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Euglenophytes from Lake Chignahuapan, Mexico

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Abstract – This study revelead the presence of several euglenophyte taxa (Euglenophyta) in Lake Chignahupan, in the Upper Lerma Basin (Mexico). A total of 21 taxa were identified, 10 belonging to the genus *Phacus*, 5 to *Lepocinclis*, 2 to *Euglena*, 2 to *Monomorphina*, one to *Cryptoglena* and one to *Trachelomonas*. The species *Crytoglena skujae*, *Euglena caudata, E. limnophila, Lepocinclis ovum* var. *dimidio-minor*, *L. salina*, *L steinii*, *Monomorphina aenigmatica*, *Phacus caudatus*, *P. ichthydion*, *P. inflexus*, *P. orbicularis*, *P. polytrophos* and *P. raciborskii* were recorded for the first time in Mexico. All observed taxa are described briefly and illustrated by microphotographs or line drawings.

Central Mexico / *Euglena* / Euglenophyta / euglenophytes / high altitude lakes / *Lepocinclis* / *Phacus*

Résumé – Euglénophytes du lac Chignahuapan, Mexique. L'étude a mis en évidence la présence de plusieurs taxons d'euglénophytes (Euglenophyta) dans le lac Chignahuapan, Haut Bassin de la Lerma (Mexique). Sur 21 taxons identifiés, 10 appartiennent au genre *Phacus*, 5 à *Lepocinclis*, 2 à *Euglena*, 2 à *Monomorphina*, 1 à *Cryptoglena* et 1 à *Trachelomonas*. Les espèces *Crytoglena skujae*, *Euglena caudata, E. limnophila, Lepocinclis ovum* var. *dimidio-minor*, *L. salina*, *L steinii*, *Monomorphina aenigmatica*, *Phacus caudatus*, *P. ichthydion*, *P. inflexus*, *P. orbicularis*, *P. polytrophos* et *P. raciborskii* sont signalées pour la première fois au Mexique. Les taxons observés sont brièvement décrits et illustrés par des microphotos ou des dessins au trait.

Euglena* / Euglénophytes / lacs de haute montagne / *Lepocinclis* / Mexique central / *Phacus

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INTRODUCTION

In Mexico, relatively limited research has been carried out on the occurrence and diversity of euglenophytes (Euglenophyta) compared with other groûps of algae (Pérez-Reyes & Salas-Gómez, 1958). Ortega (1984) carried out an important phycological study dealing with the taxonomy and ecology of freshwater algae, including euglenophytes, in which the illustrations were not original and the descriptions in need of updating. Other studies have been carried out which lacked illustrations and taxonomic descriptions altogether (Flores-Tena & Silva-Briano, 1995; López-López & Serna-Hernández, 1999; Rivera *et al.*, 1998; Schmitter-Soto *et al.*, 2002; Mora-Navarro *et al.*, 2004; Moreno-Ruíz, 2005; Aladro *et al.*, 2007; López-Adrían & Barrientos-Medina, 2005; Moreno-Ruíz *et al.*, 2008; Barrera *et al.*, 2008; Oliva-Martínez *et al.*, 2008).

The aim of this present paper is to provide a first taxonomic account of photosynthetic euglenophytes from the Upper Lerma Basin, Mexico.

MATERIALS AND METHODS

Lake Chignahuapan is located in the southern portion of the Upper Lerma Basin (19° 08.36'N, 99° 31.15'W, at 2650 m a.s.l.), near Santa Cruz Atizapán, State of Mexico (Fig. 1). The prevailing climate is characterized by a rainy summer season (June-September) and a relatively dry winter season (November-February). Mean annual precipitation is 1000 mm/year. Average annual temperature ranges between 16 and 18°C (INEGI, 1980). The surface area of the lake is 50 km^2, with a maximum depth of 1.6 m and a mean depth of 0.9 m.

Fieldwork was carried out from March to October 2001, which covers parts of both the rainy and the dry seasons. The following environmental parameters were measured in the field: Secchi disk transparency (Z_{DS}); water temperature (WT), pH and specific conductivity (SC) using a Jenway 3405 electrochemical analyzer, and dissolved oxygen (DO) using an YSI 5739 oxygen meter.

For taxonomic analyses, phytoplankton samples were collected at a depth of 0.1 m in the central-most part of the lake using a plankton net (10 µm mesh size) and preserved with 3% formaldehyde in 250 ml bottles. Specimens were examined and measured using a Zeiss optical microscope. Taxonomic identification was based on several sources including Huber-Pestalozzi (1955), Starmach (1983), Tell & Conforti (1986), Wołowski (1998, 2002, 2003), Marin *et al.* (2003), Nudelman *et al.* (2006), Kosmala *et al.* (2007a, b), and Wołowski & Grabowska (2007).

RESULTS

Cryptoglena skujae Marin *et* Melkonian *emend.* Kosmala & Zakryś **Figs 2-3, 26-27**

Syn.: *Phacus agilis* Skuja

Cells elliptic to ovate, laterally compressed with a median longitudinal furrow, 12-12.5 µm long, 6.2-7.5 µm wide; ends rounded, without a conspicuous hyaline, posterior tail. Single parietal chloroplast. Two lateral paramylon grains, large and shell-like.

