Offprint Botanica Marina Vol. 42, 1999, pp. 487–503

Species of the Genus *Thalassiosira* (Bacillariophyceae) from the Gulf of Tehuantepec, Mexico

J. A. Aké-Castillo[a], D. U. Hernández-Becerril[b] and M. E. Meave del Castillo[a,*]

[a] Depto. Hidrobiología, Universidad Autónoma Metropolitana-Iztapalapa, Apdo. postal 55–535, México, D. F. 09340 Mexico
[b] Lab. Ecología de Pesquerías, Instituto de Ciencias del Mar y Limnología, UNAM, Apdo. postal 70–305, México, D. F. 04510 Mexico

* Corresponding author

Species of the diatom genus *Thalassiosira* are an important component of the marine phytoplankton all over the world, and the Mexican Pacific Ocean planktonic flora is also rich in species of this genus. In this study 37 net plankton samples from the Gulf of Tehuantepec, Mexico were analyzed, yielding 23 taxa of the genus. Most of the species were studied using combined light and electron microscopy. New records for the Mexican Pacific Ocean are *Thalassiosira hendeyi*, *T. intrannula*, *T. pseudonana*, *T. tenera* and *T. visurgis*. The species of *Thalassiosira* recorded here seem to indicate that the Gulf of Tehuantepec represents a subtropical zone at least in one period of the year.

Introduction

Recent studies have shown that *Thalassiosira* species are an important component of the marine phytoplankton world-wide (Rivera 1981, Hallegraeff 1984, Johansen and Fryxell 1985, Makarova 1988, Harris *et al.* 1995, Hernández-Becerril and Tapia-Peña 1995). Various authors have mentioned that the number of species within this genus may exceed 100 (e. g. Hasle and Syvertsen 1996); this figure and the morphological complexity of the genus make positive species identification difficult. Some morphological features have been shown to be important as taxonomic characters within the genus *Thalassiosira*, such as the number and position of fultoportulae and rimoportulae on the valve (Hasle 1973 a, Hasle and Syvertsen 1996). These facts have led to the description of new species and the reallocation of some others previously considered members of other genera, such as the genus *Coscinodiscus* (Fryxell 1975, Hasle and Fryxell 1977, Fryxell and Hasle 1977). As most of these characters are difficult to observe by light microscopy, the use of electron microscopes, both transmission and scanning (TEM and SEM), is a very useful tool for the positive identification of *Thalassiosira* species. Makarova (1980) considers areolation pattern important in taxonomy and proposes sections within the systematics of *Thalassiosira*, but there are some observations showing this character to be variable, e. g. *T. pacifica* (Hasle 1978 b), *T. simonsenii* (Hallegraeff 1984), *T. bulbosa* (Syvertsen and Hasle 1984), *T. tealata* (Hernández-Becerril and Tapia-Peña 1995).

The present work was conducted in the Gulf of Tehuantepec, Mexico, one of the most productive zones of the Tropical Mexican Pacific (Robles-Jarero and Lara-Lara 1993), and one that has been poorly studied concerning phytoplankton, either on floristic or ecological aspects (Hernández-Becerril 1987, 1988). The purpose of this paper is to study the species of the diatom genus *Thalassiosira* and to provide a revision for the area.

Materials and Methods

The Gulf of Tehuantepec is located on the southern Pacific coast of Mexico. It is situated between 14° and 16° N and between 92° and 96° W, and it has a triangular form with an area of 31 km^2 (Figure 1). There are two typical seasons: windy season from May to October and dry season from November to April. In the dry season, strong winds from the Gulf of Mexico (called 'Tehuanos') blow with a great velocity and they are responsible for the upwellings occurring in the Gulf during this period (Roden 1961, Stumpf 1975).

Thirty-seven samples, which were taken during two oceanographic cruises: MIMAR-V in May 1989, and FIQUIMBI-I in November 1989, were studied. The samples were collected by vertical net (54 µm mesh) hauls and then fixed with Formalin to a final concentration of 4%. Figure 1 shows 14 stations where *Thalassiosira* species where found.

Material was rinsed and cleaned and then observed by light microscopy (Reichart Diastar). The cleaning method followed that proposed by Hasle (1978 a). Either rinsed or cleaned material was treated using conventional methods for SEM (JEOL, JMS-35), whereas for TEM (JEOL 1200 EX) only cleaned material was used.

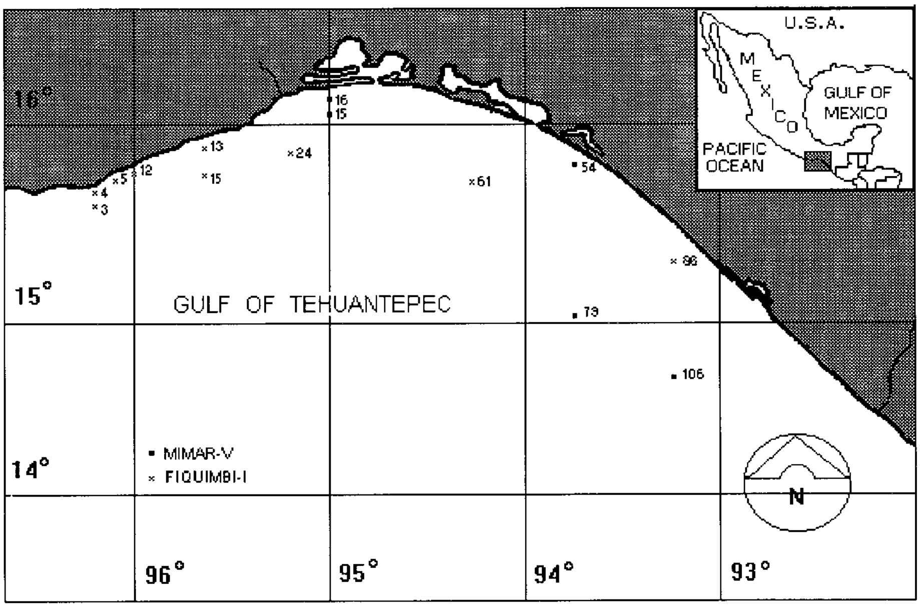


Fig. 1. Map of the study area with the stations where *Thalassiosira* species were recorded.

General terminology for diatoms follows Anonymous (1975) and Ross *et al.* (1979). Evaluation of morphological characters followed Makarova (1980), Hasle and Fryxell (1977) and Hasle and Syvertsen (1996). Specific references are given for each species.

Results

Twenty-three taxa were recorded: 19 species and 1 variety were fully identified, whereas 2 are tentative identifications, and 2 remained unidentified. We display the species studied in alphabetical order with their descriptions, and at the same time provide tabular keys where the species are arranged according to their areolar pattern and diameter to facilitate the identification of the species (Tables I, II, III, IV)

Observations

Thalassiosira decipiens (Grunow) Jörgensen
Figs 2–4

Hasle 1979, p. 88, figs 1–42
Hernández-Becerril and Tapia-Peña 1995, p. 545, figs 10–15

Cells form chains linked by mucilage threads. Valves are flat to slightly concave, with a diameter of 10–30 µm. Areolae are in an eccentric pattern with a density of 8–10 in 10 µm, and a higher density towards the valve margin of 13 in 10 µm. Cribra have numerous pores. The central areola is surrounded by 7 areolae and close to it there is a small fultoportula with 4 satellite pores. There is a ring of fultoportulae with large tubes at the margin: 4–5 in 10 µm, with 4 satellite pores too. One marginal rimoportula with a large tube occurs slightly away from the fultoportulae ring. The mantle has costae at a density of 15 in 10 µm.

Distribution: Temperate to subtropical areas (Hasle 1979). Stations: MIMAR-V 16; FIQUIMBI-I 15, 24.

Thalassiosira eccentrica (Ehrenberg) Cleve
Figs 5, 6

Fryxell and Hasle 1972, p. 300, figs 1–18
Hallegraeff 1984, p. 504, figs 15 a–d
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 16–20

Cells form chains and are linked by mucilage threads. Valves are generally flat, with a diameter of 46–49 µm. Areolae are hexagonal and arranged in an eccentric pattern with a density of 7–9 areolae in 10 µm. Fultoportulae occur in 3 rings at the margin of the valve and 1 ring of spines occurs between the mantle and valve face. Marginal fultoportulae occur at a density of 4 in 10 µm, and spines at a density of 2–3 in 10 µm. Over the valve face there are fultoportulae with no particular arrangement and they are smaller than the marginal ones. One long rimoportula with the tip flattened is situated at the margin, among the ring of spines. The mantle bears costae at a density of 12 in 10 µm.

Distribution: Cosmopolitan (Hasle 1976 a). Stations: MIMAR-V 15, 16, 79, 106; FIQUIMBI-I 3, 4, 5, 12, 15, 61.

Thalassiosira exigua Fryxell *et* Hasle Figs 7–9

Hasle and Fryxell 1977, p. 30, figs 66–73
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 23–25

The small cells have a valve diameter of 6–10 µm. Valves are nearly flat. The hexagonal areolae are disposed in a linear pattern (density of 14–36 in 10 µm), with the marginal areolae smaller. One central fultoportula is situated inside the central areola. This areola has the cribrum poorly perforated. There is one

Table I. *Thalassiosira* species with a linear areolar pattern.

