European Journal of Taxonomy 133: 1–15
http://dx.doi.org/10.5852/ejt.2015.133

ISSN 2118-9773
www.europeanjournaloftaxonomy.eu
2015 · Cocquyt C. & Taylor J.C.

Research article

New and interesting *Surirella* taxa (Surirellaceae, Bacillariophyta) from the Congo Basin (DR Congo)

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Abstract. Two new diatom taxa belonging to the genus *Surirella*, *S. ebalensis* and *S. congolensis*, are described from material of the Congo Basin, downstream Kisangani, DR Congo. The first taxon is a small, rather common species in the studied material; the second a somewhat larger diatom that was only sporadically observed. The morphology of both taxa is examined with light and scanning electron microscopy. The differences between the new and other closely related taxa such as *S. agonaensis* and *S. bonsaensis*, and *S. takoradiensis*, *S. tenuissima* and *S. pseudotenuissima*, respectively, are discussed.

Keywords. Africa, diatoms, new species, *Surirella*.

Cocquyt C. & Taylor J.C. 2015. New and interesting *Surirella* taxa (Surirellaceae, Bacillariophyta) from the Congo Basin (DR Congo). *European Journal of Taxonomy* 133: 1–15. http://dx.doi.org/10.5852/ejt.2015.133

Introduction

Algal reports from for the Democratic Republic of the Congo (DR Congo), formerly Belgian Congo and Zaire, are very limited (e.g., Duvigneaud & Symoens 1949; Hustedt *in* Huber-Pestalozzi 1949; Kufferath 1956a, b; Compère & Symoens 1987, 1988; Compère *et al.* 1989; Golama Swana Kaketa 1992, 1996 and Compère 1995). During the Belgian-Congolese Boyekoli Ebale Congo 2010 Expedition, covering 250 km of the Congo River and some of its tributaries between Kisangani and Bumba (see Nagy *et al.* 2011; Virgilio *et al.* 2011), samples for diatom studies were taken in an unexplored, from an algal point of view, part of the Congo Basin. Some extra samples were taken in this region during two smaller expeditions in the frame of the COBAFISH project. In the sampled area, where people from rural villages live predominantly from subsistence-based agriculture (closely associated with rivers) and fisheries, pristine habitats are rather scarce. The area is characterized by many oil palm and rubber plantations, coffee, cacao, and tea and cotton cultivation, generally farmed by smallholders. The nearest area from where results on diatom studies have been reported in the past is close to Kisangani (Golama Swana Kaketa 1992, 1996; Compère 1995).

From samples taken during the aforementioned Boyekoli Ebale Congo 2010 Expedition, a new diatom, *Cavinula lilandae* Cocquyt, M. de Haan & J.C. Taylor was recently described (Cocquyt *et al.* 2013). The present paper deals with the description of two other new taxa, both belonging to the genus *Surirella* Turpin. The first taxon is a small, rather common species in the studied material sampled in the Congo Basin during the 2010 expedition and during two smaller expeditions in November 2012 and September 2013. The second taxon is a somewhat larger diatom that was only sporadically observed in the studied material.

Material and methods

Material from the Congo Basin, downstream of Kisangani, was collected in May 2010 during the Boyekoli Ebale Congo 2010 Expedition. Supplementary samples were taken in November 2012 and September 2013 on two smaller expeditions in the frame of the COBAFISH project. For the description of the new taxa discussed in the present paper the following samples were examined:
- CCA 2070: Lomami River, 0.49339° N and 24.16960° E, epiphytic on *Nymphaea lotu*s Linnaeus; collected by François Darchambeau and Ernest Tambwe on 24 Nov. 2012; temperature 25.7 °C, pH 6.06, conductivity 22.2 µS cm^{-1}, 0.060 mg l^{-1} NH_4, 0.005 mg l^{-1} NO_2, 0.446 mg l^{-1} NO_3, 0.086 mg l^{-1} soluble reactive phosphorous (SRP).
- CCA 2071: Lomami River, 0.49339° N and 24.16960° E, epiphyton on dead submerged wood; collected by François Darchambeau and Ernest Tambwe on 24 Nov. 2012; temperature 25.7 °C, pH 6.06, conductivity 22.2 µS cm^{-1}, 0.060 mg l^{-1} NH_4, 0005 mg l^{-1} NO_2, 0.446 mg l^{-1} NO_3, 0.086 mg l^{-1} soluble reactive phosphorous (SRP).

In contrast to the samples from the Boyekoli Ebale Congo 2010 Expedition which were fixed *in situ* with 30% formalin, the samples collected on later expeditions in 2012 and 2013 were preserved in ethanol (20% vv.). Part of these samples were oxidized with hydrogen peroxide (30%), rinsed five times with distilled water and embedded in Naphrax® mounting medium. Light microscopic (LM) investigations were carried out with an oil immersion objective (100×) using an Olympus BX 51 microscope, equipped with Nomarski differential interference contrast optics (DIC) and an Olympus UC30 digital camera. For scanning electron microscopy (SEM) aliquots of the oxidized material were filtered through 0.3 µm Millipore® filters and then in turn fixed to aluminum stubs, air-dried and sputter-coated with 50 nm of gold. SEM studied were carried out both at the Botanic Garden Meise (Belgium) and the North-West University (South Africa) with a JEOL-5800LV operating at 25 kV and an FEI Quanta 2000 field emission scanning electron operating at 10 kV respectively.

The raw and the cleaned samples and the permanent slides for diatom investigation are housed at the herbarium of the Botanic Garden Meise (BR). A copy of each permanent slide will be deposited at the Centre de Surveillance de la Biodiversité (CSB) or at the Herbarium of the University of Kisangani, DR Congo.

Water temperature, conductivity and pH were measured using an YSI ProPlus multiprobe field meter equipped with a pH sensor 1001 ProSeries. Samples for nutrient analyses (NH_4, NO_3, NO_2 and SRP) were filtered and acidified *in situ*, and kept frozen until spectrophotometric analysis in the laboratory of the Unité d'Océanographie Chimique, Département d'Astrophysique, Géophysique et Océanographie, University of Liège, Belgium.

Results

Class Bacillariophyceae Haeckel emend. Medlin & Kaczmarska (Medlin & Kaczmarska 2004)
Subclass Bacillariophycidae D.G. Mann *in* Round *et al.* (Round *et al.* 1990)
Order Surirellales D. G. Mann *in* Round *et al.* (Round *et al.* 1990)
Family Surirellaceae Kützing (Kützing 1844)
Genus *Surirella* Turpin (Turpin 1828)

Surirella ebalensis Cocquyt & J.C. Taylor sp. nov.
Figs 1–5

Diagnosis

Valves slightly heteropolar, broadly linear to slightly cuneate with broadly rounded poles and slightly constricted margins in the larger valves, smaller valves not constricted. Apical pole broader than base

pole. Length: 39.4–64.5 µm; width: 16.1–19.4 µm, in the constricted part 18.7 µm. Wing projection very distinct, alar canals smaller than fenestrae, 2.2–3.0 in 10 µm. Fenestral bars distinct in LM, 30 in 10 µm. Striae indistinct in LM, 30 in 10 µm. Valve face covered with numerous silica granules and spines. Spines also present on the keel. Porcae perpendicular to the axial axis, reaching the axial area and becoming radiate near the poles.

