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A new *Aulacoseira* species (Bacillariophyta) from Tierra del Fuego (Argentina) and comparison with the type material of *Melosira laevis* var. *fuegiana* Frenguelli

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A new centric diatom belonging to the genus *Aulacoseira* was found during a survey of the diatom community from peatbogs of Tierra del Fuego (southern Argentina). The present paper describes *Aulacoseira frenguelliiana* sp. nov. based on detailed light and scanning electron microscopy and compares its morphological features with similar species. *Aulacoseira frenguelliiana* is characterized by short chains joined by spatulate spines, one row of marginal areolae, a very narrow ringleist and only one rimoportula. The type material of *Melosira laevis* var. *fuegiana* Frenguelli, a species described from Tierra del Fuego showing some morphological resemblance to the new species, was studied using light microscopy to clarify the taxonomic position of this species. A transfer to *Aulacoseira* is proposed as *A. fuegiana* (Frenguelli) comb. et stat nov.

Keywords: *Tierra del Fuego*, *Aulacoseira*, *peatbogs*, *morphology*, *centric diatom*

Introduction

The genus *Aulacoseira* was described in 1848 by Thwaites (1848). It is a common freshwater (tycho-)planktonic genus that is globally distributed (Round et al. 1990, Houk & Klee 2007). Simonsen (1979) resurrected the name transferring many species from the genus *Melosira* C. Agardh to *Aulacoseira*. Mantle height, morphology of the spines, areolation pattern, position and number of rimoportulae and ringleist structure are the main characters used to the differentiate species (English & Potapova 2009, Tremarin et al. 2012, Van de Vijver 2012).

Our knowledge of the genus *Aulacoseira* occurring in South America is rather poor (Tremarin et al. 2014a), and the use of Northern Hemisphere bibliography has caused many identification errors due to force-fitting south-American species into their northern hemisphere relatives. Tremarin et al. (2014a) present a good overview of all *Aulacoseira* studies in South America. Of the almost 60 described *Aulacoseira* species worldwide (Edgar & Thériot 2004), 15 of them were cited for Argentina (Vouilloud 2003). Unfortunately, most of these studies only mention species names without properly illustrating the records, making a verification of the records very difficult. Recently, however, several new *Aulacoseira* taxa were described from South America (Tremarin et al. 2011, 2012, 2013, 2014a, b, Morales et al. 2015), usually correcting previous identification errors.

The present paper describes *Aulacoseira frenguelliiana* sp. nov., a new species from Tierra del Fuego (southern Argentina) based on detailed light (LM) and scanning electron microscopy (SEM). The only *Aulacoseira* (as *Melosira*) taxon described from Tierra del Fuego is *Melosira laevis* var. *fuegiana* Frenguelli (Frenguelli 1924a, b, c). The type material of the latter was investigated to determine its similarity to *A. frenguelliiana*. As a result of this analysis, the transfer of *Melosira laevis* var. *fuegiana* into the genus *Aulacoseira* is proposed.

Material and methods

Sediment samples used in this study were collected in November 2016 in the Rancho Hambre peatbog (54°47'S, 68°19'W) situated 50 km north-east of Ushuaia (Tierra del Fuego, Argentina). This area has a cold-temperate climate with a monthly mean air temperature of 4.2°C and a monthly mean precipitation of 60 mm (González-Garrazza et al. 2012). Rancho Hambre is a dome-shaped peatbog dominated by *Sphagnum magellanicum* Bridel with a large number of shallow (depth < 2 m) water bodies. The southern margin of the peatbog is bordered by the Larsifashaj River (Mataloni 2016). In each pond pH, conductivity (µS/cm), turbidity (ntu) and temperature (°C) were measured *in situ*. Total organic carbon (TOC) analysis was

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carried out in the laboratory using a TOC-L Shimadzu apparatus.