Taxa	Diameter (µm)	Areolae in 10 µm	Location of fultoportula	External form of fultoportula	Marginal fultoportulae in 10 µm	Number of satellite pores	Number, location and external form of rimoportula	Other processes	Valve costae in 10 µm
T. exigua	6−10[1] 3.5−8[4]	V :14[1], 24[4] M: 36[1, 4]	CF: 1 inside of an areola[1, 4] MF: 1 ring[1, 4]	CF: short tube[1, 4*], MF: short tubes[1, 4*], covered with a siliceous cap[4]	5−6[1] 6−7 [4]	CF: 4[1], 2−4[4] MF: ?	MR: 1 between 2 F, short tubes[1, 4]	No[1]	27−45[1] 35−40[4]
T. cf. *bulbosa*	5−6[1]	V: 15[1] M: 20[1]	CF: 1[1] MF: 1 ring[1]	CF: short tubes[1] MF: large, bulb-shaped[1]	8[1]	CF: 4[1] MF: 2?[1]	MR: 1 between 2 F, large tube[1]	No[1]	No[1]
T. bulbosa	2−16[2]	V: 36−42[6], 20−26[6] in resting cells	CF: 1[6] MF: 1 ring[6]	CF: short tubes[6] MF: large, bulb-shaped[6]	4.5 [6]	CF: 3[6] MF: 2[6]	MR: 1 between 2 F, closer to one of them[6], large tube[6*]	No[6]	No[6*]
T. cf. *pacifica*	8−9[1]	V: 20[1] M: 40[1]	CF: 1[1] MF: 1 ring[1]	CF: short tubes[1] MF: short tubes[1]	9−10[1]	CF: 4−5? [1] MF: 3[1]	MR: 1 between 2 F, large tube? [1]	No[1]	50[1]
T. pacifica	7−46[2, 5]	V: 10−18 [2, 5] M: > 20[5]	CF: 1[5] MF: 1 ring[5]	CF: large tube[5*] MF: large tubes with external flared skirt[5]	4−7[2]	CF: 6[5*] MF: 4[5]	MR: 1 between 2 F, large tube[5]	No[5]	13−14 [5*]
T. tenera	7−18[1] 10−29[2, 4] 6.5−15[7]	V: 16[1], 9−16[2, 4], 12−13[7] M: 40[1]	CF: 1 inside of an areola[1, 4] MF: 1 ring[1, 4]	CF: short tubes[4] MF: short tubes with a siliceous wedges attached to them[4]	5[1] 3−5[2, 4]	CF: 3[1], 4−5[4] MF: 4−5?[1]	MR: 1 between 2 F, closer to one of them[4], short tubes[1, 4]	No[1]	24−30[1] 20−24 [4] 23−26 [7]
T. simonsenii	16−37[1] 30−59[4] 41−60[3]	V: 4−6[1], 7−8[3], 4−5[4] M: 8−9? [4], 12−17[4]	CF: 1[1] MF: 2 rings[4]	CF: short tubes[1, 4] MF: large tubes[4]	5−6 [2, 4]	CF: 4[4*] MF: 4[4*]	MR: 2 opposed by an angle of 130°−155°[1], 175−180°[3, 4] large tubes[1, 4]	Marginal ring of occluded processes[1, 3], 1 in 10 µm[4], large tubes[4]	7−10[1] 7−9[3*] 8−10[4]
T. hendeyi	35−37[1] 50−120[4]	V: 6−7[1], 5−6 [4] M: 12- 17[4]	CF: 1[1, 4] MF: 3 rings[4]	CF: short tubes[4] MF: short tubes[4]	2 [4]	CF: ? [1] MF: 4[4*]	MR: 2 opposed by an angle of 180°[1], 160°−180°[4*], large tubes[1, 4]	No [4]	8−10[1] 7−8[4]
T. lineata	37[1] 9−45[2] 13−26[3]	V: 9−10[1], 8−16[2, 4] 9−12[3]	SmF: over the valve[1, 3] MF: 2 rings[4]	SmF: reduced[4] MF: short tubes[4]	? [1] 5−6[2, 4]	SmF: 2[4] MF: 3?[4*]	MR: 1 between 2 rings of MF[4], short tubes[4]	No[4]	18−20[4*]
T. leptopus	70−146[1] 26−165[2]	V: 4−5[1], 4−7[2, 4] M: 9−14[1], 8−14[4]	MF: 2−3 rings in zig-zag[4]	MF: short tubes[4]	? [1] 3−8[2] 2−3[4]	MF: 5[4]	MR: 1 between 2 occluded processes[1, 4] large tube [1, 4]	Marginal ring of occluded processes, 2−5[1, 4] in 10 µm large tubes[4]	10−11[1] 10[4*]

F = Fultoportula, R = Rimoportula, C = Central, Sm = Submarginal, M = Margin or marginal, V = Valve ‘ * observed from figures.
[1]This study, [2]Hasle and Syvertsen 1996, [3]Hernández-Becerril and Tapia-Peña 1995, [4]Hasle and Fryxell 1977, [5]Hasle 1978 b, [6]Syvertsen and Hasle 1984, [7]Proschkina-Lavrenko 1961.

Table II. *Thalassiosira* species with an eccentric areolar pattern

Taxa	Diameter (µm)	Areolae in 10 µm	Location of fultoportula	External form of fultoportula	Marginal fultoportulae in 10 µm	Number of satellite pores	Number, location and external form of rimoportula	Other processes	Valve costae in 10 µm
T. profunda	2–4[1] 1.5[3] 1.9–2.8[11]	V: 40[1], 40–50[11] M: 50[1], 80[11]	CF: 1[1] MF: 1 ring[1]	CF: short tubes[1] MF: short tubes[11]	10[1] 6–7[11]	CF: 2[1,4,11] MF: 2[1], 3[4], 4[11]	MR: 1 between 2 F, opposed to the CF, short tubes[1,11]	No[1]	No[1]
Thalassiosira. sp. 1	8–9[1]	V: 25[1]	CF: 1[1] MF: 1 ring[1]	CF: short tubes[1] MF: short tubes[1]	9–10[1]	CF: 4[1] MF: 4[1]	MR: 1 between 2 F, closer to one of them, reduced[1]	No[1]	No[1]
Thalassiosira visurgis	8.3[1] 15–18[12] 9–18[13]	V: 10[1], 13–14[12,13] M: 30[1], 18[12,13]	CF: 1[1,12,13] MF: 1 ring[1,12,13]	CF: short tubes[1] MF: short tubes[1]	5–6[1] 4–5[12,13]	CF: 5[1], 4[12] MF: 4[12]	MR: 2, between 2 F, separated by an angle of < 140°, reduced[1], 120°–180°[12]	No[1]	No[1]
T. oestrupii var. *venrickae*	23[1] 8–27[8] 5.5–39[10]	V: 7–8[1], 6–9[10] M: 9–10[1], 7–11[10]	CF: 1[10] MF: 1 ring[1], 2 rings[10]	CF: reduced[10] MF: reduced[1,10]	?[1] 2–3[10]	CF: ?[1], 3[10] MF: ?[1], 3[10]	ER: 1 reduced[1,10]	No[1]	No[1]
T. decipiens	10–30[1] 9–40[7] 15–28[9]	V: 8–10[1], 8–12[7] M: 13[1], 8–15[7]	CF: 1[1,7] MF: 1 ring[1,7,9]	CF: short tubes[1] MF: large tubes[1,8,9]	4–5[1] 4–6[7] 4–7[9]	CF: 4[1,9] MF: 4[1,9]	MR: 1 between 2 F, large tube[1,9]	No[1]	15[1] 22[9]
T. eccentrica	46–49[1] 12–101[5]	V: 3–7[1], 5–8[5] M: 3–7[1], 7–9[5]	CF: 1[1,5] SmF: over the valve[1,5], MF: 3[1], 2[5] rings	CF: short tubes[1,5*] SmF: short tubes[1,5*] MF: short tubes[1,5*]	4[1] 2–5[7]	CF: ?[1] SmF: ?[1] MF: ?[1], 4[6]	MR: 1 between 2 F, large tube[1,5]	Marginal spines: 2–3[1], 3–6[5*] in 10 µm	72[1] 16[8*]
T. symmetrica	55–60[1] 30–88[5]	V: 8–9[1], 5–7[5] M: 8–9[1], 6–8[5]	CF: 1 ring with 7 F[1,5]. SmF: over the valve in rings[1,5]. MF: 1 ring[1,5].	CF: reduced[5] SmF: reduced[5] MF: reduced[5]	10–11[1] 4–6[5]	CF: 5[1,5*] SmF: 5[1,5*] MF: 4[1]	MR: 2 between 2 F, opposed by an angle of 165°[1], 170°[5], large tubes[5]	?[1] Marginal spines: 3–6[5*] in 10 µm	?[1] 10[6]
T. punctifera	62[1] 60–90[2]	V: 6[1], 4.5–6[2] M: 11[1], 6–7[2]	CF: 1 ring with 7 F[1,4], SmF: over the valve in rings[1,4], MF: 1 ring[1,4]	CF: short tubes[4] SmF: short tubes[4] MF: spine[4]	3[1,4*]	CF: 5[1] SmF: 5[1] MF: 5[1]	CR: 1[1,2,3,4], large[4] MR: 1[2,4], 2[1] separated by an angle of 70°[1], 3[3], large tube[2,4]	?[1] Granules or short spines on the centre[4]	No[1]

F = Fultoportula, R = Rimoportula, C = Central, Sm = Submarginal, M = Margin or marginal, E = Eccentric, V = Valve ‘ * observed from figures.
[1]This study, [2]Simonsen 1974, [3]Herzig and Fryxell 1986, [4]Hallegraeff 1984, [5]Fryxell and Hasle 1972, [6]Rivera 1981, [7]Hasle and Syvertsen 1996, [8]Hernández-Becerril and Tapia-Peña 1995, [9]Hasle 1979, [10]Fryxell and Hasle 1980, [11]Hasle 1973 b, [12]Hasle 1978 c, [13]Mahood et al. 1986

Table III. *Thalassiosira* species with a fasciculated areolar pattern.