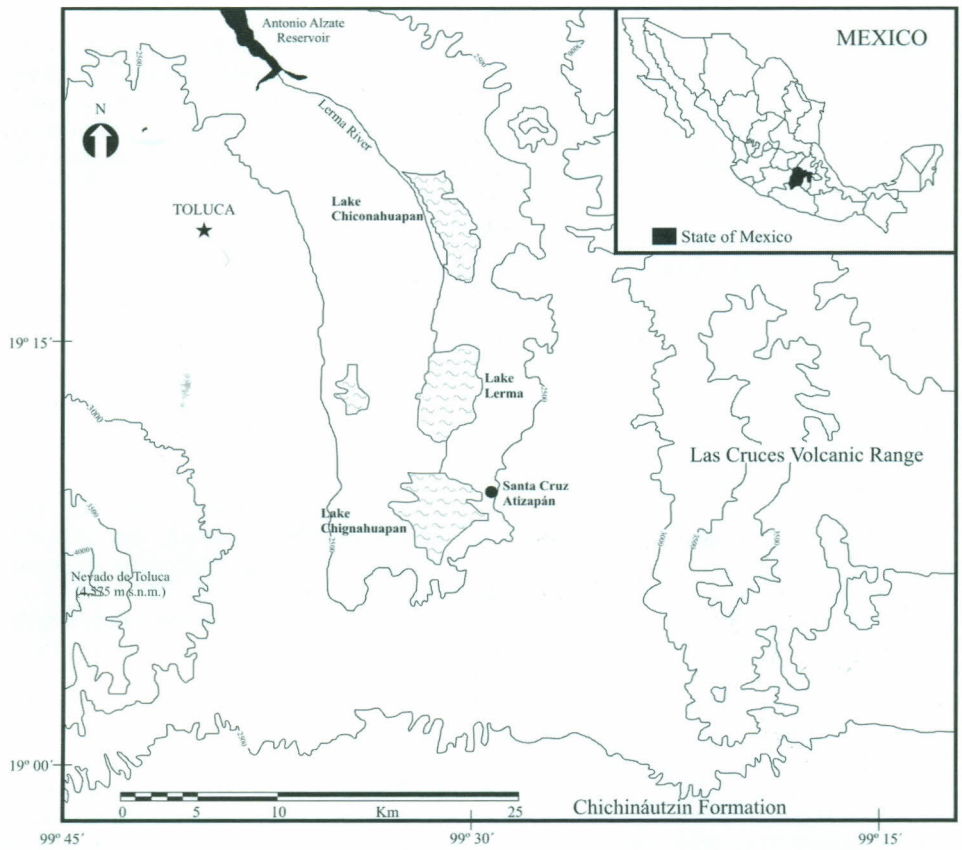


Fig 1. Location of Lake Chignahuapan. Upper Lerma Basin, State of Mexico, Mexico.

Common, occurred in the summer rainy season (July to September) but seldom dominant. The phytoplankton community was dominated by *Aphanothece saxicola* Nägeli, *Chlorella* sp., *Monoraphidium minutum* (Nägeli) Komárková-Legnerová and *Merismopedia tenuissima* Lemmermann. Z_{DS}: 0.25-0.37 m; WT: 18-20ºC; pH 6.9-8.2; SC: 628-907 µS cm^{-1}; DO: 3.6-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America, Asia and Europe.
Habitat: Lakes, ponds and wetlands (Conforti *et al.*, 2005; Wołowski, 2002; Alves-da-Silva & Bridi, 2004; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva & Tamanaha, 2008).

Euglena caudata Hübner **Figs 4, 28**

Cells spindle-shaped, 50-96.8 µm long, 11.8-22.1 µm wide; anterior end rounded; posterior end sharply pointed. Chloroplasts numerous, disc-shaped, saucer-shaped in ventral view, with shallow incised margins, with pyrenoids covered at both sides with a paramylon sheath. Paramylon grains small, oval or rod-shaped.

Common, occurred during both seasons but especially during the rainy summer season, during which the phytoplankton community was dominated by *Chlorella* sp., *Dictyosphaerium subsolitarium* Van Goor, *Monoraphidium minutum*, *M. contortum* (Thuret) Komárková-Legnerová, *Scenedesmus subspicatus* Chodat, *S. granulatus* f. *granulatus* W. *et* G. S. West, *Aphanothece saxicola*, *Merismopedia tenuissima* and *Snowella lacustris* (Chodat) Anagnostidis *et* Hindák. Z_{DS}: 0.11-0.46 m; WT: 14-21°C; pH 6.9-8.5; SC: 628-3112 μS cm^{-1}; DO: 3.6-9 mg l^{-1}.

Distribution in Mexico: first record.

General distribution: America, Asia and Europe.

Habitat: Rivers, lakes, ponds and wetlands; reported as β-mesosaprobic to α-mesosaprobic (Wołowski, 2003; Alves-da-Silva & Hahn, 2004; Conforti *et al.*, 2005; Alves-da-Silva *et al.*, 2007; Alves-da-Silva & Tamanaha, 2008).

