descendente, calloso, triangulato-reflexiusculo, cum basali angulum efformante, ad angulum acute et profunde inciso; periomphalo pone rimam oblique compresso vel obtuse carinato.

Sp. descript. diam. major 11, minor 10, axis $6\frac{1}{2}$ mill.

Majoris imperfecti diam. major 16, minor $13\frac{1}{2}$, axis $8\frac{1}{2}$ mill.

Habitat prope Moulmein.

The singular rift at the base of the columella in this species reminds the observer of some of the *Helicinidæ**; yet the aspect of the shell and its evident affinity to *H. Calias* and *H. forabilis* proclaim its relation to *Helix*. The attention of the discoverer has been called to the acquisition of living specimens at a more favourable season, and to the observation of the main external characters of the animal.

Cheltenham, April 30th, 1859.

XLVIII.—*On the Nomenclature of the* Foraminifera.

By W. K. Parker, M. Micr. Soc., and T. R. Jones, F.G.S.

I. *On the Species enumerated by Linnæus and Gmelin.*

In our former paper descriptive of some *Foraminifera* from the coast of Norway (Ann. & Mag. Nat. Hist. ser. 2. vol. xix. p. 273), we offered some general observations on the character and relations of these minute Rhizopodous creatures, especially pointing out the wide limits within which the species range under innumerable varieties of form and features. In this and some other papers which we hope to communicate from time to time, we propose to attempt the definition of some at least of the specific forms, and to settle the correct nomenclature of this interesting Microzoan group. In carrying out our intention of determining the true specific characters of the *Foraminifera*, we have necessarily had to compare the figures given by the older naturalists both with each other and with the more modern drawings published by others, as well as with the numerous specimens which we have of late been able to gather.

The principles which guide us in this examination have been already dwelt upon in the memoir above referred to, as well as in the paper on the *Miliolitidæ* by one of us in the 'Quarterly Journal of Microscopical Science,' No. 23. p. 53. We especially refer the reader to the introductory portions of the memoirs by

* The columellar slit in *Helix schistostelis* represents the corresponding feature in *Alcadia*, Gray, while the umbilical keel and columellar rift bear an analogical resemblance to those observable in *Stoastoma*, Adams. These two operculated genera inhabit the West Indies. The North American construction of *Helix pylaica*, B., was noticed in a former paper on Burmese *Helices*.

Carpenter* and Williamson† for a concise account of the progress of research in relation to the *Foraminifera*, and for able expositions of the principles which should guide the zoologist in working out the nature and history of their specific groups.

As one of our objects has been especially to determine the rightful specific names, we have commenced with the Linnæan names as given in the 12th edition of the 'Systema Naturæ‡.'

In the 12th edition, fifteen reputed species are enumerated; with one exception, they are grouped as "Nautili," coiled and straight; the other form is placed amongst the "Serpulæ." All of these species we can more or less easily recognize amongst our known forms, either by the aid of the figures in older works referred to, or by the description given.

Here we must give more credit to the older naturalists and the artists whom they employed than they have received at the hands of some, for their engravings of the *Foraminifera*. The style is always harsh; but frequently, when the figures have been carefully reproduced by tracings (the linear shadings being replaced by pencil-tints) and the lateral ground-shadows omitted, the specimens stand out as fair as in modern lithographs; and though sometimes deficient of a delicate characteristic, such as that of the septal aperture, yet they are always true as to outline and general features.

We have been able to refer to all the original figures quoted by Linnæus and Gmelin. In the case of Spengler's figures, as it happens that the first volume of the "Nye Samling" of the Danish Transactions in the British Museum is without the plates, and as we cannot find another copy of this work in London, we should have been without the means of thus closely completing the task we set ourselves, had not Prof. Forchhammer, of Copenhagen, most kindly and promptly acceded to our request that he would favour us with a pencil-copy of Spengler's figures. Our thanks are especially due to this eminent Danish naturalist for his courteous and energetic fulfilment of the request with which we troubled him. We may mention that some of Spengler's figures, reduced in size, are engraved in Wood's 'Catalogue of Shells,' pl. 13.