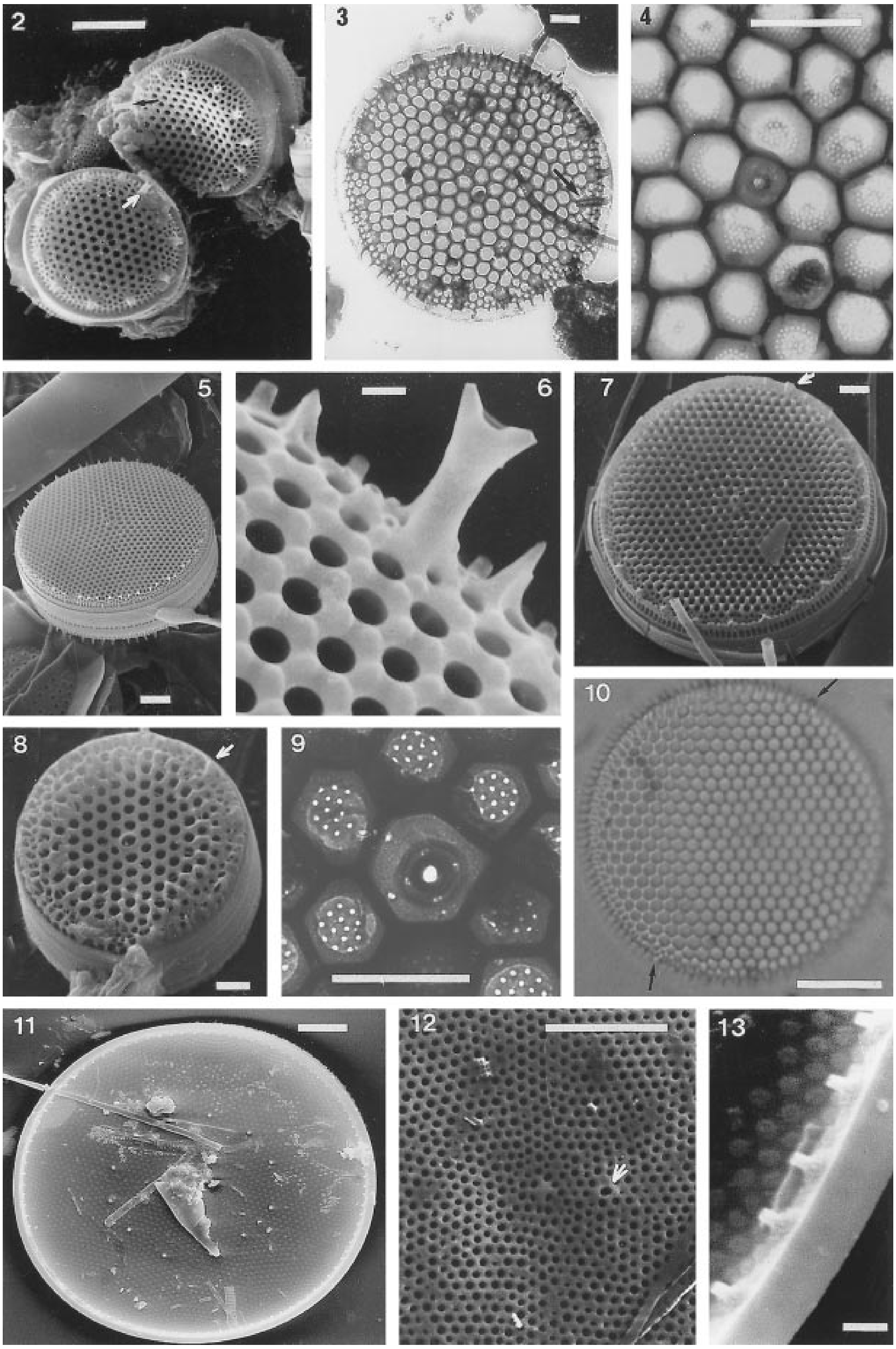
Taxa	Diameter (µm)	Areolae in 10 µm	Location of fultoportula	External form of fultoportula	Marginal fultoportulae in 10 µm	Number of satellite pores	Number, location and external form of rimoportula	Other processes	Valve costae in 10 µm
T. minuscula	8.5[1] 16–20[2] 18–21[5]	V: 50[1] 30–36[2] 29–32[5]	CF: 1[1, 2], slightly eccentric[5] SmF: 1 near MR[1, 2] MF: 1 ring[1, 2, 5]	CF: short tubes[1, 2] MF: short tubes[1, 2, 5]	3[1], 4[1, 2]	CF: 5[1] MF: 3–4?[1], 4[2]	SmR: 1[1, 2] close to SmF. Prominent[1, 2] Large tube[5]	No[1, 2]	55[1] 70[2*]
T. tealata	10–11[1] 6–10[3] 6–11[5]	V: 40[1] 30–40[3] 30–34[5]	CF: 1[1, 3, 5] MF: 1[1, 3, 5]	CF: large tube[1, 3, 5], MF: large tubes with wings in T-shaped[1, 3, 5]	5–6[1] 3[3] 5[5]	CF: ?[1] MF: ?[1]	MR: 1 close to a fultoportula, large tube[1, 3*, 5*]	No[1]	No[1]
T. subtilis	18–25[1] 15–32[2] 17–19[5]	V: 29–30[1] 30[2] 30–32[5]	CF: 1[1, 2, 5] SmF: 2 rings[1, 2] MF: 1 ring[1, 2]	CF: short tubes[1, 2, 5] SmF: short tubes[1, 2, 5] MF: short tubes[1, 2, 5]	3[1, 2*, 5*]	CF, SmF, MF: 4[1, 2]	SmR: 1 between MF and SmF rings, large tube[1, 5]	No[1]	No[1]
T. intrannula	60–67[1] 45–63[4]	V: 10–12[1] 10–13[4] M: 20–24[4]	EF: 1 ring [1, 4] MF: 1 ring	EF: reduced[1, 4] MF: reduced[1, 4]	5[1] 5–6[4]	EF: ?[1], 4[4] MF: ?[1], 4[4]	ER: 1[1, 4], reduced[1, 4]	No [1, 4]	? [1]

F = Fultoportula, R = Rimoportula, C = Central, Sm = Submarginal, M = Margin or marginal, E = Eccentric, V = Valve ‘ * observed from figures.
[1]This study, [2]Hasle 1972, [3]Takano 1980, [4]Herzig and Fryxell 1986, [5]Hernández-Becerril and Tapia-Peña 1995.

Table IV. *Thalassiosira* species with a radial areolar pattern.

Taxa	Diameter (µm)	Areolae in 10 µm	Location of fultoportula	External form of fultoportula	Marginal fultoportulae in 10 µm	Number of satellite pores	Number, location and external form of rimoportula	Other processes	Valve costae in 10 µm
T. pseudonana	3–4[1] 4–9[5]	V: 30[1] 30–35[5] M: 60[1] 55–60[5]	CF: 1[4] subcentral[1] MF: 1 ring[1, 4]	CF: short tubes[1, 4] MF: short tubes[1, 4]	10 8–17[5] 6–12[5]	CF: 2[1, 5] MF: 3[1, 5]	MR: 1 close to a F, short tubes[1, 4*]	No[1]	? [1]
T. mala	5–6[1] 4.5–8.8[2] 7–8[3]	V: 30[1] 35–38[2, 3] M: 35–42[1]	EF: 1[1, 2, 3] MF: 1 ring[1, 2, 3]	EF: short tubes[1, 2] MF: short tubes[1, 2]	10[1] 7–9[2]	EF: 3[1, 2], 4[2, 3*] MF: 3[1, 2], 4[2]	MR: 1 between 2 F, short tubes[1, 2]	No[1]	? [1]
T. sp. 2	10–11[1]	45[1]	CF: 1[1] MF: 1 ring[1]	CF: short tubes[1] MF: short tubes[1]	6–7[1]	CF: ?[1] MF: ?[1]	MR: 1 between 2 F, short tubes[1]	No[1]	? [1]

F = Fultoportula, R = Rimoportula, C = Central, Sm = Submarginal, M = Margin or marginal, E = Eccentric, V = Valve ‘ * observed from figures.
[1]This study, [2]Takano 1976, [3]Hernández-Becerril and Tapia-Peña 1995, [4]Harris *et al.* 1995, [5]Hasle and Heimdal 1976.



Figs 2−13.

Figs 2−4. *Thalassiosira decipiens*. Fig. 2. Cells in chain with marginal rimoportulae (arrows), SEM. Fig. 3. cell with marginal rimoportula (arrow), TEM. Fig. 4. Central fultoportula, TEM. Figs 5, 6. *Thalassiosira eccentrica*. Fig. 5, Complete cell with cingular bands, SEM. Fig. 6. Rimoportula, fultoportulae and spines, SEM. Figs 7−9. *Thalassiosira exigua*. Fig. 7. Frustule showing marginal fultoportulae and costae and marginal rimoportula (arrow), SEM Fig. 8. Complete cell with central fultoportula inside the areola and marginal rimoportula (arrow), SEM. Fig. 9. Central fultoportula and satellite pores, TEM. Fig. 10. *Thalassiosira hendeyi*, valve with 2 marginal rimoportulae (arrows), LM. Figs 11−13. *Thalassiosira intrannula*. Fig. 11. Internal view of a valve with 1 off-centre rimoportula, SEM. Fig. 12. External view of the rimoportula, SEM. Fig. 13. Marginal fultoportulae, SEM. Scale bars = 10 μm (Figs 2, 5, 10, 11, 12). = 1 μm (Figs 3, 4, 6, 7, 8, 9, 13).

marginal ring of fultoportulae at a density of 5–6 in 10 μm, and between two of them there is a rimoportula. The marginal processes are covered with silica attached to the fultoportulae and forming wedges. The mantle bears costae with a density of 27–45 in 10 μm.

Distribution: Tropical to subtropical (Hernández-Becerril and Tapia-Peña 1995). Stations: MIMAR-V 16, FIQUIMBI-I 14.

Thalassiosira hendeyi Hasle *et* Fryxell Fig. 10
Hasle and Fryxell 1977, p. 25, figs 35–45

Cells have a diameter of 35–37 μm. Hexagonal areolae are arranged in a linear pattern at a density of 6–7 in 10 μm and marginal ones are slightly smaller. There is one central fultoportula, evident in the light microscope, and two large marginal rimoportulae located at an angle of 180°. The mantle bears costae at a density of 8–10 in 10 μm.

Distribution: Subtropical to tropical (Hasle and Fryxell 1997). New record for the Mexican Pacific coast. Station: MIMAR-V 16.

Thalassiosira intrannula Herzig *et* Fryxell Figs 11–13
Herzig and Fryxell 1986, p. 14–16, figs 8–17

Cells have a diameter of 60–67 μm. Hexagonal areolae occur at a density of 10 in 10 μm and towards the margin 11–12 in 10 μm. The areolar pattern is fasciculated. One eccentric rimoportula, appearing externally like a hole, occurs 4–5 areolae away from the centre. One eccentric ring of fultoportulae (12) is located almost in the middle of the valve margin with each fultoportula separated by 7–9 areolae. One marginal ring of fultoportulae is present at a density of 5 in 10 μm. All the fultoportulae are reduced externally. The slit part of the rimoportula is oriented radially to the centre.

Distribution: Temperate: Atlantic Ocean (Gulf Stream) to Sub-Antarctic (Herzig and Fryxell 1986). New record for the Pacific Ocean. Station: FIQUIMBI-I 5.

Comments: This species resembles *T. punctifera* (Simonsen 1974, Hallegraeff 1984) in the position of the one rimoportula in the centre, but *T. intrannula* only has one rimoportula and is characterised by one ring of fultoportulae on the valve far from the margin.

Thalassiosira leptopus (Grunow) Hasle *et* Fryxell Figs 14, 15
Hasle and Fryxell 1977, p. 20, figs 11–14, 94–96
Hallegraeff 1984, p. 507, figs 20 a, b
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 28–29

Cells are found solitary. Valves are flat with a diameter of 70–146 μm. Hexagonal areolae occur in a linear pattern at a density of 4–5 areolae in 10 μm. The areolae of the mantle are smaller and at a density of 9–14 in 10 μm. A marginal ring of occluded processes is evident at a density of 5 in 10 μm. A rimoportula with a large external tube occurs between two occluded processes,. The valve mantle has costae at a density of 10–11 in 10 μm.

