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Spatial distribution of palynomorphs in the surface sediments of the Lagoa do Campelo lake, North region of Rio de Janeiro State, Brazil

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RESUMO – (Distribuição espacial de palinomorfos na superfície dos sedimentos de fundo da Lagoa do Campelo, região Norte do Estado do Rio de Janeiro, Brasil). Quatro amostras do sedimento superficial de fundo da Lagoa do Campelo foram coletadas em uma transecção de 500 m por 500 m de uma borda a outra, na direção nordeste/sudoeste, direção dominante dos ventos na região. A análise dos grãos de pólen, esporos de Pteridophyta e algas foi usada para a avaliação da variação espacial de deposição de palinomorfos e seus níveis de deterioração. No total, 58 tipos polínicos foram identificados. Em sua maioria foram de Cyperaceae, Poaceae e Typhaceae. Grãos de pólen ocorreram em todas as amostras analisadas, mas a área de maior concentração relacionou-se à borda nordeste da lagoa. A borda sudoeste apresentou altas percentagens de pólen e esporos com a exina degradada e com danos mecânicos, provavelmente porque foram carreados através da lagoa pelas correntes aquáticas impulsionadas pelo vento, confirmando ser a tendência deposicional dos palinomorfos danificados na mesma da direção dos ventos dominantes. Entre os tipos polínicos arbóreos e arbustivos, *Alchornea*, Arecaceae, *Cecropia*, *Celtis*, *Clethra* e Myrtaceae foram os dominantes e apresentaram mais de 1.000 grãos por grama de sedimento fresco. A quantidade de esporos de Pteridophyta foi praticamente constante em todas as amostras (± 10% do total de palinomorfos). As algas *Pediastrum tetras* (Ehrenberg) Ralfs e *Mougeotia* ocorreram em todas as amostras, *Spirogyra* somente em três delas. Os resultados obtidos fornecem novas informações sobre a riqueza, concentração e distribuição dos palinomorfos na lagoa, representando a vegetação local e regional.

Palavras-chave: palinomorfos, sedimentação, Holoceno recente, Lagoa do Campelo, Rio de Janeiro

ABSTRACT – (Spatial distribution of palynomorphs in the surface sediments of the Lagoa do Campelo lake, North region of Rio de Janeiro State, Brazil). Four samples of the surface sediments of the Lagoa do Campelo lake bottom were collected in a transect of 500 m by 500 m from edge to edge, in a northeast/southwest direction, the dominant wind direction in the region. The analysis of pollen grains, fern spores and algae were used to evaluate their spatial deposition and level of deterioration. In total, 58 types of pollen grains were identified, mainly from herbs as Cyperaceae, Poaceae and Typhaceae. Pollen grains occurred in all the analyzed sediments. The area of highest concentration was the northeast side of the lake. The southwest side showed the highest pollen grain and fern spore degradation and mechanical damage, probably as they were carried across the lake by wind-driven currents, confirming the depositional tendency of damaged palynomorphs in the same direction as the dominant wind. Among the pollen of trees and shrubs, *Alchornea*, Arecaceae, *Cecropia*, *Celtis*, *Clethra* and Myrtaceae were dominant at more than 1,000 pollen grains per gram of sediment. The quantity of fern spores was practically constant in all samples (± 10% of the total of palynomorphs). The algae *Pediastrum tetras* (Ehrenberg) Ralfs and *Mougeotia* occurred in all samples, but *Spirogyra* only in three of them. The results obtained gave new information about the richness, concentration and distribution of palynomorphs in the lake, representing the local and regional vegetation.

Key words: palynomorphs, sedimentation, recent Holocene, Lagoa do Campelo, Rio de Janeiro State

Introduction

Processes of microfossil taxonomy are the base for palynological studies in the quaternary period. A stable depositional environment is required to ensure that changes in pollen assemblages can be attributed to vegetation changes rather than depositional episodes (Jackson 1994). The studies of lake surface sediments have shown advantages in order to verify effects on the transport (aerial, fluvial, etc) of pollen grains and spores. They also explain the pollen and spore patterns of deposition in a receiving basin, as well as details of

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selective processes for diagenesis (Chmura *et al*. 1999).

Deposition of pollen grains from the air is uniform over the lake surface, but a difference in sinking speed depends upon pollen grain size or density. Wind-driven currents are known to affect the distribution of plankton (Davis 1968; Davis & Brubaker 1973) and Bradley (1965) pointed out that the settling velocity of many particles, such as diatoms are too low to reach the bottom of deep lakes in the same year of flotation. Eventually, they may be hydraulically sorted (Heusser 1978) in the same manner as particles of fine silt and clay. The resuspension of pollen grains and spores from the bottom and from the overlying, semifluid sediment stratum is a continuous process. It is probably more intensive in shallow waters than in deep ones and consequently occurs less in the central area of a water basin than near the shores. The rate of resuspension varies also with the seasons of the year (Praglowski 1977). It is possible to verify the presence of reworked grains through the aspect of the exine preservation, and consequently, the redeposition of sediments (Delcourt & Delcourt 1980; Moore *et al*. 1991). Microfossil data as percentages and concentration of palynomorphs can be aware of misinterpretations, particularly in quaternary age deposits. The knowledge of the actual process of deposition of surface sediment palynomorphs is an important background for local and regional vegetation, environment and lake dynamic interpretation. It determines also the best coring site for remote environmental studies during the quaternary period.

Several palynological investigations in lakes and lagoons were realized in Brazil during the last decade. In relation to the North region of the state of Rio de Janeiro, the first attempt dealed with sediments of the Lagoa Salgada, a lagoon without tributaries, located near to the Atlantic coast (M.B. Toledo, data not published). A differential deposition of palynomorphs was noted in dependence of the lagoon's bottom bathymetry. The highest number of pollen grains and spores was detected next to an advanced ridge of sediments into the lake.

