

*aortæ*; *b*, the two aortic valves; *c*, remnant of the auricle; *d*, cavity of the ventricle, showing various diverticula. The great muscular walls are kept apart by a style.

*Fig. 3.* The aperture (*a*) of the air-bladder, with its neighbouring reticulations and radii. Considerably reduced.

*Fig. 4.* A few of the reticulations on the inner surface of the anterior region of the swim-bladder. Natural size.

### XXX.—Notes on the Palæozoic Bivalved Entomostraca.—

No. XX. On the Genus *Beyrichia* and some new Species\*.

By Prof. T. RUPERT JONES, F.R.S., and Dr. H. B. HOLL, F.G.S.

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† This Plate has been drawn under a grant from the Royal Society for the illustration of fossil Ostracoda.

## INTRODUCTION.

In the Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. 1855, pp. 81 *et seq.*, one of us gave a short history of this genus and a description of its characters \*. Excepting that the group "*Beyrichia simplices*" now belongs to our genus *Primitia* †, there is not much to alter in the account there given, though many species have been added from several of the stages of the Palæozoic system of strata. We may remark, however, that we now prefer to regard them, together with *Leperditia*, as more closely related to Ostracoda ‡ than to Phyllopoda, to which order they were then referred with doubt (p. 85). Doubtless they are an ancient *generalized* group possessing characters since distributed among more special forms. The "*Cytheræ*" and "*Cytheropses*" mentioned at p. 84 are probably Cytherids or marine Cyprids and *Primitiæ*; and the *B. siliqua* (pp. 84 and 90) is a *Cytherellina* (Ann. & Mag. Nat. Hist. ser. 4, vol. iii. p. 215).

It is important to notice an omission at p. 83, where it should have been stated that Dr. Ernst Boll, of Neubrandenburg, proposed "*Beyrichia*" in 1847 as a name for the genus independently of Prof. F. M'Coy, both having recognized that Prof. Beyrich first referred these little fossil organisms to their right systematic group. Dr. E. Boll § added much to our knowledge of the Upper-Silurian *Beyrichiæ* from the erratic blocks of Scandinavian limestones in North Germany.

Since 1855 the *Beyrichiæ* have been much studied. The observers have been Boll, 1856 and 1862; Schmidt, 1858; Römer, 1858; James Hall, 1859 (also before and afterwards); d'Eichwald, 1860; Billings, 1866; Bock, 1867; Heidenhain, 1869; Richter, Kolmodin, Linnarsson, and Karsten, 1869; Barrande, 1872; Krause, 1877; Haupt, 1878; Brögger, 1882; Kiesow, 1884; Reuter, 1885. These, besides others, including J. W. Kirkby and ourselves, have described and illustrated new or little-known forms. A very full account of the history of the genus up to 1872 will be found in the late M. J. Barrande's Syst. Sil. Bohême, vol. i. Suppl. 1872, pp. 484 *et seq.*, worked out with his usual accuracy and

\* See also the Proc. Geol. Assoc., Pal. Biv. Entom., 1869, pp. 8, 11, &c., and the Monthly Microsc. Journ. vol. iv. 1870, p. 192.

† Ann. & Mag. Nat. Hist., Dec. 1865, pp. 415 &c.

‡ Monthly Microsc. Journ. *l. c.* pp. 189-191. See also M. Barrande's remarks to the same effect in his Système Silur. Bohême, vol. i. Suppl. 1872, p. 467.

§ This hard-working enthusiastic naturalist died January 20th, 1868, aged 51, much regretted by the members of the Natural-History Society of Mecklenburg, whose Journal he had edited for many years.

completeness. Lately Herr G. Reuter has given, in the *Zeitschr. d. d. geol. Ges.* vol. xxxvii. 1885, pp. 621 *et seq.*, a sketch of the history of the genus, with elaborate notes on its structural characters, on several of its species, their apparent genetic order, and their distribution in the Upper-Silurian rocks of Scandinavia, as indicated both by the Ostracoda found in the drifted blocks in North Germany and by those known in the parent strata.

The chief memoirs subsequent to those by Klöden (1834) and Jones (1855) treating of the Beyrichian limestones of Scandinavia in the Drift of Northern Europe are:—

- 1858. Ferd. Römer. *Neues Jahrb.* 1858, p. 270.
- 1859. Friedrich Schmidt. *Archiv f. d. Naturk. Liv-, Ehst- und Kurlands*, ser. 1, vol. ii. part 2, 1859, pp. 443, 445, 448, 453, 461–463.
- 1861. C. Grewingk. *Ibid.* part 3, 1861, pp. 571, 660, &c.
- 1862. Ferd. Römer. *Zeitschr. d. d. geol. Ges.* vol. xiv. 1862, p. 607.
- 1862. E. Boll. *Archiv Ver. Fr. Nat. Meklenburg*, 16. Jahrg. 1862, pp. 114 &c.
- 1869. G. Karsten. *Beitr. Landeskund. Herzog. Schleswig und Holstein*, ser. 1, part 1, 1869, pp. 1 &c.
- 1869. Heidenhain. *Zeitschr. d. d. geol. Ges.* vol. xxi. 1869, pp. 143–182.
- 1874. Feistmantel. *Neues Vorkommen nord. Silur. Diluv. Lampersdorf*, &c.
- 1877. A. Krause. *Zeitschr. d. d. geol. Ges.* vol. xxix. 1877, pp. 33–45 &c.
- 1878. K. Haupt. *Neues Lausitzisches Magazin*, vol. liv. 1878, p. 75.
- 1881. W. Dames. *Zeitschr. d. d. geol. Ges.* vol. xxxiii. 1881, pp. 434–441.
- 1884. J. Kiesow. *Schriften der naturforschenden Gesellschaft in Danzig*, new ser. vol. vi. part 2, 1884, pp. 205 &c.
- 1885. G. Reuter. *Zeitschr. d. d. geol. Ges.* vol. xxxvii. 1885, pp. 621–681.

Herr Reuter, like other observers, has been especially struck with the peculiarity of the extra large lobe present in many individuals among the Silurian *Beyrichia* towards one end of the ventral region of each valve. In the *Proc. Geol. Assoc., Pal. Biv. Entom.*, 1869, p. 11, its cause was referred

to *advanced age*; but G. Reuter, following R. Richter \*, thinks that the *eggs* may have lain within that lobe. A. Krause adopted this view hypothetically in his memoir (Z. d. d. g. G. vol. xxix. 1877, p. 32). They support their view by referring to Zenker's description † and figure of a right valve of a female *Cythere gibba*, with a distinct lobular swelling at the middle of the ventral border, rather bigger in its posterior than in its anterior moiety; its length is less than a third of that of the valve, and its width (height) is about one third of that of the valve.

*Cytherura gibba* (*Cythere*, Müller) is a well-known species, studied by Lilljeborg, Zenker, G. O. Sars, G. S. Brady, and D. Robertson. As with most of the Ostracoda, the female of *C. gibba* has a broader (that is, a more swollen) carapace than the male. In the genus *Cytherura* this thickness or lateral fullness is variable, and sometimes becomes strong and prominent, as in *C. Robertsoni* and *C. gibba*; but it is not localized as an isolated lump, as in Zenker's figure, which may be an accidental exaggeration, due possibly to malformation of the individual ‡. Certainly the female fullness of the carapace is strongest in the *posterior moiety* of the valves, in accordance with the *postero-dorsal* position of the ovaries in Ostracods and the Limnadiad Phyllopods, but for which a *postero-ventral* position would be quite abnormal, as intimated in the Proc. Geol. Assoc., Pal. Div. Entom. p. 11. An analogue for the *postero-ventral* position of the ovaries might possibly be found by referring to the arrangement of the eggs in some Schizopods with their "brood-plates" or lateral supplementary laminar egg-covers; but this would be going too far from the simply bivalved Ostracods.

In the bivalved carapaces of recent Ostracoda the most compressed end is found to be the anterior, and in the majority of known forms this end is also the lowest (narrowest). This rule was adopted when it was necessary to refer by name to the extremities of the Beyrichian valves and their special lobes. These relative proportions in height (1.721th) and thickness are observable in most of the *Beyrichiæ* excepting—(1) those which have naturally a semicircular ventral border, and (2) those in which the variable lobe

\* Zeitschr. d. d. geol. Ges. vol. xxi. 1869, p. 774.

† "The female brings forth living young, and for their development the hinder body is enlarged by the two swellings" (Wiegmann's Archiv, 20. Jahrg. vol. i. 1854, p. 85, pl. v. D. fig. 2).

