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Staurophora brantii, a new diatom (Bacillariophyta, Anomoeoneidaceae) from the northwestern Great Plains, USA

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Abstract

Staurophora brantii is described from streams of the northwestern Great Plains in the western United States. The new species is placed in *Staurophora* by virtue of its plastid type, valve structure, and ecology. It is distinguished from similar species by its size, valve shape, end shape, striae count, and habitat. *Staurophora brantii* sp. nov. lives in alkaline freshwater streams with soft, muddy bottoms and elevated concentrations of electrolytes, particularly sodium and sulfate. *Stauroneis tackei*, an associate of *Staurophora brantii* on the Great Plains, is transferred to *Staurophora*.

Key words: *Staurophora tackei, S. wislouchii, Dickieia, Stauroneis,* United States

Introduction

Over the last 30 years several hundred benthic algae samples have been collected for various water quality monitoring projects from streams of the northwestern Great Plains in eastern Montana, northeastern Wyoming and western North and South Dakota. The region is rolling semiarid steppe, vegetated sparsely by bunchgrasses and sagebrush and underlain with marine shales, mudstones, and sandstones (USEPA 2000). In about 150 of these samples there occurs a distinctive naviculoid diatom with a prominent transverse central area. Persistent attempts to identify this taxon from a published description have failed, prompting its recognition as new. It is described here as a new species.

Materials and methods

At each site, diatoms were collected from the surface of fine sediments using a tablespoon or a large-bore pipette with suction bulb. Samples were preserved with Lugols (IKI) solution before transport to the laboratory, where they were treated with concentrated sulfuric acid (H_2SO_4), potassium dichromate ($K_2Cr_2O_7$), and hydrogen peroxide (H_2O_2) to remove organic matter (APHA *et al*. 1992). After several rinses in distilled water, cleaned diatom material was mounted permanently on slides using Hyrax or Naphrax and examined under light microscopy (LM) with differential interference contrast optics using a Leica DM LB2 research microscope and a Spot Insight Model 14.0 monochrome digital camera. Slides and cleaned material from these samples have been deposited in the Montana Diatom Collection (MDC) in Helena and duplicate slides have been deposited in the University of Montana Herbarium (MONTU) in Missoula (http://herbarium.dbs.umt.edu/diatoms.asp).

Valve measurements were made from digital images using Spot Software (version 4.5). Some cleaned diatom material was filtered and air-dried on aluminum stubs, coated with gold-palladium (Pelco Model 3 Sputter Coater) and examined under scanning electron microscopy (SEM) with an Hitachi S–4700 Type II

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cold field emission SEM at the Electron Microscopy Facility in the Division of Biological Sciences at the University of Montana. Water chemistry measurements were made in the laboratory from grab samples that were collected at the time of benthic algae sampling. Water samples were analyzed by the Chemistry Laboratory of the Montana Department of Health and Human Services following methods proposed by the American Public Health Association (APHA *et al.* 1992).

New species description

Division **Bacillariophyta**
Class **Bacillariophyceae** Haeckel 1878 *emend*. D.G.Mann in Round *et al.* 1990
Subclass **Bacillariophycidae** D.G.Mann in Round *et al.* 1990
Order **Cymbellales** D.G.Mann in Round *et al.* 1990
Family **Anomoeoneidaceae** D.G.Mann in Round *et al.* 1990
Genus ***Staurophora*** C.Mereschk. 1903

Staurophora brantii Bahls, *sp. nov.* (Figs 1–10, 18–27)

