PHYTOPLANKTON COMMUNITY OF A POLYMICTIC RESERVOIR, LA PLATA RIVER BASIN, URUGUAY

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(With 3 figures)

ABSTRACT

This paper deals with the analysis of phytoplankton composition and abundance from four sampling stations at the polymictic system, Rincón del Bonete water reservoir in Uruguay. Sampling data were obtained in 4 seasonal periods between February and November 1993. A hundred and twenty-four taxa were identified, where *Aulacoseira granulata* (Ehrenb.) Simon., *A. granulata* var. *angustissima* (Muller) Simon., *A. granulata* var. *angustissima* f. *spiralis*, (Muller) Simon., *A.* cf. *ambigua*, (Grun.) Simon., *A.* cf.. *distans* (Ehrenb.) Simon., *Cryptomonas* spp. and *Synedra ulna* (Nitzsch) Ehrenberg, were always present. Phytoplankton abundance fluctuated between 29 (autumn) and 2129 (summer) ind/ml. The general dominance of *Aulacoseira* spp. could be related to the polymictic condition of the system. In cold months phytoplankton distribution was homogeneous among sampling stations, while in warm months, spatial heterogeneity was detected, suggesting that sampling stations can behave as independent compartments.

Key words: microalgae, freshwater, artificial lakes, *Aulacoseira*, Uruguay.

RESUMO

Comunidade do fitoplâncton em um reservatório polimítico, bacia do Rio de la Plata, Uruguai

Foi realizada uma análise da composição e abundância do fitoplâncton em quatro estações de amostragem em um sistema polimítico, o reservatório do Rincón del Bonete. Os dados amostrais foram obtidos em 4 períodos sazonais, entre fevereiro e novembro de 1993. No total foram registradas 124 taxas, estando *Aulacoseira granulata* (Ehrenb.) Simon., *A. granulata* var. *angustissima* (Muller) Simon., *A. granulata* var. *angustissima* f. *spiralis* (Muller) Simon., *A.* cf. *ambigua* (Grun.) Simon., *A.* cf. *distans* (Ehrenb.) Simon., *Cryptomonas* spp. e *Synedra ulna* (Nitzsch) Ehrenberg, sempre presentes. A abundância do fitoplâncton variou entre 29 e 2129 ind/ml, no outono e verão, respetivamente. A dominância geral do *Aulacoseira* spp. parece relacionada com a condição polimítica do sistema. No que se refere a composição, a comunidade fitoplanctônica mostrou-se homogênea no inverno. Pórem, nos meses cálidos foi observada heterogeneidade espacial, devido a qual, provavelmente, as estações de coleta estejam comportando-se como subsistemas independentes.

Palavras-chave: microalgae, água doce, reservatórios, *Aulacoseira*, Uruguai.

INTRODUCTION

Reservoirs represent one of the main anthropogenic impacts on the hydrological regime of rivers (Baxter, 1977; Rosenberg *et al*., 1995). The building of reservoirs for power generation in South America has recently increased (Tundisi, 1994). Specially, the La Plata River basin presents several regions suitable for reservoirs sites (Tundisi, 1990a). In Uruguay, Rincón del Bonete reservoir has been built for power generation on the Negro River, belong to the La Plata River basin.

The modified hydrological cycle due to water use and lake morphometry, could be the main factors controlling the stability of the water column, which in turn influence phytoplankton's structure and dynamics (Tundisi, 1990b; Kölher, 1994). Thus, studies on the phytoplankton community are relevant to manage water quality (Tundisi, 1994). Taxonomic and ecological studies concerning phytoplankton from reservoirs are scarce in Uruguay (Quirós & Luchini, 1982; Berón, 1990). The aim of this study was to characterize the phytoplankton species composition and abundance of Rincón del Bonete Reservoir.

MATERIAL AND METHODS

Study Area

Rincón del Bonete Reservoir (Fig. 1) was built in 1947 without felling of the riparian forests (Campo, 1991).