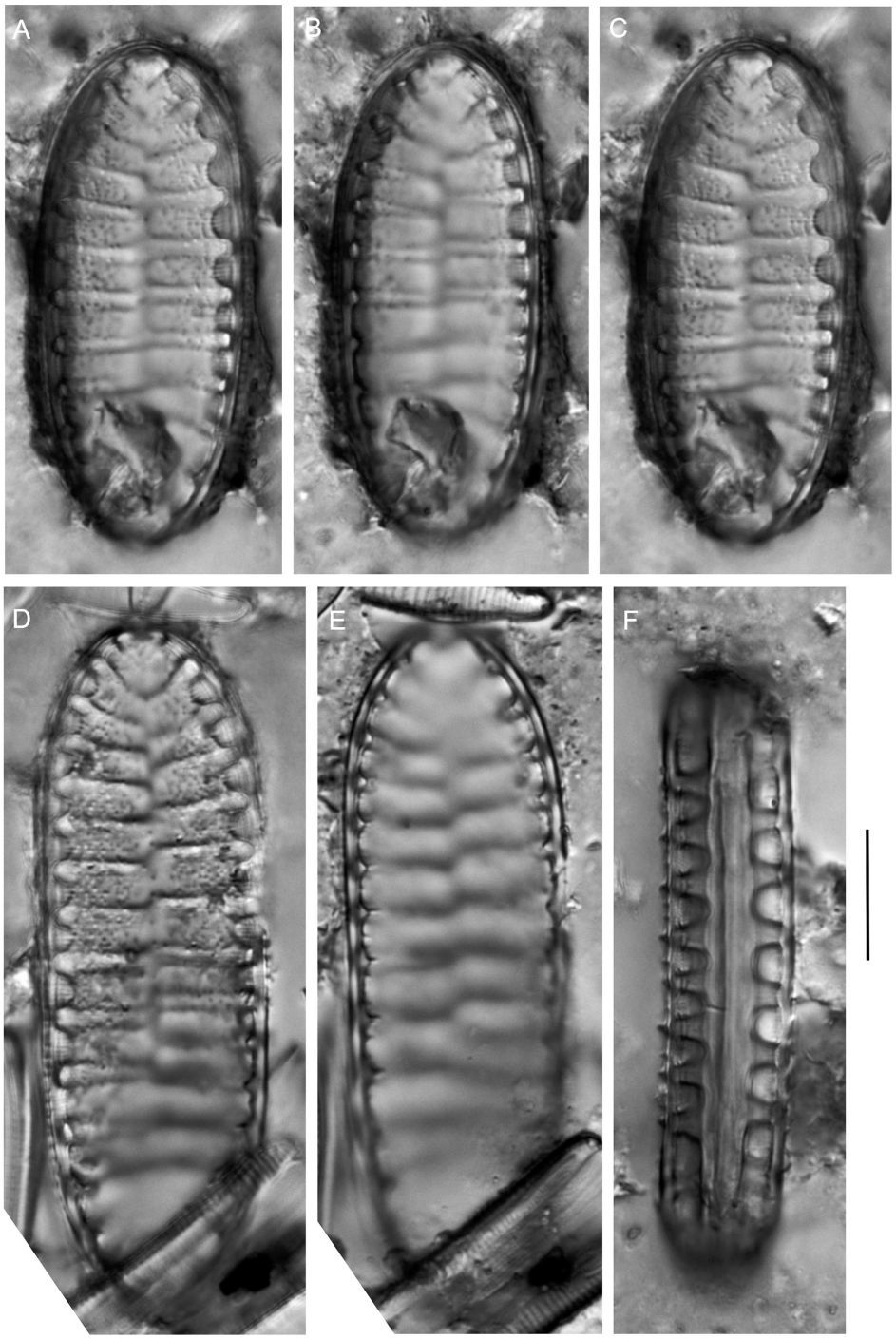

Fig. 1. *Surirella ebalensis* sp. nov., from the holotype slide BR 4398, Lomami River, DR Congo, LM (DIC). **A–C**. Valve representing the holotype, different foci of the same valve. **D–E**. Different foci of the same valve. **F**. Girdle view. Scale bar = 10 µm.