Euglena limnophila Lemmermann **Figs 5, 29**

Cells cylindrical to elliptical, elongated, spindle-shaped, 51.7-55 μm long, 12-13.3 μm wide; anterior end slightly narrow and truncate; posterior end attenuated into a caudal projection. Chloroplasts numerous, small, disc-shaped, without pyrenoids. Paramylon grains dimorphic, two large, rod-shaped; small ones, rod-like or oval, scattered throughout the cell.

The taxonomic position of *Euglena limnophila* has been uncertain within the genera *Euglena* sensu stricto, which appears to be paraphyletic or even polyphyletic (Linton *et al.*, 2000; Milanowski *et al.*, 2001, 2006; Müllner *et al.*, 2001; Marin *et al.*, 2003; Nudelman *et al.*, 2003; Kim & Shin, 2008). In a molecular phylogenetic study (Marin et *al.*, 2003), *E. limnophila* occurred in the same clade (Spathirhyncha) as *E. spathirhyncha*. In some analyses, *E. limnophila* was a sister species to species of *Lepocinclis* and *Phacus*, but in others, the clade formed a basal divergence of the Euglenales (paraphyletic with *Lepocinclis*/*Phacus*). Later, Triemer *et al.* (2006) transferred *E. spathirhyncha* and *E. adunca* to the new genus *Discoplastis*, but the phylogenetic position of *E. limnophila* is still unclear even in the light of the study of Linton *et al.* (2009) based on molecular sequence data. In this paper we identify this species as *E. limnophila* based on Huber-Pestalozzi (1955).

Found in low numbers and only in July, when the phytoplankton community was dominated by *Chlorella* sp., *Aphanothece saxicola*, *Monoraphidium minutum* and *Merismopedia tenuissima*. Z_{DS}: 0.25 m; WT: 18.3°C; pH 8.2; SC: 907 μS cm^{-1}; DO: 9 mg l^{-1}.

Distribution in Mexico: first record.

General distribution: America and Europe.

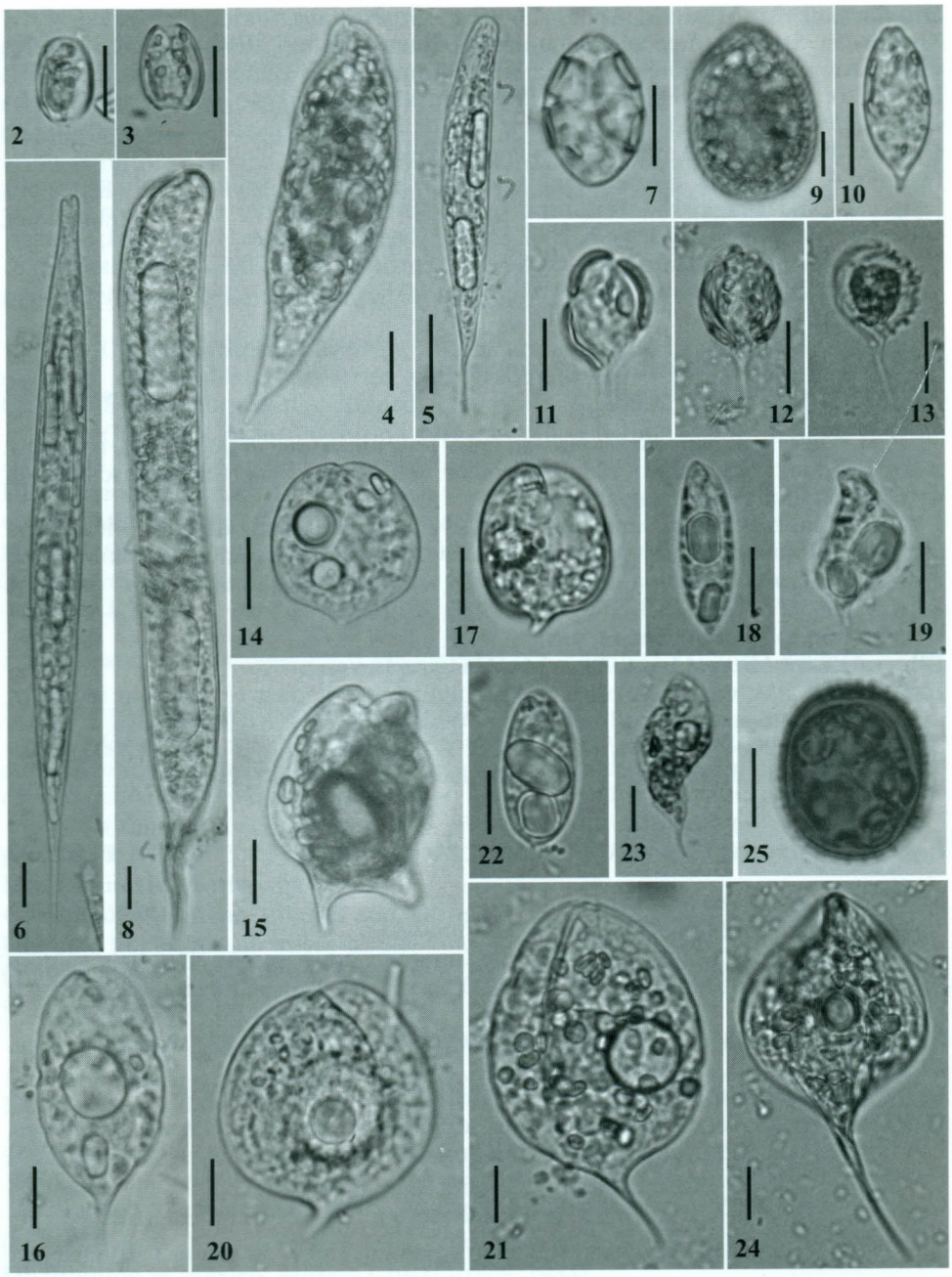
Habitat: Streams and clean lakes; reported as β-mesosaprobic to α-mesosaprobic (Wołowski, 2002; Alves-da-Silva & Hahn, 2004; Alves-da-Silva *et al.*, 2007; Alves-da-Silva & Fortuna, 2006, 2008).

