

Morphological variability of the *Cyclotella ocellata-krammeri-rossii* complex in field samples and cultures

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INTRODUCTION

The original descriptions of *Cyclotella ocellata* Pant., *C. krammeri* Håk. and *C. rossii* Håk. suggest well defined species. But a smooth transition in the characters of the frustules leads to intermediate forms. These forms can not be clearly identified as one of the species of the *Cyclotella ocellata-krammeri-rossii* complex. The wide morphological variability of *C. ocellata* has been closely analysed (Genkal & Kutzmin 1979, Klee & Steinberg 1987, Håkansson 1990, Kiss et al. 1996, Kiss et al. 1999), but the spectrum of *C. krammeri* and *C. rossii* have not been investigated so far. Only typical forms of *C. ocellata* were compared to *C. krammeri* and *C. rossii*. Furthermore, references do not state localities where *C. krammeri* and *C. rossii* were observed without the simultaneous occurrence of *C. ocellata*; even in the type material all three taxa are present. Several authors disbelieve the taxonomic autonomy of *C. krammeri* and *C. rossii* (Teubner 1995, Hegewald & Hindáková 1997). Otherwise, these taxa are listed with different optima and tolerance values in various diatom data sets (Battarbee et al. 2000, Schönfelder 2006).

The aim of this study is the investigation of the morphometric variability of natural populations and isolated clones of the *Cyclotella ocellata-krammeri-rossii* complex from two lakes in Northern Germany.

MATERIALS & METHODS

From August to November 2005 seven samples were taken from Lake Dudinghausen and Lake Tiefer See respectively. Both lakes are situated nearly 20 km south of Rostock, Northern Germany. Clone cultures were established from isolated (PatchMan, CellTram-oil, Eppendorf) single cells. The growing medium consisted of sterile filtered lake-water with added f/2-medium (Sigma).

26 randomly chosen frustules of each sample or clone-culture were used for morphometrical analyses. The collected data concerns cell-diameter, size of the central area, number of striae, punctae and orbiculi depressi, the form of the orbiculi, radial arrangement of puncta and/or orbiculi and the occurrence of shortened or divided striae. The size of the central area and the number of striae and punctae were divided by the cell-diameter to obtain size-independent characters. In addition, the arrangement of orbiculi depressi and the geometrical shapes, formed by the central field pattern, number of symmetric valve sectors were recorded. In a pair wise generalized linear model, cultures and samples were compared to each other. A classification tree was constructed from the data of the frustules.

RESULTS

The recorded data cover an interval reported for the three species. The size-independent features central area size, punctae- and striae number show little differences between the field-samples (Fig. 1, Fig. 2). Frustules of Lake Tiefer See tend to have a wider central field and a finer striation. The number of orbiculi depressi and number of symmetric valve sectors (axis of symmetry) as well as the criteria depending on valve diameter, vary in different ranges within the cultures. The pair wise comparison of samples and cultures reveals no

larger groups without significant different characteristics (Fig. 4). Caused by formation of zygotes and the simultaneously increasing cell diameter in most of the cultures, at the start of culturing, directly measured data are incomparable. In the classification tree each culture and sample scatter on several branches and the cultures do not clearly separate from each other. There are also branches containing frustules that had not been observed in the two lakes.

