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Diatoms in the fish rearing center in Temascal, Oaxaca, Mexico

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RESUMEN

Considerando la importancia y la falta de estudios sobre diatomeas de agua dulce en México, este trabajo constituye una contribución al conocimiento de este grupo, particularmente en cuanto a su composición taxonómica, distribución y abundancia en los estanques del Centro Piscícola de Temascal, Oaxaca, México. Para la realización de este estudio se muestrearon 14 estanques y dos canales (uno surtidor y otro de desagüe) en marzo de 1991. Se obtuvieron 41 muestras que incluyen plancton recolectado con una red estandar de 54 μm de malla y con una botella van Dorn, así como formas bénticas recolectadas con espatulas o con sifones. Las diatomeas fueron limpiadas y montadas en resina Naphrax. La abundancia relativa y la frecuencia se obtuvieron evaluando todos los organismos presentes en un ml de muestra original por triplicado. Se determinaron 31 especies y variedades de diatomeas pertenecientes a siete familias. El 98% correspondió al Orden Pennales y el 2% al Orden Centrales. Las especies más frecuentes y abundantes fueron: *Synedra acus* var. *acus* , *S. ulna* var. *ulna*, *Cymbella microcephala* var. *microcephala*, *C. tumida* var. *tumida*, *Diploneis puella* var. *puella*, *Gomphonema affine* var *affine*, *G . angustatum* var. *angustatum*, *G. clavatum*, *Navicula notha* var. *notha* y *Pinnularia acrosphaeria* var. *acrosphaeria*.

Palabras clave: Diatomeas, centro piscícola, Papaloapan, Temascal, Oaxaca, México.

ABSTRACT

Considering the importance and lack of studies of freshwater diatoms in Mexico, this research is a contribution to the knowledge of this group, particularly with respect to its taxonomic composition, distribution and abundance in the fish rearing ponds in Temascal, Oaxaca, Mexico. Samples from 14 ponds and two channels (one is a supply channel and the other is for draining) were taken in March, 1991. On the whole, 41 samples were obtained which included plankton collected with a 54 μm mesh standard net and a van Dorn bottle, and benthic forms collected with a spatula or a siphon. The diatoms were cleaned and mounted in Naphrax resin. Relative abundance and frequency were computed counting all the organisms present in one ml of the original sample, three times. A total of 31 species and varieties of seven families were identified, of which 98% belong to the Pennales Order and 2% to the Centrales Order. The most frequent and abundant species were: fueron *Synedra acus* var. *acus* , *S. ulna* var. *ulna*, *Cymbella microcephala* var. *microcephala*, *C. tumida* var. *tumida*, *Diploneis puella* var. *puella*, *Gomphonema affine* var. *affine*, *G . angustatum* var. *angustatum*, *G. clavatum*, *Navicula notha* var. *notha* y *Pinnularia acrosphaeria* var. *acrosphaeria*.

Key words: Diatoms, fish rearing center, Papaloapan, Temascal, Oaxaca, Mexico.

INTRODUCTION

The diatom group consists of a large number of trully planktonic and benthic species, which are widely distributed in all aquatic systems. In Mexico, studies have been carried out on their taxonomy (Ehrenberg, 1838, 1841, 1854, 1869; Wolle, 1890; Martínez-Gracida, 1891; Cleve, 1894), paleontology (Díaz-Lozano, 1917, 1937; Bradbury, 1971), floristic (Martínez-Guerrero, 1970; Mendoza-González, 1973; Hernández and Alvarez, 1983), and ecology (Osorio-Tafall, 1941a to b,1944; Peláez, 1947; Rioja and Herrera, 1951; Deevey, 1957; Murguía-Vaca, 1965).

Diatoms form an important part of the algal community in the Temascal region, as has been revealed by previous studies (Delgadillo, 1980; Figueroa, 1985; Moreno, 1985). There are no records for the fish rearing center so, this research is a contribution to the knowledge of their taxonomic composition, distribution and abundance in the ponds of the fish rearing center of Temascal, Oaxaca.

STUDY AREA

The fish rearing center of Temascal is located in the Papaloapan River basin, between 18° 29´N and 96° 23´ W (Fig. 1).

The climate in this region is subhumid. Annual precipitation in the whole region is 1, 300 to 3, 000 mm. The mean annual temperature fluctuates from 18 to 40 °C (Mosiño, 1977).

The study area comprises 14 ponds and two channels, a supply channel and a draining channel (Fig. 2).

MATERIAL AND METHODS

A total of 41 samples from 14 ponds and two channels were collecte in March 1991 (Fig. 2). On the whole, samples included plankton collected with a 54 μm mesh standard net and a van Dorn bottle, and benthos collected with a spatula or a siphon.

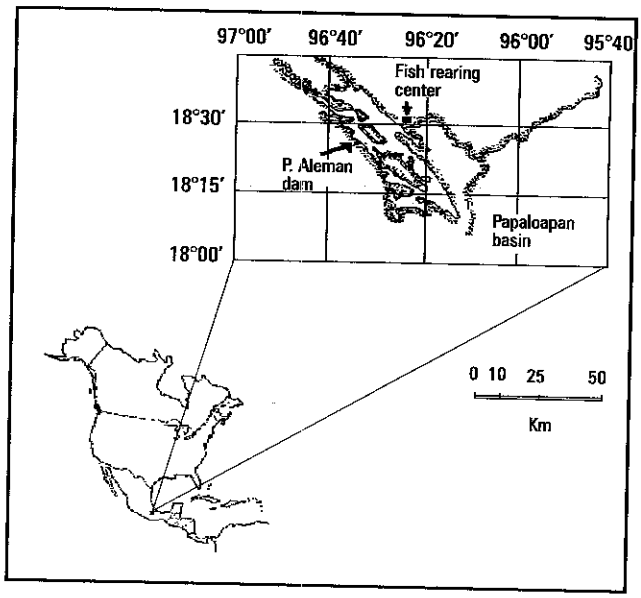

Figure 1. Location of the fish rearing center of Temascal, Oaxaca, Mexico.

