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ORIGINAL PAPER

Aeropalynological research in *Salitral de la Vidriera*, Buenos Aires province, Argentina

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Abstract This paper reports results from monitoring atmospheric pollen in *Salitral de la Vidriera*, an area of natural vegetation near Bahía Blanca city (East Central Argentina). Sampling was carried out weekly during January to December 2003 and May 2005 to April 2006 using a volumetric impact sampler. Observations of flowering in the field were carried out at the same time as the aerial sampling. During this period, 43 pollen types were identified; most of these correspond to pollen grains from either herbaceous or shrubby vegetation typical of the study area, for example *Amaranthus*, Brassicaceae, *Centaurea*, Poaceae, Chenopodiaceae, Urticaceae, some Asteraceae, and *Condalia microphylla*. This study on the atmosphere of *Salitral de la Vidriera* allowed us to identify the components of the vegetation type dominant in the area, namely a shrubby halophytic steppe. A well represented family, for example Chenopodiaceae, could, under appropriate weather conditions, be an important contributor of pollen to Bahía Blanca.

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1 Introduction

Research on the composition of airborne pollen in areas with natural vegetation is a useful point of reference not only for conducting palynological studies but also for understanding plant population dynamics (Majas and Romero 1992; Mancini 1993; Paez et al. 1997; Fontana 2003; Madanes and Millones 2004; García-Mozo et al. 2007) and pollen production and its contribution to the pollen content of the air. It also contributes to identifying local and foreign pollen and the meteorological conditions under which such contributions to the atmosphere are made (Naab 2004; Latorre and Caccavari 2006; Murray et al. 2007).

The airborne pollen in a particular region shows annual dynamics which, under the influence of meteorological variables and the phenological characteristics of species, is indicative of the differential contribution to the pollen spectrum of the area.

From a biological point of view, the estuary of Bahía Blanca is considered a wetland and, as such, it is an important area for conservation (Nebbia 2005). In addition, vegetation in *Salitral de la Vidriera*, is one of the best represented plant communities in this estuary.

In view of the above, the aim of this research was to study both the quantity and quality of airborne pollen grains in *Salitral de la Vidriera* and to evaluate the possible contribution of chenopodiaceous sources to airborne pollen in the city of Bahía Blanca.

2 Materials and methods

2.1 Study area

The area selected to conduct this research was *Salitral de la Vidriera*, which belongs to the "*partido*"[1] of Villarino, in Buenos Aires province, Argentina (Fig. 1). It is located in the lower course of the S and SW of Sauce Chico river which ends in Bahía Blanca estuary (Perillo 2004; Ángeles 2001). In the coastal area, particularly in the sector beyond the reach of ordinary tides, there are plant communities dominated by shrubs. In fact, two main shrub-community types can be clearly observed, namely a bushy halophytic steppe and a low shrubby halophytic steppe (Verettoni 1961, 1965; Verettoni and Aramayo 1976; Lamberto 1980; Nebbia 2005). It is located in the phytogeographic province of the "Espinal" (Cabrera 1976). Vegetation in this area is a low shrubby halophytic steppe dominated by Chenopodiaceae with native species of the genera *Allenrolfea*, *Atriplex*, *Heterostachys*, *Sarcocornia*, and *Suaeda*.

Both edaphic conditions and weather variability are crucial in this community. The latter is clearly evident from the vegetation which notably varies throughout the year. Abundant exotic representatives of the same family belonging to the genera *Bassia*, *Chenopodium*, *Atriplex*, *Salsola*, and *Beta* are observed in modified areas. Other vegetation components which are important in terms of abundance in *Salitral de la Vidriera* are woody species of the families Rhamnaceae (*Condalia* and *Discaria*), Fabaceae (*Prosopis*, *Prosopidastrum*, and *Geoffroea*), Asteraceae (*Cyclolepis* and *Chuquiraga*), Solanaceae (*Lycium*), and Cactaceae (*Opuntia*, *Trichocereus*, and *Echinopsis*). Grass species, particularly those belonging to the genera *Bothriochloa*, *Bromus*, *Distichlis*, *Eragrostis*, *Hordeum, Pappophorum, Poa, Setaria*, and *Trichloris* are also important, in terms of abundance, to the herb layer during different periods of time.

