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Thalassiosira fryxelliae nov. spec. (Bacillariophyceae) from Argentinian coastal waters

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Abstract

The new marine nanoplanktonic diatom, *Thalassiosira fryxelliae*, is described with light and scanning electron microscopy from material collected in Argentinian coastal waters. *T. fryxelliae* is a morphologically distinctive species with: 1) cells embedded in irregular gelatinous masses, 2) absence of central, sub-central and scattered strutted processes on the valve surface, 3) one marginal ring of strutted processes with external tubes, 4) one marginal labiate process included in the ring of the strutted processes, 5) areolation pattern variable linear, sublinear, eccentric or irregular. Externally, the marginal strutted processes have double tubes, at least in the distal part, cut distally and with the half-cylinder bent vertically with crenulated distal edges and the labiate process has a simple tube. Internally, the strutted processes are short with four operculate satellite pores and the labiate process is sessile and radially located. *Thalassiosira fryxelliae* is similar to *T. angulata* and *T. nanolineata* in morphology and distribution pattern of the marginal strutted processes and in the location of the labiate process and to *T. leptopus* and some specimens of *T. guillardii* and *T. pseudonana* in lacking one central strutted process.

Keywords: diatoms; morphology; taxonomy; *Thalassiosira fryxelliae*.

Introduction

The genus *Thalassiosira* was erected by Cleve (1873), and the description was emended by Hasle (1973). Van Landingham (1978) reported 73 taxa validly published with priority in the genus, and later Fryxell and Hasle (1979) pointed out that the genus includes more than one hundred taxa. According to Hasle and Syvertsen (1997), *Thalassiosira* is a thoroughly studied marine planktonic genus.

Previous studies (including ultrastructural analysis) of some taxa within *Thalassiosira* from Argentinian coastal waters have been performed by Lange et al. (1983), Sar and Ferrario (1987), Ferrario and Sar (1988), Gayoso (1989), Sar (1996) and Sar et al. (2001, 2002).

In the framework of a study of the suitability of different phytoplankton species as a food source for oysters in a hatchery located in the Gulf of San Matías (Río Negro, Argentina), we have focused our attention on the analysis of nanoplanktonic diatoms, and we found a small, unknown, *Thalassiosira* species. The purposes of this paper are to describe the new taxon based on light microscopy (LM) and scanning electron microscopy (SEM) and to compare it with other species with a similar morphology or type of colony.

Materials and methods

The material analyzed was collected seasonally from October 1994 to October 1996, and bimonthly from October 1996 to January 1999 at several locations along the coast of Buenos Aires Province: San Clemente del Tuyú, Santa Teresita, La Lucila del Mar, Mar de Ajó, Nueva Atlantis, Pinamar and Villa Gesell (Figure 1, Table 1), and monthly from April 1998 to February 2000 at several stations in the northern area of San Matías Gulf: Punta Orengo, Las Garzas, Banco Reparo, San Antonio Oeste, Los Álamos, Las Grutas, Bajo de Oliveira and El Fuerte (Figure 2, Table 2). In Buenos Aires Province, seawater temperature ranges from 8–24 °C and the salinity from 31–34.1 psu (unpublished data), and in the northern area of San Matías Gulf from 7–23.5 °C, with salinity ranging from 34–36 psu (Pascual et al. 2001). Qualitative samples were taken from the surface layer of the water column (between 0 and 5 m) with 30 μm net hauls and fixed with 4% formalin. In the laboratory, the preserved samples were rinsed with distilled water to remove salt and preservatives, and then the organic matter was oxidized according to Hasle and Fryxell (1970). The cleaned material was mounted for LM and SEM according to Ferrario et al. (1995). Permanent mounts were made with Hyrax or Naphrax.

The materials were deposited in the "Colección de Diatomeas Argentinas, Departamento Científico Ficología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata".

Observations were made with microscopes under phase contrast Wild M20 (Heerbrug, Switzerland) and Nikon Microphot-FX (Yokohama, Japan). The microphotographs were obtained using Nikon Microphot-FX microscope and scanning electron microscope Jeol JSMT 100 (Akishima, Japan).