The area of the lake is 1,070 Km^2 with 8,800 Hm^3 volume and an average depth of 8.0 m. It is a polymictic system due to the morphometric features, the wind effect and the artificial management (Conde *et al.*, 1994). The climate of the region is temperate (mean air temperature: 23 and 12ºC, in summer and winter, respectively), with irregular rainfall along the year (annual mean: 1180 mm) and

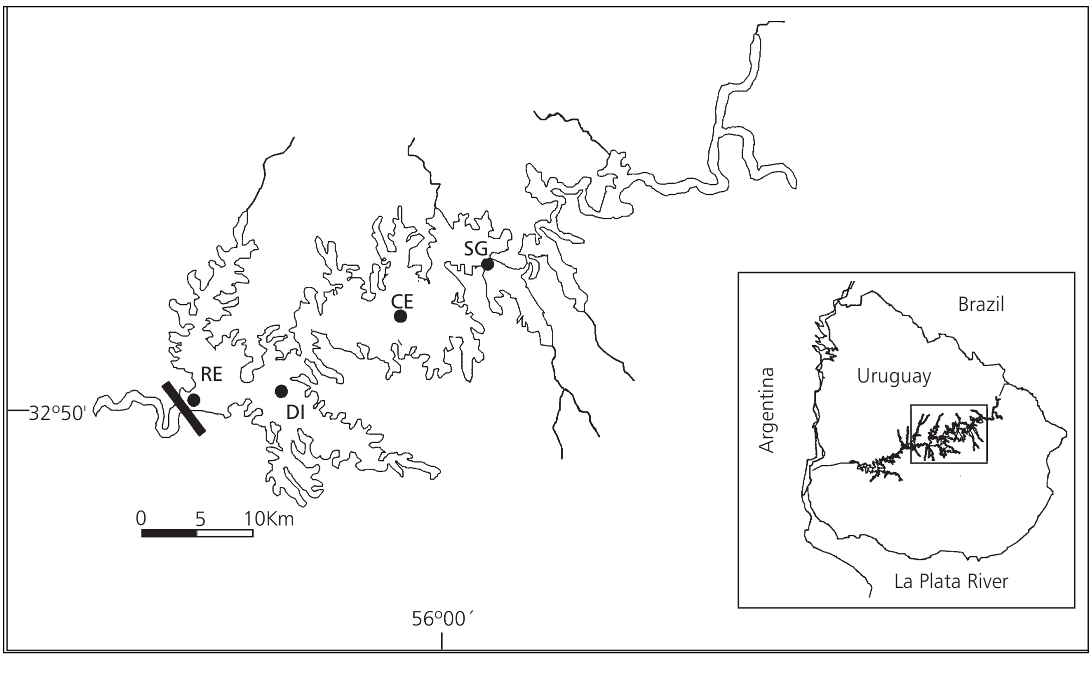

Fig. 1 — Study area showing the four sampling stations at Rincón del Bonete Reservoir. RE: represa, DI: dilfa, CE: centro and SG: San Gregorio.

an average wind speed of 11 km/h. No important industries or big cities are located at the basin and the land use is basically cattle raising.

Sampling and analyses

Samples were taken seasonally in February (summer), May (autumn), July (winter) and November (spring) during 1993, at four stations along the central axis of the artificial lake: Represa (RE), Dilfa (DI), Centro (CE) and San Gregorio (SG) (Fig. 1). Depth, temperature, euphotic zone (Secchi disc), and pH (pHmeter Basic LCD 2) were measured *in situ*. Qualitative samples of phytoplankton were taken with a 25 µm net, a subsample being immediately preserved with 4% buffered formaldehyde. It was used the classification system of Bourrelly (1972, 1981, 1985) to Class level. To identify diatoms, the oxidation technique was followed (Hasle & Fryxell, 1970).

For quantitative analysis, surface samples of 500 ml were immediately preserved with Lugol´s solution. The counting unit was defined according to De Filippo (1987) and Calijuri (1988). Countings were performed following the Utermöhl method (Utermöhl, 1958) and at least 100 individuals of the species or groups more abundant were counted (Lund *et al*., 1958).

To compare sampling stations, quantitative data of species with an abundance higher than 1% were used to perform a cluster analysis, using the Euclidean distance and the unweighted pair-group method (Legendre & Legendre, 1984).

RESULTS

The deepest station was located near the dam (15.5-23.0 m) and the shallowest in the upper zone (5.0-6.1 m).

Water temperature presented a seasonal variation at all sampling sites, with maximum values in summer (21-24°C) and minimum ones in winter (8-9°C). Neutral to alcaline pH values (7.4-8.9) were registered, and in general, highest euphotic zones occurred in summer (Table 1).

