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Stephanodiscus akanensis sp. nov., a new species of extant diatom from Lake Akan, Hokkaido, Japan

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Abstract The morphology of a new centric diatom species, *Stephanodiscus akanensis* Tuji, Kawashima, Julius & Stoermer is described using light and scanning electron microscopy. The species is so far only known from Lake Akan, Hokkaido, Japan. It is separated from other similar *Stephanodiscus* species by the characteristic position of the valve face fultoportulae and the numbers of rimoportulae.
Key words : Bacillariophyceae, Lake Akan, Centric diatoms, ultrastructure, initial valve.

Introduction

Lake Akan is a eutrophic system in eastern Hokkaido, Japan (43°27′N, 144°07′E) and lies at an elevation of 429 m. It has a surface are of 13.3 km^2, a 42 m maximum depth, and an 18 m mean depth. The lake is well known for the occurrence of *Cladophora sauteri* (Nees) Kützing colonies, which appear as macroscopic "balls" (Canter-Lund and Lund, 1995). Takayasu *et al.* (1930) first described Lake Akan's plankton flora and fauna. Negoro and Watanabe (1977) expanded our knowledge of Lake Akan's plankton flora by a light microscope (LM) investigation. Kawashima and Kobayasi (1993, 1994, 1995, 1996) and Kawashima and Mayama (1997, 1998, 2000, 2001, 2002) described the lake's diatom flora in greater detail using both the LM and scanning electron microscope (SEM). In this paper we continue to expanded the knowledge base about the plankton flora with the description of a new species, *Stephanodiscus akanensis*, from the system.

Materials and Methods

S. akanensis is described from a near shore plankton tow collected in August 1995 from a 3 m depth. The samples were processed for LM and SEM observations following the protocols of Kawashima and Kobayasi (1993). Material for SEM observation was dried onto poly-L-lysine coated 10 mm coverslips, washed with distilled water, and sputter-coated with platinum. Observations were performed with a JOEL-6301F SEM. A single specimen on an unsputter-coated coverslip was examined with the SEM. After completing SEM observations of the coverslip, it was used to make a permanent Pleurax mount for LM observation. This LM preparation serves as the holotype for the species. Observation of the specimen in the SEM prior to its preparation as a LM slide provides the opportunity to obtain complete information about the LM and SEM morphology of a single diatom specimen, in this instance the holotype specimen. Terminology for specific morphological features follows Håkansson and Locker (1981).

Diagnosis

Stephanodiscus akanensis Tuji, Kawashima, Julius & Stoermer sp. nov. (Figs. 1–5)

Valvae circulares, fronte leviter concentrice undulatae, 13–60 μm diam. Areola in fronte limboque divergentes, cribris tholiformibus penitus instructae, fasciculos formantes. Fasciculi 7–8 per 10 μm, prope centrum valvae uniseriati, versus limbum ex 2–3 seiebus areolarum constans. Costa extrinsecus parum elevata. Spinae in quiaeque extremitatibus interstriarum regulariter dospositae. Fultoportulae frontis valvae ex primo tubo poris brevi et 2 satellitibus instructae. Fultoportulae limbi per costam secundariam vel tertiariam in parte inferiori spinae extus creberae, interne ex primo tubo brevi et 3 poris satellitibus praeditae. Rimoportulae duae, oppositae, ad partem conjunctem frontis valvae et limbi praesentes, velut tubo proxime subter spina visiviles.

Valves circular, 13–60 μm in diameter with 7–8 fascicles in 10 μm. Valve surface slightly concentrically undulate. Areolae form fascicles. Fascicles uniseriate near valve center becoming bi- or triseriate near valve margin. Areolae on valve face and mantle have internally domed cribra. Interfascicles slightly raised externally. Spines regularly placed at the end of each interfascicle. One or two valve face fultoportulae, with a short primary pore tube and two satellite present. Mantle fultoportulae located below spines externally, occurring on every second or third interfascicles. Internally mantle fultoportulae have a short primary tube and three satellite pores. Two rimoportulae present opposite one another at the valve face/mantle junction, and visible externally as a short tube immeadiately beneath a spine.

