Diatom Research

ISSN: 0269-249X (Print) 2159-8347 (Online) Journal homepage: http://www.tandfonline.com/loi/tdia20

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Sabrina Bustos, Natalia V. Mattano & Nora I. Maidana

Diatom Research, 2018
https://doi.org/10.1080/0269249X.2018.1476412

Cymbella jachalensis sp. nov., a new diatom (Bacillariophyta) from San Juan, Argentina

SABRINA BUSTOS[1,2]*, NATALIA V. MATTANO[1] & NORA I. MAIDANA[1,2]

[1]*Facultad de Ciencias Exactas y Naturales, Departamento de Biodiversidad y Biología Experimental, Universidad de Buenos Aires, Buenos Aires, Argentina*
[2]*CONICET – Universidad de Buenos Aires, Instituto de Biodiversidad y Biología Experimental y Aplicada – CONICET (IBBEA), Buenos Aires, Argentina*

This paper presents a new species found in water and surface sediment samples from the Jáchal River, in San Juan Province, Argentina. This new species belongs to the group of species related to *Cymbella helvetica* Kützing, which do not have apical pore fields. It can be distinguished from known species of the group by its combination of morphometric and morphological features, such as the ventral deflection of the proximal raphe fissures, and the shape of the apex.

Keywords: *Cymbellaceae, diatoms, brackish water, taxonomy, river*

Introduction

Cymbella C. Agardh is a genus containing solitary or colonial, free–living or stipitate cells. In the past, the genus was treated as a heterogeneous group of species characterized by valves that were asymmetrical about the apical axis (cymbelloid).

Krammer (1982) subdivided *Cymbella* into three subgenera: *Cymbella*, *Encyonema* Kützing, and *Cymbopleura* Krammer, based on the presence and position of the stigmata, the apical pore fields (APFs), and the deflection of the external distal raphe fissures. Later, Krammer (1997a, b) resurrected *Encyonema* as a genus, proposed the new genera *Encyonopsis* Krammer, *Cymbellopsis* Krammer, *Pseudoencyonema* Krammer, and *Navicella* Krammer, and elevated *Cymbopleura* to a genus. Later Krammer (2002) amended the circumscription of *Cymbella*, characterizing the genus by the cymbelloid shape of the valves, the dorsally bent terminal raphe fissures, and the presence of generally one APF at each apex, and one or more stigmata on the ventral (primary) side of the valves. Following this revision, *Cymbella* probably still contained more than 140 species, of which 129 were considered by Krammer (2002) in his monograph of the European species.

The sessile species usually secrete mucilage stalks through the APFs, which are more or less discrete areas of small, round, unoccluded pores (Round et al. 1990). A small group of species, which includes *Cymbella helvetica* Kützing and related species, lack APFs (Krammer 2002).

San Juan Province is located in the west-centre of Argentina, and is characterized by having mountainous terrain with a small number of water bodies. The climate is arid, and agriculture is the predominant activity in the valleys, while in the mountains the main activity is mining. Information about algal biodiversity is scarce and what can be found is not very specific, as well as being quite old, such as the publications of Tempère & Peragallo (1915) or Frenguelli (1945). According to the literature, none of the 12 species of *Cymbella sensu stricto* reported from Argentina (Krammer 2002, Vouilloud 2003, Recasens & Maidana 2013) were previously recorded from San Juan Province, nor as belonging to the *C. helvetica* group (Krammer 2002).

As part of a wider survey of the biota associated with the Jáchal River, which is exposed to mining activity, we analysed water and surface sediment samples collected from 2012 to 2015. As part of the dominant algal assemblages in some of the samples, we found a cymbelloid diatom whose morphological and ultrastructural features do not fit any known taxa. Here we propose it as a new species of *Cymbella* and discuss its characteristics compared to related species.