The terminology followed is that recommended by Ross et al. (1979), and the bibliography on the fine struc-

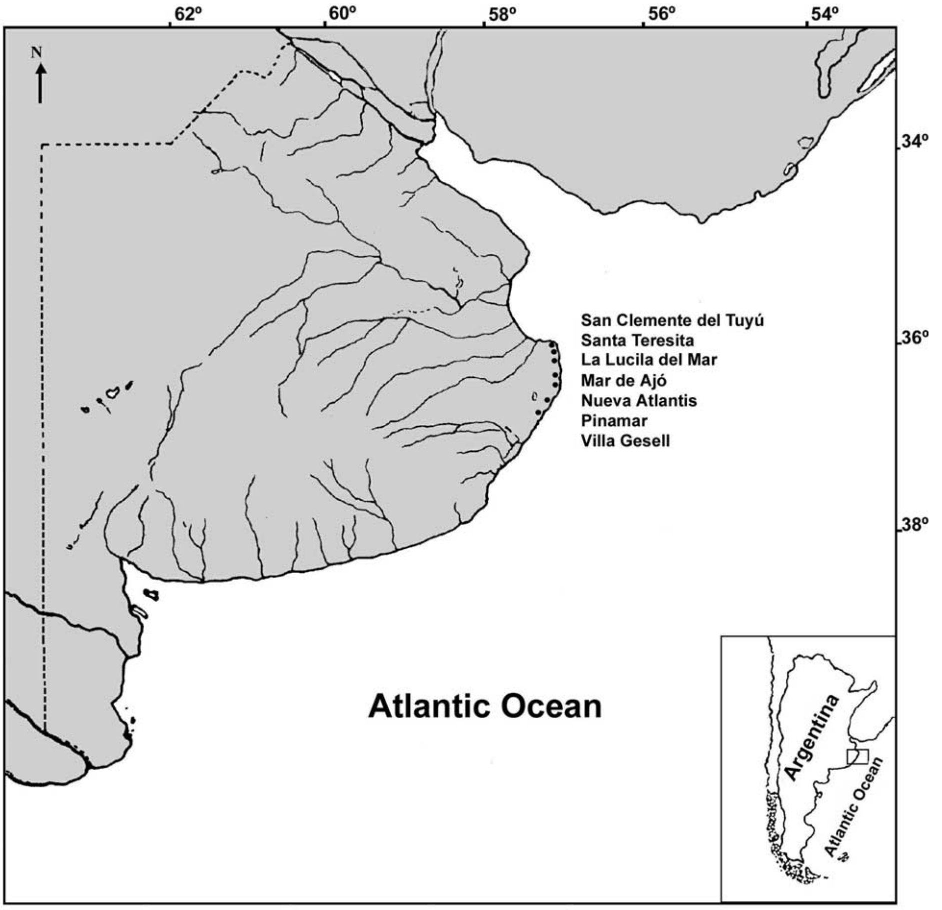


Figure 1 *Thalassiosira fryxelliae*: map of Buenos Aires Province, showing sampling stations and location of the area in Argentina.

ture of diatom frustules used is basically that compiled by Gaul et al. (1993) and Henderson and Reimer (2003).

Results

Thalassiosira fryxelliae Sar *et* Sunesen, nov. spec. (Figures 3–22)

Cellulae in massis irregularibus inclusis. Valvae saepae densae, disciformes, 6–23 μm diametro. Superficies valvae extra aliquantum convexae; limbus valvae non altus, plus minusve obliquus, costatis. Costis 14–19 in 10 μm. Marginibus valvae horizontalis, satis planus vel parum curvatus. Areolae in seriebus linearibus, curvatae excentrice, ad irregularae et differens in frustula valvarum. Areolae (11) 12–19 (20) in 10 μm in superficie valvae, areolis aliquantum amplioris in annulo secus marginem, areolis parvioribus in limbo, ca. 23–30 in 10 μm. Cribra ambitibus circularia. Superficies valvae externa granulis parvis induta. Annulus unicus fultoportularum marginalium regulariter dispositarum, ca. 4–6 in 10 μm. Fultoportulae ferme armatae tubulis exterioribus, infundibuliformis marginibus extra noman idatibus. Portulae extensionibus brevis intrinsecus, poris subsidiaries 4, 3 hac marginibus valvarum et 1 ad centrum valvarum. Fultoportulae sed absentes in centrum valvarum. Rimoportula unica, in eodem annula cum fultoportulis marginalibus superficie valvae locata; pars externalis processus ampla, rima ad parallela. Species planctonica marina.

