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Sabbea gen. nov., a new diatom genus (Bacillariophyta) from continental Antarctica

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Abstract

The non-marine diatom flora of the Antarctic Continent includes several endemic taxa recorded over the past 100 years. One of these taxa, *Navicula adminensis* D.Roberts & McMinn*,* was described from the Vestfold Hills, East Antarctica. Detailed light and scanning electron microscopy observations have shown that based on its morphological features, the species does not belong to the genus *Navicula sensu stricto*. To determine the most closely related genera to *N. adminensis*, the morphological features of *Adlafia*, *Kobayasiella*, *Envekadea*, *Stenoneis*, *Berkeleya*, *Climaconeis,* and *Parlibellus* were compared with those of *N. adminensis*. Although each of these genera shows one or more similar features, none of them accommodates the salient morphological characteristics of *N. adminensis*. Therefore, a new genus, *Sabbea gen. nov.*, is herein described, and *Navicula adminensis* is formally transferred to the new genus as *Sabbea adminensis comb. nov*. The genus *Sabbea* is characterized by uniseriate striae composed of small, rounded areolae occluded externally by individual hymenes, a rather simple raphe structure with straight, short proximal ends and short terminal raphe fissures, open girdle bands with double perforation and a very shallow mantle.

Keywords: Bacillariophyta, Cape Royds, East Antarctica, McMurdo Dry Valleys, new genus, Vestfold Hills

Introduction

At the beginning of the 20th century, British, Belgian, Danish, and German expeditions into the Antarctic provided the world with the first glimpses of diatoms from continental Antarctica (Holmboe 1902, Van Heurck 1909, West & West 1911, Fritsch 1912, 1917, Carlson 1913, Brown 1920). These primary works were later expanded upon by other authors, whom either examined intraspecific variation within a selection of these pennate diatoms (such as Kobayashi 1963, 1965), or published detailed floras of particular regions (e.g., Fukushima 1963, 1966, Cremer *et al*. 2003). Yet, many of these reported diatoms were still identified as European or cosmopolitan taxa. In 2002, Kellogg and Kellogg compiled a list of all non-marine diatom records within the Antarctic Region based on data reported in over 300 publications, and found the majority belonged to cosmopolitan taxa. Given that recent taxonomic revisions of the diatom flora from the sub-Antarctic islands and the Maritime Antarctic Region have indicated that the cosmopolitan nature of non-marine Antarctic diatoms is overestimated (Van de Vijver *et al.* 2002, Zidarova *et al.* 2016, and references therein) and originates as a result of 'force-fitting' species into American or European names (Jones 1996, Tyler 1996, Sabbe *et al.* 2003), it is likely that the same holds true for diatoms of the Antarctic continental Region as well.

Many more recent works have revealed new diatom species endemic to continental Antarctica which have been historically overlooked or misidentified as cosmopolitan/European taxa. For example, Esposito *et al.* (2008) described four new species from the McMurdo Dry Valleys, and Van de Vijver *et al.* (2012) described *Luticola pseudomurrayi* Van de Vijver & Tavernier *in* Van de Vijver *et al.* (2012: 164) and *Chamaepinnularia gibsonii* Van de Vijver *in* Van de

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Vijver *et al.* (2012: 166) from the Bunger Hills and Lützow Holm Bay, both situated in East Antarctica. Revisions of problematic genera have also been treated, as in the case of *Muelleria* (Frenguelli 1924: 256) Frenguelli (1945: 172, Spaulding & Stoermer 1997, Spaulding *et al*. 1999, Van de Vijver *et al*. 2010), *Nitzschia* Hassall (1845: 435, Hamsher *et al.* 2016), *Halamphora* (Cleve 1895: 117) Levkov (2009: 165, Van de Vijver *et al.* 2014), and *Luticola* D.G.Mann *in* Round *et al*. (1990: 670, Kohler *et al.* 2015). These studies collectively suggest that the endemic diversity of continental Antarctica is similarly underestimated with more species awaiting description, bringing results in line with those observed for the Maritime Antarctic and Sub-Antarctic Islands.

Despite this recent progress, problematic taxa still remain in areas of high scientific significance, such as the McMurdo Sound Region and the Vestfold Hills of East Antarctica. In 1911, W. and G.S. West reported a small diatom species they identified as *Navicula perlepida* Grunow (1884: 474) from the lakes at Cape Royds, Ross Island. However, it was not illustrated, and given the only modest written description, it is difficult to say for certain what diatom they saw in their microscope. Despite this, a diatom presumed to be the same species is still reported from Ross Island (Sakaeva *et al*. 2016) and the adjacent McMurdo Dry Valleys (Whittaker *et al.* 2008) in modern times and is known to be accommodated by the wrong genus, though the correct one remains in doubt (Esposito *et al*. 2008). Across the continent, Roberts & McMinn, in a series of publications, analyzed the diatom flora from the saline lakes of the Vestfold Hills, developed transfer functions for salinity, and described two *Navicula* species (Roberts & McMinn 1999 and references therein). One of these, *N. adminii* D.Roberts & McMinn (1999: 27), was described from the sediments of Lake Admin (Vestfold Hills). The species is characterized by lightly silicified valves, a simple raphe system and an extremely fine striation pattern not discernible in light microscopy (LM). The description of the new species was accompanied by several scanning electron microscopy (SEM) observations, showing a strong similarity to those later published in Esposito *et al*. (2008) from McMurdo Sound. Given that this taxon is distributed in regions of particular scientific interest, as well as its potential historic and ecological indicator value, we here investigate the taxonomic placement and ecology of this *Navicula* s.l. species. As a first step, Van de Vijver & Kusber (2018) corrected the erroneous typification (holotype and isotype originating from different lakes) and changed the name to *N. adminensis* (Van de Vijver & Kusber 2018: 1). In this work, a re-analysis of the type material of Roberts & McMinn (1999) under LM (and in combination with their published SEM pictures), together with new and published SEM observations from Ross Island and the McMurdo Dry Valleys, has resulted in new observational data on *N. adminensis* that challenge its placement within the genus *Navicula* Bory (1822: 128) as it was redefined by Cox (1979). Since the combination of morphological features observed in *N. adminensis* is unique and is not found in any described genus worldwide, a new genus, *Sabbea* Van de Vijver, Bishop & Kopalová *gen. nov.*, is proposed for this species.

Materials & Methods

Site descriptions

Samples from the Vestfold Hills and the McMurdo Sound Region of the Antarctic Continent were investigated in the present study. Table 1 lists all samples with some measured physico-chemical data.

The Vestfold Hills (68˚25'–68˚40'S, 77˚50'–78˚35'E) form an ice-free area along the Ingrid Christensen Coast, Princess Elizabeth Land, eastern Antarctica. The Vestfold Hills contain over 300 lakes, ranging in salinity from fresh to hypersaline, across an area of 400 km^2 (Roberts & McMinn 1999). They display a marked influence from the sea, and consequently salinity and silicate appear to structure the diatom flora (Roberts & McMinn, 1996). In a study of the Vestfold Hills lakes Roberts & McMinn (1999) reported on samples collected from surface sediments (0–2cm) from the deepest point of the lakes (n=33). Admin Lake, which has a maximum depth of 6 m, is located at an elevation of nearly 9 m above sea level (Roberts & McMinn 1999, Gibson 1999). Sediment sub-samples were then prepared in triplicate for diatom analysis. One of the sets of replicate microscope slides (n=30) was used in the current analysis. From these, slide "AD-3", from Admin lake was used to examine the population of *N. adminensis* from the type locality. Unfortunately, the original material, as well as the first and second replicate slide collections, no longer remain (A. McMinn, pers. comm.), which means that the holotype slide is lost and therefore, a lectotype slide must be designated (Turland et al. 2018, article 9.3).