Another representative type of vegetation in the neighboring sector of our study area corresponds to the psammophytic steppe, which is dominated by grasses belonging to the genera *Sporobolus* and *Panicum*, and a species of the genus *Hyalis*. The area is also characterized by the presence of sectors planted with exotic species in the urban areas and farms. The most widely used taxa are *Cupressus*, *Eucalyptus*, *Pinus*, and *Populus*.

Climate in the study area is temperate, with mean annual temperature close to 15°C and well-differentiated seasons. Summer and winter are both rigorous whereas the intermediate seasons are characterized by more benign conditions. Annual rainfall ranges between 560 and 630 mm. Winds are persistent throughout the year; strong winds exceeding 43 km/h are common. Winds from the N prevail all year (Capelli de Steffens and Campo de Ferreras 2004).

Some wind-direction data were recorded during sampling and were used to determine the climatic conditions influencing airborne pollen grains over long distances.

2.2 Pollen sampling and vegetation

Sampling was carried out all along the border of *Salitral de la Vidriera* (National Highway No 3 km (717; 38°44′ S–62°25′ W, Argentina), an accessible area in the "*partido*" of Villarino (30 km W of Bahía Blanca city). The sampler was placed in the free-air circulation area (Fig. 2). The aeropalynological sampling was carried out one day per week during two different periods—from January to December 2003 (period I) and from May 2005 to April 2006 (period II), continuously, using a portable volumetric impact sampler (similar to the Rotorod model 10) placed 1.5 m above the ground during a 2-h period on the sampling day. Sampling was carried out from 10 am until noon and was interrupted only on days with abundant rainfall. In the event of rain, sampling was rescheduled to another day in the same week. Sampling rods were prepared following Frenz et al. (2001).

Observations of the flowering species, and sampling, were carried out simultaneously. Reference

[1] Buenos Aires province in Argentina, is divided into "*partidos*" which are rough equivalents to counties.

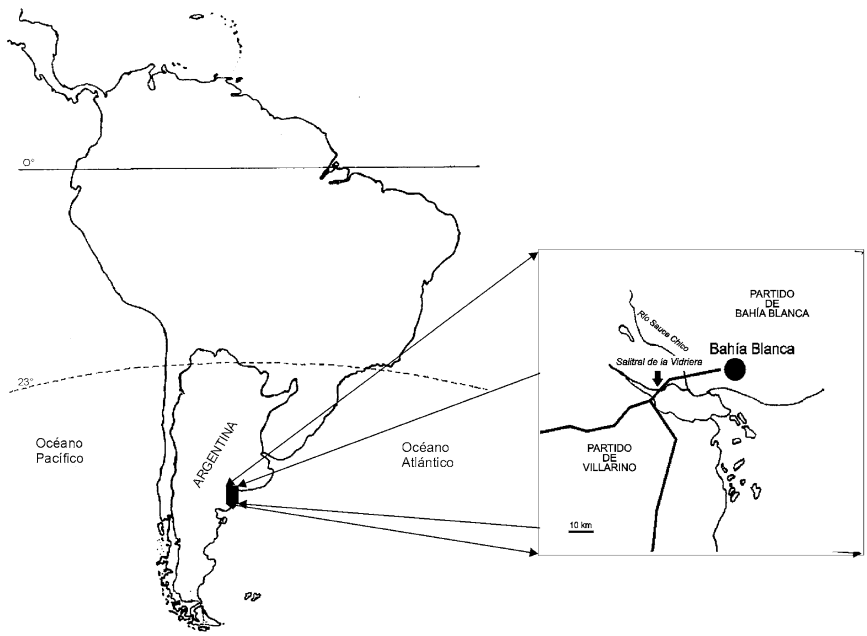

Fig. 1 Geographical site of *Salitral de la Vidriera*

Fig. 2 Sampler location site

specimens were collected and stored in the herbarium of the Universidad Nacional del Sur (BBB) in Bahía Blanca city, Argentina.

Pollen grains were identified and counted using an optical microscope (magnification 400×). Results were expressed as a mean of two sampled hours per cubic meter (grains m^{-3} air for each sample; Brown 1993). Reference material collected in the study area and bibliographic data (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) were used for identification of pollen grains.