‡ In some *Leperditiæ* the margin of the right valve is *thickened* at the same place.



(regarded by us as *antero-ventral*, by Reuter as *postero-ventral*) has pushed out and overhung the margin, thus altering the shape of the valve. Take for instance the semicircular, fig. 14, pl. v. (Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. 1855); and compare the regular figs. 5, 9, and 11, with the "big-lobed" figs. 7 and 8 on that plate. We cannot therefore adopt Mr. Reuter's cleverly devised nomenclature (*op. cit.* pp. 630, 631) for the fore and aft furrows of the Beyrichian valves, his "cephalic" and our "cephalic" being contradictory terms.

We have regarded the sulcus between the "sausage" and "middle" lobes as equivalent to the nuchal notch of Crustacea. Unfortunately there are no "ocular spots" in Beyrichian valves to give a clue to the *cephalic* extremity. In neither *B. oculina* nor *B. oculifera*, Hall, is there any satisfactory indication of this feature; nor has the exact position of the muscle-spot been determined. We may note that the Carboniferous, Devonian, and Lower-Silurian *Beyrichiæ* did not take on the exaggerated lobe, so far as we are aware.

Doubtless the alliances of the Leperditidiadæ\*, whether amongst themselves or with Ostracods on the one hand and Limnadiads on the other, are not yet well understood, as their soft parts are wanting; but, as all the living bivalved forms have the ovary in the *postero-dorsal* region, it would be too strange for this organ to be placed elsewhere in analogous fossil genera. It does not seem possible to allocate satisfactorily the internal organs to the external lobes; and until we have all the *Beyrichiæ* before us, in their great multiplicity and in their successional order, we cannot pretend to know all the features and their probable biological meanings†. With regard to the extraordinary outward growth of one lobe on each valve in *Beyrichia* it might possibly have reference to a fully-developed hepatic gland, if in this genus the liver had the same position that it has in *Cypris* according to Zenker (Archiv &c. 1854, vol. i. p. 37, pl. i. fig. 15). There is a possibility of its having had a parasitic origin, like the swelling caused by *Bopyrus* in the Prawn. The "big lobes" are not always quite equal nor quite opposite on the two sides in *Beyrichiæ*.

The protuberant and exaggerated antero-ventral lobe has

\* Month. Microsc. Journ. 1870, pp. 187 &c.

† Some of the Cypridinadæ are smooth, but others have swellings of the valves, which seem difficult to collocate with internal organs. *Cypri-della* is "swollen here and there into tubercles, fewer in the young than in the old state" (Monthly Microsc. Journ. vol. x. 1873, p. 74).

been figured or noted as present in individuals of the following species of *Beyrichia* :—

- B. tuberculata* (Klöden), Klöden, 1834, fig. 22; Jones, Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. 1855, pl. v. figs. 7 *a*, 7 *b*, 8 *a*, and P. B. E. 1869, fig. 12 *c*; Boll, 1862, fig. 1 *a*; Karsten, 1869, pl. xx. figs. 3 *b* and *c*; Krause, 1877, pl. i. fig. 12 *b*.
- B. Klædeni*, M'Coy, Jones, Proc. Geol. Assoc. P. B. E. fig. 6 *b*; Heidenhain ("*tuberculata*"), 1869, pl. i. fig. 14.
- B. protuberans*, Boll, 1862, fig. 3; Karsten, 1869, pl. xx. fig. 3 *g*: *B. Klædeni-granulata*.
- B. Klædeni*, var. *granulata* (see further on).
- —, var. *nuda* (see further on).
- —, var. smooth and partially ridged: *B. cincta*, Boll, 1862, fig. 4.
- —, var. smooth: *B. lunata*, Kolmodin, 1869, p. 17, figs. 8, 9; referred by Kolmodin to *B. Klædeni* in 1880, p. 137.
- —, var. *intermedia*, Jones (see further on).
- —, var. *subtorosa*, Jones, P. B. E. fig. 10 *b*.
- —, var. *torosa*, Jones, *ibid.* fig. 11 *b*, and Ann. & Mag. Nat. Hist. 1855, xvi. pl. vi. fig. 11.
- —, var. *antiquata*, Jones, Ann. & Mag. Nat. Hist. 1855, xvi. pl. vi. fig. 12.
- B. Buchiana*, Jones, P. B. E. fig. 13 *b*.
- —, Jones, Krause, 1877, fig. 14 *b*.
- B. Dalmaniana*, Jones, Ann. & Mag. Nat. Hist. 1855, xvi. pl. v. fig. 13.
- B. Salteriana*, Jones, Krause, 1877, fig. 17 *b*.
- —, Jones, Kiesow ("*Maccoyana*," var.), 1864, pl. iv. fig. 6.
- B. Maccoyiana* \*, Jones, Krause, 1877, fig. 16 *b*.
- B. elegans*, Boll, 1862, fig. 10 = *Salteriana*, Jones.
- B. grandis*, Kolmodin, 1880, pl. xix. fig. 8 *a*, *b* = ? *Salteriana*, Jones.
- B. impendens*, Jones, P. B. E. 1869, fig. 4 *b*.
- B. Wilckensiana*, Jones, Krause, 1877, fig. 18 *b*. The figs. 17, 18, 19 in pl. v. (Jones, *op. cit.* 1855) are correspondingly big-lobed individuals.

We may here mention that Dr. Krause suggests that *B. Dalmaniana*, Jones, is the same as *B. elegans*, Boll and that

\* The German palæontologists prefer to write this word "*Maccoyana*;" and some uniformly misspell "*Wilckensiana*."

both are *big-lobed* ("female") forms of *B. Maccoyiana*, Jones; but we cannot agree with him in this proposition. His suggestion that *B. protuberans*, Boll, is the *big-lobed* form of *B. Klædeni*, M'Coy, is highly probable. We see the same condition in Heidenhain's pl. i. fig. 14, which is wrongly referred to *B. tuberculata*, as pointed out by Krause (*op. cit.* p. 32), who doubts, however, its being *B. Klædeni*.

In his description of *B. grandis* (1880, p. 138), Dr. Kolmodin regards the big lobe there present as being *posterior*; but it may well be *antero-ventral*, as we have regarded it in other such forms. In *B. grandis* it bears on its middle a low process, hollowed out at the top like an oval-lipped hollow wart. This specimen and the one described and figured by Boll as *B. elegans* (1862, p. 135, fig. 10) are both imperfect (probably having been thin-shelled), and yet appear to have much in common—in their outlines, in the relative size and position of the central lobe, and in the oval outline of the exaggerated lobe, which is said to be neatly granulated in Kolmodin's, and cross-cut with striae, bounding minute intermediate elevations, in Boll's specimen, the meshes longest with the long axis of the lobe. The exceptional size of the front lobe and the general granulation\* of the surface make the chief differences.

The large collections of Ostracoda made of late years by Messrs. John Smith† and G. R. Vine‡ from the Upper-Silurian § shales of Shropshire having been confided to us for description, we have had a good opportunity of extending our knowledge of the *Beyrichiæ*. Mr. C. D. Sherborn has effectively aided us in our work.

By careful working Mr. Vine in 1881 had picked out of the Upper-Silurian shales supplied by Mr. G. Maw, F.G.S. ||, more than 60,000 specimens of the remains of Actinozoa, Echinodermata, Annelida, Polyzoa, Brachiopoda, Trilobita, and Entomostraca. Of the Polyzoa and Annelida he supplied descriptions in the Quart. Journ. Geol. Soc. vol. xxxviii. 1882, pp. 44 &c., and *ibid.* pp. 377 &c.; and lists of the others were given at the same time (see *ibid.* pp. 47-49).

His collection of the Entomostraca comprised many hundreds of specimens, and he commenced describing and

\* It is difficult to determine under some microscopes whether we have granules or pits.

† Geol. Mag. dec. ii. vol. viii. 1881, pp. 70-75.

‡ Quart. Journ. Geol. Soc. vol. xxxviii. 1882, pp. 44 and 48.

§ "Upper Silurian" of Murchison and the Geological Survey, but "Silurian" of the Cambridge school of geologists.

|| See the paper by Davidson and Maw, Geol. Mag. dec. ii. vol. viii. 1881, pp. 100-106.

cataloguing them. Their study and determination were, however, put aside for awhile; and ultimately Mr. Vine requested one of us to take the collection in hand for special treatment, liberally offering the whole for acceptance. The work of examining, comparing, describing, and illustrating this extensive and excellent series of Upper-Silurian Ostracoda, the more valuable on account of the known horizon of the bed from which each individual has been obtained, was undertaken with pleasure, but has necessarily occupied much time.

