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A Survey of the Marine Diatoms of Puerto Rico I. Suborders Coscinodiscineae and Rhizosoleniineae

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Abstract

A taxonomic study on the marine diatoms from the southwestern coast of Puerto Rico is reported in this paper.

Two suborders of the order Centrales, with 6 families, 11 genera, 25 species, 3 varieties and 2 forms were observed. Nine of these taxa had never been reported from the coasts of Puerto Rico and one is new for Puerto Rico and the Caribbean Sea.

The best represented genera were *Coscinodiscus* and *Rhizosolenia*. Most of the identified species were cosmopolitan and neritic, although oceanic and tychopelagic forms were also observed.

Introduction

The general characteristics of the phytoplankton in the productive oceanic areas are well known but there is very little knowledge regarding the marine phytoplankton in the coastal regions of the Caribbean Sea and the southeastern United States. Investigators attempting to identify marine diatoms in these areas have very few sources of reference and usually base their studies and identifications on works from other parts of the world.

For the area of Puerto Rico there is only a single work of relevance, Hagelstein (1938), which was part of the Scientific Survey of Puerto Rico and the Virgin Islands and in which many freshwater diatoms are also included. Other references for Puerto Rico are represented by the listings of species by Margalef (1957–1961a–1962) and by Lyons (1973). Diatoms were also mentioned in the ecological works of Glynn (1973) and Glynn, Almodóvar and González (1964).

Works from other parts of the Caribbean in which the marine diatoms or phytoplankton were studied are: Venezuela-Hulburt (1963–1968), Margalef (1965), Mazparrote, A. Voltolina and D. Voltolina (1971), Reyes (1975) and Ferraz de Reyes (1977); Colombia-Vidal and Carbonell (1977) and Caycedo (1977); Cuba-Suárez Caabro (1959) and López and Vinogradova (1972–1974) and Jamaica-Buchanan (1971).

It is the main purpose of this paper to provide an annotated taxonomic listing of the marine diatoms of this region of the Caribbean concentrating on the southwestern coast of Puerto Rico.

Methods

The study area extends from Isla Caja de Muertos near Ponce to La Parguera, Lajas. Most of the samples were taken at the fixed stations set at station 2 – Bahía Fosforescente (Phosphorescent Bay) and station 1 – the exposed part of Cayo Enrique and Cayo la Gata (Enrique-Gata Reef) (Fig. 1). Annual water temperature at these stations ranges from 26°–30 °C.

Samples were collected monthly for a period spanning two years (October 1975–March 1978). Phytoplankton were collected with a 0.5 m diameter, 80 µm mesh conical ring net towed from a small boat for 15 min. at low speed. Samples were then preserved in 5% unbuffered formalin and kept in 30 ml bottles from which subsamples were taken for qualitative analysis of weakly silicious species or either submitted to a treatment for heavily silicious forms (Müller-Melchers and Ferrando 1956). The bottles and slides from stored net hauls were cataloged in the laboratory for further reference.

All diatoms were studied with a Zeiss microscope equipped with phase contrast optics and photographed with a Nikon F2SB camera.

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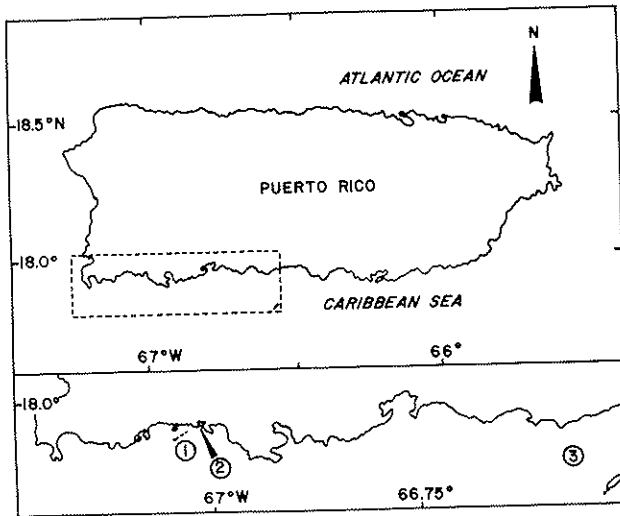


Fig. 1. Map of Puerto Rico and the area showing sampling locations: 1, Cayo Enrique-Gata; 2, Bahía Fosforescente and 3, between Ponce and Isla Caja de Muertos.

During the course of this study, the author visited the Academy of Natural Sciences of Philadelphia to identify some species which were of doubtful identity. Those "in doubt" species were compared with forms in the following diatom collections: A. N. S. P. General Collection; H. L. Smith Collection; Wm. Smith Collection; Tempère and Peragallo Collection and the Van Heurck Collection. Some of the species were also compared to the Cheever Collection at the Farlow Herbarium at Harvard University in Boston, Massachusetts. Two species which could not be confirmed at the time were later identified by Dr. Grethe Hasle at the University of Oslo in a personal communication.

The most relevant works used for the identifications were: Schmidt (1874–1959); Hustedt (1927–1966); Cupp (1943); Hendey (1964); Sournia (1968); and Van Landingham (1967–1979). The works of Hustedt (1955) and Margalef (1961b) were used for citations of ecological distribution. Classification of the species was based on the phylogenetic system proposed by Simonsen (1979). Table I provides a key for the coded citations used in the Caribbean Sea listing for each species.

Observations

Order – Centrales

Suborder – Coscinodiscineae

Family – Thalassiosiraceae

Skeletonema costatum (Grev.) Cl. 1878. Bih. K. Svenska Vetenska Akad. Handl. 5 (8): 18. Figure 2

Ecology and Distribution: Marine, neritic, eurythermal, euryhaline; cosmopolitan (4*, 18, 36, 17, 43, 30, 16, 9, 11, 13, 31, 22, 23, 48, 24, 40, 7, 41, 25, 15, 21, 19, 45, 34, 2, 46 and 44).

* See Table I

Tab. I. Key for citation codes for references of species from the Caribbean Sea and Tropical or Subtropical Atlantic Ocean

1– Buchanan (1971)	26– Mazparrote <i>et al.</i> (1971)
2– Caycedo (1977)	27– Miller <i>et al.</i> (1977)
3– Cleve (1878)	28– Montgomery & Miller (1978)
4– Davis (1950)	29– Moreira Filho (1960)
5– DeFelice & Lynts (1978)	30– Moreira Filho (1961)
6– Ferraz de Reyes (1977)	31– Moreira Filho (1964)
7– Hargraves <i>et al.</i> (1970)	32– Moreira Filho & Kutner (1962)
8– Hulburt (1962)	33– Moreira Filho <i>et al.</i> (1967)
9– Hulburt (1963)	34– Moreira Filho <i>et al.</i> (1975)
10– Hulburt (1964)	35– Müller-Melchers (1955)
11– Hulburt (1966)	36– Müller-Melchers (1957)
12– Hulburt (1967)	37– Ostrup (1913)
13– Hulburt (1968)	38– Riley (1967)
14– Hulburt & Corwin (1972)	39– Saunders (1967)
15– Hulburt & MacKenzie (1971)	40– Saunders & Glenn (1969)
16– Hulburt & Rodman (1963)	41– Smayda (1970)
17– Hulburt <i>et al.</i> (1960)	42– Suárez Caabro (1959)
18– Hustedt (1955)	43– Takano (1960)
19– Ivanov (1973)	44– Tester & Steidinger (1979)
20– King (1950)	45– Turner & Hopkins (1974)
21– López & Vinogradova (1972)	46– Vidal & Carbonell (1977)
22– Margalef (1965)	47– Wahlquist (1966)
23– Margalef (1969)	48– Wood (1968)
24– Margalef & González (1969)	49– Wood (1971)
25– Marshall (1971)	

Cited by Margalef (1957) and by Glynn *et al.* (1964), for the southern coast of Puerto Rico. Observed in samples from Cayo Enrique-Gata, Bahía Fosforescente and Bahía Ponce. Measurements: Diameter 3–10 μm . Collection: In bottles – Cayo Enrique-Gata, November 1977.

Thalassiosira anguste-lineata (?) (Schmidt) Fryxell & Hasle 1977. Nova Hedwigia 54:73, Figures 22–34. Figure 3

Ecology and Distribution: Marine, neritic; cosmopolitan (43, 16, 10, 12 and 22). A new record for the waters around Puerto Rico. Very rare in samples from Cayo Enrique-Gata. Measurements: Diameter 18 μm , perivalvar axis 12 μm . Collection: In bottles-Cayo Enrique-Gata, November 1977.

Thalassiosira eccentrica (Ehr.) Cl. 1904. Bull. Cons. Explor. Mer. 1903–1904: 216 Figures 4–5

Ecology and Distribution: Marine, oceanic and neritic, euryhaline-observed in estuaries; cosmopolitan (3, 18, 35, 36, 42, 22, 23, 43, 48, 24, 40, 7, 25, 28 and 44). Cited only by Margalef (1957) for Puerto Rico. Observed only rarely in permanent slides from Bahía Fosforescente and Cayo Enrique-Gata. Measurements: Diameter 27–36 μm , 9–10 areolae in 10 μm . Collection: Slides #124A–155A.

Thalassiosira nanolineata (Mann) Fryxell & Hasle in Hasle & Fryxell 1977. Nova Hedwigia 54:32, Figs. 74–80. Figures 6–7

Ecology and Distribution: Marine, neritic; pantropical. A new record for the coastal waters of Puerto Rico and the Caribbean Sea. Frequently observed in permanent slides from Cayo Enrique-Gata and Bahía Fosforescente. Measurements: Diameter 27–30.6 μm , 4–6 areolae in 10 μm . Collection: Slides #105B–122B.

Family: Melosiraceae

Corethron criophilum Castr. 1886. In Challenger Exped. Bot. 2:85 Pl. 21, Figure 14. Figure 8

Ecology and Distribution: Marine, oceanic, cosmopolitan (35, 22, 38, 48, 40, 25, 49, 21, 2, 46 and 44). Previously cited by Hagelstein (1938) for the canal Martín Peña in Puerto Rico. Observed very rarely in samples from Cayo Enrique-Gata and Bahía Ponce. Measurements: Diameter 14–16 μm , pervalvar axis 54–72 μm .
Collection: In bottles-Cayo Enrique, February 1977.

Leptocylindrus danicus Cl. 1889. Pelag. Diat. fr. Kattégat, p. 54. Figures 9–10

Ecology and Distribution: Marine, neritic, estuarine; cosmopolitan (35, 22, 17, 43, 8, 9, 10, 16, 48, 24, 40, 7, 15, 25, 26, 49, 14, 21, 19, 34, 2, 6, 46 and 44). Cited by Margalef (1957–1961a) for the southern coast of Puerto Rico. Observed in samples from Bahía Fosforescente, Cayo Enrique-Gata and Caja de Muertos Island-Ponce. Measurements: Diameter 12–28 μm , pervalvar axis 44–128 μm .
Collection: In bottles-Cayo Enrique, February 1976.

Paralia sulcata (Ehr.) Cl. 1873. Bih. K. Svenska Vetensk. Akad. Handl. 1 (13): 7. Figures 11–12–13

Ecology and Distribution: Marine, tychopelagic, common in the neritic plankton, eurythermal and euryhaline; cosmopolitan (3, 31, 30, 32, 16, 22, 48, 40, 7, 1, 25, 45, 34, 5, 28 and 44). Cited by Hagelstein (1938) for San Juan Bay and by Margalef (1957–1961a) for the southern coast of Puerto Rico. Frequently observed in fresh samples and permanent slides from Bahía Fosforescente; also, but infrequently, from Cayo Enrique-Gata. Measurements: Diameter 28.8–40.5 μm , pervalvar axis 13.5 μm .
Collection: In bottles-Bahía Fosforescente, July 1977 and Slides #23A–167A.

Family: Coscinodiscaceae

Coscinodiscus centralis Ehr. 1838a. Abh. Königl. Akad. Wiss. Berlin, p. 129. Figures 14–15

Ecology and Distribution: Marine, oceanic; cosmopolitan (43, 38, 40, 7, 1, 25, 45 and 44). A new record for the coastal waters of Puerto Rico. Observed only in permanent slides from some samples of Bahía Fosforescente and Cayo Enrique-Gata. Measurements: Diameter 94.5 μm , 4 areolae in 10 μm .
Collection: Slide #172B.

Coscinodiscus gigas Ehr. 1841. Abh. Königl. Akad. Wiss. Berlin, p. 412. Figures 16–17–18

Ecology and Distribution: Marine, neritic; pantropical (42, 43, 32, 48, 23 and 34). A new record for the coastal waters of Puerto Rico. Observed regularly and dominant in the samples from Bahía Fosforescente. Sometimes observed with attached protozoa. Measurements: Diameter Collection Slide #121A.

Coscinodiscus gigas var. praetexta (Janish) Hustedt 1928. In Rabh., Kryptog. Fl. Deutschland 7 (1): 457. Figs. 255–256. Figure 19

Ecology and Distribution: Marine, a variety that generally accompanies the species (36 and 34). Cited by Margalef (1957–1961a) for the southern coast of Puerto Rico. Observed commonly with the species but of greater dimensions. Measurements: Diameter 190–300 μm , 4 areolae in 10 μm .
Collection: Slide #79B.

Coscinodiscus marginatus Ehr. 1841. Abh. Königl. Akad. Wiss. Berlin p. 142. Figures 20–21

Ecology and Distribution: Marine, oceanic, cosmopolitan (16, 48, 7, 25, 49 and 34). Cited by Hagelstein (1938) for San Juan Bay in Puerto Rico. Observed rarely in permanent slides in samples from Caja de Muertos Island-Ponce. Measurements: Diameter 48 μm , 4 areolae in 10 μm .
Collection: Slide #198B.

Coscinodiscus radiatus Ehr. 1839. Abh. Königl. Akad. Wiss. Berlin, p. 148, Pl. 3, Figures 1a–c. Figure 23

Ecology and Distribution: Marine, neritic and oceanic; cosmopolitan (3, 18, 35, 36, 42, 30, 32, 8, 22, 48, 24, 40, 25, 49, 45, 28 and 44). Cited by Hagelstein (1938) for San Juan Bay in Puerto Rico. Observed in permanent slides from Cayo Enrique-Gata. Very rare. Measurements: Diameter 27–48 μm , 4–5 areolae in 10 μm at center, 7–8 areolae in 10 μm at margin.
Collection Slide #121A.

Coscinodiscus rothii (Ehr.) Grun. 1878. Sber. Abh. naturw. Ges. Isis Dresd., p. 125. Figure 24

Ecology and Distribution: Marine, neritic; cosmopolitan (18, 35, 36, 29, 48, 7 and 34). A new record for the coastal waters of Puerto Rico. Observed in permanent slides from Cayo Enrique. Very rare. Measurements: Diameter 75.6 μm , 10 areolae in 10 μm .
Collection: Slides #149B and #150B.

Psammodiscus nitidus (Greg.) Round & Mann 1980. Ann. Bot. 46: 367–373, Pl. 3. Figure 22

Ecology and Distribution: Marine, neritic; cosmopolitan (3, 37, 18, 43, 7, 25, 27 and 28). Cited previously by Hagelstein (1938) for San Juan Bay and by Margalef (1961a) for the southern coast of Puerto Rico. Observed only in permanent slides from Cayo Enrique. Very rare. Measurements: Diameter 30 μm , 8–9 areolae in 10 μm .
Collection: Slide #184A.

Family: Hemidiscaceae

Actinocyclus octonarius Ehr. 1838b. Infusionsthierchen, p. 172, Pl. 21, Figure 7. Figures 25–26

Ecology and Distribution: Marine, common in the neritic plankton; cosmopolitan (18, 35, 29, 30, 31, 32, 40, 7, 34 and 28). Cited by Hagelstein (1938) for San Juan Bay. Observed rarely in permanent slides from Bahía Fosforescente and also from the reef area. Measurements: Diameter 36 μm , 10 areolae in 10 μm at center, 20 areolae in 10 μm at margin.
Collection: Slide #127A.

Actinocyclus octonarius var. ralfsii (W. Smith) Hendey 1954. J. mar. biol. Ass. U.K. 33: 557. Figure 27

Ecology and Distribution: Marine, neritic, tychopelagic; eurythermal (31 and 46). A new record for the coastal waters of Puerto Rico. Only observed in permanent slides from Cayo Enrique-Gata. Very Rare. Measurements: Diameter 72 μm .
Collection: Slide #174A.

Actinocyclus tenuissimus Cl. 1878. Bih. K. Svenska Vetensk. Akad. Handl., 5 (8): 21, Pl. 5, Figure 34. Figures 28–29

Ecology and Distribution: Marine, neritic (28). A new record for the coastal waters of Puerto Rico. Observed in permanent slides from Cayo Enrique-Gata. Very rare. Measurements: Diameter 53.3–78.3 μm , 16–18 areolae in 10 μm . Comparative material: Cl. & Möll. Collection slides #148–149.
Collection: Slides #171A and #221A.

Family: Heliopeltaceae

Actinocyclus senarius (Ehr.) Ehr. 1843. Abh. Königl. Akad. Wiss. Berlin, Pl. 1, Figure 1. Figure 30

Ecology and Distribution: Marine-brackish, neritic, tychopelagic, euryhaline; cosmopolitan (3, 18, 30, 31, 32, 16, 22, 40, 7, 45, 34, 28 and 44). Cited by Hagelstein (1938) for San Juan Bay and Fajardo in Puerto Rico. Observed commonly in permanent slides from Bahía Fosforescente but uncommonly from the reef area. Measurements: Diameter 37.8–54 μm .
Collection: Slide #38A.

Suborder: Rhizosoleniineae

Family: Rhizosoleniaceae

Guinardia flaccida (Castr.) H. Perag. 1892. *Le Diatomiste* 1: 107, Pl. 13, Figures 4–5. Figures 31–32

Ecology and Distribution: Marine, neritic, estuarine; cosmopolitan in temperate-tropical waters (35, 43, 30, 32, 16, 22, 23, 48, 40, 7, 25, 49, 21, 10, 34 and 44). Previously cited for Puerto Rico by Hagelstein (1938) and by Margalef (1957–1961a). Observed but occasionally in samples from Cayo Enrique-Gata and Isla Caja de Muertos in Ponce. Measurements: Diameter 38–56 μm , perivalvar axis 80–120 μm . Collection: In bottles-Cayo Enrique, Nov. 1977 and Ponce-Caja de Muertos, Oct. 1975.

Rhizosolenia alata Brightw. 1858. *Q. J. Microsc. Sci.* 6: 95, Pl. 5, Figure 8. Figures 33–34

Ecology and Distribution: Marine, oceanic; cosmopolitan (4, 20, 35, 17, 30, 8, 9, 10, 11, 16, 22, 23, 38, 39, 48, 24, 40, 7, 25, 26, 49, 14, 21, 19, 45, 34, 2, 46 and 44). Cited by Margalef (1957–1961a) for the south coast of Puerto Rico. Observed regularly in samples from Cayo Enrique-Gata; Bahía Fosforescente and Isla Caja de Muertos. Measurements: Diameter 12–14 μm . Collection: In bottles-Cayo Enrique-Gata, July 1976.

Rhizosolenia alata f. *gracillima* (Cl.) Grunow 1881. *In* V. H. Syn. *Diat. Belgique* Pl. 79, Figure 8. Figure 35

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (35, 36, 22, 21, 19, 45 and 46). Cited for Puerto Rico by Hagelstein (1938) and by Margalef (1957). Observed rarely in samples from Cayo Enrique-Gata and Isla Caja de Muertos. Measurements: Diameter 4–5 μm . Collection: In bottles-Cayo Enrique-Gata, July 1977.

Rhizosolenia calcar-avis Schultze 1858. *Arch. Anat. Physiol.* p. 339, Pl. 13, Figures 5–10. Figures 36–37

Ecology and Distribution: Marine, oceanic, cosmopolitan in temperate-tropical waters (20, 35, 36, 52, 17, 43, 30, 8, 16, 22, 23, 33, 38, 48, 24, 40, 7, 25, 49, 14, 21, 19, 45, 34, 46 and 44). Cited by Hagelstein (1938) and Margalef (1957–1961a.) for Puerto Rico. Observed commonly in all samples, especially those from Bahía Ponce. Measurements: Diameter 34–38 μm . Collection: In bottles-Cayo Enrique Gata, April 1977.

Rhizosolenia fragillissima Bergon 1903. *Bull. Stn. biol. Arcachon* 6: 49, Pl. 1, Figures 9–10. Figure 38

Ecology and Distribution: Marine, neritic; cosmopolitan (9, 16, 31, 2, 13, 24, 40, 25, 14, 21, 45, 2 and 46). A new record for Puerto Rico. Observed only occasionally in samples from Cayo Enrique-Gata and very rarely from Bahía Fosforescente. Measurements: Diameter 16 μm , perivalvar axis 72 μm . Collection: In bottles-Cayo Enrique-Gata, October 1976.

Rhizosolenia hebetata f. *semispina* (Hensen) Gran 1904. *Fauna arct.* 3: 524, P. 17, Figures 11–12. Figures 39–40

Ecology and Distribution: Marine, oceanic, cosmopolitan (43, 22, 38, 40, 7, 25, 21, 19, 45 and 46). Observed frequently with *Richelia intracellularis* Schmidt as an endophyte. Cited previously by Hagelstein (1938) and by Margalef (1961a). Uncommon in samples from Cayo Enrique-Gata, Bahía Fosforescente and Bahía Ponce. Measurements: Diameter 11–16 μm . Collection: In bottles-Cayo Enrique-Gata, January 1978.

Rhizosolenia imbricata var. *shrubsolei* (Cl.) Schröder 1906. *Vjschr. naturf. Ges. Zürich* 51: 346. Figures 41–42

Ecology and Distribution: Marine, neritic, cosmopolitan in temperate-tropical waters (35, 36, 17, 43, 30, 31, 8, 10, 16, 40, 19, 2, 46 and 44). Cited by Hagelstein (1938) and Margalef (1957–1961a) for Puerto Rico. Common in samples from Bahía Fosforescente and Cayo Enrique-Gata. Measurements: Diameter 16 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1976–March 1978.

Rhizosolenia robusta Norman ex Pritch. 1861. *In* Pritch. *Hist. Infusoria.*, p. 866, Pl. 8, Figure 42. Figures 43–44–45

Ecology and Distribution: Marine, oceanic to estuarine species; cosmopolitan in temperate-tropical waters (4, 20, 35, 36, 43, 31, 22, 23, 40, 7, 25, 19, 45, 34, 46 and 44). Cited for the first time for Puerto Rico. Abundant in one sample, from Cayo Enrique-Gata. Measurements: Diameter 60 μm , 20–22 valvar areolae in 10 μm , 24–26 cingular areolae in 10 μm . Comparative material: Temp. & Perag.

Collection: Slides #477 and #792 (2nd Ed.).

This species resembles *R. firma* Karsten, *sensu* Hustedt (1930) p. 574, the description of which is based on the descriptions of Karsten (1907) p. 377, and Pavillard (1925) p. 30, and a description based on the areolation is not given.

The specimens found in Puerto Rico are in agreement with the descriptions of several authors: e.g. Peragallo (1892) p. 109; Peragallo & Peragallo (1907) p. 461; Karsten (1906) p. 163; Hustedt (1930) p. 578; Cupp (1943) p. 83. These Puerto Rican specimens differ from those figures of *R. firma* by the type of areolation of the valve and intercalary bands, by the type processes and by the geographical distribution of the two species.

