Critical Studies of Coal-measure Plant-impressions *. By the late E. A. NEWELL ARBER, M.A., Sc.D., F.G.S., F.L.S., Trinity College, Cambridge, University Demonstrator in Palæobotany.

(PLATES 8-15 and 2 Text-figures.)

[Read 15th June, 1922.]

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I. A Revision of the British Upper Carboniferous Species of the Genus *LEPIDOSTROBUS*, Brongn., preserved as incrustations.

INTRODUCTION.

THE genus *Lepidostrobus*, instituted by Brongniart in 1828 for a particular type of Lycopod cone common in the Coal Measures, is one of the most stereotyped organs known from the rocks of this period. Its general structure, as evidenced both by petrifications and impressions, is too well understood to need description here. One of the chief features of this cone, however, is the very small range in variation met with, excluding factors of such doubtful value as mere size and shape. For this reason the discrimination of species has always been a difficult matter, especially in the case of incrustations. Among petrified specimens it is known that there is, as a rule, great uniformity in type, though Mr. Maslen (21. p. 357) and, at a later date, my wife (1. p. 205) have shown that certain variations do occur, some of which are probably of sufficient importance to be regarded as of specific rank.

• [Owing to the death of the Author before these studies were finally revised, I am responsible for their present form. I have to acknowledge a grant from the Royal Society in aid of the preparation of this and other memoirs left by my husband in various stages of completion. The Cannock Chase Colliery Company have also been kind enough to contribute £10 towards the cost of the illustrations. I am indebted to the Keeper of the Geological Department of the British Museum (Nat. Hist.) and to Prof. Boulton of the University of Birmingham, for the opportunity of studying specimens in their charge. I wish, also, to express my gratitude to Prof. J. E. Marr, F.R.S., who has given me every facility for work in the Sedgwick Museum, Cambridge, where most of the specimens illustrated in this memoir will be found.—AGNES ARBER.]

These remarks apply in particular to those cones which have comparatively undifferentiated sporophylls, the standard of comparison here as regards differentiation being the leaf. In dealing with impressions of such cones it is, of course, quite impossible to recognise those characters which in the case of petrifications are regarded as of taxonomic value. Such, in fact, are only visible under the microscope. For these reasons the classification of impressions of *Lepidostrobi* has always been a difficult matter, and authorities have differed as to the species which should be recognised, and as to their essential characters.

A desire for more definite progress in this respect has, indeed, been felt from quite early times. As far back as 1838, Brongniart (3. ii. pl. 12) illustrated the range of sporophyll-form met with among the living Lycopods, to serve as a basis for such studies, and the analogy has also been pointed out by others since. I do not, however, propose to enter further into previous work on this subject here, for it will be necessary frequently to refer to the chief authorities in the course of this revision of the genus.

In attempting here to reclassify the British *Lepidostrobi* occurring as incrustations in the Coal Measures, I take as my specific unit the shape of the sporophyll.

I am unable to find any critical characters, whether derived from the features of the axis of the cone, or from any other details of its organisation, which are at all comparable in taxonomic value to the sporophyll-form.

The sporophylls of these cones have naturally two regions, the proximal and the distal. The proximal portion, often called the pedicel, is the lower part of the sporophyll, including the attachment to the axis and the surface bearing the sporangium. The position of the ligule marks the distal extremity of this region, and this rudimentary organ, of course, indicates that morphologically this portion of the sporophyll is an expanded leaf base. Very often part of the pedicel, especially that subtending the sporangium, is modified by the formation of a cushion or other enlarged growth, on which the sporangium is seated or to which it is attached. The distal portion of the sporophyll, often termed the lamina, extending from the region of the ligule to the apex of the sporophyll, is as a rule less modified, *i. e.*, more leaf-like, than the pedicel. Yet modifications sometimes occur here also, as, for instance, the development of a downwardly directed heel in the region of the ligule.

In most impressions of *Lepidostrobi*, it is usually possible to make out the essential features of both regions of the sporophyll, and it is on these characters that the species should be founded. Whether the cone is homosporous or heterosporous does not affect the question, for, as we know, the sporophylls subtending the micro- and megasporangia of the same cone are alike, and often precisely similar to those of homosporous cones.

From the study of considerable material, consisting of various cones of the *Lepidostrobus* type, preserved in the Sedgwick Museum, Cambridge,

many of which have been collected by myself, I have come to the conclusion that the cones fall into three groups or subgenera, which may be conveniently described as follows :—

Eulepidostrobos. Cones in which the sporophylls are comparatively leaf-like, with no great dissimilarity in size or shape between the pedicel and the lamina, e. g. *L. variabilis*, Lindl. & Hutt.

Ortholepidostrobos. Cones in which the distal portion of the sporophylls or laminæ are greatly expanded and developed as compared with the proximal regions or pedicels, e. g. *L. majus*, Brongn.

Sublepidostrobos. Cones in which the proximal portions of the sporophylls are much better developed than the distal regions or laminæ, e. g. *L. Jacksoni*, Arb.

The *Eulepidostrobi* are the most difficult group from a taxonomic standpoint. I am inclined to recognise only one species in Britain, *L. variabilis*, Lindl. & Hutt., where other authors distinguish several. There are, it is true, enormous differences in both size and shape between cones of this species and the strobili known as *L. Geinitzi*, Schimp., and *L. ornatus*, Brongn., but I can find no real macroscopic differences in the form of the sporophylls which can be clearly made out in impressions. No doubt such differences do exist, and, had we to deal with nothing but petrifications of these cones, we might discriminate further species founded on small characters. But the fact remains that these cones are so stereotyped that viewed merely as impressions it is not possible to discriminate between them except in respect of size, always a dangerous index in taxonomy. It is thus better to recognise the limitations of our powers in this direction by referring these fossils to one stereotyped species, than to attempt to specify a number of types which cannot be clearly distinguished from one another. The case of *L. variabilis* is exactly "on all fours" with that of *Stigmaria ficoides*.

The *Ortholepidostrobi** have at least one feature in which they stand apart from other members of the genus, i. e. the caducous nature of the sporophylls. In the other two groups the sporophylls are remarkably persistent, and it is rare to find among them a *Lepidostrobos* axis which is not fully clothed with sporophylls. In the case of the *Ortholepidostrobi*, the sporophylls are so easily detached from the axis that until a few years ago they were only known in the isolated state. They were then generally referred to the genus *Lepidophyllum*, e. g. *Lepidophyllum lanceolatum*, Lindl. & Hutt. The present paper contains the first figured examples of more than one type of these sporophylls still attached to the axis of the cone. In regard to all the British types here described, it may be now regarded as proved that they are not foliar leaves, as was at one time thought, but the sporophylls of a cone, and thus they are best referred to the genus *Lepidostrobos*. The genus

* The term "ortho" in the sense of "erect" recalls the very erect position of the laminas of the sporophylls of these cones.

Lepidophyllum should be restricted to Lycopod leaves, pure and simple. If, in making a record of one of these cones, only a detached sporophyll is known from a particular locality, the fact can be illustrated as in the following example :—*Lepidostrobos lanceolatus*, Lindl. & Hutt. [Sporophyll].

The *Sublepidostrobi* are the rarest and least known type in Britain, and in no case have we any complete knowledge of the sporophylls except the distal portions.

SYNOPSIS OF SPECIES.

1. Subgenus *EULEPIDOSTROBUS*, n. n.
Lepidostrobos variabilis, Lindl. & Hutt.
L. Russellianus, Binney.
2. Subgenus *ORTHOLEPIDOSTROBUS*, n. n.
L. brevifolius (Lesq.).
L. hastatus (Lesq.).
L. intermedius (Lindl. & Hutt.).
L. lanceolatus (Lindl. & Hutt.).
L. longibracteatus (Prestw.).
L. majus (Brongn.).
L. minor (Goode).
L. Moyseyi, sp. nova.
L. radians, Schimper.
L. triangularis (Zeiller).
3. Subgenus *SUBLEPIDOSTROBUS*, n. n.
L. Jacksoni, Arber.
L. ? spinosus, Kidst.

Subgenus *EULEPIDOSTROBUS*, n. n.

LEPIDOSTROBUS VARIABILIS, Lindl. & Hutt. (Pl. 8. figs. 1, 2, 3.)

1828. *Lepidostrobos ornatus*, Brongniart, Prod. Hist. Végét. Foss. p. 87.
 *1831. *Lepidostrobos variabilis*, Lindl. & Hutt., Foss. Flora, vol. i. pl. 10, pl. 11 (right-hand fig.).
 1831. *Lepidostrobos ornatus*, Lindl. & Hutt., *ibid.* vol. i. pl. 26 (1831).
 1837. *Lepidostrobos ornatus* var. *didymus*, Lindl. & Hutt., *ibid.* vol. iii. pl. 163.
 *1838. *Lepidostrobos* sp., Brongniart, Hist. Végét. Foss. vol. ii. pl. 23. figs. 1a to e, 2a to e, pl. 25. figs. 3 & 4 a to c.
 *1838. *Lepidostrobos* sp., Brongniart, *ibid.* vol. ii. p. 49. pl. 22. figs. 5-7.
 1847. *Lepidostrobos ornatus*, Hook. f., in Mem. Geol. Surv. vol. ii. pt. 2, p. 448, pl. 7, pl. 8 figs. 1-11.
 1850-56. *Lepidostrobos ornatus*, Bronn, Leth. Geogn. vol. i. pt. 2, p. 127, pl. 6. figs. 6-12.
 1855. *Lepidostrobos variabilis*, Geinitz, Vers. Steinkohlenf. Sachs. p. 50, pl. 2. figs. 1, 3, 4.

* Indicates figures of typical examples.

1855. *Lepidostrobus ornatus*, Goldenburg, Flora Sarapontana Foss. Heft i, p. 34, pl. B. figs. 3-5.
1869. *Lepidostrobus variabilis*, Roehl, Palæontogr. vol. xviii. p. 142, pl. 7. fig. 2.
1870. *Lepidostrobus Geinitzi*, Schimp., Traité Pal. Végét. vol. ii. p. 62, pl. 61. fig. 6.
- *1870. *Lepidostrobus variabilis*, Schimp., *ibid.* vol. ii. p. 61, pl. 58. figs. 2 a & 5; pl. 61. figs. 1, 2; pl. 62. figs. 35, 35 b.
1875. *Lepidostrobus variabilis*, Feistmantel, Palæontogr. vol. xxiii. p. 218, pl. 43. pl. 44. figs. 1-2.
- *1886-88. *Lepidostrobus variabilis*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 499, pl. 76. figs. 3-4.
- 1886-88. *Lepidostrobus ornatus*, Zeiller, *ibid.* p. 497, pl. 76. figs. 5-6.
- 1886-88. *Lepidostrobus Geinitzi*, Zeiller, *ibid.* p. 501, pl. 76. fig. 2.
1890. *Lepidostrobus Geinitzi*, Renault, Étud. Terr. Houill. Commentry. Flore Foss. pt. 2, p. 527, pl. 61. figs. 5, 6.
1893. *Lepidostrobus squarrosus*, Kidston, in Trans. Roy. Soc. Edinb. vol. xxxvii. pt. 2, p. 342, pl. 4. figs. 13, 13 a, & 14.
- *1909. *Lepidostrobus* sp., Arber, Fossil Plants, p. 68, fig. 13.

Diagnosis.—Cones cylindrical, elongated, not very narrow, very variable in size and shape, from 7×1 cm. to 15×4 cm. or more. Lamina (distal portion of sporophyll) lanceolate, small, erect, short. Cones homosporous.

States of preservation.—These cones occur in the shales and clay-ironstone nodules of the Coal Measures in various states of preservation. Some examples show the true external surface, *i. e.* all that is seen is the imbricated series of sporophyll laminae. Very often, however, the greater number of the laminae, or distal portions of the sporophylls, are broken off or have undergone considerable decay before preservation. This is of particular frequency in the case of specimens occurring in clay-ironstone, and such examples may bear a very different appearance to the perfect cone. Such specimens have been frequently described as a distinct species, *L. ornatus*. The specimens described by Hooker in 1847 are good examples. Other impressions represent longitudinal sections through the cone, which may be either radial (in which event the axis is seen) or tangential. It is only in the former case that the characters of the sporophylls can be ascertained.

Remarks.—*L. variabilis* as here defined is an extremely variable species. All gradations may be found between small and large cones with very slight differences in the shape of the sporophylls, depending chiefly on the size of the cone. A large type of cone has been distinguished by several authors under the name *L. Geinitzi*, Schimp., but of the figures accompanying these descriptions those of Schimper, Zeiller, and Renault (see above synonymy) alone show the characters of the sporophylls clearly. This type of cone is admittedly much longer and stouter than the ordinary forms of *L. variabilis*, but I am unable to see any real distinction worthy of specific rank as regards the characters of the sporophylls. Schimper in founding the species simply figures two sporophylls, which, except in size, appear to

* Indicates figures of typical examples.

me to be identical with those of *L. variabilis*. The differences between the two species indicated by Zeiller appear to me to be very slight, in some cases non-existent—a view which Renault's figures confirm. I therefore conclude that, unless an appeal is to be made to mere size and shape, which are notoriously untrustworthy taxonomic guides, there is no real distinction between the sporophylls of *L. Geinitzi* and *L. variabilis*. The two cones may be really distinct, but when they are preserved as impressions, there are no distinctly visible characters by which they may be distinguished.

In the case of *L. squarrosus*, again, according to Kidston the chief differences between that species and *L. variabilis* are the former's "larger size, and the much more lax spreading nature of the bracts." These characters do not appeal to me as worthy of specific rank.

Two very interesting and exceptional impressions of isolated sporophylls of this species are figured on Pl. 8. figs. 1, 2, & 3. Both are from the Middle Coal Measures of the Kent Coalfield.

No. 2242 *. Fig. 1, Pl. 8, shows one example, natural size, and the same organ is shown enlarged twice in fig. 2. The lamina of the sporophyll is seen on the right, and on the left the sporangium. The ligule can be clearly seen between the two organs. The structure seen on the left is another sporophyll, and not the axis. The sporangium measures 10 mm. radially and is about 6 mm. high.

No. 3201. In another example shown on Pl. 8. fig. 3 (natural size), the sporophyll is still attached to the axis. The sporangium here measures 7.5 mm. across and 4.5 mm. high.

Cones of the *Lepidostrobus variabilis* type are known to have been borne by several stem-species of *Lepidodendron*, viz.:—

Lepidodendron lycopodioides, Sternb. (including *L. lanceolatum*, Lesq.).

L. ophiurus, Brongn.

? *L. loricaum*, Arber.

Types. Lindley and Hutton's in the Hancock Museum, Newcastle-on-Tyne.

Distribution. Known from all horizons in the Coal Measures and from nearly all coalfields.

LEPIDOSTROBUS RUSSELLIANUS, Binney.

1871. *Lepidostrobus Russellianus*, Binney, in Pal. Soc. (Observ. Struct. Foss. Plants, Part II.), p. 51, pl. 9. figs. 1, 1 a, 2, & 2 a.

1871. *Lepidostrobus* (?) *dubius*, Binney, *ibid.*, p. 52, pl. 9. figs. 3 & 3 a.

1871. *Lepidostrobus tenuis*, Binney, *ibid.*, p. 53. pl. 9. figs. 4 & 4 a.

1871. *Lepidostrobus levidensis*, Binney, *ibid.*, p. 54, pl. 10. figs. 1, 1 a, & 1 b.

