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Contributors

Collingwood, Cuthbert, 1826-1908.
Hogg, Jabez, 1817-1899
Royal College of Surgeons of England

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27

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Observations *on the* Microscopic Alga *which causes the* Discoloration *of the* Sea *in* various parts *of the* World.

By Dr. C. Collingwood, M.A., F.L.S.

(Read March 11th, 1868.)

Although a great deal has been written at various times on the subject of the floating substance known to sailors as sea sawdust, whale's food, &c., it does not necessarily follow that there is not still much to be added by those who have themselves observed the phenomenon. Moreover, although travellers have from time to time recorded the appearance of this substance upon the surface of the ocean in different parts of the world, it so happens that those who have written the most elaborate articles upon it have either never seen it (as, for instance, Montagne), or had but limited opportunities for its observation, which latter was indeed the case with Ehrenberg. Again, the interesting accounts written by these naturalists have referred almost exclusively to the substance produced in the Red Sea, and to which they attribute its name, while other observant travellers have mentioned it as a singular phenomenon of somewhat rare occurrence, giving the date, and latitude, and longitude of the event. Thus Darwin, who circumnavigated the globe, and was five years at sea, cites but two occasions on which he observed it, viz., near the Abrolhos islets, and off Cape Leeuwin; the conferva seen near the Keeling Islands having been of quite a different character.

One circumstance much dwelt on by those who have described this substance is the red colour it imparts to the sea, so much so, that whether it is De Candolle who examines the waters of the lake of Morat, or Ehrenberg at the Bay of Tor, or Montagne describing the dried specimens which had been obtained from the middle of the Red Sea, they all agree in calling it *erythræum*, or *rubescens*, while Ehrenberg improves upon this by naming De Candolle's species *Oscillatoria*

Pharaonis, from a Rénanish idea that this is the natural explanation of the waters turned into blood in the plagues of Egypt. It is described by some as *blood-red*, by others orange-red, or brick-red when expanded over a large surface, and we are assured that the Red Sea or Mare eythræum of the ancients, *Bahr Souph* of the modern Arabs, is so called from this red Alga, the Arabic name simply meaning *Mare algosum*.

I do not for a moment call in question this red appearance which seems to have been so often observed in the Red Sea, but I only wish to remark that numerous as have been the occasions on which it has been my fortune to observe the sea to be discoloured by a floating Alga, in the Eastern and Western Hemispheres, I have never at any time seen it approach a red colour, much less assume the *rouge de sang* of the French writers. The only time I ever saw the sea of a blood-red colour was in a limited space in the Formosa Channel, when I satisfied myself that the red appearance was due to myriads of minute gelatinous worms which filled the water.

In passing down the Red Sea, indeed, although during a week always on the look-out, I saw no trace of red or any other discoloration. This was early in March. Ehrenberg's observations were made in December and January; Dupont's in July; and De Candolle's "at the end of winter." It was not till I was in the Indian Ocean, in long. 70° E. and lat. 5° N., that I first observed that the sea had, as I entered it in my journal, a *dusty* appearance, as though myriads of minute bodies were floating in it, not all upon the surface, but at various depths beneath. This appearance was rendered very remarkable by the sun shining upon the sea, when they sparkled in the light. Not at first recognising their nature, I supposed they might be minute animals, and the source of the luminous sparks which had shown so brilliantly at night; but, upon examination, I found them to be small bodies, having the appearance, under a lens, of sheaves of fibres, constituted as though bound round the middle, but loose at the ends (see Pl. VII, fig. A), like sheaves of corn in miniature. Placing them under a microscope, they presented appearances to be presently described, but, singularly enough, having called the attention of the surgeon of the mail-steamer to them, he at once exclaimed that it was just what he had seen when he had placed under his microscope some of the substance upon the Red Sea, which he had more than once had an opportunity of observing when a red tint was prevalent.

I will first state the localities in which I have observed this substance, and its general aspect, and afterwards describe the microscopic appearances presented by it in various places. I saw no large patches or discoloration of the sea through it anywhere in the Indian Ocean, either north or south of the line, in a single passage across each, but, as I have just stated, the first traces of it appeared to me in the North Indian Ocean in March. So in the South Indian Ocean in May, lat. 28° 29′ S., and long. 38° E., I again observed the sparkling appearance in the water, and once more found it to be due to "dust," but not of the sheaf form, but in wedge-shaped bundles to be presently described.

In the Atlantic, I only once observed it, viz., in June (lat. 8° 28′ 5″ S., and long. 28° 32′ W.), when, standing on the forecastle one day, my attention was arrested by the sparkling in the water which indicated the presence of sea-dust, and presently after we crossed three long narrow streaks of the Alga thickly accumulated upon the surface. This was the only accumulation I ever observed out of the China Seas, and we are thus reminded of the "bandes vertes" observed by Chamisso between Teneriff and Brazil, in 1811.

