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A new species of *Sellaphora* (Sellaphoraceae) from Hannaberry Lake, Arkansas, U.S.A.

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A new small-size species of *Sellaphora* was found in sediments from Hannaberry Lake, Arkansas, during the National Lakes Assessment project conducted by the United States Environmental Protection Agency. The species was studied with light microscopy and scanning electron microscopy. It differs from previously reported *Sellaphora* species by its small and delicate frustule with striation irresolvable in light microscopy. Here we present details on its morphology and size variation and report the characteristics of the lake where the species was found.

Key words: Diatom, *Sellaphora*, morphology, ultrastructure, size, Lake Hannaberry, Arkansas, USA

Abbreviations: **NLA** – National Lakes Assessment, **EPA** – Environmental Protection Agency, **LM** – light microscopy(e), **SEM** – scanning electron microscopy(e)

Introduction

Several new species of *Sellaphora* were reported in recent studies of freshwater bodies from North America (ANTONIADES et al. 2007, POTAPOVA and PONADER 2008). The North American findings came to complement the abundant recent literature describing new species or combinations since the resurrection of the genus *Sellaphora* by MANN (1989) who showed that this genus is different from *Navicula* Bory s. str. in many characteristics of both protoplast and frustule. In addition to the more than 30 new species described from South America (KUSBER and JAHN 2003, METZELTIN et al. 2005, METZELTIN and LANGE-BERTALOT 2007), 6 species were separated within the *Sellaphora pupula* complex (MANN et al. 2004) and another 6 species were described from the European lakes Prespa and Ohrid (LEVKOV et al. 2003, 2007).

Here we present details of frustule morphology and habitat characteristics of a small species that we place within *Sellaphora*.

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Materials and methods

Sediment cores were collected from freshwater bodies within the National Lakes Assessment (NLA) across all states of the U.S.A. during the summer-fall season of 2007. The survey included natural and man-made freshwater lakes, ponds, and reservoirs greater than 10 acres (4 hectares) in the conterminous U.S., excluding the Great Lakes. More details on sampling design can be found at the EPA web page http://www.epa.gov/owow/lakes/lakessurvey/siteselect_factsheet. html. Sediment cores were retrieved from the deepest basins of the lakes using a Glew corer (internal diameter 7.62 cm) that preserves an undisturbed sediment-water interface (GLEW et al. 2001). Sediment samples from the top (0–1 cm, representing sediments recently accumulated or modern samples) and from the bottom of each core (> 35 cm, representing pre-industrial sediments) were analyzed by different laboratories to allow comparisons between modern and pre-industrial diatom species composition. Within this project, more than 500 sediment samples were analyzed at the Academy of Natural Sciences of Philadelphia (ANSP).

Sediment sample digestion for diatom analysis followed the ANSP protocols (CHARLES et al. 2002). Diatom permanent slides were prepared using Naphrax^{R} mounting medium. For light microscopy (LM) we used a Zeiss Axio Imager microscope equipped with AxioCam MRm digital camera.

For scanning electron microscopy (SEM), cleaned material was dried on aluminum stubs; stubs were sputter-coated with Pt-Pd and observed under a Zeiss Supra 50 VP FE SEM (Carl Zeiss, Jena, Germany) at an accelerating voltage of 10 kV. Terminology used to describe valve structure follows ANONYMOUS (1975), ROSS et al. (1979), and MANN et al. (2004). The water chemistry characteristics for Hannaberry Lake, the site where the new *Sellaphora* species was found, were obtained from the EPA.

Results

Sellaphora pulchra Enache et Potapova sp. nov. (Figs. 1–13)

Descriptio: Valvae ellipticae-lanceolatae apicibus subcapitatis vel capitatis, 7.6–13.3 µm longae, 3.3–4.0 µm latae. Area axialis angusta, recta. Area centralis transverse rectangulata versus marginem dilatata. Striae transapicales uniseriatae radiantes in media parte, ad apices parallelae vel paulo convergentes, 30–40 in 10 µm ad area centralis, 35–45 in 10 µm in media parte et ad apicem. Areolae parvae circulares, 60–100 in 10 µm. Striae non aspectabiles microscopio photonico. Raphe recta, filiformis, poris centralibus simples paulo flexis, fissuris terminalibus curvatis ad latus secundum valvae. Plica ad partem conjunctem frontis valvae et limbi praesens. Areae terminales non vel leviter distinguibiles.

Description: Valves elliptic-lanceolate with sub-capitate to capitate ends, 7.6–13.3 µm long and 3.3–4.0 µm wide. Axial area narrow and straight. Central area bow-tie-shaped with alternating short and long striae. Transapical striae uniseriate and strongly radiate in mid-valve, becoming parallel or slightly convergent at valve ends, 30–40 in 10 µm around central area, 35–45 in 10 µm from mid-valve to apices. Areolae small, rounded, 60–100 in 10 µm transapically. Striae irresolvable under LM. Raphe straight, filiform, with simple

central endings, only slightly expanded, and terminal fissures curved towards secondary side of the valve. A fold can be observed at the junction of the valve face and the mantle. Polar bars indistinct or very slightly developed.