The Lagoa de Cima is situated more distant from the coast. It is a sweet-water lake, which receives two tributaries. Studies revealed that pollen and spore deposition in this lake depends upon the water influx and outlet and of the lake's bottom configuration, but less of the dominant wind direction (Barth *et al*. 2001; Luz *et al*. 1999).

The aim of the present study is to recognize the selective deposition of palynomorphs in the surface sediments of the Lagoa do Campelo lake. It may be used as an example of differential transport and sedimentation for palaeoecological studies. The results obtained will be correlated with the surrounding vegetation. These data may be useful also to study variations of the lake's water level, as well as to supply future quaternary researches in this region.

General features of the investigated area – The Lagoa do Campelo lake is located in the municipality of Campos dos Goitacazes, at the north of the state of Rio de Janeiro, Brazil, between the 41°11'00"W longitude and 21°39'01"S latitude (Fig. 1), and 17 km from the coast-line into the west of the deltaic plain of the river Paraíba do Sul. It is placed at an altitude of about 8 m in the bordering portion (Barriers Group-Tertiary deposits sediments), and comes in touch with the flattened littoral sediments of the Quaternary coastal plain, which recover the cretaceous layers of the Campos Basin. The Lagoa do Campelo lake remained from a 3,000 years ago lagoon system, when processes of sand deposition formed the beach ridges

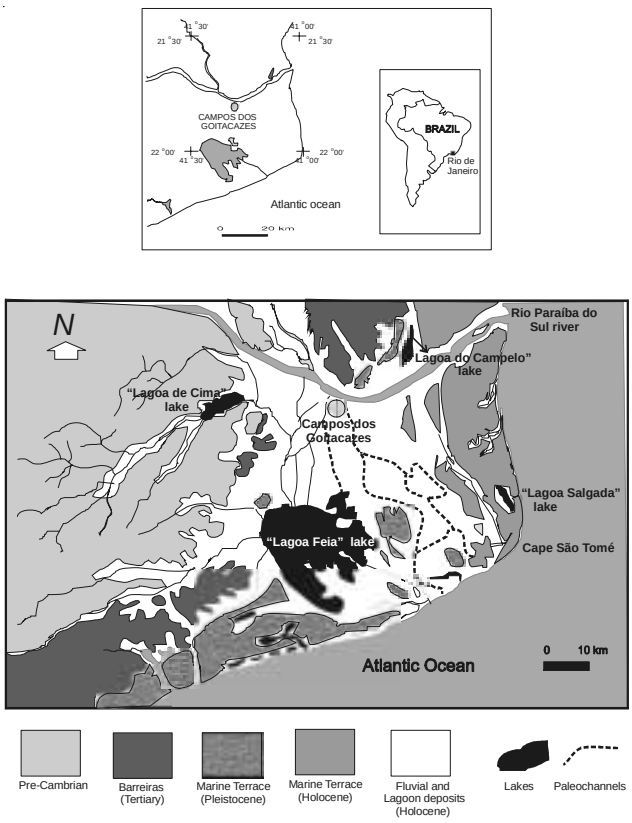

Figure 1. Geological map of the deltaic plain of the Paraíba do Sul river and location of the Lagoa do Campelo lake (Martin *et al*. 1993, modified), Rio de Janeiro State, Brazil.

of "restingas", isolating the bays from the sea (Lamego 1955; Martin *et al*. 1984; 1993).

The drainage basin of the Lagoa do Campelo is not well defined and occupies an area of circa 9.8 km^2. According to Jacobson & Bradshaw (1981), the smallest portion of the lake is less than 100 m wide. The lake is of medium size, shallow, with a nearly plain bottom topography, and has a maximal depth of 2.0 m (Fig. 2). Without tributaries and main effluent, the lake receives the water and sediment streams of various bogs and swamps, especially from the Brejo do Campelo swamp that receives the waters of the Vala do Norte dike, near to the Barriers System. The water of the Lagoa do Campelo lake is not drained into the Atlantic Ocean (Tolentino *et al.* 1986).

The water of the lake is clear, sweet, alkaline (pH = 7.5-9.0) and the salinity (0.17%) presents low calcium grade (32 ppm). The sediments comprise fine sands and the lake shows no thermal stratification (Esteves 1984; Reid & Esteves 1984). The region has a hot and humid climate with a strong seasonal influence. The rainfalls are concentrated especially in summer (AW of Koeppen), with indexes above 200 mm per month. The driest period extends from May to September. The average annual rainfall is around 900-1,100 mm, the temperature around 22 °C, and the predominant wind comes from the NE (Radambrasil Project 1983).

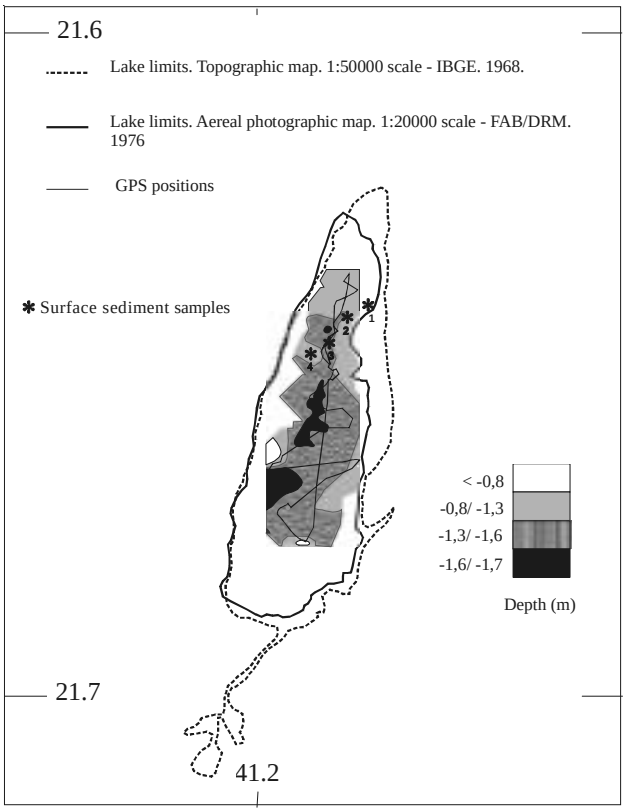

Figure 2. Bathymetric map of the Lagoa do Campelo lake, Rio de Janeiro State, Brazil.