Distribution: Temperate to tropical waters (Hasle and Fryxell 1977). Stations: FIQUIMBI-I 3, 24.

Thalassiosira lineata Jousé Fig. 16
Simonsen 1974, p. 9, pl. 1, figs 4–7
Hasle and Fryxell 1977, p. 22, figs 15–25
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 30–32

Cells have a diameter of 37 μm. Hexagonal areolae occur at a density of 9–10 in 10μm. Areolae are arranged in a linear pattern. Fultoportulae are scattered over the valve, replacing the corresponding areolae. The rimoportula and marginal fultoportulae were not observed in detail.

Distribution: Tropical to temperate waters (Hasle and Fryxell 1977). Stations: FIQUIMBI-I 5, 15, 86.

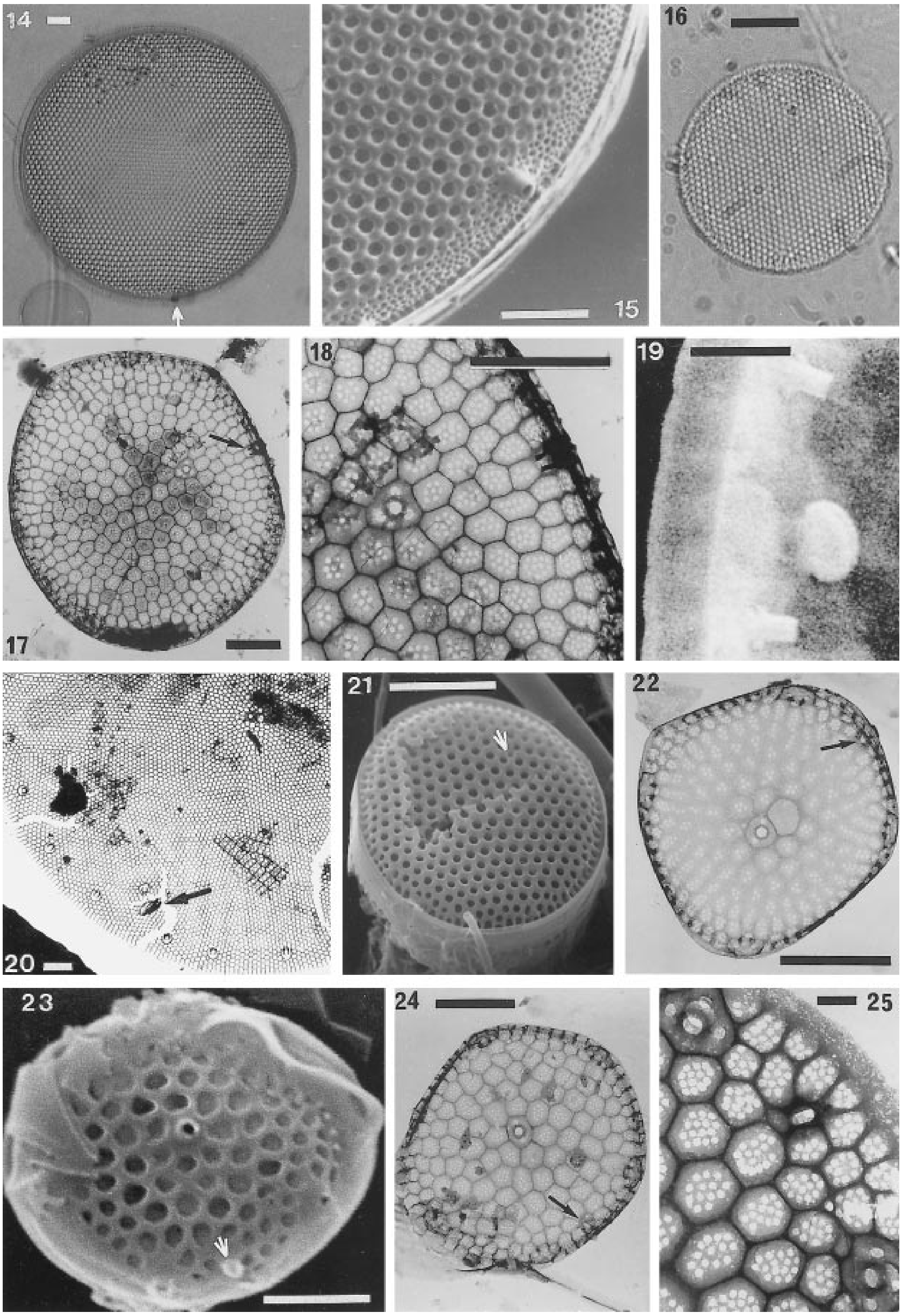
Thalassiosira mala Takano Figs 17–19
Takano 1976, p. 58, figs 1–18
Hallegraeff 1984, p. 497, figs 2 a-c
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 33–34

Valves are flat with a diameter of 5–6 μm. Irregular areolae occur in a radial pattern, at a density of 30 in 10 μm in the centre and 35–42 in 10 μm at the margin. Cribra have 1–6 pores at the centre, and more than 6 elsewhere. One eccentric fultoportula with 3 satellite pores, replacing the correspondent areola, is separated by 2 or 3 areolae from the central one. One marginal ring of fultoportulae occurs in a density of 10 in 10 μm with 3 satellite pores at each one. A short rimoportula occurs between two marginal fultoportulae, in the same direction as the eccentric fultoportula.

Distribution: This species is considered cosmopolitan (Hasle 1976 a). Stations: MIMAR-V 16, FIQUIMBI-I 15.

Thalassiosira minuscula Krasske Fig. 20
Hasle 1976 b, p. 104, figs 6–10
Hallegraeff 1984, p. 497, figs 4 a–b
Hernández-Becerril and Tapia-Peña 1995, p. 550, figs 49–60
Synonym: *T. monoporocyclus* Hasle
Hasle 1972, p. 129, figs 49–60

Valves are convex with a diameter of 8.5 μm. Areolae are hexagonal at a density of nearly 50 in 10 μm, arranged in fascicles. One central fultoportula occurs with 5 satellite pores. There is a marginal ring of fultoportulae at a density of 3–4 in 10 μm, having 3 or 4 (?) satellite pores. One large and narrow rimoportula is present close to one fultoportula slightly away



Figs 14–25.
Figs 14, 15. *Thalassiosira leptopus*. Fig. 14. Valve showing the marginal rimoportula (arrow), LM. Fig. 15. Rimoportula, SEM. Fig. 16. *Thalassiosira lineata*, valve with fultoportulae, LM. Figs 17–19. *Thalassiosira mala*. Fig. 17. Valve showing the marginal rimoportula (arrow), TEM. Fig. 18. Rimoportula and eccentric fultoportula, TEM. Fig. 19. Rimoportula, SEM. Fig. 20 *Thalassiosira minuscula*, valve with the submarginal rimoportula (arrow), TEM. Fig. 21 *Thalassiosira oestrupii* var. *venrickae*, complete cell showing the reduced rimoportula (arrow), SEM. Figs 22. *Thalassiosira profunda*, valve with the marginal rimoportula (arrow), TEM. Figs 23–25. *Thalassiosira pseudonana*. Fig. 23. Valve with marginal rimoportula (arrow), SEM. Fig. 24. Valve with marginal rimoportula (arrow), TEM. Fig. 25. Rimoportula and marginal fultoportulae, TEM. Scale bars= 10 μm (Figs 14, 15, 16, 21), =1 μm (Figs 17, 18, 19, 20, 22, 23, 24), = 200 nm (Fig. 25).

from the marginal ring of fultoportulae. The valve mantle has costae at a density of 55 in 10 µm.

Distribution: Warm water species (Hasle 1972, 1976 a). Station: FIQUIMBI-I 13.

Thalassiosira oestrupii var. *venrickae* Fryxell *et* Hasle Fig. 21

Fryxell and Hasle 1980, p. 810, figs 11–19
Rivera 1981, p. 103. Pls. 43–44
Hernández-Becerril and Tapia-Peña 1995, p. 550, figs 42, 43

The small cells have a diameter of 23 µm. Hexagonal areolae are present at a density of 7–8 in 10 µm at the centre and 9–10 in 10 µm at the margin. The areolar pattern is eccentric. The central areola is larger than the others and surrounded by seven other areolae. There is a rimoportula placed eccentrically 4 areolae away from the centre. The marginal fultoportulae have no projections outside.

Distribution: Subtropical to tropical waters (Fryxell and Hasle 1980). Station: FIQUIMBI-I 15.

Comments: This variety differs from *T. oestrupii* var. *oestrupii* (Fryxell and Hasle 1980) in the distance between the marginal fultoportulae and the length of the internal part, and in the areolar pattern and degree of silicification. In *T. oestrupii* var. *venrickae* the eccentric areolar pattern is quite characteristic.

Thalassiosira profunda (Hendey) Hasle Fig. 22

Hasle 1973 b, p. 31, figs 98–100
Hallegraeff 1984, p. 499, figs 13

The small cells have a diameter of 2–4 µm. Areolae are hexagonal at the centre of the valve with a density of 40 in 10 µm, and are rectangular towards the margin with a density of 50 in 10 µm. The areolation pattern is slightly eccentric. Close to the central areola, there is one fultoportula occupying the place of one areola. The rest of the areolae have cribra with 3–6 pores with a slightly higher density towards the marginal areolae. A ring of 4 fultoportulae occurs at the margin, and the fultoportulae are separated by 10–11 areolae. There is one short rimoportula between 2 marginal fultoportulae. All fultoportulae have only 2 satellite pores.

Distribution: Temperate to subtropical waters (Hasle 1973 b, Hallegraeff 1984). Station: FIQUIMBI-I 13.

Thalassiosira pseudonana Hasle *et* Heimdal Figs 23–25

Hasle and Heimdal 1970, p. 565, figs 27–38
Hallegraeff 1984, p. 499, figs 12 a-d
Harris *et al.* 1995, p. 121, figs 7, 25

Valves have a diameter of 3–4 µm. Areolae are hexagonal and irregular with a radial pattern and a density of 30–35 in 10 µm at the centre and 55–60 in 10 µm towards the margin. Cribra have few pores in the central areola and up to 10 in the marginal areolae. There is one short eccentric fultoportula separated by two areolae from the central one and with only 2 satellite pores. One marginal ring of fultoportulae occurs, each with 3 satellite pores and at a density of 10 in 10 µm, separated by 7–8 areolae. One marginal rimoportula occurs between 2 fultoportulae.