Cells are embedded in irregular gelatinous masses surrounding single cells or more than one cell (Figures 3, 4). Valves are often heavily silicified, circular in outline, diameter 6–23 μm. Externally, the valve face is slightly concave and the valve mantle is shallow and slanting (Figures 12, 13), distinctly ribbed (Figures 10–13, 15). Ribs are 14–19 in 10 μm. The outermost edge of the valve mantle is flattened to slightly recurved (Figures 12, 13). Areolation pattern is linear (Figures 5, 7, 10, 17, 18), eccentric (Figures 11, 19) or irregular (Figures 9, 14) and even can be different in both valves of the same frustule (Figures 5, 6). Areolae are (11) 12–19 (20) in 10 μm on the valve face with somewhat smaller areolae on its edge and on the mantle (Figures 10–13, 15), ca. 23–30 in 10 μm. External foramina and internal cribra circular in outline (Figures 16, 22). Valve surface often furnished with small granules (Figures 11, 14, 15). One ring of strutted processes (Figures 10–13, 17–20), 4–6 in 10 μm, with double external tubes, at least in the distal part, cut distally and with the half-cylinder bent vertically with crenulated distal edges (Figures 12, 15, 20). These processes have short internal tubes surrounded by four satellite pores, three placed toward the margin and the other one toward the centre (Figures 18, 21). There is no strutted process in the centre of the valve (Figures 10–14, 16–22). The single labiate process has an external tube larger and stronger than those of the strutted processes (Figures 10–14) and a small sessile internal labiate part (Figures 17–21). This process is positioned as for a strutted process or about midway between two processes,

Table 1 *Thalassiosira fryxelliae*: key to sampling stations of Buenos Aires Province, dates of collection and sample numbers at the Colección de Diatomeas Argentinas.

	SC	ST	LL	MA	NA	PI	VG
Nov. 1994	nd	4250	nd	4252	–	nd	4253
Mar. 1995	nd	–	–	–	4260	–	–
Nov. 1995	nd	–	–	–	4269	–	–
Jan. 1996	nd	–	–	–	–	4276	4277
Apr. 1996	–	–	–	–	–	4284	4285
Jun. 1996	–	–	4288	4289	nd	4290	4291
Sep. 1996	–	4293	nd	4294	nd	4295	4296
Nov. 1996	4297	–	4299	–	nd	nd	4301
Jan. 1997	–	4303	4304	–	4307	–	–
Sep. 1997	–	–	–	–	nd	4331	nd
Sep. 1998	–	4363	4364	4365	nd	4366	4367
Nov. 1998	–	–	–	4371	nd	–	–
Oct. 1999	–	–	–	–	nd	–	4389
Jul. 2000	–	–	4439	–	nd	–	–
Aug. 2000	4449	–	4486	4487	nd	4488	4489
Sep. 2000	–	4491	4492	–	nd	4494	4495

SC: San Clemente del Tuyú; ST: Santa Teresita; LL: La Lucila del Mar; MA: Mar de Ajó; NA: Nueva Atlantis; PI: Pinamar; VG: Villa Gesell.; nd: no data; –: not found in the sample.

somewhat inside the marginal ring of strutted processes (Figures 10–14, 17–21).

The areola pattern of this species is highly variable, consisting of straight parallel areolae rows without central areola, eccentric or irregular with a central areola surrounded by seven or eight areolae. Another variable feature is the areola density on the valve, higher in the smallest and lower in the largest specimens, respectively.

Whole isolated frustules were not seen because the cells are embedded in gelatinous masses in the raw material and appear disarticulated in cleaned material.

Holotype: deposited at the Colección de Diatomeas Argentinas, Departamento Científico Ficología, Museo de La Plata, Argentina, slide n° 4289/2, and labelled *Thalassiosira fryxelliae,* Mar de Ajó, June 29, 1996.