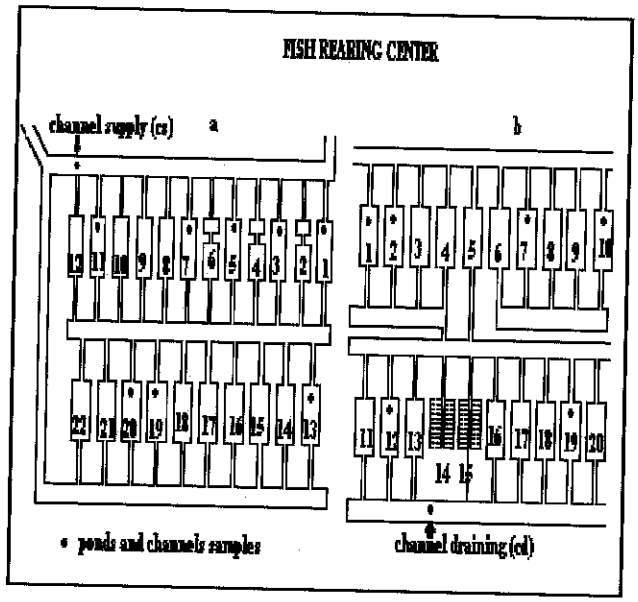

Figure 2. Location of sampling stations where diatom species were found in the Temascal fish rearing center.

The net and benthos samples were preserved in 4% formalin and the bottle samples in 1:100 acetate-lugol.

All samples were rinsed and observations of diatoms were made with a Zeiss phase contrast bright field light microscope.

One millilitre of each sample was cleaned using Simonsen (1974) technique and mounted in Naphrax resin (i. r. 1.7).

Relative abundance was computed counting all organisms present in one ml of the original sample, by triplicate in accordance with Franco-López *et al.* (1985) (Tab. 1).

Drawings were made for each group, and photomicrographs were taken in some cases. The material has been deposited in the collection of the Universidad Autonoma Metropolitana Unidad Xochimilco under the registration of FMAD (Ficoflora Mexicana de Agua Dulce) including field data.

RESULTS

Thirty-one species and varieties were found in the samples. Systematic arrangement follows Simonsen (1979). The literature used for identification is included for each species and synonymies are given. Measurements are given in μm. Information on geographical and ecological distribution of species was gathered from Foged (1959),

Table 1. Study sites in the fish rearing center.

Ponds	Day	Hours	Temp. (° C)	pH	Samples characteristics
1a	13/03/91	08:30	27.0	7.5	Water with olive-green skim.
3a	13/03/91	08.45	26.0	7.0	Water with brown-green skim.
5a	13/03/91	09:30	26.0	7.0	Water with brown-yellow skim, associate with abundant fish excrement.
7a	13/03/91	09:40	31.0	8.0	Water with floating brown mass.
11a	13/03/91	10:05	31.0	7.5	Water with floating brown mass.
13a	15/03/91	15:30	28.0	7.0	Green-lemon skim, turbid water, with organic matter.
19a	15/03/91	17:22	31.0	7.0	Olive-green turbid water, with fish aliment.
20a	15/03/91	17:15	30.0	7.0	Water with brown mass.
cs	15/03/91	13.00	28.0	6.5	Transparent water with few and small brown mass.
1b	15/03/91	10:14	28.0	7.0	Transparent water, with few organic matter.
2b	15/03/91	19.05	30.5	7.0	Green turbid water.
7b	15/03/91	10:46	31.0	7.0	Water with white spume.
10b	15/03/91	11:00	31.5	7.0	Green-lemon water.
12b	15/03/91	11:20	31.0	7.0	Green-lemon water.
19b	15/03/91	11:40	31.0	7.0	Green-lemon water.
cd	15/03/91	12:00	32.0	7.0	Transparent water.

Patrick and Reimer (1966, 1975), Ortega (1984), Maidana (1985) , Ibarra (1992), Tavera *et al.*, (1994), Novelo (1998) and this study (Tab.1). Frequency and abundance are expresed as percentages (Tab. 2).

Order Centrales
Family Thalassiosiraceae

Cyclotella stelligera (Cleve *et* Grunow) van Heurck Pl 1, fig 1.

Maidana, 1985, p. 44, pl. 1, fig. 11; Moreno, 1985, pl. 2, fig. 5.

Measurements: length 10 to 14 μm, alveoles 12 in 10 μm.

Distribution: Geographical.- cosmopolitan. Ecological.- circumneutral pH waters and temperature between 26 and 32° C; planktic and benthic organisms.

Ponds: 1a, 3a, 20a, cd, 7b, 10b.

Order Pennales
Family Diatomaceae

Opephora martyi Héribaud var. ***martyi*** in Patrick and Reimer, 1966 Pl. 3, fig. 1.

Bourrelly *et* Manguin , 1952, p. 40; Hustedt, 1959, p. 135, fig. 654; Patrick and Reimer, 1966, p. 115, pl. 3, fig. 3; Moreno, 1985, pl. 3, fig. 12.

Measurements: length 9 to 12 μm, width 4.5 to 6 μm, striae 7 to 10 in 10 μm

Distribution: Geographical.- cosmopolitan. Ecological.- shallow fresh and brackish waters, circummneutral pH and temperature from 28 to 32° C, mesotrophic to eutrophic water; planktic in lakes, dams, ponds and rivers. Ponds: 13a, 1b, 10b.

Synedra acus Kützing var. ***acus*** in Patrick and Reimer, 1966 Pl. 1, fig. 2.

Patrick and Reimer, 1966, p. 135, lám 5, fig. 1; Cuesta, 1993, p. 64, pl.3, fig. 18; Novelo, 1998, p. 296, fig. 193.

= *¿Synedra delicatissima* W. Smith 185; *Fragilaria ulna* var. *acus* (Kützing) Lange-Bertalot, 1980 in Lange-Bertalot, 1980.

Measurements: length 101 to 116 μm, width 4 to 7 μm, striae 10 to 11 in 10 μm.

The valve is slightly constricted in the middle portion, with tapering apex.

Distribution: Geographical.- USA, Mexico, central Europe, France, Spain, Poland. Ecological.- a widely distributed species, seems to prefer circumneutral water and water which does not have a very low conductivity; more often found in water of medium hardness, in temperature from 26 to 32°C. Planktic in lakes, springs, ponds, channels, and pools.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Synedra ulna (Nitzch) Ehrenberg Lange-Bertalot var. ***ulna*** in Patrick and Reimer, 1966. Pl 1, fig. 3.