Collection: In bottles-Cayo Enrique-Gata, March 1978.

Rhizosolenia setigera Brightw. 1858. *Q. J. Microsc. Sci.* 6: 95, Pl. 5, Figure 7. Figures 46–47

Ecology and Distribution: Marine, neritic, in estuaries; cosmopolitan in temperate-tropical waters (4, 35, 42, 43, 9, 16, 31, 22, 47, 48, 24, 40, 7, 25, 49, 19, 45, 34, 2, 46 and 44). Cited by Hagelstein (1938) for Puerto Rico. Observed usually in samples for Cayo Enrique-Gata, uncommon in samples from Bahía Fosforescente. Measurements: Diameter 20 μm . Collection: In bottles-Cayo Enrique-Gata, October 1976–September 1977.

Rhizosolenia stouterfothii H. Perag. 1888. *Bull. Soc. Hist. Nat. Toulouse* 22: 82, Pl. 6, Figure 44. Figure 48

Ecology and Distribution: Marine, neritic, in estuaries; cosmopolitan in cold temperate-tropical waters (4, 20, 36, 17, 43, 8, 9, 10, 11, 16, 24, 40, 7, 1, 25, 49, 14, 21, 19, 45, 2, 6, 46 and 44). Cited by Hagelstein (1938), Margalef (1957–1961a), Glynn *et al.* (1964) and Glynn (1973) for San Juan and the southwestern coast of Puerto Rico. Observed frequently in all samples, sometimes abundant in those from Cayo Enrique-Gata, Bahía Fosforescente and Isla Caja de Muertos. Measurements: Diameter 24 μm . Collection: In bottles-Cayo Enrique-Gata, September 1977.

Rhizosolenia styliformis Brightw. 1858. *Q. J. Microsc. Sci.* 6: 95, Pl. 5, Figures 5a, b, d. Figures 49–50–51

Ecology and Distribution: Marine, oceanic, cosmopolitan (3, 43, 31, 22, 16, 38, 48, 24, 7, 25, 49, 21, 19, 34 and 44). Usually found with *Richelia intracellularis* Schmidt as an endophyte.

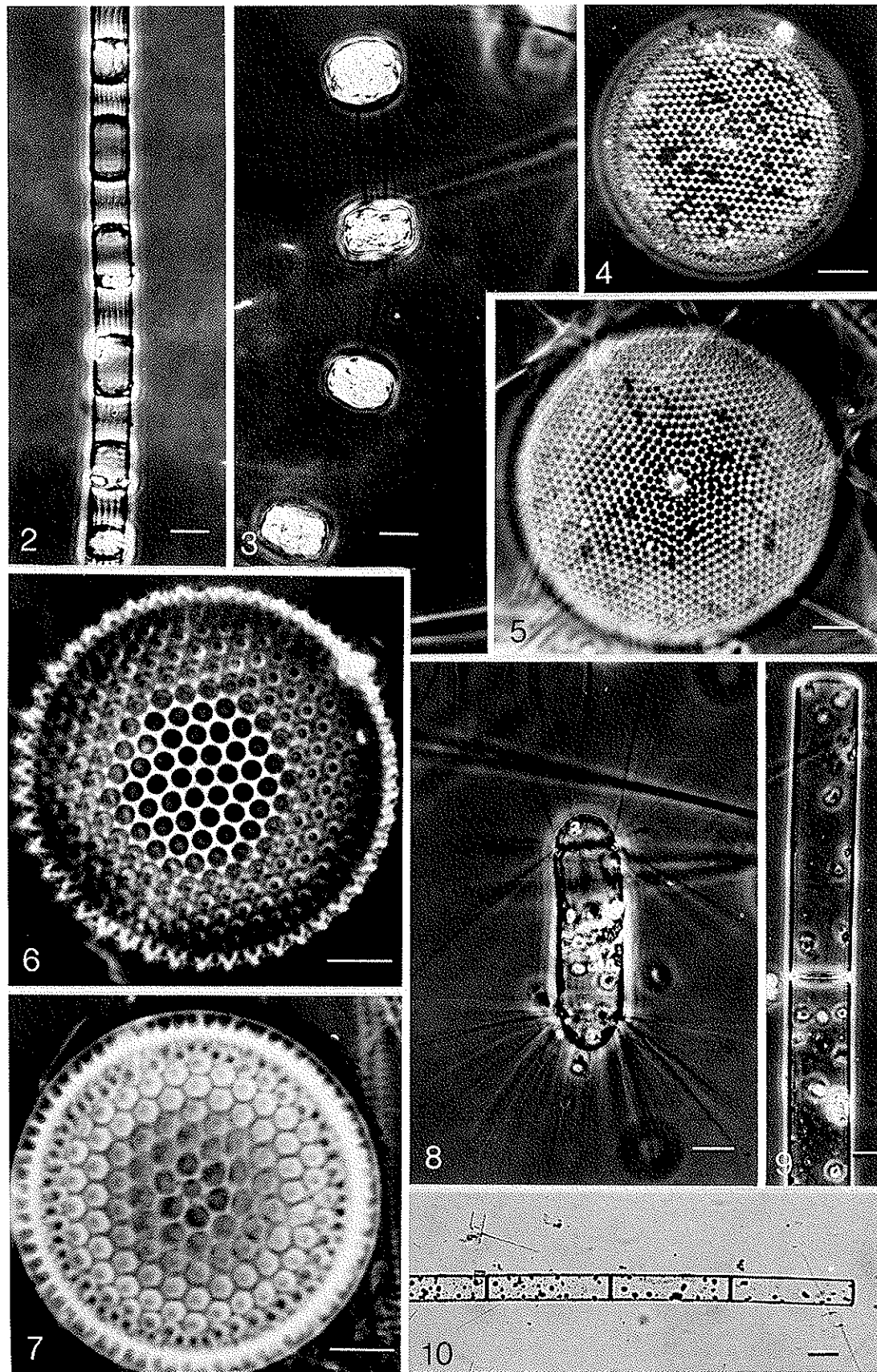
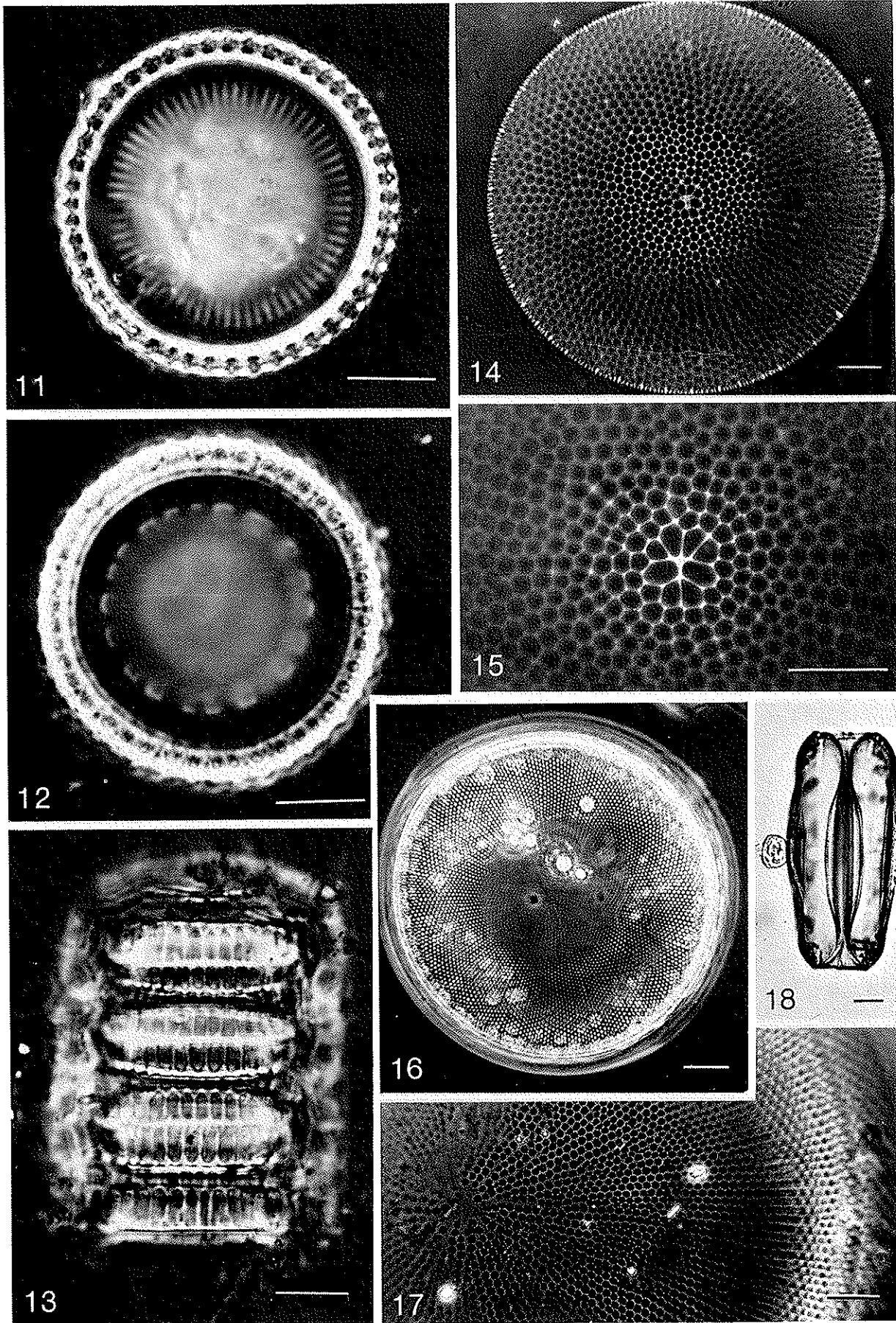


Fig. 2. *Skeletonema costatum*. Fig. 3. *Thalassiosira anguste-lineata*. Figs. 4-5. *Thalassiosira eccentrica*. Figs. 6-7. *Thalassiosira nanolineata*. Fig. 8. *Corethron criophilum*. Figs. 9-10. *Leptocylindrus danicus*. Figs. 2, 3, 8, 9 scale bars = 10 μ m, Figs. 4-5, 6-7 scale bars = 5 μ m, Fig. 10, scale bar = 30 μ m.



Figs. 11–13. *Paralia sulcata*. Figs. 14–15. *Coscinodiscus centralis*. Figs. 16–18. *Coscinodiscus gigas*. Fig. 18, girdle view showing attached protozoa. Figs. 11–13, 14–15, 17 scale bars = 10 μ m, Figs. 16, 18, scale bars = 20 μ m.

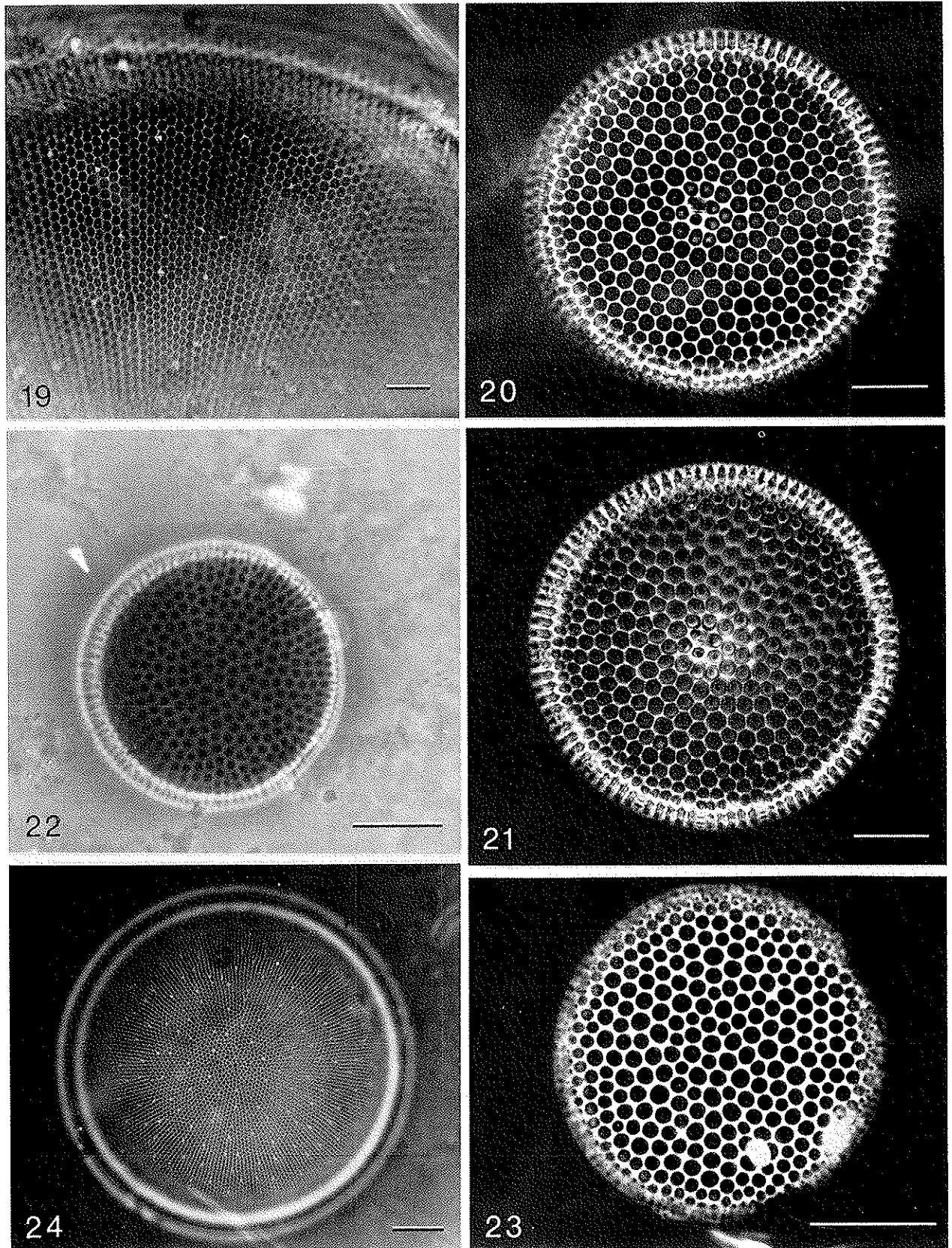
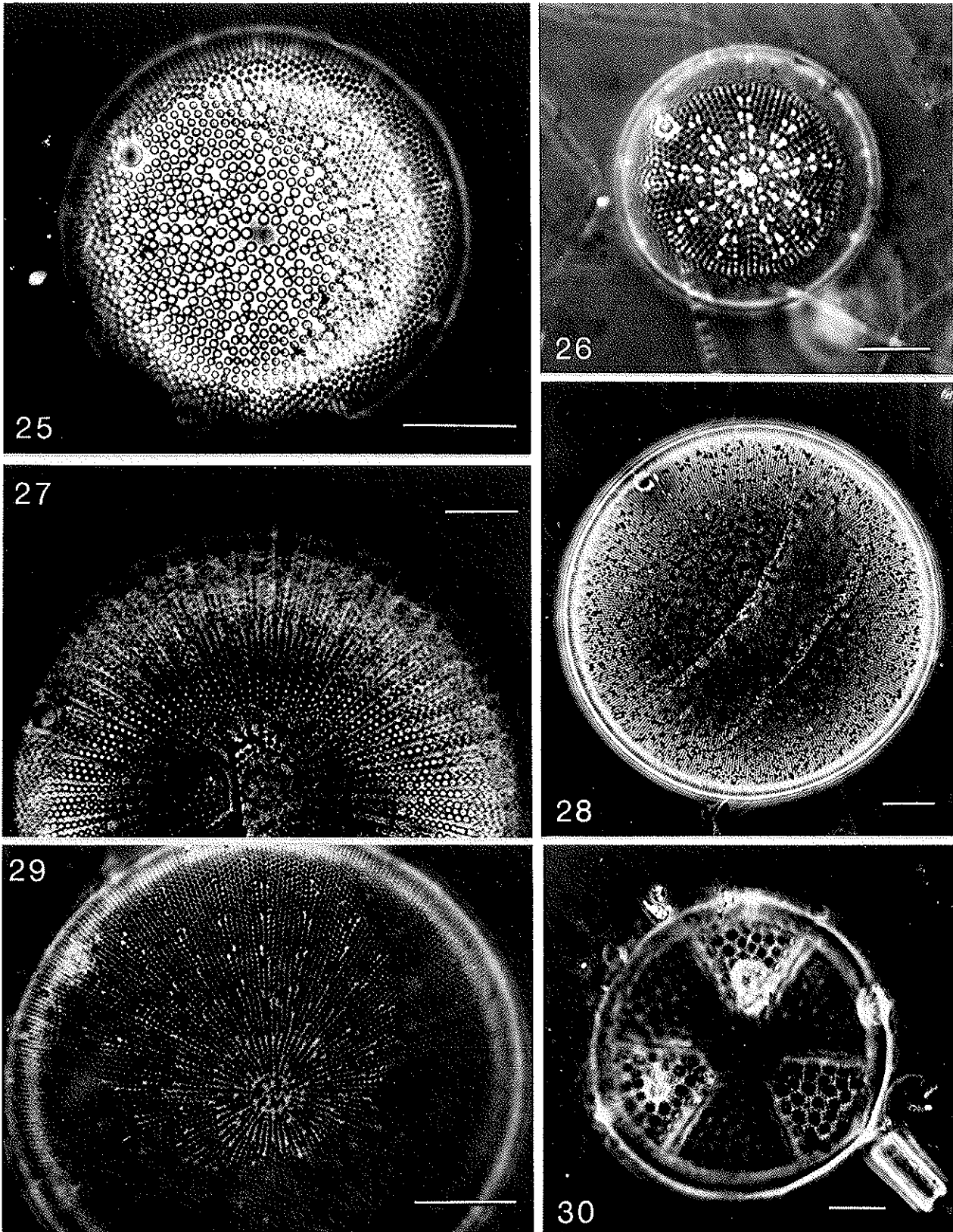
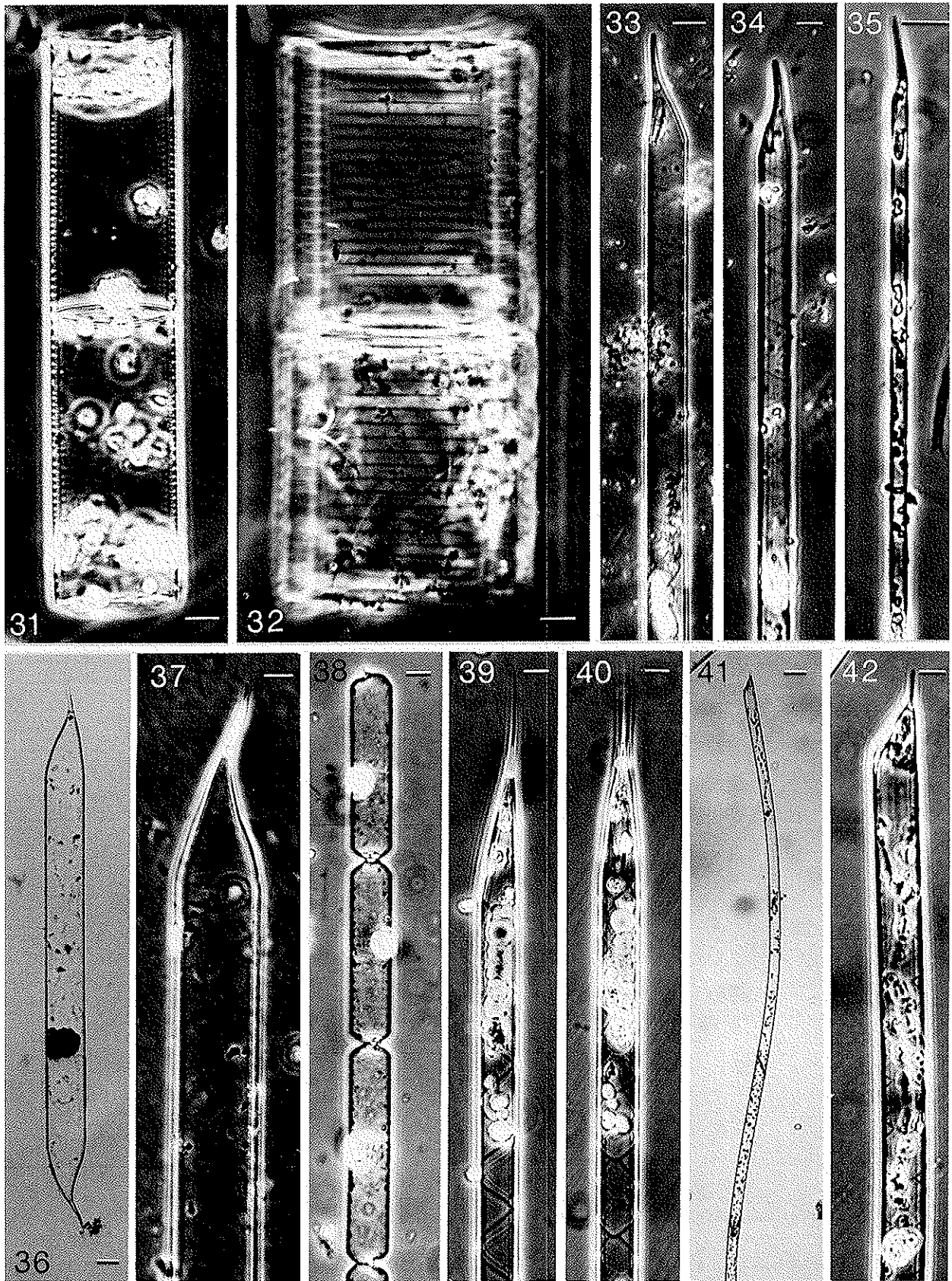


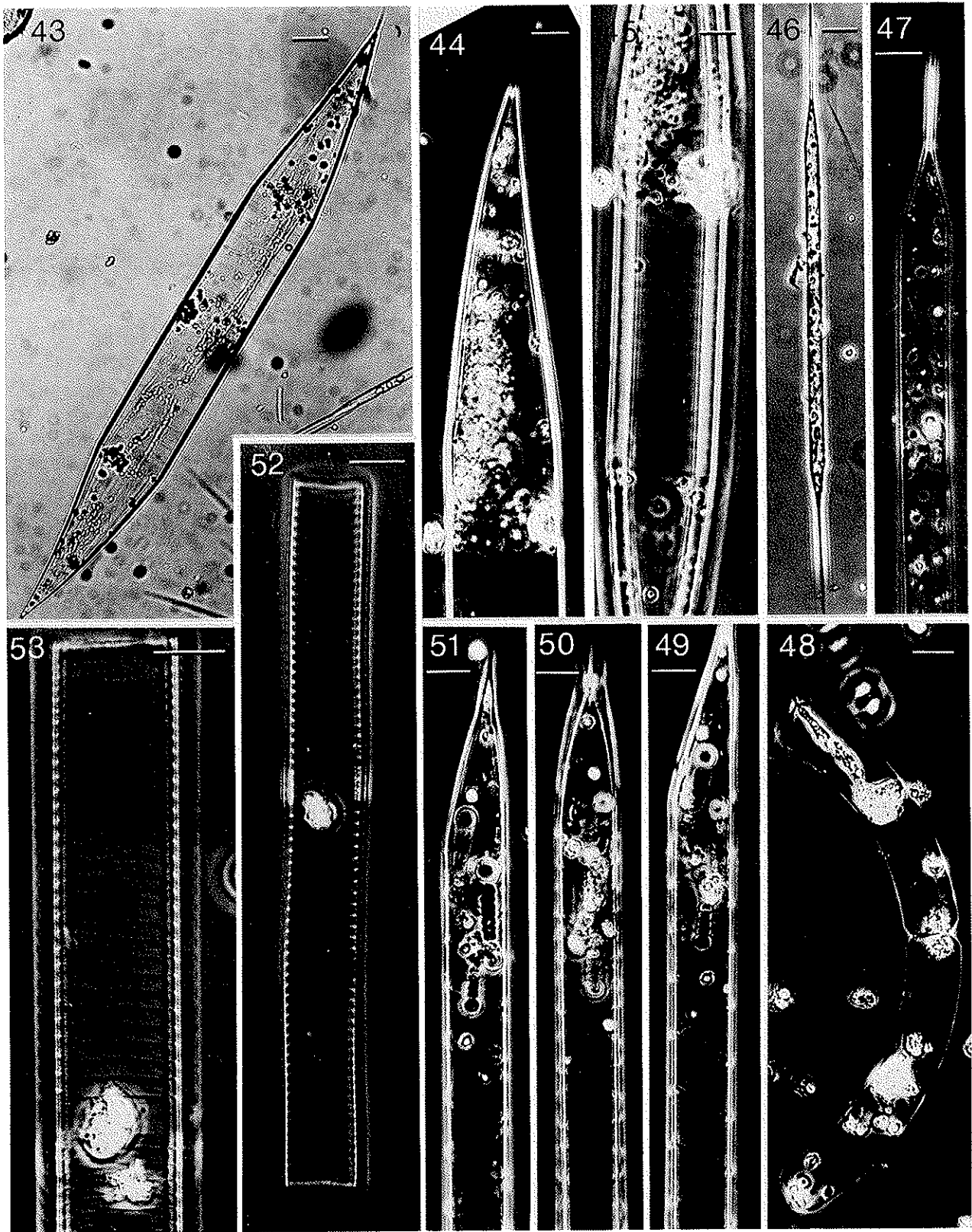
Fig. 19. *Coscinodiscus gigas* var. *praetexta*. Figs. 20–21. *Coscinodiscus marginatus*. Fig. 22. *Psammodiscus nitidus*. Fig. 23. *Coscinodiscus rothii*. Figs. 19–24, scale bars = 10 μ m.



