

A two-year report of pollen influx into Tauber traps in Mar Chiquita coastal lagoon, Buenos Aires, Argentina

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Abstract Modern pollen deposition and its relationship to the surrounding vegetation were studied at a coastal lagoon from the southeast of Buenos Aires Province (Argentina). Tauber traps were monitored monthly over a 2-year period in a coastal dune barrier, salt marsh and continental freshwater lake. Pollen deposition exhibited seasonal patterns with maximum values during summer and a spatial variability of increasing deposition from the coast to inland sites. The pollen spectra suggest that airborne pollen originates mainly from local vegetation with scarce representation of extraregional sources. Herbaceous pollen predominates, comprising up to 90% of the total amount with Poaceae,

Chenopodiineae and Asteroideae as the main types. Hydrophytic, psammophytic and extraregional types had little influence on the pollen spectra, generally comprising <5% of the total pollen. Pollen influx–vegetation abundance discrepancies were explained considering pollination syndrome, spatial distribution and structure of vegetation.

Keywords Pollen influx · Source vegetation · Seasonal pattern · Tauber trap

1 Introduction

The relationships between vegetation and pollen assemblages have been subject of discussion since the introduction of pollen analysis (Erdtman 1921). A number of techniques including the study of surface samples from moss polsters, lake sediments, soil and pollen traps were employed to elucidate this problem. The latter have the advantage that they yield influx values which permit differentiation between vegetation which have similar percentage values (Davis and Webb 1975) thus achieving more accurate calibration of pollen–vegetation relationships. On the other hand, many questions can be solved by examining changes at the more local level, for which pollen traps are also advantageous, although long sampling periods are required to assess temporal variation.

Some surveys using Tauber traps have been performed in different environments in Argentina (Cuadrado 1978,

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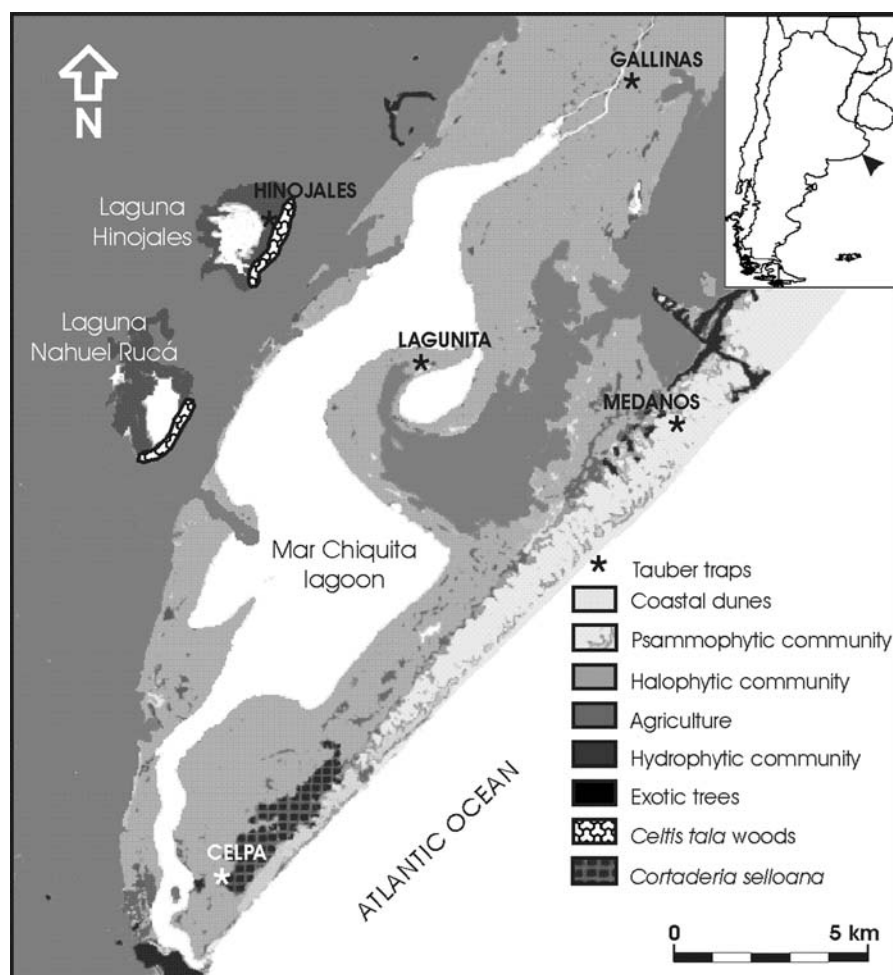
1979; Borromei and Quattrocchio 1990; García de Albano 1991; Majas and Romero 1992; Naab 1999; Latorre and Caccavari 2007). Few have been carried out in coastal environments (Fontana et al. 2001; Fontana 2003, 2004) which are of great importance to palaeoecological reconstructions of past sea level fluctuations. Particularly, the area of Mar Chiquita coastal lagoon (southeastern coast of Buenos Aires Province, Argentina) has been the focus of many palaeoecological studies, which showed that plant communities have distinct pollen assemblages that could be used as modern analogues to fossil core samples, in order to interpret past vegetation changes of the area (Nieto and D'Antoni 1985; Prieto 1993; Stutz 2000; Stutz et al. 2002; Stutz and Prieto 2003). These results agree well with the current knowledge of pollen distribution (Tauber 1965; Jacobson and Bradshaw 1981; Prentice 1985; Jackson 1990), but being based on percentage data, they give little

information about the abundance of the species of surrounding vegetation and of its annual productivity. Pollen influx values, i.e., the number of pollen grains deposited per unit of surface area at a given time, can provide more objective information (Davis 1976; Davis et al. 1980; Hicks 1997). The aim of this study was to provide information on modern pollen influx in different vegetation areas of the Mar Chiquita coastal lagoon and to assess its spatio-temporal variation.

2 Description of the study area

The study area encompasses the Mar Chiquita coastal lagoon (37°43'S, 57°24'W) and Laguna Hinojales (37°34'S, 57°27'W) located in the southeastern Pampa grasslands (Fig. 1).