The Tropical Seasonal Semideciduous forest and the "restinga" vegetation were installed in this region before the definitive settlement of the Europeans (Luz *et al.* 1999). Results of the floristic analysis of a "restinga" vegetation in Grussaí, 20 km southeast from the Lagoa do Campelo lake, was presented by Assumpção & Nascimento (2000).

A small remnant fragment of the Seasonal Semideciduous Forest can be observed at 5 km southwest of the lake. Silva & Nascimento (2001) studied the phytosociological structure of a similar forest called "Mata do Carvão", the largest remnant fragment in this region and located of about 25 km north of the Lagoa do Campelo lake.

Nowadays, a small swampy forest can be observed in the northeastern margin of the lake. Pastureland, sugar cane and subsistence plantations constitute the regional landscape. The marsh vegetation next to the lake presents Cyperaceae, Poaceae, among other taxa and a characteristic large belt of the cattail (*Typha*). The macrophyta *Egeria densa* Planch. (*Anacharis densa* (Planch.) Vict., Hydrocharitaceae, Monocotyledonea) and *Sphagnum* (Bryophyta) colonize the inner area of the lake. Some introduced trees, as species of *Eucalyptus*, can be found near to the southeastern margin of the lake.

Material and methods

Four samples were collected with a hand dredger in the top five centimeters of the lake sediments, in a transect of 500 m steps from one to the opposite side, in the northeast/southwest direction, the same direction of the dominant wind (Fig. 2). Sample 1 was located about 10 m shoreline in the NE margin of the lake and related to the 0 m of the transect line. This station was about 0.5 m deep and next to the cattail (*Typha*) belt. Sample 2 (1.0 m deep) was collected near to the center of the lake. Sample 3 was obtained in the deeper part of the lake (1.5 m) and was located near to a sand bank with Cyperaceae. Sample 4 (1.0 m deep) was located near to the cattail belt in the SW margin of the lake.

Samples were not previously dried. Two grams of each one was treated using the standard procedure (Ybert *et al*. 1992). The sediment grain size was obtained by comparision with a standard table used

by Petrobras Company, Brazil. Palynomorph counts were made at a magnification of 500x using a Leitz microscope. We intended to count more than 250 pollen grains (excluding introduced *Lycopodium clavatum* L. spores) for each sample. Pollen and spore percentages were calculated on the sum of total pollen and spores (except introduced spores of *Lycopodium*), including reworked grains. The concentration of palynomorphs was plotted using the Tilia program (Grimm 1987), considering the number of marker spores per gram of sediment (Stockmarr 1971). The percentage calculations were plotted by the Excel program of Microsoft Corporation. Pollen grain micrographs and descriptions were presented formerly in Luz & Barth (2000) and of algae in Luz *et al.* (2002).

Pollen and spores can suffer deterioration during sedimentation and transport. The alterations may be included into three categories, according to Moore *et al.* (1991). First, palynomorphs may suffer microbial corrosion, presenting patches of destroyed exine; second, they can present a strongly alterated ornamentation due to oxidation by exposition to the air; third, the mechanical action during transport show broken pollen grains and spores.

Results

In the middle of the Lagoa do Campelo and in the northeastern margin (samples 1, 2 and 3) the mean sediment grain size was very fine (<0.064 mm). In the southwestern margin, it was only fine (0.177 mm).

Fifty-seven pollen types were identified from the total of 919 pollen grains counted in all samples analyzed (Table 1). The highest pollen grain concentration was of 212,106 grains/g (sample 1), corresponding to the northeast boundary of the Lagoa do Campelo (Fig. 6). The concentration of pollen grains decreased towards the southwest margin that contained the lowest pollen grain concentration (sample 4), although this sample showed the highest number of pollen types (36 pollen types).

Pollen grains of the herbaceous vegetation comprised more than 50% of pollen grains in each sample (Fig. 4). Cyperaceae, Typhaceae and Poaceae were the dominant herbaceous pollen types comprising

Table 1. Presence of pollen types occurring in the surface sediment samples of Lagoa do Campelo lake, Rio de Janeiro State, Brazil.

Plant habitus/Pollen types	Sample 1	Sample 2	Sample 3	Sample 4
Herbs				
Alismataceae	–	X	X	–
Anthurium (Araceae)	–	–	–	X
Araceae	X	X	X	X
Begoniaceae	–	–	–	X
Cyperaceae	X	X	X	X
Dioscoreaceae	–	–	X	–
Poaceae	X	X	X	X
Polygonum (Polygonaceae)	–	X	–	X
Borreria aff. *densiflora* D.C. (Rubiaceae)	X	X	X	X
Borreria aff. *verticillata* (L.) G.F.W. Meyer (Rubiaceae)	X	X	X	X
Typha (Typhaceae)	X	X	X	X
Herbs and shrubs				
Ichthyothere/Aspilia (Asteraceae)	X	–	–	–
Phyllanthus (Euphorbiaceae)	–	–	X	–
Cuphea (Lythraceae)	–	X	–	–
Scrophulariaceae	X	X	X	X
Shrubs				
Loranthaceae	–	–	X	X
Piper (Piperaceae)	–	X	X	X
Shrubs and trees				
Arecaceae	X	X	X	–
Gochnatia (Asteraceae)	–	–	–	X
Clethra (Clethraceae)	–	X	X	–

continue

Table 1 (continuation)

