the more primitive arthropods are the dominant forms. Arachnids are known to occur in the Calciferous Sandstone Series of Scotland at Redhall, near Slateford, Edinburgh, and in the Cement-stone Group of the Lower Carboniferous at Langholme, Dumfriesshire (1911, Pocock, 'Mon. Pal. Soc.,' p. 18), and elsewhere, the genus *Archæoctonus* being represented by *A. glaber* and *A. tuberculatus*, and the genus *Cyclophthalmus* by *C. euglyptus* at Redhall, Blair Point, near Dysart, and Cramon near Edinburgh.

No insect-remains are known from any of these horizons, but if the faunal association seen in the Coal Measures is a trustworthy guide, they may be looked for with some prospect of success.

The faunal association existing in the "Soapstone Bed" of the Lower Coal Measures at Carre Heys, Colne, Lancashire (1905, Bolton, 'Geol. Mag.' [5], vol. ii), is so similar in character to the typical insect-fauna elsewhere, that it is likely that insects lived in the Lower Coal Measure period in Lancashire.

This faunal association at Carre Heys is as follows, and may be compared with the faunal association in which insects have been found to occur in other coalfields:

ARTHROPODA.

Pygocephalus cooperi, Huxley.
Anthrapalæmon serratus, Woodw.
„ *woodwardi*, Etheridge.
„ *traquairi*, Peach.
Prestwichia rotundata, Woodw.
Architarbus subovalis, Woodw.
Euphoberia browni, Woodw.
Xylobius monilifer, Woodw.

PISCES.

Hybodopsis wardi, Barkas.
Acanthodes wardi, Egerton.
Elonichthys aitkeni, Traq.

AMPHIBIA.

Eugyrinus wildi (A. S. Woodw.).
Microsaurian remains.

The oldest known fossil insect in the British Carboniferous appears to be a fragmentary wing (*Genentomum subacutum*), described by the author from shales at a depth of 637 feet below the Bedminster Great Vein in the Bristol Coalfield, and therefore at a considerable depth below the Pennant Grit.

Pseudofouquea cambrensis (Allen) was obtained from the top of the Four-foot Seam in the Lower Coal Measures at the Llanbradach Colliery near Cardiff; while the shales over the No. 2 Rhondda Seam have yielded a wing-fragment of *Boltoniella tenuitegminata* (Bolton); and the shales over the Graigola Seam have yielded the wings of two Blattoids, *Hemimylacris convexa* and *Orthomylacris lanceolata*.

The No. 2 Rhonddà Seam and the Graigola or Six-foot Vein of Swansea both occur in the Pennant Grits, the former near the base of the series and the latter at 200 yards below the Swansea Four-foot Seam, which forms the base of the Middle Coal Measures in South Wales.

In Monmouthshire, insect-remains occur in shales over the Mynddislwyn Vein, a seam at the base of the Upper Coal Measures.

The Durham and South Lancashire Coalfields have yielded insect-remains in measures near the top of the Middle Series, while those recorded from the Derbyshire Coalfield are on a still lower horizon in the Middle Series. Few fossil insects are known from the Upper Coal Measures.

HABITS AND MODE OF OCCURRENCE OF FOSSIL INSECTS.

The bodies, and more particularly the wings, of insects, have been entombed in various deposits under conditions difficult to determine. Whatever the conditions, they must have been closely related to the habits of life. The older writers claimed that wind-dispersal and water-carriage were the chief agents. Buckland, for example ('Anniv. Address to the Geol. Soc.,' 1842), supposed "that multitudes of insects have been occasionally drifted by tempests to the sea." Mantell ('Wonders of Geology,' 7th ed., 1857) pointed out that Westwood had drawn attention to the fact that "the streams brought down innumerable insects at certain periods, perhaps those of heavy rain."

Alfred Russel Wallace ('The Geographical Distribution of Animals,' 1876) and Heilprin ('The Distribution of Animals,' 1887) alike drew attention to the widespread occurrence of living insects far out at sea, in some instances still flying strongly. Members of the British Association on their voyage to Australia in 1914 verified these statements by the capture of locusts as their vessel proceeded down the Red Sea and into the Indian Ocean. More than a score of locusts were captured on the vessel by which the writer travelled, and many more must have been driven down into the water by the fringe of a simoon into which the vessel entered beyond Aden.

Many insects are destroyed yearly by falling into streams and rivers after the deposition of their eggs in the water, and by becoming entangled in the surface film.

The occurrence of whole, or almost whole, insects is more likely to furnish surer proof of the conditions under which life was passed than is the occurrence of wings only, because the bodies, being more compact and much heavier than the wings, are less likely to have drifted to great distances. Sometimes, as we shall see later when we consider special cases, such as the Coal Measures of Commentry, France, or the remarkable faunal associations of certain of the British fossil insects,

valuable information is supplied by the deposits, or by the nature of the associated forms of life.

The great group of the Palæodictyoptera and certain of the Protorthoptera and Protodonata had large wings, and were powerful fliers. We should therefore expect to find their remains widely dispersed in deposits of varied nature. This seems to be the case. Compact heavy-bodied insects like the Blattoids would have a more limited range, and their bodies after death could not be carried to great distances. Larval forms would in most cases be included in the deposits in the immediate neighbourhood of the area in which they lived.

M. Henri Fayol, in his description of the Coal Measures of Commentry, France, shows that these deposits were laid down in narrow land-locked lakes of a trough-like form lying in depressions of older schistose and crystalline rocks. The tranquil waters received only the finest mud in suspension, and the resultant mudstones have yielded a large insect-fauna, in which Blattoids are most numerous. The bodies of the insects are preserved in many cases. Certain of the insects were strong fliers, and their occurrence with the bodies intact indicates that they, in all probability, haunted the vicinity of the lakes and flew over them. When strongly-flying insects like *Boltonites radstockensis* or *Lithosialis brongniarti* died upon the land, the wings, because of their membranous and chitinous nature, would persist after the destruction of the softer body, and be swept off into streams after heavy rains or flooding of the land-surface, their great superficial area combined with their lightness making flotation easy.

The transference of insect-wings from the land into water would be accompanied by the drifting of plant-material, and the two would be buried together in the deposit then forming. The wing of *Boltonites* from Radstock was found with plant-remains in deposits of this sort, and may be taken as a proof, supported as it is by other examples of Protodonate wings, that these insects lived over the land and died upon it.

The Palæodictyoptera, with their wings capable only of an up-and-down movement in one plane at right-angles to the body, and, when in a position of rest, disposed straight outwards, are not likely to have frequented the ground, except in the open. These insects, like most of the Palæozoic forms, were all of large size, as contrasted with living types. Pruvost assumes that the characters of the wing unfitted these insects for a forest life, and that they must have been restricted to flight in the open neighbourhood of swamp pools. I do not wholly agree with this assumption, for the branches and leaves of the Coal Measure plants do not seem to have had so great a density and interlacing of foliage as seriously to impede the flight of powerful winged insects. There seems no reason why these insects should not have lived among the brakes of Lepidodendroid and Calamitean trees, and after death fallen or been blown into adjacent waters. The fact that isolated wings are often found in perfect condition and without any signs of wear

and tear such as the wings of aged insects show to-day, raises the question whether in some cases the wings were not shed, as in certain species of recent ants, the shorn insect continuing its life as a ground-feeder.

The Protorthoptera were, judging from the structure of their mouth-parts, somewhat general feeders or carnivorous, and the presence of strong walking legs suggests that they spent much of their life on the ground, possibly along the margins of swamps, where food would be especially abundant. They had, nevertheless, powerful wings, and some members, such as the Œdischiidæ, had legs adapted for leaping. Orthoptera, represented chiefly by Blattoid forms, were all fitted for flight by means of their large membranous hind-wings, and equally well fitted by powerful walking legs for life on the ground. In repose the hind-wings were hidden under the modified fore-wings.

I have elsewhere given my reason for a belief that the Blattoids were not wholly phytophagous, but in all probability carnivorous also ('Quart. Journ. Geol. Soc.,' vol. lxvii, p. 153, 1911).

Blattoids may also have entered the water in search of food, for the hind flying wings would be securely protected by the tegmina, whose broad muscular bases of attachment were sufficiently powerful to compress them down on the back and prevent water entering beneath, just as in the case of the living water-beetle, *Hydrophilus piceus*. The chitinous surface of the body and of the tegmina would not hinder progress in water, for their surfaces are no rougher than those of the modern *Dytiscus*, nor would the insect on emerging bring with it so heavy a film of water as to clog its movements. An objection may be found in the presence of stout bristle-like hairs on the legs seen on such forms as *Necymylacris lerichei* (Bolton) (1917, 'Mem. and Proc. Lit. and Phil. Soc. Manchester,' vol. lxi, p. 15), which might conceivably cause air-bubbles to cling in such profusion as to prevent the insect being able to submerge. The presence of fine hairs on the swimming legs of *Hydrophilus* and *Dytiscus* does not hinder the immersion of these insects in water, so that this is not a valid objection. If no hindrance to immersion was caused by the bristle-like hairs, they may have been useful in assisting the act of swimming.

I think the probabilities are in favour of the Blattoids being at least semi-aquatic as well as land insects.

CONDITIONS OF LARVAL INSECT LIFE.

The conditions under which larval life was passed are even more conjectural. The Protodonata may be regarded as insects whose larvæ must have been aquatic, like the aquatic larvæ of the Odonata now living, but Tillyard (1917, 'The Biology of Dragonflies,' Camb. Univ. Press, p. 306) conjectures that since adult Protodonata are found at Commentry without the occurrence of larval forms, the latter

may have dwelt in damp earth rather than in water, and that "the formation of the larval tracheal system undoubtedly proves that this at one time was the case. It may well have been so in Carboniferous times."

Tillyard's views are well worth quoting in full, especially as they support in some measure those of Pruvost: "We may picture to ourselves the giant insects of Commentry as inhabiting the shores of a large, shallow, nearly stagnant lake. In the muddy ooze around its borders grew forests of the Giant Mare's Tail, while further back on the sandy slopes the graceful Cycads and other extraordinary plants formed a more diversified medley. There, amidst rotting vegetation, these insects lived and bred. In such almost amphibious conditions it may well be that the larvæ of Protephemeroidea and Protodonata first began that series of adaptive changes which finally led them to adopt a purely aquatic mode of life."

The larvæ of *Brodia* and of other forms whose wings I describe under the name of "*Pteronepionites*" must have lived under conditions fitted for their gradual metamorphosis. The body was long, well segmented, and bore rudimentary wings, which were carried well up over the thorax in an erect or semi-erect position. Though rudimentary, the wings possess features which may have determined to a large extent the mode of life. They are attached by broad, strong bases to the thorax, and are very muscular, as shown by the stout ridges proceeding from the point of attachment into the wings, and the anterior margins are also thickened. The bodies with their lateral expansions of the terga are very suggestive of those of the Diplopoda, and like them would offer no serious obstacle to progression through rank and rotting vegetation. That these larval insects would also penetrate soft muds, if necessary, in search of food is possible, since the soft-bodied caterpillars of the Hawk-moths of to-day are able to enter hard soil before pupation takes place.

The stout wing-bases and the strengthened margins of the wings would prevent damage to these structures as the larvæ crawled about, or sought to bury themselves in the soil or muds. They were essentially adapted for a ground habit. Whether they were capable of an aquatic or semi-aquatic habit can only be settled by a knowledge of the mode of respiration.

Lubbock, Gegenbaur and others have adduced strong reasons in favour of an aquatic origin of the insects, and in the Carboniferous types we should naturally expect that the original habits had not had time to undergo any great modification. Larval wings of the "*Pteronepionites*" type must have been living structures in which metabolism was active, and very unlike the dried membranous sac-like expansions of the adult insect. The growth of the larval wings was continued throughout metamorphosis, and during this period their delicate nature, broad expanse, and the thinness of the integument may have enabled them to assist in the respiratory function.

The researches of Comstock and Needham show that larval wings of recent

insects receive a plentiful supply of tracheal branches at an early stage, and it is evident that these are much in excess of any aëration the wings are likely to require. The tracheal development seems to be a persistence from an earlier more active condition, when the larval wings may have played a part in assisting the respiration. These considerations, and the presence of spiracle-like structures in the interstitial neuration of the adult wings of many Palæodictyoptera, lend support to the inference that the wings functioned as organs of respiration. These spiracle-like structures are usually oval or rounded in outline, and thickened. In some instances they show a series of raised lines radiating from the thickened edge into the surrounding areas, as if they had been muscular strands and capable of expansion and contraction.

Are these structures the atrophied remains of spiracles once functional, and fitting the larva for a more or less aquatic existence? During a recent visit to this country Dr. Tillyard has suggested to me that they are rudiments of sensory organs which may have been scent-glands. Scent-glands are known to occur on the wings of many insects, as, for example, the Green-veined White (*Pieris napæ*), the Small White (*Pieris rapæ*) and others, and their appearance is certainly a strong argument in favour of the view. Scent-glands are, however, in all probability but specialised developments of previously existing structures, and it is possible that the glandular-like organs to which I give the name of "pseudo-spiracles," and Handlirsch the name of "pterostigmata," are an earlier development connected with the "tracheoles" of Comstock, or that primary tracheolation to which Tillyard has given the name of "archyodictyon." Tillyard does not accept the view that they had ever any connection with respiration.

The almost total absence of structures which can be accepted as functional gills in these fossil insect-larvæ may be accounted for by the perishable nature of such organs. Before dismissing the question of the respiratory function in its relation to the conditions under which larval life was passed, it is desirable to draw attention to the larval Blattoid, *Leptoblattina exilis*, Woodw. In this insect the abdominal segments have the dorsal hinder margin extended into broad lamellar expansions so filmy in texture that they may have served as organs of aëration. The lamellar expansions were longer in life than they now are, the hinder borders showing an irregular torn edge. Their extreme thinness would permit of a ready osmotic-like action, especially in damp vegetation, or in an aquatic or semi-aquatic habitat. Scudder, Handlirsch, Lameere and others are all agreed in the belief that the Blattoids frequented decaying vegetation in or near water, and under these conditions the presence of organs of aëration similar in character to the abdominal expansions of *Leptoblattina exilis* would be of the greatest value and offer no difficulties to the habit of life. No similar structures are known in any other larval Blattoid, so that the view cannot be pressed.

We shall not be far wrong in assuming that the larvæ of some of the Coal Measure insects were wholly aquatic, others semi-aquatic; that the adult Blattoids were indifferently aquatic or terrestrial; the adults of the non-Blattoid types spent most of their life in the vicinity of the swamp-pools in which their larval stages were passed, and to which they might need to return to lay their eggs.

Such a view seems to accord with the known facts, and will explain the special character of the fauna of such deposits as those of Coseley, in Staffordshire, and the brick-clays of Sparth Bottoms, Rochdale, Lancashire. These are evidently true lagoon or swamp-pool deposits as contrasted with the ordinary shales and binds of the Coal Measures.

FOOD OF COAL MEASURE INSECTS.

The nature of the food of Coal Measure insects has been much discussed, as it is so closely associated with habits. Handlirsch considers that the Gymnosperms and Pteridosperms of the Coal Measure forests were not likely to have been frequented by insects in search of food, as these plants do not prove attractive to living insects. Pruvost, on the other hand (1919, ? 1920, "La Faune Continentale du Terrain Houiller du Nord de la France," 'Mém. Carte Géol. France,' pp. 266—267), considers that many members of the Coal Measure flora possessed in their spores, or in the case of the higher plants, in their cones, a plentiful food supply for insects, and he finds in the association of a *Phyllobla*tta at Lens with the *Potonica* of *Linopteris* some support for his conclusions.

The contemporaneous rapid development of plants and insects is also quoted by Pruvost in support of his views.

Several writers have argued that the powerful wings and consequent powers of rapid flight of many of the insects are more in accordance with a predatory and carnivorous habit than with a purely frugivorous or herbivorous one, and this belief has led Lameere to write as follows (1917, 'Bull. Soc. Zool. France,' vol. xlii, pp. 36—37): "Over the lake of Commentry flew magnificent Ephemeroptera and splendid Odonatoptera, the carnivorous larvæ of which were aquatic; doubtless the Odonatoptera, when fully grown, devoured the Ephemeroptera, of which the most fully developed types, the Megasecopteridæ, which have left no descendants, must have made great slaughter among the smaller insects.

"On the ground, in the forests, swarmed innumerable Blattoids, which frequented the detritus, and which had as enemies the ferocious and agile Orthoptera, the varied counterparts of our Mantidæ. These latter must have attacked equally the large vegetarian Orthoptera, the counterparts of the Phasmæ, which probably climbed on trees, and the bulky Protohemiptera, which sucked the sap. Some of the Orthoptera jumped, and there were some which by their appearance recall our Acridians, but all these beings were mute.

"Small amphibians, and numerous arachnidians, came to limit the swarm of this articulate world in a country without birds or mammals."

Pruvost does not accept the view of a primitive aquatic origin of insects, but affirms his belief in a terrestrial origin, and thinks that even if an aquatic habit be proved for certain of the larvæ of the Coal Measure insects, the habit must have been secondary, and derived from an earlier land ancestry (*op. cit.*, p. 268).

Scudder has observed in the case of the Blattidæ that the venation of the tegmina very closely resembles the surface-features of the *Neuropteris* pinnule—so strongly in fact as to suggest mimetism.

Pruvost rightly urges that a mimetism is of little value unless the mimetic insect frequents the plant mimicked. At the same time, it can be urged that the stout compact bodies of the fossil Blattoids and their powerful walking legs were equally admirably fitted for progression among rank and decaying vegetation, and that in these conditions the Blattoids were quite as likely to have been omnivorous, while finding some degree of protection among the *Neuropteris* pinnules lying on the ground.

The writer has previously commented on the association of the wings of Blattoids with the leaves of *Cordaites* (1911, 'Quart. Journ. Geol. Soc.,' vol. lxvii, pp. 164—165), and has made the following comment: "While Carboniferous Blattoids may have been wholly phytophagous, it is interesting to note that the leaves of *Cordaites* (in the present case) are impressed with shallow pits, which show faint traces of a spiral. I have in many previous instances found that such pits owed their origin to attached shells of *Spirorbis pusillus*. Whether these leaves were partially submerged in water during life is an open question; but in all cases the plant-tissues of the pittings are depressed, and are accurate impressions of *Spirorbis*. If the Carboniferous Blattoids were not wholly vegetable feeders, the occurrence of *Spirorbis pusillus* upon the *Cordaites* may supply a reason for their frequent association."

CLASSIFICATION.

The classification of fossil insects has presented great difficulties, both to the palæontologist, and to the systematist of living forms. Palæozoic insects show to the systematist a series of forms not strictly referable to any modern grouping, but presenting certain generalised details of structure which link two or more now widely separated groups, besides other features not met with in living forms.

The palæontologist finds that he has not to deal with early and primitive types, followed by a regular series showing a developmental progression, but with an apparent sudden incursion of large series of highly modified and well-developed insects, co-existent with others of more primitive type.

Further discoveries will doubtless do much to eliminate these difficulties, but present knowledge is such that recent entomology helps very little, and the classification of Palæozoic insects must be largely based on the known fossils, realising that many of the intermediate forms are yet unknown.

The classifications of various authors vary widely, and even the broad general facts of relationship are still uncertain. The earliest attempt at a classification of fossil insects appears to have been that of Goldenberg (1873—1877, 'Fauna Saræpontana Fossilis: Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken.') He recognised a new Order, Palæodictyoptera, for the inclusion of fossil insects differing in structure and the shape of the wings from living representatives of the Orders Neuroptera and Orthoptera, while also possessing characters which seem to link the two orders together. He did not define the order, but arranged it with the other orders as follows:

Order.—PALÆODICTYOPTERA, Goldenb.
Genera.—*Dictyoneura*, Goldenb.; *Eugereon*, Dohrn; *Miamia*, Dana; *Hemeristia*, Dana; *Haplophlebium*, Scudder.
Order.—ORTHOPTERA.
Sub-order.—Orthoptera Pseudo-Neuroptera.
Genera.—*Termes*, Goldenb.; *Termitidium*, Goldenb.
Sub-order.—Orthoptera vera.
Genus.—*Blattina*, Germar.
Order.—RHYNCHOTA.
Sub-order.—Homoptera.
Genus.—*Fulgorina*, Goldenb.

Scudder (1887, article "Insecta," 'Traité de Palæontologie,' by Karl von Zittel, translated by Dr. Charles Barrois, vol. ii, 'Palæozoologie,' pp. 746—833), in his latest classification, considerably extended that of Goldenberg, while retaining the primitive group of the Palæodictyoptera. His complete arrangement is as follows:

A.—PALÆODICTYOPTERA, Goldenberg.
ORTHOPTEROIDEA, Scudder.
Family.—Palæoblattariæ, Scudder.
Sub-family.—Mylacridæ, Scudder.
Genera.—*Mylacris*, Scd.; *Premylacris*, Scd.; *Paramylacris*, Scd.; *Lithomylacris*, Scd.; *Necymylacris*, Scd.
Sub-family.—Blattinariæ, Scudder.
Genera.—*Etoblattina*, Scd.; *Spiloblattina*, Scd.; *Archimylacris*, Scd.; *Anthracoblattina*, Scd.; *Gerablattina*, Scd.; *Hermatoblattina*, Scd.; *Progonoblattina*, Scd.; *Oryctoblattina*, Scd.; *Petrablattina*, Scd.; *Poroblattina*, Scd.
Family.—Protophasmidæ, Brong.
Genera.—*Titanophasma*, Brong.; *Litoneura*, Scd.; *Dictyoneura*, Goldenb.; *Polioptenus*, Scd.; *Archæoptilus*, Scd.; *Protophasma*, Brong.; *Breyeria*, de Borre; *Meganeura*, Brong.; *Ædœophasma*, Scd.; *Goldenbergia*, Scd.; *Haplophlebium*, Scd.; *Paolia*, Smith; *Archegogryllus*, Scd.

NEUROPTEROIDEA, Scudder.

Family.—Palephemeridæ, Scd.

Genus.—*Platephemera*, Scd.

Family.—Homothetidæ, Scd.

Genera.—*Acridites*, Aud.; *Eucænus*, Scd.; *Genopteryx*, Scd.; *Genentomum*, Scd.; *Didymophleps*, Scd.; *Homothetus*, Scd.; *Mixotermes*, Sterzel; *Omalia*, van Ben.

Family.—Palæopterina, Scd.

Genera.—*Miamia*, Scd.; *Dieconeura*, Scd.; *Strephecladus*, Scd.

Family.—Xenoneuridæ, Scd.

Genus.—*Xenoneura*, Scd.

Family.—Hemeristina, Scd.

Genera.—*Lithomantis*, Woodw.; *Lithosialis*, Scd.; *Pachytylepsis*, de Borre; *Lithentomum*, Scd.; *Hemeristia*, Dana.

Family.—Gerarina, Scd.

Genera.—*Polyernus*, Scd.; *Gerarus*, Scd.; *Adiphlebia*, Scd.; *Megathentomum*, Scd.

HEMIPTEROIDEA, Scudder.

Genera.—*Eugereon*, Dohrn; *Fulgorina*, Goldenb.

COLEOPTEROIDEA, Scudder.

Palæodictyoptera having a coleopterous aspect indicated by Geinitz and Brongniart.

B.—HETEROMETABOLA, Packard.

ORTHOPTERA, Olivier.

Family.—Forficulariæ, Latreille.

Family.—Blattariæ, Latreille.

Genera.—*Neorthroblattina*, Scd.; *Scutinoblattina*, Scd.; *Blattidium*, Westw.; *Mesoblattina*, Gein.

Family.—Mantidæ, Latreille.

Genus.—*Mantis*, Linné.

Family.—Phasmidæ, Leach.

Genera.—*Agathemera*, Scd.; *Pseudoperla*, Pictet.

Families.—Acridii, Latreille; Locustidæ, Latreille; Gryllidæ, Latreille.

NEUROPTERA, Linné.

Sub-order.—Pseudoneuroptera, Erichson.

Sub-order.—Neuroptera vera.

HEMIPTERA, Linné.

Homoptera, Latreille.

Heteroptera, Latreille.

COLEOPTERA.

C.—METABOLA, Packard.

DIPTERA.

LEPIDOPTERA.

HYMENOPTERA.

A modification of this classification was introduced by Handlirsch, in his "Sub-phylum Insecta" in Eastman's translation of Zittel's 'Text-book of Palæontology,' 1913, as follows:

Class I.—PTERYGOGENEA, Brauer.

Order.—Palæodictyoptera, Goldenberg.

Families.—Dictyoneuridæ, Megaptilidæ, Hypermegethidæ, Lithomantidæ, Heolidæ, Fouqueidæ, Spilapteridæ, Lamproptilidæ, Polycreagridæ, Paolidæ.

Order.—Mixotermitoidea, Handlirsch.

Order.—Reculoidea, Handlirsch.

Order.—Protorthoptera, Handlirsch.

Families.—Spanioderidæ, Ischnoneuridæ, Caloneuridæ, Sthenaropodidæ, Œdischiidæ, Geraridæ, Cacurgidæ.

