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Modern pollen–vegetation relationships in saltmarsh habitats along a salinity gradient of a fluvial estuary

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ABSTRACT

The classification of vegetated habitats and the palynological study of surface sediments are used to evaluate the plant-pollen relationship in the saltmarshes of the Chuí River (southern Brazil). The visual plant cover was recorded in five transects perpendicular to the river's margins and positioned along 4.5 km of the estuarine gradient. Two-way Indicator Species Analysis (TWINSPAN) of the plant cover in 65 sampled quadrats was used to characterize five vegetated habitats. These habitats were distinguished by their elevation in the intertidal zone and their location in the estuarine gradient. The salinity of surface water that flooded low marshes decreased from 20 to 4 between transect 1 and transect 5. A total of 10 surface soil samples from marsh habitats were taken in the same transects as for the study of vegetation, and pollen and spores were identified. The pollen frequencies of dominant families (Cyperaceae, Poaceae, Chenopodicaeae, Juncaceae and Asteraceae) on the surface of marsh habitats show high correlations with the parent plant cover (0.66 to 0.81), but pollen taxa show a higher richness in the plant taxa. The most frequent spores (massulae) encountered in all samples belong to the aquatic fern *Azolla filiculoides*, followed by spores of the moss *Phaeoceros*. The palynological data obtained are consistent with the regional vegetation cover characteristics of saltmarshes, but it is difficult to distinguish different habitat types (Discriminant Analysis results). This low discrimination of pollen-spore assemblages is related to the widespread distribution of the indicator plant species, mostly taxa known to produce large quantities of (primarily) wind-dispersed pollen, which are also redeposited or transferred by tides or freshwater influxes. The low taxonomic resolution of pollen grains of dominant taxa, such as Cyperaceae and Poaceae, also creates difficulties to distinguish the vegetated marsh habitats based on pollen assemblages. The widespread presence of pollen from introduced plants such as *Pinus* species near the saltmarshes emphasizes the anthropogenic impact on this region.

1. Introduction

Surface palynology is the study of pollen and spores from the surface sediments of different ecosystems and their comparison with the standing vegetation cover. The aim of these studies is establish the relationship between the abundance of species present in the vegetation and their representation in the pollen spectrum. Such studies are essential for correctly interpreting fossil pollen assemblages and the palaeoecological reconstructions.

Relationships established between surface sediment pollen-and-spore assemblages and the actual vegetation cover in different parts of the world confirm the value of the use of vascular plant spores and pollen for reconstructing the vegetation cover (*e.g.*, Hjell, 1997; Mulder and Janssen, 1999; Stutz and Prieto, 2003; Fontana, 2005; Roe and Van de Plassche, 2005; Stuart et al., 2006; Deng et al., 2006; Rodríguez-Gallego et al., 2012). Discrepancies between pollen-and-spore assemblages from surface sediments and vegetation cover may be caused by: (1) variations in pollen productivity of plants, (2) unequal pollen and spore dispersion capacity, and (3) the mode of pollination (Faegri and Iversen, 1989; Bush, 2002; Rodríguez-Gallego et al., 2012). Additionally, the destruction of pollen grains and spores due to different reasons may decrease the abundance and taxonomic variety of pollen and spores in sediments and create a discrepancy between pollen-and-spore assemblages in sediments and the past vegetation cover (Bryant et al., 1994; Beecher and Chmura, 2004; Roe and Van de Plassche, 2005). In coastal plains, where open anemophylous vegetation predominates, the dispersion of pollen from surrounding territories by water and wind is very important (Stutz and Prieto, 2003; Fontana, 2005; Stuart et al., 2006). In addition to the complications to the interpretation of local pollen data that arise from to the long-distance transport of pollen by wind (Beecher and Chmura, 2004), the study of plant-pollen relationships in saltmarshes is particularly difficult because continental drainage and tidal water fluxes are an additional source of pollen from outside the marsh ecosystem. Tidal water fluxes can also redistribute pollen and plant species within the marsh (Clark and Patterson, 1985; Deng et al., 2006).

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Modern pollen studies in coastal environments on the southwestern coast of South America showed the prevalence of pollen of halophilous herbs, which correlated with the predominance of the same plant taxa in the vegetation cover (Grill and Guerstein, 1995; Stutz and Prieto, 2003; Fontana, 2005; Medeanic, 2006; Weschenfelder et al., 2008; Rodríguez-Gallego et al., 2012). However, these studies did not account for the zonation patterns in the vegetation in these environments, which can represent successional sequences driven by sedimentation and/or changes in the influence of salt (Costa and Davy, 1992; Costa et al., 1996; Costa, 1997; Isacch et al., 2006). For instance, vegetated habitats of saltmarshes could represent a succession associated with the sea level (Costa et al., 2003; Deng et al., 2006).

In this paper, we present the detailed characteristics of pollen-and-spore assemblages found in surface sediments of recent saltmarshes on the Coastal Plain of Rio Grande do Sul. The Atlantic coast in the extreme south of Brazil is characterized by wind-dominated beaches (Seeliger, 2003) and the Chuí estuary is formed by a 60 km long river that flows into the sea through a 60 m narrow channel (Hoeinghaus et al., 2011). This estuary is strongly influenced by natural oceanic and climatic disturbances, especially in winter, when cold fronts cause severe wave overwash (Costa et al., 1996; Seeliger, 2003). Additionally, the landscape surrounding the estuary is rapidly changing due to extensive afforestation in the foredunes and freshwater marshes (Seeliger et al., 2000; Seeliger, 2003). Aside from this dynamic, the Chuí saltmarshes have distinctive vegetated habitats related to the predominant salinity and flooding frequency (Hoeinghaus et al., 2011). Thus, the margins of the Chuí estuary is an excellent location for studying the relationship between pollen-and-spore data and the current vegetation cover in a highly dynamic saltmarsh.

