

V.—ON THE JURASSIC FORAMINIFERA OF SWITZERLAND:¹ being a Critical Examination of the Species Described and Figured by MM. Zwingli and Kübler.

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THESE Foraminifera were obtained from fifteen zones of the Jurassic strata, between Solothurn, in Switzerland, and the Eichberg, in Baden: three Liassic zones (Black or Lower Jura); six in the Brown or Middle Jura; and six in the White or Upper Jura; beginning with the Turneri-zone of the Lower Lias, and ending with the Pteraspis-zone of Schaffhausen. The Numismalis-marl, Amalthei-clay, Murchisonæ-bed, Discoidei-marl, Crenularis-bed, the Coral-limestone, and the Virgolian stage yielded few or no traces of Foraminifera.

The descriptions and figures of what Dr. Kübler determines as 153 species have had much care bestowed on them; but the artificial classification (D'Orbigny's), and a want of rigid comparison and discrimination of specific forms, betoken an imperfect knowledge of Foraminifera and a very limited appreciation of the works of previous observers (although some are mentioned),—such as F. A. Römer (1836), D'Archiac (1843), Buvignier (1852), Bornemann (1854), Terquem (1858 to 1870), Gümbel (1862), Brady (1867), Schwager (1867), besides D'Orbigny and Strickland, who have treated of Jurassic Foraminifera; for species and varieties already figured and named are in this work re-named again and again.

A still larger field for comparison is to be found by taking into view the very similar Microzoa obtained from the Rhætic and Triassic formations, and figured by Jones and Parker (1860), Gümbel (1861, 1869), Schwager (1864, 1870), and Reuss (1866, 1867, 1868).

The Swiss specimens are mostly figured as transparent or sub-transparent objects, with transmitted light; the opaque (porcellaneous and arenaceous) species are therefore among those that have perspective figures, excepting when they are sufficiently thin, as some *Miliolæ* and *Cornuspiræ*, to be subtranslucent.

Hesitating to labour through the very numerous figured varieties of Jurassic Foraminifera industriously embalmed in the plates of this work and those of the authors above mentioned, for the purpose of reducing them to their really few species, it is proposed in this instance to indicate broadly the foraminiferal fauna of each stage, as detailed by Dr. Kübler, and to offer some remarks on the more striking features, and on the more interesting figures. The names assigned to the figured forms are generally of very little worth; the generic appellations in many cases will have to be corrected; but we shall rarely trouble to correct the trivial name; for, besides the twenty acknowledged recurrent forms, numerous individuals of evidently the same species, and even of the same variety, have been endowed with new names.

The generic and quasi-generic groups will indicate the relative

¹ Die Foraminiferen des Schweizerischen Jura, etc. By the late Pastor H. Zwingli and Dr. J. Kübler. 4to. pp. 49, with 179 lithographic figures in 4 Plates. (Winterthur, 1870.)

proportion of special forms in each of the stages treated of, the names, on which the numbers will be founded, being here rarely little more than indicative of individuals, or at most of sub-varieties.

The figures themselves, having been carefully drawn, are useful as a collection of specimens, ready at hand, exhibiting shades of difference, as well as the general *facies* of the several foraminiferal faunæ, such as can scarcely be shown in words.

I. The Lias: Black Jura.—A. The Lower Lias. Turneri-clay of the Schambelen, Canton Aargau; immediately above the Arietes-limestone, β of Quenstedt. Pp. 5–7; pl. 1, i., figs. 1–18.

Nodosariæ 3; *Vaginulinæ* 5; *Froniculariæ* 5; *Cristellaræ* 3; *Textilaria* 1; *Biloculina* 1. The *Nodosariæ* (figs. 1–16) are varieties of *N. radícula* and other common species (or varieties), already well known. The gradational stages from the subcylindrical, costate, and limbate *Nodosaria* to its flattened *Fronicularian* form, are clearly seen in figs. 2, 11, and 9. *Text. prodomus* (fig. 17) is a common variety of the “*Sagittula*” group. *Biloc. liasica* (fig. 18) wants definition, but may well be a *Biloculine Miliola*.