TABLE 1

Values of physico-chemical parameters for the four sampling stations at Rincón del Bonete Reservoir.

	Station	Z (m)	Zeu. (m)	T. (°C)	pH
February	RE	15.0	3.4	23	8.3
	DI	12.0	2.7	21	8.9
	CE	11.0	3.0	24	8.4
	SG	5.0	1.1	22	7.8
May	RE	16.0	1.9	15	8.3
	DI	11.0	1.4	14	8.4
	CE	10.0	0.9	16	8.4
	SG	6.0	1.1	16	8.5
July	RE	16.0	1.6	9	8.4
	DI	12.0	1.6	9	8.3
	CE	12.0	1.6	9	8.3
	SG	6.1	1.7	8	7.4
November	RE	23.0	1.7	20	7.5
	DI	19.7	1.5	20	7.5
	CE	9.0	1.9	21	7.5
	SG	6.0	1.6	19	7.4

Z: depth, Zeu: euphotic zone, T.: temperature, RE: Represa, DI: Dilfa, CE: Centro, SG: San Gregorio.

A hundred and twenty-four phytoplanktonic taxa distributed in 10 Classes were identified (Table 2). *Aulacoseira granulata* (Ehrenb.) Simon., *A. granulata* var. *angustissima* (Muller) Simon., *A. granulata* var. *angustissima* f. *spiralis* (Muller) Simon., *A.* cf. *ambigua* (Grun.) Simon., *A.* cf. *distans* (Ehrenb.) Simon., *Cryptomonas spp.* and *Synedra ulna* (Nitzsch) Ehrenberg were always present. The length of the colonial filaments of *Aulacoseira* "*granulata* group" (*A. granulata* and *A. cf. ambigua*) varied widely (1 to 33 cells per filament), but 4 to 6 cells per filament was the most common length.

Phytoplankton abundance varied from 29 (autumn, CE) to 2129 ind/ml (summer, SG) (Fig. 2). Diatomophyceae was dominant during almost all the study period, being *A. "granulata* group*"* the most abundant taxa, replaced by *A.* cf. *distans* in November. Phytoflagellates, mainly represented by *Cryptomonas* spp., were the dominant group at SG in February, reaching 76% of the total abundance. Euchlorophyceae and Zygophyceae represented less than 8% of the phytoplankton abundance, while other Classes never exceeded 1%.

The cluster analysis revealed three groups: one conformed by the stations performed during the cold months (May and July), excepting RE in May. The second comprissed SG, CE and DI in November and RE in May. A third group included RE and DI in February. CE and SG in February and RE in November did not join the above mentioned groups (Fig. 3).

DISCUSSION

Abiotic factors, as the mixing of the system and inorganic turbidity, influence plankton dynamic (Tundisi, 1990b). In our study, the maximum euphotic zone registered in summer and the minimum in autumn and winter (Table 1), could be related to variations in irradiance, turbidity and winds.

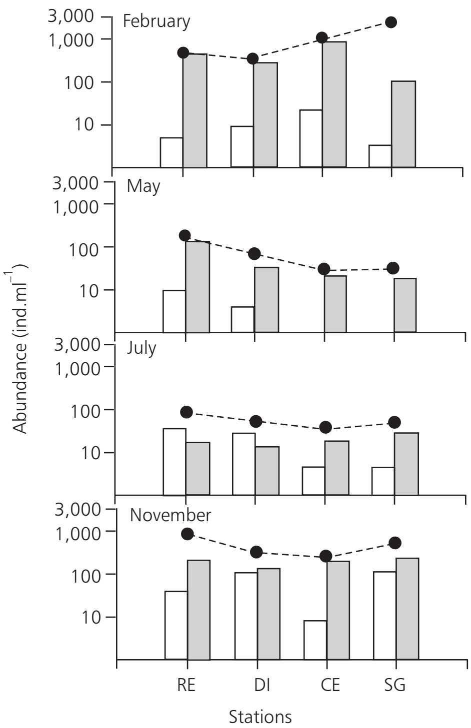

Fig. 2 — Abundance (individuals per milliliter) of total phytoplankton (solid circles), *Aulacoseira* spp. (dark bars) and other diatoms (white bars), for the four sampling stations at Rincón del Bonete reservoir. The y-axis is in logarithmic scale. Codes as in Fig. 1.