3 Results and discussion

A total of 43 pollen types were identified (Table 1) in the study; 2109 grains were counted in period I (2003) and 1587 were counted in period II (2005–2006). These values were higher than those recorded in a previous study carried out in another natural area characterized by the presence of a "monte" vegetation and located 60 km S of *Salitral de la Vidriera* (Murray et al. 2007).

Airborne pollen was found in *Salitral de la Vidriera* throughout the year; the highest concentrations were detected from December to February (summer) and in mid-May 2003. However, monthly pollen-type diversity was very variable, being highest in spring, particularly in November (Figs. 3, 4). The pollen spectrum of the study area was similar to that of another natural area (Murray et al. 2007) and differed from that of an urban area of Bahía Blanca where the predominant pollen types come from the trees growing in the city (Murray et al. 2002).

In general, most of the pollen-types counted in this study correspond to pollen grains coming from either herbaceous or shrubby vegetation typical of the study area, for example *Amaranthus*, Brassicaceae, *Centaurea*, Poaceae, Chenopodiaceae, Urticaceae, some Asteraceae, and *Condalia microphylla* Cav.

Table 1 Airborne pollen types during the two study periods

TAXA
Alnus[a]
Amaranthus/ Chenopodiaceae
Ambrosia
Apiaceae
Artemisia
Aster
Brassicaceae[a]
Casuarina[a]
Celtis
Centaurea
Condalia
Cupressaceae[a]
Cyperaceae
Echium
Ephedra
Eucalyptus[a]
Fraxinus[a]
Gomphrena
Juncaceae
Lycium
Morus[a]
Mutisiae
Nothofagus
Papilionaceae
Pinus[a]
Plantago
Platanus[a]
Poaceae[a]
Populus[a]
Prosopidastrum
Prosopis
Prunus[a]
Ranunculus
Rumex
Salix[a]
Schinus
Solanum
Styphnolobium[a]
Tamarix[a]
Taraxacum
Typha
Ulmus[a]
Urticaceae

[a] Pollen types (TAXA) including cultured species in the area

Arboreal pollen was represented by species from the farmsteads and towns nearby, namely *Alnus*, *Casuarina*, *Cupressus*, *Eucalyptus*, *Fraxinus*, *Morus*, *Pinus*, *Platanus*, *Populus*, *Prunus*, *Salix*, *Styphnolobium*, and *Ulmus*. The concentrations of these pollen types were very low except for *Eucalyptus* and Cupressaceae. In agreement with previous studies carried out in Argentina (Gassmann and Pérez 2006; Murray et al. 2007) long-distance transport phenomena were recorded during our study. Pollen from *Nothofagus*, a species originally from the subantarctic forests, and from *Celtis*, a species originally from the Tala subdistrict or other districts of the Espinal in the north and center of Argentina (Cabrera 1976), was also found in the central region of Buenos Aires province (D'Alfonso, personal communication). Analysis of wind direction revealed that *Celtis* occurs during the days when the wind comes from the W and NW, in coincidence with the probable emission sources. On the other hand, *Nothofagus* was usually detected during the days when winds came from the W, although it was also detected during the days when winds came from the NW, S, and SW. An uninterrupted, daily sampling of the atmosphere will therefore contribute to better understanding in what way wind direction has an effect on pollen concentration in the air.

Because arboreal species are abundant in the study area, their pollen types were considered separately from those of tree and herb species. Shrub pollen belongs to the species growing spontaneously in the study area, for example *Condalia*, *Ephedra*, *Lycium*, *Prosopidastrum* (Palacios and Hoc 2005), *Schinus* (Troiani et al. 1994; Muñoz 2000), and *Tamarix* (Natale et al. 2007). Interestingly, the amount of shrub pollen detected in the study area was lower than that of tree and herb species.