Type locality: Mar de Ajó, 36° 43′S-56° 41′W, Provincia

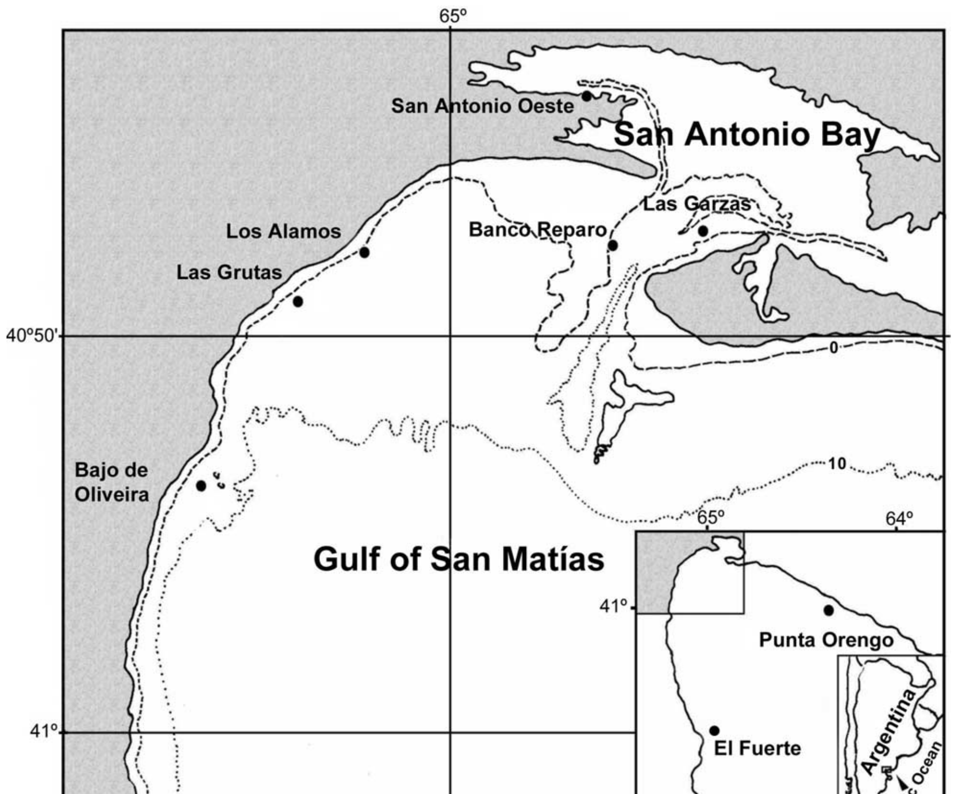


Figure 2 *Thalassiosira fryxelliae*: map of the northern part of the Gulf of San Matías showing sampling stations and the location of the area in Argentina.

Table 2 *Thalassiosira fryxelliae*: key to sampling stations of Río Negro Province, dates of collection and sample numbers at the Colección de Diatomeas Argentinas.

	PO	LGar	BR	SAO	LA	LG	BO	EF
Apr. 1998	nd	nd	4553	nd	–	4550	–	nd
May 1998	nd	nd	4571	nd	–	–	4569	–
Jun. 1998	nd	nd	4575	nd	–	–	–	4574
Jul. 1998	nd	nd	4580	nd	–	–	–	nd
Aug. 1998	nd	4585	nd	nd	nd	–	–	nd
Sep. 1998	nd	nd	4588	nd	nd	nd	–	nd
Nov. 1998	nd	nd	nd	nd	nd	4594	nd	–
Dec. 1998	nd	nd	nd	nd	nd	4596	nd	nd
Feb. 1999	4600	nd	4601	nd	nd	4598	4599	nd
Mar. 1999	–	nd	4605	nd	nd	–	–	nd
Apr. 1999	4606	nd	4607	nd	nd	nd	–	nd
May 1999	4610	nd	nd	nd	4611	–	nd	nd
Jun. 1999	4619	nd	nd	nd	nd	–	4618	nd
Sep. 1999	nd	nd	nd	nd	nd	4624	4625	nd
Feb. 2000	nd	nd	nd	4635	–	–	–	nd

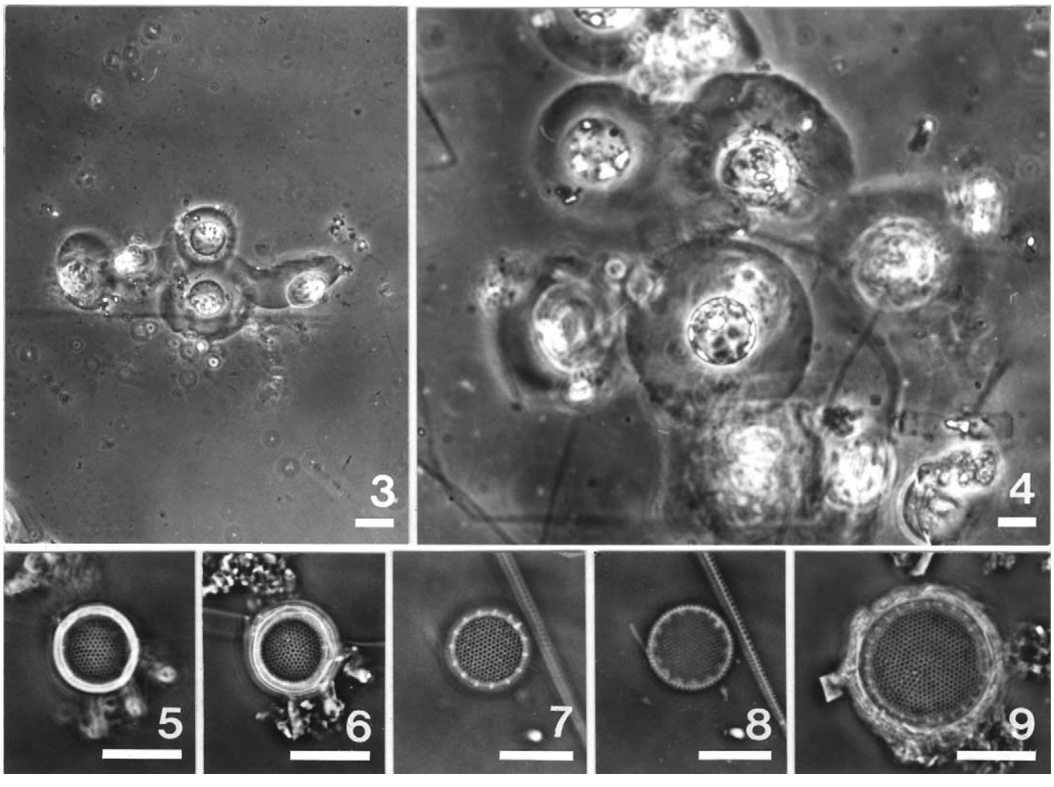
PO: Punta Orengo; LGar: Las Garzas; BR: Banco Reparo; SAO: San Antonio Oeste; LA: Los Álamos; LG: Las Grutas; BO: Bajo de Oliveira; EF: El Fuerte. nd: no data; –: not found in the sample.