Van Heurck, 1896, p. 310, pl. 10, fig. 409; Patrick and Reimer, 1966, p. 148, pl. 7, figs. 1-2; Lange-Bertalot, 1980, p. 745, pl. 8, figs. 185 to 196; Maidana, 1985, p. 57, pl. 2, fig. 5 and pl. 24, figs 1 to 3 (*Fragilaria ulna* var. *ulna*); Moreno, 1985, pl. 4, fig. 2; Tavera *et al.*, 1994, p. 43, pl. 1, fig. 7d; Novelo, 1998, p. 298, fig. 196.

= *Bacillaria ulna* Nitzsch 1817; *Frustulia splendens* Kützing, 1844; *Synedra bicurvata* Beine ex Rabenhorst 1862; *Synedra lanceolata* Kützing 1844; *Synedra splendens*

Table 2.- Relative abundance and frequency of diatoms in the fish rearing center.

	abund. (%) plankton net	benthos bottle	abund. (%) wall	depth	X_{med}	freq. (%)
Cyclotella stelligera	1.0	0.3	0.7	0.5	0.6	38
Opephora martyi var. *martyi*	0.1	0.0	0.2	0.0	0.1	19
Synedra acus var. *acus*	7.5	19.4	14.0	9.5	**12.6**	**100**
Synedra ulna var. *ulna*	9.4	15.0	10.2	8.5	**10.8**	**100**
Eunotia maior var. *maior*	3.0	0.9	6.0	10.0	**5.0**	**69**
Achnanthes exigua var. *exigua*	1.0	1.3	0.0	0.0	0.6	19
Cocconeis placentula var. *euglypta*	0.5	0.0	0.8	0.2	0.4	38
Cocconeis placentula var. *Placentula*	2.6	0.3	0.0	0.5	0.9	**56**
Capartogramma crucicula var. *crucicula*	1.0	3.0	0.0	1.0	1.3	31
Cymbella cistula var. *gibbosa*	0.0	0.0	0.0	1.6	0.4	19
Cymbella microcephala var. *Microcephala*	12.5	10.2	8.5	9.2	**10.1**	**100**
Cymbella minuta var. *pseudogracilis*	2.3	0.8	1.8	1.8	1.7	**88**
Cymbella minuta var. *silesiaca*	1.5	1.2	0.3	1.2	1.0	25
Cymbella tumida var. *tumida*	5.5	2.4	5.5	5.8	4.8	**100**
Diploneis puella var. *puella*	1.0	0.4	0.5	1.0	0.7	31
Gomphonema acuminatum var. *acuminatum*	1.5	0.0	0.0	0.0	0.4	25
Gomphonema affine var. *affine*	3.5	4.0	5.0	3.4	4.0	**100**
Gomphonema angustatum var. *angustatum*	9.6	11.3	10.5	10.2	**10.4**	**100**
Gomphonema clavatum	5.5	5.6	5.5	3.4	**5.0**	**100**
Gomphonema gracile var. *gracile*	0.8	0.8	1.8	2.3	1.4	**88**
Gomphonema parvulum var. *parvulum*	0.5	0.6	0.5	0.2	0.5	**56**
Navicula exigua	1.0	0.8	0.5	0.0	0.5	13
Navicula notha var.*notha*	4.4	6.4	6.0	3.4	**5.0**	**100**
Navicula pupula var. *pupula*	1.0	2.0	2.1	1.0	1.5	38
Navicula rhyncocephala var. *Amphiceros*	1.0	0.0	0.3	1.1	0.6	**81**
Navicula sp.1	6.4	2.0	3.0	5.9	4.3	**94**
Pinnularia abaujensis var. *rostrata*	4.2	1.8	6.0	5.5	4.4	**75**
Pinnularia abaujensis var. *subundulata*	4.1	0.6	4.0	6.1	3.7	**62**
Pinnularia acrosphaeria var. *acrosphaeria*	5.8	6.9	4.5	6.0	5.8	**100**
Rhopalodia sp.	1.0	0.5	0.8	0.5	0.7	25
Nitzschia sp.	0.8	1.5	1.0	0.4	0.9	37
	100	100	100	100	100	

Kütz. 1844; *Synedra ulna* (Nitz.) Ehr.; *Synedra ulna* var. *lanceolata* Grunow 1892; *Synedra ulna* var. *splendens* (Kütz.) v. Heurck 1885; *Fragilaria ulna* (Ehrenberg) Lange-Bertalot 1980 in Lange-Bertalot, 1980.

Measurements: length 110 to 245 μm, width 6.5 to 10 μm, striae 9 to 11 in 10 μm.

Distribution: Geographical.- cosmopolitan. Ecological.- widely distributed in freshwater, circumneutral pH, most frequently in eutrophic water and temperature from 26 to 32 °C. In waterfalls, streams, ponds and drip walls; planktic and benthic organisms.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Family Eunotiaceae

Eunotia maior (W. Smith) Rabenhort var. ***maior*** in Patrick and Reimer, 1966. Pl 1, fig. 4.

Van Heurck, 1896, p.300, pl. 9, fig. 366; Patrick and Reimer, 1966, p. 196, pl. 11, fig. 5; Moreno, 1985, pl. 4, fig. 8 (non *E. arcus* var. *falax*).

Measurements: length 90 to 146 μm, width 7 to 10 μm, striae 7 to 12 in 10 μm around the center.

Distribution: Geographical.- USA, Mexico, Belgium, England, Scotland, Ireland. Ecological.- seems to prefer circumneutral pH water, with low mineral content, temperature from 26 to 30.5 °C. Planktic and benthic, found in swamps, lakes, ponds and flowing waters.

Ponds: 1a, 3a, 7a, 11a, 19a, 20a, cs, 2b, 7b, 10b, 19b.

Family Achnanthaceae

Achnanthes exigua Grunow var. ***exigua*** in Patrick and Reimer, 1966. Pl. 1, fig. 5.

Patrick and Reimer, 1966, p. 257, pl. 16, figs. 21 to 22; Maidana, 1985, p. 82, pl. 5, fig. 6; Cuesta, 1993, p. 67, pl. 4, fig. 22a to 22b; Tavera *et al.*, 1994, p. 46, pl. 2, fig. 12; Novelo, 1998, p. 305, fig. 199.