Three pollen types share different growth forms, namely *Amaranthus*/Chenopodiaceae, *Schinus*, and *Prosopis*. As to *Amaranthus*/Chenopodiaceae, the former mainly includes herbaceous species with the exception of *Suaeda divaricata* Moq., which is an abundant shrub species in our study area. As to *Schinus* and *Prosopis*, they both include arboreal and shrub species, such as *Schinus areira* L. (a tree species typical of urban areas), and *S. fasciculata* (Griseb.) I.M. Johnst., *S. johnstonii* F.A. Barkley,

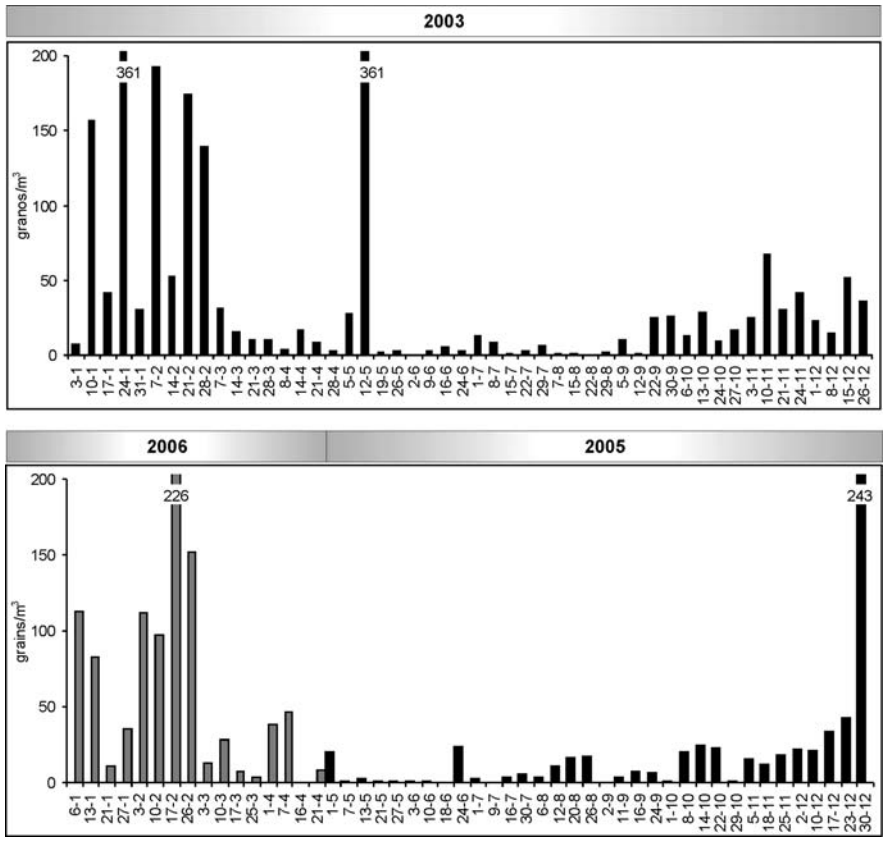

Fig. 3 Pollen count concentrations in the study area during the period January to December 2003 (period I), May to December 2005 (period II), and January to April 2006 (period II)

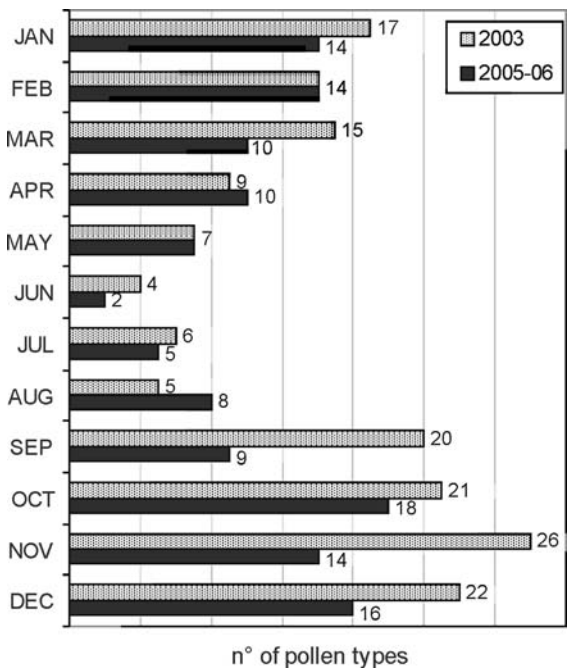

Fig. 4 Monthly pollen diversity in the atmosphere of *Salitral de la Vidriera* during periods I and II

S. praecox (Griseb.) Speg., and *Prosopis flexuosa* DC. (either tree or shrub species typical of natural environments).

Herb pollen types are also very abundant in *Salitral de la Vidriera* and they correspond to species of the families Chenopodiaceae, Asteraceae, Brassicaceae, Poaceae, and Urticaceae, and to the genera *Centaurea* and *Ambrosia*, among others, the majority of which are spontaneous (Verettoni 1961; Verettoni and Aramayo 1976).