Fig. 1 Vegetation map of the study area and location of the Tauber traps



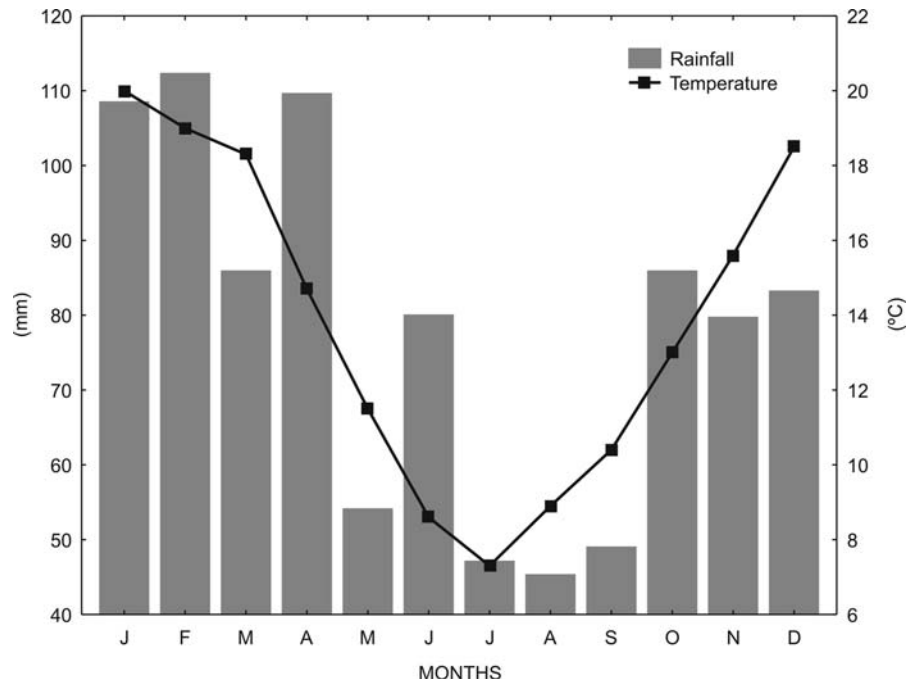
The climate of the study area is temperate with annual mean temperature and precipitation of 13.8°C and 940.6 mm, respectively (reported values from the nearest synoptic station: Mar del Plata Aero, 37°33.6'S, 57°21'W, Servicio Meteorológico Nacional, unpublished). Mean temperature varies from 20°C in January to 7.3°C in July. Rainfall occurs mainly from spring to autumn (September–May in the Southern Hemisphere), with a maximum of 112.3 mm in February and a minimum in August (45.3 mm, Fig. 2). During summer, most frequent winds are from the N, NE and E directions turning to NW to SW in winter.

2.1 Geomorphology and vegetation

The area shows a flat topography of complex geomorphologic origin, including late Pleistocene deflation and Holocene deposition processes associated to transgressive–regressive sea level fluctuations (Schnack et al. 1982; Fasano 1991; Violante 1992). From the Atlantic Ocean to inland, three main landforms can be recognised: the coastal barrier of sandy dunes and adjacent beaches, the marginal flats whose Holocene deposition process gives rise to the Mar Chiquita lagoon and associated salt marsh, and the Pampa plain with numerous deflation basins occupied by freshwater bodies like Laguna Hinojales.

Vegetation of the area has been described and classified by many authors (Vervoorst 1967; Cabrera 1976; León 1991; Stutz 2001). At the beginning of the twentieth century, human settlement had a great impact on natural vegetation. Salt marshes and the sandy dunes are the less damaged environments. Agriculture and cattle raising displaced the Pampa plain's natural steppe vegetation, replacing it with crops and their attendant flora of weeds. Exotic trees (mainly *Pinus* sp., *Cedrus* sp., *Cupressus* sp., *Eucalyptus* sp., *Populus* sp. and *Acacia* sp.) were planted as wind breaks. The only natural vegetation persists in the shallow lakes as freshwater communities characterized by emergent, floating-leaf and submerged aquatic plants. In the deepest zones of the lakes, *Myriophyllum elatinoides* and *Ceratophyllum demersum* grow with great populations of the floating plants such as *Azolla filiculoides*, *Ricciocarpus natans* and *Lemna valdiviana*. Helophytes like *Schoenoplectus californicus*, *Zizaniopsis bonariensis* and *Solanum glaucophyllum* are dominant bank species. Other common emergent species such as *Senecio bonariensis*, *Ranunculus bonariensis*, *R. apiifolius*, *Alternanthera philloxeroides*, *Buddleia elegans*, *Hydrocotyle bonariensis*, *H. ranunculoides*, *Polygonum punctatum*, *Eryngium* sp. and sedges like *Carex*, *Eleocharis* and *Cyperus* are commonly found. On silt dunes surrounding the lakes, monospecific

Fig. 2 Monthly mean temperature and precipitation at Mar del Plata Aero station for the period 1991–2000. Weather station is located 32 km SW of the study area



woodlands of *Celtis tala* constitute the only native arboreal vegetation in the area.

On the marginal flat surrounding Mar Chiquita lagoon, *Spartina densiflora* and *Sarcocornia perennis* are the main components of an extended salt marsh community. Surrounding this zone, *Distichlis spicata* and *D. scoparia* co-dominate, accompanied by *Atriplex montevidensis*, *Spartina alterniflora*, *Grindelia discoidea*, *Sida leprosa*, *Limonium brasiliense*, as well as other less important species. In the highest zone, patches of *Juncus acutus* occur with *Paspalum vaginatum*, *Ambrosia tenuifolia*, *Hydrocotyle bonariensis*, *Scirpus cernuus*, *Apium sellowianum* and *Samolus valerandi*.