1912. ? *Lepidostrobus* cf. *Russellianus*, Vernon, in Quart. Journ. Geol. Soc. vol. lxxviii. p. 621, pl. 59. fig. 1.

* The numbers refer to the Carboniferous Plant Collections, Sedgwick Museum, Cambridge.

Diagnosis.—Cones similar to those of *L. variabilis*, Lindl. & Hutt., but heterosporous.

Remarks.—It may be questioned whether heterospory is a sufficiently important character to act as a specific index by itself. I am, however, inclined to maintain Binney's species chiefly on the grounds of convenience.

Type. No. 471. Carbon. Plant Coll., Sedgwick Museum, Cambridge. Also 472 (*Lepidostrobus* ? *dubius*, Binney).

Distribution. Lower and ? Middle Coal Measures.

Lower Coal Measures :—Blackband Ironstone near Airdrie, Lanarkshire.

Middle Coal Measures :—Thick Coal, Chilvers Coton, Warwickshire.

Subgenus ORTHOLEPIDOSTROBUS, n. n.

LEPIDOSTROBUS BREVIFOLIUS (Lesq.). (Pl. 8. figs. 4, 5, 6, 7, 8.)

Sporophylls detached.

1858. *Lepidophyllum brevifolium*, Lesq., in Rogers, Geol. Pennsylv. vol. ii. pt. 2, p. 876, pl. 17. fig. 6.

1879-80. *Lepidophyllum brevifolium*, Lesq., Coal Flora Pennsylv. p. 447, pl. 69. fig. 33.

1888. *Lepidophyllum* sp., Kidston, in Trans. Roy. Soc. Edinb. vol. xxxiii. pt. 2, p. 395, pl. 27. figs. 7 a, 7 b.

1912. *Lepidophyllum brevifolium*, Arber, Phil. Trans. Roy. Soc. ser. B, vol. ccii. p. 252.

Diagnosis.—Sporophylls small, up to 1·8 cm. in length and 7-12 mm. across at the greatest width. Pedicel extremely narrow, keeled, very elongately wedge-shaped, about 8-10 mm. long. Lamina shortly triangular, often nearly equilateral, lower angles somewhat incurved towards the pedicel, about 7 to 12 mm. broad at the base, which is usually the broadest part.

Remarks.—The sporophylls of this species are, with exception of the specimen figured here, not yet known attached to the cone axis.

No. 1249. The specimen figured on Pl. 8. fig. 4, natural size, and enlarged twice on Pl. 8. fig. 5, is a medium-sized example of a detached sporophyll. The whole length of the pedicel is probably not disclosed. The region has a distinct keel.

No. 1250. Another not very perfect specimen is shown on Pl. 8. fig. 7, natural size. The pedicel here has a broad expansion on either side of the keel, and this may possibly be a flattened sporangium.

No. 1257. One of the largest examples known to me is shown natural size on Pl. 8. fig. 8. This sporophyll exceeds 17 mm. in length and 10 mm. in breadth. What appear to be traces of a sporangium are seen around the keel of the pedicel.

No. 1266. On Pl. 8. fig. 6 a specimen is shown natural size in which several sporophylls appear to be attached to an axis. The impression, however, is not very clear, and the laminas are alone distinctly seen.

Distribution. Horizon: Upper Coal Measures.

Coalfields:—Somerset—Bristol; Radstock Series at Radstock, Timsbury, etc. Forest of Dean, Park Gutter Colliery (Yorkley Coal).

LEPIDOSTROBUS HASTATUS, Lesq. (Pl. 8. figs. 9 & 10.)

Sporophylls attached and detached.

1858. *Lepidophyllum hastatum*, Lesq., in Rogers, Geol. Pennsylv. vol. ii. pt. 2, p. 876, pl. 17. fig. 7.

1866. *Lepidostrobus hastifolius*, Lesq., Geol. Surv. Illinois, vol. ii. Palæontol. p. 456.

1879-80. *Lepidostrobus hastatus*, Lesq., Coal Flora Pennsylv. p. 438, pl. 69. figs. 27 & 28.

Diagnosis.—Cone small, ovate. Sporophylls small, hastate, up to 2.5 cm. long and 7 mm. across at their greatest width. Pedicel wedge-shaped, narrow, about 1 cm. in length. Lamina about 1-1.5 cm. long and 5-7 mm. across at the base, all angles, especially the lateral, acute.

Remarks.—The present is the first British record of the species, and the only specimens so far known are detached sporophylls. Lesquereux has, however, figured a cone of this species. An excellent specimen from the Transition Coal Measures of Kent is seen on Pl. 8. fig. 9, natural size. Another example from the Upper Coal Measures of the Somerset Coalfield is seen slightly enlarged on Pl. 8. fig. 10.

Distribution. Upper and Transition Coal Measures.

Upper Coal Measures.

Coalfield:—Somerset—Bristol, Coal Pit Heath, Bristol.

Transition Coal Measures.

Coalfield:—Kent, Bishopbourne Boring.

LEPIDOSTROBUS INTERMEDIUS (Lindl. & Hutt.). (Pl. 8. figs. 11, 12, 13.)

Sporophylls detached.

1831. *Lepidophyllum intermedium*, Lindl. & Hutt., Foss. Flora, vol. i. pl. 43. fig. 3.

1877. *Lepidophyllum lanceolatum*, Lebour., Illustr. Fossil Plants, p. 105, pl. 53.

1870-72. *Lepidophyllum intermedium*, Schimp., Traité Pal. Végét. vol. ii. p. 72.

1890. *Lepidophyllum majus*, Renault, Flore Foss. Terr. Houill. Commentry, pt. 2, p. 516, pl. 59. figs. 8-9.

1904. *Lepidophyllum majus*, Zalessky, in Mém. Com. Géol. St. Pétersbourg, N. S. Livr. 13, p. 104, pl. 7. fig. 6.

Sporophylls attached.

1916. *Lepidostrobus intermedius*, Arber, in Phil. Trans. Roy. Soc. ser. B, vol. ccviii. p. 146, pl. 4, fig. 21.

Diagnosis.—Cone large, short, cylindrical, about 2-3 cm. in diameter. Sporophylls large, 3-9 cm. in length, narrowly lanceolate, uninerved, faintly striated; striæ radiating, and not extending to apex. Apex acuminate.

Remarks.—The sporophylls of this species, hitherto only known in the detached state, were recently figured by the author from South Staffordshire,

still in continuity with the axis. In the specimen in question the sporophylls were rather small (only 3–4 cm. long), whereas they are usually about 6 cm. in length and may even attain to 9 cm. Several cones with larger sporophylls still attached are figured here from Dr. Moysey's collection from the Middle Coal Measures of Derbyshire. In each case the laminae of the sporophylls are narrowly lanceolate, not more than 3 mm. broad, and the apex is markedly acuminate. These seem to be the chief characters of the species.

No. 4014. On Pl. 8. fig. 11 a cone is seen, natural size, showing the external surfaces of markedly acuminate sporophylls. Below the cone is broken across radially and shows two sporangia on each side of the axis. The length of the lamina of the sporophyll is 7.3 cm. and that of the pedicel exceeds 7 mm.

No. 4015. Another cone, also fractured obliquely below, is figured natural size on Pl. 8. fig. 12. Here the lamina exceeds 4 cm. in length and the pedicel is at least 8 mm. long.

No. 4016. A further cone with sporophylls attached is seen on Pl. 8. fig. 13. The sporophylls are here very clearly seen. They are between 4–5 cm. in length and the greatest breadth is about 5 mm.

Type. Lindley and Hutton's in the Hancock Museum, Newcastle-on-Tyne.

Distribution. Lower to Transition Coal Measures.

Transition Coal Measures.

Coalfields:—Le Botwood. Shrewsbury. Warwickshire.

Middle Coal Measures.

Coalfields:—Kent. South Staffordshire. ? Notts and Derby.

Lower Coal Measures.

Coalfields: Notts and Derby. Lanarkshire.

LEPIDOSTROBUS LANCEOLATUS (Lindl. & Hutt.). (Pl. 8. figs. 14, 15, 16, 17.)

Sporophylls detached.

1831. *Lepidophyllum lanceolatum*, Lindl. & Hutt. vol. i. pl. 7. figs. 3–4.

1855. *Lepidophyllum lanceolatum*, Geinitz, Vers. Steinkohlenf. Sachsen, p. 50, pl. 2. fig. 8.

1858. *Lepidophyllum lanceolatum*, Lesq., in Rogers, Geol. of Pennsylv. vol. ii. pt. 2, p. 875, pl. 17. fig. 1.

1868. *Lepidophyllum lanceolatum*, Roehl, Foss. Flora Steink. Form. Westphal. in Palæontogr. xviii. p. 141, pl. 28. fig. 10.

1879–80. *Lepidostrobus lanceolatus*, Lesq., Coal Flora Pennsylv. p. 436, pl. 59. fig. 38.

1886–88. *Lepidophyllum lanceolatum*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 505, pl. 77. fig. 7.

1899. *Lepidophyllum lanceolatum*, Zeiller, Étude Flore Foss. Bass. Houill. Héracée, p. 75, fig. 11 on p. 50.

1900. *Lepidophyllum lanceolatum*, Zeiller, Éléments Palæobot. p. 187, fig. 129.

1904. *Lepidophyllum lanceolatum*, Zalessky, in Mém. Com. Géol. St. Pétersb., N.S. Livr. 13, p. 104, pl. 6. fig. 2; pl. 7. fig. 10.
 1907. *Lepidophyllum lanceolatum*, Zalessky, in Bull. Com. Géol. St. Pétersb. vol. xxvi. No. 134, p. 384, pl. 13. fig. 12.
 1907. *Lepidophyllum lanceolatum*, Zalessky, *ibid.* vol. xxvi. p. 438, pl. 18. fig. 7.
 1911. *Lepidophyllum lanceolatum*, Kidston, in Mém. Mus. Roy. Hist. Nat. Belgique, vol. iv. p. 153.

Sporophylls attached.

1855. ? *Sagenaria dichotoma* (= *Lepidostrobus lepidophyllaceus*), Geinitz, Vers. Steinkohlenf. Sachs. p. 34, pl. 2. fig. 7.
 1870. *Lepidostrobus oblongifolius*, Lesq., Geol. Rep. Illinois, vol. iv. p. 441, pl. 30. figs. 3, 3 b.
 1879-80. *Lepidostrobus oblongifolius*, Lesq., Coal Flora Pennsylv. vol. ii. p. 437, pl. 69. fig. 29.
 1886-88. *Lepidophyllum lanceolatum*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 505, pl. 77. fig. 8.
 1899. *Lepidostrobus variabilis*, Hofmann & Ryba, Leitpflanzen, p. 86, pl. 16. fig. 6.

Diagnosis.—Sporophyll lanceolate, or slightly ovate-lanceolate, between 4 and 5 cm. long and 5-10 mm. (usually 7 or 8 mm.) broad at its widest part. Lamina acute and sometimes distinctly acuminate. Pedicel about 1 cm. long, wedge-shaped, lower angle acute. Nerve often broad, prominent.

Remarks.

V. 2944. A specimen from the British Museum (Nat. Hist.), from the Upper Coal Measures of Somerset, is figured natural size on Pl. 8. fig. 14. It shows the laminas of several sporophylls of the broader type very clearly.

No. 2415. A small sporophyll from the Transition Coal Measures of Kent is figured natural size on Pl. 8. fig. 15. The tip of the apex is not seen. This sporophyll exceeds 4 cm. in length, but is only 6 mm. across at its greatest width.

No. 2904. Another large sporophyll from the Middle Coal Measures of Pembrokeshire is seen natural size on Pl. 8. fig. 16. It exceeds 4.8 cm. in length, the tip not being disclosed, and is 7 mm. across at its widest part.

No. 2417. The base of a sporophyll from the Transition Coal Measures of Kent is shown enlarged on Pl. 8. fig. 17 to illustrate the pedicel in this species.

Type. Lindley and Hutton's in Hancock Museum, Newcastle-on-Tyne.

Distribution. Lower to Upper Coal Measures.

Upper Coal Measures.

Coalfields:—Radstock. South Staffordshire.

Transition Coal Measures.

Coalfields:—Kent. Wyre Forest South. North Staffordshire. South Lancashire.

Middle Coal Measures.

Coalfields:—Kent. South Welsh. Pembrokeshire. Wyre Forest North (Lower). North Staffordshire. Notts and Derby. Yorkshire. South Lancashire. Fife.

Lower Coal Measures.

Coalfields:—North Staffordshire. South Lancashire. Newcastle-Durham. Ayrshire. Lanarkshire.

LEPIDOSTROBUS LONGIBRACTEATUS (Prestw.) *. (Pl. 8. figs. 18 A & B, and 19 A & B.)

1840. *Lycopodites ? longibracteatus*, Prestwich, in Trans. Geol. Soc. ser. 2, vol. v. p. 488, pl. 38. figs. 9-11.

Diagnosis.—Axis 3-5 mm. in diameter. Lamina of sporophyll about 5 cm. long by 8 mm. in width at widest part; apex acute; fairly prominent midrib; closely parallel lateral veins meeting the midrib at an acute angle. Pedicel of sporophyll broadest at junction with lamina; greatest width apparently about 6 mm. and length 6-8 mm. Sporangium about 4-6.5 mm. long by 2-4.5 mm. high.

Remarks.—This is the cone of *Lepidophloios acerosus* (Lindl. & Hutt.), found by Prestwich in continuity with that stem. So far as I am aware, this species has not been described since. It is nearly allied to *Lepidostrobus intermedius* (Lindl. & Hutt.) and *L. lanceolatus* (Lindl. & Hutt.), but I think it is probably distinct from both these species. Williamson (Organisation, etc., pt. 19, 1893, pl. 8. fig. 54) refigures Prestwich's type by means of a very inadequate drawing, and also figures another specimen, from Aber Sychan (Brit. Mus. V. 4261), which he regards as belonging to the same species. It is certainly closely similar, but, if specifically identical, it represents a more massive example than the type-specimen.

Type. British Museum (Nat. Hist.), type. The type-specimens are refigured on Plate 8. figs. 18 A & B and 19 A & B. Figure 18 A shows the cone at the end of a branch (nat. size), while the cone is represented on a larger scale in fig. 18 B. Fig. 19 A shows the specimen from which Prestwich's pl. 38. fig. 9 was drawn; fig. 19 B is a photograph of the other half of the same nodule.

Distribution. Middle Coal Measures.

Coalfield:—Coalbrookdale.

* [I am mainly responsible for this section. I am indebted to Mr. W. N. Edwards of the British Museum (Nat. Hist.) for much kind help both in connection with the literature and in tracing the type-specimens.—A. A.]

LEPIDOSTROBUS MAJOR (Brongn.). (Pl. 8. fig. 20 and Pl. 9. fig. 21.)

Sporophylls detached.

