DIVERSITY AND ECOLOGICAL CONSIDERATIONS ON PIGMENTED EUGLENOPHYCEAE IN THE STATE PARK OF THE JACUÍ DELTA, RIO GRANDE DO SUL, SOUTHERN BRAZIL

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RESUMO

As amostras qualitativas são provenientes de ambientes lóticos e lênticos no Parque Estadual Delta do Jacuí, próximo à capital do Estado do Rio Grande do Sul (29°56' e 30°03'S e 51°12'e 51°18'W), coletadas entre maio de 1998 e setembro de 1999, distribuídas em uma margem de ilha, cinco sacos e um canal. A análise revelou alta diversidade de *Euglenophyceae* pigmentadas sendo identificados 130 táxons em nível de gênero, espécie e infra-espécies. Dentre estes, 42 táxons são novas citações do gênero Trachelomonas para o Parque. A análise de classificação utilizando TWINSPAN diferenciou quatro grupos. O estudo da composição das *Euglenophyceae* pigmentadas do Parque e sua relação com variáveis ambientais revelou um conjunto de táxons (grupo B) que apresentou preferência por ambientes fortemente influenciados pela ação antrópica, com elevados índices de contaminação orgânica e concentrações de sais de amônio, bem como de íons nitrito e ortofosfato indicando condições de poluição mediana (β-α mesossapróbios). Ainda, registra-se pela primeira vez no Brasil espécies nunca citadas em bibliografia como adaptadas a tais condições ambientais.
Palavras-Chave: *Euglenonphyceae* pigmentadas, diversidade, ecologia, sul do Brasil.

ABSTRACT

Qualitative samples were taken from both lotic and lentic environments, in the State Park of the Jacuí Delta, located in the vicinity of the capital of Rio Grande do Sul State (29°56' e 30°03'S e 51°12'e 51°18'W), collected between May 1998 and September 1999, along the shore of an island, five bays ("sacos") and one canal. The analysis revealed a high diversity of pigmented *Euglenophyceae*, with 130 taxa identified to genus, species infra-species levels. Amongst these, 42 taxa were new citations of the genus Trachelomonas for the Park. Twinspan classification analysis identified four groups. The study of the pigmented *Euglenophyceae* population composition and its relationship with environmental variables revealed a group of taxa (group B) with preference for habitats strongly changed by human action, with high levels of organic contamination and ammonium salts, as well as nitrite ions and orthophosphate, indicating moderately polluted waters (β-α mesossaprobic). Additionally, the environmental preferences of species never before described in the literature as characteristic of the conditions listed above, are given for the first time in Brazil.
Keywords: pigmented *Euglenophyceae*, diversity, ecology, southern Brazil.

INTRODUCTION

The present work has been carried out at the State Park of the Jacuí Delta and presents part of the results of the phycological flora study, within the Program for Rational Development, Recovery and Environmental Management of the Guaíba Hydrographic Basin (Pró-Guaíba), developed between 1998/1999, by the research team of the Natural Sciences Museum at the Rio Grande do Sul Zoobotanical Foundation.

The State Park of the Jacuí Delta, is one of the most important natural areas of Rio Grande do Sul, Southern Brazil. It is located in the metropolitan region of

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the city of Porto Alegre, near the Patos Lagoon (Fig. 1). The delta is formed by a great variety of aquatic environments such as islands, canals between islands and bays in islands, as well as the mouths of Jacuí, Caí, Sinos, and Gravataí rivers. This ecosystem is called *interior delta*, since the formation of the sedimentary islands did not occur in the ocean boundary, but at the heads of the Guaíba Lagoon (TAVARES et. al. 2005). Furthermore, the State Park of the River Jacuí Delta is part of the most important hydrographic basin of Rio Grande do Sul: the Guaíba Basin. This region, where the climate is sub-tropical, according to the Thornthwaite classification system, is the most populated region of the State, with the greatest concentration of economical activities, and, therefore, of environmental concerns.

Since the seventies, the Water and Sewage Municipal Department of Porto Alegre (DMAE), has carried out studies for water quality evaluation of the Guaíba Lagoon, and the River Jacuí Delta. Data collected in 2001 (PORTO ALEGRE, 2001) showed that water quality in the delta is heavily depreciated, mainly due to the contribution of the River Gravataí, which inputs the highest load of sewage and waste waters amongst all tributaries. SALOMONI et al. (2006) emphasised that the organic pollution in this river results from farming activities along its upper course, and from urban and industrial effluents along its lower course.

Freshwater algae form the base of most aquatic food webs, and are, consequently, the first community to be affected by environmental impacts. This specific sensibility to environmental conditions, as well as their high diversity, favours their potential in yielding a precise assessment of physical, chemical, and biological conditions in most habitats. Thus, taxonomical composition, and diversity of algal communities have been used for the evaluation of ecological health in several ecosystems, as well as in the identification of means of ecological damage (STEVENSON & SMOL, 2003).

Pigmented Euglenophyceae has been considered a significant group in the study of the Delta's phycological flora, resulting in the publication of five articles about this class (ALVES-DA-SILVA & ÁVILA, 1997; ALVES-DA-SILVA & CROSSETI, 1999; ALVES-DA-SILVA & HAHN, 2004; ALVES-DA-SILVA & BRIDI, 2004a; 2004b). This free-swimming microalgal group of wide geographical distribution, are found worldwide, occurring predominantly in small freshwater bodies, with high organic matter content (ROUND, 1983; MARGALÉF, 1983; WETZEL, 1993; WOLOWSKI, 1998; SLADECÉK, 1973; SLADECÉK & PERMAN, 1978; NEVO & WASSER, 2000). Several species are known indicators of organically polluted environments (e.g, SLADECÉK, 1973; SLADECÉK & PERMAN, 1978). However, studies concerning both the occurrence of Euglenophyceae, and environmental variables are still scarce (PHILIPOSE, 1982; 1989; XAVIER, 1991; WOLOWSKI, 1998; ALVES-DA-SILVA & BRIDI, 2004a, 2004b; PEREIRA & AZEITEIRO, 2003, CONFORTI et. al., 2005, among others).

Due to the significance of the Euglenophyceae in the composition of phytoplankton as well as the lack of ecological data regarding this group in Brazil, in Rio Grande do Sul and, therefore, in the State Park of the Jacuí Delta, the present study was carried out. Amongst the results, new data about the genus *Trachelomonas* in the Park are given. The present paper also represents the first effort towards a better understanding of the ecology of pigmented Euglenophyceae in the Jacuí Delta, providing essential information about the environmental preferences of these organisms, focusing on qualitative aspects

MATERIAL AND METHODS

The State Park of the Jacuí Delta is located at 29º 56', 30º 03' S and 51º 12', 51º 18' W (Fig. 1), in Rio Grande do Sul, Southern Brazil with a total area of 17,245 ha.

