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Hannelore Hakansson
Lund University

John R. Carter
Lund University

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HANNELORE HÅKANSSON and JOHN R. CARTER

Department of Quaternary Geology, Lund University, Tornavägen 13, 223 63 Lund, Sweden
Elm Bank, Denholm, Hawick, Scotland TD9 8NG

With the help of light- and scanning electron micrographs HUSTEDT'S terms "Schattenlinie", "Perlenreihe", and "Höcker" are explained using specimens in the *Cyclotella radiosa* complex, and *C. distinguenda* HUST.. The complicated history of *C. operculata (AG.)* KUTZ., published elsewhere, has shown that *C. distinguenda* HUST. is the correct name to be used for this taxon. In this connection the new nomenclatural combination *C. distinguenda* var. *unipunctata* nov. comb. is proposed.

Morphological differences are discussed and the possibility of different *"unipunctata"* species is shown. Distinct morphological features found indicate the necessity to describe a new species: *C. cyclopuncta* nov. sp. rather than elevating *C. distinguenda* var. *unipunctata* (HUST.) HÅKANSSON & CARTER or FRICKE's *"C. comta* var. *unipunctata* to specific rank.
INDEX DESCRIPTORS: Diatoms, *Cyclotella*, "Schattenlinien", "Perlenreihen", "Höcker"

Widespread confusion in the classification of species of the diatom genus *Cyclotella* (KÜTZING) BRÉBISSON arise from confusions over the definitions of the terms "Schattenlinie", "Perlenreihe", and "Höcker". These were introduced by HUSTEDT (1928) and were used in distinguishing between several species. Material collected from a tree trunk in Plitvicer See (Yugoslavia) by Mr. J. BROADHEAD has provided an excellent opportunity to address the terminological problem, and, at the same time, describe the most abundant species present in the sample. This contained *C. radiosa* (GRUN.) LEMMERMANN, *C. plitvicensis* HUSTEDT, and a questionable species resembling that illustrated by FRICKE (1900 in SCHMIDT's Atlas 1874-1956) on Taf. 224, figs 5, 11 and 11a, and possibly fig. 12, under the name *C. comta* v. *unipunctata* n.v.. Hustedt (1922, p. 235) allocated the variety *unipunctata* to *C. operculata*, particularly emphasizing the differences between *C. "comta"* (=*C. radiosa* (see HÅKANSSON 1988)), and *C. "operculata"* (=*C. distinguenda* HUST. (see HÅKANSSON 1989)). Later HUSTEDT (1928, p. 351) proposed that *C. comta* var. *unipunctata* FRICKE was synonymous with *C. operculata* var. *unipunctata* HUSTEDT.

METHODS

Material for light microscopy (LM) and scanning electron microscopy (SEM) was prepared by acid cleaning and repeated washing with distilled water. For LM the material was mounted in Naphrax and examined with a Zeiss Photomicroscope III with oil immersion and interference contrast × 1000. For SEM, the material was coated with gold/palladium and examined with a JEOL 300 SEM, operated at an accelerating voltage of 15 kV.

Comparison with the slide "lectotype 1/84 Lunz. U.S. Holz, 3" chosen by DR. R. SIMONSEN, was possible as well as a comparison with the figures 12-14 in SIMONSEN (1987).

RESULTS AND DISCUSSION

Explanation of the terms "Schattenlinie", "Perlenreihe", and "Höcker"

HUSTEDT (1928, p. 353) defined these terms as follows: *"C. comta* besitzt innerhalb der radialen Streifung in kürzeren Abständen marginale strichförmige Schattenzeichnungen, die bei Einstellung auf die Aussenseite der Valva dunkel, bei tieferer Einstellung hell erscheint. *C. operculata* besitzt in kürzeren oder längeren Abständen eine deutlich von der Peripherie entfernte Perlenreihe (Höcker an der Innenseite der Valva); die Höcker erscheinen bei Einstellung auf die Aussenseite als helle Flecken, bei Einstellung auf die Innenseite als scharf gezeichnete dunkle Punkte". (German translation: *C. comta* contains within the radial striation at short intervals marginal dash-formed shadowlike marks, which are dark when focusing on the outside of the valve and light when focusing deeper. *C. operculata* contains at shorter or longer intervals, away from the periphery, a distinct row of pearls (humps on the inside of the valve); these humps appear as light spots focusing on the outside, and as sharply defined dark dots focusing on the inside.)