Figs. 25–26. *Actinocyclus octonarius*. Fig. 27. *Actinocyclus octonarius* var. *ralfsii*. Figs. 28–29. *Actinocyclus tenuissimus*. Fig. 30. *Actinoptychus senarius*. Figs. 25–30, scale bars = 10 μ m.



Figs. 31-32. *Guinardia flaccida*. Figs. 33-34. *Rhizosolenia alata*. Fig. 35. *Rhizosolenia alata* f. *gracillima*. Figs. 36-37. *Rhizosolenia calcar-avis*. Fig. 38. *Rhizosolenia fragilissima*. Figs. 39-40. *Rhizosolenia hebetata* f. *semispina*. With *Richelia intracellularis*. Figs. 41-42. *Rhizosolenia imbricata* var. *shrubssolei*. Figs. 31-42, scale bars = 10 μ m, except Fig. 36, scale bar = 20 μ m and Fig. 41, scale bar = 30 μ m.



Figs. 43–45. *Rhizosolenia robusta*. Figs. 46–47. *Rhizosolenia setigera*. Fig. 48. *Rhizosolenia stolterfothii*. Figs. 49–51. *Rhizosolenia styliformis*. With *Richelia intracellularis*. Figs. 52–53. *Dactyliosolen antarcticus* f. *laevis*. Fig. 43 scale bar = 30 µm, Figs. 44–53 scale bars = 20 µm.

Cited by Hagelstein (1938) in Puerto Rico. Observed occasionally in samples from Cayo Enrique-Gata; Bahía Fosforescente and Isla Caja de Muertos. Measurements: Diameter 26 μm . Collection: In bottles-Cayo Enrique-gata, March 1976.

Dactyliosolen antarcticus f. *laevis* (Karst.) Heiden & Kolbe 1928. Dtsch. Südpol-Exped. Botanik, p. 510, Pl. 8, Figure 163. Figures 52–53

Ecology and Distribution: Marine, neritic, stenothermal and psychophilic (46). A new record for coastal waters of Puerto Rico. Observed in samples from Cayo Enrique-Gata and Bahía Fosforescente. Rare. Measurements: Diameter 36 μm , peralvar axis 264 μm . Collection: In bottles-Cayo Enrique-Gata, August 28, 1976.

Summary

The main purpose of this paper is to update a part of the marine diatom geographical distribution for the waters around Puerto Rico and the Caribbean Sea. Based on Simonsen (1979), two suborders of the order Centrales are presented. The results point to some quite interesting observations: — Nine, out of 30 observed taxa, are cited for the first time for Puerto Rico. These are *Thalassiosira anguste-lineata*; *Coscinodiscus centralis*; *C. gigas*; *C. rothii*; *Actinocyclus octonarius* var. *ralfsii*; *A. tenuissimus*, *Rhizosolenia fragilissima*; *R. robusta* and *Dactyliosolen antarcticus* f. *laevis*.

— One species is new for Puerto Rico and the Caribbean Sea, *Thalassiosira nanolineata*.

— The best represented families and genera are: family Coscinodiscaceae and genus *Coscinodiscus* (6 species and 1 variety) and the family Rhizosoleniaceae and genus *Rhizosolenia* (7 species, 1 variety and 2 forms).

— A majority of the taxa, 56.6%, are cosmopolitan; 23.3% are cosmopolitan in temperate-tropical waters; and 10% are pantropical.

— Most of the taxa, 66.6%, are neritic; 26.6% are oceanic and 6.6% are neritic/oceanic based on available literature.

— There are some species that have been shown to be more widely distributed than others. Those most frequently cited in the literature relating to the Caribbean

Sea and tropical or subtropical Atlantic Ocean are: *Skeletonema costatum*, *Leptocylindrus danicus*, *Rhizosolenia alata*, *R. calcar-avis*, *R. setigera* and *R. stoltzerfothii*.

— The local species distribution for the southwestern coast of Puerto Rico is the following: 7 taxa were found only from Cayo Enrique-Gata (Station 1), (see Fig. 1); 2 taxa were only observed in Bahía Fosforescente (Station 2) and 1 taxa was only found between Ponce and Isla Caja de Muertos (Station 3); 10 taxa were observed at stations 1 and 2; 3 taxa at stations 1 and 3 and 7 taxa from all stations.

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A Survey of the Marine Diatoms of Puerto Rico II. Suborder Biddulphiineae: Families Biddulphiaceae, Lithodesmiaceae and Eupodiscaceae

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Abstract

A taxonomic study on the marine diatoms from the southwestern coast of Puerto Rico is reported in this paper.

Three families of the suborder Biddulphiineae, with 3 subfamilies, 12 genera, 25 species, 1 variety and 6 forms were observed. Three of these taxa have never been reported from the coast of Puerto Rico; five are new for Puerto Rico and the Caribbean Sea and one is new for the Atlantic Ocean.

The best represented genera were *Trigonium* and *Triceratium*. Most of the identified species were cosmopolitan in temperate-tropical waters and neritic.

A new form is described: *Trigonium formosum*, f. *hexagonale* and a new combination: *Lampriscus shadboltianum* var. *crenulata*.

Introduction

Previous studies of Caribbean diatoms have reported species in the families Biddulphiaceae, Lithodesmiaceae and Eupodiscaceae. Hagelstein (1938) observed 35 species from these families, of which 28 he assigned to the genus *Biddulphia*. These species are now recognized to belong to several genera, i.e., *Biddulphia*, *Trigonium*, *Lampriscus*, *Odontella* and *Triceratium*. Margalef (1957, 1961) also reported 18 species from the waters around Puerto Rico. These three diatom families have also been well represented in other areas of the Caribbean Sea (Takano 1960, Margalef 1965 and Hargraves *et al.* 1970), the Gulf of Mexico (Saunders and Glenn 1969) and the Florida Current (Tester and Steidinger 1979).

In this paper the study of diatoms of Puerto Rico is continued so as to provide an annotated taxonomic listing of species in these three families. Ultrastructural details of some species are also provided as well as ecological and distributional notes for these species in waters around Puerto Rico, the Caribbean Sea and the tropical or subtropical Atlantic Ocean.

Methods

Description of the study area, as well as techniques for preparation and observations of the samples were previously described by Navarro (1981). For SEM study, coverglasses were mounted onto metal stubs, coated with gold-palladium and photographed with a Zeiss Novascan 30 scanning electron microscope using an accelerating voltage of 15 kV.

Observations

Order Centrales
Suborder Biddulphiineae
Family Biddulphiaceae
Subfamily Hemiauloideae

Cerataulina pelagica (Cl.) Hendey. 1937. Discovery Rep. 16: 279. Figs. 1-2

Ecology and Distribution: marine, neritic; cosmopolitan (33*, 7, 11, 8, 17, 9, 37, 18, 31, 5, 1, 20, 38, 10, 16, 14, 2, 36, 34). Cited previously by Hagelstein (1938) and by Margalef (1957, 1961) for the coast of Puerto Rico. Observed in samples from

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* See table I

Tab. I. Key for citation codes for references of species from the Caribbean Sea and tropical or subtropical Atlantic Ocean

1 -- Buchanan (1971)	21 -- Miller <i>et al.</i> (1977)
2 -- Caycedo (1977)	22 -- Montgomery & Miller (1978)
3 -- Cleve (1878)	23 -- Moreira Filho (1961)
4 -- DeFelice & Lynts (1978)	24 -- Moreira Filho (1964)
5 -- Hargraves <i>et al.</i> (1970)	25 -- Moreira Filho <i>et al.</i> (1967)
6 -- Hulburt (1962)	26 -- Moreira Filho <i>et al.</i> (1975)
7 -- Hulburt (1963)	27 -- Müller-Melchers (1955)
8 -- Hulburt (1964)	28 -- Müller-Melchers (1957)
9 -- Hulburt (1966)	29 -- Ostrup (1913)
10 -- Hulburt & Corwin (1972)	30 -- Riley (1967)
11 -- Hulburt & Rodman (1963)	31 -- Saunders & Glenn (1969)
12 -- Hulburt <i>et al.</i> (1960)	32 -- Suárez Caabro (1959)
13 -- Hustedt (1955)	33 -- Takano (1960)
14 -- Ivanov (1973)	34 -- Tester & Steidinger (1979)
15 -- King (1950)	35 -- Turner & Hopkins (1974)
16 -- López & Vinogradova (1972)	36 -- Vidal & Carbonell (1977)
17 -- Margalef (1965)	37 -- Wood (1968)
18 -- Margalef (1969)	
19 -- Margalef & González (1969)	
20 -- Marshall (1971)	

Cayo Enrique-Gata and Bahía Fosforescente. Common. Measurements: Diameter 32 μm , perivalvar axis 74 μm .

Collection: In bottles -- Cayo Enrique-Gata and Bahía Fosforescente, December 1976--February 1977--October 1977.

Eucampia cornuta (Cl.) Grunow 1881. *In*: V. H. Syn. Diat. Belgique Pl. 95, Fig. 5 Figs. 3--4

Ecology and Distribution: marine, neritic; pantropical (15, 27, 33, 7, 17, 37, 18, 19, 31, 20, 38, 36). Cited by Hagelstein (1938) and by Margalef (1957, 1961) for Puerto Rico. Observed occasionally in samples from Cayo Enrique-Gata, very rare in Bahía Fosforescente. Measurements: Apical axis 16--30 μm , perivalvar axis 56--120 μm .

Collection: In bottles -- Cayo Enrique-Gata, February, September, October and December 1976, -- Bahía Fosforescente, October 1976.

Hemiaulus hauckii Grunow 1881. *In*: V. H. Syn. Diat. Belgique Pl. 103, Fig. 10 Fig. 5

Ecology and Distribution: marine, neritic and oceanic; cosmopolitan in temperate-tropical waters. (33, 12, 6, 7, 11, 8, 30, 37, 19, 5, 20, 38, 16, 14, 36, 34). A new record for the coastal waters of Puerto Rico, Observed occasionally in samples from Cayo Enrique-Gata in March, April and May 1977. Measurements: Apical axis 19 μm , perivalvar axis 60 μm .

Collection: In bottles-Cayo Enrique-Gata, March 1977.

Hemiaulus membranaceus Cleve 1873. *Bih. K. Svenska Vetensk. Akad. Handl.* 1 (11): 6, Pl. 1, Fig. 5 Figs. 6--7

Ecology and Distribution: marine, oceanic, pantropical (27, 33, 12, 6, 7, 8, 24, 17, 9, 37, 18, 19, 31, 5, 20, 38, 16, 10, 14, 36, 34). Cited only by Margalef (1957) for the southern coast of Puerto Rico. Observed rarely in samples of Cayo Enrique-Gata and from the area of Ponce. Measurements: apical axis 30--76 μm , perivalvar axis 16--50 μm .

Collection: In bottles -- Cayo Enrique-Gata, March 1976--1977, -- Caja de Muertos Island-Ponce, October 1975.

Hemiaulus sinensis Greville 1865. *Ann. Mag. Nat. Hist. Ser.* 3, 16 (91): 5. Pl. 5, Fig. 9 Fig. 8

Ecology and Distribution: marine, neritic; pantropical (27, 13, 28, 33, 24, 17, 18, 31, 37, 5, 20, 38, 16, 14, 36, 34). Cited by

Hagelstein (1938) and Margalef (1957, 1961) for Puerto Rico. Observed commonly in samples from Bahía Fosforescente, Cayo Enrique-Gata and Ponce area. Sometimes abundant. Measurements: apical axis 14--22 μm , perivalvar axis 38 μm .

Collection: In bottles -- Bahía Fosforescente, December 1976.

This species can be distinguished from *H. hauckii* under light microscope by several characteristics, e.g. chains of *H. sinensis* are formed by 3 or more cells and are always curved; the aperture between cells is small. In *H. hauckii* the chains are straight and commonly formed by 2 cells and the aperture is larger because of the long processes.

Subfamily Biddulphioideae

Biddulphia pulchella Gray 1821. *Nat. Arrang. British Pl.* 1:294 Figs. 9--10

Ecology and Distribution: marine, neritic, tychoepelagic; cosmopolitan in temperate-tropical waters (3, 29, 27, 32, 17, 5, 36, 4, 22, 34). Previously cited by Hagelstein (1938) for San Juan Bay and by Margalef (1957, 1961) for the southern coast of Puerto Rico. Observed in permanent slides and in fresh samples from Bahía Fosforescente and the reef area. Common. Measurements: apical axis 52--72 μm , perivalvar axis 64--78 μm , transapical axis 56 μm .

Collection: Slide #62A and #169A.

Biddulphia reticulata Roper 1859. *Trans. Microsc. Soc. London* 7:14, Pl. 2, Figs. 13--15 Figs. 11--12

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (29). Cited only by Hagelstein (1938) for San Juan Bay and Fajardo in Puerto Rico. Also for St. Thomas and St. Croix. Observed rarely in permanent slides from Bahía Fosforescente and Cayo Enrique-Gata. Measurements: apical axis 91--94 μm , transapical axis 50--59 μm , 2-3 areolae in 10 μm , 9-10 puncta in 10 μm .

Collection: Slides #141B and #99B.

Biddulphia titiana Grunow 1881. *In*: V. H. Syn. Diat. Belgique Pl. 95, Figs. 7--9 Figs. 13--14

Ecology and Distribution: marine, neritic, pantropical (36). Cited by Hagelstein (1938) for San Juan Bay and by Margalef (1961) for the southern coast of Puerto Rico. Observed occasionally in samples from Cayo Enrique-Gata and Bahía Fosforescente. Measurements: apical axis 250 μm , perivalvar axis 100 μm , transapical axis 100 μm .

Collection: In bottles -- Cayo Enrique-Gata, October 1975.

Biddulphia tuomeyi (Bailey) Roper 1859. *Trans. Microsc. Soc. London* 7:8, Pl. 1, Figs. 1, 2 Fig. 15

Ecology and Distribution: marine, neritic; pantropical (3, 13, 27, 32, 24, 17, 37, 31, 5, 22, 34). Previously cited by Hagelstein (1938) for San Juan Bay and by Margalef (1957) for the south of Puerto Rico. Observed regularly in permanent slides from samples of Bahía Fosforescente and Cayo Enrique-Gata. Measurements: apical axis 46--102 μm , perivalvar axis 40--50 μm , transapical axis 28 μm .

Collection: Slide #113B.

Isthmia enervis Ehrenberg 1838. *Infusionstierchen*, p. 209, Pl. 16, Fig. 6 Figs. 16--20

Ecology and Distribution: marine, neritic, tychoepelagic; cosmopolitan in temperate-tropical waters (3, 29, 27, 32, 33, 5, 1, 2, 22, 34). Cited only by Margalef (1961) for Puerto Rico. Observed commonly in samples from Bahía Fosforescente, Cayo Enrique-Gata and Caja de Muertos Island -- Ponce. Measurements: apical axis 50 μm , perivalvar axis 180 μm . Comparative material: H. L. Smith Collection slide #204.

Collection: In bottles -- Cayo Enrique-Gata, May 1976 and Slide #53B.

Observations with the SEM (Figs. 17–20) confirm some structures reported by other authors: Dawson (1966) in *I. nervosa* and Montgomery & Miller (1978) in *I. enervis* and *I. lindigiana* (photographs only).

The valves and cingulum structure are formed by poroid areolae with a cribrum type of velum. In the cingulum these are smaller than on the valve.

Dispersed between the areolae, there are several small labiate processes (rimoportulae) with openings at their outer ends and slit-like openings with thickened margins at their inner ends.

There are also several club-shaped invaginations of the velum which form sacs with openings on their outer sides. There are no explanations for these structures in the literature, yet they are very common in all the specimens observed.

Isthmia minima Harvey & J. W. Bailey 1854. Proc. Acad. Nat. Sci. Philad. 6:430 Fig. 21

Ecology and Distribution: marine, neritic; pantropical (37, 5, 36, 22). Cited only by Hagelstein (1938) for San Juan Bay in Puerto Rico. Observed occasionally in samples from Bahía Fosforescente and the reef area. Measurements: apical axis 40 μm , perivalvar axis 192 μm .

Comparative material: H. L. Smith Collection Slide #205 and Cheever Collection Slide #A21–58.

Collection: In bottles – Cayo Enrique-Gata, October 1975.

Trigonium diaphanum Mann 1925. U.S. Nat. Mus. Bull. 100, 6 (1):163, Pl. 37, Fig. 3 Figs. 22–23

Ecology and Distribution: marine, neritic. This species is a new record for Puerto Rico, the Caribbean Sea and the Atlantic Ocean. The sole report of this species is for the Philippine Islands (Mann 1925). He described forms with three to five angles, the four angled form predominate. In the samples from Cayo-Enrique-Gata only the three and five angled forms were observed although they were not very common. Measurements: Diameter (apex of angle to middle of opposite side): 5 angles = 194.7 μm , 5–6 areolae in 10 μm , 3 angles = 152 μm , 7–8 areolae in 10 μm .

Collection: In bottles – Cayo Enrique-Gata, March–May 1976 Slide #154A.

Trigonium formosum (Brightwell) Cleve 1868. Bih. K. Svenska Vetensk. Akad. Handl. 24 (10): 663. Fig. 24

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (5). Cited only by Margalef (1961) for the southern coast of Puerto Rico. Observed frequently in samples from Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Measurements: diameter (apex of angle to middle of opposite side) 66.6–142 μm , 6–7 areolae in 10 μm .

Comparative material: Cheever Collection Slide #A38–87.

Collection: Slide #131A; in bottles – Cayo Enrique-Gata, June–July 1977; March 1978.

Trigonium formosum f. *quadrangulare* (Grev.) Hustedt 1930. In: Rabh. Kryptog.-Fl. Deutschland, 7 (1): 820, Fig. 483 Fig. 25

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (32, 22). A new record for the coastal water of Puerto Rico. Observed commonly in samples from Cayo Enrique-Gata but uncommonly from Bahía Fosforescente and Caja de Muertos Island – Ponce. Measurements: 130–153 μm (length between two sides), 6–7 areolae in 10 μm .

Comparative material: Cheever Collection Slide #A38–87.

Collection: Slide #132B, in bottles – Cayo Enrique-Gata, October 1975.

Trigonium formosum f. *pentagonale* Hustedt 1959. In: A. S., Atlas Diat. Pl. 479, Fig. 6; Pl. 480, Figs. 1–3.

Figs. 26–27

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (27, 25, 34). A new record for Puerto Rico and the Caribbean Sea. Observed occasionally in samples from Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Measurements: (apex of angle to middle to opposite side) 164–192 μm , 6–7 areolae in 10 μm .

Comparative material: Boyer Collection Slide #1-3-20 and #37; Cheever Collection A39-85-86.

Collection: In bottles – Cayo Enrique-Gata; October 1975, March 1976 Slide #131A.

Trigonium formosum (Brightwell 1856) Cleve 1868. forma *hexagonale* forma nov. Figs. 28–31

Differt a typo per forma valvarum sex angularium, margines concavi. Diameter valvarum 117–144 μm , areolae 4–5 in 10 μm area centralis, areolae 12–14 in 10 μm area angularium.

Locus typicus: Latitudo 17°59'N, Longitudo 67°W (Cayo Enrique-Gata, Puerto Rico).

Holotypus: Praeparatio no. HBFH D-551.

Isotypus: In collectione auctoris praeparatio no. 50.

Valves six cornered with concave sides. Diameter: 117–144 μm , 4–5 areolae in 10 μm at center, 12–14 areolae in 10 μm at the corners.

Type locality: Latitude 17°59'N, Longitude 67°W (Cayo Enrique-Gata, Puerto Rico).

Holotype: Slide No. HBFH D-551.

Isotype: In author's collection slide #50.

The structure of the valves observed with SEM (Fig. 29–31) is with loculate areolae decreasing in size towards the corners forming pseudocelli. The velum has 7–9 holes around the margin of the areolae but the number of holes is reduced gradually toward the corners of the valve, 6–4 until they are no more than two. One simple small spine is observed in each areolae at the internal side of a hole. Valves evidently with labiate processes. Marine, neritic, very rare, observed from samples of Cayo Enrique-Gata, March 1976 and from Bahía Fosforescente June 1976.

Trigonium reticulum (Ehr.) Simonsen 1974. "Meteor" Forsch Ergebnisse D, 19:34 Fig. 32

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (13). Cited previously by Hagelstein (1938) for Puerto Rico. Observed only in permanent slides from samples of Bahía Fosforescente and Cayo Enrique-Gata. Rare. Measurements: 31.5–46.8 μm (length between two sides), 6 areolae in 10 μm . Comparative material: H. L. Smith Collection Slide #602.

Collection: Slide #205A.

Lampriscus shadboltianum (Greville) Peragallo & Peragallo 1897–1908. *Diat. Mar. France* p. 389, Pl. 106, Fig. 1 Figs. 33a–36

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (3, 17, 5, 36, 22). Cited by Hagelstein (1938) for the San Juan Bay and by Margalef (1961) for the southern coast of Puerto Rico. Observed in samples from Bahía Fosforescente and the reef area. Common. Measurements: diameter 68–96 μm , perivalvar axis 160–250 μm , 8 areolae in 10 μm .

Comparative material: Cheever Collection Slides #38–39.