Sampling effort involved five field trips to two lotic and five lentic environments in the State Park of the Jacuí Delta, along an island shore, five bays and one canal. Field trips took place in May 1998 (M8), September 1998 (S8), November 1998 (N8), April 1999 (A9), June 1999 (J9) and September 1999 (S9), comprising the fours seasons of the year. The habitats studied were the bays 'Saco do Cabral' (SC), 'Saco das Garças' (SG), 'Saco do Quilombo' (SQ), 'Saco do Jacaré' (SJ) and 'Saco da Pólvora' (SP) along with the Channel Feliz (CF) and the banks of Serafim Island (IS) (Fig. 1).

Water samples were collected, according to the procedures described in APHA (1995) in order to determine: ammonium, nitrate, dissolved oxygen, biochemical oxygen demand, silicon, orthophosphate, organic matter, total coliforms and fecal coliforms. Also, pH, electric conductivity, transparency and water temperature were measured in the field (Tab. 1).

BIOLOGICAL SAMPLING

Biological samples were collected along the shores, using plankton nets of 25 µm pore size, and were preserved with 4% formaldehyde. Aliquots of the samples were kept alive for the observation of morphological characteristics necessary for taxonomical identification of the Euglenophyceae.

Qualitative analysis of the biotic component was carried out using a Leitz optical microscope, model Dialux, equipped with bright field and eyepiece graticules for measurements of the specimens.

For taxa identification, at specific and infra-specific levels, basic literature was consulted: CONRAD (1943), DEFLANDRE (1926; 1930), GOJDICS (1953), HUBER-PESTALOZZI (1955), NEMETH (1980), POCHMANN (1942), SHI et al. (1999), STARMACH (1983), TELL & CONFORTI (1986), WEIK (1967), WOLOWSKI (1998), as well as recent papers about the group.

All samples were deposited in the "Prof. Dr. Alarich R. H. Schultz Herbarium (HAS)" at the Natural

Sciences Museum of the Zoobotanical Foundation of Rio Grande do Sul (Tab. 2).

STATISTICAL ANALYSES

Samples were grouped according to the presence or absence of species in each sample, through Twinspan (Two Way Indicator Species Analysis) (HILL, 1979), using the software PC-Ord version 4.0 for Windows (McCUNE & MEFFORD, 1999). Default options were used (pseudo-species cutting levels: 0 – presence and absence; minimum group size per division: 5; maximum number of indicators per division: 5; maximum number of species in the final table: 200; highest division level: 6). Codes used for Twinspan analysis are given between square brackets after each species.

Grouping sharpness was determined by the verification of the statistical significance of the differences of distribution and frequencies between the Twinspan groups in the distinct cutting levels, using hypothesis testing by randomization, according to PILLAR & ORLÓCI (1996). Pairs that differed between each other were found through contrast analysis, analogue to the Scheffé test, described in PILLAR & ORLÓCI (1996).

Physical and chemical variables used to characterise the environment of the Twinspan groups, were also submitted to hypothesis testing by randomization, after previous standardization of data (log |x + 1|). Multiv version 2.1.1 (PILLAR, 2001) was the software used for this analysis.

RESULTS

Twinspan classification analysis resulted, at the fourth division level, in four groups and one isolated sampling unit, the latter corresponding to Serafim Island in May 1998, due to the exclusive occurrence of *Phacus cylindrus* Pochm [Pcyl] in that sample (Fig. 2). Using randomization tests to define grouping sharpness, the analysis was broken in the third division of the second cutting level, in the tenth division of the fourth level, and in the 22nd division of the fifth level. The test was not applied to the second division of the second level due to the isolation of one single sampling unit (Fig. 2).

Four species have been associated to Twinspan Group A: *Strombomonas fluviatilis* (Lemm.) Defl. [Sfluv], *Strombomonas scabra* var. *ovata* [Playf.] Tell & Conf. f. *minor* Tell & Conf. [Scovmi], *Strombomonas treubii* (Wol.) Defl. [Streu], and *Strombomonas verrrucosa* var. *zmiewika* (Swir.) [Svzmi].

Forty-four species seemed to be better adapted to Twinspan Group B: *Euglena allorgei* Defl. [Eal], *Euglena caudata* Hübner [Ecau], *Euglena deses* Ehr. var. *intermedia* Klebs [Ede], *Euglena ehrenbergii* Klebs (Ehr.), *Euglena limnophila* Lemm. [Elim], *Euglena mutabilis* Schmitz [Emut], *Euglena oxyuris* Schmarda [Eoxy], *Euglena polymorpha* Dang. [Epol], *Euglena sanguinea* Ehr. [Esang], *Euglena spirogyra* Ehr. [Espi], *Euglena spirogyra* Ehr. var. *fusca* Klebs [Espif], *Euglena viridis* Ehr. [Evir], *Lepocinclis caudata* (Da Cunha) Conr. [Lcau], *Lepocinclis fusiformis* (Carter) Lemm. [Lfus], *Lepocinclis fusiformis* (Carter) Lemm. var. *amphyrhynchus* Nyg. [Lfusa], *Lepocinclis ovum* (Ehr.) Lemm. [Lovu], *Lepocinclis ovum* (Ehr.) Lemm. var. *globula* (Perty) Lemm. [Lglo], *Phacus acuminatus* Stokes [Phac], *Phacus caudatus* Hübner [Pcau], *Phacus contortus* Bour. [Pcont], *Phacus longicauda* (Ehr.)Duj. var. *major* Swir. [Plmaj], *Phacus mariae* Defl. [Pmar], *Phacus orbicularis* Hübner [Porb], *Phacus pleuronectes* (Ehr.) Duj. [Ppleu], *Phacus pyrum* (Ehr.) Stein [Pyr], *Strombomonas conforti* Zal. [Sconf], *Strombomonas ensifera* (Daday) Defl. [Sens], *S. fluviatilis* (Lemm.) Defl. var. *laevis* (Lemm.) Skv. [Sflul], *S. globulosa* Conf. & Joo [Sgol], *Strombomonas gibberosa* (Playf.) Defl. [Sgib], *Strombomonas maxima* (Skv.) Defl. [Smax], *Strombomonas scabra* var. *intermedia* (Yac.) Tell & Conf. [Sscint], *Strombomonas scabra* (Playf.) Tell & Conf. var. *scabra* [Scab], *Trachelomonas armata* (Ehr.) Stein var. *steinii* Lemm. emend. Defl. [Tstei], *Trachelomonas armata* (Ehr.) Stein var. *inevoluta* Defl. [Tarin], *Trachelomonas hispida* (Perty) Stein var. *coronata* Lemm. [Thcor], *Trachelomonas hispida* (Perty) Stein var. *crenulatocollis* (Maskell) Lemm. [Thcren], *Trachelomonas megalacantha* Da Cunha [Tmeg], *Trachelomonas planctonica* Swir. var. *flexicollis* Bal. [Tpflex], *Trachelomonas sculpta* Bal. [Tscul], *Trachelomonas similis* Stokes [Tsim], *Trachelomonas similis* Stokes var. *spinosa* Hub.-Pest. [Tspi], *Trachelomonas volvocina* Ehr. [Tvolv] and *Trachelomonas volvocinopsis* Swir. [Tvolvc]. Figures 3 to 38 depict species belonging to this group, for illustrative purposes only.