de Buenos Aires, Argentina. General conditions for this date were water temperature 11°C and salinity 33.7 psu.

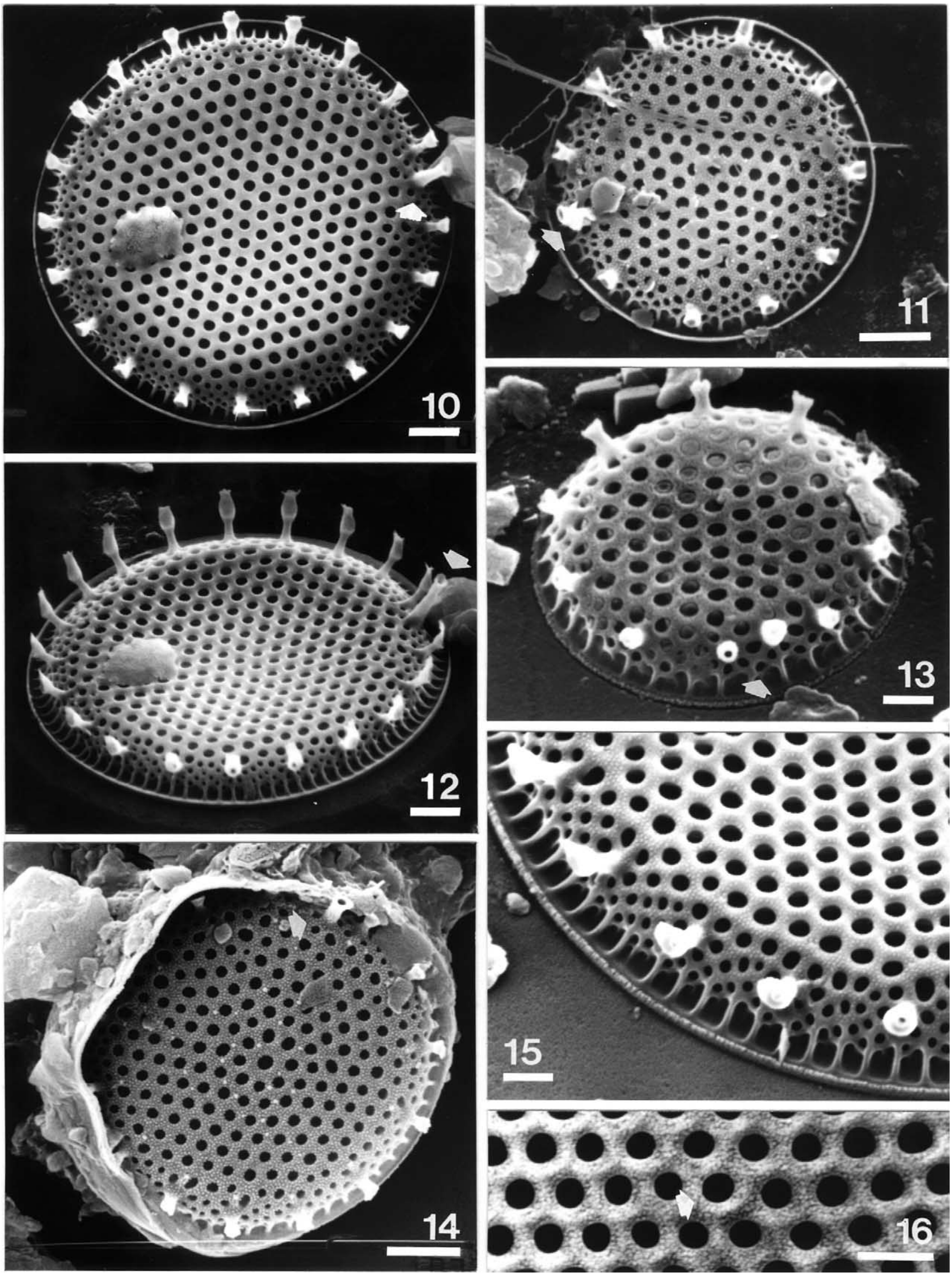
This diatom is named to honor Dr. Greta A. Fryxell, who kindly gave us her opinions about our material.

