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THE ANNALS

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[SECOND SERIES.]

" ..... per litora spargite muscum,
Naiades, et circùm vitreos considite fontes :
Pollice virgineo teneros hìc carpite flores ;
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas ;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

No. 25. JANUARY 1850.

I.—*Observations on the Conjugation of* Closterium Ehrenbergii. By the Rev. W. Smith, F.L.S.

[With a Plate.]

THE conjugation of *Closterium Ehrenbergii* (Menegh.), under the name of *Closterium lunula*, has been described in a paper by M. Morren, 'Annales des Sciences Naturelles,' 2nd ser. tom. v. 1836, but the phænomenon does not appear to have met the eye of any late observer in this country, and is wholly unnoticed by the acute and careful authors of the 'British Desmidieæ.'

I have had an opportunity, during two successive seasons, of noticing the circumstance in question, and the facts elicited seem to vary in some important respects so materially from those recorded by M. Morren, and are in themselves so different from the ordinary phænomena which accompany the conjugation of other *Closteria*, or indeed of any other of the *Desmidieæ*, that I have thought it might be interesting to those engaged in such investigations to state the particulars which have fallen under my notice.

On the 23rd March 1848, I first discovered *Closterium Ehrenbergii* in a state of reproduction. On this occasion the period of conjugation had evidently nearly expired, as but few individuals were in that condition, and the mucus stratum, which results from the aggregation of conjugating fronds, had almost wholly

disappeared. On the 29th of January 1849, I again, in a different locality, met with conjugating fronds, and on this occasion in great abundance and in very perfect condition. Conjugation was evidently but just commenced, the mucus envelope was general, the fronds exhibited the peculiar condition of the internal granular mass which betokens the approaching change, and were in those relative positions which, as will be seen hereafter, indicate a tendency to unite in the formation of sporangia. A few days later, multitudes of individuals were found in every stage of conjugation, and the process continued until the beginning of March, towards the middle of which month few perfect fronds could be discovered, and the sporangia, hitherto in vast numbers, were fast disappearing: the mucus which held them in suspension, and floating on the surface of the water, having become dissolved, they were only to be discovered upon a very careful search, entangled in the filaments of other plants or mixed with the earth at the bottom of the pool. At a later period, and in the locality of 1848, I found a few conjugated fronds on the 7th of May 1849.

The period of conjugation of this species would therefore appear to be during the first three or four months of the year. M. Morren has noted it to occur in April, and again in June, remarking, that probably two generations had lived in this interval. This opinion does not however seem to be borne out by the facts I have observed, as in no case have I been able to detect the plant in the same locality for more than a month or six weeks at one time, nor has it ever reappeared in any quantity in the same pool. I have occasionally found single fronds of *Closterium Ehrenbergii* in running water, but on all the occasions previously mentioned, it has occurred in clear shallow pools or marshes formed by springs on the open moorlands between Wareham and Corfe Castle.

I proceed to notice the phænomena of conjugation as they successively presented themselves. The first is an alteration in the granular condition of the endochrome. This, from a light yellowish green, passes to a much darker shade, and the larger granules or "diaphanous vesicles" of Ralfs, which were originally few in number and arranged in a somewhat irregular longitudinal series (Pl. I. fig. 1), become exceedingly numerous and pervade the entire frond. While this change is about taking place, the fronds approach in pairs, approximating by their concave surfaces, and finally coming into such close neighbourhood that their inflated centres are in contact and their extremities slightly overlapped (fig. 2). In a short time, probably in the course of twenty-four hours, a remarkable change takes place both in the appearance and condition of the fronds; a mass of

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delicate mucus is secreted around the approximated fronds; these remove to a little distance from each other, undergo "self-division," and present altogether an irregular oval figure, the outline of which is formed by the periphery of the mucus, the four divisions of the fronds being placed in the middle in a somewhat quadrilateral manner (fig. 3). During the progress of self-division the internal membrane of the cell-wall becomes enlarged at the suture or line of separation, and projects in the form of an irregular cone with a blunt or rounded apex forming a beak, whose side view presents a triangular outline. This beak becomes filled with endochrome, either by the dilatation or increase of the contents of the half-frond, and the divided frond assumes the appearance of one with two unequal segments, being what M. Morren calls "une Closterie à deux cones inégaux" (fig. 3). On these membranous expansions, at the concave surfaces of the fronds and close to the original sutures, there appear, almost simultaneously with the formation of the beaks, two circular projections, which rupturing at their apices, give egress to the delicate sacs which inclose the endochrome, and which drawing with them their contents and meeting with the endochrome-sacs emitted through similar projections from the other half-fronds, form by their connection irregular masses which quickly consolidate and assume the appearance of perfectly circular, smooth dark-coloured balls, the sporangia of Ralfs and seminules of Morren (figs. 4, 5).