Study area

The Jáchal River drainage has its origin in the south west of Catamarca Province where it is called the Blanco River. After flowing 144 km (approximately) to San Juan Province, the Blanco River's course is interrupted by the Cuesta del Viento Reservoir, at whose outflow the river is called the Jáchal River (Fig. 1). The Jáchal River is

*Corresponding author. E-mail: sabrina.bustos.m@gmail.com
Associate Editor: Mark Edlund

(Received 22 June 2017; accepted 5 April 2018)

Published online 27 Jun 2018

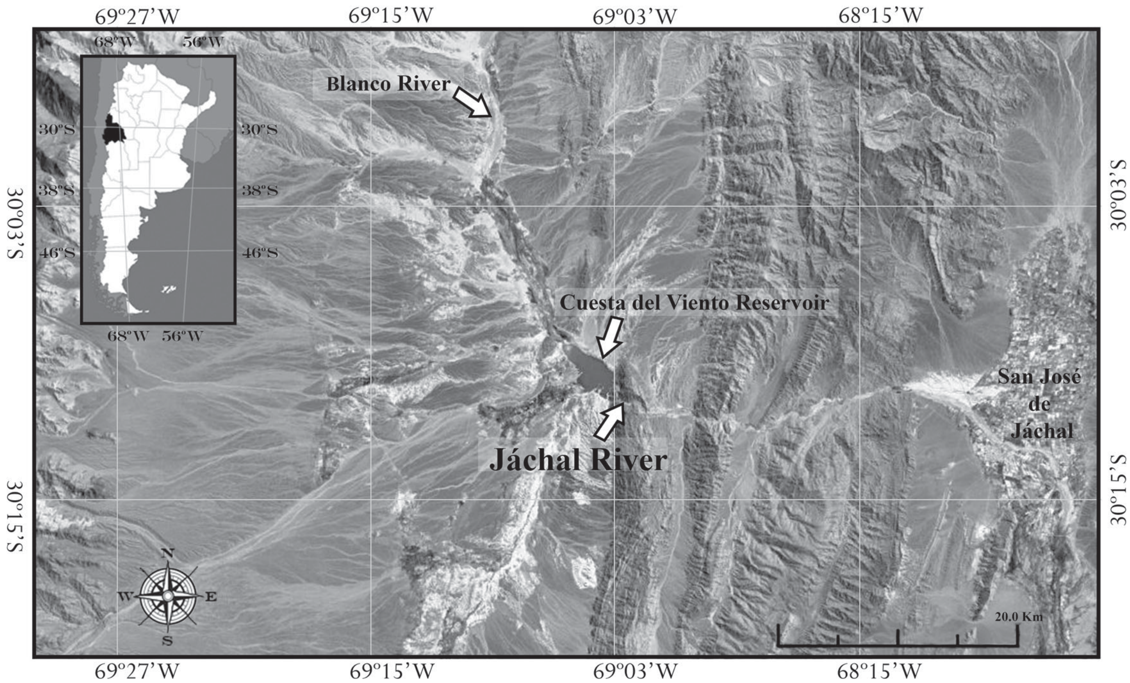


Fig. 1. Geographical location of Jáchal River (San Juan Province, Argentina).

a permanent watercourse with a length of 640 km that is primarily fed by melting snow, and has high salt, mineralization, and boron content. It is one of the most important water sources for the province, and is influenced by intensive extractive gold and silver mining activity (open pit) in the area (Gobierno de San Juan 2017).

The Jáchal River irrigates a valley that is the main agricultural area of northern San Juan Province. Onions, grapes, olives, fruits (mainly quince), and alfalfa are grown in this area. This valley has an arid desert climate type with average values of 141 mm annual rainfall, 54% relative humidity, 16.5°C average annual temperature and summer maximum temperature of 40°C (Miranda et al. 2010).