The coincident opportunity of critically examining another large and well-preserved series of Upper-Silurian Entomostraca was afforded by Mr. John Smith, of Kilwinning, kindly submitting for our determination and description the collection he had formed in 1880, and of which a provisional list was given by one of us in the 'Geological Magazine,' 1881, *loc. cit.*

Among the forms collected, as mentioned above, are the following genera:—*Beyrichia*, *Kirkbya*, *Primitia*, *Thlipsura*, *Echmina*, *Cytherella*, *Cytherellina*, *Macrocypris*, and others; but on this occasion we can take only the *Beyrichie* into consideration.

With regard to Mr. Vine's collection, he informs us that the same numbers are connected with these specimens, to indicate the beds from which they came, as those used in his "Notes on Polyzoa" &c. (Quart. Journ. Geol. Soc. *loc. cit.*), and that he has found it "quite possible to speak of the relative abundance or the paucity of species in the different washings. From the five 'Buildwas' localities those marked no. 22 and no. 37 have yielded the greatest abundance of individuals; nos. 36 and 38, the richest beds for Polyzoa, have been very poor in their yield of Ostracoda. The Coalbrook-Dale washing (no. 43) is likewise poor. In the Tickwood beds, especially no. 25, and in Mr. Young's washing, no. 25\*, the Ostracoda are abundant both in species and in individuals; and the same remark will apply to the 'Shales over the Wenlock Limestone,' no. 46."

The order of the beds and the numbers of the boxes of washed material, as adopted by Davidson and Vine, are:—

"Shales over the Wenlock Limestone, 24 and 46.

"The Wenlock Limestone, not examined.

"Upper Wenlock Shales, 25, 25\*, 41, 42. Tickwood beds.

"Middle Wenlock Shales, 43. Coalbrook-Dale beds.

"Lower Wenlock Shales, 22, 36, 37, 38, 40. Buildwas beds."

Mr. Vine has already drawn attention to the fact that much

of the finer débris of the shales must have been lost in the washing †, and the small Entomostraca must have escaped with it; but there was some unwashed clay in the cases sent to him, and from this and in cleaning the other fossils he was able to collect a fair sample of the shale. This he carefully manipulated, and out of the several fresh washings he collected more than three thousand specimens of Entomostraca. Altogether there are between forty and fifty species and notable varieties. Individuals of some of these are rare and local; others are common. The most abundant of the whole are those usually referred to smooth *Cytheræ* and *Thlipsuræ*; *Beyrichiæ* are also common.

Mr. John Young, F.G.S., of the Hunterian Museum, Glasgow, received from Mr. Maw a packet of shale weighing about ten pounds from the Tickwood beds and another of about the same weight from the Buildwas beds. The clay from the Tickwood beds he carefully washed; and in a letter to Mr. Vine (dated June 12, 1880) he gives the following particulars:—"I weighed five pounds of the dried shale and put it in water until it was thoroughly dissolved, stirred it gently with the hand, poured the muddy water off, and kept on washing until the water remained quite clear. When the residue was dried, I found that out of five pounds weight only two and a half ounces remained. This was composed of fragments of still unwashed shale, a number of specimens of small Brachiopods, fragments of Polyzoa, some of Trilobites, a species of *Conchicolites*, a number of Entomostraca, and fragments of other organisms." This gathering is marked 25\* in the list, the organisms generally agreeing with those found in no. 25.

### I. BEYRICHTIA, M'Coy, 1846.

*Beyrichia*, M'Coy, Silur. Foss. Ireland, 1846, p. 58.

*Beyrichia*, Boll, Dunker und von Meyer's Palæontogr. vol. i. July 1847, p. 127.

*Beyrichia*, auctorum.

This genus is known by small, semicircular, semi-ovate, and more or less oblong valves, strongly lobed by deep transverse furrows. The amount and extent of sulcation vary very much. Some unisulcate allies, formerly termed *Beyrichiæ simplices* (already alluded to), of simple outline, and passing into small, feebly furrowed, or non-sulcate Leperditioïd forms, have been separated as *Primitiæ*. The *Beyrichiæ* proper (*Jugosæ*) have the surface of the valves impressed with

† *Op. cit.* p. 44.



two strong vertical furrows, extending from the back to the ventral portion of the valve and dividing the surface into three unsymmetrical lobes, transverse ridges, or bosses. These vary considerably in size, mode of subdivision, and relative position in different species and their varieties, and to some extent in different stages of individual growth. The hinder and usually larger lobe is somewhat leg-of-mutton- or gigot-shaped; hence it may be termed the "gigot-lobe." It is often transversely sulcate. The lobe at the other end may be called the "sausage-lobe," whether entire or constricted. Its distended ventral extremity, making the extraordinary "big lobe," is subglobular or apple-like. The middle lobe is usually egg-shaped, but may be narrow and elongate. The gigot and middle lobes are usually connected below, but sometimes this condition is obscure; and in some specimens the ventral portions of all three lobes are almost equally united.

The ventral and two end margins of each valve are turned sharply inwards, the angle so made being marked externally by a prominent rim or ledge, slightly rounded or trenchant, along these three edges of the valve. An additional frill-like free flange sometimes (in adults) stands out along the ventral region \* above the border. These thin laminar processes, as well as the real marginal flange, are divergent, so as to give a broad basis to the carapace standing on its ventral surface. They are also sometimes frilled (crimped or goffered) with radiate striæ; sometimes they have a spiny fringe, and frequently present only denticles or short blunt spines. The surface of the valves may be minutely pitted or coarsely reticulate; and frequently small granulations, passing into tubercles, ornament the whole or part of the valves; and the large exaggerated antero-ventral lobe occasionally shows an elegantly delicate reticulate surface. The dorsal edges of the two valves meet along the hinge-line without any special modification. The other contact-edges close together by the marginal flange of the one valve being received by the edge of the other. The valves are almost equal in size, the ventral edge of the left valve very slightly overlapping that of the right.

Some special *Beyrichiæ*, typified by *B. Wilckensiana* and its variety *plicata*, constitute the group *Corrugatæ*†.

\* This supernumerary flange is also met with in some Carboniferous *Beyrichiæ* and *Kirkbyæ*.

† Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. pp. 89-90, 175, and vol. xvii. p. 83, footnote. We now omit *B. Ribeiriana*, *B. affinis*, and *B. Barandiana* (op. cit. pp. 170, 171) from the *Corrugatæ*.



They have smooth convex valves, impressed with two short vertical furrows on the dorsal region; and in the type a third smaller furrow defines a narrow semilune at the front end of the valve. Two such small, vertical, parallel furrows characterize the variety *plicata*. *B. Wilkensis* differs so much in general features from typical *Beyrichia* that we think this purse-like form ought to be raised to generic distinction as *Klædenia*, a name we propose to use in honour of Karl Friedrich von Klöden, who first noticed the *Beyrichia*.

The furrows in *Klædenia* do not alter the contours of the valves so much as the deeper and broader four sulci in *B. bussacensis*, Jones (Proc. Geol. Assoc., Pal. Biv. Entom. 1869, p. 15, fig. 23), and we may add perhaps *B. Forbesii*, Jones (*ibid.* fig. 19). This or a similar arrangement of parts may hold good according to the description (not accompanied by a figure) in Billings's *B. decora* (Sil. Foss. Anticosti, 1866, p. 66). Another possible ally is *B. persulcata*, Ulrich, from the Hudson-River Group (Journ. Cincin. Soc. N. H. vol. ii. 1879, p. 4, pl. vii. fig. 6). *B. pennsylvanica*, Jones (Ann. & Mag. Nat. Hist. ser. 3, vol. ii. pp. 252, 253, pl. x. figs. 15-18), also possesses four lobes or ridges in its adult form\*. *B. nana*, Brögger (Die silurischen Etagen 2. und 3. im Kristianiagebiet und auf Eker, 1882, p. 55, pl. xii. fig. 15), is also one of the four-lobed *Beyrichia*. These *Beyrichia* having more than three transverse lobes on their valves may be grouped as *Plurijugatae*. Our new species *Beyrichia admixta* (see further on) is one of this group, and *B. lacunata*, sp. nov., is not far removed from it.

### 1. *Beyrichia tuberculata* (Klöden).

*Battus tuberculatus*, Klöden (pars), 1834, Verstein. Mark Brandenburg, pp. 115-117, pl. i. figs. 21-23.

*Beyrichia tuberculata*, Boll, 1847, Palæontogr. vol. i. p. 127, 1862, Archiv Vereins Freunde Naturg. Meklenburg, 16. Jahr. p. 119, pl. O, figs. 1 a, b; var. = *B. Kochii*, Boll, l. c. p. 121, fig. 2 (? = var. *nuda*, Jones).