But the *China Sea* appears to be the home of this minute vegetable. Having left Singapore behind, the appearance of sea-dust became an every-day occurrence, in all its remarkable and interesting features. Nearly every day while traversing this sea more or less of it was to be seen, sometimes a mere sparkling appearance, while sometimes, and not unfrequently, the sea was covered with a thick scum of a yellowish-brown colour, like that which settles upon a stagnant pond. The sea in some places was entirely hidden by the accumulation of the Alga, which, in calm weather, presented the appearance of a regular, smooth, cream-coloured pellicle, thrown up here and there into thick folds and rugosities; and where thickest of a dirty yellow colour, but *never red.* Such a scum would cover the sea for nearly the whole day, with little interruption. But if a moderate breeze were blowing, and the sea were raised, instead of an uniform pellicle, the dust would be arranged in long irregular parallel lines, bands, or streaks, extending unbroken as far as the eye could reach, and always taking the direction of the wind. On one occasion we crossed a single band of this character, the only one seen during the day. When the sea becomes rather rough, the substance is more dispersed, and I have traced the bands under such circumstances with some difficulty. Out of four times that I crossed the China Sea, I observed these appearances, more or less well marked, during

three passages. The fourth time was in winter (December), and during the height of the monsoon—the wind very boisterous, and the sea very rough—so that the substance was doubtless so washed and thoroughly dispersed by the waves, as to be indistinguishable amidst the turmoil and foam.

The most northerly point at which I observed its accumulations forming a pellicle upon the surface of the sea was at the north entrance of Formosa Channel, in lat. 25½° N., and the most southerly point was in Rhio Strait, on the equator.

I have described the first specimens observed, from the Indian Ocean north of the line, as presenting under a lens the appearance of a *sheaf* (fig. A), but this peculiar arrangement I did not elsewhere meet with. There were, in fact, two modes of aggregation of the vegetable filaments composing the Alga in question. Everywhere in the China Sea, in the South Indian Ocean, and in the Atlantic, the form presented was that of small cylindrical bundles, more or less pointed at one end, but obliquely truncated at the other (figs. B, C), having an average length of $\frac{1}{8}$th to $\frac{1}{10}$th inch. They were cream-coloured and opaque, and examination with a lens showed that the ends were fimbriated, owing to the component fibres being loose at their extremities. A third form was occasionally mingled with these, but in very small quantities. It was a minute spherical body, solid and opaque, about the size of an ordinary pin's head, bristling with minute rays, like a miniature echinus (fig. G). This form I noticed in the North Indian Ocean, and very rarely in the China Sea, but, although associated with the sheaf- and wedge-shaped Alga, it appeared to constitute a very infinitesimal proportion of the scum upon those seas. I look upon it as a species of Oscillatoria.

The appearances presented by all these three forms under the microscope are very similar, and the first two apparently identical. The body, whether sheaf- or wedge-shaped, is at first opaque, but gentle pressure shows each bundle to be composed of a dense mass of cylindrical filaments of unequal lengths, combined together and interlacing with each other, forming an intricate network, having the appearance of a complicated basket-work with the ends of the osiers sticking straight out, as when the work is unfinished (fig. D). Each filament is long, and beautifully symmetrical, unbranched, with a rounded extremity, and perfectly even, hair-like outline. The filaments appear to be of equal diameter throughout their entire length, and are filled with a dark-green granular matter, which, before pressure is applied, renders

them nearly opaque, and prevents any examination of their structure.

The application of slight compression, however, renders this form of the cells very evident, as well as their arrangement in the filaments. Each filament appeared to be transversely divided by delicate lines, as distinct in character as the wall of the filament, each cell being seen to contain some granules of green matter in the interior, principally clustered about the centre (fig. E). Every filament, then, was composed of a linear series of tubular cells, and was, therefore, truly jointed, like a Conferva, and not like an Oscillatoria, continuously tubular. I nowhere descried anything like an empty tubule which had discharged its contents bodily, nor anything approaching to such an appearance, and, moreover, further continued pressure, after rendering the cells more and more distinct, ended by breaking the filament into distinct cells, some of which presented a rectangular aspect, others a round outline, according as they presented their sides or their ends to view (fig. F).

In neither of these forms did I ever notice anything which could be construed as a movement of oscillation, or indeed of any kind. Neither was there visible any mucilaginous envelope surrounding any of the specimens which I examined, such as is so strongly insisted on by Ehrenberg in the specimens obtained by him in 1823 in the upper part of the Red Sea.