Lepocinclis acus (O. F. Müller) Marin *et* Melkonian **Figs 6, 30**

Syn.: *Euglena acus* (O.F. Müller) Ehrenberg

Cells 173-192 μm long, 11.6-12.4 μm wide.

Most common species, occurred during both seasons, especially during the summer rainy season. Z_{DS}: 0.11-0.46 m; WT: 14-21°C; pH 6.9-8.5; SC: 628-3112 μS cm^{-1}; DO: 3.6-9 mg l^{-1}.



Figs 2-25. **2-3**. *Cryptoglena skujae*. **4**. *Euglena caudata*. **5**. *E. limnophila*. **6**. *Lepocinclis acus*. **7**. *L. ovum* var. *dimidio-minor*. **8**. *L. oxyuris*. **9**. *L. salina*. **10**. *L. steinii*. **11**. *Monomorphina aenigmatica*. **12-13**. *M. pyrum*. **14**. *Phacus acuminatus* var. *acuminatus*. **15**. *P. asymmetricus*. **16**. *P. caudatus*. **17**. *P. curvicauda*. **18**. *P. ichthydion*. **19**. *P. inflexus*. **20-21**. *P. orbicularis*. **22**. *P. polytrophos*. **23**. *P. raciborskii*. **24**. *P. tortus*. **25** *Trachelomonas hispida* var. *hispida*. Scale bar 10 µm.

Distribution in Mexico: Aguascalientes, Guanajuato, Jalisco, Mexico City, Michoacán, State of Mexico and Yucatán (Sámano-Bishop, 1940; Rioja & Herrera, 1951; Ortega, 1984; Flores-Tena & Silva-Briano, 1995; Banderas-Tarabay, 1997; López-López & Serna-Hernández, 1999; Mora-Navarro *et al.*, 2004; López-Adrián & Barrientos-Medina, 2005).
General distribution: America, Asia and Europe.
Habitat: Rivers, lakes, ditches, ponds, swamps, sinkholes, wetlands, village ponds, fishponds and brackish-water; reported as β-mesosaprobic to α-mesosaprobic (Prescott, 1955; Wołowski, 1998, 2002, 2003; Alves-da-Silva & Hahn, 2004; Salazar, 2004; Conforti *et al.*, 2005; Alves-da-Silva & Fortuna, 2006, 2008; Alves-da-Silva & Tamanaha, 2008; Alves-da-Silva *et al.*, 2007, 2008).

Lepocinclis ovum (Ehrenberg) Lemmermann
var. ***dimidio-minor*** Deflandre **Figs 7, 31-32**

Cells fusiform, 19-24 µm long, 14-16.8 µm wide; anterior end rounded; posterior end with a short blunt tail-piece. Chloroplast numerous, disc-shaped. Two paramylon grains, ring-shaped.

Found in low numbers in July and August, during which the phytoplankton community was dominated by *Aphanothece saxicola*, *Chlorella* sp., *Monoraphidium minutum*, *Merismopedia tenuissima* and *Snowella lacustris*. Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: Africa, America, Asia and Europe.
Habitat: Streams, wetlands, lakes and stagnant water bodies; reported as indicator of moderately to strongly polluted water (Wołowski, 2003; Alves-da-Silva & Hahn, 2004; Salazar, 2004; Conforti *et al.*, 2005; Alves-da-Silva & Fortuna, 2006, 2008; Alves-da-Silva & Tamanaha, 2008; Alves-da-Silva *et al.*, 2007, 2008).

Lepocinclis oxyuris (Schmarda) Marin et Melkonian **Figs 8, 33**

Syn.: *Euglena oxyuris* Schmarda

Cells 187-240 µm long, 19.3-33.5 µm wide.

Common, occurred during the summer rainy season but was seldom dominant. Z_{DS}: 0.19-0.37 m; WT: 18.3-20°C; pH 6.9-8.5; SC: 628-1209 µS cm^{-1}; DO: 3.6-9 mg l^{-1}.
Distribution in Mexico: Hidalgo, Mexico City, State of Mexico, Tabasco (Ortega, 1984; Moreno-Ruíz, 2005).
General distribution: Africa, America, Australia, Asia and Europe.
Habitat: Streams, lakes, swamps, ponds, ditches, wetlands, reservoirs, peat bogs, fish farm ponds and urban drainage; recorded as α-mesosaprobic (Prescott, 1955; Conforti, 1994; Wołowski, 2002; Alves-da-Silva & Hahn, 2004; Salazar, 2004; Conforti *et al.*, 2005; Alves-da-Silva & Fortuna, 2006, 2008; Alves-da-Silva *et al.*, 2007, 2008).