Samples for light microscopy observations were prepared following the method described in Van der Werff (1955). Subsamples of the original sediments were cleaned by adding 37% H₂O₂ and heating to 80°C for about 1 h. The reaction was completed by addition of KMnO₄. Following digestion and centrifugation (three times 10 min at 3700 × *g*), cleaned material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom material was mounted in Naphrax[®]. The slides were analysed using an Olympus BX53 microscope, equipped with Differential Interference Contrast (Nomarski) and an Olympus UC30 digital camera. For SEM, parts of the oxidized suspensions were filtered through polycarbonate membrane filters with a pore diameter of 5 μm, pieces of which were fixed on aluminium stubs after air-drying. The stubs were sputter-coated with a Pt layer (10 nm) and studied in a Jeol[®] JSM-7100F SEM at 1 kV at the Botanic Garden Meise, Belgium.

During the revision of literature records of centric diatoms in Tierra del Fuego, one species showed a fairly large similarity to the unknown species, i.e., *Melosira laevis* var. *fuegiana* Frenguelli (Frenguelli 1924a, b, c) making an analysis of the type material of this species necessary. The type material of this species was originally sampled by Professor Doello-Jurado in March 1921 in ‘Chorrillo Uaquen’, Fuego River, Tierra del Fuego, Argentina. Several slides from the Frenguelli Collection (Museo de la Plata) made from this material (known as Series 234) were analysed using a Leica DM 2500 DIC microscope equipped with a Leica DFC 420 digital camera at the Universidad Nacional de La Plata, Argentina. Due to the lack of unmounted material, SEM analysis of this taxon was not possible.

Morphological terminology follows Crawford (1981), Round *et al.* (1990), Crawford & Likhoshway (1999, 2002), Houk (2003) and Houk & Klee (2007). The morphology of the new species has been compared with the ultrastructure of known species (a.o. Krammer 1991, Krammer & Lange-Bertalot 1991, Houk 2003, Houk & Klee 2007, Tremarin *et al.* 2011, 2012, 2013, 2014a, b).

Observations

Aulacoseira frenguelliiana Casa & Van de Vijver sp. nov. (Figs 1–27)

Description: Frustules cylindrical, often solitary or linked by spines to form short, straight chains of up to 4 cells. Valve diameter 4.5–10.0 μm, mantle height 2.0–4.0 μm, mantle height/diameter ratio 0.25–0.60. Valve face flat with only one row of marginal areolae. Linking spines short, spatulate, bidentate or tridentate, positioned on every interstria. Separation valves lacking spines not observed. Mantle with slightly dextrorse rows of areolae (12–16

in 10 μm) possessing 3–6 areolae per stria. Very narrow ringleist present inside the mantle and only one rimoportula present on the mantle.

Holotype: BR-4501 (Botanic Garden Meise, Belgium), Fig. 11 represents the holotype.

Isotype: PLP-335 (University of Antwerp, Belgium).

Type locality: Rancho Hambre, Tierra del Fuego, Argentina, sample RH-E5-SED, (leg. V. Casa, coll. date 23/11/2016).

Ecology and Distribution: *Aulacoseira frenguelliiana* is a rather rare species, found in sediment samples of some ponds sampled in the Rancho Hambre peatbog, Tierra del Fuego, Argentina. The pH of the samples ranged from 4.2 to 6.2, DOC values were between 7.6 and 20.6 mg/L and the conductivity values always remained below 200 μS/cm. The largest population was found in a small shallow clear pond with fine sediments and a fairly large population of *Trichoptera* sp. larvae.

During a survey of the freshwater diatoms of the Falklands Islands/Islas Malvinas, a small population of *A. frenguelliiana* was observed (Van de Vijver, pers. obs.). Flower (2005) identified the species from the Falklands Islands/Islas Malvinas as ‘*Aulacoseira distans* (cf. *septentrionalis*)’. Analysis of the two pictures in Flower (2005, figs 57, 60) indicated that they actually represent *A. frenguelliiana* (see below).

