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SHORT COMMUNICATION

Planothidium comperei sp. nov. (Bacillariophyta), a new diatom species from Ivory Coast

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Background and aims – The diatom flora from West African rivers remains virtually unknown. In this context, and given the restricted literature for the region, we explored the diatom communities from the Agnéby and Mé river watersheds, Ivory Coast.
Methods – Diatoms were sampled on glass slides previously immersed during a period of thirty days, at different sites along the Agnéby and the Mé River. Species were identified using light and scanning electron microscopy.
Key results – Among the 258 taxa recorded, *Planothidium comperei* sp. nov. is the most abundant. A thorough description of this species is proposed. This new species shows morphological similarities with *Planothidium miotum* (J.R.Carter & Denny) Lange-Bert., whose type material from Sierra Leone is illustrated in light microcopy for comparison. A second species originally described as *Achnanthes piafica* J.R.Carter & Denny is also illustrated and combined in the genus *Planothidium*.

Key words – Diatoms, new species, *Planothidium comperei*, *Planothidium piaficum*, tropical rivers, Ivory Coast.

INTRODUCTION

The diatom flora in unimpacted tropical conditions shows a completely different composition compared to the floras of temperate zones (Sabbe et al. 2001, Vanormelingen et al. 2008). The specificity of the tropical diatom flora was recently demonstrated by several large taxonomical studies on the South America diatoms (Metzeltin & Lange-Bertalot 1998, 2007, Wetzel et al. 2011). Surprisingly, up to now, diatoms from West African rivers remain virtually unknown, even when this ecosystem, strongly influenced by the monsoon regime, represents interesting natural conditions. Related literature is then very sparse, but some authors must be cited in particular as they provided valuable drawings and micrographs of the diatom flora they collected: Hustedt (1910), Zanon (1941) (French West Africa); Guermeur (1954), Compère (1991) and Sow et al. (2013) (Senegal); Foged (1966), Cocquyt & Kusber (2010) and Cocquyt et al. (2013) (Ghana), Carter & Denny (1982, 1987, 1992) and Alfinito & Lange-Bertalot (2013) (Sierra Leone); Foged (1986) (Gambia); Compère & Riaux-Gobin (2009) (Guinea). Very few references concern Ivory Coast, and rather focus on phytoplankton (e.g. Bourrelly 1961, Couté & Iltis 1985, Ouattara et al. 2000, Niamien-Ebrottié et al. 2008).

In this context, diatoms from different sites along the Agnéby and Mé River basins, Ivory Coast, were sampled in 2012 during the dry (50 mm rainfall in February) and wet (600 mm rainfall in July) seasons. Among the 258 taxa recorded, the genus *Planothidium* Round & Bukhtiyarova (Round & Bukhtiyarova 1996: 351) was abundant. One species was particularly abundant in our samples, morphologi-

cally close to *Planothidium miotum* (J.R.Carter & Denny) Lange-Bert. (PMIO) initially described as *Achnanthes miota* by Carter & Denny (1982). We propose a formal description for this taxon that we consider as new, and named it *Planothidium comperei*. A second abundant species originally described as *Achnanthes piafica* J.R.Carter & Denny is also illustrated and combined in the genus *Planothidium*.

MATERIAL AND METHODS

Study area

The Agneby and the Mé River basins are located in the Southern part of Ivory Coast between 3°30–4°45W and 5°20–6°45N (see electronic appendix). The Agneby River (250 km long) rises in Agoua, flows into the Ebrié lagoon and covers a catchment area of 13,200 km^2. The Mé River rises in the North of Adzopé, flows into the Poto lagoon in the North of Grand Bassam with a catchment area of 4,300 km^2. This part of Ivory Coast, located on Precambrian substrates, is covered by swamps and rainforests (Avenard et al. 1971).

The environmental conditions at the sample sites are generally acidic to circumneutral (mean pH = 6.5 ± 0.5), with low conductivities (83.5 ± 46.5 µs/cm), moderate dissolved oxygen (71.2 ± 17.2%) and high temperatures (25 ± 1°C) (raw data not provided here).

