UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
INSTITUTO DE BIOCIÊNCIAS
COMISSÃO DE GRADUAÇÃO EM CIÊNCIAS BIOLÓGICAS
TRABALHO DE CONCLUSÃO DE CURSO

Ebráilon Masetto

Gymnosperm and angiosperm pollen grains in Holocene sediments from a paleolagoon in the coastal plain of extreme southern Brazil

Porto Alegre,
2. semestre
2015

Ebráilon Masetto

Gymnosperm and angiosperm pollen grains in Holocene sediments from a paleolagoon in the coastal plain of extreme southern Brazil

Trabalho de Conclusão de Curso apresentado ao Curso de Graduação em Ciências Biológicas da Universidade Federal do Rio Grande do Sul, como requisito parcial e obrigatório para obtenção do título de Bacharel em Ciências Biológicas.

Formatado conforme regras do periódico científico *Brazilian Journal of Botany*.

Orientadora: Prof.ª Dr.ª Maria Luisa Lorscheitter

Porto Alegre,
2. semestre
2015

AGRADECIMENTOS

À Profª Drª Maria Luisa Lorscheitter pela orientação e introdução à Palinologia.

Aos meus pais, familiares e amigos que há 5 anos, querendo ou não, me ouvem falar de pólen e outras plantas.

Aos professores das Universidades com as quais tive contato e às escolas de Ensino Básico onde estudei.

Ao CNPq pelo apoio financeiro a esta pesquisa e ao Laboratório de Palinologia.

À PROPESQ-UFRGS pelo apoio à pesquisa e à participação em eventos científicos.

À banca examinadora pela leitura atenta e crítica e pelas sugestões decorrentes.

Gymnosperm and angiosperm pollen grains in Holocene sediments from a paleolagoon in the coastal plain of extreme southern Brazil

EBRÁILON MASETTO[1] and MARIA LUISA LORSCHEITTER[2]

1. Universidade Federal do Rio Grande do Sul, Instituto de Biociências, Departamento de Botânica. Av. Bento Gonçalves 9500, 91540–000 Porto Alegre, RS, Brasil
2. Corresponding author: mlorsch@uol.com.br

ABSTRACT- (Gymnosperm and angiosperm pollen grains in Holocene sediments from a paleolagoon in the coastal plain of extreme southern Brazil). This paper describes pollen grains of three gymnosperms and 31 angiosperms preserved in one Quaternary sedimentary profile of a paleolagoon, Hermenegildo Beach (33°42'S-53°18'W), in the extreme southern coastal plain of Rio Grande do Sul, southern Brazil. We present these data as taxonomic references for paleoenvironmental studies in this region. The profile was collected directly from the vertical slope over an interval covering the last conventional 2600 years, as determined by radiocarbon dating. Chemical processing of the samples was performed according to standard methodology, using HCl, HF, KOH, and acetolysis, and analyses were performed on light microscopy. The pollen material was found during the counts of 300 pollen grains in each sample, controlled by saturation curves. Descriptions and illustrations are included, along with ecological data from the original organisms. The high taxonomic diversity found in this study will enhance subsequent plant successional studies, which are essential to paleoenvironmental reconstructions of the coastal plain of southern Brazil.

Key words: Palynology, Quaternary, South America, taxonomy

INTRODUCTION

The palynological analyses of Quaternary sediments from coastal plains, along with radiocarbon data, allow detection of marine oscillations and facilitate understanding of the dynamics of vegetation and climate through plant succession studies. Environmental changes over the last millennia are responsible for the current landscape physiognomy (Berglund 1986). Thus, pollen analysis of sediments also allows inferences to be made regarding the natural tendencies of the vegetation and climate, which are important for preservation and environmental monitoring (Birks and Birks 1980).

Little is known about sea-level oscillations and their effects on climate and vegetation dynamics in the southern coastal plain in the state of Rio Grande do Sul, Brazil, despite the contribution that such oscillations make to shaping the current landscape in this region.

Sedimentary palynology is only possible due to certain characteristics of palynomorphs: 1) the morphology of cell wall (the exine) is related to the source of plant, which makes taxonomic identification and inferences about the habitat possible; 2) the cell wall is composed of sporopollenin, allowing of their preservation; and 3) the production of grains in large quantities allows statistical analysis for paleoenvironmental reconstructions. Therefore, palynological catalogs of reference, based on actual or extracted material from sediments are essential for the proper identification of palynomorphs in paleoenvironmental reconstructions.

There are very few descriptions for angiosperm pollen from sedimentary profiles being used as references in paleoenvironmental studies of the > 600-km coastal plain of Rio Grande do Sul, the southernmost Brazilian state: marine (Lorscheitter 1988) and continental sites such as Terra de Areia (Neves and Lorscheitter 1995), and Santo Antônio da Patrulha (Macedo et al. 2009).

This is the first such study for the extreme southern region of the coastal plain of Rio Grande do Sul state; it was performed to provide basic reference material for paleoenvironmental reconstructions of the last millennia in this area. As a continuation of our previous publication covering fungi, algae, bryophyte, and pteridophyte palynomorphs (Masetto and Lorscheitter 2014), this report presents the results of qualitative pollen analysis in an outcrop sedimentary profile of a paleolagoon in Hermenegildo Beach, in the extreme southern region of the Rio Grande do Sul coastal plain, corresponding to the last millennia. Here, we present the taxonomy of gymnosperm and angiosperm pollen grains, with short morphological descriptions, measurements and photomicrographs. Ecological data regarding the corresponding plant accompany the descriptions.