Measurements: length 10 to 13 μm, width 5 to 6 μm, striae 20 to 22 in 10 μm in rapheless valves.

Distribution: Geographical.- cosmopolitan. Ecological.- neutral to alkaline waters; eurytherma (mainly in hot waters), in this study from 26 to 28 °C, and euryphotic. Planktic and benthic in waterfalls, lakes, rivers, springs, channels, streams, driping rocks and aquarium tanks.

Ponds: 1a, 3a, cs.

Cocconeis placentula var. ***euglypta*** (Ehrenberg) Cleve Pl. 1, fig. 6.

Osorio-Tafall, 1941a, p. 353. Pl. 30, fig. 26; Patrick and Reimer, 1966, p. 241, pl. 15, fig. 8; Maidana, 1985, p. 96, pl. 5, fig. 25, pl. 28, figs. 1 to 2; Moreno, 1985, pl. 4, fig. 14; Tavera *et al.*, 1994, p. 47, pl. 2, figs. 16 a to c; Novelo, 1998, p. 315, fig. 210.

= *Cocconeis euglypta* Ehrenberg 1854 in Patrick and Reimer, 1966.

Measurements: length 14 to 25 μm, width 8 to 15 μm, striae 15 to 21 in 10 μm in raphe valves and 17-22 in 10 μm in rapheless valves.

Distribution: Geographical.- cosmopolitan. Ecological.- halobionte indifferent, alkalibionte, in temperature from 26 to 32° C. Common in lakes, dams, rivers, waterfalls, streams, ponds, channels, pools, flowing and stagnant waters; specially as planktic, epiphyte on filamentous and benthic algae.

Ponds: 1a, 3a, 7a, 11a, cs, 7b.

Cocconeis placentula Ehrenberg var. ***placentula*** in Patrick and Reimer, 1966 . Pl. 3, fig. 2.

Van Heurck, 1896, p. 288, pl. 8, fig. 341; Patrick and Reimer, 1966, p. 240, pl. 15, fig. 7; Maidana, 1985, p. 94, pl. 5, figs. 24 and 26; pl. 28, fig. 3; Moreno, 1985, pl. 4, fig. 13; Novelo, 1998, p. 314, fig. 209.

Measurements: length 21.5 to 34 μm, width 14.5 to 20 μm, striae 20 to 24 in raphe valve, striae 19 to 26 in 10 μm in rapheless valves, pores 16 to 18 in 10μm.

Distribution: Geographical.- cosmopolitan. Ecological.- common everywhere, fresh and slightly brackish waters, circumneutral pH waters and temperature from 26 to 32°C. Planktic and epiphytic, in rivers, ponds and springs.

Ponds: 5a, 11a, 13a, 19a, 20a, cd, 2b, 7b, 10b, 19b.

Family Naviculaceae

Capartogramma crucicula (Grunow ex Cleve) Ross var. ***crucicula*** in Patrick and Reimer, 1966. Pl. 2, fig. 1.

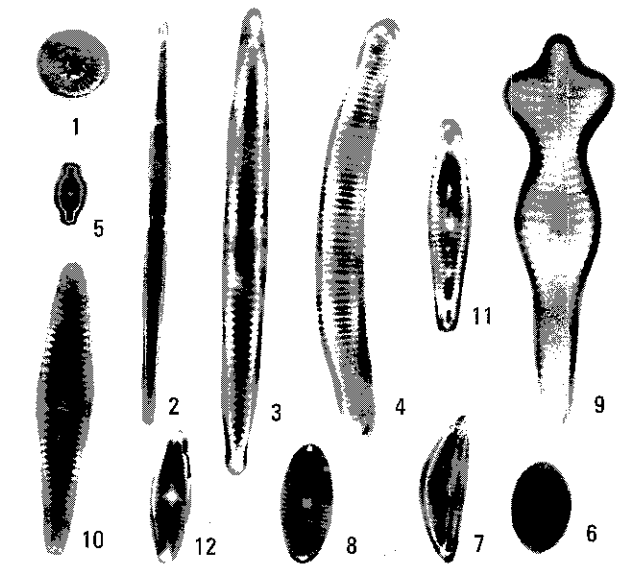

Plate 1

Fig.1. *Cyclotella stelligera;* Fig. 2. *Synedra acus* var. *acus;* Fig.3 *Synedra ulna* var. *ulna*; Fig. 4. *Eunotia maior* var. *maior;* Fig. 5. *Achnantes exigua* var *exigua;* Fig.6. *Cocconeis placentula* var. *euglypta;* Fig. 7. *Cymbella minuta* var. *silesiaca;* Fig. 8. *Diploneis puella* var. *puella*; Fig. 9. *Gomphonema acuminatum* var. *acuminatum;* Fig. 10. *Gomphonema affine* var. *affine;* Fig. 11. *Gomphonema clavatum;* Fig. 12. *Navicula pupula* var. *pupula.*

Patrick and Reimer, 1966, p. 372, pl. 30, fig. 16; Maidana, 1985, p. 105, pl. 6. fig. 11; Moreno, 1985, pl. 6, fig. 9 (non *Stauronies crucicula).*

= *Stauroneis crucicula* (Grun.) Cleve in Moreno, 1985.

Measurements: length 20 to 30 μm; width 7 to 8.5 μm, striae 22 to 25 in 10 μm.

Distribution: Geographical.- USA, Mexico, Brazil, Uruguay, Argentina, Africa. Ecological.- fresh and brackish waters, circumneutral pH waters, temperature from 26 to 32°C. Planktic and benthic in dams and ponds.

Ponds: 3a, 11a, cs, 2b,cd.

Cymbella cistula var. ***gibbosa*** Brun. Pl. 3, fig. 6.

Patrick and Reimer, 1975, p. 63, pl. 11, figs. 5 to 7.

Measurements: length 58 to 63 μm, width 20 to 27 μm, striae 8 to 10 in 10 μm around the center.

Distribution: Geographical.- Michigan, Genoa. Ecological.- circumneutral pH waters and temperature from 28 to 32°C. Planktic in ponds and lakes.

Ponds: 12b, 19b, cd.

Cymbella microcephala Grunow var. ***microcephala*** in Patrick and Reimer, 1975. Pl. 3, fig. 12.

Patrick and Reimer, 1975, p.33, pl. 4, figs. 12a to 12b; Tavera *et al.*, 1994, p. 54, pl.2, fig. 39; Novelo, 1998, p. 400, fig. 300.