Diatom flora

Sampling method – In February and July 2012, diatoms were sampled on glass slides (75 × 25 × 1 mm) previously immersed during a period of thirty days. Slides were maintained in a cage made of polystyrene (38 × 13 × 6 cm), covered by a plastic grill, and linked to a support with a rope in order to keep floating in the photic zone. After the immersion period, the cage was removed from the river; the glass slides were scraped using a razor blade and the biofilm was poured into a vial with distilled water and a few drops of 10% formalin.

The material was deposited in the diatom slides collection of Irstea Bordeaux (Cestas, France).

Qualitative analysis – According to standardized protocols (NF EN 13946, AFNOR 2003) samples were first treated with hot hydrogen peroxide (30% H_2O_2) for 30 minutes, and then for five minutes with hot hydrochloric acid (35% HCl) to clean them thoroughly. The hydrogen peroxide and the acid wastes were eliminated through successive centrifugation cycles (3 minutes, 4000 rotations per minute). A sample of this preparation was dried and mounted between slide and cover slip using the resin Naphrax® of high refractive power (Brunel Microscopes: http://www.brunelmicroscopes.co.uk/). Diatoms were identified using light microscopy (LM) (Leica-DMRB) and scanning electron microscopy (SEM).

For SEM, parts of the oxidized suspensions were filtered and rinsed with additional deionized water through a 3-µm Isopore™ polycarbonate membrane filter (Merck Millipore). Filters were mounted on aluminium stubs and coated with platinum using a BAL–TEC MED 020 Modular High Vacuum Coating System for 30 s at 100 mA. An ultra-high-resolution analytical field emission (FE) scanning electron microscope Hitachi SU–70 (Hitachi High-Technologies Corporation, Tokyo, Japan) operated at 5 kV and 10 mm distance was used for the analysis. SEM images were taken using the lower (SE-L) detector signal. Photomicrographs were digitally manipulated and plates containing light and scanning electron microscopy images were created using CorelDraw X5®.

Taxonomic determinations were mainly based on Foged (1966, 1986), Carter & Denny (1982), Krammer & Lange-Bertalot (1986, 1988, 1991a, 1991b), Gasse (1987), Simonsen (1987), Cocquyt (1998), Lange-Bertalot et al. (2011), and on the series of diatoms of Europe (Krammer 2000, 2002, 2003, Lange-Bertalot 2001, Levkov 2009).

To assure an accurate taxonomy and appropriate comparison, the type preparations of *Achnanthes miota* J.R.Carter & Denny and *A. piafica* J.R.Carter & Denny (BM 78107 and BM 78108, River Jong (Taia) at Njala [Sierra Leone], phytoplankton) (Williams & Reid 2002), were received on loan from the British Museum (London, BM) and observed using light microscopy.

TAXONOMIC NOTES

A total of 258 different taxa, divided into 46 genera, have been observed. The genera *Caloneis*, *Cocconeis*, *Eunotia*, *Gomphonema*, *Navicula*, *Nitzschia* and *Pinnularia* were the most common. Five taxa were dominant: *Planothidium comperei* sp. nov. (14.9%), *Cocconeis schroederi* Foged (14.2%), *Cocconeis* sp. (12.1%), *Eolimna minima* Lange-Bert. (9.4%) and *Planothidium piaficum* comb. nov. (6.4%).

Among the most important species structuring the diatom communities, two in particular should be highlighted. Regarding their morphological structure as described in this section, we included them in the genus *Planothidium*, well known for its explicit heterovalvarity, with a slightly concave raphe valve and a convex rapheless valve. In this genus valves are usually elliptic to lanceolate, with rounded, rostrate to capitate apices and multiseriate striae. As many *Planothidium* taxa, our two species show a typical asymmetrical central area on the rapheless valve, with a horseshoe structure named 'cavum' (Spaulding et al. 2008) (this cavum is also observed on each valve in the genus *Gliwiczia*, Kulikovskiy et al. 2013). One species is hereby described as new and a new combination is as well proposed for the other species: *Planothidium comperei* sp. nov. was the most abundant taxon in our dataset; the species shows morphological similarities with *Planothidium miotum*, whose type material from Sierra Leone is here illustrated in LM (fig. 1N-1Y) for comparison; a second species originally described as *Achnanthes piafica* J.R.Carter & Denny is as well illustrated and combined in the genus *Planothidium*, as follows.

