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Bacillariophyceae from Karstic Wetlands in México

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with 3 figures and 21 plates

Dedicated to Dr. Arturo Gómez-Pompa

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Contents

Abstract

151 samples from freshwater environments in karstic wetlands (cenotes, ponds and inundated savannah) in El Edén Ecological Reserve were analyzed to describe the diatom flora present. Latitudinal situation and environmental features of the Reserve influence significantly the floristic diatom component. Of the 156 taxa identified, 29 species have a tropical distribution; 76 are registered as alkaliphilous species and 64 have an affinity to calcareous substrata. 9 new taxa (species) are described, and 3 new combinations are proposed: *Aulacoseira periphytica* sp. nov., *Caloneis sabanicola* sp. nov., *Capartogramma paradisiaca* sp. nov., *Cymbopleura chacii* sp. nov., *Encyonema densistriata* sp. nov., *Fragilaria dzonoticola* sp. nov., *Nitzschia yalahau* sp. nov., *Pinnularia mayarum* sp. nov. *Stauroneis amphibia* sp. nov., *Achnanthidium chlidanos* (Hohn et Hellermann) comb. nov., *Cymbopleura hustedtii* (Krasske) comb. nov., *Placoneis porifera* var. *oportuna* (Hustedt) comb. nov.

The most abundant species in the Reserve are *Cymbopleura chacii* sp. nov., *Brachysira microcephala* (Grunow) Compère, *Encyonema mesianum* (Cholnoky) D.G. Mann, *Encyonema gracile* Ehrenberg, *Encyonema mexicanum* Krammer, and *Mastogloia smithii* Thwaites ex W. Smith.

Resumen

Se analizó el contenido de diatomeas de 151 muestras de humedales kársticos de agua dulce (cenotes, charcos y sabanas inundadas) en la Reserva Ecológica El Edén. La situación latitudinal y las características ambientales de la Reserva influyen significativamente la composición florística diatomológica. De los 156 taxa identificados, 29 tienen una distribución tropical, 76 han sido registrados como alcalífilos y 64 con afinidad a los sustratos calcáreos. Se describen 9 especies nuevas y se proponen 3 combinaciones nuevas: *Aulacoseira periphytica* sp. nov., *Caloneis sabanicola* sp. nov., *Capartogramma paradisiaca* sp. nov., *Cymbopleura chacii* sp. nov., *Encyonema densistriata* sp. nov., *Fragilaria dzonoticola* sp. nov., *Nitzschia yalahau* sp. nov., *Pinnularia mayarum* sp. nov. *Stauroneis amphibia* sp. nov., *Achnanthidium chlidanos* (Hohn et Hellermann) comb. nov., *Cymbopleura hustedtii* (Krasske) comb. nov., *Placoneis porifera* var. *oportuna* (Hustedt) comb. nov.

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Introduction

The floristic characterization of freshwater algae of a region is generally supplemented by a consideration of their distribution, and it is common to find designated as 'cosmopolitan' those species recorded from a wide latitudinal range (Cantoral 1997; Novelo 1998; Tavera et al. 1994). But even when no reference to global distribution is presented in a work, the use of a specific name can imply acceptance of such a wide (cosmopolitan) geographical range (Foged 1984; Sarode & Kamat 1984, for example). When this is the case, usually there is no debate about the validity of registering one taxon described, for example, from alpine lakes, as also occurring in shallow water bodies at low latitudes and at few meters above sea level; this is equivalent to regarding such taxon as "cosmopolitan". However, the taxonomic determination or the ecological affinities of the species are questionable because alpine lakes and tropical shallow ponds have quite different ecologies. It would not be surprising if these differences were associated with an unknown difference in morphology, which should be circumscribed at least in the description, if not on the specific epithet.

In the taxonomy of diatoms, morphological description of the species considers subtle characters that are virtually inaccessible without adequate equipment

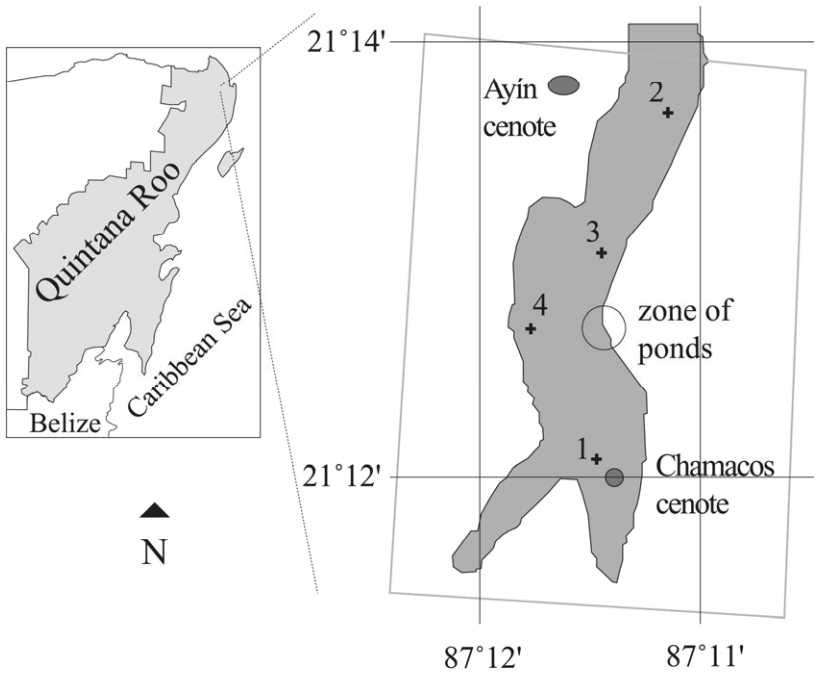


Fig. 1. El Edén Ecological Reserve, located at Northeast of the Yucatán peninsula, in Quintana Roo State (shaded). In the Reserve area enlarged to the right, the wetland zone (shaded), sites of collection, cenotes, and zone of ponds are shown.

including a scanning electron microscope. In floristics and ecology it is difficult to ensure the validity of species determination without that equipment. A way to get close to identity of species could be the use of complementary characters as the ecological affinities and the capacity to grow beyond them.

For us, together with the correct morphological description, knowledge of the geographical distribution of a species, as well as documentation of its environment, are the best framework for the recognition of biogeographically defined patterns and particular affinities to environmental conditions such as temperature, water chemistry, etc. This concept was used by Metzeltin and Lange-Bertalot (1998) in Central and South America. They note that some species that grow only in tropical conditions were more abundant in those areas than the species with a cosmopolitan distribution. They used the subtle characters mentioned above, but by making a very detailed morphological and geographical delimitation, ensured that the variation registered in their work does not correspond to ecomorphs or morphotypes of non-tropical species.

Certainly, the point where biological variation of a taxon justifies assignment of a new name is debatable and an extensive knowledge of the biology of groups is required (Winston 1999). Yet floristics does not define appropriate criteria to make this kind of decision. When the morphology of a species is unfamiliar to the observer, it is necessary to decide whether the differences are only a local manifestation of a wider morphological range or the expression of a distinct genome. When the morphology of a species looks entirely the same as one from distant latitude, a cosmopolitan distribution may be accepted if environmental factors of the two localities are similar (Komárek 1985).

Study Area

The 14.9 km^2 El Edén Ecological Reserve is in the Yalahau region of the northeast Yucatán Peninsula, in the state of Quintana Roo, México (fig. 1). The Yucatán platform is tectonically stable and not deformed by tangential stress since the middle of the Cretaceous, with Cenozoic (Upper Tertiary) deposits, principally carbonates and also evaporites and clastic deposits (De Cserna 1990). The morphogenesis of the platform has resulted in sub-horizontal strata of sedimentary rocks with development of karst forms, and the dominant exogenous process over wide areas is karstification mainly underground (Lugo-Hubp 1990; Lugo-Hubp & Córdoba-Fernández 1990). One remarkable characteristic of this platform, related to water resources, is the special water bodies defined as sinkholes in the limestone (natural wells) and called cenotes (singular: cenote) after the Maya "dzonot" (Perry et al. 2003). In the region of the Reserve, the soil unit according to the FAO/UNESCO System is rendzina with mollic A horizon directly overlying the calcareous material, with an equivalent calcium carbonate content higher than 40 % (López-García et al. 1990). The weathering residue of the exceptionally pure carbonate rocks has produced remarkably little soil cover (Perry et al. 2003).

The region has annual minimum radiation intensity in January (180-220 hrs.) and maximum in May with 260-320 hrs (Engracia-Hernández 1990), a very warm annual mean temperature (more than 26 °C) and a mean annual precipitation from 1200 to 1500 mm (Vidal-Zepeda 1990). The climate type according to Köppen's

System as modified by García is warm sub-humid from group A (Aw_1), with trade winds from the east, tropical cyclones ("nortes") in winter and a summer rain regime (García 1990). The potential vegetation in the NE of the Peninsula is evergreen tropical forest (Rzedowski & Reyna-Trujillo 1990); however, in the study area (in the Reserve) subdeciduous tropical forest and inundated savannah predominate. In addition to differences in soil and vegetation types, duration of the period of inundation, radiation intensity, and wind exposure, the savannah is exceptional in its extensive algal growths, which cover the entire substratum (Novelo & Tavera 2003). The Reserve is situated at 5-10 meters above sea level, between latitudes 21°11'30''N and 21°14'N, and longitudes 87°10'30''W and 87°12'30''W.

The collecting sites in the inundated zone are (fig. 1):

1. Savannah (21°12'06.3"N; 87°11'44.6"W), with a vascular vegetation canopy less than 30% with *Solanum donianum* Walp. dominant; soil depth 10-15 cm.
2. Savannah (21°13'42.2"N; 87°11'26.3"W), with a vascular vegetation canopy less than 40% with *Cladium jamaicensis* Crantz. dominant; soil depth 10-30 cm.
3. Tintal (21°13'01.1"N; 87°11'44.8"W), with a vascular vegetation canopy less than 5% with *Haematoxylon campechianum* L. dominant; soil depth 3-5 cm.
4. Ecotone tintal–subdeciduous tropical forest (21°12'44.1"N; 87°12'01.6"W), with a vascular vegetation canopy less than 10% with a mixture of *H. campechianum*, *Erythroxylon confusum* L, *Manilkara sapota* (L.) P. Rogen and *Crescentia cujete* L. Soil depth 5-15 cm.
5. Other sites: diverse ponds and two cenotes, "Ayín" and "Chamacos".

Methods

Diatoms from algal communities were collected during July and October of 1999 and in April, August, and November of 2000. Collections were made at four sites within the flood zone of El Edén (fig. 1). Metaphyton (direct samples of mat-like agglomerations of algae, floating among hydrophytes) and phytoplankton (net samples) were collected from the wetland during flooded periods; periphyton (direct samples of spongy films of algae covering the soil) was collected from the wetland during both the dry and flooded periods. The three communities were collected in the permanent water bodies (cenotes and ponds, fig. 1). Algal samples were preserved in formaldehyde (3%) and slide preparations for type material of new species have been deposited in the Herbarium of the School of Sciences at the Universidad Nacional Autónoma de México in the Edén – FCME collection.

A part of each sample, 1 cm^2 of metaphyton or periphyton was macerated by acid digestion for extraction and cleaning of diatoms. Water samples of plankton diatoms were processed directly by acid digestion. Permanent slides were mounted in Naphrax and observations of cleaned material were made with a Nikon E600 microscope, with differential interference contrast. LM photographs were produced with Ilford PAN F ISO 50/18 and ISO 100/36. SEM micrographs were produced in a JSM5310-LV Jeol microscope, with 10, 15 and 25 Kv. Even when several cleaning techniques were used, excess of sediment in some of the samples for SEM made difficult the complete documentation of species described in this work.

Descriptions of species are alphabetically organized according to the system of Krammer & Lange-Bertalot (1986, 1988, 1991a, 1991b), with some of the modifications proposed by Round et al. (1990) for supraspecific taxa. Some genera proposed lately were added to that system (Krammer 1997a, 1997b; Metzeltin & Lange-Bertalot 1998; Compère 2000; Kingston 2003; Kociolek & Spaulding 2003; Stoermer & Julius 2003). The Index Nominum Algarum (INA 2004) was also consulted for orthography and authorities of species; those names that did not appear there were denoted *sensu* a particular author.

Diatoms from El Edén Ecological Reserve

A considerable diatom contingent is present in the El Edén Ecological Reserve. The assignment as 'cosmopolitan' in figure 2a refers to those species well represented in the tropical and the temperate zones, but geographical distribution is not enough to assume the ecology of diatoms. We included then an ecological characterization of species according to bibliographic information (figs. 2b, 2c, 2d). Environments in El Edén (Table 1) are characterized by circumneutral to basic pH (as alkali reserve), karstic substratum, low salinity and medium conductivity. Based upon the literature, about the 50% of diatoms in El Edén fulfill at least two of these characteristics; that is they are karstic, alkaliphilous and (or) indifferent oligohalobous species in tropical as well as temperate communities. From one third to one half of the Mexican diatoms registered in other calcareous regions (Huasteca Potosina, Cantoral 1997; Montejano et al. 2000; Tehuacán Valley, Novelo 1998 and Cobá, Misol-Ha and Agua Azul, Metzeltin & Lange-Bertalot 1998) have the same composition as in El Edén flora. The most abundant taxa in the Reserve are species of *Encyonema* and *Brachysira* as well as *Mastogloia* and *Cymbopleura*. This species composition has little similarity with other floras for tropical America, such as those from Brazil, Venezuela or Guyana, where diatoms have been documented in localities with acidic pH and sometimes also saline conditions (Metzeltin & Lange-Bertalot 1998). For example, *Pinnularia* and *Eunotia*, which are typical of acidic regions with high organic matter content, are genera well represented in some areas of those countries (Metzeltin & Lange-Bertalot 1998), while in El Edén the species of these genera are represented by scarce populations; an exception being *P. acrosphaeria* which had been previously recorded from alkaline environments (Foged 1984).

The actual floristic profile is based on the dominant species, and dominance is based on the specific abundance considered as density, which is the number of species per collected area. When diversity of species is analyzed in a region, a common concern of ecologists is to know if the number of species may increase with the sample size i.e. with the number of individuals present in a sample (Magurran 1988). In the case of this study, one may ask if the size of the samples could be influenced by spatial and physiographic differences in the communities. Particularly in periphyton (films over the substratum) differences in thickness of the collected portions are not controlled, so there may be important biasing in number of collected species between samples. To evaluate our sampling, we use rarefaction, a method particularly sensitive to different sample sizes (Krebs 1999).

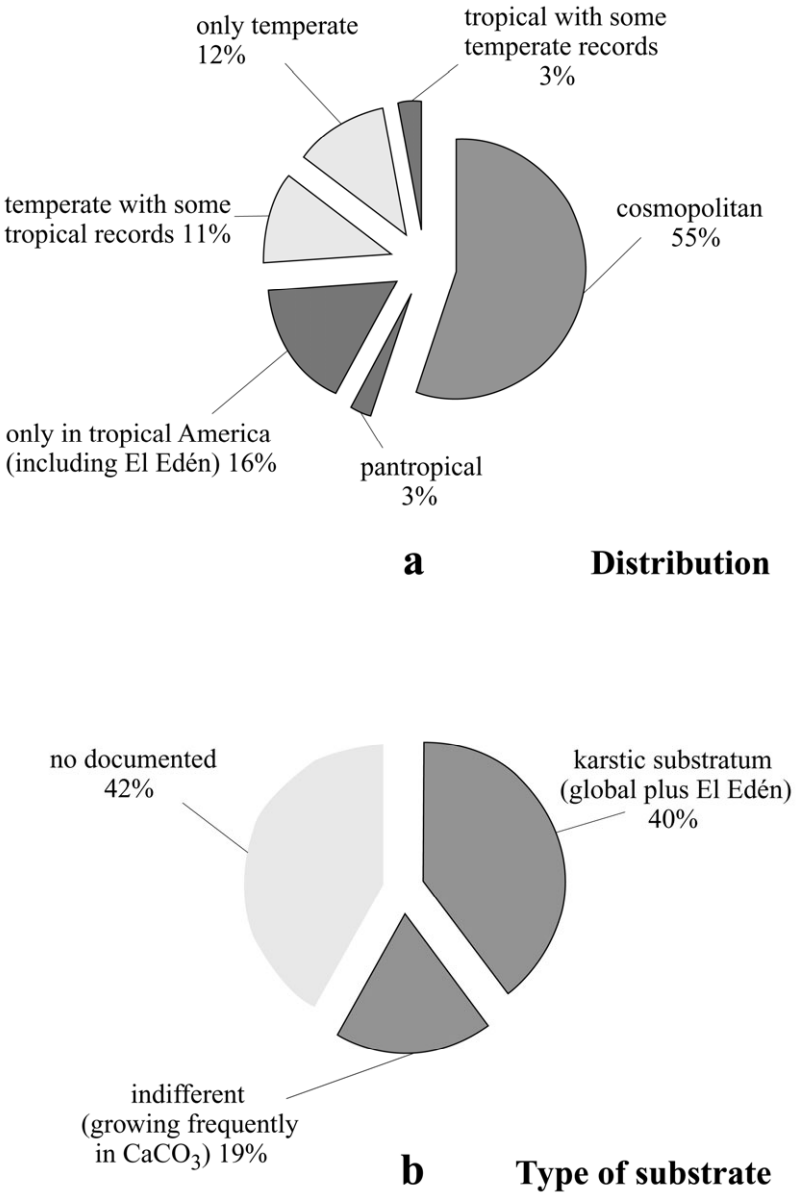
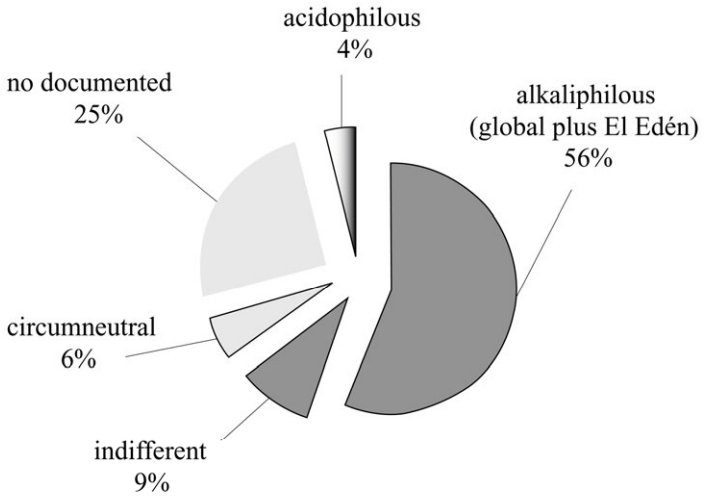


Fig. 2a,b. Percentage analyses of distribution and affinity for a type of substrate of diatom species in El Edén. From the total of 156 species, the majority (55%) has a cosmopolitan distribution (a) and 40% is characteristic of karstic substrata (b).



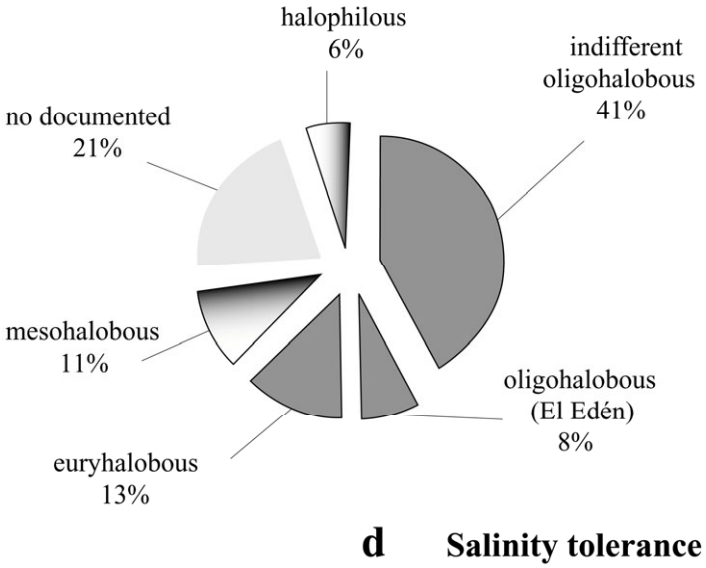


Fig. 2c,d. Percentage analyses of pH preference and salinity tolerance of diatom species in El Edén. From the total of 156 species, and 56% may be considered as an alkaliphilous floristic component (c), and at least 49% corresponds to freshwater environments (d).

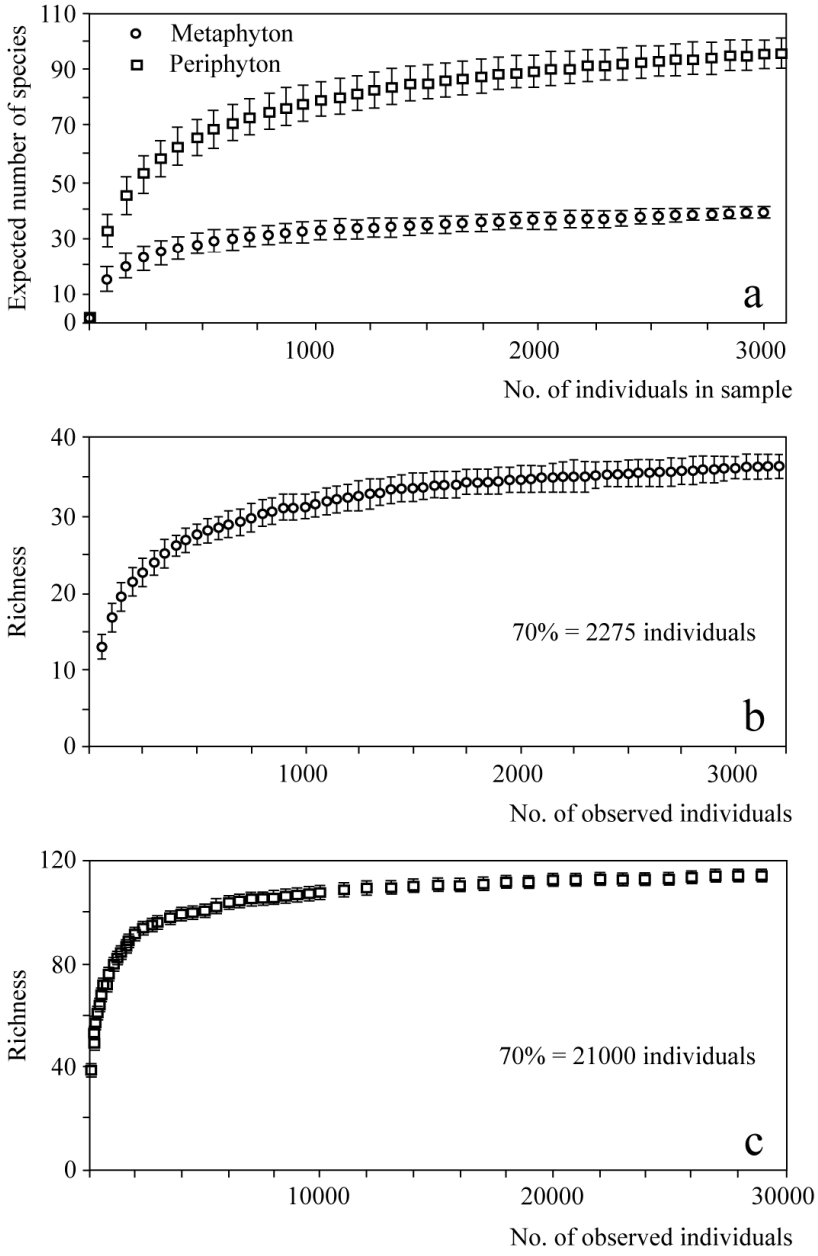


Fig. 3a-c. (a) Rarefaction curves of metaphyton and periphyton. Comparing an equal number of individuals from both communities, species richness is higher in periphyton; b, c: Accumulation curves of metaphyton (b) and periphyton (c). The asymptote was obtained with less than 70% observed individuals in each community.

Table 1. Some parameters in the aquatic conditions of the flooded savannah and in cenotes in El Edén. pH reserve (RpH) is a second pH determination after the sample is thoroughly aerated, as an index of alkali reserve.

	Site 1	Site 2	Site 3	Site 4	Chamacos cenote	Ayín cenote
conductivity µmS cm^{-1}	329	339	302	446	336	326
pH (units)	7.2	7.3	7.5	7.5	7.2	7.2
RpH	8.3	-	8.6	-	8.3	8.4
Total alkalinity $CaCO_3$ meq l^{-1}	0.997	0.998	0.930	0.923	0.973	0.923
HCO_3^- meq l^{-1}	0.966	0.812	0.746	0.839	0.870	0.746
Cl^- meq l^{-1}	0.42	0.35	0.49	0.81	0.43	0.59
CO_3^{2-} meq l^{-1}	.031	0.186	0.184	0.084	0.103	0.177
Ca^{++} meq l^{-1}	0.67	0.65	0.91	0.68	0.63	0.61
Na^+ meq l^{-1}	0.60	0.70	.056	1.31	0.62	0.70
Mg^{2+} meq l^{-1}	0.05	0.05	0.14	0.10	0.10	0.05
K^+ meq l^{-1}	0.01	0.02	0.01	0.02	0.01	0.005
SiO_2 meq l^{-1}	0.05	0.04	0.04	0.03	0.05	0.02

In El Edén there were 140 species collected from periphyton, 119 species from plankton and 104 from metaphyton. Nevertheless, sample size differed in these communities; to adequately compare species richness we constructed rarefaction curves for each community (Krebs 1999; Patrick 1968). These curves show that periphyton had the greatest species richness (fig. 3a). Plotting accumulation curves from our data (figs. 3b, c) asymptotic slopes are produced, irrespective of the community analysed, which means that the richness would not increase with the sample size.

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Descriptions of the taxa from El Edén Ecological Reserve

Key to the orders.
1a Valves with radial symmetry ..... Centrales
1b Valves with bilateral symmetry ..... Pennales (p. 17)

Key to the suborders of Centrales.
1a Marginal rimoportulae (labiate processes) ..... Coscinodiscineae
1b Marginal rimoportulae lacking..... Biddulphineae[1]

Suborder COSCINODISCINEAE

Key to the families
1a Valves with fultoportulae (strutted processes) ..... Thalassiosiraceae
1b Valves without fultoportulae ..... Melosiraceae (p. 15)

Family THALASSIOSIRACEAE

Key to the genera.
1a Different central and marginal ornamentation ..... *Cyclotella*
1b Whole surface of the valve with same ornamentation 2
2a Valves surface areolae in radial rows ..... *Stephanodiscus*
2b Valves surface areolae in linear or eccentric patterns ..... *Thalassiosira*

CYCLOTELLA Kützing

Key to the species.
1a Tangentially undulated valve surface, without cavities in the central area ..... *C. meneghiniana*
1b Valve surface without pronounced undulation; 3 large and 2-3 small circular cavities in the central area ..... *C. ocellata*

***Cyclotella meneghiniana* Kützing** (Pl. 1:1)
Frustules are solitary. Valves are circular with a pronounced undulations and short, peripheral spines; marginal fultoportulae are wanting. 2-4 evident marginal rimoportulae are present, as well as, one or two eccentric, isolated fultoportulae. Striae are thick at the margin and acute to the center of the valve. Areolae are not visible. Marginal striae are acute, alike, up to ⅓ of the radius, 8-14 in 10 µm. In the central area, the areolae form a very fine irregular waving pattern and it has not cavities. Valve diameter, 10-20 µm. Diameter central area, 4-12 µm. Height of cells, 4.8-6.4 µm.

Stoermer & Julius (2003) included *Cyclotella meneghiniana* in *Stephanocyclus* Skabitschevsky giving attention to the cell wall characteristics, but there is still some confusion between the morphology and ecology of species of *Cyclotella* and

[1] Only one isolated exemplar of *Pleurosira laevis* (Ehrenberg) Compére (Eupodiscaceae) and another of *Terpsinoe musica* Ehrenberg (Biddulphiaceae) were seen.

Stephanocyclus. They make clear that much of the experimental data on "*Cyclotella*" refer to *S. meneghiniana* which has ecological tendencies diametrically opposed to most species of *Cyclotella sensu stricto*. Because of a lack of adequate material for scanning electron microscope observations, and the different ecology of *Stephanocyclus meneghiniana* (hard and saline habitats, particularly large rivers), we retain the name *Cyclotella meneghiniana*.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Foged 1984; Hutchinson et al. 1956; Lowe 1974).

In El Edén this taxon grew mainly as plankton and metaphyton in cenotes, ponds and the inundated savannah, sometimes it was also collected in periphyton at these same environments.

***Cyclotella ocellata* Pantocsek** (Pl. 1:2)

Frustules are solitary. Valves are circular with a slight undulation and without peripheral spines. Valves have one to three eccentric fultoportulae, dispersed and four rimoportulae. Marginal striae are acute, unequal, up to ⅔ of the radius, 16-20 in 10 μm. In the central area, the areolae are very fine. Three round and radiate cavities are present in the central area. Valve diameter, 10-15 μm.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous (Casco & Toja 1991; Krammer & Lange-Bertalot 1991a).

In El Edén this taxon grew as plankton and metaphyton, and infrequent in periphyton in cenotes and the inundated savannah.

STEPHANODISCUS Ehrenberg

Key to de species.

1a Very fine areolation in the valve center ..... *S. hantzschii*
1b Very evident areolation in the valve center ..... *S. medius*

***Stephanodiscus hantzschii* Grunow** (Pl. 1:3)

Frustules are solitary. Valves are flat, with a fine structure at the surface, without hyaline marginal rings and a central area relatively differentiated from the marginal one. Costae are narrower than the striae, which are uniseriate. At the center, areolae are irregularly arranged. Two fultoportulae occur at the valve surface and fine spines are present at the margin. Valve diameter, 13-20 μm. Marginal striae, 8-11 in 10 μm.

This species is considered as temperate with some tropical records, alkaliphilous, and oligohalobous indifferent (Krammer & Lange-Bertalot 1991a; Lowe 1974; Metcalfe 1985).

In El Edén this taxon grew as plankton and metaphyton in cenotes and the inundated savannah. It was also collected as periphyton in the same environments.

***Stephanodiscus medius* Håkansson** (Pl. 1:4)

Frustules are solitary. Valves are concave, thicker at the surface and less thick at the margins. Without hyaline marginal rings and a central area very differentiated from the marginal one. Costae are narrower than the striae, which are uniseriate.

Areolae are loosely arranged at the center and radiate at the margin. One fultoportula occurs at each costa at the margin. Costae, 7-8 in 10 µm. Valve diameter, 20-22 µm. Marginal striae, 20 in 10 µm.

This species is considered as only temperate, without precise information on its ecology (Krammer & Lange-Bertalot 1991a).

In El Edén this taxon grew as periphyton in cenotes.

THALASSIOSIRA Cleve

***Thalassiosira visurgis* Hustedt** (Pl. 1:5)

Frustules are solitary with a very light convex surface. Areolae are radiate, in fascicles at the margin but disorderly at the center. One fultoportula occurs at the center and two marginal rimoportulae. Valve diameter, 11-20 µm. Areolae, 12 in 10 µm. Rows of areolae 20-22 in 10 µm.

This species is considered as only temperate and indifferent to pH (Krammer & Lange-Bertalot 1991a).

In El Edén this taxon grew as metaphyton and periphyton in cenotes and in savannah during inundated as well as dry periods.

Family MELOSIRACEAE

1a Extended, developed valve mantle; generally forming long filaments .... *Aulacoseira*

1b Short mantle; solitary of forming short filaments ..... *Melosira*

AULACOSEIRA Thwaites

Key to the species.

1a Frustules forming chains, always short; two rings of areolae in the mantle, without large linking spines ..... *A. periphytica*

1b Frustules forming short or large chains; multiple areolae in the mantle, diagonally arranged, with 1-2 large and 4-8 short connecting spines .... *A. granulata*

***Aulacoseira granulata* (Ehrenberg) Simonsen** (Pl. 1:6)

Frustules form relatively large or short chains. Mantle has 1 or 2 large and 4-8 short spines in the margin of the valve, with longitudinal grooves where large spines match to the neighboring cell. Striae are parallel to the pervalvar axis. Thick areolae are perpendicular to each other. Relatively short sulcus and pseudosulcus are not apparent. Valve view was not observed. Valve diameter, 6-13 µm. Mantle, 10-16 µm. Sulcus, 3 µm; pseudosulcus, 5 µm. Pervalvar striae, 8-10 in 10 µm. Areolae, 8 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous indifferent. As *Melosira granulata* (Ehrenberg) Ralfs: Czarnecki 1979; Foged, 1984; Lowe 1974; Metcalfe 1985; Obeng-Asamoa et al. 1980. As *Aulacoseira granulata*: Krammer & Lange-Bertalot 1991a; Novelo 1998; Padisák et al. 1998.

In El Edén this taxon grew as plankton in cenotes and the inundated savannah and as metaphyton and periphyton in ponds, cenotes and the inundated savannah; sometimes this species was observed in periphyton from the savannah during the dry period.

***Aulacoseira periphytica* sp. nov.** (Pl. 1:7)

Diagnosis: Frustula cylindrica, generaliter catenas breves (saepe duabus valvis) sejunctas formantia, longitudine latitudinem aequantia. Limbus 5-8 µm altus, spinis brevis marginalibus, sine spinis grandibus. Areolae grandes, subcirculares. Striae ad axem pervalvarem parallelae. Sulcus relative brevis, pariete crasso. Discus valvaris margine striato annulo areolarum ordinatarum; ceterum disci areolis irregularibus inordinatis. Rimoportulae marginales duae; fultoportulae in pagina valvari non visae. Cingulum 2.5 µm; striae pervalvares 10-11 in 10 µm; areolae 5-12 in 10 µm. Valvae 8-10 µm diametro, areolis marginalibus 5-8 in 10 µm, areolis in disci centro 7-8.

Holotypus: Praep. Eden 13.1 in Coll. Edén-FCME, Pl.1:7b.

Type locality: Flooded savanna (21°13'45'' N, 87°11'38'' W) in El Edén Ecological Reserve, Quintana Roo, México.

Description: Frustules are cylindrical, forming, in general, isolated short chains (often 2 frustules). Frustules are wide as long. Mantle has short marginal spines, without large spines. Areolae are large, sub circular. Striae are parallel to the pervalvar axis. Sulcus is relatively short and has a thick wall. In valve view, marginal striation is formed by a ring of ordered areolae; the rest of the disc with irregular, disordered areolae. Two marginal rimoportulae are present; fultoportulae are not observed in the valve surface. Mantle, 5-8 µm. Cingulum, 2.5 µm. Sulcus, 1.5 µm. Pervalvar striae, 10-11 in 10 µm. Areolae, 5-12 in 10 µm. Valve diameter, 8-10 µm. Marginal areolae, 5-8 in 10 µm. Areolae in the center of the disc, 7-8.

There is a tropical species, *Aulacoseira pfaffiana* (Reinsch) Krammer, (originally described as *Melosira distans* var. *africana* O. Müller = *Aulacoseira distans* var. *africana* (O. Müller) Simonsen), registered by Gasse (1986) from East African lakes; this species seems to display a preference for calcium-magnesium carbonate-bicarbonate waters and grows better under warm conditions (25-30 °C). The figures in Gasse (1986, Plate 2: 9-11) are similar to our material but show the valves constricted at the middle in girdle view. Also, they are smaller and have greater density of striae.

Our material could be also similar to *Aulacoseira distans* (Ehrenberg) Simonsen. Crawford & Likhoshway (1999) remark on the importance of SEM observation in a complete characterization of *A. distans*. Although we based our description only on LM observations, disposition of areolae in the mantle is very clear and the variability registered in *A. distans* for this character is quite different from our material (Krammer & Lange-Bertalot 1991a; Gasse 1986). There are only few records of *A. distans* and its varieties in South America (Maidana 1985), but judging from photographs and drawings in two previous records of this species in México, *Aulacoseira* aff. *distans* (Novelo 1998) and *Aulacoseira* spec. (García-Meza 1999), they are very similar to El Edén material. All these Mexican populations seem to be the same taxon.

The mantle in our exemplars shows scarce areolation with only two rings of areolae (5/10 μm) in external valves. It is denser in valves connecting with the neighbor frustule (4 rings, 12 areolae /10 μm). Besides, density of areolae is less in valve view; Krammer & Lange-Bertalot (1991a) recorded 10-16 areolae in 10 μm for *Aulacoseira distans*.

In El Edén this taxon grew as plankton and periphyton in cenotes and epipsamic in the inundated savannah[2].

MELOSIRA C. Agardh

***Melosira varians* C. Agardh** (Pl. 1:8)

Frustules are solitary or forming chains of two or three cells. Valves have a flat surface. Mantle is smooth, without sulcus but has a pseudosulcus evident. Very small pores occur in the mantle as well as in the valve surface. Valve diameter, 15-18 μm. Length, 30 μm. Mantle, 14-15 μm.

This species is considered as cosmopolitan, alkaliphilous, indifferent to oligohalobous (Krammer & Lange-Bertalot 1991a; Lowe 1974).

In El Edén this taxon grew as periphyton and metaphyton in inundated savannah, cenotes and ponds; also as plankton in cenotes.

Order PENNALES

Key to the suborders.

1a Valves without raphe ..... Araphidineae
1b Valves with raphe ..... Raphidineae (p. 25)

Suborder Araphidineae

One family ..... Fragilariaceae

Family FRAGILARIACEAE

Key to the genera.

1a Valves with transpical ribs ..... *Diatoma*
1b Valves without transpical ribs 2
2a Two rimoportulae per valve 3
2b Lacking rimoportulae or one per valve 4
3a Central fascia thickened ..... *Ctenophora*
3b Central fascia not thickened ..... *Ulnaria*
4a Broad striae (formed by linear areolae) 5
4b Narrow striae (round or transapically elongated areolae) 6
5a Ovate to elliptical valves with a depression at one pole ..... *Martyana*
5b Linear to elliptical valves, or cruciform; without rimoportulae, with marginal spines ..... *Staurosirella*

[2] Epipsamic growths are restricted to humid soil at the edges of the wetland.

6a Linear or lanceolate valves, elongated, with one rimoportulae ..... *Fragilaria*
6b Elliptical or cruciform valves without rimoportulae 7
7a Marginal striae only ..... *Pseudostaurosira*
7b Striae longer ..... *Staurosira*

CTENOPHORA (Grunow) D. M. Williams et Round

***Ctenophora pulchella* (Ralfs ex Kützing) D.M. Williams et Round** (Pl. 1:9)
Frustules are solitary. Valves are linear with straight apical axis; slightly extended ends are tapered; rounded poles and parallel margins at the center. In girdle view the frustule is slightly angular. Central area is rectangular, reaching the margin of the valve on one or both sides, where a siliceous thickening is present; axial area is wide, angular, reaching ⅓ of the valve. One apical pore field is present. Regularly arranged striae are punctate. Length, 52.5-75.0 µm. Breadth, 5-6 µm; Length:Breadth ratio 8.0-12.5. Striae, 11-12 in 10 µm, occupying less than ⅓ of the valve's width. Areolae, 20 in 10 µm.

This species has been reported from a wide range of environmental conditions, specially salinity and conductivity (Krammer & Lange-Bertalot 1991a; Kingston 2003). Our exemplars have a wider axial area than that described for the species but this single character does not seem valid enough to describe a new species, even though Round et al. (1990) consider this genus as monotypic. This may be a truly freshwater species, in spite of it is frequently present in salty-high conductivity situations. This species is considered as cosmopolitan.

In El Edén this taxon grew as periphyton in cenotes.

DIATOMA Bory

***Diatoma mesodon* Kützing** (Pl. 1:10)
Frustules form chains of 3-4 cells. Valves are isopolar, elliptical-lanceolate, without prolonged ends. Girdle view is rectangular, wide, with straight margins. Length, 12-20 µm. Breadth, 6-15 µm. Costae, 4-5 in 10 µm. Mantle, 12-13 µm, with 5 girdle bands. Transapical striae fine, 32-36 in 10 µm.

This species is considered as temperate (Krammer & Lange-Bertalot 1991a).

In El Edén this taxon grew as plankton, metaphyton and periphyton in cenotes, and rare as periphyton in inundated savannah.

FRAGILARIA Lyngbye

Key to the species and varieties.
1a Convex to slightly convex margins, lanceolate or linear valves 2
1b Straight margins, parallel or slightly concave at the center 3
2a Lanceolate valves, slightly three-undulated margins, rostrated ends .... *F. capucina* var. *vaucheriae*
2b Linear valves, slightly rhombic, subcapitate ends ..... *F. dzonoticola*
3a Parallel margins, slightly extended ends with rounded poles ..... *F. famelica*
3b Slightly concave margins, extended ends with blunt poles ..... *F. goulardii*

***Fragilaria capucina* var. *vaucheriae* (Kützing) Lange-Bertalot** (Pl. 1:11)
Frustules are solitary, bipolar, and straight in girdle view. Valves are lanceolate, with rostrate ends and rounded poles. Slightly convex margins in valve view, triundulate without visible spines. The central area is unilaterally developed, sometimes with a unilateral, horseshoe-like swelling; linear axial area of variable width. Central striae are parallel to radiate at the margins; convergent to the poles with elongated areolae. Length, 14.6-36.0 µm. Breadth, 2.0-5.3 µm. Length:Breadth ratio, 3-18. Striae, 8-16 in 10 µm at the center and 11-12 in 10 µm at the poles.