More than 60% of the pollen types detected in the air were from spontaneous vegetation (native or adventitious); approximately 5% were of mixed origin, and the remaining 35% were from non-spontaneous vegetation, particularly from species planted in the surroundings or from extra-regional pollen sources.

The most abundant pollen types in the annual pollen spectrum (higher than 0.5% of the total pollen sampled) were *Amaranthus*/Chenopodiaceae, Poaceae, *Eucalyptus*, Brassicaceae, *Centaurea*, Cupressaceae, *Ambrosia*, Urticaceae, *Aster*, and *Condalia* (Fig. 5).

Amaranthus/Chenopodiaceae pollen type was detected in the atmosphere almost throughout the year. It was the most abundant and represented 71.6–63.1% of the total annual pollen in each period studied (periods I and II, respectively). However, concentrations were high from mid-December until the end of

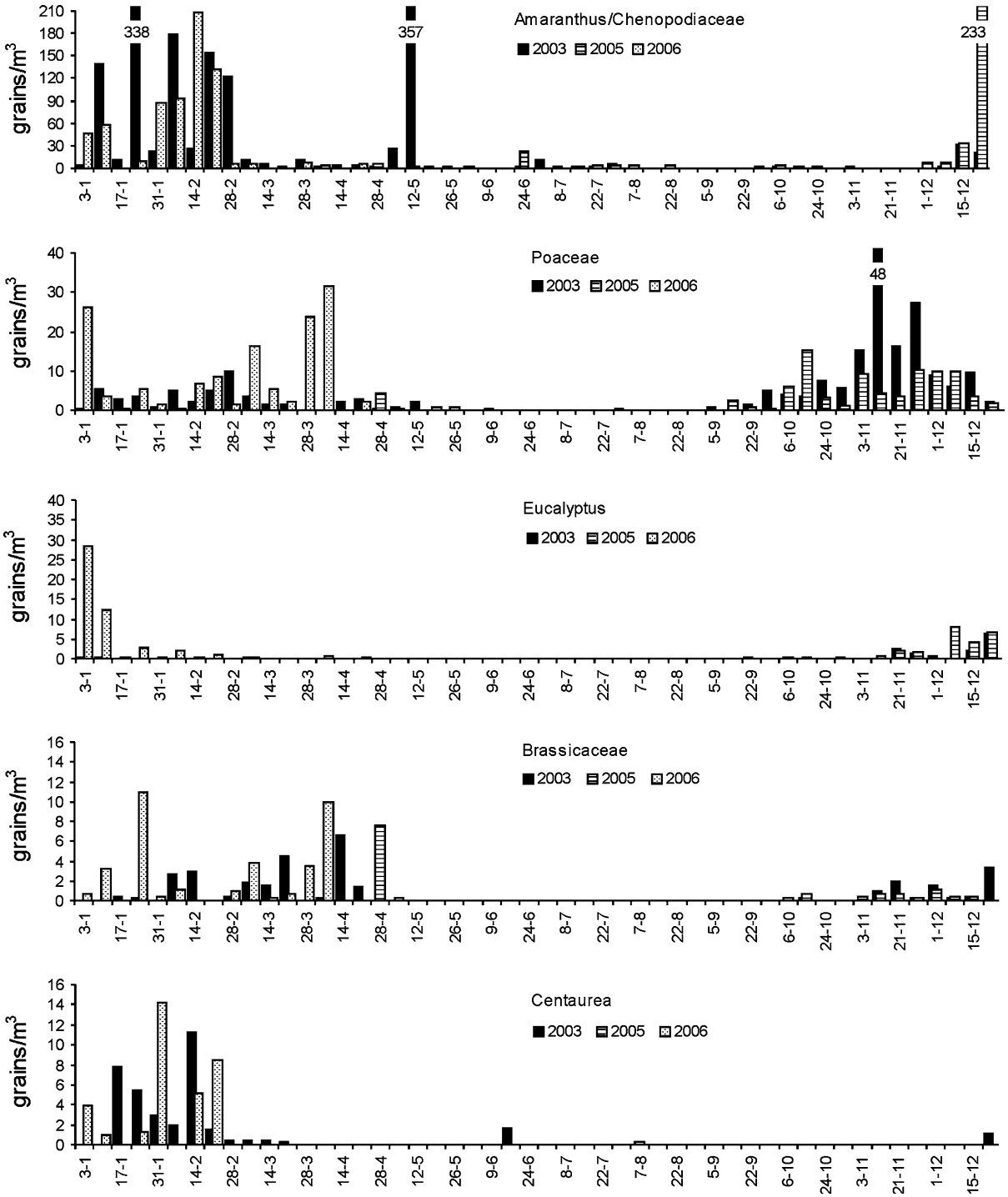

Fig. 5 Pollen count concentrations of types representing more than 0.5% of the total pollen during the sampling period

