First report of airborne pollen in Santa Rosa, La Pampa, Argentina: a 2-year survey

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Aerobiologia
International Journal of Aerobiology - including the online journal `Physical Aerobiology'

ISSN 0393-5965
Volume 30
Number 3

Aerobiologia (2014) 30:293-305
DOI 10.1007/s10453-014-9328-4

Springer

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ORIGINAL PAPER

First report of airborne pollen in Santa Rosa, La Pampa, Argentina: a 2-year survey

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Received: 16 August 2013 / Accepted: 6 February 2014 / Published online: 14 February 2014

Abstract The aim of this study was to determine the qualitative and quantitative composition of the airborne pollen of Santa Rosa city, La Pampa (Argentina), and to analyse the seasonal behaviour of the pollen types that have the highest representation in the atmosphere. The city, with temperate climate, is located in a cultivated area that corresponds phytogeographically to a xerophytic forest limiting with grasslands. The pollen sampling was performed using a Hirst-type volumetric spore trap located in the urban centre of the city, 15 m above ground level, from July 2007–June 2009. The annual pollen index was 51,647 pollen grains. The airborne pollen consisted of 73 pollen types, 42 of woody origin represented 66 % of the total and with winter-spring seasonality and 31 were of herbaceous origin, which represented 30 % of the total and with spring-summer seasonality. The composition of the woody airborne pollen reflected the formation of urban vegetation, consisting mainly of exotic taxa from tree species used in urban tree alignment. The most abundant types were as follows: Cupressaceae, *Fraxinus*, *Ulmus*, *Olea europaea*, *Styphnolobium japonicum*, Myrtaceae, Pinaceae, *Platanus*, *Celtis*- *Morus* and *Populus*. Native components such as *Condalia microphylla* were also found, indicating the 'Espinal' phytogeographical province that was typical of the area. The most abundant herbaceous airborne pollen types, in descending order, were as follows: Poaceae, *Amaranthus*-Chenopodiaceae, Urticaceae, Brassicaceae and Asteraceae. The emission sources of these pollen types were weeds that grew spontaneously in parks, waste grounds and flower beds of the city.

Keywords Airborne pollen · Urban monitoring station · Volumetric sampler · Native species · Argentina

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1 Introduction

Pollen analysis is a suitable tool to study the particular vegetation of a study site (Prentice 1985), providing a new perspective on the interrelationships between plant organisms and their environment; these relationships become evident in the dynamics of the airborne pollen. Bryant (1989) identified pollen as 'fingerprints of plants', which are closely related to flowering, reproduction and distribution of the vegetation. Such relationships provide the potential for airborne pollen observations to be used in a wide spectrum of studies dealing with anemophilous plant species (Scheifinger et al. 2013).

In each geographical area, there is a succession of different flowering species throughout the year, so it is important to document the types of airborne pollen in different locations, especially in highly populated cities.

To date, only a few papers have described airborne pollen in the South American region. This zone has a very rich biodiversity and various geoclimatic zones with marked seasonal fluctuations. Moreover, spatial variations should also be assessed within the same geographical region in order to get a wider view of the pollen spectrum of that area (Frenz 2000).

The evidence to date suggests that changes in phenology, pollen production, pollen allergenicity and geographical distribution of plants have been occurring in recent decades and that the nature of the changes may be specific for the region and species. Changes in the timing of aeroallergen production, in particular an advance of the flowering period, have been clearly shown for woody plants, and particularly for grasses, weeds and mould spores (Cecchi et al. 2010).

Daily sampling of the atmosphere allows for more accurate knowledge about the time of appearance and disappearance of different pollen types, and volumetric uptake also makes it possible to determine the actual concentration of particles contained per cubic metre of air. This information is of great importance for health because the pollen season and its intensity affect the quality of life of allergenic individuals (Dahl et al. 2013).

The most important allergic diseases are asthma and rhinitis, which affect from 5 to 30 % of the population in industrialised countries (Asher et al. 2006). These pathologies, together with conjunctivitis, are the typical clinical pictures of allergy to pollen, and they often occur in the same patient simultaneously during the pollen season (Cecchi 2013). In Santa Rosa and in nearby locations, there are records of high pollinosis (Herraiz Ballestero and Monticelli 1943). This is one of the reasons for the importance of the knowledge of the main taxa present in the air and their levels of concentration throughout the year in a particular site. Therefore, aeropalynological studies are important to understand the pollen spectrum of different geographical areas.

