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XLIV.—New observations on the dimorphism of the Foraminifera

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"cinq bras beaucoup moins larges que les radiales" are in the same condition.

He notes the absence of pinnules in his examples of *Democrinus*; but unless they have more than six or eight single brachials (= three or four syzygial pairs) this would be nothing remarkable. In *R. lofotensis* the first pinnule-bearing joint is the eighth from the radial, i. e. the epizygial of the fourth brachial; while in *R. Rawsoni* it is sometimes this and sometimes the epizygial of the third brachial which bears the first pinnule. Unless therefore the "restes très courts" of the arms of *Democrinus* have more than these three or four syzygial joints, I should not expect them to bear pinnules.

Thus, then, I do not regard *Democrinus Parfaiti* as any thing more than a somewhat elongated variety of *Rhizocrinus Rawsoni*. As pointed out elsewhere*, this species has been dredged among the Azores and in the north-west portion of the Bay of Biscay; so that its discovery off the Morocco coast is a point of some interest.

M. Perrier describes *Democrinus Parfaiti* as the fifteenth known living species of stalked Crinoids. His list comprises the eight species of *Pentacrinus* which are noticed in "The Stalked Crinoids of the Caribbean Sea," together with the two species of *Rhizocrinus*, two of *Bathycrinus* (*B. gracilis* and *B. aldrichianus*), one each of *Hyocrinus* and *Holopus*, and, finally, *Hyponome Sarsii*, Lovén. For this last, however, the name of *Bathycrinus Carpenteri* (*Ilycrinus*, Danielssen and Koren) should be substituted. *Hyponome* has long been disestablished as a genus†; for it is merely the isolated disk of a *Comatula*, and in no way related to the stalked Crinoids. To the above list there will have to be added several species of the new genus *Metacrinus*, Wyville Thomson, MS.

XLIV.—*New Observations on the Dimorphism of the Foraminifera.* By MM. MUNIER-CHALMAS and SCHLUMBERGER ‡.

ONE of us demonstrated in 1880§ that in *Nummulites* and *Assilina* each species was represented by *two forms*, which are still regarded, wrongly, as distinct species. Since that time

* Bull. Mus. Comp. Zool. vol. x. no. 4, p. 174.

† Quart. Journ. Micr. Sci. 1879, vol. xix. new ser. p. 205, and Proc. Roy. Soc. no. 194, 1879, p. 388.

‡ Translated by W. S. Dallas, F.L.S., from the 'Comptes Rendus,' March 26, 1883, p. 862.

§ Bull. Soc. Géol. de France, 3^e série, tome viii. p. 300.

we have pursued our researches upon the structure and organization of the principal genera of Miliolidæ:—*Biloculina*, *Dillina*, *Fabulina*, *Lasazina*, *Triloculina*, *Trillina*, *Quinqueloculina*, *Pentellina*, and *Heterillina*.

It appears from our recent observations that the dimorphism first discovered in the Nummulites occurs also in all the species of Miliolidæ that we have studied; and that it is therefore manifested in both the great divisions of the Foraminifera, Perforata and Imperforata.

The better to display this character it is necessary to notice the general plan of structure of the three principal genera of Miliolidæ.

The *plastrostracum** of the *Biloculina*, *Triloculina*, and *Quinqueloculina* may be regarded, from a schematic point of view, as formed by a tube coiled round a sphere (central chamber) and presenting, at each half revolution, a constriction which bounds a new chamber larger than the preceding one. The coiling is effected sometimes in a single direction; sometimes, on the contrary, at each half revolution the new chamber departs more or less from the preceding one, and the coiling then follows certain definite directions which pass through the plane of symmetry of the serial chambers.

In the *Biloculina* the coiling, taking place in a single direction, remains in the same plane of symmetry, which is consequently common to the two rows of serial and opposite chambers, which surround a central spheroidal initial chamber.

The *Triloculina* are coiled in three directions, which give origin to three planes of symmetry making an angle of 120° with each other. From this arrangement it results that the central chamber is surrounded by three rows of serial chambers.

Lastly, in the *Quinqueloculina*, which present around the central chamber five rows of the serial chambers, the coiling follows five directions, which define the same number of planes of symmetry, making with each other an angle of 72° .

The dimorphism of the Foraminifera is characterized by a difference in the size and arrangement of the first chambers. If we make transverse sections of any of the species that we have investigated, we very soon ascertain that the individuals composing them present two types of organization: the smaller ones and those of medium size have always a relatively very large central chamber (form A), while in the larger specimens this central chamber is only visible with a high magnifying power (form B). In the same species there is no external

* Test of the Foraminifera.

character, except that derived from the size, to lead us to suspect this fact. There exist further, between these two forms, other differences, which we will now indicate.

Form A.—The numerous sections that we have made of individuals belonging to this form have always shown us that they had a *large central chamber*, of a spheroidal form, with thin walls, the diameter of which varies from 200 to 400 μ . The first chambers surrounding it, in the great majority of the species, have a direction and arrangement like those of the last.

A. Fig. 1 (magn. 12).



B. Fig. 2 (magn. 28).

*Biloculina depressa.*

Biloculina depressa, d'Orb. (fig. 1), which lives in the Atlantic Ocean, may serve as an example. Its central chamber is surrounded by chambers which, from their first appearance, indicate the most simple Bilocular type, that is to say, coiling in a single direction. The first of the serial chambers, which is often narrower than the following ones, is in communication with the central chamber through a small circular aperture.

