Diatom Research (2008), Volume 23 (1), 147–157

CYCLOTELLA KATIANA SP. NOV. FROM LA REINA SWAMP, PARQUE NACIONAL NATURAL LOS KATÍOS, COLOMBIA

Silvia Sala*

Departamento Científico Ficología, Facultad de Ciencias Naturales y Museo (UNLP). Paseo del Bosque s/n°, 1900 La Plata, Argentina

John J. Ramírez-R.

Instituto de Biología, Facultad de Ciencias Exactas y Naturales, Universidad de Antioquia. Apartado 1226, Medellín, Colombia

Cyclotella katiana sp. nov. is described from La Reina Swamp, Parque Nacional Natural Los Katíos, Colombia. Studied samples were collected from the stomach contents of *Prochilodus magdalenae* (Bocachico), an iliophagous fish species. The new taxon is distinguished from the related taxa *C. atomus* Kützing, *C. meneghiniana* Kützing, and *C. meduanae* Germain, by the central valve face slightly undulated, the lack of fultoportulae in the valve face, the fultoportulae opened on every 2nd or 3rd interstriae and mantle spinulae at the valve face/mantle junction ever present. Also in the samples two other similar *Cyclotella* taxa were found; they were compared with the species above mentioned and with *C. atomus* var. *gracilis* Genkal & Kiss.

INTRODUCTION

Confusion and uncertainty in identifying small centric diatoms, especially those of the genus *Cyclotella* (Kützing) Brébisson, is still a problem despite the numerous ultrastructural studies that have been carried out in the last years (Håkansson 1988, 1989, 1990a, 1990b, 1993, 1996, 2002, Håkansson *et al.* 1993, Håkansson & Clarke 1997, Håkansson & Chepurnov 1999, Kling & Håkansson 1988, Loginova 1990a, 1990b, Lowe 1975, 1981, Genkal & Kiss 1993 and Tanaka 2007, among others). This genus comprises a large complex of centric diatoms with near 100 species (Håkansson 2002). Although it is a highly variable group, all the species have in common a valve face with a central area morphologically different from the margin. In a comprehensive revision of the genus, Håkansson (2002) grouped some of the species in the new genus *Puncticulata* and restricted *Cyclotella* to those taxa with "tangential undulation, with a smooth, apparent striation (or wrinkles), or colliculate central area; with none to several valve face fultoportulae, with a simple, alveolate striated marginal area, and with the rimoportula inserted in the ring of mantle fultoportulae". In this genus are also included some species that have the rimoportula on the valve face. Afterwards, Houk & Klee (2004) described the new genus *Discostella* where they included the "stelligeroid" taxa, based on the position of both fultoportulae and rimoportula within the striae, in contrast to *Cyclotella* where these processes are located within the interstriae (Guerrero & Echenique 2006, Tanaka 2007).

* Correspondence to Silvia E. Sala: e-mail: sesala@fcnym.unlp.edu.ar

As a consequence of the mentioned taxonomical problems, the correct identification of collected material is sometimes dubious; therefore, it is difficult to be certain about the results of many ecological investigations where *Cyclotella* species are treated as important components of freshwater habitats. This problem is more evident in South America, particularly in tropical areas, since the majority of taxonomical and ultrastructural researches were held in temperate zones of the Northern Hemisphere. Recent reviews of South American diatom flora (Metzeltin & Lange-Bertalot 1998, 2007 and Rumrich *et al.* 2000) do not include a revision of this genus.

In the present article we propose a new *Cyclotella* species based on the analyses held with light and scanning electron microscope.

MATERIAL AND METHODS

Studied samples were collected between April 28th and May 3rd 2000 from several specimens of *Prochilodus magdalenae* (Bocachico) stomach contents, an iliophagous fish species of La Reina Swamp (Chocó, Colombia).

La Reina Swamp is located inside a protected area: Parque Nacional Natural Los Katíos (PNNK, 07°49'N 77°11'W) in the Northwest of Colombia, along the border with Panama. PNNK belongs to the municipalities of Riosucio and Unguía (Department of Chocó) and Turbo (Department of Antioquia) (Fig. 1). It has 72 000 hectares and it is located at an altitude varying between 2 and 650 m.asl. To the East, one of the three sectors in which PNNK is divided, are the floodplains of the Atrato River and the swamps around it; one of these swamps is Tumaradó, whose principal water body is called La Reina. La Reina is a shallow swamp (depth between 2 and 4 meters approximately) with black-type waters and a medium content of humic substances incoming from the surrounding riparian wood. Minimum and maximum values of some physical and chemical variables are presented in Table 1. The park is placed in a zone of intertropical convergence delimited by the confluence of the northwestern and southwestern trade winds; annual precipitation varies from 2000 to 3500 mm; the mean annual temperature is 27°C in Los Katíos and 24°C in the higher places inside the park area. The dominant biome in the PNNK is the tropical rainy forest.