In Argentina, the daily urban monitoring of airborne pollen with volumetric methodology has been conducted mainly in the Pampean region, such as in the cities of Mar del Plata (Latorre and Pérez 1997; Latorre and Caccavari 2009), La Plata (Nitiu and Romero 2002; Nitiu 2006), Bahia Blanca (Murray et al. 2002, 2010), Rosario (Gattuso et al. 2003a, b) and Buenos Aires (Noetinger and Romero 1997; Nitiu et al. 2003). Other urban centres, such as San Carlos de Bariloche in the region of the Andean-Patagonian forest (Bianchi and Olabuenaga 2006), San Miguel de Tucuman in the Yungas region (García and Nitiu 2012) and Diamante in the Paraná Delta area (Latorre and Caccavari 2010), have also been studied.

La Pampa is a geographical province of Argentina situated at the beginning of the Patagonian, in the south centre of the country. The native vegetation is represented by three different phytogeographical areas, which are from east to west, and in accordance with the rainfall regime: grasslands, also known as the Pampean region; a xerophytic forest, called the 'Espinal'; and a shrub steppe called 'Monte' (Cabrera 1994). Despite the floral diversity of the whole province, there is no aerobiological monitoring in natural areas or in urban ones. There have only been studies about the current pollen rain, by using Tauber methodology, in Lihue Calel National Park, located to the south-west of the province, 300 km from the capital city (Naab 1999).

The aim of this study was to determine the qualitative and quantitative composition of the airborne pollen of the city of Santa Rosa, capital of the province of La Pampa, and to analyse the seasonal behaviour of the pollen types that are highly represented in the atmosphere, for a period of 2 years (July 2007–June2009).

The study of airborne pollen in this unknown area contributes to modelling the behaviour of airborne pollen throughout Argentina and the South American region. The results of this investigation along with future research into climatic change are expected to assist allergists in diagnosing the cause and treatment for allergy cases.

2 Materials and methods

2.1 Sampling area

Santa Rosa is the capital city of La Pampa province (36°37′S, 64°17′W; 175 m a.s.l.), with an urban area