Measurements: length 15 to 16 μm, width 3 to 4 μm, striae 16 to 20 in 10 μm around the center, becoming 18 to 22 in 10 μm near the apex.

Distribution: Geographical.- cosmopolitan. Ecological.- pH indifferent, water low to medium conductivity, it seems to be sensitive to eutrophication, in hot waters from 26 to 32 ° C. Planktics in lakes, rivers, streams, channels, ponds; benthic in lakes and lacustrine sediments, epilithic and in well aerated habitats.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Cymbella minuta var. ***pseudogracilis*** (Choln) Reimer comb. nov. in Patrick and Reimer, 1975. Pl. 3, fig. 5.

Patrick and Reimer, 1975, p. 50, pl. 9, figs. 1a to 2b; Maidana, 1985, p. 110, pl. 7, fig. 4; Moreno, 1985, pl. 8, fig. 4.

= *Cymbella turgida* var. *pseudogracilis* Chol. in Maidana, 1985.

Measurements: length 47 to 55 μm, width 9 to 11 μm, striae 8 to 9 in 10 μm.

Distribution: Geographical.- cosmopolitan. Ecological.- acid to moderately alkaline waters, pH from 7 to 8.5, temperature from 26 to 32°C. Planktic in dams and ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19^a, cs, cd, 1b, 7b, 10b, 12b, 19b.

Cymbella minuta var. ***silesiaca*** (Bleisch ex Rabenhort) Reimer comb. nov. in Patrick y Reimer, 1975. Pl. 1, fig. 7.

Patrick and Reimer 1975, p. 49, pl. 8, figs. 7a to 10 b; Moreno, 1985, pl. 8, fig. 2 (*non C. turgida*); Tavera *et al.*, 1994, p. 55, pl. 3, fig. 41.

= *C. silesiaca* Bleisch ex Rabh. 1864; *C. ventricosa* var. *silesiaca* (Bleisch ex Rabh) Cleve Euler ; *C. turgida* are included either in var. *silesiaca* or in var. *pseudogracilis* Gregory 1856 in Patrick and Reimer, 1975.

Measurements: length 24 to 35 μm, width 7 to 9.5 μm.

Distribution: Geographical.- cosmopolitan. Ecological.- euryphotic, pH indifferent, oligohalobe, in oligotrophic to eutrophic waters, temperature from 28 to 32°C. Planktic and benthic in lakes, drip walls, streams, ponds, springs and pools.

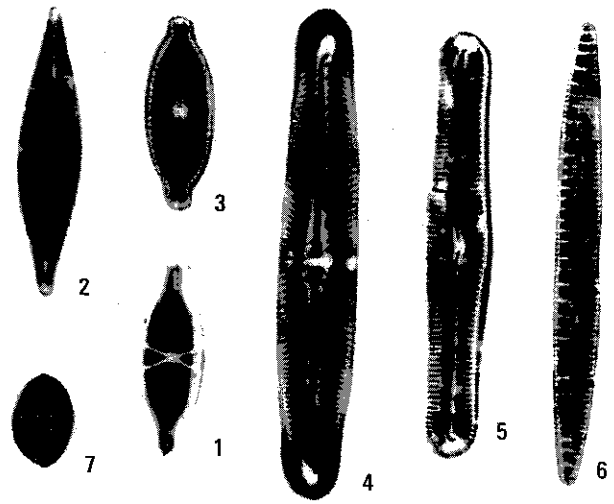

Plate 2

Fig.1. *Capartogramma crucicula* var. *crucicula;* Fig. 2. *Navicula rhynchocephala* var. *amphiceros;* Fig. 3. *Navicula exigua;* Fig. 4. *Pinnularia abaujensis* var. *rostrata;* Fig. 5. *Pinnularia acrophaeria* var. *acrosphaeria;* Fig. 6. *Nitzschia* sp; Fig.7. *Rhopalodia* sp.

Ponds: 7a, 7b, 10b, 19b.

Cymbella tumida (Brébison ex Kützing) van Heurck var. ***tumida*** in Patrick and Reimer, 1975. Pl. 3, fig. 4.

Van Heurck, 1896, p. 148, pl. 1, fig. 42; Patrick and Reimer, 1975, p. 58. pl .10, fig. 8; Moreno, 1985, pl. 8, fig. 8; Maidana,1985, p. 114, pl. 7, fig. 2 and 10.

= *Cocconema tumidum* Breb. ex Kütz. 1849; *Cymbella stomatophora* Grun.; *Cymbella tumida* (Breb. *ex* Kütz.) van Heurck 1880 in Patrick and Reimer, 1975.

Measurements: length 36 to 70 μm, width 9 to 16.5 μm, striae 9 to 10 in 10 μm around the center of the valve, 13 in 10 μm near the apex .

Smaller than reported by Moreno (1985) for adjacent areas (length 80 μm, width 20.5 μm).

Distribution: Geographical.- cosmopolitan. Ecological.- oligohalobe, alcaliphil occasionally, growing on decaying vegetation, present in organically polluted waters, water temperature from 26 to 32 °C. Planktic and benthic in ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Diploneis puella (Schumacer) Cleve var. ***puella*** Patrick and Reimer, 1966. Pl. 1, fig. 8.

Hustedt, 1930, p. 250. Fig. 394; Patrick and Reimer, 1966, p. 414, pl. 38, fig. 9; Maidana, 1985, p. 119, pl. 6, fig. 4; Moreno, 1985, pl. 6, figs. 10a to 10b (non *D. elliptica*).

= *Navicula puella* Schum 1867; *Navicula elliptica* var. *minutissima* Grun 1880; *Diploneis puella* (Schum.) Cleve in Patrick and Reimer 1966.

Measurements: length 22 to 23 μm, width 8.5 to 9 μm, costes 10 to 15 in 10 μm.

Distribution: Geographical.- Europe, USA, Argentina, Mexico. Ecological.- fresh to slightly salted water, usually hard water, circumneutral pH waters, temperature from 28 to 30°C, planktic and benthic in dams and ponds.

Ponds: 3a, 7a, 11a, cs, 2b.

Gomphonema acuminatum Ehrenberg var. ***acuminatum*** in Patrick and Reimer 1975. Pl. 1, fig. 9.

