On the identity of *Achnanthes ricula* M.H.Hohn & Hellerman and its transfer to the genus *Navigiolum* Lange-Bertalot (Bacillariophyta)

Carlos E. Wetzel, *Luxembourg Institute of Science and Technology (LIST), Environmental Research & Innovation (ERIN) Department, 41 rue du Brill, L-4422 Belvaux, Luxembourg* (carlos.wetzel@list.lu)

Luc Ector, *Luxembourg Institute of Science and Technology (LIST), Environmental Research & Innovation (ERIN) Department, 41 rue du Brill, L-4422 Belvaux, Luxembourg* (luc.ector@list.lu)

Achnanthes ricula M.H.Hohn & Hellerman (1963: p. 276, pl. 1: figs 41, 42) was described as a monoraphid diatom from Potomac River, Maryland (MD), USA. The original drawings show heterovalvar cells with distinct striae density (here reproduced as Fig. 1) and very diminutive valve dimensions (i.e. 6.2-7.8 µm long and 2.6-3.1 µm wide).

Since its original description the species has been rarely reported in the diatom literature, as observed on Table 1. Most of its records are from North America (Canada and USA) and Europe (Portugal, Spain and Bulgaria) with a few references from Central America (Costa Rica) and Asia (Taiwan), all of them without illustrations. Moreover, in many cases the records are doubtful as pointed by the authors themselves as indicated by the use of "cf." and "aff." abbreviations, including question marks.

Table 1. List of scientific references mentioning *Achnanthes ricula* M.H.Hohn & Hellerman.

Reference	Year	Country	Locality	Identitfied as
Bahls	2009	USA	USA, Oregon	*Achnanthes ricula*
Bunbury & Gajewski	2007	Canada	Southwestern Yukon and northern British Columbia	*Achnanthes* cf. *ricula*
Elias *et al.*	2017	Portugal	Aveiro (mesocosm experiment)	*Achnanthes ricula*
Fernández *et al.*	2018	Spain	Tinto and Odiel rivers, Southwest of the Iberian Peninsula	*Achnanthes ricula*
Isheva & Ivanov	2016	Bulgaria	Strouma River, Vitosha Nature Park	*Achnanthes ricula*
Ivanov *et al.*	2006	Bulgaria	South and West Bulgaria Chiprovska River	*Achnanthes ricula*
Lim *et al.*	2001	Canada	Bathurst Island, Nunavut, Canadian High Arctic	*Achnanthes ricula*
Mutchler	1998	USA	South Slough National Estuarine Research (Charleston, Oregon)	*Achnanthes ricula*
Nelligan *et al.*	2016	Canada	Harp, Red Chalk and Eagle lakes, Ontario	*Achnanthes ricula*
Racca *et al.*	2004	Canada	Training set Lake from northwestern Canada and Alaska	cf. *Achnanthes ricula*
Shiao & Wang	2011	Taiwan	Nantou County, Taiwan	*Achnanthes ricula*
Silva-Benavides	1996	Costa Rica	Rio Grande de Tárcoles and Savegre	*Achnanthes* sp. aff. *ricula* (?*Navicula* sp.)
Silva-Benavides *et al.*	2008	Costa Rica	Ciruelas and Quebrada Honda rivers	*Navicula* sp. aff. *ricula*
Wilson & Gajewski	2002	Canada	Southwestern Yukon and northern British Columbia	*Achnanthes ricula* ?

The first and only known published light micrographs (LM) from the type slide are those depicted by Krammer & Lange-Bertalot (1991, pl. 30: figs 27-31) who included the species in the fourth volume of the *Süßwasserflora* within the *Achnanthaceae*. It is clear that from the images taken a neat heterovalvar condition is not present (e.g., the images taken from the same frustule at distinct focus show no differences in the striae density reported by Hohn & Hellerman 1963). Not coincidentally, Krammer & Lange-Bertalot (1991) placed side-by-side with the type of *A. ricula* (small rhombic lanceolate valves) another population of a small naviculoid diatom ["*Navicula* (!)"] from Costa Rica that could, according to the authors, belong to *Achnanthes ricula*. More recently, a light microscopy image from the slide **ANSP** G.C. 44468 published by the Phycology Section of

the Academy of Natural Sciences of Drexel University was found (Accessed 07 Aug 2018) and is here reproduced as Fig. 2.

The genus *Navigiolum* Lange-Bertalot in Lange-Bertalot *et al.* (2003: 80) is a small genus the cells of which are characterized by comparatively small dimensions, with length > 16 µm, and width > 6 µm. The type species originated from temporary water bodies, rock pools on basalt of central Sardinia. *Navigiolum* possesses the main characters of naviculoid diatoms formerly grouped under *Navicula sensu lato*. In recent years, *Navicula sensu lato* has been subdivided into *Navicula sensu stricto* and about thirty segregate genera (see Lange-Bertalot *et al*. 2009).

