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Airborne pollen sampling in a wildlife reserve in the south of Buenos Aires province, Argentina

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Abstract The objective of this project was to study the pollen spectrum of the Marahué Wildlife Reserve (Central Argentina), the quantity and quality of airborne pollen grains, and to evaluate the contribution of outside sources, to protect a natural habitat with xerophytic shrub vegetation (''monte'') (the term ''monte'' is used for the dominant xerophytic shrub vegetation in the ''partido'' of Villarino) approximately 90 km south of Bahía Blanca. Sampling was performed weekly throughout a whole calendar year (January–December, 2003) using a volumetric impact sampler. Observations of flowering in the field were performed at the same time as the aerial sampling. Herbarium specimens were collected to make pollen collections of the species found in the study area, for reference purposes. The most abundant pollen types were Poaceae (31.3% total annual pollen), *Amaranthus*/Chenopodiaceae (25.3%), *Eucalyptus* (5%), Brassicaceae (3.9%), and *Plantago* (3.9%). This study showed the dispersion dynamics of pollen grains from characteristic species of the ''partido'' (the province of Buenos Aires is divided into partidos which are roughly equivalent to counties) of Villarino, the exotic flora of the surrounding area, and the pollen types from outside the region.

Keywords Airborne pollen · Argentina · Chenopodiaceae · Espinal · Natural vegetation · Poaceae · Rotorod sampler

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1 Introduction

Different pollen studies have been conducted in areas with natural habitats, mainly for paleoecological purposes. Among these studies have been undertaken in Buenos Aires province (Majas and Romero 1992; Madanes and Millones 2004), in the province of Santa Cruz (Mancini 1993) which included habitats such as semidesert, grass steppe, and *Nothofagus* forest, in a trans-Andina transect between Argentina and Chile (Paez et al. 1997), in the Pre-Delta National Park in Entre Ríos province (Latorre and Caccavari 2006), and in the province of Tucumán (García de Albano 2006).

In Argentina, although studies of areas of natural vegetation are scarce, several studies of the pollen content of the atmosphere of cities have been conducted, e.g. those performed in Bahía Blanca (Murray et al. 2002), Mar del Plata (Latorre and Bianchi 1997; Latorre and Pérez 1997; Latorre 1997;

Pérez et al. 2003), and Buenos Aires (Majas et al. 1992; Noetinger et al. 1994).

The main objective of this project was to study the quantity and quality of airborne pollen grains in an area of natural vegetation characteristic of ''monte'' and to evaluate the possible contribution of pollen sources from outside the reserve.

2 Materials and methods

2.1 Study area

The area selected for conducting this study is in the south of Buenos Aires province, Argentina (Fig. 1). The Marahué Wildlife Reserve is a protected area and its characteristics were appropriate for study of the typical natural vegetation of the region. This reserve is part of a 700 ha farm in the ''partido'' of Villarino, 9 km north of the Colorado river, between Pedro Luro and the coast (39°32′ S–62°25′ W, 12 m above sea level). Nearly half the farm is sown with permanent pastures (Medicago sativa L., *Bromus catharticus* Vahl, *Lolium* spp., *Trifolium repens* L., *Festuca arundinacea* Schreb. and *Zea mays* L.). There are also several fields of natural grassland or intersown with *Eragrostis curvula* Nees that are used for grazing. Approximately 80 ha of natural shrub vegetation remains in the highest parts of the farm and there are another 40 ha of natural grassland and sand dunes (Fig. 1).

Marahué is situated in the ''Espinal'' phytogeographic province (Cabrera 1976) but some species typical of the ''Monte'' phytogeographic province are also present. Much of the flora of Villarino, which includes 300 genera and 510 species, is found on the farm.

One natural habitat found in the area is sand dunes, with their psamophytic steppe vegetation and loose sandy soils. The dominant grass is *Sporobolus rigens* E Desv., and some species of the genera *Medicago* L., *Erodium* Aiton, *Aphanes* L., *Bromus* L., and *Vulpia* C.C. Gmel. are very common. There is also grassland (herbaceous steppe) where the Poaceae are predominant, mainly different species of the genera *Aristida* L., *Bromus*, *Hordeum* L., *Poa* L., and, especially, *Stipa* L. In the areas of natives shrubs the most abundant species are *Geoffroea decorticans* (Gillies ex Hook. and Arn.) Burkart, *Condalia microphylla* Cav., and *Lycium* spp. (mainly *L. chilense* Miers ex Bertero) which are found throughout the area. There are also patches of *Chuquiraga erinacea* D. Don, *Schinus fasciculatus* (Griseb.) I.M. Johnst., *Prosopidastrum angusticarpum* R.A. Palacios and P.S. Hoc, *Prosopis flexuosa* DC., *Cyclolepis genistoides* Gill. ex D.Don, and *Ephedra* spp. dispersed among the former species, and *Larrea divaricata* Cav., *Discaria americana* Gill. ex D.Don and *Aloysia gratissima* (Gillies and Hook.) Tronc. only in some places. Different vegetation communities are seen in areas modified by irrigation canals and drainage ditches. The most typical woody plants along the canals are *Baccharis*