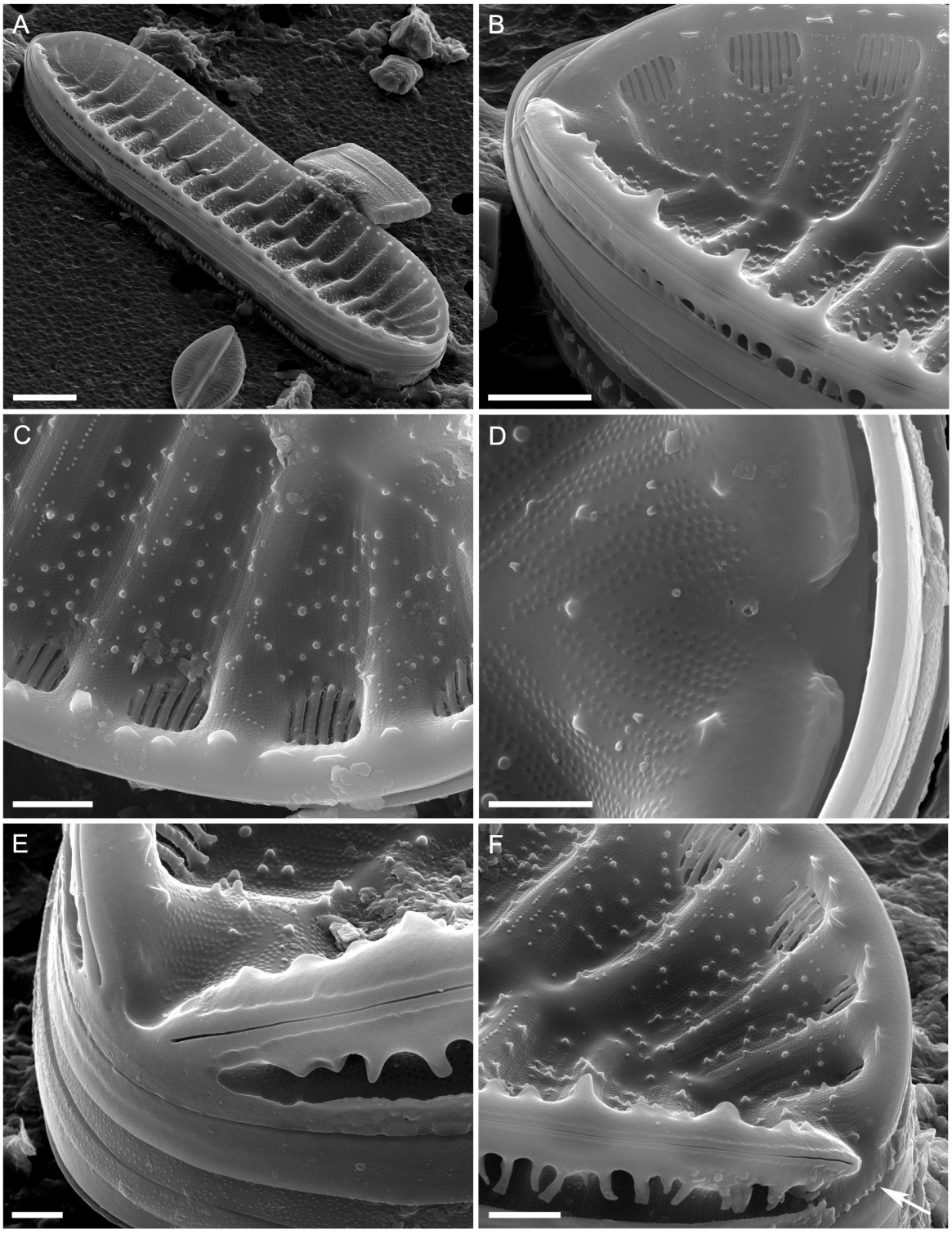

Fig. 2. *Surirella ebalensis* sp. nov., type material from sample CCA 2070, Lomami River, DR Congo, SEM. External view. B, C, F = detail of the raphe keel with blunt spines orientated towards the valve face and which are draped over a large part of the indented mantle side. **A**. Overview. **B–C**. Detail of the valve ornamented with silica granules and blunt spines. **D**. Detail of the apical pole, showing the curved raphe endings. **E–F**. Detail of the foot pole showing the straight raphe endings. **F**. Short spherical shaped silica elements near the pole (arrow). Scale bars: A = 10 µm; B = 4 µm; C, F = 2 µm; D–E = 1 µm.

Etymology

The specific epithet refers to the Lingala word for river which was used in the naming of the expedition, Boyekoli Ebale Congo 2010 (the Study of the Congo River 2010), during which numerous algal samples were collected.

Type material

Holotype

Slide BR 4398 from sample CCA 2070, Botanic Garden Meise, Belgium (BR). The valve representing the holotype is here illustrated in Fig. 1A.

Isotype

Slide Zu10/18 from sample CCA 2070, the Friedrich Hustedt Diatom Collection, Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany (BRM).

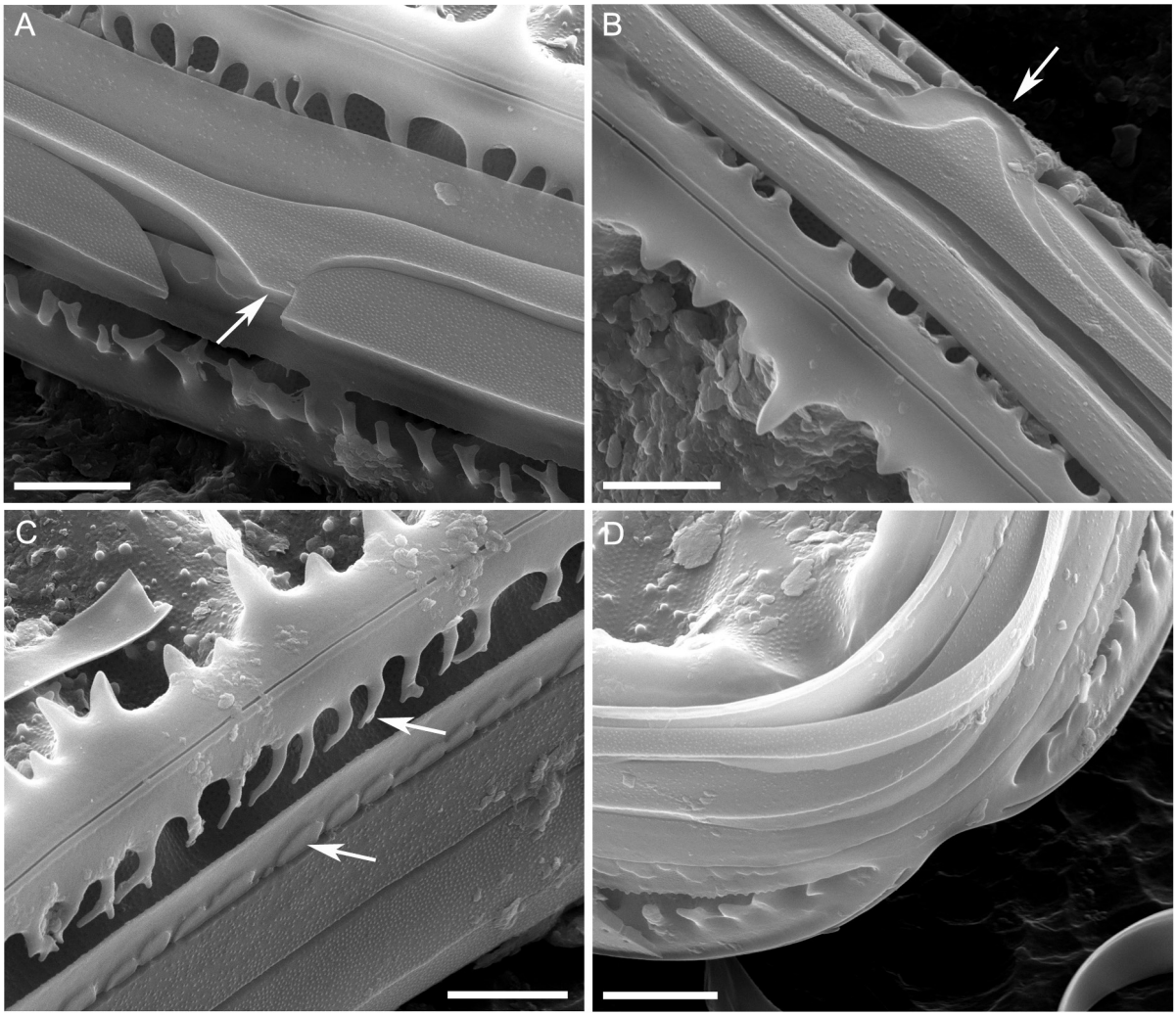

Fig. 3. *Surirella ebalensis* sp. nov., type material from sample CCA 2070, Lomami River, DR Congo, SEM. External view. **A–B**. Detail of the girdle showing a part of a girdle with ligula (arrow) and the neighbouring interrupted band. **C**. Detail of the valve mantle with the draped silica spines (arrow) and the silica plaques (arrow) near the edge of the mantle and the valvocopula. **D**. Detail of the girdle band near the pole. Scale bars = 2 µm.

Type locality

Oriental Province, DR Congo, Lomami River (0.49339° N and 24.16960° E). Epiphyton on *Nymphaea lotus*; collected by François Darchambeau and Ernest Tambwe on 24 Nov. 2012.