Lepocinclis salina Fritsch **Figs 9, 34-35**

Cells ellipsoid to ovoid, 42.5-48 µm long, 21.6-38.4 µm wide; both ends rounded, anterior end slightly depressed; pellicle spirally striated to the right. Chloroplasts numerous, discoid. Paramylon grains, round.

Common, occurred during March and July. Z_{DS}: 0.11-25 m; WT: 14-18.3°C; pH 8.2-8.3; SC: 907-3112 μS cm^{-1}; DO: 8.2-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America and Asia.
Habitat: Lakes and ponds; reported as indicator of moderately to strongly polluted water (Conforti, 1994; Alves-da-Silva & Hahn, 2004; Salazar, 2004; Alves-da-Silva & Fortuna, 2006, 2008; Alves-da-Silva & Tamanaha, 2008; Alves-da-Silva *et al.*, 2007, 2008).

Lepocinclis steinii Lemmermann **Figs 10, 36**

Cells elliptical to fusiform, 25-27.3 μm long, 10-11 μm wide; anterior end rounded and lobulate; posterior end gradually narrowed a short extension. Chloroplasts numerous, disc-shaped. Two paramylon grains, ring-shaped.

Common, occurred during July and August. Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 μS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: Africa, America and Europe.
Habitat: Streams, swamps, ditches, puddles and eutrophic reservoirs (Wołowski, 2002; Alves-da-Silva & Hahn, 2004).

Monomorphina aenigmatica (Drezepolski) Nudelman *et* Triemer **Figs 11, 37-38**

Syn.: *Phacus aenigmaticus* Drezepolski

Cells pear-shaped, slightly twisted, 22.5-25 μm long, 7.5-10 μm wide; anterior end rounded, slightly bilobed; posterior end tapered into a long slightly curved cauda. One parietal chloroplast: Three lateral paramylon plates.

Common, occurred in March and July. Z_{DS}: 0.11-0.25 m; WT: 14-18.3°C; pH 8.2-8.3; SC: 907-3112 μS cm^{-1}; DO: 8.2-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America and Europe.
Habitat: Lakes, small water bodies and wetlands; recorded as α-mesosaprobic (Barinoba *et al.*, 2004; Kočárková *et al.*, 2005; Conforti *et al.*, 2005; Alves-da-Silva & Fortuna, 2008).

Monomorphina pyrum (Ehrenberg) Mereschkowsky *emend.* Kosmala *et* Zakryś **Figs 12-13, 39-41**

Syn.: *Euglena pyrum* Ehrenberg, *Phacus pyrum* (Ehrenberg) Stein

Cells pear-shaped, 25-35 μm long, 12.5-17.5 μm wide.

Most common species occurred during March, July and August. Z_{DS}: 0.11-0.32 m; WT: 14-20°C; pH 7.9-8.3; SC: 808-3112 μS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: Mexico City (Ortega, 1984).
General distribution: America, Asia and Europe.
Habitat: Rivers, lakes, swamps, ditches, ponds and salt water; recorded as indicator of moderately to strongly polluted water (Wołowski, 1998; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Kočárková *et al.*, 2005; Aladro *et al.*, 2007; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva *et al.*, 2007, 2008).

Phacus acuminatus Stokes var. ***acuminatus*** **Figs 14, 42-43**

Cells oval to sub-circular, 25.8-26.6 µm long, 20-23.6 µm wide.

Common during both seasons, very well represented during the summer. Z_{DS}: 0.11-0.46 m; WT: 14-21°C; pH 6.9-8.5; SC: 628-3112 µS cm^{-1}; DO: 3.6-9 mg l^{-1}.
Distribution in Mexico: Campeche, Guanajuato, Jalisco, Mexico City, Michoacán and Quintana Roo (Ortega, 1984; López-López & Serna-Hernández, 1999; Mora-Navarro *et al.*, 2004; López-Adrián & Barrientos-Medina, 2005).
General distribution: America, Asia and Europe.
Habitat: Rivers, lakes, swamps, ditches, puddles, ponds, fish ponds and sinkholes. (Wołowski, 2002; Alves-da-Silva & Bridi, 2004; Kočárková *et al.*, 2005; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva *et al.*, 2008).

Phacus asymmetricus Sokoloff **Figs 15, 44-45**

Cells irregularly twisted, sporadically distorted, and incised at both ends, 40-45 long, 30-35 µm wide.

Found only in July, and always in low numbers. Z_{DS}: 0.25 m; WT: 18.3°C; pH 8.2; SC: 9.7 µS cm^{-1}; DO: 9 mg l^{-1}.
Distribution in Mexico: Mexico City (Ortega, 1984).
General distribution: America, Asia, Europe.
Habitat: Small water bodies, ponds and channels (Kočárková *et al.*, 2005; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva *et al.*, 2008).

Phacus caudatus Hübner **Figs 16, 46-47**

Cells spindle-shaped, 38.4-50.2 µm long, 19.2-24.4 µm wide; anterior end slightly narrowed; posterior end straight or slightly curved. Chloroplasts numerous, disc-shaped. Paramylon grains small, rod-shaped.