1822. *Filicites (Glossopteris) dubius*, Brongn. Sur Class. Végét. Foss. p. 232 (footnote), pl. 13 (=2), fig. 4.
 1828. *Lepidophyllum majus*, Brongn. Prodr. Hist. Végét. Foss. p. 87.
 1835. *Lepidophyllum trinerve*, Lindl. & Hutt. Foss. Flora, vol. ii. pl. 152.
 1836. *Lepidophyllum glossopteroides*, Goëpp., Syst. Filic. Foss. in Nov. Act. Acad. Cæs. Leop.-Car. vol. xvii. Supp. p. 431, pl. 44. fig. 3.
 1854. *Lepidophyllum majus*, Geinitz, Flora Hainschen-Ebersdorf. p. 55, pl. 14. figs. 12-14.
 1855. *Lepidophyllum majus*, Geinitz, Verstein. Steinkohlenform. Sachsen, p. 37, pl. 2. fig. 5.
 1862. *Fruchtblatt von Lepidophloios laricinus*, Goldenberg, Flora Saraepon. Foss. Heft 3, pp. 34 & 45, pl. 15. fig. 5.
 1870. *Lepidophyllum majus*, Schimp., Traité Pal. Végét. vol. ii. p. 72, pl. 61. fig. 8?; pl. 64. fig. 9.
 1871. *Lepidophyllum majus*, Feistmantel, Abhandl. K. Böhm. Gesell. Wissen. VI. Folge, Band v. p. 31, pl. 1. figs. 2-3.
 1845-75. *Lepidophyllum majus*, Feistmantel, Palæontogr. vol. xxiii. p. 41, pl. 42. figs. 2-4 (? fig. 1).
 1877. ? *Lepidophyllum binerve*, Lebour, Illustr. of Fossil Plants, p. 103, pl. 52.
 1901. *Lepidophyllum* (? *Lepidostrobus*) *majus*, Kidston, in Trans. Nat. Hist. Soc. Glasgow, N. S. vol. vi. pt. 1, p. 63, fig. 9.
 1911. *Lepidophyllum majus*, Kidston, in Mém. Mus. Roy. Hist. Nat. Belgique, vol. iv. p. 154.
 1912. *Lepidophyllum majus*, Arber, in Phil. Trans. Roy. Soc. ser. B, vol. ccii. p. 251.

Diagnosis.—Sporophylls very large, up to 12 cm. long, rarely less than 10 cm. in length, and almost 1.5 cm. broad, lanceolate, acuminate, with a prominent median nerve in the lower part and a very marked groove above. Pedicel wedge-shaped, about 2 cm. long and 1 cm. across at its widest part.

Remarks.—No examples of these sporophylls attached to an axis are known from Britain. Dr. David White, however, in his "Fossil Flora of the Lower Coal Measures of Missouri" (Monogr. 37, U.S. Geol. Survey, 1899), has figured (pl. 60) a cone *Lepidostrobus missouriensis*, D. White, with very similar sporophylls apparently attached to an axis. The sporophylls are more oval-lanceolate (2 cm. broad) than in *L. major*. While the two species may be distinct, the American specimen appears to leave little doubt that the organs known as *L. major* were sporophylls and not leaves.

No. 2076. An almost perfect sporophyll of this species from the Bristol Coalfield is figured on Pl. 8. fig. 20, nat. size. It measures 11 cm. in length, and 1.4 cm. across at its widest part. In the centre of the lamina there are two parallel and rather broad ridges rather distant from one another and separated by a shallow groove. The basal angles of the lamina are slightly eared.

No. 3830. On Pl. 9. fig. 21 part of the pedicel of a sporophyll of this species is shown, enlarged three times to exhibit the reticular network which

is sometimes seen in this region, and which may represent the carbonised sporangial wall.

Distribution. Lower to Upper Coal Measures.

Upper Coal Measures.

Coalfields:—Radstock-Bristol. Forest of Dean.

Middle Coal Measures.

Coalfields:—Notts and Derby. Yorkshire. South Lancashire.

Lower Coal Measures.

Coalfields:—South Lancashire.

LEPIDOSTROBUS MINOR (Goode). (Pl. 9. figs. 22, 23, 24, 25.)

Sporophylls detached.

1913. *Lepidophyllum minus*, Goode, in Quart. Journ. Geol. Soc. vol. lxi. p. 266, pl. 28. figs. 3 & 5.

1914. *Lepidophyllum minus*, Arber, in Quart. Journ. Geol. Soc. vol. lxx. p. 78.

1914. *Lepidophyllum brevifolium*, Arber, in Phil. Trans. Roy. Soc. ser. B, vol. cciv. p. 386.

Diagnosis.—Sporophyll small, sagittate, up to 15 mm. long and 5–7 mm. wide at the broadest part. Pedicel slender, elongately wedge-shaped, 5–7 mm. long and 2–3 mm. wide at the broadest part. Lamina short, triangular, nearly equilateral, about 1 cm. long, lower angles somewhat recurved towards the pedicel.

Remarks.—This species stands near to *L. brevifolius*, but the pedicel is larger, the lateral margins straighter, and the angles are more acute. The basal angles of the pedicel are more prolonged and curved downwards.

The specimens from the Wyre Forest which in 1914 I attributed to *Lepidophyllum brevifolium* should be included under this species.

Nos. 2902, 2903. One of the type-specimens from Pembrokeshire is refigured (natural size) on Pl. 9. figs. 22 & 23.

Other specimens from the Kent coalfield are figured on Pl. 9. figs. 24 and 25, both natural size.

No. 2448. Fig. 24 is a small example, only 12 mm. long.

No. 2295. Fig. 25 shows a larger specimen 18 mm. long, and a very broad example 9 mm. across.

Type. No. 2902–3. Carbon. Plant Coll., Sedgwick Museum, Cambridge.

Distribution. Middle Coal Measures.

Coalfields:—Kent. Pembrokeshire. Wyre Forest North (Lower).

LEPIDOSTROBUS MOYSEYI, sp. nova. (Pl. 9. figs. 26 & 27.)

Diagnosis.—Sporophyll small, 3 cm. long and 8 mm. broad, shovel-shaped, apparently concave; lamina 2.2 cm. long, triangular; base nearly straight;

pedicel very narrowly and elongately wedge-shaped, 8 mm. long. Apex bluntly acute.

Remarks.—This rare type in Dr. Moysey's collection is figured on Pl. 9. fig. 26, natural size, and nearly twice enlarged in fig. 27. In the shape of the lamina it appears to me to differ from any other sporophyll known to me, though it may approach to Lesquereux's *L. ovatifolius* ('Coal Flora,' vol. ii. p. 438, pl. 69. fig. 32).

Type. No. 4018. Carbon. Plant Coll., Sedgwick Museum, Cambridge.

Distribution. Middle Coal Measures.

Coalfields :—Notts and Derby.

LEPIDOSTROBUS RADIANUS, Schimper. (Pl. 9. figs. 28, 29, 30, 31.)

Sporophylls attached.

1838. *Lepidostrobos* sp., Brongn., Hist. Végét. Foss. vol. ii. pl. 23. fig. 6.

[— *Conophoroides anthemis*, König, Icones Foss. Sectil.† pl. 13. fig. 200.]

1870. *Lepidostrobos radians*, Schimp., Traité Pal. Végét. vol. ii. p. 63.

1899. ? *Lepidophyllum Jenneyi*, White, Monogr. 37, U.S. Geol. Surv. p. 214, ? pl. 59. fig. 1 a.

1901. *Lepidostrobos anthemis*, Kidston, in Trans. Nat. Hist. Soc. Glasgow, N. S. vol. vi. p. 62, fig. 8.

Sporophylls detached.

*1899. *Lepidophyllum Jenneyi*, White, Monogr. 37, U.S. Geol. Surv. p. 214, pl. 59. fig. 1 b, fig. 2; ? pl. 63. fig. 6.

Diagnosis.—Dimensions and shape of cone unknown. Sporophylls small or of medium size, broadly elliptical, length 1·5–2 cm., usually about 2 cm., greatest breadth 7–10 mm., usually about 8 cm. Pedicel similar in shape to the lamina, but usually distinctly shorter.

Remarks.—This cone is distinctly rare in Britain. No specimen of the complete cone, seen in surface-view, is known. A very few examples of what is practically a transverse section of the cone have been found, with the sporophylls all spread out in one plane, and also of detached sporophylls.

This cone has hitherto been known as *Lepidostrobos anthemis*, König. König's memoir, entitled "Icones Fossilium Sectiles," was, however, never published, though copies were widely distributed about the year 1851 on the death of the author. The lack of formal publication appears to me to render invalid the new generic and specific names contained in this memoir, and it is therefore necessary to fall back on Schimper's *Lepidostrobos radians*, expressly proposed for the specimen originally figured without specific determination by Brongniart.

No. 67. On Pl. 9. fig. 28 several sporophylls are seen, natural size, still attached to an axis.

* Indicates figures of typical examples.

† This memoir was never published, see Bibliography, 19.

No. 78. A single sporophyll 2 cm. long is shown, natural size, on Pl. 9. fig. 29. The pedicel here appears to be only a little smaller than the lamina.

No. 81. A still larger specimen, also figured natural size on Pl. 9. fig. 30, is 2.3 cm. long, and the lamina is distinctly larger than the pedicel.

No. 65. A smaller and narrower specimen is shown on Pl. 9. fig. 31, natural size.

Distribution. Middle to Transition Coal Measures.

Transition Coal Measures.

Coalfields :—North Staffordshire. South Lancashire.

Middle Coal Measures.

Coalfields :—Pembrokeshire. Yorkshire. South Lancashire.

LEPIDOSTROBUS TRIANGULARIS (Zeiller). (Pl. 9. figs. 32 & 33.)

Sporophylls detached.

1886-88. *Lepidophyllum triangulare*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 508, pl. 77. figs. 4 & 5.

1897. *Lepidophyllum Pichleri*, Kerner, in Jahrb. k.k. Geol. Reichsanst. vol. xlvii. Heft 2, p. 383, pl. 10. figs. 1-2.

Sporophylls attached.

1910. *Lepidostrobus triangularis*, Arber, in Proc. Yorks. Geol. Soc. vol. xvii. pt. 2, p. 149, pl. 16. fig. 3.

Diagnosis.—Cone cylindrical, rather small, 7 or more cm. long and about 2 cm. across. Sporophyll markedly hastate. Pedicel wedge-shaped, smaller than the lamina, 5-8 mm. long, 3-5 mm. broad at its widest point, with a single nerve. Lamina triangular, the sides somewhat concave, lower angles prolonged, acute, somewhat turned inwards towards the pedicel, 12-15 mm. long, 8-12 mm. broad at the base, sharply pointed at summit, with a single median nerve.

Remarks.—This is an infrequent type in Britain, and the sporophylls usually occur detached. The only known specimen of a nearly complete cone of this species is one collected by Dr. Moysey, which I figured some years ago from the Middle Coal Measures of Derbyshire, and which is figured here natural size on Pl. 9. figs. 32 A & B. The cone was a small one, about 7 cm. in length and 2 cm. across at its widest point. The late Professor Zeiller, who saw this specimen, agreed that it was identical with his *Lepidophyllum triangulare*. Part of the stalk of the cone is seen at the base of this specimen, but this organ is incompletely preserved, and it is thus impossible to say whether this cone should be attributed to a *Lepidodendron* or a *Sigillaria*. In some respects the sporophylls recall those of certain species of *Sigillariosirobus*.

Dr. Kidston (18. p. 136) has recently concluded that *L. triangularis* is closely related to the species here termed *L. radians*, Schimper, and, "if really distinct from it, differs only in the sides of the bracts being perhaps somewhat more concave." To my mind, however, these two species are quite distinct in the shape of the sporophyll as a whole, and especially in the dissimilarity in the size and shape of the lamina and pedicel, and in the prolongation of the lateral angles of the former, as a comparison of figs. 28-31 with figs. 32 and 33 will show.

On Pl. 9. fig. 33 a detached sporophyll is shown.

Type. ? Museum of École des Mines, Paris.

Distribution. Middle Coal Measures.

Coalfields:—South Welsh. South Staffordshire. North Staffordshire. Notts & Derby. Yorkshire.

Section **Sublepidostrobus.**

LEPIDOSTROBUS JACKSONI, Arber. (Pl. 9. fig. 34.)

Sporophylls attached.

1916. *Lepidostrobus Jacksoni*, Arber, in Phil. Trans. Roy. Soc. Ser. B, vol. ccviii. p. 147, pl. 4. fig. 19.

Diagnosis.—Cone of medium size, stalked, more or less club-shaped. Lower portion of sporophylls broad, scale-like, distal extremities prolonged as very narrow, elongated appendages, 4 mm. or more in length.

Remarks.—The type-specimen is refigured on Pl. 9. fig. 34, natural size. It has a length of 6.1 cm., and measures 2 cm. across at the apex, the broadest part. It contracts rather suddenly at the base. Only a portion of the lamina is seen, the lower part being broad but suddenly contracted above into long awn-like prolongations.

Type. No. 3250. Carbon. Plant Coll., Sedgwick Museum, Cambridge.

Distribution. Middle Coal Measures.

Coalfield :—South Staffordshire.

LEPIDOSTROBUS (?) SPINOSUS, Kidst. (Pl. 9. fig. 35.)

Sporophylls attached.

1838. *Lepidostrobus* sp., Brongn., Hist. Végét. Foss. vol. ii. p. 49, pl. 22. figs. 2, 3, & 8.

1888. *Lepidostrobus spinosus*, Kidston, in Trans. Roy. Soc. Edinb. vol. xxxiii. p. 396.

1893. *Lepidostrobus (?) spinosus*, Kidston, in Trans. Roy. Soc. Edinb. vol. xxxvii. pt. 2, p. 341, pl. 2. fig. 7, pl. 3. figs. 11 & 12.

Diagnosis.—Cone oblong and tapering to its blunt apex; bracts lanceolate, acute, single-veined, adpressed, rigid; external extremities of sporangia rhomboidal (Kidston, 1893).

Remarks.—The sporophylls of this rare type are very incompletely known. From Brongniart's figure it would appear that, as in *L. Jacksoni*, the laminae are distally contracted into narrow spines. The characters of the pedicel and the proximal portions of the lamina, which appear to differ from those of *L. Jacksoni*, are, however, obscure or unknown, and until these can be studied the specific value of this fossil must remain doubtful.

Kidston's type-specimen is refigured on Pl. 9. fig. 35, natural size.

Type. In Dr. Kidston's Collection, Stirling.

Distribution. Lower to Upper Coal Measures.

Upper Coal Measures.

Coalfield :—Radstock—Bristol.

Lower Coal Measures.

Coalfield :—Ayrshire.

EXPLANATION OF THE PLATES.

All the figures are from photographs by Mr. W. Tams of Cambridge; unless otherwise stated, the specimens figured are in the Sedgwick Museum, Cambridge. The numbers given refer to the Carboniferous Plant Collections in that Museum.

PLATE 8.