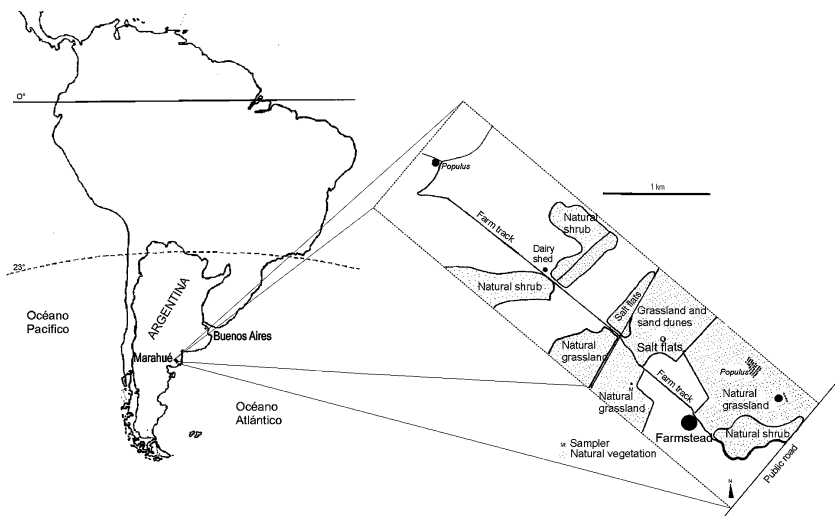

Fig. 1 Geographical location of Marahué and plan of the distribution of vegetation on the farm

salicifolia Pers. and *Tamarix* sp., and *Phragmites australis* Trin. ex Steud. and *Typha* spp. are also frequent, especially in the main drainage ditches. Plants that are tolerant of salt tend to grow on the sides of the drainage ditches, for example *Sarcocornia perennis* (Mill.) A.J. Scott and *Baccharis spartioides* Gay, and *Polypogon monspeliensis* Desf. and *Baccharis juncea* Desf. are found growing lower down at water level. Invasive species, e.g. *Atriplex heterosperma* Bunge, *Bassia scoparia* (L.) A.J. Scott, *Salsola kali* L. and *Solanum elaeagnifolium* Cav. prosper in modified habitats where the soils are rich in organic matter (Villamil and Scoffield 2002).

The climate of the region is temperate (semi-arid). Mean annual temperature is 14.8°C, ranging from 7.7°C in July to 22°C in January. The annual precipitation is 507.9 mm and the mean annual relative humidity is 53%. Northwest winds prevail throughout the year; the annual mean speed varies from 11.8 to 14.6 km h^{-1} (Sánchez et al. 1998).

The temperature, precipitation, relative humidity, and wind speed and direction data were recorded during the sampling and were used to determine the climatic conditions that affect the transport of pollen grains over great distances.

2.2 Sampling pollen and vegetation

The aeropalynological sampling was performed on a weekly basis throughout the year (January–December, 2003) using a volumetric impact sampler (Rotorod, model 40) placed at a height of 2 m above the ground. The sampler was programmed for a sampling period of 2 h continuously on the sampling day. The samples were always taken in the morning close to midday (from 10 am to 12 noon); sampling was avoided on days with abundant rainfall. In the event of rain, sampling was performed on another day in the same week. The method of Frenz et al. (2001) was followed for preparation of the sampling rods.

The sampler was placed in an area of natural grassland, with free air circulation, so it was downwind of the predominant winds (Northwest) with regard to the native shrub vegetation and the natural grassland and sand dunes.

Observations of flowering were made at the same time as aeropalynological sampling and herbarium specimens were collected and stored in the herbarium of the Universidad Nacional del Sur (BBB).

2.3 Pollen counts

An optical microscope (magnification 400×) was used for identification and counting of pollen grains and results were obtained as an average of the two sampled h m^{-3} (grains m^{-3} air for each sample; Brown 1993).

An atlas and other reference books (Erdtman 1952; Heusser 1971; Markgraf and D'Antoni 1978; Faegri and Iversen 1989; Grant Smith 1990; Moore et al. 1991; Pire et al. 1998, 2001), and pollen specimens obtained from herbarium specimens collected in the sampling area, were used for identification of pollen grains.

To analyse monthly values (numbers of pollen grains)[1] for each pollen type, the exponential classes were grouped together in the following way: Class 1: 0.32–2.99; Class 2: 3–5.99; Class 3: 6–11.99; Class 4: 12–23.99; Class 5: 24–49.99; Class 6: 50–99.99; Class 7: >100.