Order.—Orthoptera, Olivier.

Sub-order.—Locustoidea, Leach.

Sub-order.—Acridioidea, Handl.

Order.—Phasmoidea, Leach.

Order.—Dermaptera, De Geer.

Order.—Diploglossata, De Saussure.

Order.—Thysanoptera, Haliday.

Order.—Protoblattoidea, Handlirsch.

Families.—Stenoneuridæ, Protophasmidæ, Eoblattidæ, Oryctoblattinidæ, Ætophlebidæ, Cheliphlebidæ, Eucænidæ.

Order.—Blattoidea, Handlirsch.

Families.—Spiloblattinidæ, Mylacridæ, Poroblattinidæ, Neorthroblattinidæ, Mesoblattinidæ, Pseudomylacridæ, Dictyomylacridæ, Neomylacridæ, Pteridomylacridæ, Idiomylacridæ, Diechoblattinidæ, Proteremidæ.

Order.—Mantoidea, Handlirsch.

Genus.—*Palæomantis*, Bolton.

Order.—Sypharopteroidea, Handlirsch.

Order.—Hapalopteroidea, Handlirsch.

Order.—Protoephemeroidea, Handlirsch.

Order.—Protodonata, Brongniart.

Order.—Megasecoptera, Brongniart.

Order.—Protohemiptera, Handlirsch.

The publication of Handlirsch's great work, 'Die Fossilen Insekten,' 1906—1908, marked an important phase in the history of the study of fossil insects. Handlirsch surveyed the whole field of fossil entomology, and brought the great bulk of the known forms under a broad classification. The Order Palæodictyoptera was much extended, defined, and made to include a large series of families, several of which, however, are clearly widely divergent in type. This was soon recognised by other workers, as doubtless by Handlirsch himself, who may have considered it wiser to extend Goldenberg's order, even to the inclusion of forms not definitely related, rather than to formulate a new classification the components of which could not be rigidly defined. Knowing that the field of research was rapidly widening, Handlirsch exercised a wise restraint in not adding a new classification, which could only be of a temporary character. Subsequent events have proved the wisdom of his action. Since 1908, the study of fossil insects has attracted more students, new localities and

insect-horizons have been found, and many new types recorded. Some of these linking forms already known, and others indicate relationships not fully understood. The retention of the Order Palæodictyoptera has therefore resulted in the formation of a somewhat heterogeneous assemblage, all members of which have one point of agreement. They are primitive co-types, more nearly related to each other in various ways than they are to recent insects, although that relationship is not always as demonstrable as one could wish.

The most ambitious classification yet attempted is that of Prof. Lameere (1917, 'Bull. Mus. Hist. Nat., Paris,' no. 1), who has published only a summary of his conclusions. We are not able to determine how valid are his arguments, or if he is justified by evidence in setting forth his new scheme. He sweeps the Order Palæodictyoptera wholly away, pointing out that it consists of a heterogeneous assemblage, and substitutes a more detailed classification as follows:

SUBULICORNIA.

EPHEMEROPTERA.

Family.—Spilapteridæ.

Genera.—*Lamproptilia*, Brong.; *Epitethe*, Handl.; *Becquerelia*, Brong.; *Palæoptilus*, Brong.; *Compsoneura*, Brong.; *Spiloptilus*, Handl.; *Homaloneura*, Brong.; *Graphiptilus*, Brong.; *Spilaptera*, Brong.

Family.—Megasecopteridæ.

Genera.—*Aspidothorax*, Brong.; *Corydaloides*, Brong.; *Diaphanoptera*, Brong.; *Cycloscelis*, Brong.; *Sphecoptera*, Brong.; *Psilothorax*, Brong.; *Mischoptera*, Brong.; *Ischnoptilus*, Brong.

Family.—Protephemeridæ.

Genera.—*Apopappus*, Handl.; *Triplosoba*, Handl.

ODONATOPTERA.

Family.—Fouqueidæ.

Genera.—*Fouquea*, Brong.; *Rhabdoptilus*, Brong.

Family.—Dictyoneuridæ.

Genera.—*Microdictya*, Brong.; *Stenodictya*, Brong.

Family.—Dictyoptilidæ (Protodonata).

Genera.—*Archæmegaptilus*, Brong.; *Dictyoptilus*, Brong.; *Poromaptera*, Brong.; *Protagrion*, Brong.; *Gilsonia*, Brong.; *Meganeura*, Brong.

RHYNCHOTA.

PROTOHEMIPTERA.

Family.—Homoiopteridæ.

Genera.—*Lycocercus*, Handl.; *Homoioptera*, Brong.; *Lithoptilus*, Brong.

Family.—Megaptilidæ.

Genus.—*Megaptilus*, Brong.

Family.—Breyeridæ.

Genus.—*Megaptiloides*, Handl.; *Borrea*, Brong.

Family.—Mecynostomidæ.

Genus.—*Mecynostoma*, Brong.

HEMIPTERA.

Family.—Dictyocicadidæ.

Genus.—*Dictyocicada*, Brong.

ORTHOPTERA.

Nomoneura (Blattæformia, Handl.).

(*a*) Blattoidea.

Families.—Hyaloptilidæ, Protoperlidæ, Fayoliellidæ, Oryctoblattinidæ.

(*b*) Mantoidea.

Families.—Stenoneuritidæ, Stenoneuridæ, Ischnoneuridæ.

Heteroneura. (Equivalent in part to Orthoptera Cursoria and Orthopteroidea, Handl.)

(*a*) Phasmoidea.

Family.—Sthenaropodidæ.

(*b*) Locustidæ. (Equivalent in part to Orthoptera Saltatoria.)

Families.—Œdischiidæ, Caloneuridæ.

Lameere restricted his research to the French fossil insects, his studies being based on the types described and figured by Brongniart (1893, 'Bull. Soc. Industrie, Saint Etienne,' 3 sér., vii), the collections made by Fayol, and the large series of fossil insects from the Upper Coal Measures (Stephanian) of Commentry, now preserved in the National Museum of Natural History, Paris. The following remarks may be made on his classification:

EPHEMEROPTERA.—The three families forming this division are regarded as closely related, the genus *Becquerelia* of the Spilapteridæ bearing certain characters of the Megasecopteridæ, while the family is also linked through the genus *Apopappus* (which is taken to supply a natural transition between the Spilapteridæ) to the genus *Triplosoba*.

ODONATOPTERA.—The family Fouqueidæ is held to differ from the Spilapteridæ in that transverse veins are numerous, close together, and form a network over the inner margin, and in the anal area—a feature which brings it nearer to the Protodonata. The family Dictyoneuridæ possesses a network of veins extending over the whole wing, as in *Microdictya*. The remaining family, Dictyoptilidæ, contains *Archæmegaptilus*, which Lameere considers differs only from the Dictyoneuridæ in the fusion of the median and radial veins at the base of the wing. *Protagrion* is considered nearest to the true Odonata, while *Meganeura* and *Gilsonia* are specialised types.

RHYNCHOTA.—The presence of a rostrum in *Lycocercus goldenbergi*, and the resemblance of the head and leg of *Homoioptera gigantea* to the same structures in *Eugereon*, are considered sufficient proof of the Protohemipteroid characters of *Lycercus*, *Homoioptera*, and the allied genera *Lithoptilus*, *Megaptilus*, *Mecynostoma*, *Archæoptilus* and *Paramegaptilus*.

ORTHOPTERA.—Lameere regards Handlirsch's group of Protorthoptera as an assemblage of two related but distinct types, which he classifies under Nomoneura and Heteroneura. The genus *Stenoneurites* is regarded as the connecting link between the Mantoidea and the ancestors of the Blattoidea, the genus *Stenoneura* being also in some measure transitional between *Stenoneurites* and the Ischnoneuridæ.

Nomoneura.—This sub-division includes the Blattæformia of Handlirsch, and is distinguished by the wings having no precostal area, as contrasted with a second division, Heteroneura, in which a precostal area is present, and in which the legs are adapted for running and jumping. The Nomoneura include forms classified by Handlirsch under the Protorthoptera and Protoblattoidea. Lameere separates his Nomoneura into (*a*) Blattoidea, and (*b*) Mantoidea, the former characterised by a sub-costal which joins the outer or costal margin, a more or less lengthened radius, and a small cubitus. The Mantoidea have the sub-costa joining the radius, and a large preponderating cubitus.

Heteroneura.—This sub-division includes the Phasmoidea and the Locustoidea, the former containing the family (*a*) Sthenaropodidæ, in which the legs are long and stout, the head prognathous, the prothorax long and narrow in front and very wide behind, and presenting two dorsal expansions.

The wing-venation of the Sthenaropodidæ is such that they may have been the ancestors of the Phasmidæ. Lameere, however, does not regard the Sthenaropodidæ as ancestors of the Phasmidæ, but as arising with them from a common ancestor.

The members of the families Œdischiidæ and Caloneuridæ possess legs fitted for jumping, but differ considerably in their wing-venation. The Œdischiidæ are possibly linked with the Locustidæ, and the Caloneuridæ with the Acrididæ.

Circumstantial and detailed as Prof. Lameere's classification is, the arguments and deductions are not easily followed, the paper being only in abstract. A study of the fossil insect-material from Commentry alone is not in itself likely to yield all the facts and premisses upon which a classification can be built applicable to the Palæozoic insect-fauna of all coalfields and countries. Much more evidence is wanted, and until the full paper is published, it is necessary to hold the classification in suspense.

The most recent publication on the Palæozoic insects is an extensive and valuable memoir by Dr. P. Pruvost (1920, "La Faune Continentale du Terrain Houiller du Nord de la France," 'Mémoires pour servir à l'Explication de la Carte Géologique détaillée de la France,' Paris, 1920) on the fossil insects recently found by him, and others, in the neighbourhood of Lens and Liévin in the north of France. Dr. Pruvost adopts the classification of Handlirsch with few emendations as follows, and by his new material he has added considerably to our knowledge of the Protoblattoidea and Blattoidea:

Order.—Palæodictyoptera.
Family.—Stenodictyopteridæ, Brong. (Dictyoneuridæ, Handlirsch).
Family.—Spilapteridæ, Brong., emend. Handlirsch.
Order.—Protorthoptera, Handlirsch.
Families.—Œdischiidæ, Caloneuridæ.
Order.—Hapalopteroidea, Handlirsch.
Family.—Hapalopteridæ.

Order.—Protoblattoidea, Handlirsch, emend. Pruvost.
Sub-order.—Archiblattidæ, Pruvost.
Family.—Cacurgidæ, Handl.
Sub order.—Archimantidæ, Pruvost.
Family.—Cymenophlebidæ, Pruvost.
Order.—Blattoidea, Handlirsch.
Family.—Archimylacridæ, Handl.
Genera.—*Archimylacris, Asemoblatta, Manoblatta, Actinoblatta, Phyloblatta, Archæotiphe, Barroisiblatta, Grypoblatta, Mesitoblatta.*
Family.—Mylacridæ, Scd.
Genera.—*Hemimylacris, Phylomylacris, Trilophomylacris, Soomylacris, Orthomylacris, Stenomylacris,* and *Lithomylacris.*
Family.—Poroblattinidæ, Handl.
Genus.—*Premnoblatta*, Pruv.

I have compared notes with M. Pruvost, and we have arrived independently at the conclusion that for the present the classification of Handlirsch is, with few emendations, the best to adopt, and most in keeping with the known facts.

FAUNAL ASSOCIATION.

Various collectors in British Coalfields have discovered not only insect-remains, but a definite faunal association, of which the significance seems to have been overlooked, and it has therefore not received the attention it deserves.

Most of the insect-remains are found in ironstone nodules, and the beds in which these nodules occur are usually light-coloured rocks more similar to hardened clay than to normal shales. The nodules are in vast numbers, ranging in size from half-an-inch to ten and twelve inches in diameter. The beds seem more comparable to the fireclays or seat-earths than to the ordinary fissile shales, and both in lithological character and fossil contents stand in some measure apart from the ordinary Coal Measure rocks. They are not restricted to one coalfield, but have a wide distribution. Where a systematic search of beds of this character has been made, the insect-remains have been found accompanied by a fauna in which arthropods of a more primitive type than insects are conspicuous.

The character of this fauna will be best understood by reference to the following lists of fossils which have been recorded from certain localities:

Durham Coalfield.—"Zone of *Anthracomya phillipsii* (Will.)" in upper part of the Middle Coal Measures; Claxheugh escarpment, two miles west of Sunderland, Durham.

Pelecypoda.
"*Ancylus vinti*, Kirkby" (*cf.* "Spat" of *Anthracomya phillipsii*, Will.).
Anthracomya minima (Ludvig). *A. lævis*, var. *scotica*.
Merostomata.
Belinurus trechmanni (Woodw.).
Diplopoda.
Euphoberia, sp.

Ostracoda.
Beyrichia, McCoy.
Cythere or *Cypris*.

Insecta.
Lithomylacris kirkbyi, Woodward.
Phylomylacris mantidioides (Goldenberg).

Pisces.
Rhizodopsis sauroides (Will.).

Nottingham and Derbyshire Coalfield.—Below the Top Hard Coal, Middle Coal Measures (1911, Moysey, 'Geol. Mag.' [5], vol. viii, p. 506); Shipley Manor clay-pit, one and a half miles north of Ilkeston, Derbyshire.

Annelida.
Spirorbis, sp.

Pelecypoda.
Anthracomya modiolaris (Sow.).
Carbonicola aquilina (Sow.).
Naiadites modiolaris (Sow.).

Ostracoda.
Beyrichia arcuata? (Bean).
Estheria sp.
Leaia trigonioides, Moysey.

Crustacea.
Preanaspides praecursor, Woodw.
Arthropleura armata, Jordan.
,, sp. nov., Moysey.

Arachnida.
Cyclus, sp.
,, *johnsoni*, Woodw.
Belinurus bellulus, König.
,, *kœnigianus*, Woodw.
,, *longicaudatus*, Woodw.
,, sp.
Prestwichia anthrax (Prestw.).
,, *birtwelli*, Woodw.
,, *rotundata* (Prestw.).
,, sp.
Eurypterus derbiensis, Woodw.

Arachnida—(*continued*).
Eurypterus moyseyi, Woodw.
Scorpion, post-abdominal segment, Moysey.
Geralinura britannica, Pocock.
Eobuthus holti, Pocock.
Anthracosiro fritschi, Pocock.
,, *woodwardi*, Pocock.
,, sp.
Protolycosa, sp.

Insecta.
Cryptorenia moyseyi, Bolton.
Orthocosta splendens, Bolton.
Pteronidia plicatula, Bolton.

Pisces.
Elonichthys, sp.

Egg Capsules of Fishes (?).
Fayolia crenulata, Moysey.
,, cf. *dentata*, Zeiller.
Palæoxyris carbonarius (Schimper).
,, *helicteroides* (Morris).
,, *prendeli*, Lesq.
Vetacapsula johnsoni (Kidston).
,, *cooperi*, Mackie and Crocker.

Plant Remains.
Annularia; *Calamocladus*; *Sphenophyllum*; *Lepidophyllum*; *Calamites*; ferns.

Lancashire Coalfield.—Greyish-blue shales, 135—180 feet above the Royley or Arley mine, the latter at the base of the Middle Coal Measures; Sparth Bottoms, Rochdale, Lancashire. I am indebted for the following list to Mr. Walter Baldwin, F.G.S., who, with Messrs. Sutcliffe, Parker, Platt and others, has devoted years to the examination of these beds.

Vermes.
Spirorbis (*Spiroglyphus*).

Brachiopoda.
Lingula, sp.

Pelecypoda.
Carbonicola acuta (Sow.).
,, *robusta* (Sow.).
,, *turgida* (Brown).

PELECYPODA—(*continued*).

Naiadites modiolaris (Sow.).
,, *triangularis* (Sow.).
,, *carinata* (Sow.)
,, *elongata* (Hind).
Anthracomya williamsoni (Brown).

EUCRUSTACEA.

Dithyrocaris, sp.
Pygocephalus cooperi, Huxley.
,, (*? Anthrapalæmon*) *parkeri* (Woodw.).
Anthrapalæmon grossarti, Salter.
Eurypterus, sp.
Cyclus johnsoni, Woodw.
Rochdalia parkeri, Woodw.
Belinurus lunatus (Martin).
,, *königianus*, Woodw.
,, *baldwini*, Woodw.
,, *longicaudatus*, Woodw.
,, *testudineus* (Woodw.).

ARACHNIDA.

Prestwichia birtwelli, Woodw.
,, *rotundata* (Prestwich).
,, ,, var. *major*, Woodw.
,, ,, ,, *minor*, Woodw.
,, (*Euproöps*) *danæ*, Meek & Worthen.
,, *anthrax* (Prestwich).
Eoscorpius (*Mazonia*) *wardingleyi*, Woodw.
Eobuthus holti, Pocock.

ARACHNIDA—(*continued*).

Anthracoscorpio buthiformis, Pocock.
,, *sparthensis*, Pocock.
Geralinura sutcliffei, Woodw.
Anthracomartus trilobitus, Scudder.
,, sp. 1 in Platt Coll.
,, sp. 2 in Platt Coll.
Anthracosiro woodwardi, Pocock.
Phalangiotarbus suboralis (Woodw.).
,, (*Architarbus*) *rotundata*. Woodw.

DIPLOPODA.

Xylobius platti, Woodw.
Euphoberia ferox, Salter.
,, *armigera* (Baldwin)
,, *robusta* (Baldwin).
,, *woodwardi* (Baldwin).
Archiulus, sp.
Acantherpestes major, Meek & Worthen.
,, *giganteus*, Baldwin.

INSECTA.

Spilaptera sutcliffei, Bolton.
Mecynoptera tuberculata, Bolton.

PISCES.

Platysomus tenuistriatus, Traquair.
Rhizodopsis sauroides (Will.).

INCERTÆ SEDIS.

Palæoxyris prendeli, Lesq.

SOUTH STAFFORDSHIRE COALFIELD.—Binds between the "Brooch" and "Thick" coals; Tipton, Dudley, and Coseley.

EUCRUSTACEA.

Euphoberia ferox, Salter.

ARACHNIDA.

Anthracoscorpio buthiformis, Pocock.
Geralinura britannica, Pocock.
Græophonus anglicus, Pocock.
Eocteniza silvicola, Pocock.
Archæometa nephilina, Pocock.
Curculioides ansticii, Buckland.
Poliochera alticeps, Pocock.
Plesiro madeleyi, Pocock.
Geraphrynus angulatus, Pocock.
,, *hindi*, Pocock.
,, *tuberculatus*, Pocock.
,, *eggintoni*, Pocock.
,, *torpedo*, Pocock.

ARACHNIDA—(*continued*).

Geraphrynus angustus, Pocock.
Anthracomartus hindi, Pocock.
,, *priesti*, Pocock.
Anthracosiro woodwardi, Pocock.
,, *fritschi*, Pocock.
Trigonotarbus johnsoni, Pocock.

INSECTA.

Palæodictyoptera.
Pruvostia spectabilis, Bolton.
Brodia priscotincta, Scudder.
,, *furcata* (Handl.).
"*Pteronepionites*" *lepus*, Bolton.
,, *ambiguus*, Bolton.
Geroneura (*?*) *ovata*, Bolton.

INSECTA—(*continued*).
Protorthoptera.
Xeroptera obtusata, Bolton.
Scalæoptera recta, Bolton.
Coselia palmiformis, Bolton.
Blattoidea.
Aphthoroblattina johnsoni (Woodw.).
INSECTA—(*continued*).
Blattoidea—(*continued*).
Aphthoroblattina eggintoni (Bolton).
Archimylacris incisa (Bolton).
Phylloblatta transversalis (Bolton).
LARVAL BLATTOID.
Leptoblattina exilis, Woodw.

COALBROOKDALE COALFIELD, SHROPSHIRE.—Ironstone Nodules of the Pennystone Series.

EUCRUSTACEA.
Euphoberia ferox, Salter.
Anthrapalæmon (*Apus*) *dubius* (Prestw.).
ARACHNIDA.
Prestwichia anthrax (Prestw.).
,, *rotundata* (Prestw.)
,, *trilobitoides*, Woodw.
ARACHNIDA—(*continued*).
Curculioides austicii, Buckland.
Eophrynus prestvici (Buckland).
DIPLOPODA.
Acantherpestes brodiei, Scd.
INSECTA.
Lithosialis brongniarti (Mantell).

SOUTH WALES COALFIELD.—Shales in the neighbourhood of the Mynddislwyn Vein, base of the Upper Coal Measures.

ARACHNIDA.
Aphantomartus areolatus, Pocock.
Græophonus anglicus, Pocock.
Maiocercus celticus, Pocock.
Kreischeria verrucosa, Pocock.
INSECTA.
Aphthoroblattina sulcata (Bolton).
Orthomylacris lanceolata (Bolton).
Archimylacris hastata (Bolton).
,, *obovata* (Bolton).

The arthropod association in the lists given is significant, for no other animals enumerated are so readily water-borne as are insects. It may be assumed that neither the more primitive arthropods, nor the insects, have been transported to any great distance from their former habitat. Their preservation under similar conditions supports the belief that their habits and habitats were the same, or closely approximated to the same conditions of entombment.

The freedom of the deposits from comminuted carbonaceous matter, such as is usually a chief constituent of the Coal Shales, may be accounted for by the beds having been laid down in quiet lagoons or swamp lakes, into which only the finer mud particles and floating pinnules and *débris* of coal-plants could pass and accumulate. Such waters were probably fresh or brackish, shallow, and limited in area. As we have indicated elsewhere (p. 10), it has been considered that the larvæ of many of the Coal Measure insects were semi- or wholly aquatic, and if such was the case, they would be more likely to be found in the deposits accumulating in quiet waters than in others exposed to movement. The presence of Mollusca and the lower orders of Arthropoda, with such forms as *Palæoxyris*, and even fish-remains, can be accounted for by the existence of occasional or permanent passages leading to open waters, such as river channels and the open sea.

A succession of such lagunal lakes or swamp pools might be seasonal features along a depression which, in a wet season, formed a water-course.

The paucity of Mollusca is noteworthy, only one species ("*Unio*") having been recorded by Moysey, notwithstanding his careful search of material from the Shipley clay-pit at Ilkeston, Derbyshire; while Kirkby, and more recently Trechmann and Woolacott have recorded *Anthracomya phillipsii*, in addition to "*Ancylus vinti*" (now known to be the larval form of *A. phillipsii*), from the insect-bearing beds at Claxheugh, near Sunderland.

The deposits at Sparth Bottoms, Rochdale, Lancashire, are remarkable in that they have yielded three species of *Carbonicola*, four species of *Naiadites*, and one species of *Anthracomya*.

In regard to the presence of Crustacea, Thomson (1894, 'Trans. Linn. Soc. London,' Zoology [2], vol. vi, p. 3), has shown that the recent *Anaspides tasmaniæ* lives in freshwater pools and lakes which are wholly cut off from the sea, and Dr. H. Woodward (1908, 'Geol. Mag.' [5] vol. v, p. 385) has described an allied form, *Preanaspides præcursor*, from the Coal Measures of Shipley Clay-pit. Further research may prove that not only *Preanaspides*, but such forms as *Belinurus*, *Prestwichia*, *Eurypterus* and *Anthrapalæmon* were also fresh-water in habit, co-existing with insect larvæ in the lagoons and swamp lakes.

Observations by the writer during the visit of the British Association to Australia in 1914 bear on this point. While collecting in the "Bush country" at St. Margaret's Bay, Western Australia, at Warburton, S. Australia, and elsewhere, examination of almost every loose sheet of bark hanging to the gum trees revealed a colony of scorpions, millipedes, spiders and cockroaches. In the Australian localities mentioned true "bush" conditions prevailed, and seemed much unlike those of low-lying swamps, such as are predicated for the Coal Measure period. Subsequent experiences along the coast of North Queensland modified these first impressions. It was found that notwithstanding the hot tropical day, or perhaps by reason of it, the nights brought an extremely heavy dew, so that it was impossible to move four yards in the jungle before the clothing was running with water discharged from the leaves of the jungle plants. In a short time after sunrise the jungle was dry again, but much of the moisture must have been caught up under projections capable of resisting the penetration of the sun's heat. In the "bush" country, slabs of bark may give conditions which the arthropod fauna find the most tolerable during the hot season. The Australian winter with its heavy rains would more nearly accord with swamp conditions. Long stretches of the coastline of Queensland, north of Brisbane, the country along the Hinchinbrooke Channel, and in the neighbourhood of Townsville, are low-lying, and covered by dense mangrove swamps growing out into the sea and completely hiding the outlets of rivers.

The conditions seem similar to those of the low-level country, swamp and

mud flat upon which the coal forests are believed to have flourished. During the voyage along the coast, a landing was made at Lucinda Point, and an opportunity was afforded of entering the swamp. Part of the swamp was awash on landing, but as the tide receded, it was possible to reach the shore. The latter was found to be a flat shelving beach, consisting of fine marine sand on the seaward side, passing shorewards into a fine tenacious clayey mud in which the mangroves grew. The sand bore numerous remains of echini, mollusca and marine *débris*, while the mud below high-water mark and above it was penetrated in all directions by the roots of mangroves, by the burrows of crabs, and by a burrowing gasteropod, *Telescopium fuscum*.