- Fig. 1. *Lepidostrobus variabilis*, Lindl. & Hutt. Middle Coal Measures. Wingham Boring, Kent. No. 2242. (Nat. size.)
- Fig. 2. *L. variabilis*, Lindl. & Hutt. Middle Coal Measures. Wingham Boring, Kent. No. 2242. ($\times 2$.)
- Fig. 3. *L. variabilis*, Lindl. & Hutt. Middle Coal Measures. Bishopsbourne Boring, Kent. No. 3201. (Nat. size.)
- Fig. 4. *L. brevifolius* (Lesq.). Upper Coal Measures. Upper Conygre Pit, Timsbury, Somerset. No. 1249. (Nat. size.)
- Fig. 5. *L. brevifolius* (Lesq.). Upper Coal Measures. Upper Conygre Pit, Timsbury, Somerset. No. 1249. ($\times 2$.)
- Fig. 6. *L. brevifolius* (Lesq.). ? Radstock, Camerton. No. 1266.
- Fig. 7. *L. brevifolius* (Lesq.). Upper Coal Measures. Upper Conygre Pit, Timsbury, Somerset. No. 1250. (Nat. size.)
- Fig. 8. *L. brevifolius* (Lesq.). Upper Coal Measures. Upper Conygre Pit, Timsbury, Somerset. No. 1257. (Nat. size.)
- Fig. 9. *L. hastatus* (Lesq.). Transition Coal Measures. Bishopsbourne Boring. No. 3147. (Nat. size.)
- Fig. 10. *L. hastatus* (Lesq.). Upper Coal Measures. Coal Pit Heath, near Bristol. No. 2069. ($\times$ nearly 2.)
- Fig. 11. *L. intermedius* (Lindl. & Hutt.). Middle Coal Measures. Digby Clay Pit, Kimberley, Notts. No. 4014. (Nat. size.)
- Fig. 12. *L. intermedius* (Lindl. & Hutt.). Middle Coal Measures. Brindsley Clay Pit, Langley Mills, Notts. No. 4015. (Nat. size.)
- Fig. 13. *L. intermedius* (Lindl. & Hutt.). Lower Coal Measures. Trowell Coll., Notts. No. 4016. (Nat. size.)

- Fig. 14. *L. lanceolatus* (Lindl. & Hutt.). Radstock, Somerset. British Museum. V. 2944. (Nat. size.)
- Fig. 15. *L. lanceolatus* (Lindl. & Hutt.). Transition Coal Measures. Stone Hall Boring, Kent. No. 2415. (Nat. size.)
- Fig. 16. *L. lanceolatus* (Lindl. & Hutt.). Coal Measures (? Pennant Grit). Ricket's Head, Pembroke. No. 2904. (Nat. size.)
- Fig. 17. *L. lanceolatus* (Lindl. & Hutt.). Transition Coal Measures. Stone Hall Boring, Kent. No. 2417. ($\times$ nearly 2.)
- Fig. 18. *L. longibracteatus* (Prestw.). British Museum, Natural Hist. Type-specimen [V. 3627]. Fig. 18A (Nat. size); Fig. 18B, cone ($\times$ 2).
- Fig. 19A. *L. longibracteatus* (Prestw.). British Museum, Natural Hist. Type-specimen, V. 6344 (Nat. size); Fig. 19B, counterpart of type-specimen, V. 3626 (Nat. size.)
- Fig. 20. *L. major* (Brongn.). Upper Coal Measures. Coal Pit Heath Colliery, near Bristol. No. 2076. (Nat. size.)

PLATE 9.

- Fig. 21. *L. major* (Brongn.). Upper Coal Measures. Bishop Sutton Colliery, Somerset. No. 3830. Pedicel ($\times$ 3) to show network.
- Fig. 22. *L. minor* (Goode). Coal Measures (? Pennant Grit). Ricket's Head, Pembroke. No. 2902. (Nat. size.)
- Fig. 23. *L. minor* (Goode). Coal Measures (? Pennant Grit). Ricket's Head, Pembroke. No. 2903. (Nat. size.)
- Fig. 24. *L. minor* (Goode). Middle Coal Measures. Woodnesborough Boring, Kent. No. 2448. (Nat. size.)
- Fig. 25. *L. minor* (Goode). Middle Coal Measures. Maydensole Boring, Kent. No. 2295. (Nat. size.)
- Fig. 26. *L. Moyseyi*, sp. nova. Middle Coal Measures. Newthorpe Clay Pit, Notts. No. 4018. (Nat. size.)
- Fig. 27. *L. Moyseyi*, sp. nova. Newthorpe Clay Pit, Notts. No. 4018. ($\times$ nearly 2.)
- Fig. 28. *L. radians*, Schimp. Coal Measures, ? Barnsley. No. 67. (Nat. size.)
- Fig. 29. *L. radians*, Schimp. Coal Measures, ? Barnsley. No. 78. (Nat. size.)
- Fig. 30. *L. radians*, Schimp. Coal Measures, ? Barnsley. No. 81. (Nat. size.)
- Fig. 31. *L. radians*, Schimp. Coal Measures, ? Yorkshire. No. 65. (Nat. size.)
- Fig. 32A. *L. triangularis* (Zeiller). Shipley, Notts. Moysey Collection. No. 3976. (Approximately nat. size.)
- Fig. 32B. Lower part of other half of same nodule as fig. 32A, showing some detached sporophylls. (Nat. size.)
- Fig. 33. *L. triangularis* (Zeiller). Detached sporophyll from Holly Hill. No. 201, Sir Charles Holcroft Collection, Geol. Dept., University of Birmingham. (Nat. size.)
- Fig. 34. *L. Jacksoni*, Arber. Between Bottom and New Mine Coals, Pouk Hill, Walsall. No. 3250. (Nat. size.)
- Fig. 35. *L. (?) spinosus*, Kidston. After Kidston, Trans. Roy. Soc. Edinb. vol. xxxvii. pt. 2, 1893: "On the Fossil Plants of the Kilmarnock Coal Fields," pl. ii. fig. 7. (Nat. size.)

1.

2 (x2).

3.

4.

10 (x2).

5 (x2) 9.

6.

7.

8.

11.

12.

13.

14.

16.

15.

17 (x2).

20.

19^A

18^B (x2).

19^B

18^A

W. Tams photo

LEPIDOSTROBUS

II. *LEPIDODENDRON LYCOPODIODES*, Sternb., *L. OPHIURUS*, Brongn.,
and *L. LORICATUM*, *sp. nova*.

1. INTRODUCTION.

In the course of time, as the study of impressions of Coal-measure plants progresses, it has sometimes happened that doubts have arisen as to the exact nature of well-known species, which hitherto have been accepted almost without question. At first a mere suspicion arises as to whether such and such a plant is really identical with some ancient type in particular, and as to what exactly are the characters peculiar to it by which it is to be distinguished from other somewhat similar but probably distinct forms. Such suspicion may increase until a stage of uncertainty is reached. Or, again, it may be borne in on the worker, as he comes to have access to an ever-increasing range of materials, that confusions have arisen between somewhat similar but perhaps distinct species. At length a time is reached when it is necessary to set these doubts at rest by means of detailed re-examinations of the particular plants in question.

In the present notes I propose from time to time to give the results of such critical revisions as have seemed to me necessary as the result of many years' taxonomic experience of Coal-measure plants.

In the present note I deal with two of our Coal-measure species of *Lepidodendron*—*L. lycopodioides*, Sternb., and *L. ophiurus*, Brongn.,—both of very common occurrence, and also with a third type, which it is proposed here to term *L. loricatum*, *sp. nova*.

It appears to me that *L. ophiurus* has been largely confounded with *L. lycopodioides*, Sternb., and *vice versa*. Yet I hope to be able to show here that no grounds for such a confusion exist.

Two facts of importance may first of all be emphasised here. The first of these is that the only characters which are of any critical value as a means of discriminating species of *Lepidodendroid* stems are those exhibited by specimens showing the true external features of the leafless stems in question. This fact is, of course, widely recognised among palæobotanists, but at the same time the opinion appears to be widely held that even specimens in which only the decorticated or subepidermal characters are exhibited can also sometimes be determined specifically. Or, again, it is urged that shoots entirely clothed with leaves can be identified. With these conclusions I am unable to agree (cf. 26. p. 150). I reject specific conclusions founded on such evidence.

Secondly, there appears still to be a considerable confusion as to the detailed morphology of the persistent leaf-armour of such stems, the units of which, in the leafless stems, are best described as leaf bases, though some prefer the term "leaf cushions." The matter is also frequently complicated by

the effects of crushing before or since preservation and by growth-changes which took place after the leaves were shed but before fossilisation. These questions are worthy of re-examination on a broad comparative basis not confined to a few species, and involving the study of a large suite of materials. I do not propose to enter into this complicated subject here, except in regard to a single point in connection with the leaf scar, which has a particular significance in the case of the species of *Lepidodendra* which are here particularly in question. According to my view, the leaf scar is that portion of the leaf base which marks the point of the actual union of the part of the leaf which was normally and naturally shed, when it had reached a particular stage in its development, with that part of the leaf which remained permanently attached to the shoot.

The sole characters which can be made use of in discriminating species of Lepidodendroid stems relate to the size, shape, and general characteristics of the leaf base as a whole and that particular region of the leaf base which we term the leaf scar. In the majority of British and Westphalian species, as is well known, the leaf scar is a perfectly definite area, usually clearly marked and more or less rhomboidal or triangular in shape. On well-preserved examples of the outer surface of the leaf bases, the prints of the vascular trace and the parichnos can usually be clearly distinguished within the leaf scar. In some, but not all, species, subparichnoid prints may occur beneath the leaf scar. Species of *Lepidodendron*, however, vary among themselves as regards the exact size and shape of the leaf scar and its position on the leaf base.

But the point which I wish to emphasize here is that, in at least one British species, the leaf scar is of an entirely different nature. It is not a superficial area, but a mere slit, transverse, more or less curved, and exhibits no prints comparable to the leaf trace and parichnoid prints of the more typical leaf scars.

It may be recalled that exactly the same phenomenon is met with in the Palæozoic genus *Cordaites* (12. pl. 27). Here, in perhaps the majority of cases, the leaf scar is very short, slit-like, and non-print-bearing. But other cases occur in which the leaf scar has a considerable height as well as breadth, and here the row of leaf-trace prints may be often seen.

In the case of *L. ophiurus*, Brongn., and *L. lycopodioides*, Sternb., which seem to me to have been considerably confused, the form of the leaf scar is alone sufficient to distinguish the species. *L. ophiurus* has, as I hope to show here, a superficial well-marked triangular scar, whereas *L. lycopodioides* has a mere slit. I commence by a re-examination of the characters of these two species, since here clearly lies the root of the difficulty.

It is a curious fact that, although both these species are such common plants in the Coal Measures of Britain and on the Continent, they have been comparatively rarely figured,

I now propose to instance the figured examples of these plants which have been already published, whether correctly or incorrectly assigned, with critical notes on each figure, and afterwards to add diagnoses founded on these and other specimens.

2. *LEPIDODENDRON LYCOPODIOIDES*, Sternb.

(Pl. 10. figs. 1-9; Pl. 11. figs. 10-17; Pl. 12. figs. 18-22.)

Revised synonymy of *Lepidodendron lycopodioides*, Sternb. :—

1820. *Lepidodendron dichotomum*, Sternb., Vers. Darstell. Flora Vorwelt, pt. 1, p. 23, pls. 1, 2.
 1821. *Lepidodendron lycopodioides*, Sternb., Vers. Darstell. Flora Vorwelt, pt. 2, pp. 26, 31, pl. 16. figs. 1, 2, & 4.
 1821. *Lepidodendron selaginoides*, Sternb., *ibid.* pt. 2, pp. 26, 31, pl. 16. fig. 3; pl. 17. fig. 1.
 1828. *Lycopodiolites selaginoides*, Bischoff, Kryptogam. Gewächse, p. 117, pl. 13. figs. 4-5 (copy of Sternberg's figures).
 1833-34. ? *Lepidodendron selaginoides*, Lindl. & Hutt., Fossil Flora, vol. ii. pl. 113.
 1833-34. *Lepidodendron elegans*, Lindl. & Hutt., *ibid.* vol. ii. p. 118.
 1838. *Lepidodendron* sp., Brongn., Hist. Végét. Foss. vol. ii. pl. 16. figs. 1-3 (copy of Sternberg's figures).
 1858. *Lepidodendron Sternbergii*, Buckland, Geol. & Mineral. London, 3rd Edit. vol. i. p. 432; vol. ii. p. 91, pl. 75 (copy of Sternberg's figure).
 1878-79. *Lepidodendron lycopodioides*, Zeiller, Explic. Carte Géol. France, vol. iv. pt. 2, p. 111, pl. 171. fig. 1.
 1879-80. *Lepidodendron lanceolatum*, Lesq., Coal Flora Pennsylv. p. P. 369, pl. 63. figs. 3-5.
 1886-88. *Lepidodendron lycopodioides*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 464, pl. 69. figs. 2-3; pl. 70. fig. 1.
 1888. *Lepidodendron lanceolatum*, Kidston, in Trans. Roy. Soc. Edinb. vol. xxxiii. p. 394, pl. 27. fig. 5, pl. 28. figs. 3-4.
 1903. *Lepidodendron lycopodioides*, Arber, in Quart. Journ. Geol. Soc. vol. lix. p. 12, pl. 2. fig. 5.
 1903. *Lepidodendron lycopodioides*, Kidston, in Trans. Roy. Soc. Edinb. vol. xl. pt. 4, p. 795.
 1903. *Lepidodendron lycopodioides*, Arber, in Mem. & Proc. Manchester Lit. & Phil. Soc. vol. xlviii. No. 2, p. 18, and text-fig. on p. 19.
 1904. *Lepidodendron ophiurus*, Zalessky, in Mém. Com. Géol. St. Pétersbourg, N. S. Livr. 13, pp. 23 & 95, pl. 5. fig. 3.
 1909. *Lepidodendron lycopodioides*, Arber, Fossil Plants, p. 67, and fig. on p. 9.
 1910. *Lepidodendron ophiurus*, Renier, Doc. Étude Pal. Terr. Houill. p. 13, pl. 6. figs. b & c.
 1912. *Lepidodendron lanceolatum*, Arber, in Phil. Trans. Roy. Soc. ser. B vol. ccii. p. 250, pl. 12. fig. 14.
 1914. *Lepidodendron lanceolatum*, Arber, *ibid.* ser. B, vol. cciv. p. 402, pl. 28. fig. 26.

Remarks on the Specimens previously figured.

Of the figures of Sternberg's types (1821) of *L. lycopodioides*, only figs. 2 and 4 of pl. 16 are important. Fig. 1 of the same plate represents a

decorticated condition. In the case of fig. 2, the leaf bases are smooth and much longer than broad. There is no definite leaf scar, but apparently a slight, very impersistent keel occurs in the upper part of the base. Fig. 4 may be neglected entirely. It is highly suspicious on the score of accuracy and is probably entirely misleading.

Turning now to the types of the same author's *L. selaginoides* (pl. 16. fig. 3 ; pl. 17. fig. 1) one finds simply two leafy stems, which, in those parts which are leafless, are more or less decorticated. The identity of *L. selaginoides*, Sternb. with *L. lycopodioides*, Sternb., is, I believe, now generally admitted (15. p. 137 ; 16. p. 795). I do not propose to discuss this matter further, since I regard it as proved that the two forms have been found in organic continuity and are therefore one and the same plant. The specimens figured by Sternberg under the name *L. dichotomum* a year earlier than the above types, have long been a puzzle to palæobotanists and will probably continue to be a stumbling-block. I do not propose to enter in detail into previous opinion as to their nature, except to add that most authorities have regarded them as distinct from both *L. lycopodioides* and *L. ophiurus* and as the type of a distinct species (*L. dichotomum*) which was first fully figured by Zeiller. My view is that the specimens figured by Sternberg, 1820, on plates 1 & 2 (except the lower left-hand figure on plate 2), are all, so far as one can judge from the leaf bases, simply typical *L. lycopodioides*. I regard them as distinct from the specimen figured under the same species by Sternberg in 1838 on plate 68. fig. 1 of the 7th part of his 'Versuch.' This plant I propose to re-name *L. loricaum* (see p. 201).