3 Results and discussion

Pollen grains were recorded in the atmosphere throughout the year. The period with the highest concentration (more than 100 grains) was September to February (spring to summer). For total pollen in each sample (pollen grains m^{-3}) it was observed that the highest values were found at the end of January and beginning of February (summer), and at the end of September, middle of October and November, and the beginning of December (Fig. 2).

A total of 40 types of pollen (Table 1) were identified during the study and a total of 1,062 grains of pollen were counted during the sampling throughout the year. The monthly diversity of pollen types identified was very variable, and was highest in the spring. In general, most of the pollen types counted during the year of study (Fig. 3) were from trees planted in the farmsteads and in other nearby plantations, e.g. *Alnus* Mill., *Casuarina* L., *Cupressus* L., *Fraxinus* Tourn. ex L., *Juglans* L., *Morus* L., *Eucalyptus* L'Hér., *Olea* L., *Pinus* L., *Platanus* L., *Populus* L., *Salix* L. and *Ulmus* L.

[1] The monthly value was taken as the sum of the individual values obtained during the month (Mandrioli et al. 1998).

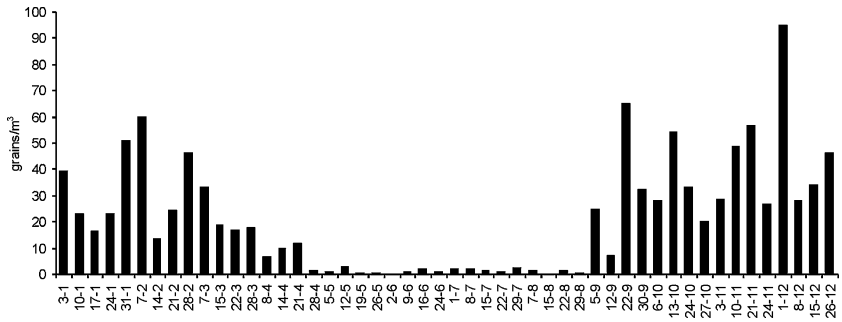

Fig. 2 Two-hour mean amounts of pollen during the year

Pollen grains from regions outside the region of the study were identified, e.g. *Nothofagus* Blume from the subantartic forest approximately at 800 km to the SW (Cabrera 1976; Gassmann and Pérez 2006). There are also some plantations in the districts of Azul and Juárez, Provincia de Buenos Aires, approximately at 350 km to the NE of the study area (D'Alfonso, personal communication, 2006) although there are no data about their abundance or their contribution to the airborne pollen. The pollen grains of *Nothofagus* were found in the atmosphere of the wildlife reserve from the end of October until the end of February, on days when the wind came from the W, NW, SW, and S, so the source of these pollen grains would seem to be the subantartic forests, although further study (continued daily sampling) is necessary to confirm these conclusions.

Celtis L. pollen grains came either from the Tala subdistrict or from other districts in the Espinal province in the north and centre of the country, 500 km or more to the NW, N, and NE (Parodi 1940; Cabrera 1976). Although these may be the sources of pollen of greatest abundance, there are also some populations of *Celtis australis* L. that are nearer, toward the NE, that have escaped from cultivation in Sras. Bayas, Olavaria (320 km) and populations of *C. tala* Gillies ex Planch. in Tres Arroyos (200 km) in the centre of the Provincia de Buenos Aires (D'Alfonso, personal communication, 2006; Villamil, personal communication, 2006). *Celti*s pollen grains were found in the atmosphere of the wildlife reserve from the end of September to the end of November, mainly on days when the winds came from the NW sector.

The presence of numerous shrub species is characteristic of this area, and so the pollen types from these species have been treated separately from the trees and herbs. The pollen from shrubs, with the exception of *Corylus* L. which is cultivated in plantations in the area, belongs to species that occur naturally in the area. The most abundant species in this category were *Tamarix* L., *Condalia* Cav., *Prosopis* L. and *Schinus* L., although the total quantity of grains counted was much lower than in the herbaceous pollen category.

The herbaceous pollen types were mainly from species occurring naturally in the area. The most abundant were from the following families or genera: Asteraceae, Brassicaceae, Chenopodiaceae, Poaceae, *Plantago* L., and *Urtica* L.

More than 50% of the pollen types detected in the air came from spontaneous vegetation. Ten percent were pollen types from spontaneous and non-spontaneous species; the other types were from non-spontaneous vegetation—exotic species specially cultivated in the farmsteads (Fig. 3).

The most abundant types of pollen in the annual pollen spectrum (more than 1.3% of the total pollen sampled) were Poaceae, *Amaranthus*/Chenopodiaceae, *Eucalyptus*, Brassicaceae, *Plantago*, *Urtica*, *Populus*, Asteraceae, *Morus* and *Tamarix*. The concentrations and dynamics of each pollen type are shown in Fig. 4. The characteristics of the pollen types are detailed below in order of their relative abundance.

