Gayana Bot. 67(1): 12-18, 2010 ISSN 0016-5301

Observations and comments on the diatom *Stephanodiscus minutulus* (Kützing) Cleve & Möller (Bacillariophyceae) found for the first time in Chile from bottom sediments collected in Lake Laja

Observaciones y comentarios acerca de la diatomea *Stephanodiscus minutulus* (Kützing) Cleve & Möller (Bacillariophyceae) encontrada por primera vez en Chile en sedimentos recolectados en el Lago Laja

Fabiola Cruces[1], Patricio Rivera[1] & Roberto Urrutia[2]

[1]Departamento de Botánica, Universidad de Concepción, Casilla 160-C, Concepción, Chile.
[2] Centro EULA, Universidad de Concepción, Casilla 160-C, Concepción, Chile.
fcruces@udec.cl

ABSTRACT

This study reports the presence of the diatom *Stephanodiscus minutulus* (Kützing) Cleve & Möller for the first time in Chilean continental waters; it is a taxon reported in many aquatic systems in Europe and North America and there are only scanty records from South America (Argentina). The species was found in a sedimentary profile collected from Lake Laja (Andes Mountains), Central Chile. The principal morphological features of *S. minutulus* are described, and comments about its relationship with other closely related taxa are given.

Keywords: Morphology, new record, related taxa, variability, trophic state.

RESUMEN

En este estudio se señala la presencia de la diatomea *Stephanodiscus minutulus* (Kützing) Cleve & Möller por primera vez para aguas continentales de Chile; es un taxón muy común en diversos sistemas acuáticos de Europa y Norteamérica, y para Sudamérica sólo existen escasos registros en Argentina. La especie fue encontrada en un perfil sedimentario colectado en el Lago Laja (Cordillera de los Andes), Chile central. Se describen las principales características morfológicas de *S. minutulus* y se entregan comentarios sobre su relación con otras especies cercanas.

Palabras clave: Morfología, nuevo registro, especies afines, variabilidad, estado trófico.

INTRODUCTION

Stephanodiscus Ehrenberg 1845 is a planktonic, freshwater genus present in rivers, lakes, and reservoirs around the world (e.g., Stoermer & Håkansson 1984, Håkansson & Hickel 1986, Håkansson & Ehrlich 1987, Round *et al*. 1990, Håkansson & Meyer 1994, Theriot & Stoermer 1982, Scheffler & Morabito 2003).

During the last decades, investigations carried out on water samples and lacustrine sedimentary material have identified some small taxa of *Stephanodiscus* as indicators of water quality in aquatic systems in Europe and North America (Laird *et al*. 2003, Marchetto *et al*. 2004, Reavie *et al*. 2006, Bracht *et al*. 2008). However, since the genus was established, there has been serious confusion about the identification of its species, as a consequence, principally, of their small size, morphological variability, and by the use of only light microscopy for their identification (Theriot 1987, Håkansson & Kling 1990).

Until now, five species of *Stephanodiscus* have been reported in Chilean continental waters: *S. hantzschii* Grunow by Kraske (1939) from the Calbuco area (41º46'S; 73º08'W) and Río Pascua (48º10'S; 73º10'W), *S. agassizensis* Håkansson & Kling by Rivera *et al*. (2003) in Lake Chungará

(18º14'S; 69º09'W), and, recently, *S. kuetzingii* Klee & Casper by Rivera & Cruces (2005) in Rapel Reservoir (34º10'S; 71º29'W). Two other *Stephanodiscus* species found previously in Chile (*S. astraea* Ehrenberg & Grunow and *S. novaezeelandiae* Cleve) correspond to taxa of the genera *Cyclotella* (Kützing) Brébisson and *Cyclostephanos* Round, respectively (Håkansson 2002).

In a diatomological analysis of sedimentary profile samples collected in Lake Laja, central Chile, we found *S. minutulus* (Kützing) Cleve & Möller, a species until now not reported from Chile and scarcely from South America.