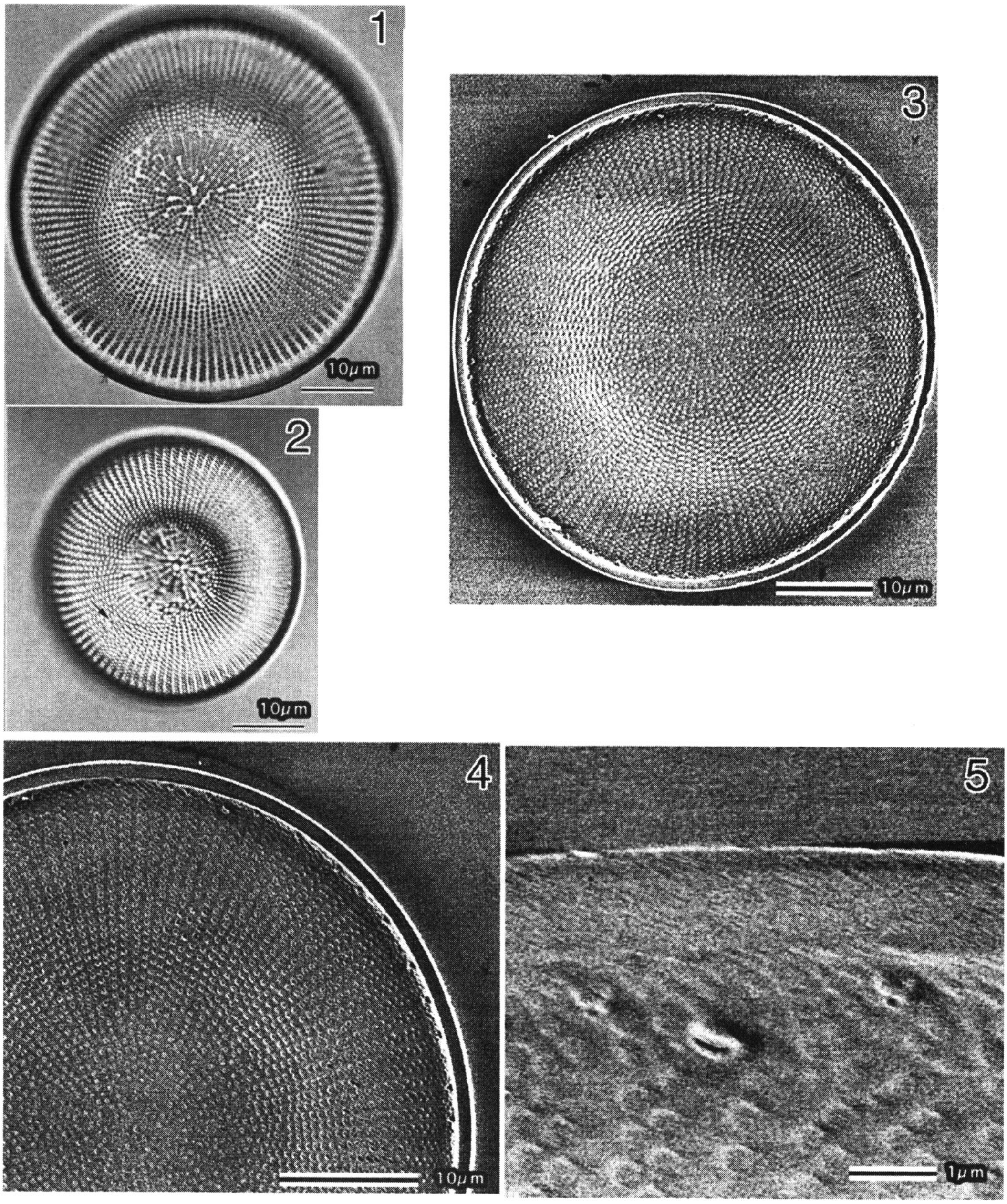
Holotype: TNS-AL-53966s, Department of Botany, National Science Museum, Tokyo, Japan.