This variety is considered as temperate with some tropical records in mountainous regions (Krammer & Lange-Bertalot 1991a; Tavera et al. 1994).

In El Edén this taxon grew mainly as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. Also, it was present in the plankton in cenotes.

***Fragilaria dzonoticola* sp. nov.** (Pl. 1:12)
Diagnosis: Frustula solitaria, symmetrice bipolaria, aspectu laterali recta. Valva linearis, leviter rhomboidea, 29-32 µm longa, 4.2-5.0 µm lata, apicibus subcapitatis, polis rotundatis. Margines in facie valvari convexi. Area centralis absens; area axialis lanceolata, quam 1/4 valvae minor. Striae parallelae, lineares, 10 in 10 µm.
Etymology: dwelling in dzonots [Mayan] = cenotes [Spanish], karstic sinkholes.
Holotypus: Praep. Eden 403.4 in Coll. Edén-FCME, Pl. 1:12a.
Type locality: Ayin cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Frustules are solitary with and symmetrical about apical and transapical axes. Girdle view is straight. Valves are linear, slightly rhombic with subcapitate ends and rounded poles. In valve view the margins are convex. Central area is absent; axial area is narrow, lanceolate, less than ¼ of the valve. Striae are parallel, linear. Length, 29-32 µm. Breadth, 4.2-5.0 µm. Length:Breadth ratio, 6-7. Striae, 10 in 10 µm.

This population is a member of *Fragilaria* because of the presence of a single rimoportula and margins without undulations. Although similar in shape to *F. capensis* Grunow, the absence of punctate striae in our exemplars, the width of the axial area as well as a less density of striae are not coincident (Witkowski et al. 2000). Besides, the ecology of *F. capensis* is strictly marine (Witkowski et al. 2000). The single observation in LM suggests morphology similar to *Staurosira construens* var. *venter* (Ehrenberg) Hamilton, but this taxon has margins clearly straight. Moreover, width of axial area and density of striae of *F. dzonoticola* do not coincide with *S. construens* v. *venter*, and species of *Staurosira* lack of rimoportulae.

In El Edén this taxon grew as periphyton in cenotes.

***Fragilaria famelica* (Kützing) Lange-Bertalot** (Pl. 2:1)
Frustules are solitary. Valves are linear with straight apical axis; slightly extended ends, subcapitate; rounded poles and parallel margins in valve view. In girdle view the frustule is straight. Central area is rectangular, longer than broad, reaching the margin of the valve only on one side; without an axial area. Striae are

very fine, punctate, and regularly arranged. Length, 75-86 µm. Breadth, 2.5-3.0 µm. Length:Breadth ratio, 25-34. Striae, 14-16 in 10 µm.

Although we do not have material documented in SEM, this species was maintained in *Fragilaria sensu* Krammer & Lange-Bertalot (1991a) based on LM visible characters, which correspond well to description of *F. famelica*. Morales (2003) discussed the separation between *F. pennsylvanica* Morales and *F. famelica* suggesting that the presence of one rimoportula may be assumed for both species, even if there is not a satisfactory documentation of *F. famelica*.

This species is considered as temperate only, present in calcareous water with high mineral content (Krammer & Lange-Bertalot 1991a; Patrick & Reimer 1966 as *Synedra famelica* Kützing).

In El Edén this taxon grew mainly as metaphyton and periphyton in the inundated savannah, cenotes and ponds. It was found infrequent in plankton the inundated savannah and cenotes.

***Fragilaria goulardii* (Brébisson) Lange-Bertalot** (Pl. 2:2)

Frustules are solitary. In valve view, the valves are linear with a straight apical axis; extended ends, blunt poles and straight to slightly concave margins at the center. In girdle view, the frustule is straight. Central area is rectangular, longer than broad, reaching the margin of the valve only in one side but with obscure (little evident) striae; very narrow axial area. Striae are very fine, punctate and regularly arranged. Length, 61.2-135.0 µm. Breadth, 8.7-10.0 µm. Length:Breadth ratio 6-15. Striae, 9-10 in 10 µm.

This species is considered as cosmopolitan, present in karstic substrata (Metzeltin & Lange-Bertalot 1998; as *Synedra goulardii* Brébisson: Aguiar & Martau 1979; Bicudo et al. 1973; Bicudo et al. 1975; Cantoral 1997; Metcalfe 1985; Metcalfe 1988; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton in cenotes.

***MARTYANA* Round**

***Martyana martyi* (Héribaud) Round** (Pl. 2:3)

Frustules are solitary, straight in girdle view and with straight apical axis. Valves are clavate, heteropolar, without protracted ends and one rounded pole, the other one acute-rounded. Convex margins in valve view, without visible spines. Central area is absent; and the straight axial area is very narrow. Striation along the entire valve surface is parallel, thick, and coarse striae. Areolae are not visible. Length, 14-15 µm. Breadth, 3.5-5.0 µm. Striae, 7-10 in 10 µm.

Although Krammer & Lange-Bertalot (1991a, as *Fragilaria leptostauron* var. *martyi* (Héribaud) Lange-Bertalot) question the possibility of finding exemplars so thin, we believe the morphology corresponds to this taxon.

This species is considered as only temperate (as *Fragilaria leptostauron* var. *martyi*: Krammer & Lange-Bertalot 1991a; as *Opephora martyi* Héribaud: Metcalfe 1988).

In El Edén this taxon grew mainly as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. Also, it was present in the plankton in cenotes.

***PSEUDOSTAUROSIRA* D.M. Williams et Round**

***Pseudostaurosira brevistriata* (Grunow) D.M. Williams et Round** (Pl. 2:4)
Frustules are solitary, straight in girdle view. Symmetrical about apical and transapical axes. Valves are linear with rostrate ends. Straight margins in valve view, without spines. Central area is wanting; axial area is wide, lanceolate. Striation is marginal, slightly radiate. Length, 12.0-17.7 µm. Breadth, 2.9-3.1 µm. Striae, 9-12 in 10 µm.

Our exemplars have more acute ends and less dense striae than those from Europe (Krammer & Lange-Bertalot 1991a).

This species is considered as cosmopolitan, alkaliphilous, oligohalobous to mesohalobous, in water with very low conductivity (as *Fragilaria brevistriata* Grunow in van Heurck: Krammer & Lange-Bertalot 1991a; Lowe 1974; Metcalfe 1985).

In El Edén this taxon grew as plankton and metaphyton in cenotes and ponds, but it was rare as periphyton in inundated savannah.

***STAUROSIRA* (Ehrenberg) Lange-Bertalot**

Key to the varieties of *S. construens*.

1a Linear to lanceolate valves, margins constricted at the center .... *S. construens* var. *binodis*
1b Margins otherwise formed 2
2a Valves elliptical ..... *S. construens* var. *venter*
2a Valves rhombic ..... *S. construens* var. *construens*

Staurosira construens* Ehrenberg var. *construens (Pl. 2:5)
Frustules are solitary or forming chains, rhombic in shape. Symmetrical about apical and transpical axes. Girdle view is straight. Valves without protracted apices, poles are rounded, and the middle part of the valve is the widest, without spines. Central area is absent; axial area is narrow, lanceolate. Radiate striae with elongated areolae. Length, 12.0-13.2 µm. Breadth, 5.4-7.2 µm. Striae, 11-13 in 10 µm.

This variety is considered as cosmopolitan, with a very wide ecological spectrum, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (as *Fragilaria construens* (Ehrenberg) Grunow: Cantoral 1997; Krammer & Lange-Bertalot 1991a; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966).

In El Edén this taxon grew mainly as periphyton and metaphyton in cenotes, ponds and in the inundated savannah, but also was present in the plankton in cenotes.

***Staurosira construens* var. *binodis* (Ehrenberg) P.B. Hamilton** (Pl. 2:6)
Frustules are solitary with bipolar symmetry. Girdle view is straight. Valves are linear with rostrate-capitate ends and rounded poles. Margins are constricted at the center of the valve without spines. Central area is absent; axial area is lanceolate, wide. Parallel striae have elongated areolae. Length, 16.2-24.9 µm. Breadth, 3.6-5.2 µm. Striae, 16-17 in 10 µm.

This variety is considered as temperate with some tropical records, alkaliphilous, oligohalobous, with tolerance to high conductivity (as *Fragilaria construens* var. *binodis* (Ehrenberg) Grunow: Metcalfe 1988; Patrick & Reimer 1966).

In El Edén this taxon grew mainly as periphyton in cenotes and ponds. Rare as metaphyton and periphyton in the inundated savannah. Also, it was present in the plankton in cenotes and the inundated savannah.

***Staurosira construens* var. *venter* (Ehrenberg) P.B. Hamilton** (Pl. 2:7)
Frustules are solitary or forming chains. Symmetrical about apical and transapical axes. Girdle view is slightly convex. Valves are wide elliptic, without protracted apices and widely rounded poles. The valve view have convex margins, spines are wanted. Central area is lacking; axial area is straight, narrow. Marginal striation with parallel, regularly arranged striae composed of elongated areolae. Length, 6-9 µm. Breadth, 5-6 µm. Striae, 10 in 10 µm.

This variety is considered as temperate with some tropical records, indifferent to pH and salt content, alkaliphilous (as *Fragilaria construens* var. *venter* (Ehrenberg) Grunow: Hutchinson et al. 1956; Lowe 1974; Metcalfe 1985).

In El Edén this taxon grew mainly as periphyton in cenotes and the inundated savannah.

STAUROSIRELLA D. M. Williams et Round

Key to the species.

1a Valves very wide at the center ..... *S. leptostauron*
1b Rhombic-lanceolate valves ..... *S. pinnata*

***Staurosirella leptostauron* (Ehrenberg) D.M. Williams et Round** (Pl. 2:8)
Frustules are solitary. Symmetrical about apical and transapical axes. Valves are rhombic with rounded ends and extended margins at the center, without spines. Central area is undistinguishable from the axial area which is wide, linear. Thick radiate striae are marginal, angular, and cuneiform in shape. At the center of the valve there are four striae clearly different from the remainder. Individual areolae are not visible. Length, 12-14 µm. Breadth, 8.0-8.5 µm. Striae, 8 in 10 µm.

This species is considered as temperate with some tropical records, alkaliphilous, pH indifferent, and oligohalobous indifferent (as *Fragilaria leptostauron* (Ehrenberg) Hustedt: Hutchinson et al. 1956; Krammer & Lange-Bertalot 1991a; Lowe 1974; Patrick & Reimer 1966).

In El Edén this taxon grew as plankton and periphyton in cenotes.

***Staurosirella pinnata* (Ehrenberg) D.M. Williams et Round** (Pl. 2:9)
Frustules are solitary. Symmetrical about apical and transapical axes. Shape of the valve is highly variable, from widely elliptical to lanceolate with rostrate ends. Margins are extended at the center. Central area is undistinguishable from the very narrow axial area. Striation is visible across the entire valve surface, with radiate, regular striae. Areolae are not visible. Length, 6.2-9.7 µm. Breadth, 3.0-5.2 µm. Striae, 6-8 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (as *Fragilaria pinnata* Ehrenberg: Hutchinson et al. 1956; Krammer & Lange-Bertalot 1991a; Lowe 1974; Metcalfe 1985).

In El Edén this taxon grew mainly as metaphyton in ponds and in the inundated savannah. Also, it was present in the plankton in cenotes.

ULNARIA Compère

Key to the species.

1a Valve length > 500 µm ..... *Ulnaria* sp.
1b Valve length < 500 µm 2
2a Valve breadth < 3 µm ..... *Synedra* (*Ulnaria?*) *acus* var. *angustissima*
2b Valve breadth > 3 µm 3
3a Rostrate ends, axial area evident ..... *U. ulna*
3b Subcapitate-rostrate ends, axial area not evident ..... *U. acus*

***Ulnaria acus* (Kützing) Aboal** (Pl. 2:10)

Frustules are very large, solitary. Valves have a linear outline with straight apical axis and subcapitate-rostrate ends. Valve view has straight margins. Central area is rectangular; axial area is not evident. An apical pore field is evident. Lineate striae, are arranged regularly. Length, 103-110 µm. Breadth, 4-5 µm; Length:Breadth ratio 22-25. Striae, 12-13 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (as *Synedra acus* Kützing: Foged, 1984; Germain 1981; Lowe 1974; Metcalfe 1985; Obeng-Asamoa et al. 1980; Patrick & Reimer 1966; Wasylik 1965b).

In El Edén this taxon grew mainly as metaphyton and periphyton in the inundated savannah, cenotes and ponds. It was found infrequent in plankton the inundated savannah and cenotes.

The following name was not formally included in *Ulnaria*. It belongs to an entity that has been considered as *S. acus* var. *angustissima*. We do not make the nomenclatural change because its status as an independent taxon from *Ulnaria acus* is still not resolved. A discussion about this problem was documented by Krammer & Lange-Bertalot (1991a, p. 145).

***Synedra acus* var. *angustissima* (Grunow) Van Heurck** (Pl. 2:11)

Frustules are very large, solitary. Valves have a linear, needle-shaped outline, with straight apical axis; ends are extended, subcapitate, and rounded poles. Margins taper from the center to the poles (not parallel). Central area is inconspicuous, lanceolate to rectangular; axial area is more than ⅓ of the valve. An apical pore field is evident. Regularly arranged striae are short, punctate. Length, 160-162 µm. Breadth, 2.5-3.0 µm. Length:Breadth ratio 60. Striae, 18-20 in 10 µm.

Our material is very conservative in dimensions and density of striae. Shape of the frustules is similar to the material presented in Pl. 114, Fig. 21 by Krammer & Lange-Bertalot (1991a). This material has an uncertain taxonomic position. Our

exemplars are also coincident with Germain's (1981) specimens identified as "*Synedra acus* var. *angustissima* Grunow".

This variety is considered as temperate with some tropical records (as *Synedr*a *acus* var. *angustissima* (Grunow) Van Heurck: Bicudo et al. 1975; Whitford & Schumacher 1963).

In El Edén this taxon grew mainly as metaphyton and periphyton in the inundated savannah and cenotes. It was found rare as plankton in the inundated savannah and cenotes.

***Ulnaria ulna* (Nitzsch) Compère** (Pl. 2:12)

Frustules are large, solitary. Valves are linear with straight apical axis; ends are extended, rostrate; poles are rounded. In valve view the cells have straight margins. Central area is rectangular; axial area is narrow. One apical pore field is evident. Striae are lineate, regularly arranged. Length, 69-225 µm. Breadth, 3-11 µm. Length:Breadth ratio 6-75. Striae, 8-14 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (as *Fragilaria ulna* (Nitzsch) Lange-Bertalot: Krammer & Lange-Bertalot 1991a; as *Synedra ulna* (Nitzsch) Ehrenberg: Bicudo et al. 1975; Cantoral 1997; Dillard 1969; Foged, 1984; Hutchinson et al. 1956; Kawecka 1981; Lowe 1974; Metcalfe 1985; Tavera-Sierra & González-González 1990; Thomasson 1965; Wasylik 1965b).

In El Edén this taxon grew mainly as periphyton and metaphyton in the dry as well as inundated savannah, cenotes and ponds. It was found infrequent in plankton in the same environments.

***Ulnaria* sp.** (Pl. 3:1)

Frustules are very large, solitary. Valves have a linear outline with straight apical axis and parallel margins; central part of the valve is straight; central area is absent, and axial area is very narrow. One apical pore field is evident. Striae are punctate, regularly arranged. Length, 500-640 µm. Breadth, 5.0-8.7 µm; Length:Breadth ratio 57-128. Striae, 8-9 in 10 µm, occupying ½ of the valve's width. 24 areolae in 10 µm.

According to Ortega (1984), Ehrenberg registered in 1838, 1841, and 1854 the presence of *Synedra gaillioni* (Bory) Ehrenberg at several localities in the central region of México. This species was also registered by Patrick & Reimer (1966) in the U.S.A. The general shape of the valve, the axial area and the density of striae in our exemplars correspond well with this species, but the length registered was always much more than 270 µm and the breadth was rarely more than 8 µm. Moreover, *S. gaillioni* has only been observed in brackish and marine environments (Hustedt 1927-1966; Patrick & Reimer 1966; Krammer & Lange-Bertalot 1991a). Because the intervals in our populations are longer and thinner than those described for *S. gaillioni*, and they have a different ecology than described for any variety, we consider this a different taxon. Further analysis is required before the identity of this taxon is definitively determined.

In El Edén this taxon grew as periphyton and plankton in cenotes.

Suborder RAPHIDINEAE

Key to the families.

1a Valves with reduced branches of the raphe, mainly on the valve mantle .... Eunotiaceae

1b Valves with developed branches of the raphe, one or both, mainly on the valve face 2

2a Raphe on one valve ..... Achnanthaceae (p. 26)

2b Raphe on both valves 3

3a Raphe generally median, without fibulae ..... Naviculaceae (p. 32)

3b Raphe eccentric or marginal, with fibulae 4

4a Raphe in one canal without keel ..... Epithemiaceae (p. 77)

4b Raphe in one canal with keel 5

5a Raphe marginal and circular in a perforated keel, generally not interrupted at the poles ..... Surirellaceae (p. 79)

5b Raphe in a marginal keel or in the valve surface generally interrupted .... Bacillariaceae (p. 68)

Family EUNOTIACEAE

***EUNOTIA* Ehrenberg**

Key to the species and varieties.

1a Valves slightly curved, without dorsal undulations 2

1b Valves strongly curved with dorsal undulations 3

2a Not extended ends, ventral and dorsal margins almost parallel ... *E. flexuosa*

2b Slightly extended ends, straight ventral margin ..... *E. formica*

3a With 2-6 dorsal undulations, one slight ventral undulation, valve lightly curved ..... *E. camelus* var. *camelus*

3b Always 4 dorsal undulations, without ventral undulations, valve strong curved ..... *E. camelus v. arcuata*

Eunotia camelus* Ehrenberg var. *camelus (Pl. 3.2)

Ends of the valve are slightly capitate, distinctly set off from the body, rounded poles. Valves without marginal spines, ventral margin curvature is almost parallel to the dorsal margin, which has a slight central swelling and 2-6 rounded humps. Polar fissures of raphe in sub-apical position. Punctate, slightly radiate striae at the center of the valve, parallel at the ends. Length, 31.0-65.8 µm. Breadth, 3.6-7.5 µm. Striae, 10-14 in 10 µm.

The length and breadth of the variety *camelus* are similar to those of our exemplars of variety *arcuata*. Both varieties were registered in the same type of environments but in different sites. The variety *camelus* has been registered in South America (Guyana) by Metzeltin & Lange-Bertalot (1998).

This species is considered as tropical, and oligohalobous (Aguiar & Martau 1979; Bicudo et al. 1973; Contin & Oliveira 1993; Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew as metaphyton and periphyton in the inundated savannah. Also, it was collected as periphyton and plankton of ponds.

***Eunotia camelus* var. *arcuata* Frenguelli** (Pl. 3:3)

Valves highly arched, with 4 humps. Ventral margin is continuous, without swellings. Ends of the valves are sub-capitate. Length, 35.0-52.5 µm. Breadth, 6.2-6.5 µm.

This variety is considered as tropical. It has been registered in Indonesia by Metzeltin & Lange-Bertalot (1998).

In El Edén this taxon grew mainly as metaphyton and periphyton in the inundated savannah. Although rare, it was collected as plankton of cenotes, ponds and inundated savannah.

***Eunotia flexuosa* (Brébisson) Kützing** (Pl. 3:4)

Valves are slightly arched, smooth, without dorsal or ventral undulations (humps); ends are not distinctly set off from the body but slightly extended and curved. Valves lack marginal spines. Ventral margin curvature is almost parallel to the dorsal margin. Raphe fissures positioned apically. Striae are parallel. Length, 81-218 µm. Breadth, 3.0-7.7 µm. Striae, 8-10 in 10 µm.

This species is considered as cosmopolitan, acidophilous, and oligohalobous (Aguiar & Martau 1979; Krammer & Lange-Bertalot 1991a; Metcalfe 1985).

In El Edén this taxon grew as metaphyton and periphyton in the inundated savannah, cenotes and ponds. Rarely was it collected as plankton in cenotes and ponds.

***Eunotia formica* Ehrenberg** (Pl. 3:5)

Valves are slightly arched, without marginal undulations; ends as wide as the valve center; rounded to acute poles. Ventral margin is straight to slightly concave. Raphe fissures in apical position. Striae are parallel. Length, 41-92) µm. Breadth, 5.6-8.0 µm. Striae, 8-10 in 10 µm at the center of the valve to 11-12 at the ends.

Krammer & Lange-Bertalot (1991a) described *E. formica* as cosmopolitan oligohalobous, in oligo to distrophic environments, but they make a note about the incompletely registered ecology of this species.

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds. Rarely was it collected as plankton in savannah and cenotes.

Family ACHNANTHACEAE

Key to the genera.

1a Very different striation in each valve, valves widely elliptical ..... *Cocconeis*
1b Similar striation in each valve, valves generally lanceolate 2
2a Striae and areolae coarse, eccentric axial area in rapheless valve .... *Achnanthes*
2b Striae and areolae fine; central axial area in rapheless valve 3
3a A horseshoe-shaped area on the rapheless valve ..... *Planothidium*
3b No horseshoe-shaped area on the rapheless valve 4
4a Valves linear, striae fine ..... *Achnanthidium*
4b Valves lanceolate; striae coarser ..... *Karayevia*

ACHNANTHES Bory

***Achnanthes inflata* (Kützing) Grunow** (Pl. 3:6)

Elliptical valves are linear, triundulate; ends are sub-capitate; poles are rounded. Valve with raphe: Radiate striae are punctate; raphe is sinuous, with distinct, straight proximal fissures; central area has a wide stauros; axial area is narrow. Valve without raphe: punctate striae are parallel at the center of the valve and curved to the ends; axial area is straight, thin, eccentric; central area is not evident. Length, 30-36 µm. Breadth, 10.0-12.5 µm. Length:Breadth ratio 2.5-3.0. Striae, 13 in 10 µm at the center of the valve and 20 to the ends in the valve with raphe, 13 in 10 µm in the rapheless valve.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (Cantoral 1997; Contin & Oliveira 1993; Foged, 1984; Tavera et al. 1994).

In El Edén this taxon grew as plankton and periphyton in cenotes, ponds and inundated savannah. Although rare, it was observed in metaphyton in the inundated savannah.

ACHNANTHIDIUM Kützing

Key to the species and varieties.

1a Apices differentiated from the rest of valve 2
1b Apices not distinct from rest of valve 4
2a Elliptical valve ..... *A. exiguum*
2b Linear valve 3
3a Straight striae. Length:Breadth ratio < 9 ..... *A. minutissimum*
3b Slightly curved striae. Length:Breadth ratio > 9 ..... *A. minutissimum* var. *gracillima*
4a Lineate striae; rectangular, small central area on raphe valve ..... *A. chlidanos*
4b Punctate striae; lanceolate, small central area on raphe valve ..... *A. biasolettianum*

***Achnanthidium biasolettianum* (Grunow) Lange-Bertalot** (Pl. 4:1)

Valves are linear without distinguishable ends. The raphe valve has punctate, straight and parallel striae; raphe is straight, filiform, with the proximal fissures close, and straight. Central area is lanceolate, small, distinguished slightly from the axial area; one central stria is slightly distant from the rest. The rapheless valve has parallel striae, finely punctate; axial area is straight, narrow, slightly eccentric; central area is only slightly enlarged. Length, 29-32 µm. Breadth, 5.0-5.5 µm. Length:Breadth ratio 5.0-6.4. Striae, 24-26 in 10 µm at the center of the valve and more dense at the ends. Areolae, 24 in 10 µm.

This species is often listed as "*A. biasolettianum* (Grunow) Round et Bukhtiyarova" but this is an invalid name (INA 2004; Kusber & Jahn 2003).

This species is considered as cosmopolitan, present in karstic substrata, oligohalobous to mesohalobous (as *Achnanthes biasolettiana* Grunow: Cantoral 1997; Dillard 1969; Krammer & Lange-Bertalot 1991b).

In El Edén this taxon grew as plankton and in cenotes.

***Achnanthidium chlidanos* (Hohn et Hellerman) comb. nov.** (Pl. 4:2)
Basionym: *Achnanthes chlidanos* Hohn et Hellerman. Transactions of the American Microscopical Society 82:273-274, Pl. II, figs. 1, 2. 1963.
Valves are linear with protracted apices; wide, blunt to flat poles. The raphe valve has lineate striae, parallel along the valve; raphe is straight, filiform, with the proximal fissures close and straight. Central area is rectangular, small; axial area is narrow; central striae become regularly shortened. The rapheless valve has lineate, parallel striae; axial area is straight, thin to lanceolate; central area is not distinguishable from the axial area. Length, 8.4-12.6 µm. Breadth, 3.0-3.6 µm. Length:Breadth ratio 2.8-3.5. Striae, 30 or more in 10 µm.

Although our exemplars are smaller than the original description (Hohn & Hellerman 1963), resemblance with this species is clear.

This species is considered as only temperate, and indifferent to pH (Krammer & Lange-Bertalot 1991b, as *Achnanthes chlidanos*).

In El Edén this taxon grew as periphyton and metaphyton in ponds, cenotes and the inundated savannah. It was rare as plankton in cenotes.

***Achnanthidium exiguum* (Grunow) Czarnecki** (Pl. 4:3)
Valves are elliptical with protracted, rostrate apices and rounded poles. The raphe valve with lineate, radiate striae, more coarsely spaced at the center of the valve; raphe is straight, filiform, with the proximal fissures close; the distal fissures of raphe are straight. The central area is narrow and in a stauroid shape; axial area is narrow. The rapheless valve has lineate, parallel striae; axial area is straight, linear, positioned at the center of the valve; central area is rectangular with an evident central thickening. Length, 12-25 µm. Breadth, 4.2-5.0 µm. Length:Breadth ratio 2.2-3.0. Striae, 20-35 in 10 µm at the center of the valve in the raphe valve; 28-28 in 10 µm in the rapheless valve.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (as *Achnanthes exigua* Grunow: Foged 1984; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1991b; Lowe 1974; Tavera et al. 1994).

In El Edén this taxon grew mainly in periphyton in inundated savannah and cenotes. Infrequent in metaphyton and plankton in the same environments.

***Achnanthidium minutissimum* (Kützing) Czarnecki** (Pl. 4:4)
Valves are linear with protracted, rostrate to sub-rostrate apices. The raphe valve has lineate striae, radiate at the center of the valve and parallel to the ends; raphe is straight, filiform, with the proximal fissures close, and straight. 1-2 short central striae are more coarsely spaced; axial area is narrow. The rapheless valve has lineate, parallel striae; axial area is straight, thin, positioned at the center of the valve; central area is not distinguished. Length, 18-24 µm. Breadth, 2.8-3.0 µm. Length:Breadth ratio 6-8. Striae, 26-34 in 10 µm at the center of the valve in the raphe valve and 30-32 in 10 µm in the rapheless valve.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (as *Achnanthes minutissima* Kützing: Cantoral 1997; Foged 1984; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton, metaphyton and plankton in cenotes, ponds and in the inundated savannah.

***Achnanthidium minutissimum* var. *gracillima* (Meister) Lange-Bertalot**

(Pl. 4:5)

Valves are linear with protracted, rostrate to sub-rostrate apices. The raphe valve has lineate striae, slightly arched, radiate at the center of the valve and parallel at the ends; raphe is straight, filiform, with the proximal fissures close, and straight; central area is rounded, small and axial area is narrow; the two central striae are more coarsely spaced; density at the ends is higher. The rapheless valve has lineate, slightly radiate striae; axial area is straight, thin, positioned at the center of the valve; central area is lanceolate. Length, 22.2-33.0 µm. Breadth, 2.4-3.0 µm. Length:Breadth ratio 9-25. Striae, 30-36 central striae in 10 µm, at the center of the valve in the raphe valve and 27-30 in 10 µm at the center of the valve and more dense to the ends in the rapheless valve.

This variety is considered as only temperate in calcareous water (as *Achnanthes minutissima* var. *gracillima* Meister: Krammer & Lange-Bertalot 1991b).

In El Edén this taxon grew as periphyton in cenotes, ponds and the inundated savannah. It was infrequent as plankton in cenotes.

***COCCONEIS* Ehrenberg**

Key to the species and varieties.

1a Valves highly arched about the apical axis ..... *C. pediculus*
1b Valves more flat or only slightly arched about the apical axis 2
2a Wide axial area in the raphe valve, length valve < 15 µm .... *C. pseudothumensis*
2b Narrow axial area in the raphe valve, length valve > 16 µm 3
3a Dense areolation in the rapheless valve, > 9 in 10 µm ..... *C. placentula*
3b Less dense areolation in the rapheless valve, < 9 in 10 µm 4
4a Coarse areolation in the rapheless valve, areolae longitudinally ordered .... *C. placentula* var. *euglypta*
4b Fine areolation in the rapheless valve, areolae ordered in zig-zag .... *C. placentula* var. *lineata*

***Cocconeis pediculus* Ehrenberg** (Pl. 4:6)

Valves are wide elliptical, with blunt ends, arched about the apical axis. The raphe valve has a very narrow, straight axial area; central area is circular, small; raphe is straight, filiform; terminal fissures are close to the margin; proximal fissures are close; striae are radiate in the middle of the valve and strongly curved at the ends. The rapheless valve has a linear and narrow axial area; striae are radiate, curved, with areolae arranged at irregular intervals, giving the appearance of longitudinal undulations. Length, 25-26 µm. Breadth, 19.0-24.4 µm. Striae, 19-22 in 10 µm on the raphe valve; 24 in 10 µm on the rapheless valve. Areolae, 8 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, oligohalobous indifferent (Cantoral 1997; Foged 1984; Krammer & Lange-Bertalot 1991b; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton in the inundated savannah and very rare as plankton in cenotes.

Cocconeis placentula* Ehrenberg var. *placentula (Pl. 4:7)
Valves are elliptical, flat or slightly arched about the apical axis. The raphe valve has a narrow axial area; central area is circular, small; raphe is straight, filiform; terminal fissures are extended into the clear marginal area; proximal fissures are close in the central area; striae are radiate, curved with a marginal hyaline interruption. The rapheless valve has a narrow, straight axial area; striae are radiate, curved, and punctate with fine areolae arranged with longitudinal undulation. Length, 9-50 µm. Breadth, 7-33 µm. Striae, 17-25 and 33 areolae in 10 µm in the raphe valve. Striae, 23-35 and 9-16 areolae in 10 µm (8-10 areolae per stria) in the rapheless valve.

Krammer & Lange-Bertalot (1991b) indicated this species has 18-20 areolae in 10 µm; however it has been previously observed in México with a greater range, such as Tehuacán, Puebla, with 14-30 areolae in 10 µm (Novelo 1998).

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, oligohalobous indifferent (Cantoral 1997; Foged 1984; Hutchinson et al. 1956; Lowe 1974; Metcalfe 1985; Padisák et al. 1998; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds; although infrequent, it also noted in the metaphyton and plankton in the same environments.

***Cocconeis placentula* var. *euglypta* (Ehrenberg) Cleve** (Pl. 4:8)
Valves are elliptical, generally smaller than the nominal variety; ends are obtuse. The raphe valve is as the nominate variety. The rapheless valve has a linear and narrow axial area; striae are punctate, 18-20 in 10 µm with 4-5 coarse areolae per stria. The striae are enlarged, slightly undulate. Length, 17-25 µm. Breadth, 10-14 µm.

This variety is considered as cosmopolitan, alkaliphilous, present in karstic substrata, oligohalobous indifferent (Cantoral 1997; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966; Tavera et al. 1994).

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds; although infrequent, also grew as metaphyton and plankton in the same environments.

***Cocconeis placentula* var. *lineata* (Ehrenberg) Cleve** (Pl. 4:9)
Valves are wide elliptical, with rounded to obtuse poles. The raphe valve is as the nominate variety. The rapheless valve has a linear and narrow axial area; striae are punctate, enlarged areolae of medium size between the nominal and the variety *euglypta*. Arrangement of areolae is with a pronounced undulation, with a longitudinal zig-zag organization. Length, 16.0-23.7 µm. Breadth, 10.0-13.7 µm. Striae, 10-14 in 10 µm in the raphe valve and 28-32 in 10 µm in the rapheless valve. Areolae, 7-10 per stria.

According to Krammer & Lange-Bertalot (1991b) this variety has 3-10 areolae per stria.

This variety is considered as cosmopolitan, alkaliphilous, present in karstic substrata, oligohalobous indifferent (Cantoral 1997; Foged 1984).

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds.

***Cocconeis pseudothumensis* E. Reichardt** (Pl. 4:10)
Valves are wide elliptical, flat, with round poles. The raphe valve has a wide axial area and oval central area; raphe is straight, filiform; terminal fissures are submarginal and proximal fissures are close; striae are homogeneous without interruptions. Striae density is not quantifiable in LM. The rapheless valve has a widely lanceolate axial area; striae are radiate, punctate, with areolation arranged concentrically, and rounded to elliptical. Length, 5-15 µm. Breadth, 3.5-10.0 µm. Striae, 10-20 in 10 µm in the rapheless valve, formed per only 3 areola; 7-12 areolae in 10 µm.

This species is considered as only temperate (Krammer & Lange-Bertalot 1991b).

In El Edén this taxon grew as periphyton in ponds and occasionally as periphyton in the inundated savannah. It was rarely observed as plankton in cenotes and as metaphyton in the savannah in the dry period at some still inundated places.

***KARAYEVIA* Round et Bukhtiyarova**

***Karayevia clevei* (Grunow) Round** (Pl. 4:11)
Valves are lanceolate with slightly protracted or rounded ends; slightly angular in girdle view. The raphe valve has radiate striae, punctate, at the center of the valve alternated one short and one long; slightly convergent to the ends; raphe is straight, filiform, with the proximal fissures close, straight. Central area is not evident; axial area is narrow. The rapheless valve has punctate, parallel striae, slightly radiate; axial area is linear and straight, narrow, positioned at the center of the valve; central area is absent. Length, 15.3-17.0 µm. Breadth, 6.0-6.7 µm. Length:Breadth ratio 2.0-2.5. Striae, 18-19 in 10 µm in the raphe valve, with 4-5 areolae at each central stria and 3 areolae at each stria to the ends. In the rapheless valve, 11-14 striae in 10 µm.

This name was proposed by Round & Bukhtiyarova (1996), based upon *Achnanthes clevei* Grunow, without designation of the type, and was later validated by Round (1998).

This species is considered as cosmopolitan, alkaliphilous, oligohalobous indifferent (as *Achnanthes clevei* Grunow: Krammer & Lange-Bertalot 1991b; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton and metaphyton in ponds, cenotes and the inundated savannah. It was rare as plankton in cenotes.

***PLANOTHIDIUM* Round et Bukhtiyarova**

***Planothidium lanceolatum* (Brébisson) Round et Bukhtiyarova** (Pl. 4:12)
Valves are elliptical, linear with rounded poles; flexed about the transapical axis. The raphe valve has lineate striae, radiate at the center of the valve, and parallel to radiate to the ends; raphe is straight, filiform, with close, straight proximal fissures; central area is rectangular, stauroid with 2-3 marginal striae; axial area is narrow. The rapheless valve has an evident horse-shoe shaped area (sinus), with lineate, radiate striae; axial area is narrow and lateral central area, reaching the

margin at one side of the valve, without an evident central thickening. Length, 10.0-19.2 µm. Breadth, 5.0-7.9 µm. Length:Breadth ratio 2.0-2.4. Striae, 13-16 in 10 µm at the center of the valve and 18 to the ends in the raphe valve; 12 in 10 µm at the center of the valve and 18 to the ends in the rapheless valve.

The name *Planothidium lanceolatum* was proposed by Round & Bukhtiyarova (1996) on page 352, missing the appropriate place of publication (INA 2004), which appears on page 349 in the same paper. These authors designated "*Achnanthes lanceolata* (Bréb) Grun in Cl. & Grun. (1880) (sic)" as the type species of *Planothidium*. But later, under *Planothidium lanceolatum* they wrote: "Basionym: *Achnanthidium lanceolata* (Bréb) Grun. in Cl. & Grun. 1880, p. 23. For figures see Van Heurck (1880) Pl. 27, Fig. 8. (sic)". *Sensu* the INA (2004) the correct authorities are: for *Achnanthidium lanceolatum* is Brébisson ex Kützing. Bot. Zeitung 4: 247. 1846 and for *Achnanthes lanceolata* is (Brébisson ex Kützing) Grunow in van Heurck, Syn. Diat. Belgique: expl. Pl. XXVII: fig. 8. 1880. Because of this confusion about the validity of the name, here we provide the complete basionym for *Planothidium lanceolatum*: *Achnanthes lanceolata* (Brébisson) Grunow in Cleve et Grunow 1880. Kungliga Svenska Vetenskaps-Akademiens Handlingar, 17 (2): 23. Figure in van Heurck 1880. Synopsis des Diatomées de Belgique, Pl. 27, fig. 8.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, euryhalobous (as *Achnanthes lanceolata* (Brébisson) Grunow: Aguiar & Martau 1979; Krammer & Lange-Bertalot 1991b; Lowe 1974; Metcalfe 1985; Wasylik 1965b; Whitford & Kim 1971).

In El Edén this taxon grew as periphyton and metaphyton in inundated savannah, cenotes and ponds.

Family NAVICULACEAE

Key to the groups of Naviculaceae.

1a Valves symmetrical to apical or transapical axes ..... Symmetrical Group
1b Valves asymmetrical to either apical or transapical axes .....
..... Asymmetrical Group (p. 56)

Symmetrical Group of Naviculaceae

Key to the genera.

1a Valves with siliceous thickenings, parallel to the raphe 2
1b Valves without longitudinal siliceous thickenings 3
2a Bifurcate thickenings at the distal parts ..... *Amphipleura*
2b Thickenings without distal bifurcations ..... *Frustulia*
3a Inter-valvar marginal-septa (partecta) ..... *Mastogloia*
3b Without marginal-septa 4
4a Valves with sigmoid apical axis ..... *Gyrosigma*
4b Valves with straight apical axis 5
5a Striae with solid appearance, like costae 6
5b Striae otherwise formed 7

6a Openings of alveoli, small, like one or two evident marginal lines, narrow striae ..... *Caloneis*

6b Openings of alveoli very wide, like marginal bands, wide striae ..... *Pinnularia*

7a Central nodule with longitudinal lyra-shaped prolongations or extended to the margin of the valves 8

7b Central nodule otherwise formed (rounded, elliptical or rectangular) 10

8a Central nodule with longitudinal lyra-shaped prolongations, but with marginal striae; conopeum present ..... *Diploneis*

8b Central nodule reaching the valve margins, transversal or in cross 9

9a Central nodule with prolongations in stauros ..... *Stauroneis*

9b Central nodule with prolongations in cross ..... *Capartogramma*

10a Proximal fissures of raphe towards opposite direction, marginal areolae in longitudinal arrangement ..... *Neidium*

10b Proximal fissures of raphe otherwise formed 11

11a Striae formed by areolae transversally elongated (SEM) forming sinuous longitudinal lines 12

11b Striae formed by rounded or longitudinal elongated areolae (SEM) without sinuous longitudinal lines 15

12a Striae interrupted at the center of the valve to each side of the raphe, forming hyaline conspicuous areas ..... *Anomoeoneis*

12b Striae not interrupted by hyaline areas 13

13a Frustules forming long chains; wide, lanceolate axial area..... *Diadesmis*

13b Solitary frustules 14

14a Longitudinal ribs enclosing raphe; areolae very separated by sinuous longitudinal lines more evident than the striae ..... *Brachysira*

14b Raphe without longitudinal ribs; very fine areolae, regularly arranged ..... *Nupela*

15a Valve with hyaline areas in form of a 'H', which interrupt the striae in the area close to the raphe ..... *Fallacia*

15b Without hyaline areas or otherwise formed 16

16a Raphe in a thickening of the valve (conopeum), thickened polar nodule ..... *Sellaphora*

16b Without thickening near the raphe 17

17a Lineolate striae (areolae with longitudinal opening) 18

17b Punctate (areolae with rounded opening) or lineate striae (not visible structure in LM) 22

18a Longitudinally aligned areolae, forming two perpendicular systems of striae ..... *Craticula*

18b Areolae not longitudinally aligned 19

19a Polar nodules evident 20

19b Polar nodules not developed, fine striae 21

20a Polar nodules transversally developed, very coarse striae ..... *Hippodonta*

20b Polar nodules curved to one side ..... *Adlafia*

21a Raphe with a siliceous thickening ..... *Eolimna*

21b Raphe without a siliceous thickening ..... *Navicula*

22a Striae with not visible structure (in LM) ..... *Kobayasiella*

22b Striae clearly punctate 23

23a Wide, transversal central area; one stigma ..... *Luticola*
23b Rounded central area; without stigma ..... *Placoneis*

ADLAFIA G. Moser, Lange-Bertalot et Metzeltin

***Adlafia minuscula* (Grunow) Lange-Bertalot** (Pl. 4:13)
Frustules are very small, solitary. Valves are lanceolate with convex margins, not distinguishable ends and cuneate poles. Raphe is very fine, straight, with close, little visible proximal fissures; terminal fissures are not evident. Axial area is very narrow, straight, with a siliceous thickening; central area is rounded, formed by the regularly shortened radiate striae. The striae are little evident. Length, 8-10 µm. Breadth, 4-5 µm. Striae, more than 30 in 10 µm.

