Typification and emended description of *Achnanthes muelleri* G.W.F.Carlson (*Achnanthaceae, Bacillariophyta*), a widespread Antarctic freshwater species

Charlotte Goeyers, *Meise Botanic Garden, Research Department, Nieuwelaan 38, 1860 Meise, Belgium & University of Antwerp, Department of Biology – ECOBE, Universiteitsplein 1, 2610 Wilrijk, Belgium*

Bart Van de Vijver, *Meise Botanic Garden Meise, Research Department, Nieuwelaan 38, 1860 Meise, Belgium & University of Antwerp, Department of Biology – ECOBE, Universiteitsplein 1, 2610 Wilrijk, Belgium* (correspondence: bart.vandevijver@plantentuinmeise.be)

Achnanthes muelleri G.W.F.Carlson (Carlson 1913: 23) was originally described from material collected by the Swedish Südpolar-Expedition 1901-1903 on South Georgia and the Falkland Islands/Islas Malvinas. Carlson (1913) lists four samples (three from South Georgia and one from the Falklands/ Islas Malvinas) in which he found the species. The taxon, however, was most likely previously described four years earlier when Otto Müller described *Achnanthes inflata* var. *sigmata* O.Müller (Müller 1909: 9, pl. 1: fig. 9) based on one rapheless valve showing some irregular deformation of the valve. Müller (1909) himself doubted whether this deformation was the result of an anomaly or was a true variety. Although both taxa seem conspecific, priority should be given to *Achnanthes muelleri* based on ICN Art. 11.2 (Turland *et al*. 2018) specifying that a name has "… no priority outside the rank at which it is published."

Achnanthes muelleri proved, however, not to be restricted to South Georgia and the Falklands/ Malvinas, but records showed it had a circum-Antarctic distribution. Its presence was confirmed (based solely on light microscopy observations) on South Georgia (Van de Vijver & Beyens 1997), Iles Crozet (Van de Vijver *et al*. 2002 and references therein), Iles Kerguelen (Le Cohu & Maillard 1983 as *A. inflata*, Van de Vijver *et al*. 2001, Le Cohu 2005), Heard Island (Van de Vijver *et al.* 2004), the Prince Edward Islands (Van de Vijver *et al*. 2008) and also in the Maritime Antarctic Region (Zidarova *et al.* 2016 and references therein). More recently, the species was also found on Campbell Island in the southern Pacific Ocean (Goeyers & Van de Vijver, unpubl. obs.). The species seems absent on continental Antarctica as no confirmed records could be found (Kellogg & Kellogg 2002).

Comparison with the original material used by Carlson (1913) unfortunately proved impossible. There is no indication where the material Carlson used might be preserved. Searches in the herbaria in Stockholm (where most of the bryophytes and lichens collected by Carl Skottsberg [1883-1963] are preserved), Göteborg (where Skottsberg worked) and Uppsala (where Carlson was given facilities according to his own account) were fruitless. Other major diatom collections worldwide do not seem to contain any material that Carlson used in his paper (Van de Vijver, pers. comm.). It is assumed therefore that the original material is lost. However, as the description of *Achnanthes muelleri* in Carlson (1913) is accompanied by three drawings showing both rapheless and raphe valve and a mantle view, one of these drawings is here designated as lectotype. Art. 40.5 of the ICN specified that for microalgae an "illustration" may be chosen as type. We interpret this as a group of figures (Carlson 1913: pl. 3: figs 5-7) as it is essential in diatoms that both raphe and rapheless valve are taken into account for correct species identification.

The present contribution illustrates and discusses the morphology of *Achnanthes muelleri* using recently collected material in the sub-Antarctic region. We detail all morphological features of the species with light and scanning electron-microscopy observations, based on a large population collected on South Georgia (sample SG-M317, leg. Louis Beyens, coll. date 2.xii.1992). The material was sampled from wet mosses during a short expedition in the vicinity of Stromness Bay. Several other relatively small populations (max. relative abundance < 5%) from the islands in the

Copyright: © 2020 The authors. Open access article distributed under Creative Commons Attribution License CC BY-NC.

southern Indian Ocean (Iles Crozet, Iles Kerguelen, Heard Island) and the southern Pacific Ocean (Campbell Island) were likewise investigated. Comparisons were made with the observations from the Maritime Antarctic region, illustrated in Zidarova *et al*. (2016: plates 15 & 16, figs 5–8). All samples were collected during austral expeditions from 1997 to date) except for the Campbell Island material that was collected in 1970 by Dale Vitt (Hickmann & Vitt 1973).

