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POLYMORPHISM IN *MASTOGLIOIA*¹

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SUMMARY

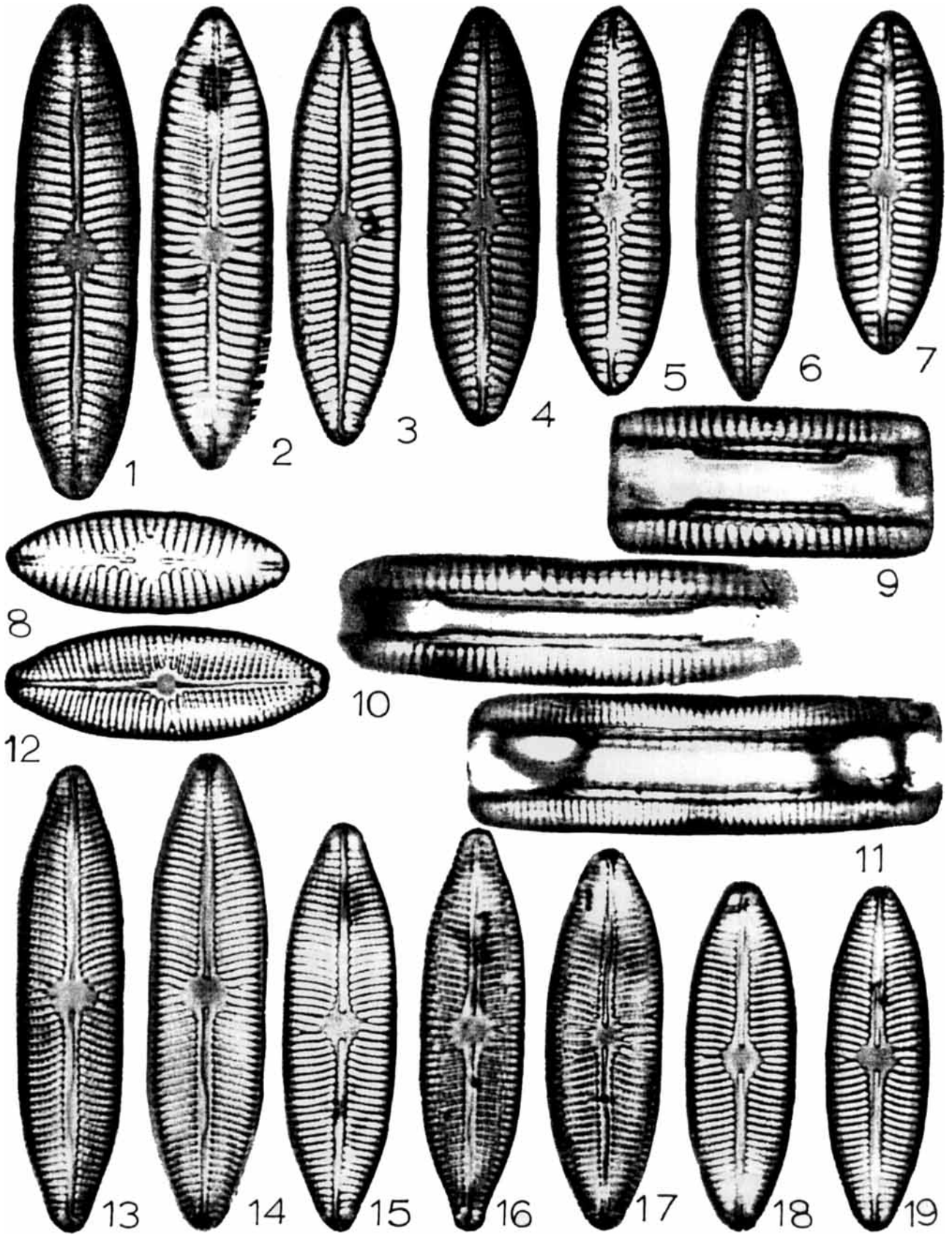
Cells in a wild population of a species belonging to the diatom genus *Mastogloia* may form frustules of 2 strikingly different morphologic types during their vegetative life cycle. Total conversion from coarsely structured morphologic form to a more finely structured form takes place during a single division; hence no intergradations between the 2 forms are evident. Intact frustules with 1 valve of each type leave no reasonable doubt of the ability to make the change.