Planothidium comperei C.E.Wetzel, N'Guessan & Tison-Rosebery, **sp. nov.**
Figs 1A–M & 2

Type: holo-: BR-4376 (Botanic Garden Meise, Belgium), the valve representing the type is here illustrated in fig. 1B. –

Type locality: Ivory Coast, Mborou, River M'Borou, River Agneby hydrographical basin, 5°58'N 4°31'W (coll. K.R. N'Guessan, coll. date: Dec. 2013).

LM: description – Valves lanceolate to elliptic-lanceolate with convex margins and subrostrate, slightly protracted apices. Valve dimensions (n = 30): length 17.0–23.0 µm, width 7.7–9.0 µm. Rapheless valve (fig. 1A–G): axial area narrow, straight linear; central area with a unilateral large horseshoe-shaped hyaline area with a relatively large cavum. Striae weakly radiate throughout the entire valve. Between 11 and 13 striae in 10 µm measured at the central part of the valve opposite to the unilateral expansion. Raphe valve (fig. 1G–M): axial area narrow, linear, widening near the central area; central area irregularly rounded; bordered on each side by usually two up to three shortened radiate striae. Raphe branches straight with expanded, drop-like proximal

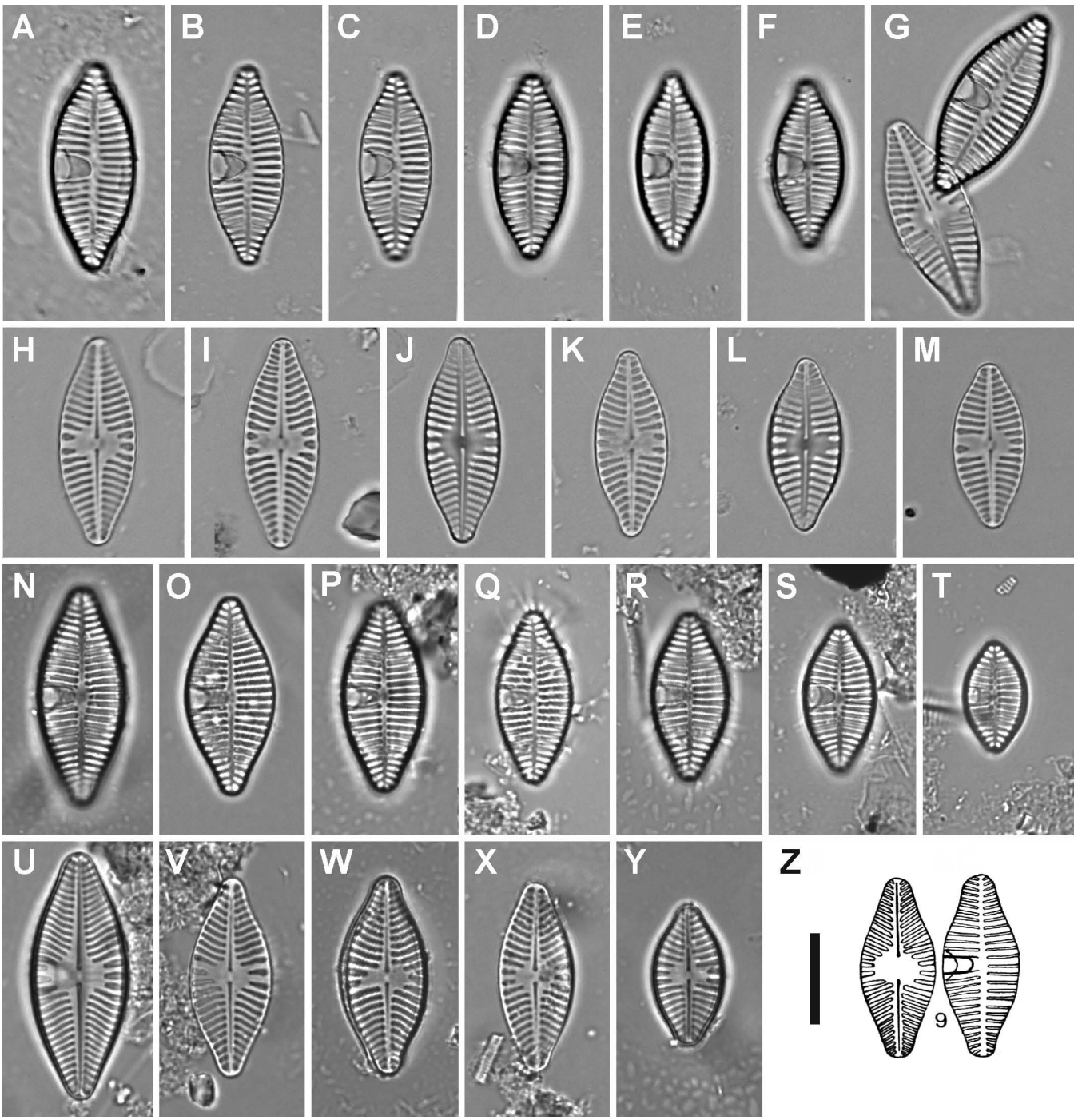

Figure 1 – A–M, light micrographs of *Planothidium comperei* from BR-4376 (M'Borou River, Ivory Coast); N–Y, light micrographs of *Planothidium miotum* (slide BM78107, River Jong, Sierra Leone); Z, drawing of *Achnanthes miota* from Carter & Denny (1982 : fig. 9). Scale bar = 10 µm.

raphe endings. Distal raphe fissures unilaterally deflected. Striae radiate throughout the entire valve, 10–11 in 10 µm. Areolae not discernible in LM.

SEM: description – Rapheless valve: externally, striae composed externally of two to four rows of small rounded areolae (usually three), the middle row being slightly smaller than the parallel outer rows (fig. 2A). Striae portion near the axial area often composed of two rows of areolae. Near the valve mantle the striae reaches up to four areolae and is interrupted near the valve mantle junction. One row of irregular sized areolae (two to four) is present on the valve mantle. Shallow