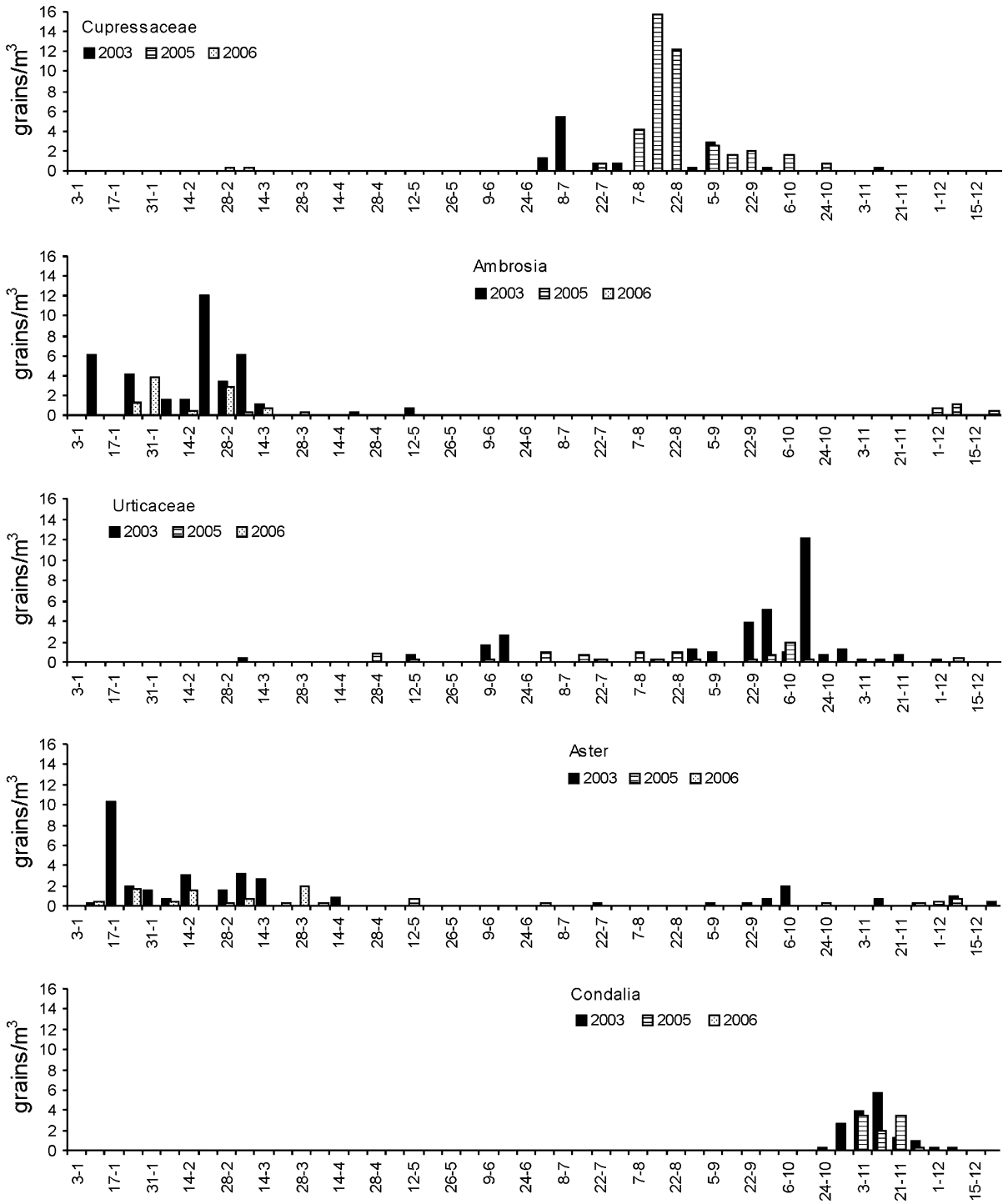

Fig. 5 continued

February. Peaks were subsequently observed in mid-June and towards the end of June. By comparing these observations with the anthesis of plants, it was possible to determine in what way each taxon contributes to the pollen spectrum. The peaks recorded in January and February (maximum peak: 338

grains m^{-3} on January 24, 2003; 208 grains m^{-3} on February 14, 2006) were probably because of the presence of numerous species included in this pollen type (*Heterostachys olivascens* (Speg.) Speg., *Sarcocornia perennis* (Mill.) A.J. Scott, *Bassia scoparia* (L.) A.J. Scott, and *Atriplex* and *Chenopodium* species). However, the peak detected in May (357 grains m^{-3} on May 12, 2003) could be attributed to *Heterostachys ritteriana* (Moq.) Moq. and, to a lesser extent, to *Allenrolfea patagonica* (Moq.) Kuntze, both of which are very abundant in the study area. The peak which, depending on the period, occurs either towards the end of June or at the beginning of July, clearly coincides with the anthesis of *Suaeda divaricata*.

Poaceae type is the second in importance and represents between 10.1 and 14.1% of the total pollen of each period. The pollen season began in September and finished at the beginning of May. Nevertheless, pollen grains were found throughout the year at very low concentrations. The most important months were November, January, and March when flowering of most grass species (approximately 25 species) occurs. Maximum peaks were registered on November 10, 2003 (48 grains m^{-3}) and on April 7, 2006 (31 grains m^{-3}).

