MaRIne PLankTOnIC DIaTOMS Of THe ORDeR RHIzOSOLenIaLeS (BaCILLaRIOPHyTa) fROM THe TROPICaL MexICan PaCIfIC

D.U. Hernández-Becerril, P. Herrera-Hernández, A. Pérez-Mendoza, J.G.A. Ceballos-Corona

VIE ET MILIEU - LIFE AND ENVIRONMENT, 2010, 60 (2): 95-107

MARINE PLANKTONIC DIATOMS OF THE ORDER RHIZOSOLENIALES (BACILLARIOPHYTA) FROM THE TROPICAL MEXICAN PACIFIC

D. U. HERNÁNDEZ-BECERRIL[1], P. HERRERA-HERNÁNDEZ[2], A. PÉREZ-MENDOZA[1], J. GERARDO A. CEBALLOS-CORONA[2]

[1] *Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de Mexico (UNAM), Apdo. postal 70-305, Mexico, D.F. 04510, Mexico*

[2] *Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo (UMSNH), Morelia, Michoacán, 58030, Mexico*

** Corresponding author: dhernand@cmarl.unam.mx*

DIATOMS
MEXICAN PACIFIC
MORPHOLOGY
PHYTOPLANKTON
RHIZOSOLENIALES

ABSTRACT. – Net phytoplankton samples from the tropical coasts of the Mexican Pacific Ocean, from the States of Sinaloa to Oaxaca, were analyzed to study marine planktonic diatoms of the order Rhizosoleniales, genera *Dactyliosolen*, *Guinardia*, *Neocalyptrella*, *Proboscia*, *Pseudosolenia*, and *Rhizosolenia*. Twenty taxa (18 species and 2 varieties) were recognized and studied by LM, SEM and TEM, in most cases. Three new records for the Mexican marine waters, particularly the Mexican Pacific Ocean, are annotated in this paper: *Dactyliosolen blavyanus*, *Rhizosolenia decipiens* and *Rhizosolenia fallax*. There have been no further records of both *Rhizosolenia decipiens* and *R. fallax*, since their original description. Additionally, the species *Rhizosolenia clevei* var. *clevei* is studied and illustrated for the first time in the Mexican Pacific. Morphologic details of many species, including complete cells with chloroplasts and the areolae vela of valves and copulae, are provided here. The *Rhizosolenia* flora in the Mexican Pacific consists of 23 taxa annotated.

INTRODUCTION

The diatom Order Rhizosoleniales Silva currently includes two families, Rhizosoleniaceae De Toni and Probosciaceae Jordan *et* Ligowski, with seven genera, mostly marine and planktonic forms. Certainly, the genus *Rhizosolenia* is one of the most important in the marine phytoplankton, due to its wide distribution all over the world, high biodiversity, biomass and abundance. In tropical and subtropical regions, the diversity of the genus increases, and some of the species spread over these areas are not well-known and have not been studied in detail. The genus has been subject of numerous contemporary studies and revisions (e.g., Hasle 1975, Sundström 1986, Hernández-Becerril & Meave 1996, 1997, Hasle & Syvertsen 1997, Jordan & Ligowski 2004), which have led to several taxo-

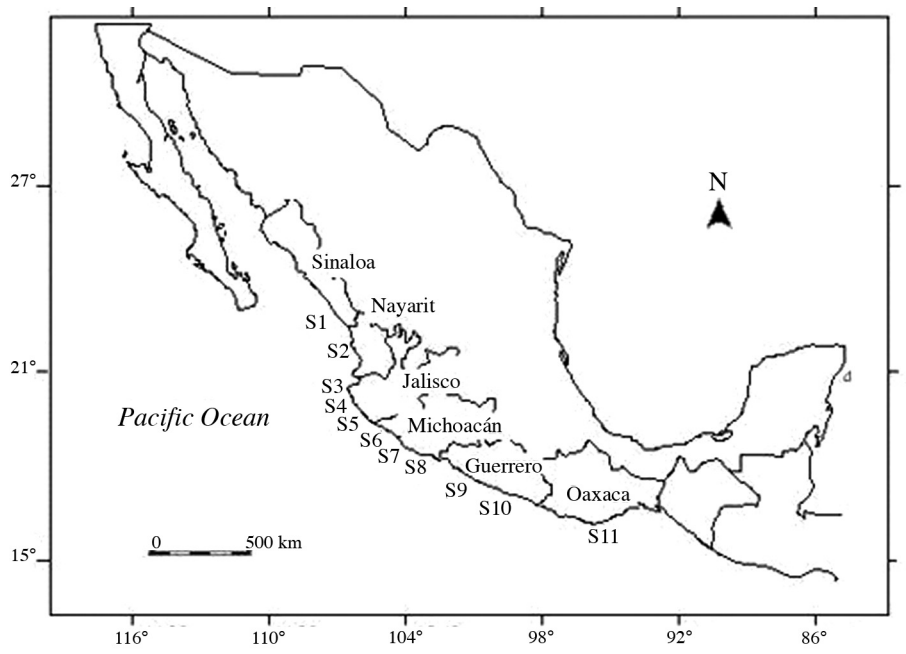
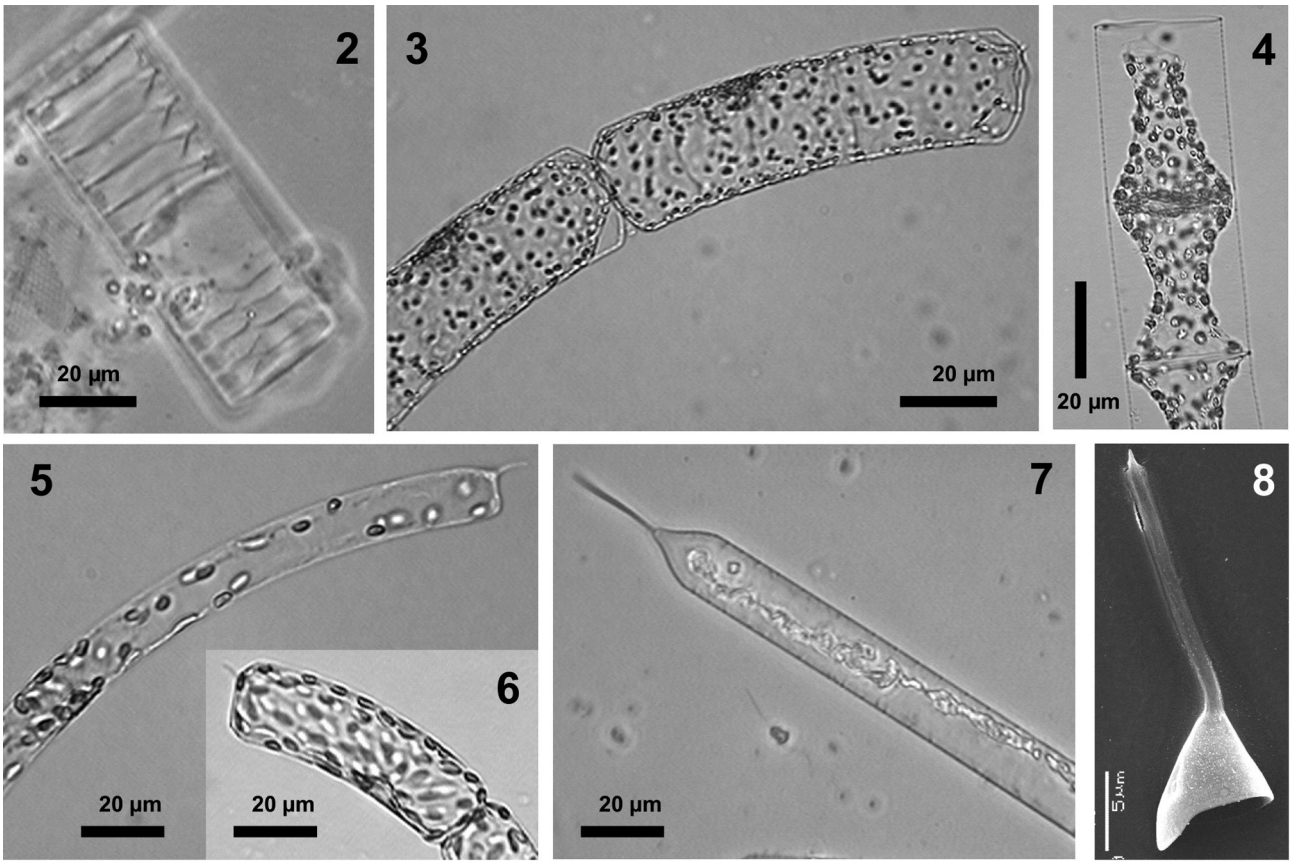


Fig. 1. – Map of Mexico, showing stations (S1-S11) along the Mexican Pacific Ocean.



Figs 2-8. – Fig. 2. *Dactyliosolen blavyanus*, LM. Fig. 3. *Dactyliosolen phuketensis*, LM. Fig. 4. *Guinardia flaccida*, LM. Figs 5, 6. *Guinardia striata*, two different chains, showing chloroplasts, LM. Figs 7, 8. *Guinardia cylindrus*, part of a cell, valve and process, LM and SEM, respectively.

nomic changes, including proposals of new genera, new species and transference of some species to other genera. A comprehensive account can be found in the chapter on diatoms by Hasle & Syvertsen (1997).

During different surveys along the Mexican Pacific coasts, we have detected some *Rhizosolenia* species that have not been recorded and are commonly found in tropical to subtropical waters in the area. This is a complement of a previous paper devoted to *Rhizosolenia* and presumed related genera (e.g., *Proboscia Pseudosolenia*, and former species presently recognized as members of *Dactyliosolen* and *Guinardia*), because that study was based on samples from more temperate to subtropical areas, such as the western coasts of Baja California and the Gulf of California (Hernández-Becerril 1995).