*Beyrichia tuberculata*, Jones, 1855, Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. p. 86, pl. v. figs. 4-9 b; Proc. Geol. Assoc., Pal. Biv. Entom. 1869, p. 12, figs. 12 a, b, c; Geol. Mag. dec. ii. vol. iii. 1881, p. 344, pl. x. figs. 8, 9, 10.

*Beyrichia tuberculata*, var. *nuda*, Jones, 1855, *op. cit.* figs. 10, 11, et var. *antiquata*, fig. 12.

*Beyrichia tuberculata*, Karsten, 1869, Beiträge zur Landeskunde d.

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\* The frilled specimens of this species (fig. 15) were wrongly referred to *B. Maccoyiana* (*loc. cit.*).

Herzog. Schleswig und Holstein, series 1, part 1, p. 57, pl. xx. figs. 3 a, b, c.

*Beyrichia tuberculata*, Krause, 1877, Zeitschr. d. d. geol. Ges. vol. xxix. p. 30, pl. i. figs. 12 a, b, and var. fig. 13.

*Beyrichia tuberculata*, var. *gedanensis*, Kiesow, 1884, Schr. naturf. Ges. Danzig, new ser. vol. vi. p. 277, pl. iv. fig. 5.

*Beyrichia tuberculata*, Reuter, 1885, Zeitschr. d. d. geol. Ges. vol. xxxvii. p. 632, pl. xxv. figs. 1 A and B [and the varieties figs. 2-9].

*B. tuberculata* (Klöden) is characterized by the nearly oblong shape and the strong growth of its valves, their well-defined margins, and their three full lobes. The front lobe is sausage-shaped, sometimes single, but usually constricted or cut crosswise, so as to be divided into two unequal lobes. The midlobe is single, oval, and usually free, but occasionally united by a low and narrow isthmus with the foot of the posterior lobe. The last is the largest, somewhat semilunar or curvi-pyriform (gigot-shaped), and more or less tripartite, rarely (in some varieties) less strongly sulcate; but in some cases it is resolved into several isolated tubercles. The surface, especially of the large lobes, is coarsely and irregularly granulate, and the margin also is sometimes tuberculate.

The late Dr. Ernst Boll objected that Klöden should be the "authority" for this species, because the latter included all his figures in *Battus tuberculatus*. As, however, he regarded some as immature forms, the figs. 21, 22, and 23 still remain as representing the typical species. His figs. 16 and 17 are *B. Wilckensiana*, Jones (fig. 16 being var. *plicata*, not *Cytherellina siliqua*, as Krause thinks). Fig. 18 is probably *B. Salteriana*, Jones, as suggested by Krause; and fig. 19 may be the *B. Bolliana* of Reuter, but cannot be *B. complicata*, as supposed by Boll; nor (together with fig. 18) does it represent *B. Wilckensiana*, as supposed by Jones in the Ann. & Mag. Nat. Hist. for August 1855, p. 87.

Dr. Boll recognized that his *B. Kochii*, described as being smooth, is like Jones's fig. 5, pl. v., 1855, which, however, is granulated, and may stand as a weak form of *B. tuberculata* (Klöden). *B. Kochii* still more closely agrees with figs. 10 and 11 of that plate; and the latter individuals, so illustrated, might be called *B. Kochii*, Boll, if the absence of ornament were a specific character in this and the analogous case of *B. Klædeni*, var. *nuda*, Jones (fig. 7, pl. vi., September 1855). So also Dr. Boll was disinclined to include Jones's fig. 12, pl. v. (var. *antiquata*), in the species *B. tuberculata*, the posterior (gigot) lobe being weakly developed; but an analogous varietal form accompanies the typical *B. Klædeni* (see pl. vi. Sept. 1855, fig. 8, and Geol. Mag. 1881, p. 345, pl. x. fig. 11);

it is noticed also by Kolmodin (Öfvers. K. Vet.-Akad. Förhandl. for 1879, vol. xxxvi. 1880, p. 137.

We must remember that by themselves neither the splitting-up of the lobes nor the granulation of the surface can be taken as specific characters, so many instances of the capricious adoption of these features being known.

(1) *Beyrichia tuberculata*, var. *gibbosa*, Reuter.

(Pl. XII. figs. 1 a, 1 b.)

Proportions\*:—Length 27. Height 16. Thickness 18.

In one specimen, seeming to belong at first sight to the varietal group of *B. Klædeni-torosa* (see further on), the subdivision of the gigot-lobe has proceeded a step further, and there are *three* lobules, thus presenting a leading character of *B. tuberculata*, Klöden. The other lobe is distended ventrally. This individual is scarcely to be distinguished from the variety figured and described by G. Reuter as *B. tuberculata-gibbosa* (Z. d. d. g. G. 1885, p. 634, pl. xxv. fig. 2 B). Krause's fig. 12 b, pl. i. (Z. d. d. g. G. 1877, p. 30), *B. tuberculata*, is very similar.

This specimen (on slide no. 9 of Mr. J. Smith's collection) is from the Upper-Silurian beds at Dudley Castle.

The same collection has a modification of *B. Klædeni*, var. *subtorosa*, which imitates a variety of *B. tuberculata* (see p. 353, under var. *subtorosa*).

2. *Beyrichia Klædeni*, M'Coy, 1846.

Some observations on this variable species, as to its history, character, and synonyms, were offered by one of us in the Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. 1855, pp. 166 *et seq.*, and in the Geol. Mag. dec. ii. vol. viii. 1881, p. 345.

The typical form is characterized by the nearly semicircular or ovate-oblong shape of the valves and their three neat lobes. The front and hind lobes are large, nearly equal, pyriform and curved; and the hind lobe turns up sharply from below towards, and often joining, the smaller oval midlobe. The surface may be granulate or smooth, and the ventral margin more or less developed. Sometimes the anterior and the posterior lobe each turn towards and meet the midlobe, with distinct necks of junction; and, when so connected, all become more or less attenuate and straight (vars. *intermedia*, *pauperata*). Sometimes the front and hind lobes run together below, leaving the midlobe distinct and either free or lying against the inner side of one of the other lobes (var. *tuberculata*). On the other hand the front and hind lobes become

\* If divided by 15, these will give the measurements in millimetres and parts of a millimetre.

constricted or bipartite, and even divided into distinct lobes (vars. *torosa*, *subtorosa*). In one instance, whether a variety or a species is doubtful (fig. 12, pl. vi. Ann. & Mag. Nat. Hist. 1855, vol. xvi.), the front lobe is tripartite and the hind lobe (obscure in the specimen) seems to be undivided. It is difficult in very many cases to determine where varietal changes end and specific distinctions take their stand.

*Beyrichia Klædeni*, M'Coy, is subject to considerable variation in the relative shape and proportions of its lobes, ridges, and furrows, besides being affected by a subdivision of the lobes, as in the varieties *subtorosa* and *torosa*. In the narrowness of the lobes and width of the furrows the varieties *intermedia* and *pauperata* are conspicuous. In the latter the furrows are very much widened at the expense of the ridges, which are not only narrow but much attenuated below, a thin line only partially connecting the front and hind lobes along the ventral margin, while the middle lobe is greatly reduced, comma-like, and isolated. This form accompanies var. *torosa* in the Upper-Ludlow rock of Aymestry Common (both as casts), and is figured in the Pal. Biv. Entom., Proc. Geol. Assoc. 1869, p. 14, fig. 8.

Several British varieties are noticed (with references) in the Geol. Mag. (*l. c.*) as being marked by the relative development of the three lobes, ranging from the variety *pauperata*, having very narrow lobes, and the var. *torosa*, with its subdivided lobes, to the typical *Klædeni*, with well-developed neatly-shaped lobes, and its var. *tuberculata*, in which the lobes take up a large portion of the valves, and, leaving the middle lobe more or less distinct, have become almost or quite confluent below. A general tuberculation of the surface is common in the last variety and is present also in some others. In the collections made by Messrs. Smith and Vine we meet with some of the varieties here alluded to, and with intermediate conditions, whether of individual growth or of progressive development. As *B. Klædeni* varies in two directions (in one set of individuals the lobes becoming narrower and wider apart, and in the other becoming thick and closer), it is difficult to take all its varieties in one order. We first take the typical forms, and then those showing attenuation of the lobes.

#### I. Lobes free and plump.

- (1) *Beyrichia Klædeni*, var. *granulata*, Jones.  
(Pl. XII. fig. 2.)

