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ORIGINAL ARTICLES.

I.—ON THE STRUCTURE AND AFFINITIES OF THE GENUS *SOLENOPORA*,
TOGETHER WITH DESCRIPTIONS OF NEW SPECIES.

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(PLATE V.)

IN the present paper I propose to give the results of a series of investigations carried on in the Zoological Laboratory of the University of Aberdeen. Through the kindness of Professor Nicholson, I have had access to his admirable collection of specimens of *Solenopora*, Dyb., and I have also had the privilege of using his extensive series of microscopic preparations of the same. With such material, and with additional preparations, I have been enabled to examine, not only species already described, but also a number of new species, of which I shall in this paper give brief descriptions. From examination of all these forms, I find it now practicable to determine the true nature of the genus *Solenopora*, Dyb.

This genus has been described from time to time under various names; but there is no doubt that *Stromatopora compacta* of Billings, *Tetradium Peachii* of Nicholson and Etheridge, *Solenopora spongioides* of Dybowski, and *Tetradium Peachii*, var. *Canadense* of Foord, are in reality names of the same organism. This particular form, described under these various names, is known as occurring in the Ordovician rocks of Canada, Esthonia, Scotland, Wales, and Shropshire; and will doubtless ultimately be detected in other regions in strata of corresponding age. A full description of the species, under the title of *Solenopora compacta*, Billings sp., was given in 1885 by Prof. Nicholson and Mr. R. Etheridge, jun. (GEOL. MAG. Dec. III. Vol. II. p. 529). At a later date Prof. Nicholson further described another species, *Solenopora filiformis*, from the Craighead Limestones (GEOL. MAG. Dec. III. Vol. V. p. 15, 1888). Still more recently specimens were obtained from the Great Oolite of Gloucestershire and Yorkshire, which, though differing in structural detail, can be readily recognized as another species of the genus *Solenopora*. Thus, the geological range of this organism can be now extended from the Ordovician series to the Jurassic rocks. Additional specimens have also been examined from Esthonia, and from Craighead, Girvan; these showing important structural peculiarities, and reminding one at once of the well-known Nullipores and other calcareous Algæ of the present day.

DECADE IV.—VOL. I.—NO. IV.

10

In a monograph on *Solenopora compacta* (GEOL. MAG. Dec. III. Vol. II. p. 529), Professor Nicholson refers the genus *Solenopora* temporarily to the Hydrozoa; but he says that "if evidence can be obtained, proving decisively the existence of a *cellular*, and not a *tubular*, structure in *Solenopora*, then the reference of the genus to the calcareous Algæ will follow as a matter of course." Now, from recent investigations carried on upon all the forms enumerated, and from a comparison of structure of these with those of Tertiary and recent Corallineæ, I have been led to the decisive conclusion that the genus *Solenopora* is in reality an ancient form of the same great group, to which our existing *Corallina*, *Amphiroa*, *Melobesia*, and *Lithothamnion* belong. Before discussing this subject in detail, however, it will be advisable that I should give a brief description of the various species of *Solenopora* with which I am at present acquainted.

I. DESCRIPTION OF SPECIES.

1. *Solenopora compacta*, Billings.

Stromatopora compacta, Billings. "Palæozoic Fossils" (1861-65).

Tetradium Peachii, Nicholson and Etheridge, jun. Ann. and Mag. Nat. Hist. ser. iv. vol. xx. p. 166 (1877).

Solenopora spongioides, Dybowski. "Die Chaetetiden der Osbalt. Silur. Form." p. 124, taf. ii. figs. 11a, b (1877).

Tetradium Peachii, var. *Canadense*, Foord. Contrib. Micro. Pal. Sil. Rocks, Canada, Geol. Survey, 1883, p. 24.

Solenopora compacta, Nicholson and R. Etheridge, jun. GEOL. MAG. Dec. III. Vol. II. No. 12, p. 529. Dec. 1885.

Solenopora compacta, Nicholson. GEOL. MAG. Dec. III. Vol. V. No. 1, p. 15, Jan. 1888.

"This species occurs in subspheroidal masses, from the size of a hemp-seed up to the dimensions of an orange. External surface lobulate. Fractured surface has a porcellaneous, sometimes fibrous aspect, and is usually white or light-brown in colour. The fractured surface also shows signs of a more or less obvious composition out of concentrically-disposed strata" (Nicholson).

In vertical section the cells are elongated, arranged in a radiating and parallel fashion, and are often disposed in concentric layers. Diameter of cells about $\frac{1}{17}$ mm. The cells have distinctly undulating walls (Fig. 1).

In tangential section the cell-walls appear sinuous, and in many cases traces of active cell-division are observed. Certain specimens show a distinct variation in the size and form of the cells. In these two sets of cells are to be noted—one set small, with a wavy or polygonal outline; the other set large, elongated or oval in form, and scattered irregularly amongst the smaller cells. The large cells represent the spore-producing cells (sporangia), and the small the ordinary tissue-cells of the organism (Fig. 2).