MATERIAL AND METHODS

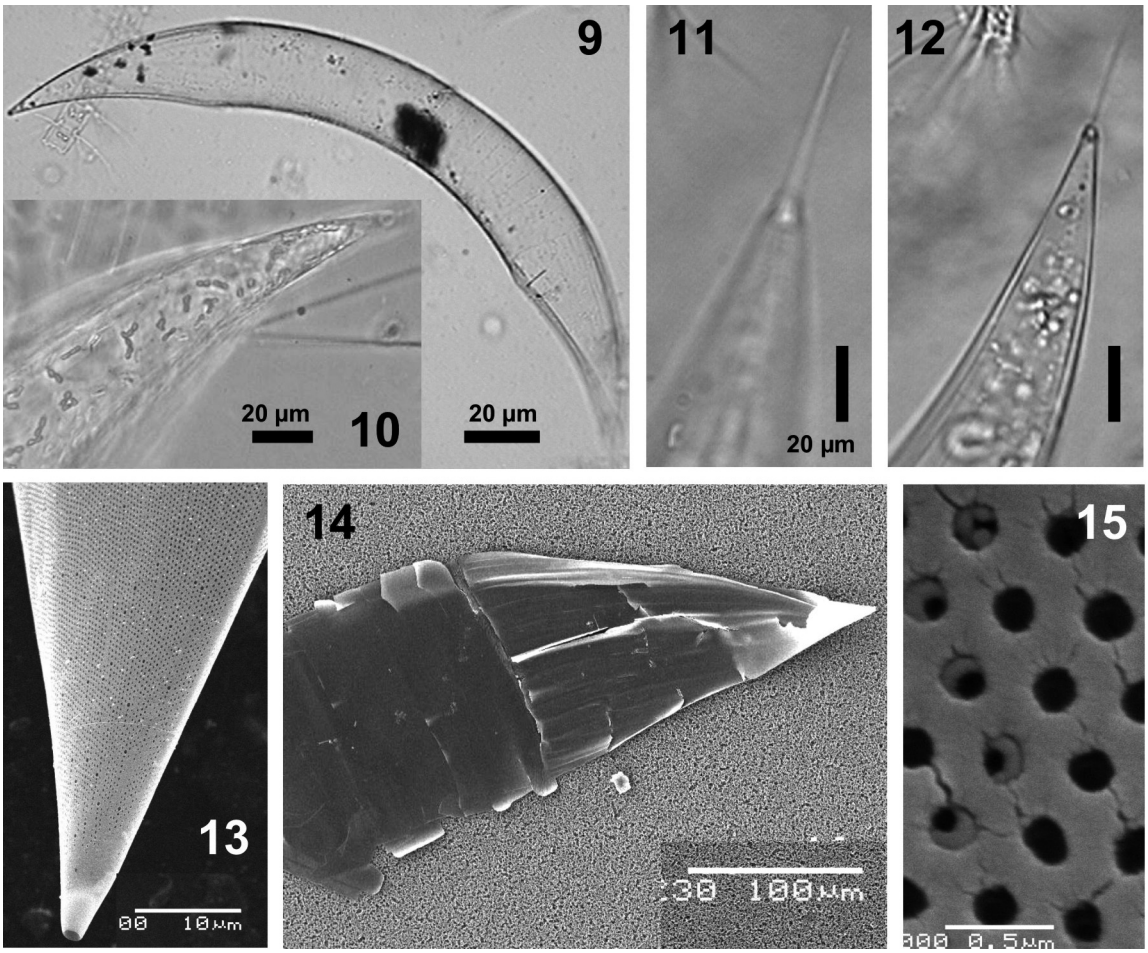
This study is based on net phytoplankton samples collected in the tropical Mexican Pacific, during the oceanographic cruise TEHUA V, carried out from 21 August to 12 September, 2007, from the coast of Sinaloa to the coast of Oaxaca (Fig. 1). Phytoplankton was obtained by vertical net hauls (mesh of 54 mm), in 11 fixed stations and immediately preserved with formalin 4 %.

Material was analyzed by LM (Olympus BX40 and Zeiss Axiolab) using either raw or cleaned material. Cleaning of diatoms was made following the proposal by Simonsen (1974). Additional observations by SEM (JEOL JSM-6369) and TEM (JEOL JEM-1200 EXII) were also made, using conventional methods (Boltoskoy 1995); only cleaned material was used for TEM.

General terminology for diatoms the classical proposals by Anonymous (1975), Ross *et al*. (1979), Round *et al*. (1990), and Hasle & Syvertsen (1997) was considered and the specific terminology for the genus *Rhizosolenia* given by Sundström (1986) and Hasle & Syvertsen (1997). The systematic arrangement follows Round *et al*. (1990) and Medlin & Kaczmarska (2004).

RESULTS AND OBSERVATIONS

A total of 20 taxa (18 species and 2 varieties) were identified and studied in this study, with 12 taxa belonging to *Rhizosolenia*, 3 to *Guinardia*, 2 to *Dactyliosolen* and one species to the genera *Neocalyptrella*, *Proboscia* and *Pseudosolenia*. *Dactyliosolen blavyanus* (Peragallo) Hasle, *Rhizosolenia decipiens* Sundström and *Rhizosolenia fallax* Sundström are new records for Mexican waters, whereas *R. clevei* var. *clevei* is described and illustrated for the first



Figs 9-15. – *Neocalyptrella robusta*. Figs 9, 10. A complete empty cell, and one valve showing the chloroplasts, LM. Figs 11, 12. Different focuses of the process, LM. Fig. 13. Detail of the tip of a valve without process, SEM. Fig. 14. Part of a cell, SEM. Fig. 15. Detail of the valve areolation pattern, SEM.

time in the Mexican Pacific.

Division Bacillariophyta

Class Coscinodiscophyceae Round *et* Crawford *emend*. Medlin *et* Kaczmarska

Order Rhizosoleniales Silva *emend*. Round *et* Crawford.

Family Rhizosoleniaceae De Toni

Genus *Dactyliosolen* Castracane

Dactyliosolen blavyanus (Peragallo) Hasle Fig. 2

Basionym: *Guinardia blavyana* H. Peragallo

References: Peragallo 1892, p. 107, pl. 1, Figs 1, 2, Hasle & Syvertsen 1997, p. 167, pl. 32; Throndsen *et al*. 2007, p. 154.

Cells cylindrical, usually solitary or in short chains. Valves flat with an indentation and no processes. Girdle bands visible in LM, with a hyaline area close to the middle of the cells. Dimensions: 26-37 μm diameter, 87-159 μm total length.

Distribution: Nayarit (S2) and Oaxaca (S11).

Dactyliosolen phuketensis (Sundström) Hasle Fig. 3

Basionym: *Rhizosolenia phuketensis* Sundström

References: Sundström 1980, p. 579, Figs 1, 3; Hernández-Becerril 1995, p. 262. Figs 50-52, Hasle & Syvertsen 1997, p. 167, pl. 31, Throndsen *et al*. 2007, p. 155.

Cells arranged in curved chains. Cells curved, all valves are trapezoidal, the terminal ones have a short spine. Dimensions: 23-29 μm diameter, 152-184 μm total length.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7), Guerrero (S9) and Oaxaca (S11).

Genus *Guinardia* H. Peragallo

Guinardia cylindrus (Cleve) Hasle Figs 7, 8

Basionym: *Rhizosolenia cylindrus* Cleve

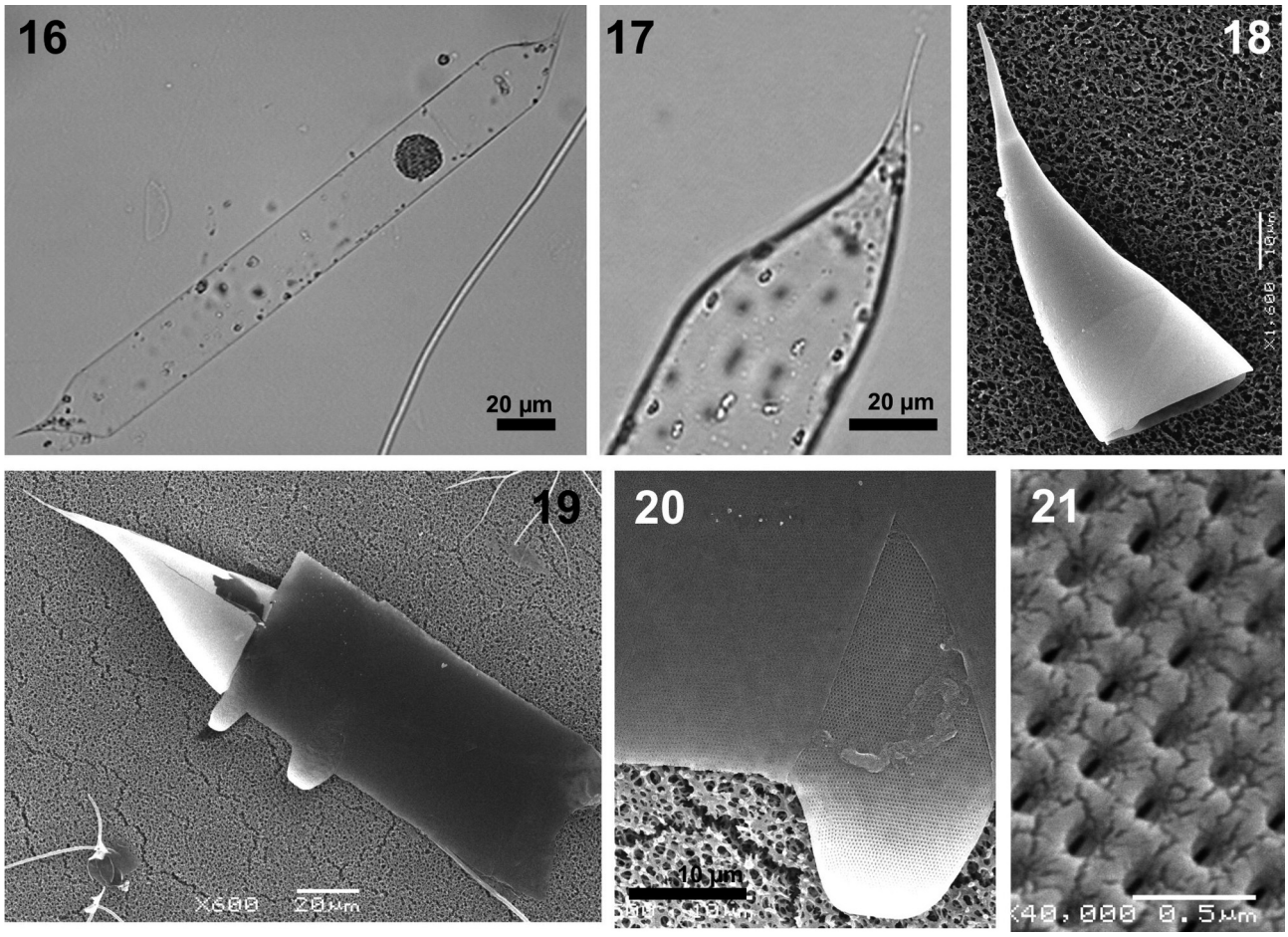
References: Cupp 1943, p. 80, Figs 42 a, b; Sundström 1986, p. 103, Figs 276-278. Hernández-Becerril 1995, p. 262. Fig 57, Hasle & Syvertsen 1997, p. 161, pl. 31.