Materials and methods

Samples were collected by scraping small submerged rocks in the Jáchal River, seasonally from 2012 to 2015, downstream from the outflow of the Cuesta del Viento Reservoir (30°12′14.34″S, 69°03′16.45′W; ca. 1400 m asl). Diatom analyses were performed following standard methods described in Battarbee (1986). The samples were oxidized with H_2O_2 (30%, 100 Vol.), heated in a microwave oven for 2 min, in order to eliminate organic matter. Samples were then rinsed repeatedly with distilled water to neutrality. Permanent slides were mounted using Naphrax® (labelled as Ja1 2012 Au, Ja1 2012 Wi, Ja1 2013 Su, Ja1 2013 Wi, Ja1 2013 Sp, Ja1 2014 Su, Ja1 2014 Au, Ja1 2014 Sp, Ja1 2015 Su, Ja1 2015 Wi and Ja1 2012 Sp) and deposited in the collection of the Laboratorio de Diatomeas Continentales (Departamento de Biodiversidad y Biología Experimental, Facultad de Ciencias Exactas y Naturales; Universidad de Buenos Aires). Light micrographs were captured using a Reichert–Jung Polyvar binocular optical microscope equipped with a PlanApo 100x, NA 1.32, immersion objective, DIC optics, and a Canon EOS 600D digital camera.

Relative abundances (%) were estimated after counting at least 200 valves along random transects on each permanent slide.

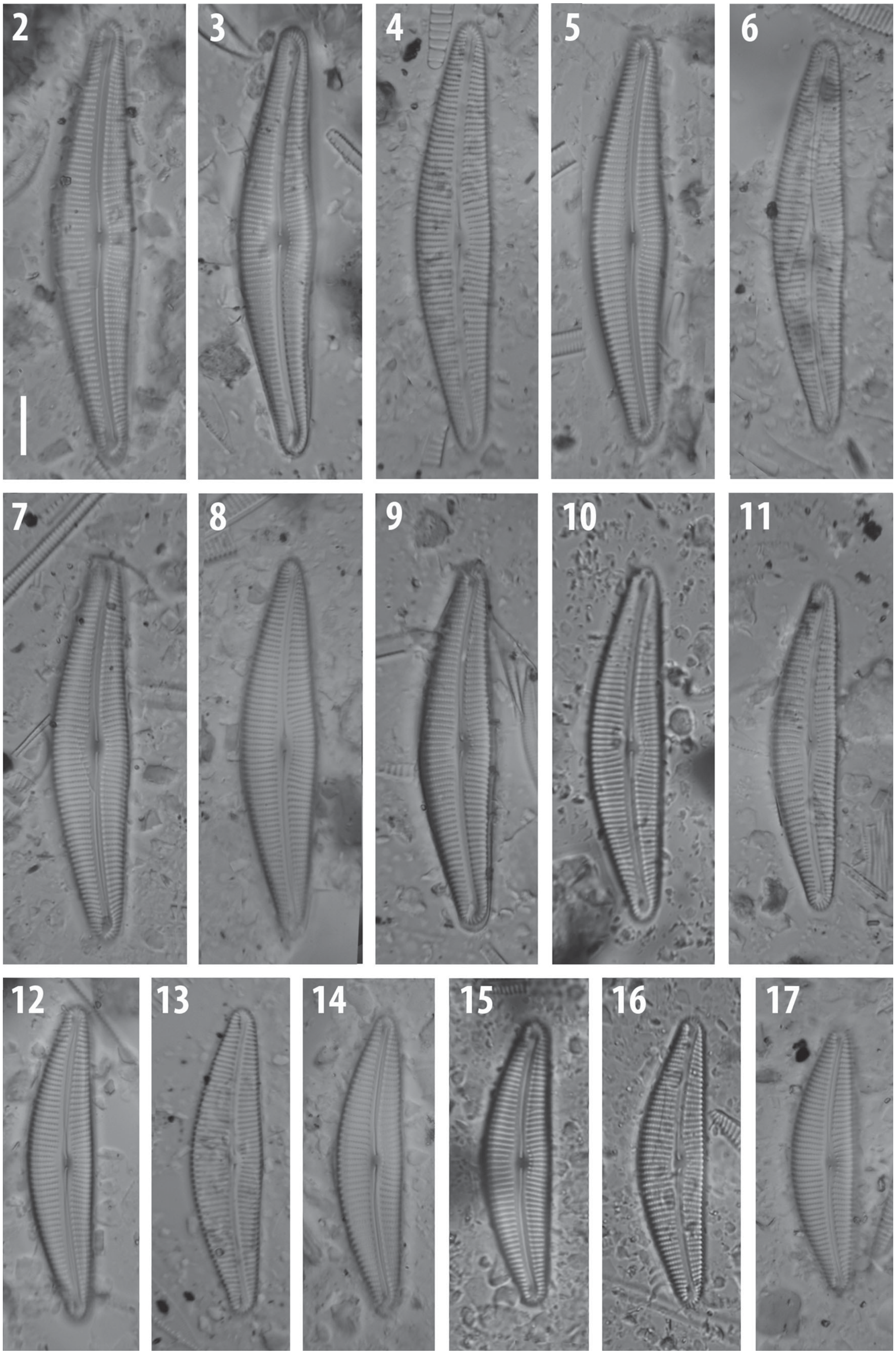
For SEM observations, aliquots of the cleaned material were dried on aluminium stubs at room temperature before being coated with gold (20 nm thickness) and examined using a Carl Zeiss SUPRA40 (15 kV) at the Centro de Microscopías Avanzadas (CMA), Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.