Plant habitus/Pollen types	Sample 1	Sample 2	Sample 3	Sample 4
Weinmannia (Cunoniaceae)	–	–	X	–
Sloanea (Elaeocarpaceae)	–	–	–	X
Alchornea (Euphorbiaceae)	X	X	X	X
Castanea *(Fagaceae)*	–	X	–	–
Casearia (Flacourtiaceae)	–	–	–	X
Lecythidaceae	–	–	–	X
Trichilia (Meliaceae)	–	X	–	–
Meliaceae	X	–	–	–
Shrubs and trees				
Cecropia (Moraceae)	X	X	–	X
Dorstenia (Moraceae)	–	X	–	–
Virola (Myristicaceae)	–	–	–	X
Myrsine (Myrsinaceae)	X		X	–
Myrsinaceae	–	X	–	X
Myrcia (Myrtaceae)	–	–	–	X
Myrtaceae	X	X	–	–
Triplaris (Polygonaceae)	–	–	–	X
Cupania (Sapindaceae)	X	–	–	–
Sapotaceae	X	–	–	–
Celtis (Ulmaceae)	X	–	X	X
Trema (Ulmaceae)	–	–	X	X
Variable				
Amaranthaceae / Chenopodiaceae	–	–	–	X
Apocynaceae	–	–	X	–
Vernonia (Asteraceae)	–	–	–	X
Asteraceae	X	X	X	X
Cassia (Fabaceae Caesalpinioideae)	–	X	X	–
Melastomataceae/Combretaceae	X	X	X	X
Acalypha (Euphorbiaceae)	–	–	X	X
Euphorbiaceae	X	–	–	X
Fabaceae Papilionoideae	X	X	X	X
Lythraceae	–	–	X	–
Malpighiaceae	–	–	X	X
Monocotyledoneae	X	X	X	–
Moraceae	X	X	X	X
Polygonaceae	–	X	–	–
Rubiaceae	–	–	X	X
Sapindaceae	–	–	–	X
Solanaceae	–	X	X	X

more than 90% of pollen grains (Fig. 5). The highest percentage and pollen concentration of cattail (*Typha*) was in sample 1 (29,182 pollen grains/g) and the highest pollen concentration of Cyperaceae in sample 3 (34,071 pollen grains/g). The percentage of Poaceae remained relatively constant at about 35% in most of the samples, although decreased to 18% in the deepest point of the transect (sample 3). Poaceae showed the highest pollen concentration in sample 2 (26,889 pollen grains/g). Other herbaceous pollen types represented less than 10% (Alismataceae, Araceae, *Borreria*, Dioscoreaceae and *Polygonum*) (Fig. 5).

Pollen grains of the arboreal/shrub vegetation occurred at less than 11% in each sample (Fig. 4). They showed the highest percentage and concentration in the sample 1, but sample 4 showed the highest number of arboreal/shrub pollen types (12 pollen types). *Alchornea*, Arecaceae, *Celtis*, *Cecropia*, *Clethra*, Lecythidaceae, Myrtaceae, *Piper*, and *Trema* were the most important arboreal/shrubs pollen types. *Casearia*, *Castanea*, *Cupania*, *Dorstenia*, *Gochnatia*, Loranthaceae, Meliaceae, *Myrcia*, Myrsinaceae, *Myrsine*, Sapindaceae, Sapotaceae, *Sloanea*, *Trichilia*, *Virola*, and *Weinmannia* are presented in very low percentages.

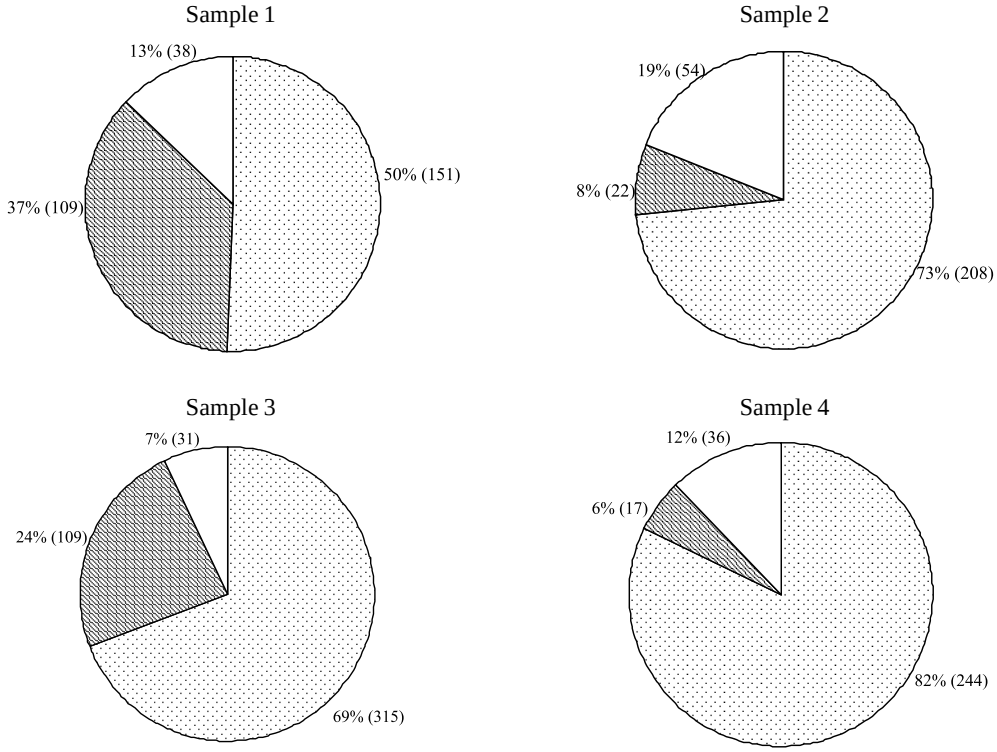

Figure 3. Percentage diagram of palynomorphs, including the number of palynomorphs counted, in the surface sediments of the Lagoa do Campelo lake, Rio de Janeiro State, Brazil. ⊡ = Pollen; ▨ = Algae; □ = Fern spores.