Proportions:—L. 18. H. 11.

The common three-lobed *Beyrichia* somewhat granulated

(Ann. & Mag. Nat. Hist. Sept. 1855, vol. xvi. p. 166, pl. vi. fig. 9). The hinder lobe is not divided nor constricted; but with age both the hind and front lobe generally bear one or more tubercles on their prominent dorsal ends. This is the "granulated variety" referred to in the Geol. Mag. 1881, pp. 345 and 346. The older individuals in some cases pass into var. *tuberculata*, Salter.

The front lobe is greatly enlarged ventrally in some specimens. This condition occurs in individuals of several distinct species (Upper-Silurian, see above, p. 342) as well as varieties; and therefore it is not a specific character, as Boll thought it was when he described and named a form similar to the above as *B. protuberans*. What organ of the animal took on an increased structure, so as to cause the valves to be thus locally swollen in the antero-ventral region, we do not know. The ovaries in living Ostracoda and Limnadiads are situated in the postero-dorsal region (see above, p. 340).

*B. Klædeni-granulata*, Smith Coll. no. 9<sub>1,2,5</sub>, from Dudley Castle; no. 10, railway-cutting, side of the Severn, Iron-bridge; no. 21, railway-cutting, Coalbrook Dale. All with the "big lobe."

Vine Coll. LXVI<sub>9</sub>, from the Tickwood Beds; XXXIX, passing into var. *tuberculata*, Salter, from bed no. 46. All big-lobed.

(2) *Beyrichia Klædeni*, var. *nuda*, Jones.

This is the *B. Klædeni* with a "smooth valve," referred to in the Geol. Mag. 1881, p. 345; see also Ann. & Mag. Nat. Hist. Sept. 1855, vol. xvi. p. 166, pl. vi. fig. 7. A smooth variety of the typical *B. Klædeni*, but larger than the figured specimen above alluded to, and with the exaggerated antero-ventral lobe, occurred in Mr. G. R. Vine's collection, from the Wenlock Shales, no. 46, but has been lost. In Mr. J. Smith's collection (no. 24 slide) is a large smooth *B. Klædeni*, or, at least, one with the granulation reduced to a minimum. This is from the Wren's Nest, Dudley. In Mr. Vine's collection (slide no. LXVI) is a large *B. Klædeni*, quite smooth, from the Tickwood Beds.

The large individuals of each variety put on strong marginal edges and exaggerate their lobes dorsally into apical bosses or projecting tips.

(3) *Beyrichia Klædeni*, var. *antiquata*, Jones.

*Beyrichia Klædeni*, var. *antiquata*, Jones, Ann. & Mag. Nat. Hist. Sept. 1855, vol. xvi. p. 167, pl. vi. fig. 8.



This is referred to above (page 348). *B. Klædeni*, var. *granulata* (some big-lobed), passing into var. *tuberculata*, Salter, together with var. *antiquata*, have been found in Upper-Silurian shales near Muirkirk and Lesmahago, Lanarkshire.

## II. Lobes less free, attenuated.

- (4) *Beyrichia Klædeni*, var. *intermedia*, Jones.  
(Pl. XII. figs. 3 and 4.)

Proportions :—Fig. 3 (*subspissa*) : L. 21. H. 14. Th. 10.  
Fig. 4 : L. 14. H. 8.

This variety was distinguished and figured in the paper on "Palæozoic Bivalved Entomostraca" in the Proc. Geol. Assoc. 1869, pp. 12 and 14, fig. 9.

Valves suboblong or nearly semicircular, with raised marginal rim and three nearly equal lobes, relatively narrow and vertical, the middle lobe not being short-oval, but reaching down into the ventral region and coalescing freely with the lower ends of the other two lobes. An approximation to this feature is evident in some specimens collected by Mr. Smith from "Woolhope" and by Mr. Vine from the "Tickwood Beds" and the "Shales over the Wenlock Limestone." In the latter, however, the lobes are somewhat thicker than in the specimens from the Upper-Ludlow shales.

In Mr. Vine's examples the surface is punctate or slightly reticulate, but usually roughened. No two have exactly the same outline and contours of lobes and margins. Some are more semicircular than others, and some have the lobes thicker and with less interspaces than others (fig. 3 *a*, *b*). This last modification might be termed subvariety *subspissa*. A raised marginal rim is distinct in all. This form is near to and corresponds with the North-American *B. lata* (Vanuxem, Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. p. 168, pl. vi. fig. 13).

Var. *intermedia* presents a more complete union of the posterior and the central lobe in a horseshoe-shaped ridge than is found in the typical form of *B. Klædeni*, and herein resembles *B. Buchiana*. The front lobe also is connected with the middle lobe by a depressed neck, a condition observable in *B. Buchiana* and some others. Besides the greater distinctness of the lobes in *B. Buchiana*, the notching or tendency to subdivision in its posterior lobe separates it from the variety of *B. Klædeni* under notice, which was designated as



*intermedia* in 1869 from specimens found by Mr. Banks near Kington in company with the typical *B. Klædeni* and its var. *torosa* (all in the state of casts).

No. 12 in Mr. Smith's collection, from the railway-cutting near Much-Wenlock, is a good example of this variety, and has the exaggerated antero-ventral lobe.

Smith Coll. no. 12 (with "big lobe"). Railway-cutting near Much-Wenlock.

554. Woolhope. (Fig. 4.)

Vine Coll. no. XLIV<sub>1</sub>. Bed no. 46. (Fig. 3.)

XLIX<sub>3</sub>. Bed no. 25.

### III. Lobes free and subdivided.

- (5) *Beyrichia Klædeni*, var. *subtorosa*, Jones.  
(Pl. XII. figs. 6 and 7.)

Proportions :—L. 18. H. 12.

This is a rather small semicircular form which has a distinct, raised, sharp, continuous marginal rim within the curved border, and the three usual lobes rather narrower than in the typical *B. Klædeni*. The hinder or gigot-lobe is variously modified by a slight sulcation, either transverse, oblique (fig. 6), or nearly vertical, sometimes double (fig. 7). These marks are not often sharply defined. In some respects it much resembles *B. Klædeni*, var. *nuda* (see above, p. 351); but the lower end of each of the outer lobes curves up more definitely towards the median lobe, and the gigot is sulcated.

In the relative narrowness of the lobes this variety approaches var. *intermedia*, Jones, above mentioned, and more closely those individuals with the thicker lobes; but the very symmetrical form and the sulcate gigot-lobe connect it with the already-published variety *subtorosa*. This is near *B. Buchiana* (Ann. & Mag. Nat. Hist. 1855, vol. xvi. p. 86, pl. v. figs. 1–3; and Proc. Geol. Assoc., Pal. Biv. Ent. 1869, p. 12, fig. 13), but the valves are not oblong (except in some cases with the exaggerated lobe) and the outer lobes are much more curved (like the terminal margins), and not almost vertically straight, as in var. *intermedia* and *B. Buchiana*.

In Mr. Smith's collection is a specimen (no. 34 slide) with two weak parallel oblique furrows on the gigot-lobe (fig. 7), thus imitating, if not actually becoming, *B. Kochii*, Boll (*op. cit.* 1862, fig. 2), which is the same apparently as *B. tuberculata*, var. *nuda*, Jones (*op. cit.* 1855, pl. v. fig. 10, see above, p. 348). This is another of those linkings between Upper-Silurian *Beyrichiæ* which would almost persuade us to group

the majority in one species, were it not that in all probability the several animals varied in their soft parts and limbs.

*B. Klædeni-subtorosa* is in the Smith Collection—no 17, from Blue Holes, Rushal Canal, Walsall; no. 31, railway-cutting, side of Severn, Ironbridge; no. 32, Stoke-Saye, Craven Arms; no. 34, Woolhope (fig. 7). In the Vine Coll. no. XLVI (fig. 6) and no. LXVI, Tickwood Beds.

(6) *Beyrichia Klædeni*, var. *torosa*, Jones.

*Beyrichia Klædeni*, var. *torosa*, Jones, Ann. & Mag. Nat. Hist. Sept. 1855, pl. vi. figs. 10 and 11, and fig. 12.<sup>?</sup>

Valves subquadrate, with two of the usual three lobes broken up each in two smaller lobes.

A specimen with a "big lobe," in Mr. Smith's collection (slide no. 9), from Dudley Castle, has the gigot-lobe divided into three lobules (figs. 1 *a*, 1 *b*), and thus closely imitates, if it does not identify itself with, a variety of *B. tuberculata*. See above, p. 349.