Van Heurck, 1896, p. 270, pl. 7, fig. 299; Patrick and Reimer, 1975, p. 112, pl. 15, figs. 2, 4 y 7; Maidana, 1985, p. 125, pl. 8, fig.1; Novelo, 1998, p. 405, fig. 305.

= *Gomphonema americanum* Ehr. (*in* part) in Boyer, 1927; *Gomphonema acuminatum* Ehr.1832; *Gomphonema coronatum* Ehr. 1840; *Gomphonema acuminatum* var. *coronatum* (Ehr.) Rabenhorst 1864; *Gomphonema acuminatum* var. *laticeps* (Ehr.) Grunow1880 in Patrick and Reimer, 1975.

Measurements: length 55 to 59 μm, width 10 to 12 μm, striae 10 to 11 in 10 μm at the center.

Distribution: Geographical.- cosmopolitan. Ecological.- circumneutral pH water, medium to low hardness water, oligohalobe, oligotrophic to slightly mesotrophic, temperature from 26 to 32 °C.

Planktic in lakes, river, cenotes, ponds and pools.

Ponds: 1a, 5a, 7a, 11a.

Gomphonema affine Kützing var. ***affine*** *in* Patrick and Reimer, 1975. Pl. 1, fig. 10.

Patrick and Reimer, 1975, p. 133, pl. 17, figs. 5; Moreno, 1985, pl. 7, fig. 10; Novelo, 1998, p. 406, fig. 306.

Measurements: length 25 to 54 μm, width 8 to 10 μm, striae 6 to 10 in 10 μm at the center of valve.

Distribution: Geographical.- cosmopolitan. Ecological.- tolerant to a wide range of conductivity in freshwater, circumneutral pH water, temperature from 26 to 32°C. Planktic and periphytic in lakes, channels and ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Gomphonema angustatum (Kützing) Rabenhort var. ***angustatum*** in Patrick and Reimer, 1975. Pl. 3, fig. 11.

Van Heurck, 1896, p. 273, pl. 7, fig. 314; Patrick and Reimer, 1975, p. 111, pl. 17, fig. 17 to 19; Maidana, 1985, p.128, pl. 8, fig. 17; Novelo, 1998, p. 407, fig. 307.

Measurements: length 26 to 37 μm, width 7 to 9 μm, striae 9 to 10 in 10 μm aroun the center.

Distribution: Geographical.-cosmopolitan. Ecological.- widely distributed in circumneutral pH water, prefers oligotrophic to mesotrophic waters, in hot waters from 26 to 32 °C. Planktic and benthic in ponds and springs.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Gomphonema clavatum Ehrenberg 1832. Pl. 1, fig. 11.

Krammer and Lange-Bertalot, 1986, p. 367-368, fig. 163(1-12); Patrick and Reimer, 1975, p. 129, pl 16, fig. 11 (*Gomphonema subclavatum* var. *commutatum*).

=*Gomphonema commutatum* Grun.; *G. montanum* var. *commutatum* (Grun.) van Heurck; *G. subclavatum* var. *commutatum* (Grun) Mayer in Patrick and Reimer, 1975.

Measurements: length 60 to 103 μm, width 8 to 12 μm, striae 8 to 11 in 10 μm at the center, 11 near apex.

Distribution: Geographical.- USA, probably Belgium . Ecological.- medium hard water, circumneutral pH water, temperature from 26 to 30°C. Planktic and benthic in pond.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Gomphonema gracile Ehrenberg emend van Heurck var. ***gracile*** in Patrick and Reimer, 1975. Pl. 3, fig. 10.

Hustedt, 1930, p. 376, fig. 702; van Heurck, 1896, p. 272, pl. 7, fig. 309; Patrick and Reimer, 1975, p. 131, pl. 17, figs. 1 to 3; Maidana, 1985, p. 134, pl. 8, fig. 15; Tavera *et al.*, 1994, p. 56, pl. 3, fig. 47; Novelo, 1998, p. 409, fig. 309.

Measurements: length 59 to 64 μm, width 8 to 9 μm, striae 10 to 12 in 10 μm at the center of valve, 11 to 13 near apex.

Distribution.- Geographical: cosmopolitan. Ecological: widelly distributed in fresh and brackish waters with circumneutral pH and low conductivity , temperature from 26 to 32°C. Prefers oligotrophic waters. Planktic and benthic species, in rivers, lakes, streams, channels, ponds, dams, drop walls, streams and waterfalls.

Ponds:1a, 5a, 7a, 11a, 13a, 19a, 20a, 2cs, cd, 1b, 2b, 7b, 10b, 19b.

Gomphonema parvulum (Kützing) Kützing var. ***parvulum*** in Patrick and Reimer, 1975. Pl. 3, fig. 8.

Van Heurck, 1896, p. 272, pl. 7, fig. 306; Patrick and Reimer, 1975, p. 122, pl. 17, figs. 7 to 12; Maidana, 1985, p. 137, pl. 8, figs. 10-12; Cuesta, 1993, p.87, pl. 7, figs. 50a to 50 c; Tavera *et al.*, 1994, p. 57, pl. 3, figs. 48a to 48b; Novelo, 1998, p. 411, fig. 312a to 312b.

The more frequent synonymous according to Patrick and Reimer, 1975 are:

=*Sphenella parvula* Kütz.; *Gomphonema micropus* Kütz.; *Gomphonema lagunula* Kütz.; *Gomphonema parvulum* Kütz.; *Gomphonella parvula* Rabh.; *Gomphonema parvulum* var. *exilis* Grun.; *Gomphonema micropus* f. *major* Grun.; *Gomphonema micropus* var. *minor* Grun.; *Gomphonema micropus* var. *exilis* Grun.; *Gomphonema parvulum* var. *lanceolata* Grun.; *Gomphonema parvulum* var. *subcapitata* Grun.; *Gomphonema parvulum* var. *exilisima* Grun.; *Gomphonema parvulum* var. *micropus* Cl; *Gomphonema parvulum* var. *curta* Roch.; *Gomphonema parvulum* var. *lagemula* Freng.; *Gomphonema parvulum* var. *genuinum* f. *semiaptera* Mayer.

Measurements: length 13 to 21 μm, width 6 to 7.5 μm, striae 11 to 14 in 10 μm around the center. This specie is highly variable in the shape of the valve.