Collection: In bottles – Cayo Enrique-Gata, July 1977–Slides #42B and #164A.

The genus *Lampriscus* was validly published by A. Schmidt (1882) Pl. 80, Fig. 11. It can be separated from other genera on the basis of the following characteristics: laminar structure of cell walls with poroid areolae occluded by rota-type vela (Ross & Sims 1972, Fig. 2); without labiate processes and with pseudocelli (unpublished observations). However, further studies of the group are required to resolve the generic limits between these related genera, e.g. *Odontella*, *Trigonium*, *Biddulphia*, *Lampriscus* and *Triceratium*.

Lampriscus shadboltianum var. *crenulata* comb. nov. Figs. 37–38

Basionym: *Triceratium gibbosum* var. *crenulata* Grun. 1882.

Ecology and Distribution: marine, neritic; pantropical (22). A new record for Puerto Rico and the Caribbean Sea. Observed occasionally with the species in samples from Cayo Enrique-Gata. Measurements: diameter 91.6–115.4 μm , 7–8 areolae in 10 μm .

Collection: In bottles – Cayo Enrique-Gata, March 1976, Slide #169B.

These specimens have the same characteristics of *Lampriscus shadboltianum* (Grev.) Perag. & Perag., except that the crenulate margin of the girdle is observed only in valve view. In girdle view it is possible to distinguish only faint lines or rows in perivalvar directions (Figs. 37–38). These forms are the same as illustrated by Grunow in Schmidt (1882) Pl. 80, Fig. 17 and Grunow in Van Heurck (1883) Pl. 109, Fig. 2 and called *Triceratium gibbosum* var. *crenulata* Grun. But according to Van Landingham (1978) this is a synonym of *T. shadboltianum* var. *elongata* (Grun.) Hustedt, however Hustedt's variety does not have a crenulate margin and in the present study it is reported as *Lampriscus orbiculatum* (Shadbolt) Perag. & Perag. Therefore a new combination is necessary for those specimens with crenulate margins as a variety of *L. shadboltianum*.

Lampriscus orbiculatum (Shadbolt 1854). Peragallo & Peragallo 1897–1908. *Diat. Mar. France* p. 388, Pl. 106, Figs. 2, 3 Figs. 33b, 39–41

Ecology and Distribution: marine, neritic; pantropical (36, 22). A new record for the coastal waters of Puerto Rico. Observed commonly in samples from Cayo Enrique-Gata; Bahía Fosfores-

cente and Caja de Muertos Islands – Ponce. Measurements: diameter 82–146 μm , perivalvar axis 230–361.4 μm , 12 areolae in 10 μm .

Collection: in bottles – Cayo Enrique-Gata March–July 1976, 1977. Slides #23A and #42B.

Family Lithodesmiaceae

Bellerochea malleus f. *biangulata* (Perag.) Hustedt 1930. *In: Rabh. Kryptog.-Fl. Deutschland*, 7 (1): 782 Fig. 456D Fig. 42

Ecology and Distribution: marine, neritic, euryhaline; cosmopolitan in temperate-tropical waters. A new record for Puerto Rico and Caribbean Sea. Observed rarely in samples from Bahía Fosforescente. Measurements: apical axis 36 μm , perivalvar axis 28 μm .

Collection: In bottles – Bahía Fosforescente, November 1976.

Streptothecha tamesis Shrubsole 1890. *J. Quekett Microsc. Club.* 4:259, Pl. 13, Fig. 4–6 Figs. 43–44

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (33, 17, 19, 31, 5, 36, 34). Cited only by Glynn (1973) for the reef area in La Parguera, Puerto Rico. Observed in samples from Bahía Fosforescente and Cayo Enrique-Gata. Uncommon. Measurements: apical axis 48 μm , perivalvar axis 124 μm .

Collection: In bottles – Cayo Enrique-Gata, August 1977.

Family Eupodiscaceae
Subfamily Eupodiscoideae

Eupodiscus radiatus: Bailey 1851. *Smiths. Contrib. Knowl.* 2 (8): 39 Figs. 45–47

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (3, 31, 5, 1, 22, 34). Cited previously by Hagelstein (1938) for the San Juan Bay, Puerto Rico. Observed occasionally in permanent slides from samples of Bahía Fosforescente and Cayo Enrique-Gata with 4 or 5 ocelli. Measurements: diameter 72–85.5 μm , 4–5 areolae in 10 μm (4 ocelli); diameter 136 μm , 3–4 areolae in 10 μm (5 ocelli).

Comparative material: H. L. Smith Collection Slide #164.

Collection: Slide #21A.

Odontella aurita (Lyngbye) C. A. Agardh 1832. *Ag., Consp. Crit. Diat.* 4:56 Fig. 48

Ecology and Distribution: marine, neritic, tychoepelagic; cosmopolitan (3, 29, 13, 28, 17, 25, 31, 16, 22). Cited by Hagelstein (1938); Margalef (1961) and Lyons (1973) for Puerto Rico. Observed irregularly in samples from Bahía Fosforescente, Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Measurements: perivalvar axis 29–30 μm , apical axis 19–20 μm .

Collection: Slide #197B.

Odontella mobiliensis (Bailey) Grunow 1884. *Denkschr. Akad. Wiss. Wien, Math.-Nat. Kl.* p. 58 Figs. 49–50

Ecology and Distribution: marine, neritic, tychoepelagic; cosmopolitan in temperate-tropical waters (15, 13, 27, 28, 23, 24, 17, 18, 5, 1, 35, 2, 36, 34). Cited by Hagelstein (1938) for the Caño Martín Peña and Margalef (1957) for the southern coast of Puerto Rico. Observed in samples from Cayo Enrique-Gata and Ponce Bay. Uncommon. Measurements: apical axis 46 μm , perivalvar axis 30 μm .

Collection: In bottles – Cayo Enrique-Gata, August–September 1977.

Odontella obtusa Kützing 1844. Bacill. p. 137 Pl. 8,
Fig. 8 Fig. 51

Ecology and Distribution: marine, neritic; cosmopolitan (36, 34). Cited only by Hagelstein (1938) for the San Juan Bay and San José Lagoon in Puerto Rico. Observed in permanent slides from samples of Cayo Enrique-Gata. Very rare. Measurements: apical axis 25 μm , pervalvar axis 42 μm .

Comparative material: H. L. Smith Collection Slide #625.

Collection: Slide #21A.

Triceratium dubium Brightwell 1859. Quart. J. Microsc.
Sci. 7:180 Pl. 9, Fig. 12 Figs. 52–54

Ecology and Distribution: marine, neritic; cosmopolitan in temperate-tropical waters (3, 29, 31, 21, 36, 22). Cited by Hagelstein (1938) for San Juan Bay and Fajardo in Puerto Rico. Observed in samples from Bahía Fosforescente, Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Common. Measurements: diameter 21–31 μm , 4 areolae in 10 μm .

Comparative material: Cheever Collection Slide #A29-1.

Collection: Slides #167A and #219B.

Triceratium favus f. quadrata Grunow 1885. In: A.S.,
Atlas Diat Pl. 84, Fig. 4 Fig. 55

Ecology and Distribution: marine-brackish, neritic; only reported from Atlantic Ocean (27, 23, 26). In Puerto Rico previously cited by Margalef (1957). Observed occasionally in samples from Bahía Fosforescente, Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Measurements: length between two sides: 38–86 μm , 2 areolae in 10 μm at center, 3–4 areolae in 10 μm at margin.

Collection: Slide #169A.

Triceratium pentacrinus (Ehr.) Wallich 1858. Quart. J.
Microsc. Sci. 6:249, Pl. 12, Figs. 10–14 Figs. 56–59

Ecology and Distribution: marine, neritic; pantropical (3, 27, 32, 5, 21, 36, 4, 22). Cited by Hagelstein (1938) for San Juan Bay and Fajardo and by Margalef (1961) for the southern coast of Puerto Rico. Observed commonly in samples from Cayo Enrique-Gata, Bahía Fosforescente and Caja de Muertos Island – Ponce. Measurements: apex of angle to middle of opposite side 62 μm , 7 areolae in 10 μm .

Comparative material: Cheever Collection Slides #A39-68-69-70.

Collection: Slide #120B.

Observations with the SEM of the internal valve face (Figs. 57–59) (for description of the external side see Ross & Sims, 1971) confirm its poroid areolae structure. The labiate processes are opposite the center of each concave valve side forming another five angled star within. Internal view of an ocellus is shown in Fig. 59.

Triceratium pentacrinus f. quadrata Hustedt 1930. In:
Rabh. Kryptog.-Fl. Deutschland, 7 (1): 814, Fig. 475.
Figs. 60–61

Ecology and Distribution: marine, neritic; pantropical (22). A new record for Puerto Rico and Caribbean Sea. Observed in samples from Cayo Enrique-Gata and Caja de Muertos Island – Ponce. Uncommon. Measurements: length between two corners 24–50 μm , 6–7 areolae in 10 μm .

Comparative material: Cheever Collection Slide #A39--71.

Collection: Slide #120B, in Bottles, June 1976.

The specimen illustrated in Figs. 60–61 shows the network of ridges over the surface of the valve, an important characteristic in this species.

Triceratium robertsonianum Greville 1863. Quart. J.
Microsc. Sci. 11 (3): 231, Pl. 9, Fig. 9 Fig. 62

Ecology and Distribution: marine, neritic, in estuaries; tycho-pelagic; pantropical. A new record for Puerto Rico and Caribbean Sea. Observed from samples of Bahía Fosforescente and Cayo Enrique-Gata. Common. Measurements: length between two corners 88–96 μm , 2 areolae in 10 μm .

Collection: Slides #21A and 169A.

Triceratium spinosum Bailey 1843. Amer. J. Sci. 46:139
Pl. 3, Fig. 12 Figs. 63–67

Ecology and Distribution: marine, neritic; pantropical (22). Cited only by Margalef (1961) for the southern coast of Puerto Rico. Observed in samples from Cayo Enrique-Gata. Rare. Measurements: length between two corners 94 μm , 4 areolae in 10 μm .

Collection: Slide #129B.

For the descriptions of the structure of the valve and the processes see Ross and Sims (1971) in which specimens from Tampa, Florida, are described. However observations of the cingulum of one valve (Fig. 64, 67) show a hinge-shaped structure along the border at the angles. This peculiar structure then would perhaps separate that cingulum into three parts. In contrast, the opposing cingulum possesses no such hinged structures. The cingular areolae are also different from those of the valve, i.e., they are small perforations without ridges, spines or small granules.

Summary

Taxonomic and geographical notes on the marine diatoms of Puerto Rico in the suborder Biddulphiineae are presented herein. The phylogenetic classification follows that of Simonsen (1979). A summary of the results indicates:

Three out of 32 taxa observed are cited for the first time for Puerto Rico. These are: *Hemiaulus hauckii*; *Trigonium formosum f. quadrangulare* and *Lampriscus orbiculatum*.

Five are new for Puerto Rico and the Caribbean Sea. These are: *Trigonium formosum f. pentagonale*; *Lampriscus shadboltianum var. crenulata*; *Bellerochea malleus f. biangulata*; *Triceratium pentacrinus f. quadrata* and *T. robertsonianum*.

One species is new for the Atlantic Ocean: *Trigonium diaphanum*.

A new form and a new combination are described: *Trigonium formosum f. hexagonale* and *Lampriscus shadboltianum var. crenulata*.

The best represented subfamilies and genera are: subfamily Biddulphioidae and genus *Trigonium* (3 species and 3 forms) and the subfamily Eupodiscoideae and genus *Triceratium* (4 species and 2 forms).

A majority of the taxa, 44%, are cosmopolitan in temperate-tropical waters; 38% are pantropical and 9% are cosmopolitan in all waters.

Most of the taxa, 94%, are neritic, 3% are oceanic and 3% are neritic/oceanic, based on available literature.

There are some species that have been shown to be more widely distributed than others. Those most frequently cited in the literature relating to the Caribbean Sea and tropical or subtropical Atlantic Ocean are: *Hemiaulus membranaceus* and *Cerataulina pelagica*.

The local species distribution for the southwestern coast of Puerto Rico is the following: 6 taxa were found only from Cayo Enrique-Gata (Station 1), 1 taxon was only observed in Bahía Fosforescente (Station 2); 13 taxa were observed at Stations 1 and 2; 5 taxa at Stations 1 and 3 and 7 taxa from all stations.

Observations with the SEM in some species are also reported: *Isthmia enervis*, *Trigonium formosum* f.

hexagonale, *Triceratium pentacrinus*, *T. pentacrinus* f. *quadrata* and *T. spinosum*.

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Legends to the Figures:

Figs. 1–2. *Cerataulina pelagica*. Figs. 3–4. *Eucampia cornuta*.

Fig. 5. *Hemiaulus hauckii*. Figs. 6–7. *Hemiaulus membranaceus*.

Fig. 8. *Hemiaulus sinensis*. Figs. 9–10. *Biddulphia pulchella*.

Fig. 9, valve view and Fig. 10, girdle view. Figs. 11–12. *Biddulphia reticulata*. Fig. 11, valve view and Fig. 12, girdle view.

Figs. 1–6, 8–12, scale bars = 10 μ m. Fig. 7, scale bar = 20 μ m.

Figs. 13–14. *Biddulphia titiana*. Fig. 13, valve view and Fig. 14, girdle view. Fig. 15. *Biddulphia tuomeyi*. Figs. 16–20. *Isthmia enervis*.

Fig. 16. Light micrograph in girdle view, Figs. 17–20 SEM views.

Fig. 17. Internal valve view, arrow shows the area enlarged in Fig. 18.

Fig. 18. Internal valve view showing the labiate processes and the invaginations of the velum. Fig. 19. External valve view, arrow shows the area enlarged in Fig. 20. Fig. 20. Arrows are showing the external opening of labiate process (small) and the external opening of invaginations (large).

Figs. 13–14, 16–17, and 19, scale bars = 20 μ m, Fig. 15, scale bar = 10 μ m. Fig. 18, scale bar = 4 μ m. Fig. 20, scale bar = 2 μ m.

Fig. 21. *Isthmia minima*. Figs. 22–23. *Trigonium diaphanum*. Valve views of 3 and 5 angled forms, showing the two different types of areolae in a valve and the labiate processes at center. Fig. 24. *Trigonium formosum*. Fig. 25. *Trigonium formosum* f. *quadrangulare*.

Figs. 26–27. *Trigonium formosum* f. *pentagonale*. Fig. 26, valve view showing the labiate processes and Fig. 27 girdle view.

Figs. 21–23, 25–27, scale bars = 20 μ m. Fig. 24, scale bar = 10 μ m.

Figs. 28–31. *Trigonium formosum* f. *hexagonale*. Fig. 28. Light micrograph in valve view. Figs. 29–31 SEM views. Fig. 29 valve view. Fig. 30. An enlarged corner area showing a pseudocellus, the loculate areolae and the small spines (arrow). Fig. 31. Valve center showing the central labiate processes (arrow) and the 7–9 holes around the margin of the areolae. Fig. 32. *Trigonium reticulatum*.

Fig. 33a. *Lampriscus shadboltianum*. Fig. 33b. *Lampriscus orbiculatum*.

Figs. 28–29, scale bars = 20 μ m. Figs. 30–31, scale bar = 5 μ m. Fig. 32, scale bar = 10 μ m. Fig. 33, scale bar = 30 μ m.

Figs. 34–36. *Lampriscus shadboltianum*. Fig. 34. Valve showing the spines at the elevations. Fig. 35. Valve view showing the areolae in rows radiating from a central circular area of areolae. Fig. 36. Valve center showing areolae covered by rota-type vela. Figs. 37–38. *Lampriscus shadboltianum* var. *crenulata*. Different focus in girdle view showing longitudinal rows in the cincture. Figs. 39–41. *Lampriscus orbiculatum*.

Fig. 39, girdle view. Fig. 40, valve view with 3 pseudocelli and Fig. 41, valve view with 4 pseudocelli and small areolae in rows radiating from a central circular area of areolae. Fig. 42. *Bellerochaea malleus* f. *biangulata*. Figs. 43–44. *Streptothecha tamesis*.

Figs. 34–36, 40–42, scale bars = 10 μ m. Figs. 37–39, 43–44, scale bars = 20 μ m.

Figs. 45–47. *Eupodiscus radiatus*. Fig. 45, valve view with 5 ocelli, Figs. 46–47, valve view with 4 ocelli. Fig. 48. *Odontella aurita*.

Figs. 49–50. *Odontella mobiliensis*. Fig. 51. *Odontella obtusa*. Figs. 52–54. *Triceratium dubium*. Figs. 52–53, valve view in different focus. Fig. 54, Anormal form.

Figs. 45, 49–50, scale bar = 20 μ m. Figs. 46–48, 51–54, scale bar = 10 μ m.

Fig. 55. *Triceratium favus* f. *quadrata*. Figs. 56–59. *Triceratium pentacrinus*. Fig. 56. Light micrograph of external valve face.

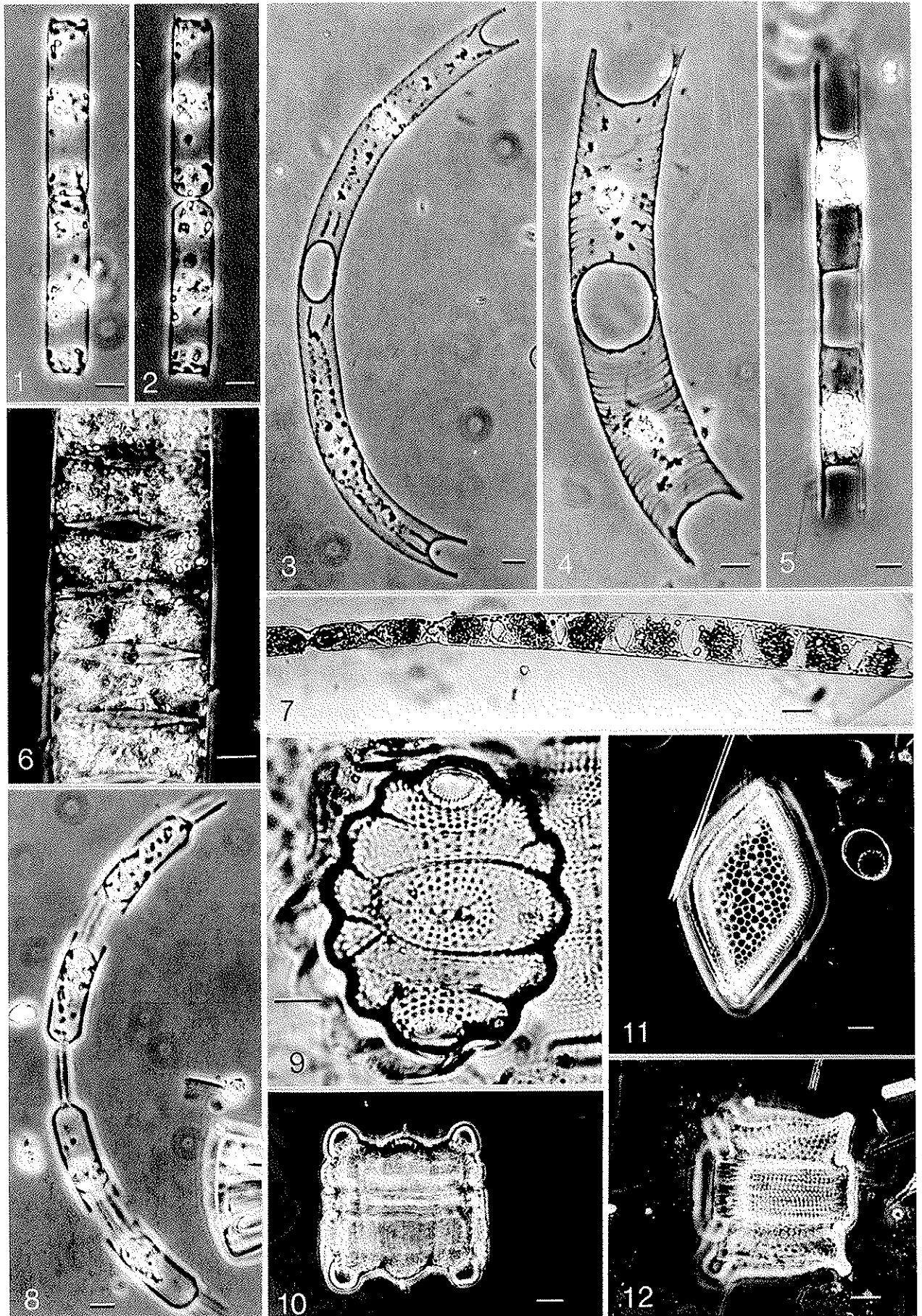
Figs. 57–59, SEM views of internal valve face. Fig. 57, showing labiate processes at the corners of five angled star within. Fig. 58, enlarged labiate process. Fig. 59, internal view of a ocellus. Figs. 60–61. *Triceratium pentacrinus* f. *quadrata*. Fig. 60, light micrograph and Fig. 61, SEM view of external valve face showing the network of ridges.

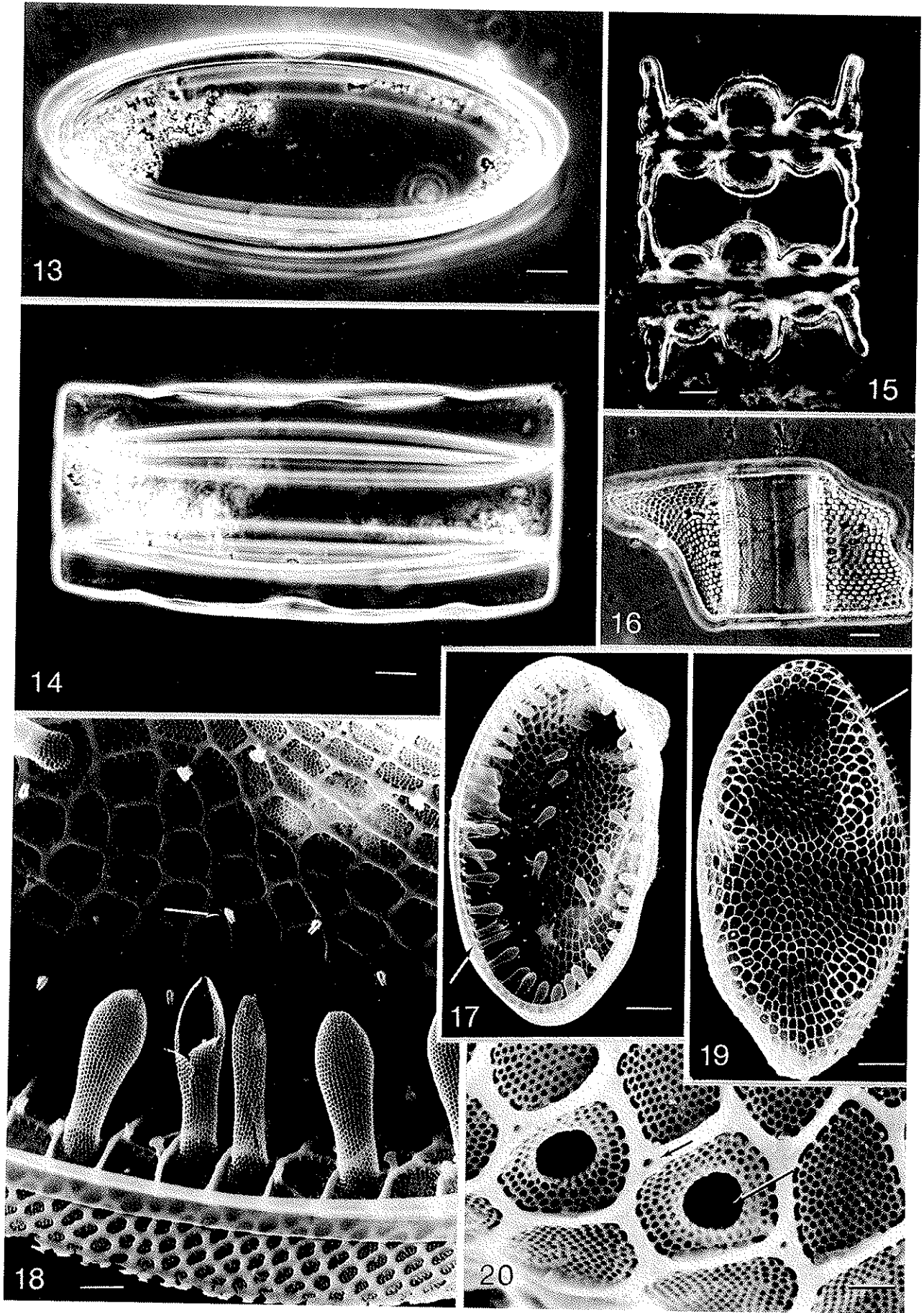
Figs. 55–57, 60–61, scale bars = 10 μ m. Fig. 58, scale bar = 1 μ m. Fig. 59, scale bar = 2 μ m.