MATERIALS AND METHODS

A 140 cm thick sedimentary profile of a paleolagoon was obtained in a Holocene outcrop at Hermenegildo Beach (33°42’S-53°18’W), municipality of Santa Vitoria do Palmar, in the extreme southern region of the Rio Grande do Sul coastal plain (Fig. 1). Twenty-eight samples were taken at 5-cm intervals directly from the outcrop, composed of dark-clay organic sediments and covered by transgressive sands. Each sample was collected directly from the vertical slope into a box measuring 8-cm3. The radiocarbon date at the base of the profile was determined by Beta Analytic Inc. (Miami, FL, USA).

The samples were treated by hydrochloric acid, hydrofluoric acid and potassium hydroxide, after which they were subjected to acetolysis and filtered through a net with a 250-µm mesh (Faegri and Iversen 1989). The samples were mounted on glycerin-coated slides (Salgado-Labouriau 1973; Faegri and Iversen 1989) and examined by light microscopy

(DIAPAN; Leica Microsystems, Wetzlar, Germany). A minimum of 300 pollen grains were counted per sample, according to saturation curves. Spores and other palynomorphs were identified in parallel counts. Photomicrographs were taken using a digital camera (DFC295; Leica Microsystems) connected to the microscope. Botanical identification was based on the reference collection of the Palynology Laboratory of the Department of Botany at the Federal University of Rio Grande do Sul, Porto Alegre, and on descriptions in the literature (Hooghiemstra 1984; Lorscheitter 1988; Neves and Lorscheitter 1995; Leal and Lorscheitter 2006; Roth and Lorscheitter 2008; Leonhardt and Lorscheitter 2008, 2010; Scherer and Lorscheitter 2009; Spalding and Lorscheitter 2010). Taxonomic treatment for Orders was based on APG III (Stevens 2015). The taxa names follow MOBOT-Missouri Botanical Garden (2015), in the lowest possible category, according to the morphology and level of pollen preservation. The word "type" was used when precise identification was not possible, following Berglund (1986). When identification was not possible, the material was separated by number to permit future identification. The palynological description of each taxon is briefly presented, with nomenclature based on Punt et al. (2007). In some cases, it was not possible to measure the polar axis of the grains due to their fixed position. Ecological data for the organisms of origin, extracted from literature, are included to facilitate future paleoenvironmental studies.

FIGURE 1

RESULTS AND DISCUSSION

The base of sedimentary profile of Hermenegildo Beach was dated in 2590±60 BP (Cal BP 2650 to 2490, 95% probability) Beta – 189288. The second part of the study is presented here with pollen grains of three gymnosperms and 31 angiosperms.

Gymnosperms

1. ***Araucaria angustifolia*** (Bertol.) Kuntze Figs. 2-3.

Oblate spheroidal to spheroidal, globose. Robust, radially symmetric, isopolar. Inaperturate, scabrate (Figs. 2-3). Tenuous exine, generally with irregular folds. Slight exine detachment at equatorial zone (Fig. 3). Polar axis: 66-92 µm; equatorial axis: 66-100 µm.

Ecological data: Pioneer heliophyte, large trees in a humid and cold environment. Form forest with other arboreal taxa in Rio Grande do Sul oriental plateau. Also occur in small clusters in Serra do Sudeste region, but not characteristic of the coastal plain (Rambo 1956a; Reitz and Klein 1966; Reitz et al.1983; Backes 1988; Backes and Irgang 2002; Souza and Lorenzi 2012).

2. ***Podocarpus lambertii*** Klotzsch ex Endl. Fig. 4.

Peroblate, robust, bilateral, heteropolar. Elliptical in polar and equatorial view outline, with leptoma. Scabrate. Bisaccate, sacci with fine and irregular lines (Fig. 4). Total height (including saccus): ca. 57 µm. Polar axis: ca. 32 µm; equatorial greater axis: ca. 73 µm; equatorial smaller axis: ca. 46 µm; sacci height: ca. 33 µm; sacci width: ca. 52 µm.

Ecological data: Pioneer trees in humid areas. With extensive geographic distribution in Rio Grande do Sul, mainly in *Araucaria* forest margin in oriental plateau, and Serra do Sudeste region, but not characteristic of the coastal plain (Reitz et al. 1983; Marchiori 1996, Backes and Irgang 2002; Marchant et al. 2002; Souza and Lorenzi 2012; Sobral and Jarenkow 2013).

3. ***Ephedra tweediana*** Fisch. & C.A. Mey. Fig. 5

Peroblate, bilateral, apolar. Ellipsoidal. Inaperturate, psilate, with many fine folds parallels to equatorial greater axis (Fig. 5). Smaller axis: 22-27 µm; equatorial greater axis: 45-75 µm.

Ecological data: Small climbing woody shrubs, from Serra do Sudeste and southern coastal plain of Rio Grande do Sul, until ca. 30ºS (Rambo 1954; Waechter 1990; Marchiori 1996; Souza and Lorenzi 2012). In sandy dry soils on dunes or margin of swamp forests (Baptista et al. 1979).

Angiosperms

4. ***Cabomba*** Aubl. Figs. 6-7.

Oblate, bilateral, heteropolar. Robust. Elliptic in polar and in major equatorial view outline. Anaperturate, monosulcate, striate. Striae parallel to the equatorial greater axis (Figs. 6-7). Evident columellae. Polar axis: ca. 40 µm; equatorial greater axis: 82-112 µm.

Ecological data: herbs with short rhizomes, common in Rio Grande do Sul, submerged in water reservoirs and swamps (Barroso 1978, Irgang and Gastal Junior 1996; Souza and Lorenzi 2012).