We here designate slide BR-4575 from SG-M317 as epitype for the species (Art. 9.8; Turland *et al.* 2018). The original material was collected by Skottsberg in Cumberland Bay in 1902, on the northern coast of South Georgia. The new material was sampled from a locality near Stromness Bay, separated from Cumberland Bay only by a narrow peninsula (Larsen Point) justifying the choice for this epitype. Based on the new observations the original species description is emended but not to the exclusion of the type.

Achnanthes muelleri G.W.F.Carlson (Figs 1–16)

Original publication: *Achnanthes muelleri* G.W.F.Carlson *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903 unter leitung von Dr. Otto Nordenskjöld*, Band IV, Lieferung 14: 23, pl. 3, figs 5-7, 1913.

Synonym: *Achnanthes inflata* var. *sigmata* O.Müller, *Beiblatt zu den Botanischen Jahrbüchern* 100: 9, pl. 1: fig. 9, 1909.

Lectotype (here designated): Plate 3, Figs 5-7, *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901-1903 unter leitung von Dr. Otto Nordenskjöld*, Band IV, Lieferung 14, 1913.

Epitype (here designated for the above lectotype of *Achnanthes muelleri* G.W.F.Carlson): dried material BR-4575 (BR, Meise Botanic Garden); sample SG-M317 (Stromness Bay, South Georgia, coll. date 2.xii.1992, leg. Louis Beyens); the epitype is here represented by Fig. 3 R-valve and Fig. 7 RL-valve

Emended description: Frustules clearly bent in girdle view with the rapheless valve dorsally and the raphe-bearing valve ventrally. Valves rhombic-lanceolate to broadly lanceolate with a clearly inflated central part and gradually tapering, occasionally protracted, then rostrate, apices. Small pseudosepta present on the raphe valves, absent on the rapheless valves. Transition from valve face to mantle abrupt. Valve dimensions (n=50): length 27.0-99.0 µm, width 9.5-17.0 µm. *Raphe valve*: axial area narrowly lanceolate, almost linear, only weakly widening towards the central area. Central area forming a narrow, usually asymmetrical, almost rectangular, narrow fascia with rarely short, isolated striae at the margins. Raphe branches almost straight to slightly undulating, externally with teardrop-like central raphe endings and clearly elongated, bent terminal raphe fissures, shortly continuing onto the mantle. Striae, 10-12 in 10 µm, radiate becoming more strongly radiate near the apices, uniseriate, composed of large, rounded areolae. Striae continuing without interruption on the mantle. Areolae clearly cribrate, usually covered by very thin, non-perforated external individual hymenes. Internally, central nodule thickened, forming a broader stauros reaching the valve margins. Internal central raphe endings unilaterally hooked. Terminal raphe endings terminating onto small helictoglossae. Virgae clearly raised between the sunken areolae. Vimines thickened. *Rapheless valve*: Thickened ridge, often broken into smaller parts, running at the valve face/mantle junction of the rapheless valve, only visible in SEM, interrupted at the apices. Ridge often lacking in certain populations. Valve face entirely surrounded by relatively broad hyaline zone. Pseudoraphe usually absent. Striae parallel in the middle becoming distinctly radiate towards the apices, 10-12 in 10 µm, continuing onto the mantle. Striae uniseriate composed of large, cribrate, rounded areolae, individually rimmed and usually covered by external thin hymenes. Terminal orbiculus present on the valve face at each apex, irregularly shaped. Internally, virgae raised, continuing from margin to margin separating the sunken areolae. Orbiculi clearly visible at

Copyright: © 2020 The authors. Open access article distributed under Creative Commons Attribution License CC BY-NC.

the apices, closed by a perforated plate. Girdle composed of several broad, open copulae, bearing a continuous row of perforations, even visible in the LM.

