Analysis of the type slide of *Achnanthes boyei* Østrup (*Achnanthidiaceae*, Bacillariophyta)

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Achnanthes boyei Østrup (1918: 41, pl. 4: fig. 60) was described based on a sample collected in 1914 from a small spring in Hallormsstaðaskógur National Forest in Iceland and named for J. Boye Petersen who collected the sample. The species was characterized (translated from the Latin description) by '*a narrowly lanceolate, weakly asymmetrical valve. The raphe valve has a narrow hyaline raphe area, widening in the central area into a broad fascia. The striae are radiate throughout. The rapheless valve has a central area lacking striae on one side and showing weakly shortened striae on the other side. The other features are similar to the raphe valve*". The description was accompanied by a rather poor drawing of a raphe- and rapheless valve. Subsequently, the species was included in Hustedt (1933: 406) and Cleve-Euler (1953: 39) but neither of them showed more than the two original drawings of Østrup and the descriptions they gave were an almost exact translation of the original Latin description. Lange-Bertalot & Krammer (1989) analysed the slide K.B. 655 [*sic*, see below], made from type material 9.213.1, conserved in the Botanical Museum in Copenhagen (**C**, Denmark) and concluded that the species showed a clear relationship with *Achnanthes lanceolata* Brébisson. Lange-Bertalot (in Lange-Bertalot & Krammer 1989: 85, pl. 84, figs 17-19′) transferred the species to the rank of variety within the *A. lanceolata* complex as *A. lanceolata* var. *boyei* (Østrup) Lange-Bertalot but a formal lectotypification was never published.

With the introduction of the genus *Planothidium* Round & Bukhtiyarova (1996: 351), a large number of former varieties, formae and subspecies of *Achnanthes lanceolata* were transferred to the new genus but *Achnanthes* (*lanceolata* var.) *boyei* was, however, not transferred, most likely because the species is only rarely reported in literature. According to the literature, the species has been reported from the British Isles (Hartley 1986), Maritime Antarctic Region (Economou-Amilli *et al.* 1998, Temniskova-Topalova & Chipev 2001), Germany (Werum 2001), Brazil (Carneiro 2003), India (Nautiyal *et al.* 2004, 2014), Macedonia (Levkov *et al.* 2005), Switzerland (Taxböck & Preisig 2007), Sweden (Kahlert 2008), Iran (Soltanpour-Gargari *et al.* 2011), Russia (Genkal *et al.* 2012, Genkal & Lepskaya 2014, Genkal & Chekryzheva 2016), and Bulgaria (Isheva & Ivanov 2016). Unfortunately, none of the published records shows illustrations of the recorded valves so they could not be verified—it is highly likely that most are the result of confusion with other similar taxa such as *P. lanceolatum* (Brébisson ex Kützing) Lange-Bertalot, *P. amphibium* C.E.Wetzel, Ector & L.Pfister or *P. capitatum* (O.Müller) Van de Vijver *et al.*

Here we detail, using LM observations, specimens from the population of *A. boyei* found on slide K.B. 6557 from sample 9.213.1, obtained in loan from the Botanical Museum in Copenhagen. Unfortunately, no unmounted material was available. The observed slide is most likely the same that Lange-Bertalot examined in Lange-Bertalot & Krammer (1989) although they reported it as K.B. 655, probably by mistake. Slide K.B.6557 was dominated by *Odontidium mesodon* (Kützing) Kützing and *Meridion circulare* (Greville) C.Agardh.

Achnanthes boyei Østrup (Figs 1–54)
Frustules rectangular and weakly bent in the middle, producing a concave raphe valve (Figs 28–29). Valves narrowly rhombic to lanceolate, occasionally with inflated central part. Apices weakly protracted, broadly rounded to clearly protracted, subcapitate to even capitate. Smaller specimens elliptic to linear-elliptic with non-protracted, broadly rounded apices. Valve dimensions (n=50): length 9–29 µm, width 4–6 µm. Rapheless valve (Figs 1–27): axial area narrow, occasionally clearly widening almost from the apices towards the central area (e.g. Figs 5, 10, 15). Central area with a large horseshoe–shaped hyaline area on one side showing a very distinct circular depression and several slightly shortened striae forming a small circular area on the other side. Occasionally, striae lacking in the middle (e.g., figs 5, 20). Striae weakly to moderately radiate in the centre, becoming distinctly radiate towards the apices, 14–15 in 10 µm. Raphe valve (Figs 30–54): Axial area very narrow, linear, almost not widening near the central area. Central area forming a rectangular to bow–tie shaped fascia, rarely bordered by 1–3 very short striae. Raphe branches straight with expanded, drop–like proximal raphe endings. Distal raphe fissures unilaterally deflected. Striae radiate becoming distinctly radiate towards the apices, 13–16 in 10 µm. Areolae on both raphe and rapheless valve never discernible in LM.