Morphological observations using scanning electron microscopy (Figs 2–5)

Axial area narrow to absent near the poles. In the middle of the valve the axial area becomes broader and then larger in the depressions than on the top of the porcae (transapical valve undulations). Porcae perpendicular to the axial axis, becoming radiate near the poles and reaching the axial area but not in the extension of each other near the axial area. Striae biseriate, seldom with uniseriate parts near the axial area (Figs 2C, 4B), about 30 in 10 µm. Near the fenestrae the striae often become triseriate, sometimes quadriseriate (Fig. 2D), and also present for a short distance on the raphe canal just above the fenestrae. Striae composed of 80–110 areolae in 10 µm. Numerous blunt spines scattered over the valve face

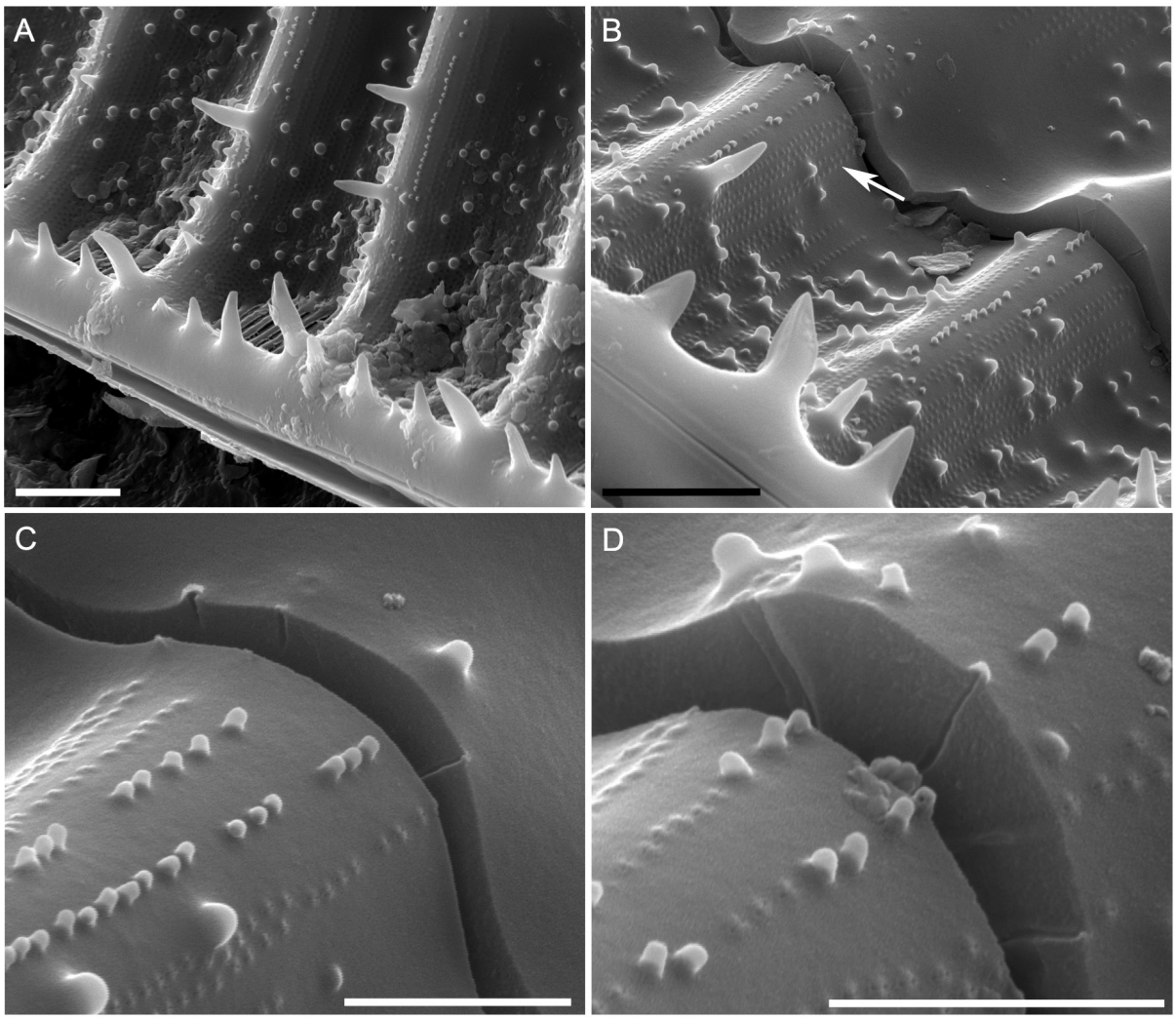

Fig. 4. *Surirella ebalensis* sp. nov., type material from sample CCA 2070, Lomami River, DR Congo, SEM. External view. Details of the various types of spines on the valve face and the keel. **A–B**. Detail of the valve surface with the biseriate striae (arrow) becoming sometimes uniseriate near the axial area. **C–D**. Section of the valve face showing the simple perforation of the silica wall at the areolae. Scale bars: A–B = 2 µm; C–D = 1 µm.

(Fig. 2B–F). On the top of the porcae these spines can become large, up to 1 µm (Fig. 4A–B). In the depressions the spines look more like elongated granules. Another kind of ornamentation is also present on the valve face: small granules located on the striae, composed of an areola that seems to secrete silica on the outside of the valve face (Fig. 4C–D). Sometimes all areolae of almost the entire stria have these granules on the valve face. On the inside the elongated granules are characterized by a perforation of the wall (Fig. 4D) that has no rimmed margins as the normal areolae do (Fig. 5A). Blunt spines are also present on the keel; the spines orientated towards the valve face are of different length and arranged on a single transapical row (Fig. 2B). These spines are often transapically elongated near their base, the shorter ones more triangular in shape (Fig. 4B). On the side towards the mantle the spines on the keel are often bifurcated; they are draped over a large part of the indented mantle side, partially covering the fenestrae (Fig. 3C). The mantle face near the edge of the mantle at the junction with the valvocopula is smooth and bears a single row of small areolae and oval silica plaques (Fig. 3C). At the apical pole these silica plaques are replaced by around 10 short spherical shaped silica elements (Fig. 2F). Bi- to triseriate