2. Study area

The study area is located in the municipality of Chuí (33° 44′ S, 53° 23′ W; Fig. 1), on the Atlantic Brazilian-Uruguayan border. The climate of this region is warm-temperate because of the warm Brazil and cold Falkland currents (Cordazzo and Seeliger, 1995; Isacch et al., 2006). The mean annual temperature is approximately 16 °C, and monthly averages of the daily mean temperature are 21.7 °C in January and 10.9 °C in July (1961–1990; Dirección Nacional de Meteorología, 2014). The mean average annual atmospheric precipitation is approximately 1122 mm. Chuí River bank marks the line of boundary between Brazil and Uruguay. The depth of the Chuí River ranges from 1.5 to 3 m. The intertidal marshes extend 4.5 km up-river, occupying approximately 7.5 ha, and oligohaline conditions are prevalent in this area (Hoeinghaus et al., 2011). The plant communities mainly consist of halophilous perennial and annual herbs, which colonized this region during the Holocene after the last post-glacial transgressive event around 4–5 k years BP (Martin et al., 2003). The species of the Cyperaceae, Poaceae, and Juncaceae are found most frequently (Cordazzo and Seeliger, 1995; Hoeinghaus et al., 2011). In the local marshes low, medium and high tide zones can be recognized by their distinctive plant cover (Costa, 1997; Isacch et al., 2006; Hoeinghaus et al., 2011). In this region and worldwide, intertidal marshes are under the threat of being diminished for agricultural and pastural land use (Costa et al., 2009). Afforestation of foredunes and freshwater marshes with *Eucalyptus saligna*, *E. grandis* and *Pinus elliottis* began in 1976. Currently, introduced arboreal plants, widely used for domestic activities, occupy extensive areas of the coastal plain of southern Brazil (Seeliger et al., 2000; Seeliger, 2003). On the Uruguayan side of the Chuí River, large parts of coastal areas were planted with *P. taeda* and *P. elliottis* (Dirección Forestal-Uruguay, 1996).

3. Material and methods

3.1. Vegetation analysis

Saltmarshes at the Chuí form 10 to 40 m wide fringes along the river banks. Visual estimates of the percentage covered by plants of saltmarshes (ground surface cover by the vertical projection of canopies) were recorded in 65 quadrats (0.25 m^2) at 2 m intervals along five transects perpendicular to the estuarine margins, starting at the leading edge of the vegetation (Fig. 1). The height of each quadrat relative to the mean water level (MWL) was determined. Height measurements along each transect were made with the help of a laser leveler (FG-L3 FPM Holding GmbH), and simultaneous measurements of the water level at the lowest parts of the transects and a hydrometric monitoring station (graduated ruler at Chuy International bridge) of the Uruguayan National Directorate of Water (DINAGUA) were made,

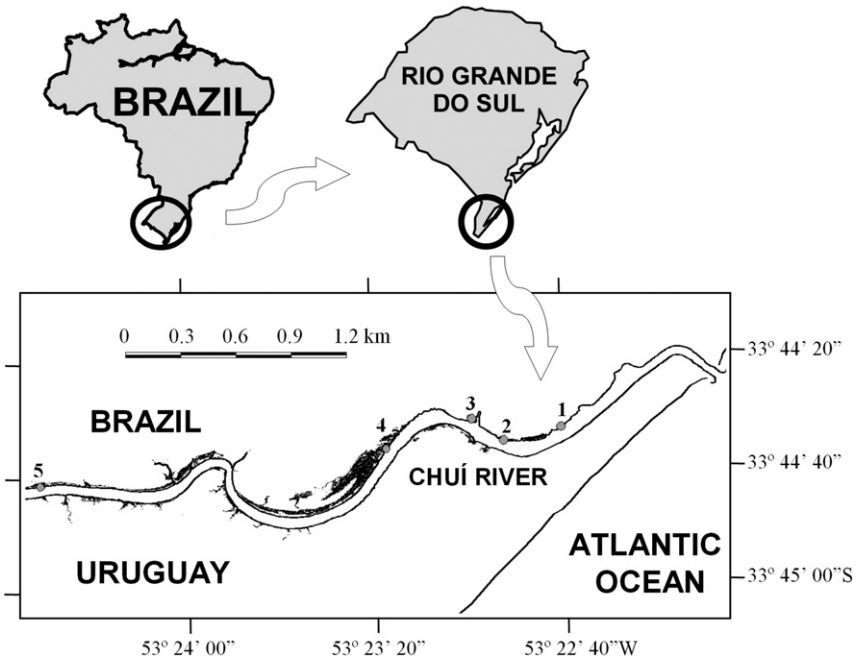

Fig. 1. The Chuí River estuary (Brazil-Uruguay border), showing the location of transect lines where vegetation cover was quantified and surface pollen-and-spore samples of saltmarshes were collected. 1–5 the sampling points; black — areas covered by saltmarshes.