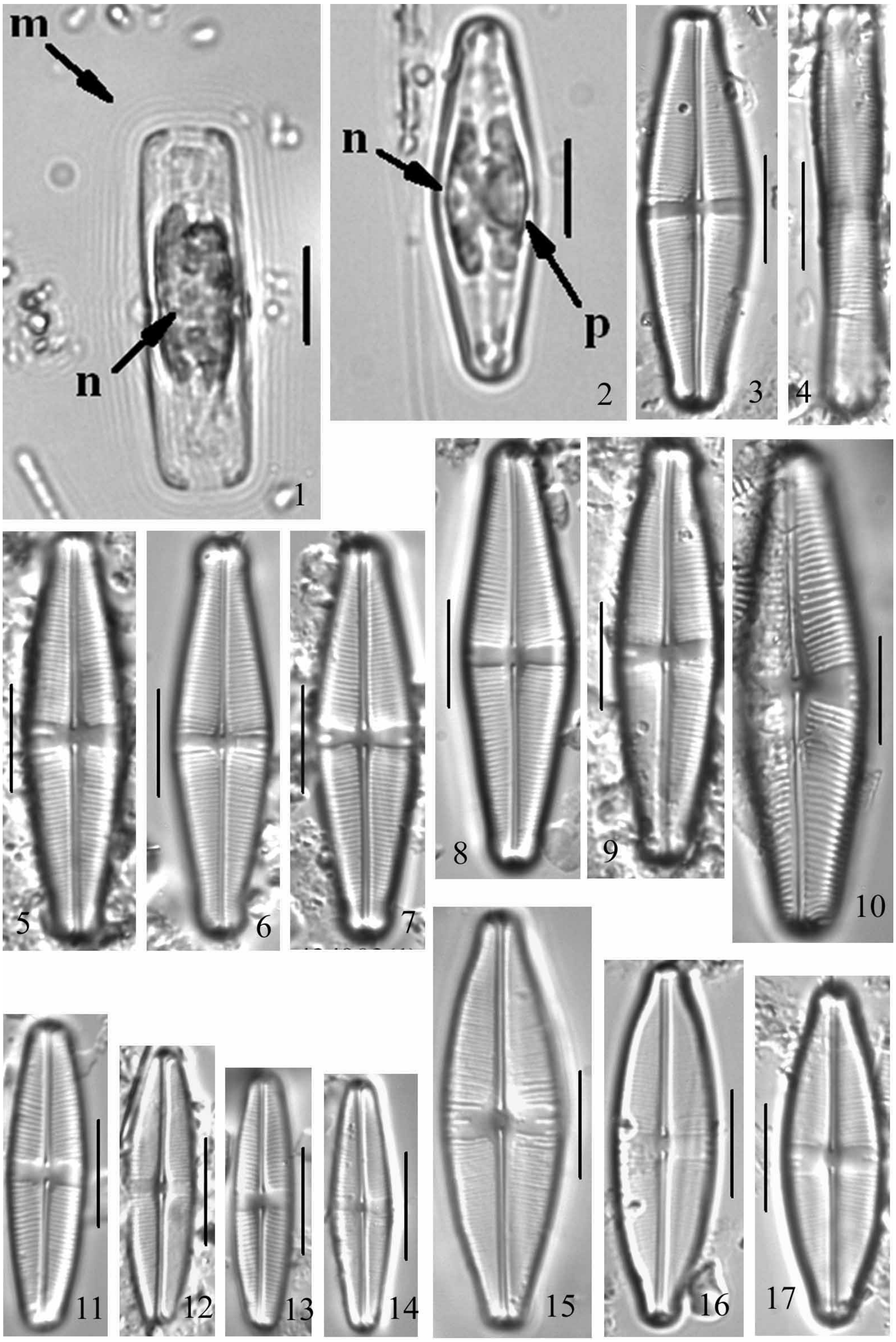
Cellulae solitariae. Unus lobus chloroplastus locatus juxta cingulum. Valvae ellipticae-lanceolatae usque rhombicae-lanceolatae, apices latus rotundi usque leviter rostrati; superficies valvarum leviter curvus vel pallium. Longitudo valvae 38–48 µm, latitudo valvae 9–12 µm. Rhaphis directa, filiformis; extremas proximales rhaphis inflatus et leviter curvae; extremas distales rhaphis fortiter curvae. Area axiale angusta linearae, leviter latus prope area centralis; area centralis latus fascia, interdum nonnullus marginum striae brevis. Striae radiantes et subtiliter punctata, (14) 18–24 in 10 µm.

Type:—USA. Montana: Crow Creek above East Powderville Road Bridge, Powder River County, 45º 40’ 44” N, 105º 07’ 19” W. Sample collected from surface sediment by Montana DEQ personnel on 1st August 2007. Montana Diatom Collection sample number 411202 (holotype slide ANSP GC64897, circled specimen on slide [=Fig. 3], isotypes: circled specimens on slides ANSP GC64898, MDC 32–60 and MDC 116–59).