In his descripition of *C. comta* (HUSTEDT 1928, p. 354) he defined in more detail these differences (translated from German). "At greater intervals, 4-5 in 10 µm, there are in between two adjacent striae dark shadow lines, which are shorter than the striae and form within the marginal zone a concentric ring. At deep focus, especially when looking from the direction of the boarder of tilted specimens, these shadow lines appear light and in between them dark circular spots are visible."

We have attempted to interpret these descriptions and to explain and illustrate them with the help of LM and SEM micrographs.

As can be seen in the light micrographs (Figs 1-8) there are differences in the marginal zone. In figures 1, 2, 4, 5 short, accentuated striae (shadow lines) are visible (arrowed). In the tilted specimen (Fig. 2) light areas appear near the margin (arrowed). The SEM micrographs (Figs 9-12) go some way toward explaining these distinctions. The shadow lines can be either the internal thickly developed costae, bearing the marginal fultoportulae (especially in the *C. radiosa* complex, Fig. 9) or they can be the very long, accentuated marginal fultoportulae as in *C. glabriuscula* (GRUN.) HÅKANSSON (Fig. 10).

The light areas (or dark depending on focus) at the margin, are the internal alveolae or chambers (Fig. 9).

Figure 6 shows *C. distinguenda* HUST. where a ring of pearls, sometimes elongated, are visible, "away from the periphery". Figure 11 shows internal views of *Cyclotella distinguenda* where all costae are of the same thickness some of them bearing fultoportulae, which are the "humps on the inside of the valve" (translated from HUSTEDT, op. cit.) and this might be a possible interpretation, see also HÅKANSSON (1989). There are, however, some characteristic features visible in the group of *Cyclotella* species illustrated in Figs 6-8. These specimens have "holes" (arrowed) in the marginal zone, they are either dark or light depending on focus level. These markings are caused by the very deeply recessed costae bearing the marginal fultoportulae (Fig. 12). This is another feature HUSTEDT could very well have