Masses of leaves, branches and other vegetable material were mixed with the mud, the latter in some places forming irregular lumps and boulder-like masses around the vegetable material. A broad shallow depression, with a few inches of water over a thick bed of mud littered with leaves, led into the swamp. It was evidently the bed of a stream during the wet season, remaining as a series of disconnected pools at other times, or drying up.

The resemblance of the physical conditions to those accepted as dominant in the Coal Measure period was so evident that special attention was given to it with a view to discovering discrepancies; yet, had the mangroves been replaced by dense groves of gum trees with their arthropod fauna, the circumstances would have been well-nigh identical. Had the faunal association of scorpions, millipedes, spiders and cockroaches of West Australia been transported to the swamp, their remains would have become entombed in material not unlike that at Sparth Bottoms or Coseley.

There is ample evidence to show that the coal plants grew on ground of this character, and we know that the remains of fossil insects are associated with the plant-remains.

The swamp conditions of the North Queensland coast reproduce with great exactitude the presumed Coal Measure conditions, but lack the arthropod fauna owing to the unsuitability of the vegetation.

Scudder had some such habitat and faunal association in mind when writing his work "Archipolypoda: a Sub-ordinal Type of Spined Myriapods from the Carboniferous Formation" ('Mem. Boston Soc. Nat. Hist.,' vol. iii, no. 5, pp. 143—182). Plate X of that work is described as "an attempted restoration of a specimen of *Acantherpestes major*, Scd." The specimen is represented as leaving the water, in which the hinder part of the body is still swimming by means of its legs, while the fore part of the body is creeping up the trunk of a Lepidodendron (*L. vestitum*). On the trunk crawls a cockroach (*Etoblattina mazona*, Scd.); and a broken stem of *Calamites cistii*, Brong., lies partly fallen in a clump of *Neuropteris loschii*, Lesq.

We are, therefore, not without some justification in assuming that the faunal

backwards in its course to the wing-apex. The intercostal area is very wide at the base, and diminishes in diameter towards the wing-apex, but it is doubtful if it reached the latter.

The subcosta is straight, but not well defined. The radius is fairly parallel to the subcosta and gives off the radial sector low down in the base of the wing; the radial sector comes off from the radius at an acute angle, and keeps parallel with it as far as preserved. Its direction is such that it must have reached the wing-apex. The median and cubital veins merit special consideration. In the specimen three veins occupy the position of the normal median and cubitus. Of these, two either arise from a common root, or so close together as to be indistinguishable, the third having a separate origin. The innermost of the three sends off from near its base a forwardly directed twig, which joins the second of the two outer veins.

It is necessary to resolve these veins into median and cubitus. To do this we must consider recent research on living insects. Comstock and Needham concluded that the primitive median vein was a four-branched structure; more recently Tillyard, from further studies of the wing-venation of recent nymphs, concludes that the primitive median had an initial dichotomy, of which the outer branch divided up into four ("M" of Tillyard, 'Proc. Linn. Soc. N.S. Wales,' vol. xliv, 1919, p. 552), and the second branch remained simple. Comstock and Needham concluded that the primitive cubitus was two-branched; Tillyard considers it (*loc. cit.*, p. 553) as three-branched, the outer or first branch having a distal forking into two feeble twigs, and an inner feeble branch which remains simple. The primary cubital fork is situated near the base of the wing.

Tillyard's views are not very different from those of Comstock and Needham, as he admits a basal fork of the cubitus, but adds a secondary forking of the end of the outer branch.

Tillyard has studied the relation of the two veins in the various Orders, and finds that the "posterior arculus" of Comstock, which is supposed to be a cross-vein from the median to the cubitus, is, as shown in the fossil Order Paramecoptera, not a cross-vein, but a true branch of the median. The various stages by which the connection becomes established and afterwards developed into a combined vein from the point of union, are fully stated (*loc. cit.*, p. 357), and the compound vein is named the "cubito-median Y-vein." An examination of the conditions observable in *Dictyoneura higginsii* shows that the united veins and their single-stemmed prolongation are in position and character identical with Tillyard's "cubito-median Y-vein." The three veins of the specimen, therefore, are the outer median vein, the inner median uniting with the first cubital vein, to form a "cubito-median Y-vein," and lastly, the second (inner) branch of the cubitus.

Tillyard recognises the presence of the "cubito-median Y-vein" in the Permian Order Paramecoptera, but its discovery in the Coal Measure genus *Dictyoneura*

shows that its origin is of much older date. The cubito-median Y-vein lies close to the outer median for a short distance, and then bends obliquely inwards to the margin of the wing. The inner cubital vein is fairly straight, and widely spaced along almost its whole length from the cubito-median Y-vein.

Six anal veins are present, all going obliquely to the inner margin, the second and third alone forking. The interstitial neuration, which I have been able to study better by immersing the specimen in water, consists of numerous irregular cross-nervures, occasionally uniting in crossing, or forming a loose meshwork, especially between the median and cubital veins.

Affinities.—With so small a wing-fragment, and with few wings of similar character as guides, it is not possible to form an accurate idea of the whole wing. The radius and radial sector entered the wing-apex, and the median-cubital elements occupied the greater part of the inner margin of the wing.

The broad intercostal space and the course of the subcosta are very similar to those in *Polycreagra elegans*, Handlirsch, but the general trend of the main veins, and most of all the character of the interstitial neuration, are so suggestive of *Dictyoneura libelluloides*, Goldenberg, that I had referred the specimen to that genus before Handlirsch's paper was published.

Handlirsch has now (1919) referred this species to a new genus, *Sherborniella*, giving the new name "for the sake of uniformity," but without diagnosis.

Family Orthocostidæ, Bolton.

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 313.

Wings with almost straight outer margin; inner margin well rounded; costa, subcosta and radius closely approximated; median, cubitus and anal veins occupying nearly the whole of the inner half of the wing.

Genus **ORTHOCOSTA**, Bolton.

1912. *Orthocosta*, Bolton, *loc. cit.*, p. 313.

Generic Characters.—Radial sector diverging from radius, and with few divisions. Median with two branches united by a commissure. Cubitus stout, forked near base, the outer branch forking twice, and the inner once. Anal area elliptical. Interstitial neuration forming an open polygonal meshwork.

Orthocosta splendens, Bolton. Plate I, fig. 2; Text-figure 1.

1912. *Orthocosta splendens*, Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 310, pl. xxxi, figs. 1—3.

Type.—Incomplete wing, and impression; Moysey Collection, Museum of Practical Geology, Jermyn Street (nos. 30,222 and 30,223).

Horizon and Locality.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire.

Specific Characters.—Radial sector reaching the inner half of the wing-tip. Outer branch of median four or five times divided, inner branch simpler and forked. Cubitus dividing low down, the outer branch the stronger, and each doubly forked. Anal veins one or two in number, alternately branched.

Description.—The species is founded on a wing-fragment, the apex, a portion of the inner margin, and the base being incomplete. The total length is 84 mm., the width 33 mm. The complete wing must have had a length of at least 100 mm., and a width of 35—40 mm. The whole insect had in all probability a span of wing measuring 25·5 cm. (10 in. or more).

The outer third of the wing is differentiated from the rest by its uniform and gentle convexity, and by the character of the costa, subcosta, radius, and median veins, which pass outwards towards the wing-apex in straight lines, and show no trace of divisions until well beyond the middle of the wing, contrasting strongly

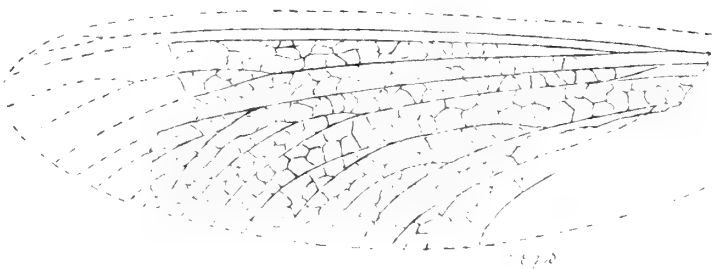

Fig. 1.—*Orthocosta splendens*, Bolton; restoration of wing, showing portion preserved and the character of the interstitial neuration, natural size.—Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Moysey Collection, Mus. Pract. Geol. (nos. 30,222 and 30,223).

with the areas occupied by the marginal divisions of the median, cubital and anal veins. The inner two-thirds of the wing is marked by deep furrows, in which lie the marginal branches of the median vein, and the whole of the cubital and anal veins. The areas between any two veins in this region are markedly convex. The differences in character of the outer and inner portions of the wing are emphasised by a line of fracture which fairly accurately separates the two. Its occurrence suggests that it has followed a natural line of weakness, the more delicate inner part of the wing breaking away from the outer stronger portion.

The costa, subcosta, radius and median are all well-developed veins, stout in structure and standing out in relief. The first three retain this evidence of strength over two-thirds of their length, the median vein showing signs of attenuation beyond the proximal third.

The general structure of the wing indicates considerable powers of flight. The outer margin, of which only a portion is preserved, appears as a stout, slightly elevated and well-rounded ridge.

The subcosta agrees in general character with the costal remnant, and is

straight to the wing-tip, parallel with the outer margin, and not far removed from it. Basally it appears to be united to the radius.

The radius gives off the radial sector at about 10 mm. from its base, and then passes out to the wing-tip, at no point being more than 10 mm. from the subcosta. The radial sector diverges widely from the radius, the two enclosing a long, narrow triangular area. At 50 mm. beyond its origin it divides into two equal branches, which diverge to a distance of 3 mm. and then become parallel. The direction of the branches of the radial sector is such that they must have ended on the inner half of the wing-apex, the outer branch probably forking again before the wing-apex was reached. The median vein consists of two branches, the common origin of which is not shown, owing to the absence of the base of the wing. To the middle of the wing the two branches are parallel, and both pass beyond this point before branching. The outer branch attains a length of 66 mm. before branching, and then gives off four branches on its outer side, the last arising close to the margin.

The second of the four branches bifurcates. The inner branch of the median gives off one forward branch only, which forks into a feeble twig dying out in the polygonal meshwork, and into a stronger division which reaches the margin. The two branches of the median are united at the base of the wing by an oblique commissural vein which comes off at an acute angle from the outer branch, and passes obliquely to the inner branch.

The basal portion of the cubitus has been lost, so that its branching is not readily determinable. The main vein seems to have divided near the base into two equal branches, which curve down to the inner wing-margin, bifurcating twice in each case before the margin is reached. The eight marginal twigs of the cubitus thus produced enclose the middle third of the inner margin. The anal area is wholly destroyed on the wing, and only a trace of one vein can be distinguished on the counterpart. This is a narrow deeply-sunk vein which gives off feeble off-shoots on both sides. It diminishes in strength, so that the last portion of its course can only be determined with difficulty. The anal area is comparatively narrow and small, and exhibits few veins.

Family Pteronidiidæ, Bolton (emend. Cockerell).

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 314.

Wings long and narrow. Outer margin arcuate. Median and cubitus with divergent branches.

The attempt to classify these wings is difficult. That they possess affinities with the genus *Polycreagra* is certain, but they are more simple and more Dictyoneurid in type. As Dr. Handlirsch observes, it is not possible to refer them to the family Polycreagridæ, and they must be taken as the type of a new family.

Genus **HYPERMEGETHES**, Handlirsch.

1906. *Hypermegethes*, Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 672.

Generic Characters.—Costal border feebly convex, subcosta and radius close together along the greater part of their length. Cubitus composed of two, possibly more, parallel and simply forked branches, divided near the point of origin. Anal veins few; interstitial neuration of fine, irregularly anastomosing nervures.

Hypermegethes northumbriæ, Bolton. Plate I, fig. 4; Text-figure 3.

1917. *Hypermegethes northumbriæ*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii. p. 55, pl. iv, figs. 2 and 3, and woodcut in text.

Type.—Portion of the basal half of a left wing, in counterpart; British Museum (no. In. 18524).

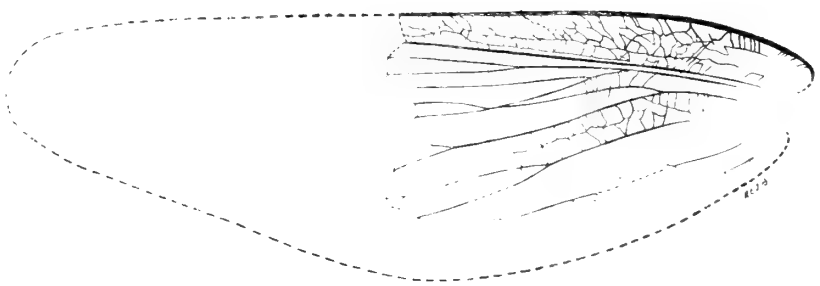

Fig. 3.—*Hypermegethes northumbriæ*, Bolton; suggested outline of left wing, restored, showing portion preserved, slightly less than natural size.—Coal Measures (shale above the Crow Coal): Phœnix Brickworks, Crawcrook, Durham. Brit. Mus. (no. In. 18524).

Horizon and Locality.—Coal Measures (shale above the Crow Coal); Phœnix Brickworks, Crawcrook, Durham.

Specific Characters.—Costal area wide, and crossed by an irregular meshwork of small veins. Median united with the radial sector basally, and giving off an inner branch which unites with the cubitus. Cubitus with a short stem forking into two equal and widely separated branches. Anal veins simple, and widely spaced.

Description.—The fragment is little more than a third of the whole wing, and its characters can only be determined with difficulty. The two halves of the nodule do not coincide, and the outline drawing of the wing is built up from details supplied by both halves. The inner margin, anal area and base of the wing have been lost, so that a little less than two-thirds of the outer portion of the basal half of the wing is present.

The portion of wing remaining being 63 mm. long, with a depth of 31 mm. at its widest part, the whole wing must have had a length of about 126 mm., or

5 in., and the whole insect a span of wing of nearly 11 in. The wing-fragment shows the basal portions of the costa, subcosta, radius, radial sector, median, and cubitus, and possibly a trace of an anal vein.

Much of the finer detail of the wing is not seen until the fossil is immersed in water—a mode of treatment suggested to me by Dr. F. A. Bather, F.R.S., who had previously photographed the wing in this manner, and brought out details of which, by ordinary methods, I could not find a trace.

The costa is moderately convex from its base to a distance of about 30 mm., beyond which it becomes straight. Separated from the outer or costal border by a wide area basally is the subcosta, an extremely feeble and hardly distinguishable vein. It passes straight to the outer margin some distance beyond the middle of the wing. The radius arises close to the subcosta, and is parallel with it. It gives off two branches posteriorly, the proximal branch passing obliquely towards the inner side of the wing-apex, while the second or distal branch arises from the radius a little further out, and keeps parallel with it.

I had formerly considered the proximal branch of the radius to be the radial sector, and the distal a branch of the radius; but as the interstitial neuration now shows the specimen to be closely related to *Hypermegethes schucherti*, the proximal branching vein must be regarded as the main stem of the median which has entered into union with the radius, and the distal branch as the radial sector.

Regarding the proximal offshoot of the radius as the median vein, it diverges widely from the radius, giving off a forward twig parallel with the radial sector, and then continues inwards and unites with the next vein, separating again a little further out on the inner side. A comparison of this assumed median vein with that of *H. schucherti*, Handl., is instructive. In the latter species the branching of the main stem of the median arises nearer the base of the wing than does the branching off of the radial sector. It is therefore somewhat in the position of the starting-point of the median vein as a free structure in the present wing. The median vein of *H. schucherti*, Handl., has, however, no union with the radius, the main stem running out towards the wing-apex parallel with the inner branch of the radius, giving off a backward branch of the cubitus, which passes obliquely inwards and unites with the anterior branch. In the middle of its length it gives origin to a twig running parallel with the main stem, and midway between that vein and the cubitus. The course of the median vein in the specimen here described is exactly similar to that of the branch of the median vein in *H. schucherti*, Handl., except that the inner branch not only unites with the cubitus, but crosses it.

The condition may be summarised by saying that, in *H. schucherti*, Handl., the median vein is entirely free and gives off an inner branch dividing into two twigs, of which the inner unites with the cubitus. In the specimen here described the median is united with the radius for some little distance, becoming free before the

radial sector is reached, and then forking, the inner twig uniting with and crossing the cubitus.

The cubitus has a short, stout basal stem, forking into two equal and somewhat widely separated branches, the outer uniting with the inner branch of the median. The inner branch is forked just before the broken edge of the wing is reached. Nearer the inner margin of the wing are traces of two other veins. The first has its basal portion missing, and follows a course parallel with the inner branch of the cubitus. It is strongly forked. The remaining vein is represented by three detached fragments. If Handlirsch's interpretation of the wing of *H. schucherti* is followed, we should regard both these veins as anal. I am, however, of opinion that, while the innermost fragmentary vein may be anal, the forked vein by its position, its forked character and stoutness, must be regarded as a portion of the cubitus. I am likewise of opinion that the first, and possibly the second, of the veins marked as anal in Handlirsch's figure of *H. schucherti*, ought also to be classed as cubital. Both in *H. schucherti*, and in this specimen, the anal area would have an enormous development and occupy most of the wing-margin, if the veins alluded to were wholly anal in character. I feel sure that, if the vein nearest the cubital had been better preserved, it would be found branching off from the cubitus.

The interstitial neuration is typically that of *Hypermegethes*. The intercostal area is filled with an irregular meshwork of fine nervures, with a tendency on the outer and inner sides to a transverse arrangement. Between the median and the cubital veins the interstitial neuration consists of short, straight and transverse nervures, and feeble traces of similar nervures can be seen in the median area. The cubital area is filled with a meshed neuration, larger and more regular than that of the intercostal area, and this seems to continue into the anal area.

Family Cryptoveniidæ, Bolton.

1912. Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 315.

Wings short and broad. Apex rounded, costal vein marginal; subcosta feeble, and extending to near apex. Radius simple; radial sector and median with few divisions; cubitus with two main branches.

Among the insect-remains discovered by the late Dr. L. Moysey at the Shipley Manor Claypit is a small wing, 16 mm. long, unlike any previously known. It is typically Palæodictyopterous, and agrees remarkably well with Dr. Handlirsch's type-figure ('Mitth. Geol. Gesell. Wien,' vol. iii, 1910, p. 505, fig. 1). It differs from that form in the greater division of the cubitus, which ends in five twigs instead of three. The greatest depth of the wing was also, in all probability, nearer the base than in his figure. With the genus *Athymodictya*, Handlirsch ('Amer. Journ. Sci.'

[4], vol. xxxi, 1911, p. 298), the relationship is even closer, as in that genus the costa and subcosta are close together, the radial sector arises low down and is divergent from the radius, the median is a simple vein ending in three branches, while the cubitus is almost identical in its divisions, the difference being that the first forking arises at a higher point than that in *Athymodictya parva*, Handl., and that the inner simple ramus of the outer branch comes off a little below the middle of the wing. The anal veins number four in *A. parva* as against five in the wing under consideration. The wings are almost equal in size. It is not possible, however, to refer this wing to *Athymodictya* owing to the character of the interstitial neuration. In *Athymodictya* this is reticulated, while in the British wing the interstitial neuration is apparently made up of transverse nervures. If this point can be clearly determined, the wing may have affinities with the Homoiopteridæ or with the Lithomantidæ, but it cannot be referred to either of these families. Neither Dr. Handlirsch nor I could satisfactorily refer the wing to any known family, and I therefore founded the family Cryptoveniidæ to receive it.

Genus **CRYPTOVENIA**, Bolton.

1912. *Cryptovenia*, Bolton, Quart. Journ. Geol. Soc., vol. lxviii, p. 315.

Generic Characters.—Wings twice as long as wide. Median, cubitus and anal veins curving sharply inwards. Interstitial neuration of straight cross-nervures.

Cryptovenia moyseyi, Bolton. Plate II, fig. 1; Text-figure 4.

1912. *Cryptovenia moyseyi*, Bolton, *loc. cit.*, p. 315, pl. xxxii, figs. 4—6.

Type.—Incomplete wing, in counterpart; Moysey Collection, Museum of Practical Geology, Jermyn Street (nos. 30,226 and 30,227).

Horizon and Locality.—Middle Coal Measures (below the top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire.

Specific Characters.—Costa feebly curved distally, subcosta reaching outer margin near wing-apex. Radius close to and parallel with the subcosta; radial sector arising from radius in basal half of the wing, the five branches occupying the inner half of the wing-tip. Median with the first branch undivided, and the second forking twice. Cubital vein strongly arcuate, two-branched, and ending in five twigs. Anal veins five or more in number, and curving sharply inwards. Wing plicated, and the interstitial neuration obscured by a mass of wrinkles.

Description.—A small delicate wing, incomplete at the base, which must have been very narrow and with the main veins crowded together. The total length of wing preserved is 16 mm., and its maximum diameter, in the cubito-anal region, is 8 mm.

The costal vein is stout and raised above the general level of the wing in the outer third of its length, where it curves backwards into the wing-tip. The subcostal is a weaker vein, parallel with and very close to the costa, dying out or joining the outer margin at the apex. The radius is a powerful undivided vein, parallel with the subcosta and reaching the middle of the wing-apex. The radial sector is given off about the middle of the length of the wing and forks into two equal branches, which again fork before reaching the margin ; the outermost branch of the second forks again and divides just before the wing-apex is reached. The

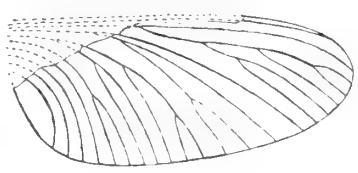

Fig. 4.—*Cryptovenia moyseyi*, Bolton ; restoration of left wing reconstructed from the wing-fragment and counter-impression, enlarged two-and-a-half times.—Middle Coal Measures (below the Top Hard Coal) ; Shipley Manor Claypit, Ilkeston, Derbyshire. Moysey Collection, Mus. Pract. Geol. (nos. 30,226 and 30,227.)

inner half of the wing-apex is occupied by the five branches of the radial sector. The median vein is a comparatively simple structure, forking low down below the middle of the wing into two nearly equal branches. The outer branch remains undivided, and gently curves to the inner margin. The inner branch divides twice, first at a point near the middle of the wing, and again before the margin is reached. The median vein therefore ends on the margin in four twigs, three members of which arise from the inner of the two main branches.

The cubital vein is strongly arcuate, dividing near the base into two branches, the outer forking twice and the inner once. The cubital vein therefore ends in five twigs.

Family Mecynopteridæ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 82.

Handlirsch established this family to receive a large wing from the Middle Upper Carboniferous of Belgium, and placed it between the families Hypermegethidæ and Lithomantidæ. The characters of the family are based on those of the type-species, *Mecynoptera splendida*, Handl.

Genus **MECYNOPTERA**, Handlirsch.

1904. *Mecynoptera*, Handlirsch, Mém. Mus. Roy. Hist. Nat. Belg., vol. iii, p. 7.
1906. *Mecynoptera*, Handlirsch, Die Fossilen Insekten, p. 82.

Generic Characters.—Wing three to four times as long as broad, veins of costal region specially compact, and thickened basally. Costa, subcosta and radius closely approximated and tuberculated. Radial sector and median well developed, and occupying a considerable portion of the wing-surface. Cubitus small. Interstitial neuration of transverse nervures in junction areas of principal veins, and with a meshwork further out.

Mecynoptera tuberculata, sp. nov. Plate II, fig. 2; Text-figures 5 and 6.

1911. *Stenodictya lobata*, Baldwin (*errore*), Geol. Mag. [5], vol. viii, p. 75.

Type.—Portions of two fore-wings, and the cubito-anal portion of a hind-wing contained in a nodule of ironstone, 3 in. long, and $1\frac{1}{2}$ in. wide; British Museum (no. In. 18,576).

Horizon and Locality.—Middle Coal Measures (grey-blue shales at 135—180 feet above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire.

Specific Characters.—Principal veins thickened at base and finely tuberculated. Costal margin almost straight, much thickened at base, and covered with a fine

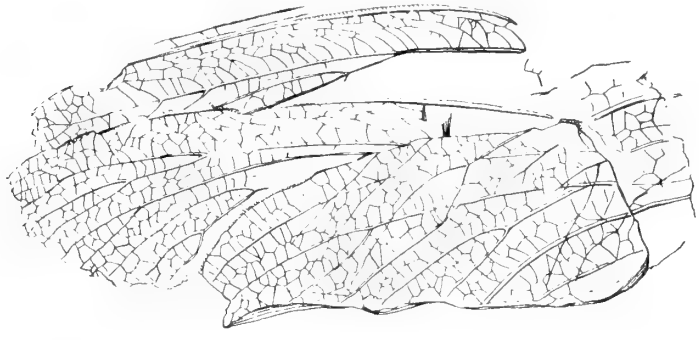

Fig. 5.