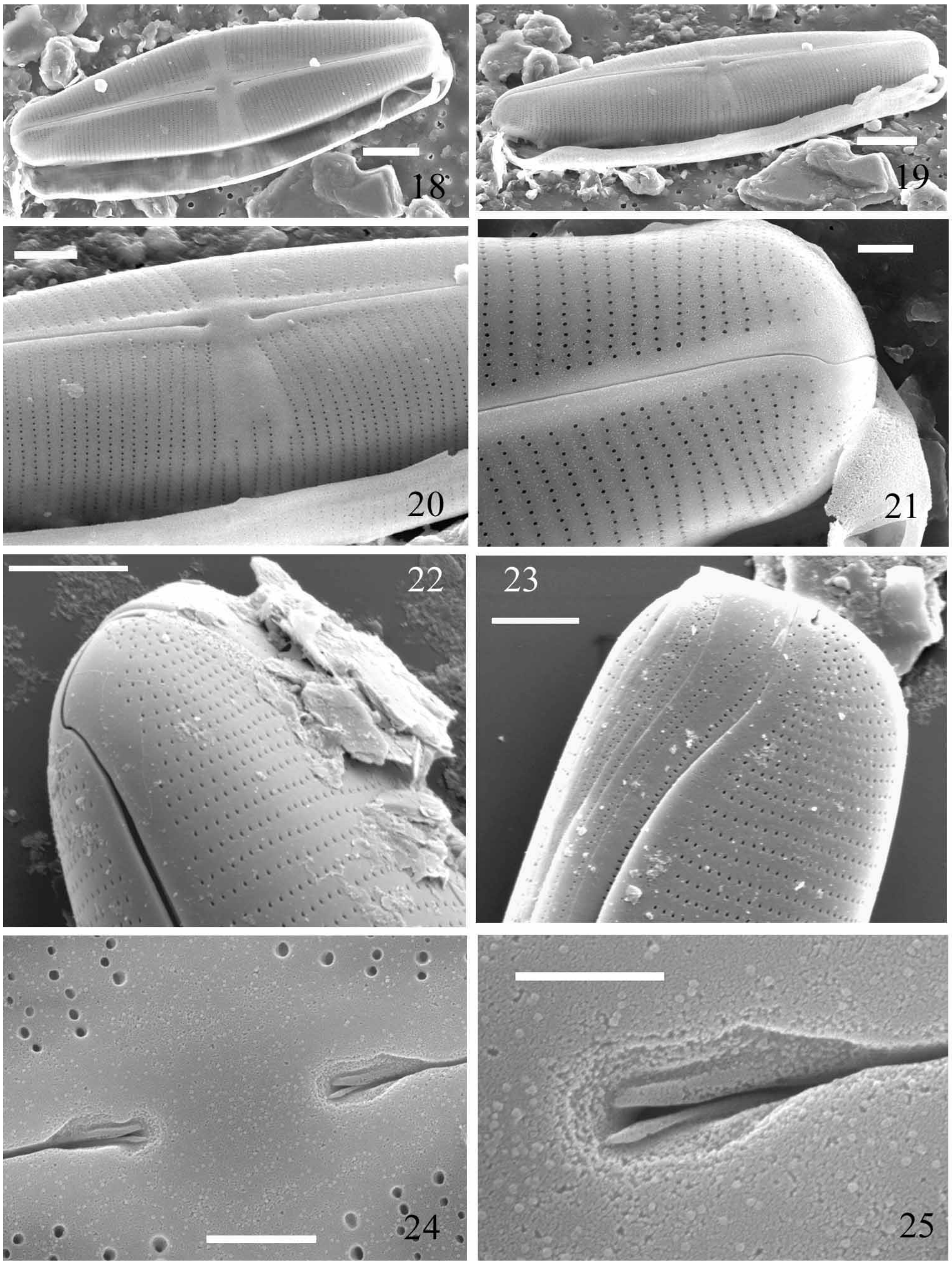
Cells solitary, lying mostly in valve view, within a laminated mucilage capsule (Fig. 1). One lobed plastid with a large lenticular pyrenoid positioned against the girdle opposite the nucleus (Figs. 1, 2). Valves elliptic-lanceolate to rhombic-lanceolate, apices broadly rounded and somewhat protracted (Figs 5–10). Valve face curved in transapical section, merging gradually into the mantle (Figs 19, 20), mantle shallower near the ends (Fig. 20). Valve length 38–48 µm; valve width 9–12 µm. Raphe sternum narrow, somewhat thickened and slightly elevated at the central nodule (Fig. 20). Overlapping girdle elements bear longitudinal rows of small round poroids (Fig. 23). Raphe straight, filiform. External proximal raphe endings bordered by lips and lying in spathulate grooves (Figs 24, 25); terminal fissures strongly curved, opening toward the secondary side of the valve (Fig. 22). Internal proximal raphe endings bent in the same direction (Fig. 27); terminal fissures end in helictoglossae (Fig. 26). Axial area narrow, linear, widening slightly near the central area. Central area a transverse fascia, wider toward the margins and with a few shortened striae on one or both sides. Only the ends of the longest of these short striae are visible in valve view, making them appear to be more widely spaced than other striae (Fig. 20). Striae radiate and uniseriate, 18–24 in 10 µm (14 in 10 µm, initial valve, Fig. 10), but more concentrated toward the poles. Striae composed of small round areolae.