Within Twinspan Group C were grouped: *Euglena elastica* Prescott [Elast] (Elast), *Phacus onyx* Pochm. var. *onyx* [Pony], *Phacus stokesii* Lemm. [Pstok], *Strombomonas deflandrei* [Sdefl], *Trachelomonas armata* (Ehr.) Stein var. *longispina* Playf. emend. Defl. [Tarlong], *Trachelomonas* (Perty) Stein var. *hispida* [This], *Trachelomonas kellogii* (Ehr.) Stein [Tkel], *Trachelomonas lacustris* Drez. [Tlac], *Trachelomonas pulcherrima* Playf. [Tpulch], *Trachelomonas splendissima* Midd. [Tsple] and *Trachelomonas zingeri* Roll [Tzin]. Twinspan group D was indicated only by two species: *Trachelomonas granulata* (Ehr.) Stein [Tgra] and *Trachelomonas hispida* (Perty) Stein var. *duplex* Defl. [Thdupl].

Remaining taxa comprised: *E. acus* Ehr., *E. acus* Ehr. var. *longissima* Defl., *E. agilis* Carter, *E. gaumei* All. & Lef., *E. hemichromata* Skuja, *E. rostrifera* Johnson, *E. tripteris* (Duj.) Klebs, *Lepocinclis ovum* (Ehr.) Lemm. var. *dimidio-minor* Defl., *L. pyriformis* Da Cunha, *L. salina* Fritsch, *L. salina* Fritsch f. *obtusa* (Hub.Pest.) Conr. (Lobt), *L. salina* Fritsch var. *vallicauda* Conr., *Lepocinclis* sp., *P. curvicauda* Swir., P. *hamatus* Pochm., *P. horridus* Pochm., *P. icthydium* Pochm., *P. lefevrei* Bour., *Phacus longicauda* (Ehr.) Duj. var. *longicauda*, *Phacus rodriguesiae* Conf., *Phacus striatus* Francé, *P. suecicus* Lemm., *P. undulatus* (Skv.) Pochm., *P. unguis* Pochm., *Strombomonas acuminata* (Schm.) Defl. var.

amphora Playf., *S. borystheniense* (Roll) Pop., *S. chodatii* (Skv.) Defl., *S. cuneata* (Playf.) Defl., *S. elegans* Conf. & Joo, *S. girardiana* (Playf.) Defl. *S. lanceolata* (Playf.) Defl., *S. moreniensis* Bal. & Dast., *S. rotunda* (Playf.) Defl., *S. scabra* (Playf.) Tell & Conf. var. *intermedia* (Yacubson) Tell & Conf.**,** *S. scabra* (Playf.) Tell & Conf. var. *ovata* (Playf.) Tell & Conf. f. *ovata, S. triquetra* (Playf.) Defl. var. *torta* Rino, *S. verrucosa* var. *genuina* Defl., *S. schauinslandii* (Lemm.) Defl., *S. tetraptera* Bal. et Dast. var. *gallica* Bour. & Couté, *S. verrucosa* (Daday) Defl., *S. urceolata* (Stokes) Defl., *Strombomonas* sp.1 e sp. 2*, Trachelomonas acanthophora* Stokes var. *acanthophora, T. acantophora* Stokes var. *minor* Bal. et Dast*., T. argentinensis* (G. de Emiliani) Conf. & Nudelman, *T. bernardi* Wol., *T. cervicula* Stokes, *T. curta* Cunha emend. Defl. var. *minima* Tell & Zal., *T. decora* Defl., *T. duquei* Conf. & Nud., *T. intermedia* Dang., *T. lemmermanii* Wol. emend. Defl., *T. megalacantha* var. *crenulatocollis* Bour., *T. oblonga* Lemm., *T. recticollis* (Playf.) Defl., *T. robusta* Swir. emend. Defl., *T. rotunda* Swir. emend. Defl., *T. superba* Swir. emend. Defl., *T. spirogyra* Balech, *T. varians* Defl., *T. volvocina* Ehr. var. *derephora* Conr., *Trachelomonas* sp. 1 e sp.2.

Randomization hypothesis tests using the physical and chemical data matrix, organised according to the Twinspan grouping, highlighted the important differentiation of Group B from the remaining groups. Table 3 gives the means, median, standard deviations, and range of abiotic factors for each group defined by Twinspan. Group B was characterised by significantly greater concentrations of ammonium, conductivity, nitrites, total coliforms, fecal coliforms, and orthophosphate (Tab.3, 4). Group C was different from group B due to the greater concentrations of fecal coliforms and orthophosphate in group B (Tab. 3, 4).

Among the remaining groups, the only significant differences were between groups A and D regarding temperature and transparency, both higher in A.

Forty two samples of different lotic and lentic environments were studied, and only pigmented organisms of the class Euglenophyceae were listed. Species diversity was high, with 130 taxa (genus, species and infra-species levels) being found. *Euglena*, *Lepocinclis, Phacus, Strombomonas* and *Trachelomonas* were the genera found. Regarding the genus *Trachelomonas*, 42 taxa were new citations for the State Park of the Jacuí Delta.

Figure 39 shows the number of pigmented Euglenophyceae taxa registered at seven sampling stations in 1998/1999 at the State Park of the Jacuí Delta.

Figure 39

DISCUSSION

Two sampling sites – Saco do Cabral (near the mouth of the River Gravataí) and Serafim Island (near the mouth of the River Caí) showed the greatest number of Euglenophyceae taxa in April 1999 (Fig. 39), when both referred sites had temperatures around 23ºC, acid pH (6.8) and a wide range of environmental variables. Ammonium, varied between 60 and 360 $\mu g.L^{-1}$, orthophosphate varied from 340 to 530 $\mu g.L^{-1}$, organic matter from 3.6 to 3.7mg. L^{-1} and fecal coliforms from 2,800 to 20,000/100mL .