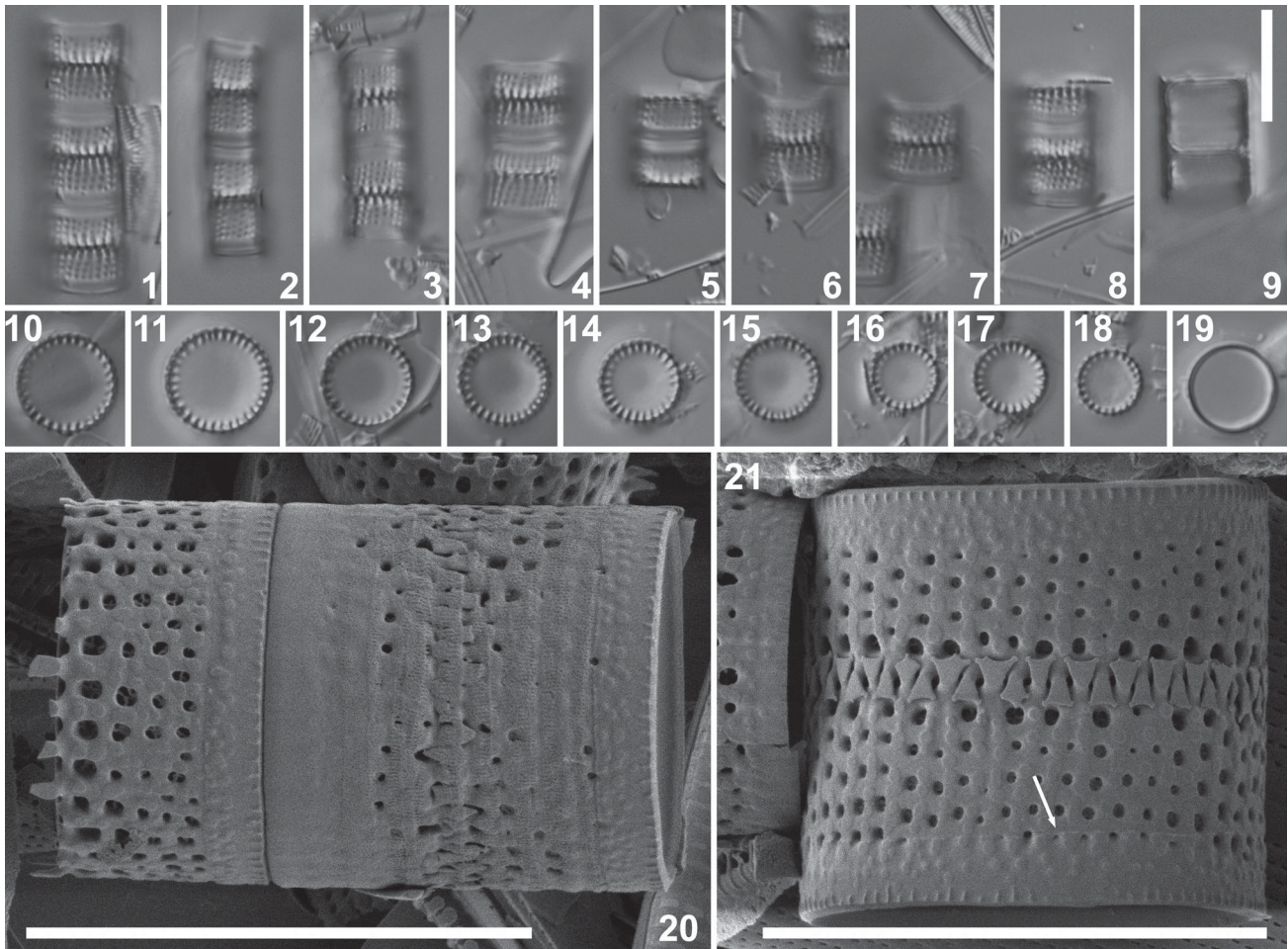
Etymology: The new species is named after Dr Joaquin Frenguelli in recognition of his research on diatoms in Tierra del Fuego.