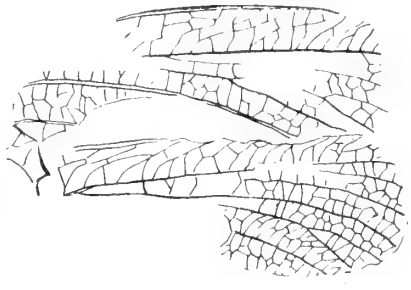

Fig. 6.

Fig. 5.—*Mecynoptera tuberculata*, sp. nov.: diagram of remains of the two fore-wings, and cubito-anal portion of a hind-wing (the sub-costa appearing as a fine line close to the radius, and sending off three branches to the costal margin), enlarged one-and-a-half times.—Middle Coal Measures (above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Brit. Mus. (no In. 18,576).

Fig. 6.—*Mecynoptera tuberculata*, sp. nov.: diagram of fragmentary impression of the two fore-wings, enlarged one-and-a-half times.—Middle Coal Measures (above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Brit. Mus. (no. In. 18,576).

tuberculation. Subcosta sunken, close to costa, and extending to the wing-apex. Radius close to costa, tuberculated, and elevated. Radial sector arising low down, much branched. Median with two main branches, the first simple, the second with three twigs. Cubital vein small.

Description.—The type-specimen comprises remnants of the two fore-wings, 60 mm. long and 18 mm. wide, and a portion of the cubital-anal area of a single hind-wing in one ironstone nodule. A similar ironstone nodule from the same horizon and locality shows the radius and radial sector areas of the two wings of a second insect.

When complete, the wings must have had a length of 65—70 mm. They were originally identified with those of *Stenodictya lobata*, Brongniart, and are quoted as such in the faunal lists of the Sparth Bottoms deposits, but with no detailed description or figures.

When the specimens were first examined they presented an apparently anomalous union or suppression of certain of the principal veins. Careful development has since shown that what was formerly considered to be the outer or costal margin of the wings was really the thickened and tuberculated radius vein, and that the outer margin, with the costa and subcosta, had been hidden under the matrix. A little of the outer marginal costa and the subcosta are now uncovered, and the wing-structure is therefore proved to be of a normal type.

The three wings in the larger, more nearly complete specimen are superposed and fragmentary. The uppermost fore-wing is represented by two portions, one having a little of the outer or costal margin, the subcosta, and the greater part of the radius and radial sector. The second part consists of the median, and a portion of the cubitus. The second fragment is displaced backwards, allowing the radius and radial sector of the second fore-wing to be seen. The median-cubital area of the hind-wing is very thin and closely pressed on the rest, but the course of the veins is clearly discernible, and by their sharp inward turn indicates that the hind-wings were much broader than the fore-wings.

Although the wings are thus broken up, displaced, and superposed, the parts missing in the one wing are present in the other, and it is possible to reconstruct their general character. The outer margin is almost straight, gently rounded into the base, and into the wing-apex. The subcosta is weak, and lies in a deep sulcus, extending into the apex of the wing. The radius is a little elevated, thickened, tuberculated in the basal third, and in close proximity to the subcostal vein. The radius is a strong vein, raised above the level of the rest of the outer margin of the wing, so that when the latter was hidden, it naturally appeared to be the outer marginal costal vein. It is much thickened in its basal third, tuberculated, and remains parallel with the subcosta in the apex of the wing.

The wing-space taken up by these three veins is very small, and their close approximation and the coriaceous thickening of the costa and radius serve to give a considerable degree of strength and rigidity to the outer margin of the wing. The radial sector passes straight outwards to the apex of the wing, giving off three inner branches in one wing and two in the other, the first branch only forking. The first branch soon forks, the outer fork dividing into two twigs, and the inner into three upon the distal inner half of the wing-apex. The median is a large vein, occupying the greater part of the inner half of the wing. It divides at its point of origin into an outer undivided branch which traverses the middle of the wing, and an inner branch which is widely separated from its fellow, and gives off three twigs to the wing-margin, the first forking in the middle of its length. Cubital veins are repre-

sented by two undivided elements which are directed obliquely to the margin. The inner margin of the wing is more curved than the outer, and merges into the apex. The interstitial neuration is remarkable. Between the costa, subcosta and radius it consists of short stout nervures crossing the areas somewhat obliquely, and in some cases arranged in **V**-shape. The area between the radius and radial sector is crossed by a numerous **S**-shaped series of nervures, which are joined up into a meshwork in the outer or radial half of the area. The area itself is very wide, and only equalled by that separating the two branches of the median.

The radial sector and the median occupy the greater part of the wing-surface.

The remaining areas are crossed by transverse nervures near the junction of branches with the principal veins, and further out by nervures which are joined up by zig-zag longitudinal branches which occasionally enclose polygonal cells. The interstitial neuration is very well developed, and must have added materially to the strength of the wings.

Affinities.—The close approximation of the costa, subcosta and radius, and the coriaceous thickening and tuberculations of the principal veins, are characters which may rank as of generic importance. Less distinctive, but also characteristic, is the interstitial neuration of the transverse nervures and meshwork, with its minute monilation.

The characters of the genus *Mecynoptera* are in closest agreement with those of this insect. There is the same approximation of the costa, subcosta and radius, the radial sector is widely spaced from the latter, and the interstitial neuration consists of transverse nervures near the junctions of the principal veins and their branches, and of a meshwork further out. The general outline of the wing is also the same.

M. splendida, Handlirsch, throws light on one point which had proved a difficulty in the determination of the wings. It has the radial sector of large size and much branched, the divisions occupying all the inner half of the apex of the wing, and extending out on the inner margin into the area usually occupied by the outer branches of the median. Prior to noting this feature in *M. splendida*, I had formed the opinion that the first division of the radial sector was the median, which had united with the radial sector and the radius.

The broken condition of the Rochdale wings prevents absolute determination of this point, but by analogy I conclude that the whole vein which branches off from the radius basally is the radial sector, and the next vein the median. This conclusion also removes the insect from the neighbourhood of *Ænigmatodes danielsi*, Handlirsch, a wing discovered in the Coal Measures of Mazon Creek, near Morris, Illinois, U.S.A., which possesses the same character of interstitial neuration, but with the divisions of the median vein stretching out to the wing-apex, and the costa, subcosta and radius more widely separated.

Unless it can be shown by the discovery of a whole wing that the reconstruction now attempted is faulty, the balance of evidence is in favour of the provisional reference of the Sparth Bottoms wing to the genus *Mecynoptera*.

Family Incertæ sedis.

Genus **PALÆOMANTIS**, Bolton.

1917. *Palæomantis*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 52.

Generic Characters.—Wings short, twice as long as broad. Apex well rounded. Radius, radial sector and median all powerful veins with few divisions. Median with two main branches. Anal veins directed almost straight inwards. Interstitial neuration forming an irregular meshwork.

Palæomantis macroptera, Bolton. Plate II, fig. 3; Text-figures 7 and 8.

1871. "Wing of large insect," Higgins, Pres. Add. Liverpool Naturalists' Field Club, vol. ii, p. 18.
1917. *Palæomantis macroptera*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 48, pl. iii, figs. 3—4, text-figs. 2—3.

Type.—Remains of two wings in nodule; Liverpool Museum.

Horizon and Locality.—Middle Coal Measures; Ravenhead railway cutting, near St. Helens, Lancashire.

Specific Characters.—Divisions of radial sector occupying almost the whole tip of the wing. Divisions of median and cubital veins occupying distal two-thirds of inner margin.

Description.—The larger half of the nodule has lost a portion which contained the tip of the right wing. The proximal third of the left wing remains, with its dorsal surface uppermost, and its ventral surface closely applied to that of the right wing. It is evident that the whole of the two wings was contained in the nodule, but, when the latter was split open, a thin film of ironstone carried away the middle and distal portions of the left wing.

One unusual feature in the position of the wings is that they lie with their ventral surfaces apposed. To bring them into this position one must have become bent under the body, instead of falling sideways across the thorax of the insect. The body of the insect would thus, if the wings still remained attached, lie between the two. No trace of the body can be seen, but the left wing has a deep inward flexure, such as it would naturally acquire if the body had been carried round with the right wing and pushed into the anal area of the left wing. Had the body been carried round in this way the right wing would not coincide in position with the left, but be thrust further out, which is actually the case, the outward displacement

of the right wing as compared with that of the left being at least 20 mm. The wings are remarkably wide—a feature which we usually associate with hind-wings.

The outer third of each wing is supported by strong and fairly rigid veins, becoming more slender as they pass towards the wing-tip. The inner margins of the wings are more membranous, and were evidently lacking in a rigidity equal to that of the outer margins.

A little more than the proximal third of the *left wing* is present and in good preservation. It is 42 mm. long and about the same in width. The impression on the other half of the nodule shows apparently all but the wing-apex. The main stems of the costa, subcosta, radius and median are all stout, and in relief on the wing-surface. The cubital and anal veins are but half the thickness of the former and lie in shallow grooves. The costal vein forms the outer margin of the wing, which is slightly convex forwards, and slopes gradually into the apex. The subcosta is

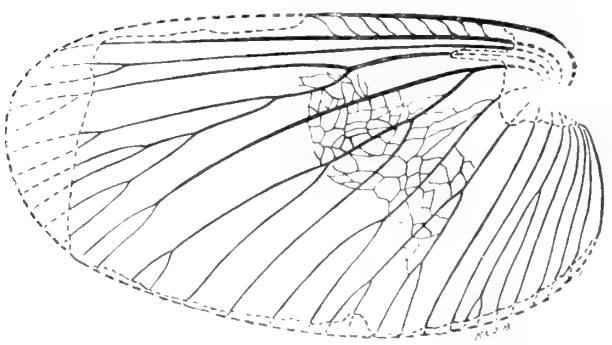

Fig. 7.

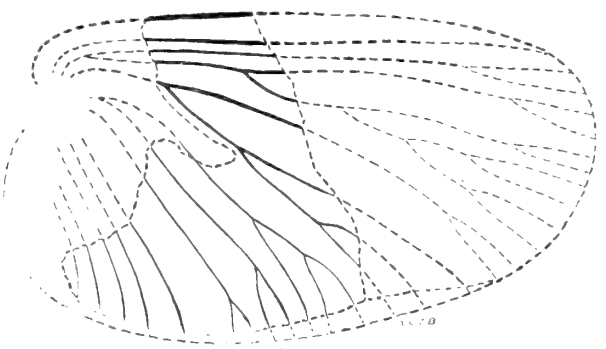

Fig. 8.

Fig. 7.—*Palæomantis macroptera*, Bolton; restoration of left wing, with restored outline, natural size. Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.

Fig. 8.—*Palæomantis macroptera*, Bolton; restoration of right wing, natural size.—Middle Coal Measures; Ravenhead Railway Cutting, near St. Helens, Lancashire. Liverpool Museum.

separated from the outer margin by a costal area 4 mm. broad. It passes almost in a straight line to the outer edge of the wing-apex, and is joined to the costa by a series of oblique transverse branches nearly parallel with each other. The radius arises close to the base of the subcosta, and diverges a little from it in its course to the apex, forking once just before the broken edge of the wing is reached. The main stem of the radial sector probably arises from the radius close to the base of the latter, but the exact point cannot be determined, owing to the base of the wing being broken away. The radial sector forks three times, and each of the resultant twigs again divides on the wing-apex. The median vein, which is stout basally, divides very low down into two branches, the outer of which has a feeble forking near the inner margin, while the inner branch forks three times. The cubitus is a much weaker vein than its fellows, and divides near its point of origin into two branches. The first branch forks once and the second twice. Seven anal veins are present, all undivided except the third, which forks twice. The interstitial

neuration is in the form of a meshwork, except in the intercostal area, where are the transverse cross-nervures already noted.

Much less of the *right wing* remains than of its fellow, but sufficient is present to show that the neuration was not quite the same. The median ends in five divisions in place of six, and the cubitus has seven final branches instead of six. The greatest width of the wing is along a line drawn from the outer margin to the middle of the cubital area on the inner margin, the width being 40 mm. The absence of the apex in each wing is unfortunate, as it renders the outline of the whole wing a little uncertain. The shape of the nodule indicates that very little of the wings is missing, if they were wholly included in the nodule, as seems probable. The somewhat semicircular inner wing-margin and the short wide wings indicate a broadly rounded wing-apex.

Affinities.—The interstitial neuration is much like that of *Hypermegethes*. The great width of the wings is a character usually associated with the hind-wings of members of the family Lithomantidæ, although in this case the wings lack the distal attenuation noticed in the hind-wings of that family. With *Titanodictya jucunda*, Scudder, there is a close relationship, both in the general character of the main veins, the interstitial meshwork in all areas other than intercostal and subcosta-radial, and in the presence of the same oblique cross-nervures in the intercostal area in these wings.

The true systematic position of the genus seems to lie between the Lithomantidæ and the genus *Titanodictya*, and closest to the latter. Because of the greater development of a meshwork neuration between the main veins, and the limitation of cross-nervures to the intercostal area, I regard this genus as more primitive than any of the Lithomantidæ, but closely related thereto.

Family Lithomantidæ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Mus., vol. xxix, p. 673; also Die Fossilen Insekten, p. 82.

This family is closely allied, by wing-structure, to the Dictyoneuridæ. The branching of the main veins has proceeded further than in the Dictyoneuridæ, and the body, where it has been preserved, shows striking differences. The family is represented in the Coal Measures of Great Britain and North America and in the Upper Carboniferous of continental Europe.

Genus **LITHOMANTIS**, Woodward.

1876. *Lithomantis*, H. Woodward, Quart. Journ. Geol. Soc., vol. xxxii, p. 60.

Generic Characters.—Large insects with two pairs of flying wings; the hinder pair double the width of the anterior pair. Prothorax produced into a central

rostral-like process, acutely pointed, and expanded into two lateral bulbous lobes. Thorax wide. The interstitial neuration consists usually of stout transverse nervures, occasionally forking or in a loose meshwork.

Lithomantis carbonarius, Woodward. Plate II, fig. 4; Text-figure 9.

1876. *Lithomantis carbonarius*, Woodward, *loc. cit.*, p. 60, pl. ix, fig. 1.
1893. *Lithomantis carbonarius*, Bronguiart, Faune Entom. Terr. Prim., p. 489, fig.
1906. *Lithomantis carbonarius*, Woodward, Geol. Mag. [5], vol. iii, p. 25, fig. 3 (*non* fig. 1).
1906. *Lithomantis carbonarius*, Handlirsch, Die Fossilen Insekten, p. 83.

Type.—Portions of the fore- and hind-wings, with prothorax, and a left anterior leg in nodule; British Museum (no. I. 8118).

Horizon and Locality.—Coal Measures; Scotland.

Specific Characters.—Hind pair of wings double the width of the fore pair. Outer wing-margin straight, costa and subcosta close together; radius a weak vein, giving off the radial sector far out. Median small. Cubitus a powerful vein with numerous widely spaced branches. Anal veins six or more.

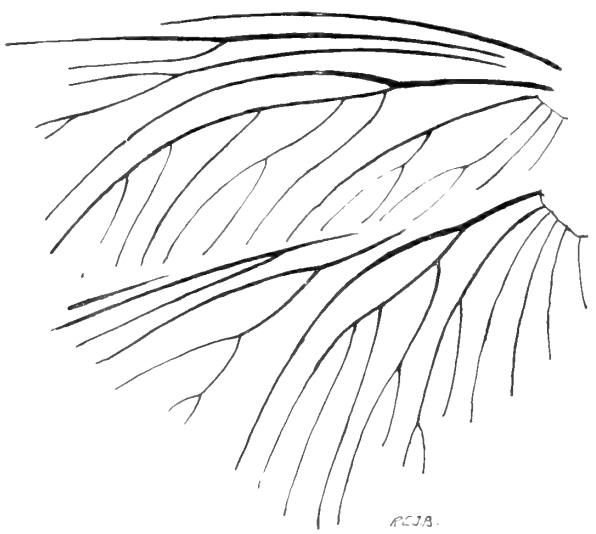

FIG. 9.—*Lithomantis carbonarius*, Woodward; diagram of neuration of the left fore- and hind-wings, natural size.—Coal Measures; Scotland. Brit. Mus. (no. I. 8118).

Description.—The type-specimen lies on the surface of one half of an ironstone nodule, the counterpart being lost. It was obtained by Mr. Edward Charlesworth from the Coal Measures of Scotland, but the locality and horizon are not known.

The remains consist of portions of two pairs of wings, those of the left side being most nearly complete. In no case is the apex of the wing or the inner margin preserved. Lying in front of the wings are a pair of very large convex lobes which Dr. Woodward regards as part of the prothorax, and in front of these is a roughly quadrangular structure prolonged forward in the middle line into a styliform process or rostrum. Woodward describes the latter as "the small head

with its eyes," but no definite trace of the latter are observable. The "head" is small, not more than 7 mm. wide, and between 5—6 mm. long at the sides; medially it is prolonged into the rostral process, which is about 8—9 mm. long and ending in a sharp point. I am unable to distinguish any dividing line between the "head" and the prothorax; on the other hand, the margin of the latter is continuous with and inseparable from it. The marking which Woodward has regarded as representing eyes is, I believe, the thickened margin. I am of opinion that the whole structure is wholly prothorax, and that the head lies concealed beneath. The main mass of the prothorax is 30 mm. wide, with a flattened margin, best seen on the left side. Within the flat margins rise two low dome-shaped lobes separated by a wide hollow in front, their margins meeting in an obtuse angle posteriorly. The median edge of each lobe dips sharply into a wide median hollow, and from each of these edges arises a series of veins, which spread out to the lateral margins of the lobes. The areas between the veins are occupied by a fine meshwork of smaller veins.

A trace of the mesothorax is shown between the bases of the fore-wings as a slight transverse bar, a small rounded tubercle lying in front and a little to the left of the middle line.

The left fore- and hind-wings are the most nearly perfect, the hind-wing being 56 mm. long, with a greatest width of 30 mm. The fore-wing is a little shorter and narrower. The outer margin appears to have been straight, and the costa and subcosta closely approximated. Traces of both veins are present. The radius is a straight thin vein not far removed from the subcosta along its whole length, and giving off the radial sector beyond the middle of the wing. The radial sector comes off at an acute angle, going out to the wing-apex and keeping closely parallel with the radius. The median is somewhat inconspicuous owing to the great length of the main stem, and the narrow areas which bound it between the radius and the prominent cubitus. It gives off two outer branches before reaching the broken edge of the wing. The median vein of the hind-wing has three outer branches, the first arising nearer the base than the point of origin of the radial sector, whereas in the fore-wing the first branch arises distally to the origin of the radial sector. The median of the hind-wing is a more important vein than its fellow in the fore-wing and occupies a greater area owing to its greater inward curvature. The cubitus is a powerful vein with widely spaced divisions, the first branch, both in fore- and hind-wings, coming off from the main stem on the outer side, and low down near the base of the wing, and then passing in a bold convex sweep down to the distal portion of the inner margin. On its inner side the cubitus gives off five branches, the fourth forking in the middle of its length. The branches arise at irregular distances, and the main stem reaches the margin far out towards the wing-apex. The cubitus of the hind-wing gives off a large outer branch which is almost equal in strength to the main stem. This arises

even nearer the base than its counterpart in the fore-wing, but its great length is masked by the development of the median. Beyond the origin of the outer branch the cubitus gives off three inward branches, the first forking. Owing to the strong inward curvature of the cubitus and its branches, the succeeding anal veins are directed almost straight inwards. The anal veins are six in number, the first forking twice, and ending on the margin in three branches.

The remaining veins are undivided. The cubital and anal veins of the fore-wing are more obliquely disposed than those of the hind-wing, and the latter has an anal area much larger than that of the fore-wing.

The interstitial neuration consists of short stout cross-nervures, which occasionally fork, and in the wider areas unite to form a meshwork.

A triangular area is marked off from the base of each wing by a deep furrow. This Woodward correlates with a similar area in the wing of *Gryllacris* (*Corydalis*) *brongniarti*, which Swinton ('Geol. Mag., [2], vol. i, 1874, p. 337, pl. xiv, fig. 3) has described as a stridulating organ. As stated elsewhere, I am of opinion that Swinton's conclusions in the case of *G. brongniarti* were founded on a misinterpretation of the wing, and that no stridulating organ, or similar structure, is present. In the case of *L. carbonarius* such a structure would apparently be useless, as none of the wings could come into such close apposition as would allow the structure to be used. I am unable to determine its purpose or significance, unless it be a portion of the musculature attachment of the wing.

Traces of a fore-leg are present, projecting from beneath the left lobe of the prothorax. Its structure is too indefinite for description.

The wings were probably one-fourth or one-third longer than the portion preserved—an estimate which would make each complete wing about 70 mm. long, with a spread of about 140 mm., or 6 inches.

Genus **LITHOSIALIS**, Scudder.

1881. *Lithosialis*, Scudder, Geol. Mag. [2], vol. viii, p. 299.

Generic Characters.—Wings three to four times as long as wide. Outer and inner margins almost parallel; intercostal area wide basally, and diminishing to extinction at apex of wing. Radius simple; median with two main branches, and cubitus large; anal veins few and oblique.

The wing on which this genus is founded is interesting as being the first discovered in British Palæozoic rocks, except the problematic examples mentioned by Lhuyd and not otherwise known. Supposed to be a plant, the wing was first sent by Mantell to Brongniart, who in turn referred it to Audouin. The latter recognised its insect character, and brought it before the Entomological Society of France, the Academy of Sciences, and the Assembly of German

Naturalists at Bonn. Audouin described the wing as that of an unknown Neuropterous insect allied to *Hemerobius*, *Semblis* and especially to *Corydalis*. Mantell (? Audouin) described it as closely resembling a species of living *Corydalis* of Carolina. Swinton states that Mantell purchased the fossil at a sale of Parkinson's collection, although Mantell ('Medals of Creation,' p. 554) says that he "discovered" it in a nodule from Coalbrookdale. Possibly the nodule had previously formed part of the Parkinson Collection. Both the figures by Mantell and Murchison are badly drawn, and it was not until 1874 that a reliable drawing was published by Swinton. The latter author devoted considerable attention to a "serrated vein" at the base of the wing, which he regarded as a stridulating organ. He therefore referred the wing to the Orthoptera, and to the genus *Gryllacris*. Scudder threw considerable doubt on Swinton's conclusions, and showed that such an organ so placed could not have been of any service. As we shall see later, the supposed stridulating organ is merely a torn edge of the base of the wing. A study of the wing-structure convinced Scudder that the wing was most closely related to the *Lithomantis carbonarius*, Woodward. Being generically distinct from *Lithomantis*, and from living types, he gave the insect the generic name of *Lithosialis*.

Lithosialis brongniarti (Mantell). Plate III, fig. 1; Text-figure 10.

1833. *Corydalis ?*, Audouin, Ann. Soc. Ent. France, vol. ii, Bull., p. 7.
1836. *Corydalis ?*, Audouin, Buckland, Bridgewater Treatise, vol. ii, p. 77.
1844. *Corydalis brongniarti*, Mantell, Medals of Creation, ed. 1, vol. ii, p. 578, lign. 124, fig. 2.
1854. "Sialidæ," Pictet, Traité de Paléontologie, ed. 2, p. 377, pl. xl, fig. 1.
1867. *Corydalis*, "allied to," Murchison, Siluria, ed. 4, p. 300, woodcut 80.
1871. *Corydalis brongniarti*, Woodward, Geol. Mag., vol. viii, p. 387 (name only).
1874. *Corydalis brongniarti*, Swinton, Geol. Mag. [2], vol. i, p. 339, pl. xiv, fig. 3.
1875. *Gryllacris* (*Corydalis*) *brongniarti*, Woodward, Geol. Mag. [2], vol. ii, p. 622.
1876. *Corydalis brongniarti*, Woodward, Quart. Journ. Geol. Soc., vol. xxxii, p. 62.
1880. *Corydalis brongniarti*, Nowak, Jahrb. k.k. Geol. Reichsanst., Wien, vol. xxx, p. 73, pl. ii, fig. 4.
1881. *Lithosialis brongniarti*, Scudder, Geol. Mag. [2], vol. viii, p. 299.
1883. *Lithosialis brongniarti*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, p. 220, pl. xvii, figs. 1, 2, 8, 9.
1885. *Protogryllacris brongniarti*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 59.
1893. *Lithomantis brongniarti*, Brongniart, Faune Entom. Terr. Prim., p. 371, figs. 17, 18.
1906. *Lithosialis brongniarti*, Handlirsch, Die Fossilen Insekten, p. 84, pl. x, fig. 13.

Type.—A left fore-wing; British Museum (Mantell Coll., *olim* Parkinson Coll., no. 11,619).

Horizon and Locality.—Coal Measures; near Coalbrookdale, Shropshire.

Specific Characters.—Radial sector with not more than three branches; median much branched, and occupying much of the distal inner wing-margin. Cubitus with three divisions. Anal veins few, and very oblique.

Description.—The left fore-wing measures 61 mm. long and 18 mm. wide across the distal third. The apex, the inner margin and a very small portion of the base are missing. The wing appears to have been strap-shaped, with a blunt apex, the inner margin curving most into the apex.