The generic terms applicable to these Linnæan species having been established at a much later date, by Defrance, Lamarck,

* Philos. Transact. 1856, pp. 181 & 547.

† Monograph Recent Foram. Gt. Britain, Ray Soc. 1858.

‡ According to Mr. Williamson (Monograph, p. 101), "Previous editions contain the Polythalamia ('Nautili') enumerated by other writers; but in the 9th, Linnæus separates them into species; in the 10th he gives them specific names; and in the 12th he attaches to them the synonyms of other authors."

D'Orbigny, and others, we have here appropriated them on the plan which we shall hereafter explain.

The idea that seems to have been present in Linnæus's mind when grouping these little Polythalamous shells had reference to the diminution of the coiled condition of form in passing from the Nautiloid *Cristellaria Calcar* to the moniliform and rod-like *Nodosaria Radicula* and *N. Fascia*. In this arrangement the relative position of the specific forms has seldom more than a distant relation to their typical value. We therefore do not bind ourselves to the acceptance of the first named of an allied group, as indicative of the typical value of such specific forms. Thus, in the Nodosarian forms, Nos. 281–288, which belong to one type-species, we do not choose either *Nodosaria Radicula* (the simplest) or *Nod. Raphanistrum* (the most perfect form), but *N. Raphanus*, which, among those that Linnæus catalogued, is the best as a well-developed model of Nodosarian growth, combining all the essential characters of the group,—the other Linnæan names being retained for the several varieties, to be used for the purpose of reference if occasion requires.

For a similar reason, we do not accept as a type-name for the species either *Planorbulina rugosa* (No. 277) or *Peneroplis umbilicatus* (No. 278), these being well adapted for the varieties for which they were respectively intended, whilst the type-forms of the species to which they belong will severally retain the names of *Pl. farcta* and *P. planatus* given to them by others.

In Mr. S. Hanley's 'Ipsa Linnæi Conchylia' (1855) are remarks on the "Nautili" of the 'Syst. Nat.,' as determined from Linné's manuscripts and Collection. These notices, though avowedly less elaborate than the remarks on the mollusks in the same volume, are very valuable, and bear witness to the author's acumen and conscientious care. In the new edition of Wood's 'Catalogue of Shells' (1856), Mr. Hanley has also removed many difficulties in the study of the Foraminifera figured in the works of the older naturalists, by most carefully tracing out "the pictorial synonymy" of the several species there illustrated, as far as the limits imposed by the character of the work permitted. We have to express our personal obligation to Mr. Hanley for favouring us with much assistance in our study of the Linnæan species.

(A.) Linné's *Nautilus Calcar* (1162. 274), being a well-developed symmetrical form, is a good type of the *Cristellariæ*. From this lenticular form we have divergent modifications, some of which affect the globular, others the discoidal and the crozier-like forms. The last of these are generally known as *Marginu-*

linæ. *C. cultrata* and *C. Cassis* are lenticular and discoidal shells with a marginal crest or keel very variable in extent. The terms *Robulina*, *Saracenaria*, and *Planularia* have been applied to some of the Cristellarian varieties.

In essential characters of structure and mode of growth, the *Cristellaria* and *Nodosaria* are one; and the *Glandulinæ*, *Linguli-næ*, *Dentalinæ*, *Rimulinæ*, *Vaginulinæ*, *Marginulinæ*, *Dimorphinæ*, *Flabellinæ*, and *Frondiculariæ* of authors necessarily fall in the same category. We propose to use the term *Nodosarina* as expressive of the type-species, including all the above. We adopt *Cristellaria* and *Nodosaria* as subspecific appellations,—the former comprising the spiral (or Nautiloid, Marginuline, and Flabelline) forms; the latter taking those that have a rectilinear or only slightly curvilinear arrangement of the loculi. It is impossible, however, to make a strict line of demarcation between the approximate members of the group, since the straight, the curved, and the spiral lose themselves in each other,—the amount of curvature and of spirality, and the greater or less closeness of the whorls being varying characters.