As for the figures given by Montagne in the 'Annales des Sciences Naturelles' (see fig. H), I can only say I cannot recognise them as anything I noticed under the microscope. Their irregular forms offer a singular contrast to the symmetrical beauty of the filaments when taken fresh from the ocean, and I can only suppose that Montagne's specimens, obtained upon a piece of linen by M. Dupont, had become, in drying, so altered in form that subsequent moistening failed to render them recognisable.

The echiniform body (fig. G), which I consider to be an Oscillatoria, was surrounded by a gelatinous envelope, and was hard and dense in the centre, and therefore opaque On applying gentle pressure, the villous appearance was shown to be due to the free ends of a great number of filaments which intermix with one another in the mass, and formed a minute solid ball. They were unbranched, but twisted around one another, and agglutinated together in a complex manner. While thus engaged in examining them, the filaments one after another suddenly broke up, the little masses of contained endochrome separating from one another, not retaining

each its cell-form, as in the case of the Confervæ just described, but rapidly vanishing under my eyes in a smoke-like manner, until, at the expiration of five or six minutes, there was nothing left of the whole ball but a general granular and amorphous appearance.

A species of Trichodesmium was met with by Dr. Hinds, H.M.S. *Sulphur*, in 1826, on the west coast of North America, and again, in 1837, near St. Salvador, and was referred by Mr. Berkeley to M. Montagne, who regarded it as a new species, and named it *T. Hindsii*. This species, he says, was like that of the Arabian Gulf (which has been called *T. Ehrenbergii*), of a fine red colour, and was further remarkable for the strong musty odour which it gave out, and which deserved the name of *olidum*. But as I have, on the one hand, remarked that I have nowhere met with Trichodesmium of a red colour, but always of the same fulvous or dirty yellow, so also I must add that on no occasion have I observed any peculiar smell, even when it has been thickest, nor have I ever heard any one with more acute perception of odour than myself remark anything unusual of that nature.

M. Ehrenberg, in the original article in 'Poggendorf's Annalen,' states that it was not a permanent phenomenon in the Red Sea, but having observed it three times, viz., on the 25th and 30th December, and 5th January, he suggests a periodicity. The appearance and disappearance of the Alga, other things remaining the same, seems to me to be more remarkable than its permanence would have been, but I have no reason to believe that it is in any way a periodic phenomenon in the China Sea, for at any day, on successive days, and at all seasons, I have observed it unchanged. Ehrenberg's specimens, also, he relates, sank to the bottom of the glass during the night, rising again in the heat of the day. I never observed any phenomenon approaching to this. They always floated in the water for the most part, but some few seemed to have greater specific gravity, and sunk to the bottom. In the ocean, I have observed the scum on the surface in early morning and at sunset; but in the cases of the sparkling appearance in the sea, the fasciculi hovered at various depths below the surface, although it was during the heat of a tropical day.

Montagne appends to his exhaustive paper in the 'Annales des Sciences' a series of conclusions on what was known, and questions for further observation, most of which are referred to, and answered in, the present paper; but there still remains the curious fact that although three species are described, *T. erythræum*, *T. Ehrenbergii*, and *T. Hindsii*,

they are all three spoken of as blood-red—a colour which I have never seen approached. Again, one of the generic characters of Trichodesmium given both by Ehrenberg and Montagne is "muco involuti," while I confidently state that no mucous envelope characterised the species so abundant in the China Sea, and which I also observed in the Indian and Atlantic Oceans. But, then, it might be said the explanation is easy, viz., that the China Sea Alga is of a different species from that of the Red Sea. I have no doubt whatever that this is the case, but the Alga met with by Darwin near the Abrolhos islets, which gave the sea "a reddish-brown appearance," and which, from his description of it, was apparently the same as that I so abundantly met with in the China Seas, was pronounced by Mr. Berkeley to be *Trichodesmium erythræum*, "the same species with that found over large spaces in the Red Sea." It is true Mr. Darwin describes it as a reddish-brown, but he elsewhere states that the endochrome was of a brownish-green—which is more suggestive of the colour, as I have always seen it. So also the substance seen by Banks and Solander in the neighbourhood of New Guinea was doubtless what I have described, and the name universally given to it by Cook's sailors, viz., *sea sawdust*, exactly expresses its appearance and colour, implying, however, nothing red.

With the exception, indeed, of the observations of Dr. Hinds, the blood-red Alga seems nowhere to have been met with but in the Red Sea and Arabian Gulf, and it would, indeed, be strange if the same Alga was always blood-red in the Red Sea, and yellowish-brown somewhere else. Moreover, Hind's specimens were immediately referred to a new species.

Next to the China Sea, the coast of Australia appears to be the favourite locality for this Alga, though there seems, indeed, to be scarcely any part in the world in which it may not be seen in greater or less abundance.

DESCRIPTION OF PLATE VII,

Illustrating Dr. Collingwood's paper on the Microscopic Alga which causes the Discoloration of the Sea in various parts of the World.