TABLE 2
List of algal taxa found at Rincón del Bonete Reservoir.

CHRYSOPHYCEAE	DINOPHYCEAE	EUGLENOPHYCEAE
Dinobryon sertularia Ehrenberg	*Peridinium* cf. *wisconsinense* Eddy	*Euglena acus* Ehrenberg
Mallomonas spp.	*Peridinium* sp. 1	*Euglena* cf. *proxima* Dangeard
Synura sp.	EUCHLOROPHYCEAE	*Euglena* cf. *variabilis* Klebs
CRYPTOPHYCEAE	*Actinastrum* cf. *hantzschii* Lagerheim	*Peranema* sp.
Cryptomonas cf. *brasiliensis* Castro, Bic. & Bic.	*Ankistrodesmus bibraianus* (Reinsch) Korsikov	*Phacus tortus* (Lemm.) Skvortzow
Cryptomonas erosa Ehrenberg	*Ankistrodesmus* spp.	*Phacus* sp. 1
Cryptomonas marssonii Skuja	*Botryococcus* cf. *braunii* Kützing	*Strombomonas* sp.
Cryptomonas pyrenoidifera Geitler	*Coelastrum microporum* Naegeli	*Trachelomonas armata* (Ehrenb.) Stein
Cryptomonas spp.	*Coelastrum cambricum* Archer	*Trachelomonas hispida* (Perty) Stein
CYANOPHYCEAE	*Crucigenia* spp.	*Trachelomonas volvocinopsis* Swir
Anabaena cf. *spiroides* Klebahn	*Chlamydomonas* spp.	*Trachelomonas* sp. 1
Anabaena sp.1	*Dimorphococcus lunatus* A. Braun	*Trachelomonas* sp. 2
Anabaena sp. 2	*Dictyosphaerium* cf. *pulchellum* Wood	*Trachelomonas* spp.
Anabaena sp. 3	*Eudorina elegans* Ehrenberg	XANTOPHYCEAE
Cylindrospermum sp.	*Eudorina* sp. 1	*Pseudostaurastrum* sp.
Lyngbya sp. 1	*Eutetramorus fottii* (Hindak) Komárek	*Tetraplektron* sp.
Lyngbya spp.	*Kirchneriella obesa* (W. West) Schmidle	ZYGOPHYCEAE
Merismopedia glauca (Ehrenb.)Kützing	*Micractinium pusillum* Fresenius	*Closterium aciculare* T. West.
Microcystis aeruginosa Kützing	*Micractinium bornhemiense* (Conrad) Korsikov	*Closterium* cf. *acutum* Brébisson
Microcystis wesenbergii Komárek	*Monoraphidium* spp.	*Closterium* cf. *gracile* Brébisson
Oscillatoria chlorina Kütz. ex Gomont	*Oocystis* sp.	*Closterium kuetzingii* Brébisson
Oscillatoria limosa (Roth) Agardh	*Pandorina morum* (Muller) Bory	*Closterium* cf. *pronum* Brébisson
Phormidium splendida Greville	*Paradoxia multiseta* Swirenk	*Closterium* sp. 1
Oscillatoria spp.	*Platydorina caudata* Kofoid	*Closterium* sp. 2
Pseudanabaena mucicola (Naum.H-.Pest.) Bourr.	*Pediastrum biradiatum* Meyen	*Closterium* spp.
DIATOMOPHYCEAE	*Pediastrum boryanum* (Turpin) Meneghini	*Cosmarium* sp. 1
Aulacoseira cf. *ambigua* (Grun.) Simon.	*Pediastrum duplex* Meyen	*Cosmarium* sp. 2
Aulacoseira cf. *distans* (Ehrenb.) Simon.	*Pediastrum simplex* (Meyen) Lemmermann	*Cosmarium* sp. 3
Aulacoseira granulata (Ehrenb.) Simon.	*Pediastrum tetras* (Ehrenb.) Ralfs	*Cosmarium* spp.
A. granulata var. *angustissima* (Muller) Simon.	*Scenedesmus acuminatus* (Lagerh.) Chodat	*Desmidium bayleyi* (Ralfs) De Bary
*A. gr.*var. *angustissima* f. *spiralis* (Muller) Simon.	*Scenedesmus denticulatus* Lagerheim	*Euastrum* spp.
Aulacoseira herzogii (Lemm.) Simon.	*Scenedesmus* cf. *opoliensis* Richter	*Gonatozygon monotaenium* De Bary
Aulacoseira sp. 1	*Scenedesmus* cf. *quadricauda* (Turpin) Bréb.	*Gonatozygon* sp.
Cyclotella / *Cyclostephanos* sp.	*Scenedesmus* sp. 1	*Pleurotaenium* sp.
Eunotia spp.	*Scenedesmus* sp. 2	*Staurastrum gladiosum* Turner
Synedra ulna (Nitzsch) Ehrenberg	*Scenedesmus* spp.	*Staurastrum manfeldtii* Delponte
Gomphonema sp.	*Sorastrum* sp.	*Staurastrum* sp. 1
Melosira varians Agardh	*Sphaerocystis schroetheri* Chodat	*Staurastrum* sp. 2
Nitzschia cf. *acicularis* (Kutz.) W. Sm.	*Treubaria* sp.	*Staurastrum* sp. 3
Nitzschia sp.	*Volvox* sp.	*Staurastrum* spp.
Rhizosolenia longiseta Zach.	ULOTHRICOPHYCEAE	*Staurodesmus* spp.
Surirella spp.	*Oedogonium* sp.	*Mougeotia* sp.
Pennales (undetermined)	*Planctonema lauterbornii* Schmidle	*Spirogyra* sp.