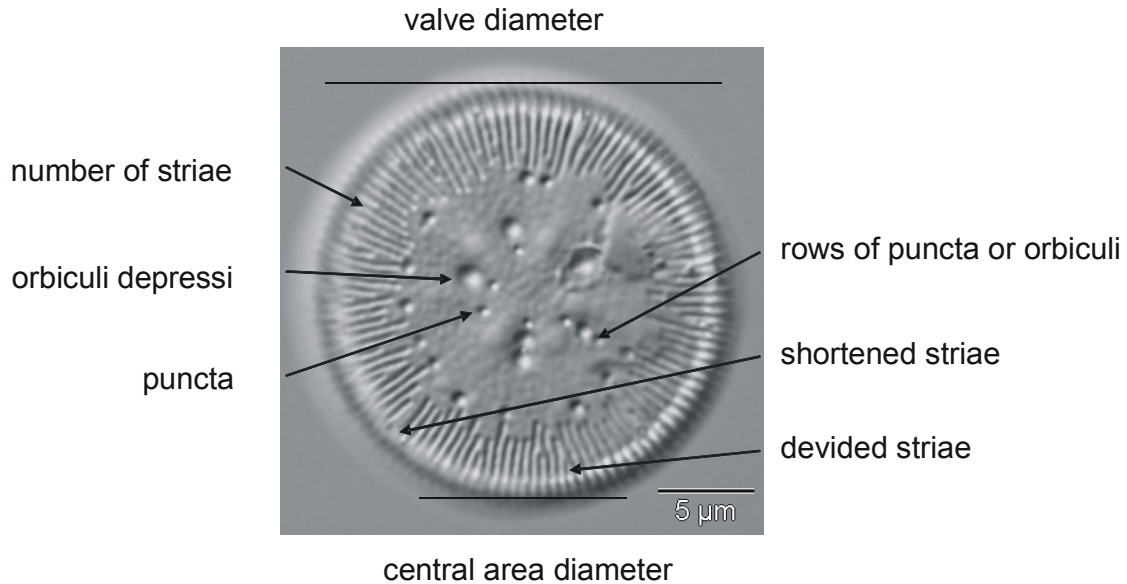


Fig 1. Valve characteristics used for the analyses.

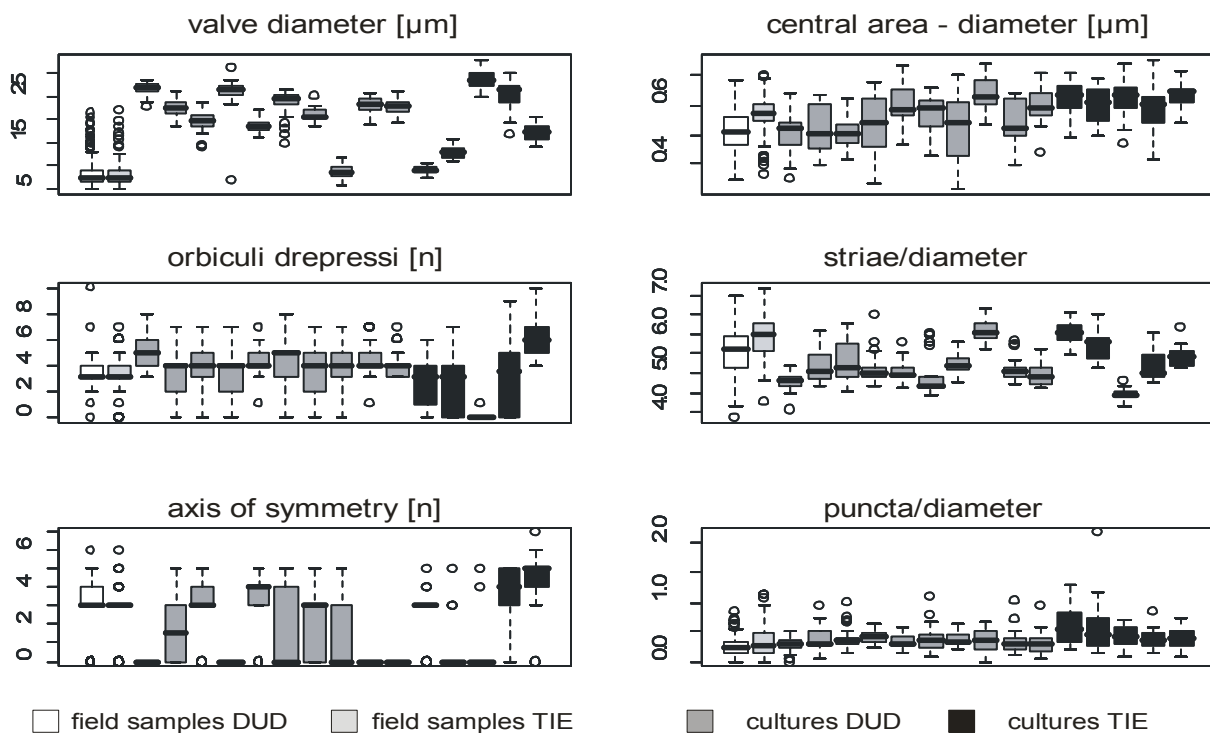


Fig 2. Box plots of some quantitative criteria of the valve, used in this study. Data of the field samples are summarised, whereas each culture is represented by a box plot.