5. Alismataceae Figs. 8-9.

Spheroidal, radially symmetric, apolar. Pantoporate, microechinate (Figs. 8-9). Tenuous distanced pores. Very fine echinae, regularly distributed over the exine surface. Diameter: ca. 20 µm.

Ecological data: Totally or partially submerged, or floating herbs, in swamps, sandy soils of humid grassland and margin of lakes and rivers of many world plates (Irgang and Gastal Junior 1996; Souza and Lorenzi 2012). Common in Rio Grande do Sul (Irgang and Gastal Junior 1996).

6. **Liliaceae** type Figs. 10-12.

Bilateral, heteropolar. Amb elliptical. Monosulcate, per-reticulate (Fig. 10). Elongated sulcus (Fig. 11-12). Fine reticulum, with lumina of short to large variable size. Evident columellae. Equatorial smaller axis: 16-25 μm; equatorial greater axis: 27-37 μm.

Ecological data: Family usually consists of bulbous herbs, with ample world distribution, warm to temperate climate (Souza and Lorenzi 2012). Occur in Rio Grande do Sul and in its Coastal Plain (Rambo 1954).

7. **Cyperaceae** Figs. 13-14.

Prolate spheroidal to subprolate, radially symmetric, heteropolar. Generally distal pole wider than proximal pole (Figs. 13-14). Inaperturate or ana-ulcerate, with distinct ulcus, and/or tenue elongated parallel equatorial apertures, in variable number and irregular in outline (Fig. 13). Scabrate, greater projections on the apertures (Fig. 13). Polar axis: 32-50 μm; equatorial axis: 27-43 μm.

Ecological data: Small to tall herbs generally with rhizomes in grassland, humid areas, or swamps, but there are species in dry and sandy soils or forest and bog margins (Rambo 1956a; Souza and Lorenzi 2012). Common in Rio Grande do Sul in general (Rambo 1954, 1956a, 1956b, 1961).

8. **Eriocaulaceae** Figs. 15-16.

Subprolate, radially symmetric, isopolar. Elliptical in equatorial view outline. Spiraperturate, microechinate (Figs. 15-16). Fine echinae regularly distributed over the exine surface (Fig.16). Evident columellae. Polar axis: ca. 45 μm; equatorial axis: ca. 35 μm. Obs.: it is difficult to find entire grains due to the long aperture and fragile exine.

Ecological data: Generally herbs with rhizomes in marsh wet soils, occasionally aquatic submerged, at tropical and subtropical regions, common in Rio Grande do Sul (Rambo 1956b, Moldenke and Smith 1976; Souza and Lorenzi 2012).

9. **Poaceae** Figs. 17-19.

Spheroidal, radially symmetric, heteropolar. Amb circular and circular in equatorial view outline (Fig. 17). Anaporate, psilate to scabrate. Pore with distinct annulus (Fig. 17-19). Evident columellae. Polar axis: ca 28 μm; equatorial axis: 27-35 μm.

Ecological data: Common small herbs with rhizomes, in dry, humid or flooded soil. Ample distribution, in almost all climates, soils and altitudes. Common in open environments, forming typical associations in grassland areas (Boldrini et al. 2008; Souza and Lorenzi 2012). Abundant in Rio Grande do Sul and in its coastal plain (Rambo 1954, 1961).

10. ***Typha*** L. Figs. 20-21.

Oblate spheroidal to spheroidal, radially symmetric, heteropolar. Amb approximately circular and approximately circular in equatorial view outline (Figs. 20-21). Anaulcerate, per reticulaterugulate (Fig. 21). Evident columellae. Polar axis: 29-38 μm, equatorial axis: 18-38 μm.

Ecological data: Aquatic herbs with rhizomes in shallow water, waterlogged marsh or in stream margins where groupings can form (Reitz 1984; Marchant et al. 2002, Souza and Lorenzi 2012). Common in Rio Grande do Sul and in its coastal plain (Rambo 1954).

11. ***Eichhornia*** Kunth Figs. 22-23.

Oblate, bilateral, heteropolar. Light concavo-convex in equatorial view outline (Fig. 22-23). Disulculate, psilate (Figs. 22). Polar axis: 22-28 μm; equatorial greater axis: 35-43 μm. Ecological data: Aquatic herbs, floating or attached roots in the bottom of water reservoirs. Generally in tropical places. Occur on the surface of rivers, streams, lakes and flooded soils (Castellanos and Klein 1967; Marchant et al. 2002; Souza and Lorenzi 2012). Common in communities on the lake surface in the coastal plain from Rio Grande do Sul (Waechter 1990).

12. ***Roupala*** Aubl. Figs. 24-25.

Radially symmetric, isopolar. Amb subtriangular with slightly convex sides (Fig. 24-25). Triporate, microreticulate. Distinct pores (Fig. 25). Evident columellae. Equatorial axis: ca. 29 μm.

Ecological data: Arboreal plants in southern Brazilian region, mainly in *Araucaria* forest mountain zones and adjacent lower and humid areas. Occur in Rio Grande do Sul (Rambo 1956b; Backes and Irgang 2002, 2004; Sobral and Jarenkow 2013).

13. ***Gunnera*** L. type Figs. 26-28.

Radially symmetric, isopolar. Amb inter-semi-lobate (Figs. 26-28). Tricolporate, reticulate. Lengthy colpori (Fig. 27). Evident columellae. Equatorial axis: ca. 32 μm.

Ecological data: Genus of large or small herbs with rhizomes or stolon. Occur in humid mountain areas and in sandy humid soil of the coastal plain southern Brazil (Rambo 1954; Fevereiro and Barbosa 1976; Marchant et al. 2002; Souza and Lorenzi 2012).