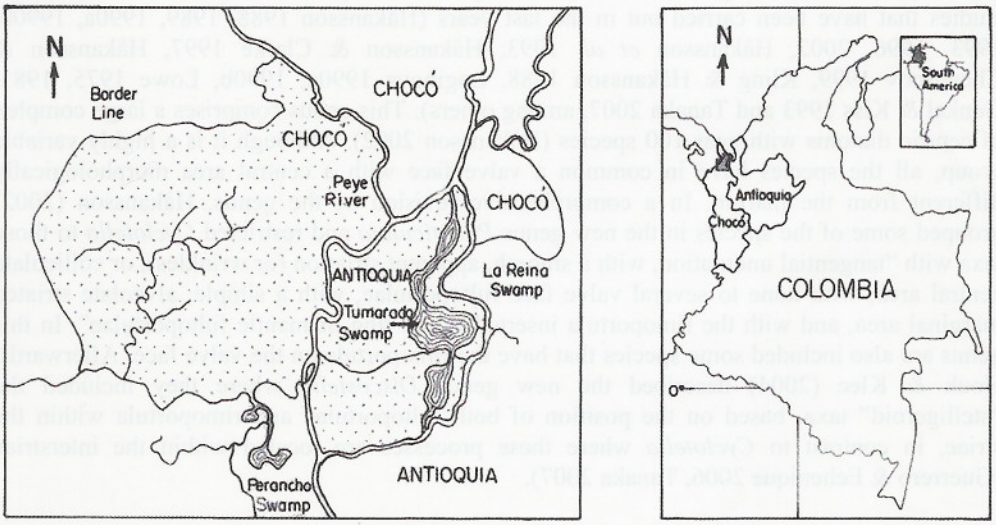


Fig. 1. Study area.

Table 1. Minimum and maximum values of physical and chemical variables in La Reina Swamp.

Variable	Minimum value	Maximum value
Maximum depth (m)	2.80	3.20
Secchi depth (m)	0.27	0.40
Water temperature (°C)	25.30	26.30
Dissolved oxygen (mg/l)	5.17	5.67
pH	6.72	6.91
Electric conductivity (µS/cm)	110.00	126.70
Total CO_2 (mg/l)	0.18	3.28

Samples were fixed with 6–8% formalin and were treated to eliminate organic matter following the method described in CEN/TC 230 (2002). Samples for light microscopy (LM) were mounted in Naphrax and for scanning electron microscopy (SEM) were mounted on glass stubs following Ferrario *et al.* (1995) and then coated with gold-palladium in a Jeol Fine Coat Ion Sputter JFC–1100. Observations were carried out with a Wild M20 LM with phase contrast and a Jeol JSM–T100 SEM at the Service of Electronic Microscopy of Museo de La Plata.

Counting interstriae density was held following Anonymous (1975) and to facilitate the comparison with other descriptions we also calculated the value of τ as recommended in Genkal (1977). In relation to the marginal fultoportulae, for more precision their position in relation to the interstriae is discussed. In order to avoid confusions derived from different measurement methods in Table 2 we also give τ. For the morphological terminology of the processes we have followed Theriot & Serieyssol (1994).

DIAGNOSIS

***Cyclotella katiana* Sala & Ramírez sp. nov. (Figs 2–12)**

Frustula solitaria, a valva visa circulares, 4.5–5.5 µm in diametro, axe pervalvari brevi, cingulum pauci fasciis laevibus. Frons area centrali leniter tangente undulata, parvis verrucis et sine fultoportula. Area marginalis striata leviter radiatum undulata striis et interstriis relative brevibus, ambae ad marginem continue (9–15 in 10 µm). Striae ad maginem latiores, 3–7 series areolarum seriebus. Areolae (75–120 in 10 µm) parvae rotundae et difficulter visibiles interne visae. Spinulae ad frontem/ marginem junturam et ad marginem semper praesentes. Fultuportularum marginalium annulus ad quoque secundum vel tertium interstriam. Tubuli interne circuncincti 3 poris satellitibus et extra parvi, 3 vel 4 spinulis obtusis circumcincti. Rimoportula unica in fultoportularum annulo inter duas interstrias fultoportulis instructas disposita; apertura externa sine spinulis.

Light microscopy

Frustules solitary, circular in valve face view, 4.5–5.5 µm in diameter. Valve face slightly differentiated into a smoother and gently undulate central area without fultoportulae and a marginal area with short striae that broaden towards the margin and have weakly developed interstriae (9–15 in 10 µm). A ring of fultoportulae placed at every second or third interstriae.

Table 2. Comparison of morphological features of *Cyclotella katiana* sp. nov. with related *Cyclotella* species.