The vegetation of the coastal barrier is mainly open vegetation composed of Poaceae, Cyperaceae and psammophytic Asteraceae species. Patches of *Spartina coarctata* with *Calycera crassifolia*, *Senecio crassiflorus* and the adventitious *Cakile maritima* as associated species, characterize recently formed dunes facing the beach. Mobile dunes show patches of the pioneer grass *Panicum racemosum*, while further inland on fixed dunes *Adesmia incana* and *Poa lanuginosa* are dominant, accompanied by *Poa Barrosiana*, *Hydrocotyle bonariensis*, *Margyricarpus pinnatus*, *Solidago chilensis*, *Oenothera mollissima*, *Polygala cyparissias*, *Senecio crassiflorus*, *Ambrosia tenuifolia*, *Baccharis juncea*, *B. microcephala*, *Gnaphalium cheiranthifolium*, *Daucus montevidensis*, *Androtrichium tryginum*, and the adventitious *Centaurium pulchellum*, *Blackstonia perfoliata*, *Medicago lupulina*, *Melilotus indicus* and *M. albus*. On lightly humid soils *Androtrichium tryginum* and *Tessaria absinthioides* are dominant, frequently associated with *Cortaderia selleana* which also grow in coarse widespread patches. Inter-dune depressions have coarser vegetation cover often related to high water tables. The main constituents are *Typha angustifolia*, *T. latifolia*, *Schoenoplectus californicus*, *S. maritimus*, *Carex extensa*, *Eleocharis montevidensis* and several species of *Juncus*.

3 Materials and methods

In order to assess the pollen influx of the main vegetation communities, Tauber pollen traps (Tauber 1974) were established at five sites: Hinojales (fresh-water community), Lagunita and Gallinas (halophytic

community), Médanos and CELPA (psammophytic community) (Fig. 1). Sampling was carried out about 1.5 m above ground level from November 1994 to August 1996. Whenever possible, traps were emptied on a monthly basis. Records from Lagunita and Gallinas lasted from November 1994 to November 1995 and January 1996 to August 1996, respectively.

Particulate matter entering the orifice of the trap was collected in 10 ml of fluid comprising 1% phenol in glycerol to reduce the decay of organic matter. Collected residues were processed following standard procedures (Erdtman 1971; Faegri and Iversen 1992) with two *Lycopodium clavatum* tablets (Stockmarr 1971) for subsequent calculation of pollen influx following Bianchi and D'Antoni (1986). A minimum of 300 grains were counted on each sample. Identifications were performed using the available literature (Heusser 1971; Erdtman 1971; Markgraf and D'Antoni 1978) and the pollen reference collection of the Palaeoecology and Palynology Laboratory at Mar del Plata University.

Owing to the unequal collection periods, pollen influx values were calculated as pollen grains per unit area of the trap opening per day ($\text{grains cm}^{-2} \text{ day}^{-1}$). Also, stacked percentage diagrams of herbs (Poaceae, Asteroideae, Cichoroideae, Cyperaceae, Brassicaceae, Chenopodiaceae, Fabaceae, Apiaceae, *Ambrosia/Xanthium*, *Plantago*), trees (*C. tala*), hydrophytes (Solanaceae, *Azolla*, *Typha*, *Triglochin*, *Myriophyllum*, *Alternanthera*, *Polygonum*, Ranunculaceae), psammophytes (Caryophyllaceae, *Fagara coco*, *Margyricarpus pinnatus*, *Calycera*), extraregional types (*Ephedra*, *Nothofagus*, *Schinus*) and other herbs (Scrophulariaceae, Monocotyledoneae, Rosaceae, Lythraceae) were plotted for each site. Cyperaceae included hydrophytic (i.e., *Schoenoplectus californicus*) and psammophytic types (i.e., *Androtrichium tryginum*) that could not be unambiguously separated. Therefore, it was excluded from both categories. Exotic tree types such as *Cupressus*, *Populus*, *Eucalyptus*, *Pinus*, *Ulmus*, *Acacia*, *Fraxinus*, *Morus*, *Tamarix*, *Alnus*, *Quercus*, and *Castanea* among others, were excluded from the analysis in order to focus on native representatives.

Pollen influx values were compared to previously reported vegetation cover percentages (Palomo et al. 2003), as well as vegetation cover percentages collected by the authors on each vegetation type. Percentage cover for each species (C_a) was calculated

from five randomly located transects of 10 m each as follows:

$$C_a = \frac{l_a}{L} \times 100$$

with L the length of the transect (1,000 cm) and l_a the sum of the lengths for species a (cm). Plant species were identified following Cabrera and Zardini (1979).

4 Results

The largest pollen amount is deposited during the warm period, between December and March, while the minimum is registered in winter, between June and August (Fig. 3). A second period of pollen deposition was detected during spring at Médanos and Hinojales, with maximum values in October.

Herbaceous pollen predominates at every site during the whole year, comprising up to 90% of the total amount. *Celtis tala*, the only native arboreal type, reached noticeable percentages at Hinojales with 80% (621.6 grains cm⁻² day⁻¹) in June 1995 and 40% (1,391.1 grains cm⁻² day⁻¹) in October 1995 and at Lagunita site (35%, 80.6 grains cm⁻² day⁻¹) during October 1995. Influx values were particularly low during 1996 owing that the pollen sampling was interrupted before the end of the pollination period.

Hydrophytic, psammophytic and extraregional types make up a small part of the pollen spectra, never more than 10% and generally <5%, and showed no clear seasonal patterns (Fig. 3). Hydrophytes were best represented at Hinojales (27.9 grains cm⁻² day⁻¹) followed by Médanos (19.0 grains cm⁻² day⁻¹) and CELPA (18.2 grains cm⁻² day⁻¹). Conversely, psammophytes showed higher values at Médanos (20.1 grains cm⁻² day⁻¹), CELPA (19.3 grains cm⁻² day⁻¹) and Gallinas (18.2 grains cm⁻² day⁻¹). Extraregional types were present with very low influx values up to 12.8 grains cm⁻² day⁻¹ at Médanos and 40.6 grains cm⁻² day⁻¹ at Hinojales collected during the whole period.