Cristellaria Calcar and its multitudinous varieties have a very wide geographical range, and occur fossil in the tertiary, cretaceous, oolitic, liassic, and upper triassic* strata. The finest living *Cristellariæ* occur in the Adriatic, and the finest fossil specimens in the tertiaries of Italy, Spain, and San Domingo. Large individuals, however, have been met with on the Norway coast, on the coast of New York, and on the Abrolhos Bank. Moderate-sized specimens are extremely numerous in the London Clay and in the Chalk. For the synonymy of *C. Calcar*, see our paper in the 'Annals,' *loc. cit.*, and especially Williamson's 'Monograph,' p. 29.

(B. *a*.) Of the *Nodosariæ* we find several varieties enumerated by Linnæus. The first in his list is *Nautilus obliquus* (1163. 281), established on a curved, tapering, ribbed *Nodosaria* figured by Gualtieri (Index Test. pl. 19. fig. N). *N. Raphanistrum* (1163. 282) and *N. Raphanus* (1164. 283) follow. These are slightly varying forms of the common, straight, ribbed *Nodosaria*,—the chambers varying in their relative number and their globosity (or, rather, in the closeness of their setting-on), the aperture varying from a central to a sublateral or excentric position, and the riblets varying in relative size and number.

The figures, by Plancus, Gualtieri, and Ledermüller, on which Linné founded his species, or which he referred to as synonymous, show these variations; and scarcely two individuals of this group of *Nodosariæ* can be found in nature presenting identical conditions in these respects; but all vary from the

* We have lately discovered numerous *Foraminifera* in the greenish clays of the New Red series near Derby.

moniliform to the fusiform and the cylindrical, from the sulcated to the many-ribbed, and from the straight to the curved,—showing, in this last circumstance, that *N. obliquus*, above referred to, is also one of the same variable group. *Nautilus Fascia* (1164. 286) is also a straight *Nodosaria* (figured by Gualtieri) with riblets, but possessing raised seams around the shell at the sutures of the chambers—a character that does not remove it from its congeners, this limbation or raised condition of the septal lines being an ordinary condition among the *Nodosarinæ* and other groups of *Foraminifera*, dependent on exogenous shell-growth, and not of specific value. *Nautilus Granum* (1164. 284) appears, from Linné's description, to be a short, straight, and ribbed *Nodosaria*, with oblique aperture, and thus represents a very common form of *Nodosaria* passing into the so-called *Glandulina*. Shells constructed similarly to the foregoing, but smooth, or nearly so, are named *Nodosaria Radicula* (Linn.) and *N. dentalina* (Lam.); and some compressed forms with obliquely-set chambers constitute the variety *N. Legumen* (Linn.).

The ribbed *Nodosariæ* (*N. obliqua*, *N. Raphanistrum*, *N. Raphanus*, *N. Fascia*, and *N. Granum*) and those destitute of ornament are only modifications of one variety, well typified by *N. Raphanus*, into or from which all the others may be traced, whether short and tapering or long and cylindrical, flattened, or subcylindrical, or like the well-grown *Nodosaria Raphanistrum*. In company with *N. Raphanistrum* we always find (as, for instance, in the tertiary sandy clays of Turin and Malaga) an immense variety of the forms above enumerated; and although *N. Raphanistrum* stands pre-eminently as the best-grown and most symmetrical, yet, on the principle which we intend to follow, of letting the published trivial names of the *Foraminifera* remain as indicative of the *species*, *subspecies*, and *varieties* intended by the authors who established them, and of adopting for the names of leading species and subspecies the appellations already given to the forms best exhibiting the typical characters (being therein guided by chronological circumstances when synonyms exist), we here adopt as the name of the subspecies *Nodosaria* that which Linnæus gave to the variety which best combines all the characters of the group.

Mr. Hanley has satisfactorily determined the *Nodosaria* denominated *Raphanistrum* by Linnæus, and has figured it in the 'Ipsa Linn. Conch.' pl. 5. f. 4. This proves to be the *Nodosaria Bacillum* of Defrance (Dict. Sc. Nat.) and the *N. æqualis* of Sowerby ('Genera' and 'Manual'). It was published in the 10th edition of the 'Syst. Nat.' without any reference to a figure; but in the 12th edition Linné referred to Ledermüller's pl. 4. f. *x* posterior, as the best published representation. This, though a dwarfish form, serves to link *N. Raphanus* with *N. Raphanistrum*.