Omitting Bischoff's figure, which is simply a copy of one of Sternberg's, we next reach Lindley and Hutton's examples figured in the second volume of their 'Fossil Flora.' While I am in some doubt about their plate 113, since the leaf bases are either decorticated or imperfectly represented, the plate 118 of the same authors appears to me to represent typical leaf bases of *L. lycopodioides*. Of Zeiller's figures, one example figured in both places is decorticated. The figs. 3, 3A of the Valenciennes Flora are, however, very important, as the earliest clear example of the characters of the leaf bases of this species. It is obvious that this great authority held the same view which I hold as to the true nature of this species. In place of a leaf scar one finds a crescentic, somewhat triangular slit, while the lower part of the keel of the leaf base has small transverse notches. One of the figures of this plant which I published in 1903 from the Lancashire coalfield may be slightly decorticated, while the other from the Cumberland field, which appeared in the same year and was re-figured on a larger scale in 1909, is typical. The transverse ridges on the keel are here prominent.

With regard to Zalessky's figure (1904) it is a little difficult without seeing the specimen to feel sure as to the species which it represents, though the leaf scar appears to me to agree with *L. lycopodioides*. The keel,

however, does not appear to be ridged. The most recent figures by Renier (1911) are also similar.

Notes on the Examples of L. lycopodioides here figured.

(The numbers refer to specimens in the Carboniferous Plant Collections, Sedgwick Museum, Cambridge.)

As in other species of *Lepidodendron*, the leaf bases of this type differ greatly in size and shape, according to the age of the branch.

No. 3205. One of the specimens of this species, with the largest leaf bases with which I am acquainted of any from this horizon, is shown, natural size, on Pl. 10. fig. 1 and enlarged in fig. 2. This is a specimen from the Middle Coal Measures of the Bishopsbourne Boring, Kent, at 2513 ft. The leaf bases here measure 14.5 mm. long by 7 mm. broad. They are much less crushed than is usually the case. The lateral angles are rounded, the apex is somewhat obtuse, and the lower extremity attenuated, straight or slightly bent. The leaf scar is a transverse slit situated very high up. As is so often the case in regard to this species, the carbon of the leaf base is extremely brittle and is liable to flake off, especially in the neighbourhood of the leaf scars. Sometimes the absence of a small triangular piece of carbon in this region simulates, and may be mistaken for, a leaf scar. The lateral lines arising from the leaf scar are long and extend downwards to or just beyond the lateral angles of the base. The keel below the leaf scar is ornamented by numerous transverse ridges, especially in the lower part of its course.

No. 2754. The leaf bases of another specimen from Bond's Main Colliery, Temple Normanton, Derby (Middle Coal Measures), are illustrated on Pl. 10. fig. 3, natural size. Here the carbonaceous film has flaked off in the neighbourhood of the scar—a characteristic feature. These leaf bases measure about 14 mm. in length and 5 mm. in breadth. They are very little compressed, and the lateral lines are clear. The keel is faint or absent, and the ornamentation is slight.

No. 107. We pass now to branched examples still bearing some leaves attached. Fig. 4, Pl. 10, shows the leaf scars of such a specimen from Toronley Colliery (coalfield unknown), natural size, and Pl. 10. fig. 5, the same enlarged. The leaf bases are here 7 or 7.5 mm. long and about 3 mm. across. In most cases they are slightly decorticated by the flaking off of the carbon. The lateral lines are clear. The keel is faint, but the ornamentation consists of round or oval conspicuous projections.

No. 927. Figs. 6 & 7, Pl. 10, represent a specimen from the Middle Coal Measures of Flimby, Cumberland, which has several times been figured. The leaf bases here are very broad, quadrate, almost square, measuring 6.5 × 5.5 mm. The angles are nearly all equal. The leaf scar is almost, if not

quite, terminal. The lateral lines are faint. The keel is faintly ornamented, especially on the lower part.

No. 950. A transition from the quadrate to the fusiform types above discussed is seen in the leaf bases figured, enlarged three times, on Pl. 10. fig. 8. Here the bases measure 6 mm. long and 3.5 mm. broad. The leaf scar here has the form of an upright slit. The ornamentation is conspicuous.

No. 68. An example with small leaf bases from the Middle Coal Measures of Barnsley is figured on Pl. 10. fig. 9, enlarged three times. The leaf bases here measure 4 mm. long and 2 mm. broad. The carbon has flaked off most of the regions around the leaf scar. The keel is very faint and no ornamentation is distinguishable.

No. 106. Since it appears to have been held that the normal conditions of the leaf scar in this species is due to an accidental and unnatural fracture of the leaf, it may be well to figure an example of such an occurrence for comparison. In fig. 10, Pl. 11, some broken bases of leaves fractured unnaturally are seen enlarged. It will be noticed that the appearance in this case is quite different from those figured above, in which the leaf base, as left attached to the stem by the natural fall of the leaf, is exhibited.

Further, since this species commonly occurs in various stages of decortication, due as we have seen in the case of carbonaceous impressions to the tendency of the carbonaceous film to flake off, it may be well to figure here some examples in which the decortication is comparatively slight.

No. 3475. On Pl. 11. fig. 11, some leaf bases from the Middle Coal Measure of Bentley, South Staffordshire, are seen slightly enlarged. This is an impression in intaglio, and probably slightly decorticated. The leaf scar is here a crescentic ridge, inside the angle of which a short vertical ridge occurs. The leaf bases are here exceptional in being separated by double bands of bark.

This species is very common in ironstone nodules and bands in the Middle Coal Measures of the Midlands, usually occurring as intaglio impressions, more rarely as casts.

My experience of these fossils leads me to believe that they are almost always more or less decorticated, though the leaf bases are rarely crushed.

No. 754. Fig. 12, Pl. 11, shows (in relief) natural size leaf bases from an ironstone cast of this species from the Middle Coal Measures at Bradford, Yorkshire. In the position of the leaf scar a small pit occurs, triangular in form (isosceles with a narrow base). The keel is very strong, but shows no ornamentation.

No. 755. Fig. 13, Pl. 11, is from a wax cast of another specimen from the same locality, this time preserved in intaglio. The irregular area around the position of the leaf scar reminds one of the appearance of many

carbonaceous casts in which the carbon film has flaked off to a considerable extent.

No. 3568. Leaf bases from a wax cast of an intaglio impression from the Ten-foot Ironstone of the famous locality of Cosely, South Staffordshire, are shown on Pl. 11. fig. 14, enlarged twice.

This is a branch of small diameter with leaves still attached at the sides. The upper leaf bases are perfect, the lower are very imperfect in the neighbourhood of the leaf scar.

Nos. 3249 & 1475. Two stages in decortication of carbonaceous impressions are also figured in Pl. 11. fig. 15 and fig. 16. The former is the less decorticated.

The Case for Lepidodendron lanceolatum, Lesq.

In 1879-80 Lesquereux figured specimens from Pennsylvania under the new specific name, *L. lanceolatum*, Lesq. In 1888 Kidston recognised this type in the flora of the Upper Coal Measures of the Radstock coalfield and adopted Lesquereux's name. More recently the present author has figured other examples from the Forest of Dean and Wyre Forest fields, and from both the Upper and Transition Coal Measures. This species is, however, unknown in the Middle Coal Measures or, indeed, from any horizon lower than the Transition series. The references to the above literature will be included in the synonymy of *L. lycopodioides* given in the present paper.

As to the identity of the British specimens, figured by Kidston and myself, with Lesquereux's plant, in the absence of examples for comparison from the Pennsylvania coalfield, one cannot feel absolute certainty, though I regard it as extremely probable that they are identical. A critical re-examination of these species of *Lepidodendra* has, however, convinced me that the British plant, hitherto assigned to *L. lanceolatum*, is nothing more nor less than *L. lycopodioides*, Sternb. The leaf bases and the leaf scars are identical with those of that species. The only point in which I can find any difference is in the size of the leaf bases in certain specimens which are much larger than those of any example of *L. lycopodioides*, Sternb., known to me from the Middle Coal Measures. This, however, is immaterial, for examples of more slender specimens with leaf scars comparable in size to *L. lycopodioides* occur in abundance. I figure here three specimens from the Upper and Transition Coal Measures which vary in size only.

No. 1624. On Pl. 11. fig. 17 is shown part of a stem from the Upper Coal Measures of the Forest of Dean, some of the leaf bases of which are represented in Pl. 12. fig. 18, enlarged three times. This is one of the specimens with the largest leaf bases known to me. They measure almost 17 mm. in length by 4 mm. in breadth. The preservation is particularly perfect, though here, as in other cases, the carbonaceous film tends to flake

off, especially in the neighbourhood of the leaf scar. The keel in this instance is rather faint, except just below the leaf scar, but the ornamentation can be recognised.

No. 1986. Enlarged leaf bases of another example from the same field are seen on Pl. 12. fig. 19 ($\times 3$). Here the leaf bases are 11 mm. long. The keel is also faint, but the ornamentation is clear.

No. 2507. Leaf bases of an example from a lower horizon, Transition Coal Measures in the Wyre Forest, are shown enlarged on Pl. 12. fig. 20. They measure 8 mm. in length. The keel is faintly recognisable in some cases, but hardly at all in others.

No. 2066. On fig. 21, Pl. 12, a few leaf bases are shown, natural size, from an example from the Upper Coal Measures of the Bristol coalfield. The leaf bases here are very elongate in proportion to their breadth, measuring 13.5 mm. long and 3 mm. broad. No keel or ornamentation can be recognised. In other specimens with similar leaf bases 10 mm. long, the shoots are branched and still leafy in places.

No. 1625. This is a specimen of a more slender branch with some leaves still attached. The leaf bases are shown on Pl. 12. fig. 22, enlarged three times. They measure 7 mm. in length by 3 mm. across. The keel is very faint, if present, but the ornamentation is clear. This example is derived from the Upper Coal Measures of the Forest of Dean. Otherwise it agrees with the specimens of *L. lycopodioides* from lower horizons, already described.

I may further add that I now think that the specimen from the Transition Coal Measures of South Staffordshire recently figured by me (2. p. 145, and text-fig. 3) as *Lepidodendron* sp. is probably an old age stage of *L. lycopodioides*.

*Figured Examples incorrectly or doubtfully identified with
L. lycopodioides.*

I turn now to criticise certain specimens attributed to *L. lycopodioides*, incorrectly as it appears to me, or in some cases doubtfully.

The synonymy given by Schimper (25. ii. p. 19) seems to me to be a confusion between *L. lycopodioides* and *L. ophiurus* and yet other species, and is thus best ignored. The specimens figured on plate 51 of that author's 'Traité' alone appear to belong to the former species. This imperfect synonymy is no doubt the initial cause of the confusion which has since arisen with regard to these fossils.

List of synonyms of this species have been published by Zeiller (27. p. 464) and Kidston (16. p. 795).

With regard to the former's list I should omit the references to Renault and Brongniart's figures as relating to *L. ophiurus*. The other examples, including those then figured by Zeiller, really do represent the true *L. lycopodioides*.

Kidston's most recent synonymy (16. p. 795), which, however, pre-dates the proposal to establish *L. simile*, Jongmans, also contains the above reference to Renault, but not to Brongniart. Many of the figures here referred to simply relate to leafy branches, in which the leaf-base characters cannot be distinguished. This is the case with Kidston's own figure published in 1902 and those of Feistmantel (1875).

Diagnosis of L. lycopodioides, Sternb.

Leaf bases approximate, separated by slight grooves, rhomboidal, somewhat prominent, usually longer than broad, very varied in size, ranging up to 17 mm. in length and 4 mm. in breadth, lateral angles rounded, upper and lower extremities usually straight, more rarely slightly bent, very acute.

Leaf scar a curved triangular or semi-lenticular slit, narrower than the leaf base and placed considerably above its centre, sometimes near the apex, at others some distance below it. From the lateral extremities of this slit, two lines or ridges curve obliquely downwards to meet the margin of the leaf base, at about the level of the lateral angles. A distinct but slight keel is present, both above and below the slit, though sometimes the keel is faint, the lower keel being usually ornamented by short and slight transverse ridges, especially in the lower part of its length. No sub-parichnoid prints occur below the leaf slit.

3. LEPIDODENDRON OPHIURUS (Brongn.).

(Pl. 12. figs. 23-26.)

Revised synonymy of *Lepidodendron ophiurus* (Brongn.) :—

- 1822. *Sagenaria ophiurus*, Brongn., in Mém. Mus. Hist. Nat. vol. viii. p. 227, pl. 15 (4).
fig. 1 a-b.
- 1828. *Lycopodiolites Ophiurus*, Bischoff, Kryptogam. Gewächse, pp. 117, 131, pl. 13.
figs. 6 a, 6 b.
- 1838. *Lepidodendron elegans*, Brongn., Hist. Végét. Foss. vol. ii. p. 35 (footnote), pl. 14.
- 1838. *Lepidodendron gracile*, Brongn., *ibid.* pl. 15.
- 1848. *Lepidodendron ophiurus*, Sauveur, Végét. Foss. Terr. Houill. Belgique, pl. 59.
figs. 2 a, 2 b.
- 1878-79. *Lepidodendron gracile*, Zeiller, Explic. Carte Géol. France, vol. iv. pt. 2, p. 112,
pl. 172. fig. 2.
- 1882. *Lepidodendron lycopodioides*, Renault, Cours Bot. Foss. vol. ii, p. 14, pl. 5. fig. 8.
- 1886-88. *Lepidodendron ophiurus*, Zeiller, Flore Foss. Bass. Houill. Valenciennes,
p. 458, pl. 68. figs. 1-6.
- 1903. *Lepidodendron Glincaum*, Kidston, in Trans. Roy. Soc. Edinb. vol. xl. p. 762,
pl. 2. figs. 20, 21; pl. 4. figs. 37-40.
- 1904. *Lepidodendron ophiurus*, Zalessky, in Mém. Com. Géol. St. Pétersbourg, N. S.
Liv. 13, pp. 23, 95, pl. 5. figs. 1, 2, 4, 6.
- 1906. *Lepidodendron ophiurus*, Fischer, in Potonié Abbild. und Beschr. Foss. Pflan.
Lief. 4, No. 73 with fig.
- 1912. *Lepidodendron simile*, Vernon, in Quart. Journ. Geol. Soc. vol. lxviii. p. 621,
pl. 57. fig. 7.

Remarks on the Specimens previously figured.

Brongniart's type (1822), although not then described, was clearly figured, and the illustration on plate 15. fig. 1 *b* of that memoir can leave little doubt as to the specific nature of the specimen. The leaf bases are here rather small with a well-marked keel both above and below the leaf scar. The keel is not ornamented. The leaf scar is situated considerably above the centre of the base, and is here shown as being rhomboidal in form with a single central print. Leaves are also seen still attached to some of the leaf bases.

The same author's *L. elegans* and *L. gracile* figured in 1838, again without description, show precisely similar leaf bases, with the exception that in some cases the keel below the leaf scar is slightly but clearly notched, and that prints are only very rarely indicated within the leaf scar. The shape of the scar is, however, perfectly definite.

Sauveur's fig. 2 *b* (1848) agrees very closely with the type, but again the species remained undescribed. The first description of this species was published in 1879 by Zeiller. In the case of the cone-bearing specimen figured by this author, no enlarged drawing of the leaf bases is given, but it is clear that the leaf scar was more or less triangular in form and not slit-like.