Observations

LM (Figs 1–19): Frustules often solitary or forming chains with two to four cells joined by short linking spines. Valve dimensions (*n* = 50): diameter 4.5–10.0 μm; mantle height 2.0–4.0 μm; mantle height/diameter ratio 0.25–0.60. Valve face with only one row of marginal areolae. Ringleist not discernible in LM (Fig. 19).

SEM (Figs 20–27): Collum lacking areolae, covered by short ribs and siliceous plaques (Figs 20, 21). Plaques also visible between the mantle striae (Figs 20, 21). Müller step clearly visible (Fig. 21, arrow). Mantle rows of areolae slightly curved to the right side, 12–16 in 10 μm, composed of 3–6 rounded to irregularly shaped and sized areolae (Figs 20, 21). Mantle areolae largest close to the valve face, next to the linking spines (Fig. 21). Linking spines well developed, short and parallel to the perivalvar axis, spatulate, most of them bidentate, occasionally tridentate (Figs 21, 22, 24), separated by a single areola.

Valve face flat (Figs 22, 23). One single row of large, rounded areolae present at the margin. Central area very large, lacking areolae (Figs 22, 23, 24). Internally, ringleist extremely narrow, almost non-existent (Figs 25, 27). One rimoportula present under the ringleist (Figs 25, 26, 27,



Figs 1–21. *Aulacoseira frenguelliana* sp. nov. Light and scanning electron micrographs of valves from the type population (Rancho Hambre, Tierra del Fuego, Argentina, sample RH-E5-SED). Fig. 11 represents the holotype specimen. LM girdle (Figs 1–9). Fig. 1. Chain of two entire frustules and two valves in girdle view. Fig. 9. Girdle view with cross-section focus. LM valve face views (Figs 10–18). Fig. 19. Valve view at different focal plane showing the extremely reduced ringleist. Figs 20–21. SEM girdle views. Fig. 20. Chain with one entire frustule and a valve. Fig. 21. Detail of the areolae and the spatulate linking spines. The arrow indicates the Müller step. Scale bars represent 10 μm .

see arrows). Striae located between heavily silicified virgae (Fig. 26).

Aulacoseira fuegiana (Frenguelli) Casa, López Bedogni & Van de Vijver nov. comb. & nov. stat. (Figs 28–36)

Basionym: *Melosira laevis* var. *fuegiana* Frenguelli (in Frenguelli (1924c) *Anales de la Sociedad Científica Argentina* 98: 49, pl. XIII, figs 1–9).

Observations

LM (Figs 28–36): Frustules solitary or forming short chains up to 10 cells long, joined by linking spines. Valve dimensions ($n = 10$): valve diameter 8.5–23.0, mantle height 8.5–17.0 μm . Valve face flat (Figs 33–36). Ringleist very narrow (Figs. 33–36). Marginal row of areolae present. Central area hyaline with possible granulate structure (Figs 34, 35). Well-developed spines forming a