Etymology:—This taxon is named in honour of Dr. Lynn A. Brant of Cedar Falls, Iowa, USA.

Observations:—*Staurophora brantii* can be compared to similar species that have a transverse fascia and a preference for waters with elevated electrolytes: *Staurophora amphioxys* (W.Greg.) D.G.Mann, *Staurophora caljonii* Cocquyt, *Staurophora elata* (Hust.) D.G.Mann, *Staurophora salina* (W.Sm.) Mereschk., and *Staurophora wislouchii* (Poretzky & Anisimova) D.G.Mann; *Stauroneis atacamae* Hust., *Stauroneis dubitabilis* Hust., *Stauroneis submarina* Hust. and *Stauroneis tackei* (Hust.) Krammer & Lange-Bert. Several of these were originally placed in the genus *Stauroneis*, although currently *Stauroneis* sensu stricto is limited to species occurring in freshwater habitats only (Round *et al.* 1990).Other brackish to marine taxa considered for comparison were dismissed because they have radically different valve outlines, e.g., *Stauroneis desiderata* Cleve, *Stauroneis pachycephala* Cleve, and *Stauroneis rossii* Hendey.



FIGURES 1–17: *Staurophora brantii* and allied species from the Northwestern Great Plains, LM. Figs 1–10: *Staurophora brantii*. Figs 1, 2: Uncleaned specimens from the type locality showing the single lobed plastid, mucilage capsule (m), nucleus (n), and large lenticular pyrenoid (p). Fig. 3: Holotype specimen. Fig. 4: Girdle view from holotype slide. Figs 5–10: Specimens from various populations. Fig. 10: Initial valve. Figs 11–14: *Staurophora tackei* from various populations. Figs 15–17: *Staurophora wislouchii* from various populations. Scale bars: 10 µm.