The McMurdo Sound Region is located in Victoria Land, East Antarctica, and includes the area between the Transantarctic Mountains and the Ross Sea. Ross Island is 2,460 km^2 in area and surrounded by the Ross Sea and McMurdo Sound. Cape Royds, situated on western Ross Island, is an ice-free, coastal area (~13 km^2) between Mt. Erebus and the Ross Sea. Five permanent, generally ice-covered lakes are found at Cape Royds along with more than

TABLE 1. Examined populations of *Navicula adminensis*. Data compiled from Roberts & McMinn 1999 and MCM LTER (http://huey.colorado.edu/diatoms/)

Sample ID/Accession Number	Locality	Lake ID	Sample type	Collection Date	South	East	pH	Salinity range (%)	Specific conductance (μ)
AD-3 (BR-collection)	Vestfold Hills	Admin Lake	Benthic sediments	Nov/Dec-1992	68°27.2	78°16.5	na	14.8 - 17.5	na
2488 (INSTAAR Diatom coll.)	Cape Royds	Blue Lake, north lobe	Benthic microbial mat	24-Jan-2013	77°32’ 38.4”	166°10’ 35.87”	6.7	na	820
2462 (INSTAAR Diatom coll.)	Cape Royds	Clear Lake	Benthic microbial mat	24-Jan-2013	77°32’ 31.85”	166°9’ 41.15”	7.4	na	845
2464 (INSTAAR Diatom coll.)	Cape Royds	Clear Lake	Benthic microbial mat	24-Jan-2013	77°32’ 31.85”	166°9’ 41.15”	7.4	na	845
359 (INSTAAR Diatom coll.)	McMurdo Dry Valleys	Lake Fryxell	Benthic sediments (16 cm depth)	1-Jan-2003	77°37’ 0”	163°11’ 0”	7.8 - 8.3†	na	160 - 3900‡
364 (INSTAAR Diatom coll.)	McMurdo Dry Valleys	Lake Fryxell	Benthic sediments (50 cm depth)	1-Jan-2003	77°37’ 0”	163°11’ 0”	7.8 - 8.3†	na	160 - 3900‡
390 (INSTAAR Diatom coll.)	McMurdo Dry Valleys	Lake Fryxell	Benthic sediments (111 cm depth)	1-Jan-1999	77°37’ 0”	163°11’ 0”	7.8 - 8.3†	na	160 - 3900‡

† pH measured up to 7 m water column depth by Lawrence and Hendy (1985)

‡ Specific conductance measured from 5 m - 7 m water column depth by Aiken et al. (1996)

10 ephemeral ponds. Of these, Blue Lake, which is the farthest from the sea, is characterized by north (0.4 km^2) and south (0.6 km^2) lobes. Benthic mat samples and water chemistry from Cape Royds lakes were collected in January 2013 (Sakaeva *et al.* 2016) as part of the McMurdo Dry Valleys Long-Term Ecological Research (MCM LTER) project. From the aforementioned data, 3 benthic mat populations from 2 lakes on Cape Royds were investigated: 2 from Clear Lake (INSTAAR, Univ. of Colorado accession numbers : 2462 & 2464) and 1 from Blue Lake (north lobe) (INSTAAR, Univ. of Colorado accession number: 2488).

The McMurdo Dry Valleys (~4,800 km^2) is the largest ice-free region of Antarctica. In Taylor Valley, Lake Fryxell (7.8 km^2) is 6.5 km inland from McMurdo Sound, up to 20 m deep, fed by glacial meltwater, and is ice-covered year-round, with near-shore "moat" regions becoming ice-free during the summer. Three samples originated from the F2 core from Lake Fryxell (INSTAAR, Univ. of Colorado accession numbers: 259, 364, and 390, respectively), analyzed by Whitaker *et al.* (2008) for inferring Holocene lake levels in Lake Fryxell. Furthermore, Esposito *et al.* (2008) examined 2 diatom specimens (INSTAAR, Univ. of Colorado accession numbers: 364 and 390, respectively), under both LM and SEM, in an effort to describe the diatom flora of the McMurdo Dry Valleys.

Sample preparation and analyses

Blue lake (INSTAAR, Univ. of Colorado accession number: 2488) and Clear Lake (INSTAAR, Univ. of Colorado accession numbers: 2462 and 2464) samples were prepared for LM observation following the method described in van der Werff (1955). Small parts of the sample were cleaned by adding 37% H_2O_2 and heating to 80°C for about 1h. The reaction was completed by addition of $KMnO_4$. Following digestion and centrifugation (three times 10 minutes at 3,700 x g), cleaned material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom material was mounted in Naphrax®. The slides were analyzed using an Olympus BX53 bright field microscope and the Olympus UC30 Imaging System. Samples and slides are stored at the BR-collection (Botanic Garden Meise, Belgium). For SEM analyses, specifically the Blue Lake samples, parts of the oxidized suspensions were filtered through a 1-µm Isopore™ polycarbonate membrane filter (Merck Millipore). The stubs were sputter-coated with a Gold-Palladium layer of 20 nm and studied on a ZEISS Ultra SEM microscope at 3 kV (Natural History Museum London, UK).

Diatom terminology follows Ross *et al.* (1979) (stria/areola structure) and Round *et al.* (1990) (raphe structure). The morphology of the new genus was compared with the ultrastructure of similar genera described worldwide: *Adlafia* Lange-Bertalot *in* Moser *et al.* (1998: 87) (Moser *et al.* 1998, Lange-Bertalot 2001), *Navicula*, *Kobayasiella* Lange-Bertalot *in* Lange-Bertalot & Genkal (1999: 272) (Lange-Bertalot 1996, 1999) *Envekadea* Van de Vijver *et al. in* Gligora *et al.* (2009: 136) (Gligora *et al.* 2009), *Climaconeis* Grunow (1862: 107) (Cox 1982, Prasad *et al.* 2000, Prasad 2003), *Berkeleya* Greville (1827: 294) (Cox 1975), *Stenoneis* Cleve (1894: 123) (Poulin 1990) and *Parlibellus* E.J.Cox (1988: 19) (Cox 1988).

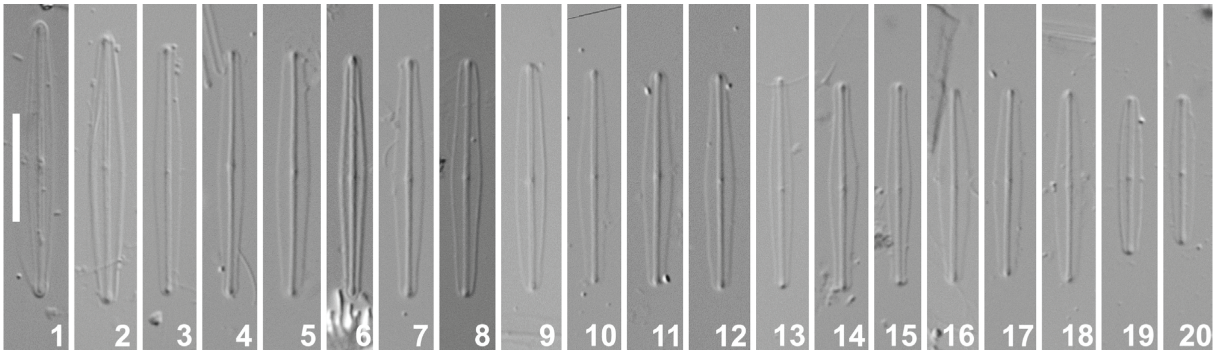
Results

***Navicula adminensis* D.Roberts *et* McMinn *in* Van de Vijver *et* Kusber (2018)** (Figs 1–29)

Replaced name: *Navicula adminii* D.Roberts & McMinn (1999)

LM (Figs 1–20):—Valves very weakly silicified, often not well-visible in LM. Valves linear-lanceolate with rhombic-convex margins and protracted, broadly rounded, often weakly subcapitate apices. Longer specimens usually with more elongated apices. Valve dimensions from the type population at Admin Lake within the Vestfold Hills: (n=50): length 14–30 µm, width 2–3 µm. Raphe-sternum clearly visible with the raphe positioned in the middle of the sternum. Proximal raphe ends hardly visible. Transapical striae not discernible in LM. **SEM (Figs 21–29):**—Frustules very thin. Girdle composed of several, open copulae, each with a double row of rounded to transapically elongated poroids (Figs 21, 22). Striae parallel to very weakly radiate throughout, composed of very small, rounded areolae, 70–80 in 10 µm (Figs 21, 24). Striae continuing without interruption from valve face onto a very shallow mantle. Around the apices, short striae composed of 1–2 areolae continuing without interruption (Fig. 26). Areolae, ca. 110 in 10 µm, covered externally by small hymenes (Fig. 23). When eroded, areolae showing a relatively large range in pore diameter (Fig. 25). External raphe branches straight, located on a weakly thickened raphe-sternum. On both sides of the raphe-sternum forming very weakly raised ribs (Figs 25, 26). Proximal raphe ends close to each other, straight, simple (Fig. 25). Terminal raphe fissures absent (Fig. 26). Internally, raphe fissures running on a raised raphe-sternum (Fig. 27).