4.1 Pollen richness and spatio: temporal variability

The higher cumulative seasonal influx was detected at Hinojales followed by CELPA, while minor seasonal accumulation rates were met at Médanos

and corresponding salt marsh sites, Lagunita and Gallinas. These trends were also detected for the arboreal and herbaceous fractions (Table 1).

Almost 80% of the total pollen was represented by Poaceae, Chenopodiineae, Asteroideae, *C. tala*, *Ambrosia/Xanthium*, Cichoroideae and Cyperaceae (among a few others) which were the most representative of the pollen spectrum (Fig. 4). A noticeable change in pollen composition was observed between sites. Poaceae is the characteristic type at CELPA, reaching up to 72% of the total spectrum and a maximum pollen deposition rate of 5,780.5 grains cm⁻² day⁻¹ during February (Figs. 4 and 5). It is also the main type at Médanos (28%, and peak concentration of 1,301.1 grains cm⁻² day⁻¹ during February) followed by Cyperaceae (22%) and *Ambrosia/Xanthium* (13%). At Hinojales, Poaceae reached 28%, with a maximum deposition rate in January with 3,729.4 grains cm⁻² day⁻¹, in addition to 'other herbs' (23%) and *C. tala* (12%).

Vegetation cover roughly followed pollen composition of these sites with high cover of Poaceae (50% at CELPA, mainly *Cortaderia selloana*, and 15.8% at Hinojales with *Distichlis spicata*, *Cynodon dactylon*, *Lolium perenne* and *Hordeum murinum*). Minor percentages of Poaceae cover were met at Médanos with 3.2% of *Panicum racemosum* (Table 2). Hinojales was also the site with the greatest number of herb species. Surprisingly, Cyperaceae was not one of the main pollen types detected in this site even though the border of the lake bears an extended freshwater marsh composed mainly of sedges. Federman (2003) reported that 16.9% of Hinojales' freshwater lake is covered with *Schoenoplectus californicus*. Unfortunately, pollen traps for the end of 1995 were lost because of vandalism and later the pollen sampling was interrupted in September 1996, both during and before the start of the *Schoenoplectus* pollination period, affecting its representation.

The pollen spectra at the Lagunita and Gallinas sites were characterized by large amounts of Chenopodiineae, comprising up to 46% and 37% with peak deposition rates of 3,750.5 and 835.6 grains cm⁻² day⁻¹, respectively, occurring during January or February (Figs. 4 and 5). Vegetation showed high cover percentages of Poaceae (mainly *Spartina densiflora*) followed by Chenopodiineae (*Sarcocornia perennis*) which jointly reach cover percentages of 60% (Table 2).