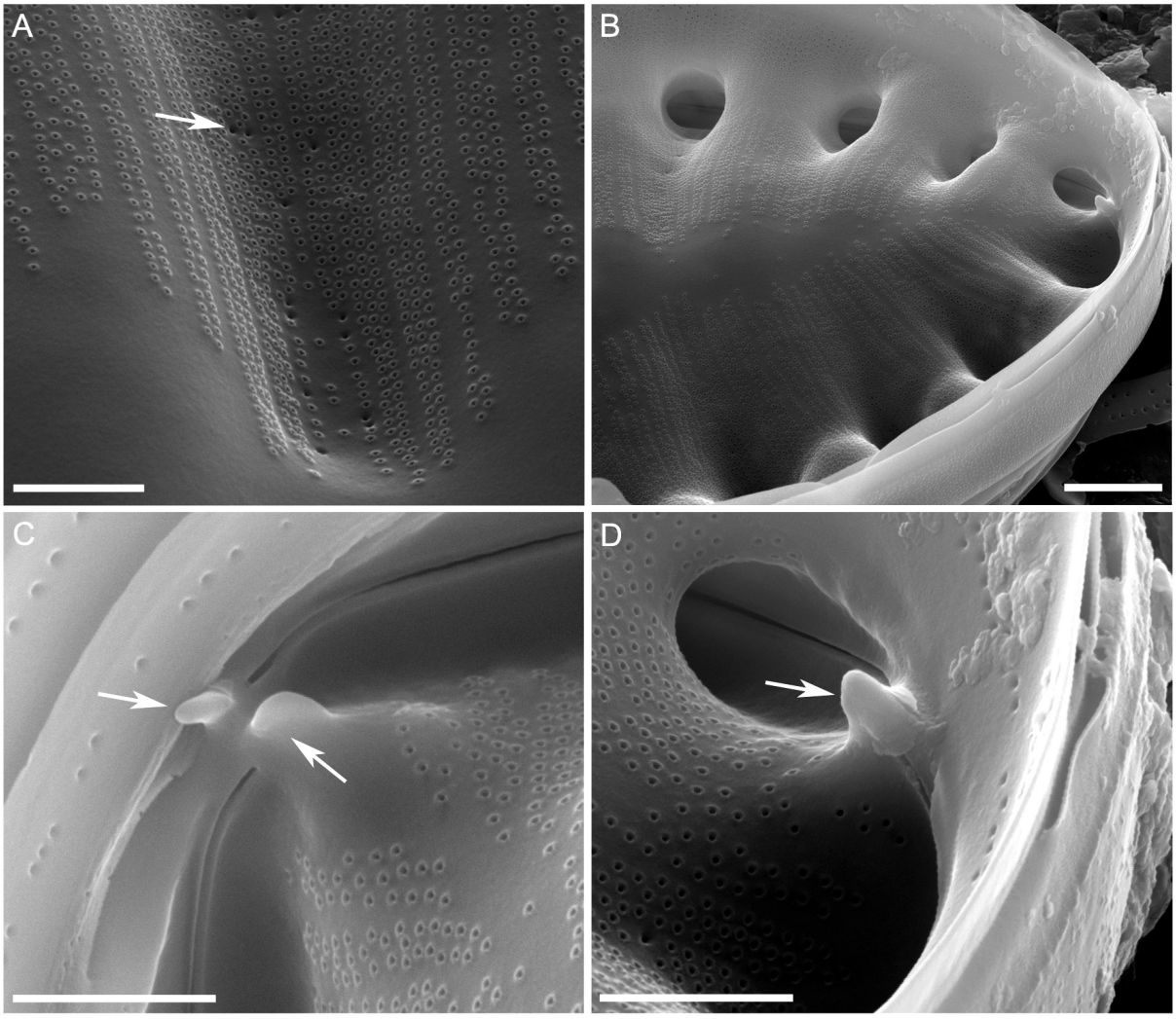

Fig. 5. *Surirella ebalensis* sp. nov., type material from sample CCA 2070, Lomami River, DR Congo, SEM. Internal view. **A**. Detail of the multiseriate striae, and the perforation of the elongated granules without rimmed margin (arrow). **B, D**. Detail of the continuous raphe near the apical pole with a reduced helictoglossa (arrow). **C**. Detail of the straight not expanded raphe endings at the foot pole and their reduced helictoglossae (arrows). Scale bars: B = 2 µm; A, C–D = 1 µm.

striae are present on the indented mantle face at the level of the fenestrae bars. Fenestrae are broader than the alar canals; 30 fenestral bars in 10 µm. External raphe endings are straight, not enlarged at both poles. Internally the raphe is continuous at the head pole while at the base pole the raphe slit is internally interrupted at different levels. Both slits end in a structure resembling a reduced helictoglossa, lacking the typical lip-like structure, and located farther away from the raphe ending (Fig. 5B–D). The girdle is composed of two bands. The open valvocopula band is not smooth but bears tiny granules (Fig. 3C); the second band with a broad ligula and the same tiny ornamentation except on the part of the ligula that is covered by the valvocopula (Fig. 3A–B).

Ecology

Physical and chemical parameters measured at the type locality are as follows: temperature 25.7 °C, pH 6.06, conductivity 22.2 µS cm^{-1}, 0.060 mg l^{-1} NH_4, 0.005 mg l^{-1} NO_2, 0.446 mg l^{-1} NO_3, 0.086 mg l^{-1} soluble reactive phosphorous (SRP).

Surirella ebalensis sp. nov. was observed in a diatom community dominated by *Eunotia bidens* Ehrenberg, *Frustulia* cf. *saxonica* Rabenhorst, *Pinnularia acrosphaeria* W. Smith, *Luticola muticoides* (Hustedt) D.G. Mann, *Encyonema minutum* (Hilse) D.G. Mann, *Stenopterobia anceps* (Lewis) Brébisson, *Eunotia* spp., *Cymbopleura* sp., *Placoneis* sp., *Caloneis* sp. and *Neidium* sp.

Surirella congolensis Cocquyt & J.C. Taylor sp. nov.
Figs 6–9

Diagnosis

Valves heteropolar, lanceolate with broadly rounded apical pole and subacute base pole, becoming gradually narrower from the apical pole to the base pole; larger valves slightly constricted mid-valve. Valve length 18.7–33.0, width (4.2) 5.5–6.9 (7.9) µm. Wing projection distinct. Alar canals short, not reaching the axial area, 5.5–6.0 in 10 µm, much smaller than the fenestrae, and rarely becoming denser near the poles. Striae about 30 in 10 µm.

Etymology

The specific epithet refers to the Congo River and the Democratic Republic of the Congo where the samples were collected.

Type material

Holotype

Slide BR 4399 from sample CCA 2071, Botanic Garden Meise, Belgium (BR). The valve representing the holotype is here illustrated in Fig. 6G.

Isotype

Slide Zu10/19 from sample CCA 2071, the Friedrich Hustedt Diatom Collection, Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany (BRM).

CCA 2071: Lomami River, 0.49339° N and 24.16960° E, epiphyton on dead submerged wood, collected by François Darchambeau and Ernest Tambwe on 24 Nov. 2012.

Type locality

Oriental Province, DR Congo, Lomami River (0.49339° N and 24.16960° E). Epiphyton on dead submerged wood.