Proximal raphe ends straight, simple (Fig. 28). Distal raphe ends terminating in very weakly developed helictoglossae (Fig. 29). Virgae usually broader than the striae (Fig. 28).



FIGURES 1–20. *Sabbea adminensis* (D.Roberts & McMinn) Van de Vijver, Bishop & Kopalová *nov. comb.* All valves were imaged from the Vestfold Hills type population on slide "AD-3". LM photographs of valves in diminishing size range. Scale bar represents 10 µm.

Remarks:—Three benthic mat populations from 2 lakes on Cape Royds were investigated: two from Clear Lake and one from Blue Lake. Table 2 shows valve length and valve width ranges for the investigated populations. From Clear Lake, (INSTAAR, Univ. of Colorado accession 2462) (n = 20) valve length ranged from 19.7 to 25.9 µm ($\bar{x}$ = 23 ± 2 µm) and mid-breadth from 2.0 to 3.1 µm ($\bar{x}$ = 2.8 ± 0.3 µm), and (INSTAAR, Univ. of Colorado accession 2464) (n = 18) valve length ranged from 17.5 to 24 µm ($\bar{x}$ = 20 ± 1.6 µm) and mid-breadth from 2.1 to 3.1 µm (average 2.5 ± 0.3 µm). Valve dimensions from a benthic mat population from Blue Lake (north lobe), (INSTAAR, Univ. of Colorado accession 2488) (n = 21), ranged from valve length 18.0 to 26.6 µm (average 20.8 ± 2.6 µm) and mid-breadth from 2.6 to 3.9 µm (average 3.2 ± 0.4 µm). Three sediment core sections taken from Lake Fryxell within the McMurdo Dry Valleys were investigated: 16 cm and 50 cm deep from a 170 cm core and 111 cm deep from a 175 cm core. At 16 cm (Accession 3559, n=10), valve length measured 13.8–23.4 µm ($\bar{x}$ = 17 ± 3.4 µm) and mid-breadth measured 2.4–3.2 µm ($\bar{x}$ = 2.7 ± 0.3 µm). At 50 cm (Accession 364, n=20), valve length measured 9.7–19.4 µm ($\bar{x}$ = 14 ± 2.8 µm) and mid-breadth measured 2.2–3.1 µm ($\bar{x}$ = 2.6 ± 0.3 µm). At 111 cm (Accession 390, n=12), valve length measured 10.0–23.7 µm ($\bar{x}$ = 14 ± 3.8 µm) and mid-breadth measured 1.9 – 3.6 µm ($\bar{x}$ = 2.6 ± 0.4 µm).

TABLE 2. Habitat conditions and population morphometrics for examined populations.

				Valve length (µ)		Valve width (µ)	
Sample ID	Locality	Lake ID	Valves measured	Range	Mean ±sd	Range	Mean ±sd
AD-3	Vestfold Hills	Admin Lake	76	18.8–28.4	21.8 ±2.9	2.1–3.2	2.7 ±0.4
2488	Cape Royds	Blue Lake, north lobe	21	18.0–26.6	20.8 ±2.6	2.6–3.9	3.2 ±0.4
2462	Cape Royds	Clear Lake	20	19.7–25.9	23.0 ±2.0	2.0–3.1	2.8 ±0.3
2464	Cape Royds	Clear Lake	18	17.5–24.0	20.0 ±1.6	2.1–3.1	2.5 ±0.3
359	McMurdo Dry Valleys	Lake Fryxell	10	13.8–23.4	17.0 ±3.4	2.4–3.2	2.7 ±0.3
364	McMurdo Dry Valleys	Lake Fryxell	20	9.7–19.4	14.0 ±2.8	2.2–3.1	2.6 ±0.3
390	McMurdo Dry Valleys	Lake Fryxell	12	10.0–23.7	14.0 ±3.8	1.9–3.6	2.6 ±0.4

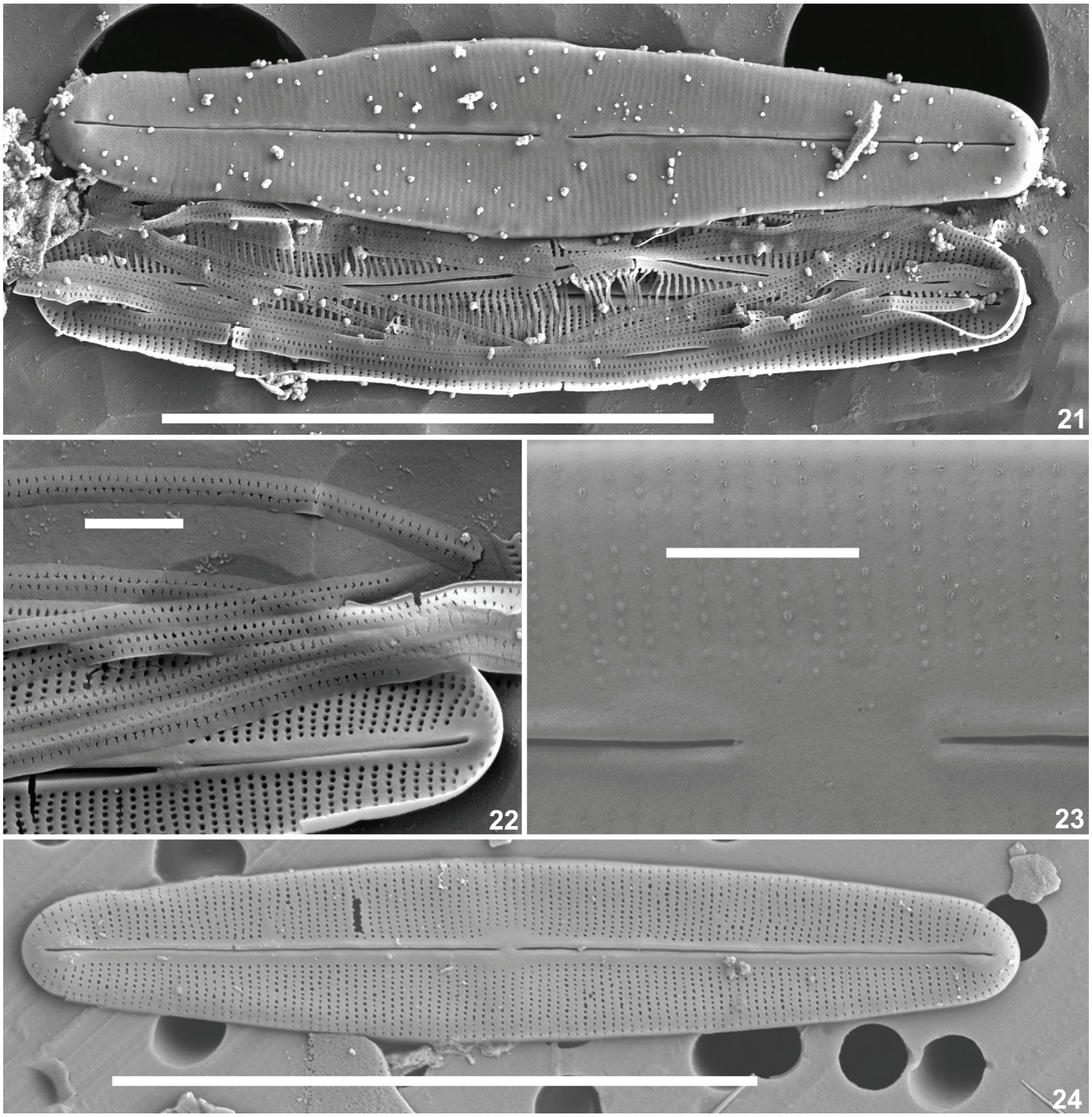
Typification: Unfortunately, the holotype and paratype slides are lost. Moreover, also the original unmounted material, used to prepare the holotype slide from, was destroyed. However, an additional set of slides, prepared from the original material of the Vestfold Hills study was kept for counting purposes. One slide (AD-3) of this set was prepared from the same original material as the (lost) holotype slide. Therefore, this slide is officially designated here as lectotype slide. As there is no original material left, an additional sample containing the population that was used for the SEM analysis from Blue Lake (accession 2488) is added as epitype.