14. ***Myriophyllum*** L. Figs. 29-31.

Oblate to oblate spheroidal, radially symmetric, isopolar. Amb circular, equatorial view slightly elliptic in outline (Figs. 29-31). Triporate to tetraporate, psilate or microverrucate. Highly protruding pores, with distinct annulus (Fig. 31). Tenuous verrucae. Evident columellae. Polar axis: 27-34 µm; equatorial axis: 31-41 µm.

Ecological data: Herbs or small shrubs, aquatic submerged in streams or in swamps, common in southern Brazil (Fevereiro 1975; Souza and Lorenzi 2012).

15. ***Alchornea triplinervia*** (Spreng.) Müll. Arg. Figs. 32-33.

Subprolate to prolate sphaeroidal, radially symmetric, isopolar. Amb circular, equatorial view slightly elliptic in outline. Tricolporate operculate, psilate (Figs. 32-33). Evident columellae. Polar axis: ca. 29 µm; equatorial axis: 26-28 µm.

Ecological data: Very common heliophyte pioneer trees in almost all environments in southern Brazil. Important in the formation of distinct forest and soils. Frequent in the Rio Grande do Sul coastal plain (Rambo 1954; Klein 1961; Reitz et al. 1983; Backes and Irgang 2002; Lorenzi 2008; Souza and Lorenzi 2012; Sobral and Jarenkow 2013).

16. ***Mimosa bimucronata*** (DC.) Kuntze Figs. 34-36.

Tetrad tetrahedral (Figs. 34-36), frontal view circular in outline. Grain small, oblate to suboblate, radially symmetric, heteropolar Amb more or less circular. Distal pole slightly wider than the proximal pole (Fig. 35). No evident aperture, psilate. Tetrad diameter: 11-12 μm. Grain: Polar axis: ca. 6 μm; equatorial axis: 7-10 μm.

Ecological data: Heliophyte pioneer trees, common in southern Brazil, present in varied humid soils of grassland, swamps or forests near the rivers, sometimes in dense extensive groupings. Well developed in degraded flooding environments. Frequent in Rio Grande do Sul coastal plain (Rambo 1953; Reitz et al. 1983; Waechter 1990; Marchiori 1997; Backes and Irgang 2002; Lorenzi 2009; Sobral and Jarenkow 2013**).**

17. ***Mimosa*** L. Figs. 37-38.

Tetrad tetragonal (Figs. 37-38), frontal view subquadrangular in outline. Grain small, oblate spheroidal to spheroidal, radially symmetric, heteropolar. Amb more or less circular. Distal pole wider than the proximal pole (Fig. 38). Thick exine. No evident aperture, psilate. Tetrad diameter: 12-14 μm. Grain: polar axis: 4-8 μm; equatorial axis: 6-8 μm.

Ecological data: Trees, shrubs, bindweeds or herbs in many varied forest and grassland environments. Very common in Rio Grande do Sul, occurring in the coastal plain (Rambo 1954; Marchiori 1997).

18. ***Inga*** Mill. type Figs. 39-41.

Polyad elliptical in frontal view outline, small to large (Figs. 39-41). Grain small, oblate spheroidal to spheroidal, radially symmetric, heteropolar. Distal pole wider than the proximal pole, amb more or less quadrangular (Fig. 40). No evident aperture, psilate to verrucate (Fig. 40). Evident columellae or obscure stratification. Polyad greater diameter: 17-56 μm; polyad smaller diameter: 13-40 μm. Grain: polar axis: 4-18 μm; equatorial axis: 5-19 μm.

Ecological data: The genus includes pioneer shrubs or small trees limited to the tropical and subtropical Americas, close to rivers or lakes. Common in Rio Grande do Sul. Along with other trees, such *Celtis* and *Trema*, forms arboreal groups in the coastal plain, preparing the soil for expansion of the Atlantic rain forest (Rambo 1951, 1954, 1961; Marchiori 1997; Souza and Lorenzi 2012).

19. ***Vicia*** L. type Figs. 42-43.

Prolate, radially symmetric, isopolar. Equatorial view elliptic in outline (Figs. 42-43). Tricolporate, mesocolpium reticulate. Colpori with developed endoaperture (Fig. 42). Evident columellae. Polar axis: ca. 33 µm; equatorial axis: ca. 19 µm.

Ecological data: The genus includes herbs sometimes climbing by tendrils, in southern and southwestern Brazilian regions. Frequently found in modified grassland, with other herbaceous and shrubs species, or in wayside, common in Rio Grande do Sul (Bastos and Miotto 1996).

20. ***Polygala*** L. Figs. 44-45.

Prolate, radially symmetric, isopolar. Equatorial view elliptic in outline. Stephanocolporate psilate. Long and fine ectoapertures (Figs. 44-45). Wide endoabertures, sideways united forming a continuous band (Fig. 44). Columellae slightly evident. Polar axis: ca. 38 µm; equatorial axis: ca. 27 µm.

Ecological data: Generally herbs and shrubs, more abundant in neotropical regions. Abundant in southern Brazil, in grassland, in varied types of soils, dry to humid, such as dunes, waysides, marshes, along river margins, shading soils close to forests, and in original or ruderal areas (Wurdack and Smith 1971; Souza and Lorenzi 2012, Lüdtke et al. 2013). Common in Rio Grande do Sul (Rambo 1954).

21. ***Celtis*** L. Figs. 46-47.

Radially symmetric, isopolar. Amb aproximately circular (Figs. 46-47). Triporate, psilate to scabrate. Pores with distinct annulus (Fig. 46). Evident columellae. Equatorial axis: ca. 26 μm.