Cylindrical cells, solitary or in short chains. Valves are conical with a long spine. Two columns of girdle bands. Dimensions: 26 μm diameter, 174 μm total length, 14 μm length of process.

Distribution: Michoacán (S7).

Guinardia flaccida (Castracane) Peragallo Fig. 4

Basionym: *Rhizosolenia flaccida* Castracane



Figs 16-21. – *Pseudosolenia calcar-avis*. Fig. 16. A complete cell, LM. Fig. 17. Terminal part of cell, with its process, LM. Fig. 18. Detail of the valve, process and valvocopula, SEM. Fig. 19. A valve and copulae, SEM. Fig. 20. Detail of the copulae, SEM. Fig. 21. Detail of the valve pattern areolation, SEM.

References: Peragallo 1892, p. 107, pl. 1, Figs 3-5, Cupp 1943, p. 78, Figs 40 a, b; Hasle & Syvertsen 1997, p. 163, pl. 31, Throndsen *et al*. 2007, p. 156.

Cells cylindrical and relatively large, solitary or in short to large chains. Valves truncated without processes. Girdle bands conspicuous. Dimensions: 17-52 μm diameter, 101-159 μm total length.

Distribution: Nayarit (S2) and Jalisco (S3, S4, S5, S6).

Guinardia striata (Stolterfoth) Hasle Figs 5, 6

Basionym: *Eucampia striata* Stolterfoth

Synonym: *Rhizosolenia stolterfothii* H. Peragallo

References: Peragallo 1892, p. 108, pl. 1, Figs 17, 18, Cupp 1943, p. 83, Figs 45 a-d, Hernández-Becerril 1995, p. 263, Figs 53-56, Hasle & Syvertsen 1997, p. 163, pl. 31, Throndsen *et al*. 2007, p. 156.

Cells connected in chains generally curved (or even in spiral) of variable number of cells. Cells also curved and elongate. Terminal valves pyramidal, with a process, as a long spine. Numerous chloroplasts all around the cells. Dimensions: 11-40 μm diameter, 107-203 μm total length.

Distribution: Nayarit (S2) and Jalisco (S3, S4, S6).

Genus *Neocalyptrella* Hernández-Becerril *et* Meave

Neocalyptrella robusta (Norman) Hernández-Becerril & Meave Figs 9-15

Basionym: *Rhizosolenia robusta* Norman

Synonym: *Calyptrella robusta* (Norman) Hernández-Becerril & Meave

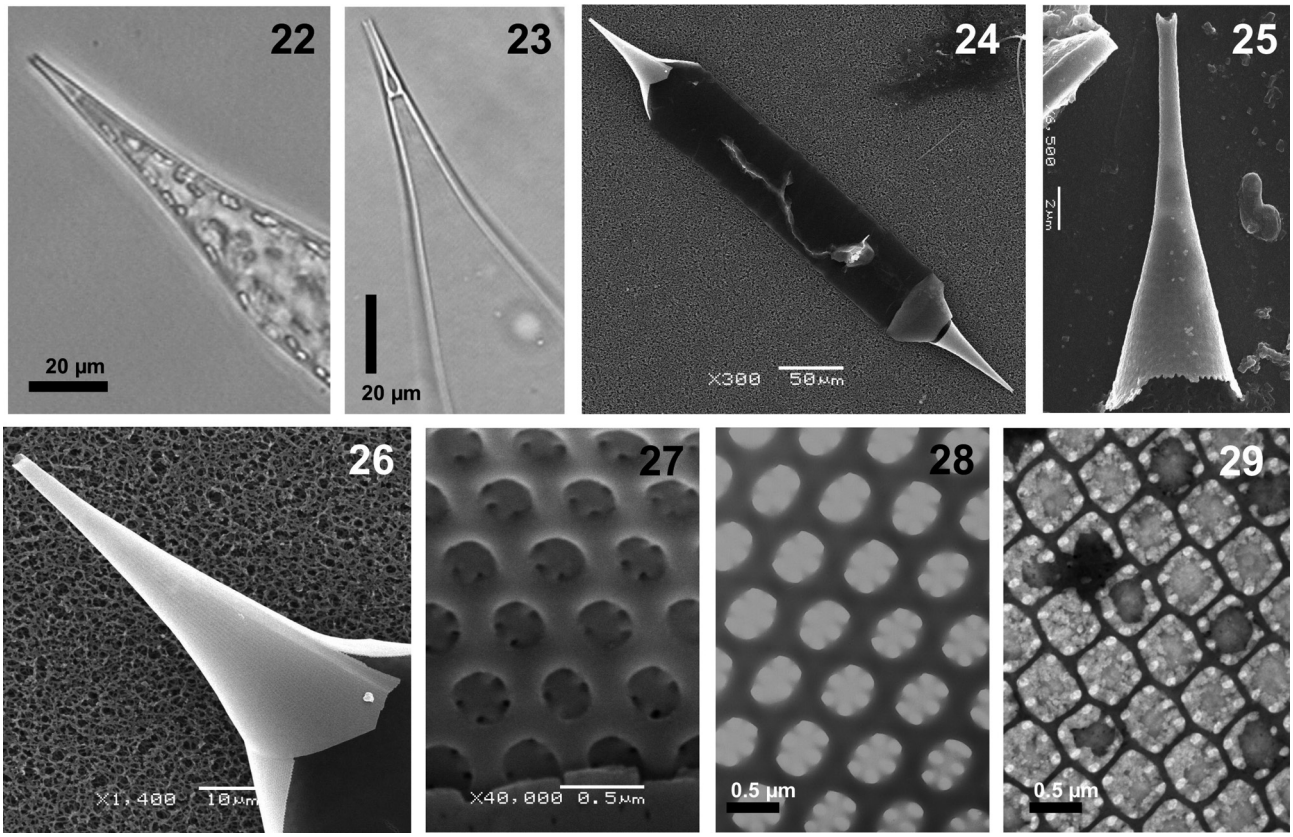
References: Cupp 1943, p. 83, Figs 46 a-i, Hernández-Becerril & Meave 1996, p. 199, Figs 1-20, Hernández-Becerril & Meave 1997, p. 329, Hasle & Syvertsen 1997, p. 159, pl. 30, Sunesen & Sar 2007, p. 637, Figs 62-67, Throndsen *et al*. 2007, p. 157.

Solitary cells, sigmoid and curved in shape. Valves conical with longitudinal ribs, ending in a long spine, sometimes this spine may be missing. A single column of girdle bands (copulae). Dimensions: 66-92 μm diameter, 121-513 μm total length, 3-14 μm length of process.

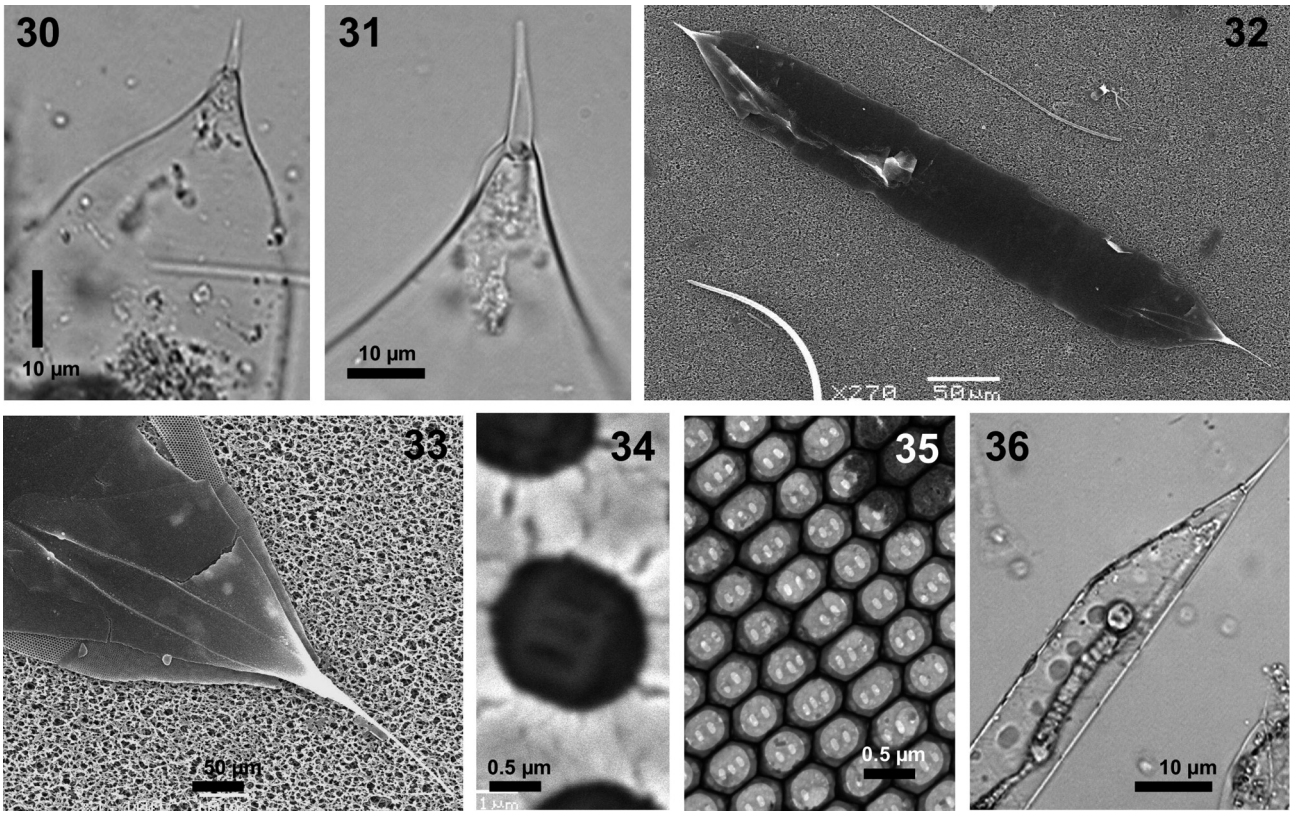
Distribution**:** Nayarit (S2), Jalisco (S3, S6), Michoacán (S7) and Oaxaca (S11).