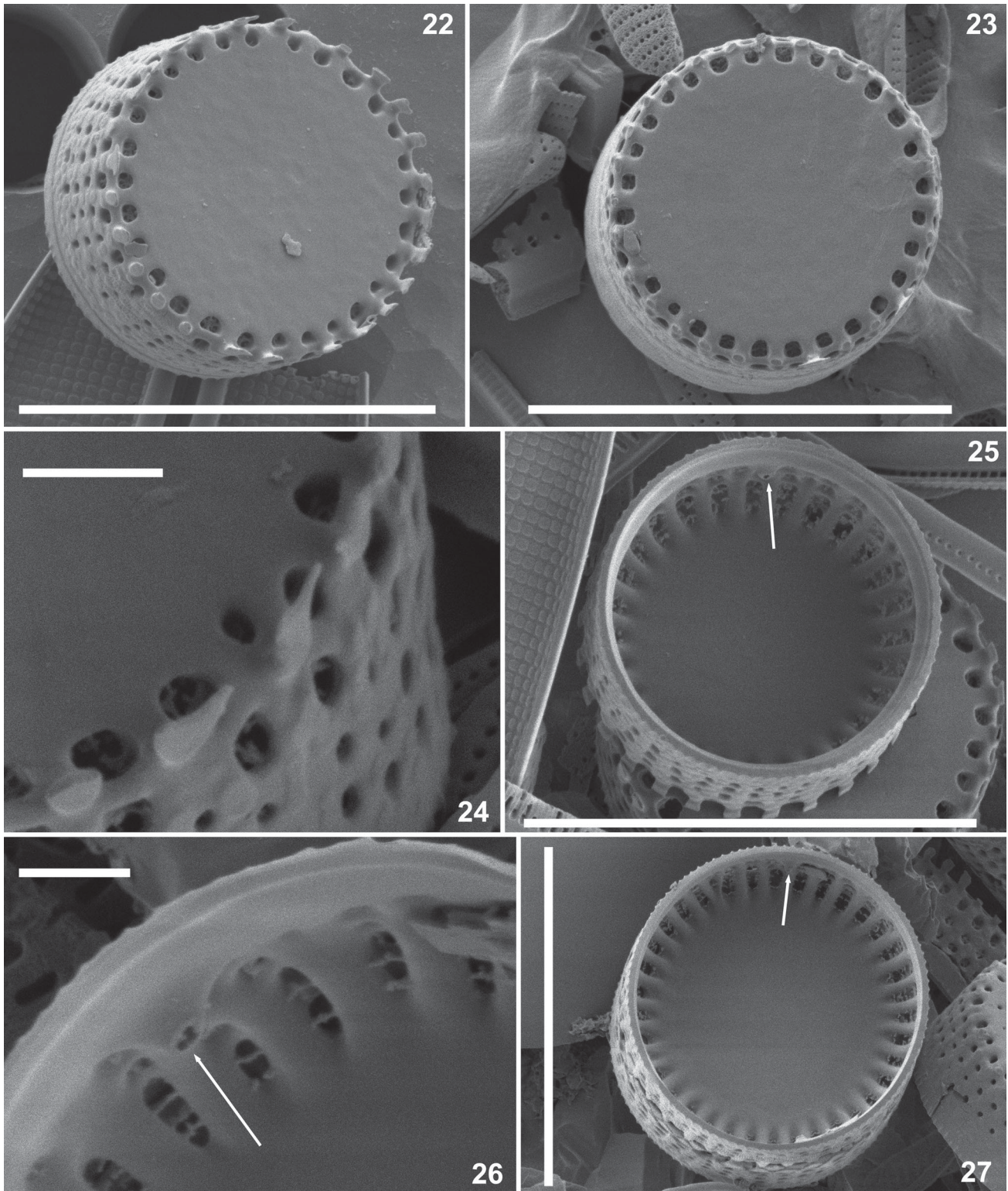
crown around the valve margin, at a density of 10 spines in 10 μm (Figs 28, 29, 30). Mantle striae straight, composed of very small areolae (Figs 30, 31). Resting spores often observed (Fig. 29, double-headed arrow, RS).

Since no unmounted material could be found, the species could not be studied using SEM.

