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ON TWO ADDITIONAL PERFORATING BODIES, BELIEVED
TO BE THALLOPHYTIC CRYPTOGRAMS, FROM THE
LOWER PALÆOZOIC ROCKS OF N. S. WALES.

By R. ETHERIDGE, JUNR., Curator.

(Plate xxiii.)

IN 1891 I described* a perforating Thallophyte under the name of *Palæachlya tortuosa*, occurring in the tissues of a Permo-Carboniferous Monticuliporoid from Queensland, and an Endophytic form, then believed to be allied to the Saprolegnian Fungi, met with in the old visceral cavities of another coral (*Stenopora crinita*, Lonsdale) from rocks of the same age in New South Wales. The latter was termed *Palæoperone endophytica*.

For the first of these minute and interesting fossils I used the late Prof. P. M. Duncan's genus *Palæachlya*,† proposed by him for the reception of certain supposed fungal borings detected in the corallums of Tertiary and Palæozoic corals, particularly *Goniophyllum pyramidale* and *Calceola sandalina*.

The recent examination of a well preserved *Favosites*, from the Devonian Limestones of the Tamworth District, has revealed the presence of two highly interesting perforating forms, one of which is, in all probability, allied to *P. tortuosa*, while the other is certainly quite distinct. The second being much the more important, will be described first.

The tissues of the *Favosites* are penetrated in various directions, but, more commonly by far, at right angles to the coral's growth, by longer or shorter chains of moniliform cells (Pl. xxiii., fig. 1), rather similar to a chain figured‡ by Prof. P. M. Duncan in the tissues of *Goniophyllum*. These lines of monillæ divide at irregular distances apart, either at an acute or obtuse angle, as the case may be, but no inosculation, contortion, or returning on themselves occur, although there is a certain amount of curvature. To use an expression of Prof. P. M. Duncan's, the chains "often dip out of and come within the focus of the microscope, in their more or less long course."§ At times they are widely separated, at others crowded together, the calibre of both the parent portions and branches being practically the same, the offshoots being quite as

* Rec. Geol. Surv. N.S.W., ii., 3, 1891, p. 95.

† Quart. Journ. Geol. Soc., xxxii., 1876, p. 210.

‡ Quart. Journ. Geol. Soc., xxxii., 1876, pl. xvi, fig. 6.

§ Proc. Roy. Soc., xxv., 174, 1876, p. 243.

large as the main portions from which they emanate, but not again branching. Many of the chains of monillæ appear to have neither beginning nor ending, but when a termination rises within the field it is seen under one of two conditions, either as an ordinary refractive, or an enlarged black globule.

The moniliform cells are usually dark along the margins of the chain, and refractive in the middle line, but here and there this refractive centre is absent, when the cells are oblong, and of a uniform drab-yellow colour. It is only when the cells are destitute of a refractive centre that they appear to be oblong, whenever the latter is present they are always strictly moniliform. As a rule there is no trace of any containing or bounding wall, or of a sheath, although the monillæ follow one another with great regularity. Instances do occur, however, in which there appear to be traces of such a sheath (Pl. xxiii., fig. 4), and in one particular case a chain unquestionably terminates in a clear and unoccupied tube (Pl. xxiii., fig. 3); but this in no way resembles the tortuous course of *Palæachlya tortuosa*, mihi, or a similar form to be described later. At intervals of greater or less extent the continuity of the chain is broken by one, two, three, or more globules or cells, very much exceeding in size the ordinary monillæ, and perfectly opaque, in fact quite black (Pl. xxiii., fig. 2). In only one instance have I observed any deviation from this opacity, and then the globule was drab-yellow. A chain may either be terminated by one of these black cells; or, one may be attached at the side of a chain, out of its alignment, as it were, and similar to a figure of Duncan's,* who terms it an oospore. One of the chains without refractive centres is all but terminated with three or more circular globules united in a cluster (Pl. xxiii., fig. 2), and in the chain terminating in the clear tube already referred to, there is a similar cluster, with two single black globules in the course of the chain also. In a few cases, where the end of a chain has come into view it merges into an irregular black mass, as seen by Duncan in a *Thamnastræa* from the Tasmanian Tertiary.†

On the other hand, no terminal loculus, crowded with zoospores, as Duncan terms them, and figured by him in *Calceola sandalina*‡ and in *Achlya penetrans*§ has come under notice; but there is certainly at one spot a black globule attached to the side of a chain, from which a rounded mass of pulverulent matter is proceeding, or is attached. In many of the old visceral chambers of the *Favosites*, the black globules, Duncan's oospores, may be seen in a free state, unaccompanied by any moniliform chains. Another interesting point remains to be noticed—along the edges

* Proc. Roy. Soc., xxv., 174, 1876, pl. vii., fig. 48.