Brassicaceae, a pollen type which represents between 1.5 and 3.3% of total pollen, was found in the atmosphere from October to April. Values were, in general, low, the highest being recorded in mid-January, 2006, and in April in both periods. Taking into account the field observations and the pollen morphology, it was determined that the most abundant species with this pollen type are *Diplotaxis tenuifolia* (L.) DC., *Rapistrum rugosum* (L.) All., and *Sisymbrium irio* L., all of which are adventitious. The native species of Brassicaceae are scarcely represented in our study area.

For *Centaurea* type (1.6–2.2% of total pollen) the most important months were January and February. The species belonging to this pollen type are *Centaurea calcitrapa* L., *C. iberica* Trevir. ex Spreng., and *C. solstitialis* L. all of which are adventitious from the Mediterranean region.

For *Ambrosia* type (1.7–0.75% of total pollen), the pollen season began in mid-December. Grains were detected until mid May although the highest values were recorded in February. This pollen type includes only one species, *Ambrosia tenuifolia* Spreng., which was not found in the sampling area although it is abundant in the outer area of Bahía Blanca, towards the NE.

As to Urticaceae type (1.6–0.6% of total pollen), the most important periods were June, September, and October. The maximum peak, with values below 12 grains m^{-3}, was recorded in mid October in both periods. *Urtica urens* L. and *Parietaria* spp., the only species forming this pollen type, are absent in *Salitral de la Vidriera* although they are abundant in the surrounding urban areas.

