

VIII.—*On the Unreliability of certain Characters, generally accepted for Specific Diagnosis in the Diatomaceæ.*

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WHEN the systematic study of diatoms was first taken up, those engaged in it, being mostly concerned with the discrimination of the various forms which they met with, naturally adopted, for their diagnostic characters, such features as were the most readily perceptible. Amongst these, there were none more easy of recognition, and of description, than those regarding number and size; and accordingly we find, in the works of Ehrenberg and Kützing, many specific characters based upon these.

Any differences in the number, whether of the elevations on the dorsal margins of the valves of *Eunotia* and *Himantidium*; of the rays or radial segments of those of *Actinocyclus*, *Actinoptychus*, *Asterolampra*, and other discoid genera; of the processes in *Eupodiscus* and *Aulacodiscus*; or of the constrictions in *Biddulphia* and *Eunotogramma*; were alike regarded as justifying the formation of so many distinct species.

As an instance of the extent to which this was carried, may be cited Ehrenberg's species quoted by Ralfs as synonyms of his *Actinocyclus Ehrenbergii*. They are 119 in number, and all based upon the varying number of the rays, from *A. ternarius* with three rays to *A. Panhelion* with 120.

Nor was a difference in number regarded as constituting a character of only specific value, for, according to the number of angles which a valve might have, it was referred to the different genera *Triceratium*, *Amphitetras*, or *Amphipentas*; although such valves may now be regarded as not even specifically distinct. Ehrenberg also proposed the genera *Tripodiscus*, *Tetrapodiscus*, and *Pentapodiscus*, for what is now seen to be a single species, *Aulacodiscus Argus* A. Schmidt, according to the number of processes. Yet this may be different in the two valves of the same frustule.

Prof. W. Smith, in his 'Synopsis of the British Diatomaceæ,' followed the older observers in using such characters for the separation of species, but with some doubt, for he remarks regarding *Actinoptychus duodenarius*, *A. sedenarius*, and *A. octodenarius* Ehrenberg, that the "three forms are probably the same species in different stages." He even goes so far as to refuse to recognize as distinct species *Biddulphia tri-ocularis*, *B. quinque-ocularis*, and *B. septem-ocularis* Kützing, and refers them all to *B. pulchella* Gray.

A few years later, Ralfs, in Pritchard's 'Infusoria,' rejected such characters, explaining that he considered species founded on them as "altogether unscientific and erroneous." He therefore constituted

*Actinocyclus Ehrenbergii*, *Eunotia Ehrenbergii*, and *E. robusta*, to include many forms, varying in this respect, previously regarded as distinct species; and his action has been generally approved by subsequent authors.

Forms differing in size alone, or with only a slight difference in the fineness of the striation, such as *Navicula rhomboides*, *N. crassinervia*, and *Frustulia saxonica*, are now generally regarded as not constituting distinct species. They are, however, still considered by some to form distinct varieties, as the names of the numerous varieties denominated by Prof. Grunow as "maxima," "major," "media," "parva," "minor," "minima," "minuta," and "minutissima," sufficiently indicate. It is probable, however, that these are, for the most part, mere stages of growth, especially as the formation of megafrustules, by a process more or less resembling conjugation, has now been observed in so many species, that the increase of size thus attained may be regarded as a normal phase in the life-history of the organisms. It would, consequently, be as reasonable to describe an oak sapling and a full grown oak tree as distinct varieties, worthy of distinguishing names.

This now generally admitted insufficiency of two of the principal characters formerly relied on as a sufficient distinction of species, renders it desirable to inquire how far dependence can be placed upon other characters, even yet usually accepted as of specific importance.

The first to be noticed may be the very slight differences in the outline of the valve, such as are portrayed in plate vii. of Prof. Van Heurck's 'Synopsis des Diatomées Belges,' illustrating § Radiosæ of *Navicula*. When we consider that forms having valves triangular, square, pentagonal, and hexagonal, which would formerly have been referred to several different genera, are by most observers now included in a single species of *Triceratium* or *Stictodiscus*, it is plainly questionable whether the very slight differences of shape, which some of Prof. Van Heurck's figures show, can be reasonably held to constitute separate species. Prof. Gregory was the first to appreciate the variability of outline in diatoms. As far back as 1855 he wrote:—"The more that the Diatomaceæ are studied the more do we perceive that in many species the shape or outline is subject to endless variations." He therefore proposed two comprehensive species, *Pinnularia varians* and *P. mutabilis*, each to include several reputed species of previous authors. The step was in advance of the day, and Gregory's species have not been generally adopted. But his view was correct, and the yet more extended knowledge of the present day proves that, although species formerly considered distinct are met with in many gatherings, each retaining its own character, and without any intermediate forms, in other gatherings they occur with every gradation of form, constituting a perfect and unbroken transition from one to the other. Under these circumstances it seems to me undesirable to retain between them the distinction of "species." Instances of an undue

multiplication of species on similar grounds occur in the groups containing *Pinnularia nobilis*, *P. major*, and *P. viridis*; in § Asymmetrica of *Gomphonema*; and in forms allied to *Navicula aspera*, to *N. liber*, to *N. firma*, to *Rhaphoneis amphicerus*, and to *Triceratium Favus*.