irregular depressions present in the central and axial area as well as in the interstriae (fig. 2A). Internally, a well-developed cavum is present with the borders joined to the neighbour interstriae. Striae internally sunken between raised virgae (fig. 2B). Raphe valve: externally, striae broader than the virgae near the axial area composed of three to five rows of rounded areolae. Proximal external raphe endings expanded (fig. 2C). Distal raphe fissures bent, continuing shortly onto the valve mantle. Internally central nodule raised, with proximal raphe endings not enlarged, slightly deflected to opposite sides. Distal raphe ends terminate internally with inconspicuous helictoglossae (fig. 2D).

Etymology – This species is dedicated to our colleague Pierre Compère on the occasion of his 80th birthday as a tribute to his career as a distinguished taxonomist, especially on African algae.

Taxonomic remarks – Four species show more or less the same valve outline and share similarities with *P. comperei*, including a unilateral horseshoe structure on the rapheless valve and apiculate to rostrate apices: *Planothidium incuriatum* C.E.Wetzel, Van de Vijver & Ector in Wetzel et al. (2013), *Planothidium apiculatum* (R.M.Patrick) Lange-Bert. (Patrick 1945, Lange-Bertalot 1999), *Planothidium infrequens* Lange-Bert. & Rumrich in Rumrich et al. (2000) and *P. miotum* (table 1).

Planothidium infrequens from acid rivers of the Andean Altiplano (Chile, Rio Lauca, South America) shows a large similarity with our new species. In general both have the same outline, being *P. infrequens* more apiculate. However, smaller overall cells dimensions of *P. infrequens* distinguish the latter from *P. comperei*.

Planothidium comperei is also similar to *P. incuriatum* based on the general outline of the apices and the valve dimensions. The criteria for separating both species lies mainly on the stria arrangement and the central area of the raphe valve, with *P. incuriatum* being more parallel and rectangular respectively, while *P. comperei* shows radiate striae and a rounded central area.