The most abundant pollen type is Poaceae, accounting for 31.30% of total annual pollen. These pollen grains can be found in the atmosphere during the whole year, except in August. The pollen season starts in the first week of September and ends in the last week of May. The presence of a few isolated pollen grains during June and July might be because of reflotation of the grains, which has been observed on very windy days. The most abundant species

Table 1 Types of pollen present in the air during the study period

Pollen type	AP/SP/HP[a]	SV/NSV[b]
Alnus	AP	NSV
Amaranthus/Chenopodiaceae	SP/HP	SV
Ambrosia	HP	SV
Apiaceae	HP	SV
Artemisia	HP	SV
Asteraceae	SP/HP	SV/NSV
Brassicaceae	HP	SV/NSV
Casuarina	AP	NSV
Celtis	AP	NSV
Centa urea	HP	SV
Condalia	SP	SV
Corylus	SP	NSV
Cupressaceae	AP	NSV
Cyperaceae	HP	SV
Ephedra	SP	SV
Eucalyptus	AP	NSV
Fraxinus	AP	NSV
Gomphrena	HP	SV
Juglans	AP	NSV
Morus	AP	NSV
Mutiseae	SP/HP	SV
Nothofagus	AP	NSV
Olea	AP	NSV
Papilionoideae	AP/SP/HP	SV
Pinus	AP	NSV
Plantago	HP	SV
Platanus	AP	NSV
Poaceae	HP	SV/NSV
Populus	AP	NSV
Prosopidastrum	SP	SV
Prosopis	AP/SP	SV
Rumex	HP	SV
Salix	AP	SV/NSV
Schinus	AP/SP	SV
Solanum	HP	SV
Tamarix	SP	SV
Taraxacum	HP	SV
Typha	HP	SV
Ulmus	AP	NSV
Urtica	HP	SV

[a] Pollen type—arboreal pollen (AP) or non-arboreal pollen (SP, shrubs; HP, herbs)

[b] Pollen type—spontaneous vegetation (SV) or non-spontaneous vegetation (NSV)

included in this pollen type are: *Bromus catharticus*, *Festuca arundinacea* y *Zea maiz* (from part of the farm with permanent pastures), *Bothriochloa* spp., *Bromus hordeaceus* L., *Cynodon dactylon* Pers., *Distichlis scoparia* Arechav., *Hordeum murinum* L., *Poa lanuginosa* Poir., *Setaria* spp., *Sporobolus rigens* E Desv., *Stipa* spp., and *Vulpia australis* (Nees) Henrard (from natural areas).

The *Amaranthus*/Chenopodiaceae type is another of the most abundant types, accounting for 25.35% of total annual pollen. The pollen season starts in the second half of August and continues until the third week of April. The values are very low during May, June, and July. The most important months are January and February, and a maximum (46 grains m^{-3}) is reached in the first week of February. *Salsola kali*, *Atriplex heterosperma*, *A. rosea* L. and *A. semibaccata* R.Br are among the most abundant species of this pollen type.

The *Eucalyptus* type accounts for 5.01% of total annual pollen. The pollen grains of this type are first detected at the beginning of October and disappear in the middle of May; the highest value (24 grains m^{-3}) is in the last week of December. The most abundant species is *Eucalyptus camaldulensis* Dehnh.

Brassicaceae is a pollen type that accounts for 3.99% of total annual pollen. It is present in the atmosphere from the second week in September until the second week in May, reaching a maximum toward the end of March. The most abundant species with this type of pollen grains are *Diplotaxis tenuifolia* (L.) DC., *Eruca versicaria* (L.) Cav. and *Hirschfeldia incana* (L.) Lagr.-Fossat.

The *Plantago* type accounts for 3.92%. The pollen season starts in November, reaching a maximum in the first week of December, and ends in mid April. The maximum value reached was 15 grains m^{-3}.

The *Urtica* type accounts for 3.87% of total pollen. The pollen season begins in the second week of June and ends in the fourth week of December. The maximum is reached in mid October. The only species that has this pollen type is *Urtica urens* L.

The pollen season of *Populus* (3.43%) is during September only, starting the first week, reaching a maximum (28 grains m^{-3}) in the fourth week, and finishing toward the end of the month.