Ecological data: Pioneer trees in forest formation, with wide distribution, on the shores or inland forests (Marchiori 1997; Marchant et al. 2002). Common in Rio Grande do Sul and present in its coastal plain (Rambo 1951, 1954, 1956a, 1961; Marchioretto 1988).

22. ***Trema micrantha*** (L.) Blume Figs. 48-49.

Suboblate to oblate spheroidal, bilateral, apolar. Small. Slightly elliptic in outline (Figs. 48-49). Biporate, psilate to scabrate (Fig. 48). Columellae slightly evident. Smaller axis: 15-19 μm; equatorial greater axis: 16-23 μm.

Ecological data: Pioneer trees, with wide distribution, on the shore or in developing inland forests. Common in Rio Grande do Sul and in its coastal plain. Together with *Inga* and *Celtis*, *T. micrantha* forms arboreal groupings, preferring shores in the more advanced succession forest stages, disappearing in the forest climax. Component of Atlantic rain forest formation (Rambo 1951, 1954, 1956a; Reitz et al. 1983; Marchioretto 1988; Marchiori 1997; Marchant et al. 2002; Backes and Irgang 2002; Lorenzi 2008; Souza and Lorenzi 2012).

23. ***Cecropia*** Loefl. Fig. 50.

Prolate, bilateral, isopolar. Small. Equatorial view elliptic in outline. Biporate, scabrate (Fig. 50). Very small pores. Polar axis: ca. 13 μm; equatorial axis: ca. 10 μm.

Ecological data: pioneer trees in forest formation, restricted to the American continent, in fertile soils, especially in plains, with rapid growth. Common in various types of forests throughout Brazil, including Rio Grande do Sul coastal plain (Rambo 1956a, Marchiori 1997; Backes and Irgang 2002; Marchant et al. 2002; Souza and Lorenzi 2012).

24. **Urticaceae** 1 Figs. 51-53.

Amb circular. Radially symmetric, isopolar. Triporate, scabrate (Figs. 51-53). Pores with annulus (Fig. 53). Equatorial axis: ca. 38 µm.

Ecological data: The family is composed of herbs or occasionally half-shrubs or rarely small, soft-wooded trees and, very rarely, lianas (Cronquist 1981). Wide distribution worldwide, mainly in temperate and tropical zones of America, with a few species reaching high altitudes. There are pioneer species of forest in the southern Brazilian vegetation. Small shrubs and trees forming the margins of forests in the Rio Grande do Sul coastal plain (Rambo 1954, 1956a, 1961; Barroso 1978; Marchiori 1997; Souza and Lorenzi 2012).

25. **Urticaceae** 2 Figs. 54-55.

Oblate spheroidal, radially symmetric, isopolar. Small. Amb circular, equatorial view elliptic in outline. Triporate, psilate (Figs. 54-55). Pores with distinct annulus (Fig. 54). Columellae slightly evident. Polar axis: ca. 19 µm; equatorial axis: 17-19 µm.

Ecological data: The same as for Urticaceae 1.

26. **Cucurbitaceae** Figs. 56-57.

Spheroidal, radially symmetric, apolar. Robust. Pantoporate, echinate, with tenuous pores. Echinae regularly distributed over the exine surface (Figs. 56-57). Evident columellae. Diameter: ca. 66 µm. Obs.: generally with irregular folds due to robust size and fine exine (Fig. 57).

Ecological data: Herbs climbing or trailing, commonly with tendrils, less often shrubs or trees, widespread in tropical and subtropical areas, with few species in temperate and cool climates (Barroso 1978; Cronquist 1981; Souza and Lorenzi 2012). Common in Rio Grande do Sul, in dry soils of grassland to very humid forests (Rambo 1954, 1961; Porto 1974).

27. ***Alnus*** Mill. Figs. 58-59.

Amb approximately pentagonal (Figs. 58-59). Radially symmetric, isopolar. Stephanoporate, psilate to slightly scabrate. Five protruding pores, with distinct annulus (Fig. 58). Distinctive arcus that extends in a sweeping curve from one pore to another (Fig. 59). Exine stratification somewhat obscure. Equatorial axis: 25-30 μm.

Ecological data: Trees in certain Andean tropical and subtropical highland humid forests of Argentine and Chile northern onwards, not occurring in Brazil (Markgraf and D'Antoni 1978; Marchant et al. 2002; Souza and Lorenzi 2012). Obs.: the pollen of *Alnus* was found in many Quaternary sedimentary profiles from Rio Grande do Sul, due to exceptional long distance airdispersion from the Andean highland (Lorscheitter 1988; Cordeiro and Lorscheitter 1994; Neves and Lorscheitter 1995; Lorscheitter and Dillenburg 1998; Leal and Lorscheitter 2006; Roth and Lorscheitter 2008; Leonhardt and Lorscheitter 2008; Scherer and Lorscheitter 2009; Macedo et al. 2009; Spalding and Lorscheitter 2015).

28. ***Nothofagus*** Blume Figs. 60-61.

Amb circular. Radially symmetric, isopolar. Stephanocolpate, microechinate (Figs. 60-61). Colpi short, with distinct marginal thickening (Fig. 61). Exine stratification obscure. Equatorial axis: ca. 33 μm.