Genus *Pseudosolenia* Sundström

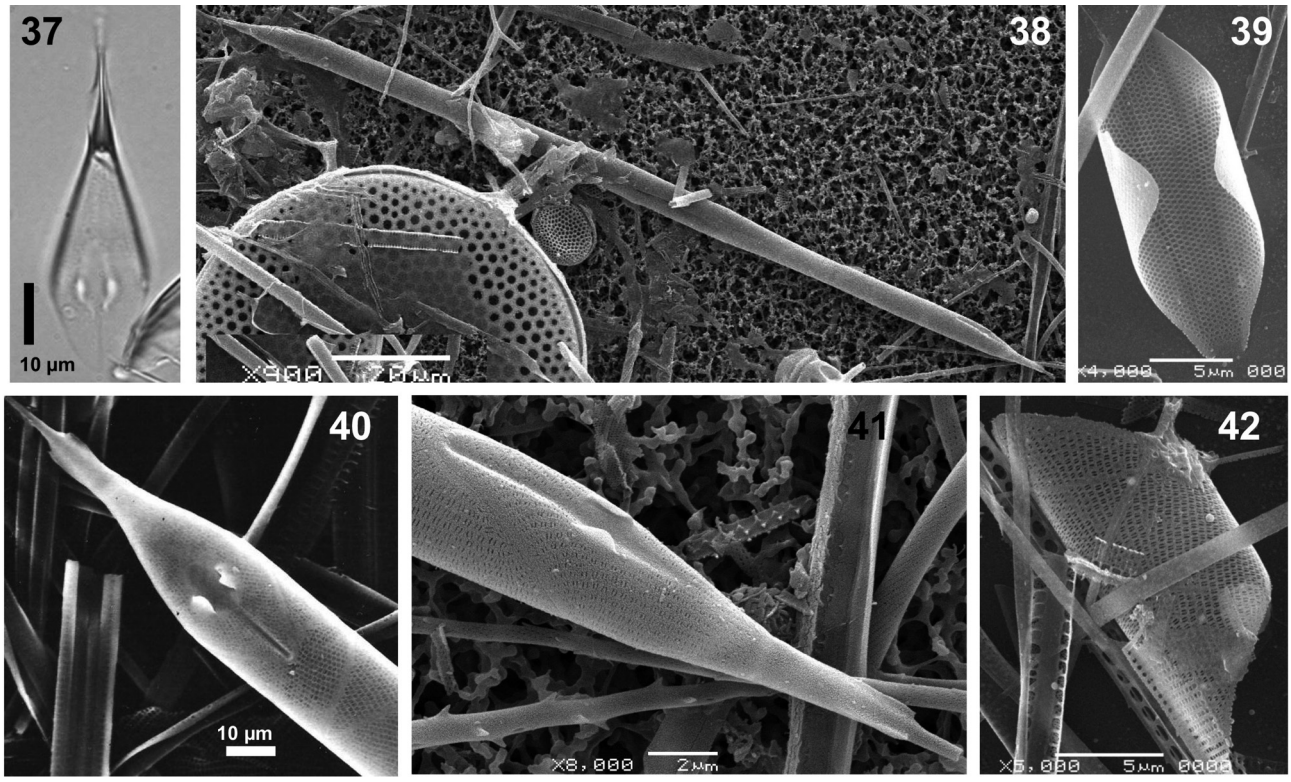
Pseudosolenia calcar-avis (Schultze) Sundström Figs 16-21



Figs 22-29. – *Rhizosolenia bergonii*. Figs 22, 23. Terminal part of cells, one with chloroplasts, and both with their process, LM. Fig. 24. Complete cell, SEM. Figs 25, 26. Details of the process, SEM. Figs 27-29. Different details of the valve wall, SEM and TEM.



Figs 30-36. – *Rhizosolenia clevei* var. *clevei* and *R. clevei* var. *communis*. Figs 30, 31. Terminal part of cell, showing process, LM. Fig. 32. Complete cell, SEM. Fig. 33. Ventral part of a valve, showing process, contiguous area and claspers, SEM. Figs 34, 35. Details of the valve areolation pattern, TEM and SEM. Fig. 36. *Rhizosolenia clevei* var. *communis*, LM.



Figs 37-42. – *Rhizosolenia decipiens*. Fig. 37. Valve showing process, contiguous area, otaria and claspers, LM. Fig. 38. Complete cell in lateral view, SEM. Figs 39, 42. Copulae in different views, SEM. Fig. 40. Valve in ventral view with process, contiguous area, otaria, claspers and some copulae, SEM. Fig. 41. Valve in lateral view showing valvocopula, SEM.

Basionym: *Rhizosolenia calcar-avis* Schultze

References: Cupp 1943, p. 89, Fig. 51, Sundström 1986, p. 95, Figs 40-46, 247-257, Hernández-Becerril 1995, p. 254, Figs 7-10, Hasle & Syvertsen 1997, p. 160, pl. 30, Sunesen & Sar 2007, p.637, Figs 68-81, Throndsen *et al*. 2007, p. 158.

Cells usually solitary, large and cylindrical. Valves conical with a sigmoid process, which tapers from the base, and no otaria are present. Two columns of copulae, rhomboidal to wing-shape. Areolae poroids, ellipsoidal, velum perforated by a slit-like pore, parallel to the main axis Dimensions: 29-55 μm diameter, 136-310 μm total length, 29-34 μm length of process.

Distribution: Nayarit (S2), and Jalisco (S3, S4, S5, S6).

Genus *Rhizosolenia* Brightwell

Rhizosolenia acuminata (H. Peragallo) H. Peragallo *in* H. & M. Peragallo Figs 69-72

Basionym: *Rhizosolenia temperei* var. *acuminata* H. Peragallo

References: Peragallo 1897-1908, p. 463, pl. 123, figs 7-8, Cupp 1943, p. 94, Fig. 53, Sundström 1986, p. 69, Figs 31 a-c, 165-176, Hernández-Becerril 1995, p. 254, Figs 11-12, Hasle & Syvertsen 1997, p. 153, pl. 29.

Large, cylindrical and solitary cells. Valves conical, with a pointed process and no otaria. Copulae arranged in multiple columns. Areolae of copulae may be nearly rectangular, with lateral margins fringed, circular foramen and six round pores, and three along each lateral margin, or more oblong and perforated by 3-6 round pores. Dimensions: 130-188 μm diameter, 377-696 μm total length, 14-29 μm length of process.

Distribution: Jalisco (S4) and Michoacán (S7).

Rhizosolenia bergonii Peragallo Figs 22-29

References: Peragallo 1892, p. 100, pl. 2, Fig. 5, Hustedt 1930, p. 575, Fig. 327, Cupp 1943, p. 81, Fig. 43, Sundström 1986, p. 72, Figs 32, 33, 177-189, Hernández-Becerril 1995, p. 256, Figs 13-16, Hasle & Syvertsen 1997, p. 155, pl. 29, Sunesen & Sar 2007, p. 629, Figs 4-15.

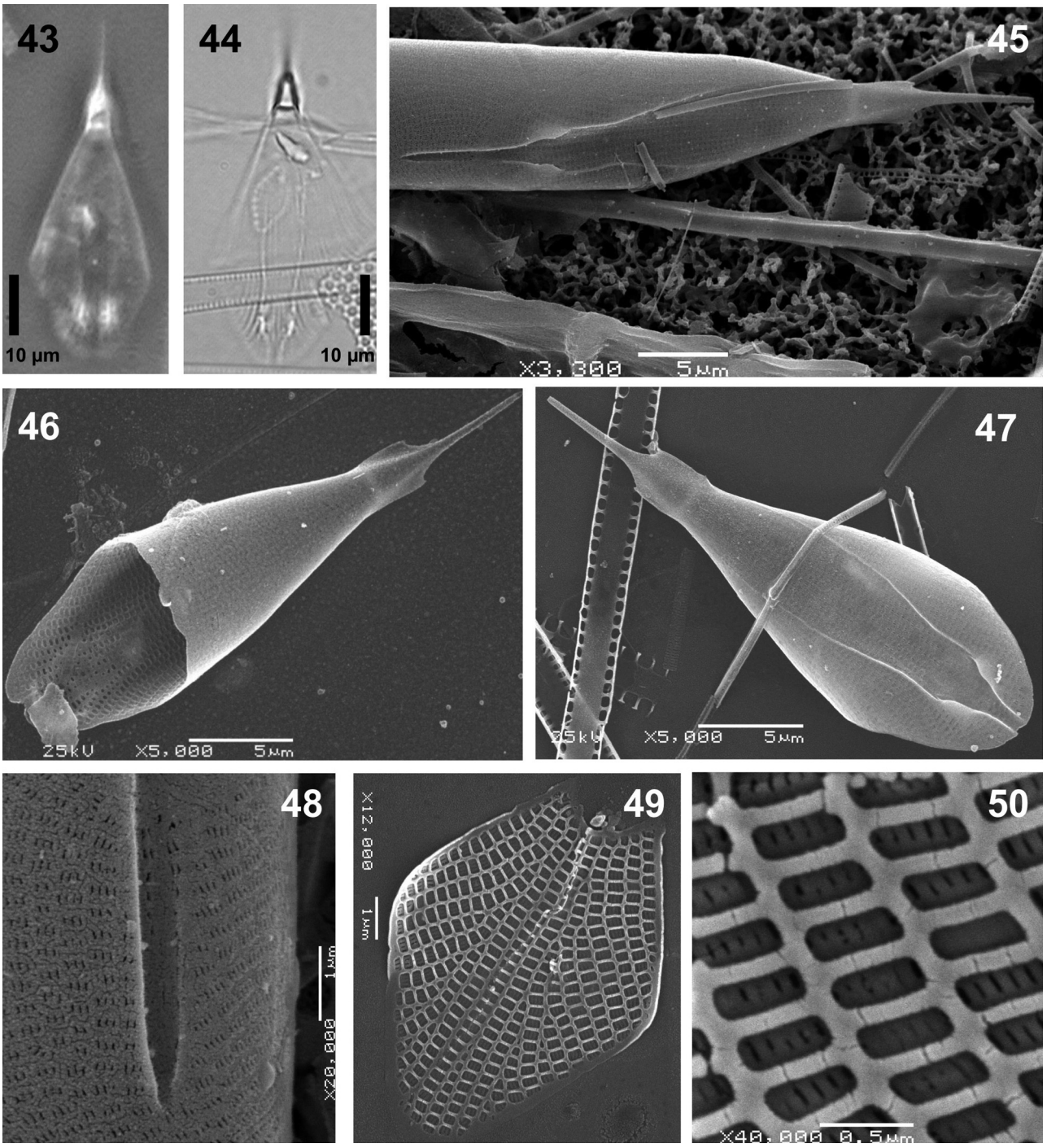
Cells solitary, cylindrical and elongate. Conical valves with a particular process, which appears bifurcate in LM, and has an opening. Otaria, contiguous area and claspers are lacking. Areolae are oblong to subrectangular, perforated by 6 pores, three located along lateral margins. Dimensions: 20-29 μm diameter, 203-406 μm total length, 11 μm length of process.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7), Guerrero (S9) and Oaxaca (S11).