† Quart. Journ. Geol. Soc., xxxii., 1876, p. 206.

‡ Quart. Journ. Geol. Soc., xxxii., 1876, pl. xvi., figs. 12 and 13.

§ Proc. Roy. Soc., xxv., 174, 1876, pl. vii., fig. 53.

of the microscopic sections wherever the chains occur, and often well into the sections, among the visceral chambers of the coral, a brown pulverulent substance occurs, always very uniform in colour; does this represent the shed contents of the black globules?

The longest chain observed attained a length of $\cdot 5$ millimetres, the diameter of the monillæ being $\cdot 0075$ millimetres, and that of the black globules $\cdot 01$.

The second form contained within the tissues of the *Favosites* consists of ramifying tortuous tubes, with definite walls, spreading out, returning on their own parts, bifurcating, or forming confused masses (Pl. xxiii., fig. 5). They may be filled with a sherry-yellow, minutely pulverulent matter, or, they may be quite clear of this substance, and only determinable by the presence of the bounding walls, not otherwise differing from the surrounding calcite of the coral, but the outline is very irregular, irrespective of their contorted course. In the majority of instances when these tubes are present, the old visceral chambers of the *Favosites* near at hand are more or less filled with the sherry-yellow pulverulent matter. This material is remarkably like that seen in the perforations of *Palæachlya perforans*,* and which Duncan calls tubes "with conidia." In a very few instances I have observed these tubes occupied by patches of dense black matter, similar to the black globular cells of the previously described form. The tortuous nature of this endophyte renders it impossible to speak with any degree of certainty as to the length of an individual tube, but the diameter appears to be tolerably uniform, viz., $\cdot 01$ millimetres.

I propose to call this organism *Palæachlya torquis*, on account of its much more irregular course. It is otherwise similar in character to, except for smaller dimensions as compared with those of *P. tortuosa*, mihi. *P. tortuosa* is distinctly visible with a one-inch objective (Watson's), whereas the tubes in *P. torquis* cannot be distinguished without the aid of the quarter-inch objective of the same maker. The diameter of the tubes in *P. tortuosa* is $\cdot 02$ millimetres.

Similar characters separate *P. torquis* from the endophyte figured, but not named, by Waagen and Wentzel, † in the corallites of *Geinitziella columnaris*, Schl. Duncan's illustrations of *Palæachlya perforans* convey, in a general way, the appearance of the tubes in *P. torquis*, allowing for the much more irregular course of them in the latter, and it may legitimately be concluded that, although allied, they are distinct.

As regards the chains of monilliform cells, the probability seems to be that they, and the tubes of *P. torquis*, represent separate

* Quart. Journ. Geol. Soc., xxxii., 1876, pl. xvi., fig. 5.

† Pal. Indica, Ser. xiii., Salt Range Fossils, i., 6, 1886, pl. cxv., fig. 1.

organisms, notwithstanding Duncan's remark that "whilst recognising two or three forms of parasitic Algæ within these sclerenchymatous structures of recent and ancient date, it does not follow that they are to be made into different species. They may all be parts of the same mycelium-like growth of the parasite, and may depend upon the nature of the nidus in which growth has taken place."* In this opinion I am supported by that of my colleague, Mr. Thomas Whitelegge, who has had great experience in the microscopic examination of Cryptogamic life.

Tubes similar to both those now under description have been investigated by many Biologists, with the result of much difference of opinion as to their nature. Prof. John Quekett appears to have been one of the first to investigate similar chains of moniliform cells, and gave an excellent illustration† of them permeating the tissues of a coral, at the same time terming them "confervoid growths." He remarked that "confervoid growths also are very frequently met with in the skeletons of corals, as all these bodies possess animal matter, which, decomposing after death, become a nidus for the development of confervæ." In addition to a coral, he figured similar chains permeating the plates of a *Chiton*,‡ "large canals running through the entire thickness of the sections sometimes preventing the moniliform appearance represented at B" (his fig. 199).