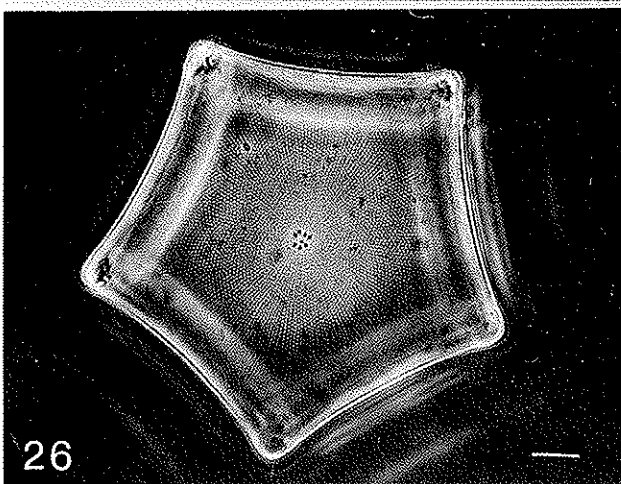
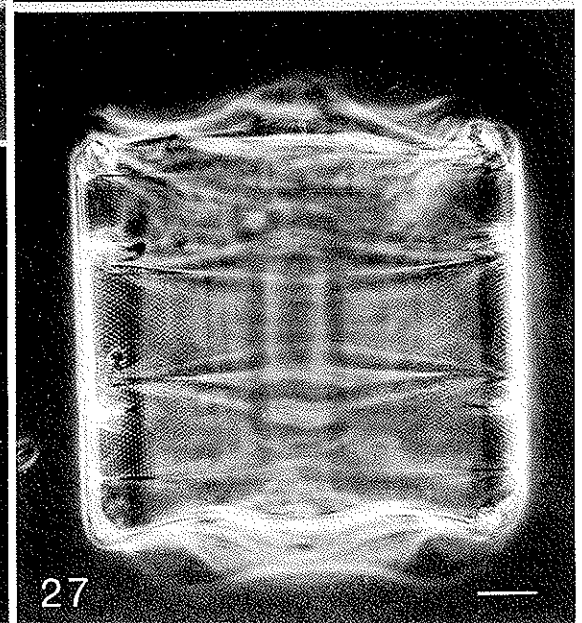
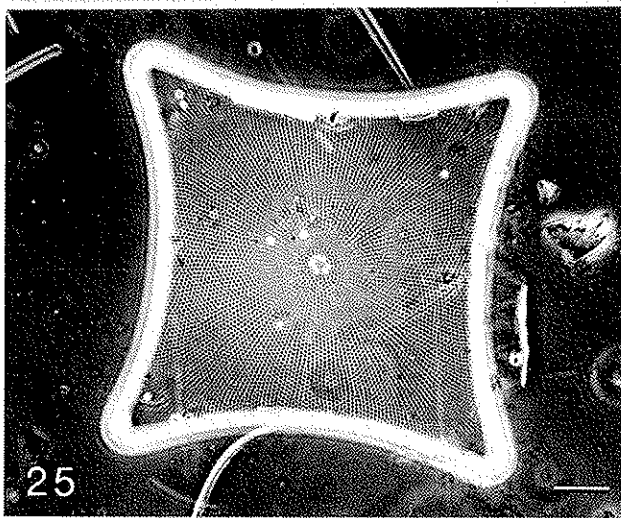
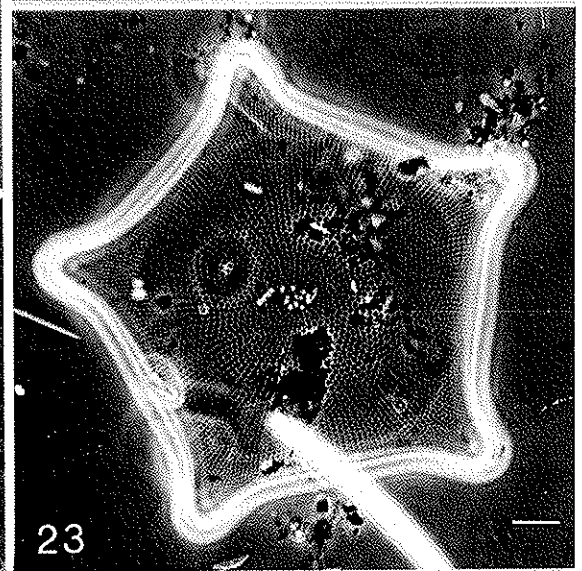
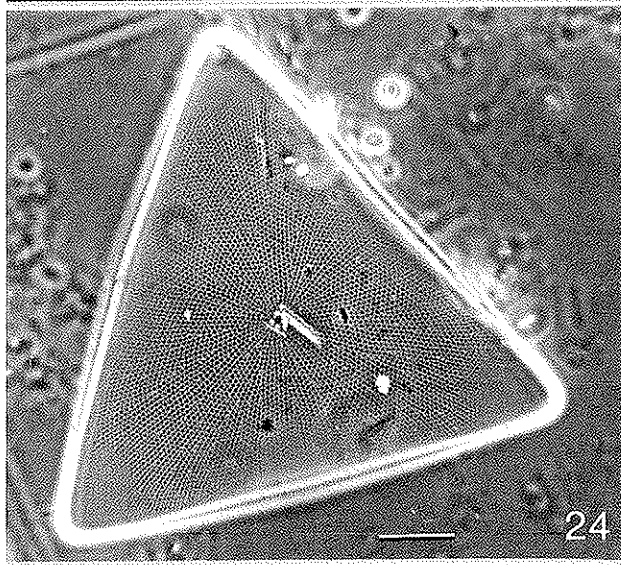
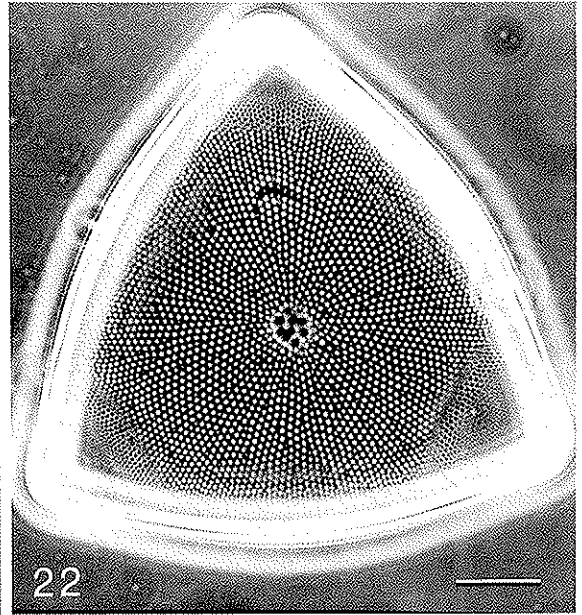
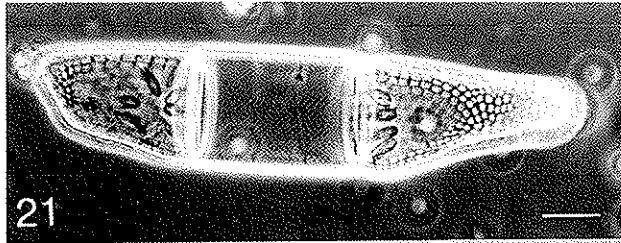
Fig. 62. *Triceratium robertsonianum*. Figs. 63–67. *Triceratium spinosum*. Fig. 63, light micrograph in valve view. Figs. 64–67, SEM views.

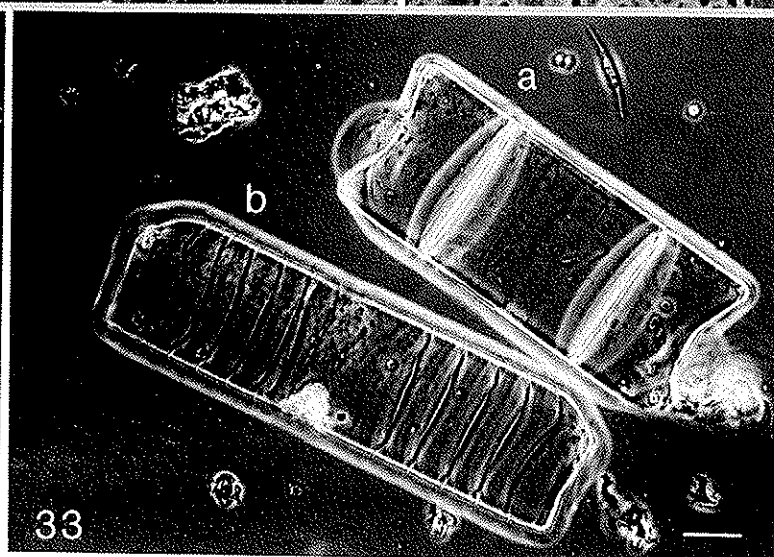
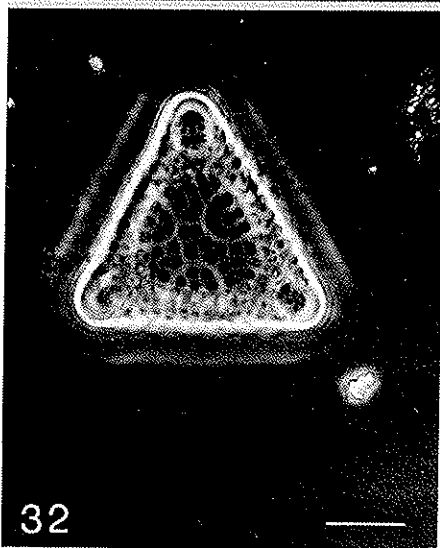
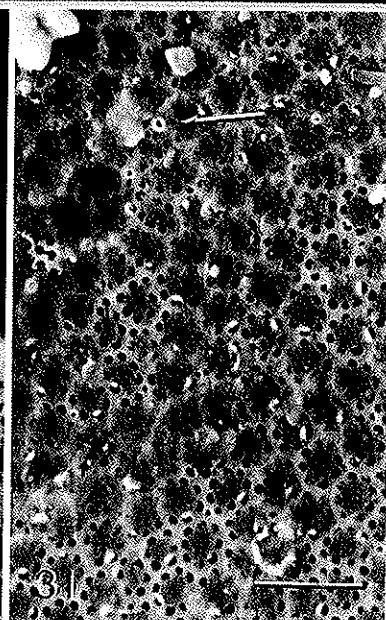
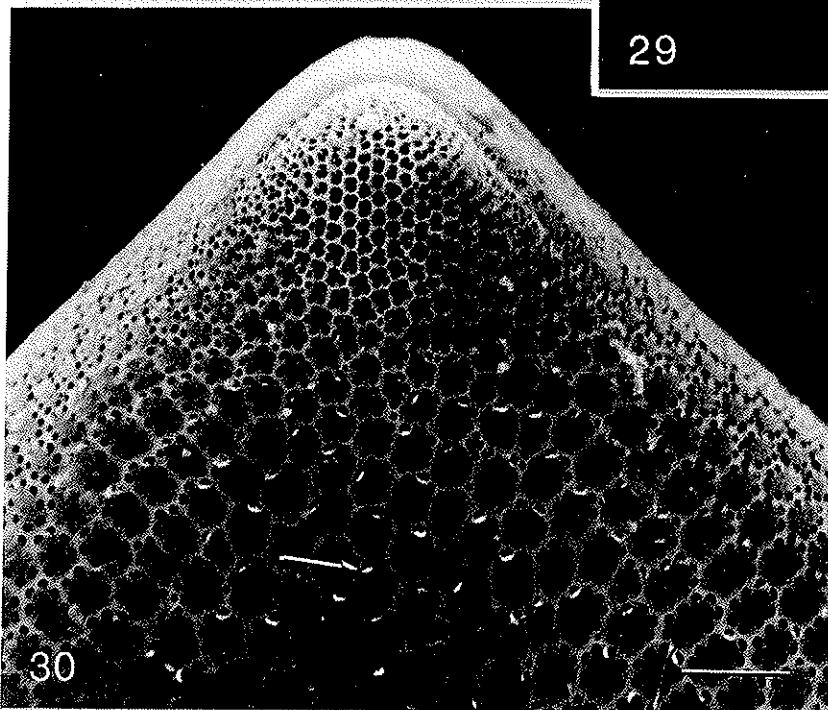
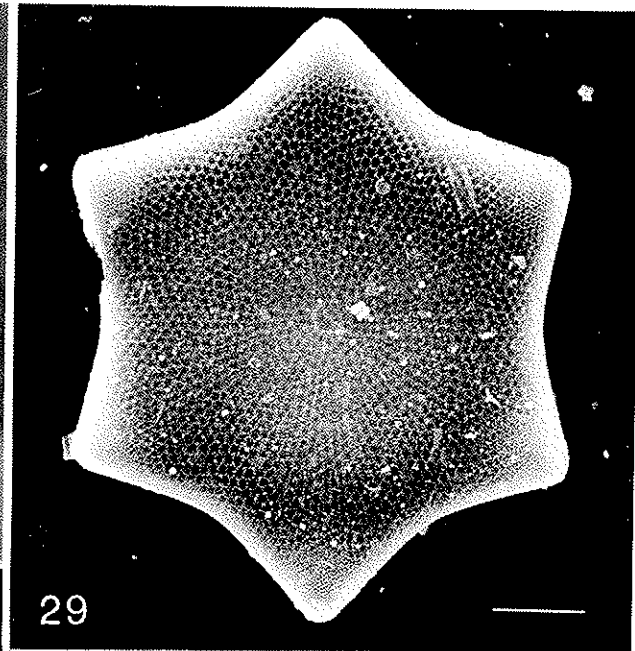
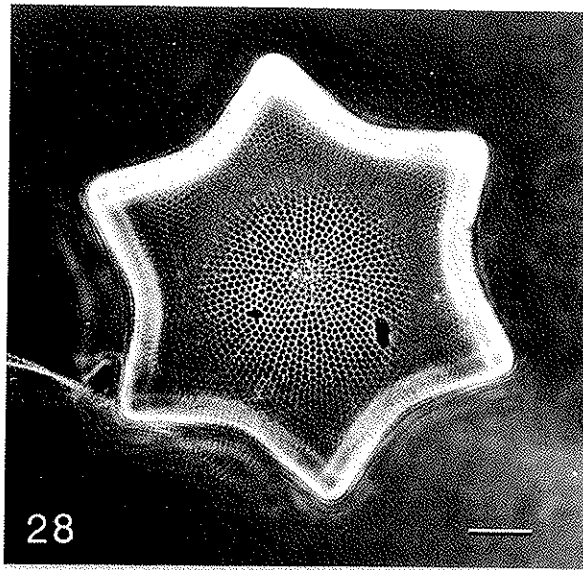
Fig. 64, girdle view showing the valve and cingulum. Two hinge-shaped structures along the border of the angles are observed. Fig. 65, detail of a corner showing an elevation with ocellus. Fig. 66, detail of outer surface of valve showing a big spine, small spines, granules and ridges separating the areolae. Fig. 67, enlarged area of a hinged structure showing also small perforations of the cingular areolae.

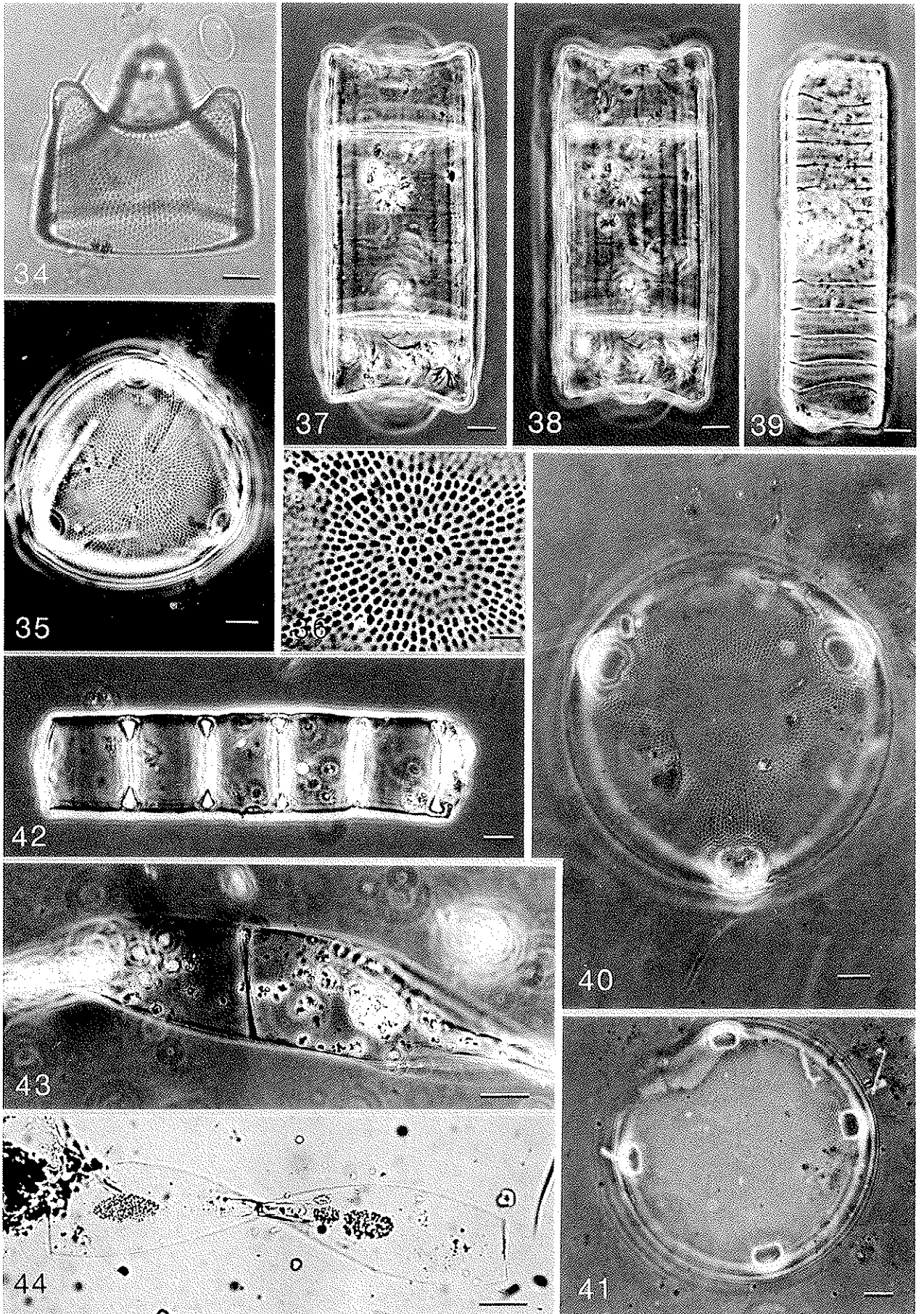
Fig. 62, 64, scale bars = 10 μ m. Fig. 63, scale bar = 20 μ m. Figs. 65–67, scale bars = 4 μ m.