Distribution: Cosmopolitan, brackish (Hasle 1978 a). New record for the Mexican Pacific coast. Station: MIMAR-V 16.

Thalassiosira punctifera (Grunow) Fryxell, Simonsen *et* Hasle Figs 26–28

Simonsen 1974, plate 2, fig. 4, plate 3.
Hallegraeff 1984, p. 504, figs 16 a–d

The cells have a diameter of 62 µm. Hexagonal areolae are arranged in an eccentric pattern with a density of 6 in 10 µm and 11 in 10 µm towards the margin. The central areola is heptagonal with a scarcely perforated cribrum and close to it there is a rimoportula surrounded by 7 fultoportulae 2 or 3 areolae away from the centre. There are other fultoportulae forming rings over the valve. There is a marginal ring of fultoportulae at a density of 4 in 10 µm. All fultoportulae have 5 satellites pores. The valve has 2 marginal rimoportulae separated by an angle of 80°. The slit part of the rimoportula is orientated parallel to the margin of the valve.

Distribution: Warm species (Simonsen 1974). Stations: FIQUIMBI-I 14, 21.

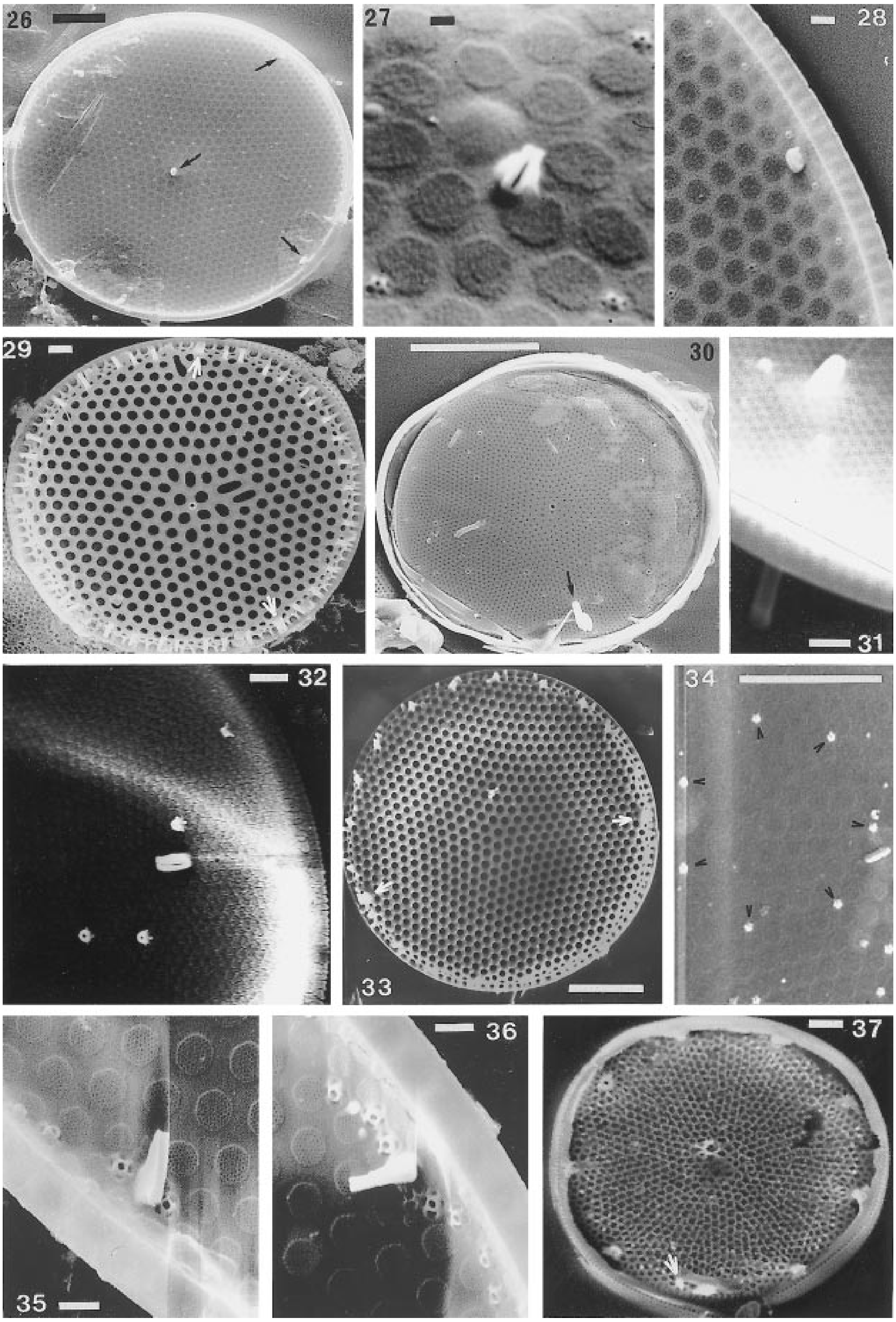
Comments: This species is related to *T. spinosa* Simonsen, which develops spines all over the valve. The organism we found had two marginal rimoportulae, and although some authors (Simonsen 1974, Hallegraeff 1984) mentioned one marginal rimoportulae for *T. punctifera*, it seems it can have more than one (Herzig and Fryxell 1986).

Thalassiosira simonsenii Hasle *et* Fryxell Fig. 29

Fryxell and Hasle 1972, p. 300, figs 1–18
Hallegraeff 1984, p. 504, figs 15 a-d
Hernández-Becerril and Tapia-Peña 1995, p. 548, figs 16–20

Valves are flat with a diameter of 16–37 µm. Areolae are hexagonal and arranged in a linear pattern, with a density of 4–6 in 10 µm. The central areola is smaller than the rest, and there is a small fultoportula adjacent to it. There is a marginal ring of occluded processes discernible in the light microscope. Two rimoportulae with large external tubes are present at an angle of 130°–155° among the marginal fultoportulae and occluded processes. The marginal fultoportulae were not observed in detail. The mantle has costae with a density of 7–10 in 10 µm.

Distribution: Cosmopolitan (Hernández-Becerril and Tapia-Peña 1995) Stations: MIMAR-V 16; FIQUIMBI-I 14.



Figs 26–37.
Figs 26–28. *Thalassiosira punctifera*. Fig. 26. Valve with one central and two marginal fultoportulae (arrows), SEM. - Fig. 27. Central rimoportula, SEM. Fig. 28. Marginal rimoportula, SEM. Fig. 29. *Thalassiosira simonsenii*, valve showing rimoportulae (arrows), SEM. Figs 30–32. *Thalassiosira subtilis*. Fig. 30. External view showing reduced fultoportulae and the rimoportulae (arrow), SEM. Fig. 31. Detail of the rimoportula, SEM. Fig. 32. Internal view showing fultoportulae and submarginal rimoportula, SEM. Fig. 33–36. *Thalassiosira symmetrica*. Fig. 33. Valve showing the two marginal rimoportulae (arrows), SEM. Fig. 34. Central ring of fultoportulae (arrows), SEM. Fig. 35. One marginal rimoportula between two fultoportulae, SEM. Fig. 36. One marginal rimoportula with various fultoportulae by its sides, SEM. Fig. 37. *Thalassiosira tealata*, valve showing the marginal rimoportula closer to one fultoportula (arrow), SEM. Scale bars= 10 μm (Figs 26, 30, 33, 34), = 1 μm (Figs 27, 28, 29, 31, 32, 35, 36, 37).

Thalassiosira subtilis (Ostenfeld) Gran emend. Hasle Figs 30–32

Hasle 1972, p. 300, figs 1–18
Hallegraeff 1984, p. 497, figs 5 a-c
Hernández-Becerril and Tapia-Peña 1995, p. 552, figs 56–58

Cells usually occur in mucilaginous masses. Valves are convex with a diameter of 18–25 µm. Areolae are hexagonal or pentagonal forming radial fascicles, with a density of 29–30 in 10 µm. One central fultoportula occurs and other fultoportulae form rings on the valve face. Marginal fultoportulae occur at a density of 3 in 10 µm. All fultoportulae have 4 satellite pores. One large rimoportula occurs in the submargin, close to a marginal ring of fultoportulae.

Distribution: Cosmopolitan species (Hasle 1976 a). Stations: MIMAR-V 15, 54; FIQUIMBI-I 5.

Thalassiosira symmetrica Fryxell *et* Hasle Figs 33–36

Fryxell and Hasle 1972, p. 312, figs 37–46
Fryxell *et al.* 1981. p. 45. figs 11–13, 30
Hernández-Becerril and Tapia-Peña 1995, p. 552, figs 59–61, 65
Rivera 1981, p. 144, figs 425–431

Cells have a diameter of 55–60 µm. Hexagonal areolae are present with a density of 8–9 in 10 µm. The areolar pattern is eccentric. There is a ring of 7 fultoportulae on the valve between the centre and the margin, 3 areolae away from the centre. Fultoportulae are scattered over the valve aligned to the central ring, separated by 2 or 3 areolae. These fultoportulae have 5 satellite pores. One marginal ring of fultoportulae occurs at a density of 10–11 in 10 µm each one with 4 satellite pores. A ring of spines occurs at a density of 2 in 10 µm. Two marginal rimoportulae are located between 2 fultoportulae and are opposed at an angle of 165°. Close to them various fultoportulae occur. The slit part of the rimoportulae is oriented perpendicular to the valve margin.

Distribution: Temperate to tropical waters (Hernández-Becerril and Tapia-Peña 1995, Rivera 1981). Stations: FIQUIMBI-I 5, 21.

Thalassiosira tealata Takano Fig. 37

Takano 1980, p. 55, figs 1–17
Harris *et al*. 1995, p. 121, figs 9, 27
Hernández-Becerril and Tapia-Peña 1995, p. 552, figs 62–64, 66, 67

Cells have a diameter of 10–11 µm. Hexagonal or loculate areolae occur at a density of 40 in 10 µm. Areolae are arranged in a fasciculated pattern. Close to the central areola a densely silicified fultoportula is located. There is a marginal ring of fultoportulae separated 2.5–3.5 µm from each other (density of 5–6 in 10 µm). One rimoportula occurs close to one marginal fultoportula. The marginal fultoportulae are armoured with wings. Small granules are present all over the valve surface. The valvocopula have rows of pores at a density of 60–70 in 10 µm close to the mantle and 80–90 in 10 µm away from it.