Lectotype (designated here): BR-4555 (Meise Botanic Garden, Belgium, slide AD-3, Admin Lake, Vestfold Hills, Antarctic Continent)

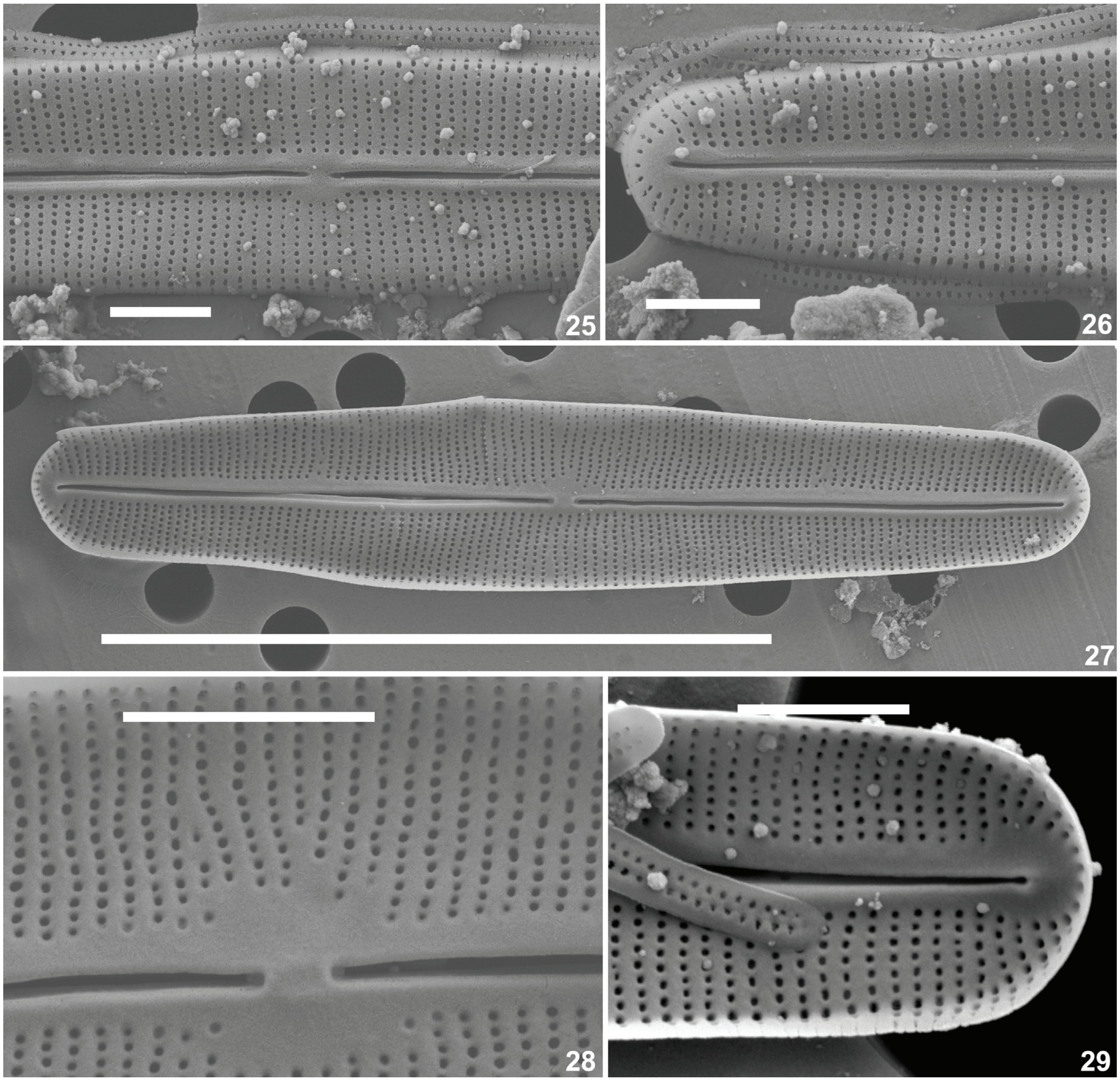
Epitype (designated here): BR-4556 (Meise Botanic Garden, Belgium, sample accession 2488, Blue Lake, McMurdo Sound, Antarctic Continent)

Ecology & Distribution:—*Navicula adminensis,* as *Navicula adminii,* has been reported from the Vestfold Hills, Bunger Hills, and the McMurdo Sound Region (Roberts & McMinn 1999, Roberts *et al.* 2000, Gibson *et al.* 2006, Sakaeva *et al.* 2016). From the McMurdo Dry Valleys, specifically Taylor Valley, Esposito *et al.* (2008) reported this taxon as *N. lineola* var. *perlepida* (Grunow 1884: 474) Cleve (1894: 107) (although under the invalidly published name *N. perlepida*), suggesting the taxon was erroneously placed in *Navicula* and needing further work (Esposito *et al*. 2008, Whittaker *et al*. 2008).

Within the Vestfold and Bunger Hills, *N. adminensis* was reported across a wide salinity gradient in 24 and 10 lakes, respectively, despite the classification of its type locality, Admin Lake, as hyposaline. However, Sakaeva *et al.* (2016) also reported *N. adminensis* at lower salinity levels in Blue Lake and Clear Lake on Ross Island and from the partially ice-free Picture Pond in Taylor Valley within the McMurdo Sound Region.



FIGURES 21–24. *Sabbea adminensis* (D.Roberts & McMinn) Van de Vijver, Bishop & Kopalová *nov. comb.* Figures taken from Blue Lake, Cape Royds, Ross Island, Antarctic Continent (INSTAAR, Univ. of Colorado accession numbers: 2488). Fig. 21. Scanning electron micrograph of an entire frustule with girdle bands. Note the external areola hymenes, the shallow mantle, the simple raphe and the girdle bands with double perforation. Fig. 22. SEM detail of the girdle bands clearly showing the two rows of pores per copula. Fig. 23. SEM external detail of the areolae with partly eroded external hymenes. Fig. 24. SEM external view of an entire valve showing the eroded uniseriate striae with small areolae. Scale bar represents 10 µm for figs 21, 24 and 1 µm for figs 22 & 23.



FIGURES 25–29. *Sabbea adminensis* (D.Roberts & McMinn) Van de Vijver, Bishop & Kopalová *nov. comb.* Figures taken from Blue Lake, Cape Royds, Ross Island, Antarctic Continent (INSTAAR, Univ. of Colorado accession number: 2488). Fig. 25. SEM external detail of the central area with the short, straight proximal raphe endings, the narrow, weakly raised ridges next to the raphe and the uniseriate striae. Fig. 26. SEM external detail of the valve apex showing the absence of the terminal raphe fissures. Fig. 27. SEM internal view of an entire valve. Fig. 28. SEM internal detail of the central area with the short, straight proximal raphe endings. Fig. 29. SEM external detail of the valve apex showing an only weakly developed helictoglossa. Scale bar represents 10 µm for fig. 27 and 1 µm for figs 25, 26, 28 & 29.