Type Material: TNS-AL-53966m, Department of Botany, National Science Museum, Tokyo, Japan.

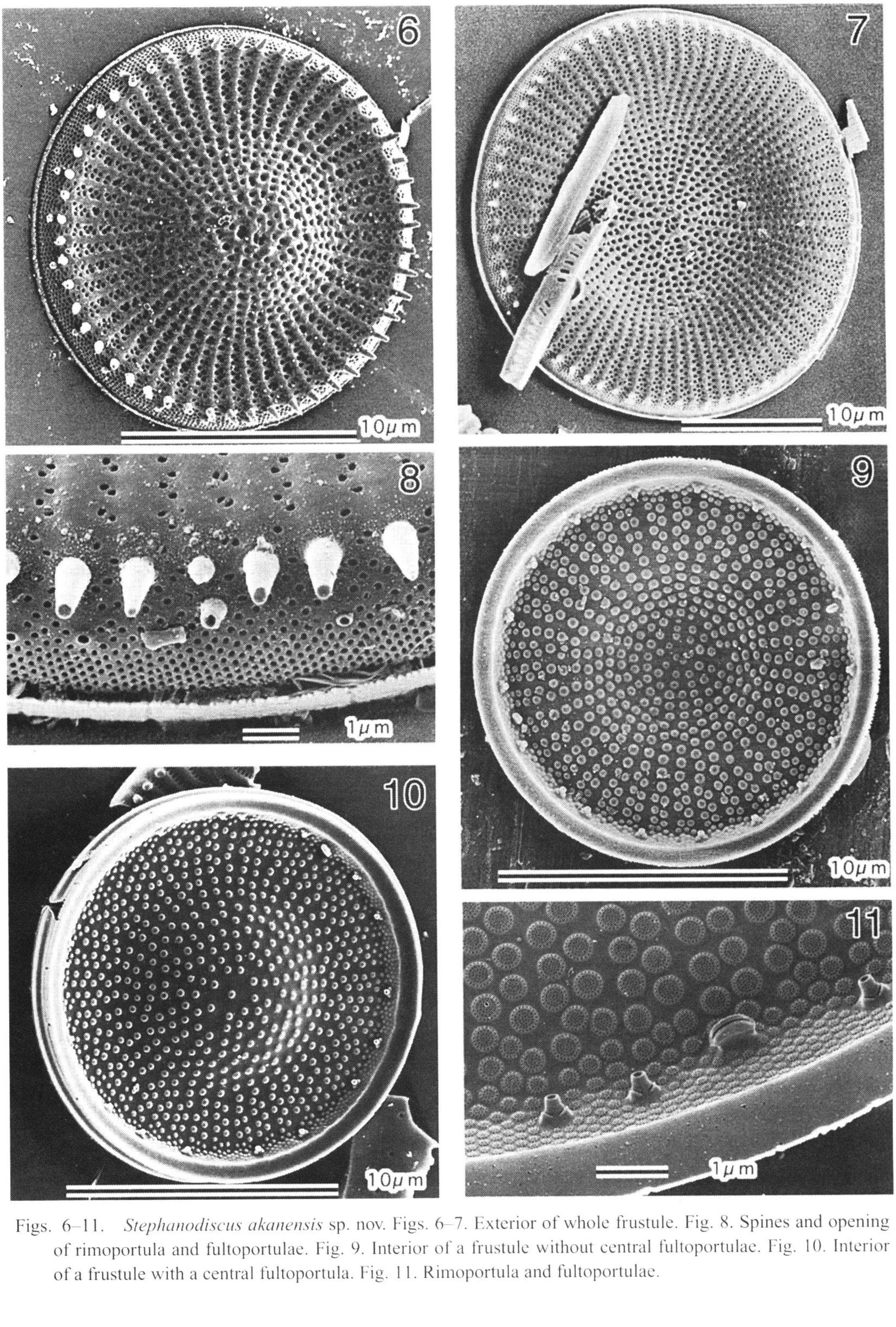
Type Locality: Lake Akan, Hokkaido, Japan.