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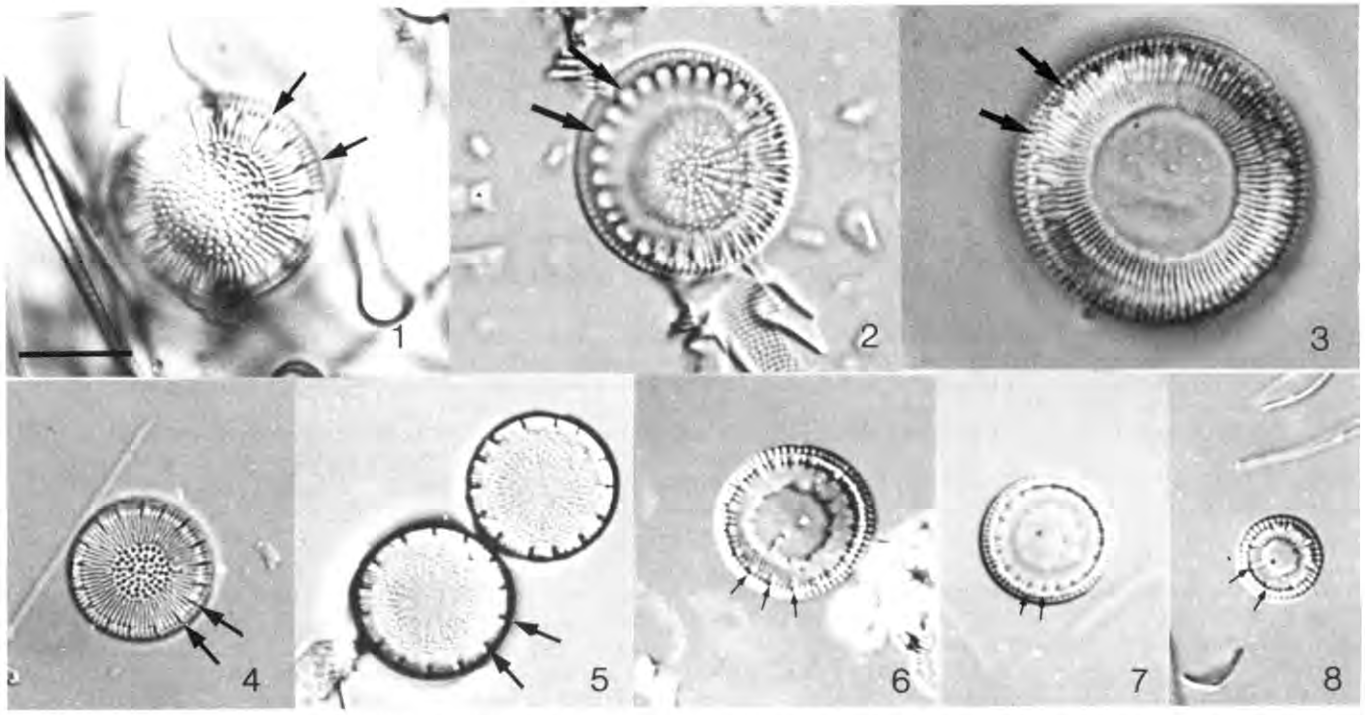


Figs. 1-8. Light micrographs, scale bar (Fig. 1) = 10 µm. Figs 1, 2, 3. Species form the *Cyclotella bodanica/radiosa* complex. The shadow lines (Figs 1 and 4, 5,); the alveolae (Fig. 2) are arrowed. Fig. 5 *C. glabriuscula,* shadow lines are arrowed. Fig. 3. *C. distinguenda* with row of pearls at the margin (arrowed). Figs 6-8. *C. cyclopuncta* nov. op. The "hollows" representing the recessed costae are arrowed. A single slightly eccentric positioned areola is visible in every specimen.

meant, when describing the "row of pearls" and the "humps on the inside of the valve".

Some taxonomical problems

It should be mentioned here, that the complicated history of *C. operculata* (AG.) KÜTZ., published elsewhere (HÅKANSSON, 1979, 1989, and HÅKANSSON & ROSS 1984), has shown that *C. distinguenda* HUST. is the correct name to be used for this taxon. It is therefore necessary to make a new nomenclatural combination: *Cyclotella distinguenda* var. *unipunctata* (HUST.) HÅKANSSON & CARTER.

Synonym: *Cyclotella operculata* var. *unipunctata* (FRICKE) HUSTEDT 1928, p. 351.

Observation of the most abundant species in the Plitivicer See material Figs. 6-8