Common, occurred in the summer (June and July). Z_{DS}: 0.19-0.25 m; WT: 18.3-19°C; pH 8.2-8.5; SC: 907-1209 µS cm^{-1}; DO: 7-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America, Asia and Europe.
Habitat: Lakes, puddles, swamps and salt-water; recorded as indicator of moderately to strongly polluted water (Wołowski, 1998, 2002; Alves-da-Silva & Bridi, 2004; Kočárková *et al.*, 2005; Alves-da-Silva *et al.*, 2007).

Phacus curvicauda Swirenko **Figs 17, 48**

Cells 27.5-30 µm long, 20-21.2 µm wide.

Found only in July, and always in low numbers. Z_{DS}: 0.25 m; WT: 18.3°C; pH 8.2; SC: 907 µS cm^{-1}; DO: 9 mg l^{-1}.
Distribution in Mexico: Oaxaca, Tabasco (Moreno-Ruíz, 2005; Moreno-Ruíz *et al.*, 2008).
General distribution: America and Europe.
Habitat: Rivers, lakes, ponds, reservoirs, ditches, puddles, swamps and salt-water; recorded as β-mesosaprobic to α-mesosaprobic (Wołowski, 1998, 2002; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Alves-da-Silva *et al.*, 2007; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva & Tamanaha, 2008).

Phacus ichthydion Pochmann **Figs 18, 49-50**

Cells elliptical, asymmetrical, 23.6-28.8 µm long, 7.3-10.3 µm wide; anterior end rounded; posterior end tapering to a short cauda. Chloroplasts numerous, oval discs. Two paramylon grains, rod-shaped.

Found in the summer (July and August) and always in low numbers. Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America and Europe
Habitat: Streams (Alves-da-Silva & Bridi, 2004).

Phacus inflexus (Kisselev) Pochmann **Figs 19, 51-52**

Cells elliptical, fusiform, 19.9-24.4 µm long, 14-14.7 µm wide; anterior end lobulate to rounded; posterior end gradually narrowed to a short acute cauda. Pellicle spirally striated to the right. Chloroplasts numerous, ovoid. Two paramylon grains, disc-shaped.

Common, occurred in the summer (July and August). Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America, Asia and Europe.
Habitat: Streams and wetlands (Alves-da-Silva & Bridi, 2004; Salazar, 2004; Conforti *et al.*, 2005; Kočárková *et al.*, 2005; Alves-da-Silva *et al.*, 2008).

Phacus orbicularis Hübner *emend.* Zakryś *et* Kosmala **Figs 20-21, 53-56**

Cells widely ovoid, 40.6-63.3 µm long, 34-40 µm wide; anterior end slightly narrowly rounded; posterior end broadly rounded with a more or less prominent and curved cauda. Pellicle with numerous struts perpendicular to the longitudinal strips. Chloroplasts numerous, oval discs. Two paramylon grains, disc-shaped.

Most common species, occurred during both seasons. It was very well represented during the summer. Z_{DS}: 0.11-0.46 m; WT: 14-21°C; pH 6.9-8.5; SC: 628-3112 µS cm^{-1}; DO: 3.6-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America and Europe.
Habitat: Rivers and small water bodies; recorded as indicator of moderately to strongly polluted water (Prescott, 1955; Wołowski, 2003; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Kočárková *et al.*, 2005; Alves-da-Silva *et al.*, 2007; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva & Tamanaha, 2008).

Phacus polytrophos Pochmann **Figs 22, 57-58**

Cells elliptical, 25.8-27.6 µm long, 9.5-11.8 µm wide; anterior end rounded; posterior end consisting of a short appendage. Chloroplasts numerous, disc-shaped. Two paramylon grains, disc-shaped, placed in a somewhat oblique position in the cell.

Common, occurred in the summer (July and August). Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.

General distribution: Africa, America, Asia and Europe.
Habitat: Streams and wetlands (Alves-da-Silva & Bridi, 2004; Conforti *et al.*, 2005; Alves-da-Silva & Fortuna, 2008).

Phacus raciborskii Drezeposki **Figs 23, 59-61**

Cells unsymmetrically elliptical, always twisted, 40-44 µm long, 13-16 µm wide; anterior end rounded, posterior end tapered to form a curved and deflected caudus. Chloroplasts numerous, disc-shaped. One or two paramylon grains, disc-shaped.