B. Middle Lias. The Numismalis-marl of Frick yielded nothing. C. Upper Lias: Toarcian. 1. *Posidonia*-shale; ϵ of Quenstedt. From the Commune of Klingau, S.W. of Zurich, Canton Aargau; and from near Schleithelm, Canton Schaffhausen. Pp. 8, 9; pl. 1, ii., figs. 1–6.

Fronicularia 1; *Vaginulina* 1; *Cristellaræ* 4. Common and well-known feeble forms, not requiring new names.

2. *Jurensis*-marl (immediately above the *Posidonia*-shale); ζ of Quenstedt. From Vetzna. Pp. 10–12; pl. 1, iii., figs. 1–12.

Nodosaria 1; *Fronicularia* 1; *Cristellaræ* 7; *Flabellina* 1; *Ophthalmidium* 1. Figs. 1–10 are well-known *Nodosariæ*, already named; among them figs. 3–10 show the passages from *Cristellaria* to *Flabellina*. *Ophthal. liasicum* (fig. 11) is the central Cornuspiral or *Adelosine* commencement of a *Miliola*.¹ A *Chirodota* (fig. 12) is recognized in the text as belonging to an Echinoderm.

II. Middle or Brown Jura: Dogger. A. Bajocian: Aalen-series: Lower Brown Jura. a. *Opalinus*-clay of the Schambelen: and α of Quenstedt: immediately above the *Radians*-bed. b. *Opalinus*-clay of Vetzna. Pp. 13–15; pl. 2, i., figs. 1–7.

Cenchr. Lagena 1; *Cornuspira* 1; *Froniculariæ* 2; *Dentalina* 1; *Cristellaria* 1; *Ophthalmidium* 1.

Cenchr. Aargovense (fig. 1) and *Lagena Aargovensis* (fig. 2) are the long and the short varieties of *Lagena globosa*. *Cornusp. Helvetica* (fig. 3) is a very interesting example of *Spirillina*. Figs. 4–6 (*Nodosariæ*) were not worth naming anew; indeed fig. 5 is equal to fig. 2, i., pl. 1. Fig. 7 (*Oph. porosum*) is a *Spiroloculine Miliola*, probably *punctate*, although described as being *porose* (see further on).

c. *Blagdeni*-bed, immediately above the *Humphresianus*-bed, but below the main oolite of the Middle Brown Jura: δ of Quenstedt. From the Vetzna. Pp. 15–17; pl. 2, ii., figs. 1–12. *Nodosariæ* 3; *Froniculariæ* 3; *Marginulina* 1; *Cristellaræ* 2; *Flabellina* 1; *Ophthalmidium* 1.

¹ See further on in the notice of the “Appendix.”

Figs. 1-10 are already named *Nodosarina* (fig. 10 is intermediate to figs. 9 and 10, iii., pl. 1); figs. 11 and 12 (*Oph. carinatum*) represent a Spiroloculine *Miliola*.

B. Bathonian: Middle Brown Jura. Parkinsoni-clays: *e* of Quenstedt. *a*. From Fuetzen, Baden. *b*. From Barga, Canton Schaffhausen. Pp. 17-19; pl. 2, iii., figs. 1-11.

Lagena 1; Cornuspiræ 3; Nodosariæ 2; Vaginulinæ 2; Cristellaræ 4; Ophthalmidium 1.

Lagena Parkinsoni (fig. 1) is *L. globosa*. *Cornuspira Eichbergensis* (fig. 2) is a *Spirillina*, possibly the same as fig. 3, i., pl. 2. Figs. 3 and 4 (*Cornusp. elliptica et gracilis*) appear to be varieties, orbicular and elliptical, of *Trochammina incerta*, though *gracilis* is said to be transparent. Figs. 5-9 are common well-known *Nodosarina*. Figs. 10 and 11 (*Oph. Okeni*) are Spiroloculine *Miliola*.

C. Callovian: Kelloway group: Upper Brown Jura. *a*. Lower division. Macrocephalus-bed, from the Eichberg, near Achdorf, Baden. Pp. 19-21; pl. 2, iv., figs. 1-14. Lagena 1; Cornuspiræ 2; Vaginulinæ 3; Frondiculariæ 2; Cristellaræ 8; Nonionina 1.