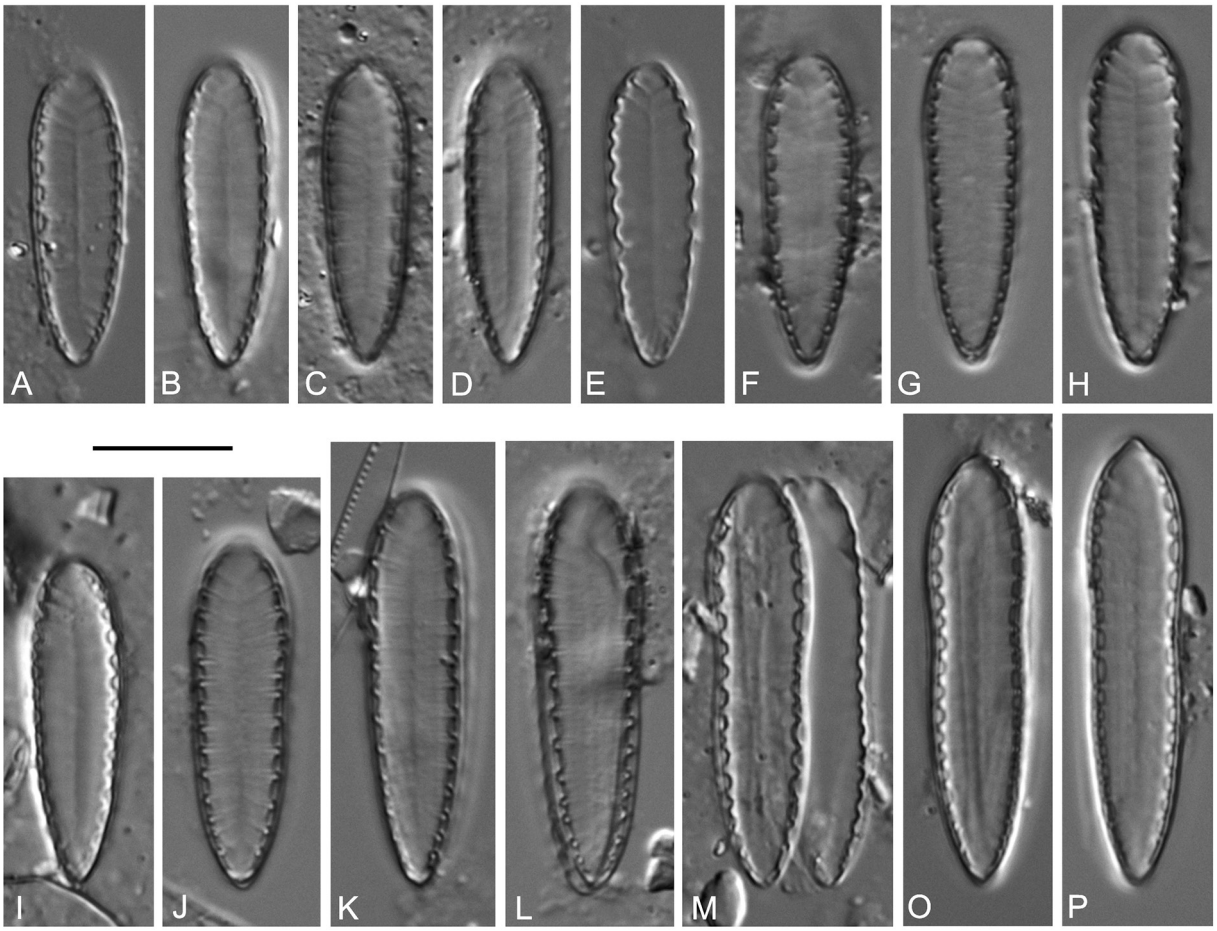

Fig. 6. *Surirella congolensis* sp. nov., from the holotype slide BR 4399, Lomami River, DR Congo, LM (DIC), valve views. **G**. Valve representing the holotype. Scale bar = 10 µm.

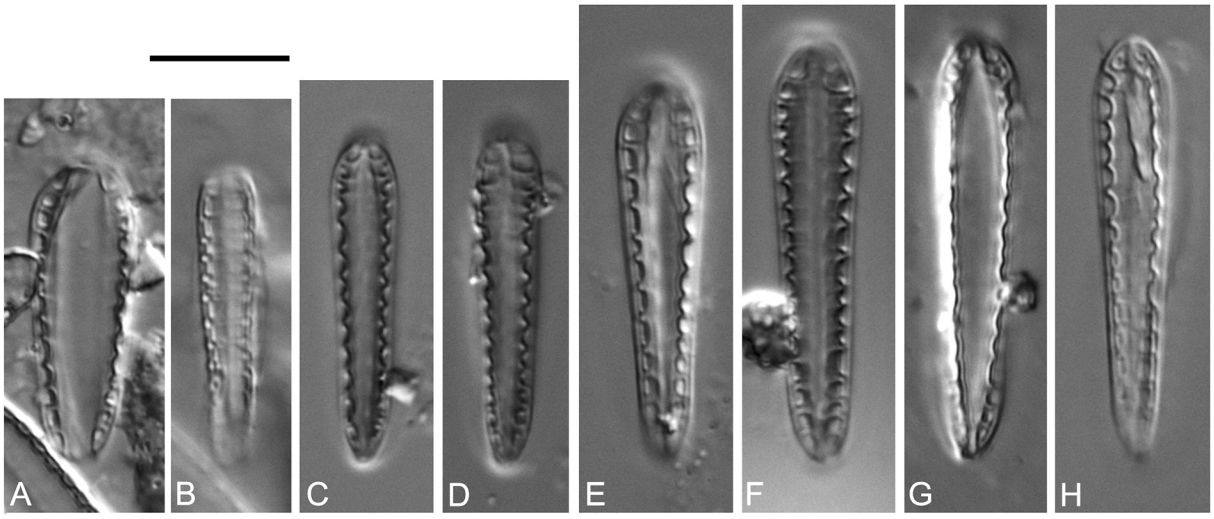

Fig. 7. *Surirella congolensis* sp. nov., from the holotype slide BR 4399, Lomami River, DR Congo, LM (DIC), girdle views. Scale bar = 10 µm.