Distribution: Geographical.- cosmopolitan. Ecological.- widelly distributed in freshwater, circumneutral pH, temperature from 26 to 32 °C, eutrophic in sanitary and farm wastes. Planktic in lakes, rivers, ponds, drip walls, springs and streams; epiphytic on filamentous algae in river edges, in channels and dripping rock faces. Ponds: 3a, 5a, 19a, 20a, cs, cd, 1b, 10b, 19b.

Navicula exigua (Gregor) Grunow. Pl. 2, fig. 3.

Patrick and Reimer, 1966, p. 522, pl. 49, fig. 24; Maidana, 1985, p. 164, pl. 12, fig. 10 (non 2 and 11); Moreno, 1985, pl. 19a to 19b (*non N. exiguiformis*).

= *Navicula exigua* var. *capitata* Patrick 1945 in Patrick and Reimer, 1966; *Navicula exigua* var. *exigua* van Landingham 1975 in Maidana 1985;

Measurements: length 28 to 31 μm, width 8 to 12 μm, striae 13 to 16 μm at the center of valve, 15 to 20 in 10 μm at the apex.

Distribution: Geographical.-USA, Mexico, Argentina, Pennsylvania. Ecological.- freshwater, seems to prefer water of less than 100 ppm hardness with $CaCO_3$ and circumneutral pH, temperature from 27 to 30°C. Planktic and benthic in ponds.

Ponds: 1a, cs.

Navicula notha Wallace var. ***notha*** in Patrick and Reimer, 1966. Pl. 3, fig 3.

Patrick and Reimer, 1966, p. 528, pl. 50, figs. 10 to 11.

Measurements: length 26 to 29 μm, width 4 to 5 μm, striae 15 to 17 in 10 μm.

Distribution: Geographical.- USA. Ecological.- freshwater and circumneutral pH, seems to prefer water with low mineral contents, temperature from 26 to 32°C. Planktic and benthic algae in ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

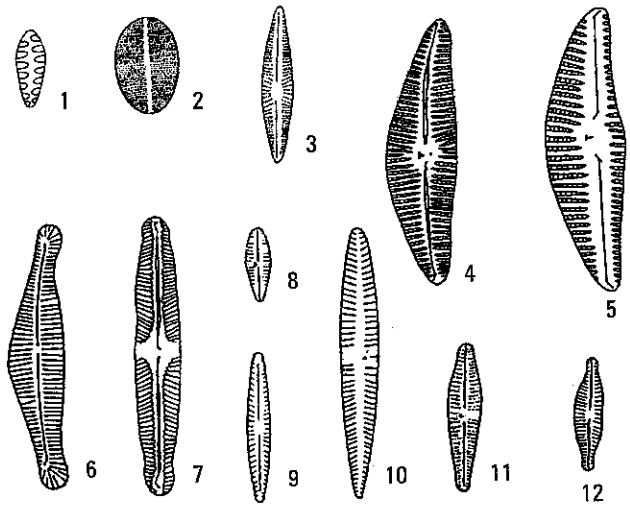

Plate 3

Fig 1. *Opephora martyi* var. *martyi;* Fig.2. *Cocconeis placentula* var. *placentula;* Fig. 3. *Navicula notha* var. *notha;* Fig.4. *Cymbella tumida* var. *tumida;* Fig. 5. *Cymbella minuta* var. *pseudogracilis;* Fig. 6. *Cymbella cistula* var. *gibbosa;* Fig. 7. *Pinnularia abaujensis* var. *subundulata;* Fig. 8. *Gomphonema parvulum* var. *parvulum;* Fig. 9. *Navicula* sp.; Fig. 10. *Gomphonema gracile* var. *gracile;* Fig. 11. *Gomphonema angustatum* var. *angustatum;* Fig. 12. *Cymbella microcephala* var. *microcephala.*

Navicula pupula Kützing var. ***pupula*** in Patrick and Reimer, 1966. Pl. 1, fig. 12.

Patrick and Reimer, 1966, p. 495, pl. 47, fig. 7; Maidana, 1985, p. 149, pl. 10, fig. 5; Moreno, 1985, pl. 5, fig. 13 (non *N. cryptocephala* var. *veneta*); Tavera *et al.*, 1994,p. 50, pl. 2, fig. 28; Novelo, 1998, p. 366, fig. 196.

Measurements: length 20 to 32 μm, width 6 to 8.5 μm, striae 12 to 15 in 10 μm at the center of the valve.

Extremely variable in cell shape.

Distribution: Geographical.- cosmopolitan. Ecological.- freshwater, seems to prefer neutral pH water with fairly high mineral contents, temperature from 28 to 30 °C, eutrophic waters, oligohalobe. Planktic, epipelic and epilithic in rivers, pools, ponds, shallow streams, dams, flowing water and waterfalls.

Ponds: 1a, 3a, cs, 1b, 10b, 19b.

Navicula rhynchocephala var. ***amphiceros*** (Kützing) Grunow. Pl. 2, fig. 2.

Patrick and Reimer, 1966, p. 505, pl. 48, fig. 15; Moreno, 1985, pl. 5, fig. 14 (*non N. radiosa*); Tavera *et al.*, 1994, p. 48, pl. 2, fig. 18 a to b (*Navicula amphiceros*).

Measurements: length 40 to 56 μm, width 10 to 12.5 μm, striae 8 to 13 in 10 μm in the center valve.

Distribution: Geographical.- USA, Mexico, Europe, Germany. Ecological.- widely distributed in freshwater, circumneutral pH and temperature from 26 to 32° C, seems to prefer water with high mineral contents in mesosaprobic conditions. Shallow streams and drip walls, planktic, benthic and epipelic species.

Ponds: 1a, 5a, 7a, 11a, 13a, 19a, 20a, 22a, cs, 1b, 2b, 7b, 10b.

Navicula sp. Pl. 3, fig. 9.

Measurements: length 10 to 16 μm, width 2.5 to 3 μm, striae 9 in 10 μm.

Distribution: Ecological.- slightly alkaline, temperature from 26 to 32° C, and eutrophic water. Planktic and benthic in ponds.

Ponds: 1a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Pinnularia abaujensis var. ***rostrata*** (Patrick) Patrick *nov. com.* in Patrick and Reimer, 1966. Pl. 2, fig. 4.