Fig. 1 (*Lag. minutissima*) is the common little *L. globosa*. Fig. 2 seems to be a *Spirillina* from the description (colourless, transparent); but it may prove to be a *Cornuspira*. The other so-called *Cornuspira* will be a *Trochammina*, if its correlation with the foregoing *C. elliptica* be correctly indicated. Figs. 3-13 are various common *Nodosarina*, unnecessarily named afresh. Fig. 14 is not a *Nonionina*, but probably a *Planorbulina*.

b. Ornati-clay: Upper division of the Callovian stage: *ζ* of Quenstedt. Pp. 21-23; pl. 2, v., figs. 1-7.

Lagena 1; Cornuspira 1; Dentalina 1; Frondicularia 1; Cristellaria 1; Flabellina 1; Ophthalmidia 3.

Cornusp. Biedermanni (fig. 1) is probably a true *Cornuspira*.¹ The *Nodosarina* (figs. 2-5) did not require new names. Fig. 6 (*Oph. carinatum*) is a Spiroloculine, and fig. 7 (*Oph. multiplex*) a Quinqueloculine *Miliola*.

III. Upper or White Jura. A. Lower White Jura: Oxfordian.

1. Birnenstorf-bed: Transversarius-zone (Oppel). *a*. From the Rebberg of Birnenstorf, Baden. *b*. From the Eichberg. Pp. 24-33; pl. 3, figs. 1-50.

Lagena 1; Cornuspiræ 3; Frondiculariæ 2; Nodosariæ 3; Dentalinæ 3; Vaginulinæ 9; Marginulinæ 5; Cristellaræ 12; Robulina, 1; Nonionina 1; Globulina 1; Vulvulinæ 3; Textilaræ 2; Ophthalmidia, 6.

Fig. 1 (*Lagena Helvetica*) is *L. lævis*. *Cornusp. Eichbergensis* (fig. 2) and *C. concava* (fig. 3) are orbicular and elliptical individuals of *Trochammina incerta*; *C. gracilis* is also mentioned, which, according to its figure (pl. 2, iii., fig. 4), appears to be a *Trochammina*, although it is said to be transparent (the thick edge, however, is duller and yellow, p. 17). Figs. 4-38 are various *Nodosarina*, each of which falls under some well-known name or another. *Nodosaria radícula* and *Dentalina communis* respectively

¹ See further on, where the Appendix on *Cornuspira* and *Ophthalmidium* is noticed.

comprise several of them. Figs. 6, 7, and 8 are curious extremes of the moniliform *Nodosariæ* (*N. pyrula*, etc.). Figs. 20 and 20a show an extremely simple form of *Cristellaria*, near to *Planularia pauperata*. Fig. 22 has its analogue in the Chalk; and, indeed, all are common, widespread, and persistent varieties. The relatively large fig. 33 is *Cristellaria* (*Planularia*) *crepidula*.

Fig. 39 (*Nonionina Birmenstorfensis*) is probably a *Planorbulina*. Figs. 40 and 40a (*Globulina Helvetica*) are *Polymorphina liasica*, Strickland, and an approximate variety. Fig. 41 (*Vulvulina farcimen*) is a *Virgulina*, having the early chambers heaped. Figs. 42 and 43 (*Vulv. minutissima* and *V. Eichbergensis*) are loose-grown pouting *Textilariæ*; and 43a appears to be a *Textilaria* of the same habit of growth, but with the normal aperture. Figs. 44–45a are *Textilariæ* of the common "sagittula" type; and fig. 45a has the not uncommon spiral commencement, which gave rise to the quasi-generic name "Spiroplecta." Fig. 46 (*Ophth. Birmenstorfense*) is a Spiroloculine *Miliola*; 47–49 (*Ophth. gracile, medium, et auris*) are Quinqueloculine; and 50 (*Ophth. cornuspiroides*) represents the early chambers of a similar *Miliola*. A *Chirota* is also figured.

2. Effing-beds; Impressa-clays (*Terebratula impressa*) of Quenstedt. From the Eichberg, Grand Duchy of Baden; Siblingen, Canton Schaffhausen; and Baden, Canton Aargau. Pp. 33–36; pl. 4, i., figs. 1–17. *Lagena* 1; *Cornuspira* 5; *Fronicularia* 1; *Dentalina* 1; *Vaginulinæ* 2; *Cristellariæ* 6; *Rotalina* 1; *Rotalia* 1; *Globulina* 1; *Vulvulinæ* 2; *Textilariæ* 2.