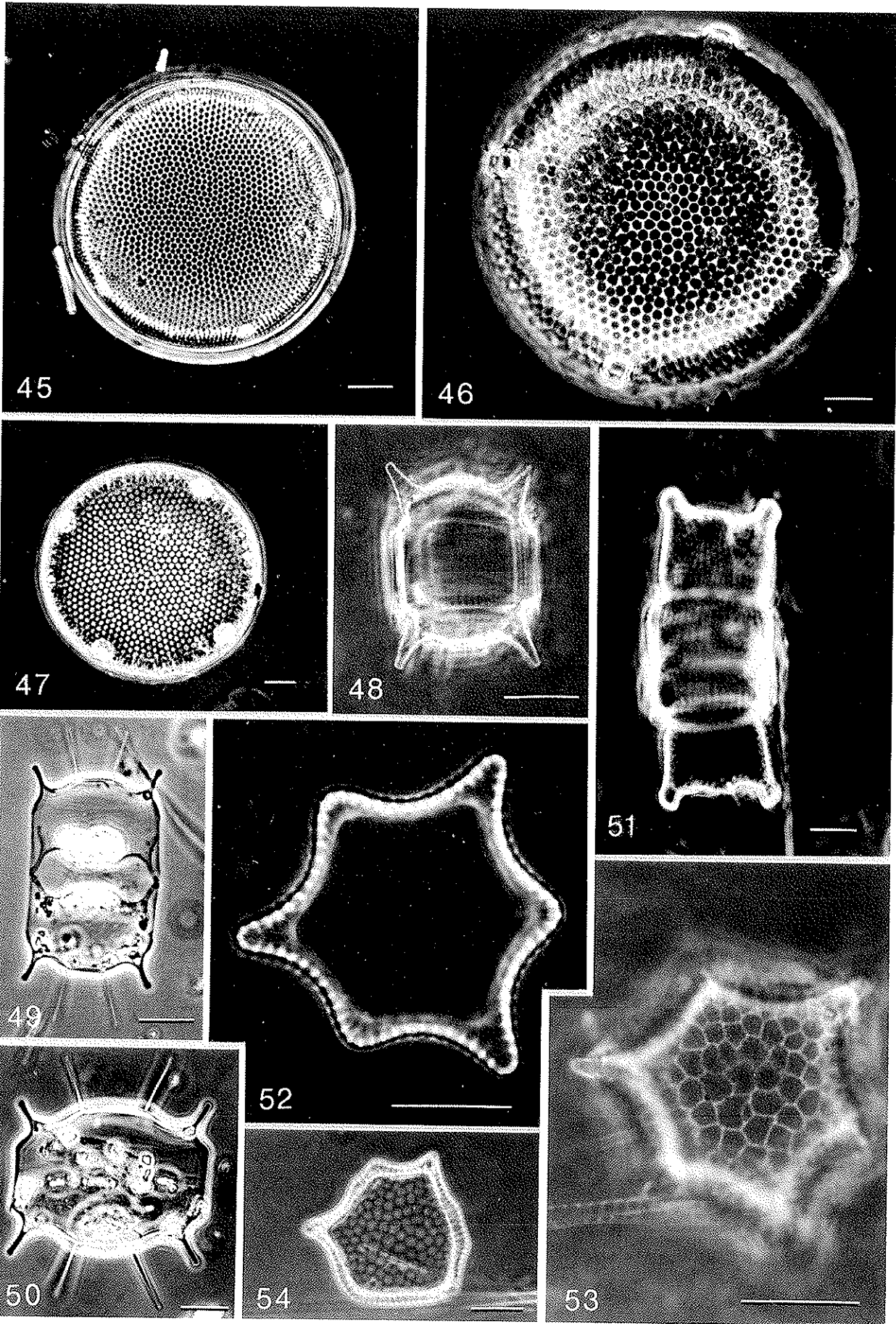


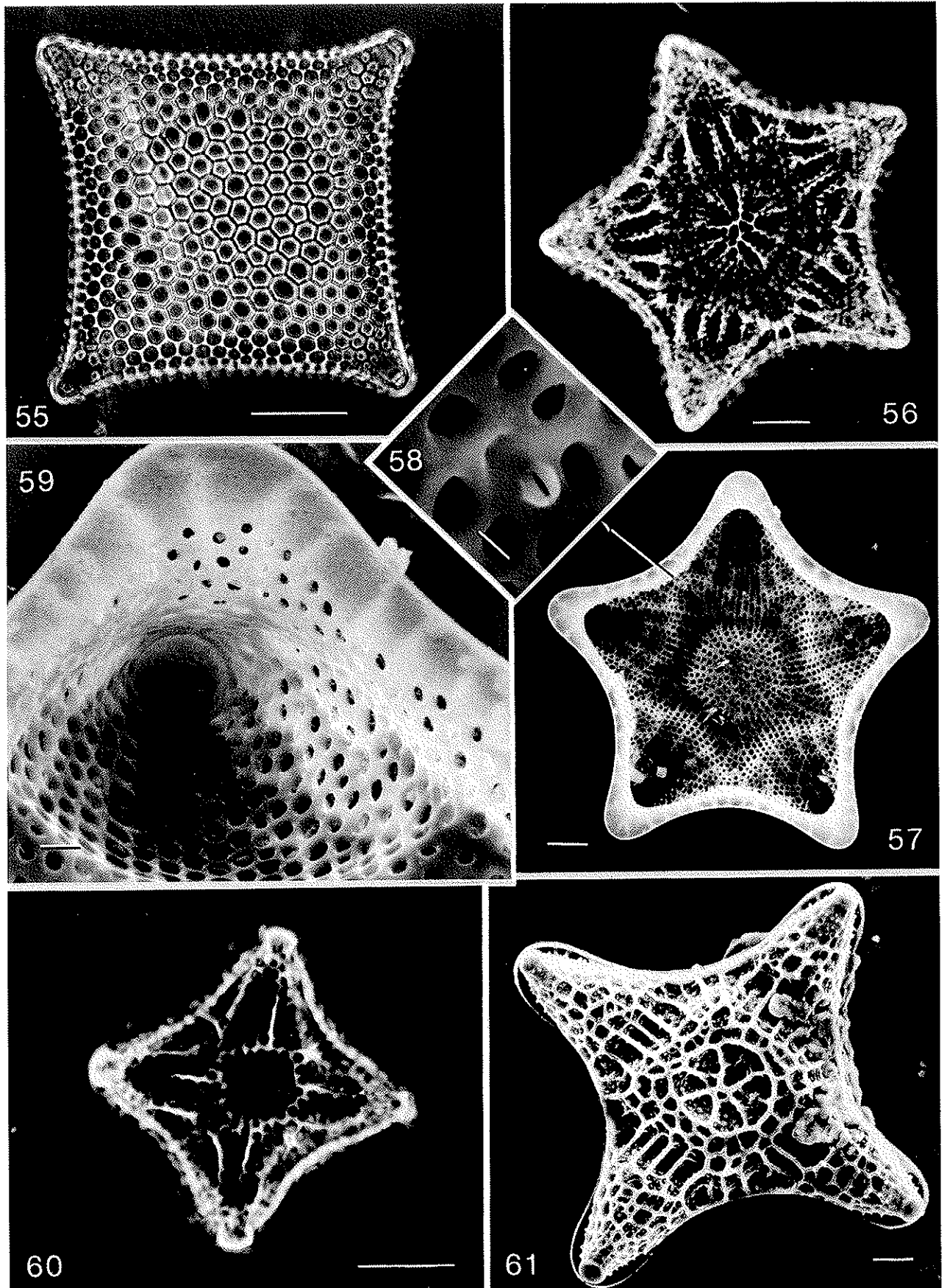


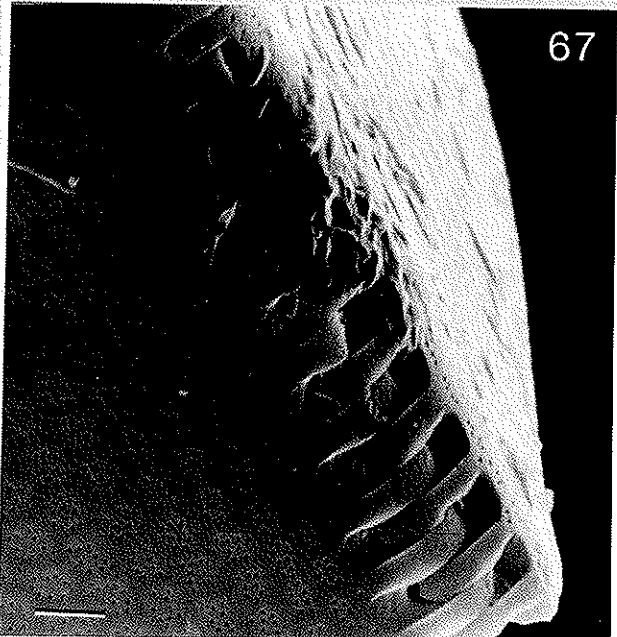
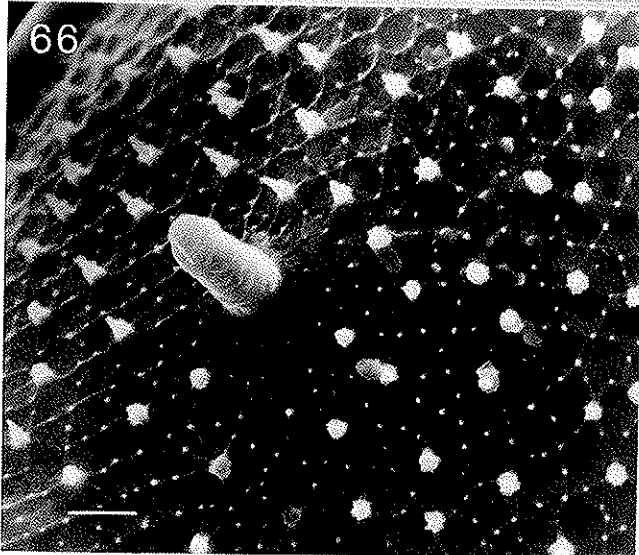
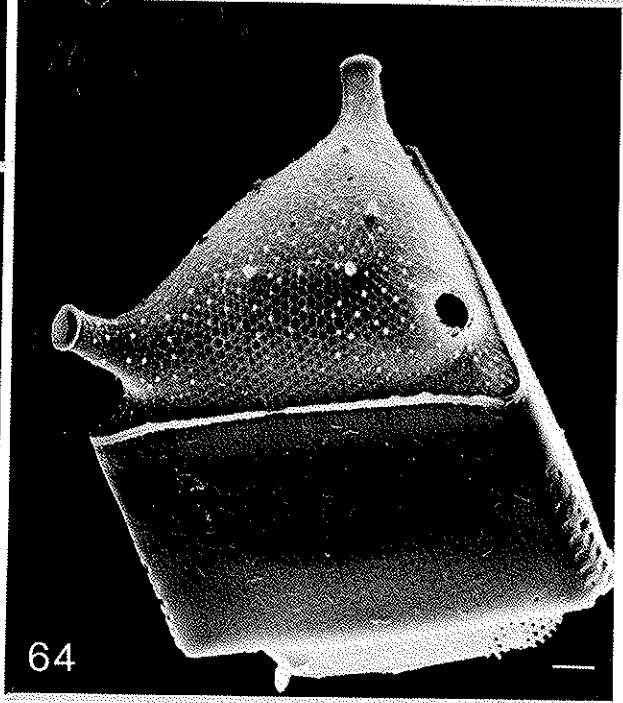
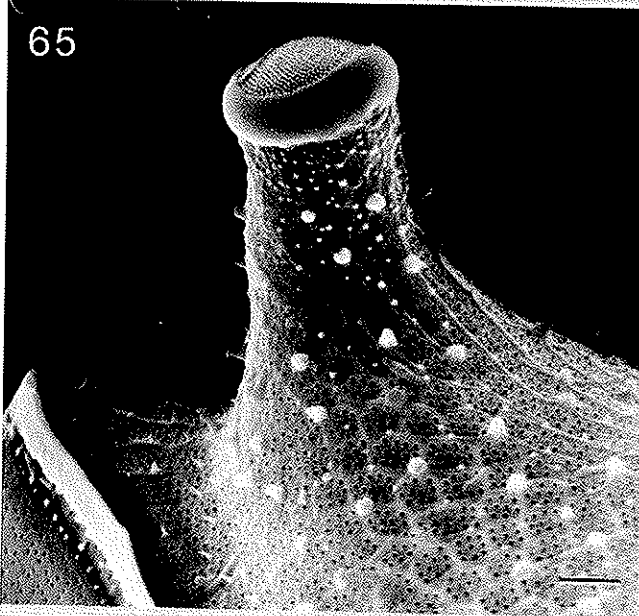
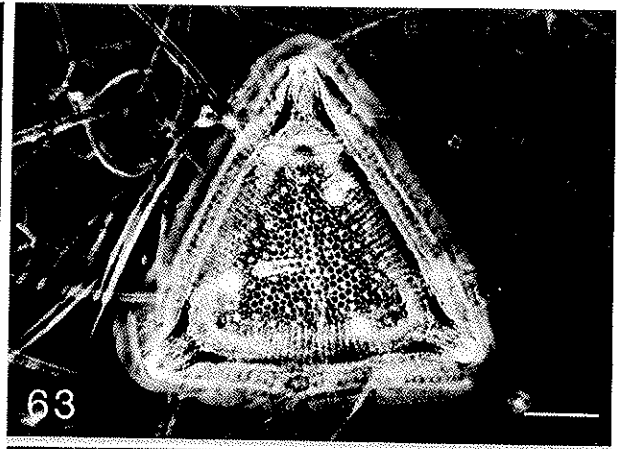
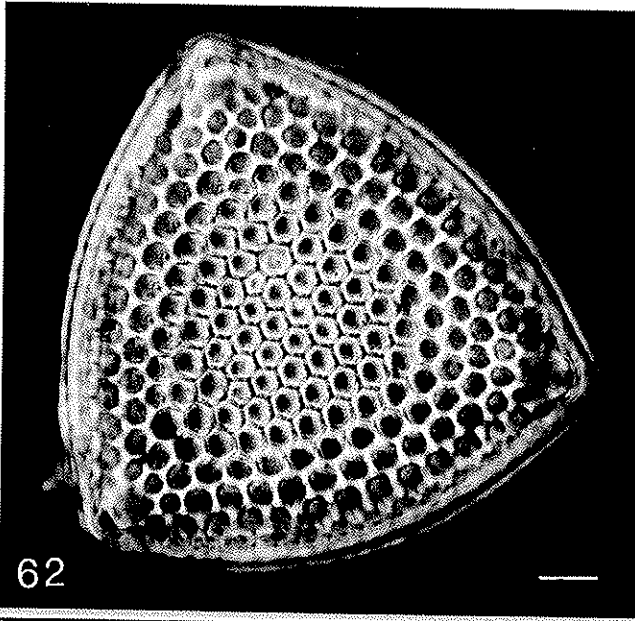












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A Survey of the Marine Diatoms of Puerto Rico III. Suborder Biddulphiineae: Family Chaetoceraceae

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Abstract

A taxonomic study on the marine diatoms from the southwestern coast of Puerto Rico is reported in this paper.

One family, Chaetoceraceae, of the suborder Biddulphiineae, with 2 genera, 31 species and 1 variety were observed. Eight of these taxa had never been reported from the coast of Puerto Rico and one is new for Puerto Rico and the Caribbean Sea.

Most of the identified species are cosmopolitan in temperate-tropical waters and neritic.

Introduction

In this paper the study of diatoms of Puerto Rico is continued to provide an annotated taxonomic listing of species. Characteristics of ecology and distribution in Puerto Rico, Caribbean Sea and Tropical or Subtropical Atlantic Ocean are also given for each taxa.

From the point of view of fisheries research, some members of the family Chaetoceraceae are of great importance as they are used as food by many organisms in the plankton (Hendey 1964). The genus *Chaetoceros* constitutes one of the most important diatoms in the marine phytoplankton due to its wide distribution and great number of species. They are found in both neritic (mostly belong to subgenus *Hyalochaete*) and oceanic environments (mostly belong to subgenus *Phaeoceros*).

In previous papers the genus *Chaetoceros* has always been well represented. Hagelstein (1938) observed 11 species in samples from a fixed station (Canal Martín Peña) in Puerto Rico and Margalef (1957, 1961) reported 28 species from the southern coast. In the Caribbean Sea, Takano (1960) observed 22 species; Margalef (1965) reported 36 species in NE of Venezuela; McCollum (1971) studied 19 species from the Caribbean Sea and Gulf of Mexico, and Hargraves *et al.* (1970) reported 15 species in the Lesser Antilles region. In the southeastern United States, Saunders and Glenn (1969) reported 35 species; Marshall (1971), 17 species, and Tester and Steidinger (1979) observed 24 species. This study then seeks to provide further information on this common diatom family for waters around Puerto Rico.

Contribution No. 301 of the Harbor Branch Foundation, Inc.

Methods

Description of the study area, as well as techniques for preparation and observations of the samples, were previously described by Navarro (1981).

For the identification of *Chaetoceros*, a difficult genus to identify at the species level, the criteria used were: colony formation, cell size and shape, nature of intercellular spaces, orientation and number of chloroplasts and morphology and orientation of setae (Hargraves 1979). Resting spores were not observed. For the genus *Bacteriastrum* similar criteria are used; however, the position of the forked part of the inner setae (parallel to the chain axis or transverse to the chain axis) is also of importance in classification (Cupp 1943). Other works used for the identifications were: Hustedt (1927-1930); Hendey (1964) and Brunel (1970).

Table I provides a key for the coded citations used in the Caribbean Sea listing for each species.

Observations

Order Centrales

Suborder Biddulphiineae

Family Chaetoceraceae

Bacteriastrum comosum Pavillard 1916. Rech. Diat. Pelag. Golfe du Lion, p. 29, Pl. 1, Fig. 3. Figs. 1-2

Ecology and Distribution: Marine, oceanic, cosmopolitan in temperate-tropical waters (37*, 21, 24, 19, 17, 39 and 40). A

* See Table 1.

Table I. Key for citation codes for references of species from the Caribbean Sea and Tropical or Subtropical Atlantic Ocean

1 – Buchanan (1971)	15 – Hulburt & Rodman (1963)	29 – Moreira Filho <i>et al.</i> (1975)
2 – Caycedo (1977)	16 – Hulburt <i>et al.</i> (1960)	30 – Müller-Melchers (1955)
3 – Davis (1950)	17 – Ivanov (1973)	31 – Müller-Melchers (1957)
4 – Ferraz de Reyes (1977)	18 – King (1950)	32 – Riley (1967)
5 – Fryxell (1978)	19 – López & Vinogradova (1972)	33 – Saunders (1967)
6 – Hargraves <i>et al.</i> (1970)	20 – López & Vinogradova (1974)	34 – Saunders & Glenn (1969)
7 – Hulburt (1962)	21 – Margalef (1965)	35 – Smayda (1970)
8 – Hulburt (1963)	22 – Margalef (1969)	36 – Suárez Caabro (1959)
9 – Hulburt (1964)	23 – Margalef & González (1969)	37 – Takano (1960)
10 – Hulburt (1966)	24 – Marshall (1971)	38 – Tester & Steidinger (1979)
11 – Hulburt (1967)	25 – Mazparrote <i>et al.</i> (1971)	39 – Turner & Hopkins (1974)
12 – Hulburt (1968)	26 – McCollum (1971)	40 – Vidal & Carbonell (1977)
13 – Hulburt & Corwin (1972)	27 – Moreira Filho (1961)	41 – Wood (1968)
14 – Hulburt & MacKenzie (1971)	28 – Moreira Filho (1964)	42 – Wood (1971)

new record for the water around Puerto Rico. Observed in samples from Ponce-Caja de Muertos and Cayo Enrique-Gata. Rare.

Measurements: Diameter 7–15 μm .

Collection: In bottles-Ponce-Caja de Muertos, October 1975.

Bacteriastrum elegans Pavillard 1916. Rech. Diat. Pelag. Golfe du Lion, p. 28, Pl. 1, Fig. 2. Fig. 3

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters. Cited only by Margalef (1957) for Puerto Rico. Observed rarely in samples from Cayo Enrique-Gata and Bahía Fosforescente.

Measurements: Diameter 16 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1978.

Bacteriastrum furcatum Shadbolt 1854. Trans. Micr. Soc. London, N.S., 2:14. Figs. 4–5

Syn.: *Bacteriastrum delicatulum* Cl. *sensu* Fryxell (1978) p. 63.

Ecology and Distribution: Marine, oceanic, eurythermal; cosmopolitan in temperate-tropical waters (30, 31, 36, 16, 7, 8, 10, 11, 15, 21, 32, 41, 23, 6, 1, 24, 42, 13, 17, 29 and 38). A new record for the coastal waters of Puerto Rico. Observed in samples from Cayo Enrique-Gata, Bahía Fosforescente and Ponce-Caja de Muertos. Sometimes abundant.

Measurements: Diameter 8–10 μm , pervalvar axis 16–18 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1977.

Bacteriastrum hyalinum Lauder 1864a. Trans. Microsc. Soc. London, N.S., 12:6. Figs. 6–7

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (30, 27, 16, 37, 15, 28, 21, 41, 23, 6, 35, 17, 29, 2 and 38). Cited by Hagelstein (1938) for the canal Martín Peña and by Margalef (1961) for the southern coast of Puerto Rico. Observed usually in samples from Cayo Enrique-Gata and Bahía Fosforescente.

Measurements: Diameter 18–27 μm , pervalvar axis 24–26 μm .

Collection: In bottles-Cayo Enrique-Gata, August 1976.

Bacteriastrum mediterraneum Pavillard 1916. Rech. Diat. Pelag. Golfe du Lion, p. 29, Pl. 2, Fig. 1. Fig. 8

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (21). A new record for the coastal waters of Puerto Rico. Observed rarely in samples from Cayo Enrique-Gata and Bahía Fosforescente.

Measurements: Diameter 19 μm .

Collection: In bottles-Bahía Fosforescente, March 1978.

Chaetoceros affine Lauder 1864b. Trans. Microsc. Soc. London N.S. 12:78. Fig. 9

Ecology and Distribution: Marine, neritic, eurythermal and euryhaline; cosmopolitan in cold temperate-tropical waters (30, 31, 16, 37, 7, 15, 28, 41, 23, 34, 6, 1, 26, 14, 24, 42, 19, 29, 4 and 38). Cited previously by Hagelstein (1938), Margalef (1957, 1961) and by Lyons (1973) for the coast of Puerto Rico. Observed frequently in samples from Cayo Enrique-Gata, Bahía Fosforescente and between Ponce-Isla Caja de Muertos.

Measurements: Apical axis 14–20 μm , pervalvar axis 14–20 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1976 and November 1977.

Chaetoceros anastomosans Grun. 1881. In V. H. Syn. Diat. Belgique. Pl. 82, Figs. 6–8. Fig. 10

Ecology and Distribution: Marine, neritic, cosmopolitan in temperate-tropical waters (21, 34 and 38). A new record for the coast of Puerto Rico. Observed rarely in samples from Cayo Enrique-Gata.

Measurements: Apical axis 8–20 μm , pervalvar axis 8–14 μm .

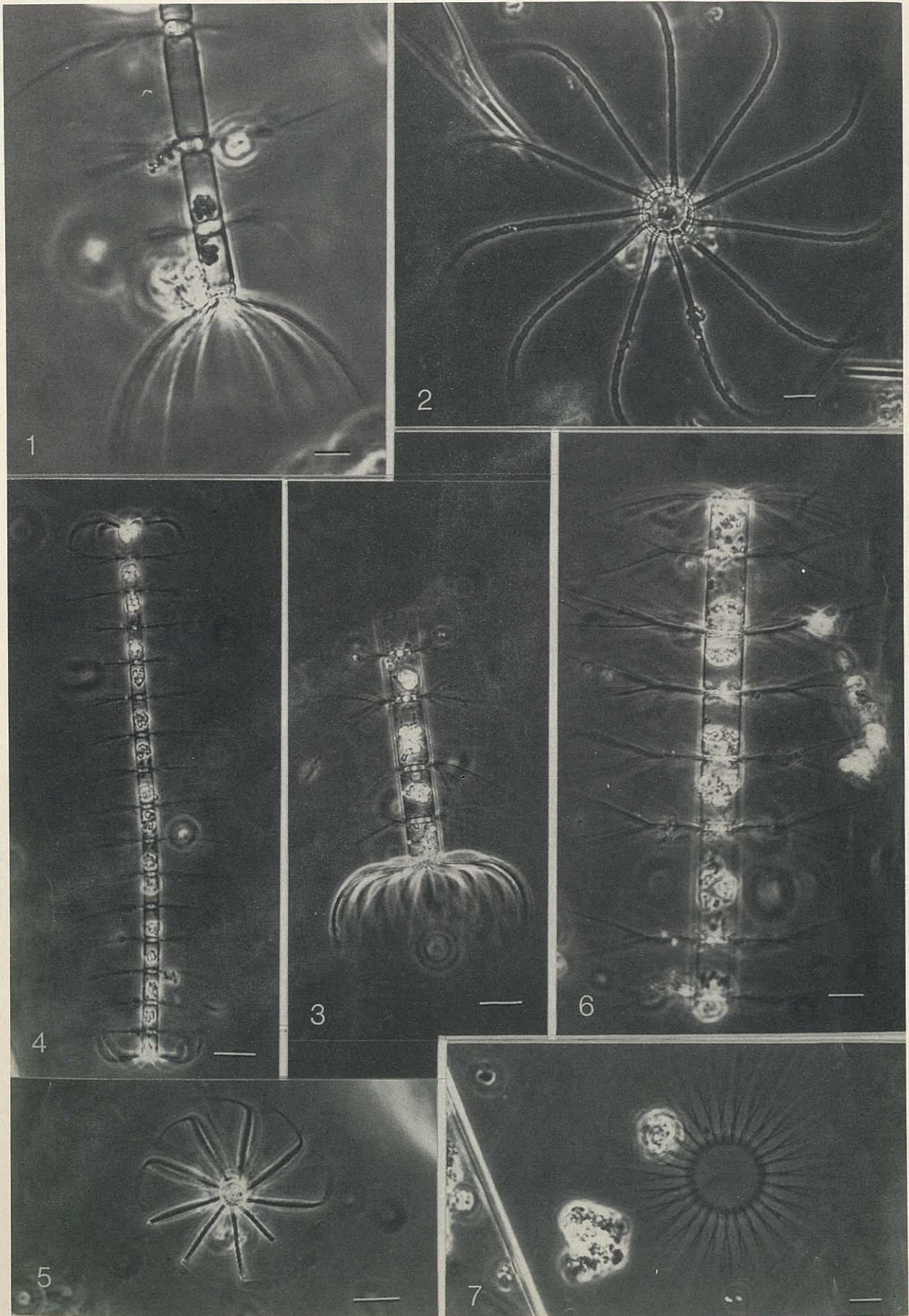
Collection: In bottles-Cayo Enrique-Gata, January 1978 and March 1978.