This paper describes and illustrates the principal morphological features found in the *S. minutulus* cells, comments about its presence and abundance in the studied area and remarks on other closely related taxa (*S. hantzschii* and *S. parvus* Stoermer & Håkansson) are given.

MATERIAL AND METHODS

Lake Laja is an Andean lake located 1,360 m asl in the Antuco Volcano area (36º54'S; 71º05W). The lake is 35 km long, 7 km wide; it has a surface of 87 km^2, and a volume of 6,000,000 m^3 depending on precipitation which causes the lake level to rise considerably in winter and early spring. On the other hand, since 1958, the lake level has been controlled because the water is used for hydropower and irrigation of cropland (Mardones & Vargas 2005).

The diatom material analyzed is deposited at the Diatom Collection, Department of Botany, University of Concepción, Chile (DIAT-CONC 3261 to 3290). It was obtained on December 2001 from a sedimentary profile taken from the deepest part of Lake Laja (120 m of depth) by using a gravity corer Uwitec. The core was sectioned at 1 cm intervals, and to carry out this work, only the sediments where *Stephanodiscus minutulus* was found (30 surface layers) were used; however deeper layers (50 cm) were previously also analyzed. According to ^{210}Pb geochronology (Appleby & Oldfield 1974), these layers represent the last century of the lake's history (Quiroz *et al*. 2005), a period during which the lake has been under anthropic intervention. To eliminate any organic matter and clean the diatom valves, the sediment was treated with hydrogen peroxide following Battarbee (1986). Over 200 valves of *S. minutulus* were analyzed using a light (Zeiss Photomicroscope III) and a scanning electron microscope (JEOL JSM-6380LV) belonging to the Electron Microscopy Laboratory of the University of Concepción, Chile. The methodology for counting total diatom valves followed Battarbee (1986), and the abundances of *S. minutulus* are given as a percentage of the total diatom valves present in each sediment layer (relative abundance). The terminology herein follows Anonymous (1975), Ross *et al*. (1979), and Håkansson (2002).

RESULTS

Morphology of *Stephanodiscus minutulus* (Kütz.) Cleve & Möller

All sedimentary material analyzed showed a good preservation of the diatom valves, allowing the recognition of its morphology. The valves are circular; 5.5-8.2 µm in diameter and the valve mantle is very shallow, 2-3 areolae in height (Figs. 1b, c). The valve face surface is flat (Fig. 1a), concave (Fig. 1b), or convex (Fig. 1c). At the valve centre the areolae (4-5 in 1 µm) are arranged in uniseriate striae, becoming bi- or triseriate towards the valve face/mantle junction (Figs. 1a-d). The interfascicles are not raised. Slit-like to irregular outline of the areolae were observed (Figs. 1a-d); internally they present a domed cribrum (Figs. 1e, f, h). A spine, of a variable length and thickness, is always present at the end of each interfascicle (Figs. 1a-d). There is only one valve face fultoportula (Figs. 1c-d, g-h) with two satellite pores (Fig. 1g) located close to the valve centre; the marginal fultoportulae, located at the mantle edge, have three satellite pores and occur on every 3-5 interfascicles (Figs. 1b, f). There is a single marginal sessile rimoportula with an elongated external tube (Figs. 1e, h; white arrows); the internal labium lies in a quite oblique orientation (Fig. 1h).