Taxon	Bibliography	Diameter (µm)	Valve face fultoportulae		Marginal fultoportulae		Rimoportula	Striae in 10 µm	Areolae in 10 µm
			N°	Number of cowlings	Position (density)	Number of cowlings			
C. katiana	This study (n = 38)	4.5–5.5	0	–	At least 8, every 2nd–3rd interstriae (4–6/ 10 µm; τ = 2.5–4.2)	3	1, shortly stalked	9–15 (τ = 5.7–10.4)	75–120
C. atomus	Håkansson & Clarke (1997)	3.5–8	1	2–3	On every 3rd–5th seldom 6th–7th interstriae	2	1	14–20 (24)	NM
C. atomus var. *gracilis*	Genkal & Kiss (1993)	5–7.5	1	2–3	Every 2nd–4th interstriae	2	1, shortly stalked	15–20 (τ = 11–15)	NM
C. meneghiniana	Håkansson (2002)	5–45	1–3	3	On every interstriae	3	1, stalked with the lip twisted	6–10	NM
	Germain (1981)	5–7	0	–	12–17 in all the circumference (6–8/ 10µm; τ = 3.5–4.6)*	–	1*	10–11* (τ = 6–6.4)*	NM
C. meduanae	Tanaka (2007)	6–8	0	0	11, on every 1st to 2nd interstria	3	1 shortly stalked, perpendicular to the interfascicle	10–12	NM
	Nagumo & Kobayasi (1985)	5–7	0	0	3–5/ 10 µm on every 2nd to 3rd interstria	3	1	13–16	NM
Cyclotella sp. 1	This study	5.8	0	–	7, on every 2nd interstriae (4/10 µm; τ = 2.2)	3	1, sessile	8–10 (τ = 4.4–5.5)	NM
Cyclotella sp. 2	This study	6.5	1	3	8, on every 2nd interstriae (6–8/10 µm; τ = 2.1)	3	1, shortly stalked	6–8 (τ =3.1–4.1)	NM

* Measured by the authors.
NM = not measured.

Scanning electron microscopy

Frustule with a short pervalvar axis, girdle with a few smooth bands. Valve face with a central area gently tangentially undulated, with small warts and without fultoportula. Striated marginal area slightly radially undulated with relatively short striae and interstriae, both continuous onto the short mantle. Striae broadening towards the mantle composed of 3–7 rows of areolae. Small and rounded areolae (75–120 in 10 μm), hardly visible in internal view. Spinulae at the valve face/mantle junction and at the mantle always present. A ring of marginal fultoportulae placed on every second or third interstriae, opened on the upper part of the mantle exterior. Tubules internally surrounded by 3 cowlings and externally small, surrounded by 3 or 4 blunt spinulae. A single stalked rimoportula located in the ring of fultoportulae, generally between two interstriae that have fultoportulae; external opening without blunt spinulae around it, and thick raised silica wall.

Type locality: La Reina Swamp, Parque Nacional Natural Los Katíos.

Holotype: slide LPC 10.007, Departamento Científico Ficología, Facultad de Ciencias Naturales y Museo (UNLP), La Plata, Argentina. Collected by Alexandra Arango.

Etymology: the specific epithet *katiana* refers to Embera-Katíos, the name of an indigenous tribe which presently lives at Alto Sinú in the Department of Córdoba, Colombia.

OBSERVATIONS

Specimens of *Cyclotella katiana* have been identified from the stomach contents of fishes collected at the type locality so it was impossible to study living cells and determine the number and morphology of plastids. When analyzed with LM the frustules are coin-shaped in girdle view, with a very short pervalvar axis, and circular in valve view (Fig. 2). As the species is very small and delicate it is not possible to see many details of the valve morphology; valves look almost smooth, with short interstriae and the ring of fultoportulae and the rimoportula (the ring of brighter spots around the margin).

SEM observations revealed that the frustule has a short pervalvar axis with girdle containing few smooth bands (Fig. 3). The striae are composed of a variable number of rows of areolae that form fascicles broadening towards the mantle (Fig. 5). Externally the interstriae are at the same level as the striae (Figs 3–4) while internally they are elevated but not forming alveoli (Figs 6, 7). The areolae are small, round and disorganized towards the mantle; internal vela are difficult to see. The central area is faintly variable, imperforated and, in most specimens, slightly tangentially undulated (Figs 3–5). The valve face is ornamented by warts, more concentrated on the elevated central area than in the marginal area where the striae are located (Figs 3, 4). Numerous and conspicuous but small, blunt spinulae surround the valve face/mantle junction and on the mantle (Figs 3, 4).

Mantle fultoportulae are located at every second or third interfascicle (Figs 3, 4, 6). Externally they open as a very short tube surrounded by 3–4 spinulae (Fig. 4) and internally it is surrounded by 3 cowlings (Fig. 6). A single rimoportula is placed between two fultoportulae, on the mantle edge (Figs 4, 6, 7). Its outer opening is smaller than those of the fultoportulae, it lacks spinulae and is surrounded by a thick silica rim (Fig. 4). Internally, the rimoportulae are shortly stalked, radially or transversally orientated in relation to the interstriae (Fig. 7).