The various populations on the sub-Antarctic islands all differ in minor details. The valve outline varies from clearly rhombic to more broadly lanceolate, although it is not possible to separate the populations based on their valve outline as different outlines can be present within the same population. Several populations, such as on the South Shetland Islands (Maritime Antarctic Region) seem to lack the usual marginal crest on the rapheless valve (Zidarova *et al.* 2016), but are similar in all other morphological features. Some populations, such as the ones observed on Campbell Island in the southern Pacific Ocean, lack the rims around the areolae on the rapheless valve. On the islands in the southern Indian Ocean, the marginal crest is subdivided into several smaller parts. Nevertheless, all other features correspond entirely with the original population on South Georgia indicating that there is some phenotypic plasticity within the *A. muelleri* populations in the Antarctic Region, but that all these populations should be considered conspecific. Molecular research will be necessary to elucidate whether the different populations should be considered being cryptic species or not.

Achnanthes muelleri is mostly found living on mosses in the sub-Antarctic islands. The largest populations were found on wet terrestrial mosses in seepage areas and small pools with a slightly more alkaline pH (>8.0) and moderate to higher conductivities (Van de Vijver & Beyens 1997, Van de Vijver *et al*. 2002, 2004, 2008). Müller found one valve in southern Patagonia but did not specify the exact locality except the indication 'Kark – Tümpel'. Most of the samples that were discussed in Müller (1909) originate from the border of Argentina and Chile near the Torres del Paine national park. On the islands in the Maritime Antarctic Region, *A. muelleri* was rather rarely found abundantly in terrestrial habitats in coastal areas with elevated salinity levels and higher nutrient input (Zidarova *et al.* 2016). Chattová *et al.* (2014) observed the species on Ile Amsterdam, a very isolated, small island in the southern Indian Ocean, just north of the sub-Antarctic Region. Although found on the Falklands/Malvinas, Campbell Island, Ile Amsterdam and southern Patagonia, no records exist to date from Tasmania or New Zealand, most likely indicating that the species is not present there (Hodgson *et al.* 1997, John 2018 and references therein).

The authors wish to thank Prof. Dr Louis Beyens who collected the sample on South Georgia. Dr Wolf-Henning Kusber is acknowledged for his advice on typification of *Achnanthes muelleri*. Mrs Petra Ballings helped with the SEM, providing all of our SEM pictures.

Carlson, G.W.F. (1913). Süsswasseralgen aus der Antarktis, Südgeorgien und den Falkland Inseln. *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901–1903, unter Leitung von Dr. Otto Nordenskjøld*, Band 4 (Botanik): 1–94.

Chattová B., Lebouvier M. & Van de Vijver B. (2014). Freshwater diatom communities from Ile Amsterdam (TAAF, southern Indian Ocean). *Fottea* 14: 101–119.

Hickmann, M. & Vitt, D.H. (1973). The aerial epiphytic flora of moss species from Subantarctic Campbell Island. *Nova Hedwigia* 24: 443–448.

Hodgson, D.A., Vyverman, W. & Tyler, P. (1997). Diatoms of meromictic lakes adjacent to the Gordon River, and of the Gordon River estuary in south-west Tasmania. *Bibliotheca Diatomologica* 35: 1–173.

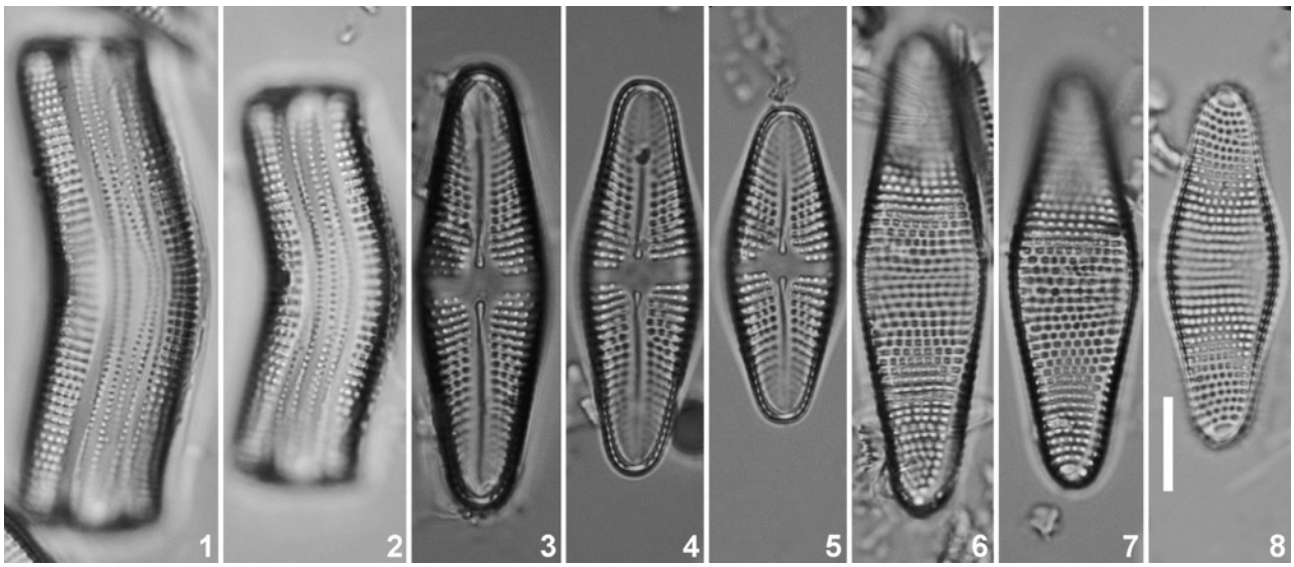
John, J. (2018). *The Diatom Flora of Australia, Volume 2: Diatoms from Tasmania Taxonomy and Biogeography*. Koeltz Scientific Books, 656 p.