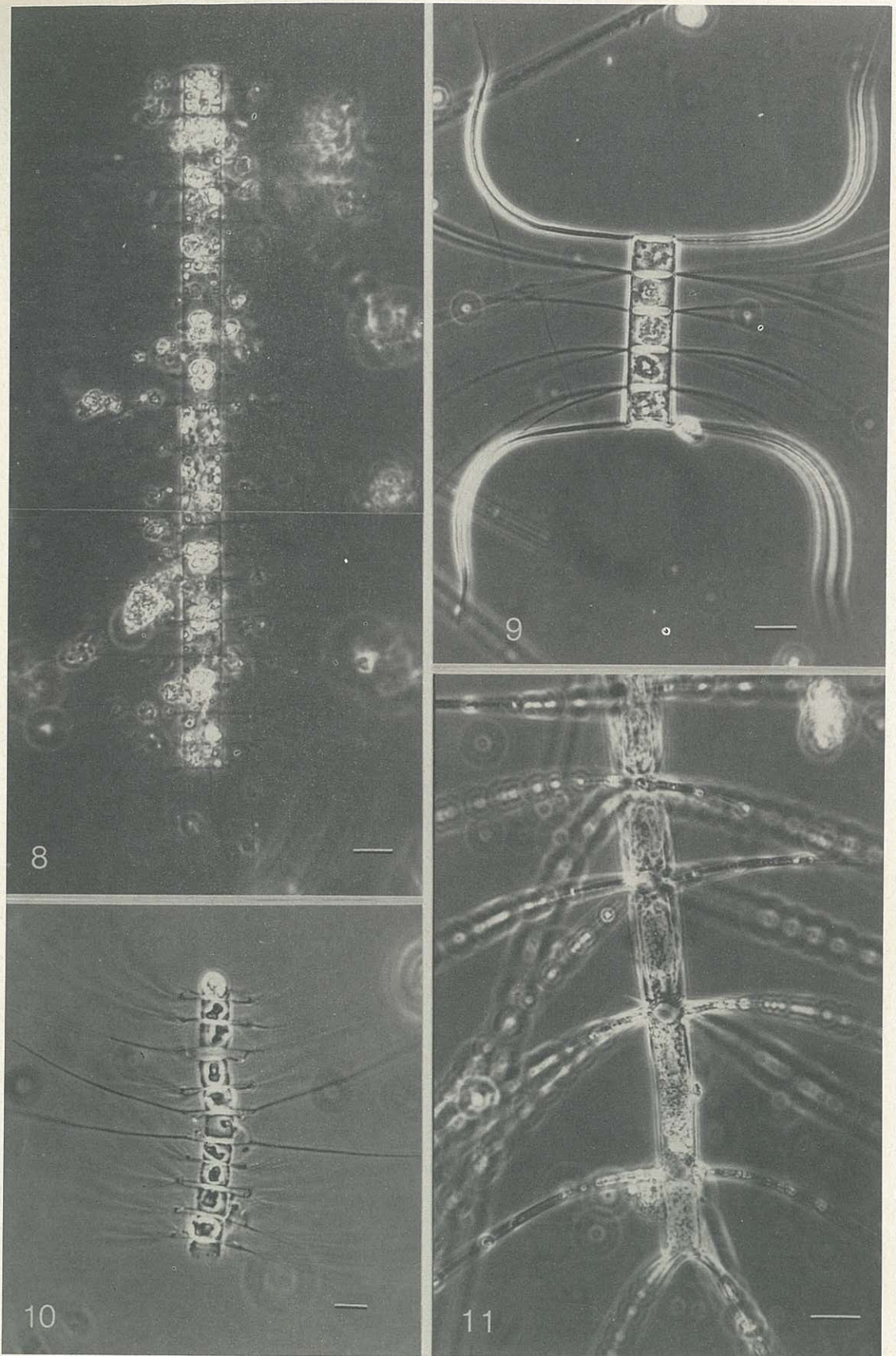
Chaetoceros atlanticum Cl. 1873b. Bih. K. Svenska Vetensk. Akad. Handl., 1 (13): 11. Fig. 11

Ecology and Distribution: Marine, oceanic, stenohaline; cosmopolitan (36, 9, 21, 41, 22, 24, 19, 17 and 38). Cited by Margalef (1957) for the south of Puerto Rico. Observed in samples from Cayo Enrique-Gata, not common in the area.

Figs. 1–7.

Figs. 1–2. *Bacteriastrum comosum*. Fig. 3. *Bacteriastrum elegans*. Figs. 4–5. *Bacteriastrum furcatum*. Figs. 6–7. *Bacteriastrum hyalinum*. Figs. 1–2, 7, scale bars = 10 μm ; Figs. 3–6, scale bars = 20 μm





Figs. 8–11.

Fig. 8. *Bacteriastrum mediterraneum*. Fig. 9. *Chaetoceros affine*. Fig. 10. *Chaetoceros anastomosans*. Fig. 11. *Chaetoceros atlanticum*. Figs. 8–9, 11, scale bars = 20 μm ; Fig. 10, scale bar = 10 μm

Measurements: Apical axis 16–22 μm , pervalvar axis 23–34 μm .
Valves with central processes.

Collection: In bottles-Cayo Enrique-Gata, March 1978.

Chaetoceros breve (?) Schütt 1895. Ber. dt. bot. Ges. 13:38. Fig. 12

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (30, 21, 34, 6, 24, 19, 34, 29, 40 and 38) Previously cited by Margalef (1957, 1961) and by Lyons (1973) for Puerto Rico. Observed commonly in samples from Cayo Enrique-Gata and Bahía Fosforescente. Resting spores were not observed.

Measurements: Apical axis 26 μm , pervalvar axis 16 μm .

Collection: In bottles-Cayo Enrique-Gata, October 1976.

Chaetoceros coarctatum Lauder 1864b. Trans. Microsc. Soc. London N.S. 12:79. Figs. 13–14

Ecology and Distribution: Marine, oceanic; cosmopolitan in temperate-tropical waters (18, 30, 31, 36, 37, 28, 21, 41, 22, 23, 6, 26, 24, 42, 17, 40 and 38). Cited only by Margalef (1957, 1961) for the south coast of Puerto Rico. Observed in several samples with *Vorticella oceanica* Zach as an epiphyte. Usually in samples from Cayo Enrique-Gata, Bahía Fosforescente and Ponce-Isla Caja de Muertos.

Measurements: Apical axis 26 μm , pervalvar axis 39–40 μm .

Collection: In bottles-Ponce-Caja de Muertos, October 1975 and Cayo Enrique, December 1977.

Chaetoceros compressum Lauder 1864b. Trans. Microsc. Soc. London N.S. 12:78. Fig. 15

Ecology and Distribution: Marine, neritic; cosmopolitan (30, 31, 37, 7, 8, 15, 9, 28, 12, 22, 34, 6, 26, 24, 17, 29 and 38). Cited by Hagelstein (1938) and by Margalef (1957) for Puerto Rico. Uncommon in the samples from the reef area and Ponce-Isla Caja de Muertos.

Measurements: Apical axis 4 μm , pervalvar axis 8 μm .

Collection: In bottles-Cayo Enrique-Gata, March 1977.

Chaetoceros constrictum Gran 1897. Norske Nordh. Exped. Bot., Protoph 24:17. Fig. 16

Ecology and Distribution: Marine, neritic; cosmopolitan (30, 21, 23, 34, 1 and 24). Cited for the southern coast of Puerto Rico by Margalef (1957). Observed rarely in samples from Bahía Fosforescente and Cayo Enrique-Gata.

Measurements: Apical axis 20 μm , pervalvar axis 18 μm .

Collection: In bottles-Cayo Enrique-Gata, October 1976.

Chaetoceros costatum Pavillard 1911. Bull. Soc. Bot. France 58:24. Fig. 17

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (21, 22, 9, 33 and 34). Cited by Margalef (1957) for the southern coast of Puerto Rico. Observed only in samples from Cayo Enrique-Gata. Very rare.

Measurements: Apical axis 18 μm , pervalvar axis 8 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1976.

Chaetoceros curvisetum Cl. 1889. Pelag. Diat. fr. Kattegat, p. 55. Figs. 18–19

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (30, 31, 27, 8, 15, 21, 11, 23, 34, 6, 26,

24, 25, 17, 20, 29, 40 and 38). Cited by Margalef (1957, 1961) for the southern coast of Puerto Rico. Observed frequently in the samples from Cayo Enrique-Gata, Bahía Fosforescente and Ponce-Caja de Muertos.

Measurements: Apical axis 10 μm , pervalvar axis 20 μm .

Collection: In bottle-Cayo Enrique-Gata, November 1977 and February 1978.

This species resembles *C. pseudocurvisetum* Mangin. However in that species, the edges of the valves are joined in two areas on each side asymmetrically with apertures lenticular; in *C. curvisetum* these apertures are circular or elliptical and the cells are joined by two corners.

Chaetoceros dadayi Pavillard 1913. Bull. Soc. Bot. France 60:131. Fig. 20

Ecology and Distribution: Marine, oceanic; cosmopolitan in temperate-tropical waters (37 and 19). A new record for the coastal waters of Puerto Rico. Observed only in one sample from Cayo Enrique-Gata attached to *Tintinnus inquilinus* Daday. Very rare.

Measurements: Apical axis 9 μm , pervalvar axis 6 μm .

Collection: In bottles-Cayo Enrique-Gata, February 1978.

Chaetoceros debile Cl. 1894. Bih. K. Svenska Vetensk Akad. Handl. 20 (3): 13. Fig. 21

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (3, 30, 15, 9, 34 and 38). A new record for the coastal waters of Puerto Rico. Observed in samples from Cayo Enrique-Gata and Bahía Fosforescente. Uncommon. Resting spores were not observed.

Measurements: Apical axis 22–32 μm , pervalvar axis 10 μm .

Collection: In bottles-Cayo Enrique-Gata, March 1977 and March 1978.

Chaetoceros decipiens Cl. 1873b. Bih. K. Svenska Vetensk Akad. Handl., 1 (13): 11. Fig. 22

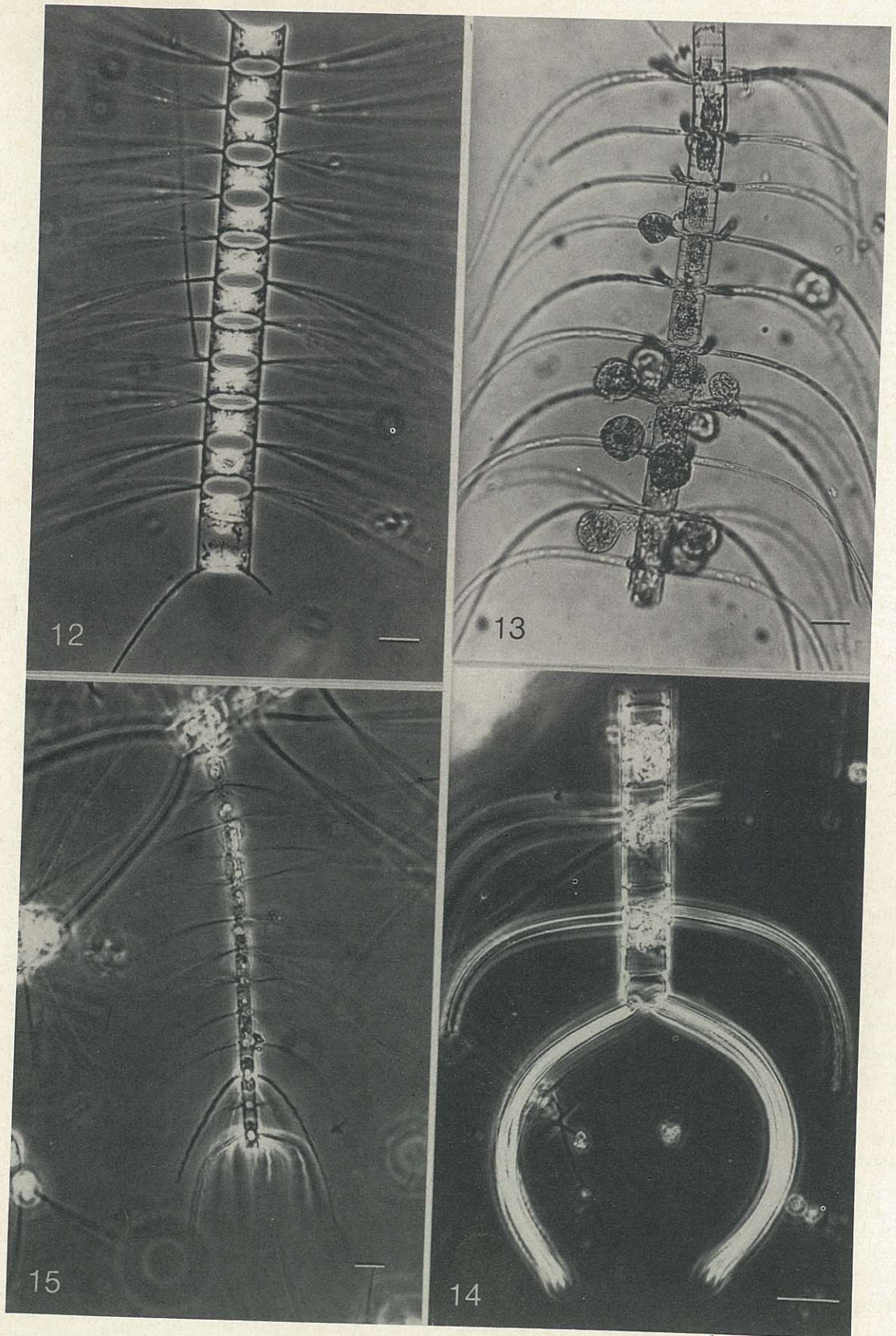
Ecology and Distribution: Marine, oceanic; cosmopolitan (3, 30, 16, 37, 15, 8, 21, 11, 12, 22, 23, 34, 6, 14, 26, 24, 25, 42, 13, 19, 17, 39, 29, 4 and 38). Cited by Hagelstein (1938) for the canal Martín Peña and by Margalef (1957, 1961) for the southern coast of Puerto Rico. Observed frequently in all samples from Cayo Enrique-Gata, also common in Ponce-Caja de Muertos and Bahía Fosforescente.

Measurements: Apical axis 12–30 μm , pervalvar axis 12–20 μm .

Collection: In bottles-Ponce-Caja de Muertos, October 1975.

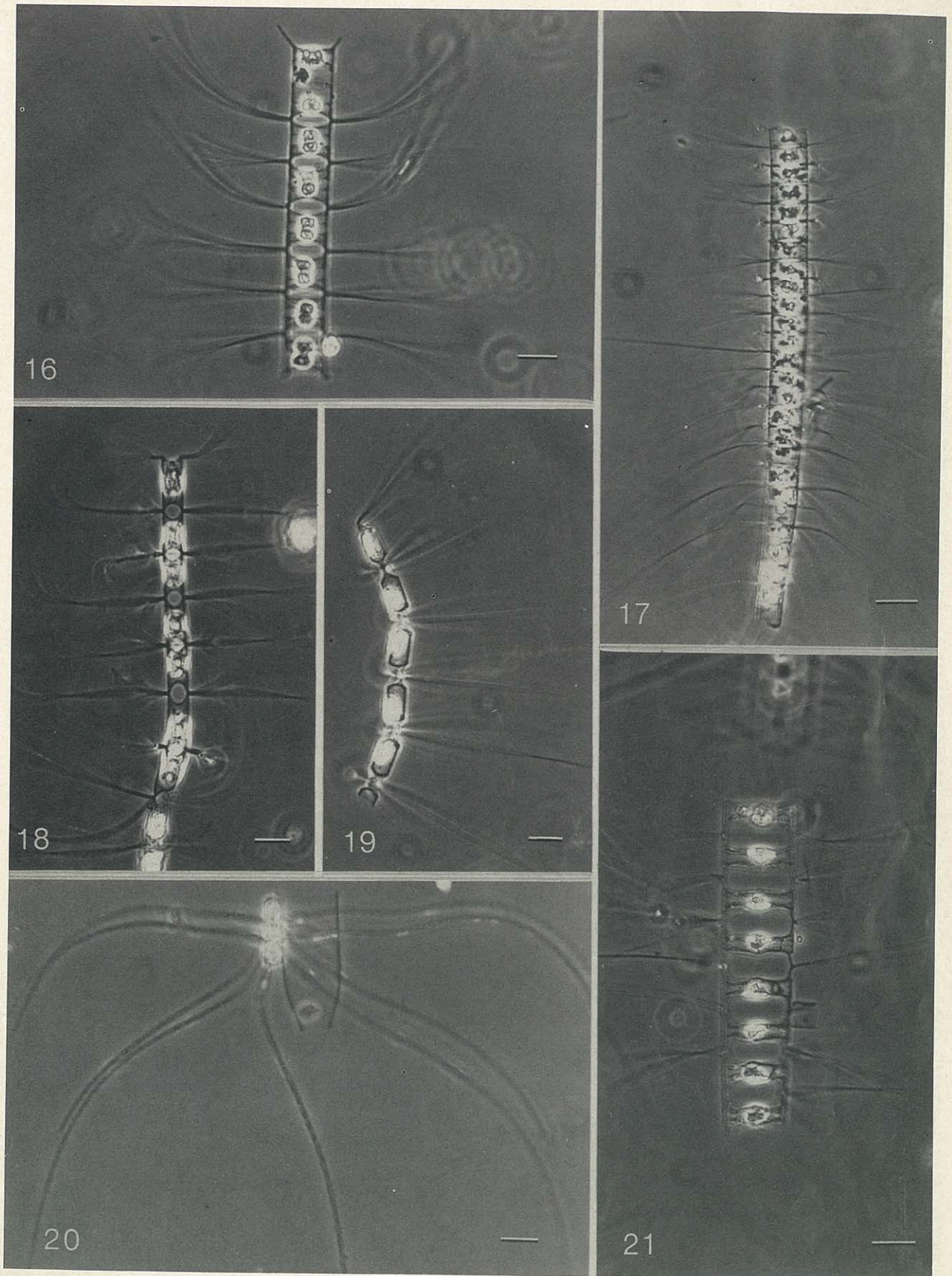
The specimens observed in Puerto Rico have setae of intercalary valves which are different from those found in North European waters, i.e., the setae seem to unravel at the ends, with large holes. Evensen and Hasle (1975) discussed this characteristic; they showed in their Figs. 67–69 specimens from the Gulf of Mexico which could be considered a different taxon. They called their specimens *Chaetoceros cf. decipiens*.

Dr. G. A. Fryxell (pers. comm.) also has observed similar forms in the Gulf of Mexico as those collected from Puerto Rican waters. Further studies with scanning electron microscope and cultures are necessary to elucidate the difference between these forms and *Chaetoceros decipiens* Cl.



Figs. 12-15.

Fig. 12. *Chaetoceros breve*. Figs. 13-14. *Chaetoceros coarctatum*. Fig. 13. With *Vorticella oceanica* attached. Fig. 14. Posterior terminal setae. Fig. 15. *Chaetoceros compressum*. Fig. 12, scale bar = 20 μm ; Figs. 13-14, scale bars = 30 μm ; Fig. 15, scale bar = 10 μm



Figs. 16–21.

Fig. 16. *Chaetoceros constrictum*. Fig. 17. *Chaetoceros costatum*. Figs. 18–19. *Chaetoceros curvisetum*. Fig. 20. *Chaetoceros dadayi*, with *Tintinnus inquilinus* attached. Fig. 21. *Chaetoceros debile*. Figs. 16–21, scale bars = 20 μ m

Chaetoceros didymum Ehr. 1846. Abh. Konigl. Akad. Wiss. Berlin, p. 75 Figs. 23–24

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (3, 30, 31, 15, 28, 21, 23, 34, 6, 24, 26, 13, 17, 29, 2 and 38). Cited by Margalef (1957, 1961) and by Glynn *et al.* (1964) in Puerto Rico. Observed frequently in samples from Cayo Enrique-Gata and Bahía Fosforescente.

Measurements: Apical axis 16–30 μm , perivalvar axis 10 μm .

Collection: In bottles-Cayo Enrique-Gata, November 1977.

Chaetoceros didymum var. *anglica* (Grun.) Gran 1905. Diat. Nord. Plankton, p. 80. Fig. 25

Ecology and Distribution: Marine, neritic; pantropical (37, 21, 34, 26, 2 and 40). Cited by Hagelstein (1938) for the canal Martín Peña in Puerto Rico. Observed in samples from Bahía Fosforescente, Cayo Enrique-Gata and Ponce-Caja de Muertos. Common.

Measurements: Apical axis 16 μm , perivalvar axis 18 μm .

Collection: In bottles-Cayo Enrique-Gata, April 1977.

Chaetoceros diversum Cl. 1873a. Bih. K. Svenska Vetensk. Akad. Handl. 1 (11): 9. Figs. 26–27

Ecology and Distribution: Marine, neritic; pantropical (30, 37, 27, 21, 12, 41, 26, 25, 19, 17, 2, 40 and 38). Cited previously by Margalef (1961) for Puerto Rico. Observed in samples from Cayo Enrique-Gata, Bahía Fosforescente and Ponce-Caja de Muertos. Common.

Measurements: Apical axis 8–10 μm , perivalvar axis 6–7 μm .

Collection: In bottles-Cayo Enrique-Gata, March 1977.

Chaetoceros eibenii Grun. 1881. In V. H. Syn. Diat. Belgique, Pl. 82, Figs. 9–10. Fig. 28

Ecology and Distribution: Marine, oceanic; cosmopolitan (34 and 38). A new record for the coast of Puerto Rico. Observed in samples from Cayo Enrique-Gata and Ponce-Caja de Muertos. Rare.

Measurements: Apical axis 40–48 μm , perivalvar axis 40 μm .

Collection: In bottles-Ponce-Caja de Muertos, October 1975.

Chaetoceros filiferum (?) Karsten 1907. Wiss. Ergebn. Dtsch. Tiefsee-Exped. "Valdivia", 2 (3): 392, Pl. 44, Figs. 5a–b. Fig. 29

Ecology and Distribution: Marine, oceanic. A new record for the coastal waters of Puerto Rico and the Caribbean Sea. Observed in samples from Cayo Enrique-Gata and Bahía Fosforescente, sometimes abundant.

Measurements: Apical axis 32 μm , perivalvar axis 11 μm .

Collection: In bottles-Cayo Enrique-Gata, December 1976, March 1977.

The specimens found in Puerto Rico are in agreement with the description of Karsten (1907) in the type of setae crossing, the number of chloroplasts (two), the position of the nuclei and valve outline (convex), but do not fit with Hendey's (1937) description of setae, i.e., short, slightly curved or Karsten's (1907) drawings of the setae.