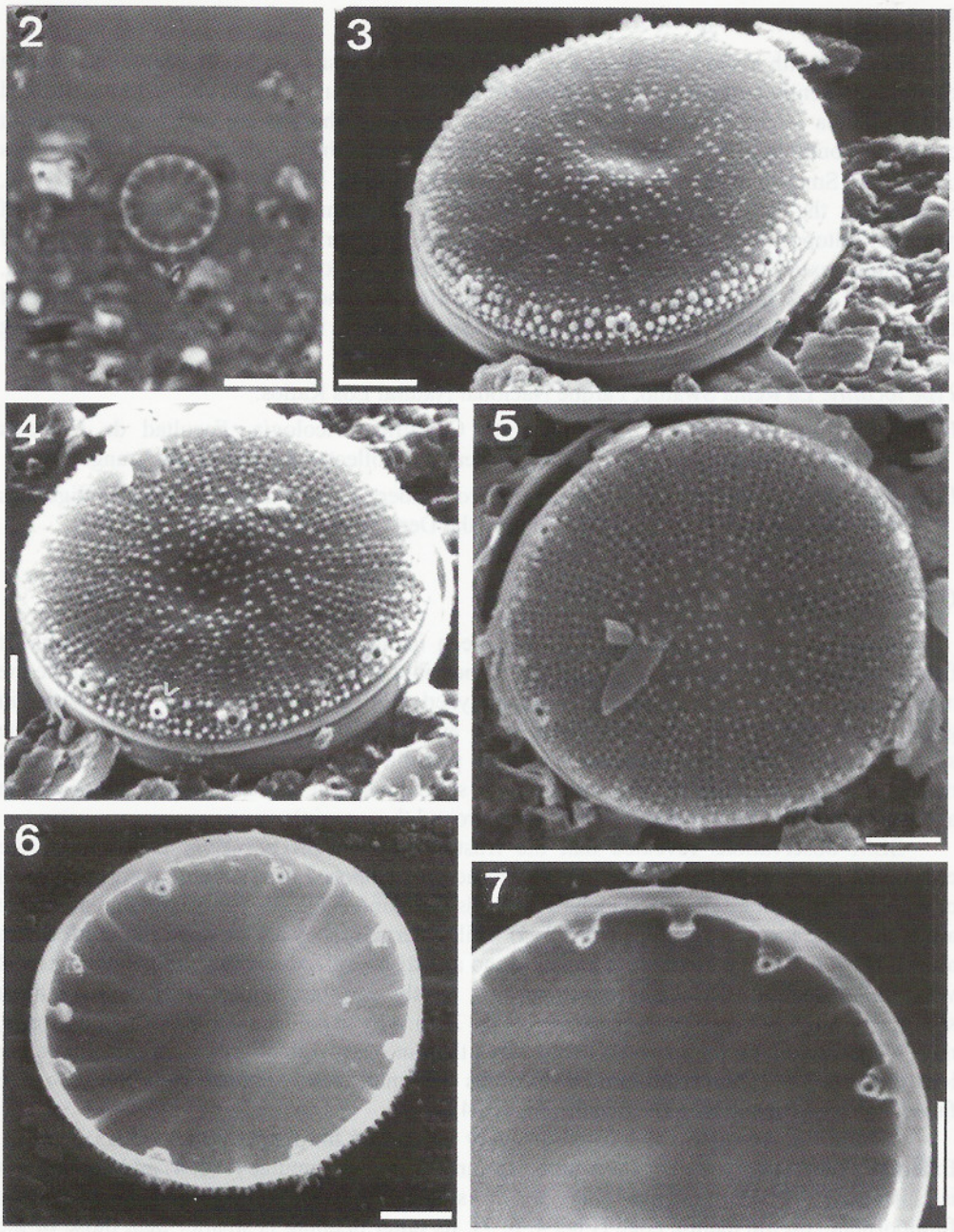
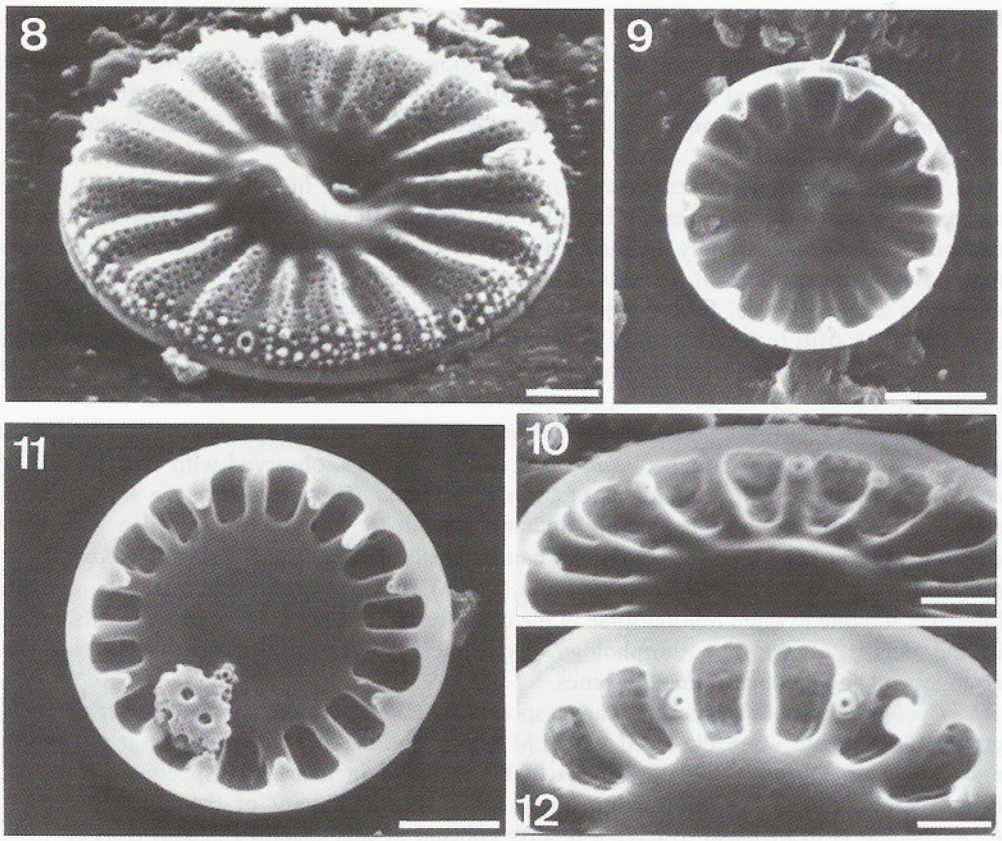