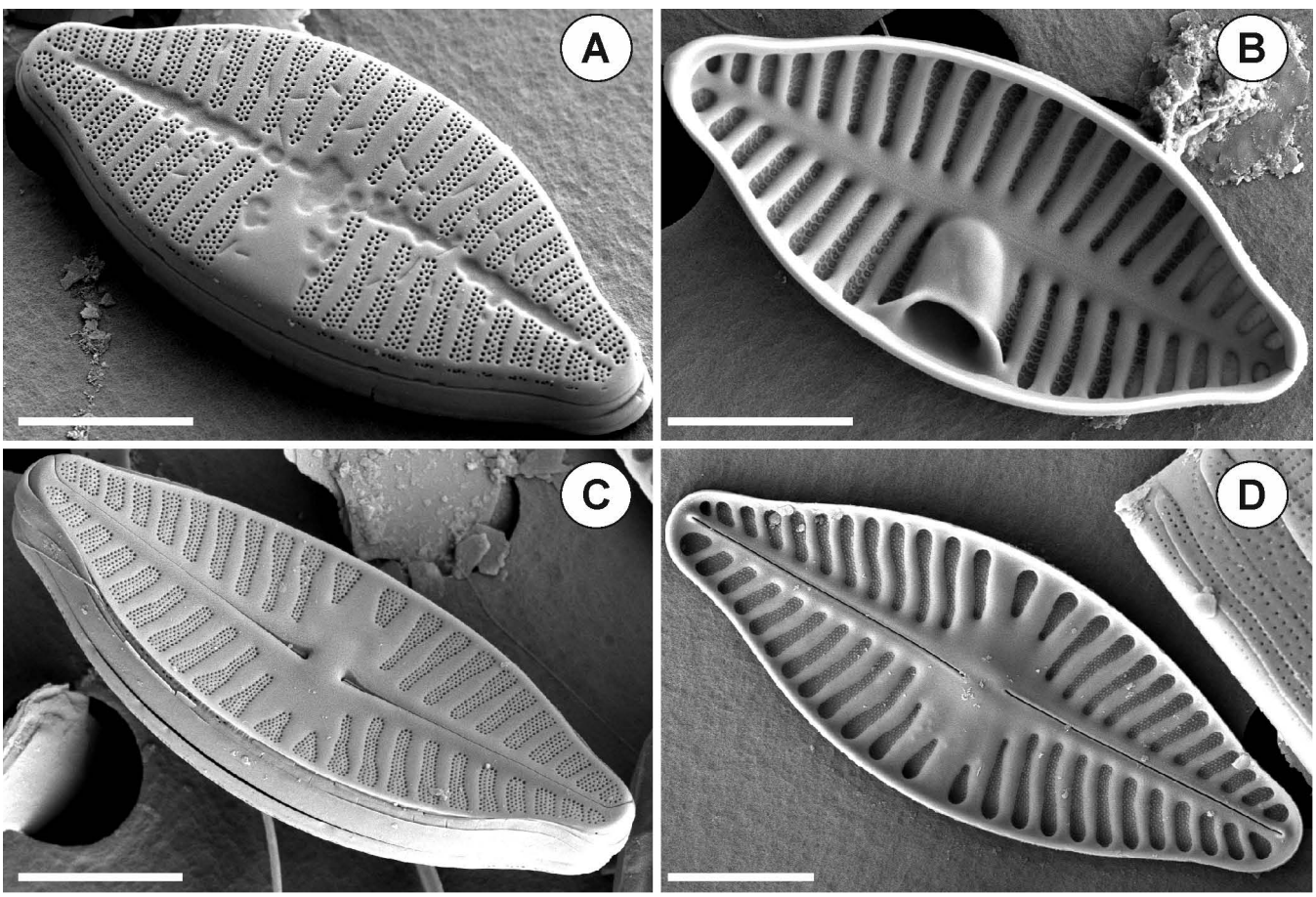

Figure 2 – Scanning electron micrographs of *Planothidium comperei* from BR-4376 (River M'Borou, Ivory Coast): A, external view of rapheless valve; B, internal view of rapheless valve; C, external view of raphe valve; D, internal view of raphe valve. Scale bars = 5 µm.