Comments: This species is related to *T. curviseriata* Takano (Takano 1981), but differs in both the areolar density and the length of the wings.

Distribution: Cold to subtropical waters (Hernández-Becerril and Tapia-Peña 1995, Takano 1980). Station: FIQUIMBI-I 5.

Thalassiosira tenera Proschkina-Lavrenko Figs 38–44

Hasle and Fryxell 1977, p. 28, figs 54–65
Harris *et al*. 1995, p. 121, figs 6, 24

Valves are flat with a diameter of 7–18 µm. Areolae are hexagonal and arranged in a linear pattern with a density of 16 in 10 µm. The marginal areolae are irregular and smaller than those of the centre, with a density of nearly 40 in 10 µm. The central areola is larger than the others and has a small fultoportula adjacent with 3 satellite pores and numerous pores in the cribrum. The central areola may be covered with a siliceous cap. A marginal ring of small fultoportulae is present with a density of 5 in 10 µm and with 4–5 (?) satellite pores. These are covered with a siliceous layer that forms wedges attached to each process. A rimoportula is located at the margin, between two fultoportulae. The costae at the valve mantle have a density of 24–30 in 10 µm.

Distribution: Cosmopolitan species (Hasle and Fryxell 1977). New record for the Mexican Pacific coast. Stations: FIQUIMBI-I 14, 24.

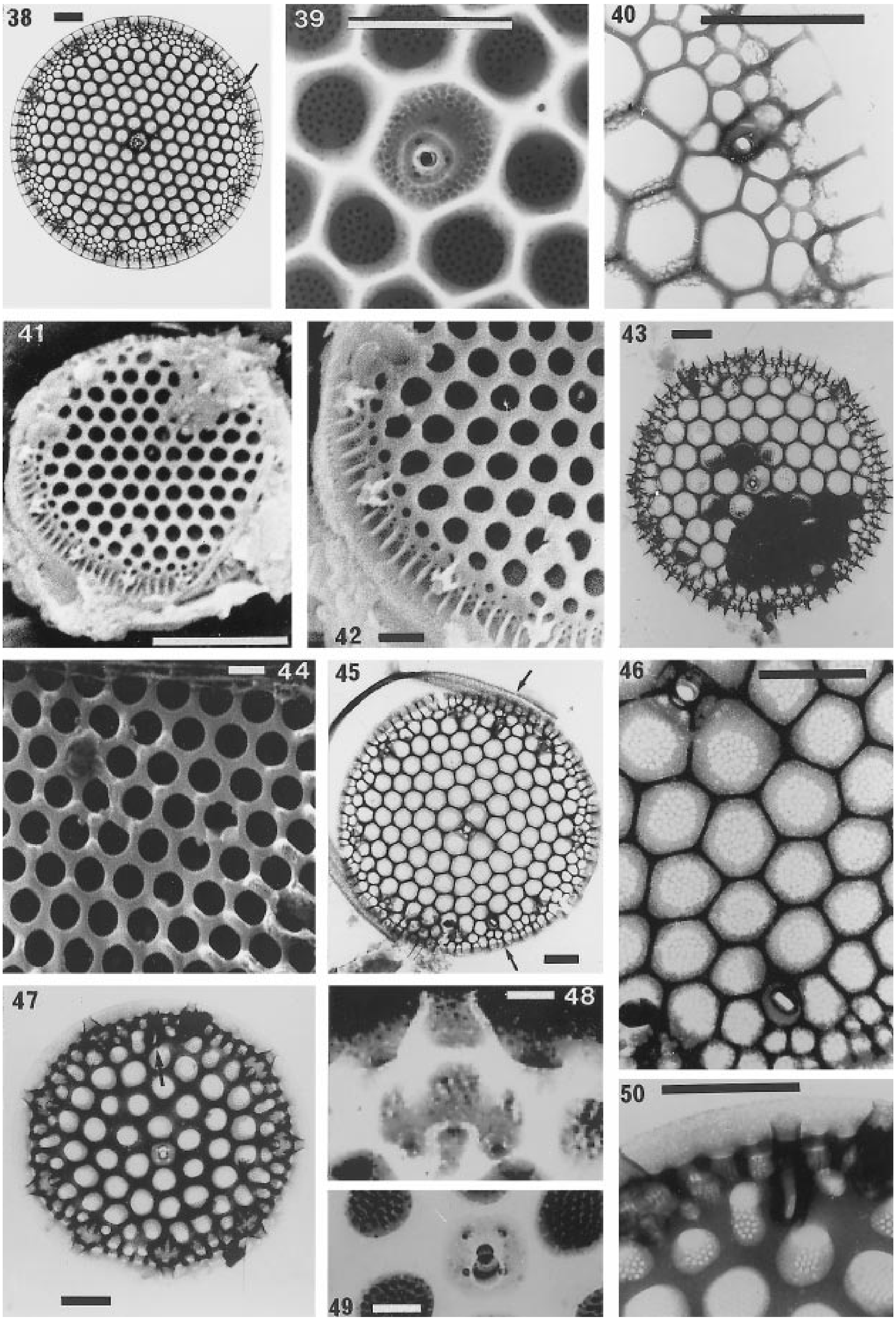
Thalassiosira visurgis Hustedt Figs 45, 46

Hasle 1978 c, p. 261–266, figs 1–4
Mahood *et al*. 1986, p. 138, figs 56–61, 95, 96

Cells are 8 µm in diameter. Hexagonal areolae are arranged in an eccentric pattern with a density of 10 in 10 µm in the centre and towards the margin the areolae are irregular with a density of 20 in 10 µm. The mantle has smaller areolae in a density of 30 in 10 µm. One central fultoportula with 5 satellite pores is surrounded by 4 areolae. One marginal ring of fultoportulae occurs at a density of 5–6 in 10 µm. Two short rimoportulae are placed slightly away from the marginal ring of fultoportulae, opposite each other at an angle of 140°.

Distribution: This species has been reported in rivers in Germany (Hustedt 1957), some lakes and rivers of United States (Hasle 1978 c), rivers and estuaries from England (Belcher and Swale 1986) and San Francisco Bay (Mahood et al. 1986),). New record for the Mexican Pacific Ocean Station: FIQUIMBI-I 3.

Comments: This species has 2 marginal rimoportulae and this character is not common in the genus. This species resembles *T. elsayedii* Fryxell, but it lacks the



Figs 38–50.

Figs 38–44. *Thalassiosira tenera*. Fig. 38. Valve with marginal rimoportulae (arrow), TEM. Fig. 39. Central fultoportula inside of an areola, TEM. Fig. 40. Rimoportula, TEM. Fig. 41. Complete cell showing areolation, SEM. Fig. 42. Marginal fultoportulae with wedges, SEM. Fig. 43. Valve with bigger areolae, TEM. Fig. 44. Detail of the valve with some granules, SEM. Figs 45, 46. *Thalassiosira visurgis*. Fig. 45. Valve showing two marginal rimoportulae (arrows), TEM. Fig. 46. Detail showing the central fultoportula and one marginal rimoportula, TEM. Figs 47–50. *Thalassiosira* cf. *bulbosa*. Fig. 47. Valve with marginal rimoportula (arrow), TEM. Fig. 48. Detail of a marginal fultoportula, TEM. Fig. 49. Central fultoportula with four satellite pores, TEM. Fig. 50. Rimoportula and marginal fultoportulae, TEM. Scale bars = 10 µm (Fig. 41), = 1 µm (Figs 38, 39, 40, 42, 43, 44, 45, 46, 47, 50), = 200 nm (48, 49).

spines which are characteristic of *T. elsayedii* (Fryxell 1975).

Thalassiosira cf. *bulbosa* Syvertsen Figs 47–50
Syvertsen and Hasle 1984, p. 168, figs 1–32

Valves are flat or slightly depressed in the centre, with a diameter of 5–6 µm. The areolation pattern appears somewhat linear, although it is rather irregular. Areolae have a density of 15 in 10 µm in the centre and 20 in 10 µm towards the margin. Cribra have numerous pores. There is a central fultoportula in the place of one areola and it has 4 satellite pores. A marginal ring of fultoportulae is present with a density of 8 in 10 µm. Each fultoportula is bulb-shaped and with 2 or 3 (?) satellite pores. One rimoportula is placed between two marginal fultoportulae.

Comments: In TEM the bulb-shaped fultoportulae can be observed. This character has only been observed in *T. bulbosa*. However, this species had 4 satellite pores in the central fultoportulae and in the marginal fultoportulae these pores were not observed clearly, so it could not be identified positively. This species resembles *T. exigua* in light microscopy, and may therefore be easily misidentified.

Distribution: *Thalassiosira bulbosa* is considered as a cold water species and it has been recorded only in the Arctic Ocean (Syvertsen and Hasle 1984). Station: FIQUIMBI-I 13.

Thalassiosira cf. *pacifica* Gran *et* Angst Figs 51, 52
Hasle 1978 b, p. 88, figs 3, 40, 42–69
Rivera 1981, p. 105, pls. 45–49

Cells form chains linked by mucilage threads. Valves are concave to flat, with a diameter of 8–9 µm. Areolae are hexagonal in a linear pattern, with a density of 20 in 10 µm in the centre and 40 in 10 µm towards the margin. Cribra have numerous pores. A central fultoportula is adjacent to a central areola and with 4 or 5 satellite pores. At the margin, the fultoportulae are arranged in a ring, separated by 4–5 areolae with 3 satellite pores, and at a density of 9–10 in 10 µm. A rimoportula is located between two marginal fultoportulae. The mantle has costae with a density of 50 in 10 µm.

Comments: *Thalassiosira pacifica* has mostly the rimoportula replacing a marginal fultoportula, but it can also be present between two of them (Hasle 1978 b). In addition, the areolar pattern is very variable in this species, resulting in complicated positive identification.

Distribution: Cold to temperate waters (Hasle 1978 b, Rivera 1981). Station: FIQUIMBI-I 15.

Thalassiosira sp. 1 Figs 53, 54
Cells have a diameter of 8–9 µm. Areolae are fine, arranged in an eccentric pattern with a density of 25 in 10 µm. One central fultoportula is surrounded by 4 areolae. There is one marginal ring of fultoportulae with a density of 9–10 in 10 µm. All fultoportulae have 4 satellite pores. One marginal reduced rimoportula occurs between 2 fultoportulae, closer to one of them.

Comments: This species does not have external extension of the fultoportulae and it looks like *T. perpusilla* Kozlova, but differs in the position of the rimoportula and the density of the fultoportulae. Additionally, *T. perpusilla* is distributed only in southern cold water areas (Hasle and Syvertsen 1996).