Zeiller (1879), under the name of *Lepidodendron gracile*, L. et H., gives the first description of the plant which we here regard as *L. ophiurus*. This description, somewhat abbreviated, is as follows :—Branches slender, cushions rhomboidal, rather prominent, 3–4 times as long as wide, extremities acute, lateral angles rounded. Leaf scar placed in the uppermost quarter of the axis of the cushion, rather high than broad, with the upper angle rounded. Keel very clear, with only some very small, scarcely distinct, transverse folds. Lines of decurrence arising from the lateral angles of the leaf scar. Vascular print indistinct, placed towards the centre of the leaf scar.

Renault's figure, published in 1882 and referred to *Lepidodendron lycopodioides*, Sternb., is no doubt one of the earlier stages in the confusion which has arisen between these two species. The leaf bases agree with those of Brongniart's later figures, except that the keel is perhaps more strongly notched than in any examples previously figured. The usual prints of the leaf scar, although scarcely indicated in Renault's drawing, are duly noticed in his diagnosis. We now reach the most important figures of this plant which have yet appeared, the illustrations so well described by Zeiller in 1886–88. Reserving a few remarks on his synonymy of this species for the moment, we may notice that Zeiller figures a definite leaf scar, which is also fully described in the text. It has a single central print. The keel of the leaf base is not ornamented.

Of the specimens attributed to this species by Zalessky in 1904, the majority are correctly referred, though one or two appear to be examples of

L. lycopodioides, or perhaps of other species also. Passing by Fischer's contribution, the most recent figure of this plant is that given by Vernon under the name *Lepidodendron simile*, Jongmans.

Several examples of the cones of this species have been figured by Nathorst, Kidston, and others, but I do not propose to discuss these here, as I am solely concerned with the vegetative shoots of this plant. I would, however, point out that those recently attributed by Kidston (18. pl. 11. figs. 2 & 3) belong, in my opinion, to *L. lycopodioides*.

Notes on the Examples of L. ophiurus here figured.

No. 131. A portion of an example of this species with rather large leaf bases is figured on Pl. 12. fig. 23, natural size, and in fig. 24, enlarged. The leaf bases vary from 7·5 to 10 mm. in length, and average about 5 mm. across at their widest point. The leaf bases are separated by double bands of bark, and the lateral angles are somewhat rounded, though still distinctly angular. The upper and lower extremities are straight or slightly curved. The leaf scar lies above the centre and is, as is usually the case, very clearly marked. It occupies almost the whole width of the rib. It bears the three usual prints, often rather faintly preserved. It is comparatively tall, the upper and lateral angles being acute, while the lower angle is very obtuse or somewhat concave. The lateral lines are short and not clearly marked. The keel is faint except at the very base, and the ornamentation is either absent or very faint. There are no sub-parichnoid prints.

No. 3472. In the specimen seen enlarged three times on Pl. 12. fig. 25, the leaf bases are much smaller. They measure 4 mm. in length by 2 mm. in breadth. There is only one print of the leaf scar visible and that is central. The keel is well marked and is without ornament.

No. 3478. Another example is shown enlarged three times on Pl. 12. fig. 26. This has quite small leaf bases, as is commonly the case among the leafy twigs of this species. Here they measure 3 mm. in length by 2 mm. or a little more in breadth. They are otherwise similar to those seen in the specimen last described, except that no prints can be seen of the leaf scar.

Figured Specimens incorrectly or doubtfully identified with L. ophiurus.

It may be noticed in passing that Schimper (25. ii. p. 19) overlooked or ignored Brongniart's *L. ophiurus*. The *L. elegans* and the *L. gracile* of Brongniart are referred by him to *L. Sternbergii*, Brongn., which I regard as an error.

With regard to Zeiller's list of synonyms published in 1888, I should merely reject as doubtful the references to Sternberg's *Lycopodiolites affinis* (1826, pt. 4, pl. 56. fig. 1), Lindley & Hutton's *Lepidodendron gracile* (1831, vol. i. pl. 9), and the same authors' *L. dilatatum* (1831, vol. i. pl. 7. fig. 2).

These specimens appear to me to be all decorticated and their specific attribution doubtful.

Dr. Kidston's most recent lists (18. p. 132) of synonyms of *L. ophiurus* also contain the above references, which I should omit. There is, further, a more doubtful reference to Lindley and Hutton's *Lepidodendron Sternbergii* (1831, vol. i. pl. 4; 1834, vol. ii. pl. 112), as well as to figures of cones and leafy shoots of this species which are not under consideration here. Some of the former, as I have said, belong to *L. lycopodioides*.

The Case for Lepidodendron simile, Jongmans.*

In 1909, Jongmans (14. p. 174) published the following synonymy, and figured examples to which the new term *L. simile* (sic) was applied:—

1833-34. *Lepidodendron elegans*, Lindl. & Hutt. Foss. Flora, vol. ii. pl. 118.

1838. *Lepidodendron elegans*, Brongn., Hist. Végét. Foss. vol. ii. p. 35, pl. 14.

1878-79. *Lepidodendron lycopodioides*, Zeiller, Explic. Carte Géol. France, vol. iv. pt. 2, p. 111, pl. 171.

1882. *Lepidodendron lycopodioides*, Renault, Cours Bot. Foss. vol. ii. p. 14, pl. 5. fig. 8.

1886-88. *Lepidodendron lycopodioides*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 464, pl. 69, figs. 2-3; pl. 70. fig. 1.

This synonymy appears to me to represent a confusion between two distinct species.

The Brongniart and Renault figures are, as I have attempted to show here, examples of *L. ophiurus*.

On the other hand, Lindley and Hutton's plant and all the specimens here indicated as figured by Zeiller in 1878-79 and 1886-88 appear to me to be undoubtedly *L. lycopodioides*, Sternb.

In discussing this synonymy one is at a disadvantage, for, although something like ten years have passed since it was first put forward, and although Kidston (15. p. 137; 18. p. 134) has subsequently repeated it on several occasions, no diagnosis of Jongmans' species has ever been published. We have not been told what are the essential characters in which these particular plants are all supposed to agree, and how they differ from other related species. In fact, in view of the modern laws of nomenclature, it is doubtful whether Jongmans' name has, in the absence of a diagnosis, any scientific status whatever. Kidston has merely told us that the foliage of *L. lycopodioides* is distinct from that of the plants which he cites as *L. simile*, some of which, however, are *L. lycopodioides* pure and simple, according to no less an authority than the late Prof. Zeiller. With this view I quite agree, and I reject *L. simile*, Jongmans, as adding confusion to an already involved question.

* This is a MS. name of Kidston's, but this authority is ignored here since MS. names are best discarded. The specific name was first actually published by Jongmans, who thus became the author.

Diagnosis of L. ophiurus, Brongn.

Leaf bases approximated, separated by slight grooves, rhomboidal, prominent, always longer than broad, of small to medium size, 3–10 mm. long and 2–5 mm. wide, lateral angles rounded, but still angular, upper and lower extremities straight or more rarely slightly curved. Leaf scar clearly marked, situated considerably above centre of leaf base, occupying nearly its whole width, upper and lateral angles acute, lower angle very obtuse. From the lateral angles two lines descend sometimes to near the lower extremity of the leaf base, parallel to its contour and a short distance from its margin. Keel well marked or faint, usually without ornamentation, but sometimes with a few faint, short, transverse ridges. Keel above leaf scar prominent. Prints of the leaf scar of the usual type, rather faint, sometimes invisible, or only a central print to be seen.

4. *LEPIDODENDRON LORICATUM, sp. nova.*

(Pl. 13. figs. 27–37.)

Bound up with the preceding species, at any rate to some extent historically, is another type of stem usually known as *Lepidodendron dichotomum*, Sternb., or *L. dichotomum*, Zeiller. This plant I now propose, for reasons which will be found fully stated below, to transfer to a new species as *L. loricatum, sp. nova.*

Synonymy of *Lepidodendron loricatum, sp. nova* :—

1838. ? *Lepidodendron dichotomum*, Presl, in Sternberg, Vers. Darstell. Flora Vorwelt, pt. 7, p. 177, pl. 68. fig. 1.
 1878–79. ? *Lepidodendron dichotomum*, Zeiller, Explic. Carte Géol. France, vol. iv. pt. 2, p. 107, pl. 72. fig. 1.
 1886–88. *Lepidodendron dichotomum*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 446, pl. 67. fig. 1.
 1903. *Lepidodendron dichotomum*, Arber, in Mem. & Proc. Manchester Lit. & Phil. Soc. vol. xlviii. No. 2, p. 20, pl. 1. figs. 1 & 2.
 1904. *Lepidodendron dichotomum*, Zalessky, in Mém. Com. Géol. St. Pétersbourg, N.S. Livr. 13, p. 9, pl. 2. figs. 3, 5, 6; pl. 3. figs. 3, 5, 7–12; pl. 4. fig. 11.
 1912. *Lepidodendron dichotomum*, Arber, in Phil. Trans. Roy. Soc. ser. B, vol. ccii. p. 251, pl. 11. fig. 6.
 1914. *Lepidodendron dichotomum*, Arber, *ibid.* ser. B, vol. cciv. p. 402, pl. 29. fig. 36.

Remarks on the Specimens previously figured.

In the first part of Sternberg's 'Versuch,' published in 1820, the first three plates relate to a *Lepidodendron* which the author termed *L. dichotomum*. Neglecting the third plate, we have already shown that most of the figures of plates 1 & 2 of that work are, in our opinion, identical with the other specimens figured in the following year by the same author as *Lepidodendron lycopodioides*, Sternb. The latter name is thus, strictly speaking, a

synonym of *L. dichotomum*, but, as in the course of time it has become almost universally used to denote this particular fossil, it is nevertheless maintained as the accepted name for this species. It may be also noted that the figures of these two plates were re-named *Lepidodendron Sternbergii* by Brongniart in 1828 (4. p. 85). This, however, is an unnecessary complication which may be ignored.

The next step in the matter dates from 18 years later (1838), when Presl in the 7th part of the same 'Versuch' of Sternberg's (see above synonymy) figured a further specimen under the same name, *L. dichotomum* *. This illustration is small and possibly not very accurate, and considerable doubt has long existed as to what it really represents. My conclusions on this point are two-fold. Firstly, I am convinced that it is an entirely distinct plant from the specimens first figured as *L. dichotomum*. It is therefore obvious that it must receive a fresh name. Secondly, I am not satisfied that the specimens which Zeiller, Zalesky, and I have in more recent years figured under the name of *L. dichotomum* are the same plant as that shown in the later figure of Sternberg. They may be. This possibility is not ruled out of court, but until Sternberg's type, if still known, has been re-examined, the matter must remain doubtful. In any case, some new specific name must be applied to the more recent specimens, since the name *L. dichotomum* is inapplicable, quite apart from the question whether Sternberg's later figure does or does not represent the plant which occurs in Britain. I therefore propose the new species *L. loricatum* to include the more recent examples included in the above synonymy, beginning with Zeiller's figure. These specimens all appear to be a very homogeneous set and call for no further remarks here.

Notes on the Specimens of L. loricatum, sp. nova, here figured.

No. 2506. Beginning with the napiform types and those with the largest leaf bases, we turn to the specimen, part of which is figured natural size on Pl. 13. fig. 27 and enlarged twice in fig. 28.

The leaf bases are here slightly taller than broad, measuring 6 mm. one way and 5 mm. the other. The upper angle of the leaf base is very rounded, the lower prolonged and acute. The leaf scar is situated near the apex of the base and is prominent. It occupies about two-thirds the width of the base. All its angles are nearly equally acute, except the upper, which is so very broadly rounded as to be almost non-existent. The leaf scar prints are quite clear (fig. 28). The keel is faint.

No. 2470. An enlarged figure of part of another specimen from the Transition Coal Measures of Kent is seen on Pl. 13. fig. 29. This is similar

* The Presl names are all MS. and therefore are ignored. The authority is taken as Sternberg in all cases, since he actually published them.

to the last specimen, but the leaf bases are rather smaller, measuring 5 or 5.5 mm. in length and only 2.5 to 3 mm. in breadth. The upper angle of the base is also rather more pointed than in the last specimen. The leaf scar prints are particularly clear.

No. 959. Prominent leaf bases from another specimen from the Middle Coal Measures of Cumberland are seen enlarged on Pl. **13**. fig. 30. These show the sub-imbricate arrangement of bases, the rounded upper angle, and apical leaf scar. The leaf bases are here as high as broad (5 mm.).

No. 3109. Part of a further specimen from the Transition Coal Measures of Kent is seen natural size on Pl. **13**. fig. 31, and enlarged three times in fig. 32. The leaf bases here measure about 4 mm. each way. The leaf scar is clearly oblique and placed considerably below the angle of the leaf base, and nearly all its sides and angles are equal. There is no appearance of any keel.

No. 1645. Passing next to fusiform types, the specimen from the Upper Coal Measures of the Forest of Dean, figured on Pl. **13**. fig. 33, natural size, and in fig. 34, enlarged twice, is a good example of a type with comparatively large leaf bases. They measure 10.5 mm. by 5 mm. across. The base is fusiform, with attenuated and sharp upper and lower angles. The leaf scar is set obliquely slightly above the centre of the base and occupies two-thirds of its breadth. The lateral and lower angles are sharp, but the upper is slightly rounded. The leaf-scar prints are clear. A keel is present, but is not very prominent, and has no ornamentation. There is no keel above the leaf scar.

No. 1953. Part of another specimen from the Upper Coal Measures of the Forest of Dean is shown enlarged on Pl. **13**. fig. 35. The leaf bases here measure about 10 mm. by 4 mm. The leaf scar is prominent and the keel is well marked without ornamentation.

No. 3130. Another specimen from the Transition Coal Measures of the Kent Coalfield is seen on Pl. **13**. fig. 36, natural size, and in fig. 37, enlarged three times. The leaf bases are here very long (7 mm.) in proportion to their breadth (1.5 mm.). The keel is very faint.

Figured Examples incorrectly or doubtfully identified with the Plant here termed L. loricatum, sp. nova.

Owing to the confusion which has arisen from the fact that Sternberg included at least two different plants under the name *L. dichotomum*, few, if any, of the synonyms previously published have any bearing on the fossil here under consideration. Schimper's (25. ii. p. 20) synonymy may be passed by as foreign to this question. Zeiller, who published the first good figures of the species here termed *L. loricatum*, includes a number of references which I should reject, especially the inclusion of Sternberg's

earlier figures (1820) assigned to *L. dichotomum* *. Thus Feistmantel's (8. pl. 32. figs. 1, 3, 5) figures of *L. dichotomum* appear to me to relate more probably to a species of *Lepidophloios*. Lindley and Hutton's *L. Sternbergii* (20. i. pl. 4) is a decorticated specimen and probably belongs to *L. lycopodioides*.

Among the specimens figured by Geinitz (9. p. 34, pl. 3. figs. 1-12) under the name *Sagenaria dichotoma* there are probably included representatives of more than one species. Several of the specimens, at any rate, are clearly indeterminable specifically and others are very doubtful. All that one can conclude is that, if any of them represent *L. loricatum*, it is probably figs. 8 and 12, but I am not convinced that this is the case. Turning next to Zalessky's synonymy, which includes several references common to Zeiller's which have just been criticised, we find also a comparison with Roehl's (23. pl. 8. fig. 6 ; pl. 11. fig. 2) figures of *L. dichotomum*, both of which appear to me to be probably distinct from *L. loricatum* as here defined. I should also be inclined to regard as distinct Ettingshausen's *L. brevifolium* (6. pl. 24. fig. 5 ; pl. 26. fig. 3) and also the Radnitz specimens attributed by the same author to *L. Sternbergii* (7. pl. 26. figs. 1, 2 ; pls. 27, 28). With regard to Sauveur's figures I should reject as indeterminable *L. minutum* (24. pl. 61. fig. 3), while *L. clathratum* (24. pl. 61. fig. 4) may be *L. ophiurus*, though this is uncertain.