Discussion

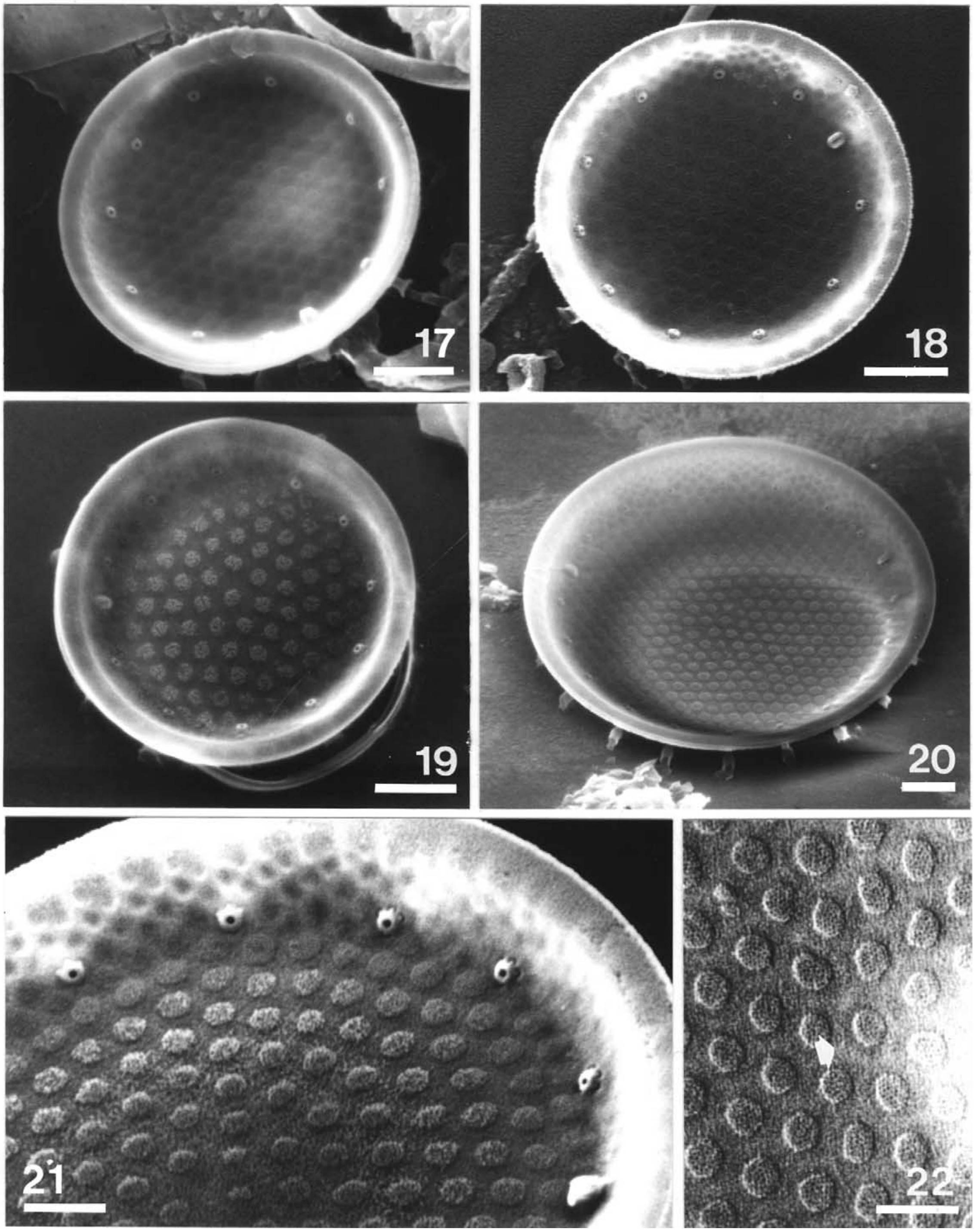
Thalassiosira fryxelliae resembles *T. nanolineata* (Mann) Fryxell *et* Hasle in general appearance. Both taxa posses one ring of marginal strutted processes with double external tubes in the distal part, one labiate process included in this ring, valve mantle shallow and slanting distinctly ribbed, and areolation pattern often linear, although it is more variable in the former. The main distinctions are the absence of central strutted processes in *T. fryxelliae* which are present in *T. nanolineata* (numbers 1–5), and the position of the ring of strutted processes, placed in the junction between the valve face and mantle in the former and in the mantle in the latter. Other differences obtained by comparison of the morphometric data of the new species with those pointed out by Hasle and Fryxell (1977) for *T. nanolineata* are summarized in Table 3.