Ecological data: Trees widespread in the southern Hemisphere (Cronquist 1981; Marchant et al. 2002), in Subantarctic Andean forests from Chile and Argentine in South America (Markgraf and D'Antoni 1978; Marchiori 1997). Not occuring in Brazil. Obs.: Along with *Alnus*, the pollen of *Nothofagus* was found in many Quaternary sedimentary profiles from southern Brazil, due to the exceptional air dispersion from the Andean Southern highland (Lorscheitter 1988; Cordeiro and Lorscheitter 1994; Neves and Lorscheitter 1995; Lorscheitter and Dillenburg 1998; Roth and Lorscheitter 2008; Leonhardt and Lorscheitter 2008).

29. **Melastomataceae** Figs. 62-63.

Prolate, radially symmetric, isopolar. Small. Amb circular. Equatorial view elliptic in outline (Fig. 62-63). Tricolporate, psilate. Three colpori alternating with three pseudocolpi (Fig. 62). Exine stratification obscure. Polar axis: ca. 16 µm; equatorial axis: ca. 11 µm.

Ecological data: Herbs, shrubs or trees, less often epiphytes or lianas. In grasslands, marshes or margin of forests, mainly in tropical and subtropical regions of Southern America; abundant in Brazil. More concentrated in Rio Grande do Sul highlands, but spread in the south and southwest regions, and in its coastal plain (Rambo 1954, 1956b, Souza and Lorenzi 2012).

30. **Myrtaceae** Figs. 64-65.

Limb angular (Figs. 64-65). Radially symmetric, isopolar or heteropolar. Small. Tricolporate, psilate to slightly scabrate (Fig. 64). Parasyncolporate in one or both poles, forming a triangular apocolpial field. Exine stratification somewhat obscure. Equatorial axis: 20-22 µm.

Ecological data: Trees or shrubs, mainly in tropical and subtropical regions. Well distributed in Brazilian forests, being one of the most common families of the country. In Rio Grande do Sul, the family includes the major number of forest species. In the coastal plain, occurring in tropical rain forests, low forests of dunes, grasslands, dry slopes of lakes and marsh ground (Rambo 1954, 1956a, 1956b, 1961; Marchant et al. 2002; Sobral 2003; Souza and Lorenzi 2012).

31. ***Ludwigia*** L. Figs. 66-67.

Oblate. Radially symmetric, heteropolar. Robust. Equatorial view showing a marked convex distal pole and a less convex proximal pole (Figs. 66-67). Tripororate with distinct atrium, verrucate. Highly protruding subequatorial developed apertures, with annulus (Fig. 66). Small irregular verrucae. Exine stratification somewhat obscure. Polar axis: ca. 53 μm; equatorial axis: ca. 70 μm.

Ecological data: Herbs and shrubs with wide distribution in South America, from low to high latitudes. Very common in margins of lakes in Brazil, in marshes, and in flooded land, including bogs. Common in the coastal plain of Rio Grande do Sul (Rambo 1954, 1956a, 1956b; Marchant et al. 2002).

32. **Anacardiaceae** Figs. 68-70.

Subprolate to prolate. Radially symmetric, isopolar. Equatorial view elliptic in outline (Figs. 68- 70). Tricolporate, per-reticulate-striate. Rectangular endoapertures, crosswise elongated (Fig. 68). Evident columellae. Polar axis: 29-44 μm; equatorial axis: 23-32 μm.

Ecological data: Trees, shrubs, or woody vines, rarely only half-shrubs (Cronquist 1981). In tropical and subtropical regions from all over the world. They can inhabit different environments, usually low-lying, in small dense forests, border forests, or grassland, in stream margins, flat land or hillsides, also eroded soils, common in Rio Grande do Sul (Barroso 1984; Fleig 1987; Souza and Lorenzi 2012).

33. **Meliaceae** Figs. 71-72.

Subprolate, radially symetric, isopolar. Equatorial view compressed elliptic in outline (Figs. 71- 72). Tetracolporate, psilate (Fig. 71). Exine stratification somewhat obscure. Polar axis: ca. 34 μm; equatorial axis: ca. 27 μm.

Ecological data: Generally large trees or shrubs, widespread in tropical and subtropical regions, few species in temperate climates (Cronquist 1981). Common in plain environments of Brazilian forests (Girardi 1975; Marchant et al. 2002). Well represented in tropical forest from Rio Grande do Sul (Girardi 1975), including its coastal plain (Rambo 1954, 1961).

34. **Malvaceae** Figs. 73-75.

Spheroidal, radially symmetric, isopolar (Figs 73-75). Robust. Triporate equinate. Pores with annulus. Echinae regularly distributed (Fig. 74). Evident columellae. Diameter: ca. 62 μm. Obs: rare grains, fractured.

Ecological data: Herbs, lianas, shrubs or trees, with ample distribution in tropical, subtropical and temperate regions (Barroso 1978; Marchant et al. 2002; Souza and Lorenzi 2012). Found in tropical and *Araucaria* forests, mangroves, margin of rivers, grasslands, and bogs. Occur in Rio Grande do Sul and in its coastal plain (Rambo 1954, 1956b; 1961).

Here we identify pollen of 34 taxa, including three gymnosperms and 31 angiosperms. The pollen in the distinct taxa showed a high degree of morphological diversity and indicated varied habitats. This study extended the results of our first palynological catalog for the extreme southern region of the coastal plain from Rio Grande do Sul, providing reference material for paleoenvironmental research of the last millennia in this region.

Acknowledgments - The authors thank Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Universidade Federal do Rio Grande do Sul for their financial support.