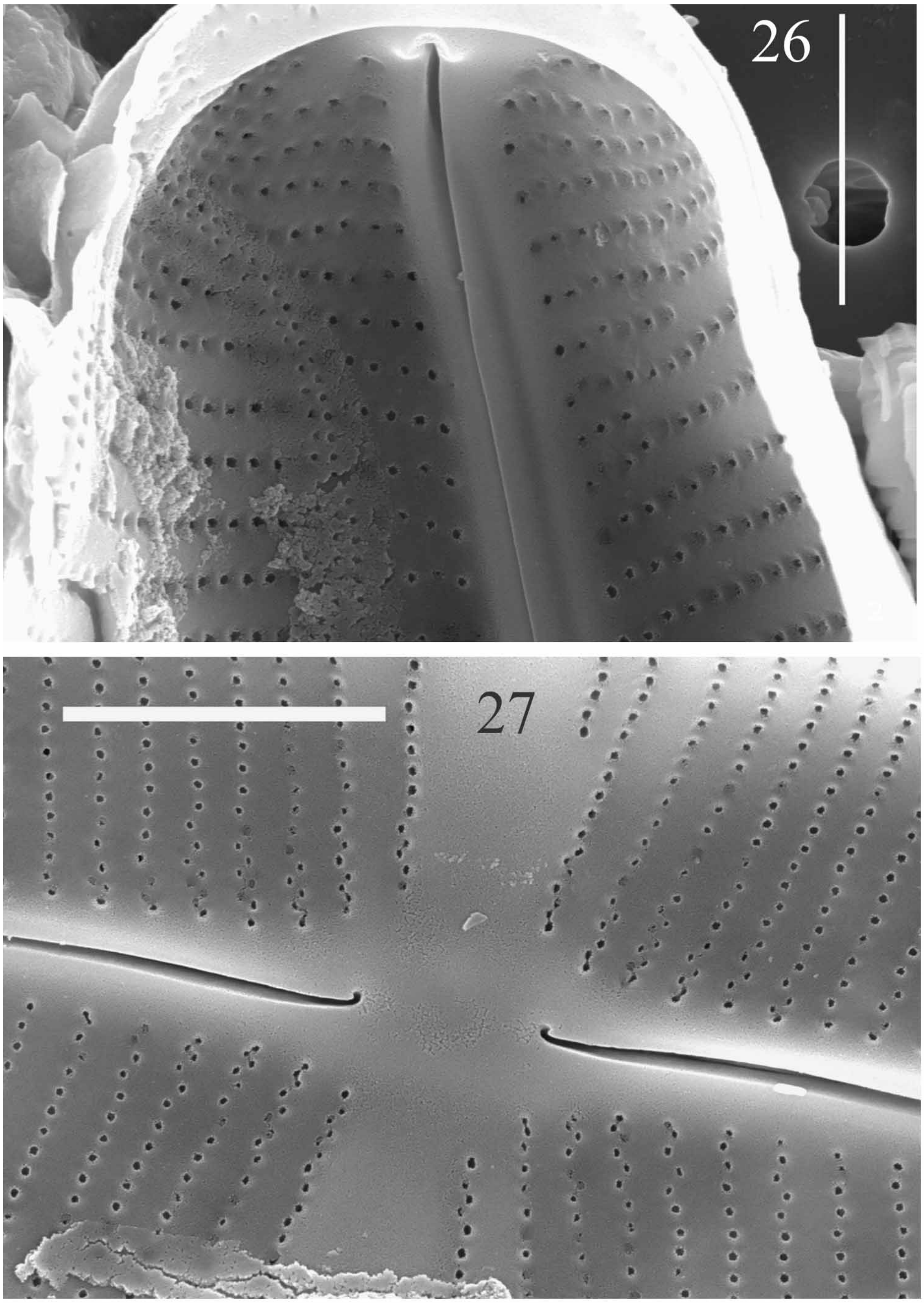


FIGURES 18–25: *Staurophora brantii* from the type locality, SEM, external. Fig. 18: Frustule with valves slightly displaced. Fig. 19: Oblique view of valve surface showing gradual transition between valve face and mantle. Fig. 20: Closeup of valve center from Fig. 19 showing short marginal striae in central area and slightly raised raphe sternum. Fig. 21: Closeup of valve end from Fig. 18 showing crowded terminal striae and terminal raphe fissure disappearing over the rounded pole. Fig. 22: Oblique view of valve end showing terminal raphe fissure curved back toward the near (secondary) side. Fig. 23: Side view of valve end showing multiple overlapping girdle elements with longitudinal rows of poroids. Figs 24, 25: Closeup of central raphe endings bordered by lips and lying in spathulate grooves. Scale bars: Figs 18, 19: 5 µm; Fig. 20: 2 µm; Fig. 21: 1 µm; Figs 22, 23: 2 µm; Fig. 24: 1 µm; Fig. 25: 500 nm.

Staurophora brantii may be distinguished from most of those listed above by its size, valve and end shape, striae count, and habitat. Although similar in most of these features, *Stauroneis submarina* Hust. has a narrow linear central area, unlike the broad deltoid central area of *Staurophora brantii*.

Staurophora brantii overlaps in distribution and shares some habitats on the Northwestern Great Plains with two closely allied taxa: *Stauroneis tackei* is much smaller and has linear-lanceolate valves (Figs 11–14), while *Staurophora wislouchii* has broadly elliptical valves with short protracted ends (Figs 15–17).

Habitat, Ecology and Distribution:—*Staurophora brantii* lives on fine sediments in streams of the Northwestern Great Plains. Most streams in this ecoregion are ephemeral or intermittent, typically consisting of a series of interconnected pools with bottoms composed of fine silt and decomposing organic matter. Records of this taxon in the Montana Diatom Database are distributed by state as follows: Montana (118), North Dakota (3), South Dakota (10), and Wyoming (20). Abundance-weighted mean values for water quality variables in streams where *Staurophora brantii* occurs suggest that it prefers fresh alkaline waters with somewhat elevated concentrations of electrolytes, particularly sodium and sulfate. The most frequently co-occurring associates of *Staurophora brantii* are largely mobile, epipelic taxa that prefer elevated concentrations of dissolved solids.