(B. *b*.) A smooth *Nodosaria* appears in Linné's catalogue (1164. 285) as *Nautilus Radicula*. This is a very common form—the simple Nodosarian type—consisting of a series of smooth, gradually increasing, globose chambers, having the peculiar shell-tissue and the distinctive aperture belonging to the species. *Nodosaria Radicula* passes, by insensible gradations, on the one hand into the short, lumpy, Glanduline condition, and on the other into the elongate forms, moniliform or subcylindrical, straight or curved; it also frequently occurs flattened, becoming a *Lingulina*. In either case it puts on more or less freely the little raised lines or riblets of exogenous shell-matter which constitute the characteristic ornamentation of the *Nodosarinæ*. Had we chosen to adopt the simpler form of a species as the type (as Prof. Williamson has been inclined to do), *N. Radicula* would have well served for this purpose.

The delicate tapering and curved *Nodosariæ*, of which *Dentalina communis*, D'Orb., is a well-known form, do not appear to have been recognized by Linnæus or by Gmelin, although Ledermüller figured them in his 'Mikroskopische Augen- und Gemüths-Ergötzung,' 1761, pl. 4. figs. *o*, *p*, & pl. 8. fig. *l*. This form has been ranked by Lamarck as a species under the name *Nodosaria dentalina*, which we shall find useful.

The *Nodosariæ*, ribbed, smooth, and dentaline, are abundant in the Mediterranean and on most sea-coasts at certain depths; they abound in the London Clay, Chalk, Gault, and in the Kimmeridge, Oxford, Lias, and Upper Trias Clays. *Nodosariæ* occur also in the Carboniferous and Permian rocks. They are very fine in some of the Italian and Spanish tertiary beds and in those of San Domingo. In the Chalk and Gault also some fine individuals frequently occur.

(B. *c*.) *Nautilus Legumen* (1164. 288) is the well-marked *Nodosaria* (*Vaginulina*) *Legumen*. The *Vaginulinæ*, with their compressed obliquely-set chambers and lateral aperture, are conveniently separated from *Nodosaria* proper; but no real divisional line exists between the *Vaginulina* and *Nodosaria* (through the Dentaline forms) on one side, and *Cristellaria* (through the Marginulines) on the other.

The *Vaginulinæ* have a similar range to that of the *Nodosariæ*, excepting that they have not yet been found in any older rock than the Upper Trias.

(C.) Linné's *Nautilus crispus* (1162. 275), the *Polystomella* of Lamarck, is an easily recognizable form under variously modified conditions, chiefly as to its thickness and its sculpture; and it occurs on every coast.

(D.) *Nautilus Beccarii* (1162. 276) is the common form of the *Rotalia Beccarii* of the Mediterranean and Atlantic. This species has a world-wide range under many strikingly different

modifications, which still retain their own peculiarities of structure, mode of growth, and ornamentation.

(E.) *Nautilus rugosus* (1162. 277) is not safely determinable, there being no figures to refer to, and the description being applicable to several Foraminifers. It appears most like the *Planulina Ariminensis* or the *Operculina complanata*. It is from the South Sea.

(F.) *Nautilus umbilicatus* (1163. 278) and *N. Semilituus* (1163. 280) are varieties of a species of *Peneroplis*, the type being the *Peneroplis planatus* (D'Orb.), a passable figure of which is given by Schröter in his 'Neue Litterat.' (1784), vol. i. pl. 1. fig. 7. Another specimen figured on the same plate (fig. 9) is a narrower form of *P. Semilituus*, the chambers being nearly cylindrical, and the shell well representing a crozier (*Lituus*); the *P. Semilituus* has its chambers flattened, so that the staff and head of the "crozier" are no longer formed of a cylindrical body; *P. umbilicatus* is also flattened, and does not possess the straight portion of the shell, being nautiloid, and representing only the head of the crozier, flattened; lastly, *P. planatus* has its latter chambers widely flattened out, and resembles in outline a bonnet rather than a crozier *.

D'Orbigny's *Dendritina* is also a true *Peneroplis*, without the straight portion, and not flattened. Some of the *Spirolinæ* of authors are *Peneroplides* with stick-like crozier-forms (some, however, belong to *Lituola*).