Table 1 – Main criteria to distinguish *Planothidium* species discussed in this study.

	Planothidium abbreviatum	*Planothidium apiculatum*	*Planothidium biporomum*	***Planothidium comperei***	*Planothidium incuriatum*	*Planothidium infrequens*	*Planothidium miotum*
References	Reimer (1966), Potapova (2012)	Patrick (1945)	Hohn & Hellermann (1963), Wetzel et al. (2013)	this study	Wetzel et al. (2013)	Rumrich et al. (2000)	Slide BM78107, this study
Geographical zones distribution	temperate / sub-tropical	temperate	temperate / sub-tropical	tropical	temperate / sub-tropical	tropical	tropical
Valve outline	elliptic-lanceolate	elliptic-lanceolate, large	lanceolate	elliptic-lanceolate	lanceolate to elliptic-lanceolate	elliptic-lanceolate	lanceolate to elliptic-lanceolate
Apices	subrostrate	apiculate	capitate to subcapitate	subrostrate, slightly protracted	rostrate, protracted	protracted to subrostrate	protracted, obtusely
Central area (raphe valve)	rectangular to elliptic	large rhomboid or transversely elliptical	rectangular to rounded	irregularly rounded	rectangular to slightly rounded	transversely elliptical	rounded, large
Valve length	11–26 µm	28 µm	13–26 µm	17–23 µm	18–25.4 µm	14–18 µm	14–27 µm
Valve width	6.1–8.5 µm	9–12.7 µm	6–7 µm	7.5–9 µm	6.4–7 µm	6–7 µm	7–10 µm
Striae (rapheless valve)	11–12 in 10 µm	10 in 10 µm	13–15 in 10 µm	11–13 in 10 µm	13–15 in 10 µm	11–13 in 10 µm	13–15 in 10 µm
Striae (raphe valve)	11–12 in 10 µm	10–12 in 10 µm	13–15 in 10 µm	10–11 in 10 µm	13–15 in 10 µm	11–13 in 10 µm	10–13 in 10 µm

Planothidium apiculatum also has valves with an elliptical-lanceolate outline and apiculate apices. Moreover, in *P. apiculatum*, the raphe valve has a large rhomboid or transversely elliptical central area. However, the cell dimensions clearly separate both taxa. *Planothidium comperei* is also similar to *Planothidium rostratum* sensu auct. non null, however the lectotype of *Achnanthes rostrata* Østrup (Østrup 1902: 253, pl. 1, fig. 11) from Thailand (Siam) illustrated by Krammer & Lange-Bertalot (1991b: pl. 43, figs 1–4) has smaller dimensions (length 9.3–14.0 µm, width 5.2–6.5 µm) and strongly capitate apices.

Planothidium miotum is a tropical species from Sierra Leone and is most likely to be confounded with *P. comperei*. However, the main criteria to distinguish *P. comperei* from *P. miotum* is the stria density of the rapheless valve which is much denser in *P. miotum* (13–15 in 10 µm, usually 13) than in *P. comperei* (11–13 in 10 µm, usually 11). Other differences can be related to the apices, usually more rostrate in *P. comperei* than in *P. miotum.* The type material of *P. miotum* has been observed by us as explained below.

Planothidium comperei differs also from *P. frequentissimum* (Lange-Bert.) Lange-Bert. by its larger valve dimension and distinct valve outline (Krammer & Lange-Bertalot 1991a, Wetzel & Ector 2014).

Planothidium miotum (J.R.Carter & Denny) Lange-Bert. Fig. 1N–Y

Basionym – *Achnanthes miota* J.R.Carter & Denny (Carter & Denny 1982). – Type: holo-: BM78107 (BM). – Type locality: Sierra Leone, River Jong at Njala, sample 11 (coll. P. Denny, coll. date 7 Feb. 1976).