Kidston's *L. Glincanum* (16. pl. 2. figs. 20, 21 ; pl. 4. figs. 37-40) appears to be *L. ophiurus*.

Diagnosis of L. loricatum, sp. nova.

Leaf bases approximate, separated by slight grooves, napiform and sub-imbricated or fusiform and non-imbricated, somewhat prominent, in napiform types as broad as high or slightly longer than broad, on an average about 5 mm. each way or sometimes 4 mm. or less in breadth ; in fusiform types twice as long as broad or even more, up to 10 mm. long and up to 5 mm. broad, lateral angles rounded, lower angle nearly always prolonged, upper angle broadly rounded or blunt and short in napiform types, acute and prolonged in fusiform types. Leaf scar situated at or below the upper limit of leaf base occupying the greater width or even the whole of the base, often set obliquely on the base, prominent, rhomboidal. Upper angle usually somewhat rounded, or all sides and angles nearly equal and acute. From the lateral angles two lines may diverge downwards and outwards, but soon merge in the margin of the leaf base ; these are often invisible. Prints of leaf scar three, the median being the most distinct. A punctate ligular scar occurs above the leaf scar. Sub-parichnoid scars always absent. Keel of

* These were re-figured by Bischoff and Brongniart and in the editions of Buckland (5. i. p. 432 ii. p. 91, pl. 75).

leaf base faint or often absent in napiform types, slight or fairly prominent in fusiform examples; rarely if ever occurring above the leaf scar.

5. CONCLUSIONS.

From what has been said, I think it is clear that the three species of *Lepidodendron* with which I am concerned here are quite distinct. Great variations in the form, size, and shape of the leaf base may occur in all of them, but the characters of the leaf scars are more constant and constitute the chief but not the only important diagnostic data. The chief peculiarities of these three species may be contrasted as follows:—

Character.	<i>L. lycopodioides.</i>	<i>L. ophiurus.</i>	<i>L. loricatum.</i>
Leaf scar	angular slit.	rhomboidal.	rhomboidal.
Orientation of leaf scar ..	straight.	straight.	usually oblique.
Prints of leaf scar	invisible.	faint or rarely visible, or only a central print is seen.	always visible.
Leaf base	fusiform.	fusiform.	napiform (subimbri-cated) or fusiform.
Ornamentation of keel ..	present	absent or very feeble.	absent.
Lower angle of leaf base ..	————	very obtuse.	acute.

The three species agree in the relatively small size of their leaf bases as compared with many others (e. g., *L. aculeatum*, Sternb.), and in the absence of sub-parichnoid prints. There is, however, much variation to be found among them, especially in the degree of angularity of the upper extremity of the leaf base, whether both its terminations are straight or bent, the position of the leaf scar relative to the centre of the leaf base, and the prominence of the keel.

Further, in addition to defining these species more accurately, an attempt is here made to institute a pure synonymy of these plants, especially with a view to establishing the nature of ancient types in the light of modern specimens.

It is shown that *L. lanceolatum*, Lesq., is identical with *L. lycopodioides*, Sternberg, and that *L. simile*, Jongmans, is a confusion between that species and *L. ophiurus*.

EXPLANATION OF THE PLATES.

(All the specimens figured are in the Carboniferous Plant Collections, Sedgwick Museum, Cambridge, to which the numbers refer. The photographs are by Mr. W. Tams, Cambridge.)

PLATE 10.

LEPIDODENDRON LYCOPODIODES, Sternb. (Pl. 10. figs. 1-9 & Pl. 11. figs. 10-16.)

- Fig. 1. No. 3205. Middle Coal Measures. Bishopsbourne Boring, Kent. (Nat. size.)
 Fig. 2. No. 3205. Middle Coal Measures. Bishopsbourne Boring, Kent. ($\times 2$.)
 Fig. 3. No. 2754. Bond's Main Colliery, Temple Normanton, Derbyshire. (Nat. size.)
 Fig. 4. No. 107. Coal Measures. Toronley Colliery. Locality unknown. (Nat. size.)
 Fig. 5. No. 107. Coal Measures. Toronley Colliery. Locality unknown. ($\times 3$.)
 Fig. 6. No. 927. Middle Coal Measures. Cannel Band, Flimby, Cumberland. (Nat. size.)
 Fig. 7. No. 927. Middle Coal Measures. Cannel Band, Flimby, Cumberland. ($\times 2\frac{1}{2}$.)
 Fig. 8. No. 950. Middle Coal Measures. Robin Hood Pit, Flimby, Cumberland. ($\times 3\frac{1}{2}$.)
 Fig. 9. No. 68. Coal Measures. Barnsley. ($\times 3$.)

PLATE 11.

- Fig. 10. No. 106. Coal Measures. Jarrow. ($\times 3$.)
 Fig. 11. No. 3475. New Mine Coal. Bentley, South Staffordshire. ($\times 1\frac{1}{2}$.)
 Fig. 12. No. 754. Coal Measures. Bradford. (Nat. size.)
 Fig. 13. No. 755. Wax cast of specimen from Coal Measures. Bradford. (Nat. size.)
 Fig. 14. No. 3568. Wax cast of specimen, Claycroft, Cosely, South Staffordshire. ($\times 2$.)
 Fig. 15 A. No. 3249. Between Bottom and New Mine Coal. Pouk Hill, Walsall. (Nat. size.)
 Fig. 15 B. No. 3249. Between Bottom and New Mine Coal. Pouk Hill, Walsall. ($\times 3$.)
 Fig. 16. No. 1475. Near base of Lower Coal Measures. Queen's Seam, Broomhill Colliery, nr. Amble, Northumberland. (Nat. size.)

LEPIDODENDRON LANCEOLATUM, Lesq. = *L. lycopodioides*, Sternb.
 (Pl. 11. fig. 17 & Pl. 12. figs. 18-22.)

- Fig. 17. No. 1624. Coal Measures. 2nd Division, Lightmoor Colliery, Forest of Dean Gloucestershire. (Nat. size.)

PLATE 12.

- Fig. 18. No. 1624. Coal Measures. 2nd Division, Lightmoor Colliery, Forest of Dean Gloucestershire. ($\times 3$.)
 Fig. 19. No. 1986. Coal Measures, 2nd Division, Park End Colliery, Forest of Dean Gloucestershire. ($\times 3$.)
 Fig. 20. No. 2507. Transition Coal Measures. Bayton Colliery, Forest of Wyre. ($\times 3$.)
 Fig. 21. No. 2066. Upper Coal Measures. Shortwood Colliery, nr. Bristol. (Nat. size.)
 Fig. 22. No. 1625. 2nd Division, Lightmoor Colliery, Forest of Dean, Gloucestershire ($\times 3$.)

LEPIDODENDRON OPHIURUS (Brongn.). (Figs. 23-26.)

- Fig. 23. No. 131. Coal Measures. Locality unknown. (Nat. size.)
 Fig. 24. No. 131. Coal Measures. Locality unknown. ($\times 2$.)
 Fig. 25. No. 3472. Coal Measures. Shallow Seam, West Cannock Colliery. No. 1 Pit Hednesford, South Staffs. ($\times 3$.)
 Fig. 26. No. 3478. Thick Coal. Cakemoor Colliery, Blackheath, South Staffs. ($\times 3$.)

PLATE 13.

LEPIDODENDRON LORICATUM, sp. nova. (Figs. 27-37.)

- Fig. 27. No. 2506. Transition Coal Measures. Bayton Colliery, Forest of Dean. (Nat. size.)
 Fig. 28. No. 2506. Transition Coal Measures. Bayton Colliery, Forest of Dean. ($\times 2$.)
 Fig. 29. No. 2470. Transition Coal Measures. Barfreston Boring, Kent. ($\times 3$.)
 Fig. 30. No. 959. Ardwick Series. Manchester. ($\times 2$.)
 Fig. 31. No. 3109. Transition Coal Measures. Chilton Boring, Kent. (Nat. size.)
 Fig. 32. No. 3109. Transition Coal Measures. Chilton Boring, Kent. ($\times 3$.)
 Fig. 33. No. 1645. Upper Coal Measures. Flour Mill Colliery, Forest of Dean, Gloucestershire. (Nat. size.)
 Fig. 34. No. 1645. Upper Coal Measures. Flour Mill Colliery, Forest of Dean, Gloucestershire. ($\times 2$.)
 Fig. 35. No. 1953. Coal Measures. Trafalgar Colliery, 2nd Division, Forest of Dean, Gloucestershire. ($\times$ nearly 3.)
 Fig. 36. No. 3130. Transition Coal Measures. Chilton Boring, Kent. (Nat. size.)
 Fig. 37. No. 3130. Transition Coal Measures. Chilton Boring, Kent. ($\times 3$.)

III. NEUROPTERIS OBLIQUA, Brongn., and N. CALLOSA, Lesq.

1. INTRODUCTION.

It appears to me that some confusion has arisen between the frond species known as *Neuropteris obliqua*, Brongn., *Neuropteris acuminata*, Zeiller, and *Neuropteris impar*, Potonié. At any rate, it will be admitted that considerable differences of opinion have existed as to whether some or all of these forms are or are not identical, and as to the principal characters by which they may be distinguished from one another and from other species. I give here the results of my re-examination of these questions. The difficulty appears to arise from the dimorphic nature of a species here termed *N. obliqua*, Brongn., and also from a confusion which has arisen between one form of this species and a plant which I find to be entirely distinct, and which I believe to be the *Neuropteris callosa* of Lesquereux.

I begin with a consideration of the former species.

2. NEUROPTERIS OBLIQUA (Brongn.).

Synonymy of *Neuropteris obliqua*, Brongn. :—

A. Minor Pinnules.

1832. *Pecopteris obliqua*, Brongniart, Hist. Vég. Foss. p. 320, pl. 96. figs. 1-4.
 1880. *Odontopteris binervosa*, Acheppohl, Niederrhein.-Westfäl. Steinkohlengebirge, Oberhausen und Leipzig, p. 118, pl. 36. fig. 5.
 1903. *Neuropteris obliqua*, Arber, Quart. Journ. Geol. Soc. vol. lix. p. 4, pl. 1. fig. 2.
 1907. ? *Mixoneura obliqua*, Zalesky, Bull. Com. Géol. St. Pétersbourg, vol. xxvi. No. 134 p. 404, pl. 15. figs. 11, 12, & 16.
 1907. *Mixoneura obliqua*, Zalesky, *ibid.* No. 135, p. 479, pl. 19. figs. 1, 3-9.
 1913. ? *Neuropteris obliqua*, Gothan, Abhandl. k.-preuss. geol. Landesanst. N.F. Heft 75, p. 207, ? pl. 50. fig. 5, pl. 53. fig. 5.

B. Major Pinnules.

- 1886-88. *Neuropteris acuminata*, Zeiller, Flore Foss. Bass. Houill. Valenciennes, p. 255, pl. 41. fig. 4.
 1906. *Neurodopteris obliqua*, Gothan, in Potonié, Abbild. und Beschr. Foss. Pflanzen, Lief. iv. No. 68, text-figs. 2 B, 4, 5, pl. unnumbered, following p. 11, fig. B.
 1907. *Mixoneura obliqua*, Zalesky, Bull. Com. Géol. St. Pétersbourg, vol. xxvi. No. 134, p. 479, pl. 19. figs. 2 & 10.
 1910. *Neuropteris acuminata*, Arber, Proc. Yorks. Geol. Soc. vol. xvii. pt. ii. p. 138, pl. 17. fig. 3.
 1911. *Neuropteris impar*, Kidston, Mém. Mus. R. Hist. Nat. Belgique, vol. iv. p. 83, pl. 8. figs. 2, 3, 3 a.

C. Major and Minor Pinnules.

1837. ? *Neuropteris heterophylla*, Lindley & Hutton, Foss. Flora, vol. iii. p. 90, pl. 183.
 1893. *Neurodopteris impar*, Potonié, Jahrb. k.-preuss. geol. Landesanstalt für 1892, p. 1, pl. 1. figs. 1, 2, 4.
 1906. *Neurodopteris obliqua*, Gothan, in Potonié, Abbild. und Beschr. Foss. Pflanzen, Lief. iv. No. 68, pl. unnumbered following p. 11, fig. B.
 1911. *Neuropteris impar*, Kidston, Mém. Mus. R. Hist. Nat. Belgique, vol. iv. p. 83, pl. 8. fig. 1.

Remarks on the Synonymy of Neuropteris obliqua, Brongn.

Neuropteris obliqua (Brongn.) is a species of Coal-measure frond which has already caused considerable trouble and confusion. We are as yet probably not at an end of our difficulties in this respect. These fronds were, like those of certain other species of the genus, dimorphic. On one side of the frond we may find pinnæ composed of a large number of small triangular pinnules here termed minor pinnules, while, on the other, simple, large, ovate-lanceolate leaflets may occur, here called the major pinnules. Or, again, the pinnæ may consist solely of major or minor pinnules. The minor pinnules, which were the first described portions of these fronds, are often typically Odontopteroid. They are often decurrent, and, further, a considerable portion of the lateral nerves arise directly from the rachis and not from the median nerve, which is weak. They are very little arched, but are sinuous in their course, each nerve dichotomising two or three times. The sinuous course of the nerves necessitates unequal intervals of lamina between the nerves, and this feature is highly characteristic of this species.

Did the evidence end here, this species would be more correctly classed with *Odontopteris* than *Neuropteris*, especially on account of the attachment of the pinnules and the origin of the lower lateral nerves. It has, in fact, been placed in that genus by more than one authority, while Potonié expressed the facts by suggesting a new genus *Neurodopteris*, which, however, has not been adopted by other workers. Similar resemblances occur to other genera, such as *Alethopteris* and *Callipteris*. In fact, the definitions of these form-genera break down over such cases as this, and it is purely a matter of convention in which genus this species is placed.

The major pinnules were first known in 1886, and were regarded as a separate species. Neglecting two early figures, about which considerable doubt exists [the *Neuropteris heterophylla* of Lindley and Hutton (20. iii. pl. 183), the type of which is lost, but which may be a specimen of

FIG. 1.

Neuropteris obliqua, Brongn. Major and minor pinnules. Potonié, II., Ueber einige Carbonfarne, IV. Theil, 1893, pl. 1. fig. 1. *Neurodontopteris impar* (Weiss) Potonié.

N. obliqua incorrectly drawn, and also the *Neuropteris Scheuchzeri* of Sauveur (24. pl. 34. fig. 2)], we have the specimen figured by Zeiller in 1886 (27. p. 255, pl. 41. fig. 4) as *N. acuminata*. In this specimen the pinna is composed entirely of the major pinnules. Other excellent examples of these pinnules have been

more recently figured by Kidston (15. p. 83, pl. 8. figs. 2, 3, 3a). The major pinnules are large, very variable in shape, and the leaflets resemble those of *Neuropteris Scheuchzeri*, Hoffm., somewhat in habit. They are not attached by the whole base, but by a restricted portion, which is, however, sufficiently broad sometimes to allow of the origin of some of the lateral basal veins directly from the rachis. The lateral nerves are more frequently dichotomised than in the minor pinnules, but possess a similar inclination, and are also sinuous in their course.