Distribution: station: FIQUIMBI-I 5.

Thalassiosira sp. 2 Figs 55, 56

Valves are slightly convex with a diameter of 10–11 µm. Areolae occur at a density of 40–45 in 10 µm following a radial pattern. One central fultoportula and one marginal ring of fultoportulae are present in a density of 6–7 in 10 µm. One reduced rimoportula occurs between 2 fultoportulae at the margin. Valvocopula have numerous pores: 6 in 1 µm.

Comments: This species resembles *T. minuscula* but the rimoportula in the latter is away from the margin. In addition *Thalassiosira* sp. 2 does not have any fultoportula close to the rimoportula.

Distribution: station: FIQUIMBI-I 24.

Discussion

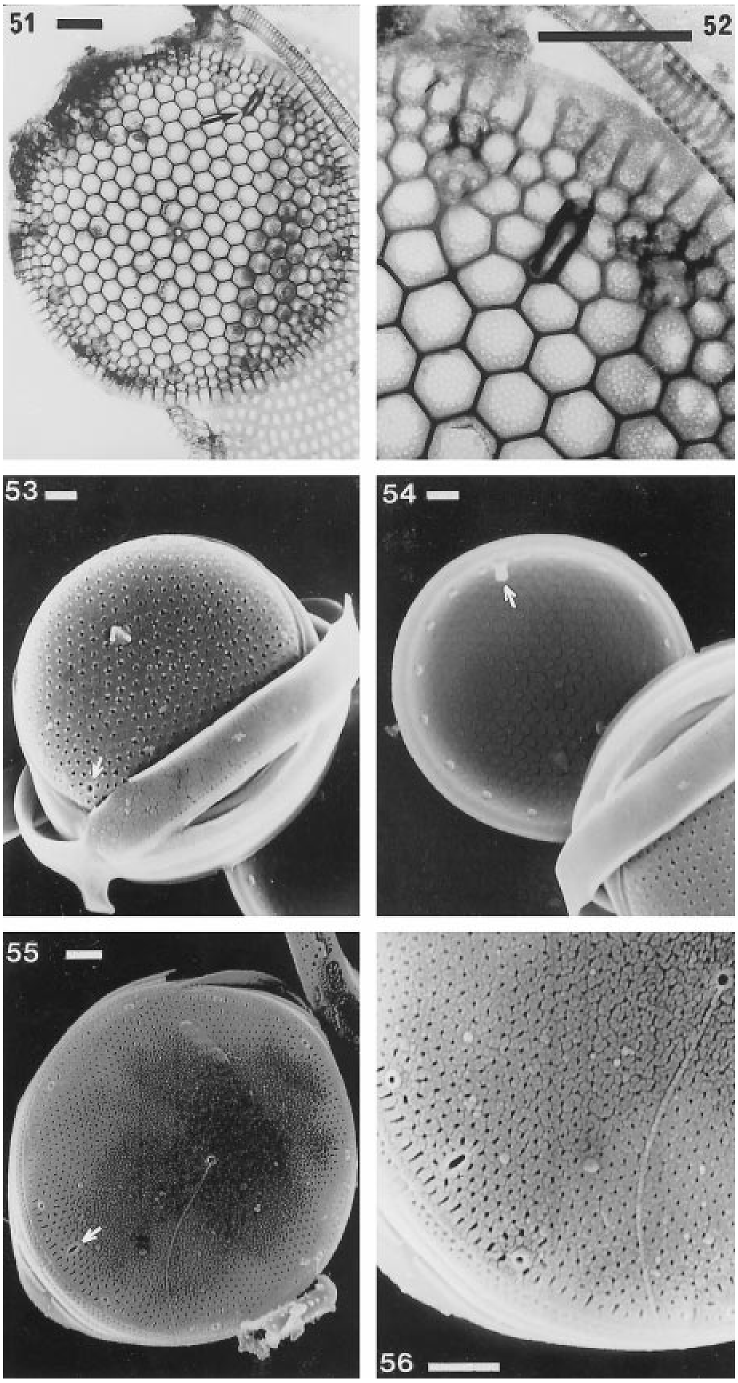
Morphology

In this study, we record 23 taxa for the Gulf of Tehuantepec. Of these, 5 species are reported for first time for the Mexican Pacific: *T. hendeyi*, *T. intrannula*, *T. pseudonana*, *T. tenera* and *T. visurgis*. Two species could not be identified as their characters did not agree with previous descriptions where the taxa have been studied in detail and also 2 species are only tentatively identified.

Eight of the total studied species belong to microplankton (20–200 µm): *T. decipiens*, *T. eccentrica*, *T. hendeyi*, *T. intrannula*, *T. leptopus*, *T. simonsenii*, *T. subtilis* and *T. symmetrica* and the rest belong to the nanoplankton fraction (2–20 µm), thus the difficulty of making positive identification using only light microscopy.

Information concerning ultrastructural characters of the frustules is provided, and in some cases there are some interesting considerations. The number and position of rimoportulae is used as the most important taxonomic character (Hasle and Syvertsen 1996) and most of the species within the genus have only one. The species with 2 rimoportulae or more are rather uncommon, and moreover there are species with a variable number of rimoportulae (Table V), thus the identification based only on rimoportulae become harder. In this study we recorded 5 species having more than 1 rimoportula: *T. hendeyi*, *T. punctifera*, *T. simonsenii*, *T. symmetrica* and *T. visurgis*. In *T. punctifera* one central rimoportula and two marginal ones were observed, which lead to its identification since this species has been pointed out having a variable number of marginal rimoportulae (Herzig and Fryxell 1986).

Another character that has not been considered taxonomically important within the genus is the number of satellite pores. In our observations there is a consistency in the number of satellite pores for *T. profunda* and *T. pseudonana* with previous studies,



Figs 51−56

Figs 51, 52. *Thalassiosira* cf. *pacifica*. Fig. 51. Valve showing areolar pattern and rimoportula (arrow), TEM. Fig. 52. Rimoportula and marginal fultoportulae, TEM. Figs 53, 54. *Thalassiosira* sp. 1. Fig. 53. External view of a valve showing the reduced rimoportula (arrow), SEM. Fig. 54. Internal view showing fultoportulae and rimoportula (arrow), SEM. - Figs 55, 56. *Thalassiosira* sp. 2. Fig. 55. Valve showing areolar pattern and the reduced rimoportula (arrow), SEM. Fig. 56. Detail of the rimoportula and marginal fultoportulae, SEM. Scale bars = 1µm.

Table V. Marine *Thalassiosira* species with more than 1 rimoportula

Species	Number	Position	Global distribution	Reference
T. baltica	3–4	M: ?	Temperate-cold waters	Hasle and Syvertsen 1996
T. bipartita	2	M: 150–180°	Subtropical	Hallegraeff 1992
T. elsayedii	2	M: 180°	Gulf of Mexico	Fryxell 1975
T. fragilis	2	M: 150–180°	Temperate	Herzig and Fryxell 1986
*T. hendeyi**	2	M: 180°	Subtropical	Hasle and Fryxell 1977
T. weissflogii (= *T. hustedtii* var. *vana*)	1–2?	M: ?	Caspian Sea	Fryxell and Hasle 1977
T. ignota	1–2	M: ?	?	Fryxell and Hasle 1979
*T. punctifera**	2 (4)	C: 1, M: 1 (3)	Tropical	Herzig and Fryxell 1986
*T. simonsenii**	2	M: 180°	Wide distribution	Hasle and Fryxell 1977
T. spinosa	2	C: 1, M: 1	Tropical	Hallegraeff 1984
*T. symmetrica**	2	M: 170°	Wide distribution	Fryxell and Hasle 1972
T. tumida	2–10	M: radial orientated	Cold waters	Johansen and Fryxell 1985
*T. visurgis**	2	M: 140°	Temperate fresh to brackish water	Hasle 1978 c Mahood et al. 1986

M: marginal, C: central
* Recorded in this study

in which there were 2 at least in the central fultoportula, whereas for the rest of the species studied at least three are present. In *T.* cf. *bulbosa*, the 2 satellite pores of the marginal fultoportulae seems to be an important and distinct character. Also, these species and *T. mala* show a cribra scarcely perforated, whereas on the rest of the species the cribra have numerous pores. These characters could be important for the correct delimitation in these taxa.

In this study both *T. exigua* and *T. tenera* ‘ very similar species, were recorded in the windy season, the first being more frequently observed the last one. Hasle and Fryxell (1977) have pointed out that the differences between these species are the smaller diameter of the former as well as the structure of the valvocopula. In this work we did not observe the valvocopula but the small diameter and high density of the marginal costae lead to its identification as *T. exigua*. Another difference was the cribra, being scarcely perforated in *T. exigua*, whereas in *T. tenera* it has numerous pores. These differences can be observed in Figures 9 and 39, and in plates 13 and 14 of Hasle and Fryxell (1977). In addition, the central fultoportulae in *T. exigua* had 4 satellite pores (Fig. 9) while in *T. tenera* it had only three (Fig. 39); however, Hasle and Fryxell (1977) have pointed out this character could be variable in both species. Additionally the form of the fultoportulae can be very variable in both species due to a siliceous layer covering all fultoportulae (Hasle and Fryxell 1977) and forming wedges attached to the marginal ones (figs 7, 42).

Distribution

The 23 species of *Thalassiosira* recorded in this study can be considered a high number comparing with similar studies for the same genus in other regions: 23 for Australian coasts (Hallegraeff 1984), 13 in the lower Thames and some estuaries from Great Britain (Belcher and Swale 1986), 20 in San Francisco Bay, U. S. A. (Mahood *et al.* 1986), 21 in Bahía Blanca Estuary, Argentina (Gayoso 1989), 18 in Loch Creran, Scotland (Harris *et al.* 1995). This high number of species found in the Gulf of Tehuantepec, together with the 34 species of *Thalassiosira* reported for Gulf of California (Hernández-Becerril and Tapia-Peña 1995, Moreno *et al.* 1996) seem to indicate that this genus is diverse on the Mexican Pacific coasts.

Six species can be considered typically tropical: *T. exigua*, *T. hendeyi*, *T. leptopus*, *T*, *lineata*, *T. oestrupii* var. *venrickae* and *T. punctifera*. The rest have been reported from temperate to subtropical waters and including three cold water species: *T. tealata*, *T. pacifica* and *T. bulbosa*. The latter one, recorded previously only in the Arctic Ocean (Syvertsen and Hasle 1984). *Thalassiosira visurgis* is considered a fresh-brackish water species, but in this study it was found in a typical marine sample far from the coast. It is possible that this species should be considered as allochthonous and carried out from the important system of coastal lagoons of the Gulf of Tehuantepec.