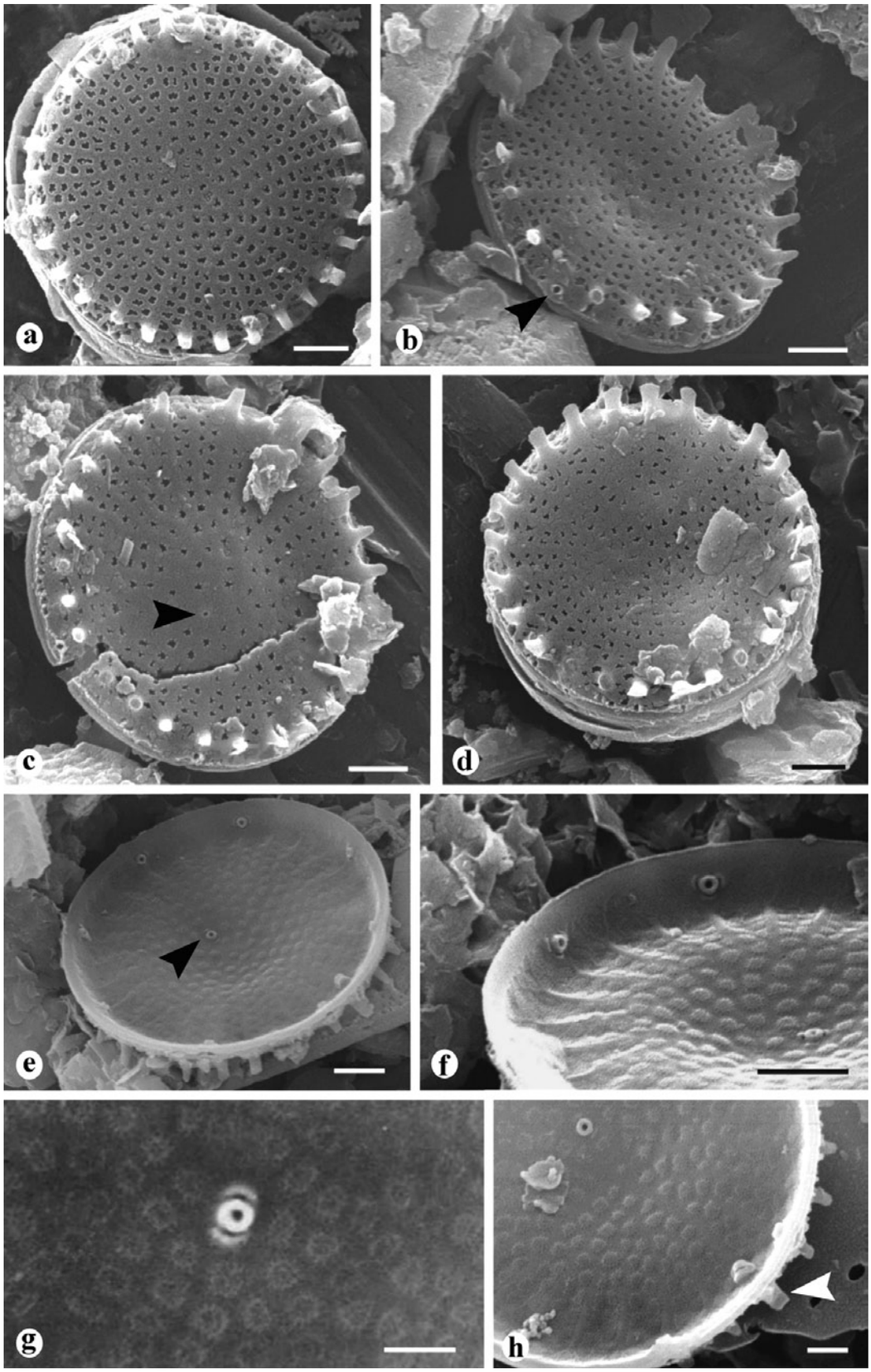
Stratigraphic abundance

The species *S. minutulus* appeared in Lake Laja at the beginning of twentieth century (Fig. 2), showing variable abundances that fluctuated between 0 and 4.83%, with a tendency to increase to the superficial layers and recording the maximum value in 1998.

DISCUSSION

The morphological features observed in the Chilean specimens agree well with those distinctive characteristics described for *Stephanodiscus minutulus* (Kützing) Cleve & Möller, especially with respect to the number and position of strutted and labiate process, areolae arrangement and morphology of valve mantle (Kobayasi *et al*. 1985, Scheffler & Morabito 2003). Nevertheless, the outline of areolae was variable in the samples analyzed, and a gradient from flat to undulate valve face surface was observed, a situation described previously by others authors (Round 1981, Håkansson 2002, Scheffler & Morabito 2003).