IV. *Lobes coalescing below.*

(7) *Beyrichia Klædeni*, var. *tuberculata*, Salter.  
(Pl. XII. figs. 8 *a*, *b*, 9 *a*, *b*.)

Proportions :—Fig. 8 : L. 35. H. 30.—Fig. 9 : L. 22.  
H. 12. Th. 9.

*Beyrichia Klædeni*, var. *tuberculata*, Salter, Geol. Mag. dec. ii. vol. viii. 1881, pp. 345, 346 (for synonyms, &c.).

We have remarked above (p. 351) that old individuals of the granulate *B. Klædeni* have the roots of their lobes so much thickened that they nearly coalesce, as in the variety before us. The extremes seem at first sight to be quite distinct, but sufficient gradations to connect them are met with.

1. In var. *tuberculata* the front and hind lobes are not at all separated; that is, they do not thin away and become constricted below, but are broadly confluent in the ventral region. The surface bears small tubercles, and in some cases a minute interstitial pitting is also present (Smith Coll. no. 18, Woolhope; figs. 8 *a*, *b*). It sometimes has the exaggerated or hypertrophied lobe, and is then almost undistinguishable from an old big-lobed *B. Klædeni-granulata*.

These specimens are coarsely granulated and at the dorsal ends of the lobes bear one or more tubercles or small knobs.

2. Mr. Vine's XXXVIII (bed no. 25) similar, but not quite so coarsely granulose. The internal cast shows a deeper sulcus than is seen on the valve.

3. Mr. Vine's XLI (bed no. 25), not differing from the foregoing except being larger and smoother, that is, much less coarsely granulated. Front and hind lobes fully confluent.

This variety retains its leading characters among numerous specimens in the Upper-Silurian shales, though the tuberculation varies in intensity. Mr. Smith's no. 15 (Severn, Iron-bridge) has one specimen with a subdentate edge, as also in fig. 8*a*. Occasionally individuals have the "big lobe."

A fine old individual of var. *tuberculata*, Salter (not *B. tuberculata*, Klöden), is in Mr. John Smith's collection (no. 19), from a yellowish shale in a roadside quarry at Gleedon Hill, between Buildwas and Much-Wenlock (see Geol. Mag. Feb. 1881, pp. 72 and 74). It was associated with numerous small Brachiopods and Crinoids, some Polyzoa, Conodonts, and minute pearl-like bodies, such as those described and elucidated by Prof. Sollas (Quart. Journ. Geol. Soc. vol. xxxv. 1879, p. 501, pl. xxiv. figs. 12, 17-20). For similar little pearl-like fossils see C. Barrois's 'Terrains anciens des Asturies et de la Galice,' 1882, p. 45, pl. xx. fig. 4 (uppermost figures), there referred to coccoliths.

Smith Coll. no. 15. Railway-cutting, side of Severn, Iron-bridge.

18. Woolhope (figs. 8*a*, *b*).

19, with big lobe. Gleedon Hill, Much-Wenlock.

23. Benthall Edge.

24, rather variable as to tubercles and midlobes. Wren's Nest, Dudley.

Vine Coll. no. XXXVIII. Bed no. 25: and subvar. *clausa*.

XL. Beds nos. 22 and 46.

XLI. Bed no. 25.

LXI. Coarse. Bed no. 46.

XLIV<sub>11</sub>. Bed no. 22.

LXV<sub>8</sub>, with big lobe; <sub>9</sub> and <sub>10</sub> granulate and one *B. Kl.-nuda*. Bed no. 46.

LXVI<sub>8</sub>, <sub>9</sub>. Smoothish and granulate. Bed no. 25.

Subvariety *clausa*, nov. (Fig. 9.)

Mr. Vine's no. XLVII, from the bed no. 46, exhibits a weak condition of the variety *tuberculata* (Salter), similar to that shown by the small specimen (a cast) from the Upper Llandovery of Howler's Heath, near Malvern, figured in the Geol. Mag. decade ii. vol. viii. 1881, p. 345, pl. x. fig. 12, and belonging to this subgroup, in which the hind

and front lobes take up a large portion of the surface, leaving the middle lobe small, but distinct, in a subcentral depression. Ventral margin slightly developed. The surface bears small scattered tubercles, as in Salter's fig. 14 *a*, from which it slightly differs in shape, being longer in proportion. Edge view narrow-oval.

In shape and the position of the middle lobe, this form has some resemblance to *B. impendens*, Jones\*, but it is sufficiently distinct in several respects.

In the "Shales over the Wenlock Limestone," no. 46. This small subvar. of *tuberculata*, Salter, has a "very limited range in the Shales" (Vine).

(8) *Beyrichia Klædeni*, var. *scotica*, nov.  
(Pl. XII. fig. 10.)

Proportions :—L. 12. H. 9.

A closely allied form comes from the Middle-Silurian (Llandovery) rocks near Girvan, Ayrshire. It is shorter, being more nearly semicircular; the middle lobe is rather more definitely egg-shaped, and there is a thick raised marginal rim in all. A *smooth subvariety* was described and figured as *B. Klædeni* by one of us in the 'Monograph of the Silurian Fossils of the Girvan District,' by Nicholson and Etheridge, Jun., 1880, p. 218, pl. xv. figs. 8–8 *b*†; and of the present strongly granulate form (fig. 10) we have seen four imperfect specimens (in Mrs. Gray's collection) from Bargany-Pond Burn. Of these, one small hollow cast, preserving the best proportion of characters, is here figured; but the mid-lobe is higher up than in older individuals. Excepting this lobe the surface bears large scattered granules, sometimes concentrically arranged, and the raised margin has a distinct row of them also. The specimens occur in a hard limestone and have not been got out free of matrix.

3. *Beyrichia concinna*, sp. nov.  
(Pl. XII. figs. 22 *a*, *b*.)

Proportions :—L. 10. H. 5. Th. 5.

This little unique carapace is very neat, compact, and semioval, deeply impressed in the dorsal region of each valve with two short and unequal sulci, marking off a short and distinct midlobe. This is continuous with the general con-

\* See Nicholson and Etheridge's 'Monograph Silur. Foss. Girvan, vol. i. 1880, p. 219 (references, &c.).

† We may here mention that a few other *Beyrichiæ* and *Primitiæ* from Girvan remain to be described.

vexity of the valve, and lies closely against one of the main lobes, which are quite confluent below. The surface of the valves is delicately reticulate, the marginal rim is distinct and uniform. The edge view is sharp-ovate, notched at the sides not quite symmetrically.

This rare form (no. 29 of Mr. J. Smith's collection) is from Dormington, near Stoke-Edith. It is apparently related to the subvariety *clausa* (fig. 9), but its reticulate ornament and other features sufficiently distinguish it.

#### 4. *Beyrichia Maccoyiana*, Jones.

(Pl. XII. figs. 11 *a, b, c*, 12, 13 *a, b*.)

*Beyrichia Maccoyiana*, Jones, Ann. & Mag. Nat. Hist. ser. 2, vol. xvi. 1855, p. 88, pl. v. fig. 14. (Not *B. Maccoyiana*, Jones, *ibid.* ser. 3, vol. i. 1858, p. 252, pl. x. fig. 15, which is *B. pennsylvanica*, *ibid.* p. 253, retaining the marginal frills absent in figs. 16-18.)

*Beyrichia Maccoyana*, Boll, 1862, Archiv Ver. Freunde Naturg. Meklenburg, 16. Jahrg. p. 134, pl. O. fig. 9.

*Beyrichia hians* (?), Boll, 1856, Zeitschr. d. d. geol. Ges. vol. viii. p. 323, fig. 4; and 1862, Archiv &c. p. 136, pl. O. fig. 11.

*Beyrichia Maccoyana*, Heidenhain, 1869, Zeitschr. d. d. geol. Ges. vol. xxi. p. 171, pl. i. fig. 13.

*Beyrichia Maccoyana*, Krause, 1877, Zeitschr. d. d. geol. Ges. vol. xxix. p. 34, pl. i. fig. 16 *a, b*.

[We are not inclined to admit as synonyms *B. Dalmaniana*, Jones, and *B. elegans*, Boll, as suggested by Dr. A. Krause, *op. cit.* pp. 34, 35.]

*Beyrichia Maccoyana*, Kolmodin, 1879, Öfvers. K. Vetensk.-Akad. Fördhandl. vol. xxxvi. p. 138 (not all the synonyms).

*Beyrichia Maccoyana*, et varr., Reuter, 1885, Zeitschr. d. d. geol. Ges. vol. xxxvii. p. 643, pl. xxvi. figs. 16-18 *c*.