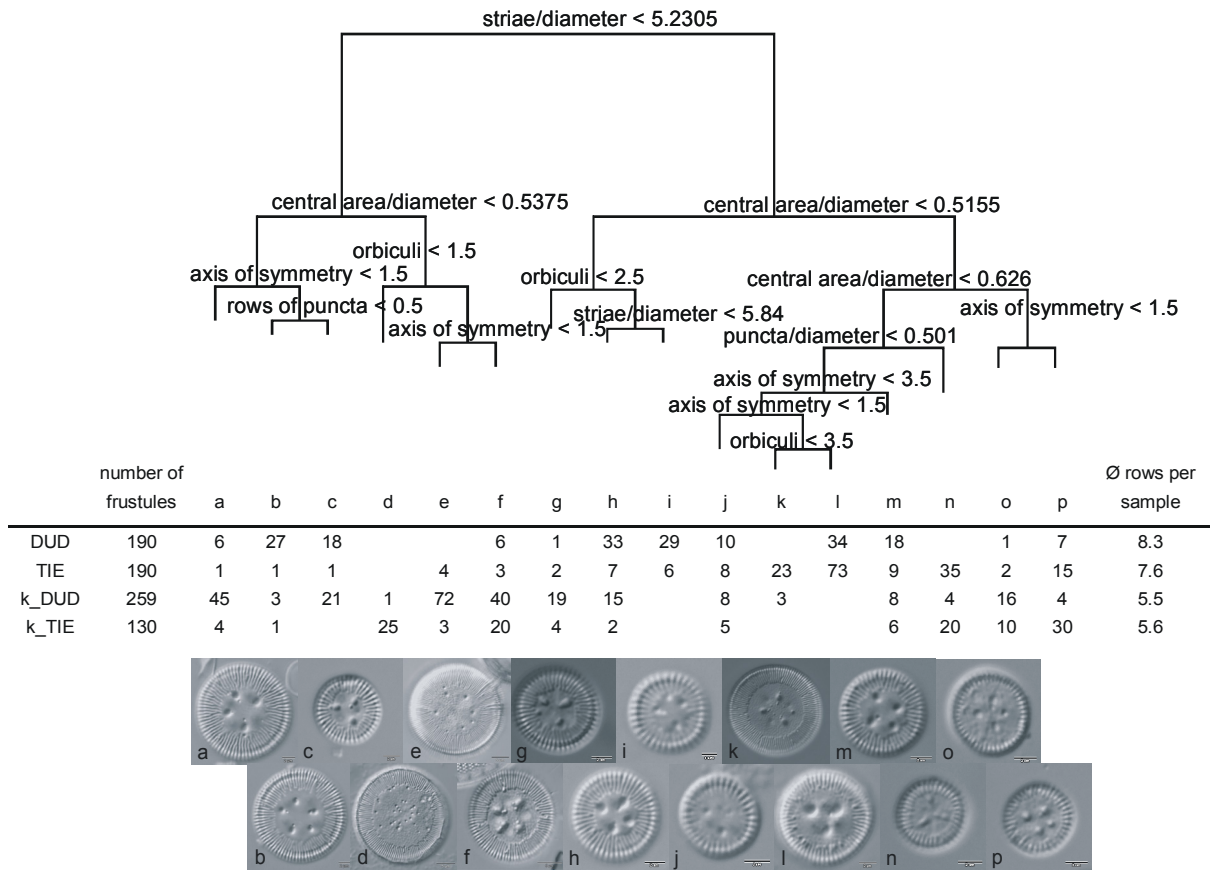


Fig 3. Tree of classification for all measured frustules (n=769), decisions given at the splits according to the left branch. Table summarises the distribution of the frustules. The first two columns show the origin (DUD = Lake Dudinghausen, TIE = Lake Tiefer See, K DUD = cultures obtained from Lake Dudinghausen, K TIE = cultures obtained from Lake Tiefer See) and number of frustules. The last column summarizes in how many branches a culture or sample is classified. Below the table, characteristic pictures of frustules are shown.