Distribution and ecology – The species was described from a phytoplanktonic sample of the River Jong in Sierra Leone (West Coast of Africa) and up to now has only been reported from the type locality. The first illustrations from the type material were presented by Krammer & Lange-Bertalot (1991b: pl. 46, figs 19–21) from the type slide "*Typenpräp. Sierra Leone/Afrika*", however only three valves are showed, not allowing further observations of population variability. The species was not present in samples from Ivory Coast.

Morphological remarks – Raw type material from Carter & Denny (1982) was not found for SEM analysis. However, LM analysis from the type slide (BM78107, River Jong (Taia) at Njala [Sierra Leone], phytoplankton) allowed to perform the distinction between *P. miotum* and *P. comperei*. In general, valve dimensions of *P. miotum* are larger and wider than *P. comperei*. Another remark concerns the cavum aperture which is usually smaller in *P. miotum* when compared to *P. comperei.* See fig. 1N–Z.

Planothidium piaficum **(**J.R.Carter & Denny) C.E.Wetzel & Ector, **comb. nov.**
Fig. 3A–G & I–L

Basionym – *Achnanthes piafica* J.R.Carter & Denny, Beihefte zur Nova Hedwigia 73: 286, plate 1, fig. 10. 1982 (Carter & Denny 1982). – Type: holo-: BM78108 (BM). – Type locality: Sierra Leone, River Jong at Njala, sample 11 (coll. P. Denny, coll. date 7 Feb. 1976).

Distribution and ecology – Tropical species only known from the type locality (Sierra Leone) and from the Agneby and the Mé River (Ivory Coast).

Morphological remarks – Raw type material from Carter & Denny (1982) was not found for SEM analysis. We illustrate here the material from Ivory Coast (Mafou, River Mé, 5°73'N 3°97'W, sample 17920, coll. K.R. N'Guessan, coll. date: Dec. 2013), since the species was very rare and only a few broken valves were found in the type slide BM78108 (River Jong) (see Krammer & Lange-Bertalot 1991b: pl. 43, fig. 5). The analysis of the material from Ivory Coast however is in agreement with the drawings provided by Carter & Denny (1982: fig 10, here represented as fig. 3H). We propose therefore a new combination based on this population.

Light microscopic images from Ivory Coast population (fig. 3A–G) show valves with an elliptic-lanceolate to oval outline and protracted, capitate ends. Raphe valve with straight filiform raphe, axial area narrow lanceolate, central area rectangular, striae subparallel to slightly radiate. Rapheless valve with a clearly visible cavum unilaterally expanded.