Fig.

A.—Sheaf-form of *Trichodesmium*, from the Northern Indian Ocean (seen with a lens).

B.—Ordinary wedge-form of ditto, characteristic of the China Sea (nat. size).

C.—Ditto (seen with a lens).

D.—The fimbriated ends magnified, showing the loose, simple, filamentous structure.

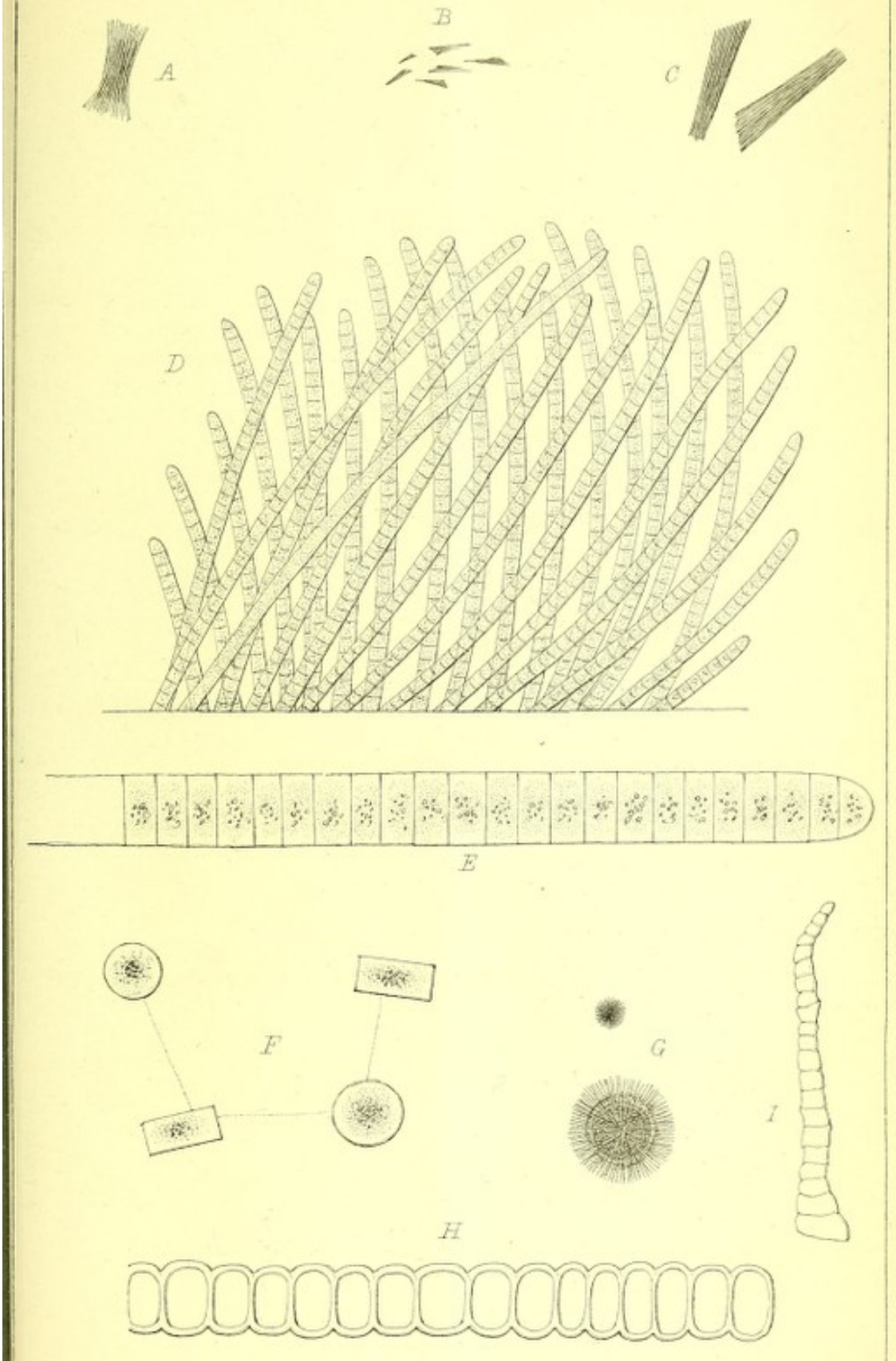
E.—A single filament (highly magnified).

F.—Single cells in process of disruption.

G.—*Oscillatoria*, found in conjunction with *Trichodesmium* (nat. size, and with a lens).

H.—A normal filament of *Trichodesmium Ehrenbergii* (from Montagne).

I.—Extremity of a filament of *Trichodesmium Hindsii* (from Montagne).



C Collingwood del. T. West sc.

W. West imp.