Kellogg T.B. & Kellogg D.E. (2002). Non-marine and littoral diatoms from Antarctic and sub-Antarctic locations. Distribution and updated taxonomy. *Diatom Monographs* 1: 1–795.

Le Cohu, R. & Maillard, R. (1983). Les diatomées monoraphidées des îles Kerguelen. *Annales de*

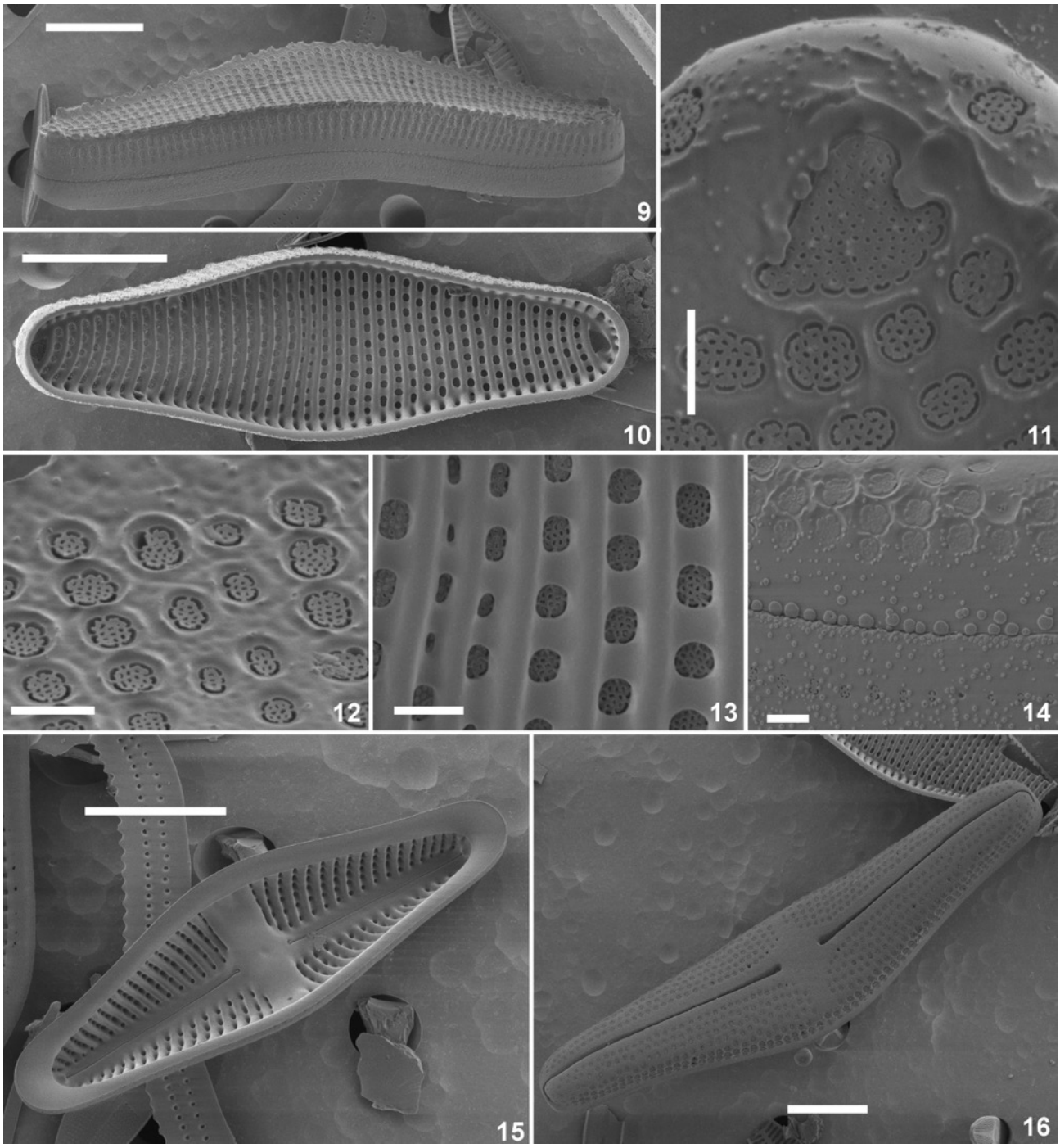
Copyright: © 2020 The authors. Open access article distributed under Creative Commons Attribution License CC BY-NC.