Observations

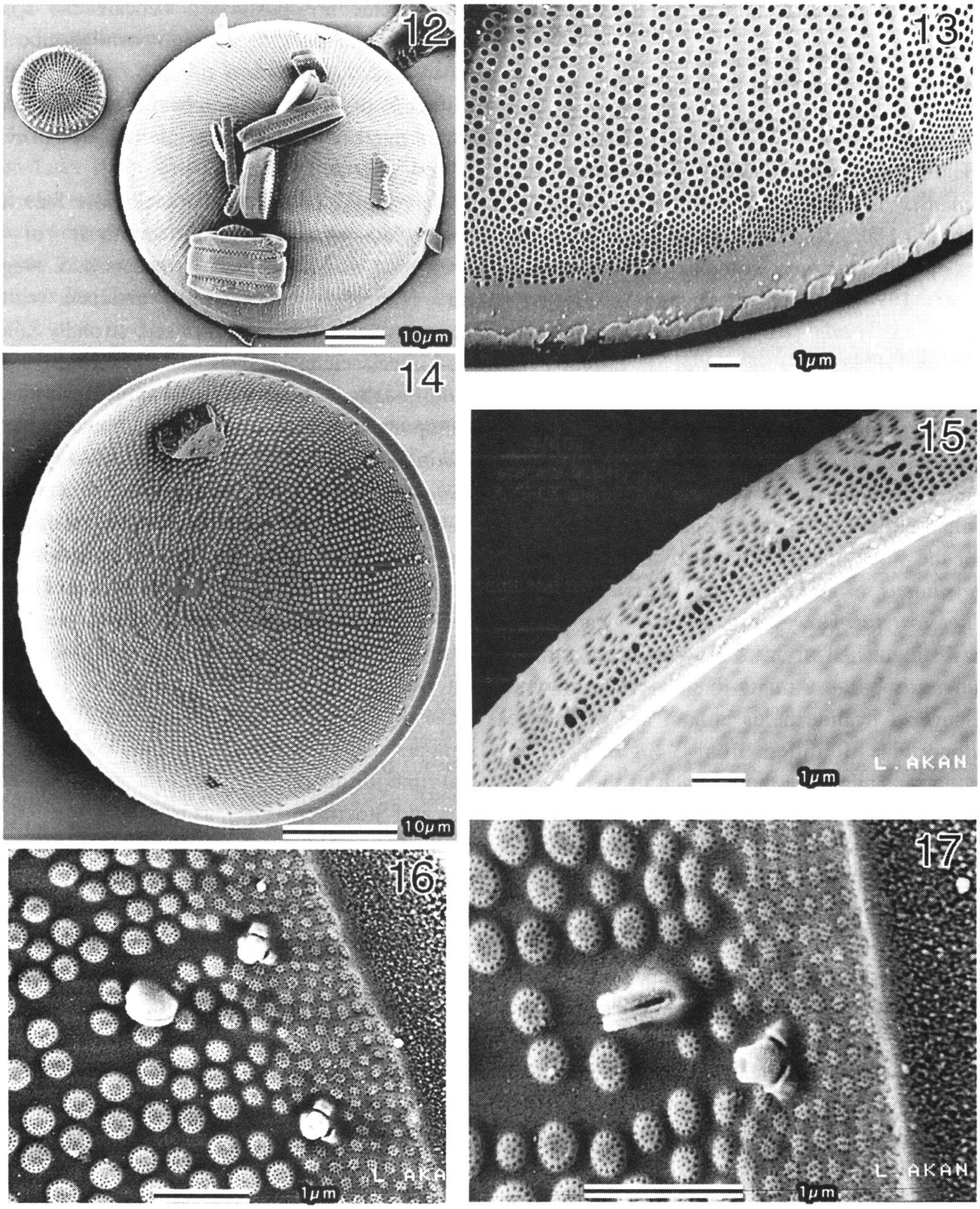
The fascicles of areolae are separated by distinct interfascicles (Figs. 1, 2). The areolae begin as single rows at the center of the valve face and increase to 2–3 rows (rarely 4) toward the valve face margin (Figs. 1–4, 6, 7). Areola density increases on the valve mantle beginning near the mantle fultoportulae horizon and continuing to the valve mantle edge. The areolae pattern also changes in conjunction with the density difference, moving from a fasciculate pattern to a decussate one. Areolae density on the mantle is approximately 60 in 10 μm and a single row parrallel to the valve radius contains 4–9 areolae. Punctae on the mantle occur in vertical files, numbering 6–7 punctae per vertical file. Spines occur at each interfascicle. One (rarely 2) valve face fultoportulae with two satelite pores occurs near the valve margin (Fig. 10). In some specimens this valve face process appears to be absent (Fig. 9). The number of valve face fultoportulae does not appear to be cell size related. *Stephanodiscus akanensis* does not have a "heterotopic fultoportulae position" as defined by Håkanson and Meyer (1994). The mantle fultoportulae with 3 satellite pores are positioned on the upper valve mantle (Figs. 3, 5, 6–8). Externally, mantle fultoportulae openings appear as simple pores with a slightly thickened rim, lacking a well developed external tube (Fig. 8). The two (rarely one) rimoportulae are opposite position from one another (Fig. 9). The rimoportulae occur directly underneath a spine and above the mantle fultoportulae horizon (Fig. 8). The labium of the rimoportulae appears to be variable direction (Figs. 9, 11). Initial cells were observed, and range from 55–60 μm in diameter. Spines are absent on initial valves and a broad, hyaline zone is present on the lower mantle (Figs. 12, 13), in contrast to the morphology expressed in vegetative valves. Internally, initial valves posses mantle fultoportulae with 3 satellite pores (Figs. 14, 16, 17), similar to the vegetative valves. Externally, the fultoportulae and rimoportuale appear as simple pores (Fig. 15), differing from the fultoportulae siliceous rim