Fig. 2. Holotype *Cyclotella katiana,* LM. Valve view. **Figs 3–7**, *Cyclotella katiana*, SEM. **Figs 3, 4**, valves in external view. Tilted specimens showing the external opening of the mantle fultoportulae surrounded by small blunt spines and the external opening of the rimoportula (arrow head) and of the fultoportulae. **Fig. 5**, valve face external view, note the striation pattern. **Fig. 6**, Valve in internal view showing the distribution pattern of the rimoportula and fultoportulae (note the three cowlings around the internal tube) and open chambers (alveoli openings forming chambers open toward the valve centre). **Fig. 7**, detail of a valve in internal view showing the opening of the fultoportulae and rimoportula. Scale bars = 5 μm (Fig. 2); 1 μm (Figs 3–7).



Figs 8–12. SEM. **Figs 8–10**, *Cyclotella* sp. 1. **Fig. 8**, external view of valve in oblique position. Note the opening of the fultoportulae. **Fig. 9**, valve in internal view, showing the distribution pattern of the fultoportulae and rimoportula. **Fig. 10**, detail of another specimen showing the fultoportulae surrounded by three cowlings and the sessile rimoportula. **Figs 11, 12**, *Cyclotella* sp. 2. **Fig. 11**, valve in internal view showing the fultoportula on the valve face. Note the ring of mantle fultoportulae and rimoportula and closed chambers. **Fig. 12**, detail of the same specimen. Note the fultoportulae with a short tube surrounded by three cowlings and the shortly stalked rimoportula. Scale bars = 1 μm (Figs 8, 10, 12); 2 μm (Figs 9, 11).

In samples from the same swamp, four specimens that resemble *C. katiana* were found but with some morphological differences. Three of them, named *Cyclotella* sp. 1 (Figs 8–10), are 5.8 μm in diameter and have 8–10 interstriae in 10 μm. The valve has a transapically undulated central area, without fultoportulae, and a striated marginal area with externally elevated striae and recessed interstriae that internally conform conspicuous alveoli. The mantle fultoportulae, with three cowlings, are placed every second interstriae and a sessile rimoportula is placed between two fultoportulae. *Cyclotella* sp. 2 (Figs 11, 12) is 6.5 μm in diameter and has 6–8 interfascicles in 10 μm. Its central area is less transapically undulated than in *Cyclotella* sp. 1 and it has one eccentric fultoportula with three cowlings. Besides, the striated marginal area has conspicuous alveoli; a ring of fultoportulae, with three cowlings, placed every first or second interstriae and a shortly stalked rimoportula, placed between two fultoportulae.

DISCUSSION

The studied material does not fit with previously described taxa. Nevertheless, some characters of the external and internal morphology of *Cyclotella katiana* resemble those of *C. atomus* Hustedt, *C. atomus* var. *gracilis* Genkal & Kiss, *C. meduanae* Germain and *C. meneghiniana* Kützing.