[*Nautilus Siphunculus* (1164. 287) has nothing to do with *Foraminifera*, but probably belongs to the *Serpulæ*. Soldani figures numerous specimens ("Tubuli armillati," &c.) varying in details; 'Testac. ac Zooph.' pl. 27.]

(G.) *Serpula Seminulum* (1264. 791) is the *Quinqueloculina Seminulum*,—a good type for the vastly numerous group of quinqueloculine *Miliolæ*, which occur in every sea.

Gmelin's edition of the 'Systema Naturæ' (1788) contains seven names of *Foraminifera* in addition to those given by Linnæus.. These were determined on the evidences afforded by figures and descriptions by Spengler, Schröter, and Gronovius.

(H.) *Rotalia* (*Calcarina*) *Spengleri* is the *Nautilus Spengleri* (Gmelin, 3371. 10). This shell has been well figured also by Schröter (from the Adriatic), and by Fichtel and Moll (from the Indian and Red Seas). Spengler's specimen (Danske Skrift. N. S. vol. i. pl. 2. f. 9 *a–c*) was from Amboyna.

Lamarck's *Siderolites calcitrapoides* (Anim. sans Vertèb. vol. vii. p. 624) is the same species, from Maestricht.

* It has already been observed by Mr. Hanley (Ipsa Linn. Conch. p. 158) that Montagu's *N. Semilituus* is not that of Linnæus (after Plancus in Fabius Colonna's 'Phytobasis').

Calcarina Defrancii, D'Orb., from the Red Sea (Ann. Sc. Nat. vol. vii. p. 276. no. 3), is a delicate compressed variety of *Calcarina Spengleri*, with the spire apparent. Spengler figures this elegant form (*op. cit.* pl. 1. f. 3 *a–d*) from Coromandel.

Calcarina Calcar (D'Orb. Ann. Sc. Nat. vii. p. 276. no. 1; and Modèles, no. 34. 2e livraison), from Martinique, Isle of France, and Madagascar, is a variety of the same, with shorter spines. *Rotalia armata*, D'Orb. (Ann. Sc. Nat. vii. p. 273. no. 22; and Modèles, no. 70), from Cayenne and Martinique, and fossil at Chavagnes (Maine-et-Loire), near Nantes, and near Bordeaux, is a short-spined variety of the same species.

D'Orbigny gives three other names to forms of *Calcarina*, without figures or descriptions; they are from Port Jackson, the Isle of France, Rawack, and the Mariannes Islands.

Deshayes's *Calcarina rarispina* (Lyell's 'Manual,' 5th edit. p. 228. f. 236), from Grignon, is the same as *Rotalia armata*, D'Orb.

Calcarina is a subgeneric form of *Rotalia*.

Calcarina Spengleri has a wide distribution in the Mediterranean and tropical seas, and occurs fossil in the Eocene Tertiaries of France and in the Chalk of Maestricht.

[A form that has been mistaken for the *Calcarina Spengleri*, but more allied to the Sponges in its mode of growth, occurs fossil at Palermo, San Domingo, &c., and recent at the Fiji Isles and New Zealand.]

(I.) *Nautilus unguiculatus* (3372. 11), founded on Spengler's specimen (Kong. Danske Vid. Selsk. Skrift. Nye Saml. vol. i. p. 381. pl. 2. f. 9 *d*), is a six-spined *Polystomella crispa*, from the East Indies. This beautiful variety (*P. Regina*, D'Orb.) is not common. It occurs fossil in the Vienna Tertiaries, and in the Eocene beds at Baljik, Bulgaria, on the Black Sea. (See Wood's Cat. pl. 13. f. 18.)

(J.) *Nautilus Lituus* (3372. 13), figured and described by Spengler (as *Nautilus rectus*), from the Red Sea, is a delicate *Peneroplis* with narrow subcylindrical chambers throughout,—forming a small crozier-like body, instead of the flatter and bonnet-like shell of *P. planatus* (see Wood's Cat. pl. 13. f. 20). It is the *Spirolina cylindracea* of Lamarck, and is common in the Mediterranean and Indian Seas, and in the Grignon Tertiaries. Spengler has figured two other intermediate varieties of *Peneroplis* (*op. cit.* pl. 1. f. 4, 5), both from the Red Sea. *P. planatus* is widely distributed in the warmer seas.