Figs. 1–5. *Stephanodiscus akanensis* sp. nov. Figs. 1, 3–5. Holotype. Figs. 1–2. LM DIC images. Figs. 3–5. SEM images using the low vacuum SEM. Figs. 1, 3 Holotype frustule without central fultoportulae. Fig. 2. Frustule with central fultoportula (arrow). Figs. 4, 5. Rimoportula and fultoportulae.



Figs. 6–11. *Stephanodiscus akanensis* sp. nov. Figs. 6–7. Exterior of whole frustule. Fig. 8. Spines and opening of rimoportula and fultoportulae. Fig. 9. Interior of a frustule without central fultoportulae. Fig. 10. Interior of a frustule with a central fultoportula. Fig. 11. Rimoportula and fultoportulae.



Figs. 12–17. *Stephanodiscus akanensis* sp. nov., Initial valves. Fig. 12. Exterior of whole initial valve and a vegetative cell. Figs. 13, 15. Opening of fultoportulae. Fig. 14. Interior of whole initial valve. Figs. 16–17. Rimoportula and fultoportulae on initial valve.

and rimoportulae tube expressed in the vegetative valve.

Discussion

The valve face morphology of *Stephanodiscus akanensis* is similar to that of *S. oregonica* (Ehrenb.) Håk., *S. alpinus* Hust., and the members of the *S. niagarae* complex (Håkansson and Meyer 1994), which includes *S. niagarae* Ehrenb., *S. rotula* (Kütz.) Hendy, *S. neoastrea* Håk. et Hickel, *S. aegyptiacus* Ehrenb., *S. galileensis* Håk. et Ehrlich, *S. agassizensis* Håk. et Kling, and *S. heterostylus* Håk. et Meyer (Håkansson. 2002).