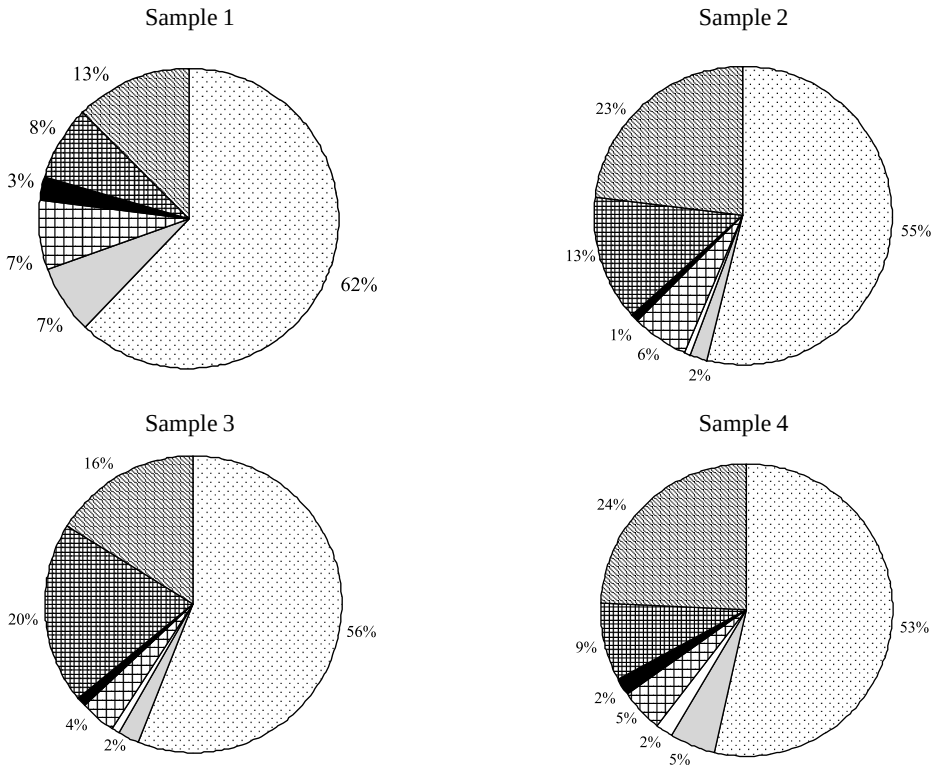

Figure 4. Percentage diagram of pollen grains related to the plant habitus in the surface sediments of the Lagoa do Campelo lake, Rio de Janeiro State, Brazil. ⊡ = Herbs; ■ = Shrubs and herbs; □ = Shrubs; ⊞ = Shrubs and trees; ■ = Trees; ▦ = Variables habitus; ▨ = Indererminate d pollen grains.

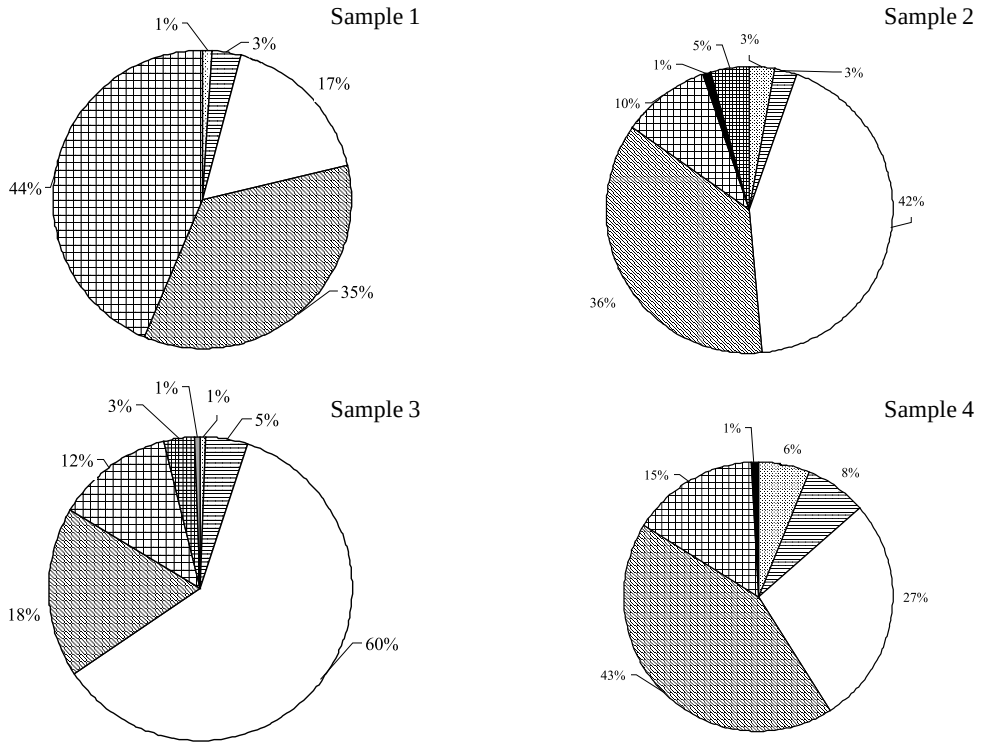

Figure 5. Percentage diagram of pollen grains related to the herbaceous plants in the surface sediments of the Lagoa do Campelo lake Rio de Janeiro State, Brazil. ⊡ = Araceae; ▤ = *Borreria*; □ = Cyperaceae; ▧ = Poaceae; ⊞ = Typhaceae; ■ = *Polygonum*; ▦ = Alismataceae; ■ = Dioscoreaceae.