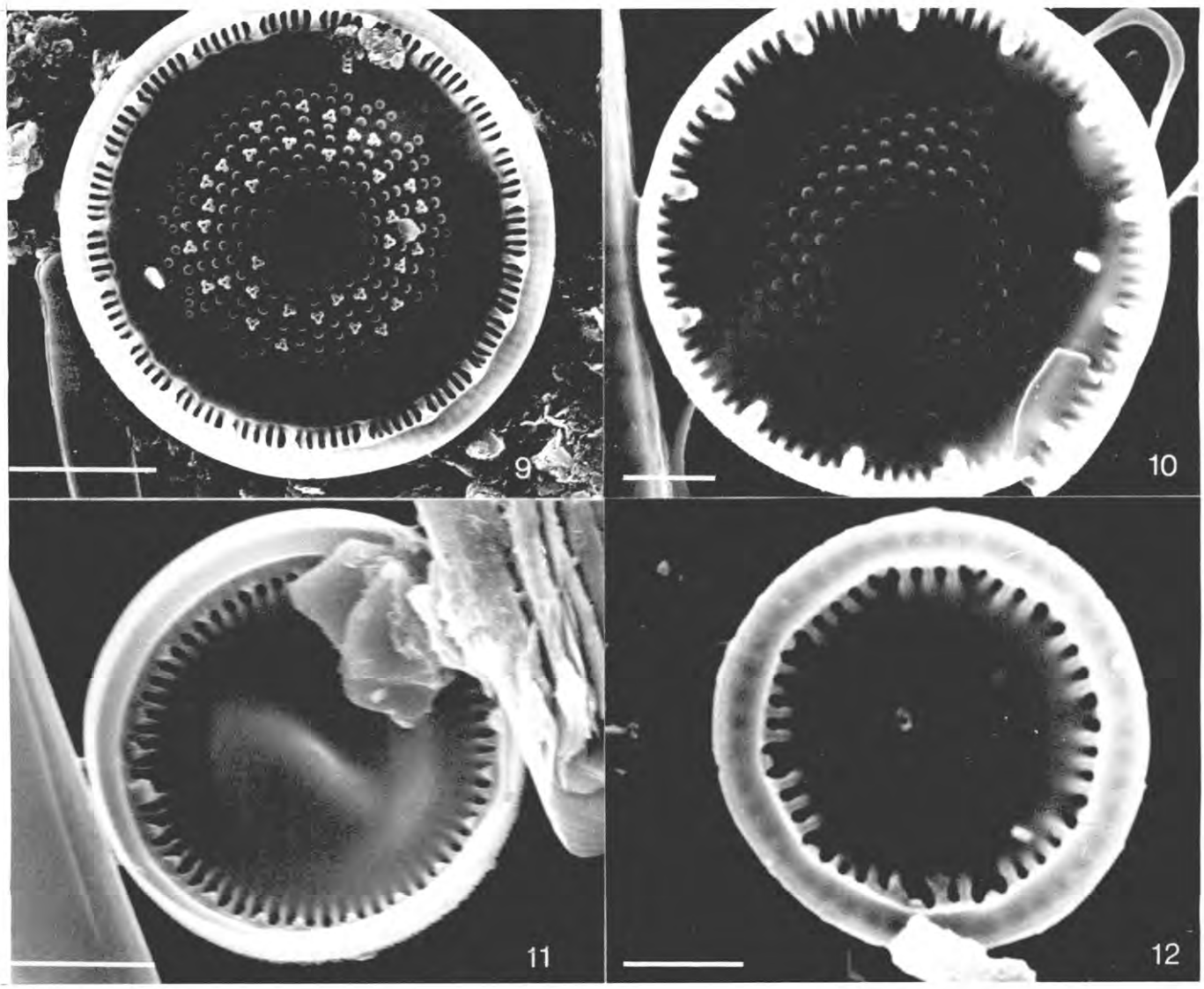
The most abundant *Cyclotella* found in this material has a diameter ranging from ca 3.5µm to 13.5µm, with a flat, irregular central area and a striated marginal zone. The central area is raised and smooth, with a single eccentrically-positioned fultoportula. The striae in the marginal zone are of unequal lengths adjacent the central zone. Typically, there are small hollows at the junction of the valve face and mantle; these are either light or dark depending on the level of focus. These characteristic features are also visible in the Figures by FRICKE (1900 in SCHMIDT's Atlas, Taf. 224, Fig. 11), which he refers to as "*C. comta* v. *unipunctata* n.v.". FRICKE, however, published other taxa under the same name (op. cit. Figs 5-12). Apparently he found it difficult to decide whether the light or dark spots at the margin were shadows between the marginal striae — "comta" — humps (?) — "operculata" (translated from German of FRICKE's figure description). The present authors suggest that the specimens shown in his figures 5, 10, 11 and 11a and possibly 12, belong to one taxon, whilst the specimens shown in his figures 6-9 belong to other taxa.