In *S. akanenesis*, the valve face fultoportulae number either 0 or 1 (rarely 2) and are positioned near the valve margin. This also characterizes *S. aegyptiacus*, *S. galileeensis*, *S. agassizensis*, and *S. heterostylus*. However, *S. akanensis* can easily be distinguished from *S. aegyptiacus* and *S. galileensis* because of its finer interfascicle and absence of hyaline fields around the valve face fultoportulae. It differs from *S. agassiensis* in having a smaller size range. Each of the preceding species always has a single rimoportula, differing from *S. akanensis* which generally bears 2 rimoportulae and only rarely exhibits a single rimoportula. *S. akanensis* differs from *S. heterostylus* in its mantle fultoportulae positioning. In *S. heterostylus* the mantle fultoportulae are always located beneath a spine and positioned near the spine base. In *S. akanensis* the mantle fultoportulae are also located beneath spines, but their distance from the spine base is greater than the positioning expressed in *S. heterostylus*. Additionally, *S. heterostylus* has a higher maximum number of valve face fultoportulae, as described by Håkansson and Meyer (1994). *S. niagarae* has a broader mantle with areolae consisting of pervalvar rows of 10–12 areolae, in contrast to *S. akanensis* which possesses pervalvar rows of 4–9 areolae. The rimoportulae of *S. niagarae* are positioned within the spine horizon, with the external rimoportuae tube taking the place of a spine (Theriot and Stoermer. 1984). In contrast, *S. akanensis* the rimoporulae are positioned beneath the spine horizon, with the external rimoportulae tube located directly beneath a spine. *S. niagarae* also differs from *S. akanensis* in having a higher maximum number of valve face fultoportulae (Theriot and Stoermer. 1984).

Valves of *S. akanensis* that lack valve face fultoportulae appear similar to those of *S. oregonica*, *S. alpinus*, and *S. neoastrea*. *S. oregonica* is strongly concentrically undulate, with a lacunate central area, and raised, strongly silicified interfascicles (Håkansson and Kling. 1999). Additionally, *S. oregonica* only expresses a single rimoportula (Håkansson. 1986). These features distinguish *S. oregonica* from *S. akanensis*. *S. neoastrea* can be distinguished from *S. akanensis* through observation of rimoportulae placement. In *S. neoastrea* the rimoportulae are positioned between interfascicle (Håkansson and Hickel, 1986; Håkansson and Meyer, 1994), but in *S. akanensis* the rimoportulae are positioned on a interfascicle (Figs. 9–11). *S. akanensis* is distinguishable from *S. alpinus* through differences in rimoportulae placement. *S. alpinus* has the external rimoportula tube in place of a spine (Håkansson and Stoermer, 1984), as in *S. niagarae*, while in *S. akanensis* the external rimoportula tube occurs directly under a spine. The maximum number of valve face fultoportulae expressed in each species represents an additional difference between *S. akanensis* and *S. alpinus*. *S. alpinus* always has 0 or 1 valve face fultoportulae, while *S. akanensis* can have 2 valve face fultoportulae.

Takayasu *et al.* (1930) first described Lake Akan's plankton flora and fauna. There is no information concerning *Stephanodiscus* species in this paper. Negoro and Watanabe (1977) discussed *S. astrea* and *S. astrea* var. *minutula* being present in Lake Akan. Kawashima and Kobayasi (1993) described the diatom flora in detail, using both LM and SEM observations. They discussed an unidentified *Stephaonodiscus* sp. and *Actinocyclus* sp., which they felt had been identified by earlier investigators as *S. astrea* and *S. astrea* var. *minutula*. Hustedt (1930) was widely used by many Japanese diatomists for identification of freshwater diatom species. This work contains limited information about *Stephanodiscus* species, and its use can lead to misidentification of specific *Stephanodiscus* species. Recently, Tuji & Kociolek (2000) described two new species from Lake Biwa, *Stephanodiscus suzukii* Tuji & Kociolek and *S. pseudosuzukii* Tuji & Kociolek, which were previously identified as *S. carconensis* var. *carconensis* Grunow and *S. carconensis* var. *pusilla* Grunow by Skvortzow (1936). Tuji (2002) also re-described *Aulacoseira nipponica* (Skvortzow) Tuji from Lake Biwa, where they had been identified previously as *A. solida* (Eulenstein) Krammer. Misidentification of Japanese centric diatom taxa should continues, and the rediscovery of new species like *S. akanensis* emphasize the need for more study of freshwater centric diatom taxonomy in Japan.

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