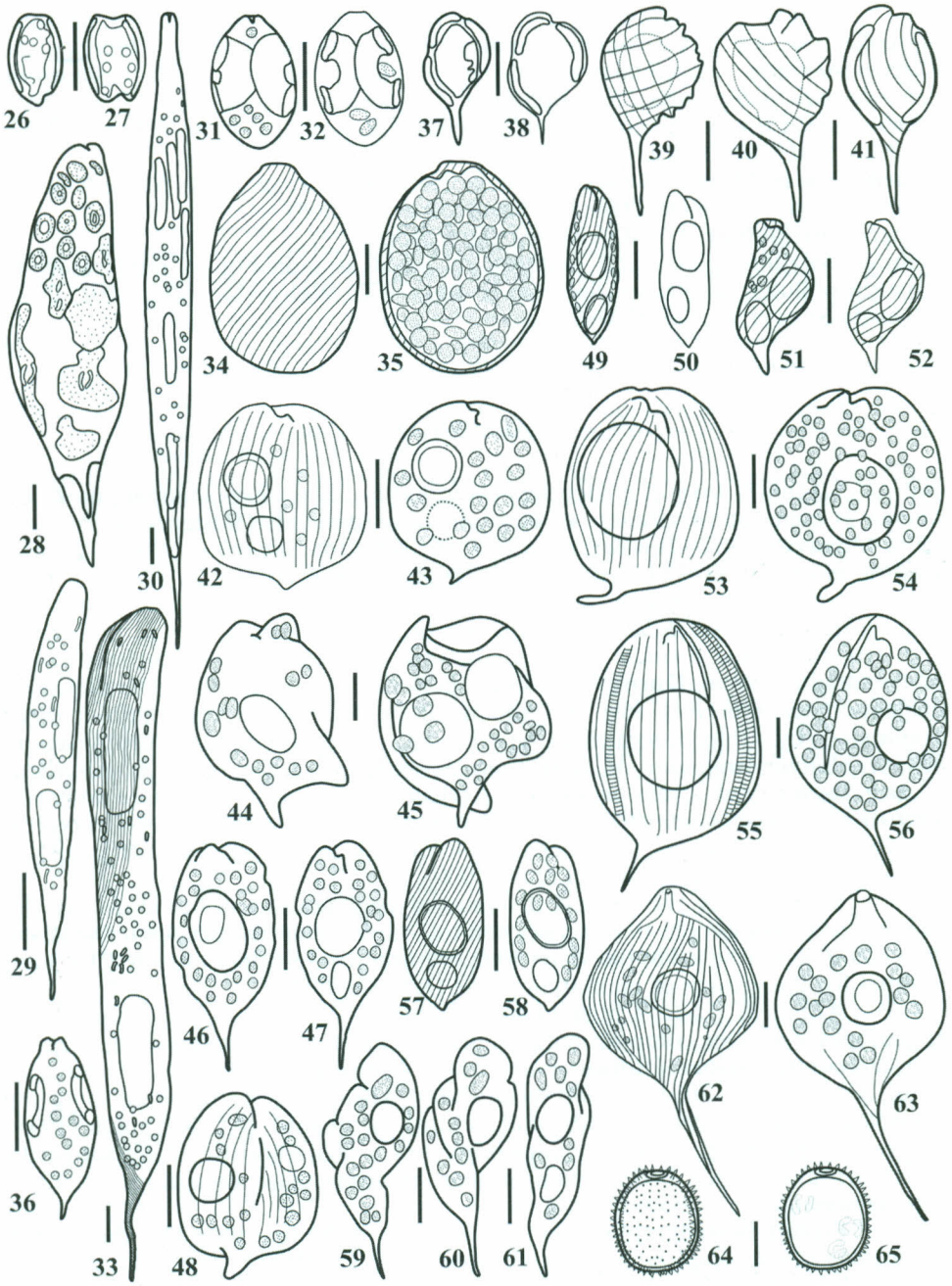
Found in the summer rainy season (July and August) and always in low numbers. Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: first record.
General distribution: America
Habitat: Rivers, small water bodies (Prescott, 1955; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva & Tamanaha, 2008; Alves-da-Silva *et al.*, 2008).

Phacus tortus (Lemmermann) Skvortsov **Figs 24, 62-63**

Cells 74-75.4 µm long, 36-37.5 µm wide.

Found in the summer (July and August) and always in low numbers. Z_{DS}: 0.25-0.32 m; WT: 18.3-20°C; pH 7.9-8.2; SC: 808-907 µS cm^{-1}; DO: 5.4-9 mg l^{-1}.
Distribution in Mexico: Campeche, Jalisco, Tabasco (Ortega, 1984; Mora-Navarro *et al.*, 2004; López-Adrián & Barrientos-Medina, 2005; Moreno-Ruíz, 2005).
General distribution: America, Asia and Europe.
Habitat: Rivers, lakes, ditches, puddles, swamps and ponds; recorded as β-mesosaprobic (Prescott, 1955; de Smet & Evens, 1972; Wołowski, 2002; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Alves-da-Silva & Fortuna, 2008; Alves-da-Silva & Tamanaha, 2008; Alves-da-Silva *et al.*, 2008).