The outer margin is feeble, almost straight over the greater part of its length, and slightly sloped backwards. Basally it dips abruptly inwards to the point of attachment. The subcosta is widely spaced from the outer or costal margin proximally, the two gradually approaching each other until they meet at the wing-apex. The radius passes straight out to the apex, giving off the radial sector before the middle of the wing is reached; the radial sector remains undivided up to the distal third of the wing, beyond which it forks twice. The median vein divides a little further out than the radial sector, forming two strongly divergent branches, an outer large branch with two large forward twigs, and a small inner branch which forks, the inner twig forking again. The median, therefore, ends on the inner margin of the wing in six twigs.

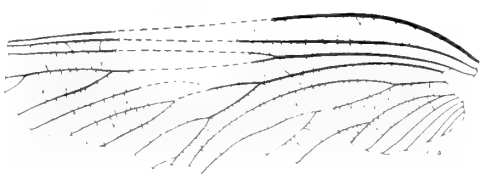

Fig. 10.—*Lithosialis brongniarti* (Mantell); diagram of neuration of left fore-wing, natural size.—Coal Measures; near Coalbrookdale, Shropshire. Mantell Collection, *olim* Parkinson Collection, Brit. Mus. (no. 11,619).

The cubitus divides into three branches, the first arising low down, and passing in a bold sweep beyond the middle of the inner margin. The anal veins are five in number, all but the first being undivided. The first anal forks near the base, the outer branch forking again.

The whole wing is covered by a numerous series of strong transverse nervures, rarely branching, and usually crossing at right-angles to the main veins. A few are oblique or curved.

The "file" or "serrated vein," described at length by Swinton, and by him correlated with that present in recent forms of *Gryllacris*, appears to be nothing more than an irregular torn edge of the basal part of the wing, which is also lifted up a little above the general level. The torn edge extends along the line of the median vein for a short distance, and wholly lacks the symmetry and detail given to it by Swinton.

Affinities.—Although closely allied to *Lithomantis carbonarius*, Woodw., this wing differs in the great width basally of the intercostal area, and in the straighter course of the cubitus and anal veins, due to the greater length of the wing. The interstitial neuration is much the same.

Genus **PRUVOSTIA**, novum.

Generic Characters.—Fore-wings two and a half times as long as wide; outer and inner wing-margins almost parallel; wing-apex well rounded. Subcosta widely removed from the costal margin basally, and apparently not connected with the costa or radius. Radius straight with divergent radial sector. Radial sector, median and cubitus all distally branched Anal veins few. Interstitial neuration of straight cross-nervures.

Certain features of this wing are suggestive of the Protorthoptera. These are the wide basal, intercostal area, the basal origin of the radial sector, and the remote branching of the radial sector, median and cubital veins.

It is, however, more nearly allied to *Lithosialis* than to *Metrygia anglis*, Handl., for example, among the Protorthopteroids. The great length before division of the main stems of the radial sector, median and cubitus, their strong divergence, and the many branches of the median, form an assemblage of characters not elsewhere known, and certainly deserving of generic recognition.

It is with pleasure that I attach to this genus the name of Dr. P. Pruvost, of Lille University, in recognition of his valuable work on the fossil insects of the north of France.

Pruvostia spectabilis, sp. nov. Plate III, fig. 2; Text-figure 11.

Type.—A left fore-wing; British Museum (Johnson Collection, no. I. 15,894).

Horizon and Locality.—Middle Coal Measures (clay ironstone nodules in the Binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire.

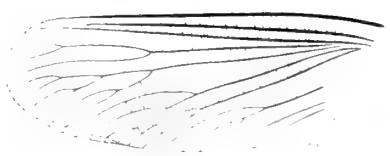

Fig. 11.—*Pruvostia spectabilis*, sp. nov.; diagram of neuration of left fore-wing, natural size.—Coal Measures (clay ironstone nodules in the binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 15,894).

Specific Characters.—Outer margin convex at base, and inclining inwards to the apex. Subcosta straight, not reaching the apex of wing. Radius straight, giving off radial sector near base; radial sector twice branched, median divergent, three times branched, the first two branches forking. Cubitus dividing basally into two, the outer forking three times, the inner branch once.

Description.—A left fore-wing 52 mm. long and 24 mm. wide, almost covering the surface of one half of the median plane of a reddish-brown ironstone nodule. A little of the base of the wing is missing, while a part of the wing-apex is concealed

by a film of ironstone which cannot be removed. Fortunately the slight film of ironstone does not hide the outline of the wing, and it is evident that the outer and inner wing-margins are almost parallel, while the apex is well rounded. The outer margin merges by a well-rounded contour into the wing-apex. The subcosta is well-marked, widely removed from the outer border proximally, and lies in a shallow groove formed of the intercostal and radial subcostal areas. These two areas are reduced distally to less than half their proximal diameter owing to the backward inclination of the outer margin. The subcosta seems to die out near the radius, about 7 mm. from the wing-apex, and gives off a numerous series of irregularly spaced and forwardly directed nervures, which are at first straight and then curved towards the wing-apex. At their point of origin the cross-nervures are very distinct, but they thin, and occasionally die out, before reaching the outer margin. The radius is a strong vein, passing perfectly straight out from the wing-base to the outer part of the wing-apex. The radial sector arises near the base of the radius, gradually diverging from it up to the junction of the middle and outer thirds, where a single branch is given off, the latter taking a position parallel with the main stem of the radial sector, and entering the middle of the wing-apex. Eleven mm. further out and within 7 mm. of the apex a second branch is given off, which lies evenly between the main stem and the first branch. The median vein arises so close to the radius as to appear united with it. Like the radial sector, it does not divide until it reaches the junction of the middle and outer thirds of the wing. Here the first inward branch arises, and at equal distances further out are given off two more; the first two each fork in the middle of their length, the third remaining undivided; the median ends therefore on the inner wing-margin in six divisions. The cubitus consists of two, and possibly three, main stems. Owing to the base of the wing being broken away these stems are not seen to be in actual union. Little doubt can exist as to the union of the first two, but if the third vein is a branch of the cubitus, it can only join the other two by a strong outward curvature. This third vein may be the first anal, although its manner of division is similar to that of the cubitus, in this respect agreeing with what is seen in the first anal of *Lithosialis brongniarti*. The next vein is parallel with the one succeeding, which is undoubtedly anal, while it shows an increasing basal divergence from the second cubital. For this reason I have regarded the third vein as the first anal. The first branch of the cubitus diverges widely from the median, passing obliquely to the inner margin of the wing, which is reached just beyond the middle third. Owing to the great divergence of the first cubital branch from the median, the area between the two, at the point where they first branch, is very wide—almost twice the width of any other area.

The first cubital vein gives off three outward twigs. The second is parallel to the first as far as its division into two equal twigs. The next vein is that to which I have already alluded as a possible third branch. It is widely separated

from the undoubted cubitus, and by reason of its two forward branches resembles the cubital elements in front of it. Its wide separation from the second branch of the cubitus supports the view that it is the first anal vein. The undoubted anal veins are two in number, undivided, and passing backwards very obliquely to the wing-margin. More anal veins may have been present, but it is very doubtful. The wing-surface is much wrinkled across both the length and breadth, and traversed by numerous cross-nervures, which are most evident in the median area.

Affinities.—The wing is typically Palæodictyopteroid, and in the development of the radius, radial sector, and cubitus, shows an affinity to *Lithosialis brongniarti*. It differs markedly from that species, however, in the great length of the main stems before divisions arise.

Dr. Tillyard, to whom I have shown my enlarged drawings, is of opinion that *Prurostia* is allied to *Pseudofouquea* rather than to the Lithomantidæ.

Family Breyeriidæ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 95.

Wings markedly triangular, with broadened bases. Costa, subcosta and radius brought closely together in the outer part of the wing, the median with few divisions. Cubitus and anal veins directed almost straight inwards, at right angles to the length of the wing.

Genus **BREYERIA**, Borre.

1875. *Breyeria*, Borre, Ann. Soc. Entom. Belg., vol. xviii, p. 40.
1908. *Stobbsia*, Handlirsch, Die Fossilen Insekten, p. 1348.

Generic Characters.—Wings two and a half times as long as wide. Outer wing-margin straight; apex curved inwards. Inner wing-margin strongly convex. Costa marginal, subcosta parallel and joining the radius near the wing-apex. Radius giving off the radial sector near the base of the wing, and reaching the apex undivided. Radial sector subparallel to radius. Median boldly curved inwards almost at a right angle. Cubitus less curved than the median. Anal veins few. Interstitial neuration of two kinds, that of the intercostal and radial sector areas of short straight nervures, and that of the remaining areas of irregular thin nervures which tend to anastomose into a loose meshwork or reticulate arrangement.

Breyeria woodwardiana (Handlirsch). Text-figures 12, 13.

1903. "Allied to *Lithomantis carbonarius*," Stobbs, Geol. Mag. [4], vol. x, p. 524.
1906. Palæodictyopteron, sp., Handlirsch, Die Fossilen Insekten, p. 126.

1906. *Lithomantis carbonarius* (?), Woodward, Geol. Mag. [5], vol. iii, p. 26, fig. 1.
1908. *Stobbsia woodwardiana*, Handlirsch, Die Fossilen Insekten, p. 1348, text-fig.

Type.—Greater part of a left hind-wing; Mr. J. T. Stobbs' Collection.

Horizon and Locality.—Peacock marls overlying the Peacock Coal, and near the top of the workable Coal Measures; Foley, near Longton, Staffordshire.

Specific Characters.—Radial sector dividing in its distal half into fine inwardly directed twigs which end on the distal third of inner margin. Median and cubitus with few widely spaced branches, occupying greater part of inner margin. Anal veins about three to four in number.

Description.—The specimen has not been available for examination, and my observations are based on the figures published by Woodward and Handlirsch. It is probable that neither of these figures is wholly correct, Handlirsch pointing out what appears to be an obvious error by Woodward in the character of the cubitus

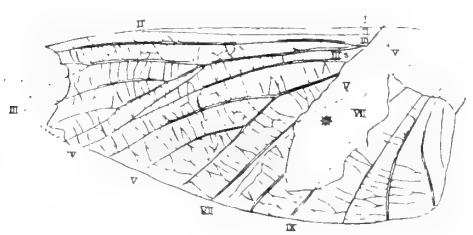

Fig. 12.

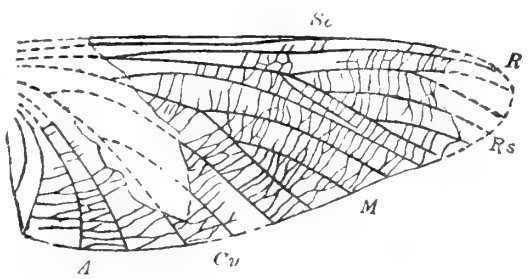

Fig. 13.

Fig. 12.—*Breyeria woodwardiana* (Handlirsch); left hind-wing as restored and figured by Dr. H. Woodward under the name of *Lithomantis carbonarius?*, natural size.—Coal Measures (Peacock marls overlying the Peacock Coal): Foley, near Longton, Staffordshire. Mr. J. T. Stobbs' Collection.
Fig. 13.—*Breyeria woodwardiana* (Handlirsch); same left hind-wing as restored and figured by Dr. A. Handlirsch under the name of *Stobbsia woodwardiana*, nearly natural size. *A* = IX, anal; *Cu* = VII, cubitus; *M* = V, median; *R* = III, radius; *Rs* = IV, radial sector; *Sc* = II, subcosta; *I*, costa.

vein, and the position and mode of division of the radial sector being doubtful. Notwithstanding this difficulty, I have by means of an old plaster cast been able to satisfy myself upon the more essential details.

The fragment is 50 mm. long and 20 mm. wide, and consists of the greater part of a left wing, of which the base and a portion of the basal third are stated to be obscured by a pinnule of *Neuropteris*. The maximum width is across the anal area, beyond which the wing rapidly narrows owing to the forward direction of its inner margin. The costal vein is marginal and strong, passing in an almost straight line distally until joined by the subcosta, after which it curves gradually backwards into the wing-apex. The subcosta is parallel with the costal margin over more than two-thirds of the wing, and then joins the costa. The base of the radius is not shown in the figures, except a very small portion in front of the point of origin of the radial sector, the latter arising in the basal third of the wing; beyond the radial sector the radius passes out to the wing-apex, keeping parallel with the costal margin.

The radial sector presents several difficulties. In neither of the two published figures is this vein depicted as we might expect. In all other respects the wing agrees remarkably closely with those of *Breyeria* and *Megaptiloides*, where the radial sector sends off inwards a series of simple branches, and runs out fairly parallel with the radius to the wing-apex. In place, however, of the radius passing straight outwards, it is represented as dividing into two branches in the distal fourth of the wing, the outer branch forking once and the inner forking twice. The inner branch of the radial sector diverges widely from the outer, and its three divisions go to the inner side of the wing-apex. A small branch is shown by Woodward as joining the radial sector to the first branch of the median, while the same branch is shown by Handlirsch as coming off from the radius immediately in front of its division into two, and passing down towards the inner margin between the inner branch of the radial sector and the first branch of the median, but not uniting to the latter. The median vein arises near the radius and sweeps out in a bold curve to the middle of the inner margin, giving off three outer undivided branches. Dr. Woodward, in his restoration of the base of the wing, has inadvertently indicated the main stem of the cubitus as joining the median. This is corrected in Handlirsch's drawing. The cubitus consists of a strongly curved stem giving off two branches, but only the inner marginal portions of the veins are present. The anal veins are three or four in number, and directed backwards at right angles to the length of the wing.

The interstitial neuration consists of feeble transverse nervures, which either pass irregularly across between the main veins or occasionally fork.

Affinities.—Dr. Woodward doubtfully refers the wing to *Lithomantis carbonarius*, Woodw. Handlirsch, in the earlier part of his work, 'Die Fossilen Insekten' (p. 126), classed it as a "Palæodictyopteron" only, and afterwards, owing to its supposed relationship to *L. carbonarius*, and its evident likeness to *Lithosialis* and *Hadroneura*, established the genus *Stobbsia* for it, placing the species in the Lithomantidæ. There are, however, certain features of the wing which militate against his view. The close apposition of the costa, subcosta and radius are in marked contrast to the condition in that family, where these veins are widely spaced, and where there is also a very wide intercostal area. The radial sector is also more complex. In those details in which the wing departs from the Lithomantidæ, it approaches the characters of the genera *Breyeria* and *Megaptiloides*. The resemblances to *Megaptiloides brodiei*, Brong., and *Breyeria borinensis*, Borre, are very close, so far as can be determined by the distal fragment of the former wing and the more than three-fourths of the latter wing. The main difference between this wing and those of *Breyeria borinensis* and *B. lachlani* is in the character of the subcosta, which in the latter two species joins the radius. Whether the published figures of the Staffordshire wing are correctly drawn in this particular we do not know, and as we have already seen that these figures are

wrong in other details, we are compelled to assign the specimen to the family Breyeriidæ, and doubtfully to the genus *Breyeria*, with which it seems in agreement.

Family Spilapteridæ (Brongniart), Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 101.

Radial sector more or less branched; median divided into two main branches, the outer much divided; cubitus with an outer branch sending numerous twigs to the inner margin. Intercostal area occupied by a series of straight cross-nervures.

The family Spilapteridæ, founded by Brongniart in 1885, has been re-defined by Handlirsch and Lameere. The latter extended the group to include species which Brongniart had placed partly in the family Platypteridæ and partly in Protephemeridæ. All the forms thus brought together by Handlirsch agree in the possession of a typical palæodictyopteroid neuration and the general characters enumerated above.

Lameere ('Bull. Mus. Hist. Nat. Paris,' 1917, no. 1), who rejects Handlirsch's views and classifications (see above, p. 15), has remodelled the family and given it a new significance. He is of opinion that the genera *Lamproptilia*, *Epitethe*, *Becquerelia*, *Palæoptilus*, *Compsoneura*, *Spiloptilus*, *Homaloneura*, *Graphiptilus* and *Spilaptera* form a natural family, the Spilapteridæ, in which a progressive evolution in the longitudinal venation can be observed. The family is regarded as linked to that of Megasecopteridæ through the genus *Becquerelia*, and to the Protephemeridæ through the genus *Apopappus*. The three families are then grouped in his new order, Ephemeroptera. Such a classification is based on the belief that a perfect evolutionary sequence can be made out. Unfortunately, in presenting this classification, Lameere gives only a summary of his reasons and evidence, and it is not possible to criticise his argument. It is, to say the least, very doubtful if, in the present state of knowledge, we can judge relationships always correctly, while the sequence of evolution is still more difficult.

Handlirsch has acknowledged that he is unable to undertake any division of the family Spilapteridæ, as he understands it, and is content to await the discovery of the bodies of these insects for a fuller knowledge of the family. As the more rational view, Handlirsch's definition of the family is adopted.

Genus **SPILAPTERA**, Brongniart.

1885. *Spilaptera*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.

Generic Characters.—Insects closely resembling *Palæoptilus;* fore-wings narrower basally than the hind-wings; body slender.

Spilaptera sutcliffei, Bolton. Plate III, fig. 3; Text-figure 14.

1917. *Spilaptera sutcliffei,* Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 53, pl. iv, fig. 1, and text-fig.

Type.—Basal third of a wing; Manchester Museum (no. L. 8197).

Horizon and Locality.—Middle Coal Measures (grey-blue shales 135—180 feet above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire.

Specific Characters.—Subcosta parallel with the costal margin; median vein dividing near the base into two branches, of which the outer forks just beyond the point of origin of the radial sector. Cubitus a large and much-divided vein. Anal veins few in number.

Description.—This specimen was formerly labelled "*Stenodictya lobata*," and is one of three recorded by Sutcliffe, Baldwin, and others, in their papers on the fossils found at Sparth Bottoms. The remaining two are described (p. 37) under

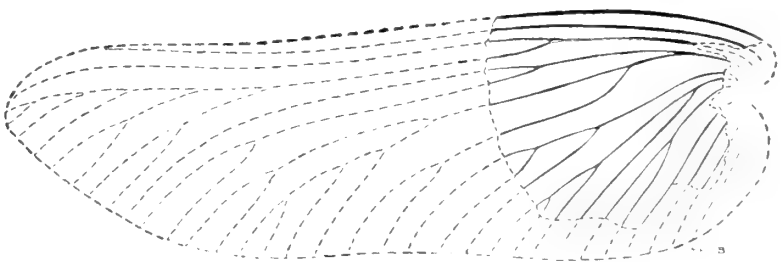

Fig. 14.—*Spilaptera sutcliffei,* Bolton: restoration of left wing, natural size—Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Manchester Museum (no. L. 8197).

Mecynoptera tuberculata, Bolton. The specimen consists of the basal third of a wing lying on the median plane of a small irregular micaceous sandy nodule. The finer structure of the wing has not been preserved, owing, no doubt, to the coarse grain of the matrix. The chief veins of the wing are robust structures, and these are fortunately well marked and clear. The wing-fragment is 35 mm. in length along the outer margin, and 27 mm. in greatest width, but as the inner margin is broken away and lost, the total width of the wing exceeded this, and may have been over 30 mm. It belongs to a left wing, and when complete must have been at least 90 mm. in total length. The perfect insect must therefore have had a spread of wing of nearly 200 mm., or about 8 inches.

The outer margin is feebly convex, the subcosta fairly parallel, sunk in a groove, and gradually approaching the outer margin as it passes towards the wing-apex. The rate of approach is so gradual that the junction must have been far out near the wing-apex. The intercostal area is crossed by a series of straight nervures which are oblique in their course outwards.

The radius is strong, standing up above the surface, and almost parallel with the subcosta. The radial sector arises from the radius at about 22 mm. from the base of the wing. The median vein, owing to its inward direction away from the radial sector, is better shown. It forks very low down into two equal branches, both of which are widely spaced. The outer branch divides almost opposite the point of origin of the radial sector, while the inner branch forks much nearer the base of the wing, the innermost branch curving sharply back from its fellow, so that the area between them is wide almost from the commencement.

The general direction of the branches of the median is such that they would reach the outer half of the inner margin of the wing.

The cubitus consists of two main stems, the basal union being missing; the outer branch passes, after twice forking, in a double curve down to the inner margin of the wing, the inner branch being directed more directly backwards, and forking three times in the basal third. Fragments of four anal veins are distinguishable, the first dividing near the middle of its length into two equal branches. The interstitial neuration seems to have consisted of comparatively few straight and well-spaced nervures, some of which can be seen crossing the wide area between the innermost twig of the median and its fellow. No others are visible, except those in the intercostal area already mentioned.

Affinities.—Notwithstanding the fact that only about one-third of the wing is known, it is yet possible to determine the generic characters with a reasonable degree of accuracy. The mode of division of the radius and median, the manifest importance of the latter, the wide area between the median and cubitus, and the few widely spaced cross-nervures, are all typical Spilapteroid characters. The wing cannot be confused with that of *Stenodictya*, in which the median is much less developed, and the interstitial neuration closely reticulated. The only other genus to which it might be referred, that of *Becquerelia*, is distinguished by a union of the anal veins, which in *Spilaptera* and in this specimen are distinct.

Spilaptera has hitherto comprised only three species. From *S. packardi*, Brong., the specimen differs by the subcosta being parallel with the outer margin; by the equal separation of the subcosta, radius and median in the basal third of the wing; and by the division of the median into two branches close to the base of the wing. *S. libelluloides*, Brong., of which the distal half of the wing only is known, has a much feebler cubitus, which divides by forking further out than in *S. sutcliffei*. *S. renusta*, Brong., was established on a fragment much similar to that of *S. libelluloides*, in which the subcosta is a short vein, and the radial sector arises nearer the middle of the wing.

Family Lamproptilidæ (Brongniart), Handlirsch.

1885. Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.
1906. Handlirsch, Die Fossilen Insekten, p. 109.

Fore- and hind-wing strongly marked. Veins of the anal and cubital groups numerous and directed obliquely backwards. Hind-wings short and broad.

Genus **BOLTONIELLA**, Handlirsch.

1885. *Lamproptilia*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 63.
1919. *Boltoniella*, Handlirsch, Revision der Paläozoischen Insekten, p. 21.

Generic Characters.—Fore-wings two and a half times as long as wide; hind-wings as long as wide. Outer margin of former curved, of hind-wings almost straight. Apex of wings rounded. The fore-wings are almost elliptical, and the hind-wings rectangular in shape. The costa is marginal and the costal area somewhat narrow. The subcosta joins the costa far out. Radius simple, the radial sector arising near the base of the wing and giving off three forked branches, which pass obliquely to the inner half of the wing-apex. Median dividing into two main branches, the inner twice as much divided as the outer. Cubitus with two main branches, each breaking up into numerous twigs. Interstitial neuration consisting of widely spaced straight cross-nervures.

Handlirsch, who has formed this genus, admits that it reminds one in many ways of *Lamproptilia*, but by reason of the small size and closer spaced cross-nervures he separates it from that genus.

Boltoniella tenuitegminata (Bolton). Plate III, fig. 4.

1911. *Lamproptilia tenuitegminata*, Bolton, Quart. Journ. Geol. Soc., vol. lxvii, p. 170, pl. x, fig. 6.

Type.—A right hind-wing, in a small fragile block of brown mudstone or shale, crowded with plant-remains; Museum of Practical Geology, Jermyn Street, London (no. 24509).

Horizon and Locality.—Coal Measures (No. 2 Rhondda Seam, base of the Pennant Series); $1\frac{3}{4}$ miles north-east of Resolven Station, Glamorganshire.

Specific Characters.—Broad wings of great tenuity and blattoid-like in character. Principal veins much divided, and fading out on the inner margin. Apex of wing bluntly rounded. Anal veins very numerous.

Description.—The type-specimen consists of a right hind-wing of considerable tenuity, the underlying plant-remains being easily traceable through the texture of the wing. The greatest length is 29 mm., and the greatest breadth 7 mm. The neuration is so similar to that which I have observed in the hind-wings of blattoids

from Commentry, France, that it is difficult to refrain from classing the wing as blattoid. The neuration is extensively branched and the wing-boundaries are not well marked, but the wing appears to have been somewhat quadrangular in outline, with a sinuous inner margin, and the base much broader than is seen in the ordinary form of blattoid hind-wing. The outer margin seems to have been straight, a portion of it still remaining in the middle third. The two margins merge in a well-rounded apex. The subcostal area is narrow, strap-shaped, and probably extended over the whole length of the outer margin. No traces of cross-nervures can be seen on it. The radius divides near the base, giving rise to a series of branches which curve inwards as they approach the apex of the wing. The course of the branches is irregular, the interspaces widening and narrowing, possibly owing to the wing having crumpled during deposition. The median divides into two branches low down, each of which is repeatedly forked, the final divisions becoming attenuated and untraceable before the inner margin of the wing is reached. The course of the cubitus is obscured by a reed-like plant, only two basal portions being distinguishable. The anal area is filled by a broad series of thread-like veins, which sweep obliquely inwards in a fan-shape, and occupy a large part of the inner margin.