The discharge of the endochrome and formation of the sporangia are accomplished with much rapidity, and may often be seen taking place in the field of the microscope, the whole operation not occupying more than a few minutes. It will be seen from an inspection of the figures, that during the formation of the sporangia there appears to be a second development of mucus in the form of rings around the reproductive bodies; this is probably only the effect of the pressure produced by the growth of the sporangia on the mass of investing mucus. It will also be seen that the pale transverse band adopted by Ralfs as a character of the genus *Closterium*, and which in figs. 1 and 2 occupies the centre of the undivided frond, is, upon self-division taking place, removed a little towards the extremities of the half-fronds (fig. 3). The reason as well as the cause of this motion I am unable to explain, but it seems to confirm the propriety of adopting the band itself as a permanent and important character.

With regard to the subsequent changes which take place in the sporangia, the time which elapses before they produce young fronds, and the mode in which such evolution of a fresh race is accomplished, I have not been fortunate enough to ascertain any-

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thing with certainty. I preserved a mass of the conjugated fronds and multitudes of the perfect sporangia in water, which I frequently changed, for more than four months, but could not detect any appearance of young fronds, nor did I notice any material change in the sporangia until decomposition supervened with the increased temperature of the season.

M. Morren contends that a sporangium becomes converted into a single frond, and gives a series of figures in illustration of the changes which the sporangium undergoes until it becomes "une Closterie à deux cones inégaux" (fig. 7 *a, b, c, d*). Now as I have shown that this form is the result of the self-division of the ordinary frond and invariably precedes conjugation, I am disposed to think that M. Morren has mistaken fronds thus divided, and afterwards thrown out of their relative positions, for modified sporangia. Certain it is that among myriads of conjugated fronds and their sporangia I have been unable to trace the gradations figured by M. Morren, nor have I on any occasion detected the slightest modification in the sporangia after their full maturation. A divided frond smaller than the others, or one in which the self-division has been arrested, may occasionally be discovered, but the very rarity of such examples precludes the idea that such forms result from the normal development or growth of the sporangia.

How the species in *Closterium Ehrenbergii* may be renewed, appears still involved in the same uncertainty as that which envelopes the propagation of every other species of *Desmidieæ*. Self-division in the case before us seems only to accompany conjugation, and will not, as in the other *Desmidieæ*, account for the existence at certain periods of vast multitudes of the fronds. Another mode of increase, analogous to the propagation by zoospores in *Sphæroplea crispa* and other Algæ, has been assigned to the *Desmidieæ*, and it has been alleged that the endochrome escapes in the form of zoospores, and becomes transformed into new fronds. M. Morren not only affirms this to be the case, but gives a figure illustrative of the conversion of these zoospores, or as he terms them "propagules," into new fronds. Mr. Ralfs merely observes that the escape of the granular contents of the mature frond is *probably* one mode by which the *Desmidieæ* are increased. He however regards the "swarming of the granules" (a curious circumstance observable in the *Desmidieæ* and other Algæ, and which I am disposed to regard as a disturbance attendant upon the decay of the granular mass) as identical with the movement of the zoospores, and after accurately describing the phænomenon, goes on to state, that with the history of these granules after their escape from the frond he was altogether unacquainted. Mr. Ralfs afterwards gives a figure (British Des-

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midieæ, pl. 27), upon the authority of his coadjutor Mr. Jenner, representing the bursting of the sporangium and the growth of the young fronds from its contents in *Closterium acerosum*, so closely resembling the figure by M. Morren of the conversion of the propagules of *Closterium Ehrenbergii* into young fronds, that I cannot but believe a similar phænomenon to have been noticed by both observers, and am inclined to accept the view of Mr. Jenner as the correct one, and to regard propagation by zoospores or "propagules" as one not yet satisfactorily established in the *Desmidieæ*.

Increase by self-division, where a single frond separates into two equal parts, and generates at the suture two new segments respectively attached to the old, and thus forms from itself two perfect fronds, is one mode by which these minute organisms multiply with amazing rapidity; but this is merely a repetition or increase of the individual; the species must be renewed by another method, and that I believe to be the result of conjugation, or in other words, the conversion of the sporangial contents into young fronds; the subject however still requires elucidation from the cautious and skilful use of the microscope.

I may remark in conclusion, that in a generic arrangement, based upon the reproductive organs, *Closterium Ehrenbergii* will stand apart from all other *Desmidieæ*. In it alone a pair of conjugating fronds produce two sporangia. It is however allied to others of the present genus through *Closterium lineatum*, the sporangium of which, according to Mr. Ralfs, is binate, and shows a disposition to separate into two parts.