INTRODUCTION

One of the basic assumptions of systematics is relative stability of morphologic characteristics within a taxon. The general validity of this assumption is strikingly illustrated in the Bacillariophyta

(diatoms) where the structure of the frustule, upon which modern systematic treatments are based, is remarkably constant throughout the vegetative phase of the life cycle of a given species under natural conditions. The average size of cells in a given population, at least of most species, is gradually reduced during a series of divisions (14) due to the rigidity of the overlapping thecae and the number in which new valves are formed (18). Concomitantly, certain changes may occur in the shape of the frustules (6), but these changes follow a rather constant pattern and are well known for most diatom species. Von Stosch (19) has shown that this pattern may be upset by appropriate manipulations in culture. Sexual reproduction occurs, if conditions are favorable, when the cells reach a certain minimum size range which is more or less constant for a given species (4). The morphology of the zygote (auxospore) is usually quite unlike that of the vegetative cells and atypical

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frustules (Erstlingszellen) may be formed during the first few divisions following sexual reproduction. According to Hustedt (11), ecologic conditions at the time of auxospore formation may induce changes in morphology of the frustule that are perpetuated during vegetative reproduction and give rise to populations having an internally constant morphology quite different from that of the parent population. Apparently such alterations in morphology are not induced by genetic changes in the cells, as they will return to their typical form during subsequent sexual cycles if conditions are favorable. Such aberrant populations could be, and perhaps often are, described as new taxa. Lund (12) has shown that populations of a given species growing on soil tend to be smaller in average size than populations of the same species growing in an aquatic habitat. Occasionally deformed valves are found within an otherwise normal population. These deformities tend to be reproduced during vegetative cell division (3) so that a large proportion of isolated populations may have deformed valves. Such teratological forms are relative rarities and have excited the interest of numerous workers. In the genus *Melosira*, populations of a given species may exist in any of 2 or more morphologically different forms (13). These forms have been designated as alpha, beta, or gamma status. The factors which cause this response have never been fully investigated experimentally but field observations show reduction in dissolved silica can cause change from the α to β status.

MATERIALS AND METHODS

Material used in this study was collected in an area locally known as Silver Lake Fen, located in the NW 1/4 of section 32, TWP 100N, Range 38W, near the town of Lake Park in Dickinson County, Iowa. The physiography of this area was reported by Anderson (1), and its algal flora has been studied by Gashwiler & Dodd (5). Collections of diatoms were taken from mats of *Riccardia* thalli which were kept moist by seepage water. After fresh material had been examined it was cleaned by Van der Werff's (21) method, mounted in Hyrax, and examined with a Bausch and Lomb R series microscope fitted with 98 \times , 1.30 N.A. fluorite oil immersion objective and ribbon filament illumination. Photographs were taken with a similar microscope using a 90 \times , 1.40 N.A. apochromatic oil immersion objective and critical illumination.

RESULTS

After casual observation it appeared that among the many diatom species present in the collections there were 2 populations of *Mastogloia*, 1 belonging to *M. grevillei* Wm. Smith (Fig. 1-9) and another (11-19) generally referred to in the literature as *M. elliptica* var. *dansei* (Thwaites ex Wm. Smith) Cleve. The general shape of the valves, shape of the axial and central areas, structure of the raphe, and structure of the septae and locules are nearly identical in these 2 populations. There is, however, considerable difference in the number and apparent structure of the striae, a feature usually given considerable

weight in systematic treatments of this group. Upon observation of a large number of specimens, it was discovered that certain intact frustules have 1 valve of each type (Fig. 10). Such cells are quite rare, comprising only about 0.5% of the specimens in which both valves are attached. The fact that the valves of most frustules are separated makes it difficult to determine the absolute frequency of such cells in the total population. Nonetheless, the presence of intact frustules having both types of valves makes it patently apparent that the 2 seemingly separate populations belong to the same genetic entity. The alteration in frustular morphology must take place during vegetative cell division and not during auxospore formation as the frustules having both types of valves are of the intermediate size range. It thus appears that environmental stress may cause alterations in the frustular morphology of certain naviculoid diatoms analogous to those observed in the centric genus *Melosira*.