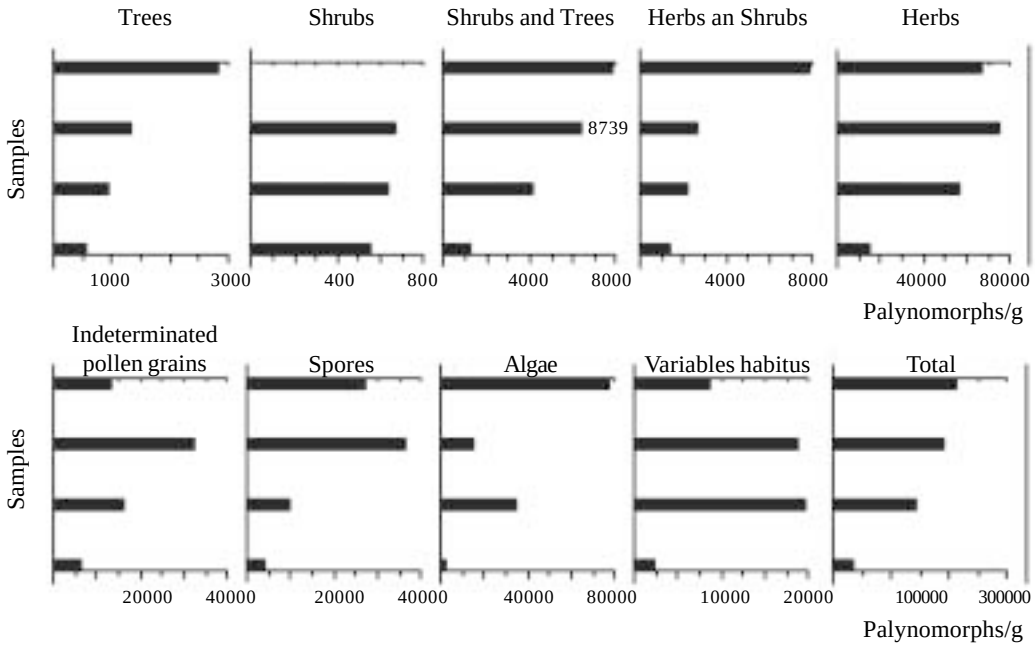

Figure 6. Concentration diagram of palynomorphs per gram in the surface sediments of the Lagoa do Campelo lake, Rio de Janeiro State, Brazil.

The fern spores reached a total of 159 spores counted in all samples analyzed, and represented less than 11.9% of the total of the palynomorphs. Its quantity was practically constant in all samples (± 10% of the total of palynomorphs) (Fig. 3). The highest percentage and concentration occurred in sample 2 (36,300 spores/g).

The quantity of algae was variable in all samples (Fig. 3 and 6). The highest algae concentration reached 77,582 individuals/g in sample 1 and the lowest (1,887 individuals/g) in sample 4. *Pediastrum tetras* (Ehrenberg) Ralfs was the dominant species among the algae identified, and the highest percentage occurred in sample 1 (Fig. 7). *Spirogyra* and *Mougeotia* were dominant in sample 4. *Mougeotia* occurred in all samples and presented the highest percentages in sample 2 (14%) and 4 (24%). *Spirogyra* did not occurred in sample 1 (Fig. 7).

Discussion

Pollen grains – Most of pollen grains observed in the surface sediment samples of the Lagoa do Campelo bottom came from the adjacent bog and swampy areas. According to Koff *et al.* (2000), the predominant local pollen source was considered to came from the vegetation of a 200 m wide area around the lake. The pollen grains from these areas were frequently exposed to oxidation and microbial activity. Successive wetting and drying caused significant damages to palynomorphs and was rapid and severe (Campbell 1991; 1999). The pollen grains and spores that were deposited in the surface sediments of the Lagoa do Campelo presented a strong exine destruction due to its temporary sedimentation in the swampy areas with exposition to the air, reflecting the depositional process in the Lagoa do Campelo lake (Fig. 8). During rainfalls, they were carried into the lake. Sinking down in the margins of the lake, palynomorphs were resuspended according to the action of the winds. The resuspended sediment was then transported by water currents and mixed with sediments originated from different parts of the basin and probably from different depositional strata.

Pollen and spore deposition at the Lagoa do Campelo is controlled primarily by wind and hydraulic