Figs 26-65. **26-27**. *Cryptoglena skujae* showing a parietal chloroplast and lateral paramylon grains. **28**. *Euglena caudata* showing chloroplasts saucer-shaped and pyrenoids. **29**. *E. limnophila* showing dimorphic paramylon bodies. **30**. *Lepocinclis acus* showing monomorphic paramylon rods. **31-32**. *L. ovum* var. *dimidio-minor* showing ring-shaped paramylon grains and disc-shaped chloroplasts. **33**. *L. oxyuris* showing dimorphic paramylon rod. **34-35**. *L. salina* showing pellicle spirally striated to the right and chloroplasts discoid. **36**. *L. steinii* showing lobulate anterior end, chloroplasts disc-shaped and paramylon grains. **37-38**. *Monomorphina aenigmatica* with a parietal, spherical chloroplast and paramylon plates. **39-41**. *M. pyrum* with a spherical chloroplast and two parietal paramylon bodies. **42-43**. *Phacus acuminatus* var. *acuminatus* showing longitudinally striated pellicle and chloroplasts disc-shaped. **44-45**. *P. asymmetricus* showing chloroplasts discoid and paramylon bodies. **46-47**. *P. caudatus* with chloroplasts disc-shaped and paramylon grains. **48**. *P. curvicauda* showing a longitudinally striated pellicle, chloroplasts disc-shaped and paramylon bodies. **49-50**. *P. ichthydion* showing a pellicle spirally striated to the right, chloroplasts disc-shaped and paramylon bodies. **51-52**. *P. inflexus* showing a pellicle spirally striated to the right, chloroplasts oval-discs-shaped and two large paramylon grains. **53-56**. *P. orbicularis*, **53-54**. cells with small dimensions, ending with a short, more or less refluxed tail; **55-56**. cells larges, ending with a relatively long tail, and a long fold reaching the end of the cell. **57-58**. *P. polytrophos* showing a striate pellicle twisted to the right and paramylon grains. **59-61**. *P. raciborskii* showing chloroplasts disc-shaped and one or two paramylon grains. **62-63**. *P. tortus* with one paramylon grain. **64-65**. *Trachelomonas hispida* var. *hispida* showing a lorica covered by spines and apical pore without collar. Scale bar 10 µm.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Trachelomonas hispida (Perty) Stein *emend.* Deflandre var. ***hispida*** **Figs 25, 64-65**

Lorica 20-22.5 µm long, 15-17.5 µm wide.

This most common euglenophyte species occurred during both seasons. At collection the phytoplankton community was dominated by *Chlorella* sp., *Dictyosphaerium subsolitarium*, *Monoraphidium minutum*, *M. contortum*, *Scenedesmus subspicatus*, *S. granulatus* f. *granulatus*, *Aphanothece saxicola*, *Merismopedia tenuissima* and *Snowella lacustris*. Z_{DS}: 0.11-0.46 m; WT: 18.3-21°C; pH 6.9-8.5; SC: 628-3112 µS cm^{-1}; DO: 3.6-9 mg l^{-1}.

Distribution in Mexico: Jalisco, Oaxaca, Tabasco (Ortega, 1984; Mora-Navarro *et al.*, 2004; Moreno-Ruíz, 2005; Moreno-Ruíz *et al.*, 2008).

General distribution: Africa, America and Europe.

Habitat: Swamps, ponds and puddles; recorded as indicator of moderately to strongly polluted water (de Smet & Evens, 1972; Wołowski, 1998, 2002, 2003; Alves-da-Silva *et al.*, 2007, 2008).

DISCUSSION

Of the 21 taxa of euglenophytes found in Lake Chignahuapan, most are known as common inhabitants of eutrophic environments (Sládecek & Perman, 1978; Munawar, 1972; Tell & Conforti, 1986; Alves-da Silva *et al.*, 2007). *Phacus* was the most species- rich genus with 10 species, followed by *Lepocinclis* with 5, *Euglena* and *Monomorphina* with 2, *Cryptoglena* and *Trachelomonas* with one. The species *Euglena caudata*, *Lepocinclis acus*, *Phacus acuminatus*, *P. orbicularis* and *Trachelomonas hispida* var. *hispida* were the most frequently found ones in the studied area. During the study period, in general the abundance of euglenophytes was very low and the main phytoplankton communities were dominated by Chlorococcales (*Chlorella* sp., *Dictyosphaerium subsolitarium*, *Monoraphidium minutum*, *M. contortum*, *Scenedesmus subspicatus*, *S. granulatus* f. *granulatus*) and cyanoprokaryotes (*Aphanothece saxicola*, *Merismopedia tenuissima*, *Snowella lacustris*). These communities have been described as typical of eutrophic water bodies (Reynolds, 1984; Padisák & Dokulil, 1994; Nogueira & Leandro-Rodrigues, 1999; Borics *et al.*, 2000).

In our study the highest diversity of euglenoids was found during the summer rainy season (21 taxa as opposed to 7 taxa during the dry winter season). This could be attributed to the water temperature, whose values (18.3 to 21°C) are optimal for the growth of planktonic algae (Round, 1981).

Although Lake Chignahuapan is situated in a tropical region, its euglenophyte species composition is similar to that recorded from other tropical and temperate regions (Borics *et al.*, 2000; Wołowski, 2003; Alves-da-Silva & Bridi, 2004; Salazar, 2004; Conforti *et al.*, 2005). This could be attributed to its low transparency, high organic loads, and neutral to alkaline pH. Reynolds (1998) suggested that the presence of euglenophytes is characteristic of eutrophic to hypereutrophic water bodies with similar environmental conditions to Lake Chignahuapan.

From a biogeographic point of view, this is the first time that the species *Crytoglena skujae*, *Euglena caudata, E. limnophila, Lepocinclis ovum* var. *dimidio-minor*, *L. salina*, *L steinii*, *Monomorphina aenigmatica*, *Phacus caudatus*, *P. ichthydion*, *P. inflexus*, *P. orbicularis*, *P. polytrophos* and *P. raciborskii* have been recorded in Mexico.

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