Discussion

The first record of *Navicula adminensis* is found in West & West (1911), reported as *N. perlepida*. The species was originally described by Grunow in 1884 from Franz Joseph Land (Grunow 1884) and later recombined by Cleve to *N. lineola* var. *perlepida* (Cleve 1894). Unfortunately, apart from some basic data on length and width, the only information given in West & West (1911, p. 282) is the high similarity between the Antarctic population and specimens from the Arctic. Later authors (Esposito *et al.* 2008, Van de Vijver *et al.* 2012) suggested, based on valve outline and the fine morphological structure, that *Navicula adminensis* could in fact be conspecific with *Navicula lineola* var. *perlepida*. Given the very fine structure, only scanning electron microscope observations could resolve the conspecificity question. Unfortunately, unmounted material was no longer available from the Grunow collection in Vienna (Austria) (A. Igersheim, pers. comm.). In literature, only a few published images are available from the var. *perlepida* (other than Antarctic populations that are considered belonging to *Navicula adminensis*). Hustedt (1961) showed a few line-drawings that unfortunately did not provide conclusive morphological information. Witkowski *et al.* (2000) discussed the species in his Baltic diatom monograph and illustrated both *N. lineola* and its variety *perlepida* (plate 156, figs15–16 and 12–14 resp.).

The most interesting record was found in Poulin & Cardinal (1982) who published several SEM pictures (figs 63–65). In their description the presence of a transapical fascia in the central area bordered by a few scattered areolae was explicitly mentioned. Moreover, the striae become denser toward the valve apices. Valve dimensions of the observed specimens show a valve length of 30–52 µm, a valve width of 3–5 µm and a stria density of 35–38 in 10 µm increasing to 39–42 in 10 µm near the apices. All these observations are in contrast with the morphology as recorded for *N. adminensis*: a fascia has never been observed in any of the reported populations, the stria density is uniform throughout the entire valve and reaches almost 80 in 10 µm. The population studied in Poulin & Cardinal (1982) originated from Manitounuk Sound in the southeastern Hudson Bay (Canada), relatively far away from the type locality of the species near Franz Joseph Land (Grunow 1884). Although there is no conclusive evidence that both Arctic populations represent the same species, the observed LM morphology in Poulin & Cardinal (1982) shows no differences with the species described by Grunow. However, the Arctic populations differ markedly from *N. adminensis* making conspecificity between *N. lineola* var. *perlepida* and *N. adminensis* unlikely.

Whether all Antarctic records of *N. lineola* var. *perlepida* should be considered to be *N. adminensis*, remains a question that can only be solved by careful re-examination of the material, as most of the published records did not present LM or SEM images. Whittaker *et al*. (2008) found *Navicula lineola* var. *perlepida* to be dominant within layers of a sediment core associated with increased carbonate concentrations in Lake Fryxell (Taylor Valley, McMurdo Dry Valleys). Although the species was unfortunately not imaged in the publication, its presence was later confirmed by one of the co-authors (S. Spaulding, pers. comm.). Esposito et al. (2008) illustrated the species from the McMurdo region, naming it also *N. lineola* var. *perlepida*. The latter authors presented detailed SEM observations that showed a clear conspecificity with the population from Admin Lake that was used for the description of *N. adminensis* (Roberts & McMinn 1999).

In 1979, Cox typified the genus *Navicula* based on *N. tripunctata* (O.F.Müller 1786: 52) Bory (1827: 563). The main morphological features of *Navicula* s.s. include a typical lineolae-structure of the striae, a boat-shaped valve outline, two rectangular, plate-like plastids, internal raphe branches located on the side of an axial costa, external terminal raphe fissures deflected to the same (secondary) side and indistinct or weakly curved proximal raphe pores. It is clear that *N. adminensis* shows an entirely different set of morphological characters, making its placement within the genus *Navicula* s.s. no longer possible. A transfer to another, more suitable and taxonomically discrete genus is therefore necessary.

The presence of *N. adminensis* in both hyper- and hypo-saline lakes, but with an accompanying diatom flora of both marine and freshwater species (based upon re-investigation of Vestfold Hills material used in Roberts & McMinn, 1999), make a comparison with both similar marine and freshwater genera necessary. Only a few freshwater genera share some of the morphological features of *N. adminensis*: *Adlafia*, *Envekadea* and *Kobayasiella*. In the marine realm, especially in the family Berkeleyaceae, the genera *Stenoneis*, *Climaconeis*, *Parlibellus* and *Berkeleya* should be considered as holding the possible closest relationship to *N. adminensis*. Table 3 presents all these genera together with their discriminating features. Based on the table, it is clear that almost all mentioned genera show some resemblance to *N. adminensis,* but none sufficiently adequate to host the species.

The genera *Envekadea*, *Adlafia* and *Kobayasiella* show a superficial resemblance when only considering the morphological features visible in light microscopy. All three genera contain species with very fine areolae making the striae hardly visible in LM. Unlike *N. adminensis*, all three genera have an entirely different raphe structure with deflected or even hooked terminal raphe fissures (*N. adminensis* lacks terminal raphe fissures) and internally with well-developed helictoglossae, unlike the weakly-developed helictoglossae in *N. adminensis*. The striae in *Kobayasiella* are composed of one transapically elongated areola and the raphe has an umbilicus, visible as a slight 'notch', at about one third to halfway along the straight raphe (Vanhoutte *et al.* 2004), a feature never observed in *N. adminensis*. Almost all *Adlafia* species show a typical striation pattern with radiate striae becoming convergent near the apices, whereas the striae in *N. adminensis* are parallel throughout the entire valve. *Envekadea*, containing mostly brackish water species, has a very distinct sigmoid raphe system, rather large areolae arranged in radiate striae and well-developed helictoglossae. All three genera can therefore be excluded as a host genus for *N. adminensis*.

TABLE 3. Discriminating features of cell morphology and ecology acoss genera similar to *Sabbea*

	Envekadea	***Adlafia***	***Kobayasiella***	***Stenoneis***	***Climaconeis***	***Berkeleya***	***Parlibellus***	***Sabbea***
Valve size (µ)	25-52	<25 (40)	relative small	variable	variable	variable	variable	<60 µ
Valve outline	linear-lanceolate with (sub)- capitate apices	linear to linear-lanceolate, protracted, subcapitate or rostrate apices	linear to elliptic-lanceolate, protracted, subcapitate or rostrate apices	linear, bluntly rounded, sometimes protracted apices	narrowly linear, linear-lanceolate or lunar with slight capitate apices	linear to linear-lanceolate with slightly capitate apices	lanceolate, or linear, with bluntly or acutely rounded apices	linear with parallel margins and weakly protracted to broadly rounded apices
Raphe	straight, filiform	filiform, weakly curved	filiform, umbilicus present	straight, filiform	straight, filiform	short, straight, filiform	straight	straight
Proximal raphe endings	greatly expanded, forming conical depressions, straight	indistinct	indistinct	expanded, straight	simple to slightly expanded, sometimes deflected to the ventral margin	straight, weakly expanded	simple, or slightly expanded, short terminal fissures turned towards same side	simple, slightly expanded into pores or hooked, usually towards secondary side
Proximal internal endings	very slightly deflected to one side	clearly deflected, indistinct	T-shaped, straight	turned to one side	simple	straight	simple, or fissure continuing into narrow rib-or helictoglossa-like structure	straight, unexpanded
Terminal raphe fissures	very short terminating in expanded, golfclub-like pores bent to opposite directions, giving the raphe a sigmoid look	deflected to the same side	strongly deflected or hooked to the same side	more-or-less absent, terminating in expanded pores, deflected slightly to the same side	terminal fissures absent	straight or slightly deflected to the secondary side	very short, turned towards the same side of the valve	absent (endings very short)

...continued on the next page

TABLE 3. (Continued)