According to Hamm (1968) in SOUZA (2002), Saco do Cabral (Fig. 39), where the highest richness of Euglenophyceae was found, could be classified as β-mesossaprobic regarding ammonium and BOD, α-mesossaprobic regarding oxygen deficit, and oligossaprobic regarding organic matter.

As asserted by ROUND (1983), Euglenophyceae are algae characteristic of environments rich in ammonia. The present study supports this statement, since all taxa were found in waters where the average ammonium concentration varied between 121$\mu g. L^{-1}$ and 546 $\mu g. L^{-1}$, being classified, according to Hamm in SOUZA (2002), as of average pollution (β/α mesossaprobic).

REYNOLDS (1998) pointed out that Euglenophyceae are usually characteristic of eutrophic to hipereutrophic environments with high organic loads, high turbidity, neutral to alkaline pH, and that several species of this class are potential indicators of such environments. However, CONFORTI et al. (2005) working at "Tablas de Daimiel" in Spain, a hipereutrophic environment, concluded that the richness and biovolume of Euglenophyceae showed fluctuations that were not correlated with the environmental data: organic, particulate and total carbon, ammonium, total nitrogen, orthophosphate and phosphorus. To these authors, therefore, the use of the Euglenophyceae as indicators of hipereutrophic water environments must be restricted and carefully thought of.

Several Brazilian authors, including ALVES-DA-SILVA & FERRAZ (1991), ALVES-DA-SILVA & TORRES (1994), ALVES-DA-SILVA & ÁVILA (1997), CARDOSO (1982), CECY (1990), GOULART et al. (2002), MENEZES (1989, 1991), MOSS (1998), SANT´ANNA et al. (1989), XAVIER (1990, 1991) AND XAVIER et al. (1991), amongst others, have found Euglenophyceae in natural or artificial environments characterized by β-mesosaprobic to polisaprobic conditions.

In fact, the study of the diversity and ecology of pigmented Euglenophyceae in the State Park of the Jacuí Delta and their relationship with environmental variables allowed the characterization of a group of taxa which may live in environments strongly changed by human action (Twinspan Group B), with high organic loads, and high concentrations of ammonium salts, as well as of nitrites and orthophosphate ions. This group, which was represented by "Saco do Cabral" in autumn 1998, and spring 1999, "Saco das Garças" in Spring 1998, and the shore of "Serafim Island" in autumn 1999, environmental data represent 34.6% of the taxa identified. The former two habitats receive waters from the River Gravataí, a moderately to strongly polluted system (SALOMONI et al., 2006), while Serafim Island receives waters from the River Caí, another moderately polluted system.

Validating these results, the following species, characteristic of the Twinspan Group B mentioned above, were listed by SLADECÉCK (1973), SLADECÉCK AND PERMAN (1978) as indicators of moderately to strongly polluted waters (β-mesosaprobic to α-

mesosaprobic) in Europe: *Euglena allorgei, Euglena ehrenbergii, Euglena deses* var. *intermedia*, *Euglena limnophila*, *Euglena mutabilis*, *Euglena oxyuris Euglena polymorpha*, *Euglena sanguinea, Euglena spirogyra, Euglena viridis, Lepocinclis fusiformis*, *Lepocinclis ovum, Phacus caudatus*, *Phacus longicauda* var. *longicauda*, *Phacus orbicularis, Phacus pleuronectes*, *Phacus pyrum, Trachelomona hispida* var. *crenulatocollis, Trachelomonas similis*, *Trachelomonas volvocina* and *Trachelomonas volvocinopsis*. PEREIRA & AZEITEIRO (2003) pointed out that *P. pleuronectes* may occur in environments varying from β-mesosaprobic to α-mesosaprobic. Also, WOLOWSKI (1998) mentioned that *Euglena spirogyra* var. *fusca, Phacus acuminatus* var. *acuminatus* and *P. curvicauda* var. *curvicauda* might be found in environments varying from β-mesosaprobic to α-mesosaprobic, and that *Euglena caudata,* also thrives in polysaprobic environments.

Widening these results, the environmental preferences of species never before described in the literature as characteristic of the conditions listed above - moderately polluted waters - are given herein. These species were included in Twinspan group B, as follows: *Lepocinclis caudata*, *Lepocinclis fusiformis*, *Lepocinclis ovum var. amphyrhynchus, Lepocinclis ovum* var. *globula, Phacus contortus, Phacus longicauda* var. *major*, *Phacus mariae, Strombomonas conforti, Strombomonas ensifera S. fluviatilis laevis*, *S. globulosa*, *Strombomonas gibberosa*, *Strombomonas maxima*, *Strombomonas scabra* var. *intermedia*, *Strombomonas scabra, Trachelomonas armata* var. *steinii, Trachelomonas armata* var. *inevoluta*, *Trachelomonas hispida* var. *coronata, Trachelomonas megalacantha*, *Trachelomonas planctonica* var. *flexicollis*, *Trachelomonas sculpta*, *Trachelomonas similis* e *Trachelomonas similis* var. *spinosa.*

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Table 1. Environmental characterization of the TWINSPAN (**BOD**: biochemical oxygen demand; **ºC**: water temperature; **Cond**: conductivity; **FC**: fecal coliforms; **NH_4**: ammonium; **NO_3**: nitrate; **NO_2**: nitrite; **OM**: organic matter; **PO_4**: orthophosphate; **s**: standard deviation; **Si**l: silicon; **TC**: total coliforms; **Trp**: transparency; **$\%O_2$**: saturated dissolved oxygen).