This species is considered as temperate but actually there are several tropical records, circumneutral (as *Navicula minuscula* Grunow: Czarnecki 1979; Hustedt 1930; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1966; Schlichting 1969; Sieminska 1964; Tavera et al. 1994).

In El Edén this taxon grew as periphyton and plankton in ponds and cenotes.

AMPHIPLEURA Kützing

***Amphipleura chiapasensis* Metzeltin et Lange-Bertalot** (Pl. 4:14)
Valves are lanceolate with a medial siliceous thickening and with a terminal bifurcation, less than ⅓ of the valve; the thickening is straight in the middle, and ends up in an arrow shape. Striae are very fine and hardly visible with light microscope. Length, 82-146 µm. Breadth, 7-22 µm. Transversal striae, 24-28 in 10 µm ; longitudinal striae, 24 in 10 µm.

According to Metzeltin & Lange-Bertalot (1998), the distinction between *Amphipleura lindheimerii* Grunow and *A. chiapasensis* does not seem to be absolute. Since enough material could not be found for SEM observation, we decided to determine our populations as *A. chiapasensis* because this species was described from a calcareous, alkaliphilous environment like El Edén. Likewise, our exemplars are smaller and thinner than *A. lindheimerii*.

This species is considered as present only in tropical America, in karstic substrata, and oligohalobous (Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew mainly as periphyton in cenotes; also as metaphyton in the inundated savannah. It was rare as plankton in cenotes.

ANOMOEONEIS Pfitzer

Key to the species.
1a Lanceolate valves with extended, rostrate ends ..... *A. sphaerosphora*
1b Rhombic valves, without extended ends ..... *A. costata*

***Anomoeoneis costata* (Kützing) Hustedt** (Pl. 5:1)
Valves are rhombic without extended ends and rounded poles. At the center of the valve, in each stria, there is one row of areolae separated from the rest. Distal

fissures of raphe are curved to the same side; axial area is wide and straight; central area is rounded with attenuated striae at the margin and with higher density than the rest of the valve. Length, 50-77 µm. Breadth, 15-25 µm. Striae, 12-14 in 10 µm. Areolae, 12 in 10 µm, alignment appears undulate or zig-zag.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (as *Anomoeoneis costata*: Bradbury 1970, 1971; Metcalfe 1985, 1988; Patrick & Reimer 1966; Whitford & Kim 1971; as *Anomoeoneis sphaerosphora* f. *costata* (Kützing) Schmidt: Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton in cenotes.

***Anomoeoneis sphaerosphora* (Ehrenberg) Pfitzer** (Pl. 5:2)

Valves are elliptical-lanceolate with protracted, rostrate ends. Axial area is linear with one row of points isolated from the striae; central area is unilaterally developed; striae are punctate and radiate to parallel. Proximal fissures of raphe are straight; distal fissures are curved to the same side. Length, 51-54 µm. Breadth, 15.0-15.6. Striae, 20 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and halophilous (Bradbury 1971; Foged 1984; Germain 1981, as euryhaline; Hustedt 1930; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985, 1988; Novelo 1998; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah and in cenotes.

BRACHYSIRA Kützing

***Brachysira microcephala* (Grunow) Compère** (Pl. 5:3)

Valves are lanceolate with slightly protracted to extended ends and acute to blunt poles; margins are convex along the whole valve. Axial area is straight, narrow; central area is rounded, small. Raphe is straight, filiform; striae are radiate at the center of the valve and parallel toward the poles; lineolae are barely visible, the space between lineolae follows an undulate pattern. Length, 16-35 µm. Breadth, 3-6 µm. Striae, (32) 35-39 in 10 µm. Areolae, 18-31 in 10 µm.

There are two similar abundant populations growing in El Edén, without intermediate forms; one with slightly protracted ends (Pl. 5:3a,b,e), and another with extended ends (Pl. 5:3c,d,f). *Brachysira procera* Lange-Bertalot et Moser and *B. liliana* Lange-Bertalot are similar species but with different ecologies (Lange-Bertalot & Moser 1994); our populations correspond better with *B. microcephala* (including *B. neoexilis* Lange-Bertalot according to Wolfe & Kling 2001).

This species is considered as cosmopolitan, tolerant to conductivity and pH from acidic to alkaline, present in calcareous water (Lange-Bertalot & Moser 1994).

In El Edén this taxon grew as two populations, the one with protracted ends grew as periphyton in the inundated savannah, where was one of the most abundant species, sometimes also in the dry period; it grew also as periphyton in cenotes and ponds and was common as metaphyton (rare in plankton) in all these

environments. The population with extended ends grew only as periphyton in cenotes and metaphyton in the inundated savannah.

CALONEIS Cleve

Key to the species.

1a Linear-lanceolate valves with undulations (triundulate) ..... *C. silicula*
1b Linear-lanceolate to rhombic valves, without undulations 2
2a Longitudinal lines hardly visible, wide axial area ..... *C. bacillum*
2b Evident longitudinal lines, very near to the margin; narrow axial area .... *C. sabanicola*

***Caloneis bacillum* (Grunow) Cleve** (Pl. 5:4)

Valves are linear, rhombic-lanceolate in shape with rounded ends. Central area is without thickenings. A wide axial area is continuous with the wide central area. Raphe is straight with straight terminal fissures. Longitudinal, marginal lines are hardly visible. Striae are parallel along the entire length of the valve. Length, 12-35 µm. Breadth, 6-7 µm. Striae, 22-25 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Bradbury 1971; Cantoral 1997; Czarnecki 1979; Germain 1981; Holmes & Whitton 1981; Hustedt 1930; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1966; Sieminska 1964; Wasylik 1965b).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. It was rare as plankton in cenotes, savannah, and ponds.

***Caloneis sabanicola* sp. nov.** (Pl. 5:5)

Diagnosis: Valvae lineari-lanceolatae, 19.5-30.0 µm longae, 4.5-7.0 µm latae, apicibus capitatis, polis rotundatis. Area centralis sine striis marginalibus, moderate latus; area axialis tenuis, recta. Raphe filiformis recta, fissuris proximalibus rectis, fissuris terminalibus formatis signo interrogationis. Lineae marginales longitudinales margine proximissimae. Striae in valvae centro parallelae, apices versus leviter convergentes, 24-38 in 10 µm.

Etymology: dwelling in the sabana (sabana [Spanish] = savannah [English]), one of the vegetation types found in the area.

Holotypus: Praep. Eden 389.1 in Coll. Edén-FCME, Pl. 5:5a.

Type locality: Chamacos cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are linear-lanceolate with capitate ends. Expanded central area without marginal striae is moderately wide; axial area is narrow, straight. Raphe is straight, filiform with straight proximal fissures. Marginal longitudinal lines positioned close to the margin. Striae are parallel at the center of valve, and slightly convergent at the ends. Length, 19.5-30.0 µm. Breadth, 4.5-7.0 µm. Striae, 24-38 in 10 µm.

The shape of the valve is similar to *C. budensis* (Grunow) Krammer but this species has larger frustules and a curved, clearly lateral raphe, as well as terminal fissures that are 'question mark' shaped. Also, striae density is less in *C. budensis* and although it is mentioned as cosmopolitan, it may prefer cold environments. Another species that may be similar is *C. macedonica* Hustedt, which has been registered in warm environments (South Africa), but it is much larger than our populations and has less dense striae (Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as plankton and metaphyton in cenotes and as periphyton and metaphyton in the inundated savannah.

***Caloneis silicula* (Ehrenberg) Cleve** (Pl. 6:1)

Valves are lanceolate, triundulate without extended ends; rounded to slightly acute poles. Axial area is wide, ½ of the valve; central area is lanceolate forming a rectangular fascia with siliceous thickenings, in crescent shape. Lateral raphe has close proximal fissures, slightly curved to the same side. Terminal raphe fissures bent in question mark shape. Marginal longitudinal lines are not evident. Slightly radiate striae at the center of valve, parallel at the ends. Length, 59.0-60.5 µm. Breadth, 11.0-11.5 µm. Striae, 16-20 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous (Foged 1984; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1986; Novelo 1998; Wasylik 1965a, 1965b).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and inundated savannah. It was rare in plankton in cenotes.

***CAPARTOGRAMMA* Kufferath**

Key to the species.

1a Valve with extended, rostrate ends ..... *C. crucicula*
1b Valve with not extended ends ..... *C. paradisiaca*

***Capartogramma crucicula* (Grunow ex Cleve) R. Ross** (Pl. 6:2)

Valves are elliptical-lanceolate with extended ends and blunt poles. The whole valve has radiate striae. Apical septa are present. Axial area is straight, narrow; central area, forming a stauros in the shape of an 'X' with marginal striae at the center of the valve, is regularly shortened. Length, 20.0-30.6 µm. Breadth, 6.5-9.4 µm. Striae, 24-26 in 10 µm.

This species has been observed in Brazil and Mexico and it is considered as tropical with some temperate records, present in karstic substrata, and mesohalobous (Aguiar & Martau 1979; Cantoral 1997; Contin & Oliveira 1993; Lowe 1974; Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew as periphyton and metaphyton in ponds and in the inundated savannah.

***Capartogramma paradisiaca* sp. nov.** (Pl. 6:3)

Diagnosis. Valva lanceolatae bis valde lanceolato-rhombica, 13-35 µm longa, 5.0-7.5 µm lata, apicibus non extensis, polis acutis, compartimentibus et septis apicalibus praedita. Area axialis recta, angustissima; area centralis stauro litteram

"X" simulanti instructa, striis marginalibus in valvae centro, irregulariter abbreviatis. Raphe filiformis recta, poris parvis rotundatis centralibus. Valva tota striis punctatis radiatibus. Striae 20-28 in 10 µm.
Etymology: Edén [Spanish] = paradise, in allusion to El Edén Ecological Reserve.
Holotypus: Praep. Eden 6.1 in Coll. Edén-FCME, Pl. 6:3a.
Type locality: Station Pond in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are strongly lanceolate-rhombic in shape, without extended ends and poles acute. Apical septa are present. Axial area is narrow, straight; central area, forming a stauros in shape of an 'X' with marginal striae at the center of the valve, is irregularly shortened. Raphe is straight, filiform with small, rounded proximal ends. Striae are punctate, radiate the entire length of the valve. Length, 13-35 µm. Breadth, 5.0-7.5 µm. Striae, 20-28 in 10 µm.

We do not know another species with similar shape of the valve or density of striae. For instance, *Capartogramma pumila* Metzeltin et Lange-Bertalot, another tropical diatom, is smaller and with 24-26 striae in 10 µm.

In El Edén this taxon grew scarcely as periphyton in ponds and in the inundated savannah.

CRATICULA Grunow

***Craticula cuspidata* (Kützing) D.G. Mann** (Pl. 6:4)

Valves are lanceolate without extended or rostrate ends, poles rounded to blunt. Convex margins; axial area is straight, narrow; the central area is not distinguishable from the axial area. Raphe is straight, filiform. Proximal fissures of raphe are close, straight; terminal fissures are straight. Central nodule is small. Striae are parallel, straight the entire length of the valve. Areolae are longitudinally aligned, forming two systems of striae that cross each other at 90°. Length 55.8-75.8 µm. Breadth, 14.0-17.7 µm. Striae, 20-25 in 10 µm. Areolae, 30-40 in 10 µm.

Most of our exemplars exhibit rostrate to sub-rostrate ends and it is common to find valves with craticula.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (as *Navicula cuspidata* (Kützing) Kützing: Aguiar & Martau 1979; Foged 1984; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Metcalfe 1988; Patrick & Reimer 1966; Sarode & Kamat 1984; Wasylik 1965b).

In El Edén this taxon grew mainly as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was rare as plankton in cenotes and in the inundated savannah.

DIADESMIS Kützing

***Diadesmis confervacea* Kützing** (Pl. 6:5)

Frustules are small, forming chains. Valves are lanceolate with convex margins and have attenuated ends and rounded poles. Raphe is straight with close, straight

proximal fissures and straight terminal fissures. Central nodule is evident. Axial area is wide, lanceolate; central area is not distinguished. Striae are radiate, straight and punctate the entire length to the valve. At the limits of the central area, the striae are regularly shortened and are slightly more coarsely spaced than the rest. Length, 16.3-17.5. Breadth, 6.3-7.0. Striae, 20-24 in 10 µm. Areolae, 20 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous indifferent (Czarnecki 1979; Foged 1984; Gasse 1986; Hustedt 1930; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Metcalfe 1988; Patrick & Reimer 1966; Sarode & Kamat 1984).

In El Edén this taxon grew as periphyton in the inundated savannah and, cenotes. It was infrequent as plankton in these same environments.

DIPLONEIS Ehrenberg

Key to the species.

1a Areolae in quincunx 2
1b Areolae otherwise arranged 3
2a Striae with simple rows of areolae, length 17-21 µm; breadth <15 µm ..... *D. oblongella*
2b Striae with double row of areolae, length 45-47 µm; breadth >15 µm ..... *D. subovalis*
3a Small, rounded central area, 24 areolae in 10 µm ..... *D. elliptica*
3b Wide, elliptical central area, 16-18 areolae in 10 µm ..... *D. ovalis*

***Diploneis elliptica* (Kützing) Cleve** (Pl. 6:6)

Frustules are linear-elliptical with rounded poles. Conopeum is narrow, lanceolate and curved at the center of the valve. Central area is small, rounded. Areolae are longitudinally aligned, undulate. The whole valve has radiate striae. Length, 24.0-55.5 µm. Breadth, 11.0-22.5 µm. Striae, 10-12 in 10 µm. Areolae 24 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966).

In El Edén this taxon grew mainly as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was infrequent as plankton in cenotes.

***Diploneis oblongella* (Nägeli) Cleve-Euler** (Pl. 6:7)

Frustules are linear-elliptical to elliptical. In some exemplars the margins of the valve are parallel. Poles are rounded. Conopeum is narrow, lanceolate and curved at the center of the valve. Central area is wide, rounded. Areolae aligned in a quincunx pattern. Striae have a simple row of areolae, slightly radiate. Length, 17.3-21.6 µm. Breadth, 6.6-15.0 µm. Striae, 22-24 at the center of the valve and 30-32 to the ends in 10 µm. Areolae, 35 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (Aguiar & Martau 1979; Cantoral 1997; Krammer & Lange-Bertalot 1986; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was common as plankton in the same environments.

***Diploneis ovalis* (Hilse) Cleve** (Pl. 6:8)

Frustules are linear-elliptical to oval with rounded poles. Conopeum is narrow, linear, curved at the center of the valve. Central area is wide, elliptical. Areolae are longitudinally aligned, undulate. The whole valve has slightly radiate striae. Length, 20-45 μm. Breadth, 18.7-25.0 μm. Striae, 12-14 in 10 μm. Areolae, 16-18 in 10 μm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Foged 1984; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton, metaphyton and plankton in the inundated savannah, cenotes and ponds.

***Diploneis subovalis* Cleve** (Pl. 6:9)

Frustules elliptical with rounded poles. Conopeum is narrow, lanceolate and curved at the center of the valve. Central area is wide, elliptical. Areolae aligned in a quincunx pattern. Striae have a double row of areolae. The whole valve has radiate striae. Length, 45-47 μm. Breadth, 25 μm. Striae, 10-11 in 10 μm. Areolae, 22-24 in 10 μm.

This species is considered as belonging to tropical zones but with a worldwide distribution (Tavera et al. 1994). It has been recorded as alkaliphilous and oligohalobous indifferent in Mexico (Cantoral 1997). Krammer & Lange-Bertalot (1986) consider that it is unknown in Europe.

In El Edén this taxon grew as plankton in cenotes. It was very rare and scarce as metaphyton in the inundated savannah.

***EOLIMNA* Lange-Bertalot et W. Schiller**

***Eolimna subminuscula* (Manguin) G. Moser, Lange-Bertalot et Metzeltin** (Pl. 6:10)

Frustules are small, solitary. Valves are lanceolate and have convex margins, without extended ends; poles are acute. Raphe is filiform with a siliceous thickening; proximal fissures of raphe and terminal fissures are straight. Axial area is narrow; central area is small, not distinct from the axial area. Striae are lineate, straight along the entire length of the valve, parallel in the middle and convergent to the ends. The central striae are regularly shortened. Striae are barely distinguishable in LM. Length, 6-17 μm. Breadth, 4.2-10.0 μm. Striae, 24-30 in 10 μm.

This species is considered as temperate with some tropical records, alkaliphilous, and oligohalobous indifferent (Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Metcalfe 1985; Metcalfe 1988; Novelo 1998, all as *Navicula subminuscula* Manguin).

In El Edén this taxon grew as periphyton and metaphyton in ponds, cenotes and in the inundated savannah, where it was present also in the dry period.

FALLACIA Stickle et D.G. Mann

***Fallacia pygmaea* (Kützing) Stickle et D.G. Mann** (Pl. 7:1)
Valves are lanceolate with convex margins. Ends are not differentiated from the valve, poles are rounded. Raphe is filiform with close, straight proximal fissures and straight terminal fissures. Central area is wide, rectangular. The whole valve has straight and radiated striae. At the center of the valve, striae are regularly shortened by a hyaline zone in an 'H' shape. Length, 20-27. Breadth, 8.0-9.5 µm. Striae, 20-30 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (As *Navicula pygmaea* Kützing: Bicudo et al. 1973; Foged 1984; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1986; Lowe 1974; Patrick & Reimer 1966; Sarode & Kamat 1984).

In El Edén this taxon grew as periphyton in cenotes.

FRUSTULIA Rabenhorst

***Frustulia vulgaris* (Thwaites) De Toni** (Pl. 7:2)
Valves are lanceolate without extended apices and poles rounded. Raphe is curved with distal fissures simple and straight proximal fissures; terminal nodule ended in a pencil tip shape (porto crayon). Striae are radiate at the center of the valve and parallel at the ends; areolae are not longitudinally aligned (longitudinal striae appear undulate). Central area is lanceolate. Length, 50-58 µm. Breadth, 10-11 µm. Striae, 24-32 in 10 µm. Areolae, 33-35 in 10 µm.

This species is considered as cosmopolitan, circumneutral, alkaliphilous, and oligohalobous indifferent (Aguiar & Martau 1979; Bicudo et al. 1973; Dillard 1969; Germain 1981; Hirano 1969; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1966; Whitford & Kim 1971).

In El Edén this taxon grew as periphyton in the inundated savannah and in cenotes. It was rare and very scarce in the wetland zone during the dry period.

GYROSIGMA Hassall

Key to the species.

1a Eccentric raphe ..... *G. obscurum*
1b Central raphe ..... *G. scalproides*

***Gyrosigma obscurum* (W. Smith) Griffith et Henfrey** (Pl. 7:3)
Valves are slightly sigmoid, lanceolate. Apices are narrow; poles are rounded. Raphe is eccentric, slightly sigmoid with straight proximal fissures and curved distal fissures. Central area is small, rounded. Striae are parallel transverse. Length, 102-149 µm. Breadth, 12.0-29.8 µm. Striae, 30-32 in 10 µm.

This species seems to have a wide latitudinal distribution. Its type locality is in England, but has been registered in Florida, U.S.A. (Patrick & Reimer 1966) and in Cuba (Foged 1984). Also is considered as euryhalobous (Foged 1984; Krammer & Lange-Bertalot 1986; Patrick & Reimer 1966).

In El Edén this taxon grew as plankton in cenotes. It was rare as periphyton in ponds and in the inundated savannah.

***Gyrosigma scalproides* (Rabenhorst) Cleve** (Pl. 7:4)

Valves are sigmoid. Apices taper progressively with attenuated-rounded poles. The raphe is in a central position, with proximal fissures curved in the same direction; distal fissure of raphe are curved. Central area is long, longitudinally-elliptic. Longitudinal rows of areolae are curved at the center, as the same width as the transverse striae. Length, 72-85 µm. Breadth, 12-13 µm. Striae, 20 longitudinal and 24 transverse in 10 µm.

This species has been described from Europe as 40-70 µm long and 7-11 µm wide (Krammer & Lange-Bertalot 1986), but Metzeltin & Lange-Bertalot (1998) registered in Chiapas, México (Misol-Ha waterfall) exemplars of 142.5 µm long and 28 µm wide.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous indifferent (Aboal 1988; Aguiar & Martau 1979; Bicudo et al. 1973; Cantoral 1997; Foged 1984; Krammer & Lange-Bertalot 1986; Lowe 1974; Wasylik 1965a).

In El Edén this taxon grew as periphyton in cenotes and ponds. Very rarely grew as periphyton in the inundated savannah and as plankton in cenotes.

HIPPODONTA Lange-Bertalot, Metzeltin et Witkowski

***Hippodonta hungarica* (Grunow) Lange-Bertalot, Metzeltin et Witkowski** (Pl. 7:5)

Frustules are small, solitary. Valves are linear-lanceolate to elliptical. Margins are convex. Two forms are present, with and without extended apices, but both have rounded poles. Intermediate forms have not been observed. Raphe is linear with close, straight proximal fissures and straight terminal fissures. Axial area is narrow; central area is smooth, small, rhomboidal to lanceolate in shape and formed by one up to three short striae at each margin. These short striae are more coarsely spaced than the rest; interstriae similar to striae. Length, 18-40 µm. Breadth, 6-9 µm. Striae, 3-11 in 10 µm.

This species is considered as present only in tropical America, alkaliphilous, and oligohalobous indifferent (Foged 1984 [as *Navicula hungarica* Grunow]; Witkowski et al. 2000).

In El Edén this taxon grew as periphyton in cenotes.

KOBAYASIELLA Lange-Bertalot

***Kobayasiella* sp.** (Pl. 7:6)

Frustules are small, solitary. Valves are linear-lanceolate, with straight to slightly convex margins. Apices are subrostrate with poles rounded. Raphe is straight, very evident. Axial area is narrow, indistinguishable from the small central area. No visible striation in LM. Length, 14-18 µm. Breadth, 3.5-4.0 µm.

Morphology and measures of these populations are similar to *Kobayasiella subtilissima* (Cleve) Lange-Bertalot; however, length is smaller, the non visible

striation and scarce material for SEM made it impossible to assign them to this taxon.

In El Edén this taxon grew as periphyton and metaphyton in cenotes and in savannah, during the inundated as well as in the dry periods. It was rare as plankton in the inundated savannah.

LUTICOLA D.G. Mann

Key to the species.

1a Valves lanceolate in shape with convex margins, without extended apices and poles acute ..... *L. goeppertiana*

1b Valves rhombic-lanceolate valves, undulate, sub-capitate apices and poles rounded..... *L. mutica* var. *intermedia*

***Luticola goeppertiana* (Bleisch) D.G. Mann** (Pl. 7:7)

Frustules are small, solitary. Valves are lanceolate; the whole valve with convex margins without extended ends and acute poles. Raphe without thickenings, with close proximal fissures, curved to the opposite margin of the stigma; terminal fissures are straight, without expanded polar nodules. Axial area is narrow-linear; central area is smooth, stauroid. One elongated stigma is present. The whole valve has straight and radiate striae, formed by ordered areolae of the same size. The central area is delimited by 2-4 marginal striae, spaced the same as the rest. Inter-striae have same width as the striae. Length 16.8-25.0 µm. Breadth, 6.6-8.0 µm. Striae, 20-24 in 10 µm. Areolae, 13-20 in 10 µm.

This species is considered as cosmopolitan, preferring high concentration of electrolytes (Krammer & Lange-Bertalot 1986; Tavera et al. 1994, as *Navicula goeppertiana* (Bleisch) H.L. Smith); present in karstic substrata, alkaliphilous, and oligohalobous (Cantoral 1997).

In El Edén this taxon grew as metaphyton and periphyton in cenotes and ponds.

***Luticola mutica* var. *intermedia* (Hustedt) Hawkins et Kelly** (Pl. 7:8)

Frustules are small, solitary. Undulate valves are rhombic-lanceolate. Extended, sub-capitate ends have rounded poles. Raphe is filiform, with proximal fissures distant or the margin in the central area, and curved to the same side; terminal fissures curved to the same side. Axial area is narrow, straight; central area is rectangular with very short marginal striae. One elongate stigma is present, close to the margin. The whole valve has radiate, punctate striae, spaced the same as the rest. Length 19-28 µm. Breadth, 7.0-8.8 µm. Striae, 32 in 10 µm. Areolae, 20 in 10 µm.

As *Navicula mutica* f. *intermedia* Hustedt has been observed in tropical sites by Hustedt (1930), and Sarode & Kamat (1984), with some sporadic records in Europe (Bock 1970). It is considered as circumneutral, and oligohalobous (Foged 1984).

In El Edén this taxon grew as plankton in cenotes.

MASTOGLOIA Thwaites

Key to the species.

1a Frustule with acute apices, raphe reverse-lateral ..... *M. elliptica*
1b Frustule with subrostrate apices and filiform raphe, slightly sinuous .... *M. smithii*

***Mastogloia elliptica* (C. Agardh) Grunow** (Pl. 8:1)

Valves are elliptical-lanceolate with acute apices; axial area is straight; central area is small, elliptical. Striae are parallel to slightly radiate, composed of a single row of areolae. The central striae are regularly shortened. Raphe is reverse-lateral. Terminal fissures of raphe are curved to the same direction. Partecta are each of the same size, with straight internal margins. Length 38.8-42.5 µm. Breadth, 9.0-9.5 µm. Striae, 12 in 10 µm. Areolae, 16 in 10 µm and 10 partecta in 10 µm. Partecta, 22-26 on each side.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and halophilous to euryhalobous (Cantoral 1997; Foged 1984; Krammer & Lange-Bertalot 1986; Metcalfe 1985).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah and in cenotes.

***Mastogloia smithii* Thwaites ex W. Smith** (Pl. 8:2)

Valves are elliptical-lanceolate with sub-rostrate apices and acute to rounded poles; axial area is straight, narrow; central area is small, elliptic to rectangular. Striae are slightly radiate, formed by a single row of areolae. The central striae are regularly shortened. Raphe is filiform, slightly sinuous. Terminal raphe fissures are curved to the same direction. Partecta are each of the same size of ¼ of the valve's wide, with straight internal margins. Length 28.5-56.0 µm. Breadth, 7.6-9.5 µm. Striae, 18-20 in 10 µm. Areolae, 16-20 in 10 µm and 5 to 9 partecta in 10 µm. Partecta, 15-18 on each side.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and mesohalobous indifferent (Cantoral 1997; Foged 1984; Lowe 1974; Patrick & Reimer 1966).

In El Edén this was the most abundant species. It grew as periphyton and metaphyton in the inundated and the dry savannah and in ponds and cenotes. Although common, was less abundant as plankton in the same environments.

NAVICULA Bory

Key to the species.

1a Extended, rostrate apices ..... *N. rostellata*
1b Not extended or only very slightly apices 2
2a Central area in 'X' form ..... *N. heimansii*
2b Central area otherwise formed 3
3a Central area lanceolate ..... *N. cryptotenella*
3b Central area otherwise formed 4
4a Regularly shortened striae, on both sides of the central area ..... *N. erifuga*
4b Irregularly shortened striae, on one or both sides of the central area 5

5a Central area rectangular ..... *N. rivulorum*
5b Central area rounded or rhombic 6
6a The two central striae longer than the neighbors ..... *N. radiosa*
6b The two central striae shorter than the neighbors ..... *N. podzorskii*

***Navicula cryptotenella* Lange-Bertalot** (Pl. 8:3)
Frustules are solitary. Valves are lanceolate with convex margins. Apices are gradually attenuated, acute to slightly extended and poles rounded. Proximal fissures of raphe are close and straight; the terminal fissures are straight. Central nodule is small. Axial area is narrow, linear; central area is small and smooth, lanceolate in shape. Finely lineolate striae are straight, radiate at the center of the valve and convergent toward the ends. At the central area, on one side, the central stria is longer than the rest and the adjacent striae are alternately short and long; on the other side, the central striae are regularly shortened, in diagonal, leaving isolated, one or two central striae. In some exemplars the first pattern is repeated in both sides of the valve. The central striae are spaced the same as the rest. Length, 16-31 µm. Breadth, 4.5-6.0 µm. Striae, 12-16 in 10 µm at the center of the valve and 18-22 in10 µm to the ends. Lineae, 20-30 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (Cantoral 1997; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Novelo 1998).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, ponds and cenotes. It was infrequent in plankton in cenotes and in the inundated savannah.

***Navicula erifuga* Lange-Bertalot** (Pl. 8:4)
Frustules are solitary. Lanceolate valves have convex margins without extended apices. Poles are acute-rounded. Thin, central raphe with close and rounded proximal fissures; the terminal fissures are curved to the same side and bifurcated. Axial area is narrow; central area is rounded, slightly eccentric, formed by 5 or 6 regularly shortened striae. The striae are lineolate but the lineae are not easy visible. Striae are radiate at the center of the valve and convergent toward the ends. At the middle, two striae are enclosed by the two adjacent in such way that form a 'V' pattern. Length, 21-32 µm. Breadth, 5.4-6.5 µm. Striae, 10-16 in 10 µm at the center of the valve and 14-20 in 10 µm to the ends. Lineae, more than 30 in 10 µm.

This species is considered as cosmopolitan with isolated populations in brackish water or with high electrolytic content (Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was very rare as plankton in cenotes.

***Navicula heimansii* van Dam et Kooyman** (Pl. 8:5)
Frustules are solitary, medium to large size. Valves are lanceolate, narrow, with convex margins. Very acute apices are not distinguishable from the rest of the valve; poles are acute-rounded. Straight, filiform raphe has close and evident proximal fissures; the terminal fissures are curved to the same side. Axial area is narrow, widening to the center of the valve; small, transapical central area, in an

'X' shape formed by the longer central striae and the symmetrically alternated short and long neighbor striae. The striae are lineolate, curved, radiate at the center of the valve and convergent at the ends. At the middle, the five central striae are alternately short and long. Length, 29-39 µm. Breadth, 5-6 µm. Striae, 16-18 in 10 µm. Lineae, close to 40 in 10 µm.

This species is considered as cosmopolitan, in very saline biotopes with high electrolytic content (Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah.

***Navicula podzorskii* Lange-Bertalot** (Pl. 8:6)

Frustules are solitary, medium to large in size. Lanceolate valves have convex margins; acute apices are not extended; poles are rounded. Straight, filiform raphe has close, drop-shape proximal fissures; comma-shape terminal fissures are curved to the same side. Axial area is narrow, linear; central area is rounded to rhomboidal, smooth, formed by irregularly shortened striae; the two central striae are shorter than the rest. All striae have areolae of the same size. Striae are curved, angular at the center of the valve and straight at the ends. The 12 striae forming the central area are generally arranged as follows: at one side of the valve there is one set of six striae alternately sort and long; at the edges of these, there are 2 sets of three regularly shortened striae. At the other side of the valve, the 12 striae are regularly shortened. The whole valve has interstriae of the same width as striae. Lineae concentrically curved in the central zone. Length, 51-61 µm. Breadth, 8.4-9.0 µm. Striae, 15-16 in 10 µm at the center of the valve and 17-18 in 10 µm at the ends. Lineae, 20-25 in 10 µm.

This species has been recorded in Yucatán, México (Kobá cenote, Metzeltin & Lange-Bertalot 1998), in calcareous environments.

This species is considered as present only in tropical America, alkaliphilous.

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, ponds and cenotes. It was rarely frequent as plankton in cenotes and in the inundated savannah.

***Navicula radiosa* Kützing** (Pl. 8:7)

Frustules are solitary, medium to large in size. Lanceolate valves have convex margins. Apices are not extended; poles are acute-rounded. Raphe is straight, fine with straight proximal fissures; the terminal fissures are slightly curved to the same side. Axial area is narrow, straight; central area is lanceolate to rhombic, formed by irregularly shortened striae; the two central striae are shorter than the rest. Striae are lineate, radiate at the center of the valve, convergent towards the ends. The central striae are irregularly shortened, the central stria is longer than the rest; the adjacent ones are enclosed by the neighbors, producing a much accentuated radial pattern. Length, 39-69 µm. Breadth, 7-12 µm. Striae, 12-18 in 10 µm. Lineae, 30 in 10 µm.

The density of striae is greater than that recorded (10-12 in 10 µm) by Krammer & Lange-Bertalot (1986).

This species is considered as cosmopolitan, circumneutral to alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Contin & Oliveira 1993; Foged 1984; Hutchinson et al. 1956; Krammer & Lange-

Bertalot 1986; Lowe 1974; Martínez de Fabricius & Corigliano 1989; Metcalfe 1988; Stein & Gerrath 1969; Tavera et al. 1994; Wasylik 1965a; Whitford & Schumacher 1963).

In El Edén this taxon grew mainly as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was present also in the dry period and was frequent, although not abundant, as plankton in the same environments.

***Navicula rivulorum* Lange-Bertalot et Rumrich** (Pl. 8:8)

Frustules are small. Lanceolate valves have convex margins. Apices are not extended; poles are acute. Sinuous raphe has close proximal fissures and terminal fissures curved in the same direction. Central nodule is prominent. Axial area is narrow; central area is small, rectangular. Lineate (little visible lineae) striae are slightly radiate. At the center of the valve, the two central striae at one side are irregularly shortened; at the other side striae are regularly shortened. Length, 10-20 μm. Breadth, 2.5-4.0 μm. Striae, 19-20 in 10 μm at the center of the valve and 24-25 to the ends.

Our material has a bit wider intervals than those given by Rumrich et al. (2000). They registered this species in alkaline rivers.

This species is known at present only in America (Rumrich et al. 2000; Tudesque & Ector 2002).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and in the inundated savannah.

***Navicula rostellata* Kützing** (Pl. 8:9)

Frustules are solitary. Lanceolate valves have rostrate apices and blunt poles. Straight raphe has close proximal fissures and terminal fissures curved to the same side. Axial area is wide, straight; central area is elliptical, transverse and distinct, occupying more then ½ of the valve. Center lineate striae are radiate and slightly convergent towards the ends. All striae are the same distance and width as the interstriae. The central striae are regularly shortened and slightly curved. Length, 40-42 μm. Breadth, 9-10 μm. Striae, 7-14 in 10 μm. Lineae, 24-28 in 10 μm.

Our populations are very similar to those registered by Metzeltin & Lange-Bertalot (1998) in Brazil.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (as *Navicula viridula* var. *rostellata* (Kützing) Cleve: Cantoral 1997; Gasse 1986; Germain 1981; Hustedt 1930; Krammer & Lange-Bertalot 1986; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1966; Sarode & Kamat 1984).

In El Edén this taxon grew as periphyton in ponds, cenotes and in the inundated savannah. It was rare, however abundant, as plankton in cenotes.

NEIDIUM Pfitzer

***Neidium ampliatum* (Ehrenberg) Krammer** (Pl. 9:1)

Frustules are solitary, medium to large size. Linear valves have extended rostrate apices and rounded poles. Axial area is narrow, straight; central area is rectangular to lateral-orbicular. Raphe is straight; proximal fissures of raphe are curved in 90°

to opposite sides, occupying the whole central area; distal fissures of raphe are bifurcated. Striae are straight and parallel, punctate with two rows of areolae. Length, 40.0-91.5 µm. Breadth, 10-17 µm. Striae, 20-23 in 10 µm. Areolae, 14-16 in 10 µm.

This species is considered as cosmopolitan in mountainous regions as well as lowlands in biotopes with moderate conductivity (Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and ponds. It was rare as metaphyton and plankton in the inundated savannah.

NUPELA Vyvermann et Compère

***Nupela astartiella* Metzeltin et Lange-Bertalot** (Pl. 9:2)

Frustules are solitary, small. Elliptical-lanceolate valves have convex margins, slightly extended apices, and cuneate poles. Raphe valve: Filiform raphe has small, wide proximal fissures. Striae are parallel along the entire length of the valve. Axial area is narrow, linear; central area is small. Valve with reduced raphe: axial area is narrow, lanceolate, little distinguished from the central area. Striae are parallel. Length, 18-20 µm. Breadth, 6.4-7.0 µm. Striae, 28-30 in 10 µm on the raphe valve; 30 in 10 µm on the valve with reduced raphe.

While our exemplars are larger than populations registered in Brazil, 10-17 µm long, 4.5-5.4 µm breadth (Metzeltin & Lange-Bertalot 1998) this does not justify a different taxon as morphology and density of striae are identical.

This species is considered as present only in tropical America (Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew as plankton in cenotes.

PINNULARIA Ehrenberg

Key to the species and varieties.

1a Striae wide and distant ..... *P. borealis*
1b Striae narrow and close 2
2a Central striae strongly radiate ..... *P. subrostrata*
2b Central striae moderately radiate 3
3a Axial area wide (> ½ of the valve) ..... *P. acrosphaeria*
3b Axial area moderate (⅓) or small (¼ or less) 4
4a Raphe strongly lateral, only large forms 5
4b Raphe slightly lateral, small to large forms 7
5a Valves > than 22 µm wide ..... *P. major*
5b Valves < than 22 µm wide 6
6a Terminal striae slightly convergent ..... *P. tropica*
6b Terminal striae slightly radiate ..... *P. streptoraphe* var. *parva*
7a Margins convex 8
7b Margins straight, parallel or straight to slightly convex or triundulate 9
8a Ends not extended, cuneate to slightly acute ..... *P. mayarum*
8b Ends extended, rostrate..... *P. certa*
9a Margins triundulate ..... *P. subgibba* var. *capitata*

9b Margins straight, parallel or straight to slightly convex 10
10a Valve length less than 30 µm, apices capitate..... *P. joculata*
10b Valves larger than 30 µm, apices straight or subcapitate 11
11a Central area wide, trapezoidal in shape, to each side of the valve ... *P. gibba*
11b Central area narrow, rhomboidal in shape 12
12a Internal openings of alveoli visible as longitudinal marginal lines .....
..... *P. divergens*
12b Internal openings of alveoli not visible ..... *P. microstauron*

***Pinnularia acrosphaeria* W. Smith** (Pl. 9:3)
Valves are linear, tumid at the middle part with slightly capitate apices and poles rounded, blunt. Axial area is wide, straight, extending to ½ the width of the valve; central area is longitudinally-lanceolate, slightly distinguished from the axial area. Both axial and central areas have an irregular ornamentation in relief. Raphe is straight, slightly lateral, with distal fissures in the shape of question marks. Striae are narrow, close, slightly radiate at the center of the valve and parallel towards the ends. The internal openings of alveoli are barely evident. Length, 53.5-75.2 µm. Breadth, 10.0-12.7 µm. Striae, 20 in 10 µm.

This species is considered as tropical with some temperate records, alkaliphilous, and oligohalobous indifferent (Aguiar & Martau 1979; Contin & Oliveira 1993; Bicudo et al. 1973; Bradbury 1971; Metcalfe 1985, 1988; Metzeltin & Lange-Bertalot 1998; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and ponds. It was infrequent as plankton in cenotes and in the inundated savannah.

***Pinnularia borealis* Ehrenberg** (Pl. 9:4)
Valves are linear with straight, nearly parallel margins; without extended ends and poles blunt. Axial area is narrow, straight, extending to $^1/_6$ the width of the valve; central area is rectangular. Raphe is straight, slightly lateral, with proximal fissures as small pores and distal fissures having a question mark shape. Striae are coarse, wide and parallel. The internal openings of alveoli are not evident. Length, 25-30 µm. Breadth, 10.0-12.7 µm. Striae, 6 in 10 µm.

Our exemplars are smaller than those from Europe and the United States which have 24-110 µm in length and 5-18 µm in breadth (Krammer & Lange-Bertalot 1986; Patrick & Reimier 1966).

This species is considered as cosmopolitan, oligohalobous indifferent (Aguiar & Martau 1979; Bicudo et al. 1973; Bock 1970; Foged 1984; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1966; Sarode & Kamat 1984).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and ponds. It was infrequent as plankton in cenotes, as well as in plankton and metaphyton in the inundated savannah.