	Envekadea	*Adlafia*	*Kobayasiella*	*Stenoneis*	*Climaconeis*	*Berkeleya*	*Parlibellus*	*Sabbea*
Striation pattern	very dense, radiate in the centre, then abruptly convergent close to the apices	very dense, clearly radiate, ad the apices convergent,	radiate in the centre, then abruptly convergent close to the apices	equistant, rather parallel to convergent, usually faint in LM,large hyaline zone in the central area	equistant, rather parallel to convergent, a stauros is present in some species	fairly dense, parallel to convergent near the poles	somewhat more distantly spaced at center	parallel throughout the entire valve
Striae	uniseriate, continuing over the face/mantle junction	uniseriate, continuing without interruption from face to mantle	presence of a hyaline ridge at the face/ mantle junction	uniseriate, rather disorderly	uniseriate, continuing over the face/mantle junction	uniseriate	uniseriate	uniseriate
Areolae	large, rectangular to polygonal pores, usually occluded externally by porous hymenes	simple, small rounded poroids, occluded externally by hymenes	transapically elongated, finely hymenated	small, round poroids, usually occluded externally by hymenes	small round to oval poroids, closed internally by hymenes	simple round poroids closed internally by hymenes	small round poroids occluded by hymenes; one or few centrally located but appear not to penetrate to valve interior	small, rounded, externally occluded by individual hymenes
Girdle structure	2-3 non-porous bands	2 bands each with double row of poroids	2 bands with one or two rows of poroids	not studied	numerous bands with 2 rows of poroids	5 open bands with two rows of round/oval poroids	many open bands with two transverse rows of poroids	several open copulae with double perforations
Plastids	one, H-shaped in valve view	unknown	one, H-shaped, asymmetrical	unknown	4-20 H-shaped plastids	one consisting of 2 girlde-appressed plates	2 butterfly shaped; lying one each side against girdle	???
Habitat	freshwater-marine	freshwater	freshwater	marine	marine	brackish-marine	brackishmarine	freshwater- brackish

The marine genus *Climaconeis* shows the greatest similarity to *N. adminensis*, especially considering the linear-shaped valve outline (Cox 1982) and the fine structure of the striae, not visible in LM. The genus is characterized by having finely areolated striae, a simple raphe structure with straight external raphe branches lacking terminal raphe fissures and distinct proximal raphe ends (Cox 1982, Round *et al.* 1990). The fine striae are a feature shared with *N. adminensis,* although near the central area the striation pattern differs in most *Climaconeis* species which have shortened and often radiate striae. However, several differences exclude the placement of *N. adminensis* in *Climaconeis*. Several (though not all) *Climaconeis* species, having a typical scalariform valvocopula, bear 'craticular bars' growing from both sides of the valvocopula and interdigitating in near the valve middle. Unfortunately, some *Climaconeis* species seem to lack this feature such as *C. delicatula* (Cleve 1894: 144) E.J.Cox (1982: 166) making this criterion less decisive in excluding *N. adminensis* from *Climaconeis*. Prasad (2003) discussed the morphology and taxonomy of the genus *Climaconeis* and presented a table with all known species and their morphological features. It is clear that the presence of the craticular bars is randomly distributed in the genus.

A more diagnostic character is that *Climaconeis* species show a very typical, large, prominent helictoglossa at the apices (see for instance Round *et al.* 1990, p. 521 fig. g), a feature found in all *Climaconeis* species worldwide (Cox 1982, Prasad *et al.* 2000, Reed & Williams 2002, Prasad 2003). This type of helictoglossa is never observed in *N. adminensis,* which only shows a very faint helictoglossa. The areolae in *Climaconeis* are closed internally by hymenes whereas in *N. adminensis*, the areolae are covered externally. Internally, the raphe in *Climaconeis* is located in a well-developed raphe-sternum, often accompanied by raised ribs, a feature not observed in any of the investigated *N. adminensis* populations.

Besides *Climaconeis*, three other genera were placed in the Berkeleyaceae family. The genus *Stenoneis* contains species with a characteristic striation pattern, showing irregular hyaline areas where areolae are lacking; this has never been observed in *N. adminensis* (Round *et al.* 1990, Poulin 1990). The proximal raphe endings in *Stenoneis* are always expanded and clearly visible, even in LM, usually appearing as two thickened structures next to the raphe endings in the central area (see Poulin 1990, figs 15 & 22). Internally, the raphe sternum is well-developed with two prominent longitudinal ribs on both sides of the raphe (Round *et al.* 1990). The distal raphe endings terminate on clear helictoglossae. None of these characteristics has ever been seen in *N. adminensis*. The only feature shared with *Stenoneis* is the presence of external hymenes covering the areolae (Poulin 1990) but this is insufficient to include *N. adminensis* in *Stenoneis*. The third genus in the Berkeleyaceae, *Berkeleya*, has a different raphe structure with deflected proximal and terminal raphe endings, the internal hymenes covering the areolae and the well-developed helictoglossae. In most *Berkeleya* species, the raphe-sternum has a unique structure with only half of it being continuous and the other interrupted near the central area (Round *et al.* 1990, p. 519, fig. g). Finally, *Parlibellus* contains species with a more lanceolate valve outline, typical hooked external terminal raphe fissures, hymenes covering the areolae internally, a well-developed central nodule and differences in stria structure with the central striae more spaced. The mantle in most *Parlibellus* species is rather high, unlike *N. adminensis* that has a very low mantle (Cox 1988).

In conclusion, it is clear that *N. adminensis* cannot be placed into any of the genera discussed above. Expanding the original genus description of the most closely related genus, *Climaconeis*, with the features observed in *N. adminensis*, could potentially be a solution, although it would require drastically modifying the characterization of some features, such as the helictoglossa and the internal hymens, and this would create a genus that is so broad that a lot of other species would fit likewise in there. Molecular evidence could lend another perspective, possibly linking the species to one of the already described genera, but up to now all attempts to culture *N. adminensis* have been unsuccessful.

Therefore, a new genus, Sabbea Van de Vijver, Bishop & Kopalová *gen. nov.*, is proposed to accommodate species with a very simple raphe structure lacking external terminal raphe fissures and having only a very faint helictoglossae, uniseriate striae with occluded externally by hymenes, a low valve mantle and doubly perforated girdle bands.

Formal description

Sabbea* Van de Vijver, Bishop & Kopalová *gen. nov.

Valves linear with a low mantle. Girdle composed of several, open copulae, each with a double row of rounded to transapically elongated poroids. Raphe sternum well-developed with the raphe positioned in the middle of the sternum. Raphe straight, simple with straight, non-expanded proximal raphe ends. Terminal raphe fissures absent. Internally, helictoglossae only weakly developed to almost absent. Striae very fine, not discernible in LM, uniseriate, parallel, composed of small, rounded areolae, externally occluded by small hymenes.

Type:—*Sabbea adminensis* (D.Roberts & McMinn) Van de Vijver, Bishop & Kopalová *comb. nov.*

Etymology:—the genus is named in honor of our dear friend and colleague Prof. dr. Koen Sabbe (Ghent University, Belgium) for his outstanding contributions to diatom science and the International Society for Diatom Research

New combination

Sabbea adminensis **(D.Roberts & McMinn) Van de Vijver, Bishop & Kopalová *comb. nov.***

Basionym: *Navicula adminensis* Roberts & McMinn 1999 Bibliotheca Diatomologica 44, p. 27, plate 4, figs 2–4.

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References

Bory de Saint-Vincent, J.B.M. & Coll. (Eds.) (1822) *Dictionnaire Classique d'Histoire Naturelle Paris*. Vols. 1–17. Rey & Gravier, libraires-éditeurs; Baudouin Frères, libraires-éditeurs. Available from: https://archive.org/details/dictionnaireclas01bory/page/n6 (Accessed 23 Sept. 2019)

Bory de Saint Vincent, J.B.M. (1827) *Encyclopédie Méthodique, Histoire Naturelle Des Zoophytes ou Animaux Rayonnés*. Paris, pp. 563–565. Available from: https://archive.org/details/bub_gb_Y-thEeccPd8C/page/n6 (Accessed 23 Sept. 2019)

Carlson, G.W.F. (1913) Süsswasseralgae aus der Antarktis, Südgeorgien und den Falkland Inseln. *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903, unter leitung von dr. Otto Nordenskjøld*: 4 (Botanique): 1–94. Available from: http://digital.slv.vic.gov.au (Accessed 23 Sept. 2019)

Cleve, P.T. (1894) Synopsis of the Naviculoid Diatoms, Part I. *Kongliga Svenska-Vetenskaps Akademiens Handlingar* 26: 1–194. Available from: https://ia800204.us.archive.org (Accessed 23 Sept. 2019)

Cleve, P.T. (1895) Synopsis of the Naviculoid Diatoms, Part II. *Kongliga Svenska-Vetenskaps Akademiens Handlingar* 27: 1–219.