The two rapheless valves illustrated by Lange-Bertalot & Krammer (1989, pl. 84: figs 17, 18) differ slightly from the valves that we have depicted from type material. Their fig. 18 is most likely a teratological valve as it shows a clear asymmetry along the transapical axis whereas the frustule illustrated as figs 17, 17′ is one of the largest valves found in the sample. Their raphe valve (fig. 17) is very similar to our fig. 30. It is possible that with a different focus, the typical sinus would have been more visible in the rapheless valve of their fig. 17′.

Achnanthes boyei is very similar to *Planothidium lanceolatum*. Van de Vijver et al. (2013) analysed the type material of *Planothidium* (*Achnanthidium*) *lanceolatum* from Falaise (France), illustrating the entire cell cycle. Morphometrically, *Achnanthes boyei* and *P. lanceolatum* do not differ from each other: valve length, valve width and stria density entirely overlap. The valve outline of both taxa does not show any difference either. The only difference that can be observed is that the sinus on the rapheless valve is more pronounced in *A. boyei* compared to *P. lanceolatum*. Analysis of a large number of rapheless valves of *P. lanceolatum* showed, however, that some of these valves present a rather shallow, but still distinct sinus.

Two other *Planothidium* species could have been confused with *A. boyei* in the past. *Planothidium capitatum*, described from South America and the Maritime Antarctic Region (Wetzel et al. 2014), shows a similar pronounced sinus on the rapheless valve but has a different valve outline with typical capitate apices contrary to *A. boyei* that has more broadly rounded to weakly rostrate apices. Similarly, *P. amphibium* has a clearly elliptic-lanceolate valve outline and more or less capitate apices (Wetzel et al. 2014). It is clear that *A. boyei* is not conspecific with either of these species.

Valve outline features were quantified with the diatom morphometry software SHERPA (Kloster et al. 2014) for both *A. lanceolata* (LM data from Van de Vijver et al. 2013) and *A. boyei* since both show highest similarities concerning valve outline. The images obtained from the type slides of *A. lanceolata* (n=20) and *A. boyei* (n=17) were loaded into the software SHERPA after which the success of retrieving the contour data was checked (Fig. 55). Outcomes included shape measures (e.g., length, width, area, perimeter, width/length ratio) and heuristic descriptors (e.g., compactness, ellipticity and roundness). Correlations between these selected parameters are shown in Fig. 55. They show a clear overlap between both populations. The two described species could not be distinguished by characteristics of the valve shape contour and dimensions. Thus, based on the morphological analysis using light microscopy and the similarity with *Planothidium lanceolatum* we propose to treat *Achnanthes boyei* Østrup as a heterotypic synonym of *Planothidium lanceolatum* (Brébisson ex Kützing) Lange-Bertalot.

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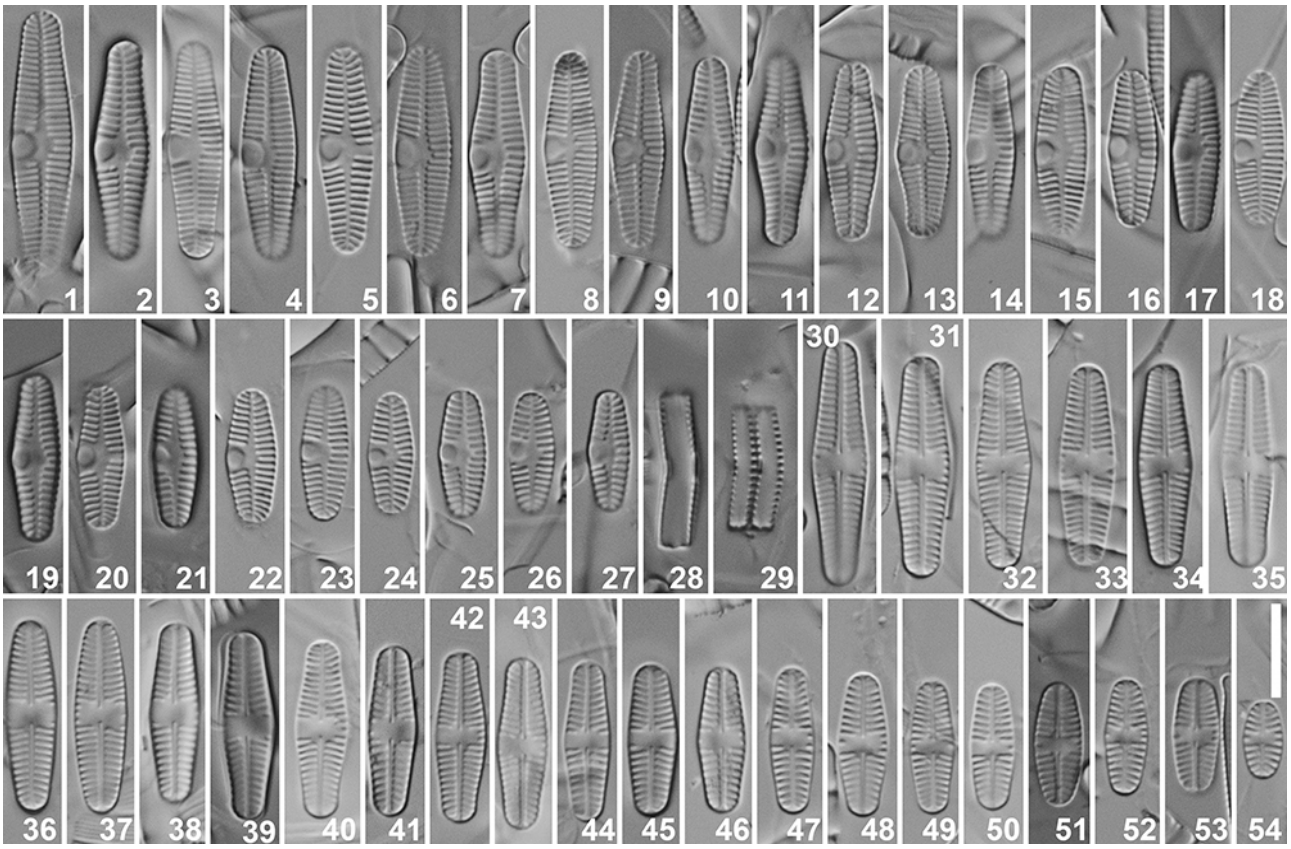