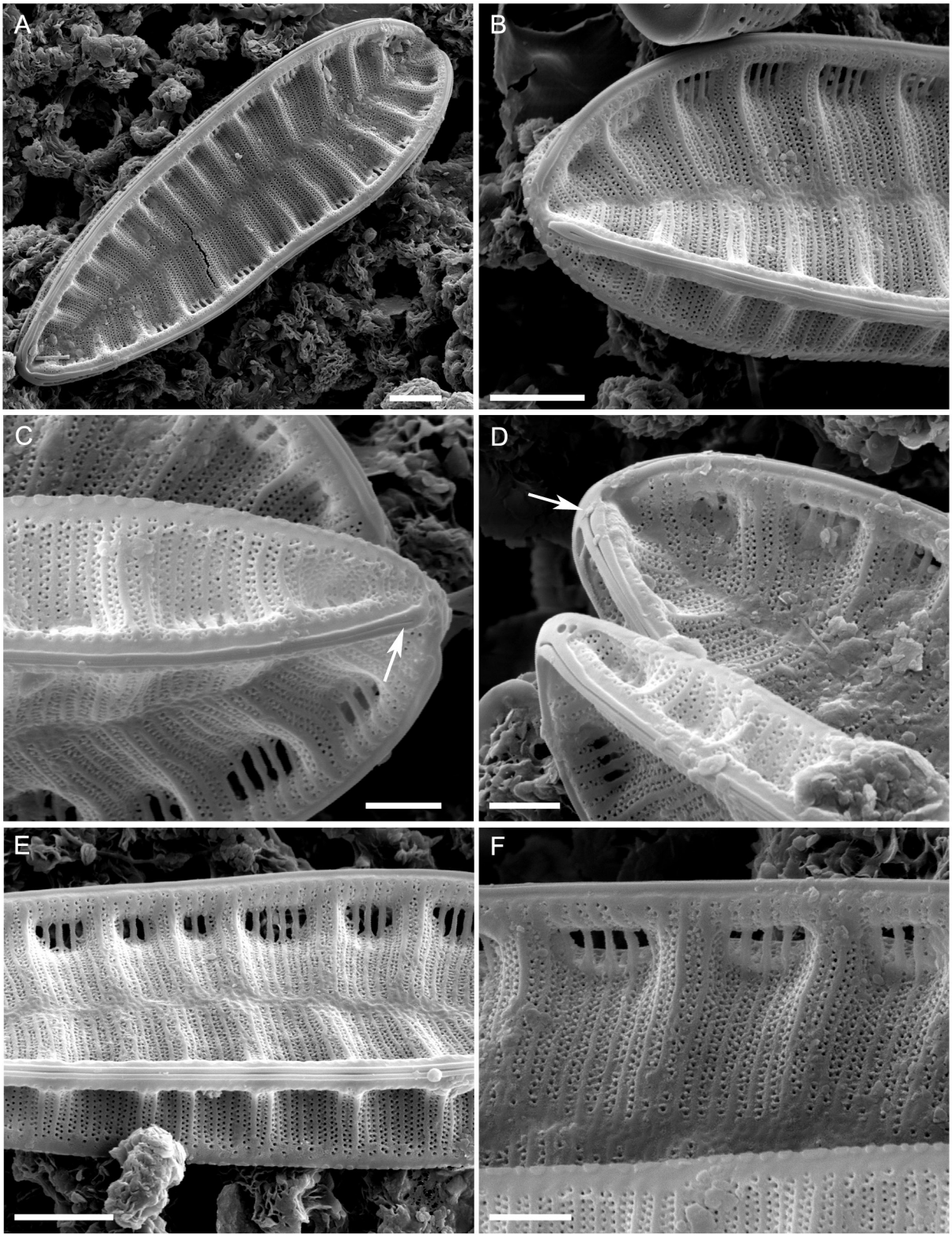

Fig. 8. *Surirella congolensis* sp. nov., type material from sample CCA 2071, Lomami River, DR Congo, SEM. External view. **A**. Overview. **B–C**. Detail of foot pole showing the straight not expanded raphe endings (arrow). **D**. Detail of the apical pole showing the slightly curved raphe endings (arrow). **E–F**. Detail of the biseriate striae and the open fenestrae with the fenestral bars. Scale bars: A–B = 2 µm; C–F = 1 µm.

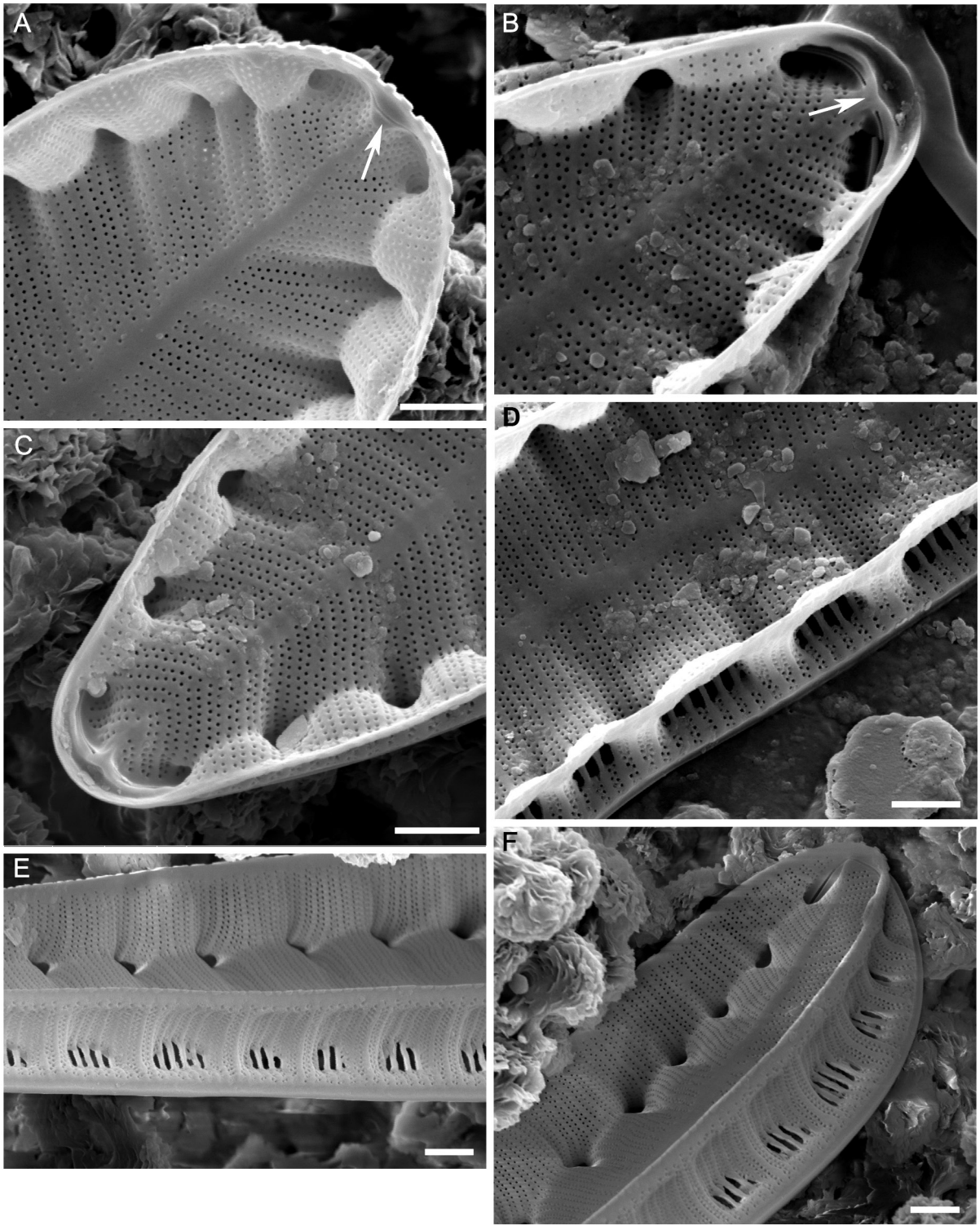

Fig. 9. *Surirella congolensis* sp. nov., type material from sample CCA 2071, Lomami River, DR Congo, SEM. Internal view. **A–B**. Head pole showing the continuous raphe (arrow). **C–D**. Foot pole showing the interruption of the raphe and the straight slightly expanded terminal raphe endings. **E–F**. Detail of the alar canals. Scale bars: B–C = 2 µm; A, D = 1 µm.

Morphological observations on scanning electron microscopy (Figs 8–9)

External view

Axial area narrow. Striae biseriate, continuing on the keel also above the fenestrae and on the mantle side. Raphe endings near the apical pole straight not enlarged (Fig. 8B–C), near the base pole straight and slightly bent towards the valve face (Fig. 8D). Striae composed of round areolae, in 10 µm, biseriate and continuing on the raphe sternum. Fenestrae open and divided by fenestral bars, openings between the fenestral bars located in the prolongation of the striae. No ornamentation such as spines or silica granules present on the valve face, except for silica plaques present at the edge of the valve mantle at the place where the valvocopula is attached to the valve (Fig. 8E).

Internal view

Raphe continuous on the apical pole (Fig. 9A) and interrupted near the foot pole with straight and slightly expanded raphe endings (Fig. 9B–C).

Girdle composed of several open, unornamented bands.

Ecology

Physical and chemical parameters measured at the type locality are as follows: temperature 25.7 °C, pH 6.06, conductivity 22.2 µS cm^{-1}, 0.060 mg l^{-1} NH_4, 0.005 mg l^{-1} NO_2, 0.446 mg l^{-1} NO_3, 0.086 mg l^{-1} soluble reactive phosphorous (SRP).