Under light microscopy, the general appearance of *S. minutulus* is very similar to that of *S. parvus* Stoermer & Håkannson and *S. hantzschii* (Table I). According to Håkansson (2002), *S. hantzschii* can be separated from *S. minutulus* principally by the lack of a valve face fultoportula, a higher mantle and a greater number of rows of areolae on it. The authoress characterized *S. parvus* as having flat valves with a valve face fultoportula in an eccentric position.


a
b
c
d
e
f
g
h

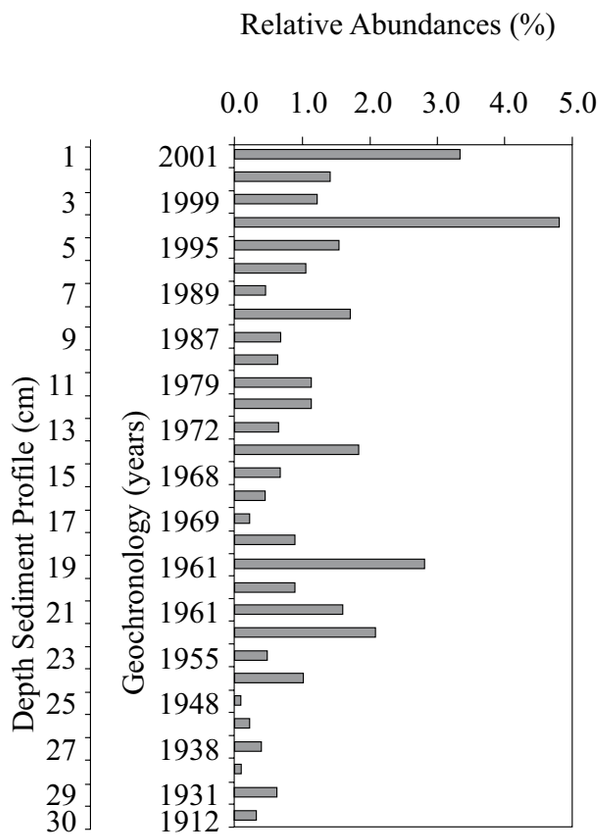


Figure 2. Profile of abundance of *S. minutulus* in Lake Laja.

Figura 2. Perfil de abundancia de *S. minutulus* en el Lago Laja.

The Argentinian material reported as *S. minutulus* by Sala (1990) and *S. parvus* by Ferrario *et al.* (1989) and Echenique & Guerrero (2003) agree well with the morphological features described by Håkansson for *S. minutulus*. In the present study, we have not included the reports of *S. minutulus* and *S. parvus* given from Argentina by Gómez (1999) and Mayr *et al.* (2005) respectively, because they gave neither a diagnosis of the taxa nor a draw or picture.

We agree with Kobayasi *et al*. (1985), Scheffler & Morabito (2003), and Genkal & Korneva (1990) in order to consider *S. parvus* as a synonym of *S. minutulus*. These authors found that *S. minutulus* is a polymorphic taxon according to the chemical conditions of the water bodies it inhabits.

Stephanodiscus minutulus has been reported in many North American and European freshwater lakes and reservoirs, and its presence has generally been related to meso- or eutrophic conditions; however, in South America the knowledge of *S. minutulus* is still scanty.

With respect to the abundance of *S. minutulus* in the sedimentary profile of Lake Laja, the increase in valve concentration in more recent layers could indicate increased nutrient levels in the lake. It is important to note that before layer 30 of the profile (*ca.* 1910 year) the sedimentary material did not record valves of *S. minutulus*. Besides, the increase of this taxon corresponds in time to the onset of significant human manipulation of the lake. This information is also supported by the analysis of some chemical parameters determined in the sedimentary material, which indicate that the lake became less oligotrophic during the last decades (in prep.).