FIGURES 26-27: *Staurophora brantii* from the type locality, SEM, internal. Fig. 26: Closeup of valve end showing thickening of valve margin at the apex and terminal raphe fissure ending in an helictoglossa. Fig. 27: Closeup of valve center showing proximal raphe endings bent in the same direction. Scale bars: Fig. 26: 2 µm; Fig. 27: 3 µm.

Discussion

Assigning this new species to a genus was not straightforward. However, *Stauroneis* Ehrenb. could immediately be eliminated as a candidate as it has two plastids and its central raphe endings are differently structured (Round et al. 1990). Species in the genus *Stauroneis* are also restricted to freshwater or aerial habitats. For example, all 51 species of *Stauroneis* sensu stricto recorded to date from the Northern Rocky Mountains are associated with mean specific conductance values of 250 µS/cm or less (Bahls 2010). The genera *Craspedostauros* E.J.Cox and *Krsticiella* Levkov were also considered but dismissed for structural reasons. Species in the genus *Craspedostauros* have two chloroplasts, cribrate areolae, and helictoglossae internally at the proximal ends of raphe branches (Cox 1999). Representatives of the genus *Krsticiella* have cymbelloid (dorsiventral) valves and internal proximal raphe endings that are expanded (Levkov et al. 2007).

Dickieia Berk. *ex* Kütz. was resurrected and amended by Mann (1994) to accommodate *Navicula ulvacea* (Berk. ex Kütz.) Cleve and other brackish and marine naviculoid taxa having a single complex plastid, curved valve faces, round poroids with hymenate occlusions, and several overlapping girdle bands. Frustules of *Dickieia ulvacea* Berk. ex Kütz. sometimes produce mucilaginous fronds, but this is not a constant feature of the species or of other species in the genus. Like other members of the genus, *Dickieia ulvacea* does not produce a well defined central transverse fascia, but rather has one to a few shorter, more widely spaced striae on either side of the central area, thus forming a "pseudostauros" (Hanic & Lobban 1979). However, a stauroid central area appears in several disparate groups of raphid diatoms and cannot be used as a distinguishing feature (Round et al. 1990). As far as they go, descriptions of *Dickieia* species (e.g., Cox 1985) conform to features of the new taxon from the Great Plains. However, the ultrastructure of *Dickieia* species has not been described in detail and the question remains whether it matches the structure of specimens from the Great Plains.

On the other hand, the new species agrees well with all features of *Staurophora* Mereschk., as described by Round et al. (1990), including a single plastid, external proximal raphe endings that are bordered by lips and lie in spathulate grooves, internal proximal raphe endings that are bent in the same direction, and multiple cingula with longitudinal rows of poroids.

Fourtanier & Kociolek (1999) noted that *Staurophora* is a later homonym of the liverwort genus *Staurophora* Willd. 1809 and therefore an invalid name for a genus of diatoms. However, Prasad & Silva (2000) proposed conserving the name *Staurophora* Mereschk against *Staurophora* Willd., a proposal that was subsequently accepted (ICBN 2006, Appendix III: 165).

Recently, Cox (2010) suggested that because members of the genera *Dickieia* and *Staurophora* share the same cytoplasmic and structural features, they should be combined into a single genus, for which the name *Dickieia* would have priority. However, such action requires additional studies on the fine structure of representative *Dickieia* species to confirm that the two genera do indeed share critical diagnostic features.

As the generic name *Staurophora* is adopted in this study, a new combination is required for *Stauroneis tackei*:

Staurophora tackei **(Hust.) Bahls, *comb. nov.* (Figs 11–14)**

Navicula tackei Hust. (1942: 194, figs 6–7). Type: GERMANY: "Bremen-Warturm, Tümpel. 1.", (holotype BRM N10/84, Simonsen 1987: 305, pl. 459, figs 1–4).

Stauroneis tackei (Hust.) Krammer & Lange-Bert. (1985: 116, pl. 5, figs 7, 8)

Stauroneis palustris Hust. (1945: 914, pl. 42, figs 30–32). Type: MACEDONIA: "Katlanowo-See", (lectotype BRM 206/1, Simonsen 1987: 327, pl. 507, figs 1–5).

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