Proportions : { Fig. 11 : L. 22. H. 15. Th. 14.  
                           Fig. 12 : L. 19. H. 12.  
                           Fig. 13 : L. 22. H. 16.

Several specimens, from the Upper-Silurian Shales, in Messrs. Smith's and Vine's collections, are sufficiently similar in character and features to allow us to refer them to this Scandinavian species. In these English examples the hinder lobe is large and pyriform, uniting below by a definite curve with the middle lobe, and the anterior lobe, also pyriform but smaller, comes down and touches their connecting isthmus. The "middle" lobe is occasionally somewhat excentric (fig. 12).

The surface is punctate, but more often reticulate, like the impressions on the head of a thimble, but much more delicate. The radiate marginal fringe or frill is more distinct in some individuals than in others, and this in adults is really not the margin itself but a free flap spreading outwards from the valve above it. It is often unequal in breadth in its semicircular extension, and projects outwards and downwards,



giving a broad ovate outline to the ventral surface of the closed and perfect carapace (fig. 11 c), which has the real marginal rims besides.

In some smaller specimens (XLII, said to be of "very local" occurrence by Mr. Vine) the margin is narrower and simple, and the front and hind lobes are confluent below.

Taking the varieties together, the width of the free margin and the ventral confluence of the lobes are variable, being different in individuals. In fig. 12 (Mr. Smith's no. 22) the front and middle lobes are closer together than usual, and the flange has not put on the crimped or goffered pattern.

In fig. 13 a the hypertrophy of the anterior lobe (which is not very common in this species) has misshaped the valve and encroached greatly on the frilled border. The reticulation on the valve is irregular, but on the "big lobe" it is small, neat, and elegantly regular (fig. 13 b).

E. Boll figured and described some *Beyrichia* of this alliance in the Zeitschr. d. deutsch. geol. Ges. vol. viii. 1856, pp. 321 and 324, as *B. Jonesii*, Boll, figs. 1 and 2; *B. spinulosa* (*nodulosa*, Boll, 1862), fig. 3; and *B. hians*, Boll, fig. 4, from the drifted blocks of Upper-Silurian limestone found in North Germany. In 1862, 'Archiv Ver. Freunde Natur. Meklenburg,' 16. Jahrg. pp. 133, 134, *B. spinigera*, Boll, fig. 7, and *B. Maccoyana*, Jones, fig. 9, were added from the same source.

The margin is tubercled in *B. nodulosa*, and marked with prickles in *B. spinigera*; but in the other three the marginal frill is radiately striate, with some variations in pattern and intensity. The lobes differ in their proportions in all. *B. hians* is so called because in the described valve (unique?) the antero-ventral edge is, as it were, pressed inward and upward (projecting at one spot obliquely outward), so that the carapace gaped there when the valves were closed, if the notch be a real feature and not the result of local accident.

Smith's no. 13, small. Railway-cutting, Much-Wenlock.

14. Railway-cutting, Coalbrook Dale.

17. Blue Holes, Rushal Canal, Walsall.

20. Railway cutting, Coalbrook Dale.

22. Lincoln Hill, Ironbridge.

25 (fig. 13 a, b), with "big lobe." Railway-cutting, side of Severn, Ironbridge.

27. Railway-cutting, side of Severn, Ironbridge.

28. Railway-cutting, side of Severn, Ironbridge.

Vine's no. XLII.

XLIII<sub>1</sub>. (fig. 11). } Tickwood Beds.

LXVI.



5. *Beyrichia Jonesii*, Boll.

*Beyrichia Jonesii*, E. Boll, 1856, Zeitschr. d. d. geol. Ges. vol. viii. p. 322, figs. 1 and 2; 1862, Archiv Ver. Fr. Nat. Meklenburg, 16. Jahr. p. 134, fig. 8.

? *Beyrichia verrucosa*, Kolmodin, 1869, Sverig. Silur. Ostrac. p. 19, fig. 12.

? *Beyrichia Jonesii*, Kolmodin, 1880, Öfv. K. Vet.-Akad. Fördhandl. vol. xxxvi. p. 137.

*B. Jonesii* has the middle lobe relatively small and pressed more or less closely against the inner side of one of the lobes. The ventral union of the lobes, usually by a thin isthmus, is variable in extent. Surface of the large lobes granulate or tuberculate. The marginal rim well developed and radiate. In Kolmodin's *B. verrucosa*, which he regards as *B. Jonesii*, the front and hind lobes freely coalesce, and, together with the margin, are tuberculated. In the latter feature this resembles Boll's *B. nodulosa*, otherwise it resembles Boll's fig. 2 (1856) and fig. 8 (1862).

A specimen closely resembling fig. 1 of Boll's *B. Jonesii* has been found by Dr. Holl in the Wenlock Limestone of Eastnor Park, below the Herefordshire Beacon, on the west side, near Malvern.

6. *Beyrichia admixta*, sp. nov. (Pl. XII. fig. 5.)

Proportions:—L. 13. H. 7.

These few, small, oblong valves (Smith Coll. no. 55<sub>2</sub>, from Woolhope) have three distinct subequal vertical lobes, evenly united below, and also the beginning or root of an obscure supernumerary lobe, apparently a duplication of the gigot, as if it were to be divided vertically, but only a part of it exposed.

This form is closely allied, if not belonging, to the four-ridged group (*Plurijugatæ*). It evidently requires a distinct name; *admixta* has reference to this intermediate character.

7. *Beyrichia lacunata*, sp. nov.  
(Pl. XII. figs. 18, 19, 20.)

Proportions: { Figs. 18, 20: L. 12. H. 6.  
Fig. 19: L. 11. H. 6.

These oblong little valves vary in dimensions, outline, and contour. Some are longer than others, and then have the ventral margin somewhat incurved, instead of being straight or

slightly convex. The ends are unequally rounded. The valves all bear a raised ridge just within and concentric with the ventral and terminal margins; also three narrow transverse lobes. These freely coalesce below, and, though somewhat variable, yet usually show that one (posterior), which forms a loop at its upper portion (being there either impressed with an oval pit, or formed of two short ridges meeting at top), curves boldly forward below, and makes one with the usually straight middle lobe; whilst another (anterior) ridge-like lobe goes off from (or joins) the root of the others with a variable curve, or even at an angle. The depressed spaces, or sulci, between the lobes, and between them and the strong marginal rim, are deep and broad. The surface of the valves is obscurely pitted. If the loop-like depression on the gigot were open at the top, we should have a four-lobed *Beyrichia*; but in some individuals the anterior and middle lobes keep together in either an oblique or a curved position, and even nearly coalesce at the top (in the antero-dorsal region), as if, intending to form a loop, they would imitate that of the other lobe, and thus make a single, curved, narrow, ridge-like lobe, having a loop (or oval depression) at each end.

The form is rather rare and is new to us; we call it *lacunata*. Barrande's *B. bohémica* (Syst. Sil. B. vol. i. Suppl. p. 498, pl. xxvi. fig. 13, and pl. xxxiv. figs. 18-22) and M'Coy's figures of *B. complicata* (Pal. Foss. Cambr. 1851, p. 136, pl. i. E, fig. 3) approach in character to this species.

Smith Coll. no. 16. Railway-cutting, Severn, Ironbridge.

55. Woolhope.

Vine Coll. no. XLV. Tickwood Beds, nos. 25 and 25\*.

## II. BOLLIA, gen. nov.

In these Beyrichian Entomostraca the valves bear two lobes meeting below with a thin curved isthmus. They have also a marginal ridge, sometimes unequally divided ventrally. By the lessening of the lobes and the increase of the marginal rim some forms seem to show a passage into *Kirkbya*. The simple horseshoe swelling on the valve differs so much from the *three-lobed* and the *plurijugate Beyrichiæ* and from the *corrugate* form or *Klædenia*, that we propose to give this a generic standing as BOLLIA, in honour of the late Dr. Ernst Boll, of Neubrandenburg (see above, p. 338).

1. *Bollia bicollina*, sp. nov.  
(Pl. XII. figs. 14 *a*, *b*, *c*, 15, & 16.)