The studied species differs from *C. atomus* in the absence of fultoportulae at the central area and in the lower number of fascicles in 10 µm. Besides, in *C. atomus* the striated marginal area is more strongly undulated than in *C. katiana* in which is almost flat. *C. atomus* may have or not spinulae at the valve face/mantle junction, whereas *C. katiana* always has numerous blunt spinulae. Furthermore, in *C. atomus* the mantle fultoportulae are placed at every third to fifth (seldom sixth to seventh) interstriae and have only two cowlings while in *C. katiana* they are placed at every second or third interfascicles and have 3 cowlings (Table 2).

Cyclotella meneghiniana seems to be an extremely variable species, with a large size range (5–45 µm). Even though *C. katiana* is a small species, observed with LM it could be confused with the smaller specimens of *C. meneghiniana*. These two taxa are similar in the central area more or less tangentially undulate and in the mantle fultoportulae with three cowlings. Nevertheless, *C. meneghiniana* can be easily distinguished from *C. katiana* by its more distantly spaced interfascicles (6–10 in 10 µm), the presence of a fultoportula on every interstria and one to three fultoportulae in the central area (Table 2). There are also differences in the details of the fine morphology, e.g., internal tube of the rimoportula and the arrangement and number of mantle spines.

Cyclotella meduanae is the nearest species to *C. katiana* due to the similarity in the general appearance when observed with LM and in the lack of fultoportulae at the central area; however, Ogawa (1990 in Tanaka 2007) included in this taxon specimens with one central fultoportula. The information about the fine morphology of the type material of *C. meduanae* is insufficient to have a precise concept of this species (Sabater & Klee 1990, Ludes & Coste 1996, Prygiel & Coste 2000, Tanaka 2007). Besides, Håkansson (2002) considered that *C. meduanae* is closely related to *C. meneghiniana* and that they could even be conspecific. Trying to overcome these limitations, we base our comparison only in the protologue of the species (Germain 1981), although we analyzed the materials described by other authors. *C. meduanae* has a nearly flat valve face and a larger number of mantle fultoportulae, 12–17, all around the circumference; apparently one in each interstria while in *C. katiana* fultoportulae are placed every 2nd or 3rd interstriae and it has at least 8 fultoportulae (Table 2). It is difficult to establish the fultoportulae density of *C. meduanae* because the EM photographs of the type material (Germain 1981: pl. 154, figs 4, 4a) are insufficient to distinguish them precisely. It seems that the number of marginal fultoportulae is less numerous than that described by this author (Table 2). Besides, the interfascicles in *C. katiana* are internally very weakly developed while they are strongly developed in *C. meduanae.* On the other hand, *C. katiana* resembles materials described as *C. meduanae* by Sabater & Klee (1990) from the Río Ebro, in the distribution of rimoportula and fultoportulae (Figs 16, 17) and in its external valve morphology (Fig. 20); however, in the absence of more detailed information it was impossible to carry out a more precise comparison. Furthermore, the materials illustrated by these authors differ from the protologue of *C. meduanae* in the number and distribution of the marginal fultoportulae. Our taxon also resembles the materials of *C. meduanae* from Japan illustrated by Tanaka (2007), but *C. katiana* differs with this taxon (Tanaka 2007: pl. 26, figs 3, 4) in its almost flat valve surface, in the number and distribution of strutted processes on every 1st or 2nd interfascicle (Tanaka 2007: pl. 27, figs 1, 2) and in the more defined alveoli that form well visible open chambers in internal valve view (Tanaka 2007, pl. 27, figs 1–4). Besides, our material's central area is less clearly defined as in the

material illustrated in Nagumo & Kobayasi (1985, pl. III, fig. 25) and Tanaka (2007, pl. 26, fig. 3 and pl. 27 figs 1–2). Furthermore, the central area of *C. katiana* has small spinulae distributed less densely that in the marginal area and this character is absent in *C. meduanae*.

Finally, *C. katiana* is a bit smaller than *Cyclotella* sp. 1 and *Cyclotella* sp. 2, has approximately the same density of marginal fultoportulae with three cowlings but they differ in the central area, less tangentially undulated and in the absence of marginal chambers in the former species. *Cyclotella* sp. 1 also differs from *C. katiana* in having a sessile rimoportula, and in the outer openings of the marginal fultoportulae without spinulae around it. On the other hand, the characters that make different *Cyclotella* sp. 2 from *C. katiana* are the eccentric fultoportulae on the valve face and the distribution of the marginal fultoportulae.

Cyclotella sp 1 is very similar to the specimens of *C. meduanae* illustrated in Nagumo & Kobayasi (1985: pl. III, fig. 25), Kiss & Padisák (1988: pl. 1, figs 8, 9), Prygiel & Coste (2000, pl. 4), Tanaka (2007, pl. 46, fig. 9) and other unpublished TEM photographs kindly provided by Coste. These materials coincide in the central and marginal valve face areas markedly differentiated and in the marginal area with elevated fascicles and interfascicles clearly distinguishable. Besides, they coincide in the number of marginal fultoportulae (8). But our material differs from the description given by Germain in the number of marginal fultoportulae. The identity of these materials will be dubious until the valve morphology of more specimens can be analyzed.