Fuller observations seem to have been made on the simpler tubes, whether of a straight or tortuous nature. Drs. Bowerbank and Carpenter contemporaneously conducted examinations of those permeating the hard parts of Mollusca, and both at first clearly misunderstood their nature. Bowerbank referred to these tubes as "Haversian canals," and speaking of them in the shell of *Ostrea* remarked, "sometimes they pursue their course through this tissue in nearly a straight line for a considerable distance without branching or anastomosing, while in other parts they are tortuous, frequently anastomose, and throw off branches, which have cæcoid terminations."§

In the years 1844 and 1847 Dr. W. B. Carpenter examined tubular perforations in the tests of Mollusca. He referred to simple tubes, more or less regularly disposed, and closely resembling those of an ordinary mycelium. In his first Report he said,|| "The direction and distribution of these tubes are extremely various in different shells; in general they exist in considerable numbers,

* Quart. Journ. Geol. Soc., xxxii., 1876, p. 209.

† Lectures on Histology, ii., 1854, p. 153, fig. 78.

‡ *Ibid.*, p. 323, fig. 199 B.

§ Trans. Micro. Soc. i., 1844, p. 139, pl. xvi., fig. 5.

|| On the Microscopic Structure of Shells.—Brit. Assoc. Report, 1844 (1845), p. 13.

they form a network, which spreads itself out in each layer, nearly parallel to its surface; so that a large part of it comes into focus at the same time, in a section which passes in the plane of the lamina." And again, "I have frequently seen in them indications of a cellular origin, as if they had been formed by the coalescence of a number of cells arranged in a linear direction." These tubes were observed in various Bivalves, particularly *Lima scabrosa*, *Anomia ephippium*, and in species of *Chama*.* Dr. Carpenter's illustrations† convey an excellent idea of some of the tubes in our specimens. Carpenter evidently regarded the tubes as a portion of the Molluscan economy, but later, Köllicker pointed out that all the more or less horizontally spreading tubes described by Carpenter were those of parasites.‡ It is, however, only just to state that Dr. Carpenter was afterward conscious of this, and corrected§ his earlier conclusions.

In 1851 Mr. C. B. Rose investigated|| tubes perforating the scales of recent and fossil fish, and looked upon them as "infusorial parasites."

Quekett's investigations of shell structure were equally successful, for on referring to the subnacreous layer of *Anomia*, *Lima*, and *Arca*, he remarked¶:—"The tubes sometimes run in a vertical direction, but more frequently horizontally, between or upon the laminae of which the shell is composed; they are almost always of uniform character, and very frequently branched, so that some of them present very much the appearance of confervæ. . . . Some of these tubes presented a beaded appearance, indicating that they are made up of cells like the tubular fibres of many fungi." Quekett's tubes** are generally similar to those tubes permeating the *Favosites*, but perhaps a little too regular and too much branched, but not so others seen in a Rice-shell.††

In 1858, Mr. C. Wedl described‡‡ tubes traversing the tests of Brachiopoda, Univalves and Bivalves, but his illustrations do not bear particularly on those now under description. He likened them to the living *Saprolegnia ferox*, which he regarded as a Confervan. About the same time Köllicker showed§§ that similar

* *Ibid.*, 1847 (1848), p. 100.

† *Ibid.*, 1844 (1845), pl. ix., fig. 20, pl. xviii, fig. 4.

‡ Proc. Roy. Soc. xx., 1859, p. 97; Quart. Journ. Micro. Soc., viii., 1860, pp. 172 and 181.

§ The Microscope, 6th Edit., 1881, p. 382.

|| *Fide* Duncan, (I have not seen the paper).

¶ Lectures on Histology, ii., 1854, p. 276.

** *Loc. cit.*, fig. 162.

†† *Loc. cit.*, fig. 163 B.

‡‡ Sitz. K. K. Akad. Wissensch., xxxiii., 28, 1858, p. 451.