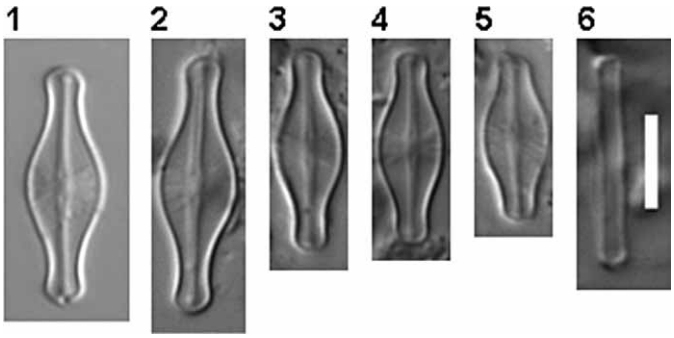
Holotype: Slide ANSP GC64854, Diatom Herbarium, Academy of Natural Sciences of Philadelphia (ANSP).

Isotype: Slide ANSP GC64855, Diatom Herbarium, Academy of Natural Sciences of Philadelphia (ANSP).

Type locality: Hannaberry Lake, Jefferson County, Arkansas, Mississippi Alluvial Plane, coordinates: 34.1177 N; 91.5542 W, lake surface sediment.

Etymology: specific epithet refers to the beauty of the species' delicate and elegantly shaped frustule.

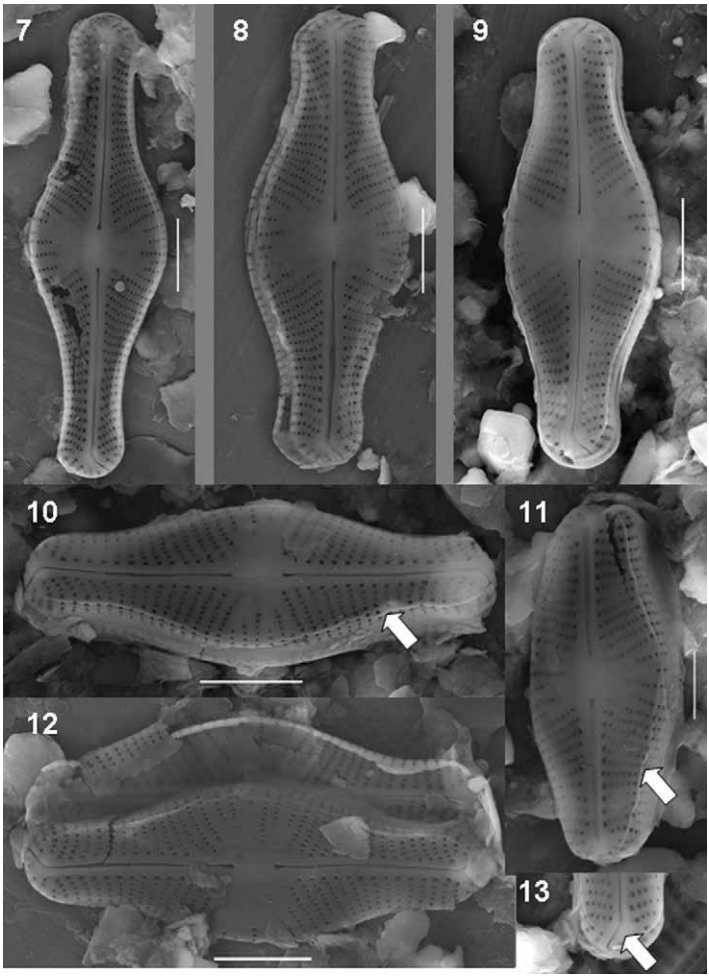
Sellaphora pulchra is distinguished from other naviculoid diatoms by its delicate frustule, striae irresolvable under LM (Pl. 1, Figs. 1–6), small size and characteristic shape. The raphe of *Sellaphora pulchra* is difficult to observe in LM, which may lead to its misidentification as a monoraphid diatom. SEM observations show that the raphe is filiform, straight, with simple, slightly expanded (Figs. 8–10) or drop-like in larger specimens (Figs. 7, 12) external proximal endings. The terminal raphe fissures are curved and extend to valve mantle (Pl. 2, Figs. 7–13). The areolae are small, poroid, arranged in uniseriate striae. At the valve apices the interstriae are occasionally wide, thus forming structures that may be interpreted as 'polar bars' (Fig. 13).



Pl. 1. *Sellaphora pulchra* sp. nov., LM. Type material, Hannaberry Lake, Arkansas. **Fig. 1** – holotype, ANSP GC64854; **Figs. 2–5** – variation in size and shape. **Fig. 6** – girdle view. Scale bar = 5 μm.