Cox, E.J. (1975) Further studies on the genus *Berkeleya* Grev. *British Phycological Journal* 10: 205–217. https://doi.org/10.1080/00071617500650191

Cox, E.J. (1979) Taxonomic studies on the diatom genus *Navicula* Bory. The typification of the genus. *Bacillaria* 2: 137–153.

Cox, E.J. (1982) Taxonomic studies on the diatom genus *Navicula* Bory. IV. *Climaconeis* Grun., a genus including *Okedenia inflexa* (Bréb.) Eulenst. ex De Toni and members of *Navicula* sect. *Johnsonieae* sensu Hustedt. *British Phycological Journal* 17: 147–168. https://doi.org/10.1080/00071618200650161

Cox, E.J. (1988) Taxonomic studies on the diatom genus *Navicula* Bory. V. The establishment of *Parlibellus* gen. nov. for some members of *Navicula* sect. Microstigmaticae. *Diatom Research* 3: 9–38. https://doi.org/10.1080/0269249X.1988.9705014

Cremer, H., Roberts, D., McMinn, A., Gore, D. & Melles, M. (2003) The Holocene Diatom Flora of Marine Bays in the Windmill Islands, East Antarctica. *Botanica Marina* 46: 82–106. https://doi.org/10.1515/BOT.2003.010

Esposito, R.M.M., Spaulding, S.A., McKnight, D.M., Van de Vijver, B., Kopalová, K., Lubinski, D., Hall, B. & Whittaker, T. (2008) Inland diatoms from the McMurdo Dry Valleys and James Ross Island, Antarctica. *Botany* 86: 1378–1392. https://doi.org/10.1139/b08-100

Frenguelli, J. (1924) Resultados de la Primera Expedición a Tierra del Fuego (1921) - Diatomeas de Tierra del Fuego. *Anales de la Sociedad Cientifica Argentina* 97: 87–118, 231–266.

Frenguelli, J. (1945) El Platense y sus diatomeas, Las diatomeas del Platense. *Revista del Museo de La Plata (Nueva Serie), Seccioìn*

Paleontologiìa 3: 77–221.

Fritsch, F.E. (1912) Freshwater algae. *In*: *Natural History. London. British Museum. National Antarctic Expedition 1901–1904. v.6 (Zoology & Botany)*. 60 pp.

Fritsch, F.E. (1917) Freshwater algae. British Antarctic ("Terra Nova") Expedition, 1910. *Natural History Report* 1–17.

Fukushima, H. (1963) Diatoms from Bybog Osane (Antarctic Continent) and Ongul Kalven Island. *Antarctic Record* 17: 56–58.

Fukushima, H. (1966) Diatoms from Molodezhnaya Station and Mirny Station Antarctica. *Antarctic Record* 27: 13–17.

Gibson, J.A.E. (1999) The meromictic lakes and stratified marine basins of the Vestfold Hills, East Antarctica. *Antarctic Science* 11 (2): 175-192.
https://doi.org/10.1017/s0954102099000243

Gibson, J.A.E., Roberts, D. & Van de Vijver, B. (2006) Salinity control of the distribution of diatoms in lakes of the Bunger Hills, East Antarctica. *Polar Biology* 29: 694–704.
https://doi.org/10.1007/s00300-006-0107-8

Gligora, M., Kralj, K., Plenković-Moraj, A., Hinz, F., Acs, E., Grigorszky, I., Cocquyt, C. & Van de Vijver, B. (2009) Observations on the diatom *Navicula hedinii* Hustedt (Bacillariophyceae) and its transfer to a new genus *Envekadea* Van de Vijver et al. gen. nov. *European Journal of Phycology* 44: 123–138.
https://doi.org/10.1080/09670260802389783

Greville, R.K. (1827) *Scottish Cryptogamic Flora, or colored figures and descriptions of cryptogamic plants, belonging chiefly to order Fungi. Edinburgh and London. Volume 5*. pp. 241–301.

Grunow, A. (1862) Die österreichischen Diatomaceen nebst Anschluss einiger neuen Arten von andern Lokalitäten und einer kritischen Uebersicht der bisher bekannten Gattungen und Arten. Erste Folge. Epithemieae, Meridioneae, Diatomeae, Entopyleae, Surirelleae, Amphipleureae. Zweite Folge. Familie Nitzschieae. *Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien* 12: 315–472, 545–588.
https://doi.org/10.5962/bhl.title.64361

Hamsher, S., Kopalová, K., Kociolek, J.P., Zidarova, R. & Van de Vijver, B. (2016) The genus *Nitzschia* on the South Shetland Islands and James Ross Island. *Fottea* 16: 79–102.
https://doi.org/10.5507/fot.2015.023

Hassall, A.H. (1845) *A history of the British Freshwater Algae (including descriptions of the Diatomaceae and Desmidiaceae) with upwards of one hundred Plates. I. Text.* Taylor, Walton, and Maberly, London, 462 pp.
https://doi.org/10.5962/bhl.title.22609

Holmboe, J.D. (1902) IV. *Navicula mutica* Kütz. Aus dem antarktischen Festlande. *Nyt Magazin for Naturvidenskaberne, Christiana* 40: 221–222.

Hustedt, F. (1961) Die Kieselalgen Deutschlands, Österreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. *In*: Rabenhorst, L. (Ed.) *Kryptogamen Flora von Deutschland, Österreich und der Schweiz*. Vol. 7. Teil 3, Lief. 1. Akademische Verlagsgesellschaft m.b.h. Leipzig, pp. 1–160.

Jones, V.J. (1996) The diversity, distribution and ecology of diatoms from Antarctic inland waters. *Biodiversity and Conservation* 5: 1433–1449.
https://doi.org/10.1007/BF00051986

Kellogg, T.B. & Kellogg, D.E. (2002) Non-marine and littoral diatoms from Antarctic and subantarctic regions. Distribution and updated taxonomy. *Diatom monographs* 1: 1–795.

Ko-Bayashi, T. (1963) Variations on some pennate diatoms from Antarctica (Part 1): III. Variations of *Navicula muticopsis* Van Heurck var. *muticopsis* f. *murrayi* (W. & G.S. West) Ko-Bayashi. *Japanese Antarctic Research Expedition 1956-1962, Scientific Reports Series E* 18: 1–20.

Ko-Bayashi, T. (1965) Variations on some pennate diatoms from Antarctica. *Japanese Antarctic Research Expedition (JARE) 1956-1962 Scientific Reports Series E* 24: 1–28.

Kohler, T.J., Kopalová, K., Van de Vijver, B. & Kociolek, J.P. (2015) The genus *Luticola* D.G.Mann (Bacillariophyta) from the McMurdo Sound Region, Antarctica, with the description of four new species. *Phytotaxa* 208: 103–134.
https://doi.org/10.11646/phytotaxa.208.2.1

Konfirst, M.A., Sjunneskog, C., Scherer, R.P. & Doran, P.T. (2011) A diatom record of environmental change in Fryxell Basin, Taylor Valley, Antarctica, late Pleistocene to present. *Journal of Paleolimnology* 46: 257–272.
https://doi.org/10.1007/s10933-011-9537-6

Lange-Bertalot, H. (1996) *Kobayasia* gen. et spec. nov. *Iconographia Diatomologica* 4: 278–287.

Lange-Bertalot, H. & Genkal, S.I. (1999) Diatoms from Siberia I. *Iconographia Diatomologica* 6: 272–275.

Lange-Bertalot, H. (2001) *Navicula* sensu stricto, 10 genera separated from *Navicula* sensu lato, *Frustulia*. *Diatoms of Europe* 2: 1–526.