The continuity between the minor pinnules (*N. obliqua* of Brongniart) and the major (*N. acuminata* of Zeiller) was first proved in a specimen discovered by Weiss, but described by Potonié in 1893 as *Neurodontopteris impar*. This frond shows simple major pinnules on one side and pinnate pinnae composed of minor pinnules on the other (fig. 1, p. 209).

Potonié (22) does not appear to have recognised the identity between the minor pinnules of this specimen and the *Neuropteris obliqua* of Brongniart, and even Kidston (15) expresses himself as not quite convinced on this point, though he regards it as highly probable. Gothan (11. p. 207), however, has more recently referred these specimens to Brongniart's species, and with this conclusion I am also in agreement. It is thus clear that the terms *N. acuminata*, Zeill., and *N. impar*, Pot., are mere synonyms of *N. obliqua*, Brongn.

Neuropteris obliqua was known to me chiefly by the major pinnules—of which there is a good collection from several coalfields in the Sedgwick Museum, Cambridge—until a few years ago, when I collected undoubted examples of the minor pinnules from the Middle Coal Measures of Bond's Main Colliery in Derbyshire. It is true that I had imagined that one already possessed at Cambridge many specimens of these minor pinnules, but as soon as I had acquired the Derbyshire specimens I realised that I—and, as I believe, others also—had been confusing a quite distinct, though similar, plant with the true *Neuropteris obliqua*. This other type of frond, which is much more abundant in Britain than *N. obliqua*, is here redescribed under the name *N. callosa*, Lesq.

Remarks on Specimens here figured.

Excellent illustrations of this species have already been published, so only a few selected types are figured here for comparison with the distinct species *N. callosa*, Lesq.

No. 1430. On Pl. 14. fig. 1 is seen, natural size, a typical pinna bearing major pinnules of the lanceolate type below and passing above into minor pinnules. The larger pinnules have a distinctly sinuate margin. The nervation is very clear, except at the base of the pinnules.

No. 2180. Another specimen from the Ingleton Coal Measures is also

figured, natural size, on Pl. 14. fig. 2. Here the lanceolate pinnules are seen partly dissected at the base into minor pinnules, a transition from the major to the minor type of pinnule. The apical portions are broadly lanceolate.

No. 1362. An example from the Middle Coal Measures of Barnsley, Yorkshire, with very large major pinnules of the ovate-lanceolate type, is figured on Pl. 14. fig. 3, natural size. These pinnules measure 5 cm. in length by 2.5 cm. in breadth.

No. 1708. An example of part of a pinna with minor pinnules is shown, natural size, on Pl. 14. fig. 4, and enlarged in fig. 5 to emphasize the nervation. The pinnules are here elongately oval, 2 cm. in length by nearly 1 cm. in breadth. They are attached by a considerable portion of the base. A few of the basal nerves, in addition to the median nerve, arise directly from the rachis. The sinuous course of the subdivisions of the median nerve and their spacing in the centre of the leaflet are characteristic.

No. 2793. Typical pinnules of the minor type are seen, natural size, on Pl. 14. fig. 6 (left-hand side), and enlarged twice in fig. 7 (left-hand side). This specimen is from the Middle Coal Measures of Bond's Main, Derbyshire.

The pinnules vary slightly in shape, but are elongately oval, 8 mm. or less in length and 3.5 mm. or less across. They are attached by their whole base, somewhat decurrent, and a large part of the lower nervation arises directly from the rachis. The terminal pinnule is elongate and narrow.

No. 2798. The nervation in a similar case from the same locality is also seen enlarged on Pl. 14. fig. 8A.

Diagnosis of Neuropteris obliqua, Brongn.

Fronde dimorphic, composed entirely of minor or of major pinnules, or containing pinnules of both types. Minor pinnules small, up to 2 cm. long and nearly 1 cm. broad, often considerably smaller, elongately oval or elongately triangular, more or less parallel-sided, attached to the axis by the whole base or, in the broader types, only by part of the base. Apical pinnule very large or long and narrow. Lateral nerves very clear, not very stout; a considerable portion of the lateral nerves arise directly from the rachis and not from the median nerve. Lateral nerves very little arched, sinuous, each dichotomising 2-3 times, markedly distant from one another in centre of leaf. Major pinnules very variable in size and shape, even in the same pinna, lanceolate (up to 2.5 x 1 cm.), ovate-lanceolate (up to 5 x 2.5 cm.), oval or semicyclopteroid (about 3.5 x 2.5 cm.), sometimes very broad and unsymmetrical, attached to the rachis by a very small part of the base, which, however, is sometimes sufficiently broad to allow of the origin of some of the basal lateral veins directly from the rachis. The lanceolate

pinnules are frequently lobed or divided into minor pinnules at the base. The cyclopteroid-like pinnules have a broader point of attachment and a more radiating nervation, partly arising directly from the rachis. The lateral nerves are more frequently dichotomised than in the minor pinnules, but possess a similar inclination and are also sinuous in their course.

Distribution.

The following is the distribution of this species in Great Britain, so far as it is known to me :—

Middle Coal Measures.

Derbyshire Coalfield :—Top Hard Coal, Shipley Clay Pit, Derby.

Yorkshire Coalfield :—Above Silkstone Coal, Bond's Main Colliery, Derbyshire. Old Hards Coal, Hartley Bank Pit, Horbury, Yorks. Horizon uncertain, Barnsley, Yorks.

Ingleton Coalfield :—W. of Ingleton.

Denbighshire Coalfield :—Llag Hill near Wrexham.

? Kent Coalfield.

Devonshire.

Lower Coal Measures.

Northumberland Coalfield :—Horizon uncertain, Felling.

3. *NEUROPTERIS CALLOSA*, Lesq.

I turn now to another type, which I hope to be able to show here is quite distinct from *N. obliqua*, Brongn., but which has been confused with it, although it is of very much commoner occurrence than that species. This plant I believe to be the *Neuropteris callosa* of Lesquereux, a species which has already been doubtfully recorded by Dr. Kidston from three British coalfields.

Synonymy of *Neuropteris callosa*, Lesquereux :—

1879-80. *Neuropteris callosa*, Lesquereux, 2nd Geol. Surv. Pennsylv. p. P. 115, pl. 16. figs. 1-4 (? figs. 5-8).

1909. *Neuropteris obliqua*, Arber, Quart. Journ. Geol. Soc. vol. lxx. p. 26, pl. 1, fig. 3.

1911. *Neuropteris obliqua*, Kidston & Jongmans, Arch. Néerl. Sci. Exact. et Nat. ser. 3 B, vol. i. p. 25, pl. (unnumbered), fig. 3.

Remarks on the Specimens previously figured.

Lesquereux's type was diagnosed as follows :—"Bipinnate; ultimate pinnæ linear; leaflets alternate, sessile by a broad base, oblong or oval, obtuse; veins flabellate from the base, strongly marked, slightly curved; cyclopterid pinnules cordate at the point of attachment, unequilateral, polymorphous."

Of Lesquereux's figures, pl. 16. figures 2-4, are the most characteristic. Two of these figures are reproduced in text-fig. 2, p. 213. The bluntly

oblong-oval pinnules slightly eared at the base, the sinuate nerves, erect and little arched, dichotomising three times or less, are features all clearly portrayed in these figures. Cyclopteroid pinnules similar to those shown by Lesquereux on pl. 16. figs. 6 & 8, are often associated with this plant, but, so far as I am aware, they have not been found in continuity, and I therefore hesitate to apply the specific name to them.

FIG. 2.

Neuropteris callosa, Lesq. Pinnules to show nervation. Lesquereux, L.
Atlas to the Coal Flora of Pennsylvania, 1879, pl. 16.

The specimen from Kent figured by myself in 1909 and the seed-bearing examples described by Kidston and Jongmans in 1911, both referred to *N. obliqua*, now appear to me to be identical with Lesquereux's plant.

So far as I am aware, these are the only trustworthy examples of this very common type which have yet been figured, though, among the many hundreds of Neuropterids described on the Continent, there may, of course, be some which on re-investigation would prove to be identical.

Description of the Specimens figured here.

No. 2730. Part of the pinna of this species is shown natural size on Pl. 15. fig. 9, and some pinnules from the same specimen in fig. 10, enlarged three times to show the nervation.

The pinnules in this case are rather small, the largest being about 7 mm. or less in length and 5 mm. across at their widest point. They are strictly oval. The terminal pinnule is narrow and rather short in this case, though in some instances here its full length is not disclosed. The pinnules are closely set on the rachis and sometimes overlap one another slightly. They are very slightly eared at the base. The nerves (fig. 10) are clear, but fine and nearly all of equal strength. They are slightly arched and flexuous and equally spaced.

No. 613. Pinnules from another specimen are shown nat. size in Pl. 15. fig. 11 A, and enlarged ($\times 2$) in fig. 11 B. The pinnules here are larger, some of them being about 1 cm. long.

No. 1170. Some pinnules, larger still, are shown magnified three times in fig. 12. Some of these measure 12 mm. in length. The characteristic nervation is clearly seen.

No. 2381. The terminal region of the pinna in which some of the pinnules reach a length of 15 mm. is shown enlarged twice in fig. 13. The tip of the terminal pinnule is hidden in the rock.

No. 2632. A fragment of an apical portion of a pinna in which the pinnules are very small, but the nerves clearly seen, is shown in fig. 14, enlarged three times.

No. 1916. In fig. 15 an enlarged photograph of a specimen from the Kent coalfield, which I figured in 1909, is given. The pinnules are here elongately oval, nearly 2 cm. long, and overlap one another.

Diagnosis of Neuropteris callosa, Lesq.

Frond large, tri- or ?quadripinnate. Penultimate pinnæ broad, often but not always with a broad axis; ultimate pinnæ lanceolate, axis very slender. Pinnules typically Neuropteroid, inserted by a very small part of the base, oval or elongately oval, varying much in size from about 4 mm. up to 20 mm. or more in length, entire, broadly rounded at the apex, markedly cordate, almost eared at the base, closely set on the axis, and frequently overlapping one another. Pinnules markedly caducous. Nervation clearly marked, but nerves fine, all nearly equally strong and equally spaced, lateral nerves all arising from the median nerve, not crowded, somewhat arched, flexuous in their course, dichotomising once to three times. Lamina between the veins frequently punctate. Terminal pinnule rather small, elongately lanceolate or oval-lanceolate.

Distribution.

The distribution of *Neuropteris callosa*, Lesq., in this country, so far as it is known to me, is:—

Transition Coal Measures.

Kent: Several borings at Waldershare, etc.

Middle Coal Measures.

Kent: Many borings at Goodnestone, etc.

Pembrokeshire: Rickets Head, near Newgate, etc.

Wyre Forest: Kinlet, Alton Boring, No. 1.

Titterstone Cleve Hills: South Coal.

Yorkshire (Derbyshire): Below Top Hard Coal, Shipley.

Yorkshire: Monkton Main Colliery.

? Ingleton: Ingleton Colliery.

Doubtful records which I have not seen are:—

Transition Coal Measures.

? South Lancashire: Bradford Colliery, Manchester [Gerrard (10. p. 561) & Kidston (17. p. 321)].

Middle Coal Measures.

? Leicestershire Coalfields:—Bretby, S. Derby (Horwood, 13. p. 154).

4. CONCLUSIONS.

From the specimens figured here I think it will be clear that *Neuropteris callosa*, Lesq., is quite distinct from *N. obliqua*, Brongn. The pinnules of the former could only be mistaken for the minor pinnules of the latter. In both cases the nerves are slightly flexuous, but the insertion of the pinnules, the origin of the basal nerves, and the spacing of the veins in the latter species will alone serve to distinguish this type from *N. callosa*. On the other hand, *N. callosa* lies much nearer to other species of the same genus, especially *N. tenuifolia* (Schl.), and, in a more remote degree, *N. heterophylla*, Brongn. In *N. tenuifolia*, however, the pinnules are usually much larger, the veins are not flexuous, the median nerve is much stronger near the base of the pinnule, and the lateral nerves are often more distinctly arched and highly divided. *Neuropteris callosa* is distinguished from *N. heterophylla* by the fact that the pinnules do not become decompound as in that species. The nervation in *N. heterophylla* is also much coarser and more crowded, and the veins are not flexuous, but more frequently dichotomised.

At the same time it must be admitted that difficulties in discriminating between all these species may arise when dealing with fragmentary or not exceptionally clear materials, or with certain portions of pinnæ. I am, for instance, still rather in doubt as to which species the specimens figured by Zeiller in his Valenciennes Flora (page 48) under the name *N. obliqua* belong to, though I am inclined to think they are there correctly named and are distinct from *N. callosa*, Lesq.

EXPLANATION OF THE PLATES.

All the figures are from photographs by Mr. W. Tams, of Cambridge, from specimens in the Sedgwick Museum, Cambridge. The numbers refer to the Carboniferous Plant Collections in that Museum.

PLATE 14.

NEUROPTERIS OBLIQUA, Brongn. (Figs. 1-8.)

- Fig. 1. Coal Measures, locality unknown, No. 1430 (nat. size).
 Fig. 2. " " Ingleton Colliery, No. 2180 (nat. size).
 Fig. 3. " " Barnsley, No. 1362 (nat. size).
 Figs. 4 & 5. " " locality unknown, No. 1708. Fig. 4 (nat. size). 5 ($\times 3$).

Figs. 6 & 7. Above Silkstone Coal, Bond's Main Colliery, Temple Normanton, Derby No. 2793. Fig. 6 (nat. size). Fig. 7 ($\times 2$).

Figs. 8 A & 8 B. Above Silkstone Coal, Bond's Main Colliery, Temple Normanton, Derby No. 2798 ($\times 2$).

PLATE 15.

NEUROPTERIS CALLOSA, Lesq. (Figs. 9-15.)

Figs. 9 & 10. Coal Measures, Sheffield, No. 2730. Fig. 9 (nat. size). Fig. 10 ($\times 3$).

Figs. 11 A & 11 B. Coal Measures, locality unknown, No. 613. Fig. 11 A (nat. size). Fig. 11 B ($\times 2$).

Fig. 12. Coal Measures, Wakefield or Pontefract, No. 1170. ($\times 3$).

Fig. 13. Middle Coal Measures, Mattice Hill, Sandwich, No. 2381. ($\times 2$).

Fig. 14. Sweet Coals, Kinlet Colliery, Wyre Forest, Salop, No. 2032. ($\times 3$).

Fig. 15. Transition Coal Measures, Waldershare Boring, Kent, No. 1916. ($\times 2$).

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1.

5 (x3).

2 (x2).

3.

4.

6.

7 (x2).

8 (x3).

9 (x3)

W. Tams photo.

Huth coll.

10 (x3).

14 (x2).

15^B (x3).

11 (x 1½).

12.

13.

17.

15^A

16.

18 (x3)

19 (x3).

20 (x3)

21.

25 (x3).

26 (x3).

23.

22 (x3).

24 (x2).

27.

28 (x2).

29 (x3).

34 (x2).

35 (x3).

30 (x2).

31.

32 (x3).

33.

36.

37 (x3)

LEPIDODENDRON LORICATUM, sp. nova.

1.

2.

3.

4.

8^B (x2).

5 (x3)

6.

7 (x2)

8^A (x2)

9.

11^A

W. Tams photo.

10 (x3).

11^B (x2).

13 (x2).

14 (x3).

12 (x3).

15 (x2).

Huth coll.

NEUROPTERIS CALLOSA, Lesq.