Surirella congolensis sp. nov. was observed in a diatom community dominated by *Navicula feuerbornii* var. *africana* Foged, *Gomphonema brasiliense* subsp. *pacificum* Gerd Moser, Lange-Bertalot & Metzeltin, *Orthoseira roeseana* (Rabenhorst) O'Meara, *Eolimna* spp. and *Eunotia* spp.

Discussion

Surirella ebalensis sp. nov. resembles *S. agonaensis* Foged described from Ghana in West Africa (Foged 1966; Cocquyt & Kusber 2010). The shapes of the valves differ slightly, but the valve width is distinctly narrower in *S. ebalensis* sp. nov. (16.1–19.4 µm) compared to the broader *S. agonaensis* (27.5–30.0 µm). The valve length also is smaller: 40.3–64.4 versus 78–80 µm, respectively. The alar canals are denser in *Surirella ebalensis* sp. nov. than in *S. agonaensis*: 2.2–3.0 compared to 1.4–1.6. Moreover, the wing projection is very distinct in the new species compared to the slightly distinct projection in *S. agonaensis*. Besides these differences observed in LM, the SEM study of *S. ebalensis* sp. nov. showed the presence of draped, often forked silica spine-like structures extending on the keel at the mantle side partially covering the fenestrae (Fig. 3C), these structures are absent in *S. agonaensis* (Cocquyt & Kusber 2010). The spines of variable length on the top of the porcae (Fig. 4A–B) as present in *S. ebalensis* sp. nov., have not until now been observed in *S. agonaensis*, where silica granules are the only ornamentation on the valve face.

The closely related *S. bonsaensis* Foged, also decribed from Ghana in West Africa (Foged 1966; Cocquyt & Kusber 2010) differs in valve shape, which is broadly linear and isopolar, and in larger valve dimensions (length 70–80 µm, width 24.5–26.0 µm). There exists a small overlap in number of alar canals in 10 µm: 2.2–3.0 in *S. ebalensis* sp. nov. and 2.0–2.4 in *S. bonsaensis*. As in *S. agonaensis* the wing projection in *S. bonsaensis* is also less pronounced than the distinct projection in *S. ebalensis* sp. nov.. Moreover the striation is coarser (25 in 10 µm in *S. bonsaensis*, 30 in 10 µm in *S. ebalensis* sp. nov.) and in LM no spines or other ornamentation of the valve face is visible.

A third taxon described from Ghana, *Surirella esamangensis* Foged (Foged 1966; Cocquyt & Kusber 2010), is also closely related to the new species described here. Some overlap exists in valve length (58.5–64.0 µm versus 40.3–64.5 µm), density of alar canals (2.0–2.4 in 10 µm versus 2.2–3.0 in 10 µm) and striae density (25–30 in 10 µm versus 30 in 10 µm) but not in valve width (22.5–24.0 µm versus

16.1–19.4 µm). Moreover, in *S. esamangensis* the valve shape is elliptic and slightly heteropolar with evenly rounded apical and base pole and a relatively indistinct wing projection.

Spines on the keel in other *Surirella* taxa were also observed in material from Sulawesi (Bramburger *et al.* 2006), e.g., *Surirella alata* Hustedt, *S. fimbriata* Hustedt and *S. tubicola* Bramburger & Hamilton. These spines are of different length than in the Congo material studied, but the spines in our material are often much larger. In the Sulawesi material spines were also observed on the valve face, for example in *S. tenacis* Bramburger & Hamilton. Both are hollow structures, different from the flat full spines found in for example *S. nervosa* (A.W.F. Schmidt) Mayer. Some of the spine-like structures present on the valve face resemble the four spines present on the valve face of *S. quadridentis* Bramburger & Hamilton. However, these four spines of *S. quadridentis* resemble more the spine-like structures of *Cymatopleura calcarata* Hustedt: also hollow structures (Cocquyt 2001) which are probably processes and not true spines. More studies, including internal valve views and cell wall ontogeny are needed to understand these spine-like structures.

Surirella congolensis sp. nov. is closely related to *S. takoradiensis* Foged, described from Ghana in West Africa (Foged 1966; Cocquyt & Kusber 2010). Although both taxa are heteropolar and about the same length (18.7–33.0 compared to 20.0–27.0 (38.0) µm for *S. takoradiensis*) the valve shape differs: lanceolate in *S. congolensis* sp. nov. while ovate to oval-elliptical in *S. takoradiensis*, slightly constricted in the larger valves compared to no constriction at all, subarcuate compared to rounded base pole. Valves are narrower in *S. congolensis* sp. nov. (5.5–6.9 µm, seldom up to 7.9 µm) than in *S. takoradiensis* (7.0–9.0 (10.5) µm), and the alar canals in 10 µm are mostly denser, 5.5–6.0 and 4.0–6.0, respectively. The fenestrae are lower in *S. congolensis* sp. nov. than in *S. takoradiensis* where the fenestrae are almost rectangular in girdle view.

Surirella congolensis sp. nov. is also related to *Surirella pseudotenuissima* Leclercq, described from Sumatra by Leclercq (1983) using material of the Friedrich Hustedt Diatom Collection (BRM X4/75, picture of the type in Hustedt 1938, tab. 43, fig. 8). Although *S. pseudotenuissima* is a tropical species it was reported from temperate regions in Europe (Belgium) by Denys (1985). It is a heteropolar species with a similar valve length of 25.0–57.0 µm, but much broader with a width of 9.5–13 µm. The alar canals (3.4–5.0 in 10 µm compared to 5.5–6.0 in 10 µm in *S. congolensis* sp. nov.) as well as the striae (23–26 striae in 10 µm compared to about 30 in 10 µm in *S. congolensis* sp. nov.) are coarser. The new taxon is also related to *Surirella tenuissima* Hustedt which has heteropolar valves with a length of 17.0–38.0 µm, a width of 6.0–11.0 µm and 4.0–7.0 alar canals in 10 µm, which are smaller than the fenestrae (Hustedt *in* Huber-Pestalozzi 1942). *Surirella tenuissima* is a littoral species reported from South America and Indo-Malaysia. In Sulawesi and the Philippines (Leyte) it was also found in the plankton (Hustedt *in* Huber-Pestalozzi 1942).

Acknowledgements

The first author is grateful to the Belgian Federal Science policy who funded the COBAFISH project (SD/AR/05A) in which the present study was undertaken. J.C. Taylor is a beneficiary of a mobility grant from the Marie Curie Actions of the European commission co-financed by the Belgian Federal Science Policy. J.C. Taylor is the recipient of South African National Research Foundation (NRF) incentive funding. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and therefore the NRF does not accept any liability in regard thereto. Part of the material studied was sampled during the Boyekoli Ebale Congo 2010 expedition, organized by the Congo 2010 Consortium (composed of the University of Kisangani, the Royal Museum for Central Africa, the Royal Belgian Institute of Natural Sciences and the National Botanic Garden of Belgium) and funded by the Belgian Development Aid, the Belgian Science Policy and the Belgian Lottery. The authors are grateful to François Darchambeau and Ernest Tambwe and the other members of the COBAFISH field expedition in 2012 for sampling and measuring the physical and chemical parameters.

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Manuscript received: 4 March 2015
Manuscript accepted: 9 June 2015
Published on: 17 August 2015
Topic editor: Thomas Janssen
Desk editor: Charlotte Thionois

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