The inner margin of the wing to a third of its total length is quite filmy, the veins crossing the area as faint shadowy lines. The distal two-thirds is more strongly impressed, while in the broad base of attachment the stems of the principal veins seem to have been more than usually robust. No trace of transverse nervures or reticulation can be seen.

Affinities.—The nearest analogues to this wing are, I believe, the forms described by Brongniart as *Lamproptilia grand'euryi* and *L. stirrupi* ('Études sur le Terrain Houiller de Commentry,' vol. iii [1893], pp. 467—70, pl. xxxv [19], figs. 7—9). It appears to be more closely related to *L. stirrupi* than to *L. grand'euryi*, but is more quadrangular, and its costal area is broader. The anal portion of the wing is of greater tenuity, and occupies fully half of the inner margin.

Family Brodiidæ, Handlirsch.

1906. Handlirsch, Die Fossilen Insekten, p. 113.
1919. Handlirsch, Revision der Paläozoischen Insekten, p. 73.

Wings in which the anal area is much reduced and specialised, the radius undivided, and the median, cubitus, and anal veins arched and directed back towards the inner margin.

From a re-examination of the originals in the British Museum, Handlirsch has concluded that the family does not belong to the Palæodictyoptera, but to the Order Megasecoptera. This view seems at variance with his own definition of the

to be beyond the mark in estimating the total span of the insect as about 130 mm., or over 5 inches.

The outer or costal margin is straight, or feebly convex at most, over the greater part of its length, curving distally into the wing-apex. Close to the base it swells out into a slight hump-like elevation which is seen in all cases where the wing has been broken off close to the body. The whole of the outer margin bears a dense series of minute, conical, sharply pointed spinules of a black colour. These are arranged in two rows on the proximal half, with the points of the spinules directed towards the wing-apex. The bases of the spinules are expanded, and give a doubly corded or monilated appearance to the wing-margin. Tillyard regards these spinules as modifications of large hairs which he has termed "macrotrichia," and I see no reason to dissent from his view.

The subcosta at its origin is widely spaced from the outer margin, and passes out beyond the middle of the wing, gradually approaching, but failing to reach it. The subcosta is a strong, straight vein, the greater part elevated above the level of the wing-membrane, and distally flattening into it and disappearing.

The radius is a strong vein, more convex than the outer or costal margin, and therefore more widely separated from it at either end than in the middle. The basal portion is parallel with the subcosta for the whole length of the latter; it then becomes parallel with the outer margin for a short distance, and afterwards curves into the wing-apex. A single row of spinules can be distinguished along the whole vein in some specimens, and gives a slight monilation to the vein-surface. The radial sector is well marked, and comes off from the radius about the point of origin of the first forward branch of the median. The two veins are close together for some distance, but in the distal half of the wing they become parallel, the interspace being equal in width to that between the radius and the outer margin. The radial sector gives off four inward branches, which end on the inner side of the wing-apex. The first branch arises just beyond the middle of the wing, at an acute angle, and is separated from the second by an interval which is double the length of that separating the second and third. The fourth branch is very short, and so close to the margin as to be absent in some specimens.

The median vein for the first quarter of its course lies in the middle line of the wing, and then bends inwards in a wide curve to the distal third of the inner margin. It gives off two outward branches, both of which are larger and stronger than those of the radial sector. Both branches have the same sweeping curve possessed by the branches of the radial sector, and are parallel with the latter, while the main stem becomes almost straight.

The cubitus is a single vein, not united at the base to the median, and passing obliquely to the margin. Some wings have broken off so far out from the base that the cubitus appears to join the wing-margin at the junction of the middle and distal thirds. A striking feature of the cubitus is its isolated position upon the

margin, for while the interval between it and the stem of the median is much wider than any other in the fore-part of the wing, the interval between the cubitus and the next vein is nearly twice as wide. There is, in fact, a progressive widening between the veins as they are traced from the apex to the base of the wing, the areas between the median and its branches being wider than those enclosed by the branches of the radial sector.

Two somewhat dissimilar anal veins are present. The first has a wide curve to a point far out on the margin, sometimes giving off a short branch, while the second vein is much shorter and joins the margin at an acute angle. In some specimens this vein is seen to give off two, or even three, short oblique branches.

The shape of the wings is very similar to that of the wings of mosquitoes (*Anopheles*), and they bear evidence of having been folded in a plicate or fan-like fashion along their length. The first two folds are united at the wing-base, and pass out along the radius and the first outward branch of the median. The third fold lies along the line of the cubitus vein. The degree of plication which a wing retained when silted up modifies considerably the apparent distance between the several veins and their branches, and at times hides important junctions. In one example (Brit. Mus., no. In. 18431) the wing was well flattened out before being buried, and the origin of the veins and their true position can now easily be determined. This specimen shows that the radial sector arises much nearer the wing-base than the first outward branch of the median—a feature not usually shown in the remaining specimens.

The general build of the wing is such that the bases of the costal and subcostal veins on the outer margin, and those of the anal veins on the inner, must have served as the main support to the distal two-thirds of the wing, the latter consisting mainly of the radial sector and its branches, the median, and the distal half of the cubitus. Flight must have been mainly maintained by the action of this more distal expanded area, while the strain of movement would fall across the narrow neck-like base of the wing, and may ultimately have led to fracture and the loss of the wings. It is quite possible, also, that these insects were capable of finding food among the decaying vegetation of the coal forests, and thus prolonging life for a considerable period after the wings were lost. Such a presumptive sequence of events would account for the total absence of any trace of the bodies or legs, although the wings of this species are more numerous than any others in the Coal Measures and preserved in good condition.

Colour Bands.—Scudder mentions this species as the most striking instance among Palæozoic insects of the preservation of "colour bands," and as he states, some wings show three broad irregular belts of dull umber-brown colour across the wings. Close examination of these "colour bands" in the type-specimen, and in other examples, leads us to doubt the correctness of his view. In all cases where the "colour bands" do not show on the wings, the areas appear to be

totally destitute of any traces of the wing-membrane, and the course of the veins only is shown across the matrix. It is much more likely that the "colour-band" effect has been produced by conditions of preservation owing to the wing-membrane being destroyed in those areas which do not show colour.

Affinities.—Although Scudder founded both genus and species, he did not attempt any diagnostic description of either, confining his efforts mainly to a discussion of relationships. His figure is unusually poor, and adds nothing to the text. Scudder's general conclusion was that the wing was neuropteroid in character, but "refusing to affiliate closely with the restricted families of the present day." A manuscript note in Brodie's handwriting placed with the type-specimen would seem to show that Scudder's views acquired greater definition later. Brodie writes under date, February, 1880: "I sent this wing to Mr. Scudder, and he supposes it to belong to the white ants (Termitidæ), or close to the group of which Goldenberg's *Dictyoneura* is the best type." The first detailed descriptive note of the species was published in 1893 by Brongniart, with an

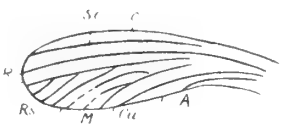

FIG. 16.—*Brodia priscotincta*, Scudder; immature wing, twice natural size.—Middle Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Madeley Collection, Brit. Mus. (no. I. 2966). *A*, anal; *C*, costa; *Cu*, cubitus; *M*, median; *R*, radius; *Rs*, radial sector; *Sc*, subcosta.

excellent enlarged drawing. Brongniart very doubtfully assigned the wing to the Protodonata, and "alongside the Campyloptera."

Immature Wings.—The collection of insect-remains which I describe later (p. 67) under the name of "*Pteronepionites*" were found at the same horizon and localities as *Brodia priscotincta*, and it is fairly certain that some of them are immature forms of this species. It will be noted that these larval forms are broad-bodied and well segmented, and with lateral outgrowths of a pleura-like character upon the abdomen. They indicate that *Brodia priscotincta* went through a progressive metamorphosis, the rudimentary wings gradually developing as the insects lived as ground-feeders among dank and rotting vegetation.

One of these wings (Pl. IV, fig. 3) in the Madeley Collection in the British Museum (no. I. 2966) is an impression 18 mm. in length by 4 mm. in maximum breadth, contained in a small grey ironstone nodule. As is usually the case with these grey nodules, the details of the wing are much obscured by the matrix, and the precise method of division of the veins is far from being clear.

The outer margin is regularly convex and formed by the costa. It gradually merges into the expanded and well-rounded wing-apex. The subcosta extends

the whole length of the wing, ending in the apex, and being parallel to the costal margin. A wide area separates it from the next vein.

The course of the radius is similar to that of the subcosta. The point at which the radial sector arises cannot be determined, but it lies in the base of the wing.

The radial sector is parallel with the radius over the greater part of its length, and gives off three inward branches in the distal third of the wing, all of which end on the inner side of the wing-apex.

The course of the inner third of the median is indistinguishable. The main stem reaches the middle of the wing before it gives off the first outer branch, which bends round and becomes parallel with the inner branch of the radial sector. The second branch arises a little further out, and at a more acute angle than the first, passing down to the inner margin of the wing midway between the first branch and the main stem.

The cubitus is a long undivided vein which passes, first in a curve, and then in a straight line to the inner margin.

Lying inward to the cubitus are traces of another undivided vein, which may represent the anal. It bends inwards more rapidly than the cubitus, and the interval between the two veins is very wide. The inner margin of the wing is sigmoidal in outline.

The general characters of this immature wing are unmistakeably those of the genus *Brodia*, and only the absence of spinules on the costal margin and radius, and the lack of a fourth branch to the radial sector, distinguish the specimen from adult wings of *B. priscotincta*. These details are not of specific value, and may be due to the immature condition of the wing, which is but one-third the length of that of a normal *B. priscotincta*.

The general characters of the wing are much like those of *Brodia priscotincta* (*juvenis*), and the specimen may be a slightly older larva of that form. The outline of the wing is much the same, but the branching of the principal veins is better shown and their apical curvature less pronounced.

The wing also lends considerable support to the belief that these insects did not possess a resting or pupal stage, but that the metamorphosis was regularly progressive.

Brodia priscotincta, Scudder, *forma juvenis*, Bolton. Plate IV, figs. 1, 2; Text-figures 17, 18.

1919. *Brodia nympha*, Handlirsch, Revision der Paläozoischen Insekten, p. 76, fig. 90.

Type.—A pair of wings, one almost complete, the other showing the apical half only; British Museum (Johnson Collection, no. I. 1563).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The fossil is contained in a brown ironstone nodule, the whole wing having a length of 21 mm., and a maximum diameter of 4 mm. It is membranous, and oblanceolate in shape. The outer wing-margin, of which only the distal half is preserved, is flatly convex and curves inwards, meeting the inner margin in a rounded apical angle. The inner margin is feebly concave. The wing has three longitudinal folds, and the extreme tenuity of the integument is accompanied by a corresponding thinness of the veins. The greater portion of the costa and the whole of the subcosta are missing. The outer portion of the radius is present. It is parallel with the outer margin, and curves round into the wing-apex. The radial sector is parallel with the subcosta, and curving round into the apex is lost, by reason of its tenuity. Lying inward to the main stem of the radial sector in the distal half of the wing are two long veins, and traces of two others, all following the same course, and curving to the inner margin. The two long veins

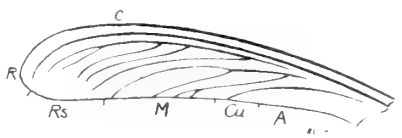

FIG. 17.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, two-and-a-half times natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1563). Lettering as in Text-figure 16, p. 62.

appear to arise from the radial sector, in which case the two of which traces only are seen would do so also. The radial sector therefore seems to give origin to four inwardly directed parallel branches. The whole course of the next vein is not clearly determinable. It passes to just beyond the middle of the inner margin, in an almost straight oblique course, and gives off a single forked outer branch parallel with the fourth branch of the radial sector. This vein can only be the median. The next vein is the cubitus. It is undivided, and goes to the middle of the inner margin. Anal veins are only indicated by feeble traces of a single undivided vein, which apparently reached the margin midway between the cubitus and the base of the wing.

Another similar wing from the same horizon and locality in the British Museum (no. I. 1564) is 17 mm. long and 5 mm. wide, and lies on the surface of a split nodule of dark-brown ironstone. The wing-membrane is very thin, and forms a slight glaze on the otherwise granulated surface—a feature which has made the details of structure difficult to determine. The costa is marginal, the outer margin convex, and gradually curving into the rounded apex of the wing. The inner margin is slightly convex distally, and straight proximally.

The subcosta is a feeble vein whose course cannot be traced with certainty

beyond the middle of the wing. It is close to the margin and parallel with it for its whole length. The radius is well marked, sunken, and also parallel with the margin except distally, where it is more inwardly curved. It ends on the apex in a short fork. The radial sector arises near the base, and is parallel with the radius. It appears to give off three to four branches, the first arising very near the base of the wing. The whole course of this branch can be traced, but of the middle two only faint traces are left in the region of the wing-apex. The fourth branch is very short, and corresponds in position with the last branch of the radial sector in *Brodia priscotincta*. The median vein forks low down into two equal branches, which reach the middle of the inner margin.

The cubitus is a long undivided vein passing out almost to the middle of the inner margin, and separated from the next vein, which seems to be the first anal. The course of the latter is more oblique to the inner margin than that of the cubitus.

In its general character this wing is distinctly similar to that of *B. priscotincta*, although it lacks a second branch to the median, and the first anal does not seem to be forked.

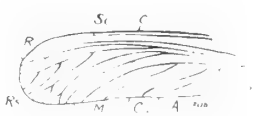

Fig. 18.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, twice natural size.—Middle Coal Measures (binds) between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Madeley Collection, Brit. Mus. (no. I. 1564). Lettering as in Text-fig. 16, p. 62.

Affinities.—Handlirsch regards these as nymphal wing-sheaths, but their extreme tenuity militates against this view. He is probably wrong in referring *Brodia* to the Megasecopteridæ, but right in regarding these wings as those of heterometabolous insects, and not holometabolous as Lameere supposed.

Immature though the wings undoubtedly are, the more nearly perfect example possesses an assemblage of characters which I believe points to its relationship. The shape of the wing, the character and course of the subcosta, the number and position of the branches of the radius, the simple forking of the median and the anal veins, are all characters pertaining to the genus *Brodia*. The differences in detail between this wing and that of *B. priscotincta* are such as may be looked for between the nymph-stage and the adult. Among previously described larval wings, the only type which seems comparable is *Lameereites curripennis*, Handlirsch, based on four nymph-wings or wing-cases, as Handlirsch has them, found in the Coal Measures (Pennsylvanian) at Mazon Creek, Illinois, U.S.A. (1911, Handlirsch, 'Amer. Journ. Sci.' [4], vol. xxxi, p. 375).

In these wings, the outer or costal margin is more strongly curved, and the costa and radius extend over the bluntly curved apex down to its junction with the inner margin. The succeeding veins arise nearer the base of the radius, only one

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The fossil is contained in a brown ironstone nodule, the whole wing having a length of 21 mm., and a maximum diameter of 4 mm. It is membranous, and oblanceolate in shape. The outer wing-margin, of which only the distal half is preserved, is flatly convex and curves inwards, meeting the inner margin in a rounded apical angle. The inner margin is feebly concave. The wing has three longitudinal folds, and the extreme tenuity of the integument is accompanied by a corresponding thinness of the veins. The greater portion of the costa and the whole of the subcosta are missing. The outer portion of the radius is present. It is parallel with the outer margin, and curves round into the wing-apex. The radial sector is parallel with the subcosta, and curving round into the apex is lost, by reason of its tenuity. Lying inward to the main stem of the radial sector in the distal half of the wing are two long veins, and traces of two others, all following the same course, and curving to the inner margin. The two long veins

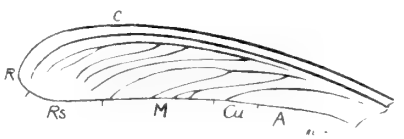

FIG. 17.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, two-and-a-half times natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Johnson Collection, Brit. Mus. (no. I. 1563). Lettering as in Text-figure 16, p. 62.

appear to arise from the radial sector, in which case the two of which traces only are seen would do so also. The radial sector therefore seems to give origin to four inwardly directed parallel branches. The whole course of the next vein is not clearly determinable. It passes to just beyond the middle of the inner margin, in an almost straight oblique course, and gives off a single forked outer branch parallel with the fourth branch of the radial sector. This vein can only be the median. The next vein is the cubitus. It is undivided, and goes to the middle of the inner margin. Anal veins are only indicated by feeble traces of a single undivided vein, which apparently reached the margin midway between the cubitus and the base of the wing.

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The subcosta is a feeble vein whose course cannot be traced with certainty

beyond the middle of the wing. It is close to the margin and parallel with it for its whole length. The radius is well marked, sunken, and also parallel with the margin except distally, where it is more inwardly curved. It ends on the apex in a short fork. The radial sector arises near the base, and is parallel with the radius. It appears to give off three to four branches, the first arising very near the base of the wing. The whole course of this branch can be traced, but of the middle two only faint traces are left in the region of the wing-apex. The fourth branch is very short, and corresponds in position with the last branch of the radial sector in *Brodia priscotincta*. The median vein forks low down into two equal branches, which reach the middle of the inner margin.

The cubitus is a long undivided vein passing out almost to the middle of the inner margin, and separated from the next vein, which seems to be the first anal. The course of the latter is more oblique to the inner margin than that of the cubitus.

In its general character this wing is distinctly similar to that of *B. priscotincta*, although it lacks a second branch to the median, and the first anal does not seem to be forked.

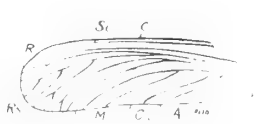


Fig. 18.—*Brodia priscotincta*, Scudder, *forma juvenis*, Bolton; diagram of wing-neuration, twice natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Madeley Collection, Brit. Mus. (no. I. 1564). Lettering as in Text-fig. 16, p. 62.

Affinities.—Handlirsch regards these as nymphal wing-sheaths, but their extreme tenuity militates against this view. He is probably wrong in referring *Brodia* to the Megasecopteridæ, but right in regarding these wings as those of heterometabolous insects, and not holometabolous as Lameere supposed.

Immature though the wings undoubtedly are, the more nearly perfect example possesses an assemblage of characters which I believe points to its relationship. The shape of the wing, the character and course of the subcosta, the number and position of the branches of the radius, the simple forking of the median and the anal veins, are all characters pertaining to the genus *Brodia*. The differences in detail between this wing and that of *B. priscotincta* are such as may be looked for between the nymph-stage and the adult. Among previously described larval wings, the only type which seems comparable is *Lameereites curripennis*, Handlirsch, based on four nymph-wings or wing-cases, as Handlirsch has them, found in the Coal Measures (Pennsylvanian) at Mazon Creek, Illinois, U.S.A. (1911, Handlirsch, 'Amer. Journ. Sci.' [4], vol. xxxi, p. 375).

In these wings, the outer or costal margin is more strongly curved, and the costa and radius extend over the bluntly curved apex down to its junction with the inner margin. The succeeding veins arise nearer the base of the radius, only one

apparently being a branch of that vein, while the median and the cubital areas are occupied by numerous veins whose origins are not indicated.

The differences between *Lameereites curvipennis* and this specimen are considerable. The balance of evidence is greatly in favour of an affinity with *Brodia priscotincta*, and the specimen may represent a nymph or larval stage of that species.

It is undesirable to attach a specific name to immature wings agreeing so closely with a known species. I propose to regard it as *B. priscotincta*, *forma juvenis*.

Brodia furcata, Handlirsch. Plate III, figs. 7, 8; Text-figure 19.

1919. *Brodia furcata*, Handlirsch, Revision der Paläozoischen Insekten, p. 75, fig. 89.

Type.—A left wing and impression showing the under-surface; British Museum (no. I. 2962).

Horizon and Locality.—Middle Coal Measures (above the "Brooch" Coal); Dudley and Coseley, Staffs.

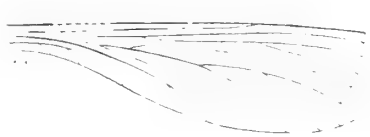


Fig. 19.—*Brodia furcata*, Handlirsch; showing forking of the second branch of the median into two equal twigs, natural size.—Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire. Brit. Mus. (no. I. 2962).

Specific Characters.—Radial sector reduced in area, and possibly with three branches. Median having the second branch dividing into two equal twigs, both of which reach the margin. Median area enlarged.

Description.—This wing differs so much from the type-form as to be worthy of specific distinction. Its total length is 44 mm. and the greatest width 12·5 mm. The base of the wing is much more nearly complete than usual, and very narrow (5 mm.) for a short distance, beyond which it widens by the development of the strong convex inner margin. The wing shows the usual plication, which fortunately is not continued into its base, so that the course of the veins in the latter is not obscured, as is so often the case in *B. priscotincta*. The outer or costal margin forms an almost straight line, and bears a double row of spinules, those at the base of the wing pointing inwards. No basal hump, as in *B. priscotincta*, is shown. The subcosta is widely spaced from the outer margin proximally. The radius and radial sector present no special features, and but one inward branch is present. Whether four branches arose from the main stem, as in the type-species, cannot be determined owing to the loss of the apical portion of the wing. It is doubtful if such was the case, as the portion missing is not great. The outer three branches of the radial sector are usually 10—12 mm. apart, so that if the wing

possessed the same number of branches of the radial sector as in *B. priscotincta*, its total length would have been 70 mm.—an unusual length. The median vein is the most powerful of the whole series, and occupies a middle diagonal area equal in extent to the combined costal and radial areas. The first branch arises in line with the radial sector, and much nearer the base of the wing than in *B. priscotincta*, and also lies so much nearer the cubitus that the area separating the two is but half the diameter of the area in the former species. This shortening of the main stem and its movement inwards has been brought about by the division of the second branch into two equal twigs, which pass out to the margin between the first branch and the main stem. The median vein therefore takes a larger share in the wing-structure than in *B. priscotincta*, and the radial and cubital areas are correspondingly reduced. The cubitus presents no special features. Notwithstanding the shortening up of the area separating it from the median, the area between the cubitus and the anal veins is very large. The cubitus has suffered no displacement by the increased division of the median. The first anal vein is very long, passing well beyond the first third of the wing and dividing just before reaching the wing-margin. The second anal vein is two-thirds the length of the first, and bends inwards more gradually to the margin, giving off two short oblique branches in its basal half.

"PTERONEPIONITES."

Many larvæ of fossil blattoids have been recorded, but very few of other groups. These larvæ may eventually reveal the changes undergone up to the adult stage, and the development of the neuration of the wings. In addition, the occurrence of larvæ in deposits is more likely to be indicative of habitat than the presence of adult wings, as the inability of larvæ to fly and their lesser power of flotation would ensure inclusion in adjacent deposits. It is therefore necessary that their occurrence, and as much as possible of their structural appearance, be fully recorded. Any attempt to classify them under genera and species would rather retard than accelerate progress, and it seems advisable to record them under some term which will leave no doubt of their larval character. Handlirsch ('Amer. Journ. Sci.' [4], vol. xxxi, p. 375, 1911) has already described larval "wing-cases" of a somewhat similar character under the generic name of "*Lameereites*," and placed them under the order Megasecoptera.

Had not Handlirsch given a generic value to the name "*Lameereites*," it would have been possible to extend the use of his term to all larval wings. Failing this I would suggest the use of the word "*Pteronepionites*" for all larval wings which cannot be referred to a known genus, adding a specific designation when any larval wing presents features of a definitely recognisable character. Handlirsch restricts the name "*Lameereites*" to the wings of larval Megasecopteridæ, but recognises the

close similarity between them and *Pteronepionites* ('Revision der Paläozoischen Insekten,' p. 76).

"Pteronepionites" johnsoni, sp. nov. Plate IV, fig. 4; Text-figure 20.

Type.—Immature wing, 12 mm. long and 4 mm. wide; British Museum (Madeley Collection, no. I. 2967).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The wing, like all these immature structures, is of extreme tenuity, and the finer details are masked by the coarse granular nature of the matrix composing the nodule. The outer margin is straight, curving backwards until it meets the inner margin in a bluntly-pointed apex. The inner margin is strongly convex, a distal infolding indicating that the wing was apparently never fully extended. Very feeble traces occur of a short straight subcosta, which

FIG. 20.—"*Pteronepionites*" *johnsoni*, sp. nov.; diagram of wing-neuration, two-and-a-half times natural size.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffordshire.—Madeley Collection, Brit. Mus. (no. I. 2967).

reached the margin near the apex of the wing. The radius is stout and straight and reaches the wing-apex, giving off a well-marked radial sector, which, diverging from the radius, passes in a wide curve into the wing-apex. The median remains undivided for nearly a third of its length, and then bifurcates into two equal branches which assume a parallel position, and reach the outer third of the inner margin. The cubitus is represented by two veins, the first having a sigmoidal sweep and the second a simple curve. Both reach the middle third of the inner margin. No trace of anal veins can be observed.

"Pteronepionites" ambigua, sp. nov. Plate IV, fig. 5.