The pollen grains of the Asteraceae type (2.99%) are found in the atmosphere from the third week of October until the third week in May, although a few

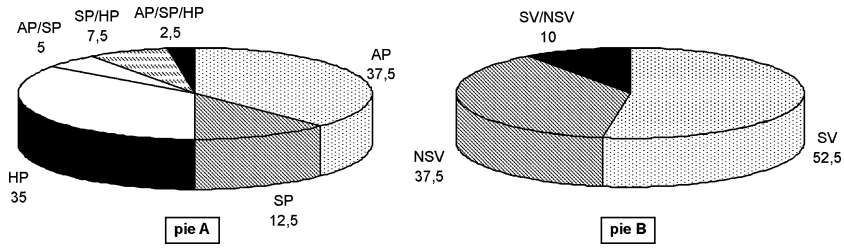

Fig. 3 The percentages of pollen types from trees (arboreal pollen; AP), shrubs (SP), and herbs (HP) (**A**), and from spontaneous (SV) or non-spontaneous (NSV) vegetation (**B**)

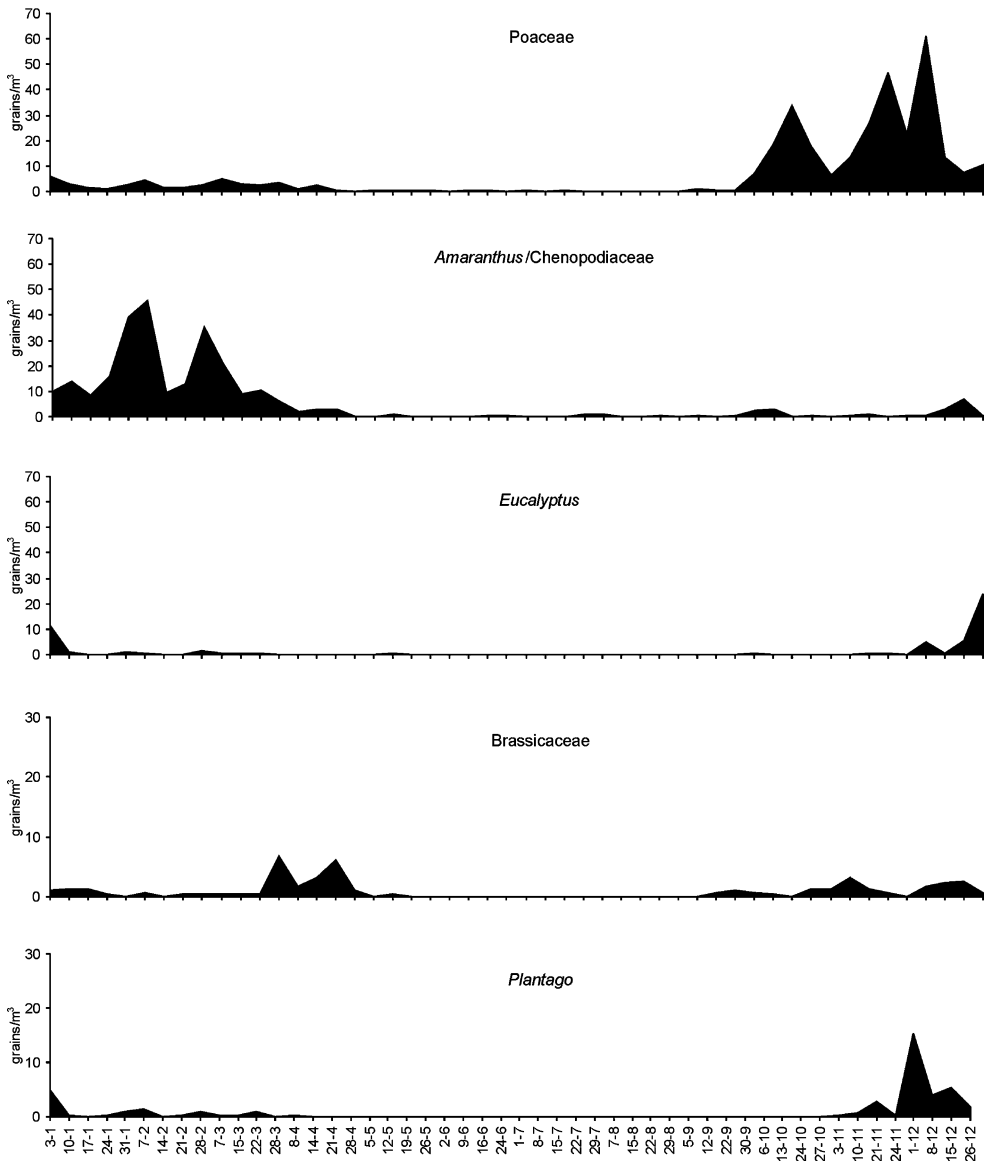

Fig. 4 Mean amounts of pollen (in the two-hour samples) of types that accounted for more than 1.3% of the total pollen during the sampling period