Comparing our figures (6-8) with those published by SIMONSEN (1987) we found some similarities but also differences. Both have one punctum in the central zone of the valve and the striae are of unequal length, but in the figures given by SIMONSEN (op. cit. figs 12-14) the hollows as shown in our figures (Figs 6-8) are missing. This might very well depend on focus level, where sometimes the hollows are not clearly visible (see our figure 6). One of us (HH) had the opportunity to examine the lectotype slide (1/84, Lunz, U.S. Holz, 3) and found specimens with different characters. In the material there were valves with the marginal zone characteristics typical of the *C. radiosa* complex, others typical of *C. distinguenda* HUST. and others similar to the species we found in Mr. BROADHEAD's material. We are here only relying on the features visible in LM and in SIMONSEN's (1987) figures but these are in our opinion sufficient for species differentiation. Unfortunately, FRICKE's material could not be located for reinvestigation. From the material collected by Mr. BROADHEAD only a permanent slide is available and so a careful SEM investigation is not possible. For this reason, Article 7:4 and 7:9 of the ICBN (Greuter et al. 1988) is invoked and FRICKE's Figures 11 and 11a (showing a single specimen, at two different levels of focus) are chosen as the lectotype.

In designating this as a lectotype, the question arises whether this species should be assigned to *C. radiosa,* or — as HUSTEDT (1922) has done — *C. distinguenda.* As explained above, both *C. radiosa* and *C. distinguenda* have other morphological features, especially in the marginal zone. Furthermore, *C. radiosa* has loculi and fultoportulae intermixed in the central zone, while *C. distinguenda* has no central fultoportula — its central zone being undulate — in sharp contrast to that of the *Cyclotella* species described here (HÅKANSSON 1989).

CONCLUSION

Neither the specimens illustrated by FRICKE in SCHMIDT's Atlas Tafel 224, figures 11 and 11a, nor the species collected from the



Figs 9-12. Scanning electron micrographs, scale bars figs 9, 11 = 5μm; figs 10,12 = 2μm. Fig. 9. *C.* cf *radiosa* internal view with the marginal costae where every fourth to sixth is thicker silicified bearing the fultoportula. Fig. 10 *C. glabriuscula.* Internal view with the very long marginal fultoportulae. Fig. 11. *C. distinguenda* with short marginal fultoportulae (the "Höcker" = humps) which can be seen in the light micrographs as "rows of pearls". Fig. 12. *Cyclotella* sp with marginal fultoportulae and recessed costae (the "hollows" in the light micrographs).

the tree trunk in Plitvicer See, have the features described as characteristic of *C. radiosa* or *C. distinguenda*. Indeed, it has features that merit the erection of a species in its own right, and we prefer to describe this as a new species rather than raise FRICKE's or HUSTEDT's variety to specific rank:

DIAGNOSIS

Cyclotella cyclopuncta nov. sp.
Valva circularis, diametro 4-14 μm. Superficies valvae plana, area centrali dimidium area valvae occupanti et fultoportulam unam eccentrice positam ferenti. Striae marginales inaequaliter longae. aream centralem indentatum cingente, c. 20 in 10μm. Depressiones parvae, apparenter pallidae atrataeve secumdum focum microscopii, prope junctarum inter superficiem valvae et limbum positae, et inter eas 4-7 striae.

Type locality: Plitvicer See, tree-trunk
Holotype: Carter Collection no 4112
Iconotype: Fig. 8

Valve circular, from 4-14μm in diameter. Valve surface flat with an irregular central area covering about half the valve area and having a single eccentrically placed fultoportula. Marginal striae of unequal length surrounding the indented central area, about 20 in 10 μm. Small hollows, which appear light or dark according to focus, are placed close to the junction of the valve face and mantle and are so spaced as to accommodate from 4 to 7 striae between them.

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