Rhizosolenia clevei Ostenfeld var *clevei* . . . Figs 30-35

Synonyms: *Rhizosolenia similis* Karsten, *Rhizosolenia castracanei* Peragallo var. *rhomboidea* Subrahmanyan

References: Sundström 1984, p. 348, Figs 1, 4-9, Sundström 1986, p. 53, Figs 21, 121, 122, 125. Hasle &



Figs 43-50. – *Rhizosolenia fallax*. Figs 43, 44. Two valves showing process, contiguous area and claspers, LM. Fig. 45. Valve in lateral view, SEM. Figs 46, 47. Two valves in ventral and dorsal views, respectively, SEM. Fig. 48. Detail of cell wall, SEM. Figs 49, 50. A copula and detail of the areolation pattern, respectively, SEM.

Syvertsen 1997, p. 151, pl. 28.

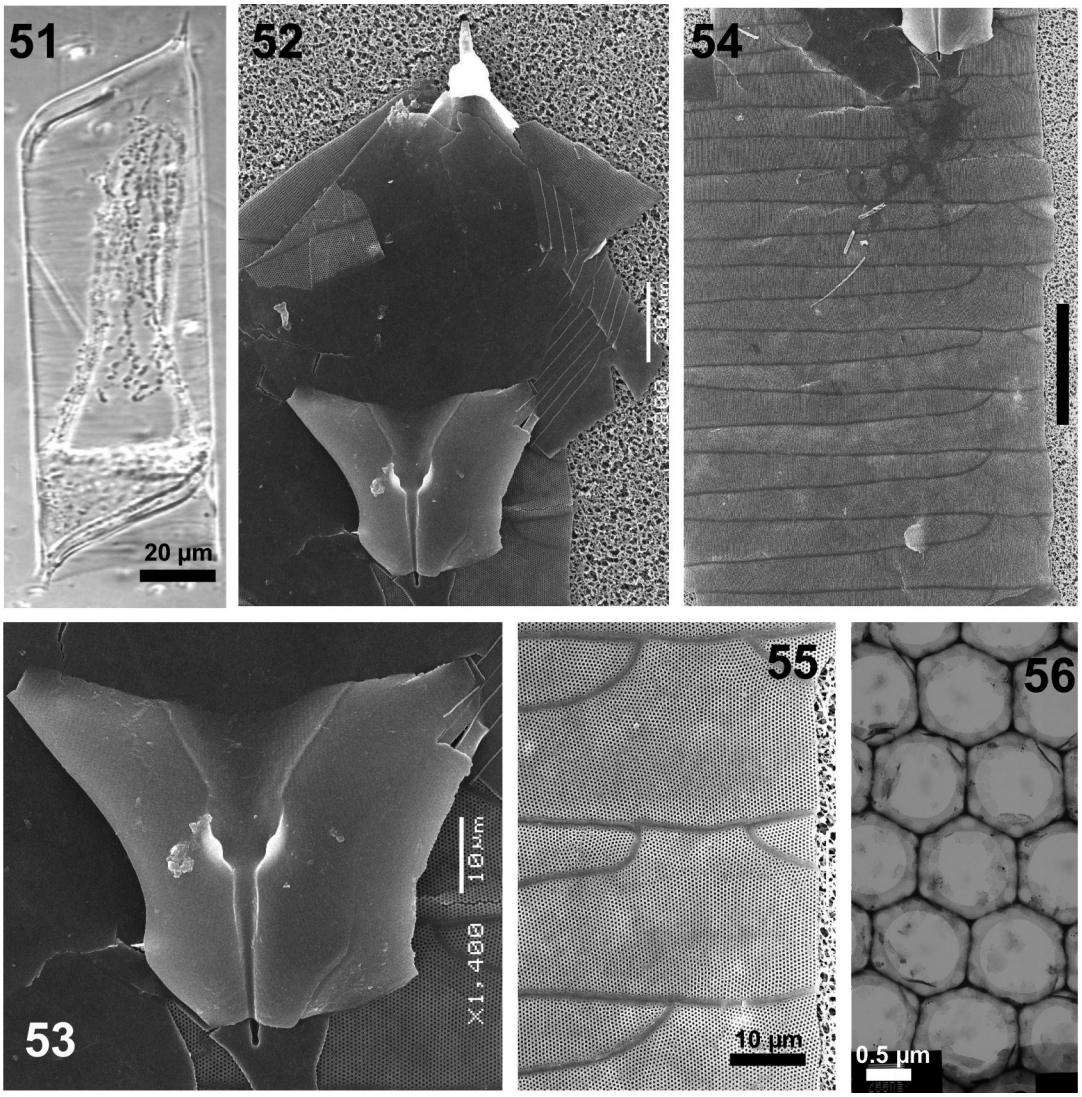
Cells large and solitary. Valves conical with a fairly large process and otaria. Contiguous area and claspers evident. Two columns of copulae are present. Areolation in copulae are rectangular to hexagonal, with circular foramen and 2-4 oblong pores parallel to the main axis. Dimensions: 26-55 μm diameter, 246-609 μm total length, 14-29 μm length of process.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), Guerrero (S9) and Oaxaca (S11).

Rhizosolenia clevei var. *communis* Sundström

Fig. 36

References: Sundström 1984, p. 348, Figs 2, 3, 10-15, Sundström 1986, p. 54, Figs 124, 126-127, Hernández-Becerril 1995, p. 256, Figs 20-22, Hasle & Syvertsen



Figs 51-56. – *Rhizosolenia formosa*. Fig. 51. Complete cell, LM. Fig. 52. Valve showing process, contiguous area and claspers, SEM. Fig. 53. Detail of contiguous area and claspers, SEM. Fig. 54. Copulae, SEM. Fig. 55. Detail of copulae, SEM. Fig. 56. Areolae from copulae, TEM.

1997, p. 151, pl. 28.

Cells solitary, very often containing the Cyanobacterium *Rhichelia intracellularis* Schmidt. Valves triangular (lateral view) to conical (ventral or dorsal views), with a pointed process. Dimensions: 7-46 μm diameter, 240-600 μm total length, 13-27 μm length of process.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), Guerrero (S9) and Oaxaca (S11).

Rhizosolenia crassispina Schröder Figs 76-80

References: Sournia 1968, p. 73, pl. 2, Figs 11 a, b, pl. 10, Fig. 67, Hernández-Becerril 1995, p. 264, Figs 23-24.

Large and solitary (or in pairs) cells. Valves conical with a large and long process. The process is inflated about its middle part and then it becomes very thin. No otaria, contiguous area, or claspers present. Elongate chloroplasts all over the cell. Dimensions: 29-43 μm diameter, 203-334 μm total length, 30-52 μm length of process.

Distribution: Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), and Oaxaca (S11).

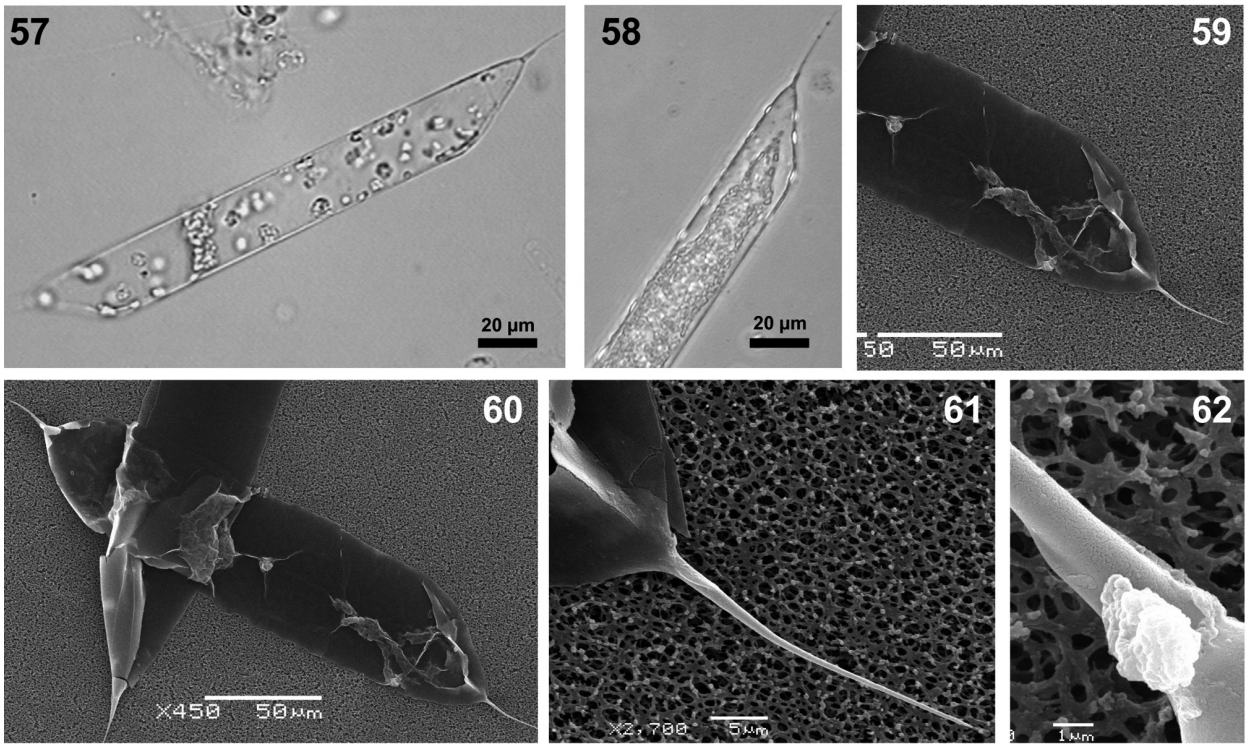
Rhizosolenia decipiens Sundström Figs 37-42

References: Sundström 1986, p. 92, Figs 39, 234-240, Hasle & Syvertsen 1997, p. 156, pl. 29.