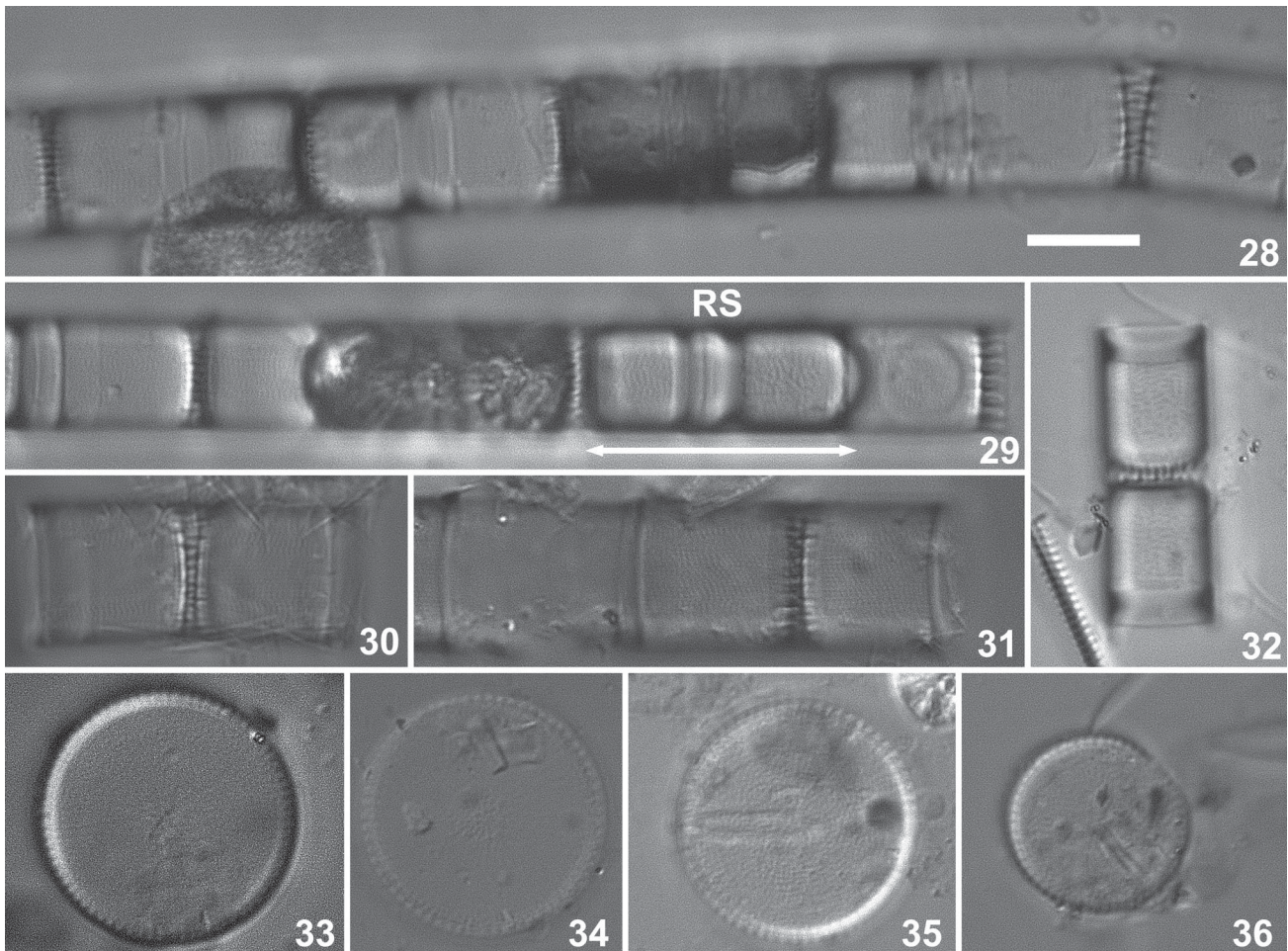
Discussion

Aulacoseira frenguelliana cannot be confused with most *Aulacoseira* species based on its areola pattern, the absence of a developed ringleist, the short spatulated spines and the presence of only one rimoportula.