Images captured with both LM and SEM were measured using Zeiss Axiovision v4.8.2.0 software.

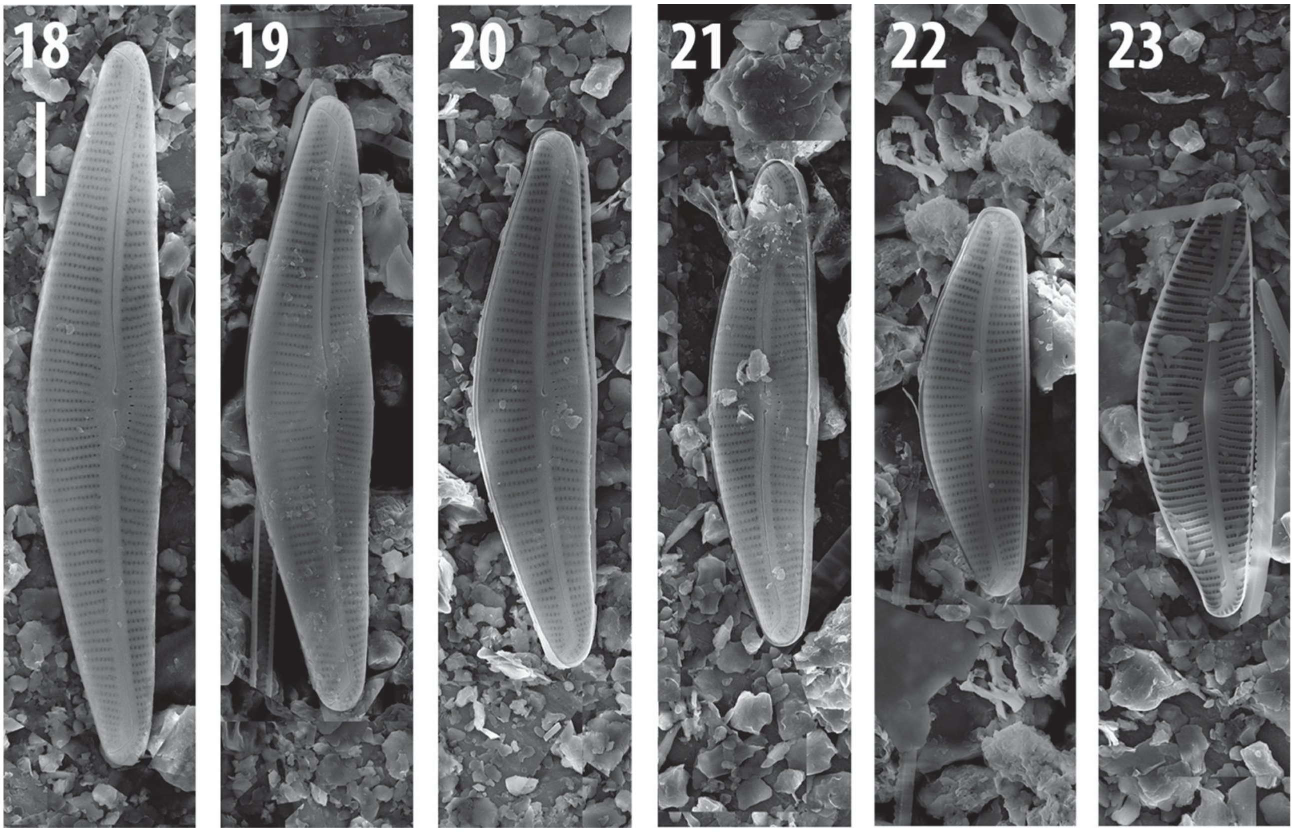
Results

Cymbella jachalensis sp. nov. (Figs 2–27)

Valves lanceolate, with the dorsal margin more strongly arched than the ventral one, and rounded to subrostrate ends without APFs. Axial area very narrow; central area almost indistinguishable (Figs 2–17). Raphe central, distinctly lateral, filiform near the distal and proximal ends (Figs 18–22). External proximal raphe ends with drop-shaped pores, curved to the ventral side (Fig. 26). External distal raphe fissures bent at an angle of 32–47° towards



Figs 2–17. *Cymbella jachalensis* sp. nov. (LM) Variability in valve dimensions during the studied period. Figs 2–11. Slide Ja1 2015 Su. Figs 12–17. Type material, slide Ja1 2014 Sp. Fig. 12. Holotype. Scale bar = 10 μm.



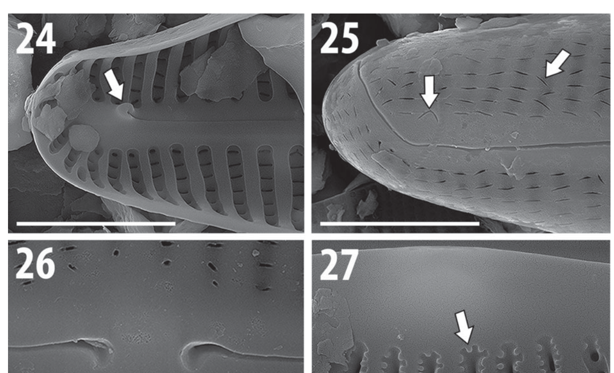
Figs 18–23. *Cymbella jachalensis* sp. nov. (SEM). Figs 18–22. External views. Fig. 23. Internal view. Type material, slide Ja1 2014 Sp. Scale bar = 10 µm.

the dorsal side of the valve, reaching the valve mantle (Fig. 25). Internally, the raphe fissure appears continuous across the central nodule (intermissio is lacking, Fig. 23) and ends distally in helictoglossae (Fig. 24). Striae slightly radiate at the centre to slightly convergent at the ends, where they surround the apices. Areolae