The *Lagena* is *L. lævis*. Of the "*Cornuspira*," figs. 2–4 represent *Trochammina incerta*, and figs. 4a and 4b show passages from the same towards *Tr. gordialis*. The *Nodosariæ* (figs. 5–13) are common, well-known, variable forms, which have been named again and again.

Fig. 14 (*Rotalina Badensis*) may possibly be a *Planorbulina*; but far more probably it is a rotaline *Lituola* (*Endothyra*). Fig. 15 (*Rotalia Siblingensis*) is not a *Rotalia*, but probably a *Planorbulina*. The *Globulina* is *Polymorphina liasica*.

Figs. 16–17a (*Vulvulinæ* and *Textilariæ*) are well-known *Textilariæ*, occurring at many other horizons, and already named more than once.

B. Middle White Jura: Corallian stage: Geissberg-beds (with and without *Nulliporites*¹), Baden, Canton Aargau. Pp. 36–37; pl. 4, ii., figs. 1–3.

Cornuspira 1; *Vaginulinæ* fragments; *Cristellaria* 1; *Robulina* 1; *Nonionina* 1; *Ophthalmidia*, fragments.

The "*Cornuspira*" is a *Trochammina* (see pl. 3, fig. 2). The *Nodosariæ* have been previously named and re-named. The "*Nonionina*" is the same as pl. 3, fig. 39, and probably pl. 2, iv., fig. 14, and should be classed with *Planorbulinæ*, being not far removed from *Pl. ammonoides*.

C. Upper White Jura: Kimmeridgian stage. 1. Astartian formation, Rödgersdorf, Canton Solothurn. Pp. 37–38; pl. 4, iii., fig. 1.

Rotalina Moeschii (fig. 1) is relatively large, and probably a

¹ See GEOL. MAG., No. 105, p. 122.

Planorbulina. It differs from fig. 15, pl. 4, i., in its greater number of chambers, and in its septal lines being excavated instead of being filled up with shell-matter (limbate).

2. Strombian formation: Baden-bed of the Eastern Tunnelwand of Baden, Canton Aargau: " γ alba" of Quenstedt. Pp. 38-39; pl. 4, iv., figs. 1-10.

Lagena 1; Cornuspiræ 5; Dentalina 1; Cristellarie 5; Nonionina, 1; Textilaria 1; Ophthalmidia, fragments.

Lagena Badensis (fig. 1) is *L. lævis*. *Cornusp. Eichbergensis* (fig. 2) is said to show pores when magnified 400 diameters; if so, it is a *Spirillina*; but its habit is decidedly that of a *Trochammina*. (Pl. 3, fig. 2, p. 24, also "*C. Eichbergensis*," is a *Trocham. incerta*, both by figure and description.) *C. elliptica* (fig. 3) is an elliptical *Tr. incerta*. Fig. 4 (*C. conveza*, yellowish-grey, transparent; pores doubtful) appears to be a true *Cornuspira*, or a Cornuspiral *Miliola*, very thin. The "*Nonionina*," being referred to pl. 4, ii., fig. 3, must be regarded as a *Planorbulina*. The *Nodosarinæ* (figs. 5-9) do not at all require new names.

3. Rhinefall-rock: Steraspis-zone (Oppel): " δ alba" of Quenstedt (?). Lohn and Barga, Canton Schaffhausen. P. 40; pl. 4, v., figs. 1-3.

Cornuspira 1 (= *Trochammina* ?); *Vaginulina* 2 (varieties of *Dentalina communis*); *Robulina* 1; *Textilaria* 1; *Vulvulina* 1 (= *Textilaria* or *Virgulina* ?). *Chirodotæ* are also mentioned, and one is figured.

Appendix: pp. 45-47; pl. 4, vi., figs. 1-5.

Cornuspira Bayonnensis (fig. 1) and *C. undulata* (fig. 2), from the Tongrian Tertiary beds of Bayonne, are either true *Cornuspira* or young Cornuspiral *Miliolæ*. *Ophthalmidium tongricum* (figs. 3 and 4), from Bayonne and Dalsberg, and *Oph. superbum* (fig. 5), from Bayonne, are *Miliolæ*; the former Spiroloculine; the latter Quinqueloculine, probably punctate or reticulate. They are all represented as seen with transmitted light, like the majority of the specimens figured in this memoir.