Concerning the cosmopolitan species is important to notice that *T. decipiens*, *T. eccentrica*, *T. mala*, *T. subtilis*, and *T. simonsenii* were recorded in May and November (dry and windy seasons) whereas the temperate ones were only recorded in November (windy season). The only one tropical species recorded only in May (dry season) was *T. hendeyi* .

In conclusion, we believe that in spite of the localization of the Gulf of Tehuantepec in the Tropical Pacific, the group of species of *Thalassiosira* recorded seems to indicate that this region represents a subtropical zone at least in one period of the year. This may be due to the combined influence of the upwellings and a lowering of the temperature in the superficial layers of water due to the strong winds. Studies in other diatom groups, particularly *Chaetoceros* (Aké-Castillo 1997) support this conclusion.

Acknowledgements

We express our acknowledgements to Sirenia González Pozos (UME, CINVESTAV-IPN), Yolanda Hornelas Orozco (SAMEB, ICMyL-UNAM) and Patricia Castillo (UAM-I) for their help in using TEM and SEM in the respectively work units. Some micrographs were taken at the University of Bristol. The photographic work was made by Jorge Lodigiani. G. Fryxell supported the identification of one species and two anonymous reviewers made important comments. G. T. Boalch improved the English.

Accepted 7 May 1999

References

Aké-Castillo J. A. 1997. Sistemática y taxonomía de *Chaetoceros* Ehrenberg y *Thalassiosira* Cleve (Bacillariophyceae) del Golfo de Tehuantepec, México. Tesis Maestría en Ciencias. CINVESTAV-IPN Unidad Mérida, México. 84 pp. 26 Lám.

Anonymous. 1975. Proposals for a standarization of diatom terminology and diagnoses. *Nova Hedwigia*, *Beih. 53*: 323–354.

Belcher, J. H. and E. M. F. Swale. 1986. Notes on some small *Thalassiosira* species (Bacillariophyceae) from the plankton of the lower Thames and other British estuaries (identified by Transmission Electron Microscopy). *Br. phycol. J. 21*: 139–145.

Fryxell, G. A. 1975. Three new species of *Thalassiosira*, with observations on the occluded process, a newly observed structure of diatom valves. *Nova Hedwigia*, *Beih. 53*: 57–82.

Fryxell, G. A. and G. R. Hasle. 1972. *Thalassiosira eccentrica* (Ehrenb.) Cleve, *T. symmetrica* sp. nov., and some related centric diatoms. *J. Phycol. 8*: 297–317.

Fryxell, G. A. and G. R. Hasle. 1977. The genus *Thalassiosira*: some species with a modified ring of strutted processes. *Nova Hedwigia*, *Beih. 54*: 67–98.

Fryxell, G. A. and G. R. Hasle. 1979. The genus *Thalassiosira*: *T. trifulta* sp. nova and other species with tricolumnar supports on strutted processes. *Nova Hedwigia*, *Beih. 64*: 13–32.

Fryxell, G. A. and G. R. Hasle. 1980. The marine diatom *Thalassiosira oestrupii*: structure, taxonomy and distribution. *Amer. J. Bot. 67*: 804–814.

Fryxell, G. A., G. F. Hubbard and T. A. Villareal. 1981. The genus *Thalassiosira*: variations of the cingulum. *Bacillaria 4*: 41–63.

Gayoso, A. M. 1989. Species of the diatom genus *Thalassiosira* from a coastal zone of the South Atlantic (Argentina). *Bot. Mar. 32*: 331–337.

Hallegraeff, G. M. 1984. Species of the diatom genus *Thalassiosira* in Australian waters. *Bot. Mar. 27*: 495–513.

Hallegraeff, G. M. 1992. Observations on the mucilaginous diatom *Thalassiosira bipartita* (Rattray) comb. nov. from the tropical Indo-West Pacific. *Diatom Research 7*: 15–23.

Harris, A. S. D., L. K. Medlin, J. Lewis and J. Jones. 1995. *Thalassiosira* species (Bacillariophyceae) from a Scottish sea- loch. *Eur. J. Phycol. 30*: 117–131.

Hasle, G. R. 1972. *Thalassiosira subtilis* (Bacillariophyceae) and two allied species. *Norw. J. Bot. 19*: 111–137.

Hasle, G. R. 1973 a. Thalassiosiraceae, a new diatom family. *Norw. J. Bot. 20*: 67–69.

Hasle, G. R. 1973 b. Some marine plankton genera of the diatom family Thalassiosiraceae. *Nova Hedwigia*, *Beih. 45*: 1–49.

Hasle, G. R. 1976 a. The biography of some marine planktonic diatoms. *Deep Sea Res*. 23: 319–338.

Hasle, G. R. 1976 b. Examination of diatom type material: *Nitzschia delicatissima* Cleve, *Thalassiosira minuscula* Krasske and *Cyclotella nana* Hustedt. *Br. Phycol. J. 11*: 101–110.

Hasle, G. R. 1978 a. Diatoms. *In*: (A. Sournia, ed.) *Phytoplankton Manual*. UNESCO, Paris. pp. 136–142.

Hasle, G. R. 1978 b. Some *Thalassiosira* species with one central process (Bacillariophyceae). *Norw. J. Bot. 25*: 77–110.

Hasle, G. R. 1978 c. Some freshwater and brackish water species of the diatom genus *Thalassiosira* Cleve. *Phycologia 17*: 263–292.

Hasle, G. R. 1979. *Thalassiosira decipiens* (Grun.) Jørg. (Bacillariophyceae). *Bacillaria 2*: 85–108.

Hasle, G. R. and G. A. Fryxell. 1977. The genus *Thalassiosira*. Some species with a linear array. *Nova Hedwigia*, *Beih. 54*: 15–66.

Hasle G. R. and B. R. Heimdal. 1970. Some species of the centric diatom genus *Thalassiosira* studied in the light and electron microscopes. *Nova Hedwigia*, *Beih. 31*: 543–581.

Hasle, G. R. and E. E. Syvertsen. 1996. Marine diatoms. *In*: (C. Tomas, ed.) *Identifying Marine Diatoms and Dinoflagellates*. Academic Press, San Diego. pp. 5–385.

Hernández-Becerril, D. U. 1987. Especies de fitoplancton tropical del pacífico mexicano. I. Diatomeas y silicoflagelados. *Rev. Lat- amer. Microbiol. 29*: 413–426.

Hernández-Becerril, D. U. 1988. Especies de fitoplancton tropical del pacífico mexicano. II. Dinoflagelados y cianobacterias. *Rev. Lat-amer. Microbiol. 30*: 187–196.

Hernández-Becerril, D. U. and M. I. Tapia-Peña. 1995. Planktonic diatoms from the Gulf of California and coasts off Baja California: species of the genus *Thalassiosira*. *Bot. Mar. 38*: 543–555.

Herzig, W. N. and G. A. Fryxell. 1986. The diatom genus *Thalassiosira* Cleve in Gulf Stream Warm Core Rings: taxonomy, with *T. intrannula* and *T. lineoides*, spp. nov. *Bot. Mar. 29*: 11–25.

Hustedt, F. 1957. Die Diatomeenflora des Flussystems der Weser im Gebiet der Hansestadt Bremen. *Abh. naturw. Verw. Bremen 34*: 181–440.

Johansen, J. R. and G. A. Fryxell. 1985. The genus *Thalassiosira* (Bacillariophyceae): studies on species occurring south of the Antarctic convergence zone. *Phycologia 24*: 155–179.

Mahood, A. D., G. A. Fryxell, M. McMillan. 1986. The diatom genus *Thalassiosira*: Species from the San Francisco Bay system. *Proc. Calif. Acad. Sciences 44*: 127–156.

Makarova, I. V. 1980. Principles of the systematics of *Thalassiosira* Cleve and the significance of its taxonomic characters. *In*: (R. Ross, ed.) *Proc. 6th Diatom Symposium*. Koeltz, Koenigstein. pp. 1–9, 4 pls.

Makarova, I. V. 1988. Diatomovie vodorosli morei SSSR: rod *Thalassiosira* Cl. *USSR Acad. Sci.* "Nauka", Leningrad, 116 pp. (In Russian).

Moreno, J. L., S. Licea, H. Santoyo. 1996. *Diatomeas del Golfo de California*. Univ. Autón. de Baja California Sur. SEP-FOMES, PROMARCO, México. 273 pp.

Proschkina-Lavrenko, A. I. 1961. Diatomeae novae e Mari Nigro (Pronyo Euxino) *et* Azoviano (Maeotico). *Notul. syst. Inst. cryptog.* URSS *14*, 33–39

Rivera, P. 1981. Beiträge zur Taxonomie und Verbreitung der Gattung *Thalassiosira* Cleve (Bacillariophyceae) in den Küstengewässern Chiles. *Bibl. Phycol. 56*: 220 pp.

Robles-Jarero, E. G. and J. R. Lara-Lara. 1993. Phytoplankton productivity in the Gulf of Tehuantepec. *J. Plank. Res. 15*: 1341- 1358.

Roden, G. I. 1961. Sobre la circulación producida por el viento en el Golfo de Tehuantepec y sus efectos sobre las temperaturas superficiales. *Geofísica Internacional 1*: 55–76.

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

Simonsen, R. 1974. The diatom plankton of the Indian Ocean Expedition of R/V "Meteor" 1964–1965. *"Meteor" Forsch. Ergebnisse, Reihe D, 19*: 1–107.

Stumpf, H. G. 1975. Satellite detection of upwelling in the Gulf of Tehuantepec, Mexico. *J. Phys. Oceanogr. 5*: 383–388.

Syvertsen, E. E. and G. R. Hasle. 1984. *Thalassiosira bulbosa* Syvertsen, sp. nov., an Arctic marine diatom. *Polar Biology 3*: 167–172.

Takano, H. 1976. Scanning electron microscopy of diatoms-II. *Thalassiosira mala* Takano. *Bull. Tokai Reg. Fish. Res. Lab. 87*: 57–65.

Takano, H. 1980. New and rare diatoms from Japanese marine waters-V. *Thalassiosira tealata* sp. nov. *Bull. Tokai Reg. Fish. Res. Lab. 103*: 55–63.

Takano, H. 1981. New and rare diatoms from Japanese marine waters-VI. Three new species in Thalassiosiraceae. *Bull. Tokai Reg. Fish. Res. Lab. 105*: 31–41.