Environmental	**Group A (n=18)**				**Group B (n=6)**				**Group C (n=4)**				**Group D (n=13)**			
Variables	**Mean**	**s**	**Min.**	**Max.**	**Mean**	**s**	**Min.**	**Max.**	**Mean**	**s**	**Min.**	**Max.**	**Mean**	**s**	**Min.**	**Max.**
NH_4 ($\mu g.L^{-1}$)	100	119	12	377	546	413	60	1300	222	111	68	330	121	107	20	390
TC (NMP/100 mL)	4,919	7,101	500	28,000	14,800	5,530	5,000	20,000	8,800	5,671	5,000	17,000	7,300	7,476	300	22,000
FC (NMP/100 mL)	2,409	6,594	40	28,000	9,511	8,448	800	20,000	650	499	210	1,288	2,162	3407	40	11,000
Cond($\mu S.cm^{-1}$)	78	27	48	132	126	38	78	173	76	16	54	91	69	19	46	97
BOD($mg.L^{-1}$)	0.8	0.9	0.2	3.2	1.4	0.9	0.1	2.4	1.0	0.6	0.3	1.6	1.0	0.8	0.3	2.5
OM ($mg.L^{-1}$)*	3.5	3.6	1.4	7.9	5.8	1.8	3.6	8.0	10.0	8.0	3.6	7.0	6.2	2.3	3.5	7.0
NO_3 ($\mu g.L^{-1}$)	750	228	300	1100	1083	553	600	2100	950	465	400	1500	1000	321	300	1400
NO_2 ($\mu g.L^{-1}$)	18	15	1	48	62	46	20	131	19	13	5	33	12	7	2	24
PO_4 ($\mu g.L^{-1}$)	249	328	60	1520	670	610	290	1900	229	137	30	330	376	537	60	2120
$\%O_2$ ($mg.L^{-1}$)	71	19	14	94	54	28	29	105	55	30	22	95	65	17	41	90
pH	6.5	0.3	6.0	7.0	6.4	0,3	6.0	6.8	6.4	0.5	5.9	7.0	6.2	0.6	5.0	7.0
Sil ($mg.L^{-1}$)	11.66	4.76	4.90	25.44	12.17	3.23	8.14	15.19	16.54	5.62	11.14	24.44	10.63	8.15	3.70	34.00
ºC	20.9	3.1	16.7	25.6	21.1	2.5	17.4	23.2	18.5	3.7	13.1	21.3	16.6	2.8	12.4	20.2
Trp (cm)	35	7	25	52	31	7	25	45	36	17	20	55	26	7	15	43

***** Not measure in May of 1998.

Table 2. Sampling stations, sites and dates, and samples register number in the Prof. Dr. Alarich Schulz Herbarium (HAS) on seven freshwater habitats (systems) in the State Park of the Jacuí Delta, between May 1998 and November 1999.

Stations	**Sampling sites**	**Sampling dates**	**HAS**	**Stations**	**Sampling sites**	**Sampling dates**	**HAS**
1	Saco do Cabral: SC	7/5/1998	34632	4	Feliz Channel:CF	5/4/1999	34887
1	Saco do Cabral: SC	15/9/1998	34791	4	Feliz Channel:CF	14/6/1999	34951
1	Saco do Cabral: SC	10/11/1998	34805	4	Feliz Channel:CF	27/9/1999	34965
1	Saco do Cabral: SC	5/4/1999	34881	5	Saco do Quilombo: SQ	7/5/1998	34639
1	Saco do Cabral: SC	14/6/1999	34945	5	Saco do Quilombo: SQ	15/9/1998	34799

1	Saco do Cabral: SC	27/9/1999	34959	5	Saco do Quilombo: SQ	10/11/1998	34813
2	Saco das Garças: SG	7/5/1999	34633	5	Saco do Quilombo: SQ	5/4/1999	34889
2	Saco das Garças: SG	15/9/1998	34793	5	Saco do Quilombo: SQ	14/6/1999	34953
2	Saco das Garças: SG	10/11/1998	34807	5	Saco do Quilombo: SQ	27/9/1999	34967
2	Saco das Garças: SG	5/4/1999	34883	6	Saco do Jacaré: SJ	7/5/1999	34643
2	Saco das Garças: SG	14/6/1999	34947	6	Saco do Jacaré: SJ	15/9/1998	34801
2	Saco das Garças: SG	27/9/1999	34961	6	Saco do Jacaré: SJ	10/11/1998	34815
3	Serafim Island: IS	7/5/1999	34635	6	Saco do Jacaré: SJ	5/4/1999	34891
3	Serafim Island: IS	15/9/1998	34795	6	Saco do Jacaré: SJ	14/6/1999	34957
3	Serafim Island: IS	10/11/1998	34809	6	Saco do Jacaré: SJ	27/9/1999	34969
3	Serafim Island: IS	5/4/1999	34885	7	Saco da Pólvora: SP	7/5/1999	34645
3	Serafim Island: IS	14/6/1999	34949	7	Saco da Pólvora: SP	15/9/1998	34803
3	Serafim Island: IS	27/9/1999	34963	7	Saco da Pólvora: SP	10/11/1998	34817
3	Canal Feliz:CF	7/5/1999	34637	7	Saco da Pólvora: SP	5/4/1999	34893
4	Feliz Channel:CF	15/9/1998	34797	7	Saco da Pólvora: SP	14/6/1999	34955
4	Feliz Channel:CF	10/11/1998	34811	7	Saco da Pólvora: SP	27/9/1999	34971

Table 3. Results of auto-resampling and randomization tests to verify the statistical significance of the differences of distribution and frequencies of species and physical and chemical variables, between TWINSPAN groups. (**BOD**: biochemical oxygen demand; **ºC**: water temperature; **Cond:** conductivity; **FC:** fecal coliforms; **NH_4**: ammonium; **NO_3**: nitrate; **NO_2**: nitrite; **PO_4**: orthophosphate; **Sil**: silicon; **TC**: total coliforms; **Trp**: transparency; **$\%O_2$**: saturated dissolved oxygen).

TWINSPAN Groups	**Specific distribution and frequency**	$p(Q_{RND} \geq Q_{OBS})$ **Physical and chemical variables**												
		NH_4	**TC**	**FC**	**Cond**	**BOD**	**NO_3**	**NO_2**	**PO_4**	**$\%O_2$**	**pH**	**Sil**	**ºC**	**Trp**
Between groups	*0.0001	*0.0023	*0.0132	*0.0485	*0.0068	0.4057	0.1919	*0.0105	*0.0194	0.1585	0.4588	0.0654	*0.0017	*0.0220
contrast:														
AxB	*0.0001	*0.0003	*0.0021	*0.0155	*0.0046	**	**	*0.0019	*0.0063	**	**	**	0.9176	0.3266
AxC	0.2249	0.0585	0.0844	0.6590	0.3500	**	**	0.7493	0.5085	**	**	**	0.2310	0.7568
AxD	0.1282	0.2581	0.3726	0.9152	0.4369	**	**	0.7669	0.3447	**	**	**	*0.0003	*0.0024
BxC	*0.0002	0.3835	0.5300	*0.0293	0.2398	**	**	0.0686	*0.0081	**	**	**	0.2736	0.6565
BxD	*0.0001	*0.0274	*0.0329	*0.0154	*0.0008	**	**	*0.0011	0.0648	**	**	**	*0.0071	0.2183
CxD	0.5830	0.3434	0.2789	0.6939	0.1511	**	**	0.6109	0.2095	**	**	**	0.3263	0.1166

***p* = probability that randomized sum of squares (Q_{RND}) be as extreme as the observed sum of squares (Q_{OBS}) in 10,000 iterations. * = significant with $\alpha \leq 0.05$**