Proportions :  $\left\{ \begin{array}{l} \text{Fig. 14 : L. 23. H. 15.} \\ \text{Fig. 15 : L. 22. H. 15.} \\ \text{Fig. 16 : L. 9. H. 7.} \end{array} \right.$

Valves oblong, with rounded and nearly equal ends ; some individuals proportionately longer than others ; straight on the back, more or less outcurved on the ventral edge. The surface is finely punctate, and bears two lobular elevations, one on each side of a median bay-like sulcus, and constituting two irregular obliquely transverse lobes, which converge downwards and meet near the middle of the ventral region by a low, narrow, bent isthmus, sinuous in the adult, but more simply curved in the young state (fig. 16). The upper or dorsal portions of this horseshoe lobe are swollen and project outwards, and in the larger specimens somewhat divergently, giving a symmetrically pinched and knobbly outline to the dorsal profile of the carapace (fig. 14 *b*). The ventral aspect (fig. 14 *c*) shows the parallel, broad, lower margins conjoined, and a slight median swelling at the curved neck or root of the lobes on the sides ; there is also a slight indication of one pair of the lobes more prominent on one side than the other.

There are also two strong semilunar ridges, one at each end of the valve, outside the lobes and parallel with the marginal border, which has a slight outer rim. These two ridges die out opposite each other, below the curved neck of the two large lobes.

In Mr. Vine's collection, nos. XLVIII<sub>1-4</sub>, LXII, LXIV<sub>12, 13</sub>, all from the " Buildwas Beds " of the Wenlock Shale.

A small or young form (fig. 16), with essentially the same features as those of *B. bicollina*, occurs in Mr. J. Smith's collection, no. 55<sub>3</sub>, from Woolhope.

2. *Bollia uniflexa*, sp. nov. (Pl. XII. figs. 17 *a*, *b*.)

Proportions :—L. 23. H. 16. Th. 10.

Valves nearly semicircular, but somewhat modified by a slope on the antero-ventral edge, where the narrow sharp ridge just within the margin is much reduced in thickness. The middle surface of each valve is raised into a strong somewhat horseshoe-like or subrescentric lobe, or rather into two broad, suboval, unequal lobes, obliquely transverse to the length of the valve, and united below. They converge rapidly downwards and join ventrally by a narrow sharply curved isthmus. Towards the dorsal border they thicken and bulge out. A

deep median sulcus separates the two limbs of this thick, curved, lobular ridge, and the surface of the valve sinks deeply all round outside the lobes, between them and the narrow ridge which stands just within the fore and aft margins. This submarginal ridge represents the thicker semilunar ridges in *B. bicollina*.

The surface has a reticulate ornament. The dorsal aspect of the carapace is irregularly subovate, blunt at the end, and lumpy at four spots with the ends of the lobes.

At first sight this appears to be possibly a varietal form of the foregoing (p. 361, figs. 14, 15, and 16), but we find no intermediate stages.

This species is evidently an ally of *Bollia colwallensis* (*Beyrichia*), Holl (Geol. Mag. dec. ii. vol. viii. 1881, p. 346, pl. x. fig. 14); and in the simply curved elevation of *B. comma*, Jones (Sil. Foss. Girvan, 1880, p. 219, pl. xv. fig. 9), perhaps we have a distant homologue of the great curved lobe, constituting the characteristic feature both in the unique specimen before us and in *B. bicollina*. These two are closely related; they may be only sexually different, but convenience calls for distinctive names, since a specific standing is possible. The Lower-Silurian *B. Grewingkii*, Bock (Neues Jahrb. &c. 1867, p. 594), according to the description, may also be an ally.

The broader lobes and thinner semilunar ridges, together with the semicircular outline of the valves, distinguish *B. uniflexa* from *B. bicollina*. The dorsal outlines are easily recognized on account of the lobes forming more isolated projections in the latter species.

Vine Coll. no. XXXVIII<sub>1</sub> (only one specimen, with *B. Klædeni*, var. *tuberculata*, Salter), from bed no. 25.

### III. KLÆDENIA, gen. nov. (See above p. 347.)

1. *Klædenia intermedia*, Jones & Holl, var. *marginata*.  
(Pl. XII. figs. 21 a, b.)

Proportions:—L. 9. H. 6. Th. 5.

*Beyrichia intermedia*, J. & H., Ann. & Mag. Nat. Hist. ser. 4, vol. iii. 1869, p. 218, pl. xv. fig. 7; Jones & Kirkby, *ibid.* vol. xv. p. 55, pl. xvii. fig. 11.

This neat little form, one specimen of which has been collected by Mr. Vine (No. LIV<sub>12</sub>, bed no. 37) agrees with the species referred to above, except that it has a marginal rim, and does not show the little foremost furrow.

It evidently belongs to the same group as *K. Wilckensiana*, namely, what were called the *Beyrichiæ corrugata*; and the smooth convexity of the main portion of the valve, the very

short sulci, and the small but prominent midlobe, reaching to the dorsal edge, strongly distinguishing these species, we propose to separate them from their Beyrichian allies, under the generic title of *KLÆDENIA* (see above, p. 347).

## EXPLANATION OF PLATE XII.

[All the figures are magnified 15 diameters, except figs. 8*b* and 13*b*.]

- Fig. 1. *Beyrichia tuberculata* (Klöden), var. *gibbosa*, Reuter. With the hypertrophied lobe. *a*, right valve; *b*, dorsal view of carapace. Smith Coll. no. 9<sub>3,4</sub>. Dudley Castle.
- Fig. 2. *Beyrichia Klædeni*, M'Coy, var. *granulata*, Jones. With the big lobe. Smith Coll. no. 9<sub>1</sub>. Dudley Castle.
- Fig. 3. *Beyrichia Klædeni*, M'Coy, subvar. *subspissa*, Jones. *a*, right valve; *b*, dorsal view of carapace. Vine Coll. XLIV<sub>1</sub>. Bed 46.
- Fig. 4. *Beyrichia Klædeni*, M'Coy, var. *intermedia*, Jones. Right valve. Smith Coll. no. 55<sub>4</sub>. Woolhope.
- Fig. 5. *Beyrichia admixta*, sp. nov. Right valve. Smith Coll. no. 55<sub>2</sub>. Woolhope.
- Fig. 6. *Beyrichia Klædeni*, M'Coy, var. *sultrorsa*, Jones. Left valve, with one sulcus on the gigot. Vine Coll. XLVI. Tickwood Beds.
- Fig. 7. The same. With two sulci on the gigot. Smith Coll. no. 34. Woolhope.
- Fig. 8. *Beyrichia Klædeni*, M'Coy, var. *tuberculata*, Salter. *a*, left valve; *b*, portion magnified about 25 diam. Smith Coll. no. 18. Woolhope.
- Fig. 9. The same, smaller form, subvar. *clausa*. *a*, right valve; *b*, dorsal view of carapace. Vine Coll. XLVII. Shales over Wenlock Limestone.
- Fig. 10. *Beyrichia Klædeni*, var. *scotica*, nov. Hollow cast of a left valve. Mrs. Gray's Coll. Near Girvan.
- Fig. 11. *Beyrichia Maccoyiana*, Jones. *a*, left valve; *b*, dorsal view of carapace; *c*, ventral aspect of carapace. Vine Coll. XLIII<sub>1</sub>. Bed 25.
- Fig. 12. *Beyrichia Maccoyiana*, Jones. Right valve. Young or variety. Smith Coll. no. 22<sub>5</sub>. Lincoln Hill, Ironbridge.
- Fig. 13. *Beyrichia Maccoyiana*, Jones. *a*, right valve, with "big lobe;" *b*, portion of the hypertrophied lobe, magnified about 50 diam. Smith Coll. no. 25. Railway-cutting, Ironbridge.
- Fig. 14. *Bollia bicollina*, gen. et sp. nov. *a*, left valve; *b*, dorsal view of carapace; *c*, ventral view. Vine Coll. XLVIII<sub>1</sub>. Bed 22.
- Fig. 15. The same. Right valve. Vine Coll. XLVIII<sub>4</sub>. Bed 22.
- Fig. 16. The same, young. Left valve. Smith Coll. no. 55<sub>8</sub>. Woolhope.
- Fig. 17. *Bollia uniflexa*, gen. et sp. nov. *a*, right valve; *b*, dorsal view of the carapace. Vine Coll. XXXVIII<sub>1</sub>. Bed 25.
- Fig. 18. *Beyrichia lacunata*, sp. nov. Left valve. } Smith Coll. no. 55.
- Fig. 19. The same. Right valve. } Woolhope.
- Fig. 20. The same. Right valve. } Vine Coll. XLV. Bed 25.
- Fig. 21. *Klædenia intermedia*, Jones & Holl, var. *marginata*, nov. *a*, left valve; *b*, dorsal edge. Vine Coll. LIV<sub>12</sub>. Bed 37.
- Fig. 22. *Beyrichia concinna*, nov. *a*, right valve; *b*, dorsal view of carapace. Smith Coll. no. 19. Dormington, near Stoke-Edith.