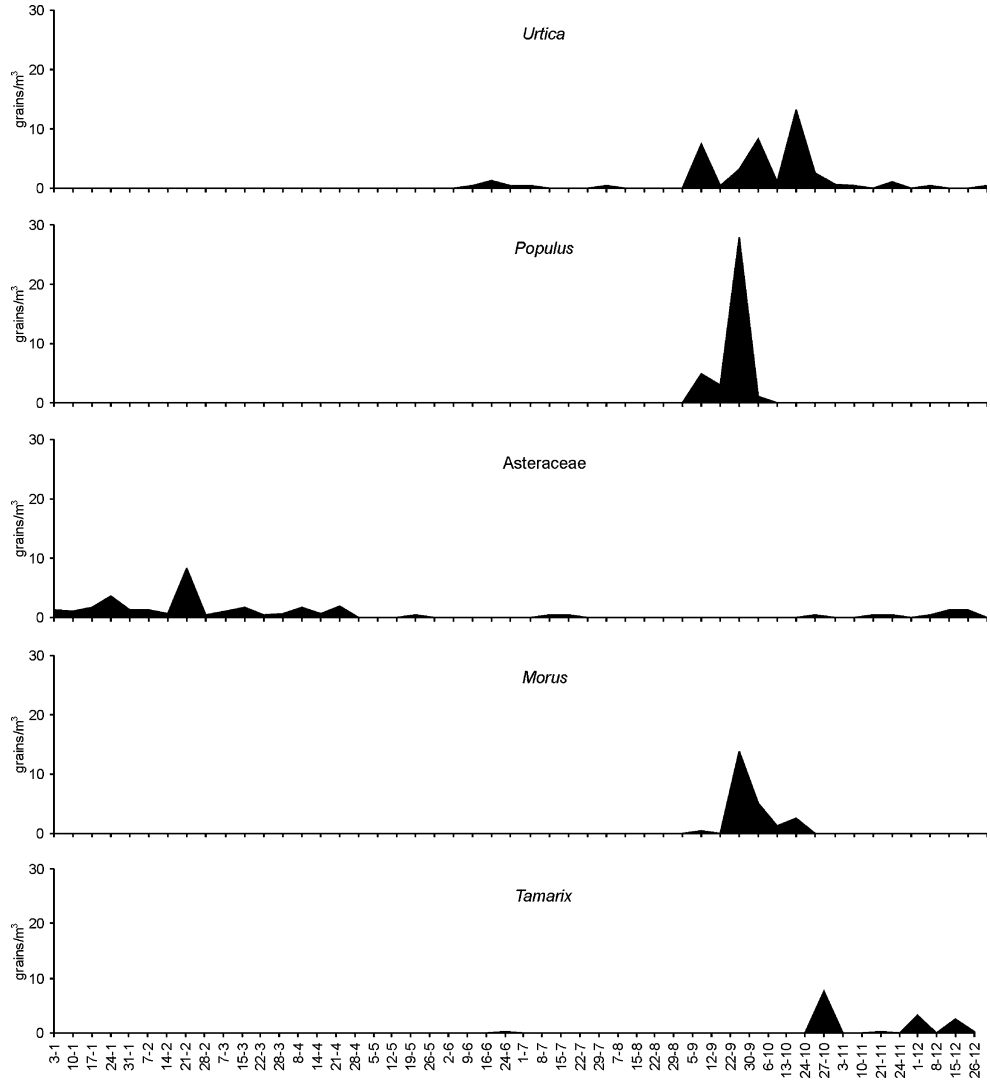

Fig. 4 continued

grains may appear during the winter, possibly because grains are returned to the atmosphere by reflotation, because no plants with this type of pollen were recorded during those months. The weekly values do not reach 10 grains m^{-3}. The most abundant species with this pollen type are *Baccharis salicifolia*, *B. spartioides*, *B. ulicina* Hook. and Arn., *Conyza* spp., *Carduus thoemeri* Weinm., *Gaillardia megapotamica* (Spreng.) Baker, *Gamochaeta filaginela* (DC.) Cabrera, and *Solidago chilensis* Meyen.

The *Morus* type (2.17%) has a very short pollen season and was only detected from the first week of September to the second week of October. The maximum is reached at the end of September (14 grains m^{-3}).

Values for the *Tamarix* pollen type (1.36%) do not exceed 10 grains m^{-3} air; the pollen season starts at the end of October and finishes in the last week of December.

Pollen types that account for less than 1.3% total annual pollen have annual totals of less than 10 grains. It is, however, interesting that pollen grains of some native shrub species appear in this group, e.g. *Condalia microphylla* during November and December, *Prosopidastrum angusticarpum* in December and February, *Prosopis* spp. in October