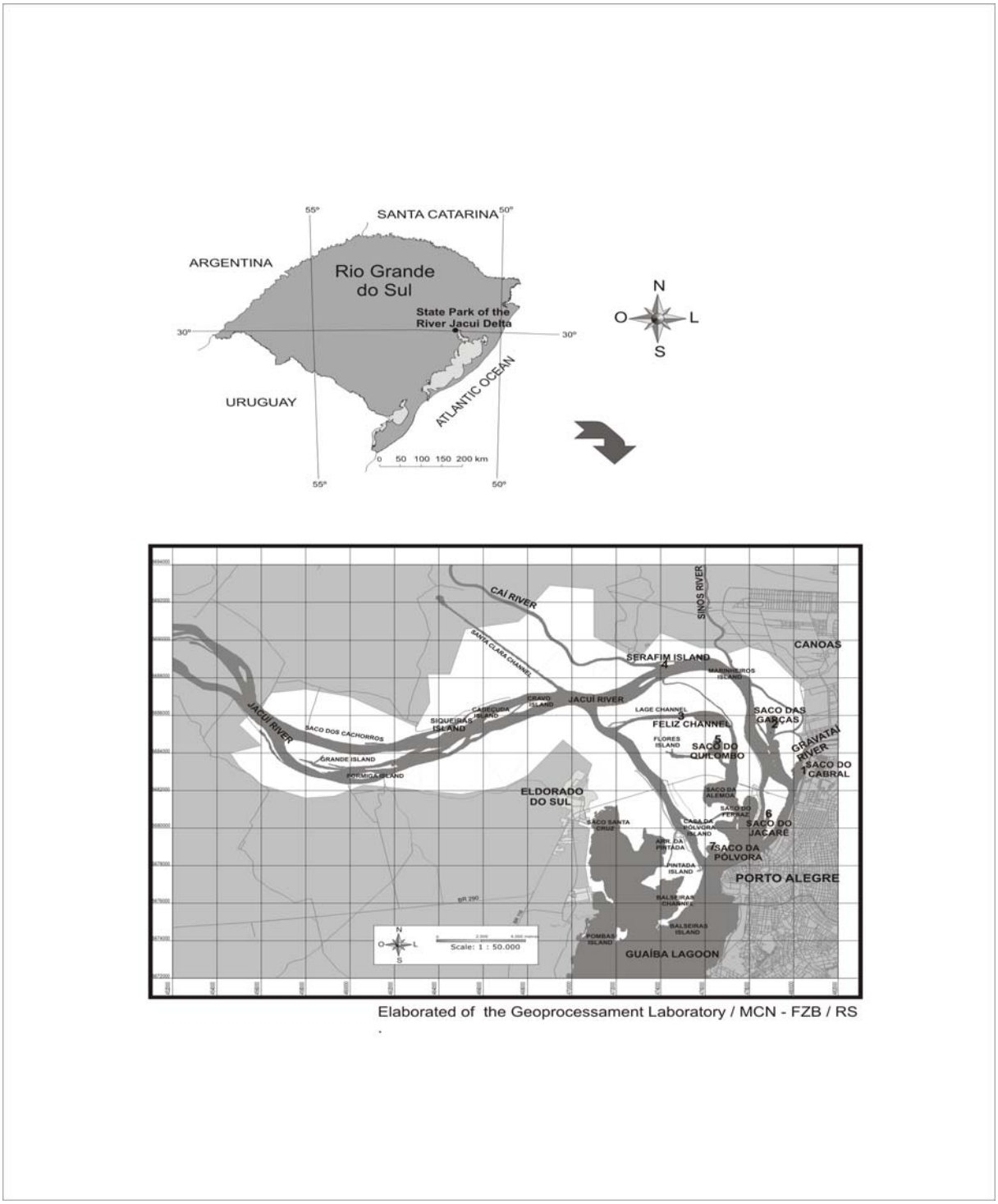


Figure 1: State Park of the River Jacuí Delta; map of the area indicating the seven sampling stations (1-7).