Varieties.—There exist certain varieties of the above species which differ from the type-form, either in the size of the tissue-cells, or in the structure and form of the cell-walls.

Solenopora compacta, var. *Trentonensis*, nov. var. This variety, illustrated in Fig. 2, is found in the Trenton Limestones, and varies

somewhat from the type. The tissue-cells have their walls somewhat polygonal, and only feebly sinuous. Cell-division, too, is not observed to be in the same state of activity as exhibited in the ordinary forms.

fig 1

FIG. 1.—Long. sect. *Solenopora compacta*, Bill. sp., $\times 50$ d., showing concentric arrangement of cells.

Solenopora compacta, var. *Peachii*, Nich. and Etheridge, jun. Prof. Nicholson has noted that certain specimens obtained from

fig 2

FIG. 2.—Tang. sect. *Solenopora compacta*, Bill. sp., from the Trenton Limestones, $\times 100$ d. Larger cells seen in section are the spore-producing cells (sporangia).

the Craighead Limestones, Girvan, Ayrshire, possess much wider cells than any other form examined. They are alike, in every

other particular, to the typical species described from Canada and Esthonia, and so he distinguishes the Ayrshire forms as a special variety—*Solenopora compacta*, var. *Peachi*.

Observations.—It is observed that throughout the whole of the above species increase takes place for the most part by longitudinal division of the tissue-cells, and that the cells tend to grow in length more than in breadth. Not only so, but there seems to exist a species of sub-dichotomy or sub-trichotomy by which two or three peripheral cells arise from the outer end of a more central cell (see Fig. 1). This process has also been found to occur in certain of the calcareous Algae¹ (e.g. *Lithothamnion*). Transverse division occurs in other species, and in the description of the following forms it will be seen that there are types, very like *Solenopora compacta*, in which cell-multiplication by transverse fission is the rule. Even in the present species such a mode of increase is by no means entirely absent.

Formation and Locality.—Ordovician, Craighead Limestones, Girvan, Ayrshire; Trenton and Black River Limestones, North America; Limestones of Saak, Esthonia, where it makes up great beds of limestone, most of the examples in this case being comparatively small. Dr. Dybowski also obtained it from Herrküll, Esthonia, in beds of Ordovician age ("Borckholm beds" of Friedrich Schmidt). The specimens examined are from the collection of Prof. Nicholson.

2. *Solenopora lithothamnioides*, n.sp. (Pl. V. Fig. 2.)

The single specimen examined shows that this species occurs in conical masses of the size of a walnut. Its fractured surface has a distinct porcellaneous aspect, and exhibits a greyish-brown colour. It possesses the concentrically laminated structure characteristic of the genus. It is much harder and more compact in texture than any of the other species.

In vertical section distinct concentrically arranged layers of cells are seen. Each layer is composed of numerous cells arranged in parallel rows. The walls of the cells are slightly sinuous, when examined with a high power. The transverse divisions between the cells are thinner than the vertical divisions, and in many cases are obliterated, leaving fine concentrically disposed clear markings. Cells $\frac{1}{12}$ — $\frac{1}{8}$ mm. long and $\frac{1}{10}$ — $\frac{1}{6}$ mm. broad. In tangential section the cells are more or less rounded and only slightly sinuous in their outline. The cell-walls are thinner than in *S. compacta*.

Observations.—This species is nearly allied to *S. compacta*, and differs mainly in the character and form of its cell-wall, in the greater regularity of the concentric layers, and in the fact that each concentric layer is composed of parallel rows of small cells. As regards the last point, the same may be true of *S. compacta*, if we are to accept the presence of the commonly observable fine concentric clear spaces as indicative of the original divisions between

¹ A. Rothpletz, "Fossile kalkalgen aus Familien der Codiaceen und der Coral-lineen." Zeitschr. d. Deutschen geolog. Gesellschaft, Jahrg. 1891.

the cells. These spaces are well displayed in specimens from the Trenton limestones and from Esthonia, which specimens are assuredly examples of *Solenopora compacta*.¹ In the specimens of *S. compacta* hitherto described no definite proof has been found that these spaces do correspond to cell-walls. In *Solenopora lithothamnoides*, however, distinct walls are seen which agree in position with the clear markings seen also in the same species (see Pl. V. Fig. 2).

Formation and Locality.—Ordovician (Silurian?), Shalloch Mill, near Girvan, Ayrshire. (Coll. H. A. Nicholson.)

3. *Solenopora nigra*, n.sp. (Pl. V. Fig. 3.)