Type.—A pair of larval wings still attached to the crushed and almost obliterated body; British Museum (Madeley Collection, no. I. 2968).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The insect lies in a fragment of a light grey ironstone nodule, and is not well preserved. One wing is whole, but more than half of the second is missing, and its apex is obscured by the matrix. The whole wing has a length of 6·5 mm. and a width of 2 mm. Each is much thickened over the basal half,

and strongly ridged or furrowed along the line of a powerful vein or tracheal trunk (the wing is so immature as to render the latter possible), occupying the position of the radius and median veins. Traces of a third vein occupying the position of the cubitus are present on the inner half of the wing. The body-segments are numerous, 3—4 mm. in depth, and seem to have had pleura-like expansions. The region in front of the thorax is bent backwards and below the abdominal segments. The thoracic segments are larger and more robust than those of the abdomen.

The thinness of the body, and the difficulty of determining boundaries with satisfactory accuracy, render all attempts at a more precise determination impossible. We can, however, say with confidence that the remains are those of an insect possessing a long segmented body, an elongated head-region, and wings carried upright over the back.

"Pteronepionites" lepus, sp. nov. Plate IV, fig. 6.

Type.—Remains of a larval insect, having a segmented body and two immature wings, in a flattened nodule of light-grey ironstone; British Museum (Madeley Collection, no. I. 2969).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, Staffs.

Description.—The impression of two wings is clearly discernible, the segments of the abdomen are less so. With oblique lighting, six segments can be made out behind the thorax. The wings are slightly unequal in size, and the anterior is longer and thicker than the posterior wing; it is also somewhat infolded at the base. The differences between the two wings, and their relative positions, would seem to indicate that they are the fore- and hind-wings of the one side.

The fore-wing has a length of 9 mm. and a width of 2·5 mm., while the hind-wing is 8 mm. long and 2 mm. wide. The fore-wing has a strap-shaped appearance, and the line of attachment to the body is its broadest part. A stout ridge, swollen at its junction with the body, traverses the greater part of the length of the wing, dying out before the apex is reached. The wing is too small for definite determination of this swelling, but it appears due to incomplete extension of the wing-membrane, rather than to the presence of a vein. The distal fourth is flat and thin, and the apex well rounded. The outer and inner margins are parallel and undulated. A few faint and irregular lines may be indications of veins.

The hind-wing has undergone greater expansion than the fore-wing, and lies almost flat on the nodule. Both outer and inner margins are gently convex, the convexity of the inner margin being the greater. Feeble traces of a subcosta, and

of a stout vein which forks before the middle of the wing is reached, are distinguishable. The latter vein occupies the position I should assign to the radius. No further traces of veins are visible.

The two wings are separated by an interval of 3 mm. at their bases. No definite details can be made out in the thoracic region. Behind the hind-wing are faint impressions of a series of abdominal segments. These are about three times as deep as wide, and appear to have borne lateral spiny processes. There are also traces of tubercles.

The head-region is only indicated by faint discolorations. As in the case of other examples of "*Pteronepionites*" we have met with, the remains are so filmy in character, and merge so much into the matrix, that it is impossible to define the outer limits of the various segments with absolute clearness, and no attempt can be made at a systematic determination of characters.

The specimen is a larval form with wings not yet fitted for flight, but with a degree of differentiation in the fore-wings which indicates that they were thicker and less flexible than the hind-wings.

The abdomen is long, wide, and well segmented, the lateral expansions being not unlike those of *Euphoberia ferox*. So closely does the abdomen resemble the segmented body of a Diplopod, that in the absence of the wings we believe it would be readily classed as belonging to that group, and as possessing nothing in common with insects.

It is difficult to resist the belief that these larval insects were capable of crawling about in decaying vegetation, and that their larval life was thus spent, until by successive ecdysis the wings had acquired sufficient strength to lift the body from the ground, and enable the insect to fly.

Family ÆNIGMATODIDÆ, Handlirsch.

1906. Handlirsch, Proc. U.S. National Mus., vol. xxix, p. 683.
1906. Handlirsch, Die Fossilen Insekten, p. 116.

Wing strongly arched, and broadly rounded at the apex. Anal area small, and not marked off from the rest of the wing. Subcosta reaching almost to the wing-apex; radius simple, and radial sector with three divisions. Median with four branches. Costa represented by an oblique vein with a terminal fork, followed by three simple, strongly curved anal veins. Interstitial neuration partly of regular cross-nervures, and partly of a polygonal network.

Handlirsch founded this family on an incomplete wing in which the greater part of the outer border, subcosta and radius is missing. From the upper Middle Coal Measures of Mazon Creek, Ill., U.S.A.

Genus **ÆNIGMATODES,** Handlirsch.

1906. *Ænigmatodes*, Handlirsch, Die Fossilen Insekten, p. 116.

Generic characters as above.

Ænigmatodes (?) regularis, sp. nov. Plate IV, fig. 7; Text-figure 21.

Type.—Fragmentary wing; British Museum (no. In. 18,604).

Horizon and Locality.—Middle Coal Measures (over the Barnsley Thick Coal); Monckton Main Colliery, Barnsley, Yorkshire.

Specific Characters.—Radial sector, median, and cubital areas occupying most of the wing, and all with well-spaced branches united by straight nervures, except in the marginal area between the median and cubital veins where they form a slight meshwork. Inner margin well rounded.

Description.—Little more than half of this wing is preserved, and lies on a fragment of hard grey bind associated with broken-up plant-remains. The greatest length of the fragment is 42 mm., and the width 15 mm. The length

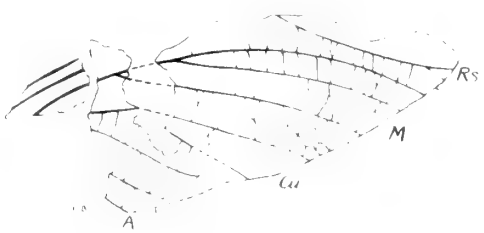


Fig. 21.—*Ænigmatodes* (?) *regularis*, sp. nov.; diagram of neuration of wing-fragment, one-and-a-half times natural size.—Coal Measures (over the Barnsley "Thick" coal); Monckton Main Colliery, Barnsley, Yorkshire. Brit. Mus. (no. In. 18,604). Lettering as in Text-figure 16, p. 62.

of the complete wing was probably 50—60 mm., and the width 18—20 mm. The outer margin is missing, and of the subcosta and radius only portions of the basal third are present. These are separated by a narrow area crossed by short transverse nervures.

In the distal third of the wing is the innermost branch of the radial sector, which ends on the margin in a small fork. The line of fracture of the wing has closely followed the line of the radial sector, and a portion of another branch of the radial sector may have been present along the line of the extreme broken edge of the wing. The median vein sweeps in a convex curve to far out on the inner margin, giving off two well-spaced branches. The next two veins, one of which forks, are more oblique in their course, and may also belong to the median, but the basal curve rather indicates that these veins are cubital, as is the succeeding vein, of which only a small portion is left. A trace of an anal vein is present near the wing-margin. The interstitial neuration consists of well-marked transverse nervures, regularly spaced in the outer parts of the wing, and uniting in a loose

meshwork in the wide area between the inner branch of the median and the cubitus.

Affinities.—The nearest approach to a wing of this character is that of *Ænigmatodes danielsi*, Handlirsch, in which the greater part of the outer margin is also missing. The Yorkshire specimen, which may be a hind-wing, is three times as long as *Æ. danielsi*, and the veins have a stronger inward curvature. In the absence of more definite details, it seems best provisionally to refer the specimen to the genus *Ænigmatodes*.

Genus **PSEUDOFOUQUEA**, Handlirsch.

1906. *Pseudofouquea*, Handlirsch, Die Fossilen Insekten, p. 125.

Wings three times as long as wide. Cubitus with inner and outer branches. Anal veins, so far as known, not united. Interstitial neuration of feeble cross-nervures except between cubitus and first anal, where it is irregularly reticulate.

Pseudofouquea cambrensis (Allen). Plate IV, fig. 8; Text-figure 22.

1901. *Fouquea cambrensis*, Allen, Geol. Mag. [4], vol. viii, p. 65, text-fig. on p. 66.
1906. *Pseudofouquea cambrensis*, Handlirsch, Die Fossilen Insekten, p. 125, pl. xiii, fig. 5.
1916. *Pseudofouquea cambrensis*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 59, pl. iv, figs. 4—5, and text-fig.

Type.—A broken left fore-wing, of which the two parts are preserved on fragments of black shale; one fragment, bearing the basal part of the wing, in the Museum of Practical Geology, Jermyn Street (no. 7272), the other, containing the impression of the distal 28 mm. of the wing, in the Welsh National Museum, Cardiff (no. 13,120).

Horizon and Locality.—Lower Coal Measures (top of the Four Foot Seam); Llanbradach Colliery, near Cardiff.

Specific Characters.—Wings stout and obtusely pointed. Costa marginal and flatly convex. Subcosta reaching margin in the outer third. Radius parallel with subcosta, and ending in apex of wing. Radial sector diverging widely from radius, and ending on the wing-apex in five divisions. Comstock regards it as a typical dichotomous radial sector, with an accessory vein on the second branch ('Wings of Insects,' 1918). Radius and radial sector occupying all the wing-apex. Median dichotomously branched, with an accessory vein in the fourth branch. Cubitus widely divergent from median, and giving off alternate twigs from its outer and inner sides, those of the inner side being much the feeblest. Anal veins four in number. Interstitial neuration of feeble cross-nervures, except between the base of the first anal vein and the cubitus, where it is irregularly reticulate.

Description.—The total length of the wing is now 32 mm., 9 mm. having been

lost from its tip since it was measured by Allen, who gives the total length as 41 mm. The greatest width is 15 mm.

The subcosta is widely separated from the outer or costal margin in the base of the wing, and gradually approaches and unites with it beyond the middle. The radius is parallel with the subcosta throughout its length, and gives origin to the radial sector basally. The radial sector diverges from the radius over the whole of its course. It now shows but one inwardly directed branch, which forks at the broken edge of the wing. Allen's figure indicates that two more branches were given off, both being undivided. The radius and radial sector occupied almost the whole of the apex of the wing.

The median vein forks in the basal fourth, the outer branch again forking before the middle of the wing is reached. The inner branch of the median diverges almost in a straight line from the outer branch, and also forks, and bears an accessory twig upon the fourth branch. A feeble accessory twig appears to be given off near the middle of the wing, but dies out in the integument. The cubitus

Fig. 22.—*Pseudofouquea cambrensis* (Allen); restoration of whole wing, natural size. Lower Coal Measures (top of the Four Foot Seam); Llanbradach Colliery, near Cardiff. Basal portion of wing in Mus. Pract. Geol. (no. 7272). Impression of apical portion of wing in the Welsh National Museum (no. 13,120).

is a remarkable vein, unlike that of any other fossil wing (Comstock, 'Wings of Insects,' 1918, p. 106). For nearly half its length it passes in a broad curve to the inner margin, giving off a series of alternate twigs upon its outer and inner sides, those of the inner being weaker than those of the outer side. The two outer twigs are strongly developed, while those on the inner side of the cubitus, four in number, are weaker and shorter. The feeble continuation of the main stem reaches the margin between the two sets of branches. Four anal veins are distinguishable. The inner two arise from a common base, the outer two not uniting. This is unlike the condition in *Fouquea*, where the anal veins branch off regularly from a single stem.

The area lying between the first anal vein and the main stem of the cubitus is very wide—much wider, indeed, than any other area.

The interstitial neuration consists of weak cross-nervures, except between the base of the first anal vein and the main stem of the cubitus, where it is irregularly reticulate.

Affinities.—The characters of the cubital and anal veins definitely remove the species from the genus *Fouquea*, and the cubitus, with its strong, anteriorly directed twigs, and its feebler inner series, is wholly unlike that of any other insect, and would alone suffice to justify the generic rank given by Handlirsch.

So far I am in agreement with Handlirsch, but I regard the enlarged areas between the inner divisions of the radial sector and the cubitus, and between the cubitus and the anal veins, as more suggestive of the Protorthoptera, notably *Thoronysis ingbertensis*, Ammon. More than this cannot be said, and *Pseudofouquea cambrensis* must be regarded provisionally as Palæodictyopterid, with a possibility of Protorthopterid or even Orthopterid affinities.

INCERTÆ SEDIS.

Genus **ARCHÆOPTILUS**, Scudder.

1881. *Archæoptilus*, Scudder, Geol. Mag. [2], vol. viii, p. 295.

A wing of unusually robust type. Only one is known, consisting of not more than the basal fifth of a whole wing whose total length may have been 25·4 cm. to 35·5 cm. The fragment is too small for a correct determination of its systematic position, and has been referred to widely separated families by various workers.

Archæoptilus ingens, Scudder. Plate IV, fig. 9; Text-figure 23.

1881. *Archæoptilus ingens*, Scudder, Geol. Mag. [2], vol. viii, pp. 295, 300.
1883. *Archæoptilus ingens*, Scudder, Mem. Bost. Soc. Nat. Hist., vol. iii, pp. 217, 223, pl. xvii, figs. 10—12.
1885. *Archæoptilus ingens*, Brongniart, Bull. Soc. Amis Sci. Nat. Rouen [3], ann. xxi, p. 60.
1885. *Archæoptilus ingens*, Scudder, Zittel's Handbuch der Palæontologie, vol. ii, p. 757.
1893. *Archæoptilus ingens*, Brongniart, Faune Entom. Temps Prim., p. 498, pl. xxxvii, fig. 6.
1906. *Archæoptilus ingens*, Handlirsch, Die Fossilen Insekten, p. 117, pl. xii, fig. 18.

Type.—Basal fifth of wing, in counterpart; British Museum (no. I. 3997).

Horizon and Locality.—Middle Upper Coal Measures; between Shelton and Clay Lane, near Chesterfield, Derbyshire.

Specific Characters.—Wings very large; costa, subcosta, and radius broad and robust. The costal border spiny. Interstitial neuration of stout transverse nervures.

Description.—Only the basal part of the wing and its counterpart are preserved, having a total length of 43 mm., and a greatest breadth of 33 mm. Scudder's estimate of the length of the whole wing as 35·5 cm. is probably excessive.

Scudder (*loc. cit.*, 1881) thus describes the specimen: "All the principal veins are a millimetre or more thick, and the cross-veins of the upper interspaces are tolerably distant, stout, prominent, and generally simple. The marginal (costa) vein, forming the front (outer) border of the wing is studded with short oblique spines (? macrotrichia). The other veins lie at very different levels on the stone,

and below the interspaces mentioned, seem rather closely crowded, and much more curved, sweeping downward, while the upper veins show little tendency to turn from a longitudinal course."

The great apparent width of the costa is caused by the formation of an expanded chitinous bar along its outer margin, the free edge bearing the spines described by Scudder. The costa, with its chitinous bar, the subcosta and the radius are so broad as to appear strap-like, are widely separated, and the intervening areas are crossed by equally strong nervures. The costa can be distinguished on the cast from the frontal bar and appears as a narrow rounded vein.

The subcosta is a very broad vein, crossed by oblique striæ which are directed outward from the upper edge of the vein. A broad interval (9 mm.) separates it from the costa, the area being crossed by stout, slightly oblique, transverse nervures. The general direction of the subcosta is such that it must have reached the margin of the wing near the apex. At the base it is much enlarged, the

FIG. 23.—*Archæoptilus ingens*, Scudder; diagram of whole wing from Scudder's original restoration, one-quarter natural size.—Upper Coal Measures; near Chesterfield, Derbyshire. Brit. Mus. (no. I. 3997).

enlargement probably indicating the attachment to the body of the insect. The expanded inner portion of the base is fused with the equally expanded base of the radius.

The radius diverges from the subcosta in its outward course, and is even more enlarged than the subcosta. It is connected with the latter by a series of thirteen transverse nervures in the wing-fragment. Most of these are slightly convex, and two are united by lateral branching.

The median vein was apparently closely apposed to, or united with the base of the radius, and is much less robust than the latter, the intervening area being narrow, and crossed by short, thin, straight, transverse nervures which do not appear to continue into the base of the wing. The cubitus is not so readily distinguishable, and diverges sharply inwards towards the inner margin. The anal veins are 4—5 in number, and are strongly curved inwards, occupying not more than one-fifth of the inner margin of the wing. The first three may have been united at their base. The wing is marked by a series of folds along the lines of the principal veins.

Affinities.—This remarkable wing-fragment has caused considerable conjecture as to its true character and relationship. Scudder in his second note (*loc. cit.*,

1883) somewhat vaguely placed it, "with a strong degree of probability, in the same general group as some other Palæozoic wings." This reference can only be to the Palæodictyoptera. Later he published a restoration of the wing, and classed it with the Protophasmidæ. Brongniart at one time regarded it as a Dictyoneuron, and later as a "Neurorthopteron" of the group Sthenaropterida. Still later he placed it as a Neuropteron in the group Platypteridæ. Handlirsch considers that the costa is marginal, and that this character, with the sharp inward curve of the anal veins, justifies its inclusion in the Palæodictyoptera, although he does not attempt to indicate its allies.

A second species was described by Brongniart as *A. lucasi* ('Bull. Soc. Amis Sci. Nat. Rouen' [3], ann. xxi, p. 60, 1885), but this throws no light on the genus, nor does it appear to be generically referable to *Archæoptilus*.

The only details preserved which can be used in the determination of relationship are the spiny outer margin, the great width of the principal veins, the well-developed cross-nervures, and the strongly curved and numerous anal veins. Even these are too fragmentary for safe conclusions to be drawn in the absence of other material.

The general structure of the wing-fragment is to me more suggestive of the Protodonata than of the Palæodictyoptera, but the presence of well-marked anal veins discounts this view, unless we are prepared to accept the specimen as an early and archaic prototype of the Protodonata.

Order MIXOTERMITOIDEA, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 695, and Die Fossilen Insekten, p. 126.
1919. Handlirsch, Revision der Paläozoischen Insekten, p. 26.

Subcosta much shortened; radial sector arising close to the base, with 2—3 branches, of which only one forks. Median long, four-branched and suggestive of the Palæodictyoptera. Cubitus with 2—3 inward branches. Anal vein 3, simple. Cross-nervures strong, wide-spread and regular.

This is a provisional order established by Handlirsch to include two forms only—*Mixotermes luganensis*, Sterzel, from the Coal Measures of Saxony, and *Geroneura wilsoni*, Matthew, from the Carboniferous of St. John, New Brunswick, North America. Both wings show clearly their Palæodictyopteroid ancestry, but Handlirsch is uncertain whether they should be brought near to the Protorthoptera or to the Perlidæ.

Genus **GERONEURA**, Matthew.

1889. *Geroneura*, Matthew, Trans. Roy. Soc. Canada, vol. vi, sect. iv, p. 57.

Generic Characters.—Wing three times as long as wide; apex obtusely rounded;

subcosta short and joining outer margin before middle of wing. Radius and radial sector occupying almost the whole of the wing-apex. Median, cubitus, and anal divisions few. Interstitial neuration of stout cross-nervures at wide intervals.

Geroneura (?) ovata, sp. nov. Plate V, fig. 1.

Type.—Portion of left wing; British Museum (Madeley Collection, no. I. 2965).

Horizon and Locality.—Middle Coal Measures (binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffs.

Specific Characters.—Radial sector rising in outer third of wing, with three divisions. Median vein large, the two outer branches forking in line with origin of the radial sector, the third branch undivided. Cubital veins few, undivided, and reaching the distal part of the inner margin of the wing.

Description.—The specimen consists of the impression of the upper surface of the distal portion of a left wing, having a length of 32 mm., and a breadth of 26 mm. The impression lies on the surface of a thin flattened half-nodule of fine sandy grit, and is but faintly indicated. The total length of the wing was probably from twice to three times the length of the portion preserved, and its breadth may have been a little more than 26 mm. The outer margin is gently convex, and curves into the broadly rounded apex. Very little is left of the inner margin, which also seems to have been convex. The distal portion of the costal margin is present for a length of 20 mm. There is no trace of the subcosta, so that this vein did not extend much, if at all, beyond the middle of the wing. The radius gives off the radial sector about the distal third of the wing, the two veins remaining almost parallel with the wing-apex. The radial sector gives off a single inward forked vein. The next three veins seem to be divisions of the median. The first two each give off an outer branch in line with the division of the radius and radial sector, and the outer of the two also forks before reaching the edge of the wing. The third vein is single for its whole length, but evidently united with the second a short distance outside the line of fracture of the nodule. The remaining four veins appear to belong to the cubitus. No anal veins are distinguishable. All the veins, with the exception of the small forks of the radial sector and first median, are parallel and widely spaced. They are united by a series of strong, straight cross-nervures placed widely apart. Notwithstanding the strength of the veins and of the cross-nervures, the smooth impression of the wing-fragment seems to indicate that the veins were not sunk below the general surface of the wing, as is usually the case.

Affinities.—The determination of the relationship of so small a wing-fragment would be difficult were it not for the unusual direction of the main veins, their mode of branching, and the character of the cross-nervures. These characters are a special feature of the order Mixotermitoidea, Handl.

The wing-fragment must be referred to this provisional order in the absence of knowledge of the whole wing-structure. The much-divided median vein is more comparable with that of *Geroneura wilsoni*, Matthew, than with that of *Mixotermes luganensis*, Sterzel, and is also correlated with a shorter subcostal vein, although in *G. wilsoni* that vein extends beyond the point at which the radial sector arises from the radius. An open series of cross-nervures is present in both genera, as in this specimen, and both have the same well-rounded apex. The wing-fragment is suggestive of *Hemeristia occidentalis*, Dana, but has a less branched radial sector. I provisionally refer it to *Geroneura* with the specific name of *ovata*.

Order PROTORTHOPTERA, Handlirsch.

1906. Handlirsch, Proc. U.S. National Museum, vol. xxix, p. 695, and Die Fossilen Insekten, p. 123.
1919. Handlirsch, Revision der Paläozoischen Insekten, p. 28.

Head large, with strong mouth-parts, and bearing long slender antennæ; prothorax large and elongated, and the body strongly built. Legs either uniform in character and fitted for running, or the hind-legs modified for leaping. Wings more specialised than those of the Palæodictyoptera, and capable of folding on the abdomen when at rest, with the enlarged anal areas of the hind-wings doubled under, owing to the formation of a fold between the anal area and the rest of the wing. The principal veins and their subdivisions not so strongly curved inwardly as in the Palæodictyoptera.

Handlirsch established this order to include a series of insects intermediate in character between true Orthoptera and Palæodictyoptera, to which Scudder had previously given the name of Palæodictyoptera Neuropteroidea.

Genus **ÆDŒOPHASMA**, Scudder.

1885. *Ædœophasma*, Scudder, Geol. Mag. [3], vol. ii, p. 265.

Generic Characters.—Large wings two-and-a-half times as long as wide; inner margin more convex than outer margin, and curving distally into the latter. Principal veins broad and flat in the basal third, and diminishing in size distally. Subcosta and radius reaching the wing-apex. Median vein with two main branches, the outer with most subdivisions. Cubitus with two main branches, each much subdivided. Anal veins numerous. Interstitial neuration of irregular nervures, and a loose meshwork in the wider areas.

Ædœophasma anglica, Scudder. Plate V, fig. 2; Text-figure 24.

1885. *Ædœophasma anglica*, Scudder, Geol. Mag. [3], vol. ii, p. 265, and in Zittel's Handbuch der Palæontologie, vol. ii, p. 758, fig. 941.

1906. *Ædœophasma anglicà*, Handlirsch, Die Fossilen Insekten, p. 125, pl. xiii, fig. 4.
1916. *Ædœophasma anglica*, Bolton, Quart. Journ. Geol. Soc., vol. lxxii, p. 43, pls. iii, iv, and text-figure.

Type.—Greater part of a left wing in an ironstone nodule; Liverpool Museum (presented by Major Chambers in 1858).

Horizon and Locality.—Middle Coal Measures; South Lancashire (locality unknown, but the nodule so similar to those derived from the Ravenhead Railway Cutting that it may be from that section).

Specific Characters.—As generic characters.

Description.—The specimen was partly described and named by Scudder in 1885, and re-examined and figured by the present writer in 1916.

The wing lies in counterpart in a fine-grained ironstone nodule, and its total length as now exposed is 87 mm., its greatest breadth (across the middle) 40 mm. When whole, the wing was probably 100 mm. long.

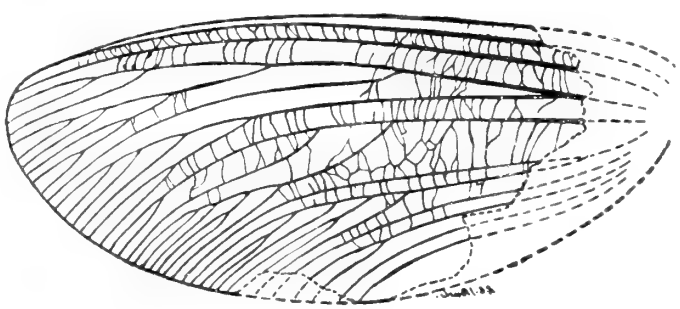


Fig. 24.—*Ædœophasma anglica*, Scudder; restoration of whole wing, showing the general character of the venation, natural size.—Middle Coal Measures; South Lancashire. Liverpool Museum.