with slit-like external openings (lineolate) (Fig. 25). Stigmata (6–9) on the ventral side of the valve, with round to transapically elongated external openings and internally surrounded by teeth-like projections (Figs 26–27).

Dimensions: apical axis 44.5–74.3 µm (mean 55.0 ± 6.5 µm; $n = 122$); transapical axis 9.5–14.0 µm (11.7 ± 0.8 µm; $n = 121$); apical/transapical axis ratio 3.9–6.0 (4.7 ± 0.4; $n = 121$); 8–11 (9.8 ± 0.6; $n = 121$) dorsal striae in 10 µm; 9–11 (10.0 ± 0.6; $n = 121$) ventral striae in 10 µm; 13–20 (5.5 ± 0.5; $n = 111$) areolae in 10 µm; 6–9 stigmata (6.8 ± 0.8; $n = 110$)

Holotype: Slide Ja1 2014 Sp. BA 52276, deposited in the Herbario de Plantas Celulares, Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia'. Illustrated in LM as Fig. 12.

Type locality. Argentina, San Juan Province: Jáchal River, 30°12′S, 69°03′W



Figs 24–27. *Cymbella jachalensis* sp. nov. (SEM). Figs 24–25. Details of the apices. Fig. 24. Internal view, the arrow points to the well developed helictoglossa. Fig. 25. External view; note the irregular areola shape and disposition (arrows). Figs 26–27. Valve centre. Fig. 26. External view; note the drop-shaped proximal raphe endings and five stigmata on the primary side. Figs 24, 27. Internal views, stigmata internal openings are surrounded by teeth-like projections (arrow). Type material, slide Ja1 2014 Sp. Scale bar = 5 μm.