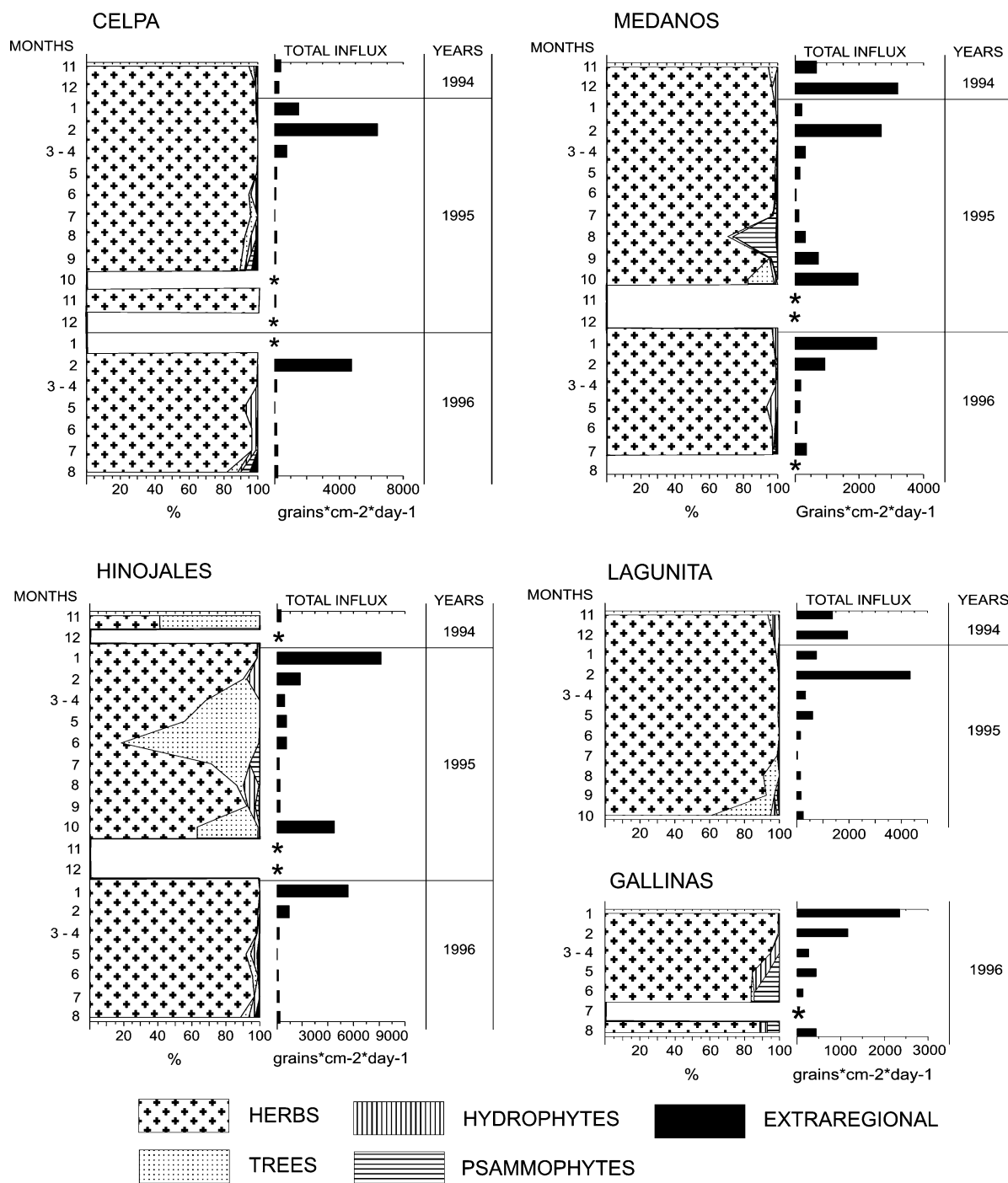


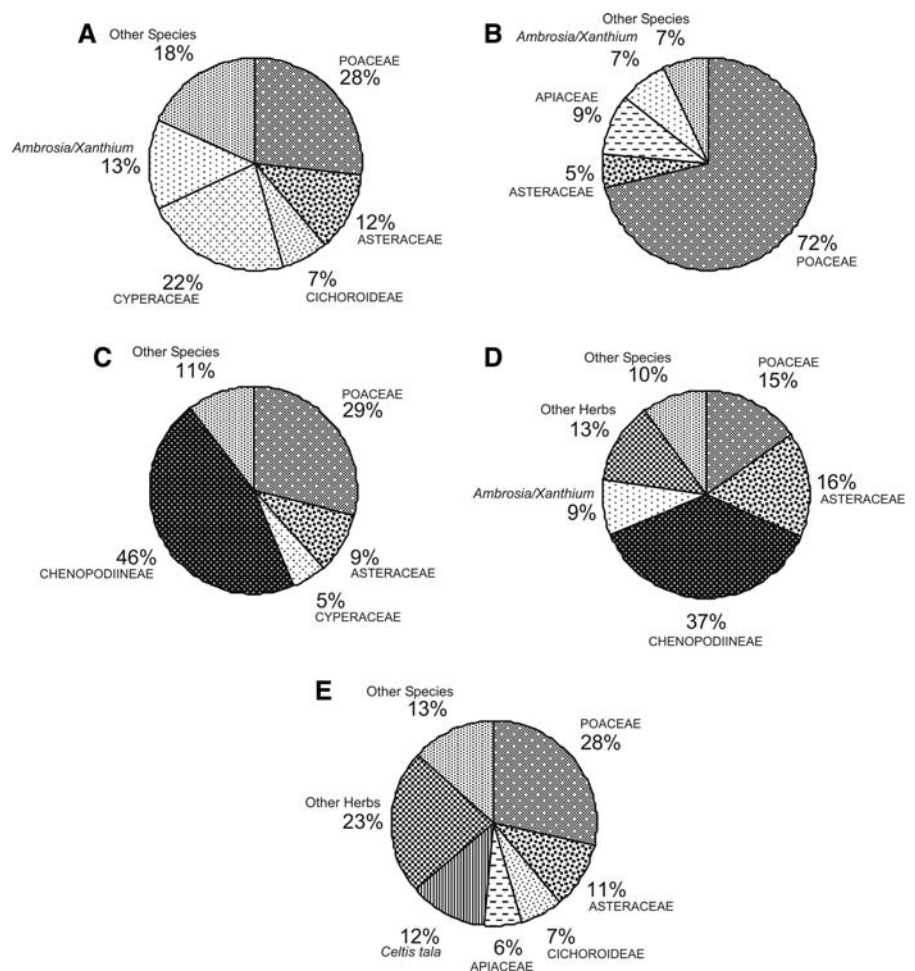
Fig. 3 Average daily pollen influx for each month and percentage pollen contribution of herbs, trees, hydrophytes, psammophytes and extraregional types to each site

Poaceae, Chenopodiineae, *Ambrosia/Xanthium*, *Plantago*, Solanaceae, *Typha*, Asteroideae, Cichoroidae, Cyperaceae, Brassicaceae, Fabaceae and

Apiaceae were the main pollen types associated with summer deposition regardless of the site. Particular maximums vary in accordance with their particular

Table 1 Cumulative influx during maximum pollination period and maximum herbaceous and arboreal seasons (grains $\text{cm}^{-2} \text{ day}^{-1}$) on each sampling site

Season and year	Sampling sites				
	Hinojales	Gallinas	Lagunita	CELPA	Médanos
Pollination period (Dec–Mar)					
1995	11,265.3		6,798.6	8,764.6	3,371.2
1996	6,612.8	3,772.5		4,940.1	3,625.5
Herbaceous season (Jan–May)					
1995	305.1		382.7	368.8	367.0
1996	290.4	371.8		256.0	261.5
Arboreal season (Jun–Oct)					
1995	2,070.9		85.8	3.7	286.5
1996	8.5	3.1		4.1	0.9

Fig. 4 Main pollen types and their percentage contribution to annual deposition at each site. **a** Médanos. **b** CELPA. **c** Lagunita. **d** Gallinas. **e** Hinojales

flowering periods, although most of them peaked in January (Fig. 5). Some of them, such as Asteroideae, Cichoroideae, Cyperaceae, Brassicaceae, Fabaceae

and Apiaceae, also showed another maximum during spring. It may be noticed that these examples correspond to large pollen groups including different species