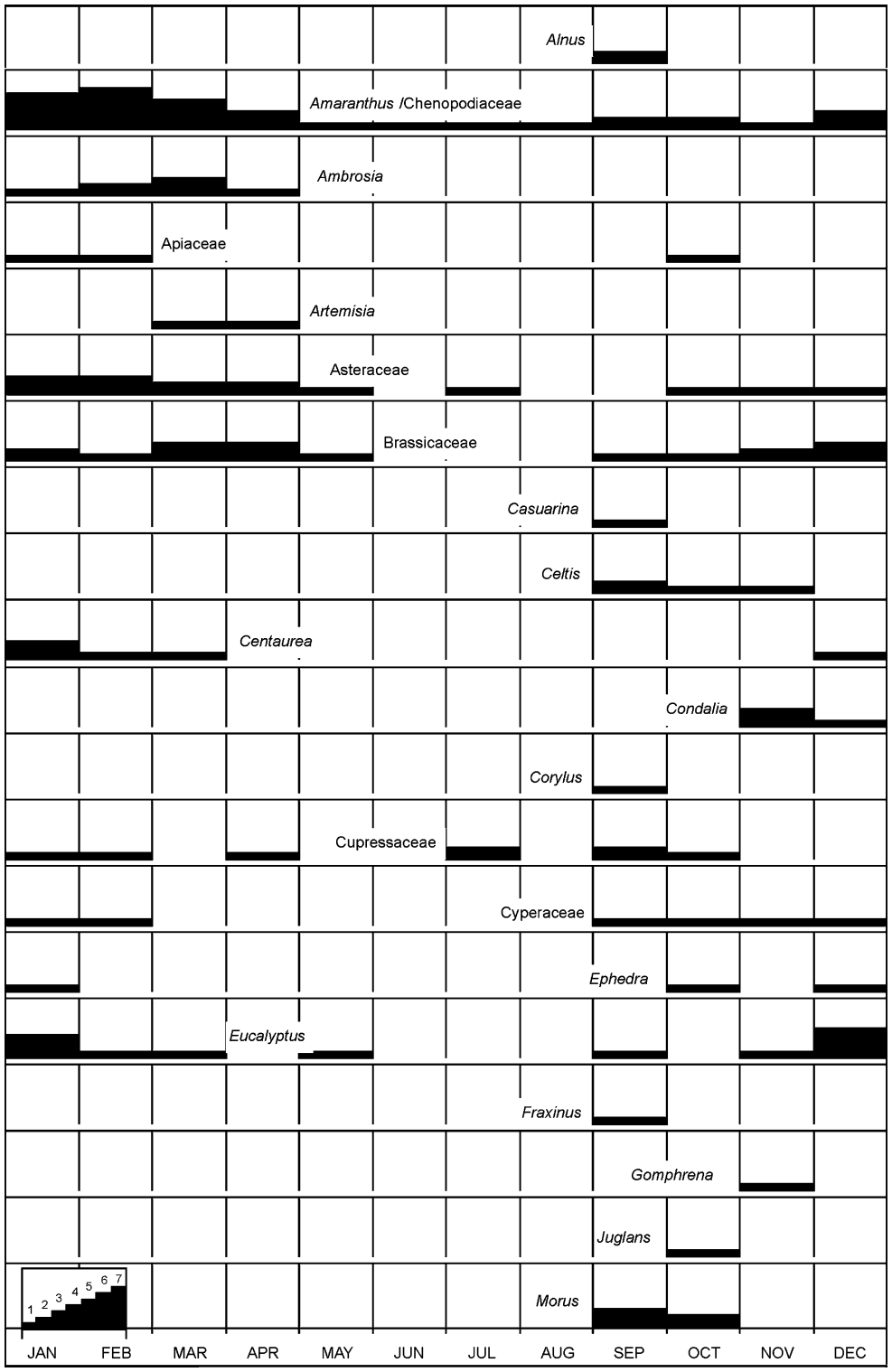

Fig. 5 Airborne pollen during the year

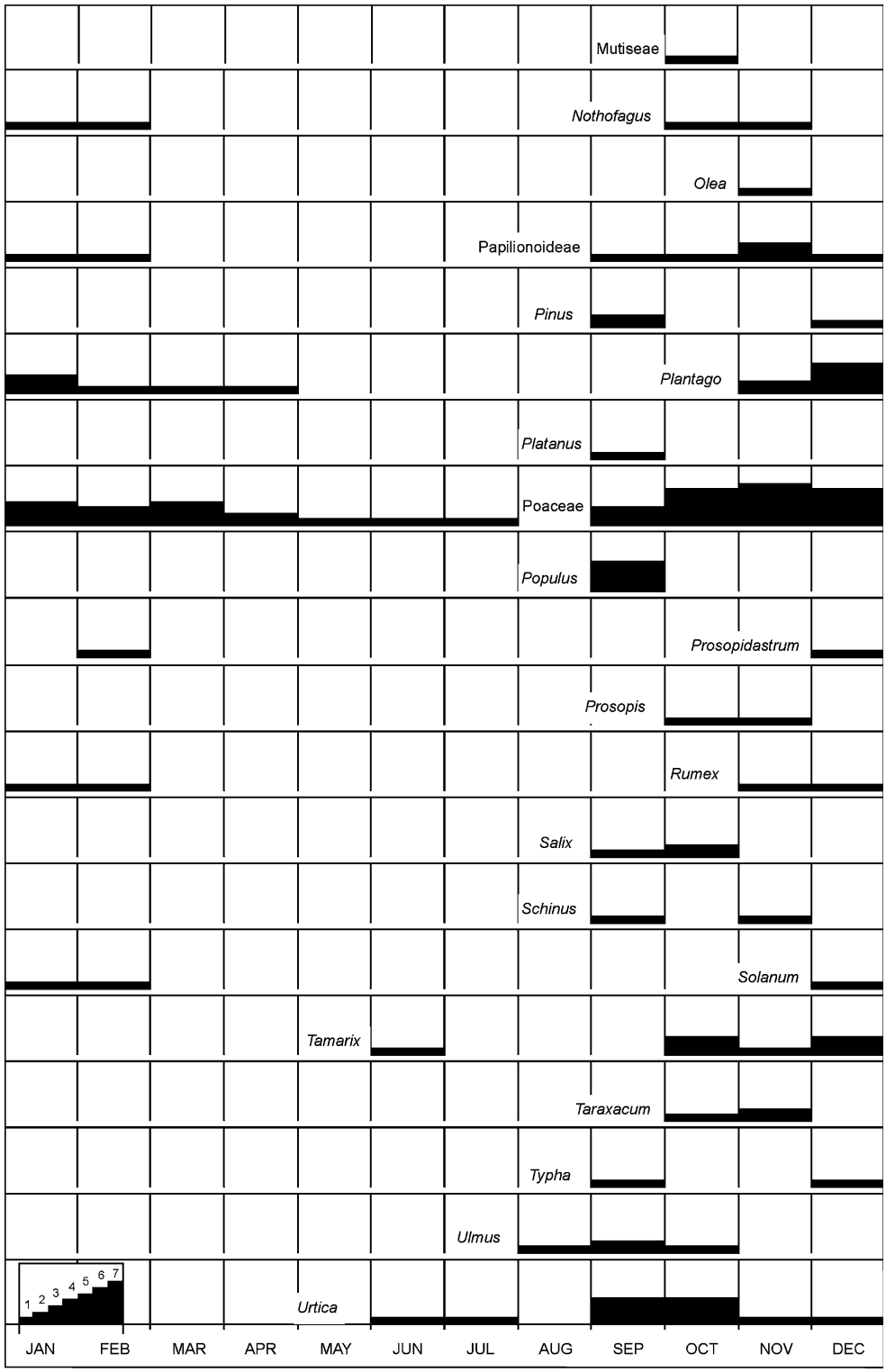

Fig. 5 continued

and November, and *Schinus* spp. in September and November.

Figure 5 shows the variation of pollen concentration through 2003 for each pollen type identified in the wildlife reserve.

It was not possible to compare the pollen types identified or their abundance with results from other studies (Madanes and Millones 2004; Majas and Romero 1992) on natural areas near t the study area, because a different method was used.

Bahía Blanca is one of the nearest cities to the study area where continual volumetric sampling of the air has been undertaken. Daily average pollen concentrations are nearly 1,500 grains m^{-3} and, on occasion, daily values of approximately 3,000 grains m^{-3} have been measured (Murray et al. 2002). In comparison with these values, those obtained in Marahué are low. In a study using the same sampling method and performed simultaneously, however, it was shown that the total quantities of pollen obtained are comparable with those obtained in Bahía Blanca, but differ from those obtained in the Saltral de la Vidriera, a natural habitat with halophytic steppe vegetation, where the dominant pollen type is *Amarathus*/Chenopodiaceae (Murray et al. 2003).

4 Conclusions