DISCUSSION

There is relatively little doubt that the coarsely structured form in the population investigated has been consistently referred to as *M. grevillei* in the literature. It matches well the published descriptions of this entity and comparison with the Wm. Smith material in the diatom herbarium of the Academy of Natural Sciences of Philadelphia leaves little doubt as to its identity with Smith's taxon.

It is, however, evident that considerable confusion exists in the literature regarding specimens assignable to the finely structured form. The first area of conflict is in the identity of specimens assigned to *M. elliptica* var. *dansei* by various authors. Cleve's (2) variety is based on *M. dansei* Thwaites ex Wm. Smith. It is interesting to note that Smith's (16) illustration of this entity (his Plate 62, Fig. 388) is placed in juxtaposition to his original illustration of *M. grevillei* (Plate 62, Fig. 389) described in the same work. These illustrations and those of Grunow [in Van Heurck (7), Plate 4, Fig. 18, 20], also cited by Cleve in his description of *M. elliptica* var. *dansei*, could easily fit into the variation sequence shown by my specimens. I seriously doubt that Cleve would have reached the conclusion he did if he had been cognizant of the unusual structural alteration possible in *M. grevillei* as he notes in his description of *M. grevillei* (2): "This species resembles *M. elliptica* var. *dansei* but has a different structure of the valve." Without this knowledge Cleve's decision appears entirely tenable in that, to the best of our present knowledge, the structure of the valve surface is a more stable morphologic characteristic than valve shape (6). Although this generality should now be critically reexamined, the essential logic of Cleve's work is demonstrated by the wide acceptance his epithet gained among later workers.

Skvortzow (15) apparently correctly recognized

the affinities of the finely structured form to *M. grevillei* and published *M. grevillei* var. *sinica* based on specimens collected near Tientsin, China. Hustedt (8) considered this entity to be a synonym of *M. elliptica* var. *dansei*. He later (10) described *M. recta* based on specimens collected from 2 lakes in central Celebes. In his discussion of this species Hustedt refers to it specimens from Java that he had earlier (9) identified as *M. elliptica* var. *dansei*. Voigt (22) applied the name *M. recta* Hust. to specimens he obtained from Karachi, Pakistan, and described a new variety, *M. recta* var. *pulchella*, based on specimens from the same locality.

As I have already pointed out, the author of *M. recta* admitted to a certain amount of confusion between this entity and his concept of *M. elliptica* var. *dansei*. There are 2 primary differences between *M. recta*, as originally described and illustrated by Hustedt, and the finely structured form considered here: (1) the considerably greater maximum size of Hustedt's entity, and (2) the presence of a siliceous rib bordering the raphe which is cited as a definitive characteristic by Hustedt, but is not well developed in my specimens. Some of the other distinguishing characteristics such as undulation of the raphe (compare present Fig. 13 to 15) and relative size of the central area (compare present Fig. 12 to 16) put forth by Hustedt are rather ephemeral and must be treated with due caution. Returning to the major distinguishing characteristics, close inspection of Hustedt's figures arouses suspicion that he was not dealing with a true variation sequence. His Fig. 54 through 57 are consistent and agree rather closely to the range of variation shown by my specimens. Figure 58, on the other hand, is not consistent with the other figures and does not, in fact, agree with his description of the species. On the basis of the evidence available, I am forced to the conclusion that the entity represented by Hustedt's Fig. 54 through 57, whatever its correct designation is, does not, in fact, reach a maximum size of 80 μ . So far as the presence or absence of a rib bordering the raphe is concerned, determination of the thickness of structures in normal preparations is always more or less a matter of the investigator's judgment. Probably no one is more eminently qualified than Hustedt to make such a judgment, but I must point out that at certain planes of focus (see present Fig. 17) my specimens give a refractive pattern that might be construed as a thickening in the region of the valve immediately bordering the raphe. This pattern is caused by the abutment of the thinner portion of the valve subtending the striae into the relatively thickened axial area and not by any marked thickening of the margins of the axial area (see reference 17 for analogous structure in *M. grevillei*).