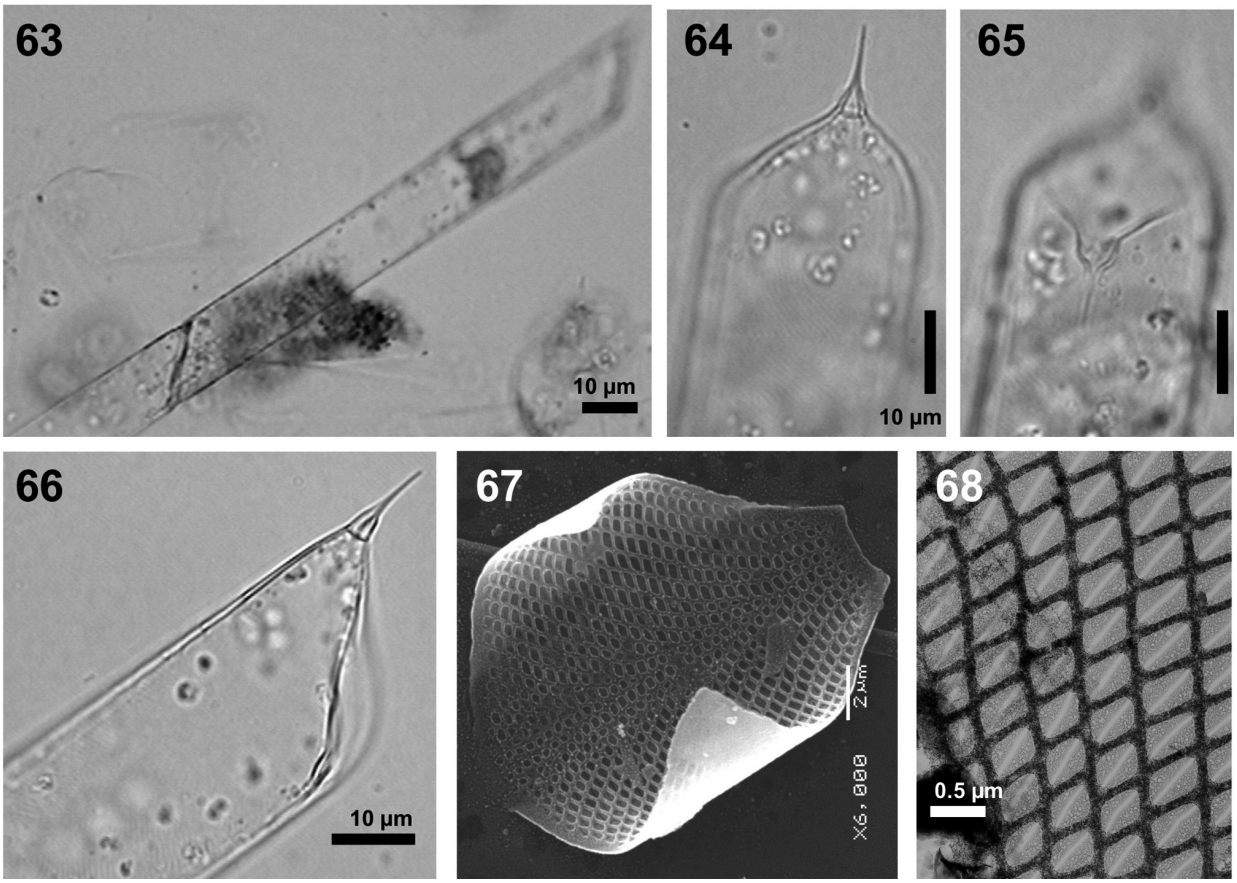
Cells solitary or in pairs, long and cylindrical. Valves conical, with the ventral part longer than the dorsal one, long process and otaria arising from the middle or 2/3 of the length of the process, contiguous area narrow and claspers evident. Two columns of copulae. Areolation of valve and copulae rectangular, with a single thin rod dividing two elongate pores perpendicular to the main axis. Dimensions: 15-20 μm diameter, 145-168 μm total length, 9-12 μm length of process.

Distribution: Michoacán (S7, S8), and Oaxaca (S11).

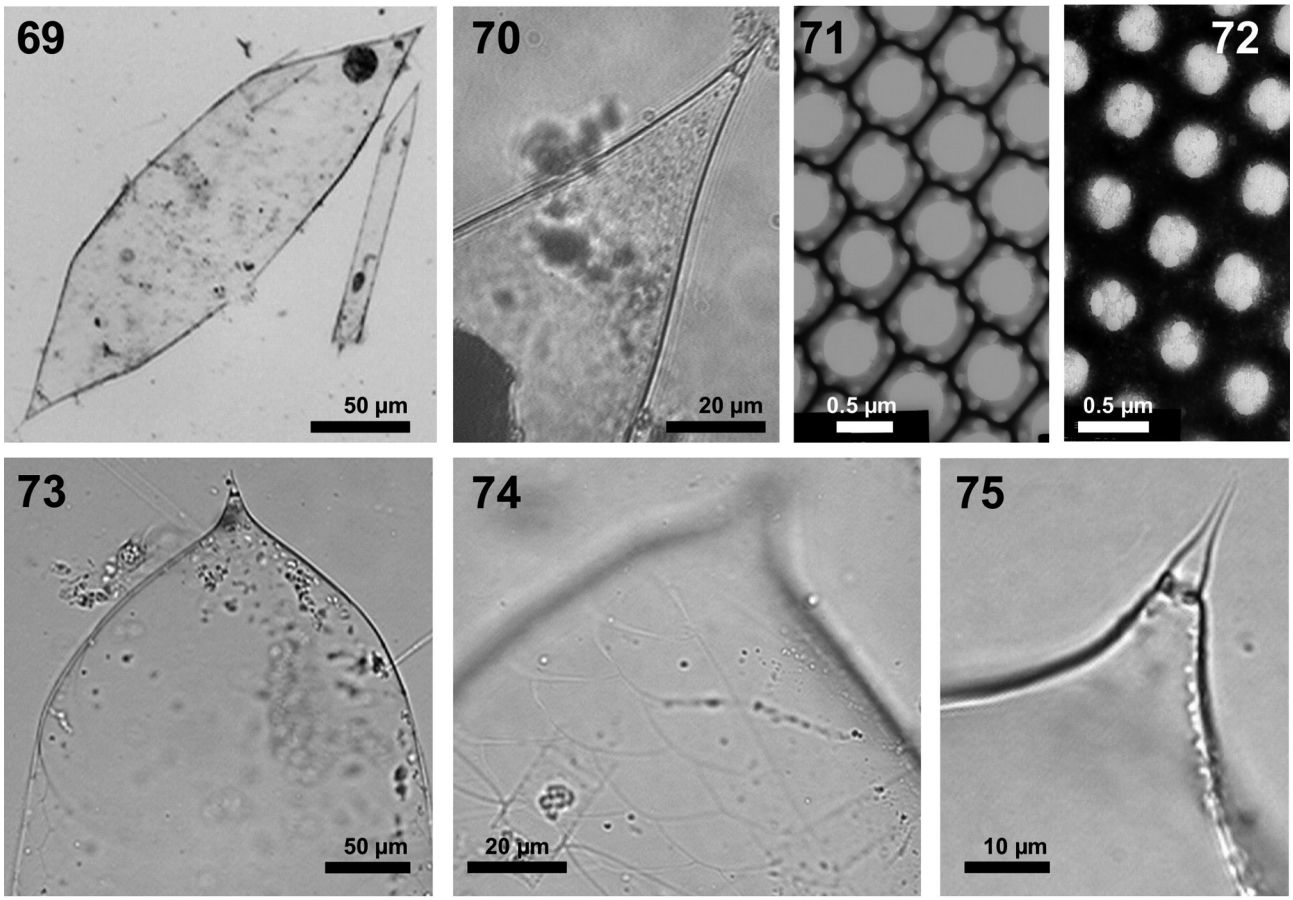
Rhizosolenia fallax Sundström Figs 43-50



Figs 57-62. – *Rhizosolenia hyalina*. Fig. 57. Complete cell with chloroplasts, LM. Fig. 58. Terminal part of cell, showing process, LM. Figs 59, 61. Details of terminal part of cell and process, SEM. Fig. 60. Complete cell, SEM. Fig. 62. Detail of process, SEM.



Figs 63-68. – *Rhizosolenia imbricata*. Fig. 63. Two cells connected in a chain, LM. Figs 64, 65. Valve, showing process, otaria, contiguous area and claspers, focus varies, LM. Fig. 66. Terminal part of a cell in lateral view, LM. Fig. 67. One copula, SEM. Fig. 68. Detail of the cell wall, TEM.



Figs 69-75. – *Rhizosolenia acuminata* and *R. temperei*. Figs 69, 70. Complete cell and terminal part showing the process, LM. Figs 71, 72. Details of cell wall, TEM. Figs 73-75. *Rhizosolenia temperei*. Figs 73, 74. Terminal part of cell, showing process and copulae, respectively, LM. Fig. 75. Detail of process, LM.

References: Sundström 1986, p. 89, Figs 38, 227-233, Hasle & Syvertsen 1997, p. 156, pl. 29.

Cells cylindrical, elongate and generally solitary. Valves conical with a large process and conspicuous otaria, which arise from 1/3 to the middle of the length of the process. Contiguous area and claspers occur in the ventral part of the valves. Two columns of copulae. Copulae with areolation consisting of rectangles perforated by 2-5 longitudinal slits. Dimensions: 30 μm diameter, 250-470 μm total length, 28 μm length of process.

Distribution: Jalisco (S6), and Oaxaca (S11).

Rhizosolenia formosa Peragallo Figs 51-56

Synonym: *Rhizosolenia styliformis* fo. *altisima* Brightwell *in* Peragallo.

References: Peragallo 1888, p. 83, pl. 6, Fig. 43, Sundström 1986, p. 33, Figs 88-93, 96-99, Hernández-Becerril 1995, p. 256, Figs 25-28, Hasle & Syvertsen 1997, p. 146, pl. 26.

Cells are very large and solitary. Valves conical, asymmetrical, with a process on the tip and otaria. Contiguous area and claspers in the ventral part of the valves. The copulae are arranged in two dorsiventral columns, very elongate laterally. The areolation is hexagonal in the copulae, foramen circular, velum perforated by six round pores located at the angles of each hexagon. Dimensions: 110-153 μm diameter, 188-826 μm total length, 17-30 μm length of process.

Distribution: Jalisco (S6).

Rhizosolenia hyalina Ostenfeld *in* Ostenfeld *et* Schmidt Figs 57-62

Synonym: *Rhizosolenia pellucida* Cleve

References: Sundström 1986, p76, Figs 190-192, Hernández-Becerril 1995, p. 258 Figs 32, 33, Hasle & Syvertsen 1997, p. 151, pl. 28; Sunesen & Sar 2007, p. 631, Figs 16-24.