Figures 3–9 *Thalassiosira fryxelliae*: light microscopy.
(3–4) Colonies of different size, cells enveloped in mucilage. (5–6) Valves of the same frustule showing different areola pattern. (5) Note linear areola pattern. (6) Note eccentric areola pattern. (7–8) Same valve at different focus showing processes pattern. (9) Valve showing irregular areola pattern. Scale bars: Figure 3=20 µm, Figures 4–9=10 µm.



Figures 10–16 *Thalassiosira fryxelliae*: scanning electron microscopy.
Figures 10, 12, and 15 show specimens corresponding to the sample used for the preparation of the holotype slide. (10–14) Valves in external view showing one ring of strutted processes, a single labiate process (arrows), valve face with no processes and ribbed valve mantle. Note the variations in areola pattern and in position of the labiate process. Note in Figure 12 the tilted valve showing strutted processes with double external tubes cut distally and with the half-cylinder bent vertically with crenulated distal edges. See in Figure 14 the valve surface furnished with small granules. Note cell surrounded by a mucilaginous envelope. (15) Detail of the valve near the margin. Note the ribs and smaller areola on valve mantle and the double tubes of the strutted processes. (16) Detail of the central areola (arrow) in external view. Note the absence of processes. Scale bars: Figures 10–12, 14=2 μm; Figures 13, 15, 16=1 μm.



Figures 17–22 *Thalassiosira fryxelliae*: scanning electron microscopy.
Figure 21 shows specimen corresponding to the sample used for the preparation of the holotype slide. (17–20) Valves in internal view showing one ring of strutted processes, a single, sessile labiate process and valve face with no processes. Note the variations in areola pattern and in position of the labiate process. (21) Detail of the valve near the margin. Note short internal tubes of strutted processes surrounded by four satellite pores, three placed toward the margin and one toward the centre. (22) Detail of the central areola (arrow) in internal view. Note the absence of processes. Scale bars: Figures 17–20=2 μm; Figures 21, 22=1 μm.

Thalassiosira fryxelliae and *T. angulata* (Gregory) Hasle share the characteristic distribution of the marginal strutted and labiate processes and shape of their external part. After having compared our material with that described by Hasle (1978a), the most important difference found is the presence of one central strutted process in the latter species that is absent in the former. Nevertheless, this difference is not always obvious because the central strutted process is not conspicuous in LM as it is located on the crossing walls of the areola in the valve centre. Other morphological differences between both species are summarized in Table 3.

A diagnostic, morphological character of *Thalassiosira fryxelliae* rarely observed in the genus is the absence of strutted processes on the valve face. According to the information presented in Hasle and Syvertsen (1997),

Table 3 *Thalassiosira fryxelliae*: comparison with other similar species.

Species	Diameter (μm)	Areolae (in 10 μm)		Marginal ribs (in 10 μm)	Strutted processes		Occluded processes	Labiate processes	Observations
		Valve	Margin		Marginal (in 10 μm)	Valve face			
T. fryxelliae Sar *et* Sunesen	6–23	(11)12–19(20)	23–30	14–19	One ring, 4–6	None	None	One marginal as for a strutted process or about midway between two processes	Areolae pattern linear, eccentric or irregular and eventually different in both valves of the same frustule
T. nanolineata (Mann) Fryxell *et* Hasle	18–27 (37?)	6–8	More	10–12	One ring, 4–6	1–6, around the central areola	None	One marginal between two strutted processes	Linear areolae pattern
T. angulata (Gregory) Hasle	12–39	8–18	14–24	14–24	One ring, 2–5	1, central	None	One marginal close to a strutted process	Areolae in tangential curved rows on valve face and in radial rows on mantle.
T. leptopus (Grunow) Hasle *et* Fryxell	26–165	4–7	More	–	Two or three rings, 3–8	None	One marginal ring located in the slanting valve mantle	One located in the slanting valve mantle	Linear areolae pattern
T. pseudonana Hasle *et* Heimdal	2.3–9	30–35	50–70	–	One ring, 6–14	0–3, subcentral	None	One marginal between two strutted processes	Slightly raised siliceous ribs radiating from an annulus
T. guillardii Hasle	4–14	30–40	70–80	–	One ring, 7–8	0–3, subcentral	None	One marginal taking the place of a strutted process	Slightly raised siliceous ribs radiating from an annulus

See text for authorities and references. –: no data.

Table 4 *Thalassiosira fryxelliae*: comparison with species of mucilage colony formers.