Some species share the areolation pattern at the valve face, with only one peripheral row of areolae, e.g., *A. alpigena* (Grunow) Krammer, *A. kruegeriana* Morales et al., *A. pantanalensis* Tremarin et al., *A. lirata* (Ehrenberg) R. Ross, *A. pardata* English & Potapova (Genkal



Figs 22–27. *Aulacoseira frenguelliana* sp. nov. Scanning electron micrographs of valves from the type population (Rancho Hambre, Tierra del Fuego, Argentina, sample RH-E5-SED). Figs 22–23. External views of the valve face with only marginal striae and a marginal ring of spines. Fig. 24. External detail of linking spines, marginal striae and areolae of the mantle. Figs 25, 27: Internal view of an entire valve showing one rimoportula (see arrow). Fig. 26, Detail of the internal opening of the rimoportula. Scale bars represent 10 μm , except for Figs 24 and 26 where scale bar = 1 μm .



Figs 28–36. *Aulacoseira fuegiana* (Frenguelli) comb. nov. Light micrographs of valves in Series 234 (‘Chorrillo Uaquen’, Fuego River, Tierra del Fuego, Argentina). LM girdle (Figs 28–32) and valve face views (Figs 33–36). The double-headed arrow shows a resting spore (RS). Scale bar represents 10 μm .

& Kulikovskiy 2016) and *A. septentrionalis* (Camburn & Charles) Genkal & Kulikovskiy. Table 1 shows a comparison between the new species and similar *Aulacoseira* species with one marginal row of areolae on the valve face.

Aulacoseira alpigena is the most similar species. Both have valve faces with only one row of areolae, short spatulate linking spines and mantle striae that are curved to the right. Several differences, however, separate them: *A. frenguelliana* possesses only one rimoportula, has almost no ringleist and areolae of variable size and shape, whereas *A. alpigena* has one to several rimoportulae, a large ringleist and uniform mantle areolae. *Aulacoseira frenguelliana* also presents a lower stria density (12–16 vs. 15–22 in 10 μm) and a smaller size range (diameter 4.5–10.0 μm and mantle height 2.2–4.1 μm vs. diameter 4–15 μm and mantle height 4–7 μm)

Aulacoseira kruegeriana, described from Bolivia (Morales et al. 2015), has a larger ringleist, serrated linking spines and a longer rimoportulae, all features not observed in *A. frenguelliana*. Moreover, the mantle striae appear

entirely parallel and straight, whereas in *A. frenguelliana* they are curved to the right side. *Aulacoseira pantanalensis*, a species described from southern Brazil (Tremarin et al. 2014a), also forms short chains of up to four cells, joined by short spatulate spines. Furthermore, *A. pantanalensis* has similar valve dimensions (diameter: 6.3–11.0, mantle height 2.9–6.0), similar stria density (14–16 in 10 μm), the same number of rounded areolae per stria (3–6) and a shallow ringleist. However, *A. pantanalensis* is distinguished by having straight, parallel mantle striae, more than one rimoportula near the valve face/mantle junction and bluntly rounded linking spines. Additionally, *A. pantanalensis* was found in very eutrophic habitats (Loverde-Oliveira & Huszar 2007), whereas *A. frenguelliana* was only found in bog ponds with low conductivity, low pH and low nutrient values.

Another species presenting some similarities with *A. frenguelliana* is *A. lirata*, but the latter can be separated based on its thick ringleist, a feature typically absent in *A. frenguelliana*. *Aulacoseira pardata*, described from

Table 1. Comparison table of *Aulacoseira frenguelliiana* and similar *Aulacoseira* taxa with one marginal row of areolae on the valve face.