Other common diatom species identified in the Lake Laja samples were *Asterionella formosa* Hassall, *Aulacoseira granulata* (Ehrenberg) Simonsen, *A. distans* (Ehrenberg) Simonsen, *Cyclotella stelligera* (Cleve & Grunow in Cleve) Van Heurck, *Staurosira construens* Ehrenberg and *Staurosira pinnata* Ehrenberg.

←

Figure 1. *Stephanodiscus minutulus*. SEM. a-d, external view; e-h, internal view. (a) Flat valve with areolae of irregular outline forming uniseriate, bi or triseriate striae; a spine at each interfascicle. (b) Concave valve, external opening of a marginal fultoportula (arrow). (c) Convex valve, external opening of the valve face fultoportula (arrow). (d) Concave valve. (e) Valve face fultoportula (black arrow) and marginal rimoportula (white arrow). (f) Marginal fultoportulae with three satellite pores; areolae with a domed cribrum. (g) Valve face fultoportula with two satellite pores. (h) Marginal rimoportula with an elongated external tube (arrow). Scale bars: a-f, h = 1.0 µm, g = 0.5 µm.

Figura 1. *Stephanodiscus minutulus*. SEM. a-d, vista externa; e-h, vista interna. (a) Valva plana con areolas de contorno irregular fomando estrías uniseriadas, bi- o triseriadas; una espina en cada interfascículo. (b) Valva cóncava, abertura externa de una fultoportula marginal (flecha). (c) Valva convexa, abertura externa de la fultoportula de la cara valvar (flecha). (d) Valva cóncava. (e) Fultoportula de la cara valvar (flecha negra) y rimoportula marginal (flecha blanca). (f) Fultoportulae marginales con tres poros satélite; areolas con criba elevada. (g) Fultoportula de la cara valvar con dos poros satélite. (h) Rimoportula marginal con un tubo externo alargado (flecha). Escalas: a-f, h = 1,0 µm, g = 0,5 µm.

TABLE I. Principal morphological features of *S. minutulus*, *S. parvus* and *S. hantzschii* according to different authors.

TABLA I. Principales características morfológicas de *S. minutulus*, *S. parvus* y *S. hantzschii* de acuerdo con diferentes autores.

FEATURES	*S. minutulus*			*S. parvus*			*S. hantzschii*
	PRESENT STUDY	HÅKANSSON 2002	KOBAYASI *ET AL.* 1985	HÅKANSSON 2002	STOERMER & HÅKANSSON 1984	FERRARIO *ET AL.* 1989	HÅKANSSON 2002
Diameter (µm)	5.5 - 8.2	2 - 12	7 - 15	5 - 11	5 - 11	5.5 - 9.0	5 - 30
Valve face surface	Flat, concave or convex	Concave or convex	Flat, concave or convex	Flat	Relatively flat	Flat, concave	Almost flat
Mantle height	Shallow	Shallow	Shallow	Shallow	Very shallow	Shallow	High
Position of single valve face fultoportula	Centric or slightly eccentric	Slightly eccentric	Centric	Slightly eccentric	Eccentric	Centric or slightly eccentric	Absent
Position of marginal fultoportulae	Every 3-5 interfascicles	Every 3-5 interfascicles	Every 3-6 interfascicles	No data	Every 3-6 interfascicles	Every 3-5 interfascicles	Every 3-5 interfascicles
Number of satellite pores on valve face and marginal fultoportulae	2 / 3	2 / 3	2 / 3	2 / no data	2 / 3	No data	Absent / 3
Areolae outline	Slit-like to irregular	Slit-like	Slit-like to rounded	Slit-like to fast rounded	Rounded	Rounded	Rounded
Rows of areolae toward the margin	Single to bi or triseriate	Single to bi or triseriate	Single to bi or triseriate	Single to bi or triseriate	Single to biseriate	Single to bi or triseriate	Single to up three

ACKNOWLEDGEMENTS

The authors are very grateful to Prof. Dr. Sergei Genkal for his helpful comments and suggestions. We wish to thank Dr. Mark Edlund and Dr. E. F. Stoermer for providing us with some papers related to *Stephanodiscus*. We also acknowledge the assistance of the staff of Electron Microscopy Laboratory of the University of Concepción, Chile, and the funding granted by Fondecyt Project 1070508.

