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Chaetoceros pauciramosus sp. nov. (Bacillariophyceae), a Widely Distributed Brackish Water Species in the *C. lorenzianus* Complex

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To understand the diversity of the diatom genus *Chaetoceros* Ehrenberg, the *C. lorenzianus* complex was previously chosen as a model and three new species were described. In the present study, yet another new species, *Chaetoceros pauciramosus* sp. nov., was discovered from Chinese tropical waters and the temperate south-eastern Baltic Sea. In the latter locality it has been known since 2003 and identified as *C.* cf *lorenzianus*, and now found to comprise a dominating component of the autumn phytoplankton community. Vegetative cells and resting spores were examined by light and electron microscopy. The LSU and SSU of the nuclear rDNA were sequenced. The characters suggesting that *C. pauciramosus* belongs to *C. lorenzianus* complex are: 1) the vegetative cells contain four or more chloroplasts, 2) the cells have stiff setae and form regular straight chains, 3) the terminal setae differ in the direction from the intercalary setae. The relationship was well-supported by molecular phylogenetic analyses inferred from both LSU and SSU markers. The primary valve of the resting spore has two conical elevations, each with dichotomously branching processes, similar to other species in the *C. lorenzianus* complex. Each process forms a tree-like structure with the pointed distal tips which

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possess one or two thin spikes, that distinguishes *C. pauciramosus* from allied taxa. In the phylogenetic trees, *Chaetoceros pauciramosus* clustered with *C. elegans*, in agreement with their morphologically similar resting spores.

Key words: Diversity; *Chaetoceros*; morphology; molecular phylogeny; *Chaetoceros pauciramosus.*

Introduction

Chaetoceros Ehrenberg is one of the largest marine planktonic diatom genera with taxa distributed globally from polar to tropical waters. Species often dominate the phytoplankton community and may form blooms (Kownacka et al. 2013; Takano 1990), sometimes with negative impact on fish in fish farms (Fryxell and Hasle 2004; Hallegraeff 1993; Rensel 1993) and on free-living crabs by mechanical irritation of the gills (Tester and Mahoney 1995). More than 500 species and infraspecific taxa have been reported, and around 200 taxa are currently accepted taxonomically (Guiry and Guiry 2018). Some of the remaining taxa are thought to be synonymous (Hasle and Syvertsen 1997; Jensen and Moestrup 1998; Rines and Hargraves 1988; Sundström 1973; VanLandingham 1968) and several species have not been recorded or examined after the first, often non-detailed, description.

Due to the high species diversity, several subgenera, each comprising one or more sections, were established to accommodate the many taxa (Gran 1905; Hernández-Becerril 1993, 1996). The section *Dicladia* (Ehrenberg) Gran is one of the smaller sections, and species are characterized by two conical elevations on the primary valve of the resting spore (Hasle and Syvertsen 1997; Hernández-Becerril 1996). For many years, *Dicladia* was thought to include the three species *C. lorenzianus* Grunow, *C. decipiens* Cleve and *C. mitra* (Bailey) Cleve and described as the *Chaetoceros lorenzianus* complex, indicating that it was a phylogenetic well-described entity (Li et al. 2017). Recently, three additional species were discovered from warmer waters, i.e., *C. elegans* Li, Boonprakob, Moestrup & Lundholm, *C. laevisporus* Li, Boonprakob, Moestrup & Lundholm and *C. mannaii* Boonprakob, Li, Moestrup & Lundholm (Li et al. 2017).

In the *C. lorenzianus* complex, two conical elevations have been recorded on the primary valve of each resting spore in *C. elegans*, *C. laevisporus*, *C. lorenzianus* and *C. mitra*, while resting spores are unknown in *C. decipiens* and *C. mannaii*. The first-described species, *C. lorenzianus*, has not yet been studied in detail (Li et al. 2017) and resting spores are unknown in this species as well.

Blooms of a species from this complex identified as *Chaetoceros* cf*. lorenzianus* have been reported to occur in the Gulf of Gdańsk, Poland from 2003 onwards, with concentrations reaching 1.2 million cells L^{-1} in 2008 (Kownacka et al. 2013). Although the species was examined by both light microscopy and scanning electron microscopy, its identity, however, remained an enigma (Kownacka et al. 2013). The same species was subsequently recorded from the Lithuanian coast (Kownacka et al. 2013). During a visit of Nina Lundholm and Øjvind Moestrup to Gdańsk, September 2012, cultures were isolated which allowed for molecular sequencing of the taxon. At the same time, an unknown species was found in the South China Sea, which turned out to be identical to the Baltic species. The taxon is described in the present article, and it represents the fifth taxon of the group with conical elevations on the primary valves of the resting spore.

Results

Because of its distinct morphology and the position in the molecular phylogenies inferred from LSU and SSU analyses, a new species, *Chaetoceros pauciramosus* sp. nov., is erected here. The morphology of the vegetative cells and the resting spores are described in detail below, together with ultrastructural details of frustule elements. The data are based mainly on culture material, and some Polish field material was obtained for comparison.

Chaetoceros pauciramosus Z. Y. Chen, N. Lundholm, Ø. Moestrup, J. Kownacka and Y. Li sp. nov. (Figs 1–3**).**

Formal diagnosis: Straight or slightly curved chains of 3–16 cells. Several, often 4–6 chloroplasts in each cell. Cells quadrangular in girdle view. Valve face saddle shaped, with costae diverging from a central annulus and continuing onto the mantle. A silica rib is present on the valve edge. A rimoportula is visible on the terminal valve. A furrow is located