REFERENCES

Backes P (1988) Condicionamento climático e distribuição gegráfica de *Araucaria angustifolia* (Bert.) O. Ktze. no Brasil. Pesquisas Botânica 39:5-39

Backes P, Irgang B (2002) Árvores do Sul: Guia de Identificação & Interesse Ecológico. Instituto Souza Cruz, Porto Alegre

Backes P, Irgang B (2004) Mata Atlântica: as árvores e a paisagem. Instituto Souza Cruz, Porto Alegre

Baptista LRM (coord.), Ceroni ZSV, Irgang BE, Longhi HM, Waechter JL, Miotto STS, Mariath JEA, Rosito JM, Prado JF, Zanim D (1979) Levantamento florístico preliminar da Reserva Biológica do Lami - Porto Alegre, Rio Grande do Sul. NIDECO, Série Urbana 1:1-59

Barroso GM (1978) Sistemática de angiospermas do Brasil. v. 1, Editora da Universidade de São Paulo, São Paulo

Barroso GM (1984) Sistemática de angiospermas do Brasil. v. 2, Imprensa Universitária da Universidade Federal de Viçosa, Viçosa

Bastos NR, Miotto STS (1996) O gênero *Vicia* (Leguminosae - Faboideae) no Brasil. Pesquisas Botânica 46:85-180

Berglund (1986) Handbook of Holocene Palaeoecology and Palaeohydrology. John Wiley & Sons, New York

Birks HJB, Birks HH (1980) Quaternary Palaeoecology. Edward Arnold, London

Boldrini II, Longhi-Wagner HM, Boechat SC (2008) Morfologia e taxonomia de gramíneas sul-rio-grandenses. 2ª ed. Editora da Universidade Federal do Rio Grande do Sul, Porto Alegre

Castellanos A, Klein RM (1967) Pontederiáceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 2-2

Stevens PF (2010) APweb – www.mobot.org/MOBOT/research/APweb according to Theodor C.H. Cole (Heidelberg) and Hartmut H. Hilger (Berlin) 2010

Cordeiro SH, Lorscheitter ML (1994) Palynology of Lagoa dos Patos sediments, Rio Grande do Sul, Brazil. Journal of Paleolimnology 10:35-42

Cronquist A (1981) An integrated system of classification of flowering plants. Columbia University Press, New York

Faegri K, Iversen J (1989) Textbook of Pollen Analysis. 4th ed., John Wiley & Sons, New York

Fevereiro PCA (1975) Haloragáceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-17

Fevereiro PCA, Barbosa VP (1976) Guneráceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-18

Fleig M (1987) Anacardiaceae. In: Schultz AR (coord) Flora Ilustrada do Rio Grande do Sul. B Inst Bioc, Porto Alegre, n. 42, pp 1-72

Girardi AMM (1975) Meliaceae In: Schultz AR (coord) Flora Ilustrada do Rio Grande do Sul. Bol I C B, Porto Alegre, v.33, fas X, pp 1-64

Hooghiemstra H (1984) Vegetational and Climatic History of the High Plain of Bogotá, Colombia: A Continuous Record of the Last 3,5 Million Years. J. Vaduz, Cramer

Irgang BE, Gastal Junior CVS (1996) Macrófitas aquáticas da Planície Costeira do RS. Porto Alegre [s.n.]

Klein RM (1961) Aspetos fitofisionomicos da Mata Pluvial da Costa Atlantica do sul do Brasil. Boletín de la Sociedad Argentina de Botánica 9:121-140

Leal MG, Lorscheitter ML (2006) Pólen, esporos e demais palinomorfos de sedimentos holocênicos de uma floresta paludosa, Encosta Inferior do Nordeste, Rio Grande do Sul, Brasil. Iheringia Sér Bot 61:13-47

Leonhardt A, Lorscheitter ML (2008) Pólen de gimnospermas e angiospermas do perfil sedimentar de uma turfeira em São Francisco de Paula, Planalto Leste do Rio Grande do Sul, Sul do Brasil. Revista Brasil Bo. 31:645-658

Leonhardt A, Lorscheitter ML (2010) Pólen de Magnoliopsida (Asteridae) e Liliopsida do perfil sedimentar de uma turfeira em São Francisco de Paula, Planalto Leste do Rio Grande do Sul, Sul do Brazil. Revista Brasil Bot 33:381-392

Lorenzi H (2008) Árvores Brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. v. 1, 5ª ed., Editora Plantarum, Nova Odessa

Lorenzi H (2009) Árvores Brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. v. 2, 3ª ed., Editora Plantarum, Nova Odessa

Lorscheitter ML (1988) Palinologia de sedimentos quaternários do testemunho T15, Cone do Rio Grande, Atlântico Sul, Brasil. Descrições taxonômicas. Pesquisas Porto Alegre 21:61-117

Lorscheitter ML, Dillenburg SR (1998) Holocen palaeoenvironments of the northern coastal plain of Rio Grande do Sul, Brazil, reconstructed from palynology of Tramandaí lagoon sediments. Quaternary of South America and Antarctic Peninsula 11:73-97

Lüdtke R, Souza-Chies TT, Miotto STS (2013) O gênero *Polygala* L. (Polygalaceae) na região Sul do Brasil. Hoehnea 40(1):1-50

Macedo RB, Souza PA, Bauermann SG (2009) Catálogo de pólens, esporos e demais palinomorfos em sedimentos holocênicos de Santo Antônio da Patrulha, Rio Grande do Sul, Brasil. Iheringia Sér Bot 64(2): 43-78

Marchant R, Almeida L, Behling H, Berrio JC, Bush M, Cleef A, Duivenvoorden J, Kappelle M, De Oliveira P, Oliveira-Filho AT, Lozano-Garcia S, Hooghiemstra H, Ledru MP, Ludlow