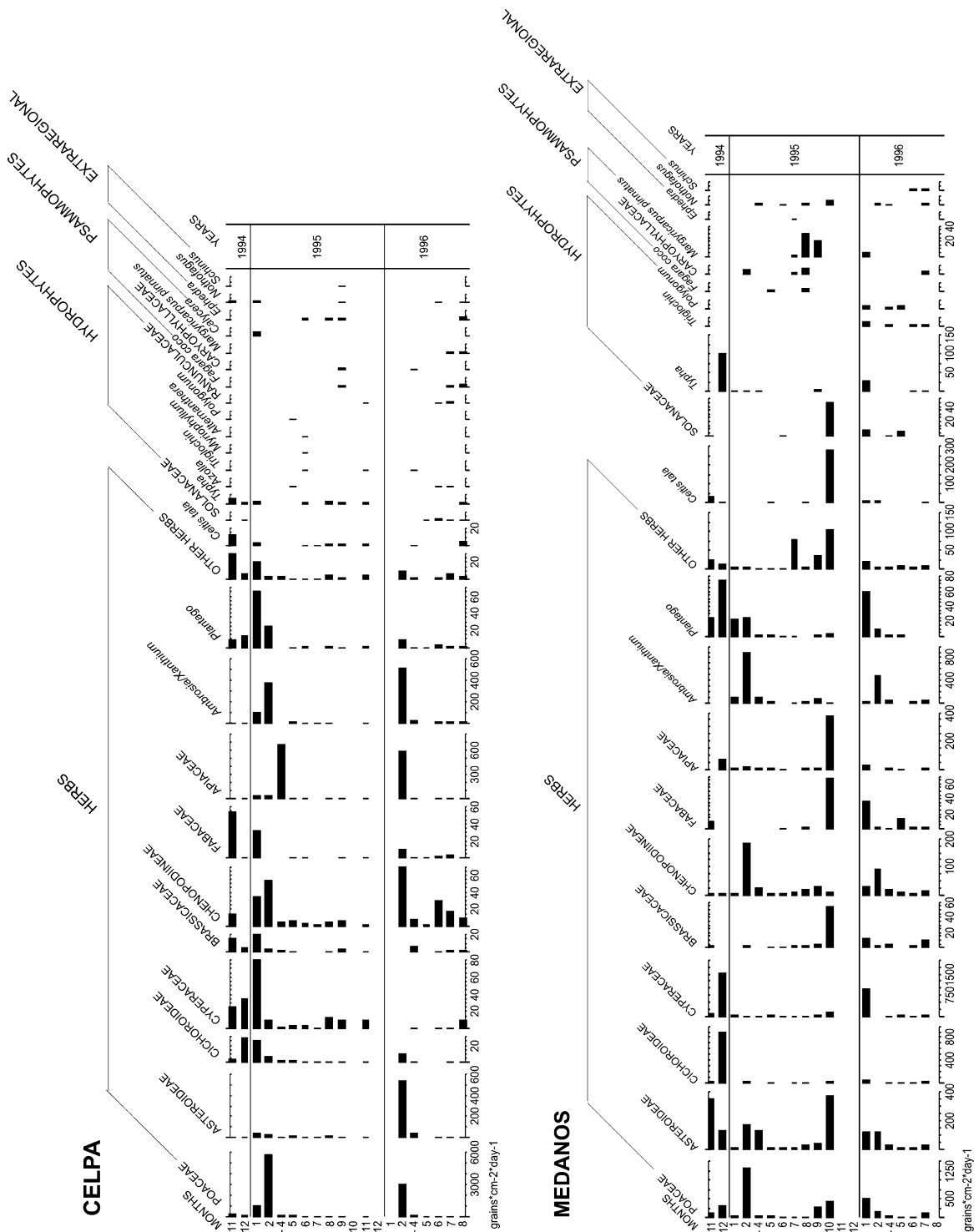


Fig. 5 Monthly pollen type influxes for each site during the study period

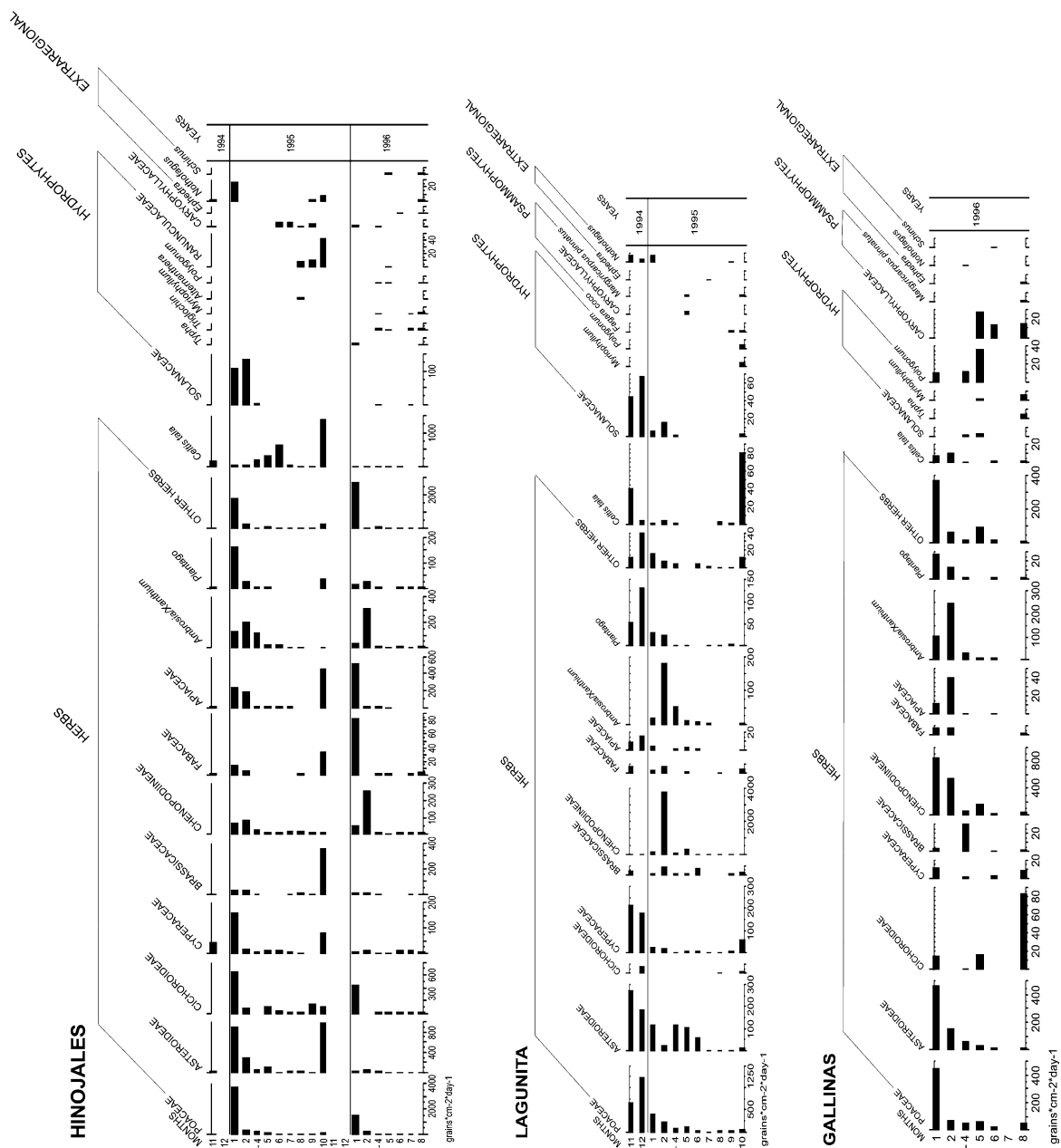


Fig. 5 continued

Table 2 Percentage species cover on each vegetation type

Species	Psammophytic community	<i>Cortaderia</i> meadow	Salt marsh	Freshwater community
<i>Hydrocotyle bonariensis</i>	4.3	2.7	2	0.4
<i>Oenothera mollissima</i>	1.6			
<i>Androtrichum tryginum</i>	4.7	0.3		
<i>Ambrosia tenuifolia</i>	0.5	0.5		0.2
<i>Gnaphalium cheiranthifolium</i>	6.6	7		
<i>Margyricarpus pinnatus</i>	4.7			
<i>Solidago chilensis</i>	0.5			40.2
<i>Adesmia incana</i>	3.1	0.5		
<i>Senecio crassiflorus</i>	1			
<i>Panicum racemosum</i>	3.2			
<i>Baccharis juncea</i>	1.5			
<i>Cortaderia selloana</i>		50.3		
<i>Juncus acutus</i>		8.9	10	
<i>Medicago lupulina</i>		1.5		1
<i>Stenotaphrum secundatum</i>		20	1	
<i>Distichlis spicata</i>		11	2	10
<i>Cynodon dactylon</i>		2.5		3
<i>Stipa paposa</i>		5		
<i>Spartina densiflora</i>			50	
<i>Sarcocornia perennis</i>			10	
<i>Limonium brasiliense</i>			2	
<i>Eleocharis palustris</i>				6
<i>Lolium perenne</i>				2
<i>Apium sellowianum</i>				3.5
<i>Hordeum murinum</i>				0.8
<i>Phyla canescens</i>				2
<i>Solanum galucophyllum</i>				0.6
<i>Aster squamatus</i>				7.5
<i>Altrnanthera philloxeroides</i>				0.8
<i>Polygonum punctatum</i>				0.2
<i>Centaurium pulchellum</i>				0.2
<i>Acmella decumbens</i>				2.8
<i>Gamochaeta purpurea</i>				0.2
<i>Plantago major</i>				0.2
<i>Xanthium cavanillesii</i>				1.3
<i>Trifolium repens</i>				0.4
<i>Budleggia elegans</i>				0.1
<i>Senecio madagascarensis</i>				0.3
<i>Malvella leprosa</i>				1
<i>Quenopodium rubrum</i>				2.6
<i>Juncus imbricatus</i>				5
<i>Carduus acanthoides</i>				2
<i>Schoenoplectus californicus</i>				5.1
<i>Triglochin striata</i>				0.6

Table 2 continued

Species	Psammophytic community	<i>Cortaderia</i> meadow	Salt marsh	Freshwater community
<i>Ranunculus apiifolius</i>				1.5
<i>Bacopa monieri</i>				1.5
Total number of species	11	12	7	31

whose flowering period could differ substantially, producing the second observed maximum. Besides, Cichoroideae also showed another unexpected concentration peak of almost 80 grains cm⁻² day⁻¹ at the Gallinas site in August.