The combination of morphological features seen in *Navigiolum* does not fit any other previously established genus (i.e., facultative formation of spines, areolae occluded externally by a hymen, striae mostly uniseriate but partly becoming biseriate). The genus was described as a polythetic genus that shares many morphological features with *Mayamaea* Lange-Bertalot (see also Barragán *et al.* 2017), which seemingly is the only closely related genus among established genera.

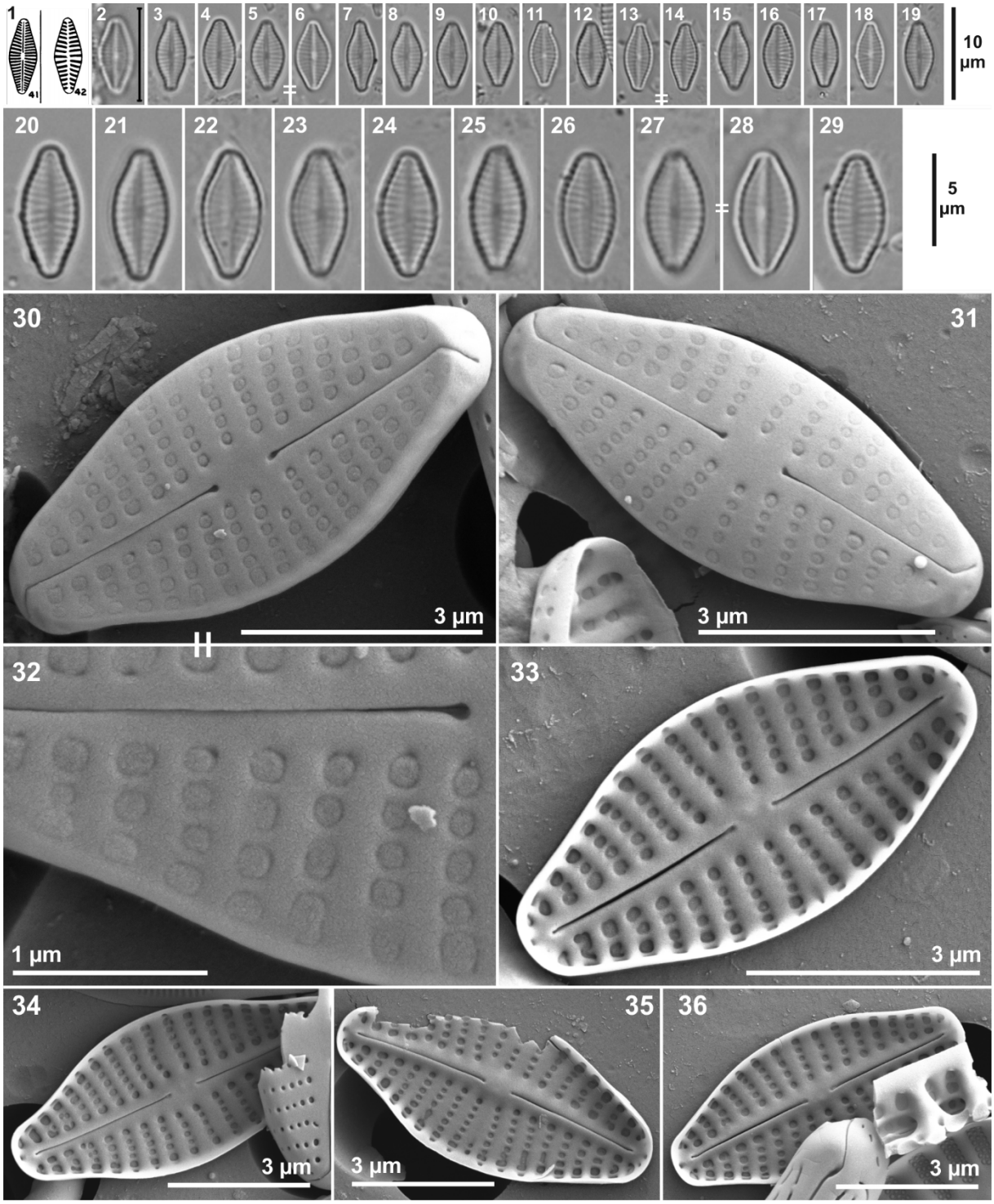
To date, all the published images of *Achnanthes ricula* agree in dimensions and striae density with populations recently found by us during water quality assessment in French rivers within the European Water Framework Directive (WFD) biological assessments using diatoms as bioindicators (Table 2). The species was generally initially identified as "*Navicula* sp.".

We observed under light (LM) and scanning electron microscopy (SEM) one population from France (Figs 3-36), collected at the *Canal de l'Est (Branche Sud)* at the locality of Crévéchamps (Région Grand Est, France). In LM, the species looks much like the specimen depicted from the type slide (Fig. 2) (type slide deposited at the Diatom Herbarium of the Academy of Natural Sciences of Drexel University (former Philadelphia Academy of Sciences) **ANSP** G.C. 44468 from Maryland, USA).
Sometimes the raphe cannot be resolved, giving the impression of a 'monoraphid' species (e.g., Figs 20, 29); however, a sharper focus (Figs 27, 28) shows clearly a biraphid diatom with weakly radiant striae and slightly protracted apices. SEM images shows straight and simple raphe branches that are bent towards the same side reaching the valve mantle at the apices. Proximal raphe ends are of simple drop-like shape. Uniseriate striae are composed by irregular round areolae occluded externally by hymenes that can become biseriate (Figs 34, 35).