Figs 1–54. ***Achnanthes boyei* Østrup**. LM pictures taken from slide K.B. 6557, sample n° 9.213.1. Figs 1–27. Rapheless valves. Figs 28–29. Frustules in girdle view. Figs 30–54. Raphe valves. (figs 11–17). Scale bar = 10 µm.

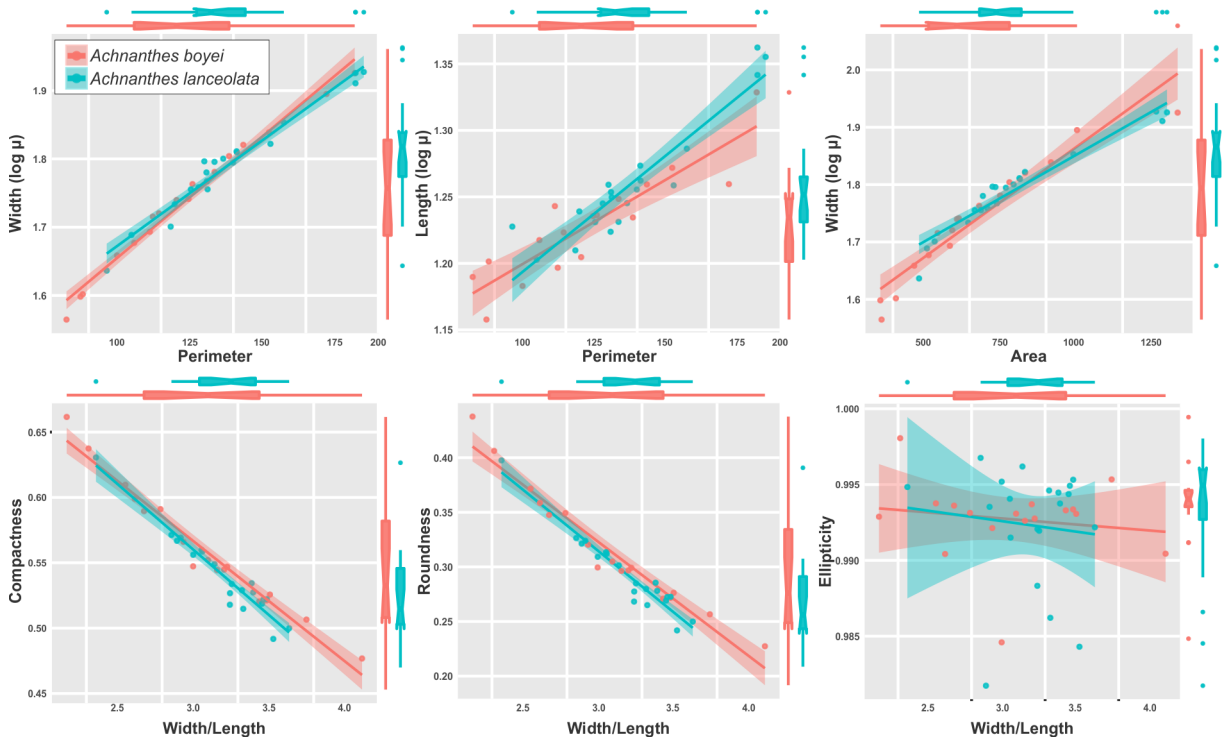

Fig. 55. Scatter plots of relationships between morphological parameters (width, length, area, perimeter, width/length ratio) and heuristic descriptors (compactness, roundness and ellipticity) of valves found in the type slides of *Achnanthes lanceolata* (Lectotype slide IV–2–C6: Caen, Calvados department, Basse–Normandie region, France, Eulenstein Diat. Spec. typ. N° 61 (coll. n° IV–2–C6) in the National Botanic Garden of Belgium (**BR**) and *Achnanthes boyei* (slide K.B. 6557 in **C**). Results obtained with the software SHERPA (Kloster et al. 2014).