REFERENCES

Anonymous. 1975. Proposal for a standardization of diatom terminology and diagnosis. Nova Hedwigia Beiheft 53: 323-354.

Appleby, P.G. & F. Oldfield. 1974. Calculation of lead-210 dates assuming a constant rate of supply of unsupported 210Pb to the sediment. Catena 5: 1-8.

Battarbee, R. 1986. Diatom analysis. In: B.E. Berglund (ed.), Handbook of Holocene Palaeoecology and Palaeohydrology, pp. 527-569. John Wiley & Sons, Chichester.

Bracht, B., J. Stone & S. Fritz. 2008. A diatom record of late Holocene climate variation in the northern range of Yellowstone National Park, USA. Quaternary International 188: 149-155.

Echenique, R. & J.M. Guerrero. 2003. Las Algas del Sistema del Río Limay (Argentina). III Chrysophyta, Bacillariophyceae. 1: Centrales. Boletín de la Sociedad Argentina de Botánica 38: 149-163.

Ehrenberg, C.G. 1845. Vorläufige zweite Mitteilung über die weitere Erkenntnis der Beziehungen des kleinsten Lebens zu den vulkanischen Massen der Erde. Berichte über die zur Bekanntmachung geeigneten Verhandlung der Königlich-Preussischen Akademie der Wissenschaften zu Berlin, S. 133-157.

Ferrario, M., R. Godina & M. Damborenea. 1989. Sobre algunos taxa de Diatomeas Centrales continentales para Argentina. Iheringia Botánica 39: 55-67.

Genkal, S.I. & L.G. Korneva. 1990. Morphology and systematic of some species of the genus *Stephanodiscus* Ehr. In: Flora and productivity of pelagic and littoral phytocoenoses of the Vilga basin reservoir. pp. 219-236. Leningrad (In Russian).

Gómez, N. 1999. Epipelic diatoms from the Matanza-Riachuelo river (Argentina), a highly polluted basin from the pampean plain: biotic indices and multivariate analysis. Aquatic Ecosystem Health and Management 2: 301-309.

Håkansson, H. 2002. A compilation and evaluation of species in the genera *Stephanodiscus*, *Cyclostephanos* and *Cyclotella* with a new genus in the family Stephanodiscaceae. Diatom Research 17: 1-139.

Håkansson, H. & B. Hickel. 1986. The morphology and taxonomy of the diatom *Stephanodiscus neoastraea* sp. nov. British Phycological Journal 21: 39-43.

Håkansson, H. & A. Ehrlich. 1987. *Stephanodiscus galileensis* sp. nov. from Holocene Subsurface Sediments of Lake Kinnereth, Israel. Diatom Research 2: 15-21.

Håkansson, H. & H. Kling. 1990. The current status of some very small freshwater diatoms of the genera *Stephanodiscus* and *Cyclostephanos*. Diatom Research 5: 273-287.

Håkansson, H. & B. Meyer. 1994. A comparative study of species in the *Stephanodiscus niagarae* complex and a description of *S. heterostylus* sp. nov. Diatom Research 9: 65-85.

Kobayasi, H., H. Kobayashi & M. Idei. 1985. The fine structure and taxonomy of the small and tiny *Stephanodiscus* (Bacillariophyceae) species in Japan. 3. Co-occurrence of *Stephanodiscus minutulus* (Kütz.) Round and *S. parvus* Stoerm. & Håk. Japanese Journal of Phycology 33: 293-300.