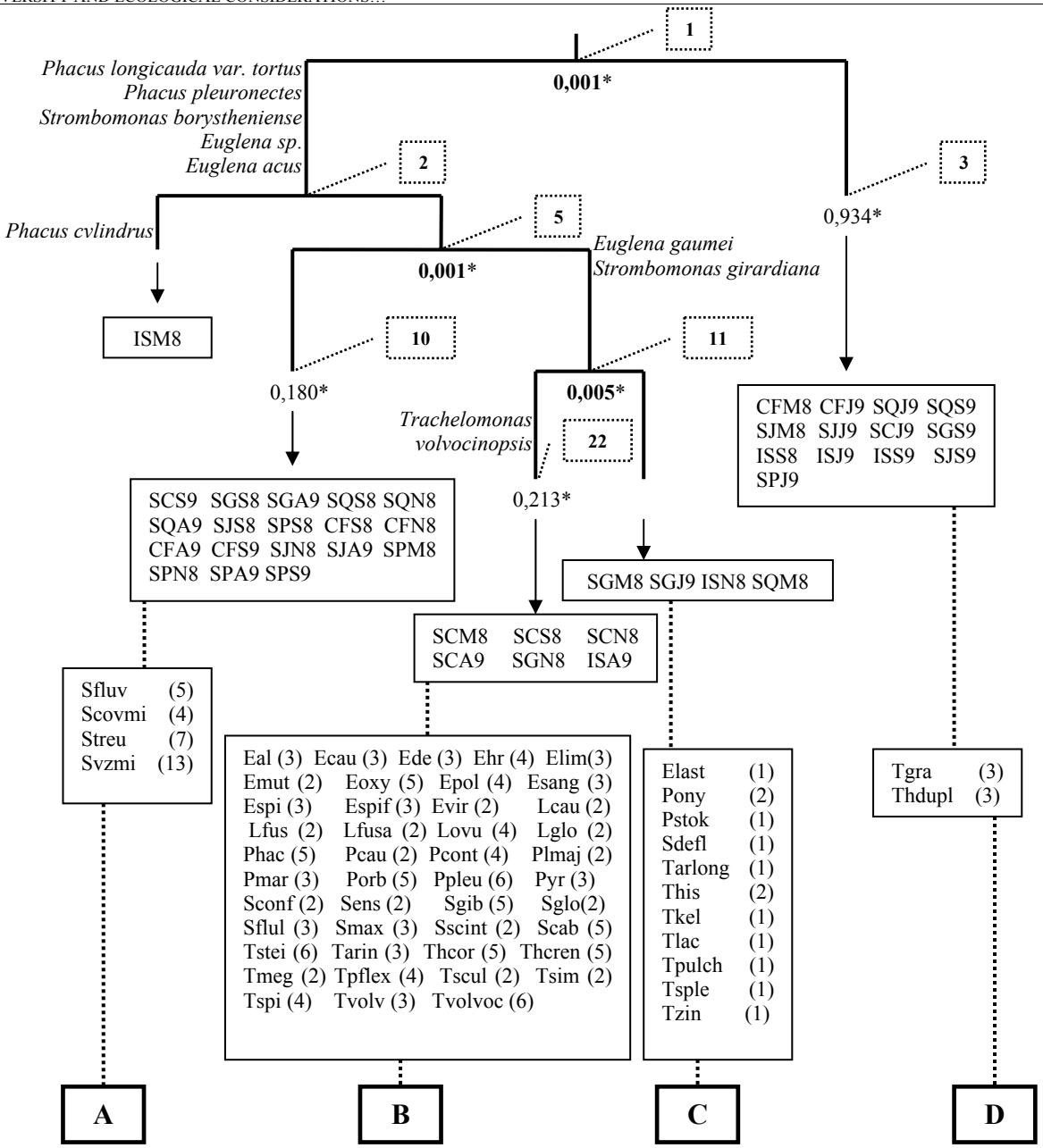
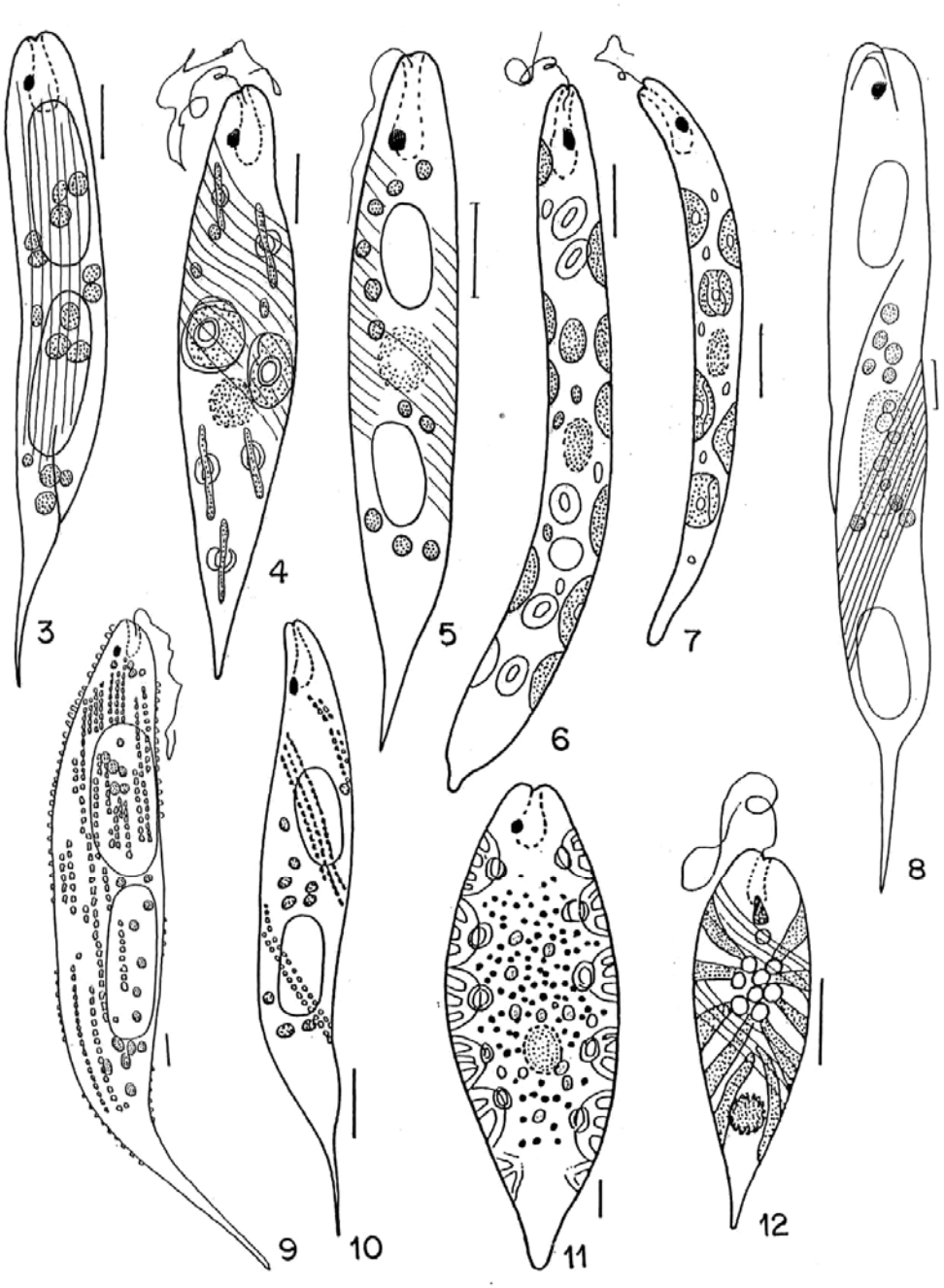
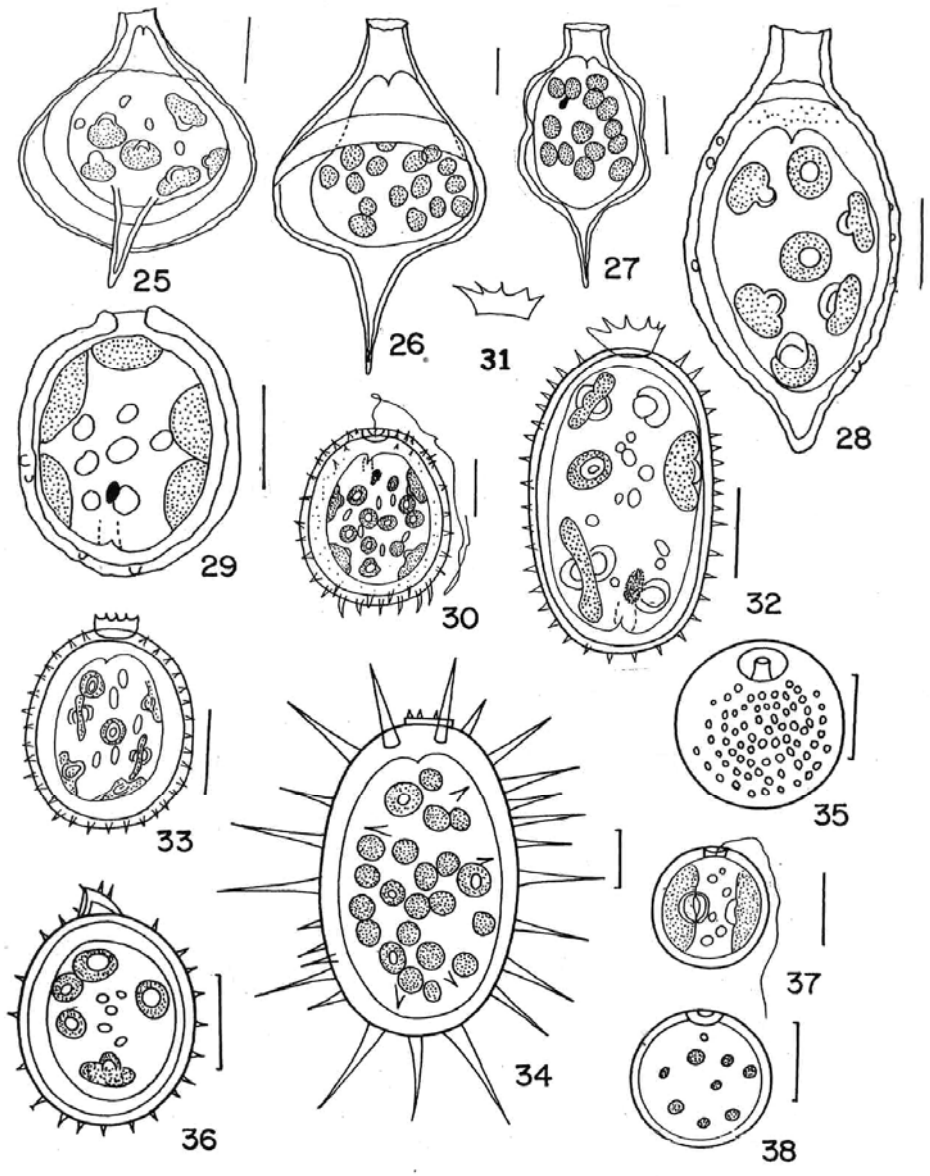