The character upon which Prof. Smith chiefly relied, regarding it as "sufficiently constant to form a safe guide" to the determination of species, was striation, and especially the relative fineness or coarseness of the striæ. In this belief he maintained that "striation is the best guide." A more extended examination of forms from different localities has, however, shown that the supposed constancy of this character does not exist. The range of variation, so gradual that each step is almost imperceptible, is, on the contrary, very great. Striation is, in fact, only another term for cellulation, which in one form or other is observable in almost all diatom valves; and although the relative fineness or coarseness of the cellulation of discoid forms is a character still frequently made use of for specific distinction, it is in reality one of extreme variability. Of this any one may be convinced by examining any gathering which contains in abundance such a form as *Coscinodiscus concinnus* variety *Jonesianus*. Valves will be found with the cellules three times as fine as those on other valves, with a complete series connecting the two. In other species, as for example *Coscinodiscus elegans*, *Cestodiscus pulchellus*, and *Melosira granulata*, the two valves of the same frustule not unfrequently differ greatly in the size of their cellules. In *Denticula* the costæ on the two valves of the same frustule, and in *Pinnularia* even those on the two sides of the same valve, occasionally differ considerably from each other. In *Cocconeis* the different striation of the upper and lower valve is now well known; but before it had been fully recognized, it sometimes led to the two valves being placed in different genera. Thus *Mastogloia maxima* Grunow is nothing but the lower valve of a form of the common and extremely variable *Cocconeis scutellum*. In view of the magnitude of these differences in valves, which can be shown to belong to the same species, distinctive characters based upon comparatively very slight differences in the spacing of striation, in other words of the cellulation, are clearly inadmissible.

Not only does the spacing of the striation vary, but occasionally its character also. When a frustule is in course of subdividing, the appearance of the striation on the two newly formed inner valves is sometimes entirely different to that on the two older outer valves. The difference obviously arises from the valves being in different stages of development; yet, if the older and younger valves were observed apart from each other, they would probably be regarded as distinct species, and might even be referred to quite different sections of the genus.

A character dependent upon the so-called striation, which is equally subject to variation, is the position and extent of the blank

spaces. In Raphidiæ, they may lie on either side of the raphe; or transversely to the valve, forming a pseudo-stauros; or midway between the raphe and the margin. In discoid forms they may be either central or radial. All are more or less inconstant; yet numerous species have been proposed for extremely slight variations; and in *Navicula* two of the main sections of the genus, adopted by Prof. Grunow, the "Lyratæ" and the "Hennedyæ," have been based upon them, although even the two typical species, *N. lyra* and *N. Hennedyi*, are themselves connected by a series of intermediate forms.

The arrangement of the striæ in the megafrustule of a species, in some cases differs from that in the ordinary form. A slide, for which I am indebted to the late Mr. Haughton Gill, shows the megafrustule of a species of *Amphora*, with a large central blank. It therein differs so materially from the parent frustules, that it would certainly be regarded as a distinct species, had not its formation by their union been observed. The cultivation of diatoms, as originally suggested by Dr. Miquel of Paris, has probably much to teach us in this respect.

The distinction formerly relied on, as separating the two genera *Eupodiscus* and *Aulacodiscus*, was the presence or absence of radial blanks between the processes and the centre of the valve; but more complete observation has shown that this feature is quite unreliable, and consequently Mr. Rattray, in his monograph of *Aulacodiscus*, includes in that genus even the original typical species of *Eupodiscus*, such as the old *E. Argus* and *E. Rogersii*.

A character used for specific diagnosis, chiefly in the Cryptoraphidiæ, which is also very variable, is the relief of the valve. The valve may be flat, or more or less convex, or with an elevation or depression in the centre; and on such characters numerous species have been formed; yet the two valves of a frustule may differ completely in this respect; or the terminal valves of a filament differ considerably from the others. A notable instance occurs in *Triceratium Montereyi* Brightwell, described as differing from *T. arcticum* in the centre of the valve being elevated in a very peculiar manner; but the front view of a frustule sometimes shows that one valve is quite flat, the other quite conical, in fact, in the same gathering, specimens of these forms and of *Biddulphia balæna*, which is only another form of the same species, may be found, some with both valves flat, some with one valve flat and the other convex, and some with both valves convex.

There only remains to notice one more character too variable to be at all relied on, namely, the presence or absence of spines or apiculi, whether marginal or variously placed on the surface of the valve. The species of *Stephanopyxis* and *Systeptania* were mostly distinguished from each other by differences in these appendages; but there can be little doubt that several of them should be united. By such a character, too, Ehrenberg distinguished his genus *Odontodiscus*, now

abandoned. *Coscinodiscus* (*Odontodiscus*) *excentricus* is a good example, for it exhibits a complete gradation from the entire absence of teeth, to a thick-set coronet.

The natural result of the adoption, for specific diagnosis, of such characters as have been mentioned above, has been the undue multiplication of specific names, and the overburdening of diatom nomenclature with an enormous mass of synonyms. Apart from the too frequent description of altogether identical forms by different authors, under different names, specific designations have been given to forms differing from each other only in characters which are quite inconstant. Some observers justify the practice, maintaining that it is convenient to have distinctive names for forms, however unimportant the points in which they differ from each other, without entering into the question as to what constitutes a "species."

Fortunately, that is a question into which it is quite unnecessary for us to enter. All that we have to consider, in connection with our present subject, is the much simpler one, what does *not* constitute a species. The two valves of an oyster differ considerably from each other, but none would suggest that they belong to two species, or that it is desirable to give them different specific names. The plumage of a young bird is sometimes very unlike that of the adult form; but it is not, on that ground, to be regarded as a distinct species. In like manner, neither the two valves of a diatom, nor the stages of growth through which it passes, however unlike they may appear, should be so regarded: and, however convenient it may be to give distinctive names to each slight variation in diatoms, I venture to maintain that the practice is unscientific.

No true conception of the limits of a species in diatoms can be formed until the complete life-history of these organisms has been, at any rate in some instances, traced out; and this has yet to be accomplished. Meanwhile it will be better to refrain from designating as "species," not only forms which, by actual observation, are known to appertain to an already established species, but also forms which, from what we know of other species, may be reasonably believed to belong to or spring from established species.

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