Patrick and Reimer, 1966, p. 614, pl. 58, fig. 4; Moreno, 1985, pl. 6, fig. 14 (non *P. interrupta*).

= *Pinnularia gibba* var. *rostrata* Patrick in Patrick and Reimer, 1966.

Measurements: length 50 to 85 μm, width 10.5 to 11.5 μm, striae 10 to 13 in 10 μm at the center valve.

Distribution: Geographical.- Pennsylvania, Mexico. Ecological.- found in water with low mineral contents , circummneutral to slightly acid pH water, temperature from 26 to 32° C. Planktic and benthic in ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 19a, 20a, cs, cd, 1b, 10b, 19b.

Pinnularia abaujensis var. ***subundulata*** (A. Mayer ex Hustedt) Patrick. Pl. 3, fig. 7.

Patrick and Reimer, 1966, p. 614, pl. 58, fig. 5; Moreno, 1985, pl. 6, fig. 17 (*P. gibba* f. *subundulata*); Tavera, 1994, p. 57, pl. 3, fig. 49 (non *P. graciloides*).

= *Pinnularia gibba* f. *subundulata* A. Mayer ex Hust. in Patrick and Reimer, 1966.

Measurements: length 60 to 61 μm, width 8.5 to 10.5 μm striae 10 to 11 in 10 μm around the center .

Distribution: Geographical.- USA, Cuba, Mexico. Ecological.-circumneutral pH, low conductivity water, temperature from 26 to 31° C, sensitive to organic pollution. Planktic and benthic in lakes, ponds, drip walls, rivers, lagoons and streams.

Ponds: 1a, 3a, 5a, 13a, 19a, cs,1b, 2b, 7b, 12b.

Pinnularia acrosphaeria W. Smith var. ***acrosphaeria*** in Patrick and Reimer, 1966. Pl. 2, fig. 5.

Patrick and Reimer, 1966, p. 623, pl. 60, figs. 2 to 3; Maidana, 1985, p. 186. Pl. 15, fig. 3; Moreno, 1985, pl. 6, fig. 17 (non *P. gibba* f. *subundulata*).

= *P. acrosphaeria* W Sm., 1853; *Navicula acrosphaeria* var. *minor* Perag. and Herib.; *P. acrosphaeria* f. *minor* Cl in Patrick and Reimer, 1966.

Measurements: length 64 to 67.5 μm, width 16 to 23 μm, striae 12 in 10 μm in central area and near apex.

Distribution: Geographical.- cosmopolitan. Ecological.- neutral waters of low mineral content, temperature from 26 to 32° C. Planktic and benthic in ponds.

Ponds: 1a, 3a, 5a, 7a, 11a, 13a, 19a, 20a, cs, cd, 1b, 2b, 7b, 10b, 12b, 19b.

Family Epithemiaceae

Rhopalodia sp. Pl. 2, fig. 7.

Moreno, 1985, pl. 9, fig. 3.

Measurements: length 15 to 19 μm, width 6 to 7.5 μm.

It is very similar to *Rhopalodia gibberula* var. *succincta* (Béb.) Fricke in Bourrelly and Manguin (1952), but *R. gibberula* is slightly larger, it has more fibulae and the central area is more expanded. Distribution: Geographical.- Mexico. Ecological.- slightly alkaline water, circumneutral pH water, temperature from 28 to 32° C. Planktic and benthic in ponds.

Ponds: cs, cd, 7b, 19b.

Family Nitzschiaceae

Nitzschia sp. Pl. 2, fig. 6.

Moreno, 1985, pl. 9, fig. 5 8 (como *N. denticula* Grun).

Measurements: length 60 to 65 μm, width 4 to 5.5μm, striae 8 in 10 μm aroun the center.

It is very similar to *N. frustulum* var. *perminuta* Grun. but *N. frustulum* is smaller and slightly rostrated in Bourrelly *et* Manguin (1952).

Distribution: Geographical.- Mexico. Ecological.- freshwater and circumneutral pH, temperature from 27 to 32° C. Planktic and benthic in ponds.

Ponds: 1a, 7a, 11a, 13a, 19a, 20a.

DISCUSSION

Thirty one species and varieties of seven families (according to Simonsen, 1979) were identified in 41 samples; of these, 98% belong to the Pennales Order and 2% to the Centrales Order.

The large number of varieties (21) is an example of the complex variations that are found in the diatom group. The morphological variability in the length, width and stries numbers, arises from ecological and genetic processes over short scales of time (hours, days, months). In this work, more varieties correpond to species type.

It was observed that 18 of the 31 registered species were found in more of the 50% ponds probably due to the fact that most are in contact, close the extreme anthropic eutrophication in all of them (non limitative nutrients), their shallowness and the homogeneity in the pH and temperature, and the cosmopolitan species. There isn´t one specific distribution pattern.

The most frequent and abundant species in the fish rearing Center are: *Synedra acus* var. *acus* , *S. ulna* var. *ulna*, *Cymbella microcephala* var. *microcephala*, *C. tumida* var. *tumida*, *Diploneis puella* var. *puella*, *Gomphonema affine* var *affine*, *G . angustatum* var. *angustatum*, *G. clavatum*, *Navicula notha* var. *notha*, and *Pinnularia acrosphaeria* var. *acrosphaeria*.

This diatom survey is the first in the fish rearing center. In the region of Temascal, diatom species have been recorded, of which 20 were found in Miguel Aleman dam (Moreno, 1985). The new records in Temascal region are: *Synedra acus* var. *acus* , *Achnantes exigua* var. *exigua*, *Cymbella cistula* var. *gibbosa*, *Cymbella microcephala* var. *microcephala*, *Gomphonema affine* var. *affine*, *G . angustatum* var. *angustatum*,*G.gracile* var. *gracile*, *G. parvulum* var. *parvulum*, *G. clavatum*, *Navicula notha* var. *notha*, *Navicula* sp1.

Tavera *et al.*, (1994) reported ten species (32.25%) in sud Papaloapan basin (17° 08´to 17° 35´ N and 96° 23´to 96° 57´W) and Novelo (1998), Avila (1985) and Cuesta (1993) reported thirteen species (41.93 %) in common in the west Papaloapan basin (18° 20´to 18° 40´and 97° to 97° 40´ W). These data confirm the above mentioned.

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