| | <i>A. frenguelliiana</i> | <i>A. alpigena</i> | <i>A. lirata</i> | <i>A. pantanalensis</i> | <i>A. pardata</i> | <i>A. kruegeriana</i> | <i>A. septentrionalis</i> |
|-------------------------|--|---|-----------------------------------|----------------------------|----------------------------|--|-----------------------------|
| Valve diameter (µm) | 4.5–10.0 | 4.0–15.0 | 7.0–27.0 | 6.3–11.0 | 5.0–10.0 | 5.0–18.0 | 6.0–9.0 |
| Mantle height (µm) | 2.0–4.0 | 4.0–7.0 | 3.0–10.0 | 2.9–6.0 | 3.0–7.0 | 3.5–7.5 | 6.0–7.0 |
| Mantle rows of areolae | Dextrorse | Oblique to spiralling | Straight to slightly dextrorse | Parallel, straight | Parallel, straight | Dextrorse | Parallel to slightly curved |
| Number of rows in 10 µm | 12–16 | 15–22 | 8–12 | 14–16 | 11–15 | 16–20 | 14–16 |
| Areolae on valve face | 1 marginal row | 1(–2) marginal row(s) | 1 marginal row | 1 marginal row | 1 marginal row | 1 marginal row | 1 marginal row |
| Linking spines | Short, spatulate, bidentate to occasionally tridentate | Spatulate to dendritic | Short, distally spatulate | Short, spatulate | Short, acute, serrated | Branched often with lateral extensions | Short |
| Rimoportula | 1, located under the ringleist | 1 to several, clearly stalked, at the ringleist | At least one, above the ringleist | 2 near to ringleist | Few, located on the mantle | At least one close to the ringleist | Unknown |
| Ringleist | Very narrow, not visible in LM | Narrow | Broad | Almost absent, very narrow | Narrow | Rather narrow | Narrow |

western North America (English & Potapova 2009), is differentiated based on its serrated linking spines, the presence of more than one rimoportula on the mantle and differences in mantle height (3–7 µm vs. 2.0–4.0 µm). Finally, *A. septentrionalis* shares the reduced areolar pattern on the valve face with *A. frenguelliiana* (Camburn & Charles 2000). The type material of this species was recently re-investigated (Tremarin *et al.* 2014a). Both species can be separated by the presence of long, anchor-shaped linking spines in *A. septentrionalis* and mantle striae with uniformly shaped and sized areolae (contrary to the mantle areolae in *A. frenguelliiana* that are variable in size and shape). Valves similar to *A. frenguelliiana* were identified by Flower (2005) from the Falklands/Islands Malvinas and have an almost identical areolar pattern on the valve mantle, similar spines and a marginal row of areolae on the valve face. The original identification as *A. distans* (cf. *septentrionalis*) should therefore be corrected to *A. frenguelliiana*.

The drawings that accompanied Frenguelli's (1924c) description of *M. laevis* var. *fuegiana* show some resemblance to *A. frenguelliiana*, making analysis of the type material necessary to exclude conspecificity, as Frenguelli's taxon has never been reported since. All slides made from Series 234 were examined. None of the observed valves, however, clearly resembled *A. frenguelliiana*, which has a lower mantle height, larger mantle areolae and clearly curved mantle striae. The analysis showed that *M. laevis* var. *fuegiana* should be transferred to *Aulacoseira* based on the structure of the mantle striae, the presence of linking spines and the type of colony. It also shows almost no resemblance to any other *Aulacoseira* taxon. *Aulacoseira crenulata* (Ehrenberg) Thwaites has comparable small mantle areolae and lacks valve face areolae in its central area, although a clear ring of marginal areolae is visible. Unfortunately, it is impossible to compare the ultrastructure due to lack of material, but both species show differences in the valve face morphology and the shape and size of the linking spines (Houk 2003).

Possible confusion may arise with the recently described genus *Conticribr* Stachura-Suchoples & Williams (2009) based on the absence of areolae on the valve face. However, *Conticribr* possesses fultoportulae that are visible in LM, a feature that was not observed in *A. fuegiana*. Other differences with *Conticribr* include the very low mantle height in the latter, compared to the deep mantle in *Aulacoseira*, the formation of colonies via mucus threads rather than linking spines. Therefore, transfer to *Conticribr* is not appropriate.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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