The highest abundance of *Aster* pollen (1.5–0.7%) in the atmosphere was recorded from January to March, the maximum peak being in mid January (10 grains m^{-3} in period I), the values recorded for the rest of the year were, in general, very low. During period II, values were below 2 grains m^{-3}. The most abundant species belonging to this pollen type are *Aster squamatus* (Spreng.) Hieron., *Baccharis articulata* (Lam.) Pers., *B. juncea* (Lehm.) Desf., *B. salicifolia* (Ruiz & Pav.) Pers., *B. ulicina* Hook. & Arn., *Conyza albida* Wiild. ex Spreng., *Gaillardia megapotamica* (Spreng.) Baker, *Gnaphalium leucopeplum* Cabrera, *Grindelia brachystephana* Griseb., *Hysterionica jasionoides* Willd., *Senecio cerato-phylloides* Griseb., *Solidago chilensis* Meyen, and *Verbesina encelioides* (Cav.) Benth. & Hook. f.

Eucalyptus (0.8–4.6%) and Cupressaceae (0.6–2.6%) were important during January 2006 and August, 2005, respectively. *Eucalyptus* type is mostly represented by *Eucalyptus camaldulensis* Dehnh. whereas the most abundant species of Cupressaceae belong to the genus *Cupressus.* Both are plants cultivated in the farmsteads and urban areas close to the study area.

Condalia type (0.72–0.58%) could be observed as from the end of October to the beginning of December. It was represented by *Condalia microphylla*, an abundant species, with values below 6 grains m^{-3}.

Among the pollen types recorded in very low amounts (lower than 0.5% of total annual pollen), the highest values corresponded to *Lycium* and *Prosopidastrum*, which were not abundant in urban zones near the study area (Murray et al. 2002).

The volumetric sampling conducted in the atmosphere of *Salitral de la Vidriera* allowed us not only to identify the components of a shrubby halophytic steppe dominated by Chenopodiaceae but also to learn about the input both from exotic flora and that from other regions.

The city closest to the study area is Bahía Blanca where continuous volumetric air monitoring is undertaken and where daily values of total pollen close to 1500 grains m^{-3} have been recorded. In a few cases, daily values of approximately 3000 grains m^{-3} have also been recorded (Murray et al. 2002). Other studies carried out simultaneously with sampling, and following the same methodology, demonstrated that the amounts of total pollen in *Salitral de la Vidriera* are different from those recorded in Bahía Blanca, because of the predominance of the *Amaranthus*/Chenopodiaceae pollen type in the study area. The total amounts of pollen in *Salitral de la Vidriera* are, in fact, threefold higher than those in Bahía Blanca, as a result of the dominance of the *Amaranthus*/Chenopodiaceae type (Murray et al. 2003, 2007; Murray 2007).

4 Conclusions

This study on the atmosphere of *Salitral de la Vidriera* allowed us to identify the components of the vegetation type dominating this area, namely a shrubby halophytic steppe composed of Chenopodiaceae, Poaceae, *Ambrosia*, *Centaurea*, Brassicaceae, *Aster*, *Tamarix*, *Condalia*, *Prosopis*, *Schinus*, *Ephedra*, *Lycium*, and *Prosopidastrum*. It also allowed us to learn about the input from the exotic flora mainly composed of *Cupressus*, *Eucalyptus*, and *Populus*, among others, and about the input resulting from other regions (*Nothofagus* and *Celtis*). Pollen was detected throughout the year. Nevertheless, the most important months were January and February with predominance of the type *Amaranthus*/Chenopodiaceae. Flowering of *Heterostachys ritteriana* and *Allenrolfea patagonica* in May and of *Suaeda divaricata* in either June or July, depending on the year considered, was particularly relevant.

Flora in our study area is relatively diverse. However, this is not evident from pollen types identified, mainly because high diversity occurs in the stenopalynous families or genera. On the other hand, there are species, for example *Larrea divaricata*, *Chuquiraga erinaceae*, *Geoffroea decorticans*, *Discaria americana*, *Cyclolepis genistoides*, and some Cactaceae, which were not represented in the samplings. This could be because:

1. their pollen grains are not airborne;
2. such species are not abundant in the area; and/or
3. pollen production by these species is very low.

It is also worth taking into account that under appropriate weather conditions, Chenopodiaceae, a family which is very well represented in our study area, may be an important contributor of pollen to Bahía Blanca.

This study cannot represent diurnal patterns, and any anthesis peaks that are not early in the day might be underestimated. Further studies based on daily and continuous data about the atmosphere and pollen production will greatly contribute to clarifying the potential input of each species to the pollen spectrum and the correlation with meteorological variables.

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