Kraske, G. 1939. Zur Kieselalgenflora Südchiles. Archiv für Hydrobiologie 35: 350-468.

Laird, K., B. Cumming, S. Wunsam, J. Rusak, R. Oglesb, S. Fritz & P. Leavitt. 2003. Lake sediments record large-scale shifts in moisture regimes across the northern prairies of North America during the past two millennia. Proceedings of the National Academy of Science 100: 2483-2488.

Marchetto, A., A. Lami, S. Musazzia, J. Massaferro, L. Langonec & P. Guilizzoni. 2004. Lake Maggiore (N. Italy) trophic history: fossil diatom, plant pigments, and chironomids, and comparison with long-term limnological data. Quaternary International 113: 97-110.

Mardones, M. & J. Vargas. 2005. Efectos hidrológicos de los usos eléctrico y agrícola en la cuenca del río Laja (Chile centro-sur). Revista de Geografía Norte Grande 33: 89-102.

Mayr, C., M. Fey, T. Haberzettl, S. Janssen, A. Lücke, N. Maidana, C. Ohlendorf, F. Schäbitz, G.H. Schleser, U. Struck, M. Wille & B. Zolitschka. 2005. Palaeoenvironmental changes in southern Patagonia during the last millennium recorded in lake sediments from Laguna Azul (Argentina). Palaeogeography, Palaeoclimatology, Palaeoecology 228: 203-227.

Quiroz, R., P. Popp, R. Urrutia, C. Bauer, A. Araneda, H. Treutler & R. Barra. 2005. PAH fluxes in the Laja Lake of south central Chile Andes over the last 50 years: Evidence from a dated sediment core. Science Total Environment 349: 150-160.

Reavie, E., K. Neill, J. Little & J. Smol. 2006. Cultural Eutrophication Trends in Three Southeastern Ontario Lakes: A Paleolimnological Perspective. Lake Reservoir Management 22: 44-58.

Rivera, P. & F. Cruces. 2005. First record of *Stephanodiscus kuetzingii* Klee & Casper (Bacillariophyceae) from living material collected in Rapel Reservoir, Central Chile. Diatom Research 20: 163-170.

Rivera, P., F. Cruces & I. Vila. 2003. Primera cita de *Stephanodiscus agassizensis* Håkansson & Kling (Bacillariophyceae) en Chile. Gayana Botánica 59: 83-88.

Ross, R., E.J. Cox, N.I. Karayeva, D.G. Mann, T.B.B. Paddock, R. Simonsen & P.A. Sims. 1979. An amended terminology for the siliceous components of the diatom cell. Nova Hedwigia Beiheft 64: 513-533.

Round, F. 1981. The diatom genus *Stephanodiscus*: an electron-microscopic view of the classical species. Archive Protistenkunde 124: 455-470.

Round, F.E., R.M. Crawford & D.G. Mann. 1990. The Diatoms. Biology & Morphology of the Genera. Cambridge University Press, Cambridge. 747 pp.

Sala, S. 1990. Ultraestructura de algunas Bacillariophyceae de agua dulce citadas por primera vez en Argentina. Darviniana 30: 219-221.

Scheffler, W. & G. Morabito. 2003. Topical observations on centric diatoms (Bacillariophyceae, Centrales) of Lake Como (N. Italy). Journal of Limnology 62: 47-60.

Stoermer, E.F. & H. Håkansson. 1984. *Stephanodiscus parvus*: validation of an enigmatic and widely misconstrued taxon. Nova Hedwigia 39: 497-511.

Theriot, E. 1987. Principal component analysis and taxonomic interpretation of environmentally related variation in silification in *Stephanodiscus* (Bacillariophyceae). British Phycological Journal 22: 359-373.

Theriot, E. & E.F. Stoermer. 1982. Observations of North American population of *Stephanodiscus* (Bacillariophyceae) species attributed to Friedrich Hustedt. Transactions of the American Microscopical Society 101: 368-374.

Recibido: 30.09.09
Aceptado: 15.12.09