***Pinnularia certa* Krammer et Metzeltin** (Pl. 9:5)
Valves are linear with convex margins, apices extended and rostrate, rounded poles. Axial area is lanceolate, extending to ¼ the width of the valve; central area is wide, stauros-like, without marginal striae, or thickenings. Raphe is slightly lateral, with straight proximal fissures and distal fissures in the shape of a sickle.

Striae are narrow, fine, radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are not evident. Length, 47-65 µm. Breadth, 8.5-9.0 µm. Striae, 9-10 in 10 µm.

This species has been recorded in Brazil and Guyana by Metzeltin & Lange-Bertalot (1998). Our exemplars seem more similar to the Guyana populations; however, in our exemplars the apices tend to be subcapitate and the proximal fissures are straight. The South American exemplars have rostrate apices and proximal fissures curved.

This species is considered as present only in tropical America.

In El Edén this taxon grew as metaphyton and periphyton in cenotes and in the inundated savannah. It was very rare as plankton in cenotes.

***Pinnularia divergens* W. Smith** (Pl. 9:6)

Valves are linear, with straight, non-protracted apices and rounded blunt poles. Axial area is narrow, extending to $^{1}/_{5}$ the width of the valve; central area is rhombic, differentiated from the axial area and forming a stauros-like area which reaches the margins. At this level of margins, the central area has thickenings on both sides. Straight, slightly lateral raphe has distal fissures that are bayonet-shaped. Striae are thin, fine, radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are visible as longitudinal marginal lines. Length, 70-75 µm. Breadth, 12-14 µm. Striae, 11-12 in 10 µm.

This species is considered as cosmopolitan, circumneutral, and halophobous (Foged 1984; Krammer & Lange-Bertalot 1986; Maidana 1985; Metzeltin & Lange-Bertalot 1998; Novelo 1998; Sieminska 1964; Skuja 1949).

In El Edén this taxon grew as periphyton in the inundated savannah.

***Pinnularia gibba* (Ehrenberg) Ehrenberg** (Pl. 9:7)

Valves are linear with straight to slightly convex margins, slightly widened at the center of the valve, subcapitate apices and rounded poles. Axial area is straight, widening at the central area, extending to ⅓ the width of the valve; central area is wide, stauros-like, reaching the margins, well differentiated from the axial area. Raphe is straight, slightly lateral, with distal fissures in the shape of a question mark. Striae are thin, fine, radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are evident. Length, 62.0-94.2 µm. Breadth, 10.8-12.0 µm. Striae, 9-12 in 10 µm.

This species is considered as cosmopolitan, acidophilous, present in karstic substrata, and oligohalobous indifferent (Contin & Oliveira 1993; Foged 1984; Lowe 1974; Wasylik 1965a).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah and cenotes.

***Pinnularia joculata* (Manguin) Krammer** (Pl. 9:8)

Valves are linear with straight margins; apices are extended, capitate and poles are rounded. Axial area is wide, lanceolate; central area is wide extended in a fascia reaching the margins. The raphe is slightly lateral, with distal fissures question mark-shaped and rounded, small central pores, bent to the same side. Striae are thin, fine, radiate at the center of the valve and convergent towards the ends. The

internal openings of alveoli are not evident. Length, 14-23 µm. Breadth, 4.0-4.5 µm. Striae, 20-24 in 10 µm.

This species was described as *Pinnularia interrupta* var. *joculata* Manguin from Guadeloupe Island mainly as aerophytic (Bourrelly & Manguin 1952).

This species is considered as present only in tropical America.

In El Edén this taxon grew as metaphyton and periphyton in ponds.

***Pinnularia major* (Kützing) Rabenhorst** (Pl. 9:9)

Valves are linear with parallel margins, slightly swollen at the center; apices are continuous and poles are rounded. Axial area is wide, extending to ⅓ the width of the valve; central area is wide, slightly rounded, as an enlargement of the axial area. Raphe is strongly lateral, sinuous, curved to one side; distal fissures of raphe are in the shape of a sickle; central pores are rounded and close, small. Striae are fine, slightly radiate at the center of the valve and slightly convergent towards the ends. The internal openings of alveoli are narrow, evident mainly at the middle part of the valve. Length, 103.9-200.0 µm. Breadth, 22.5-30.0 µm. Striae, 6-8 in 10 µm.

Some exemplars are smaller than those from Europe and the United States which have 140-310 µm in length and 25-40 µm in breadth (Germain 1981; Krammer & Lange-Bertalot 1986; Patrick & Reimer 1966).

This species is considered as cosmopolitan, acidophilous, present in karstic substrata, and oligohalobous indifferent (Contin & Oliveira 1993; Germain 1981; Krammer & Lange-Bertalot 1986; Metcalfe 1985, 1988; Patrick & Reimer 1966; Stein & Gerrath 1969; Wasylik 1965b).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds, though it is infrequent in metaphyton. It was rare as plankton in cenotes and in the inundated savannah.

***Pinnularia mayarum* sp. nov.** (Pl. 9:10)

Diagnosis. Valva linearis, 30-60 µm longa, 9.0-11.5 µm lata, marginibus convexis; apicibus cuneatis non extensis, polis leviter acutis. Area axialis lata, lanceolata, usque ad 1/3 valvae attingens; area centralis stauroidea, area axiali non dissimilis. Raphe parva lateralis, recta, fissuris proximalibus approximatis, fissuris distalibus falcatis. Striae angustae approximatae, in valvae centro valde radiales, apicaliter convergentes. Alveolorum margo non manifestus.
Striae 12-14 in 10 µm.
Etymology: Pertaining to the Mayans, the ethnic group inhabiting the region.
Holotypus: Praep. Eden 403.1 in Coll. Edén FCME, Pl. 9:10b.
Type locality: Ayín cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are linear with convex margins; apices are not protracted, cuneate, poles are slightly acute. Axial area is wide, lanceolate, extending to ⅓ the width of the valve; central area is wide, stauroid, not differentiated from the axial area. Raphe is straight, slightly lateral with close proximal fissures and distal fissures in shape of a sickle. Striae are narrow, fine, strongly radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are not evident. Length, 30-60 µm. Breadth, 9.0-11.5 µm. Striae, 12-14 in 10 µm.

Our populations seem to be similar to *P. microstauron* var. *brebissonii* (Kützing) Mayer *sensu* Krammer & Lange-Bertalot 1986 [syn. *P. brebissonii* (Kützing) Rabenhorst]; however, this taxon has almost paralell margins and rounded poles. Although the dimensions are similar, (20-90 μm length; 7-11 μm breadth and 10-13 striae in 10 μm), the ecology recorded for this taxon is different: oligosaprobic waters with high conductivity. Besides, *Pinnularia brebissonii* (Kützing) Rabenhorst *sensu* Germain 1981 lives in water with high content of organic matter and high conductivity; meanwhile, Patrick & Reimer 1976 states that this taxon [syn. *P. micrastauron* var. *brebissonii* (Kützing) Hustedt] prefers cool water of low mineral content. Also, our populations are similar to *P. brebissonii* var. *acuta* Cleve-Euler (syn. *P. microstauron* var. *brebissonii* (Kützing) Hustedt) but this variety grows in oligotrophic water with low electrolytic content in mountain zones from Europe (Krammer 2000).

In El Edén this taxon grew as periphyton in the inundated savannah and cenotes. It was a scarce species.

***Pinnularia microstauron* (Ehrenberg) Cleve** (Pl. 10:1)

Valves are linear with straight, parallel margins; apices are extended, subcapitate and poles are rounded. Axial area is narrow, straight and linear, extending to ⅓ the width of the valve; central area is rhombic, stauros-like, with striae only on one margin and differentiated from the axial area. Raphe is slightly straight, lateral, with distal fissures question mark shaped; central pores are rounded, small. Striae are narrow, fine, radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are not visible as longitudinal marginal lines. Length, 35.0-73.5 μm. Breadth, 7.5-12.5 μm. Striae, 9-10 in 10 μm.

This species is considered as cosmopolitan, acidophilous, and halophilous, indifferent (Aguiar & Martau 1979; Bicudo et al. 1975; Contin & Oliveira 1993; Foged 1984; Forest et al. 1959; Hirano 1969; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1986; Metcalfe 1985).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated savannah, likewise as periphyton in savannah during the dry period.

***Pinnularia streptoraphe* var. *parva* Krammer** (Pl. 10:2)

Valves are linear with slightly convex margins, non-protracted apices and rounded poles. Axial area is wide, straight, extending to ⅓ the widht of the valve. Central area is rounded and differentiated from the axial area. Raphe is sinuous, strongly lateral, with distal fissures question mark-shaped; central pores are close and rounded, small. Striae are narrow, fine, and slightly radiate at the center of the valve and parallel towards the ends. The internal openings of alveoli are evident at the middle of the valve. Length, 85-114 μm. Breadth, 16-22 μm. 8-10 striae in 10 μm.

P. streptoraphe var. *parva* was recorded in Lago Calado, Brazil by Metzeltin & Lange-Bertalot (1998). This variety is considered as present only in tropical America.

In El Edén this taxon grew as periphyton and metaphyton in ponds and in the inundated savannah where it was rare as plankton, likewise as periphyton in savannah during the dry period.

***Pinnularia subgibba* var. *capitata* Metzeltin et Lange-Bertalot** (Pl. 10:3)
Valves are linear with slightly triundulate margins; extended, subcapitate apices and rounded poles. Axial area is straight, moderately wide, becoming lanceolate near the ends and extending to ⅓ the width of the valve; central area is wide, rhombic, stauros-like shaped, reaching the margins, not differentiated from the axial area. Slightly lateral raphe has proximal fissures close, and rounded, small, central pores, bent to one side; distal fissures are sickle-shaped. Striae are narrow, fine, radiate at the center of the valve and convergent towards the ends. The internal openings of alveoli are not evident. Length, 62-86 µm. Breadth, 8.9-13.0 µm. Striae, 9-10 in 10 µm.

This variety was described from Lago Calado, Brazil by Metzeltin & Lange-Bertalot (1998) and it is considered as present only in tropical America.

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. It was rare as plankton in cenotes.

***Pinnularia subrostrata* Lohman et Andrews** (Pl. 10:4)
Valves are linear with straight margins, apices are slightly extended, subcapitate and poles rounded. Axial area is narrow, straight, extends less than $^{1}/_{5}$ the width of the valve. The rhombic central area is not differentiated from the axial area. Straight, slightly lateral raphe has distal fissures sickle-shaped, and rounded, small central pores. Striae are narrow, fine, and radiate at the center, changing abruptly to convergent towards poles. The internal openings of alveoli are not evident. Length, 34.6-45.0 µm. Breadth, 6-8 µm. Striae, 10-11 in 10 µm.

This species is considered as present only in temperate regions (Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds and. It was very rare as plankton in cenotes and in the inundated savannah.

***Pinnularia tropica* Hustedt** (Pl. 10:5)
Valves are linear with straight margins and non-protracted apices and rounded poles. Axial area is straight, extends to ⅓ the width of the valve. The rounded central area is differentiated from the axial area. The sinuous, strongly lateral raphe has close proximal fissures and distal fissures question mark-shaped. Narrow, fine striae are radiate at the center of the valve and parallel to slightly convergent towards the ends. The internal openings of alveoli are barely evident. Length, 76-100 µm. Breadth, 12-16 µm. Striae, 7-9 in 10 µm.

This species was described by Hustedt from Congo (INA 2004) and Foged recorded it in Cuba (1984). It is considered as tropical, circumneutral, and oligohalobous indifferent.

In El Edén this taxon grew as plankton and metaphyton in cenotes.

***PLACONEIS* Mereschkowsky**

***Placoneis porifera* var. *opportuna* (Hustedt) comb. nov.** (Pl. 10:6)
Basionym: *Navicula porifera* var. *opportuna* (Hustedt) Lange-Bertalot in Krammer & Lange-Bertalot. Bibliotheca Diatomologica 9: 86, fig. 198. 1985.

Valves are lanceolate with slightly extended apices and acute poles. The rectangular, small central area is without a stigma. Axial area is very narrow, straight. Punctate striae are radiate along the entire length of the valve and have interstriae wider than the striae. Proximal raphe fissures are rounded and the distal fissures are curved in opposite direction. Length, 19-21 µm. Breadth, 9.0-9.5 µm. Striae, 12 in 10 µm at the center of the valve and 16 in 10µm to the ends. Areolae, 20-24 in 10 µm.

The distinction between *Navicula porifera* var. *porifera* Hustedt and *N. porifera* var. *opportuna* was based on the presence of a stigma on the central area in the former taxon. Our material is clearly part of *Placoneis* according the description by Cox (2003). *Placoneis porifera* was combined by Ohtsuka and Fujita (2001) based on *Navicula porifera* Hustedt and because the name of *Placoneis porifera* var. *opportuna* is not yet considered as part of *Placoneis*, we propose the new combination.

This variety is considered as present only in temperate regions (as *Navicula porifera* var. *opportuna*: Krammer & Lange-Bertalot 1986).

In El Edén this taxon grew as metaphyton in the inundated savannah.

SELLAPHORA Mereschkowsky

Key to the species.

1a Apices capitate or subcapitate, with pseudoseptum 2
1b Apices non differentiated, without pseudoseptum 3
2a Frustules greater than 44 µm in length ..... *S. pupula*
2b Frustules smaller than 30 µm in length ..... *S. guyanensis*
3a Filiform raphe, frustules smaller than 16 µm in length ..... *S. stroemii*
3b Sinuous raphe, frustules greater than 20 µm in length ..... *S. laevissima*

***Sellaphora guyanensis* Metzeltin et Lange-Bertalot** (Pl. 10:7)

Solitary frustules are small. Linear valves have convex margins, extended, capitate apices with rounded poles and with an apical pseudoseptum. Filiform, straight raphe has a conopeum with close, straight to slightly curved proximal fissures and straight distal fissures. Axial area is narrow and central area is stauroid with marginal striae. Punctate, curved striae are radiate to parallel at the ends; central striae are short, one or two form a central fascia. Length, 20-27 µm. Breadth, 5.5-7.5 µm. Striae, 24-28 in 10 µm. Areolae, barely visible, > 30 in 10 µm.

This species was described from Guyana by Metzeltin & Lange-Bertalot (1998). Our exemplars are a little bigger, with less capitate ends and more dense striation than the populations from Guyana.

This species is considered as present only in tropical America.

In El Edén this taxon grew as plankton in cenotes and periphyton in the inundated savannah.

***Sellaphora laevissima* (Kützing) D.G. Mann** (Pl. 10:8)

Solitary frustules are small to medium in size. Valves have straight, parallel margins and rounded poles that are not differentiated from the body of the valve.

A pseudoseptum is lacking. Sinuous raphe has a conopeum; close proximal fissures of raphe are slightly curved to the same side; distal fissures do not reach the pole. Polar nodules are laterally expanded, without thickenings; the central nodule is small. Axial area is narrow, linear; central area is rectangular, smooth. The whole valve has lineate, curved (radiate) striae. Terminal striae are of the same width as the rest. Striae bordering the central area are curved, regularly shortened on both sides of the valve and more coarsely spaced in relation to the rest. Interstriae have similar width as the striae, without transversal thickenings. Length, 20.0-47.9 µm. Breadth, 7-10 µm. Striae, 18-24 in 10 µm.

This species is considered as cosmopolitan, circumneutral to alkaline pH with high conductivity (as *Navicula laevissima* Kützing: Gasse 1986; Krammer & Lange-Bertalot 1986; Metcalfe 1985, 1988; Novelo 1998; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated and dry savannah. It was very rare as plankton in cenotes and savannah.

***Sellaphora pupula* (Kützing) Mereschkowsky** (Pls. 10:9, 11:1)
Solitary frustules are medium to large in size. Linear valves have straight to convex margins and slightly capitate apices, little differentiated from the valve's body. Widely rounded poles have an apical pseudoseptum. Filiform raphe has a conopeum; proximal fissures of raphe are straight, close; distal fissures are straight. Axial area is narrow and the central area is rectangular and smooth. The whole valve has curved, radiate striae, finely areolate. All striae have the same width. Straight, irregularly shortened striae form the central area and are more spaced in relation to the rest. Interstriae have a similar width as the striae. Length, 44-55 µm. Breadth, 9.8-11.0 µm. Striae, 14-22 in 10 µm.

This species is considered as cosmopolitan, circumneutral to indifferent to pH, and oligohalobous indifferent (as *Navicula pupula* Kützing: Contin & Oliveira 1993; Foged 1984; Germain 1981; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1986; Lowe 1974; Patrick & Reimer 1966; Sieminska 1964; Tavera et al. 1994).

In El Edén this taxon grew as periphyton, metaphyton and plankton in cenotes, ponds and in the inundated savannah.

***Sellaphora stroemii* (Hustedt) D.G. Mann** (Pl. 11:2)
Linear valves have slightly convex margins, without extended apices and widely rounded poles. Filiform raphe has a conopeum; indistinct proximal fissures and distal fissures reach the pole. Axial area is narrow and straight. Central area is almost rectangular and small, formed by the shortening of the two central striae, more coarsely spaced in relation to the rest. The whole valve has straight, radiate striae, that are finely punctate. Length, 15-16 µm. Breadth, 4.5-5.0 µm. Striae, 28-30 in 10 µm.

This species is considered as temperate with some tropical records (as *Navicula stroemii* Hustedt: Holmes & Whitton 1981; Krammer & Lange-Bertalot 1986; Novelo 1998).

In El Edén this taxon grew as periphyton and metaphyton in cenotes. Also, it grew in the inundated and dry savannah.

***STAURONEIS* Ehrenberg**

Key to the species.

1a Valve with convex margins and capitate ends without pseudoseptum; areolae not aligned ..... *S. phoenicenteron*

1b Valve with parallel, straight margins and rostrate ends, pseudoseptum present; areolae ordered in crossing lines, at 60-80 degrees each other .... *S. amphibia*

***Stauroneis amphibia* sp. nov.** (Pl. 11:3)

Diagnosis. Valvae lineari-lanceolatae, 27.8-37.0 µm longae, 5.4-9.0 µm latae, marginibus parallelis rectis, apicibus rostratis a valvae corpus distinctis, polis rotundatis pseudosepto polari praeditis. Raphe filiformis sine incrementis incrassatis, fissuris proximalibus rectis, fissuris distalibus in eodem cursu curvatis. Area axialis linearis angusta, recta, prope area centrali dilatata; area centralis stauroidea laevis, epunctata, sine stigmatis. Striae radialis in valvae centro, absentes in area centrali. Striae totae rectae; intervalla aequilata, latitudine strias aequantia. Areolae ordinatae in lineis decussatis ad angula 60-80°. Striae 20-37 in 10 µm. Areolae 26 in 10 µm.

Etymology: (Latin) amphibius: living in water and on land, referring to the fact that it grows in the dry as well as in the rainy season.

Holotypus: Praep. Eden 414.2 in Coll. Edén FCME, Pl. 11:3c.

Type locality: Site 4 of the flooded savannah in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are linear-lanceolate with straight, parallel margins. Rostrate ends are differentiated from the valve's body; poles are rounded with a polar pseudoseptum. Filiform raphe has no thickenings. Proximal fissures are close, straight, and distal fissures are curved in the same direction. The narrow, straight and linear axial area widens near the central area. Central area is stauroid, smooth without points or stigmata. Striae are radiate in the center of the valve but absent in the central area. All striae are straight of uniform density throughout and as wide as the interstriae. Areolae ordered in crossing lines, at 60-80 degrees each other. Length, 27.8-37.0 µm. Breadth, 5.4-9.0 µm. Striae, 20-37 in 10 µm. Areolae, 26 in 10 µm.

This species is similar to *Stauroneis agrestis* Petersen, but Petersen's taxon was described with less extended poles, and smaller and more lanceolate valves (Krammer & Lange-Bertalot 1986; Rumrich et al. 2000).

In El Edén this taxon grew as periphyton in the inundated and dry savannah.

***Stauroneis phoenicenteron* (Nitzsch) Ehrenberg** (Pl. 11:4)

Lanceolate to elliptical-lanceolate valves have convex margins and capitate apices without pseudosepta. The axial area is narrow; a wide stauros is present. Raphe is lateral in the middle part of the valve and has distal fissures question mark-shaped and straight proximal fissures. Areolae of striae not aligned longitudinally. Striae are slightly radiate in the center of the valve as well as to the ends. Length, 69.7-112.0 µm. Breadth, 12-29 µm. Striae, 14-16 in 10 µm. Areolae, 16-18 in 10 µm.

This species is considered as cosmopolitan, pH indifferent, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Foged 1984; Holmes & Whitton 1981; Lowe 1974; Patrick & Reimer 1966; Wasylik 1965b).

In El Edén this taxon grew as periphyton and metaphyton in ponds, in cenotes and in the inundated savannah and as plankton in cenotes and in the inundated savannah.

Asymmetrical Group of Naviculaceae

Key to the genera.

1a Asymmetrical to transapical axis 2
1b Asymmetrical to apical axis 3
2a Raphe similar in both valves ..... *Gomphonema*
2b Reduced raphe in one valve ..... *Rhoicosphenia*
3a Girdle view ellipsoidal, not rectangular; dorsal cingular bands wider than ventral ..... *Amphora*
3b Rectangular girdle view, both cingular bands equal in width 4
4a Valve tumid and lacking striae at the center of the ventral margin .... *Reimeria*
4b Ventral margin straight or not so, but always with striae 5
5a Distal fissures of raphe ventrally curved, sometimes with dorsal stigmoids 6
5b Distal fissures of raphe dorsally curved, sometimes with ventral stigmata . 7
6a Stigmoids generally present ..... *Encyonema*
6b Without stigmoids or stigmata ..... *Encyonopsis*
7a One or several ventral stigmata ..... *Cymbella*
7b Without stigmata ..... *Cymbopleura*

***AMPHORA* Ehrenberg**

Key to the species.

1a Small valves, less than 20 µm long ..... *A. pediculus*
1b Medium to large valves, more than 20 µm long 2
2a Lineate dorsal striae, interrupted at the center, 14-15/10 µm ..... *A. copulata*
2b Finely punctate dorsal striae, 19-26 in 10 µm 3
3a All dorsal striae, similar and equally spaced ..... *A. coffeaeformis*
3b Central dorsal striae wider and more spaced than the rest ..... *A. veneta*

***Amphora coffeaeformis* (C. Agardh) Kützing** (Pl. 12:1)

Frustules are semi-elliptical in valve view, with subrostrate poles which are curved slightly ventrally. Ventral margin is straight to slightly concave. The dorsal margin is convex. Axial area is narrow and straight in valve view; the central area is absent. Radiate dorsal striae are complete (not interrupted) and finely punctate; ventral striae are not visible. Raphe is fine, straight with straight distal fissures. Length, 30-48 µm. Breadth, 5.4-7.0 µm. Length:Breadth, 5-6. Striae, 19-23 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and mesohalobous (Cook & Whipple 1982; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Patrick & Reimer 1975; Whitford 1956).

In El Edén this taxon grew as plankton in cenotes and in the inundated savannah; also, it was collected as periphyton and metaphyton in the inundated savannah.

***Amphora copulata* (Kützing) Schoeman et Archibald** (Pl. 12:2)

Semi-elliptical frustules without protracted, but slightly rostrate and straight poles. Ventral margin is straight and dorsal margin is convex. The central nodule has neither ornamentation nor thickenings. Axial area is narrow; central area mainly ventral, shaped like a staurose. Radiate dorsal striae are lineate, interrupted in the central part; regularly shortened central striae. Ventral striae are radiate, lineate. Raphe is fine, sinuous. Distal raphe fissures are curved ventrally. Length, 25.8-34.2 µm. Breadth, 6.0-7.2 µm. Length:Breadth, 2-2.5. Striae, 11-13 in 10 µm along the ventral margin, 14-15 in 10 µm along the dorsal margin.

Lee & Round (1988) established the correct name for this species which often has been named as *Amphora libyca* Ehrenberg.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Cantoral 1997). As *A. libyca*, Krammer & Lange-Bertalot (1986) consider this species to be present in every type of water with medium to high conductivity.

In El Edén this taxon grew as plankton and periphyton in cenotes and in the inundated savannah; it was very rare as plankton in the same environments.

***Amphora pediculus* (Kützing) Grunow** (Pl. 12:3)

Frustules are semi-elliptical with poles not protracted, rounded, and curved in valve view. Ventral margin is straight and the dorsal margin is convex. The axial area is narrow and straight and the central area is small and shaped like a staurose. Parallel dorsal striae are coarsely punctate. Ventral striae are reduced. Raphe is fine, straight with straight distal fissures. Length, 7.5-17.5 µm. Breadth, 2.5-4.0 µm. Length:Breadth, 3-4. Striae, 20-22 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Cantoral 1997; Gasse 1986; Germain 1981; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Novelo 1998; Padisák et al. 1998).

In El Edén this taxon grew as periphyton in cenotes, ponds and in the inundated savannah; as well as plankton in cenotes and in the inundated savannah.

***Amphora veneta* Kützing** (Pl. 12:4)

Frustules are semi-elliptical in valve view with slightly protracted poles, rostrate and curved. Ventral margin is straight and the dorsal margin is convex. Central nodule has neither ornamentation nor thickenings. Straight axial area is narrow; the dorsal-unilaterally expanded central area is rectangular and small. Radiate dorsal striae are finely punctate; 3-4 central striae are more coarsely spaced than the rest; ventral striae are not visible. Raphe is fine, straight with ventrally curved distal fissures. Length, 27-40 µm. Breath, 4.6-6.5 µm. Length:Breadth, 5-6. Striae, 26 in 10 µm. Areolae, 20 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Foged 1984; Gasse 1986; Germain 1981; Herbst & Maidana 1989; Ibarra & Novelo 1997; Lowe 1974; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1975; Sarode & Kamat 1984).

In El Edén this taxon grew mainly as periphyton and metaphyton in cenotes and in the inundated savannah; as well as plankton in cenotes.

CYMBELLA Agardh

Key to the species.

1a Slightly extended and subrostrate ends ..... *C. cistula*
1b No differentiated ends 2
2b Visible internal central fissure (intermissio), a ventral stigma .... *C. mexicana*
2a No visible internal central fissure, 5 to 7 ventral stigmata ..... *C. aspera*

***Cymbella aspera* (Ehrenberg) Cleve** (Pl. 12:5)

Valves are asymmetrical to the apical axis, with ventral margin straight, undifferentiated apices, and widely rounded poles. The axial area is wide and central area is ovoid. The raphe is central, reverse-lateral and has small proximal ends that are curved ventrally. Distal raphe fissures are curved dorsally. Coarsely punctate striae are radiate along the whole valve, the terminal are denser than the central striae. Length, 118-120 µm. Breadth, 23.0-23.5 µm. Length:Breadth ratio, 5. Striae around the center, 7 in 10 µm (ventral) to 8 in 10 µm (dorsal), and at the apices 12 in 10 µm (ventral) to 10 in 10 µm (dorsal). Areolae, 16 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, oligohalobous indifferent (Dillard 1969; Hirano 1973; Lowe 1974; Wasylik 1965b).

In El Edén this taxon grew mainly as periphyton in cenotes, ponds and in the inundated savannah and as plankton in cenotes.

***Cymbella cistula* (Hemprich et Ehrenberg) Kirchner** (Pl. 12:6)

Valves are strongly asymmetrical to the apical axis, the ventral margin is straight to slightly dilated at the center; the subrostrate ends have rounded poles. The axial area is narrow and linear, and the central area is rounded, slightly differentiated from the axial area. Raphe is slightly ventral, reverse-lateral and has small proximal fissures that are curved ventrally. Distal raphe ends are curved towards the dorsal margin, almost to 90°. Two or three ventral stigmata are present. Punctate striae are parallel at the center of the valve and radiate to the ends. Length, 40-60 µm. Breadth, 14-18 µm. Length:Breadth ratio, 2-4. Striae around the center 8-13 in 10 µm at ventral margin, 6-12 in 10 µm at the dorsal margin, and at the apices 10-14 in 10 µm. Areolae, 18 in 10 µm.

This species is considered as temperate with some records in America, alkaliphilous in water with high conductivity (Holmes & Whitton 1981; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1986; Sheath & Cole 1992; Wasylik 1965b).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and in the inundated savannah and as plankton in cenotes.

***Cymbella mexicana* (Ehrenberg) Cleve** (Pls. 12:7, 13:1)
Valves are strongly asymmetrical to the apical axis with a slightly concave to straight ventral margin, undifferentiated ends and widely rounded poles. The axial area is wide, and the central area is small and elliptical. The internal central fissure is evident as an angular connection between the proximal fissures of raphe (intermissio). The reverse-lateral raphe has prominent proximal fissures, ventrally curved and brief distal fissures that do not reach the mantle of the valve. One stigma, slightly ventral, is located between the fissures. Radiate striae occur the whole length of the valve. Length, 153-227 µm. Breadth, 35.0-45.3 µm. Length:Breadth ratio, 3-6. Striae around the center 5-7 in 10 µm at dorsal margin, 6-8 in 10 µm at the ventral margin, and at the apices, 10-12 in 10 µm. Areolae, 10-12 in 10 µm.

This species is considered as tropical with some temperate records, alkaliphilous, present in karstic substrata, and oligohalobous to halophilous (Cantoral 1997; Bradbury 1971; Metcalfe 1985, 1988; Patrick & Reimer 1975; Sheath & Cole 1992; Whitford 1956).

In El Edén this taxon grew mainly as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. It was infrequent as plankton in cenotes and in the inundated savannah.

***CYMBOPLEURA* (Krammer) Krammer**

Key to the species.

1a Naviculoid valves with straight, slightly extended ends; > 40 µm ..... *C. chacii*

1b Cymbelloid valves, dorsally curved ends; < 32 µm ..... *C. hustedtii*

***Cymbopleura chacii* sp. nov.** (Pl. 13:2)
Diagnosis. Valvae lineari-lanceolatae, 42-50 µm longae, 5.4-9 µm latae, marginibus parallelis rectis, apicibus rostratis a valvae corpus distinctis, polis rotundatis septo polari praeditis. Raphe filiformis sine incrementis incrassatis, fissuris proximalibus rectis, fissuris distalibus in eodem cursu curvatis. Area axialis linearis angusta, recta, prope area centrali dilatata; area centralis stauroidea laevis, epunctata, sine stigmatis. Areolae in striis totis similares; striae radialis in valvae centro, absentes in area centrali. Striae terminales completae. Striae totae rectae; intervalla aequilata, latitudine strias aequantia. Areolae ordinatae in lineis decussatis ad angula 60-80°. Striae 20-37 in 10 µm. Areolae 26 in 10 µm.
Etymology: Honoring Chac, Mayan god of rain, one of the main deities in the Mayan pantheon.
Holotypus: Praep. Eden 20.1 in Coll. Edén FCME, Pl. 13:2a.
Type locality: Chamacos cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Naviculoid valves are moderately asymmetrical to the apical axis. Both dorsal and ventral margins are slightly convex. Apices of the valve are not distinguished and the poles are rounded. Axial area is moderately wide; the central area is wide, elliptical. The lateral raphe has small, straight proximal

fissures. Stigmata are wanting. Terminal raphe fissures are slightly curved dorsally, little defined in the light microscope. Punctate striae are slightly radiate at the center of the valve and radiate towards the ends. Length, 42-50 µm. Breadth, 10-13 µm. Striae, 12-17 ventral at the middle of the valve, 10-14 dorsal in 10 µm; 19-20 terminal in 10 µm. Areolae, 20-25 in 10 µm.

We consider our material as part of *Cymbopleura* because it presents a naviculoid outline; the raphe has straight proximal fissures and dorsally curved terminal fissures. Although raphe is similar to the genus *Cymbella*, *Cymbopleura* is distinguished also by the absence of stigma or stigmata.

This species is near to *Cymbopleura incerta* (Grunow) Krammer (as *Cymbella incerta* (Grunow) Cleve subgenus *Cymbopleura* Krammer *sensu* Krammer & Lange-Bertalot 1986), which has valves more dorsal-ventral and wider, as well as a rounded central area. Moreover, *Cymbella incerta* was described as a Nordic-alpine species, registered in moors by Krammer & Lange-Bertalot (1986). Reimer (in Patrick & Reimer 1975), reports *Cymbella incerta* from lake sediments in the U.S.A.

In El Edén this taxon grew mainly as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was dominant in metaphyton and infrequent as plankton in cenotes. It grew also as periphyton in the savannah at the dry period.

***Cymbopleura hustedtii* (Krasske) comb. nov.** (Pl. 13:3)

Basionym: *Cymbella hustedtii* Krasske. Botanisches Archiv 3:204, fig. 11. 1923.

Cymbelloid valves have convex dorsal margin and moderately convex ventral margin and apices slightly protracted, curved dorsally; poles are rounded. Axial area is narrow, and central area is lanceolate in shape. The lateral raphe has rounded, close, proximal fissures and distal fissures in a bayonet shape. Stigmata are wanting. Finely punctate striae are slightly radiate at the center of the valve and radiate to parallel towards the ends. Length, 19-32 µm. Breadth, 7-9 µm. Length:Breadth ratio, 2.6-3.3. Striae, 10-13 dorsal at the middle of the valve and 12-16 ventral in 10 µm.

We propose this new combination because Krammer (1997) included under *Cymbopleura* the name *Cymbella hustedtii* but this was not formally considered. Later (Krammer 1999, 2003) it was not mentioned under *Cymbopleura*. In our interpretation of this taxon, it should be included in *Cymbopleura*.

Compère (1981) noted a very fine areolation to this species, more than 30 in 10 µm, as in our exemplars. Krammer & Lange-Bertalot (1986) registered it in oligotrophic waters from mountainous zones.

This species is considered as cosmopolitan, pH indifferent, present in karstic substrata and oligohalobous indifferent (as *Cymbella hustedtii*: Cantoral 1997; Foged 1984; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1986; Lowe 1974).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated savannah; rarely grew as periphyton in the savannah at the dry period. It was infrequent as plankton in the inundated savannah and cenotes.

***ENCYONEMA* Kützing**

Key to the species.

1a	Extended ends	*E. densistriata*
1b	Ends not extended	2
2a	Ventral margin straight	*E. silesiacum*
2b	Ventral margin swollen or slightly convex	3
3a	Stigmoids wanting	*E. mexicanum*
3b	A stigmoid is present	4
4a	Wide axial area; central area not distinguishable	*E. neogracile*
4b	Narrow axial area; central area little evident	*E. mesianum*

***Encyonema densistriata* sp. nov.** (Pl. 13:4)

Diagnosis. Valvae cymbelloideae, interdum leviter naviculares, 18-32 µm longae, 4.0-4.5 µm latae (ratio inter longitudinem et latitudinem, 4.5-8), margine dorsali leviter curvato, margine ventrali leviter convexo vel recto, apicibus acutis vel leviter elongatis, polis rotundatis. Area axialis recta, angusta; area centralis non distinguibilis. Raphe leviter ventralis, fissuris proximalibus marginem dorsalem versus curvatis, fissuris distalibus ventraliter curvatis. Structura stigmatiformis dorsalis praesens. Striae radiales subtiliter punctatae, 16-24 (centro-dorsales) in 10 µm, 20-22 (centro-ventrales) in 10 µm.

Etymology: An allusion to the high number of striae per µm.

Holotypus: Praep. Eden 403.3 in Coll. Edén-FCME, Pl. 13:4b.

Type locality: Ayín cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are cymbelloid sometimes slightly naviculoid, with dorsal margin slightly curved, and a slightly convex to straight ventral margin. Acute to slightly elongated apices have rounded poles. Axial area is narrow and straight and not distinguishable from the central area. The raphe is slightly ventral, with small proximal fissures bent towards the dorsal margin; distal fissures are curved ventrally. A dorsal stigmoid is present. Striae are radiate and finely punctate, 16-24 in 10 µm (central dorsal), 20-22 in 10 µm (central ventral). Length, 18-32 µm. Breadth, 4.0-4.5 µm. Length:Breadth ratio, 4-8.

This species is similar to *Encyonema carina* Lange-Bertalot et Krammer (Krammer 1997a) due especially the high density of striae, but *E. carina* lacks a stigma. *Encyonema carina* has quite different ecology as compared to our taxon, it is known only from the type locality (Lustsee) a deep (18 m) prealpine, cool and oligotrophic lake in Bavaria, Germany.

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was rare in periphyton from the savannah in the dry period.

***Encyonema mesianum* (Cholnoky) D.G. Mann** (Pl. 14:1)

Valves are clearly asymmetrical to the apical axis with the ventral margin swollen slightly in the central portion of the valve. Apices are not protracted and have rounded poles. The axial area is narrow and straight; the central area is not distinguishable. The lateral raphe is ventrally placed. Distal raphe fissures are deflected ventrally to the mantle border. A stigmoid is located on the dorsal side

of the central area, close to the raphe fissures. Central striae are slightly radiate and parallel at the ends, clearly punctate. Length, 45-58 µm. Breadth, 11.0-12.5 µm. Length:Breadth ratio, 3.6-5.0. Striae, 10-11 in 10 µm (central dorsal), 9-13 in 10 µm (central ventral). Areolae, 20 in 10 µm.

This species is considered as temperate in Nordic, mountainous regions with some records in Tropical America, alkaliphilous, present in karstic substrata and oligohalobous (as *Cymbella mesiana* Cholnoky: Cantoral 1997; Krammer & Lange-Bertalot 1986; Novelo 1998; Sheath & Cole 1992; Tavera et al. 1994).

In El Edén this taxon grew as metaphyton and periphyton in cenotes, ponds and in the inundated savannah. Although it was rare, was recurrently collected in plankton from cenotes and inundated savannah, as well as periphyton from the savannah in the dry period.

***Encyonema mexicanum* Krammer** (Pl. 14:2)

Valves are clearly asymmetrical to the apical axis with slightly convex ventral margins. Apices are not protracted and have acute poles. The axial area is narrow and straight; the central area is slightly round. The raphe occurs in ventral position. Distal ends of raphe are deflected ventrally. Stigmoids are absent. Central striae slightly radiate and parallel to convergent at the ends, clearly punctate. Length, 34-40 µm. Breadth, 8.5-10.0 µm. Length:Breadth ratio, 3.4-4.0. Striae, 9-10 in 10 µm (central dorsal), 13 in 10 µm (central ventral). Areola number, 20 in 10 µm.

Our populations correspond better to the description of Krammer (1997a) for *Encyonema mexicanum*, although this species is a bit wider and was described from Mexican fossil material. They are also similar to *Encyonema elginense* (Krammer) D.G. Mann, but this species, according to Krammer (1997a), has a finer structure and has been registered in oligotrophic environments, as a Nordic species and in central Europe (alpine); the same cold places in high mountains are its habitat in South America (Chile).

This species is considered as present only in tropical America (Krammer 1997a).

In El Edén this taxon grew as metaphyton and periphyton in cenotes, ponds and in the inundated savannah. It was rare in plankton at the same environments.

***Encyonema neogracile* Krammer** (Pl. 14:3)

Valves are cymbelloid with dorsal margin convex and ventral margin slightly swollen in the central part. Apices are not protracted and have acute-rounded poles. Axial area is wide and straight; and central area is not distinguishable. Raphe is in a ventral position, slightly lateral. Distal ends of the raphe are deflected ventrally. A stigmoid is present. Central striae are parallel and slightly radiate to parallel at the ends, clearly punctate. Length, 43-60 µm. Breadth, 8-12 µm. Length:Breadth ratio, 3.5-7.5. Striae, 9-10 in 10 µm (central dorsal), 14 in 10 µm (central ventral), up to 20 in 10 µm (terminal). Areola number, 24-26 in 10 µm.

Although this species grows mainly in the Alps and in the Nordic zone, it has been registered in Brazil (Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew as metaphyton and periphyton in cenotes, ponds and in the inundated savannah. It was rare in plankton at the same environments and little frequent in periphyton from the savannah in the dry period.

***Encyonema silesiacum* (Bleisch) D.G. Mann** (Pl. 14:4)
Valves are cymbelloid with dorsal margin strongly curved and straight ventral margin. Apices are not protracted and have acute poles. Axial area is narrow and straight and without a central area. Raphe is in ventral position, strongly lateral with proximal fissures bent to the dorsal margin: Distal fissures are curved ventrally. The central nodule is small. A stigmoid is present near the dorsal central stria. Length, 20-25 µm. Breadth, 5.0-6.5 µm. Length:Breadth ratio, 3-5. Striae, 14-16 in 10 µm (central dorsal), 16-18 in 10 µm (central ventral). Areolae, 28-30 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (as *Cymbella silesiaca* Bleisch: Cantoral 1997; Krammer & Lange-Bertalot 1986; Novelo 1998; as *Cymbella minuta* var. *silesiaca* (Bleisch) Reimer: Aguiar & Martau 1979; Patrick & Reimer 1975; Tavera et al. 1994).