Levkov, Z. (2009) *Amphora sensu lato. Diatoms of Europe* 5: 1–916.

Moser, G., Lange-Bertalot, H. & Metzeltin, D. (1998) Insel der Endemiten Geobotanisches Phänomen Neukaledonien (Island of endemics New Caledonia - a geobotanical phenomenon). *Bibliotheca Diatomologica* 38: 1–464.

Müller, O.F. (1786) *Diatomaceen (Vibrio paxillifer, V. bipunctatus, V. tripunctatus, Gonium pulvinatum). Animalcula infusoria fluviatilia et marina quae detexit, systematice, descripsit et ad vivum delineare curavit O.F. Muller.* Havniae, LVI + 367 pp.

Poulin, M. & Cardinal, A. (1982) Sea ice diatoms from Manitounuk Sound, southeastern Hudson Bay (Quebec, Canada). II. Naviculaceae, genus *Navicula*. *Canadian Journal of Botany* 60: 2825–2845.
https://doi.org/10.1139/b82-343

Poulin, M. (1990) Sea Ice diatoms (Bacillariophyceae) of the Canadian Arctic. I. The genus *Stenoneis*. *Journal of Phycology* 26: 156–167.
https://doi.org/10.1111/j.0022-3646.1990.00156.x

Prasad, A.K.S.K., Riddle, K.A. & Nienow, J.A. (2000) Marine diatom genus *Climaconeis* (Berkeleyaceae, Bacillariophyta): two new species, *Climaconeis koenigii* and *C. colemaniae*, from Florida Bay, USA. *Phycologia* 39: 199–211.
https://doi.org/10.2216/i0031-8884-39-3-199.1

Prasad, A.K.S.K. (2003) Fine structure and taxonomy of two species of the marine diatom genus *Climaconeis* (Berkeleyaceae, Bacillariophyta): *C. silvae* sp. nov. and *C. riddleae* sp. nov. from the Caribbean Sea and Florida bay, USA. *Hidrobiológica* 12: 9–22.

Reid, G. & Williams, D.M. (2002) The marine diatom genus *Climaconeis* (Berkeleyaceae, Bacillariophyta): two new species from Abu Dhabi, United Arab Emirates. *Diatom Research* 17: 309–318.
https://doi.org/10.1080/0269249x.2002.9705550

Roberts, D. & McMinn, A. (1996) Relationships between surface sediment diatom assemblages and water chemistry gradients in saline lakes of the Vestfold Hills, Antarctica. *Antarctic Science* 8: 331–341.
https://doi.org/10.1017/s0954102096000508

Roberts, D. & McMinn, A. (1999) Diatoms of the saline lakes of the Vestfold Hills, Antarctica. *Bibliotheca Diatomologica* 44: 1–83.

Roberts, D., McMinn, A. & Zwartz, D. (2000) An initial palaeosalinity history of Jaw Lake, Bunger Hills based on a diatom–salinity transfer function applied to sediment cores. *Antarctic Science* 12: 172–176.
https://doi.org/10.1017/S0954102000000225

Ross, R., Cox, E.J., Karayeva, N.I., Mann, D.G., Paddock, T.B.B., Simonsen, R. & Sims, P.A. (1979) An amended terminology for the siliceous components of the diatom cell. *Nova Hedwigia Beiheft* 64: 513–533.

Round, F.E., Crawford, R.M. & Mann, D.G. (1990) *The Diatoms. Biology and Morphology of the Genera*. Cambridge University Press, Cambridge, 747 pp.

Sabbe, K., Verleyen, E., Hodgson, D.A., Vanhoutte, K. & Vyverman, W. (2003) Benthic diatom flora of freshwater and saline lakes in the Larsemann Hills and Rauer Islands, East-Antarctica. *Antarctic Science* 15: 227–248.
https://doi.org/10.1017/S095410200300124X

Sakaeva, A., Sokol, E.R., Kohler, T.J., Stanish, L.F., Spaulding, S.A., Howkins, A., Welch, K.A., Lyons, W.B., Barrett, J.E. & McKnight, D.M. (2016) Evidence for dispersal and habitat controls on pond diatom communities from the McMurdo Sound Region of Antarctica. *Polar Biology* 39: 2441–2456.
https://doi.org/10.1007/s00300-016-1901-6

Spaulding, S.A. & Stoermer, E.F. (1997) Taxonomy and distribution of the genus *Muelleria* Frenguelli. *Diatom Research* 12: 95–115.
https://doi.org/10.1080/0269249x.1997.9705405

Spaulding, S.A., Kocielek, J.P. & Wong, D. (1999) A taxonomic and systematic revision of the genus *Muelleria* (Bacillariophyta). *Phycologia* 38 (4:) 314–341.
https://doi.org/10.2216/i0031-8884-38-4-314.1

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F. (Eds.) (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabile* 159. [Glashütten: Koeltz Botanical Books]
https://doi.org/10.12705/Code.2018

Tyler, P.A. (1996) Endemism in freshwater algae, with special reference to the Australian region. *Hydrobiologia* 336: 127–135.
https://doi.org/10.1007/BF00010826

Van de Vijver, B., Frenot, Y. & Beyens, L. (2002) Freshwater diatoms from Ile de la Possession (Crozet Archipelago, Subantarctica). *Bibliotheca Diatomologica* 46: 1–412.

Van de Vijver, B., Mataloni, G., Stanish, L. & Spaulding, S.A. (2010) New and interesting species of the genus *Muelleria* (Bacillariophyta) from the Antarctic region and South Africa. *Phycologia* 49: 22–41.
https://doi.org/10.2216/09-27.1

Van de Vijver, B., Tavernier, I., Kellogg, T.B., Gibson, J., Verleyen, E., Vyverman, W. & Sabbe, K. (2012) Revision of type materials of Antarctic diatom species (Bacillariophyta) described by West & West (1911), with the description of two new species. *Fottea* 12: 149–169.
https://doi.org/10.5507/fot.2012.012

Van de Vijver, B., Kopalová, K., Zidarova, R. & Levkov, Z. (2014) Revision of the genus *Halamphora* (Bacillariophyta) in the Antarctic Region. *Plant Ecology and Evolution* 147: 374–391.
https://doi.org/10.5091/plecevo.2014.979

Van de Vijver, B. & Kusber, W.-H. (2018) Correction of the typification of *Navicula adminii* Roberts & McMinn (Bacillariophyceae). *Notulae algarum* 65: 1.

Van der Werff, A. (1955) A new method for cleaning and concentrating diatoms and other organisms. *Verhandlungen der Internationalen Vereinigung für theoretische und angewandte Limnologie* 12: 276–277.
https://doi.org/10.1080/03680770.1950.11895297

Van Heurck, H. (1909) Diatomées. *In:* Résultats du Voyage du S.Y. Belgica en 1897-1898-1899. Rapports Scientifiques. Botanique. Antwerpen: Imprimerie J.-E. Buschmann. Botanique 6: 1–129.

Vanhoutte, K., Verleyen, E., Vyverman, W., Chepurnov, V. & Sabbe, K. (2004) The freshwater diatom genus *Kobayasiella* (Bacillariophyta) in Tasmania, Australia. *Australian Systematic Botany* 17: 483–496.
https://doi.org/10.1071/sb03035

West, W. & West, G.S. (1911) Freshwater algae. *British Antarctic Expedition (1907-1909) Science Report, Biology* 1: 263–298.

Whittaker, T.E., Hall, B.L., Hendy, C.H. & Spaulding, S.A. (2008) Holocene depositional environments and surface-level changes at Lake Fryxell, Antarctica. *The Holocene* 18: 775–786.
https://doi.org/10.1177/0959683608091797

Witkowski, A. Lange-Bertalot, H. & Metzeltin, D. (2000) Diatom flora of marine coasts I. *Iconographia Diatomologica* 7: 1–925.

Zidarova, R., Kopalová, K. & Van de Vijver, B. (2016) Diatoms from the Antarctic Region. Maritime Antarctica. *Iconographia Diatomologica* 24: 1–504.