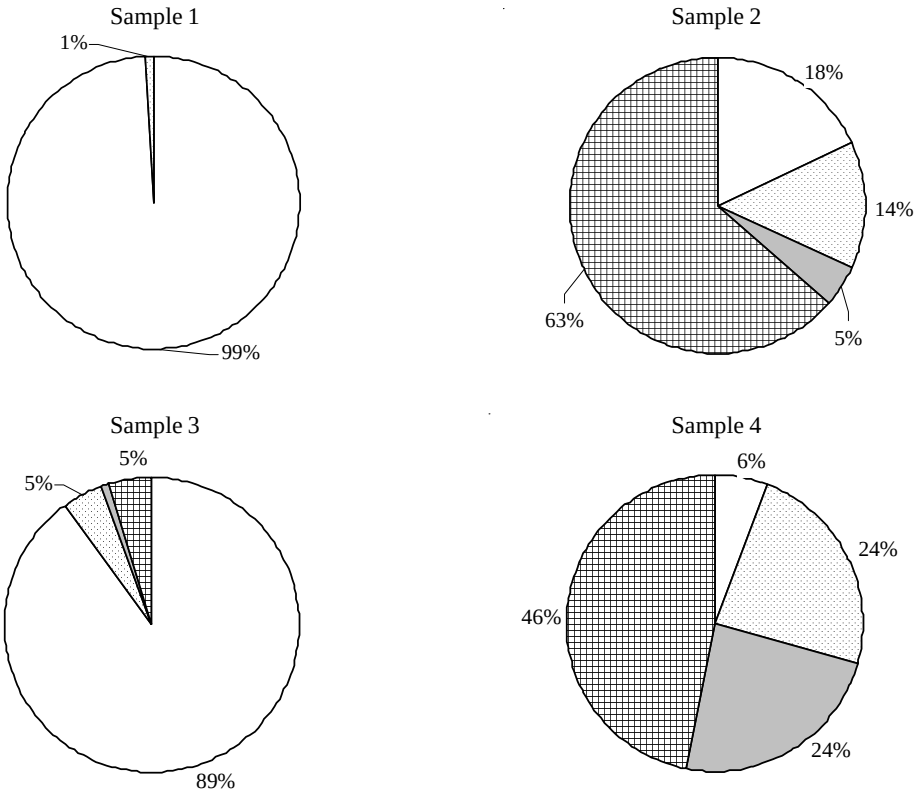

Figure 7. Percentage diagram of algae in the surface sediments of the Lagoa do Campelo lake Rio de Janeiro State, Brazil. □ = *Pediastrum*; ⧄ = *Mougeotia*; ■ = *Spirogyra*; ▦ = Others

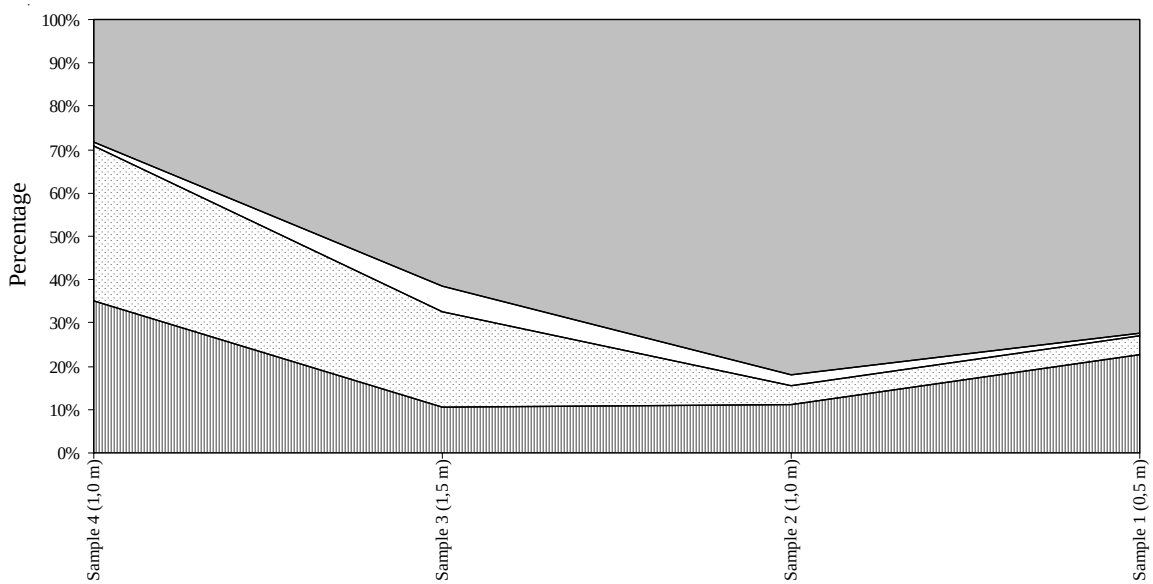

Figure 8. Percentage graph of damaged pollen grains in the surface sediments of the Lagoa do Campelo lake Rio de Janeiro State, Brazil. ▥ = Mechanical damage; ⚄ = Degradation; □ = Corrosion; ■ = Intact pollen grains.

sorting. The west margin should to be the best depositional place of wind-pollinated arboreal species. It presented the highest percentage of broken grains (72%) with thinned exine and the less concentration of all pollen grains. This pattern may be explained by the turbulence in the lake water originated by the NE wind that spread pollen grains laterally to other areas, before and after sinking (reworked grains), resulting in a lower pollen concentration in this station. The pollen grains suffered probably constant processes of resuspension at this margin. This station demonstrated clearly the processes of destruction of palynomorphs during transport and fossil diagenesis. The palynological results obtained of sample 4 showed that the southwest margin of the Lagoa do Campelo is the area of damaged palynomorphs accumulation, in especially of pollen grains.

It was expected that the main pollen source area should be situated in the vicinity of the Lagoa do Campelo. According to Chmura *et al.* (1999), pollen deposition in similar medium sized lakes was based upon wind-pollinated arboreal species. Local plant species provided the dominant assemblages of herbaceous vegetation. The belt bordering vegetation was reflected largely in the pollen spectra. Koff *et al.* (2000) have demonstrated that the proportion of local pollen influx into the lake should fall as the lake area increases. In spite, mainland fringe marshes generally contained high pollen concentration, where source plants grew near to the sampling area (Woo *et al.* 1998). The northeast margin of the lake was the best area to study the depositional processes of local palynomorphs (*Typha* and *Pediastrum tetras*). Cattail (*Typha*) occurred in all samples, but the protected northeast margin of the lake showed the highest percentage.

The high concentration and percentage of pollen of Poaceae in our samples correspond to the abundant occurrence of these plants around the lake shores (grassland of the flat-land, swampy areas and also from the hydrophilous Poaceae). The high concentration of hydrophilous Cyperaceae pollen types is related to pollen contribution from the large belt around the lake, and the regional vegetation. Sample 3 was collected near to a sand-bank covered by Cyperaceae, explaining the high concentration of this pollen type.