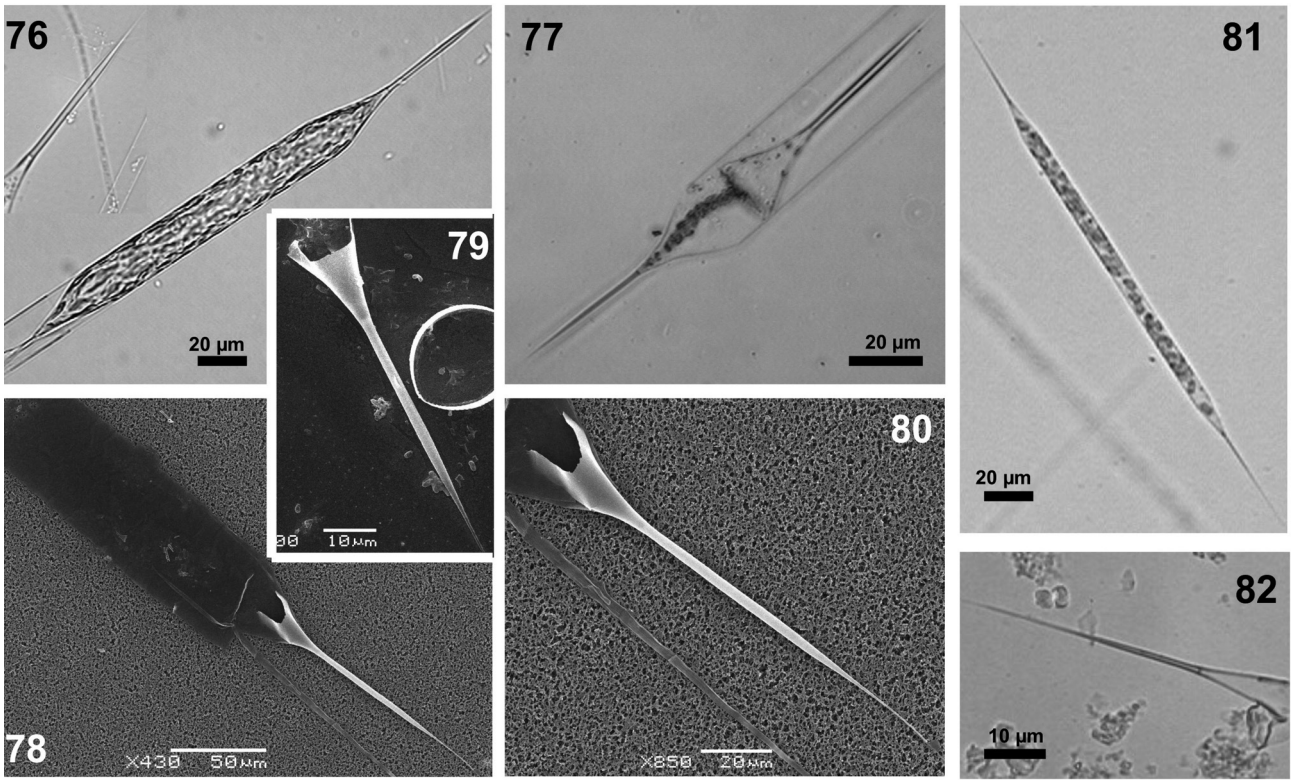
Cells solitary or in short chains (up to three cells). Valves from conical to triangular, undulated in lateral view, with a characteristic process (thicker at its base, not straight, but rather bent around the midpoint) and otaria. Two columns of copulae. Dimensions: 14-43 μm diameter, 232-377 μm total length, 20-29 μm length of process.

Distribution: Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), Guerrero (S9, S19) and Oaxaca (S11).

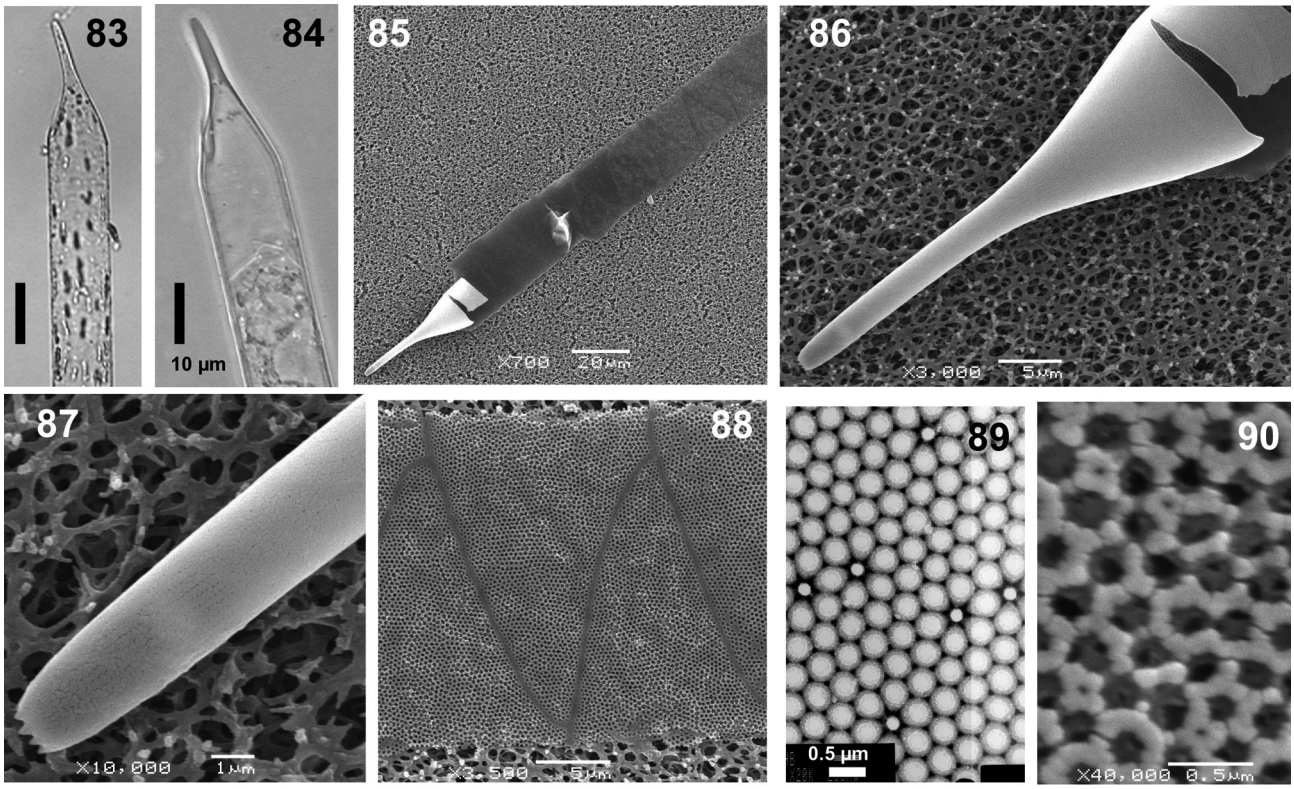
Rhizosolenia imbricata Brightwell Figs 63-68

Synonyms: *Rhizosolenia shrubsolei* Cleve, *Rhizosolenia imbricata* var. *shrubsolei* (Cleve) Schröder

References: Sundström 1986, p. 80, Figs 200-204,



Figs 76-82. – *Rhizosolenia crassispina* and *R. setigera*. Fig. 76. Complete cell with chloroplasts, LM. Fig. 77. Two cells, one being produced, LM. Fig. 78. Terminal part of cell, SEM. Figs 79, 80. Detail of processes, SEM. Figs 81, 82. *Rhizosolenia setigera*, complete cell and detail of process, LM.



Figs 83-90. – *Proboscia indica*. Figs 83, 84. Terminal part of cells, one with chloroplasts, LM. Fig. 85. Terminal part of cell, SEM. Figs 86, 87. Details of proboscis, SEM. Fig. 88. Detail of cingulum showing copulae, SEM. Figs 89, 90. Details of areolation pattern of copulae, TEM and SEM, respectively.

Hernández-Becerril 1995, p. 258, Figs 46-49, Hasle & Syvertsen 1997, p. 155, pl. 29, Sunesen & Sar 2007, p. 634, Figs 48-61, Throndsen *et al*. 2007 p. 162.

Cells cylindrical, solitary or in chains. Valves conical to triangular and undulated in lateral view with a large process. The process is triangular at its base and has otaria. Valves have contiguous area and claspers. Two columns of copulae. Copulae have a characteristic areolation with the velum of a diagonal slit on each rectangular areola.

Dimensions: 16-43 μm diameter, 145-406 μm total length, 8-17 μm length of process.

Distribution: Jalisco (S3, S4, S5, S6), Guerrero (S9) and Oaxaca (S11).

Rhizosolenia setigera Brightwell Figs 81, 82

References: Hustedt 1930, p. 588, Fig. 336, Cupp 1943, p. 88, Fig. 49, Sundström 1986, p. 104, Figs 286-288, Hernández-Becerril 1995, p. 264, Figs 44, 45, Hasle & Syvertsen 1997, p. 157, pl. 30; Sunesen & Sar 2007, p. 633, Figs 25-34, Throndsen *et al*. 2007, p. 161.

Cells solitary or in pairs, cylindrical, thin and elongate. Valves conical with a long and sharp process with no otaria. The process is tapering gradually to its end. Round chloroplasts are present all over the cell. Dimensions: 6-18 μm diameter, 150-185 μm total length.

Distribution: Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), and Oaxaca (S11).

Rhizosolenia temperei Peragallo . . . . . Figs 73-75

References: Peragallo 1888, p. 83, pl. 5, Fig. 40, Sundström 1986, p 66, Figs 30, 155-163, Hernández-Becerril 1995, p. 258, Figs 41, 42, Hasle & Syvertsen 1997, p. 151, pl. 29.

Very large and solitary cells. Valves conical to more rounded, asymmetrical, with a large process and no otaria. Several columns of copulae. Dimensions: 171 μm diameter, 377 μm total length, 15 μm length of process.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S4) and Michoacán (S8).

Family Probosciaceae Jordan *et* Logowski

Genus *Proboscia* Sundström

Proboscia indica (Peragallo) Hernández-Becerril *emend*. Jordan & Logowski Figs 83-90

Basionym: *Rhizosolenia indica* H. Peragallo

Synonym: *Rhizosolenia alata* fo. *indica* (Peragallo) Gran

References: Hustedt 1930, p. 602, Fig. 346: Cupp 1943, p. 93, Fig. 52-C, Hernández-Becerril 1995, p. 254, Figs 5, 6, Sunesen & Sar 2007, p. 639, Figs 89-97, 99.