§§ Proc. Roy. Soc., x., 1859, pp. 96 - 98; Quart. Journ. Micro. Soc., viii., 1860, pp. 172 - 181.

tubes existed in the hard parts of Sponges, Foraminifera, Corals, Brachiopoda, and Univalve and Bivalve Shells, and contained sporangia; he regarded them as unicellular fungi. The late Prof. H. N. Moseley appears also to have worked at similar endophytes in 1875, but I regret a want of knowledge of his reference.

The last paper to which I shall refer is Duncan's second communication—"On bodies penetrating Recent and Tertiary Corals," wherein he terms the form *Achlya penetrans*.^{*} He remarks that a parasite closely resembling this lived in the tissues of Upper Silurian Corals and Foraminifera, "the main differences between the ancient and modern forms consist in the larger calibre of some of the filaments of the first, their long, often unbranching course, and the frequent development of *Conidia*-looking bodies within them, and the spherical shape of the spores." It does not appear to be quite clear whether Duncan here retains the name he elsewhere proposed for the "ancient" form, viz., *Palæachyla perforans*, or includes both the "ancient and modern forms" under *Achlya penetrans*.

I am quite in accord with an observation of Mr. A. C. Seward, † who says:—"It is generally a very difficult, and often an impossible task, to discriminate between the borings of fungi and algae in fossil material." In this belief I shall simply leave the tubes described by me as *Palæachyla tortuosa* in the position formerly assigned to them, pending further investigations that future discoveries may afford.

The very much more intricate growth of the tubes described in preceding pages, and their smaller calibre, induce me to consider them as distinct from *P. tortuosa* of the Permo-Carboniferous, and for the sake of clearness they may be known as *P. torquis*.^{*}

In considering the systematic position of the moniliform chains of cells, many difficulties present themselves, and in a preliminary investigation of this kind—and it can only be considered preliminary—I merely wish to point out the very strong general resemblance these chains of cells bear to certain unicellular algæ of the group Schizophyceæ, and particularly the Nostocaceæ. The moniliform chains are very like the trichomes of *Nostoc*, allowing for the absence in the former of irregular interlacing, and the enlarged black cells equally resemble the heterocysts of the same genus, which seem to be—so far as my sections enable me to judge—either basal, terminal, or intercalary. Compare the many excellent figures given by Mr. M. C. Cooke, particularly those of

^{*} Proc. Roy. Soc., xxv, 1876, 174, p. 252.

† Seward—Fossil Plants, i., 1898, p. 129.

‡ *i.e.*, That which is twisted.

Nostoc carneum or *N. commune*,* and again *N. hyalinum*.† It would, perhaps, be out of place to call attention to the resemblance between endophytic chains of cells of Palæozoic age, with a genus possessing a gelatinous thallus, or envelope, like *Nostoc*, were it not for the fact that Mr. A. C. Seward has collected several instances where the cells of Nostocaceæ in chains have been found in calcareous pebbles at the bottom of lakes in Ireland, and in the State of Michigan.‡ The genera are *Schizothrix*, *Nostoc*, *Stigonema*, and *Dichothrix*, the first-named enclosed in its comparatively hard tubular sheath. I have already stated that I believed I could distinguish, in more than one instance, a sheath or vagina, enclosing some of the moniliform chains.

In the Nostochineæ, the trichome is either simple or branched; simple in the Nostocaceæ, branched in the Scytonemæ, etc. In the present instance the trichome is decidedly branched, thus showing a departure from the Nostocaceæ. Furthermore, some genera at least of the Nostochineæ contain marine species.§ As to the endophytic habit, it is known that species of *Nostoc* occur in the tissues, or mucilage-containing spaces of certain scale mosses.||

In conclusion, and on the whole, it may perhaps be not too much to say that there is evidence of the existence in Palæozoic times of a *Nostoc*-like endophytic alga, which, for systematic purposes, may be known as *Palæopede*§ *whiteleggei*. It is named in honour of Mr. Thomas Whitelegge, of the Australian Museum, to whom I am indebted for several valuable suggestions.

* Cooke—Brit. Fresh Water Algæ, 1882-4, Atlas, pl. xc., fig. 2, pl. xci., fig. 5.

† Bennett & Murray—Handb. Crypt. Bot., 1889, p. 431, fig. 359.