Figure 2: Results of Two Way Indicator Species Analysis (Twinspan) applied to 42 sampling units. Sampling sites and dates, as well as species associated to each group are indicated in the squares. SC = Saco do Cabral, SG = Saco das Garças, SQ = Saco do Quilombo, SJ = Saco do Jacaré, SP = Saco da Pólvora, CF = Feliz Channel and IS = Serafim Island (IS); May 1998 (M8), September 1998 (S8), November 1998 (N8), April 1999 (A9), June 1999(J9) and September 1999 (S9). Numbers inside dashed squares indicate divisions. Numbers in brackets indicate the number of occurrences within that group. * = results of randomisation tests.



Figures 3-12. 3. *Euglena acus* Ehr. var. *acus*. 4. *Euglena caudata* Hübner. 5. *Euglena limnophila* Lemm. *var. limnophila*. 6. *Euglena deses* Ehr. var. *intermedia* Klebs. 7. Euglena mutabilis Schmitz. 8. *Euglena oxyuris* Schmarda var. *oxyuris*. 9. *Euglena spirogyra* Ehr. var. *fusca* Klebs. 10. Euglena *spirogyra* Ehr. var. *spirogyra*. 11.*Euglena sanguinea* Ehr. 12. *Euglena viridis* Ehr. Scale = 10μm.



Figures 25-38. 25-26. *Strombomonas confortii* Zaloc. 27. *Strombomonas gibberosa* (Playf.) Defl. 28. *Strombomonas scabra* (Playf.) Tell & Conf. var. *intermedia* (Yacubson) Tell & Conf. 29. *Strombomnas scabra* (Playf.) Tell & Conf. 30. *Trachelomonas armata* (Ehr.) Stein var. *steinii* Lemm. emend. Defl.31-32. *Trachelomonas hispida* (Perty) Stein var. *crenulatocollis* (Maskell) Lemm. 33. *Trachelomonas hispida* (Perty) Stein var. *hispida*. 34. *Trachelomonas megalacantha* Cunha. 35. *Trachelomonas sculpta* Bal.. 36. *Trachelomonas similis* Stokes var. *spinosa* Hub.-Pest. 37. *Trachelomonas volvocina* Ehr. 38. *Trachelomonas volvocinopsis* Swir. Scale = 10μm.

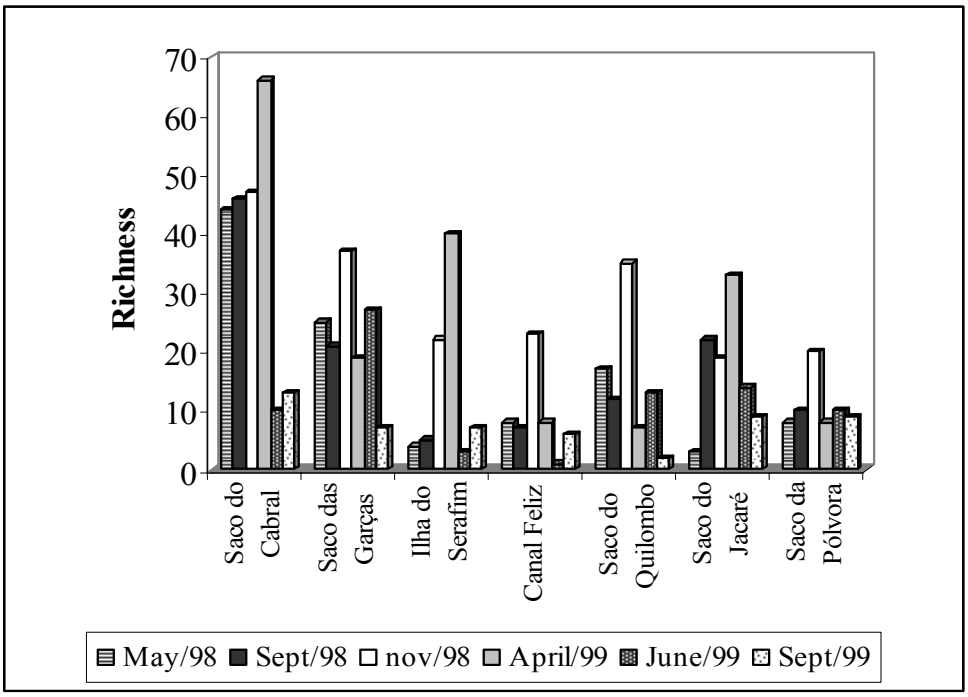


Figure 39. Species richness of pigmented Euglenophyceae at seven sampling stations in 1998/1999 at the State Park of the Jacuí Delta.