(K.) *Nautilus inæqualis* (3373. 20), founded on Spengler's figure and description (*Nautilus rectus*), is a straight, attenuated form of *Vertebralina* (*Articulina*) *striata*. It is from the Red Sea. (See Wood's Cat. pl. 13. f. 32.) This uniserial form of *Vertebralina* is common in the Red Sea, and in the Tertiary beds at Baljik and Grignon.

(L.) *Serpula nautiloides* (3739. 1) is undoubtedly, as shown by

Schröter's figure (Neue Litterat. vol. iii. p. 283, pl. 3. figs. 22, 23), an attached specimen (with the lower side of the chambers imperfect) of that form of *Lituola* which we termed *Placopsilina* in our memoir on some *Foraminifera* from Norway (*op. cit.* p. 29). It was found affixed to the "Madrepora prolifera" from the coast of Norway.

Lituola nautiloides is one of an immense group of varieties, of which the type is *Lituola nautiloidea*, Lamarck. These are found in every sea, and very frequently in the fossil state; they occur both fixed and free.

(M.) *Nautilus helicites* (3371.6), figured by Schröter (Vollständige Einleitung, &c. vol. iv. (1784) pp. 368 & 377, pl. 10. fig. 2), is possibly an *Amphistegina*. It is from the Chalk of Maestricht.

(N.) *Nautilus Beccarii β. ammonoides* (Gmelin, 3370.4; Gronov. Zoophyl. 1781, p. 282, and Tabularum Explic. p. v. pl. 19. figs. 5, 6) and *N. Balthicus* (Gmelin, 3370.5; Schröter, Naturforscher, 1782, vol. xvii. p. 120; and 'Einleitung Conch.' vol. i. p. 20) are referable to the Foraminifer usually known as *Operculina complanata*, Basterot, sp., which is the best form of this variety, and attains a large size at the Philippine Isles and New Zealand, and occurs also in the Mediterranean and Atlantic, and abundantly in some of the tertiary strata. Gronovius's specimens were in sea-sand from Bengal; Schröter's from the Baltic, attached to the root of a Fucus. *Operculina* is a subgeneric form of *Nummulina*.

Tabular List of the Foraminifera *enumerated by* Linné *and* Gmelin.

Linnæan Names.	Typical Species and Subspecies.		
Nautilus Calcar, *L.*	Cristellaria Calcar		Nodosarina.
—— obliquus, *L.*.....	Nodosaria (Dentalina)	N. Raphanus	
—— Raphanistrum, *L.*.	Nodosaria		
—— Raphanus, *L.*	Nodosaria		
—— Fascia, *L.*	Nodosaria		
—— Granum, *L.*.....	Nodosaria		
—— Radicula, *L.*.....	Nodosaria		
—— Legumen, *L.*	Vaginulina (Dentalina)		
—— crispus, *L.*	Polystomella crispa.		
—— Beccarii, *L.*.....	Rotalia Beccarii.		
—— rugosus, *L.*	[?Planulina Ariminensis *vel* Operculina complanata?]		
—— umbilicatus, *L.* ..	Peneroplis	P. planatus.	
—— Semilituus, *L.*....	Peneroplis		
Serpula Seminulum, *L.*	Miliola (Quinqueloculina) Seminulum.		
Nautilus Spengleri, *Gm.*	Rotalia (Calcarina) Spengleri.		
—— unguiculatus, *Gm.*	Polystomella crispa.		
—— Lituus, *Gm*.....	Peneroplis planatus.		
—— inæqualis, *Gm*....	Vertebralina (Articulina) striata.		
Serpula nautiloides, *Schr.*	Lituola (Placopsilina) nautiloidea.		
Nautilus helicites, *Schr.*	[?Amphistegina *vel* Operculina?]		
—— Beccarii β. ammonoides, *Gm.*	Nummulina (Operculina) complanata.		
—— ammonoides, *Gron.*			
—— Balthicus, *Schr*.			

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