There are two characteristic spring pollen types, *C. tala* and Ranunculaceae, with maximum concentrations during October most conspicuously detected at Hinojales.

Very few pollen types were present during winter. The most representative ones, *Margyricarpus pinna-tus*, *Polygonum* and Caryophyllaceae, showed relatively high pollen concentrations between May and August.

5 Discussion

According to Hicks and Hyvärinen (1986), Tauber traps located 1.5 m high should be expected to collect airborne pollen which represents regional rather than local vegetation. Nevertheless, recent studies compared pollen catches in Tauber and Burkard traps and showed that both records reflected local anemophilous vegetation (Levetin et al. 2000). Our results showed that Poaceae, Asteroideae and Chenopodiaceae are the main types of the airborne assemblages for the study area (Fig. 4), which were also recalled to be characteristic types of the grassland region (Mancini 1994). Nevertheless, careful inspection of the deposition pattern of these taxa present seasonal maxima (summer) other than those reported for the Pampa grassland by other authors whose results showed regional representation with maximum concentration in spring (Majas and Romero 1992; Fontana 2003). Many warm-season species like megathermic Panicoideae, *Cortadeira selloana*, *Panicum* sp., *Paspalum dilatatum*, *Eragrostis* sp., *Solidago chilensis*, *Ambrosia tenuifolia* and *Hydrocotyle bonariensis*, which flower from summer to autumn (León and Bertiller 1982), were reported in the study

area (Palomo et al. 2003). Some of these species are present in the vicinity of the traps with high cover percentages. A special case is *Spartina densiflora*, the most ubiquitous taxon in the salt marsh that reach cover percentages from 60 to 100% (Palomo et al. 2003). *Spartina* was frequently seen to be blooming from November to March reaching plenitude phase during December/January (Alberti, personal communication). In accordance with Levetin et al. (2000), this evidence supports the hypothesis that pollen traps mainly reflect local vegetation, since the Pampa grassland is characterized by mesothermic species that start to flower early in spring time (León and Bertiller 1982).