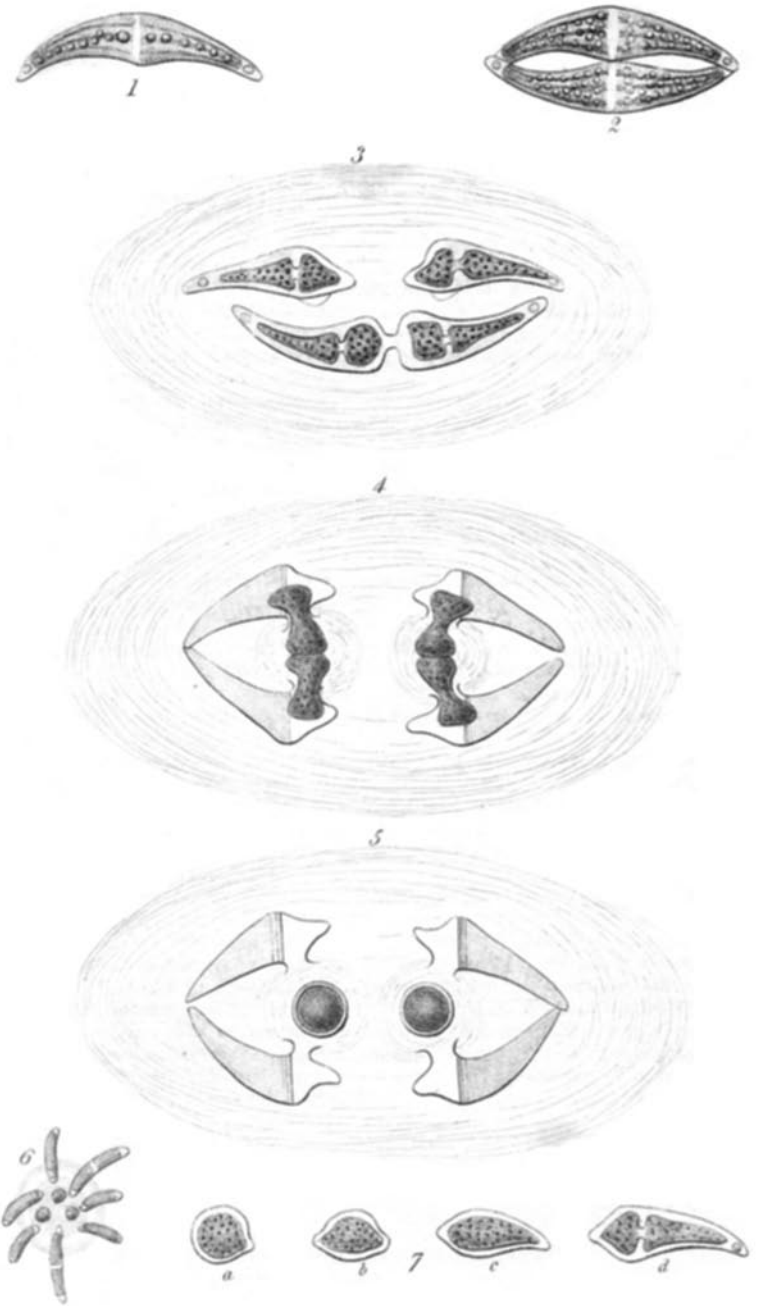
Wareham, November 1, 1849.

EXPLANATION OF PLATE I.

Fig. 1. A single frond of *Closterium Ehrenbergii* in its ordinary condition.
Fig. 2. Two fronds approaching and in the apposition which precedes conjugation.
Fig. 3. Conjugating fronds undergoing self-division, the upper showing the protuberances through the torn apices of which the contents of the divided fronds pass into the sporangia.
Fig. 4. Conjugating fronds showing the passage of the endochrome-sac and its contents.
Fig. 5. Conjugated fronds having perfected their sporangia.
Fig. 6. Development of the "propagules" into young fronds (after Morren). Compare with the figure given in the 'British Desmidieæ,' pl. 27, of the conversion of the sporangial contents into young fronds in *Closterium acerosum*.
Fig. 7. *a*, *b*, *c*, *d*. Development of a sporangium into "une Closterie à deux cones inégaux," from Morren.

The figures are all magnified 100 linear. Length of ordinary frond $\frac{1}{74}$ of an inch; greatest breadth of ditto $\frac{1}{400}$; length of divided frond $\frac{1}{100}$; length of beak $\frac{1}{400}$; diameter of sporangium $\frac{1}{333}$.

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