



Morphology and molecular studies on large *Neidium* species (Bacillariophyta) of North America, including an examination of Ehrenberg's types

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Abstract

The genus *Neidium* contains a large array of diatoms with a wide range in structural and morphological forms. Many of the larger species in this genus are old taxa dating back to the 1800s. However, there continues to be confusion over these large species including *N. iridis*, *N. dilatatum*, *N. firma*, and *N. amphigomphus*. In this study, selected *Neidium* taxa from North America were examined using LM and SEM images from both Ehrenberg's original samples and present day samples from Ontario (Canada) and New York State (USA). As well, *Neidium* individuals were isolated from Adirondack Park, NY (USA) and Ontario (Canada), amplified using a nested PCR protocol and sequenced for *rbcL* and *18S* barcoding genes. The sequence data was concatenated to construct phylogenetic trees using Maximum Likelihood and Bayesian Analysis techniques. Here we present emended species descriptions and sequence data of four previously named *Neidium* taxa: *N. tumescens*, *N. hitchcockii*, *N. dilatatum* and *N. amphigomphus*. In addition, we designate isolectotypes for *N. hitchcockii*, *N. dilatatum* and *N. amphigomphus*. A new species is also formally described—*N. fossum*, *sp. nov.*—with a designated holotype and sequence data. *Neidium fossum* is distinguished by its size, longitudinal canal structure, central area and proximal raphe ends. Future work combining traditional morphological methods and phylogenetic methods will allow for further delineation of *Neidium* species and other diatom taxa.

Introduction

The diatom genus *Neidium* Pfitzer (1871: 39) currently contains over 300 taxa and has a history dating back to the late 1800's when Pfitzer (1871), separated a small group of taxa away from *Navicula* Bory de Saint Vincent (1822: 128) based on cellular structure, especially chloroplast formation and orientation. Pfitzer identified four species—*N. affine* (Ehrenberg 1843: pl.2/5, fig. 4) Pfitzer (1871: 39), *N. amphigomphus* (Ehrenberg 1843: 417) Pfitzer (1871: 39), *N. amphirhynchus* (Ehrenberg 1843: 417) Pfitzer (1871: 39), and *N. firmum* (Kützing 1844: 92) Pfitzer (1871: 39)—which still belong within *Neidium*. Later Cleve (1894) studied the valve morphology and made interesting observations on the proximal and distal raphe fissures, combined with unique areolae along the valve margins. Cleve added 10 more taxa to this genus. From these early studies, six species were described by Ehrenberg (1843) based on specimens from North and South America. Although Ehrenberg (1843, 1854) was thorough in his early work, using lower brightfield microscopic studies (*ca.* 400×), he either changed his concept of described species through time or merged morphological forms into single species. To this day, confusion in the identification of taxa like *N. iridis* (Ehrenberg 1843: 418) Cleve (1894: 69), *N. amphigomphus*, *N. amphirhynchus*, *N. dilatatum* (Ehrenberg 1843: 418) Cleve (1894: 70), *N. maximum* (Cleve 1894: 69) Meister (1912: 109) and *N. ampliutum* (Ehrenberg 1854: 16) Krammer in Krammer & Lange-Bertalot (1985: 101) exists, while other taxa like *N. hitchcockii* (Ehrenberg 1843: 418) Cleve (1984: 69) are well defined (Hamilton *et al.* 1995). This confusion was further linked to the similarity of valve morphologies between many of the species. The identification problem faced by Ehrenberg was illustrated by Hamilton & Jahn (2005) with the typification of the generic type *N. affine* using Ehrenberg's type material from Newfoundland, Canada. In addition, later researchers including Cleve, Mayer, Hustedt, Reimer and Krammer made interpretations of *N. iridis* and *N. amphigomphus* which did not resolve the taxonomy of these large-sized *Neidium* species.