Sample 4 presented the highest number of pollen types and of arboreal/shrub pollen types. Sample 3, the deepest station in the transect line, acted like a trap receiving deposits showing a high number of regional pollen types. Resuspension of pollen grains and spores in this point were less intensive. Some of the arboreal/shrub pollen types were representatives of the Seasonal Semideciduous forest and were observed in significant concentrations in our samples, as *Alchornea*, Arecaceae, *Casearia*, *Cecropia*, *Celtis*, *Clethra*, Combretaceae, *Cupania*, *Dorstenia*, Euphorbiaceae, Fabaceae, *Gochnatia*, Lecythidaceae, Meliaceae, Moraceae, *Myrcia*, *Piper*, *Myrsine*, Rubiaceae, Sapotaceae, *Sloanea*, Solanaceae, *Trichilia*, *Trema* and *Virola*. According to Silva & Nascimento (2001), the

Myrtaceae and Leguminosae presented the major richness of species in the "Mata do Carvão". Other ones were representatives of the restinga vegetation, as *Alchornea*, Arecaceae, *Casearia*, *Cupania*, *Gochnatia*, Loranthaceae, Meliaceae, *Myrsine*, *Sloanea* and *Trichilia*. The pollen types of Myrtaceae, *Cupania* and *Myrsine* of the Lagoa do Campelo sediments, were representatives of the restinga forest (Assumpção & Nascimento 2000), they were coming probably from the small forest area located in the northeast margin of the lake. *Alchornea*, Arecaceae, *Casearia*, *Cecropia*, *Celtis*, *Cupania*, Moraceae, *Myrcia*, *Piper*, *Myrsine*, *Sloanea*, *Trema*, *Trichilia* and *Virola* were representatives of swampy forest areas.

M.B. Toledo (data not published) studied the surface sediments of the Lagoa Salgada (northern region of the Rio de Janeiro State), situated in a restinga area about 1.5km from the seashore to the west (southeast of the Campos municipality). Although he did not considered the effect of transport on pollen grains, he did not mentioned any evidence of pollen destruction. He recognized 39 pollen types that were not observed in our sediments as Anacardiaceae, *Anadenanthera*, *Cordia*, *Guarea*, *Hyptis*, *Ilex*, *Ouratea*, *Piptadenia*, *Schinus*, *Strychnos* and *Tetrapteris*, while 23 pollen types of the Lagoa do Campelo lake sediments were not observed by this author, as *Cecropia*, *Cupania*, *Dorstenia*, *Gochnatia*, Lecythidaceae, Myrsinaceae, *Myrcia*, *Sloanea*, *Virola* and *Weinmannia*. Regarding the arboreal/shrub vegetation, *Alchornea*, Arecaceae and *Celtis* were mentioned as the most representatives, agreeing partially with our results, since we included *Cecropia*, *Clethra* and Myrtaceae also. In relation to the herbaceous vegetation, the Lagoa Salgada presented the *Amaranthus*/Chenopodiaceae pollen type as the most representative. This pollen type showed low concentration and percentage in sample 1 only. The herbaceous vegetation related to *Borreria*, Cyperaceae and Poaceae, was noted as important in both studies. Regarding the differences between our and M.B. Toledo (data not published) results, they were due to the different location of the two lakes, as the Lagoa Salgada lake is located in an area of restinga "beach formation" and the Lagoa do Campelo in the deltaic plain of the river Paraíba do Sul. Sometimes the Lagoa Salgada becomes drought. According to the phytosociological study of Assumpção & Nascimento (2000), Amaranthaceae/Chenopodiaceae, *Borreria* and Poaceae are common plants in the "beach grass formation" of the restinga. The arboreal/shrubs pollen types of the Lagoa Salgada lake reflect the "beach formation with clumped groups of vegetation" (Arecaceae, *Schinus*, *Desmodium* and *Cordia*) besides the pollen types of the "restinga forest formation" (*Schinus* and *Byrsonima*). These data obtained of the Lagoa Salgada lake demonstrate the NE wind action that transport the pollen grains from the "beach grass formation", near the seashore, into the lake.

M.B. Toledo (data not published) considered the bathymetry of the Lagoa Salgada as the most important factor for differential deposition of palynomorphs, where the central and deeper part of the lake presented the largest accumulation of palynomorphs. For the Lagoa do Campelo, the wind energy associated with the lake's bathymetry was the most important factor for the differential sedimentation of palynomorphs.

Fern spores – The quantity of fern spores was more or less the same in all our samples. They showed strong exine deterioration, reflecting the depositional process in the Lagoa do Campelo. Like the pollen grains, fern spores were coming from the boggy and swampy areas around the lake and were exposed to oxidation and microbial activity.

Algae – Huszar & Silva (1992) and Huszar & Esteves (1988) studied the net phytoplankton, but no deposition activities in the Lagoa do Campelo. *Pediastrum tetras* appeared as the most important species of algae in our study. *Spirogyra* and *Mougeotia* were not mentioned by these authors.

Samples 1 and 3 presented the highest values of algae per gram. In both samples, *Pediastrum tetras* was the dominant species (Fig. 7). Sample 1 was protected from the winds by the cattail belt and sample 3 was located in the deepest area of the transect line. Samples 2 and 4 showed very low values of algae (Fig. 3), demonstrating that the better preservation of algae in surface sediments of the Lagoa do Campelo occur in the wind protected areas.

In conclusion, the deposition of palynomorphs in the Lagoa do Campelo follows the main wind sense and direction (NE-SW) of the north region of Rio de Janeiro state, as in the Lagoa Salgada also (M.B. Toledo, data not published). The Lagoa do Campelo presents a longer north-south configuration, so that the major quantity of pollen and algae was deposited near to the eastern border, but the major diversity of pollen grains was found next to the west border. Large sized palynomorphs, as fern spores, were deposited preferentially in the deeper parts of the lake. Pollen

and spore preservation was bad, meaning exposition to the air, drying of lake sediments, and corrosion by microorganisms. They were mainly introduced into the lake by rain-water. The pollen spectra indicated a major performance of the local vegetation.

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