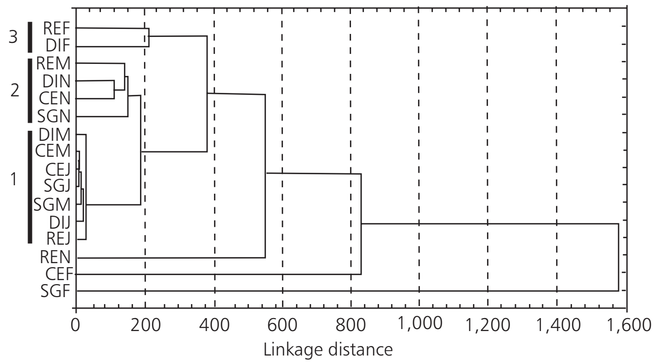

Fig. 3 — Cluster analysis based on species abundance, using euclidean distance and the UPGMA method. Codes as in Fig. 1.

In this polymictic system, water circulation usually involves the whole water column (Conde *et al*.,1994), a characteristic also present in most of the reservoirs in tropical South America (Tundisi, 1990a).

Fluctuation of phytoplankton abundance could be related to seasonal temperature variation and the depth of euphotic zone (Tundisi, 1990b). During cold months (May and July) low phytoplankton abundance coincides with low temperatures and reduced euphotic zone (Fig. 2). Moreover, turbidity seems to be not generated by phytoplankton, and the presence of inorganic suspension solids can be expected (Pintos *et al.*, 1991; Conde, *et al.*, 1994), with a negative effect on phytoplankton light availability.

Algal community were mainly dominated by *Aulacoseira* spp. (Diatomophyceae) (Table 2, Fig. 2) which presented a high frequency of filaments with 4 to 6 cells, a characteristic related to turbulent conditions (Davey, 1987). *Aulacoseira* is a R-strategist widespread diatom, that can dominates in reservoirs under turbid conditions (Hutchinson, 1967; Reynolds, 1993). The dominance of *Aulacoseira* spp. found at Rincón del Bonete reservoir was also observed in Salto Grande polymictic reservoir (Quirós & Luchini, 1982) and in the large rivers of La Plata River basin (O' Farrell & Izaguirre, 1994).

The cluster analysis revealed spatial differences among sampling stations in spring and summer. The dominance of small phytoflagellates at SG in February, mainly represented by *Cryptomonas* spp. (Table 2) explained the location of this station in the cluster graphic representation (Fig. 3). Phytoplankton community was homogeneous during cold months, while differences between sampling stations were found in warmer ones, suggesting that sampling sites could be independent compartments. Further studies considering nutrients and physical factors in a more frequent sampling sequence are needed to provide a full description of the community.

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