Both *Mayamaea* and *Navigiolum* possess exclusively species with relatively small to very small cell dimensions. The areolae pattern, similar in general, is masked by closing membranes lying flush with the valve surface. Distinguishing features of *Navigiolum* are crescent-like to reniform areola foramina that become subdivided biseriate comma-like in most of the species whilst being roughly circular in *Mayamaea*. Moreover, the valve shape is generally lanceolate and not elliptical in *Navigiolum*. The ends are facultatively protracted rostrate but always acutely rounded, never bluntly rounded as compared to *Mayamaea*. Indeed, this small naviculoid diatom shows a similar areolae structure in SEM as *Navigiolum simplex* Lange-Bertalot, B.Fumanti, Cavacini & Tagliaventi (2003: 181, figs 11, 12, 34, 35), but does not resemble any of the reported species in the recent revision of *Mayamaea* by Barragán *et al.* (2017). Based on our observations the following combination is here proposed:

***Navigiolum ricula* (M.H.Hohn & Hellerman) C.E.Wetzel & Ector, *comb. nov.* (Figs 2-36)**
Basionym: *Achnanthes ricula* M.H.Hohn & Hellerman. *Transactions of the American Microscopical Society*, Vol. 82, Issue 3, p. 276, pl. 1: figs 41, 42. 1963. Note: "*ricula*" is a Latin noun in apposition (diminutive of "*rica*", a veil), and is indeclinable.

Holotype: Slide G.C. 44468 (**ANSP**). Type locality: Potomac River, Maryland, USA.



Figs 1-36. ***Navigiolum ricula*** **(M.H.Hohn & Hellerman) C.E.Wetzel & Ector,** ***comb. nov.*** Fig. 1: Reproduction of *Achnanthes ricula* M.H.Hohn & Hellermann (1963, fig. 1). Fig. 2: LM image from the type slide G.C. 44468 (ANSP). Type locality: Potomac River, Maryland. Figs 3-29: LM images from a population sampled at the Canal de l'Est (Branche Sud) at Crévéchamps (France) in 14/08/2015. Figs 30-32: External SEM showing general valve outline and intact areolae occlusions. Figs 34-36: Internal view showing general aspects of the valve. Note the uniseriate striae becoming

irregularly biseriate near the valve apices on Fig. 34. On Fig. 35 the biseriate condition is found near the valve face/mantle junction.

Table 2: Reports of *Navigiolum ricula* in France.

Basin	**River**	**Locality**	**Date**	**Relative abundance**	**Dominant species in the sample**
Adour-Garrone	Luy	Cherrou	24/08/2015	3.0%	*Sellaphora nigrii* (De Notaris) C.E.Wetzel & Ector, *Cocconeis euglypta* Ehrenberg emend Romero & Jahn, *Navicula cryptotenella* Lange-Bertalot, *Nitzschia dissipata* (Kützing) Grunow
Adour-Garrone	Luy de France	Amou	24/08/2015	1.7%	*Nitzschia dissipata* (Kützing) Grunow, *Sellaphora nigrii* (De Notaris) C.E.Wetzel & Ector, *Gomphonema minutum* (C.Agardh) C.Agardh, *Cocconeis euglypta* Ehrenberg emend Romero & Jahn, *Nitzschia costei* Tudesque, Rimet & Ector
Adour-Garrone	Luy de Béarn	Amou	24/08/2015	1.3%	*Sellaphora nigrii* (De Notaris) C.E.Wetzel & Ector, *Cocconeis euglypta* Ehrenberg emend Romero & Jahn, *Nitzschia dissipata* (Kützing) Grunow, *Gomphonema minutum* (C.Agardh) C.Agardh.
Rhin-Meuse	Canal de l'Est (Branche Sud)	Crévéchamps	04/10/2014	8.5%	*Sellaphora nigrii* (De Notaris) C.E.Wetzel & Ector, *Nitzschia soratensis* E.Morales & Vis, *Amphora pediculus* (Kützing) Grunow, *Achnanthidium minutissimum* (Kützing) Czarnecki, *Rhoicosphenia abbreviata* (C.Agardh) Lange-Bertalot
Rhin-Meuse	Canal de l'Est (Branche Sud)	Crévéchamps	14/08/2015	8.9%	*Sellaphora nigrii* (De Notaris) C.E.Wetzel & Ector, *Amphora pediculus* (Kützing) Grunow, *Cyclotella atomus* Hustedt, *Nitzschia soratensis* E.Morales & Vis, *Rhoicosphenia abbreviata* (C.Agardh) Lange-Bertalot, *Simonsenia delognei* Lange-Bertalot

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