Wiechers B, Markgraf V, Mancini V, Paez M, Prieto A, Rangel O, Salgado-Labouriau ML (2002) Distribution and ecology of parent taxa of pollen lodged within the Latin American Pollen Database. Review of Palaeobotany and Palynology 121:1-75

Marchioretto MS (1988) Estudo taxonômico das espécies dos gêneros *Celtis* e *Trema* (Ulmaceae) no Rio Grande do Sul. Pesquisas Botânica 39:49-80

Marchiori JNC (1996) Dendrologia das gimnospermas. Editora da Universidade Federal de Santa Maria, Santa Maria

Marchiori JNC (1997) Dendrologia das angiospermas: das magnoliáceas às flacurtiáceas. Editora da Universidade Federal de Santa Maria, Santa Maria

Markgraf V, D'Antoni HL (1978) Pollen Flora of Argentina: modern spore and pollen types of Pteridophyta, Gymnospermae, and Angiospermae. The University of Arizona Press, Tucson

Masetto E, Lorscheitter ML (2014) Palynomorphs in Holocene sediments from a paleolagoon in the coastal plain of extreme southern Brazil. Acta bot bras 28(2):165-175

MOBOT-Missouri Botanical Garden (2015) Eletronic Database accessible at http://www.tropicos.org. Accessed 11 Feb 2015

Moldenke HN, Smith LB (1976) Eriocauláceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-103

Neves PCP, Lorscheitter ML (1995). Palinologia de sedimentos de uma mata tropical paludosa (Terra de Areia, Planície Costeira Norte, Rio Grande do Sul, Brasil). Descrições Taxonômicas - Parte II: Gimnospermas e Angiospermas. Acta Geologica Leopoldensia 41:45-82

Porto ML (1974) Cucurbitaceae. In: Schultz AR (coord) Flora Ilustrada do Rio Grande do Sul VIII. Bol I C B, Porto Alegre, v. 31, fas VIII, pp 1-64

Punt W, Blackmore S, Nilsson S, Thomas ALE (2007) Glossary of pollen and spore terminology. Review of Paleobotany and Palynology 143:1-81

Rambo B (1951) A migração da selva higrófila no Rio Grande do Sul. Sellowia 3, Anais Botânicos do H B R:55-91

Rambo B (1953) Estudo comparativo das Leguminosas riograndenses. Sellowia 5, Anais botânicos do H B R:107-184

Rambo B (1954) História da flora do litoral riograndense. Sellowia 6, Anais Botânicos do H B R:113-172

Rambo B (1956a) A fisionomia do Rio Grande do Sul: ensaio de monografia natural. 3ª ed. Editora da Universidade do Vale do Rio dos Sinos, São Leopoldo

Rambo B (1956b) A flora fanerogâmica dos Aparados riograndenses. Sellowia 7, Anais Botânicos do HBR:235-298

Rambo B (1961) Migration routes of the south Brazilian rain forest. Pesquisas Botânica 12:5-54

Reitz R, Klein, RM (1966) Araucariáceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-62

Reitz R, Klein RM, Reis A (1983) Projeto madeira do Rio Grande do Sul. Sellowia. 34-35:1-525

Reitz R (1984) Tifáceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-14

Roth L, Lorscheitter ML (2008) Palinomorfos de um perfil sedimentar em uma turfeira do Parque Nacional dos Aparados da Serra, leste do Planalto do Rio Grande do Sul, Brasil. Iheringia Sér Bot 63(1): 69-100

Salgado-Labouriau, ML (1973) Contribuição à Palinologia dos Cerrados. Academia Brasileira de Ciências, Rio de Janeiro

Scherer C, Lorscheitter ML (2009) Pólen de gimnospermas e angiospermas em sedimentos quaternários de duas matas com Araucária, planalto leste do Rio Grande do Sul, Brasil. Acta bot bras 23(3):681-969

Sobral M (2003) A família das Myrtaceae no Rio Grande do Sul. Editora da Universidade do Vale do Rio dos Sinos, São Leopoldo

Sobral M, Jarenkow JA (2013) Flora Arbórea e Arborescente do Rio Grande do Sul, Brasil. 2ª ed., RiMa Editora, São Carlos

Souza VC, Lorenzi H (2012) Botânica Sistemática: guia ilustrado para identificação das famílias de Fanerógamas nativas e exóticas no Brasil, baseado em APG III. 3ª ed., Editora Plantarum, Nova Odessa

Spalding BBC, Lorscheitter ML (2010) Palinologia de sedimentos da turfeira do Banhado Amarelo, São Francisco de Paula, Rio Grande do Sul, Brasil. Gimnospermas e angiospermas. Hoehnea 37(3): 419-434

Spalding BBC, Lorscheitter ML (2015) Dry and humid phases in the highlands of southern Brazil during the last 34,000 years, and their influence on the paleoenvironments of the region. Quaternary International 377: 102-111

Stevens PF (2015) Angiosperm Phylogeny Website. Version 12, July 2012 [and more or less continuously updated since] http://www.mobot.org/MOBOT/research/APweb/ Accessed 03 Jun 2015

Waechter JL (1990) Comunidades vegetais das restingas do Rio Grande do Sul. In: Simpósio de Ecossistemas da Costa Sul e Sudeste Brasileira Estrutura, função e manejo. Aciesp, São Paulo, v. 3, pp 1-21

Wurdack JJ, Smith LB (1971) Poligaláceas. In: Reitz R (ed) Flora Ilustrada Catarinense. Herbário Barbosa Rodrigues, Itajaí, I Parte, pp 1-70.

FIGURAS DISPONIBILIZADAS SOMENTE NA PUBLICAÇÃO EM PERIÓDICO