Form B.—Although the individuals belonging to this form are always the largest, transverse sections passing strictly through the centre are very difficult to obtain. The initial chamber, which is likewise spheroidal, is of extreme smallness in comparison with that of the preceding form, its average diameter hardly exceeding 18–25 μ . In all the species that we have studied the first chambers which appear group themselves by five around the central chamber, in accordance with five directions, which recall the mode of development of the *Quinqueloculinae* and *Pentellinae*; but soon, either suddenly or by gradual transition, the coiling changes, and the new chambers are arranged, exactly, according to the species, like those of the corresponding form A. The section * of *B. de-*

* The figure represents only the central part of the section; the last two chambers are wanting.

pressa, d'Orb. (fig. 2), shows that the first ten chambers surrounding the central chamber are arranged in five series; but suddenly the succeeding chambers become more embracing and arrange themselves like those of the form A (fig. 1).

Biloculina comata, Brady, form A (fig. 3), which also inhabits the Atlantic Ocean, possesses a central chamber smaller than that of *B. depressa*; its walls are very thin; it

A. Fig. 3 (magn. 12).

B. Fig. 4 (magn. 28).



Biloculina comata.

is nearly spheroidal, its greatest diameter being $258\ \mu$, and its smallest $240\ \mu$. Towards its upper part we see the oval section of the first chamber, which resembles a narrow canal and is very different from the following ones. This character, which is common to all the *Biloculinae*, may be verified in fig. 1.

The following chambers have the normal arrangement of this genus (coiling in a single plane of symmetry); but their walls are very thick and externally present numerous parallel riblets.

Biloculina comata, Brady, form B (fig. 4) *.—The central chamber is spheroidal and very small ($21\ \mu$); the first chambers which surround it are grouped at first by five, then by four, three, and two; and it is only from this moment that the chambers are arranged as in the *Biloculinae*. There is then only a single plane of symmetry common to the last chambers, the coiling taking place in a single direction. These different phases of the coiling therefore remind us, in one and the same species, of the arrangement of the *Quinqueloculinae*, *Triloculinae*, and *Biloculinae*.

In an early communication we shall indicate the modifications that we have ascertained in other genera, and give the

* In our figure the last chamber but one is incomplete, and the last one is entirely wanting.

two principal hypotheses that may be imagined to explain this dimorphism.

The following is a translation of the article referred to as giving the first intimation of the author's observations (Bull. Soc. Géol. France, sér. 3, tome viii. p. 300) :—

"M. Munier-Chalmas announced to the Society that his researches upon *Nummulites lævigata*, *planulata*, *variolaria*, *irregularis*, and upon *Assilina granulata* and *spira*, have led him to conclude that these species are dimorphic. It is probable that this fact will prove to be general.

"When we find in the same deposit *Nummulites* of very different dimensions which have externally the same specific characters, we very soon remark, on breaking them, that the small individuals have a very large central chamber, while that of the individuals of large size is comparatively very small; and as there are no intermediates between these two forms, they have been made into distinct species. But, on the other hand, as we never find the young of the *small-chambered Nummulites* above mentioned, M. Munier-Chalmas has been led to regard the latter forms as originating from the individuals with large chambers, which are associated with them in most cases. From this he considers it results :—

"1. That the individuals with large chambers continue to increase externally at the same time that they absorb their large central chamber, and that in its place they prolong their spiral inwardly, probably in consequence of a spiral inrolment preexisting in the embryo.

"2. That the individuals which become arrested in their development retain their large chamber without modification : thus, for each of these species, they constitute a peculiar stage corresponding to an arrest of development.

"In the list, in order to avoid confusion between these two stages, one might prefix to the specific name of the individuals with large chambers the designation *præ*, merely indicating a first stage of development. To cite only one example, we should thus have *Nummulites lævigata* for the large individuals with small central chambers, and *N. prælævigata* for the *N. Lamarckii*, or first evolutive phase of *N. lævigata*. If this theory of dimorphism among the *Nummulites* is verified, it will be necessary to diminish considerably the number of species."

To the above statements M. P. De la Harpe replied at considerable length in a paper read before the Geological

Society of France in January 1881 (Bull. Soc. Géol. France, sér. 3, tome ix. p. 171), in which, after discussing the phenomena observed by him and indicating the pairs of so-called species of Nummulites which he also recognized, he summed up his opinions as follows (*l. c.* p. 175) :—

“If the species of the same couple have some common characters, such as analogous external adornments and septa of the same form and of the same inclination, they have on the other hand plenty of different characters, such as—spirals of which the mode and rate of coiling is different, septa differently spaced and distributed, especially in the vicinity of the centre, and chambers differing in form, size, and number.

“To pass from one form to the other, therefore, we have not merely to prolong the spiral, but to modify it in its essential elements. The internal arrangement of the two forms has been made in accordance with two plans of architecture which are completely different, and of which it is impossible to derive the one from the other.

“Ah! had M. Munier-Chalmas expressed the opinion that these two similar forms are the two sexes of the same species, it would have been more difficult to answer him, so much do the circumstances of their constant association, their relative frequency, and the analogy of their external characters give them the air of a veritable couple. No doubt it will be answered that there is nothing in the organization of the existing Rhizopods to justify one in supposing that there is any separation of sexes in them. But is this answer conclusive? Evidently not.

“Our conclusion therefore is that in each couple of Nummulites there are such anatomical differences between the two forms with and without a central chamber that it is impossible to consider them two ages of the same species. It would be more probable to regard them as the two sexes, if our actual knowledge with regard to the physiology of the Rhizopoda was not opposed to this view.”

Remarks upon the subject of the occurrence of pairs of Nummulites as described by M. De la Harpe, and on the presence in them of large and small primordial chambers, will be found in various parts of the ‘Catalogue of the Fossil Foraminifera in the Collection of the British Museum,’ by Prof. T. Rupert Jones (1882), the supplementary notes to which also contain the translation of a letter from M. De la Harpe to the author relating to the same subject.