Volumetric sampling of pollen grains in the atmosphere of the Marahué Wildlife Reserve has revealed the dynamics of dispersion of pollen grains from typical species of ''monte'', the exotic flora in the area, and contributions from other zones (subantartic forest and the Tala subdistrict). The most abundant pollen types were Poaceae and *Amaranthus*/Chenopodiaceae with percentages greater than 25%. Pollen from cultivated exotic species found in the atmosphere of the reserve were *Eucalyptus*, *Pinus*, *Populus*, *Ulmus*, and Cupressaceae. Although all these genera are found in the surroundings of the study area, *Alnus*, *Casuarina*, *Corylus*, *Fraxinus*, *Juglans*, *Morus*, *Olea*, *Platanus*, and *Salix* come from neighbouring plantations, farmsteads, or towns further away from the sampling area. The presence of pollen grains from outside the region was noted, e.g. *Nothofagus* and *Celtis*; the former comes mainly from the subantartic forest (800 km to the SW) and the latter from the Espinal province in the centre of the country (500 km or more to the NW). Although the diversity of the flora is substantial, it is not reflected in the pollen types that were identified, because many of the large families are stenopalynous. Some typical ''monte'' species are poorly represented, possibly for two reasons—either the pollen grains are not transported by the wind (entomophilous plants, for example *Geoffroea decorticans* (Gill. ex Hook. and Arn.) Burk., *Lycium* sp., *Trichocereus* sp., *Opuntia* sp., etc.) or there are few specimens in the reserve.

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