The specimens of Voigt (22), reported as *M. recta*

and *M. recta* var. *pulchella*, appear to be fully comparable to my specimens, and I would consider the 2 illustrations furnished to represent the extremes in size range of a single entity.

If the interpretation developed so far is substantially correct, it follows that the morphology of the frustule in the species of *Mastogloia* investigated is controlled in some way by the level of total dissolved solids in the ambient water. Published reports of entities referable to the coarsely structured form come from habitats having relatively low levels of total dissolved solids, while entities referable to the more finely structured form are consistently reported from brackish or other highly mineralized waters. The only localities where the two may be expected to occur together are those in which rapid changes of ecological conditions force the transformation of an established population.

So far as the nomenclature to be applied to the entity or entities represented in the population studied is concerned, one may admit to the possibility of three cases, as outlined briefly below:

| | I. | II. | III. |
|--|-------------------------------------|----------------------------------|-----------------------------------|
| <i>M. grevillei</i> |] = <i>M. grevillei</i> ct forma |] = <i>M. dansei</i> ct forma |] = <i>M. dansei</i> ct formae |
| <i>M. grevillei</i> var. <i>sinica</i> | | | |
| <i>M. dansei</i> | non | | |
| <i>M. elliptica</i> var. <i>dansei</i> | non | | |
| <i>M. recta</i> | non | non | |
| <i>M. recta</i> var. <i>pulchella</i> | non | non | |

Study of Smith's slides of *M. dansei* and of material from Pakistan containing *M. recta* does not completely resolve this problem, and the intermediate forms, if they do indeed exist, are not present in the collections I have so far examined. Experimental evidence has proven difficult to develop as the organism in question has proven refractory to standard culture techniques. Although I consider the third of the alternatives presented above to be the likely one in light of the evidence at hand, I am reluctant to make a formal combination at the present time, as I have not had the opportunity to examine Thwaites' specimens of *Dickieia dansei* (20) which would become the nomenclatural type of any such combination.

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BIOLUMINESCENCE AND CHLOROPLAST MOVEMENT IN THE DINOFLAGELLATE *PYROCYSTIS LUNULA*¹

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SUMMARY

The lunate cysts of *Pyrocystis lunula* have a bioluminescent emission spectrum with a peak intensity of $477.5 \pm 1 \text{ m}\mu$. The light originates from the protoplasm in the center of the cysts. Six to eight hr after the cysts were placed in the dark, they produced 300 to 800 times more luminescence than controls maintained under constant illumination. Plastids contract distally when the cysts are placed in the dark. If kept in the dark, the plastids contract distally and expand with a circadian rhythm persisting several days. At intensities of $2200 \mu\text{w cm}^{-2}$ or less, the plastids are expanded. The plastids are contracted into the central area of the cysts at light intensities of

$4000 \mu\text{w cm}^{-2}$ and above. The *Gymnodinium* stage of the life cycle is not bioluminescent.

INTRODUCTION

During the *Challenger* Expedition (1872-1876), Murray (12) first described the genus *Pyrocystis* and noted that ". . . these forms are highly phosphorescent." Schütt described the species *Pyrocystis lunula* from the plankton of the Humboldt Current in 1895. Since then, *P. lunula* has proved to be a cosmopolitan marine species (11). Three stages in the life cycle are known: *Gymnodinium*-type swimmers, crescent-shaped cysts, and large spherical cysts up to 200μ in diameter (for review, see 11). We have isolated *P. lunula* and report here some observations on the crescent-shaped cysts and the *Gymnodinium* stage of the life cycle.

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