Species	Diameter (µm)	Areolae (in 10 µm)		Marginal ribs (in 10 µm)	Strutted processes		Labiate processes	Observations
		Valve	Margin		Marginal (in 10 µm)	Valve face		
T. fryxelliae Sar *et* Sunesen	6–23	(11)12–19(20)	23–30	14–19	One ring, 4–6; external tubes of the processes long	None	One marginal as for a strutted process or about midway between two processes	Valve slightly concave, mantle low; areola pattern linear, eccentric or irregular and eventually different in both valves of the same frustule
T. subtilis (Ostenfeld) Gran	15–32	ca. 30	ca. 30	–	One ring, 2–3; external tubes of the processes short	One subcentral and scattered processes	One at approximately the same distance from valve margin as second row of strutted processes	Valve dome-shaped; areola pattern fasciculate
T. diporocyclus Hasle	12–24	24–31	–	–	One ring, 2–3; a second ring midway in the valve mantle more widely spaced; external tubes of the processes short	One near the centre	One located approximately within peripheral ring of strutted processes	Valve dome-shaped with central part flat; fasciculate areolation pattern
T. minuscula Kraaske	10–32	32	32–36	–	One ring, 4–5; lacking external tubes	One near the centre	One prominent process radially oriented, close to one or two small strutted processes in from the margin	Valve hemispherical; fasciculate areolation pattern
T. fragilis Fryxell	19–30.5	40–50	–	–	One ring, 2–3; lacking external tubes	One near the centre and 3–6 scattered processes	Two labiate processes; two areola from the margin, 150–180° apart	Valve hemispherical; fasciculate areolation pattern
T. partheneia Schrader	4.4–14	40–60	40–60	–	One ring, 3–5; external tubes of the processes short	One central	One marginal, between two strutted processes	Valve hemispherical; areola pattern linear with some fasciculation
T. mala Takano	4–10	25–35	40–50	–	One ring, 4–11; lacking external tubes	One eccentric	One marginal, between two strutted processes	Valve face flat, mantle low; eccentric-linear areolation pattern
T. proschkinae Makarova	3–11.5	24–30	24–30	–	One ring, 4–5; lacking external tubes	One central with six areolae around	One close to central strutted process	Valve face flat, mantle low; areola pattern eccentric

See text for authorities and references. –: no data.

only *T. leptopus* (Grunow) Hasle *et* Fryxell shares this uncommon feature with the new species. A comparison between the comprehensive description of *T. leptopus* given by Hasle and Fryxell (1977) and our material allows us to establish that both taxa have important differences in the processes pattern, morphology of the processes and morphometric data (Table 3). *T. leptopus* presents three types of marginal processes placed in the valve mantle: one large labiate process, numerous small marginal strutted processes arranged in 2–3 rings without external tubes, and one marginal ring of irregularly spaced larger occluded processes that may be confused in LM with strutted processes.

As shown in Hasle and Heimdal (1970) and Hasle (1978b), two nanoplanktonic species, *Thalassiosira pseudonana* Hasle *et* Heimdal and *T. guillardii* Hasle, may have no sub-central strutted processes and a marginal ring of strutted processes with one labiate process. Those specimens of both species that have no processes on the valve surface may be distinguished easily from *T. fryxelliae* since the valve structure is revealed with LM in the latter while it is not revealed in the former species. More exhaustive comparisons including the morphometric data are presented in Table 3.

Hasle (1972, 1983) and Fryxell et al. (1984) reported that *Thalassiosira subtilis* (Oestenfeld) Gran, *T. diporocyclus* Hasle, *T. minuscula* Krasske, *T. fragilis* Fryxell, *T. partheneia* Schrader, *T. mala* Takano and *T. proschkinae* Makarova have been observed in large gelatinous colonies. Additionally, Fryxell et al. (1984) discussed the common characters of all these species and a few more that are suspected to form this type of colony. They pointed out that these species are all small, possess one central strutted process, several of them have dome-shaped valves and none has long external tubes on the strutted processes. As in all these species, *Thalassiosira fryxelliae* makes gelatinous colonies and is small, but in contrast with them, it has no central strutted process and marginal strutted processes with long external tubes. Some other morphological comparisons with species of this group of mucilage colony formers are presented in Table 4.

To summarize, *Thalassiosira fryxelliae* is a nanoplanktonic species that may be differentiated from other described species of the genus by possession of the following combination of characters: 1) cells embedded in irregular gelatinous masses, 2) absence of the central, sub-central and scattered strutted processes on the valve surface, 3) one marginal ring of strutted processes with external tubes, 4) one marginal labiate process included in the ring of the strutted processes, 5) areolation pattern variable linear, sub-linear, eccentric or irregular.

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