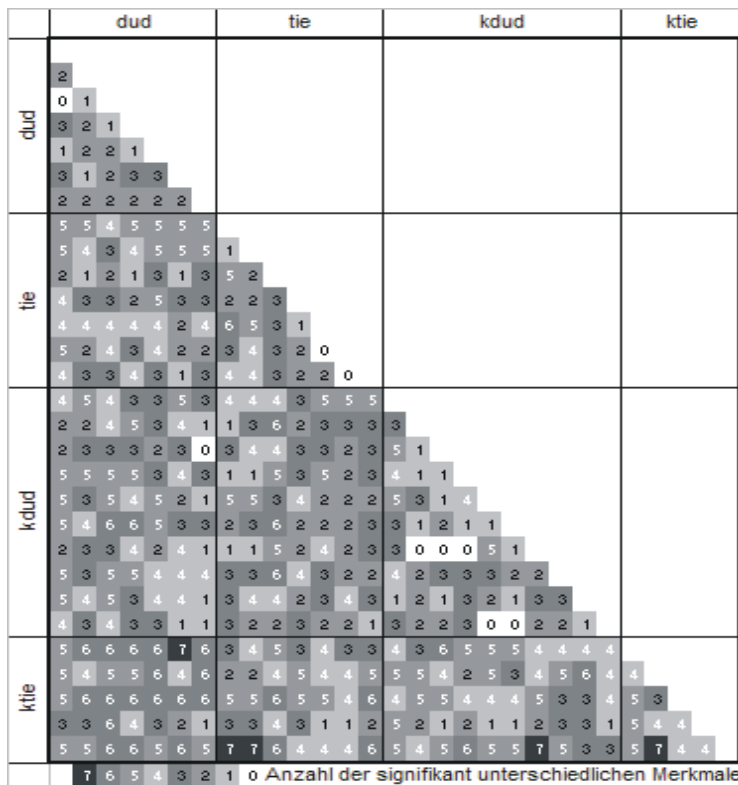


Fig 4. Pair wise comparison of samples (dud, tie) and cultures (k dud, k tie). The number of significant different criteria is illustrated. Used characters are: central area size, number of orbiculi depressi and number of symmetric sectors, frequency of striae and punctae, shape and arrangement of orbiculi depressi and the occurrence of radial rows of punctae.

Table 1. Table summarising and comparing the obtained data with morphometric characters given in literature.

Criterion (min-max)	Duding- hausener See	Range of measured data			Kiss et al. (1996)	Håkansson (1990)	
		Tiefer See	Dudinghause- ner See (cultures)	Tiefer See (cultures)	<i>Cyclotella</i> <i>ocellata</i>	<i>Cyclotella</i> <i>krammeri</i>	<i>Cyclotella</i> <i>rossii</i>
Frustule diameter [µm]	4.8–21.8	4.9–21.9	5.4–31.4	7.3–33.2	4.0–27.0	8.0–40.0	5.0–18.0
Central area/ diameter	0.35–0.68	0.37–0.70	0.32–0.74	0.42–0.76	Small– large	Small	Large
Striae/diameter	3.9–7.0	4.3–7.2	4.1–6.7	4.1–6.6	4.4–7.9	3.8–5.7	?
Orbiculi depressi	0–10	0–7	0–8	0–10	0–6	0	0

CONCLUSION

Only the samples from the lakes show differences in central-area size and striation. In the pair wise comparison of all field samples and cultures (Fig. 4) no groups were detectable, neither between the field samples nor among the cultures. The tree of classification does not group according to the originally described species, but shows a wide overlapping of morphological features in the cultures (Fig. 3). For this reason, *C. ocellata*, *C. krammeri* and *C. rossii* are undistinguishable by light microscopy in the lakes Dudinghausener See and Tiefer See. We therefore conclude in accordance with Hegewald & Hindáková (1997) that *Cyclotella ocellata* seems to show the entire morphological variability of the *Cyclotella ocellata-krammeri-rossii* complex, in field samples as well as in clone cultures from these lakes (see Table 1).

For final clarification of the taxonomic status of *C. krammeri* and *C. rossii* further investigation into the autecology as well as DNA sequence analyses are necessary.

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