Cells usually solitary or in pairs. Valves conical with a proboscis of variable length and minute spines at its tip. Contiguous area resembles a groove, with no claspers. Two columns of copulae. Hexagonal areolae in copulae with a circular foramen, and interlocular pores scattered between areolae, surrounded by six areolae. Elongate chloroplasts all over the cell. Dimensions: 12-29 μm diameter, 203-507 μm total length, 25-43 μm length of proboscis.

Distribution: Sinaloa (S1), Nayarit (S2), Jalisco (S3, S4, S5, S6), Michoacán (S7, S8), Guerrero (S9, S10) and Oaxaca (S11).

DISCUSSION

In this paper, a total of 20 taxa (18 species and two varieties) were identified and studied, including 12 taxa belonging to *Rhizosolenia*, 3 species to *Guinardia*, 2 species to *Dactyliosolen*, and one species to the genera *Neocalyptrella*, *Proboscia* and *Pseudosolenia*. All taxa found are considered to be marine and planktonic, and all of the genera belong to the diatom Order Rhizosoleniales.

New findings for the Mexican Pacific Ocean (and indeed in Mexican marine waters) are: *Dactyliosolen blavyanus*, *Rhizosolenia decipiens* and *Rhizosolenia fallax*. In fact, there are no further references about the presence, morphology and distribution of the species *Rhizosolenia decipiens* and *R. fallax*, since their original description by Sundström (1986), and the present study is a contribution to the knowledge of these two species. Hasle & Syvertsen (1997) established the distribution of both species, *Rhizosolenia decipiens* as a warm water regions form, whereas *Rhizosolenia fallax* was considered as a temperate to tropical waters form, however they were only cited Sundström (1986).

Additionally, the species *Rhizosolenia clevei* var. *clevei* is studied and illustrated for the first time in the Mexican Pacific. This species was annotated as occurring in the Mexican Pacific, but with no available illustration (Meave del Castillo *et al*. 2003). Many details in SEM and TEM of many species, especially of the genera *Neocalyptrella*, *Proboscia*, *Pseudosolenia* and *Rhizosolenia*, are provided here, particularly the vela of the valve wall.

Previous studies of species of genera from the order Rhizosoleniales, notably *Rhizosolenia*, in the Mexican Pacific (Gárate-Lizárraga 1989, Hernández-Becerril 1995, Moreno *et al*. 1996; Gárate-Lizárraga *et al*. 2003) and the list of planktonic diatoms from the Mexican Pacific (Meave del Castillo *et al*. 2003) indicate the presence of 21 taxa of *Rhizosolenia* (the most diverse genus in the order Rhizosoleniales). From the 28 taxa recorded by Hernández-Becerril (1995), the species that were not found in this study are: *Proboscia alata* (Brightwell) Sundström, *Rhizosolenia castracanei* H. Peragallo, *Rhizosolenia debyana* H. Peragallo, *Rhizosolenia hebetata* fo. *semispina* (Hensen) Gran, *Rhizosolenia pungens* Cleve-Euler and *Guinardia delicatula* (Cleve) Hasle. We can now count up to 23 *Rhizosolenia* taxa found in the Mexican Pacific Ocean. The most frequent species in this study were: *Guinardia striata*, *Pseudosolenia calcar-avis*, *Rhizosolenia bergonii* and *R. imbricata*.

Many of the taxa (species, varieties and forms) found in this study are regarded as tropical to subtropical in distribution, with very few considered more temperate or

widely distributed in warm to temperate waters. Particularly large forms as *Dactyliosolen phuketensis*, *Neocalyptrella robusta*, *Proboscia indica*, *Rhizosolenia acuminata*, *R. crassispina*, *R. formosa* and *R. temperei* are commonly referred to as more tropical forms, whereas *Guinardia flaccida*, *G. striata*, *Pseudosolenia calcar-avis*, *Rhizosolenia bergonii, R. setigera* may be found in more temperate to colder waters.

We may consider that detailed studies are still lacking to recognize not only the presence of some other tropical and subtropical *Rhizosolenia* species, but the possibility of description of new species of the genus and other genera related: Sundström (1986) showed a number of different species occurring in tropical and subtropical waters that have not been recorded as yet in the Mexican Pacific, and other not sufficiently studied species distributed in such environs. Two species poorly studied (and yet not recorded or recognized since their original description) are *Rhizosolenia atlantica* H. Peragallo and *Rhizosolenia pacifica* H. Peragallo, described by Peragallo (1892), which may be widely distributed in temperate and subtropical areas, and which show a superficial similarity with both *Rhizosolenia decipiens* and *Rhizosolenia fallax*. Future studies will possibly indicate conspecificity and distribution features of the species.

ACKNOWLEDGEMENTS. – Many thanks are due to Dr Ma L Machain for her invitation to participate in the oceanographic cruise TEHUA V. Recognition is also due to Biol Y Hornelas Orozco (SMEB, ICMyL, UNAM) for facilities in the SEM. Two anonymous reviewers contributed to improve previous versions of the paper.

REFERENCES

Anonymous 1975. Proposals for a standardization of diatom terminology and diagnoses. *Nova Hedw Beih* 53: 323-354.

Boltovskoy A 1995. Técnicas de microscopía electrónica de barrido: aplicación a las microalgas. *In* Alveal K, Ferrario ME, Oliveira EC Sar EA eds, Manual de Métodos Ficológicos, Universidad de Concepción, Concepción, Chile: 119-138.

Cupp EE 1943. Marine plankton diatoms of the west coast of North America. *Bull Scripps Inst Oceanogr* 5: 1-238.

Gárate-Lizárraga I 1989. Nuevos registros de especies del género *Rhizosolenia* en la región central del Golfo de California y Bahía Magdalena B.C.S. *Inv Mar CICIMAR* 4: 291-296.

Gárate-Lizárraga I, Siqueiros-Beltrones DA, Maldonado-López V 2003. First record of a *Rhizosolenia debyana* bloom in the Gulf of California, Mexico. *Pac Sci* 57: 141-145.

Hasle GR 1975. Some living marine species of the diatom family Rhizosoleniaceae. *Nova Hedw Beih* 53: 99-153.

Hasle GR Syvertsen EE 1997. Marine diatoms. *In* Tomas CR ed, Identifying Marine Phytoplankton, Academic Press, San Diego: 5-385.

Hernández-Becerril DU 1995. Planktonic diatoms from the Gulf of California and coasts off Baja California: the genera *Rhizosolenia, Proboscia, Pseudosolenia*, and former *Rhizosolenia* species. *Diatom Res* 10: 251-267.

Hernández-Becerril DU, Meave del Castillo ME 1996. The marine planktonic diatom *Rhizosolenia robusta* (Bacillariophyta): morphological studies support its transfer to a new genus, *Calyptrella* gen. nov. *Phycologia* 35: 198-203.

Hernández-Becerril DU, Meave del Castillo ME 1997. *Neocalyptrella,* gen. nov., a new name to replace *Calyptrella* Hernández-Becerril et Meave. *Phycologia* 36: 329.

Hustedt F 1930. Die Kieselalgen Deutschland, Osterreichs und der Schweiz. Rabenhorst, L. Kryptogamenflora. Akad. Verlag. Leipzig 7(1).

Jordan RW, Ligowski R 2004. New observations on *Proboscia* auxospores and validation of the family Probosciaceae fam. nov. *Vie Milieu* 54: 91-103.

Meave del Castillo ME, Zamudio-Reséndiz ME, Aké-Castillo J, Guerra-Martínez SL Barbosa-Ledesma IF 2003. Biodiversidad de diatomeas (Bacillariophyta) en la columna de agua del Pacífico Mexicano. *In* Barreiro-Güemes MT Meave del Castillo ME Signoret-Poillon M Figueroa-Torres MG eds, Planctología Mexicana, Sociedad Mexicana de Planctología, A.C. México: 43-84.

Medlin LK, Kaczmarska I 2004. Evolution of the diatoms: V. Morphological and cytological support for the major clades and a taxonomic revision. *Phycologia* 43: 245-270.

Moreno JL, Licea S, Santoyo H 1996. Diatomeas del Golfo de California. Universidad Autónoma de Baja California Sur, Mexico.

Peragallo H 1892. Monographie du genre *Rhizosolenia* et de quelques genres voisins. *Le Diatomiste* 1: 79-82, 99-117, 1-5 pls.

Peragallo H 1888. Diatomées de la Baie de Villefranche. *Bull Soc Hist Nat Toulouse* 22: 1-100.

Peragallo H, Peragallo M 1897-1908. Diatomées marines de France et des districts maritimes voisins. M. J. Tempère, 491 p., 137 pls.

Ross R, Cox EJ, Karayeva NI, Mann DG, Paddock TBB, Simonsen R, Sims PA 1979. An amended terminology for the siliceous components of the diatom cell. *Nova Hedw Beih* 64: 513-533.

Round FE, Crawford RM, Mann DG 1990. The Diatoms. Biology and morphology of the genera. Cambridge University Press, Cambridge.

Simonsen R 1974. The diatom plankton of the Indian Ocean expedition of R.V. "Meteor" 1964-1965. *Meteor Forsch Ergebn*, *Reihe D* 19: 1-66, 41 pls.

Sournia A 1968. Diatomées planctoniques du Canal de Mozambique et de l'Île Maurice. *Mém ORSTOM* 31: 1-120, 13 pls.

Sundström B 1980. *Rhizosolenia phuketensis* sp. nov. and *Rhizosolenia stolterfothii* H. Peragallo (Bacillariophyceae). *Bot Notiser* 133: 579-583.

Sundström B 1984. Observations on *Rhizosolenia clevei* Ostenfeld (Bacillariophyceae) and *Richelia intracellularis* Schmidt (Cyanophyceae). *Bot Mar* 27: 345-355.

Sundström B 1986. The marine diatom genus *Rhizosolenia*. A new approach to the taxonomy. Ph D Diss, Lund University, Sweden.

Sunesen I, Sar EA 2007. Marine diatoms from Buenos Aires coastal waters (Argentina). IV. *Rhizosolenia* s. str., *Neocalyptrella*, *Pseudosolenia*, *Proboscia*. *Phycologia* 46: 628-643.

Throndsen J, Hasle GR, Tangen K 2007. Phytoplankton of Norwegian coastal waters. Almater Forlag AS, Oslo.

Received November 4, 2009
Accepted May 19, 2010
Associate Editor: C Gobin