Chaetoceros lacinosum Schütt 1895. Ber. dt. bot. Ges., 13:38. Figs. 31–32

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (16, 8, 15, 9, 21, 12, 25, 13, 17, 2 and 38). Cited only by Margalef (1957, 1961) for Puerto Rico. Observed in samples from Bahía Fosforescente, Cayo Enrique-Gata and Ponce-Caja de Muertos. Uncommon.

Measurements: Apical axis 12–13 μm , perivalvar axis 8 μm .

Collection: In bottles-Cayo Enrique-Gata, October 1977.

This species resembles *C. pelagicum* Cl., but the aperture is rectangular and the terminal setae are thick, emerging almost parallel, or are curved, so that the ends converge; cells also have two chloroplasts. In *C. pelagicum* the aperture is large, usually as large as the cells, terminal setae are divergent and there is only one chloroplast per cell.

Chaetoceros lauderi (?) Ralfs 1864. Trans. Microsc. Soc. London, N.S., 12:77, Pl. 8, Figs. 3–4. Fig. 33

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (21, 34 and 38). Cited by Margalef (1957, 1961) for Puerto Rico. Observed occasionally in samples from Cayo Enrique-Gata.

Measurements: Apical axis 12–22 μm , perivalvar axis 40 μm . Resting spores were not observed.

Collection: In bottles-Cayo Enrique-Gata, March 1977.

Chaetoceros lorenzianum Grun. 1863. Verh. Zool.-Bot. Ges. Wien, 13:157. Fig. 34

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (30, 31, 37, 7, 28, 21, 41, 22, 23, 34, 6, 1, 26, 42, 19, 17, 20, 29, 40 and 38). Cited previously by Hagelstein (1938) for the canal Martín Peña and by Margalef (1957, 1961) for the southern coast of Puerto Rico. Observed frequently in samples from Cayo Enrique-Gata and Bahía Fosforescente.

Measurements: Apical axis 12–16 μm , perivalvar axis 20 μm .

Collection: In bottles-Cayo Enrique-Gata, December 1976.

Chaetoceros neogracile Van Landingham 1968. In: Catalogue of the Fossil and Recent Genera and Species of Diatoms and their Synonyms, 2:733. Fig. 30

Ecology and Distribution: Marine, neritic, eurythermal; cosmopolitan (1, 24 and 38). A new record for the coastal waters of Puerto Rico. Observed in samples from Bahía Fosforescente, abundant in May 1977, also in Cayo Enrique-Gata.

Measurements: Apical axis 20 μm , perivalvar axis 10 μm .

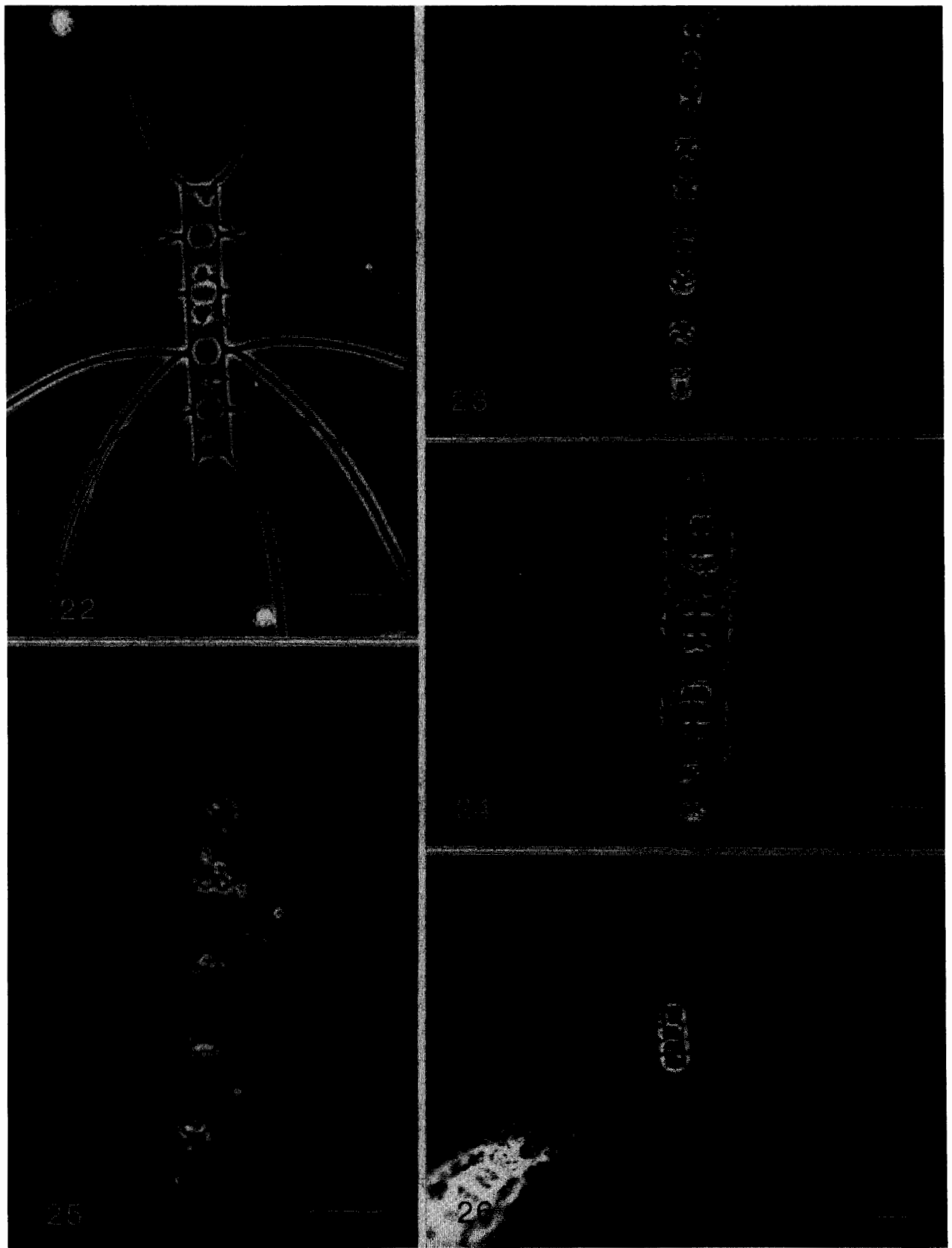
Collection: In bottles-Bahía Fosforescente, May 1977.

Chaetoceros pelagicum Cl. 1873b. Bih. K. Svenska Vetensk. Akad. Handl. 1 (13): 11. Fig. 35

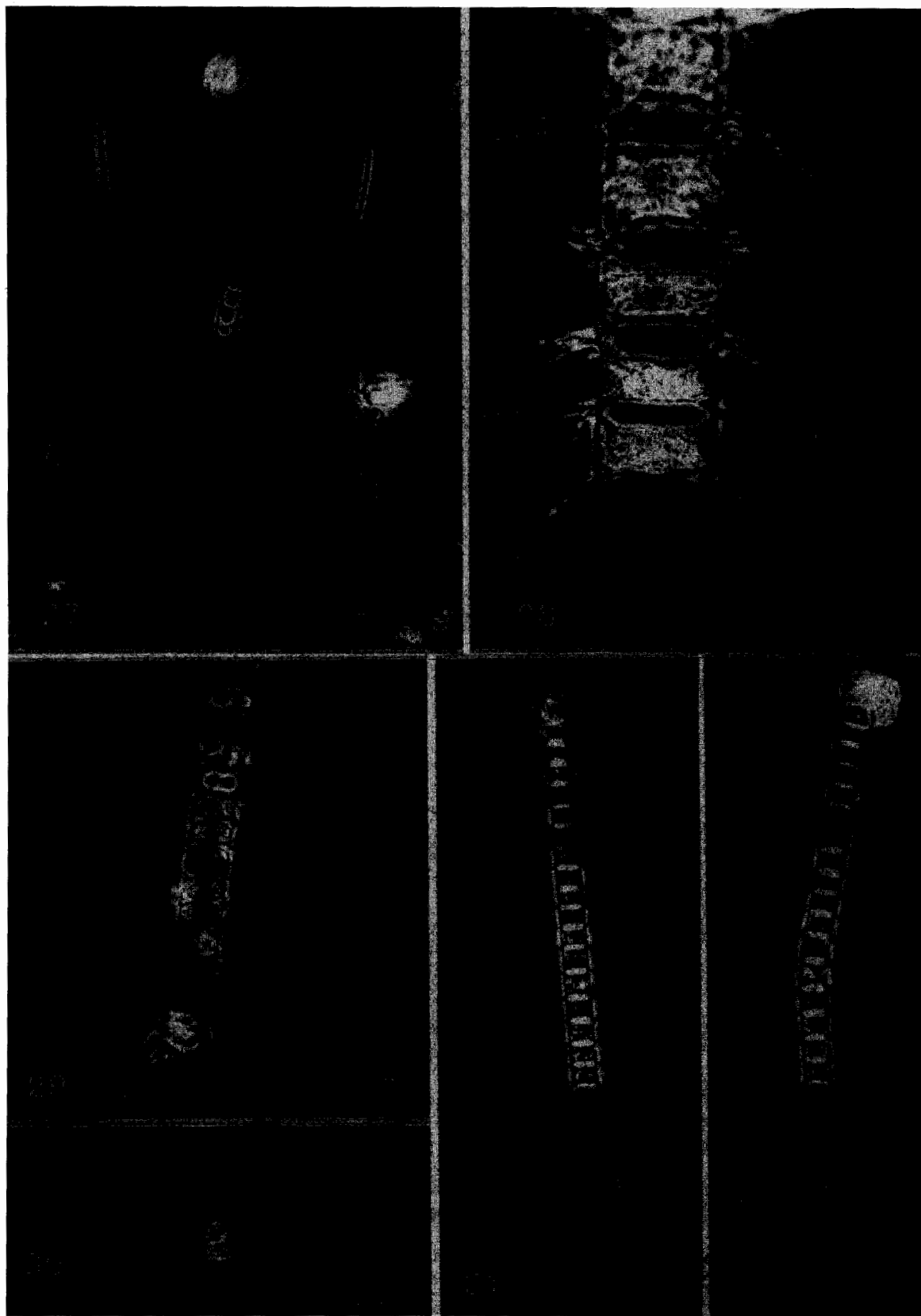
Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (34, 6, 17). Cited only by Hagelstein (1938) for the canal Martín Peña in Puerto Rico. Observed occasionally in samples from Cayo Enrique-Gata.

Measurements: Apical axis 10–12 μm , perivalvar axis 12–16 μm .

Collection: In bottles-Cayo Enrique-Gata, December 1976.

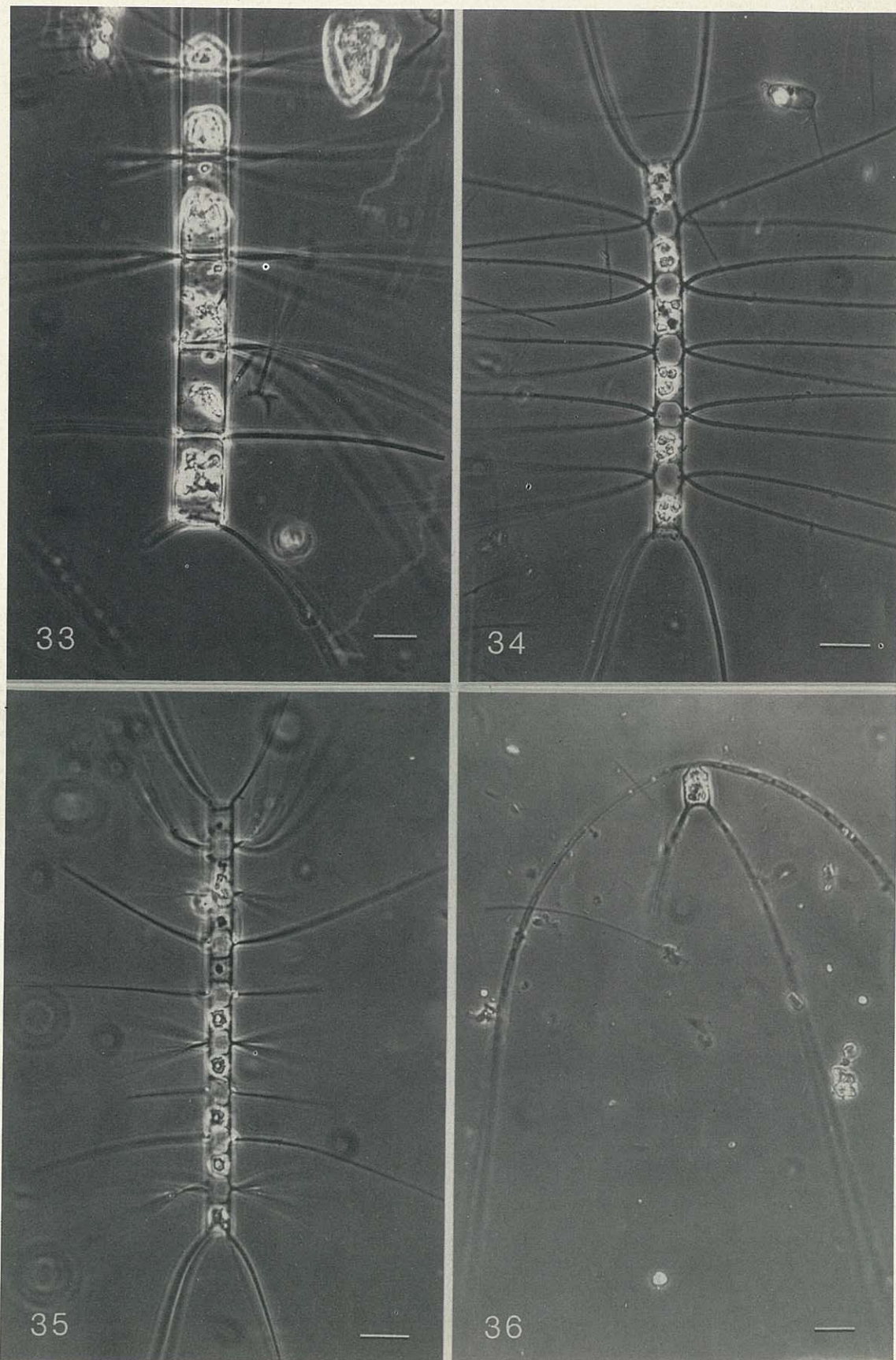


Figs. 22-26.
 Fig. 22. *Chaetoceros decipiens*. Figs. 23-24. *Chaetoceros didymum*. Fig. 25. *Chaetoceros didymum* var. *anglica*. Fig. 26. *Chaetoceros diversum*. Figs. 22-26, scale bars = 20 μ m



Figs. 27-32.

Fig. 27. *Chaetoceros diversum*. Fig. 28. *Chaetoceros eibenii*. Fig. 29. *Chaetoceros filiferum*. Fig. 30. *Chaetoceros neogratile*.
Figs. 31-32. *Chaetoceros laciniosum*. Figs. 27-28, 30-32, scale bars = 20 μm ; Fig. 29, scale bar = 30 μm



Figs. 33-36.

Fig. 33. *Chaetoceros lauderi*. Fig. 34. *Chaetoceros lorenzianum*. Fig. 35. *Chaetoceros pelagicum*. Fig. 36. *Chaetoceros peruvianum*.
Figs. 33-36, scale bars = 20 μ m

Chaetoceros peruvianum Brightw. 1856. Q. J. Microsc. Sci. 4:107. Fig. 36

Ecology and Distribution: Marine, oceanic; cosmopolitan (27, 7, 28, 21, 23, 34, 6, 24, 26, 19, 17, 20, 40 and 38). Cited by Margalef (1957, 1961) for Puerto Rico. Observed commonly in samples from Bahía Fosforescente and Cayo Enrique-Gata.

Measurements: Apical axis 10–24 μm , perivalvar axis 12–16 μm .

Collection: In bottles-Bahía Fosforescente, March 1977.

Chaetoceros pseudocurvisetum Mangin 1910. Bull. Soc. Bot. France, 57:350, Figs. 3, II and 4, II. Figs. 37–39

Ecology and Distribution: Marine, neritic; cosmopolitan in temperate-tropical waters (30, 31, 37, 21, 34, 24 and 5). Cited by Hagelstein (1938) for the canal Martín Peña in Puerto Rico. Observed in samples from Cayo Enrique-Gata and Bahía Fosforescente. Common.

Measurements: Apical axis 16–18 μm , perivalvar axis 20–30 μm .

Collection: In bottles-Cayo Enrique-Gata, November 1977.

Chaetoceros rostratum Lauder 1864b. Trans. Microsc. Soc. London, N.S., 12:79. Fig. 40

Ecology and Distribution: Marine, oceanic; cosmopolitan in temperate-tropical waters (30, 31, 37, 21 and 26). Cited previously by Margalef (1957, 1961) for Puerto Rico. Observed in samples from Cayo Enrique-Gata. Very rare.

Measurements: Apical axis 14 μm , perivalvar axis 20 μm .

Collection: In bottles-Cayo Enrique-Gata, March 1977.

Chaetoceros tortissimum Gran 1900. Nyt. Mag. Naturvid. 38 (2): 122. Fig. 41

Ecology and Distribution: Marine, neritic; cosmopolitan (18, 37, 21 and 34). Cited only by Margalef (1961) for the southern coast of Puerto Rico. Observed in samples from Cayo Enrique-Gata and Bahía Fosforescente, sometimes abundant.

Measurements: Apical axis 14–18 μm , perivalvar axis 8–10 μm .

Collection: In bottles-Cayo Enrique-Gata, August 1976.

Chaetoceros sp. Fig. 42

This species was observed rarely in samples from Cayo Enrique-Gata. Its principal characteristics are: the long, straight parallel setae perpendicular to the chain axis and one chloroplast in each cell. Resting spores were not observed.

Measurements: Apical axis 12–13 μm , perivalvar axis 12 μm .

Collection: In bottles-Cayo Enrique-Gata, December 1976.

Summary

This paper provides some taxonomic and geographical records for the Puerto Rican marine diatoms in the family Chaetoceraceae. These notes are arranged in the phylogenetic sequence suggested by Simonsen (1979) for this family of the suborder Biddulphiineae. In summary, several observations of note are:

– Eight out of 32 taxa are cited for the first time for Puerto Rico. These are: *Bacteriastrium comosum*; *B. furcatum*; *B. mediterraneum*; *Chaetoceros anastomosans*; *C. dadayi*; *C. debile*; *C. eibenii* and *C. neogracile*.

– One species is new for Puerto Rico and the Caribbean Sea, *Chaetoceros filiferum*.

– A majority of the taxa, 66.6%, are cosmopolitan in temperate-tropical waters; 26.6% are cosmopolitan and 6.6% are pantropical.

– Most of the taxa, 67.7%, are neritic and 32.2% are oceanic, based on available literature.

– There are some species that have been shown to be more widely distributed than others. Those most frequently cited in the literature relating to the Caribbean Sea and tropical or subtropical Atlantic Ocean are: *Bacteriastrium furcatum*; *Chaetoceros decipiens*; *C. affine* and *C. lorenzianum*.

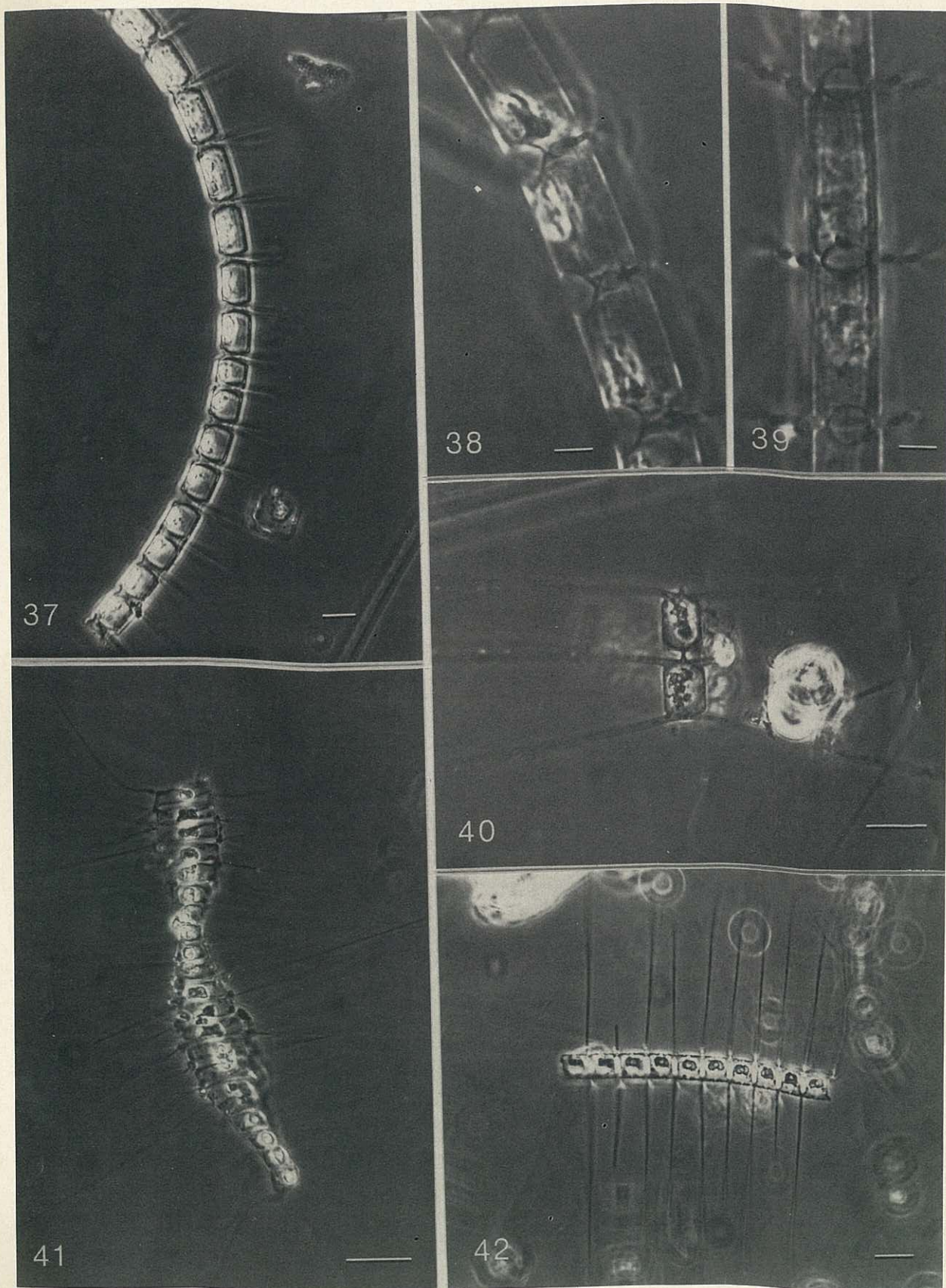
– The local species distribution for the southwestern coast of Puerto Rico is the following: 9 taxa were found only from Cayo Enrique-Gata (Station 1); 12 taxa were observed from Cayo Enrique-Gata and Bahía Fosforescente (Station 2); 3 taxa were observed from Cayo Enrique-Gata and Ponce-Caja de Muertos (Station 3) and 8 taxa from all stations.

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Figs. 37-42.

Figs. 37-39. *Chaetoceros pseudocurvisetum*. Fig. 40. *Chaetoceros rostratum*. Fig. 41. *Chaetoceros tortissimum*. Fig. 42. *Chaetoceros* sp. Figs. 37, 40-42, scale bars = 20 μ m; Figs. 38-39, scale bars = 10 μ m

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