In El Edén this taxon grew mainly as periphyton and infrequent as metaphyton in the flooded savannah, cenotes and ponds. It was present (very rarely) in plankton from the inundated savannah and cenotes.

***ENCYONOPSIS* Krammer**

Key to the species.

1a Ends not extended ..... *E. ruttneri*
1b Ends extended 2
2a Frustule with capitate ends, acute to blunt poles; small, lateral central area .. .. *E. cesatii*
2b Frustule with sub-capitate ends, rounded poles; without defined central area ..... *E. microcephala*

***Encyonopsis cesatii* (Rabenhorst) Krammer** (Pl. 14:5)
Valves are naviculoid, slightly asymmetrical to the apical axis, and have margins that are slightly convex. Apices are slightly extended, capitate; poles are acute to blunt. Axial area is narrow, straight; central area is small, lateral. The lateral raphe is slightly ventral; proximal ends have small evident fissures. Large distal fissures are shaped like a comma and curved ventrally. Central striae are slightly radiate; terminal striae are radiate, all finely punctate. Length, 21-27 µm. Breadth, 4-5 µm. Central striae, 20-24 in 10 µm; terminal striae, 24-26 in 10 µm.

This species is considered as temperate with some records in America, circumneutral, and oligohalobous indifferent. Commonly reported in neutral to acidic pH (as *Cymbella cesatii* (Rabenhorst) Grunow: Foged 1984; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1986; Patrick & Reimer 1975; Wasylik 1965b).

In El Edén this taxon grew mainly as periphyton in the inundated savannah, cenotes and ponds. It was rare in metaphyton in the inundated savannah and in plankton of cenotes.

***Encyonopsis microcephala* (Grunow) Krammer** (Pl. 14:6)
Valves are naviculoid, barely asymmetrical in the apical axis, with slightly convex margins. Apices of the valve are slightly extended, sub-capitate with rounded poles. Axial area is narrow, straight and without a distinguishable central area. Raphe is lateral and proximal ends have evident fissures; distal fissures are short and circular. Striae are parallel and lineate. Length, 16-20 µm. Breadth, 3.5-4.0 µm. Striae, 20-24 in 10 µm (central, dorsal), 24-26 in 10 µm (central, ventral).

This species is considered as cosmopolitan but frequent in mountainous regions, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (as *Cymbella microcephala* Grunow: Cantoral 1997; Foged 1984; Gasse 1986; Germain 1981; Holmes & Whitton 1981; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Lowe 1974; Novelo 1998; Patrick & Reimer 1975; Schoeman 1973; Sieminska 1964; Tavera et al. 1994).

In El Edén this taxon grew mainly as periphyton in the inundated savannah and also, however infrequent, in periphyton in cenotes and ponds. Growing as metaphyton in the same environments keeps the same ratio. It was very rare in plankton in the inundated savannah.

***Encyonopsis ruttneri* (Hustedt) Krammer** (Pl. 15:1)
Valves are naviculoid, barely asymmetrical to the apical axis, with slightly curved dorsal margins and straight ventral margins. Apices are not protracted and poles are round. Axial area is thin, straight and without a distinguishable central area. Raphe is filiform, straight with proximal fissures bent to the dorsal margin; distal fissures are curved ventrally. Dorsal striae are slightly radiate, parallel ventral striae, all finely punctate. Length, 21-24 µm. Breadth, 4.5-5.0 µm. Striae, 22-26 in 10 µm (central, dorsal), 24-26 in 10 µm (central, ventral).

This species was described from Sumatra as acidophilous, though Krammer (1997b) indicates has a cosmopolitan distribution.

In El Edén this taxon grew always as an infrequent species, in metaphyton and plankton in the inundated savannah, and in periphyton of cenotes.

REIMERIA Kociolek et Stoermer

***Reimeria sinuata* (W. Gregory) Kociolek et Stoermer** (Pl. 15:2)
Valves are symmetrical to the transapical axis and asymmetrical to the apical axis with a tumid ventral margin in the central part, indistinguishable apices and rounded poles. Axial area is wide and central area is unilateral, without striae at the swollen side. Raphe is filiform, slightly ventral in position, with small, straight proximal fissures and terminal fissures not evident; a central stigma is present. Striae are finely punctate and slightly radiate. Length, 10.8-13.0 µm. Breadth, 3.0-3.5 µm. Striae, 12-13 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and oligohalobous indifferent (as *Cymbella sinuata* W. Gregory: Hirano 1973; Holmes & Whitton

1981; Krammer & Lange-Bertalot 1986; Lowe 1974; Tavera et al. 1994; Wasylik 1965b).

In El Edén this taxon grew as plankton in cenotes, but it was a rare species in the locality.

GOMPHONEMA Ehrenberg

Key to the species.

1a Linear-lanceolate valve 2
1b Valve otherwise formed 4
2a Filiform, straight raphe ..... *G. parvulum*
2b Lateral raphe 3
3a Rounded apical pole, acute basal pole, long central area .... *Gomphonema* sp.
3b Both poles acute; rounded, small central area ..... *G. gracile*
4a Clavate valve ..... *G. affine*
4b Tri-undulate valve 5
5a Central part wider than the ends ..... *G. vibrioides*
5b Apical part, wider than the central part 6
6a Acute apical pole ..... *G. acuminatum*
6b Blunt apical pole ..... *G. truncatum*

***Gomphonema acuminatum* Ehrenberg** (Pl. 15:3)

Valves are triundulate (biconstricted). The apical part of the valve up to the central nodule is shorter than the basal part. Apical pole is acute and basal pole is rounded, narrow. Sinuous raphe has evident terminal fissures. Axial area is narrow, straight. Central area is small, irregular, formed by the irregular shortening of striae and possesses one central stigma. Punctate striae are the same distance between the central and other striae at both sides of the valve. Striae are strongly radiate. An apical pore field is evident at the footpole. Length, 50-52 µm. Breadth, 10 µm. Striae, 9-12 in 10 µm central and 13 in 10 µm terminal.

This species is considered as cosmopolitan, circumneutral, and oligohalobous indifferent (Bicudo et al. 1973; Czarnecki 1979; Dillard 1969; García-Rodríguez & Tavera 2002; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985; Metcalfe 1988; Novelo 1998; Patrick & Reimer 1975; Whitford & Schumacher 1963).

In El Edén this taxon grew as metaphyton and periphyton in cenotes and in the inundated savannah. It was little frequent as plankton in the same environments.

***Gomphonema affine* Kützing** (Pl. 15:4)

Valves are clavate. The apical part of the valve up to the central nodule is shorter than the basal part. Apical pole is rounded and the basal pole is acute. Lateral raphe has evident terminal fissures. Axial area is narrow, straight. The unilateral and rectangular central area is formed by a shortening of one stria. One central stigma is present. Punctate striae are parallel to slightly radiate and more separated at the center of the valve. The terminal striae are slightly radiate and curved. An apical pore field is evident at the footpole. Length, 45-86 µm. Breadth,

10-14 μm. Striae, 8-12 in 10 μm central and 9-10 in 10 μm terminal. Areolae, 16-20 in 10 μm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, oligohalobous, and in a wide range of conductivity (Aguiar & Martau 1979; Cantoral 1997; García-Rodríguez & Tavera 2002; Germain 1981; Krammer & Lange-Bertalot 1986; Metzeltin & Lange-Bertalot 1998; Novelo 1998; Patrick & Reimer 1975).

In El Edén this taxon grew mainly as periphyton in the inundated savannah, cenotes and ponds. It was infrequent as metaphyton and plankton in the same environments.

***Gomphonema gracile* Ehrenberg** (Pl. 15:5)

Valves are linear-lanceolate, almost rhomboidal in shape. The apical part of the valve up to the central nodule is shorter than the basal part. Both poles are acute. Lateral raphe has evident terminal fissures. Wide axial area is ¼ to ⅓ of the valve width. Central area is small, not evident and possesses a central stigma. Punctate striae are regularly shortened. At one side of the valve, the same distance between the central and other striae; at the other side, a median stria is more separated from the rest. Central striae are slightly radiate and terminal striae are parallel. An apical pore field is evident at the footpole. Length, 43.4-87.5 μm. Breadth, 7.5-11.4 μm. Striae, 10-15 in 10 μm central and 12-16 in 10 μm terminal. Areolae, 28 in 10 μm.

Some populations growing as periphyton and metaphyton in the inundated savannah and ponds show acute-rounded ends. The half of the valve is identical to the inferior. Length, 72-75 μm. Breadth, 8-10 μm. Striae, 9 in 10 μm. Areolae, 20 in 10 μm. This form is similar to the tropical *G. gracile* forms shown by Krammer & Lange-Bertalot (1991b Taf. 79, figs. 5-7).

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent in waters with high conductivity (Aguiar & Martau 1979; Bicudo et al. 1973; Bradbury 1971; Cantoral 1997; Foged 1984; Holmes & Whitton 1981; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1986; Lowe 1974; Metcalfe 1985, 1988; Novelo 1998; Patrick & Reimer 1975; Tavera et al. 1994).

In El Edén grew this taxon as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was rare as plankton in the same environments and very rare as periphyton in savannah at the dry period.

***Gomphonema parvulum* Kützing** (Pl. 15:6)

Valves are linear to linear-lanceolate in shape. The apical part of the valve up to the central nodule is equal to or shorter than the basal part. Apical pole is acute-rounded to slightly rostrate, the basal pole is acute. Raphe is filiform, straight, with evident terminal raphe fissures. Axial area is narrow, straight. The rectangular, unilateral central area is formed by the shortening of the central stria, more separated from the rest. One stigma is present. Striae are punctate, three separated at one side of the valve; at the other side, striae are slightly radiate. Terminal striae are parallel. An evident pore field is present at the basal pole. Length, 23-38 μm. Breadth, 6-8 μm. Striae, 13-16 in 10 μm. Areolae, 24 in 10 μm.

This is a highly variable species, but our populations are very conservative with regard to the linear-lanceolate shape.

This species is considered as cosmopolitan, pH indifferent, present in karstic substrata, and oligohalobous indifferent (Bicudo et al. 1975; Cantoral 1997; Contin & Oliveira 1993; Foged 1984; Holmes & Whitton 1981; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1986; Lowe 1974; Novelo 1998; Patrick & Reimer 1975).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. Although rare, it grew also as plankton in cenotes.

***Gomphonema truncatum* Ehrenberg** (Pl. 15:7)

Valves are rhombical in shape, triundulate (biconstricted). The apical part of the valve up to the central nodule is shorter than the basal part. Apical pole is obtuse and blunt; basal pole is acute. The raphe is sinuous, with rounded proximal fissures and straight, not bifurcate, terminal fissures. Axial area is narrow and straight. Central area is small and rectangular-transverse. One stigma is present. Punctate striae are radiate at the center of the valve and parallel at both poles. Length, 38-49 μm. Breadth, 10 μm. Striae, 10-12 central and 22-25 terminal in 10 μm. Areolae, 20 in 10 μm.

This species is considered as cosmopolitan, circumneutral to alkaliphilous, present in karstic substrata, and oligohalobous to mesohalobous (Aguiar & Martau 1979; Cantoral 1997; Krammer & Lange-Bertalot 1986; Novelo 1998; Patrick & Reimer 1975).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah and infrequent as plankton in cenotes.

***Gomphonema vibrioides* E. Reichardt et Lange-Bertalot** (Pl. 16:1)

Valves are triundulate with the central portion widest. The apical part of the valve up to the central nodule is shorter than the basal part. Poles are acute-rounded. Lateral raphe has the proximal fissures curved to the same side and the terminal fissures bifurcated. Axial area is narrow and straight. Central area is not distinguishable from the axial area. Punctate striae are slightly radiate at the center of the valve and parallel at the ends. One stria at the center of the valve is more separated from the rest. One central stigma is present. Length, 62-95 μm. Breadth, 8-10 μm. Striae, 9-12 central and 10-11 terminal in 10 μm. Areolae, 20 in 10 μm.

This species is considered as present only in tropical America, present in karstic substrata, and oligohalobous (Metzeltin & Lange-Bertalot 1998).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. Although infrequent, it grew also as plankton in cenotes and in the inundated savannah.

***Gomphonema* sp.** (Pl. 16:2)

Valves are linear-lanceolate to slightly clavate in shape. The apical part of the valve up to the central nodule is shorter than the basal part. Apical pole is rounded and basal pole is acute. The raphe is lateral and straight, with evident terminal fissures. Axial area is narrow, straight. Central area is small, rectangular-longitudinal. One central stigma is present. Striae are punctate and only the central striae are more separated from the rest. Striae are parallel at the center of the valve

and slightly radiate towards the ends. An apical pore field is evident at the footpole. Length, 35-43 µm. Breadth, 5.0-6.5 µm. Striae, 9-10 in 10 µm central and 12 in 10 µm terminal. Areolae, 24 in 10 µm.

Our exemplars are similar in shape to *Gomphonema angustum* C. Agardh (Krammer & Lange-Bertalot 1986), but *G. angustum* has more rounded poles and often posseses an isolated central stria at one side of the valve, and the central area is expanded unilaterally. We do not have enough material for a complete documentation of the Mexican population.

In El Edén grew scarcely as periphyton in the inundated savannah. Few exemplars were collected as plankton in cenotes.

RHOICOSPHENIA Grunow

***Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot** (Pl. 16:3)

Valves are slightly to distinct heteropolar, linear-lanceolate to clavate in shape, with slightly convex margins. The frustule is slightly bent in girdle view. Reduced raphe valve: the convex valve has a slightly narrow axial area, without an evident central area. The superior branch of the raphe is larger than the inferior; striae are lineate, parallel at the center of the valve and radiate towards the ends. Raphe valve: the concave valve has a narrow, straight axial area, and a longitudinally elongated central area. The raphe is filiform; striae are lineate, slightly radiate at the center of the valve and parallel towards the ends. The central striae are wider than those at the apices. Length, 16-35 µm. Breadth, (4.0) 8.6-10.5 µm. Striae, 8-12 in 10 µm central in the raphe valve and 14-18 in 10 µm terminal striae in the reduced raphe valve.

This species is considered as cosmopolitan, alkaliphilous, and halophilous to oligohalobous indifferent (Krammer & Lange-Bertalot 1986; Novelo 1998; Sheath & Cole 1992; Tavera et al. 1994; as *Rhoicosphenia curvata* (Kützing) Grunow: Bicudo et al. 1973; Dillard 1969; Germain 1981; Lowe 1974; Metcalfe 1985, 1988; Patrick & Reimer 1966).

In El Edén this taxon grew as periphyton, metaphyton and plankton in cenotes, in the inundated savannah and in ponds.

Family BACILLARIACEAE

Key to the genera.

1a Raphe positioned on the same side of each valve of a frustule .... *Hantzschia*
1b Raphe positioned on the opposite sides of each valve of a frustule 2
2a Valve surface with longitudinal undulations ..... *Tryblionella*
2b Valve surface without undulations ..... *Nitzschia*

HANTZSCHIA Grunow

Key to the species.

1a Raphe is interrupted, central nodule present ..... *H. amphioxys*
1b Raphe is continuous, central nodule absent ..... *H. vivax*

***Hantzschia amphioxys* (Ehrenberg) Grunow** (Pl. 16:4)
Valves are linear to curved with a concave margin at the raphe side. Apices straight, not abruptly constrained, extended. Fibulae are short, irregularly arranged. Areolation is fine. An evident central nodule interrupts the course of the raphe. Length, 64-108(-275) µm. Breadth, 6.0-9.2 (-10) µm. Fibulae, 8-11 in 10 µm. Striae, (13-)16-20 in 10 µm.

Many of our exemplars have extended apices, like the exemplars of *Hantzschia amphioxys* var. *vivax* (Hantzsch) Grunow, which was registered in Europe by Hustedt (1930) and in Bahandra, India, by Sarode & Kamat (1984).

This species is considered as cosmopolitan, present in karstic substrata, and euryhalobous (Akiyama 1970; Bicudo et al. 1973; Contin & Oliveira 1993; Forest et al. 1959; Germain 1981; Hirano 1973; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1988; Lowe 1974; Lund 1945; Metcalfe 1985; Novelo 1998; Tavera et al. 1994).

In El Edén grew as periphyton in the inundated savannah, ponds and cenotes; it was infrequent as metaphyton in ponds and cenotes and very rare as plankton in cenotes.

***Hantzschia vivax* (W. Smith) Grunow** (Pl. 16:5)
Valves are linear and straight and have extended ends. Both margins are straight but there is a particular difference in the margins at the apices, the margin with the raphe keeps straight up to the pole, the other one becomes narrower in a cuneiform shape. Fibulae are short and regularly arranged. Areolae are fine. Central nodule is lacking. Length, 110.0-183.7 µm. Breadth, 10-13 µm. Fibulae, 6-8 in 10 µm. Striae, 11-15 in 10 µm. Areolae, 20 in 10 µm.

According to the Index Nominum Algarum (2004), W. Smith registered this species as *Nitzschia vivax* in brackish and freshwater. According to Witkowski et al. (2000), this species lives in the sea or in saline inland waters. It was registered in continental waters only in environments with high conductivity in the temperate zone (Krammer & Lange-Bertalot 1988). Our exemplars have a higher number of fibulae and it is remarkable the linearity of the valves, without being bent toward the poles. Probably this may be a special taxon but it requires more studies.

In El Edén this taxon grew as periphyton in cenotes.

NITZSCHIA Hassall

Key to the species and varieties.

1a Visible conopeum, raphe on the face of valves, sometimes slightly or moderatelly eccentric. Central nodule lacking. Linear-lanceolate valve, apical axis straight ..... *N. dissipata*
1b Not visible conopeum; eccentric to marginal raphe, with or without central nodule 2
2a Straight frustule 3
2b Sigmoid frustule in girdle and/or valve view 17
3a Constricted margin of the raphe, central nodule always present 4
3b Not constricted margins or only slightly, central nodule not always present 6

4a Striae very fine, not visible in LM ..... *N. lacunarum*
4b Striae fine, but visible in LM 5
5a Small frustules (< 37 µm); short, blunt fibulae ..... *N. umbonata*
5b Large frustules (>84 µm); large, cuneiform fibulae ..... *N. palustris*
6a Very wide fibulae, widely spaced and punctate striae 7
6b Fibulae not very wide, striae fine 8
7a Very large valves, scalpeliform ..... *N. scalaris*
7b Small, lanceolate valves ..... *N. sinuata* var. *delognei*
8a Slightly angular girdle view, slightly constricted raphe margins .... *N. linearis*
8b Straight in girdle view, straight or slightly constricted raphe margins 9
9a Subcapitate ends, scalpeliform ..... *N. vitrea*
9b Straight ends, not differentiated from the valve body 10
10a Fibulae, equidistant along the whole valve, central nodule lacking..... 11
10b Central fibulae more distant than in the rest of the valve, raphe interrupted by a central nodule 13
11a Wide, rounded poles, lineal-elliptic valve, > 30 striae in 10 µm .... *N. communis*
11b. Acute or acute-rounded poles, linear-lanceolate valves 12
12a Extended ends, fibulae of the same length ..... *N. gracilis*
12b Ends not extended, fibulae of variable length ..... *N. palea*
13a Fibulae thin, large, acute ..... *N. amphibia*
13b Fibulae coarse, wide 14
14a Very small valves (< 12 µm), blunt, rounded poles ..... *N. inconspicua*
14b Medium to large valves (> 18 µm), acute to acute-rounded poles 15
15a Large valves (> 65 µm), lineated striae ..... *N. intermedia*
15b Medium valves (< 59 µm), punctate striae 16
16a Valves with 10 to16 fibulae in 10 µm ..... *N. frustulum*
16b Valves with 6 to 7 fibulae in 10 µm ..... *N. yalahau*
17a Raphe with central nodule ..... *N. nana*
17b Raphe without central nodule ..... *N. sigma*

***Nitzschia amphibia* Grunow** (Pl. 16:6)

Valves are small, lanceolate to linear-lanceolate in shape; straight in valve view with concave to slightly straight margins and acute-rounded apices with rounded poles. Apical and pervalvar axes are straight. Strongly silicified valve has a flat valve surface and a short keel. Raphe is marginal with regularly spaced fibulae that are wide, cuneiform and of variable length. A central nodule is always present. The striae are coincident with the fibulae, straight in the center of the valve and curved towards the ends, punctate. Areolation is not aligned longitudinally. Length, 15-33 µm. Breadth, 3.9-5.6 µm. Fibulae, 10-15 in 10 µm. Striae, 13-15 in 10 µm. Areolae, 24 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Bicudo et al. 1973; Cantoral 1997; Contin & Oliveira 1993; Foged 1984; Germain 1981; Holmes & Whitton 1981; Hutchinson et al. 1956; Hustedt 1930; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985; Novelo 1998; Sarode & Kamat 1984; Whitford 1956).

In El Edén this taxon grew as plankton, periphyton and metaphyton in the inundated savannah, ponds and cenotes. It also grew as periphyton in the savannah during the dry period.

***Nitzschia communis* Rabenhorst** (Pl. 17:1)

Valves are small, linear-elliptical to elliptical in shape; straight in valve view. Margins are concave to straight with rounded apices and blunt poles. Apical and pervalvar axes are straight. Weakly silicified valve has a flat valve surface and a short keel. Raphe is marginal with regularly distant fibulae, short, blunt and of equal length. Central nodule is lacking. Length, 27-29 µm. Breadth, 4.2-4.5 µm. Fibulae, 9-10 in 10 µm, striae are not visible (more than 30 in 10 µm).

This species is considered as temperate with some records in America, alkaliphilous, present in karstic substrata, and mesohalobous indifferent (Bradbury 1971; Czarnecki 1979; Germain 1981; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1988; Lowe 1974; Lund 1945; Metcalfe 1985, 1988; Novelo 1998; Sieminska 1964).

In El Edén this taxon grew as periphyton in the inundated savannah, cenotes and ponds. It was infrequent as plankton in cenotes.

***Nitzschia dissipata* (Kützing) Rabenhorst** (Pl. 17:2)

Valves are linear-lanceolate, straight in valve view, with straight margins and slightly extended apices and acute-rounded poles. Apical and pervalvar axes are straight. The valve surface is flat and has a short keel. The eccentric raphe has a superficial conopeum and irregularly-distant fibulae that are short blunt-tooth in shape, of equal length. Central nodule is lacking. Striae are not visible. Length, 50-76 µm. Breadth, 3.7-4.0 µm. Fibulae, 8-10 in 10 µm. Striae, more than 40 in 10 µm. Areolation is not visible.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Bradbury 1971; Cantoral 1997; Dillard 1969; Foged 1984; Hirano 1973; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985, 1988; Novelo 1998; Wasylik 1965b).

In El Edén this taxon grew as periphyton in ponds and as plankton in cenotes.

***Nitzschia frustulum* (Kützing) Grunow** (Pl. 17: 3)

Valves are straight, lanceolate to linear-lanceolate with convex margins; slightly extended, subcapitate to slightly rounded apices and rounded poles. Apical and pervalvar axes are straight. The valve surface is flat and has a short keel. Raphe is marginal and has irregularly distant fibulae that are short, blunt-tooth in shape, and equal length. A central nodule is present. The striae are coincident with the fibulae, approximately 2 striae per fibula. Striae are straight, punctate, with a coarse structure. Areolae are aligned diagonally. Length, 18-52 µm. Breadth, 2.5-5.0 µm. Fibulae, 10-16 in 10 µm. Striae, 19-32 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (Bradbury 1971; Foged 1984; García-Rodríguez & Tavera 2002; Germain 1981; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985, 1988; Novelo 1998; Sarode & Kamat 1984).

In El Edén this taxon grew as periphyton and metaphyton in ponds, cenotes and the inundated savannah. It was infrequent as plankton in cenotes and ponds.

***Nitzschia gracilis* Hantzsch** (Pl. 17:4)

Valves are large and linear, straight in valve view, with straight, parallel margins; apices are extended and have rounded poles. Apical and pervalvar axes are straight. The valve surface is flat and has a short keel. The marginal raphe has irregularly distant fibulae, in short blunt-tooth shape and equal in length. Central nodule is lacking. Striae are slight visible. Length, 57-70 µm. Breadth, 3.5-4.5 µm. Fibulae, 10-14 in 10 µm. Striae, 28 or more in 10 µm. Areolation is not visible.

This species is considered as temperate with some records in America, indifferent to pH, and oligohalobous (Holmes & Whitton 1981; Krammer & Lange-Bertalot 1988; Metcalfe 1985; Wasylik 1965a).

In El Edén this taxon grew as metaphyton and plankton in cenotes and in the inundated savannah. It was rare as periphyton cenotes and in the inundated savannah.

***Nitzschia inconspicua* Grunow** (Pl. 17:5)

Valves are small, straight-lanceolate with convex margins and without protracted apices and blunt poles. Apical and pervalvar axes are straight. Valve surface is flat and has a short keel. Raphe is marginal and has irregularly distant fibulae that are robust, in short, blunt-tooth shape and are equal in length. A central nodule is present. Lineate striae are coincident with the fibulae. Length, 4-12 µm. Breadth, 2.5-3.8 µm. Fibulae, 8-10 in 10 µm. Striae, 32-34 in 10 µm. Areolation is very fine, not visible.

This species is considered as temperate with some records in America, oligohalobous indifferent (Germain 1981; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1988; Metcalfe 1985, 1988; Novelo 1998).

In El Edén this taxon grew as plankton, metaphyton and periphyton in cenotes. It was rare as metaphyton in the inundated savannah.

***Nitzschia intermedia* Hantzsch** (Pl. 17:6)

Valves are large, linear-lanceolate without a constriction at the center and with a central nodule, both margins are straight to slightly concave; the apices are slightly extended, subrostrate, with blunt poles. Apical and pervalvar axes are straight. Valve surface is flat and has a short keel. Raphe is marginal with fibulae regularly distant, short and blunt, occupying less than ¼ of the valve width. Striae are straight, lineate and some of them are coincident with the fibulae. Length, 65-100 µm. Breadth, 5-9 µm. Fibulae, 7-16 in 10 µm. Striae, 20-30 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (Cantoral 1997; Germain 1981; Hustedt 1930; Krammer & Lange-Bertalot 1988; Metcalfe 1985, 1988).

In El Edén this taxon grew as periphyton and metaphyton in cenotes and the inundated savannah.

***Nitzschia lacunarum* Hustedt** (Pl. 17:7)

Valves are small to medium, linear, slightly constricted at the center in valve view. Both margins are convex. Apices are acute, slightly extended with rounded poles. Apical and pervalvar axes are straight. Valve surface is flat and has a short keel. Raphe is marginal with irregularly distant fibulae that are in acute-tooth shape, short, equal in length. A central nodule is present. Fibulae and striae do not

coincide. Striae are straight, lineate. Length, 36-51 µm. Breadth, 4.5-7.2 µm. Fibulae, 8 in 10 µm. Striae, more than 30 in 10 µm, slightly visible. Areolation is very fine, not visible.

This species is considered as only temperate, present in waters rich in carbonates, and mesohalobous (Czarnecki 1979; Lowe 1974; Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as metaphyton in the inundated savannah and ponds. It was rare as periphyton and plankton in ponds and cenotes.

***Nitzschia linearis* W. Smith** (Pl. 18:1)

Valves are large, linear, slightly constricted at the center in valve view; slightly biconcave in girdle view. One margin is straight and the other margin is slightly concave. Apices are curved in the same direction, scalpeliform and acute with cuneate poles. Apical and pervalvar axes are straight. Valve surface is flat and has a short keel. Raphe is marginal with irregularly distant fibulae, in acute tooth-shape, short, and equal in length. A central nodule is present. Fibulae and striae do not coincide. Striae are straight, lineate. Length, 90.9-110.0 µm. Breadth, 4.2-5.0 µm. Fibulae, 11-12 in 10 µm. Striae, more than 40 in 10 µm. Areolation is not visible.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Bradbury 1971; Cantoral 1997; Foged 1984; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1988; Lowe 1974; Tavera et al. 1994).

In El Edén this taxon grew as periphyton in ponds and in the savannah, especially at the dry period. It was infrequent as metaphyton in the inundated savannah and as plankton in cenotes.

***Nitzschia nana* Grunow** (Pl. 18:2)

Valves are medium to large, linear, and slightly sigmoid in girdle view and distinctly sigmoid in valve view. Apices are rounded and have blunt poles. Pervalvar axis is straight. Valve surface is flat and has a short keel. Raphe is marginal and has irregularly spaced fibulae. Fibulae are short, rectangular in shape, and of equal length. An evident central nodule is present. Length, 65.0-140 µm. Breadth, 4.5-5 µm. Fibulae, 7-9 in 10 µm. Striae, more than 30 in 10 µm.

At the Northern zone of the wetland were observed exemplars up to 140 µm, in the inundated period.

This species is considered as only temperate, euryhalobous (Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as periphyton and metaphyton in the inundated savannah, cenotes and ponds. It was infrequent as plankton in the same environments.

***Nitzschia palea* (Kützing) W. Smith** (Pl. 18:3)

Valves are small, linear-lanceolate, slightly constricted at the center in valve view and have straight, parallel margins, acute apices and rounded poles. Apical and pervalvar axes are straight. Valvar surface is flat and has a narrow keel. Raphe is marginal with irregularly distant fibulae. Fibulae are rectangular, blunt-tooth in shape, and variable in length. Central nodule is lacking. Striae are barely visible.

Length, 20-65 µm. Breadth, 4.0-5.5 µm. Fibulae, 9-16 in 10 µm. Striae, 30-32 in 10 µm. Areolation is not visible.

This species is considered as cosmopolitan, pH indifferent, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Foged 1984; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985).

In El Edén this taxon grew as periphyton, metaphyton and plankton in cenotes, ponds and in the inundated savannah.

***Nitzschia palustris* Hustedt** (Pl. 18:4)

Valves are large, linear-lanceolate, slightly constricted at the center in valve and girdle views. Apices are cuneate with rounded poles. Apical and pervalvar axes are straight. Valve surface is flat and has a wide keel. Raphe is marginal with irregularly distant long fibulae, which are cuneiform in shape. The central nodule is slightly evident. The fibulae and striae do not coincide. Striae are straight, punctate with fine areolation. Length, 84.8-102.0 µm. Breadth, 5.0-7.7 µm. Fibulae, 3-4 in 10 µm. Striae, 10-13 in 10 µm. Areolae, 23 in 10 µm.

This species is considered as only temperate, circumneutral (Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as periphyton, metaphyton and plankton in cenotes, ponds and in the inundated savannah.

***Nitzschia scalaris* (Ehrenberg) W. Smith** (Pl. 18:5)

Valves are large, linear, and straight in valve view and have straight margins without extended apices, slightly scalpeliform in shape with acute poles. Apical and pervalvar axes are straight. Valve surface is curved, convex and has a wide keel. Raphe is marginal with irregularly distant fibulae that are acute-tooth shaped, short and of unequal length. Central nodule is lacking. The striae are coincident with the fibulae, straight. Length, 333-338 µm. Breadth, 25-30 µm. Fibulae, 17-30 in 100 µm. Striae, 9-10 in 10 µm. Areolae, 18-20 in 10 µm.

This species is considered as cosmopolitan, meso to polyhalobous (Bicudo et al. 1973; Foged 1984; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as periphyton and metaphyton in ponds.

***Nitzschia sigma* (Kützing) W. Smith** (Pl. 18:6)

Valves are large, sigmoid, scalpeliform with straight margins and have scalpeliform apices with rounded poles. Apical and pervalvar axes are sigmoid. Valve surface is flat and has a narrow keel. Raphe is marginal with equidistant, acute fibulae. Central nodule is lacking. Striae have a zigzag areolation pattern. Length, 81.2-112.0 µm. Breadth, 6-7 µm. Fibulae, 8-10 in 10 µm. Striae, 18-20 in 10 µm. Areolae, 20-24 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, and euryhalobous (Bicudo et al. 1973; Foged 1984; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1988; Novelo 1998; Whitford & Schumacher 1963).

In El Edén this taxon grew as periphyton in cenotes.

***Nitzschia sinuata* var. *delognei* (Grunow) Lange-Bertalot** (Pl. 18:7)
Valves are small, lanceolate, and without a central constriction. Both margins are convex, apices are subrostrate, slightly extended, and have blunt poles. Apical and pervalvar axes are straight. Valve surface is undulate and has a wide keel. Raphe is marginal with regularly distant fibulae which are acute and long, and occupy ½ of the valve width. Central nodule is lacking. The striae are coincident with the fibulae, straight and punctate. Areolation is coarse, aligned longitudinally. Length, 10-15 µm. Breadth, 6.0-6.5 µm. Fibulae, 5-8 in 10 µm. Striae, 16-17 in 10 µm.

Our exemplars have striae that are less dense than reported by Krammer & Lange-Bertalot (1988).

This variety is considered as present only in temperate regions in waters with medium to high conductivity (Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as periphyton and plankton in cenotes.

***Nitzschia umbonata* (Ehrenberg) Lange-Bertalot** (Pl. 18:8)
Valves are small, linear and slightly constricted at the center; both margins are slightly concave. Apices of the valve are slightly extended, subcapitate; poles are acute. Apical and pervalvar axes are straight. Valve surface is flat and the keel is narrow. Raphe is marginal and has regularly distant fibulae that are short and blunt. The central nodule is indistinct. The striae are coincident with the fibulae. They are straight, lineate and very fine. Length, 34-37 µm. Breadth, 8.0-8.3 µm. Fibulae, 10-12 in 10 µm. Striae, 25-30 in 10 µm.

This species is considered as temperate with some records in America, indifferent to pH and euryhalobous in waters with high conductivity (Krammer & Lange-Bertalot 1988; Ibarra & Novelo 1997; Metcalfe 1985,1988; Novelo 1998).

In El Edén this taxon grew as periphyton in cenotes.

***Nitzschia vitrea* Norman** (Pl. 18:9)
Valves are small to medium, linear and have straight margins. Apices are subcapitate, scalpeliform in shape and have rounded poles. Apical and pervalvar axes are straight. Valve surface is flat and has a narrow keel. Raphe is marginal with regularly distant fibulae that are short, solid and occupy less than ¼ of the valve width. The central nodule is not visible. The striae are coincident with the fibulae and punctate. Length, 48-52 µm. Breadth, 7-8 µm. Fibulae, 7-8 in 10 µm. Striae, 20-22 in 10 µm. Areolae, 12-16 in 10 µm, in a zigzag pattern, elongated.

This species is considered as cosmopolitan and euryhalobous (Bradbury 1971; Foged 1984; Krammer & Lange-Bertalot 1988).

In El Edén this taxon grew as periphyton in the inundated savannah.

***Nitzschia yalahau* sp. nov.** (Pl. 19:1)
Diagnosis. Frustula parva, valvis linearibus 30.0-58.7 µm longis, 4.0-4.5 µm latis, marginibus rectis, apicibus acutis, polis rotundatis. Axes apicalis et pervalvaris recti. Pagina valvaris plana, carina brevi. Raphe marginalis; fibulae equidistantes, dentiformes, breves. Nodulus centralis praesens. Striae fibulis concordantes, 16-18 in 10 µm. Areolae 24 in 10 µm.
Etymology: Mayan name of the region of the type locality in the Yucatán peninsula.
Holotypus: Praep. Eden 403.2 in Coll. Edén-FCME, Pl. 19:1a.

Type locality: Ayin cenote in El Edén Ecological Reserve, Quintana Roo, México.

Description: Valves are small, linear with straight margins. Apices are acute, with rounded poles. Apical and pervalvar axes are straight. Valve surface is flat and has a narrow keel. Raphe is marginal with equidistant fibulae that are short-tooth shaped. A central nodule is present. Every two or three striae are coincident with the fibulae. Length, 30.0-58.7 µm. Breadth, 4.0-4.5 µm. Fibulae, 6-7 in 10 µm. Striae, 16-18 in 10 µm. Areolae, 24 in 10 µm.

Although the form resembles *Nitzschia amphibia* in shape, they differ in the density of fibulae and striae. Another species very similar in shape and dimensions is *N. neotropica* Lange-Bertalot et Rumrich (Rumrich et al. 2000) described from The Andes and acidic conditions, in Ecuador. *N. neotropica* has a higer Length:Breath ratio (Length, 60-80 µm. Breadth, 4.5-5.5 µm); the valve is slightly constrincted at the center with an evident central nodule and apices are rostrate and very acute.

In El Edén this taxon grew as periphyton in cenotes.

TRYBLIONELLA W. Smith

***Tryblionella hungarica* (Grunow) Frenguelli** (Pl. 19:2)

Valves are small, linear and straight with parallel margins and acute-cuneate apices that have rounded poles. Apical and pervalvar axes are straight. Valve surface is biundulate and has a narrow keel. Raphe is marginal and has irregularly distant fibulae that are short, cuneiform and equal in length. A central nodule is present. Striae are undulate, linear. Length, 54.6-90.0 µm. Breadth, 6-8 µm. Fibulae, 12 in 10 µm. Striae, 16-19 in 10 µm. Individual areolae are not visible.

This species is considered as cosmopolitan, alkaliphilous, and mesohalobous to halophilous (as *Nitzschia hungarica* Grunow: Foged 1984; Germain 1981; Hirano 1973; Holmes & Whitton 1981; Hustedt 1930; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985, 1988).

In El Edén this taxon grew as plankton and periphyton in cenotes. It was rare as metaphyton in the inundated savannah.

Family EPITHEMIACEAE

Key to the genera.

1a In valve view, valves symmetrical with regard to apical axes ..... *Denticula*
1b In valve view, valves asymmetrical with regard to apical axes 2
2a Raphe in ventral position with the center V-shaped, pointed towards the dorsal margin ..... *Epithemia*
2b Raphe in dorsal position with proximal ends curved towards the ventral margin ..... *Rhopalodia*

DENTICULA Kützing

Key to the species.

1a Raphe near the edge of the valve; costae not capitate, 5-8 fibulae in 10 µm .. .. *D. kuetzingii*

1b Raphe placed on the middle of the valve; costae capitate, 2-3 fibulae in 10 µm ..... *D. valida*

***Denticula kuetzingii* Grunow** (Pl. 19:3)

In valve view, the shape of the valve is linear to lanceolate; rectangular in girdle view. The acute apices are protracted slightly from the valve outline. Poles are rounded. Raphe is positioned near the edge of the valve. Costae are acute, not capitate in girdle view and of similar size. Striae are composed of single rows of areolae. Length, 19-50 µm. Breadth, 4.7-7.0 µm. Fibulae, 5-8 in 10 µm. Striae, 16-18 in 10 µm. Areolae, 16-18 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous (Cantoral 1997; Ibarra & Novelo 1997; Krammer & Lange-Bertalot 1988; Novelo 1998; Tavera et al. 1994).

In El Edén this taxon grew as periphyton and metaphyton in cenotes, ponds and in the inundated savannah. It was also collected as periphyton in savannah during the dry period and as plankton in cenotes and in the inundated savannah.

***Denticula valida* (Pedicino) Grunow** (Pl. 19:4)

In valve view, the shape of the valve is linear to lanceolate; rectangular in girdle view. The acute apices are protracted slightly from the valve outline. Poles are rounded. Raphe is placed medially on the valve. Costae are acute, capitate in girdle view, and of similar size. Striae are composed of simple rows of areolae. Length, 25-32 µm. Breadth, 5-6 µm. Fibulae, 2-3 in 10 µm. Striae, 20-28 in 10 µm. Areolae, 24-28 in 10 µm.

This species is considered as temperate in waters with high conductivity and present in karstic substrata, there are some records in America (Cantoral 1997; Krammer & Lange-Bertalot 1988; Patrick & Reimer 1975).

In El Edén this taxon grew as periphyton in the inundated savannah, ponds and cenotes. It was rare as plankton in the inundated savannah.

EPITHEMIA Brébisson

Key to the species.

1a Valves have both margins curved ..... *E. turgida*

1b Valves have convex dorsal margin and straight ventral margin 2

2a Costae capitate, 4-8 rows of areolae between costae ..... *E. argus*

2b Costae not capitate, 2 rows of areolae between costae ..... *E. sorex*

***Epithemia argus* (Ehrenberg) Kützing** (Pl. 19:5)

Valves have a straight ventral margin and a convex dorsal margin. Apices are not protracted and the poles are rounded. Raphe curves ventrally at the center and mainly straight at the margin. The central nodule is positioned close to the dorsal margin. Costae are capitate in girdle view; in valve view costae are radiate and have 4-8 rows of areolae between them. Length, 65-70 µm. Breadth, 10-11 µm. Costae, 2 in 10 µm. Striae, 10-14 in 10 µm. Areolae, 12-14 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Cantoral 1997; Holmes & Whitton 1981; Krammer & Lange-Bertalot 1988; Martínez de Fabricius & Corigliano 1989; Metcalfe 1985, 1988; Patrick & Reimer 1975).

In El Edén this taxon grew as periphyton in cenotes. It was a rare species.