1. *Cornuspira* is here described as having both porose and non-porose species; the division of the simply spiral, discoidal Foraminifera into *Cornuspira*, *Trochammina*, and *Spirillina*, according to structure and habit of shell, not being known, apparently, to Dr. Kübler.

2. *Ophthalmidium* (formerly called "*Oculina*" by Zwingli and Kübler) is defined as having a somewhat Spiroloculine growth, but never being complanate, always attenuate at the ends, and always commencing with a curved subdiscoidal chamber. It may seem convenient to recognize this as a modification of *Miliola*, especially because the early chamber (or rather the early tubular, continuous, and rarely segmented chambers) of such forms is Cornuspiral,—that is, zoologically equivalent to an incipient *Cornuspira*. Indeed, when separate, such specimens cannot be distinguished from young or arrested individuals of that genus, which, however, in its full development affects the flat spiral habit of growth, as *Miliola*

affects the half-turn envelopment, on one, two, or three planes. The *Adelosina* of D'Orbigny, however, is just this young state of *Miliola*, constructed in the same subdiscoidal form, and has been recognized as the general type of young *Miliola*. The subsequent plan of growth is so much varied (within certain limits) as to give room perhaps for the somewhat convex Spiroloculine form indicated by "*Ophthalmidium*," though not of special value. What is of more importance is Dr. Kübler's statement as to the porosity of some of these individuals, such as pl. 4, v., fig. 5 (*Oph. superbum*), and pl. 2, i., fig. 7 (*Oph. porosum*). Although Dr. Kübler warmly and conscientiously avows his belief that these are not merely punctate shells, we cannot help thinking that the microscopic appearances, with transmitted light, in specimens mounted with turpentine or balsam, have deceived him. The larger perforations, noticed in the specimens appear to be accidental, and not in anywise essential.

The several Foraminiferal groups above treated of are evidently members of one fauna, existing through the Jurassic period, without undergoing any great modifications. Indeed the same fauna is fully recognizable in the Triassic strata. The Swiss specimens under notice comprise *Cornauspira*; *Miliola* (*Biloculina*, *Quinqueloculina*, *Spiroloculina*); *Trochammina*; *Endothyra* (?); *Nodosarina* (*Lagena*, *Nodosaria*, *Dentalina*, *Vaginulina*, *Marginulina*, *Frondulularia*, *Flabellina*, *Cristellaria*, *Planularia*); *Polymorphina*; *Textilaria*; *Virgulina*; *Spirillina*; *Planorbulina*.

The *Miliolinæ* appear to be more fully represented in these Jurassic beds of Switzerland than in those of other countries. The rotaline *Lituola* ("*Rotalina Badensis*"), or *Endothyra* (?), of the Oxfordian of Effing, is interesting (if it be sandy, as we presume), being of the curious series of arenaceous Foraminifera that imitate the hyaline forms, and among which the Lagenoid, Flabellinoid, and Marginulinoid *Lituolæ*, figured by Terquem, from the Inferior Oolite (Parkinsoni-bed), are well-marked types.

The *Nodosarinæ* are abundantly represented, mostly by very simple, feeble, and variable forms, as is usual in the Triassic, Rhætic, and Jurassic strata.

Spirillina Helvetica, from the Middle Brown Jura (Opalinus-clay and Parkinsoni-clay) is the oldest known of the genus.

The *Planorbulina* comprise three species: 1. One near *Pl. ammonoides* ("*Nonionina oblonga*," "*N. Birmenstorfensis*," "*N. Badenensis*"), from the Macrocephalus-bed of the Lower Callovian; the Oxfordian of Birmenstorf, the Corallian of Geissberg, and the Kimmeridgian formation at Baden, Aargau: 2. *Pl. Siblingensis* from the Oxfordian Impressa-clays of Effing; and 3. *Pl. Moeschii* from the Astartian formation of the Kimmeridgian stage of Rödersdorf.

Mr. W. K. Parker, F.R.S., has kindly aided me in forming an opinion on several difficult points in the study of Dr. Kübler's descriptions and illustrations of these fossil Foraminifera of Switzerland.