On the other hand, *Cyclotella* sp 2 resembles *C. atomus* var. *gracilis* Genkal & Kiss (1993) with a well defined ring of alveolar chambers at the margin; the eccentric position of the fultoportulae which have three cowlings; and the number and position of the well defined marginal fultoportulae; but it differs from *C. atomus* var. *gracilis* in the number of cowlings of the marginal fultoportulae (2) and in the striae density (15–20 in 10 μm).

Even though, it is necessary to examine more specimens of *Cyclotella* sp. 1 and *Cyclotella* sp. 2 to establish their identity, it is possible to state that they do not fit with the related taxa *Cyclotella atomus* var. *atomus*, *C. atomus* var. *gracilis*, *C. meduanae*, *C. meneghiniana* and *C. katiana*.

Finally, it is necessary to point out that the comparisons with *C. meduane* was limited and speculative until the type material is analyzed with SEM, something that we unsuccessfully tried

ACKNOWLEDGEMENTS

We want to acknowledge Lic. José M. Guerrero for the critical revision of the manuscript and Dr Daniel Giuliano, from the Herbario of the Museo de Ciencias Naturales de La Plata, for his help with the Latin diagnosis. We also want to acknowledge Dr Keve. T. Kiss, Dr Hiroyuki Tanaka, Dr Michel Coste and Dr Karen Serieyssol who kindly sent photographs and papers that allowed us to improve our paper.

REFERENCES

ANONYMOUS. (1975). Proposals for standardization of diatom terminology and diagnoses. *Nova Hedwigia*, **53**, 232–354.

CEN/TC 230, prEN 13946. (2002). Water quality-Guidance standard for the routine sampling and pretreatment of benthic diatoms from rivers.

FERRARIO, M. E., SAR, E. A. & SALA, S. E. (1995). Metodología básica para el estudio del fitoplancton con especial referencia a las diatomeas. In: *Manual de Métodos Ficológicos* (K. Alveal, M.E. Ferrario, E. Oliveira & E Sar, eds), 1–23. Universidad de Concepción, Concepción.

GENKAL, S. I. (1977). K metodike podschota nekotorih taksonomicheski znachimih strukturnih elementov stvorki u diatomovih vodoroslej sem. Thalassiosiraceae Lebour emend Hasle (Bacillariophyta). *Botanicheskii Zhurnal*, **62,** 848–851

GENKAL, S. I. & KISS, K. T. (1993). Morphological variability of *Cyclotella atomus* Hustedt var. *atomus* and *C. atomus* var. *gracilis* var. nov. In: *Proceedings of the Twelfth International Diatom Symposium,* Renesse, The Netherlands 30 August–5 September 1992 (H. Van Dam, ed.), *Hydrobiologia*, **269/270,** 39–47. Kluwer Academic Publishers.

GERMAIN, H. (1981). *Flore des diatomées Diatomophycées*. 441 pp. Societé Nouvelle des Editions Boubée, Paris.

GUERRERO, J. M & ECHENIQUE, R. (2006). *Discostella* taxa (Bacillariophyta) from the Río Limay basin (northwestern Patagonia, Argentina). *European Journal of Phycology*, **41**, 83–96.

HÅKANSSON, H. (1988). A study of species belonging to the *Cyclotella bodanica/comta* complex (Bacillariophyceae). In: *Proceedings of the 9th International Diatom Symposium,* Bristol, U.K. (F.E Round, ed.), 329–534. Biopress Ltd. & Koeltz Scientific Books, Koenigstein.

HÅKANSSON, H. (1989). A light and electron microscopical investigation of the type species of *Cyclotella* (Bacillariophyceae) and related forms, using original material. *Diatom Research,* **4**, 255–276.

HÅKANSSON, H. (1990a). *Cyclotella tripartita* nov. sp. and the relationship to similar taxa. In: *Ouvrage dédiè a H. Germain* (M. Ricard, ed.), 75–82. Koeltz Scientific Books, Koenigstein.

HÅKANSSON, H. (1990b). *Cyclotella meneghiniana* Kütz. (Bacillariophyceae) its morphology and reappraisal of similar species. *Nova Hedwigia, Beiheft* **100**, 19–37.

HÅKANSSON, H. (1993). Morphological and taxonomical problems in four *Cyclotella* species. *Diatom Research*, **8**, 309–316.

HÅKANSSON, H. (1996). *Cyclotella striata* complex: typification and new combinations. *Diatom Research*, **11**, 241–260.

HÅKANSSON, H. (2002). A compilation and evaluation of species in the general *Stephanodiscus*, *Cyclostephanos* and *Cyclotella* with a new genus in the family Stephanodiscaceae. *Diatom Research*, **17**, 1–139.