***Epithemia sorex* Kützing** (Pl. 19:6)

Valves have a straight to slightly concave ventral margin and convex dorsal margin. Apices are slightly rostrate and have rounded poles. Ventral raphe is curved, visible throughout most of the length of the valve, with terminal parts dorsally curved. The central nodule is positioned close to the dorsal margin. Costae are not capitate in girdle view; in valve view costae are radiate and have 2 rows of areolae between them. Length, 10-21 µm. Breadth, 5.3-7.8 µm. Costae, 5-7 in 10 µm. Striae, 10-14 in 10 µm. Areolae, 15-17 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and euryhalobous (Gasse 1986; Germain 1981; Hustedt 1930; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1975; Sarode & Kamat 1984; Tavera et al. 1994).

In El Edén this taxon grew as periphyton and metaphyton in ponds and in the inundated savannah. It was infrequent as plankton in cenotes and in the inundated savannah.

***Epithemia turgida* (Ehrenberg) Kützing** (Pl. 19:7)

Valves have straight to slightly concave ventral margin and convex dorsal margin. Apices are protracted and have rounded poles. Ventral raphe is curved, visible only at the center of the valve. The central nodule is positioned at the middle of the valve, close to the dorsal margin. Costae are not capitate in girdle view; in valve view costae are radiate with 2-3 rows of areolae between them. Length, 68.7-106.2 µm. Breadth, 12-16 µm. Costae, 2-3 in 10 µm. Striae, 8-16 in 10 µm. Areolae, 5-10 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, euryhalobous (Hutchinson et al. 1956; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985; Novelo 1998; Patrick & Reimer 1975; Tavera et al. 1994; Whitford & Kim 1971).

In El Edén this taxon grew as periphyton and plankton in cenotes and in the inundated savannah.

RHOPALODIA O. Müller

Key to the species.

1a Valve with a square bracket-shape outline, large with a swelling in the central zone ..... *R. gibba*

1b Valve with a semi elliptic outline ..... *R. musculus*

***Rhopalodia gibba* (Ehrenberg) O. Müller** (Pl. 20:1)

In girdle view the valves are linear and have apices that are not protracted. In valve view, the valves are linear to slightly curved, with a swelling at the center of

the valve; apices are acute and poles are curved. The dorsal margin is constricted at the center and the ventral margin is straight. Striae are composed of a single row of puncta. Fibulae are parallel. Two rows of areolae are located between each costa. Length, 131.5-320.0 µm. Breadth, 6.9-10.0 µm. Fibulae, 8-10 in 10 µm Striae, 19-20 in 10 µm.

This species is considered as cosmopolitan, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Cantoral 1997; Foged 1984; Holmes & Whitton 1981; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1988; Lowe 1974; Metcalfe 1985; Padisák et al. 1998; Patrick & Reimer 1975; Stein & Gerrath 1969; Whitford & Kim 1971).

In El Edén this taxon grew as periphyton in savannah, cenotes and ponds. It was infrequent as plankton in cenotes and in the inundated savannah.

***Rhopalodia musculus* (Kützing) O. Müller** (Pl. 20:2)

In girdle view, valves are lanceolate-elliptical in shape and have acute apices. In valve view, the valves are strongly curved and have acute apices. The dorsal margin is curved, and the ventral margin is straight. Striae are composed of a single row of puncta composes. Fibulae are radiate. Four to six rows of areolae are between each costa. Length, 27-31 µm. Breadth, 8.4-10.0 µm. Fibulae, 3-5 in 10 µm. Striae, 16-18 in 10 µm.

This species is considered as cosmopolitan, indifferent to pH, and mesohalobous (Foged 1984; Krammer & Lange-Bertalot 1988; Metcalfe 1985; Patrick & Reimer 1975).

In El Edén this taxon grew as periphyton in the inundated savannah and cenotes. It was rare as plankton in cenotes.

Family SURIRELLACEAE

Key to the genera.

1a Valve with a circular outline bent at the parapical axis ..... *Campylodiscus*
1b Valve lanceolate or heteropolar ..... *Surirella*

CAMPYLODISCUS Ehrenberg

***Campylodiscus hibernicus* Ehrenberg** (Pl. 21:1)

Valves are circular in shape, folded like a saddle. Apical axis is straight (lacking apical inflexion). Fibulae are long and have rectangular pseudoinfundibulae, extending to the fibulae. The radiate costae leave a space at the center of the valve and join at the poles. There are dispersed spines and very fine striae on the valve face. Diameter of the valve, 55.7-131.3 µm. Fibulae, 17-24 in 100 µm. Striae, 28 in 10 µm.

This species is considered as temperate with some records in America, alkaliphilous, present in karstic substrata, and euryhalobous (Cantoral 1997; Krammer & Lange-Bertalot 1988).

In El Edén, although it was rare, this taxon grew as periphyton and plankton in cenotes. Also, it was collected, very rarely, as periphyton in the inundated savannah.

SURIRELLA Turpin

Key to the species.

1a Isopolar valves, a central stria present ..... *S. biseriata*
1b Heteropolar valves, without central stria 2
2a Defined channels, straight ..... *S. tenera*
2b Channels absent, pseudoinfundibulae little delimited, without axial area .... *S. brebissonii*

***Surirella biseriata* Brébisson** (Pl. 21:2)

Valves are straight, isopolar, linear-lanceolate in shape, slightly constricted at the center; apices are cuneate. In girdle view valves are straight; surface of the valve slightly undulate, with a central stria. Keel margin is wide with parallel canals which are straight in the whole valve and narrower at the margin. Striae are lineate. Axial area is narrow, without axial spines. Length, 102-164. Breadth, 28-40 µm. Pseudoinfundibulae, 18-20 in 100 µm. Striae, 24-28 in 10 µm.

This species is considered as temperate in waters with high conductivity. There are some records in America as oligohalobous (Dillard 1969; Krammer & Lange-Bertalot 1988; Metcalfe 1985; Wasylik 1965b; Whitford & Schumacher 1963).

In El Edén this taxon grew as plankton in cenotes and as periphyton in the inundated savannah.

***Surirella brebissonii* Krammer et Lange-Bertalot** (Pl. 21:3)

In valve view, valves are slightly heteropolar and oval and have acute poles. Surface of the valve is concentrically undulate. Pseudoinfundibulae are little delimited, extended up to the center of the valve. The axial area is absent. Well defined striae are radiate, lineate. Length, 55-80. Breadth, 30-38 µm. Pseudoinfundibulae, 40-50 in 100 µm. Striae, 12-16 in 10 µm.

This species is considered as temperate with some records in America circumneutral, and euryhalobous (Krammer & Lange-Bertalot 1988; Novelo 1998).

In El Edén this taxon grew as periphyton in the inundated savannah and plankton in cenotes.

***Surirella tenera* W. Gregory** (Pl. 21:4)

Valves are heteropolar and have one pole rounded and the other pole acute. Surface of the valve is flat. A wide keel margin is present; canals are parallel, straight, and have the same width; in the broader end, the canals close to form a circle. In the valve view, the canals reach the half of the valve, where a clear median-line is formed. The axial area is absent and axial spines are lacking. Over the raphe wing there are semielliptical, well marked windows. Striae are not visible. Length, 90-102. Breadth, 30-35 µm. Canals, 24 in 100 µm.

This species is considered as cosmopolitan, circumneutral, alkaliphilous, present in karstic substrata, and oligohalobous indifferent (Bicudo et al. 1973; Cantoral 1997; Contin & Oliveira 1993; Foged 1984; Germain 1981; Hutchinson et al. 1956; Krammer & Lange-Bertalot 1988; Novelo 1998).

In El Edén this taxon grew as periphyton in cenotes and in savannah during the dry period and as plankton in the inundated savannah.

References

Aboal, M. (1988): Diatomées des cours d'eau saumâtres temporaires ou permanents du SE de l'Espagne. – *Memoires de la Societé Royal Botanique Belgique* **10**: 48-54.

Aguiar, L.W. & Martau, L. (1979): Diatomáceas de lagos do Parque Zoologico, Rio Grande do Sul, Brasil. – *Iheringia. Série Botanica* **25**: 27-110.

Akiyama, M. (1970): Some aerial and soil algae from the Ryukyo Islands. – *Memoires of the Faculty of Education Shimane University* **3**: 24-45.

Bicudo, C.E.M., Corte Real, M. & Martau, L. (1973): Catálogo das algas de águas continentais do Estado do Rio Grande do sul, Brasil: I. Bacillariophyceae. – *Iheringia Série Botanica* **17**: 56-68 + 1 map.

Bicudo, C.E.M., Martau, L. & Ungaretti, I. (1975): Catálogo das algas de aguas continentais do Estado de Santa Catarina, Brasil. – *Iheringia Série. Botanica* **21**: 71-80.

Bock, W. (1970): Felsen und Mauern als Diatomeenstandorte. – *Nova Hedwigia, Beiheft* **31**: 395-441.

Bourrelly, P. & Manguin, E. (1952): *Algues d' eau douce de la Guadeloupe et Dépendances. Centre National de la Recherche Scientifique*, 235 pp. Societé d'Edition d'Enseignements Supérieur, Paris.

Bradbury, J.P. (1970): Diatoms from the Pleistocene sediments of Lake Texcoco, México. – *Revue de Geographie physique et de geologie dynamique* **12**: 161-168.

Bradbury, J.P. (1971): Paleolimnology of Lake Texcoco, México. Evidence from diatoms. – *Limnology and Oceanography* **16**: 180-200.

Cantoral Uriza, E. (1997): *Diatomeas (Bacillariophyceae) de ambientes lóticos en la cuenca baja de la Huasteca Potosina*. 201 pp. Tesis de Doctorado (Ph.D. Dissertation) Facultad Ciencias, Universidad Nacional Autónoma de México, México.

Casco, A. & Toja, J. (1991): Benthic microalgae of La Minilla Resevoir (South West Spain). – *Verhandlungen Internationale Vereinigung für Theoretische und Angewande Limnologie* **24**: 1386-1389.

Compère, P. (1981): Ultrastructural aspects of the frustule of some forms of *Cymbella hustedtii* Krasske. – In: R. Ross (ed.), *Proceedings of the 6th International Diatom Symposium*. *Budapest 1980*. Koeltz Scientific Books, Königstein, p. 155-166.

Compère, P. (2000): Keydiato_br., available online at: http://www.br.fgov.be/SCIENCE/EDITION/keydiato_BR.html (Last accessed: January, 2007).

Contin, L.F. & Oliveira, R.J.M. (1993): *Flora dos Estados de Goiás e Tocantins. Criptógamos. Vol. 2. Diatomáceas (Chrysophyta, Bacillariophyceae). No. 1*, 36 pp. Editora UFG, Universidade Federal de Goiás, Goiânia.

Cook, L.L. & Whipple, S.A. (1982): The distribution of edaphic diatoms along environmental gradients of a Louisiana salt marsh. – *Journal of Phycology* **18**: 64-71.

Cox, E.J. (2003): *Placoneis* Mereschkowsky (Bacillariophyta) revisited: resolution of several typification and nomenclatural problems, including the generitype. – *Botanical Journal of the Linnean Society* **141** (1): 53-83.

Crawford, R.M. & Likhoshway, Y.V. (1999): The frustule structure of original material of *Aulacoseira distans* (Ehrenberg) Simonsen. – *Diatom Research* **14** (2): 239-250.

Czarnecki, D.B. (1979): Epipelic and epilithic diatom assemblages in Montezuma Well National Monument, Arizona. – *Journal of Phycology* **15**: 346-352.

De Cserna, Z. (1990): Carta Tectónica (Tectonic Chart). IV.2.1. *Atlas Nacional de México, Vol II. Naturaleza*. Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Dillard, G.E. (1969): The benthic algal communities of a North Carolina Piedmont Stream. – *Nova Hedwigia* **17**: 9-29.

Engracia-Hernández, M. (1990): Carta Clima (Climate Chart). IV.4.1. *Atlas Nacional de México, Vol II. Naturaleza*. Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Foged, N. (1984): *Freshwater and Littoral Diatoms from Cuba*. – Bibliotheca Diatomologica **5**. 243 pp. J. Cramer, Stuttgart.

Forest, H.S., Willson, D.L. & England, R.B. (1959): Algal establishment on sterilized soil replaced in an Oklahoma praire. – *Ecology* **40**: 475-477.

García, E. (1990): Carta Clima (Climate Chart). IV.4.10. *Atlas Nacional de México. Vol II. Naturaleza.* Instituto de Geografía, Universidad Nacional Autónoma de México, México.

García-Meza, J.V. (1999): *Algas de desechos mineros* 183 pp. Tesis de Maestría (M.Sc. Dissertation). Facultad Ciencias, Universidad Nacional Autónoma de México, México.

García-Rodríguez, J. & Tavera, R. (2002): Phytoplankton composition and biomass in a shallow monomictic tropical lake. – *Hydrobiologia* **467**: 91-98.

Gasse, F. (1986): *East African diatoms. Taxonomy, ecological distribution*. – Bibliotheca Diatomologica **11**. 202 pp. J. Cramer, Stuttgart.

Germain, H. (1981): *Flore des Diatomées. Diatomophycees. Eux douces et saumâtres du Massif Armoricain et des contrée voisines d'Europe Occidentale*. 444 pp. Société Nouvelle des Editions Boubée, Paris.

Herbst, N. & Maidana, N.I. (1989): Diatoms of Chaco (República Argentina): 1. – *Nova Hedwigia* **49**: 207-232.

Hirano, M. (1969): Freshwater algae from Rangtang Himal, Nepal Himalaya. – *Contributions from the Biology Laboratory, Kyoto University* **22**: 1-42.

Hirano, M. (1973): Freshwater algae from Mesopotamia. – *Contributions from the Biology Laboratory, Kyoto University* **24**: 105-119.

Hohn, M.M. & Hellerman, J. (1963): The taxonomy and structure of diatom populations from three eastern North American rivers using three sampling methods. – *Transactions of the American Microscopical Society* **82**:250-329.

Holmes, N.T.H. & Whitton, B.A. (1981): Plants of the river Tyne system before the Kielder water scheme. – *Naturalist* **106**: 97-107.

Hustedt, F. (1927-1966): *Die Kieselalgen Deutschlands, Österreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete.* – In: L. Rabenhorst's Kryptogamenflora von Deutschland, Österreich und der Schweiz. Vol. 7. 1:920 + 2:845 + 3:816 pp., Leipzig. (Johnson Reprint Corporation, New York. 1971).

Hustedt, F. (1930): *Bacillariophyta (Diatomeae)*. – In: A. Pascher (ed.), Süßwasserflora von Mitteleuropa. Band 10. 466 pp., Gustav Fischer Verlag. Jena.

Hutchinson, G.E., Patrick, R. & Deevey, E.S. (1956): Sediments of Lake Pátzcuaro, Michoacán, México. – *Bulletin of the Geological Society of America* **67**: 1491-1504.

Ibarra, C. & Novelo, E. (1997): Diatomeas de Texcala, Puebla. – *Boletín de la Sociedad Botánica de México* **61**: 49-57.

Index Nominum Algarum (INA 2004), University Herbarium, University of California, Berkeley. Compiled by Paul Silva. Available online at: http://ucjeps.berkeley.edu/INA.html (Last accessed: January, 2007).

Kawecka, B. (1981): Sessile algae in European mountain streams 2. Taxonomy and autoecology. – *Acta Hydrobiologica, Kraków* **23**: 17-46.

Kingston, J.C. (2003): Araphid and Monoraphid Diatoms. – In: J.D. Wehr & R.G. Sheath (eds.), *Freshwater Algae of North America. Ecology and Classification*. Academic Press, San Diego. p. 595-636.

Kociolek, J.P. & Spaulding, S.A. (2003): Symmetrical naviculoid diatoms. – In: J.D. Wehr & R.G. Sheath (eds.), *Freshwater Algae of North America. Ecology and Classification*. Academic Press, San Diego. p. 637-653.

Komárek, J. (1985): Do all cyanophytes have a cosmopolitan distribution? Survey of the freshwater cyanophyte flora of Cuba. – *Archiv für Hydrobiologie Suppl., Algological Studies* **38-39**: 359-386.

Krammer, K. (1997a): *Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 1. Allgemeines und* Encyonema *Part*. – Bibliotheca Diatomologica **36**: 382 pp, J. Cramer, Stuttgart.

Krammer, K. (1997b): *Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 2.* Encyonema *part.,* Encyonopsis *und* Cymbellopsis. – Bibliotheca Diatomologica **37:** 469 pp., J. Cramer, Stuttgart.

Krammer, K. (1999): Validierung von *Cymbopleura* nov. gen. – In: H. Lange-Bertalot & S.I. Genkal, *Diatoms from Siberia I. Islands in the Artic Ocean*. – Iconographia Diatomologica. Annotated Diatoms micrographs. Vol. 6: 304 pp., Koeltz Scientific Books. Königstein: 292

Krammer, K. (2000): *Diatoms of Europe. Diatoms of the European inland waters and comparable habitats. Vol 1. The genus* Pinnularia, 703 pp, Gantner Verlag, Ruggell.

Krammer, K. (2003): *Diatoms of Europe: Diatoms of the European inland waters and comparable habitats elsewhere. Vol. 4.* Cymbopleura, Delicata, Navicymbula, Gomphocymbellopsis, Afrocymbella, *Supplements to Cymbelloid taxa.* 530 pp, Gantner Verlag, Ruggell.

Krammer, K. & Lange-Bertalot, H. (1985): *Naviculaceae. Neue und wenig bekannte Taxa, neue Kombinationen und Synonyme sowie Bemerkungen zu einigen Gattungen*. – Bibl. Diatomologica **9**: 469 pp., J. Cramer, Stuttgart.

Krammer, K. & Lange-Bertalot, H. (1986): *Bacillariophyceae. Teil 1: Naviculaceae*. – In: H. Ettl, J. Gerloff, H. Heyning & D. Mollenhauer (eds.), Die Süßwasserflora von Mitteleuropa Band 2/1: 876 pp., Gustav Fischer Verlag, Stuttgart.

Krammer, K. & Lange-Bertalot, H. (1988): *Bacillariophyceae. Teil 2: Bacillariaceae, Epithemiaceae, Surirellaceae*. – In: H. Ettl, J. Gerloff, H.

Heyning & D. Mollenhauer (eds.), Die Süßwasserflora von Mitteleuropa. Band 2/2: 576 pp, Gustav Fischer Verlag, Stuttgart.

Krammer, K. & Lange-Bertalot, H. (1991a): *Bacillariophyceae. Teil 3. Centrales, Fragilariaceae, Eunotiaceae*. – In: H. Ettl, J. Gerloff, H. Heyning & D. Mollenhauer (eds.), Die Süßwasserflora von Mitteleuropa. Band 2/3: 576 pp, Gustav Fischer Verlag, Stuttgart.

Krammer, K. & Lange-Bertalot, H. (1991b): *Bacillariophyceae. Teil 4. Achnanthaceae. Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema. Gesamtliteraturverzeichnis Teil 1-4.* – In: H. Ettl, J. Gerloff, H. Heyning & D. Mollenhauer (eds.), Die Süßwasserflora von Mitteleuropa. Band 2/4: 438 pp., Gustav Fischer Verlag, Stuttgart.

Krasske, K. (1923): Die Diatomeen des Casseler Becken und seiner Randgebirge nebst einigen wichtigen Funden aus Niederhessen. – *Botanisches Archiv* 3: 185-209

Krebs, C.J. (1999): *Ecological Methodology*. Second Edition. 620 pp, Benjamin/Cummings Series. Addison Wesley Longman Inc., Menlo Park.

Kusber, W.-H. & Jahn, R. (2003): Annotated list of diatom names by Horst Lange-Bertalot and co-workers. Version 3.0. Available online at: http://www.algaterra.org/Names_Version3_0.pdf. (Last accessed Jan., 2007).

Lange-Bertalot, H. & Moser, G. (1994): Brachysira*. Monographie der Gattung. Wichtige Indikator-Species für das Gewässer-Monitoring und* Naviculadicta *nov. gen. Ein Lösungsvorschlag zu dem Problem* Navicula *sensu lato ohne* Navicula *sensu stricto*. – Bibliotheca Diatomologica **29**: 212 pp., J. Cramer. Stuttgart.

Lee, K. & Round, F.E. (1988): Studies on freshwater *Amphora* species. II. *Amphora copulata* (Kütz.) Schoeman & Archibald. – *Diatom Research* **3** (2): 217-225.

López-García, J., Melo-Gallegos, C., Manzo-Delgado, L. & Hernández-Corzo, G. (1990): Carta Suelos (Soils Chart) IV.7.1. *Atlas Nacional de México, Vol II. Naturaleza*. Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Lowe, R.L. (1974): *Environmental requirements and pollution tolerance of freshwater diatoms*. 334 pp, EPA-670/4-74-005. U.S. Environmental Protection Agency. National Environmental Research Center. Cincinnati.

Lugo-Hubp, J. (1990): Carta Geomorfología (Geomorphology Chart) IV. 3.4. – *Atlas Nacional de México*, *Vol II. Naturaleza.* Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Lugo-Hubp, J. & Córdoba-Fernández, C. (1990): Carta Geomorfología. Morfogénesis (Geomorpology Chart. Morphogenesis) IV. 3.3. – *Atlas Nacional de México*, *Vol II. Naturaleza*. Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Lund, J.W.G. (1945): Observations on soil algae I. The ecology, size and taxonomy of British soil diatoms. Part I. – *New Phytologist* **44**: 196-219.

Magurran, A.E. (1988): *Ecological diversity and its measurement*. 179 pp., Princeton University Press, Princeton.

Maidana, N.I. (1985): *Contribución al estudio taxonómico de las diatomeas (Bacillariophyceae) de la Provincia de Misiones, República Argentina.* 276 p +

39 lams. Tesis de Doctorado (Ph.D. Dissertation). Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.

Martínez de Fabricius, A.L. & Corigliano, M.d.C. (1989): Composición y distribución de comunidades algales en el rio Ctalamochita (Córdoba - Argentina). – *Revista Universidad Nacional de Rio Cuarto* **9**: 5-13.

Metcalfe, S.E. (1985): *Late Quaternary environments of central México: A diatom record.* 565 pp., Ph.D. Dissertation. Hertford College and the School of Geography, Oxford.

Metcalfe, S.E. (1988): Modern diatom assemblages in Central Mexico: the role of water chemistry and other environmental factors as indicated by TWISPAN and DECORANA. – *Freshwater biology* **19**: 217-233.

Metzeltin, D. & Lange-Bertalot, H. (1998): *Tropical Diatoms of South America I. About 700 predominantly rarely known or new taxa representative of the neotropical flora*. – In: H. Lange-Bertalot (ed.), Iconographia Diatomologica. Annotated Diatom Monographs **5**: 695 pp., Koeltz Scientific Books, Königstein.

Montejano, G., Carmona-Jimenez, J. & Cantoral-Uriza, E.A. (2000): Algal communities from calcareous springs in La Huasteca, central México: A synthesis. – In: M. Munawar, S.G. Lawrence, I.F. Munawar & D.F. Malley (eds.), *Aquatic Ecosystems of Mexico. Status & scope,* p. 135-149. Backhuys Publ., Leiden.

Morales, E.A. (2003): *Fragilaria pennsylvanica*, a new diatom (Bacillariophyceae) species from North America, with comments on the taxonomy of the genus *Synedra* Ehrenberg. – *Proceedings of the Academy of the Natural Science of Philadelphia* **153** (1): 155-166.

Novelo, E. (1998): *Floras ficológicas del Valle de Tehuacán, Puebla*. 599 pp. Tesis de Doctorado (Ph D. Dissertation). Facultad de Ciencias, Universidad Nacional Autónoma de México, México.

Novelo, E. & Tavera, R. (2003): The role of periphyton in the regulation and supply of nutrients in a wetland at El Edén, Quintana Roo. – In: A. Gómez-Pompa, M. Allen, S.L. Fedick & J.J. Jiménez-Osornio (eds.), *Lowland Maya area: Three Millennia at the Human - Wildland Interface,* p. 217-239. The Haworth Press, Binghampton.

Obeng-Asamoa, E.K., John, D.M. & Appler, H.N. (1980): Periphyton in the Volta Lake. I. Seasonal changes on the trunks of flooded trees. – *Hydrobiologia* **76**: 191-200.

Ohtsuka, T. & Fujita, Y. (2001): The diatom flora and its seasonal changes in a paddy field in Central Japan. – *Nova Hedwigia* **73** (1-2): 97-128.

Ortega, M. (1984): *Catálogo de algas continentales recientes de México*. 566 pp. Universidad Nacional Autónoma de México, México.

Padilla y Sánchez, R. & Aceves-Quesada, F. (1990): Carta Geología (Geology Chart) IV.1.1. *Atlas Nacional de México*, *Vol II. Naturaleza.* Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Padisák, J., Krienitz, L., Scheffler, W., Koschel, R., Kristiansen, J. & Grigorszky, I. (1998): Phytoplankton succession in the oligotrophic Lake Stechlin (Germany) in 1994 and 1995. – *Hydrobiologia* **369/370**: 179-197.

Patrick, R. (1968): The structure of diatom communities in similar ecological conditions. – *American Naturalist* **102**: 173-183.

Patrick, R. & Reimer, C. (1966): *The Diatoms of the United States. Vol. 1. Part 1.* – Monograph No. 13, 688 pp. Academy of Natural Sciences of Philadelphia, Philadelphia.

Patrick, R. & Reimer, C. (1975): *The Diatoms of the United States, Vol. 2, Part 1.* – Monograph No. 13, 213 pp. Academy of Natural Sciences of Philadelphia, Philadelphia.

Perry, E., Velazquez-Oliman, G. & Socki, R.A. (2003): Hydrogeology of the Yucatán Peninsula. – In: A. Gómez-Pompa, M. Allen, S.L. Fedick & J.J. Jiménez-Osornio (eds.), *Lowland, Maya area: Three Millennia at the Human - Wildland Interface*, p. 115-138. The Haworth Press, Binghampton.

Round, F.E. (1998): Validation of some previously published "Achnanthoid" genera. – *Diatom Research* **13** (1): 181.

Round, F.E. & Bukhtiyarova, L. (1996): Four new genera based on *Achnanthes* (*Achnanthidium*) together with a re-definition of *Achnanthidium*. – *Diatom Research* **11** (2): 345-361.

Round, F.E., Crawford, R.M. & Mann, D.G. (1990): *The diatoms. Biology and morphology of the genera*, 747 pp. Cambridge University Press, Cambridge.

Rumrich, U., Lange-Bertalot, H. & Rumrich, M. (2000): *Diatomeen der Anden von Venezuela bis Patagonien/Feuerland und zwei weitere Beiträge*. – In: H. Lange-Bertalot (ed.), Iconographia Diatomologica. Annotated Diatom Monographs **9**: 672 pp., Gantner Verlag, Ruggell.

Rzedowski, J. & Reyna-Trujillo, T. (1990): Carta Vegetación (Vegetation Chart) IV.8.2. – *Atlas Nacional de México*, *Vol II. Naturaleza.* Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Sarode, P.T. & Kamat, N.D. (1984): *Freshwater diatoms of Maharashtra*, 338 pp. Saikripa Prakashan. Maharashtra.

Schlichting, H.E. Jr. (1969): The importance of airborne algae and protozoa. – *Journal of the Air Pollution Control Association* **19**: 946-951.

Schoeman, F.R. (1973): *A systematical and ecological study of the diatom flora of Lesotho with special reference to the water quality*. 155 pp. + 10 pls. V&R Printers, Pretoria.

Sheath, R.G. & Cole, K.M. (1992): Biogeography of stream macroalgae in North America. – *Jounal of Phycology* **28**: 448-460.

Sieminska, J. (1964): *Bacillariophyceae Okrzemki*. *Flora Slodkowodna Polski*, 610 pp. Polska Akademia Nauk. Warzawa.

Skuja, H. (1949): Zur Süsswasseralgenflora Burmas. – *Nova Acta Regiae Societatis Scientiarum Upsaliensis,* **Serie 4, 14**: 188 pp. + XXXVII pls.

Stein, J.R. & Gerrath, J.F. (1969): Freshwater algae of British Columbia: The Queen Charlotte Islands. – *Syesis* **2**: 213-226.

Stoermer, E. F. & Julius, M.L. (2003): Centric Diatoms. – In: J.D. Wehr & R.G. Sheath (eds), *Freshwater Algae of North America. Ecology and Classification*. Academic Press, San Diego. p. 559-594.

Tavera-Sierra, R. & González-González, J. (1990): Caracterización ficoflorística de los paredones de la Sierra de Juárez, Oaxaca. Importancia de las formas de crecimiento algales en la tipificación de un ambiente. – *Boletín de la Sociedad Botánica de México* **50**: 121-133.

Tavera, R., Elster, J. & Marvan, P. (1994): Diatoms from Papaloapan basin communities, Mexico. – *Archiv für Hydrobiologie Suppl., Algological Studies* **74**: 35-65.

Thomasson, K. (1965): Notes on algal vegetation of Lake Kariba. – *Nova Acta Regiae Societatis Scientiarum Upsaliensis*, **Serie 4, 19**: 3-34.

Tudesque, L. & Ector, L (2002): Inventaires des diatomées benthiques des rivières de la Guadeloupe (campagnes 2000-2001). Rapport final. Cellule de Recherche en Environnment et Biotechnologies – CREBS. Luxembourg. 44 pp. Available online at: http://www.guadeloupe.ecologie.gouv.fr/page_semad/production_service/product_eau.htm. (Last accessed January, 2007)

Vidal-Zepeda, R. (1990): Carta Clima (Climate Chart) IV.4.4. – *Atlas Nacional de México*, *Vol. II. Naturaleza.* Instituto de Geografía, Universidad Nacional Autónoma de México, México.

Wasylik, K. (1965a): Communities of algae form the Sola River and its tributaries. – *Acta Hydrobiologica, Kraków* **7**: 9-60.

Wasylik, K. (1965b): Remnants of algae in bottom sediments of the Lakes Wielki Staw and Morskie Oko in the Tatra Mountains. – *Limnological Investigations in the Tatra Mountains and Dunajec River Basin* **1**: 39-58.

Whitford, L.A. (1956): The communities of algae in the springs and spring streams of Florida. – *Ecology* **37**: 433-442.

Whitford, L.A. & Kim, Y.C. (1971): Algae from alpine areas in Rocky Mountain National Park, Colorado. – *American Midland Naturalist* **85**: 425-430.

Whitford, L.A. & Schumacher, G.J. (1963): Communities of algae in North Carolina and their seasonal relations. – *Hydrobiologia* **22**: 133-196.

Winston, J.A. (1999): *Describing species. Practical taxonomic procedure for biologist*, 518 pp. Columbia University Press, New York.

Witkowski, A., Lange-Bertalot, H. & Metzeltin, D. (2000): *Diatom Flora of Marine Coasts. Vol. I.* – In: H. Lange-Bertalot (ed.), Iconographia Diatomologica. Annotated Diatom Monographs **7**: 925 pp., Koeltz Scientific Books, Königstein.

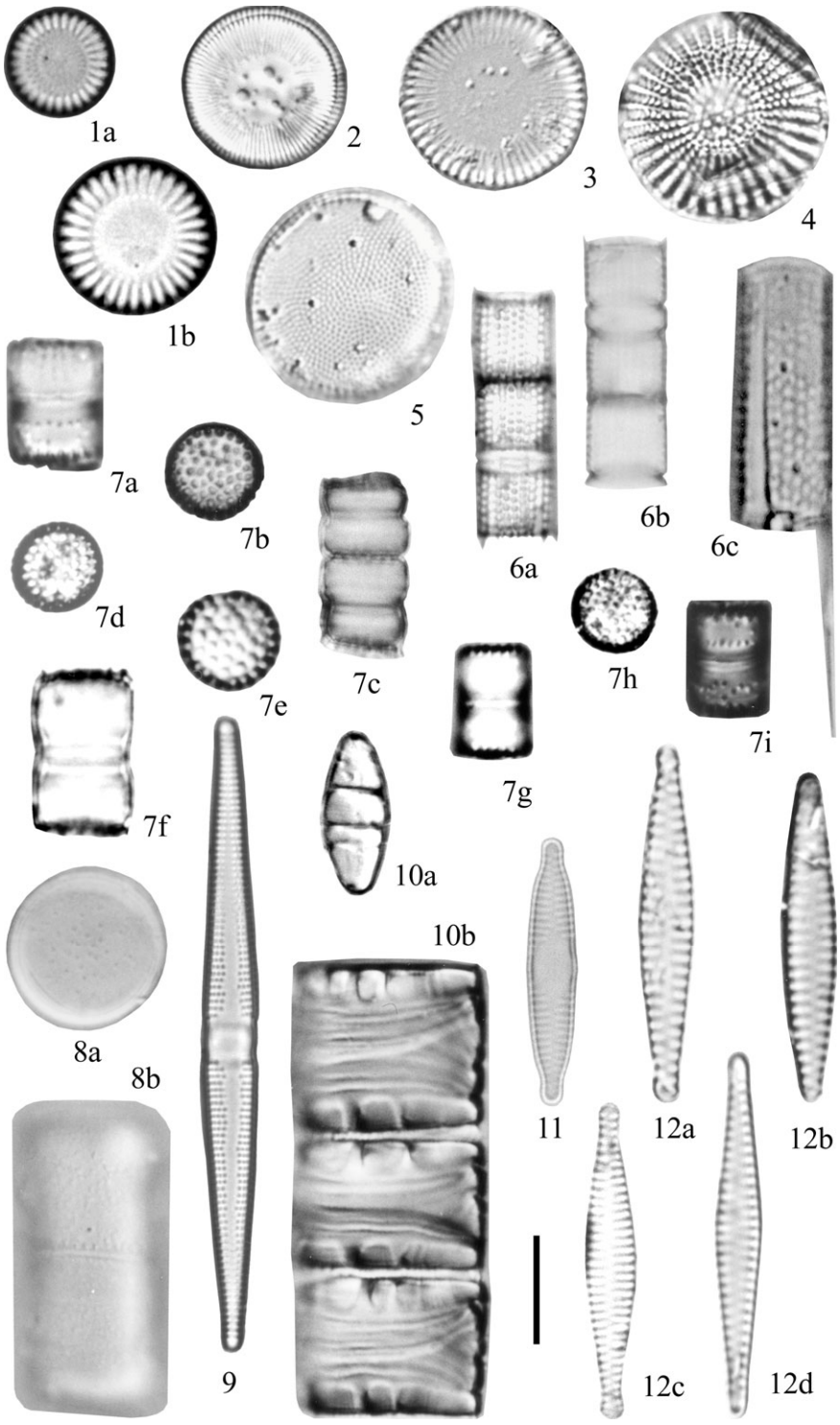
Wolfe, A. & Kling, E. (2001): A consideration of some North American soft-water *Brachysira* taxa and description of *B. arctoborelis* sp. nov. – In: R. Jahn, J.P. Kociolek, A. Witkowski & P. Compère (eds.), *Lange-Bertalot-Festschrift*, p. 243-264, Gantner Verlag, Ruggell.

PLATES

Plate 1

Scale bar = 10 μm.

1a-b) *Cyclotella meneghiniana* Kützing.
2) *Cyclotella ocellata* Pantocsek.
3) *Stephanodiscus hantzschii* Grunow.
4) *Stephanodiscus medius* Håkansson.
5) *Thalassiosira visurgis* Hustedt.
6a-c) *Aulacoseira granulata* (Ehrenberg) Simonsen. Girdle view.
7a-d) *Aulacoseira periphytica* sp. nov. From El Edén. 7b: Holotype. 7a, 7c: Girdle view.
7e-g) *Aulacoseira periphytica* sp. nov. From Guanajuato, Guanajuato. 7f, 7g: Girdle view.
7h-i) *Aulacoseira periphytica* sp. nov. From Tehuacán Valley, Puebla. 7i: Girdle view.
8a-b) *Melosira varians* C. Agardh. 8b: Girdle view.
9) *Ctenophora pulchella* (Ralfs ex Kützing) D.M. Williams et Round.
10a-b) *Diatoma mesodon* Kützing. 10b: Girdle view.
11) *Fragilaria capucina* var. *vaucheriae* (Kützing) Lange-Bertalot.
12a-d) *Fragilaria dzonoticola* sp. nov. 12a: Holotype.


1a
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1b
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7a
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6a
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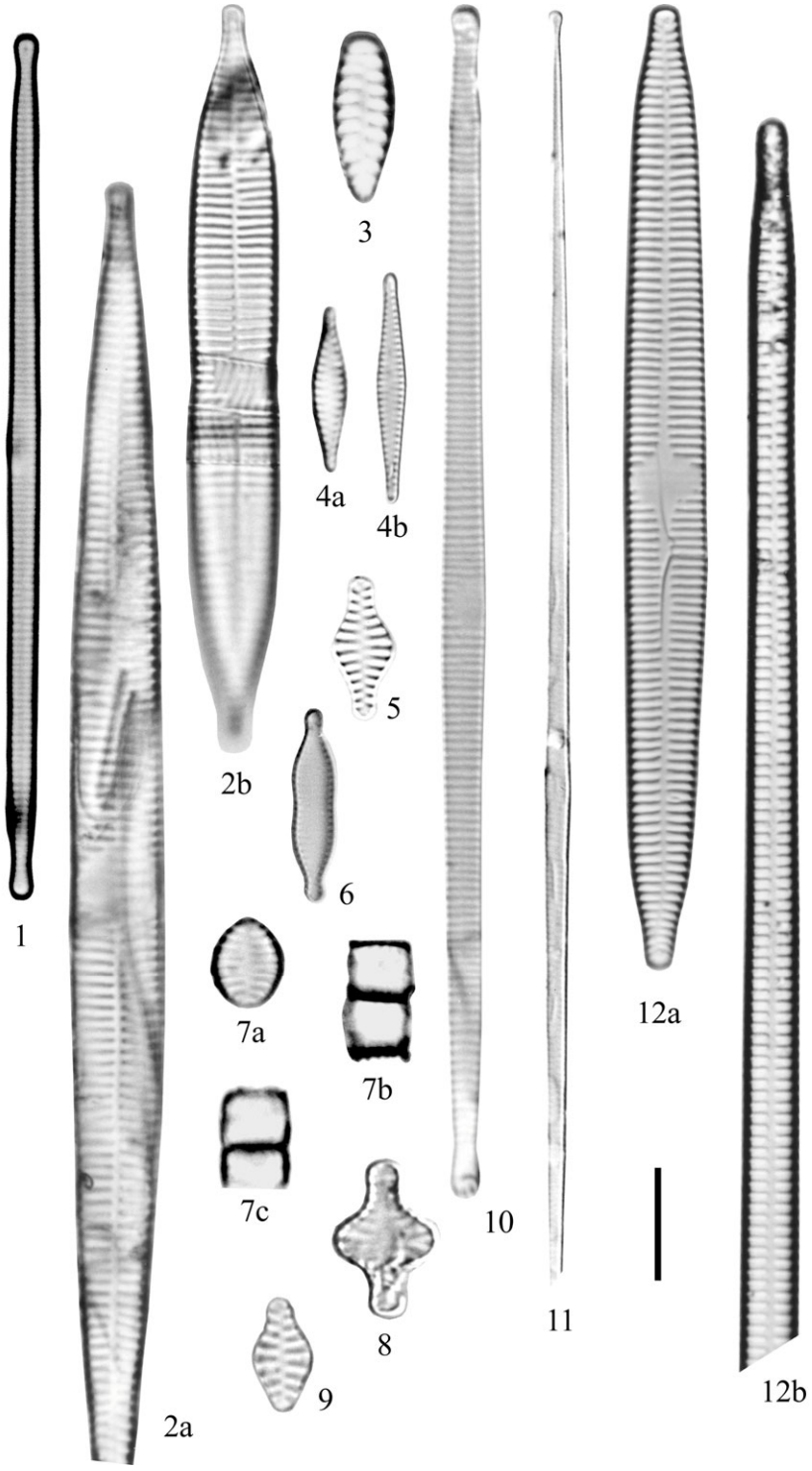
7g
7f
10a
10b
8a
8b
11
12a
12b
9
12c
12d

Plate 2

Scale bar = 10 μm.