Table 1. Relative abundances of *Cymbella jachalensis* sp. nov. and the main accompanying diatom species (> 3% in at least one sample) in the studied samples.

	2012		2013			2014			2015		
	Au	Wi	Su	Wi	Sp	Su	Au	Sp	Su	Wi	Sp
Adlafia minuscula						3.6					
Achnanthidium catenatum											8.5
Achnanthidium minutissimum	2.0	3.5	7.5	6.6	4.0	4.4	2.1	6.3	1.5	9.8	0.7
Amphora chilensis					17.4	36.1					
Amphora lineola			31.4	12.0							
Berkella linearis		0.4						5.2			
Cyclotella meneghiniana	6.1	30.0	2.0	1.2		0.7	6.4		8.0		0.8
Cyclotella ocellata	0.1	0.4	13.2	1.2	3.3	4.4	0.1		1.5		2.3
Cyclotella affinis				11.4	2.7						2.3
Cymbella jachalensis	**8.4**	**17.0**	**3.4**	**14.4**	**2.0**	**8.1**	**8.9**	**28.8**	**35.1**	**8.1**	**1.5**
Denticula elegans				2.4						3.3	
Diatoma moniliformis	2.0	3.0	1.5	9.0	2.7	6.6	2.1		2.2	47.2	44.6
Fragilaria capucina	0.3		2.0	6.6	0.7	1.5	0.4	0.6	3.7		0.7
Fragilaria crotonensis				7.8							
Fragilaria tenera						3.7			2.2		1.5
Gomphonema olivaceum	1.4	1.3	2.5	5.4	0.3	0.7	1.4	4.4		3.8	0.8
Gyrosigma spenceri	0.1		0.5			1.5	0.1		0.7		6.2
Halamphora chilensis								2.2			3.9
Navicula erifuga						8.1			2.9		
Navicula salinarum									3.7		
Navicula veneta			1.0	6.6	7.4	4.4					6.2
Nitzschia capitellata	5.1		1.0	4.2	18.7		5.4				1.5
Nitzschia desertorum	24.0						25.4				
Nitzschia fonticola								0.6	6.6		1.5
Nitzschia liebetruthii								3.6			
Nitzschia palea	18.9	0.4	9.8		1.0	3.0	20.0	1.4	1.5		
Nitzschia pusilla		0.9			3.7	0.7		11.5			3.9
Nitzschia solita	11.1		0.5								
Nitzschia aff. gandersheimiensis									5.1		
Tabularia af. affinis									6.6		
Ulnaria ulna		32.2	3.9	3.6	1.3	0.7					2.3

Note: Au: autumn; Wi: winter; Su: Summer; Sp: spring.

Autecology. In circumneutral to alkaline waters (pH 7–8.8), with moderately high conductivities (1300–2300 $\mu S\ cm^{-1}$) (Nicolás Garcia Romero, pers. comm.).

Common diatom associates: The new species sometimes appeared as part of the dominant assemblages, but there were no species that always co-occurred with *Cymbella jachalensis* (Table 1).

Observations: In several samples taken in the Jáchal River, some of the valves display a peculiar areola construction (Fig. 25).

Discussion

Cymbella jachalensis, which was present throughout the study period, is easily recognizable by its shape and dimensions, the absence of APFs, and the large number of stigmata.

Due to the absence of APFs, *C. jachalensis* can be included in the species group close to *C. helvetica* (Krammer 2002), which includes *C. cantonatii* Lange-Bertalot, *C. subhelvetica* Krammer, *C. lange-bertalotii* Krammer, *C. helvetica* Kützing, *C. balatonis* Grunow, *C. compacta* Østrup, and *C. suavis* Pantocsek. *C. jachalensis* differs from the majority of these species by its size and the shape, the angle of the dorsally deflected distal raphe fissures (32–47°) and the density of the striae and areolae. These differences are summarized in Table 2.