This species presents itself in small oval, ovate, or rounded masses up to the size of a pea. It has always a dark appearance, and it is very difficult to prepare good transparent sections from it. When fractured the concentric arrangement in layers is well seen, and the surface presents a porcellaneous or somewhat fibrous aspect. In vertical section the distinct concentric layers of cells peculiar to the last species are not nearly so manifest. The cell-walls are thick, dense, and feebly sinuous, the transverse equalling the longitudinal in thickness. Cells $\frac{1}{30}$ — $\frac{1}{60}$ mm. wide and about $\frac{1}{6}$ — $\frac{1}{17}$ mm. long. The cells near the point from which radiation proceeds are much narrower and longer than the peripheral cells. The whole cellular tissue often tends to assume a fan-like appearance. In tangential section the cells appear rounded or oval, and somewhat sinuous in their outline. Walls thick, and cell-division active (Fig. 3).

fig 3

FIG. 3.—Tang. sect. *Solenopora nigra*, n.sp., from Esthonia. $\times 50$ d.

Observations.—This species occurs in great masses of limestone, of which it is one of the principal constituents, and such is the appearance of a mass of this limestone that one might readily mistake it for an ordinary Nullipore limestone such as we meet with in the Tertiary series. One is struck, also, with the similarity in form, appearance, and arrangement of the cells, to what is

¹ These concentrically arranged clear spaces were alluded to by Prof. Nicholson in the *GEOL. MAG.* Dec. III. Vol. II. No. 12, p. 533, December, 1885. He showed there also that, corresponding to the clear spaces in the tubes, there were interruptions in the longitudinal walls.

found in the species to be next described, viz. *Solenopora Jurassica*, Nicholson.

Formation and Locality.—Ordovician Limestones, Saak, Esthonia, Russia. (Coll. H. A. Nicholson.) Here it occurs along with *S. compacta* and *S. dendriformis*.

4. *Solenopora Jurassica*, Nicholson (MS.).

This form occurs in subspherical masses varying from the size of a marble to that of an orange or even larger. The fractured surface has a porcellanous appearance, and shows the arrangement in concentric layers very markedly. Each layer has a reddish-brown colour internally, fading into a whitish appearance externally.

In vertical section the cells are arranged in a radiating fashion. They have about the same diameter as those of *Solenopora compacta* (about $\frac{1}{10}$ mm.), and their length varies from $\frac{1}{2}$ mm. to $\frac{3}{4}$ mm. The arrangement of the cells is upon the same principle as in *Solenopora nigra*, and they do not group themselves into layers corresponding to the concentric strata seen with the naked eye. The cell-walls are very distinct, and not sinuous. The transverse walls are slightly concave on the peripheral side (Fig. 4). Certain zones are observed

fig 4

FIG. 4.—Long. sect. of *Solenopora Jurassica*, Nich. (MS.), from Chedworth, Gloucestershire. $\times 50$ d.

to have their walls either very indistinct or obliterated by crystallization. These zones correspond to the more lightly coloured portions of the concentric layers of the mass as visible to the unaided eye. Some sections show oval or rounded spaces here and

there, which are, in all probability, the remains of the reproductive organs (conceptacles). In tangential section the cells appear more or less rounded, and also often polygonal. Cell-division is active, and where the cells are not polygonal intercellular spaces are observed to be present. In certain sections are found spaces of a rounded or oval character; and, further, in the same specimens, are observed at intervals clusters of cells arranged in a rosette-like fashion (see Fig. 5). This latter condition may simply be due to the results of cell-division; but to this I shall refer later on. The empty spaces may be all that is left of former reproductive organs.

fig 5

FIG. 5.—Tang. sect. of *Solenopora Jurassica*, Nich. (MS.), from Malton, Yorkshire, showing rosette-cells and spaces (conceptacles). $\times$ nearly 50 d.

In one specimen from Malton these spaces are arranged in a row, but there was great difficulty experienced in getting good sections for examination, on account of the imperfect state of preservation.

Observations.—This is the only species of Jurassic age yet known. It occurs under the same conditions as the other species. The form of its cells has already been shown to be similar to those of *Solenopora nigra*. The distinct nature of cell-walls, both transverse and longitudinal, places it apart from all the other species.

Formation and Locality.—Jurassic, Great Oolite, Chedworth, Gloucestershire, and Malton, Yorkshire. (Coll. H. A. Nicholson.)

EXPLANATION OF PLATE V.

- FIG. 1.—Vertical section of a Tertiary Nullipore (*Lithothamnion*), from "Leitha-Kalk" of Austria. $\times$ 25 d.
 ,, 2.—Vertical section of *Solenopora lithothamnioides*, n.sp., from Shalloch Mill, Girvan, Ayrshire. The specimen shows concentric layers of cells, each layer being composed of numerous cells arranged in parallel rows. $\times$ 12 d.
 ,, 3.—Vertical section of *Solenopora nigra*, n.sp., from the Ordovician Limestone of Saak, Esthonia. $\times$ 25 d.
 ,, 4.—Vertical section of *Solenopora fusiformis*, n.sp., from Craighead, Girvan. A great part of the specimen is destroyed, and the structure obliterated by secondary crystallization. $\times$ 12 d.

(To be continued in our next Number.)

FIG. 1.—Vertical section of *Lithothamnion*.

FIGS. 2-4.—Vertical sections of *Solenopora*.

To illustrate Dr. Alex. Brown's paper.