1) *Fragilaria famelica* (Kützing) Lange-Bertalot.
2a-b) *Fragilaria goulardii* (Brébisson) Lange-Bertalot.
3) *Martyana martyi* (Héribaud) Round.
4a-b) *Pseudostaurosira brevistriata* (Grunow) D.M. Williams et Round.
5) *Staurosira construens* Ehrenberg var. *construens*.
6) *Staurosira construens* var. *binodis* (Ehrenberg) P.B. Hamilton.
7a-c) *Staurosira construens* var. *venter* (Ehrenberg) P.B. Hamilton. 7b, 7c: Girdle view.
8) *Staurosirella leptostauron* (Ehrenberg) D.M. Williams et Round.
9) *Staurosirella pinnata* (Ehrenberg) D.M. Williams et Round.
10) *Ulnaria acus* (Kützing) Aboal.
11) *Synedra acus* var. *angustissima* (Grunow) Van Heurck.
12a-b) *Ulnaria ulna* (Nitzsch) Compère.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2a
2b
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4a
4b
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7a
7b
7c
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11
12a
12b

Plate 3

Scale bar = 10 μm.
1a-b) *Ulnaria* sp. 1a: Scale bar = 55 μm.
2) *Eunotia camelus* Ehrenberg var. *camelus.*
3) *Eunotia camelus* var. *arcuata* Frenguelli.
4) *Eunotia flexuosa* (Brébisson) Kützing.
5a-b) *Eunotia formica* Ehrenberg. 5a: Girdle view.
6a-b) *Achnanthes inflata* (Kützing) Grunow.

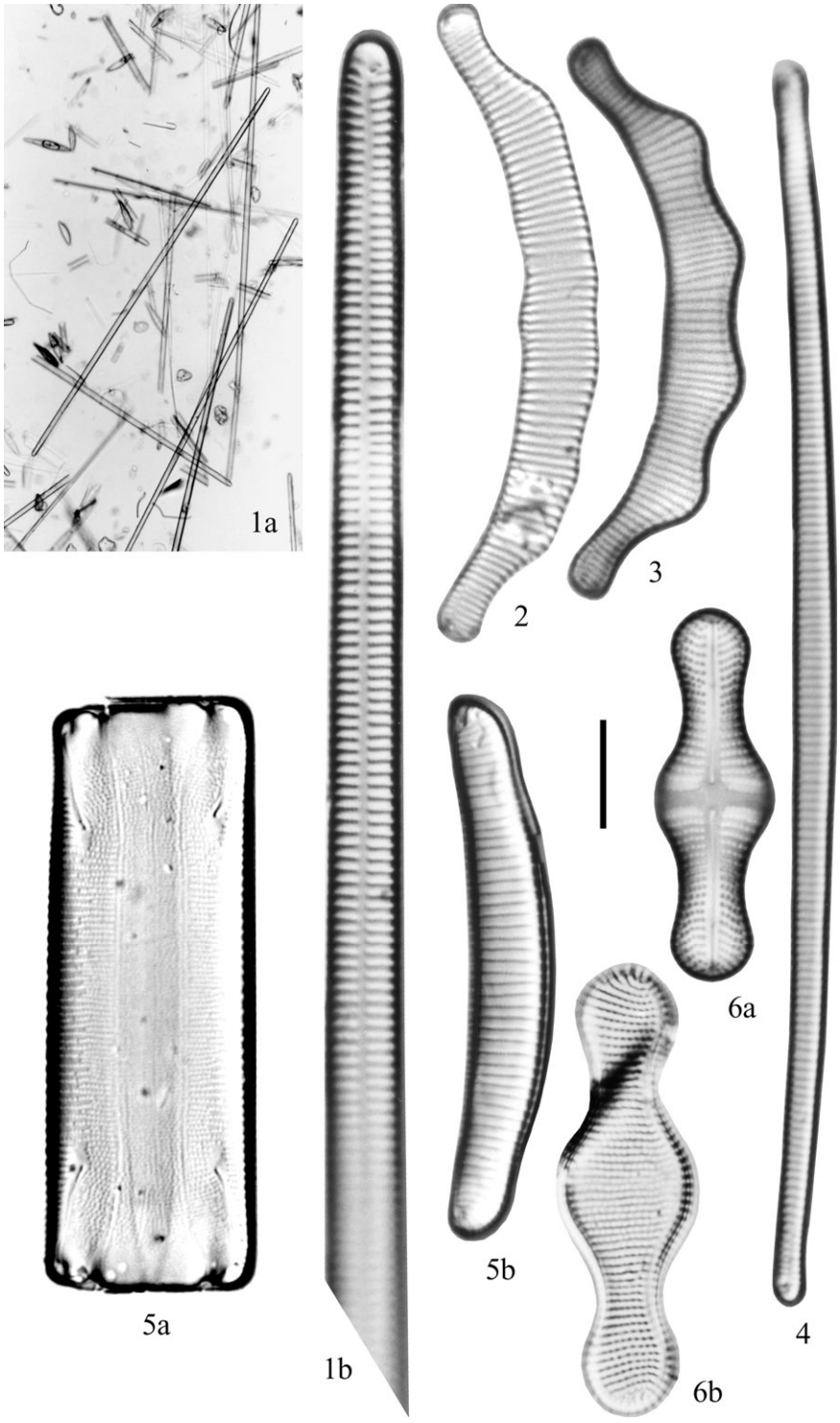

1a
1b
2
3
4
5a
5b
6a
6b

Plate 4

Scale bar = 10 μm.

1a-c) *Achnanthidium biasolettianum* (Grunow) Lange-Bertalot.
2a-b) *Achnanthidium chlidanos* (Hohn et Hellerman) comb. nov.
3a-b) *Achnanthidium exiguum* (Grunow) Czarnecki.
4a-b) *Achnanthidium minutissimum* (Kützing) Czarnecki.
5a-c) *Achnanthidium minutissimum* var. *gracillima* (Meister) Lange-Bertalot. 5b: Girdle view.
6) *Cocconeis pediculus* Ehrenberg.
7) *Cocconeis placentula* Ehrenberg var. *placentula*.
8) *Cocconeis placentula* var. *euglypta* (Ehrenberg) Cleve.
9) *Cocconeis placentula* var. *lineata* (Ehrenberg) Cleve.
10a-b) *Cocconeis pseudothumensis* E. Reichardt.
11a-c) *Karayevia clevei* (Grunow) Round.
12a-c) *Planothidium lanceolatum* (Brébisson) Round et Bukhtiyarova.
13) *Adlafia minuscula* (Grunow) Lange Bertalot.
14) *Amphipleura chiapasensis* Metzeltin et Lange-Bertalot.

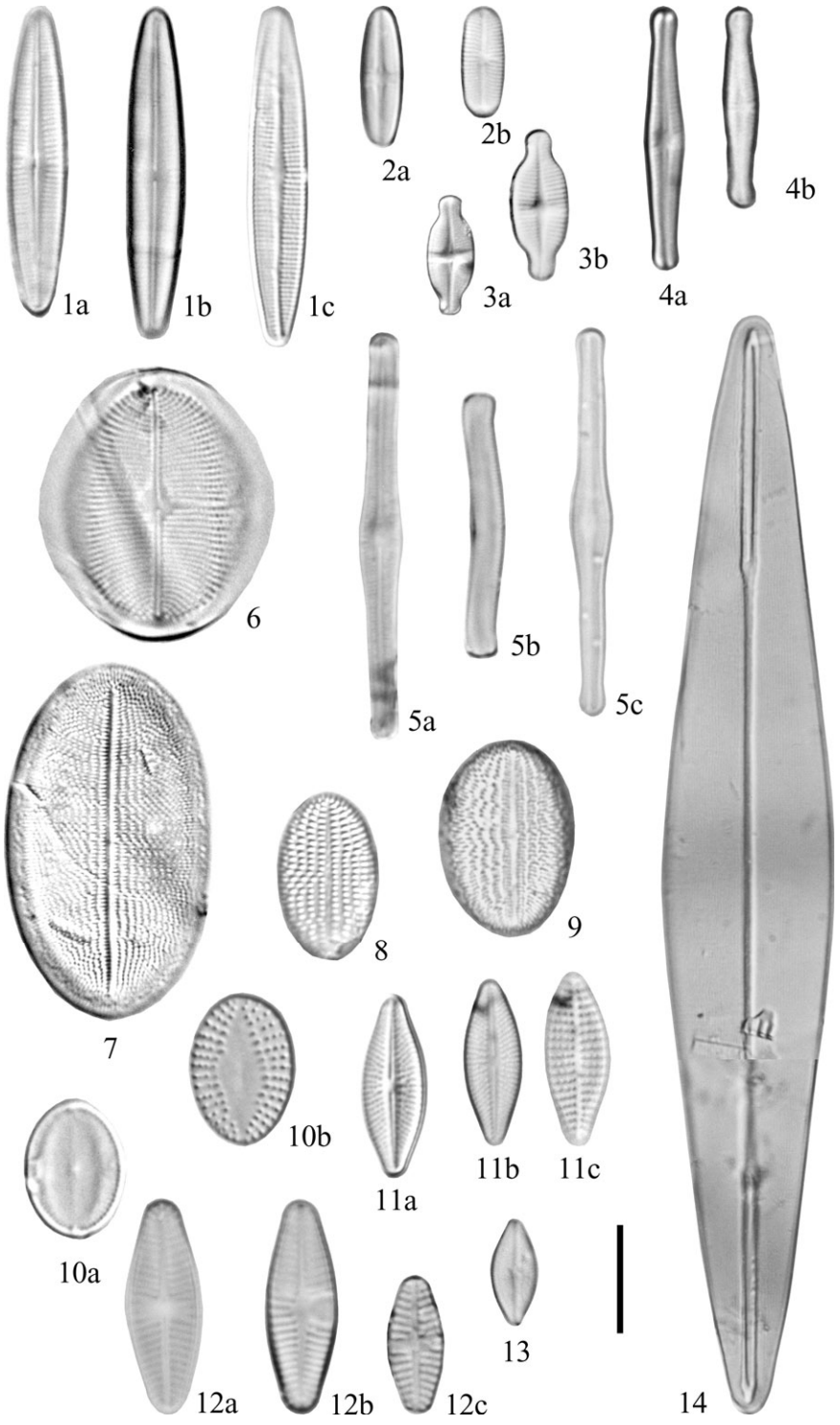

1a
1b
1c
2a
2b
3a
3b
4a
4b
5a
5b
5c
6
7
8
9
10a
10b
11a
11b
11c
12a
12b
12c
13
14

Plate 5

Scale bar = 10 μm.
1) *Anomoeoneis costata* (Kützing) Hustedt.
2) *Anomoeoneis sphaerosphora* (Ehrenberg) Pfitzer.
3a-f) *Brachysira microcephala* (Grunow) Compère.
4a-b) *Caloneis bacillum* (Grunow) Cleve.
5a-e) *Caloneis sabanicola* sp. nov. 5a: Holotype.

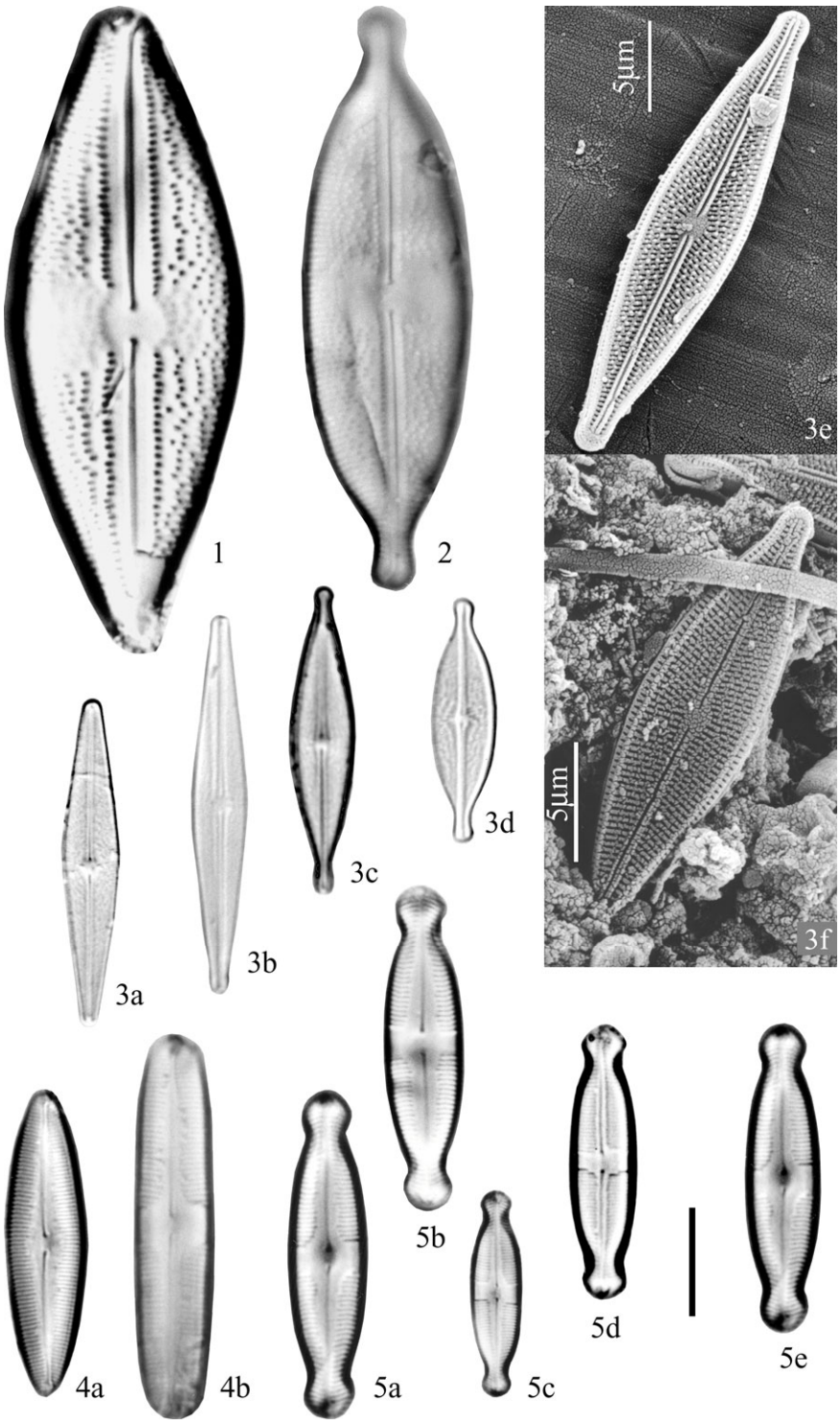

1
2
5µm
3e
5µm
3f
3a
3b
3c
3d
5b
4a
4b
5a
5c
5d
5e

Plate 6

Scale bar = 10 μm.

1) *Caloneis silicula* (Ehrenberg) Cleve.
2) *Capartogramma crucicula* (Grunow ex Cleve) R. Ross.
3a-e) *Capartogramma paradisiaca* sp. nov. 3a: Holotype.
4a-b) *Craticula cuspidata* (Kützing) D.G. Mann. 4b: Focus in craticula.
5) *Diadesmis confervacea* Kützing.
6) *Diploneis elliptica* (Kützing) Cleve.
7) *Diploneis oblongella* (Nägeli) Cleve-Euler.
8) *Diploneis ovalis* (Hilse) Cleve.
9) *Diploneis subovalis* Cleve.
10a-b) *Eolimna subminuscula* (Manguin) Moser, Lange-Bertalot et Metzeltin.

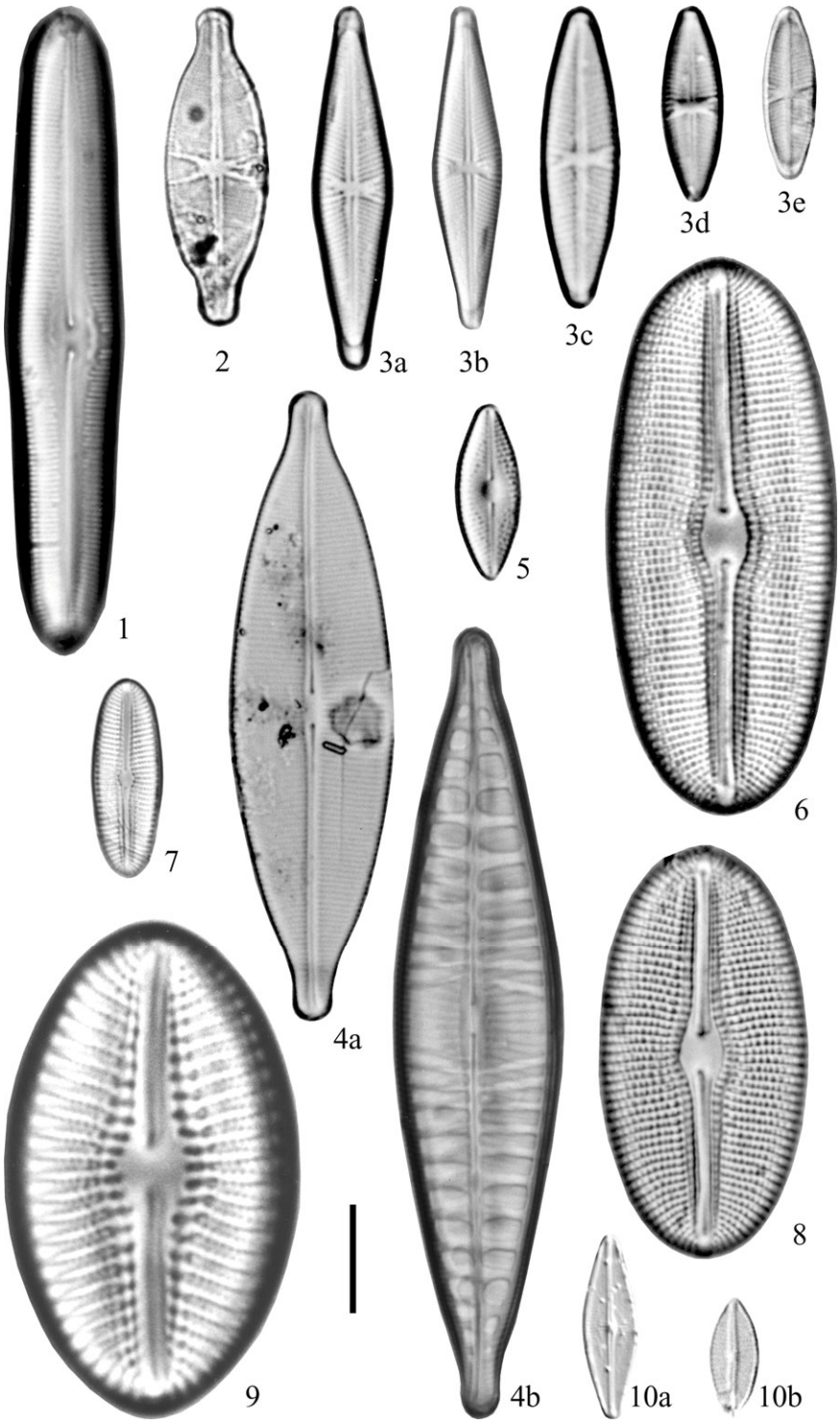

1
2
3a
3b
3c
3d
3e
4a
4b
5
6
7
8
9
10a
10b

Plate 7

Scale bar = 10 μm.

1) *Fallacia pygmaea* (Kützing) Stickle et D.G. Mann.
2a-b) *Frustulia vulgaris* (Thwaites) De Toni.
3) *Gyrosigma obscurum* (W. Smith) Griffith et Henfrey.
4a-b) *Gyrosigma scalproides* (Rabenhorst) Cleve.
5a-b) *Hippodonta hungarica* (Grunow) Lange-Bertalot, Metzeltin et Witkowski.
6a-c) *Kobayasiella* sp.
7a-b) *Luticola goeppertiana* (Bleisch) D.G. Mann.
8a-b) *Luticola mutica* var. *intermedia* (Hustedt) Hawkins et Kelly.

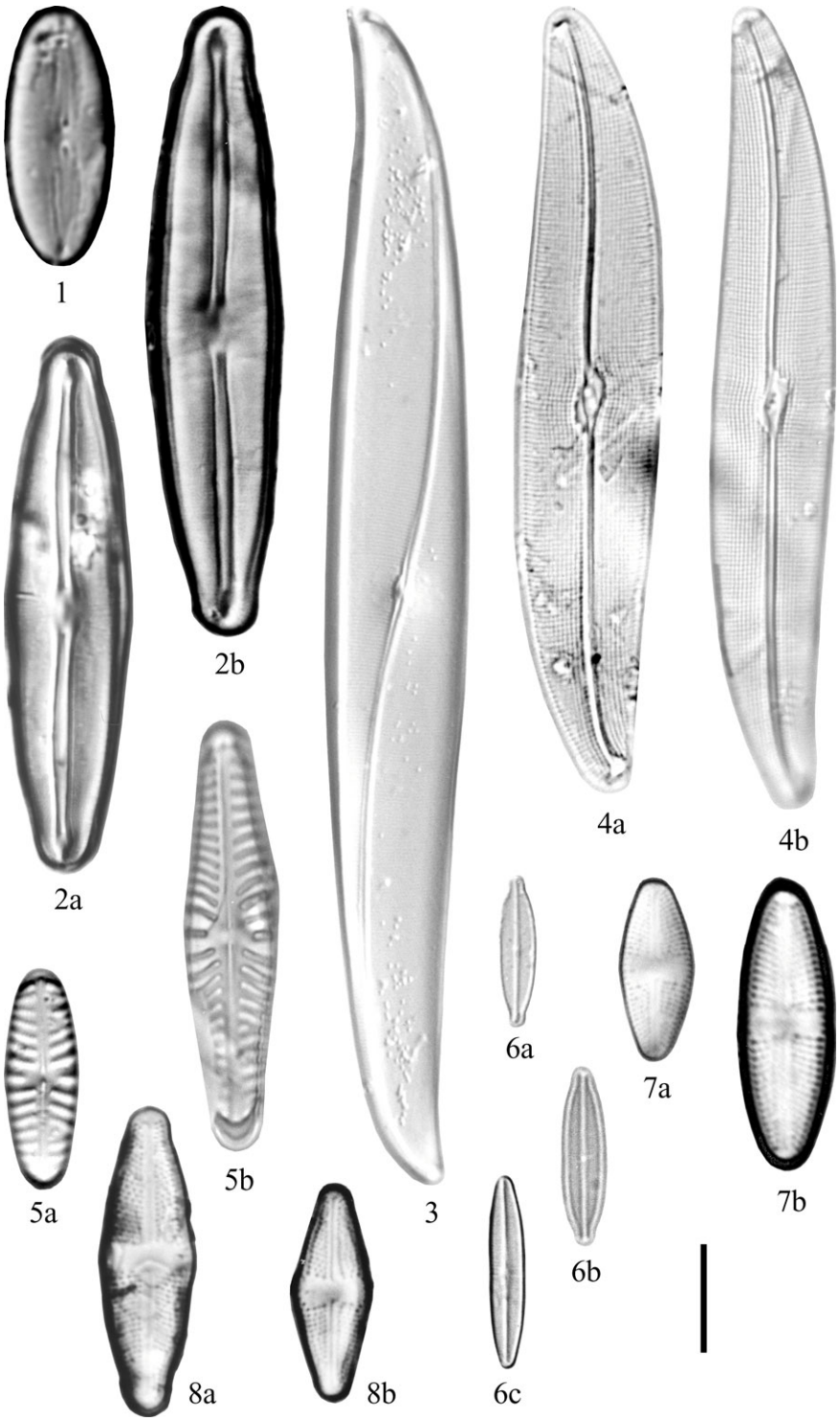

1
2b
2a
3
4a
4b
5b
5a
6a
7a
7b
6b
8a
8b
6c

Plate 8

Scale bar = 10 μm.

1a-b) *Mastogloia elliptica* (C. Agardh) Grunow. 1b: Internal view.
2a-b) *Mastogloia smithii* Thwaites ex W. Smith. 2b: Internal view.
3) *Navicula cryptotenella* Lange-Bertalot.
4a-c) *Navicula erifuga* Lange-Bertalot.
5) *Navicula heimansii* van Dam et Kooyman.
6a-b) *Navicula podzorskii* Lange-Bertalot.
7) *Navicula radiosa* Kützing.
8a-b) *Navicula rivulorum* Lange-Bertalot et Rumrich.
9) *Navicula rostellata* Kützing.

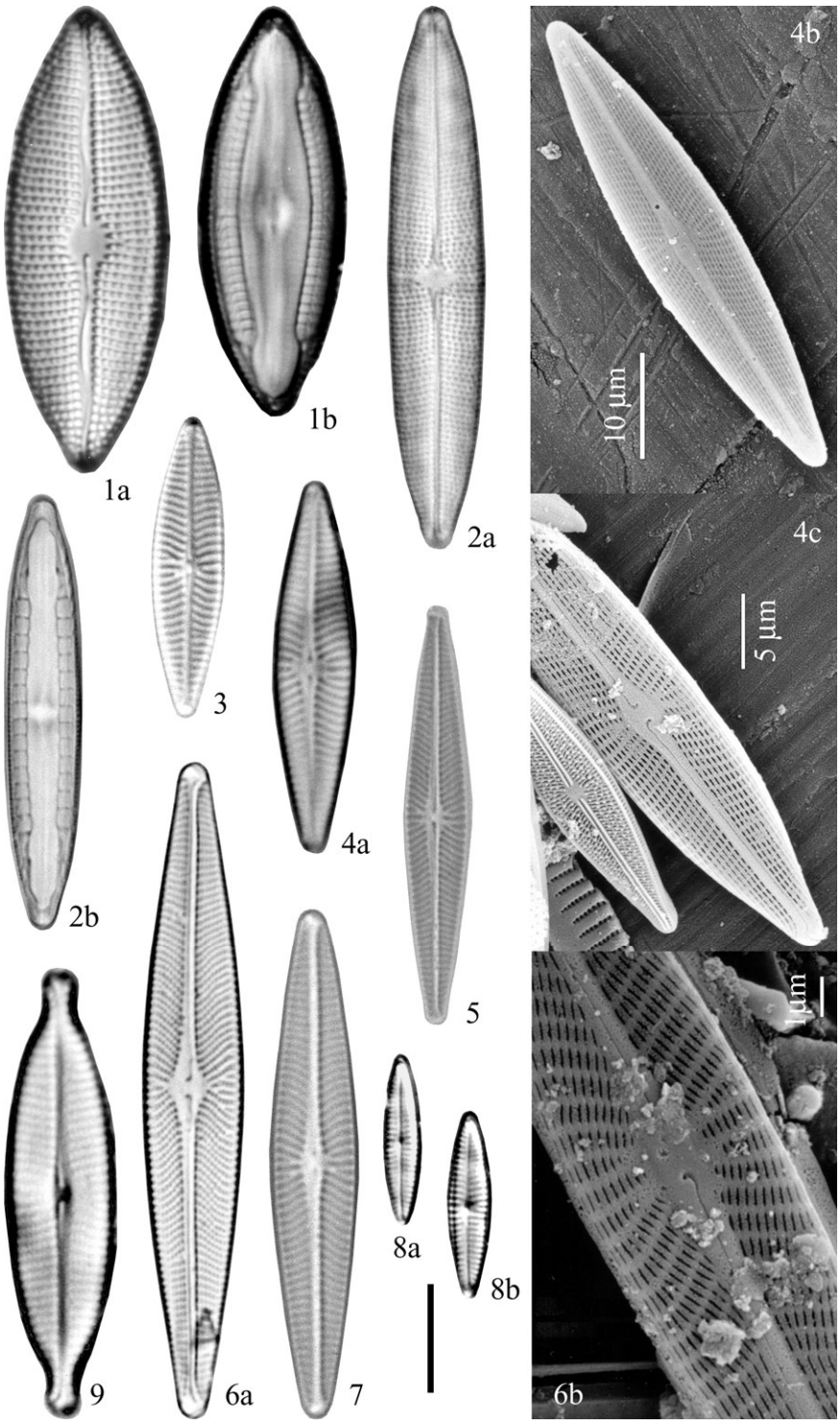

1a
1b
2a
2b
3
4a
5
6a
6b
7
8a
8b
9
4b
10 µm
4c
5 µm
1 µm

Plate 9

Scale bar = 10 μm.
1) *Neidium ampliatum* (Ehrenberg) Krammer.
2) *Nupela astartiella* Metzeltin et Lange-Bertalot.
3) *Pinnularia acrosphaeria* W. Smith.
4) *Pinnularia borealis* Ehrenberg.
5) *Pinnularia certa* Krammer et Metzeltin.
6) *Pinnularia divergens* W. Smith.
7) *Pinnularia gibba* Ehrenberg.
8) *Pinnularia joculata* (Manguin) Krammer.
9) *Pinnularia major* (Kützing) Rabenhorst. Scale bar = 20 μm.
10a-c) *Pinnularia mayarum* sp. nov. 10b: Holotype.

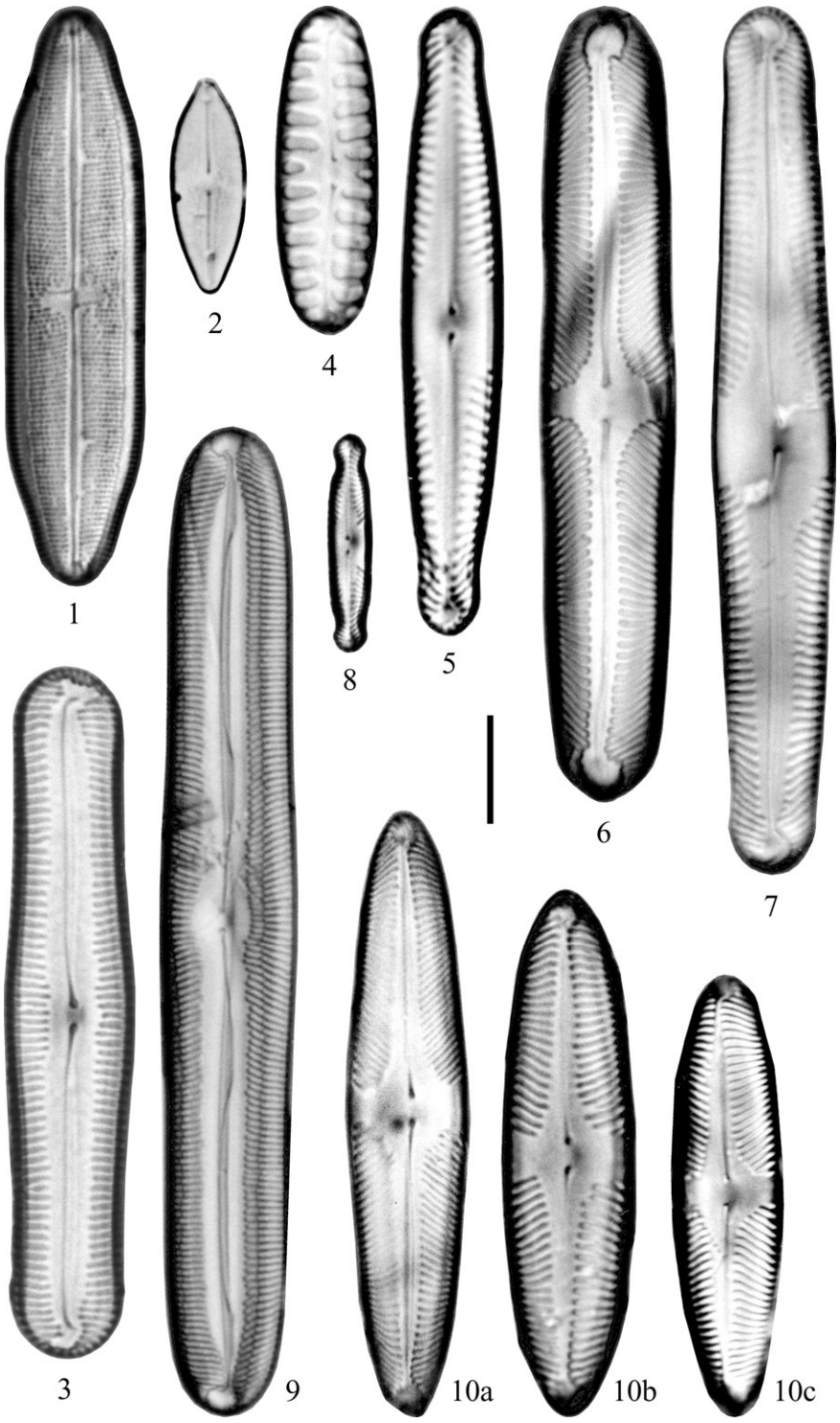

1
2
4
5
6
7
8
3
9
10a
10b
10c

Plate 10

Scale bar = 10 μm.

1) *Pinnularia microstauron* (Ehrenberg) Cleve.
2) *Pinnularia streptoraphe* var. *parva* Krammer.
3) *Pinnularia subgibba* var. *capitata* Metzeltin et Lange-Bertalot.
4) *Pinnularia subrostrata* Lohman et Andrews.
5) *Pinnularia tropica* Hustedt.
6) *Placoneis porifera* var. *opportuna* (Hustedt) comb. nov.
7a-c) *Sellaphora guyanensis* Metzeltin et Lange-Bertalot.
8) *Sellaphora laevissima* (Kützing) D.G. Mann.
9a-b) *Sellaphora pupula* (Kützing) Mereschkowsky.

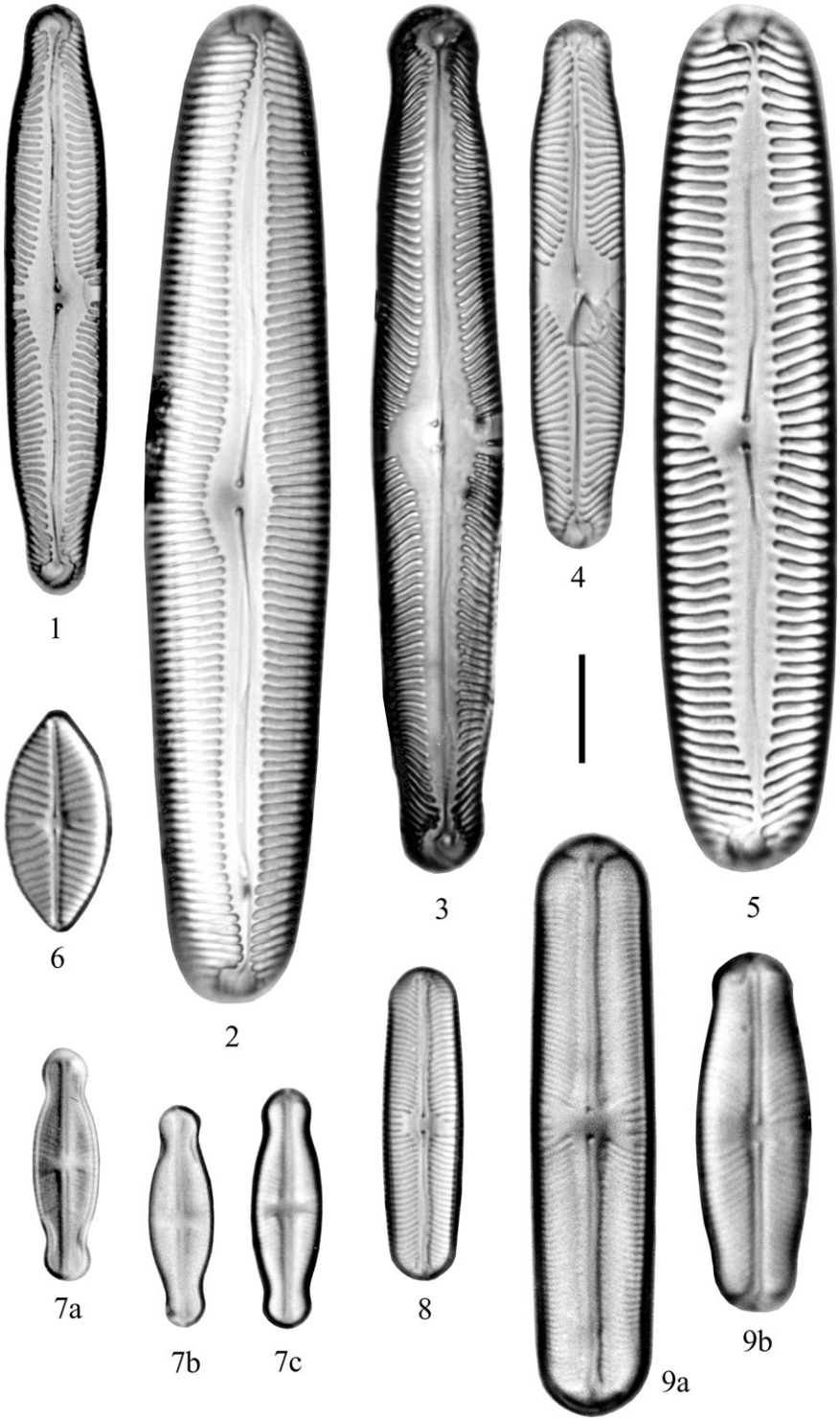
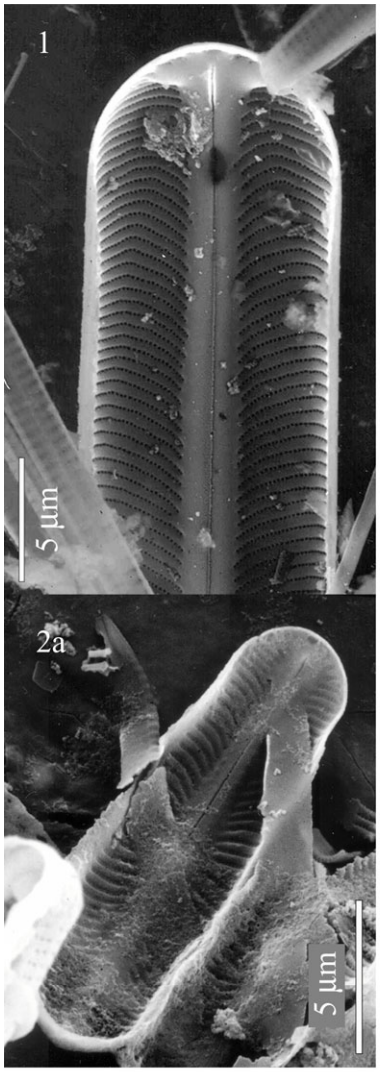
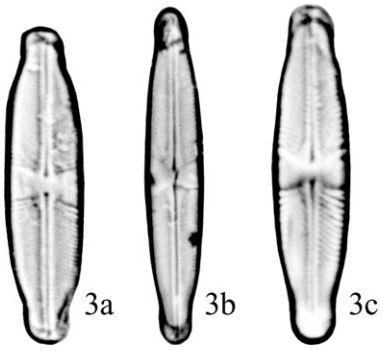

1
2
3
4
5
6
7a
7b
7c
8
9a
9b

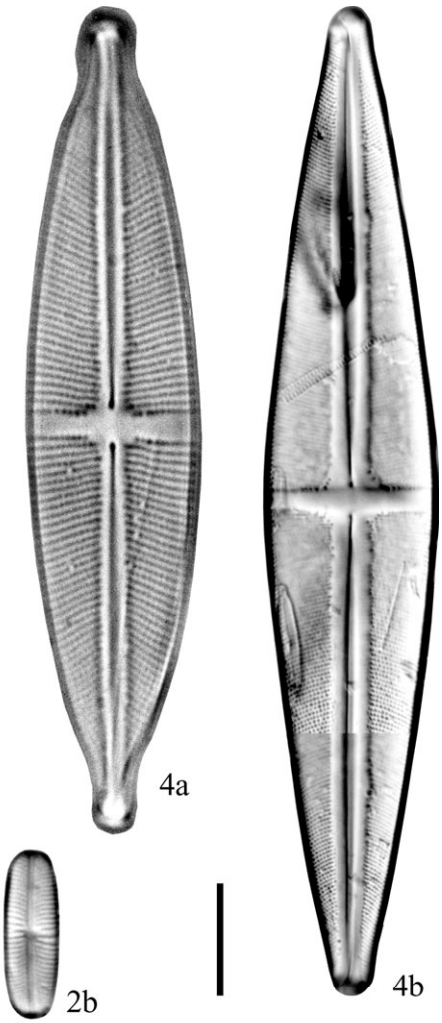
Plate 11

Scale bar = 10 μm.

1) *Sellaphora pupula* (Kützing) Mereschkowsky. Internal view.
2a-b) *Sellaphora stroemii* (Hustedt) D.G. Mann. 2b: Internal view.
3a-f) *Stauroneis amphibia* sp. nov. 3c: Holotype.
4a-b) *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg.


1
5 µm
2a
5 µm


3a
3b
3c


4a
2b
4b

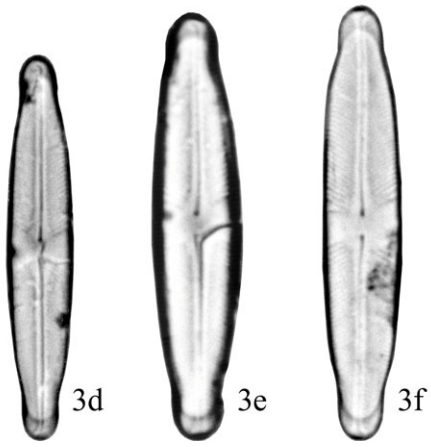

3d
3e
3f

Plate 12

Scale bar = 10 μm.