The particular case of *C. compacta* poses a problem. The original description (Østrup 1910: 54, fig. 2: 39) is brief, seems to have been made based on a single individual, and is only illustrated by one drawing (the iconotype). The presence (or absence) of stigmata is not mentioned and, if present, they cannot be distinguished in the figure.

The single valve used by Metzeltin & Lange-Bertalot (1998) to illustrate *C. compacta* differs from the specimen illustrated by Østrup (1910) mainly in the shape of the valve ends, in the greater width of the axial area, and the presence of a central area. In his monograph of the genus, Krammer (2002: pl 173, figs 1–11; pl 174, figs 1–9; pl 175, figs 1–10) includes, in addition to the original

Table 2. Comparison of morphological and morphometric features of *Cymbella jachalensis* sp. nov. to morphologically related species in the *C. helvetica* group.

	C. jachalensis sp. nov.	*C. compacta* Østrup (type material)	*C. compacta (sensu* Krammer 2002)	*C. lange-bertalotii* Krammer	*C. subhelvetica* Krammer	*C. helvetica* Kützing	*C. cantonatii* Lange-Bertalot	*C. balatonis* (Grunow) Cleve	*C. suavis* Pantocsek
General shape of valve	Lanceolate, dorsiventral	Lanceolate-subelliptical	Lanceolate-elliptical, slightly dorsiventral	Lanceolate, distinctly dorsiventral	Lanceolate, distinctly dorsiventral	Rhomboid-lanceolate, slightly dorsiventral	Lanceolate-elliptical, slightly dorsiventral	Broadly rhomboid-lanceolate, slightly dorsiventral	Broadly rhomboid-lanceolate, slightly dorsiventral
Apical shape	rounded-slightly rostrate	rounded	rounded	narrowly rounded	narrowly rounded	rounded	rounded	narrowly rounded	rounded
Central pores	ventrally bent	ventrally bent	ventrally bent	not bent	not bent	dorsally bent	not bent	dorsally bent or not bent	not bent
Length (µm)	44.5–74.3	29	28–76	38–100	33–70	75–154	30–55	78–120	81–120
Width (µm)	9.5–14.0	12	12–15	10–16	8.5–11	18–26	10–13	24–30	28–32
Maximum L/W ratio	6.0	2.8	5.1	5.5	6.3	6.6	4.2	4.0	
Dorsal striae (10 µm)	8–11	11	9–12	8–12	9–11	6–8	10–13	7–8	6–7
Ventral striae (10 µm)	9–11	13	10–16	11–14	13–15	10–12	Not mentioned	Not mentioned	Not mentioned
Areolae (10 µm)	13–20	Not mentioned nor visible in the picture	18–24	18–24	20–25	14–18	29–33	15–17	8–12
Areola shape	Slit like	Narrow-rectangular	Slit like	Slit like	Slit like	Slit like	X–shaped	Slit like	Slit like
Stigmata	6–9	Not mentioned nor visible in the picture	4–8	4–8	No available information	up to 10	4–8	3–8	not visible in the LM
Angle of raphe curvature at distal ends	32°–47°	Not mentioned nor visible in the picture	40°	45°	45°	45°	40°	45°	45°

illustration of *C. compacta*, a large number of valves showing remarkable variability in size and shape, but which do not share the main characteristics of the species described by Østrup.

Although *C. jachalensis* is similar in shape and dimensions to the valves that Krammer included in *C. compacta* (Krammer 2002: pls 173–175), it does not match the original description of this species (Table 2). The specimens shown by Krammer probably belong to another species, not *C. compacta*, and need to be studied further in order to be correctly identified.

Acknowledgements

We wish to thank Mr. N. Garcia Romero (Ambiente y Territorio S.A.) for providing the studied samples and Mr. D. L. Glusman (Lion Shyma S.R.L.) for helping us with the figures.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Thiss research was funded by FONCyT [PICT 2014-2863] and UBACYT [20620130100003BA].

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