Limnologie 19(3): 143–167.
Le Cohu, R. (2005). Révision des principales espèces dulçaquicoles d'Achnanthales (Bacillariophyta) des îles subantarctiques de Kerguelen. *Algological Studies* 116 : 79–114.
Müller, O. (1909). Bacillariaceen aus Sudpatagonien. *(Engler's) Botanische Jahrbucher fur Systematik, Pflanzengeschichte, und Pflanzengeographie*. Leipzig 43 (Heft 4, Beiblatt Nr. 100):1–40.
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.
Van de Vijver, B. & Beyens, L. (1997). The epiphytic diatom flora of mosses from Strømness Bay area, South Georgia. *Polar Biology* 17: 492–501.
Van de Vijver, B., Ledeganck, P. & Beyens, L. (2001). Habitat preference in freshwater diatom communities from Sub-Antarctic Îles Kerguelen. *Antarctic Science* 13: 28–36.
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., Beyens, L., Vincke, S. & Gremmen, N. (2004). Moss-inhabiting diatom communities from Heard Island, Subantarctic. *Polar Biology* 27: 532–543.
Van de Vijver, B., Gremmen, N.J.M. & Smith, V. (2008) Diatom communities from the Sub-Antarctic Prince Edward Islands: diversity and distribution patterns. *Polar Biology* 31: 795–808.
Zidarova, R., Kopalová, K. & Van de Vijver, B. (2016). Diatoms from the Antarctic Region. Maritime Antarctica. *Iconographia Diatomologica* 24: 1–504.



Figs 1–8. *Achnanthes muelleri* G.W.F.Carlson. LM images from the epitype collection, sample SG-M317 (Stromness Bay, South Georgia). Figs 1–2. Two frustules in girdle view. Figs. 3–5. Raphe valves. Figs 6–8. Rapheless valves. Scale bar represents 10 μm.

Copyright: © 2020 The authors. Open access article distributed under Creative Commons Attribution License CC BY-NC.



Figs 9–16. *Achnanthes muelleri* G.W.F.Carlson. SEM images from the epitype collection, sample SG-M317 (Stromness Bay, South Georgia). Fig. 9. Rapheless valve in girdle view with one of the copulae attached. Fig. 10. Internal view of a rapheless valve showing the two orbiculi (arrows). Fig. 11. External detail of the orbiculus. Fig. 12. External detail of the cribrate areolae. The external hymenes are eroded. Fig. 13. Internal detail of areolae between the raised virgae. Fig. 14. External detail of the mantle plaques and the granulate structure of the mantle and the copulae. Note the single row of areolae on the copulae. Fig. 15. Internal view of an entire raphe valve. Note the hooked central raphe endings and the pseudosepta. Fig. 16. External view of an entire view. Scale bar represents 10 μm except for figs 11–14 where scale bar represents1 μm.

Copyright: © 2020 The authors. Open access article distributed under Creative Commons Attribution License CC BY-NC.