1) *Amphora coffeaeformis* (Agardh) Kützing.
2a-d) *Amphora copulata* (Kützing) Schoeman et Archibald. 2a, 2b: Girdle – ventral view.
3a-b) *Amphora pediculus* (Kützing) Grunow. 3a: Girdle – ventral view.
4a-b) *Amphora veneta* Kützing.
5a-b) *Cymbella aspera* (Ehrenberg) Cleve. Scale bar = 20 μm.
6) *Cymbella cistula* (Hemprich et Ehrenberg) Kirchner.
7) *Cymbella mexicana* (Ehrenberg) Cleve. Scale bar = 25 μm.

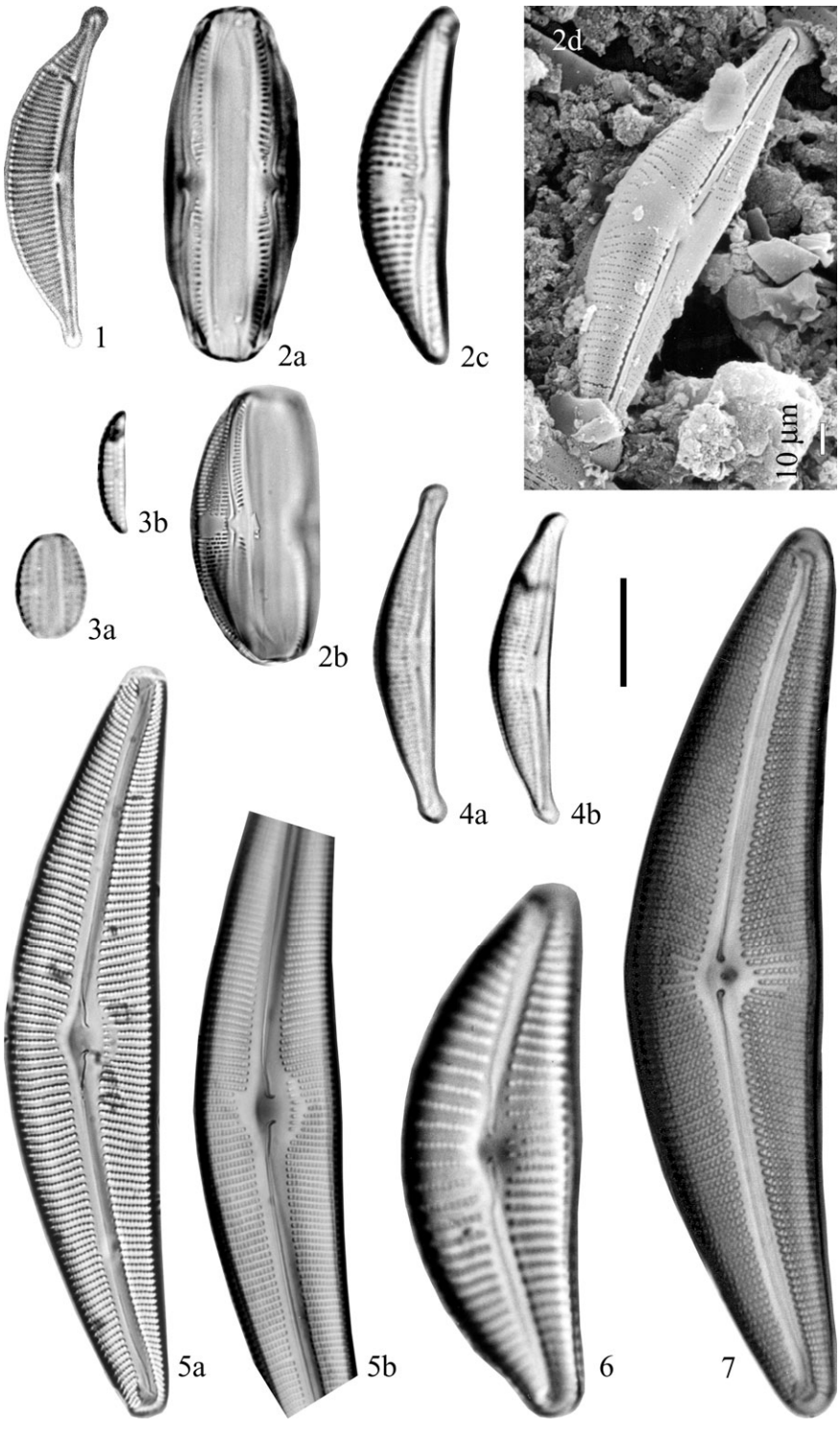

1
2a
2c
2d
10 µm
3b
3a
2b
4a
4b
5a
5b
6
7

Plate 13

Scale bar = 10 μm.
1) *Cymbella mexicana* (Ehrenberg) Cleve. Scale bar = 25 μm.
2a-c) *Cymbopleura chacii* sp. nov. 2a: Holotype.
3a-c) *Cymbopleura hustedtii* (Krasske) comb. nov.
4a-h) *Encyonema densistriata* sp. nov. 4b: Holotype.

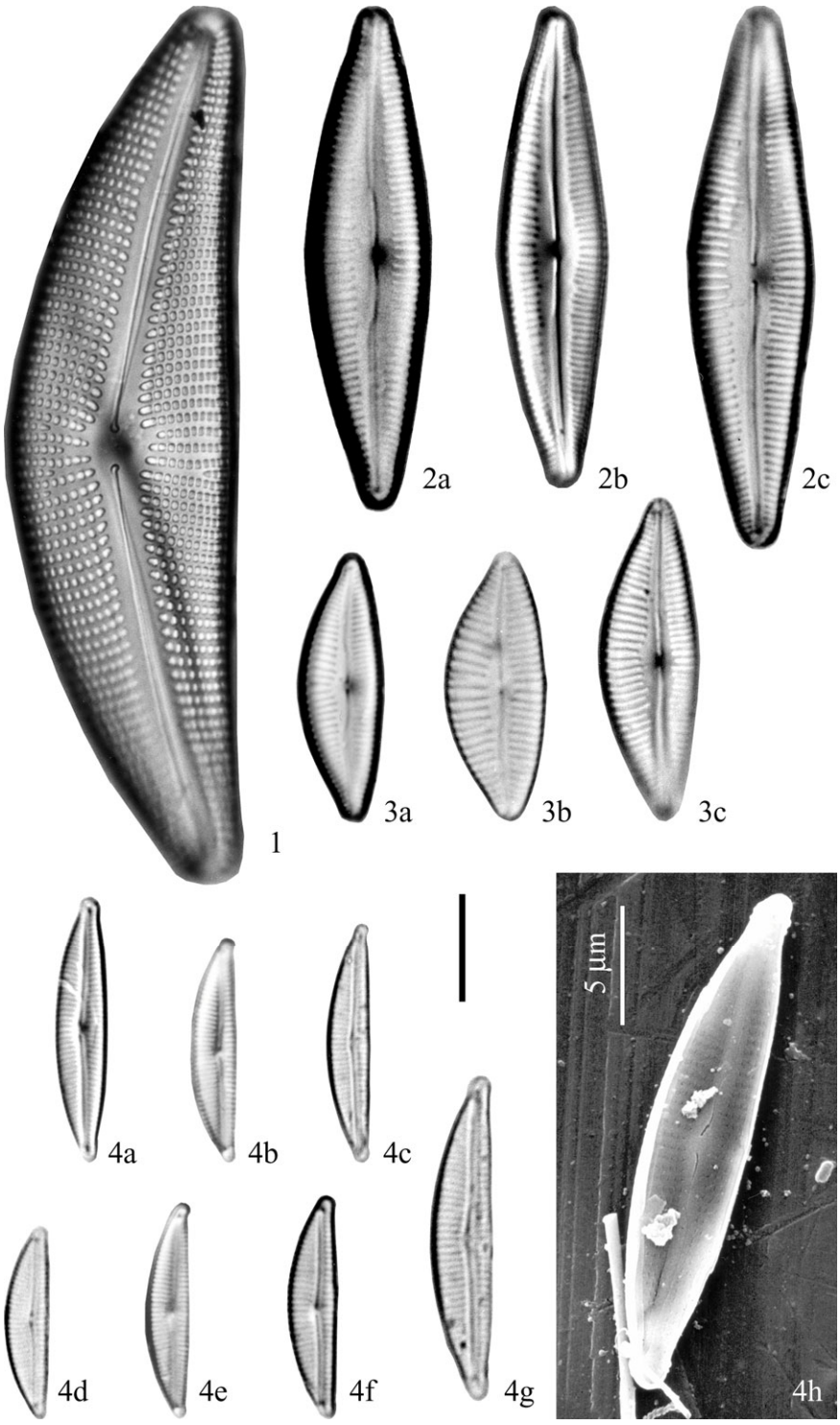

1
2a
2b
2c
3a
3b
3c
4a
4b
4c
4d
4e
4f
4g
5 µm
4h

Plate 14

Scale bar = 10 μm.

1a-b) *Encyonema mesianum* (Cholnoky) D.G. Mann.
2a-b) *Encyonema mexicanum* Krammer.
3a-c) *Encyonema neogracile* Krammer.
4a-b) *Encyonema silesiacum* (Bleisch) D.G. Mann.
5a-b) *Encyonopsis cesatii* (Rabenhorst) Krammer.
6a-b) *Encyonopsis microcephala* (Grunow) Krammer.

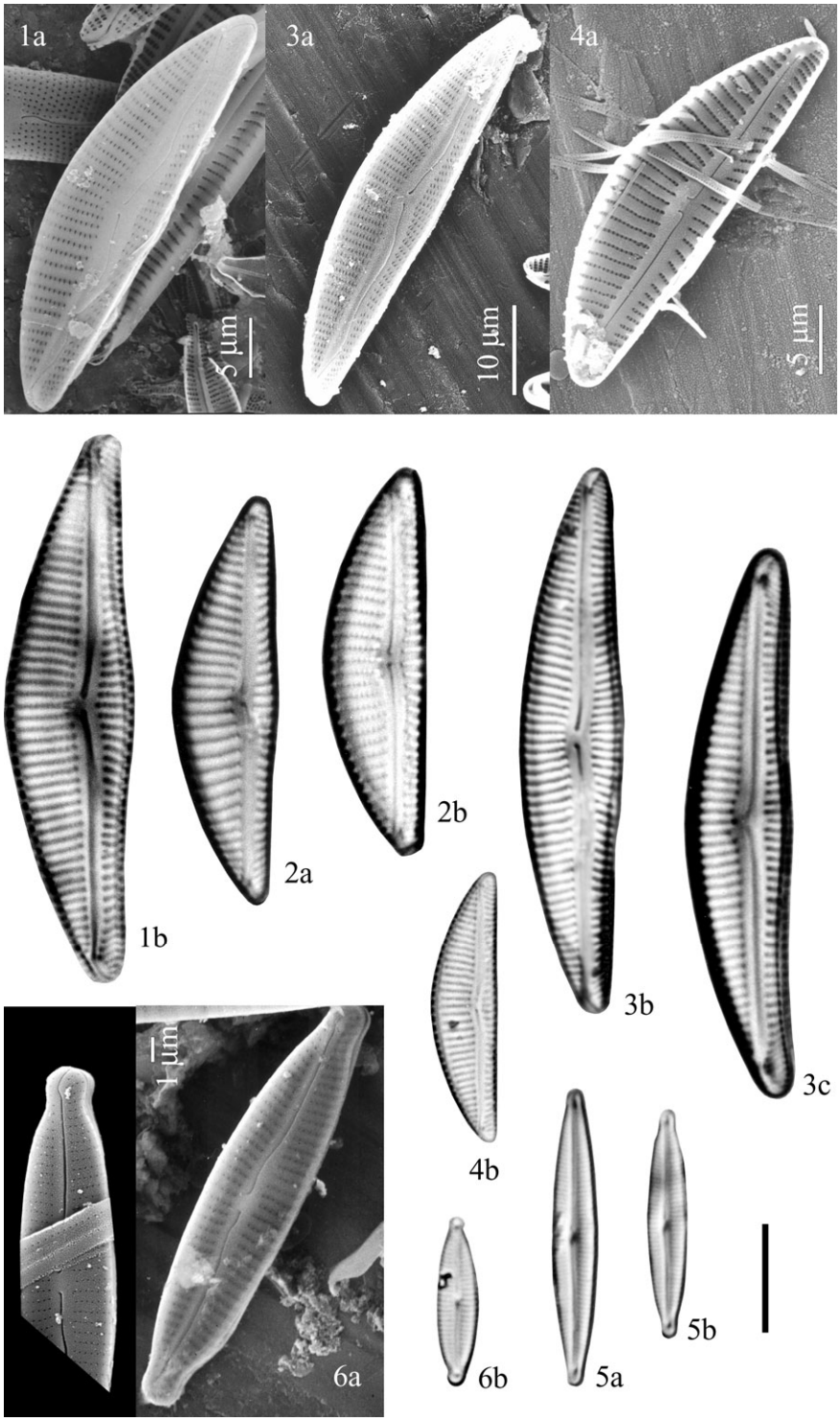

1a
3a
4a
5 µm
10 µm
5 µm
1b
2a
2b
3b
3c
4b
1 µm
6a
6b
5a
5b

Plate 15

Scale bar = 10 μm.

1a-c) *Encyonopsis ruttneri* (Hustedt) Krammer.
2) *Reimeria sinuata* (Gregory) Kociolek et Stoermer.
3) *Gomphonema acuminatum* Ehrenberg.
4a-b) *Gomphonema affine* Kützing.
5a-c) *Gomphonema gracile* Ehrenberg.
6) *Gomphonema parvulum* Kützing.
7a-b) *Gomphonema truncatum* Ehrenberg.

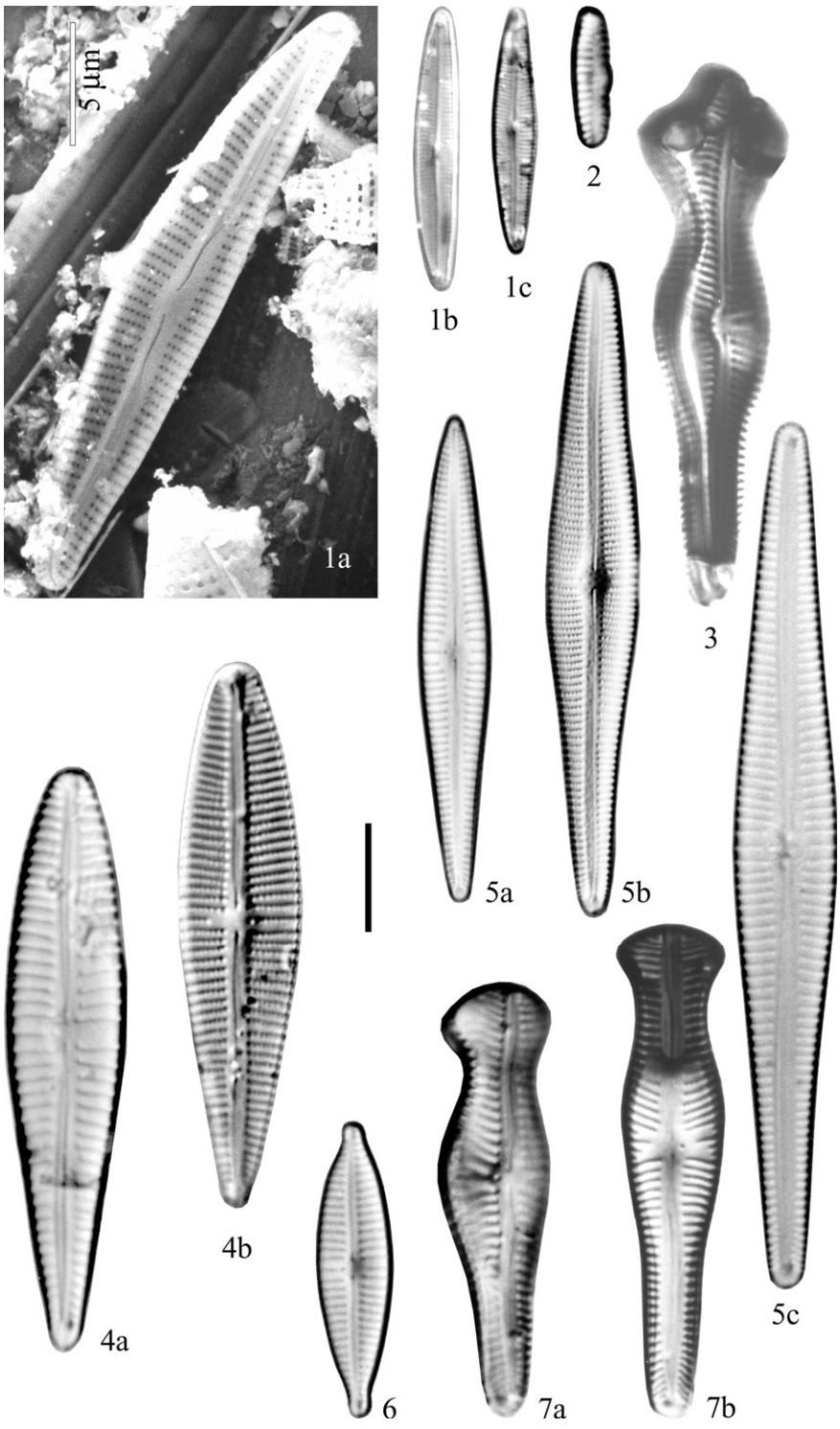

5 µm
1a
1b
1c
2
3
4a
4b
5a
5b
5c
6
7a
7b

Plate 16

Scale bar = 10 μm.

1a-c) *Gomphonema vibrioides* E. Reichardt et Lange-Bertalot.
2) *Gomphonema* sp.
3a-b) *Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot. 3b: Girdle view.
4) *Hantzschia amphioxys* (Ehrenberg) Grunow.
5a-b) *Hantzschia vivax* (W. Smith) Grunow. 5b: Scale bar = 20 μm.
6a-c) *Nitzschia amphibia* Grunow. 6a: Internal view.

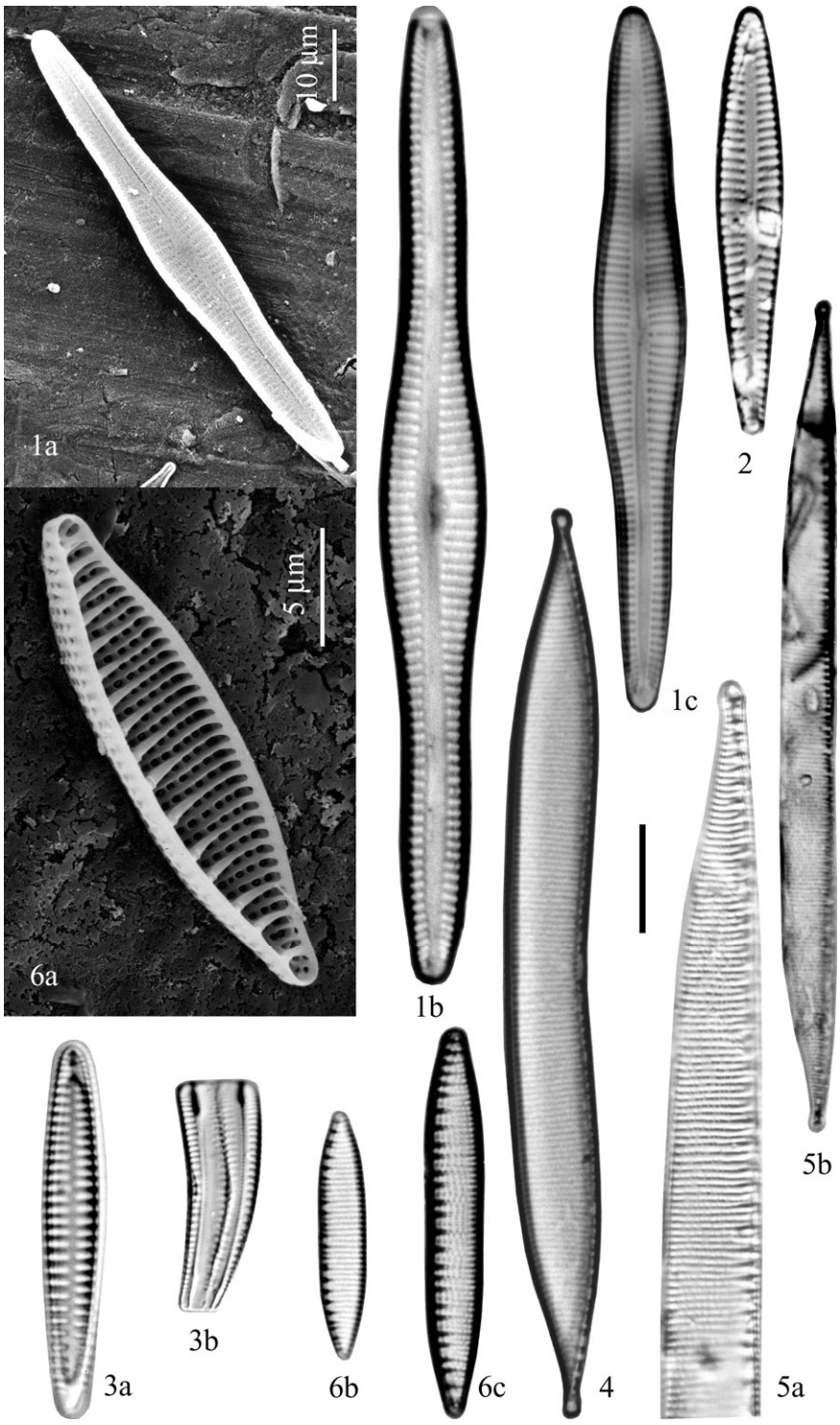

10 µm
1a
5 µm
6a
1b
1c
2
5b
3a
3b
6b
6c
4
5a

Plate 17

Scale bar = 10 μm.

1) *Nitzschia communis* Rabenhorst.
2) *Nitzschia dissipata* (Kützing) Rabenhorst.
3a-c) *Nitzschia frustulum* (Kützing) Grunow. 3c: Girdle view.
4a-b) *Nitzschia gracilis* Hantzsch.
5a-b) *Nitzschia inconspicua* Grunow. 5b: Girdle view.
6) *Nitzschia intermedia* Hantzsch.
7) *Nitzschia lacunarum* Hustedt.

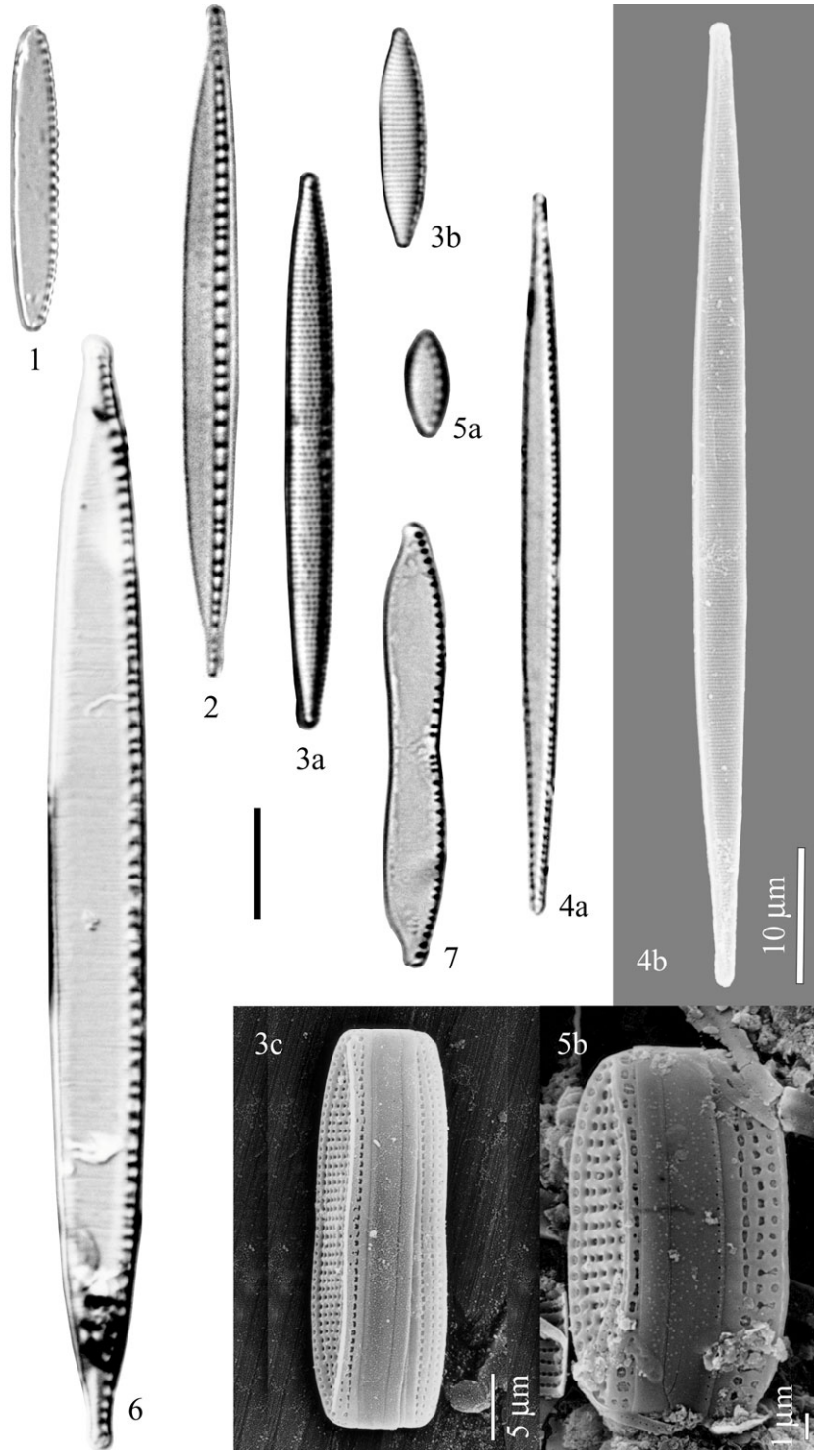

1
2
3a
3b
5a
4a
4b
10 µm
6
7
3c
5 µm
5b
1 µm

Plate 18

Scale bar = 10 μm.

1) *Nitzschia linearis* W. Smith.
2) *Nitzschia nana* Grunow.
3) *Nitzschia palea* (Kützing) W. Smith.
4) *Nitzschia palustris* Hustedt.
5a-b) *Nitzschia scalaris* (Ehrenberg) W. Smith. 5a: Scale bar = 25 μm. 5b: Scale bar = 20 μm.
6) *Nitzschia sigma* (Kützing) W. Smith.
7) *Nitzschia sinuata* var. *delognei* (Grunow) Lange-Bertalot.
8) *Nitzschia umbonata* (Ehrenberg) Lange-Bertalot.
9) *Nitzschia vitrea* Norman.

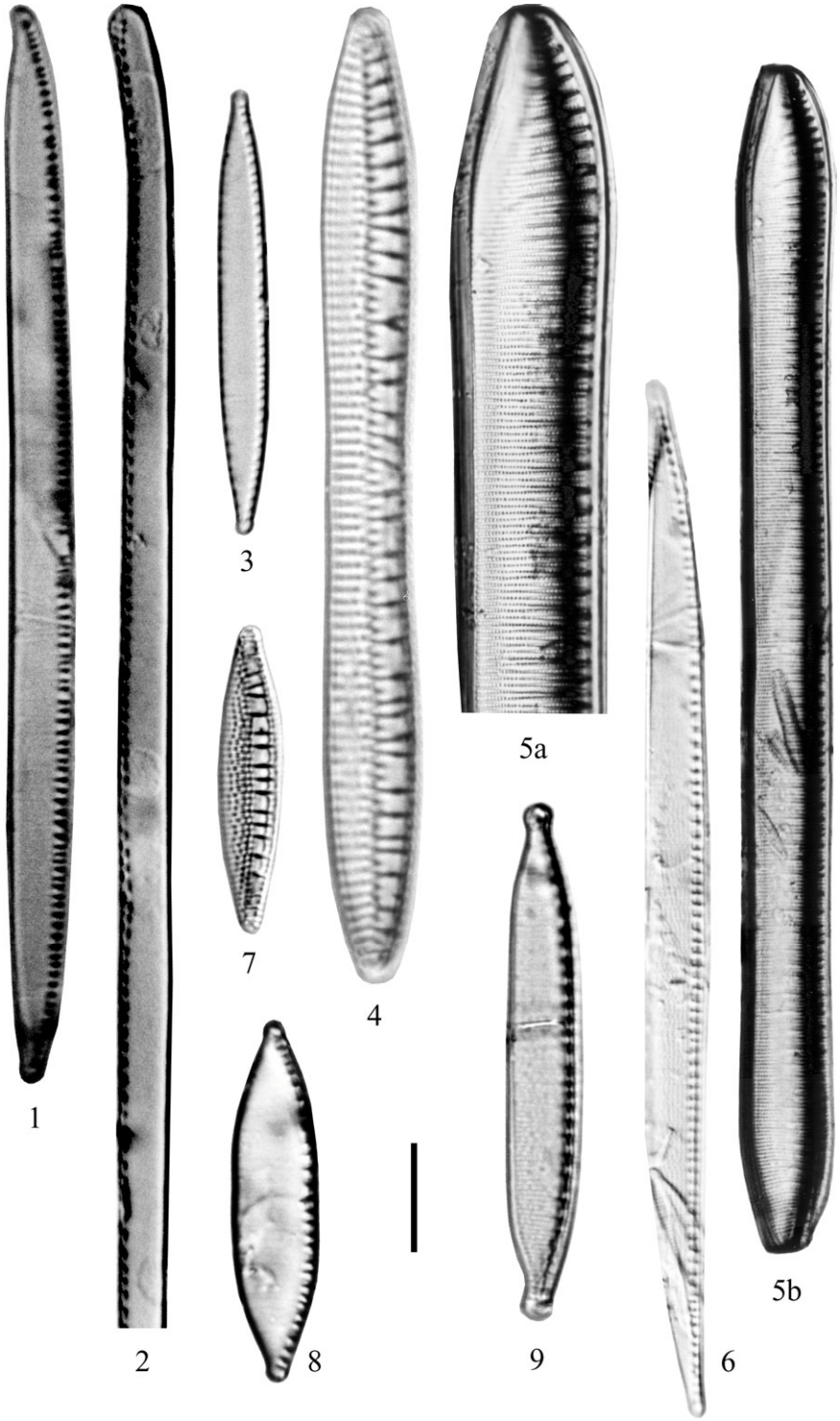

1
2
3
4
5a
5b
6
7
8
9

Plate 19

Scale bar = 10 μm.

1a-d) *Nitzschia yalahau* sp. nov. 1a: Holotype.
2) *Tryblionella hungarica* (Grunow) Frenguelli.
3a-b) *Denticula kuetzingii* Grunow. 3a: Focus in costae.
4a-b) *Denticula valida* (Pedicino) Grunow. 4a: Focus in costae; 4b: Girdle view.
5) *Epithemia argus* (Ehrenberg) Kützing.
6) *Epithemia sorex* Kützing.
7) *Epithemia turgida* (Ehrenberg) Kützing.

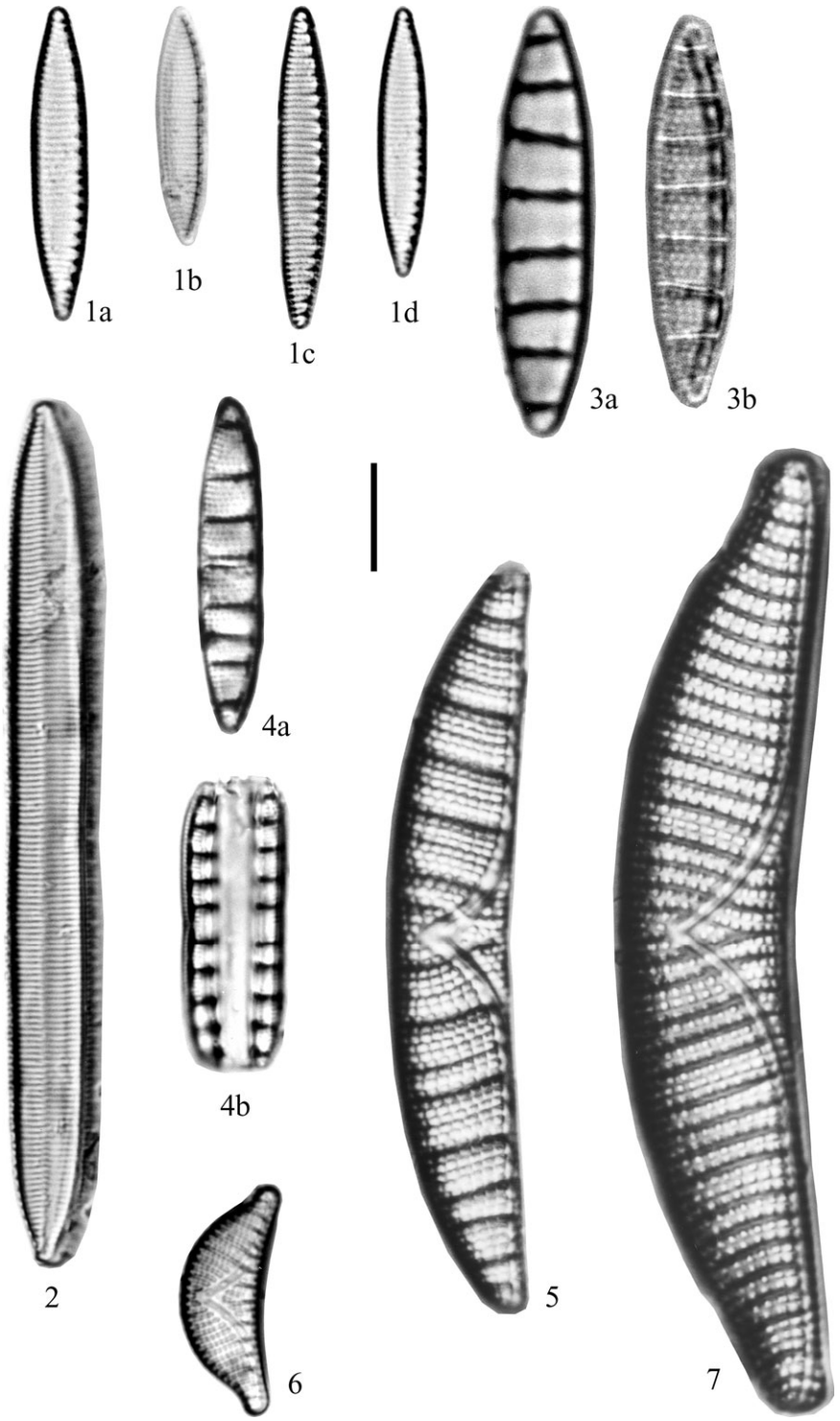
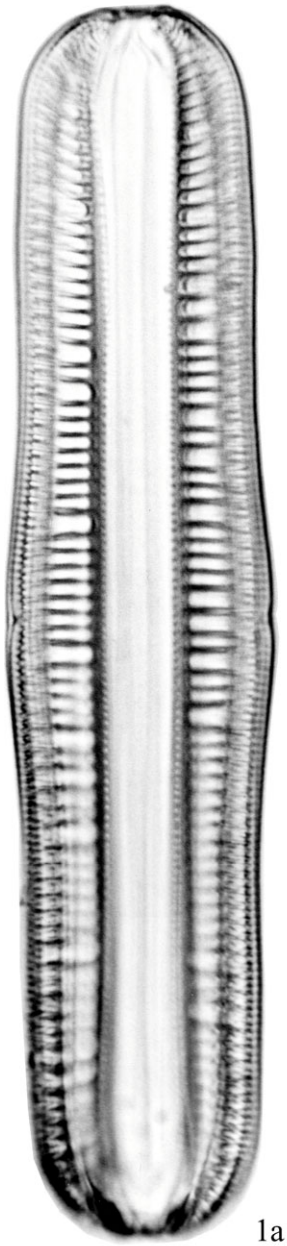
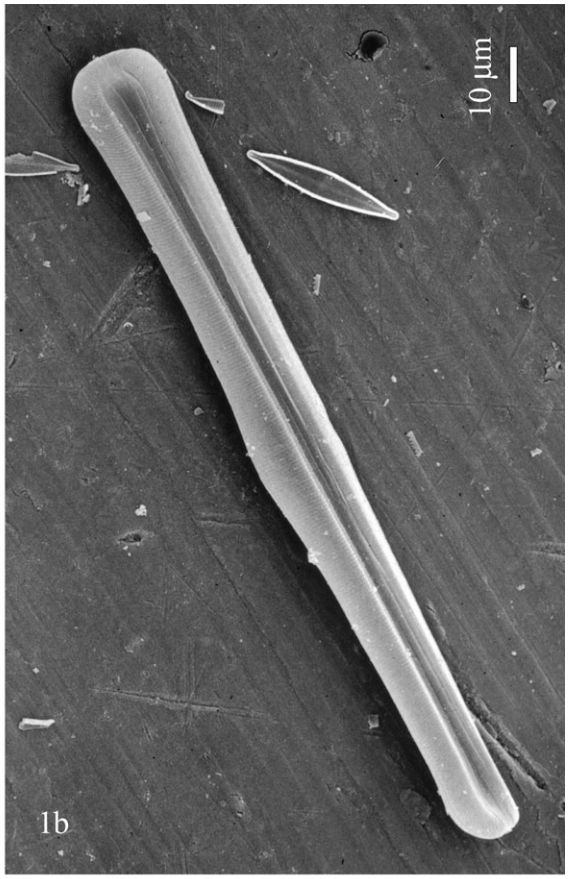

1a
1b
1c
1d
3a
3b
2
4a
4b
5
6
7

Plate 20

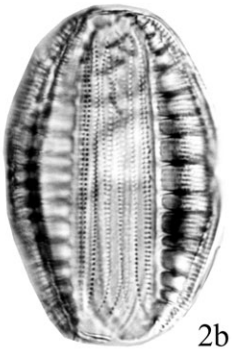
Scale bar = 10 μm.
1a-b) *Rhopalodia gibba* (Ehrenberg) O. Müller. 1a: Scale bar = 20 μm.
2a-b) *Rhopalodia musculus* (Kützing) O. Müller.



1a



2a

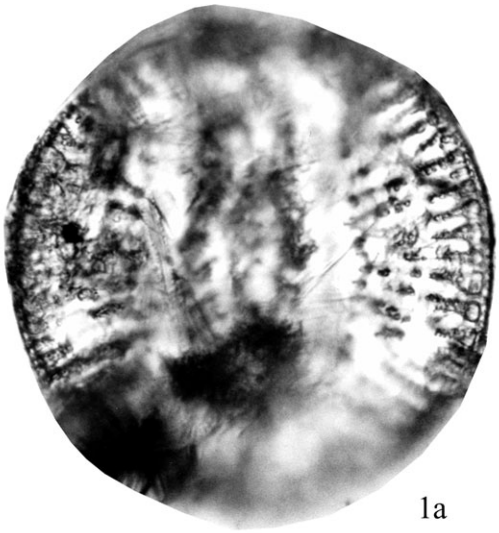


2b

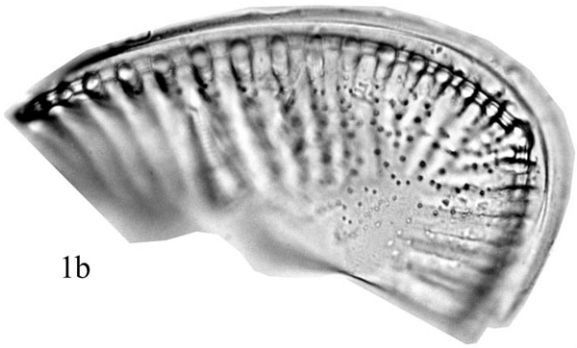
Plate 21

Scale bar = 20 μm.

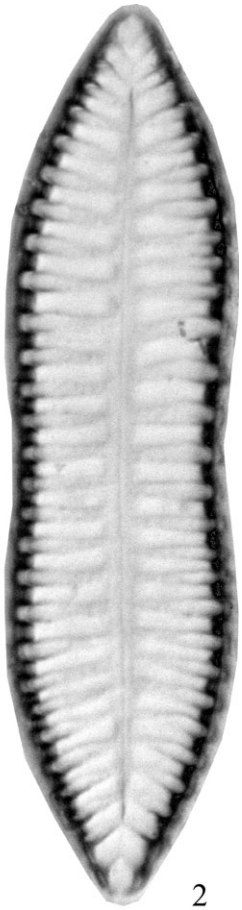
1a-b) *Campylodiscus hibernicus* Ehrenberg.
2) *Surirella biseriata* Brébisson.
3) *Surirella brebissonii* Krammer et Lange-Bertalot.
4) *Surirella tenera* W. Gregory.



1a



1b



2

3

4

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