‡ Seward—Fossil Plants, i., 1898, p. 123.

§ Bennett & Murray—Handb. Crypt. Bot., 1889, p. 441; Seward—*loc. cit.*, p. 122.

|| Campbell—Mosses and Ferns, 1895, pp. 115, 117, 119, 122, etc.

¶ ἰπέδη, a chain or fetter.

EXPLANATION OF PLATE XXIII.

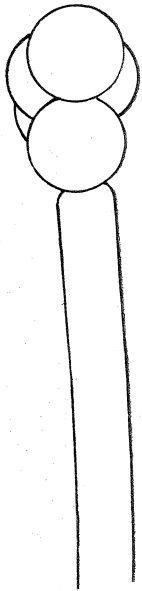
Palæopede whiteleggei, Eth. fil.

- Fig. 1. Trichome (?) of moniliform cells, and heterocysts (?) .5 mm. long.
- „ 2. Four heterocysts (?) at the end of a non-segmented tube filled with similar black pulverulent matter to themselves. .1 mm. long, diameter .02.
- „ 3. Five moniliform cells and a heterocyst (?) terminating in a clear tube. .07 mm. long.
- „ 4. Moniliform cells enclosed in a sheath or vagina. .08 mm. long.

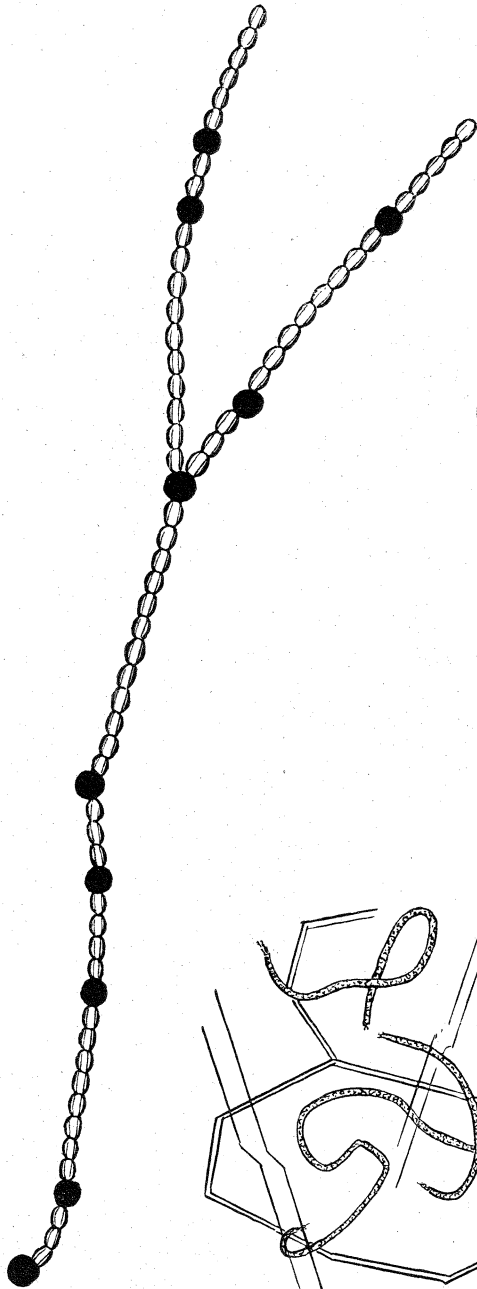
Palæachlya torquis, Eth. fil.

- „ 5. Tubes filled with yellow granular matter. .01 mm. in diameter.

[From drawings by Mr. Edgar R. Waite, Australian Museum].



2.



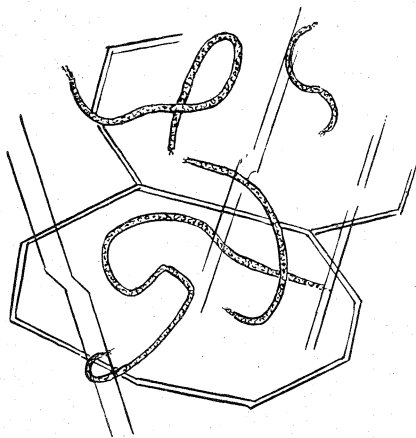
1.



4.



3.



5.