The outer or costal margin is gently convex. The subcosta is a broad flat vein, gradually diminishing in width towards the wing-apex, which it just fails to reach.

The radius is an even broader vein than the subcosta, is also flattened in its basal third, and reaches the outer angle of the wing-tip, keeping parallel with the subcosta.

The median vein divides low down into two equal branches, the outer giving off four inwardly directed twigs. The first of these remains undivided; the second forks twice, and the outer and inner divisions of the second bifurcation again divide, so that the vein ends on the apical margin in six divisions. The remaining two branches are undivided. The divisions of the outer branch of the median occupy the greater part of the wing-apex.

The inner branch of the median does not divide until it has reached the apical fourth of the wing, where it gives off four twigs which pass inwards to the junction of the inner margin with the apex. Only the first of these twigs forks.

The cubitus has the same broad flattened basal portion which is so characteristic of the veins we have already dealt with. The main stem lies somewhat near

the first branch of the median, and remains parallel with it over almost the whole of its length. Inwardly it is separated somewhat widely from a slighter vein which, I believe, joined it near the base, and formed the first inward branch. The main stem sends off at the middle of the wing a strongly curved branch which bends first inwards and then outwards towards the apex, breaking up into five twigs before reaching the inner margin. The second of these twigs forks. A second undivided branch comes off a little further out, and a third very small one almost on the margin. The next two veins were probably united a little way out from the base, and their direction is such that the single stem from which they arose may have arisen, as suggested above, as the first inward branch of the cubitus. The outer of the two veins is undivided, and reaches the inner margin beyond the middle of the wing. The innermost vein runs fairly parallel with the first along its whole length, giving off, as it does so, four inwardly directed twigs, of which the first and fourth fork. The whole vein ends on the margin in six twigs. Four anal veins are shown, one only forking.

The interstitial neuration of the radial and median areas consists of straight or slightly curved nervures, placed at nearly equal distances. The very wide cubital and cubito-anal areas are filled by a loose meshwork, and a few irregular wavy nervures. The anal area is crossed by simple straight nervures.

Affinities.—Scudder was originally of opinion that this wing was related to *Meganeura* (*Dictyoneura*) *monyi*, Brong., representing a member of the group Protophasmidæ. Handlirsch removed the genus to the group of Palæodictyoptera incertæ sedis.

Scudder was undoubtedly mistaken in referring the wing to the Protophasmidæ, as a glance at the figure of *Protophasma dumasii*, Brong., will at once show ('Die Fossilen Insekten,' pl. xvi, figs. 1—2). Handlirsch did not see the specimen, and had to base his determination on a sketch of the wing which he considered "confusedly drawn." The latter probably accounts for the interpretation which he placed on the various principal veins. More recently I have been able to expose more of the structure, and diagnosed the wing accordingly. If Handlirsch's view were correct, the radial sector would be of enormous proportions, and occupy all the wing-apex. The base of the radius, so far as shown, is widely divergent from the base of the median—more so, in fact, than at any other part of the whole course of the radius and supposed radial sector. These veins, therefore, have come into union only at the actual point of origin of the wing. This may have been the case, but in my opinion, the radius is wholly simple and undivided, and no radial sector is present. The median and cubitus are large, much divided, and take up the greater part of the wing-area, while the anal veins are few.

If this view be correct, the wing is a very primitive example of the Protorthoptera, still retaining evidence in the costa, subcosta and radius, of its Palæodictyopteroid origin.

PLATE I.

FIG. PAGE.

1*a*. *Dictyoneura higginsii* (Handlirsch); basal portion of left wing. × 1½. Middle Coal Measures (horizon not known); Ravenhead Railway Cutting, nr. St. Helens, Lancashire. Liverpool Museum. 25.

1*b*. Ditto; impression of the wing. × 1½. 25.

2*a*. *Orthocosta splendens*, Bolton; left wing. Natural size. Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30222. 27.

2*b*. Ditto; impression of the wing. Natural size. Mus. Pract. Geol. (Moysey Coll.), no. 30223. 27.

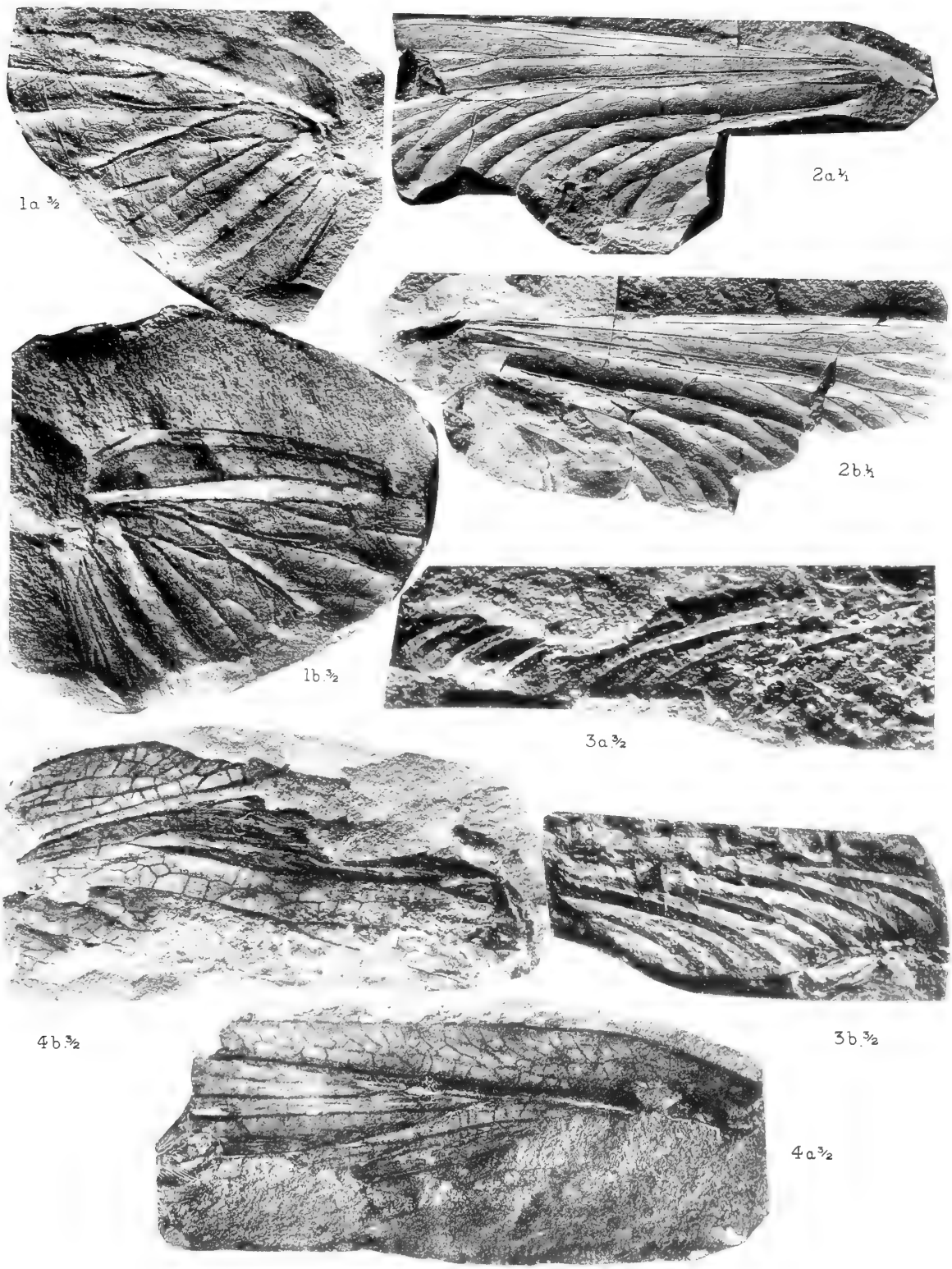
3*a*. *Pteronidia plicatula*, Bolton; inner half of left wing. × 1½. The straight inner margin and the plication are well shown. Middle Coal Measures (below the Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30224. 30.

3*b*. Ditto; impression of portion of the wing, showing the oblique cross-nervures. × 1½. Mus. Pract. Geol. (Moysey Coll.), no. 30225. 30.

4*a*. *Hypermegethes northumbriæ*, Bolton; basal half of a left wing. × 1½. Coal Measures (shale above the Crow Coal); Phœnix Brickworks, Crawcrook, Durham. British Museum, no. In. 18524. 32.

4*b*. Ditto; counterpart of portion of basal half of the wing, the interstitial neuration having been rendered visible by immersion of the nodule in water during photography. × 1½. 32.

Bolton, Insects of Coal Measures. PLATE I.



1. DICTYONEURA. 2. ORTHOCOSTA. 3. PTERONIDIA.

4. HYPERMEGETHES.

J W Tutcher, photo

London Stereoscopic Co. imp

PLATE II.

FIG. PAGE.

1*a*. *Cryptovenia moyseyi*, Bolton; greater part of left wing, dorsal surface uppermost. × $3\frac{1}{2}$. Middle Coal Measures (below Top Hard Coal); Shipley Manor Claypit, Ilkeston, Derbyshire. Mus. Pract. Geol. (Moysey Coll.), no. 30226. 35.

1*b*. Ditto; impression of dorsal surface of left wing showing interstitial neuration. × $3\frac{1}{2}$. 35.

2*a*. *Mecynoptera tuberculata*, sp. nov.; portions of two fore-wings and cubito-anal portion of hind-wing superposed. × $1\frac{1}{2}$. Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. British Museum, no. In. 18576. 37.

2*b*. Ditto; impression of the two fore-wings showing interstitial neuration. × $1\frac{1}{2}$. 37.

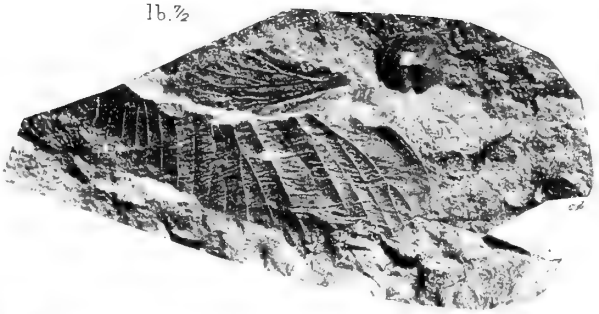
3*a*. *Palæomantis macroptera*, Bolton; fragment of left wing, dorsal aspect, the underside of the right wing showing beneath. Natural size. Middle Coal Measures; Ravenhead railway cutting near St. Helens, Lancashire. Liverpool Museum. 40.

3*b*. Ditto; impression of greater part of dorsal surface of left wing. Natural size. 40.

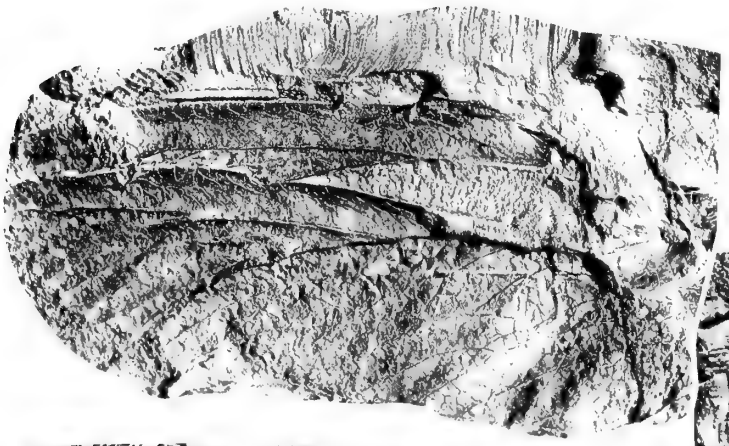
4. *Lithomantis carbonarius*, Woodward; portions of fore- and hind-wing, the prothorax with domed lateral lobes, and the anterior styliform process. (The latter ends in a sharp point not shown in the photograph. A little of the mesothorax is seen between the bases of the fore-wings.) Natural size. Coal Measures; Scotland. British Museum, no. I. 8118. 43.

Bolton. Insects of Coal Measures.

1a. ½

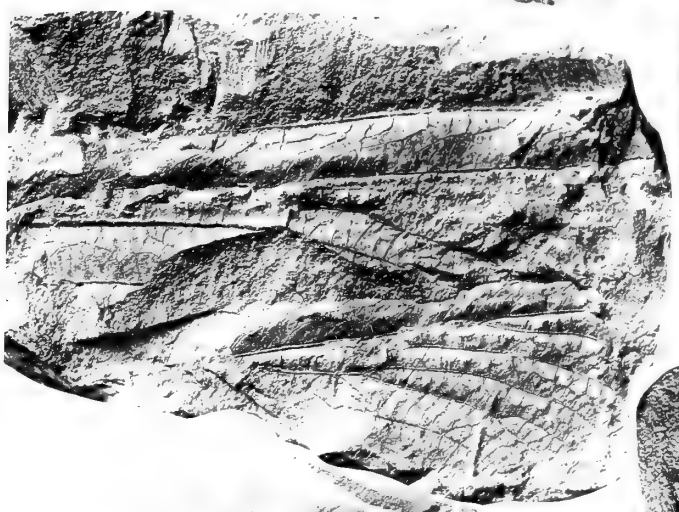


1b. ½



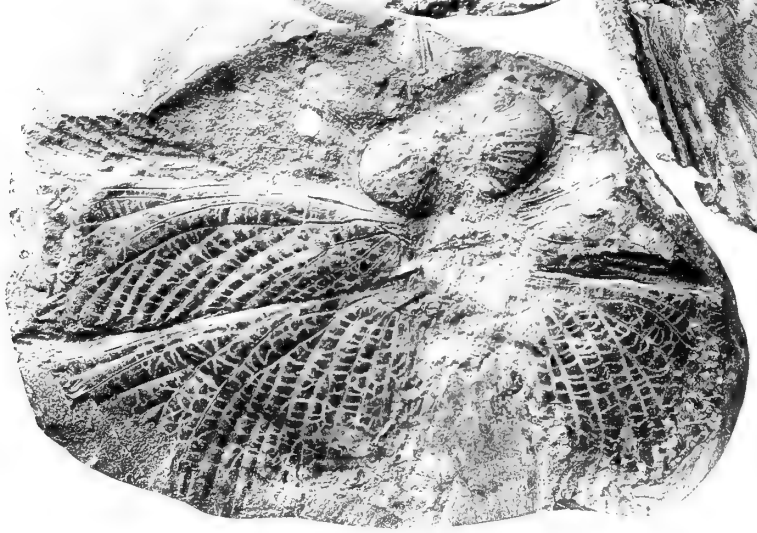
2a. ½

3a. ½



2b. ½

3b. ½



4. ½

1. CRYPTOVENIA. 2. MECYNOPTERA. 3. PALÆOMANTIS.

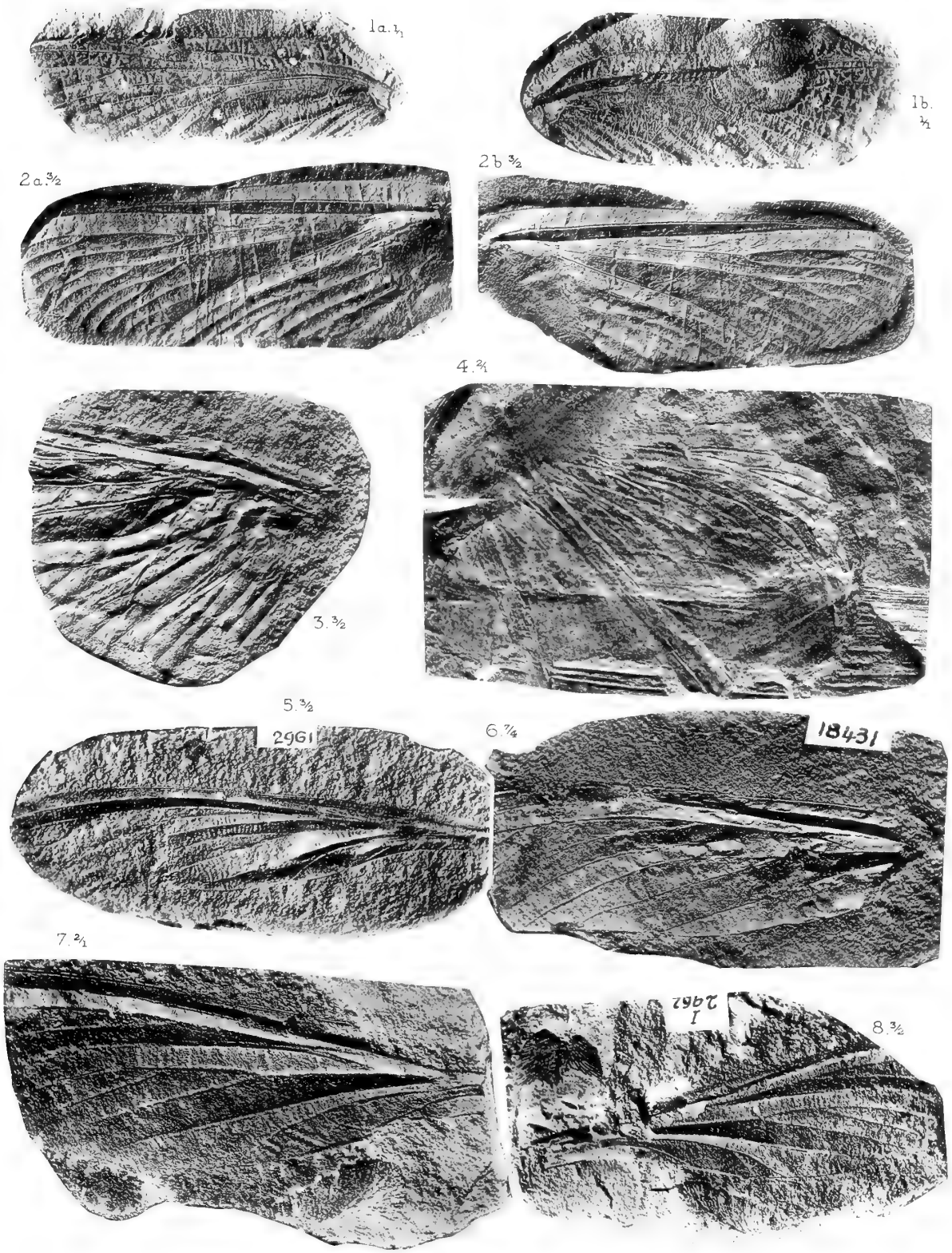
4. LITHOMANTIS.

PLATE III.

Fig.		Page.
1*a*.	*Lithosialis brongniarti* (Mantell); left fore-wing. Natural size. Coal Measures; near Coalbrookdale, Shropshire. British Museum (Mantell Coll. *olim* Parkinson Coll.), no. 11619.	46.
1*b*.	Ditto; impression of greater part of left fore-wing. Natural size.	46.
2*a*.	*Pruvostia spectabilis*, gen. et sp. nov.; left fore-wing. × 1½. Middle Coal Measures (ironstone nodules in the binds between the "Brooch" and "Thick" coals); Coseley, near Dudley, Staffordshire. British Museum (Johnson Coll.), no. I. 15894.	48.
2*b*.	Ditto; impression of same. × 1½.	48.
3.	*Spilaptera sutcliffei*, Bolton; basal part of left wing. × 1½. Middle Coal Measures (shales above the Royley or Arley Mine); Sparth Bottoms, Rochdale, Lancashire. Manchester Museum, no. L. 8197.	54.
4.	*Boltoniella tenuitegminata* (Bolton); right hind-wing. × 2. Coal Measures (No. 2 Rhondda Seam, base of Pennant Series); 1¾ miles north-east of Resolven Station, Glamorganshire. Mus. Pract. Geol., no. 24509.	56.
5.	*Brodia priscotincta*, Scudder; almost complete left wing, showing the attenuated base. × 1½. Middle Coal Measures (clay ironstone nodule from binds between the "Brooch" and "Thick" Coals); Dudley, Staffordshire. British Museum, no. I. 2961.	59.
6.	Ditto; portion of right hind-wing, under surface uppermost. (The original furrows of the wing have been flattened out, the veins more widely separated.) × 1¾. Middle Coal Measures (clay ironstone nodule from binds between "Brooch" and "Thick" Coals); Coseley, Staffordshire. British Museum, no. In. 18431.	59
7.	*Brodia furcata*, Handlirsch; wing lacking about one-sixth of the apical end. × 2. Middle Coal Measures (above the "Brooch" Coal); Dudley, Staffordshire. British Museum, no. I. 2962.	66.
8.	Ditto; impression of same, showing the narrow base of wing. × 1½.	66.

Bolton. Insects of Coal Measures.

PLATE III



1. LITHOSIALIS. 2. PRUVOSTIA. 3. SPILAPTERA.
4. BOLTONIELLA. 5-8. BRODIA.

J. W. Tutcher, photo

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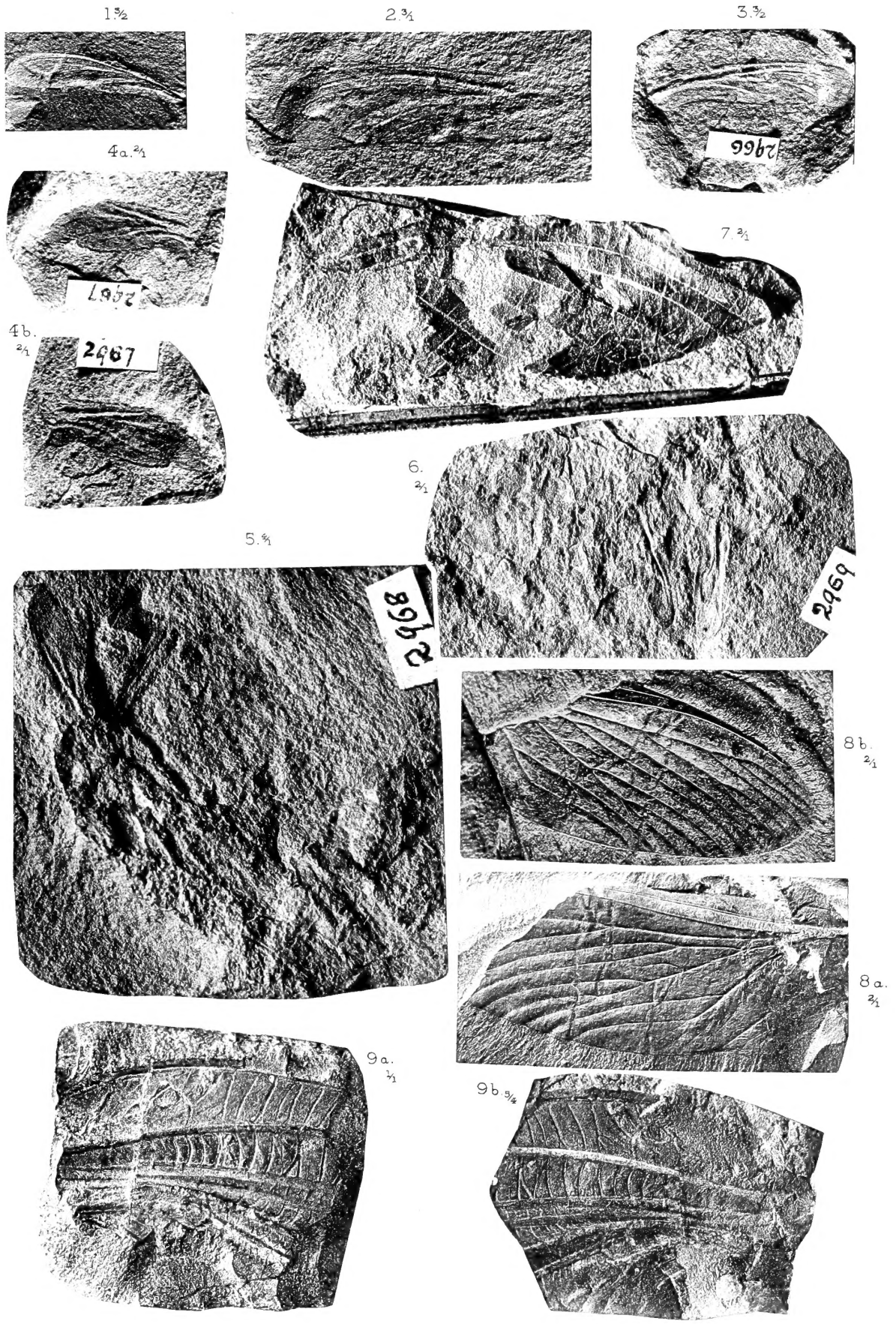
PLATE IV.

Bolton. Insects of Coal Measures. PLATE IV.



1-3. BRODIA. 4-6. PTERONEPIONITES. 7. ÆNIGMATODES.
8. PSEUDOFOUQUEA. 9. ARCHÆOPTILUS.