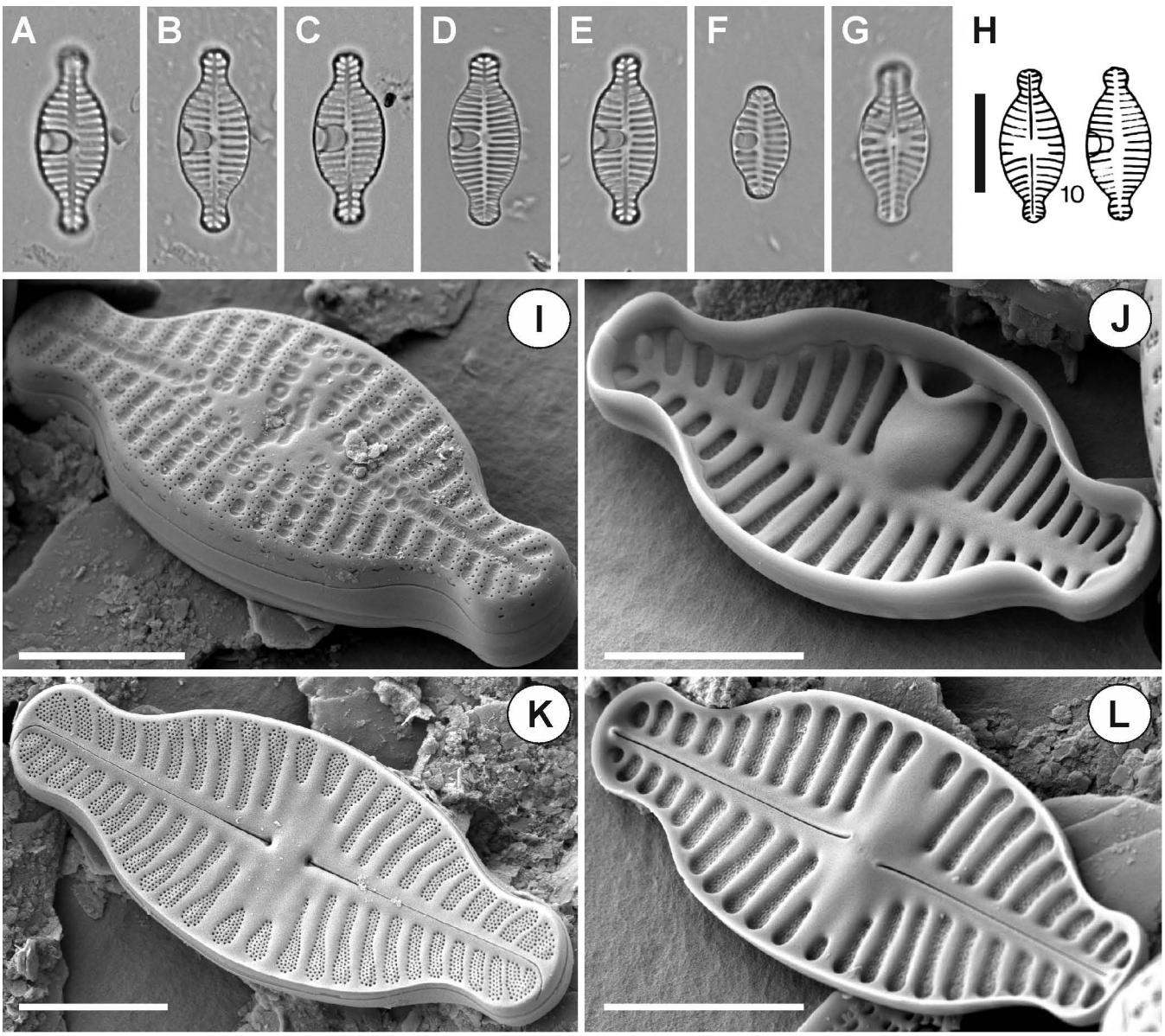

Figure 3 – A–G, light micrographs (LM) of *Planothidium piaficum*; H, Drawing of *Achnanthes piafica* from Carter & Denny (1982, fig. 10); I–L, scanning electron micrographs (SEM) of *Planothidium* piaficum: I, external view of rapheless valve, J, internal view of rapheless valve; K, external view of raphe valve; L, internal view of raphe valve. LM and SEM images from sample 17920 (Mafou River, Ivory Coast). Scale bars = 5 µm.

In SEM, rapheless valve shows the most striking patterns, with very small areolae placed in the interstriae (fig. 3I) and rounded irregular depressions on the valve surface, making it quite extraordinary among the *Planothidium* illustrated in SEM until now. Externally, striae composed of two to three rows of small rounded areolae. Striae interrupted near the valve mantle junction. Internally, a well-developed cavum with a small aperture is present with the borders joined to the neighbour interstriae. Striae internally sunken between raised virgae (fig. 3J). Raphe valve: externally, striae broader than the virgae near the axial area, composed of one to five rows of rounded areolae. Stria interrupted at the borders not reaching the mantle. Proximal external raphe endings expanded. Distal raphe fissures curved, continuing shortly onto the valve mantle (fig. 3K). Internally central nodule raised, with proximal raphe endings not enlarged, slightly deflected to opposite sides. Distal raphe ends terminate internally with inconspicuous helictoglossae (fig. 3L).

SUPPLEMENTARY DATA

Supplementary data are available in pdf at *Plant Ecology and Evolution*, Supplementary Data Site (http://www.ingentaconnect.com/content/botbel/plecevo.supp-data), and consist of a map of the studied watersheds and localization of the sampling sites cited in the text.

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