Discussion

Several genera have been recently established to accommodate small naviculoid diatoms with uniseriate striae previously placed within *Navicula* sensu lato. These genera are often based on a few morphological characters, such as the shape of the valve, raphe structure, and position of the sieve membranes in relation to the valve external or internal surface. *Adlafia* and *Mayamaea*, for instance, have sieve membranes positioned closer to the internal valve surface within areolae, while *Eolimna*, *Fistulifera,* as well as *Sellaphora* have membranes near external valve surface (MOSER et al. 1998). The species discovered in



Pl. 2. *Sellaphora pulchra* sp. nov., type material, SEM. **Figs. 7–9** – valve face in external view showing uniseriate striae, bow-tie-shaped central area, filiform raphe with simple only slightly expanded central endings, and terminal fissures curved towards secondary side of the valve. **Figs. 10–11** – the marginal fold is visible at the junction between valve face and mantle, arrowed. **Fig. 12** – external valve view and partial internal view of the opposite valve. **Fig. 13** – detail of valve apex with indistinct polar bar. Scale bars = 2 μm.

Hannaberry Lake obviously does not have areolae occluded externally, and therefore cannot be placed in *Adlafia* or *Mayamaea.* It also cannot be placed in *Fistulifera*, which does not possess terminal raphe fissures. The difference between *Eolimna* and *Sellaphora* is currently not clear. The diatom known as *Eolimna minima* (Grunow) Lange-Bertalot, for example, has been shown to be a sister taxon to *Sellaphora* in a molecular phylogenetic study (EVANS et al. 2008). *Eolimna* has fimbriae in the valvocopula and raphe on a raised sternum (MOSER et al. 1998). These features were not present in our specimens, and, therefore, we placed the new species in *Sellaphora*.

Morphologically, the species most similar to *Sellaphora pulchra* is in our opinion *Naviculadicta rionautensis* Rumrich et Lange-Bertalot (RUMRICH et al. 2000, Pl. 70, Figs. 14–18), from which *S. pulchra* is distinguished particularly by its much finer striae and shape. *Sellaphora* species with fine striation, such as *Sellaphora wallacei* (Reimer) Potapova et Ponader (POTAPOVA and PONADER 2008: 172, Fig. 1) and *S. rioplatensis* Metzeltin, Lange-Bertalot et Garcia-Rodríguez (METZELTIN et al. 2005: 212, Pl. 67, Figs. 13–27) have already been reported from the Americas. *S. pulchra* differs from these two species by the valve shape, bow-tie-shaped central area, and the absence of distinct polar bars. *Navicula impexa* Hustedt (HUSTEDT 1961: 151, Fig. 1282; SIMONSEN 1987: 475, Pl. 728, Figs. 15–18), another small-size species with irresolvable striae, differs from *S. pulchra* by the absence of a bow-tie-shaped central area and by the valve shape.

Sellaphora pulchra displays some similarities to other small-size species of *Navicula* sensu lato, such as *N. medioconvexa* Hustedt (HUSTEDT 1961: 151, Fig. 1283), *N. digna* Hustedt (SIMONSEN 1987: 440, Pl. 657, Figs. 10–12), *N. schmassmannii* Hustedt (SIMONSEN 1987: 475, Pl. 122, Figs. 11–12; 174, Pl. 276, Figs. 22–30), *N. mediopunctata* Hustedt (SIMONSEN 1987: 174, Pl. 276, Figs. 17–21), and *Sellaphora hustedtii* (Krasske) Lange-Bertalot (LANGE-BERTALOT et al. 1996: 116, Pl. 18, Figs. 4–5). However, it can be easily distinguished from these species by its morphological features. *N. medioconvexa* has coarser striae (~ 30 striae/10 μm), different valve shape, broader ends, and slightly larger size (12–16 μm long and 4–4.5 μm wide). *Navicula digna*, a species with morphological features very similar to *N. medioconvexa* but with finer striae (36/10 μm) differs from our new species by the shape of the valve and smaller central area. *N. schmassmannii* differs from *S. pulchra* by the lack of bow-tie-shaped central area and smaller size (6–10 μm long and 2.5–3 μm wide). *S. hustedtii* is larger than *S. pulchra* and displays coarser striae. *N. mediopunctata* has similar valve outline with *S. pulchra*, but the bow-tie-shaped central area is absent and transapical striae are parallel.

Sellaphora pulchra was found only in two top sediment samples from Hannaberry Lake (ANSP slides NLS00252 and NLS00254). Presently, Hannaberry Lake is a freshwater eutrophic lake, with Ca concentration (1559 μeq L^{-1}) higher than the average for lakes sampled within the NLA project (median = 1053 μeq L^{-1}), and with average levels of silica (Tab. 1). The high productivity of the lake is indicated by the high nutrient (Tab. 1) and chlorophyll *a* (1360 μg L^{-1}) concentrations.

Tab. 1. Limnological characteristics of Hannaberry Lake

Parameter	Hannaberry Lake
pH	8.3
Secchi (m)	0.5
Conductivity (μS cm^{-1}, 25 °C)	410
Turbidity (NTU)	9.4
Color (PCU)	10
Dissoled Organic Carbon (mg L^{-1})	5.4
Total Phosphorus (μg L^{-1})	100
Total Nitrogen (μg L^{-1})	956
SiO_2 (mg L^{-1})	6.8

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