HÅKANSSON, H. & CHEPURNOV, V. (1999). A study of the variation in valve morphology of the diatom *Cyclotella meneghiniana* in monoclonal cultures: effect of auxospore formation and different salinity conditions. *Diatom Research,* **14**, 251–272.

HÅKANSSON, H. & CLARKE, K. B. (1997). Morphology and taxonomy of the centric diatom *Cyclotella atomus*. *Nova Hedwigia,* **65**, 207–219.

HÅKANSSON, H., HAJDU, S., SNOEIJS, P. & LOGINOVA, L. (1993). *Cyclotella hakanssoniae* Wendker and its relationship to *C. caspia* Grunow and other similar brackish water *Cyclotella* species. *Diatom Research*, **8**, 333–347.

HOUK, V. & KLEE, H. (2004). The stelligeroid taxa of the genus *Cyclotella* (Kützing) Brébisson (Bacillariophyceae) and their transfer into the new genus *Discostella* gen. nov. *Diatom Research*, **19**, 203–228.

KISS, K. T. & PADISÁK, J. (1988). Species succession in the Thalassiosiraceae: quantitative studies in the large, shallow Lake Balaton, Hungary. In: *Proceedings of the 10th International Diatom Symposium,* Joensuu, Finland, August 28–September 2, 1988 (H. Simola, ed.), 481–490. Koeltz Scientific Books, Koenigstein.

KLING, H. & HÅKANSSON, H. (1988). A light and electron microscopy study of *Cyclotella* species (Bacillariophyceae) from central and northern Canadian lakes. *Diatom Research,* **3**, 55–82.

LOGINOVA, L. P. (1990a). Classification of the diatom genus *Cyclotella*. In: *Proceedings of the 10th International Diatom Symposium,* Joensuu, Finland, August 28–September 2, 1988 (H. Simola, ed.), 37–46. Koeltz Scientific Books, Koenigstein.

LOGINOVA, L. P. (1990b). Evolution and Phylogeny of the diatom genus *Cyclotella*. In: *Proceedings of the 10th International Diatom Symposium,* Joensuu, Finland, August 28–September 2, 1988 (H. Simola, ed.), 47–53. Koeltz Scientific Books, Koenigstein.

LOWE, R. L. (1975). Comparative structure of the valve of some *Cyclotella* species (Bacillariophyta). *Journal of Phycology*, **11**, 415–424.

LOWE, R. L. (1981). The frustule morphology and distribution of *Cyclotella gamma* Sov. (Bacillariophyceae). *Proceedings of Iowa Academy of Sciences,* **88**, 82–84.

LUDES, B. & COSTE, M. (1996). Diatomées et médecine légale. Applications de la recherche des diatomées au diagnostic de la submersion vitale. Tec & Doc Lavoisier, Paris. Editions Médicales Internationales, Cachan.

METZELTIN, D & LANGE-BERTALOT, H. (1998). *Tropical Diatoms of South America I.* Koeltz Scientific Books, Germany.

METZELTIN, D & LANGE-BERTALOT, H. (2007). *Tropical Diatoms of South America II.* A.R.G. Gantner Verlag K.G., Germany.

NAGUMO, T. & KOBAYASI, H. (1985). Fine structure of three freshwater and brackish water species of the genus *Cyclotella* (Bacillariophyceae) *C. atomus*, *C. caspia* and *C. meduanae*. *Bulletin of Plankton Society Japan*, **32**, 101–109.

PRYGIEL, J. & COSTE, M. (2000). Guide méthodologique pour la mise an œuvre de l'Indice Biologique Diatomées. NF T 90–354. Agence de l'Eau Artois-Picardie. Cemagref, groupement de Bordeaux.

RUMRICH, U., LANGE-BERTALOT, H. & RUMRICH, M. (2000). Diatomeen der Anden von Venezuela bis Patagonien/Feuerland Und zwei weitere Beiträge. A.R.G. Gantner Verlag K.G., Germany.

SABATER, S. & KLEE, R. (1990). Observaciones sobre diatomeas centrales del fitoplancton del río Ebro, con especial interés en algunas pequeñas *Cyclotella*. *Diatom Research*, **5**, 141–154.

TANAKA, H. (2007). Taxonomic Studies of the Genera *Cyclotella* (Kützing) Brébisson, *Discostella* Houk et Klee and *Puncticulata* Håkansson in the Family Stephanodiscaceae Glezer et Makarova (Bacillariophyta) in Japan. 204 pages, 70 plates. *Bibliotheca Diatomologica*, Band **53**. Berlín.

THERIOT, E. & SERIEYSSOL, K. (1994). Phylogenetic systematics as a guide to understanding features and potential morphological characters of the centric diatom family Thalassiosiraceae. *Diatom Research*, **9**, 429–450.

Manuscript received for publication December 2007