Some unexpected discrepancies between pollen influx and vegetation cover were met in some cases. Pollen representation of psammophytes at Gallinas was unexpectedly high, mainly due to high influxes of Caryophyllaceae pollen. Also Cichoroideae showed a raised peak concentration during August 1996. Koff (2001) reported that big deviations may be caused by the great influence of local herbaceous vegetation. Considering that neither of the two families are wind-pollinated nor present within the salt marsh (Palomo et al. 2003), these data are not consistent with the local vegetation, but with the presence of insect remains in the trap residues. Insects have been frequently reported as a source of this kind of deviation (van der Knaap et al. 2001), but prevention from falling into the traps has already been discussed without any simple solution (Hicks et al. 1999). On the other hand, pollination syndrome could also be responsible for some differences. As an example, at Médanos there are extensive patches of bare soil where vegetation cover is mainly represented by entomophilous species like *Baccharis articulata*, *Hydrocotyle bonariensis* or *Gnaphalium cheiranthifolium* that were not represented in airborne samples.

Differences in the composition of pollen spectra may also be influenced by vegetation structure and

spatial distribution. Interference of vegetation structure may be considered when palynological richness is used as a measure of floristic diversity (Odgaard 1999). Airborne samples from the salt marsh exhibited higher percentages of Chenopodiaceae than Poaceae while vegetation cover showed a reversed pattern with higher Poaceae percentages than Chenopodiaceae. Stutz and Prieto (2003) also found Chenopodiaceae higher than Poaceae pollen representation in sediment surface samples. They argued that foliage interference could be responsible for higher in situ deposition. *Sarcocornia* inflorescences release pollen from 20 to 30 cm high, often interspersed in *Spartina* foliage whose release height is 50–90 cm above ground level. According to our results, foliage interference seems to be of little importance to *Sarcocornia* (Chenopodiaceae) pollen uplift and transport or maybe its productivity largely exceeds *Spartina* (Poaceae) values. On the other hand, *Sarcocornia* is not only present within the *Spartina* belt but also in pure stands near the shore with approximately 50% of bare soil. This particular distribution could increase *Spartina* pollen emission and/or dispersion. Besides, bare soil enables intense heating which drives stronger uplift than coarser vegetation patches.

There is also another feature influencing composition of the airborne assemblages like reentrainment. It was noted that *C. tala* reached 80% of the total count in June 1995 at Hinojales (621.6 to a total deposition of 776.6 grains $\text{cm}^{-2} \text{day}^{-1}$), although its main deposition corresponds to October. Majas and Romero (1992) detected a similar pattern for a Tauber trap located near a *Celtis* woodland; however, values differ enormously (almost 14 grains day^{-1} (1 grains $\text{cm}^{-2} \text{day}^{-1}$) in June and 550 grains day^{-1} (28 grains $\text{cm}^{-2} \text{day}^{-1}$) in October. Both sites recorded an annual maximum in October when *C. tala* is blooming (Murriello et al. 1993) and a relative maximum at June when vegetation is at a resting period when it reaches maximum leaf falling (Murriello et al. 1993; Arturi et al. 1996). Tilling of surrounding crop fields from nearby *Celtis* woodlands also occur during winter. It is supposed that the relative maximum recorded in June corresponded to resuspension from soil sediments because of farming activities and falling leaves which could release pollen trapped on their surfaces. Unfortunately, there are no appropriate meteorological records to achieve

insight into the role of atmospheric dynamics in the behaviour of the different pollen taxa that certainly influence pollen deposition. The nearest meteorological station is located almost 30 km to the SW, which is not representative of a coastal locality which could be strongly influenced by local circulations such as sea–land breeze.

Although not a very important component of the analyzed pollen spectra, extralocal or extraregional types such as *Nothofagus*, *Schinus* and *Ephedra* are present throughout the area. It is noticeable that deposition values are not very different from each other, being consistent with a long-range transport hypothesis. *Nothofagus* species are the main component of the subantarctic forests located about 1,100 km to the SW of the study area (Cabrera 1976). Several studies have previously recorded *Nothofagus* in the air of Buenos Aires Province (Borromei and Quattrocchio 1990; Majas and Romero 1992; Bianchi 1994; Latorre and Pérez 1997; Latorre and Bianchi 1997; Pérez 2000; Pérez et al. 2001) and even in late Quaternary pollen studies (Borromei 1995, 1998; Prieto 1996). Recently, backward-modeled trajectories assigned the presence of this pollen type to particular local atmospheric characteristics at the source and sink areas in conjunction with a favorable scenario established at the synoptic scale (Gassmann and Pérez 2006). Accordingly, long-range transport occurs in free atmosphere, associated with eastward displacement of the troughs corresponding to the Westerlies circulation. *Ephedra* and *Schinus* are representatives of the Monte Province (Morello 1958), about 500 km to the SW of the study area. Nevertheless, they have been recorded at different localities closer to the study area. *Ephedra* species have been recorded in the dune systems at Monte Hermoso, the Balcarce ranges and the riverbanks of the Paraná River while *Schinus* species occur at Monte Hermoso, the Austral ranges of Buenos Aires Province and *Celtis* woodlands ('talares') (Vervoorst 1967; Cabrera 1968; Fontana 2005). Therefore, *Schinus* and *Ephedra* pollen could have extralocal or regional source areas located north or south of the study area. Therefore, it could be postulated that airborne pollen of these types could reach the study area transported either by southerly cold fronts, as proposed for *Nothofagus*, or by anticyclonic circulation from the north, as described for *Celtis* by Gassmann and Pérez (2006).

Considering all these features it must be concluded that local vegetation is the main source for airborne samples of the considered environments, with contributions from extralocal to extraregional sources. These results agree with those obtained by Stutz and Prieto (2003) for surface samples from the same environments.

The analysis of Tauber trap residues proved to be an adequate methodology for giving insight into modern relationships between source area and influx values in order to recognize vegetation communities through pollen assemblages. These relationships are useful to “fine tune” modern analogues and build more comprehensive models to assist the interpretation and reconstruction of palaeoenvironments. In this way, we are also analyzing influx–surface sample relationships, which will be reported in a future paper.

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