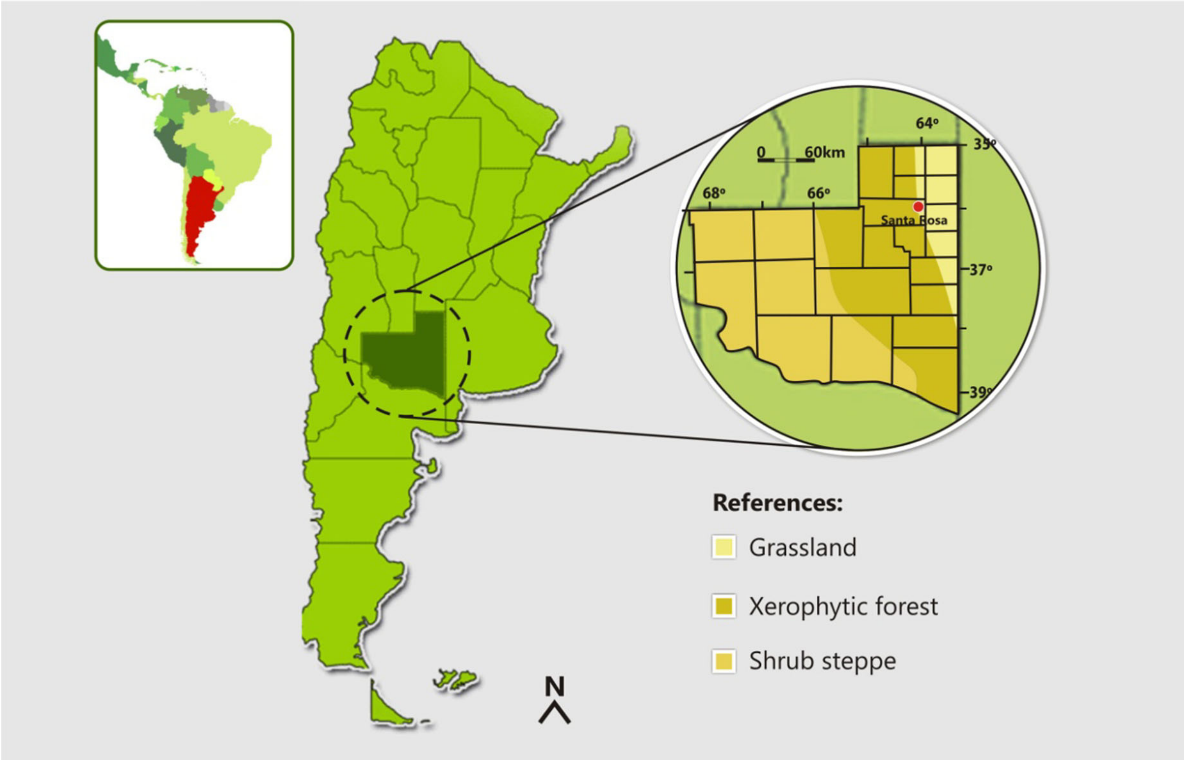


Fig. 1 Geographical location and vegetation of the study site

of 21.8 km^2 and a population of 103,777 inhabitants. The climate is temperate, with a mean annual temperature of 15.6 °C and well-differentiated seasons. The annual mean precipitation is 718.7 mm, and the predominant wind directions are from N–NE and S–SW (Vergara and Casagrande 2012).

This town is located in the border between two phytogeographical regions: the 'Espinal', a xerophytic forest, and the 'Pampeana steppe' (grasslands), both strongly modified by agriculture (Cabrera 1994) (Fig. 1).

The most abundant species of urban trees in the downtown area of the city are *Fraxinus pennsylvanica, Robinia pseudoacacia* var. *umbraculifera, Lagestroemia indica* and *Prunus ceracifera* var. *atropurpurea.* The species *Styphnolobium japonica, Callistemon lanceolatus* and *Platanus* x *acerifolia* are fewer in quantity, and in green spaces abound various species of Pinaceae and Cupressaceae.

Regarding the spontaneous growth of herbaceous flora, the most represented families are Poaceae, Asteraceae, Brassicaceae and Chenopodiaceae (Rúgolo de Agrazar et al. 2005; Prina 1995; Steibel 1986; Troiani and Steibel 1999).

2.2 Pollen sampling methodology

Pollen sampling was performed using a Hirst-type volumetric spore trap (Lanzoni VPPS 2000), from July 2007–June 2009. The sampler was located on the roof of the La Pampa University building, in the urban centre of the city, 15 m above ground level.

The air intake was 10 L/min. Slides were prepared according to standard methods, stained with fuchsin and mounted in glycerine jelly. Pollen counts were analysed by four horizontal lines per slide at a magnification of 400 (Galán Soldevilla et al. 2007). The pollen was identified from pollen atlases and the pollen collection of the local flora (D'Antoni and Markgraf 1978; Grant Smith 1990; Reille 1992).

The data were expressed as daily pollen concentration per cubic metre of air. For each pollen type, the aerobiological variables were as follows: the annual pollen index (PI), the percentage of total number of grains (%), the main pollen period (MPP), the pollen peak day and the pollen peak concentration. The MPP was established from which the sum of daily mean pollen concentration reaches 1 % of the total sum until the time when the sum reaches 99 %, i.e. the time with 98 % of the whole pollen amount (Galán et al. 1995).

2.3 Meteorological data

Meteorological daily data were obtained from the Agrometeorological Station of Agriculture College, La Pampa National University. The following variables were considered: mean, maximum and minimum temperatures, mean relative humidity, mean wind speed and total rainfall.

3 Results

The results indicate that during the studied period, 51,647 pollen grains were counted (25,712 from 2007 to 2008 and 25,935 from 2008 to 2009), of which 33,867 were from tree or shrub sources corresponding to 42 pollen types (woody pollen, WP) and 15,419 were from herbaceous sources corresponding to 31 pollen types (herbaceous pollen, HP) (Table 1).

The main aerobiological variables for those pollen types representing more than 0.5 % of the total number of grains are shown in Table 2.

In the first study year (July 2007–June 2008), the annual pattern of PI showed two prevailing time periods: one winter-spring, from July to November, which registered 69 % of the total annual pollen grains; and another for summer, from December to March, which represented 29 % of the total (Fig. 2). Between July and September, the airborne pollen was dominated by WP, mostly represented by Cupressaceae, *Fraxinus, Ulmus, Populus* and *Platanus*, while during October and November, apart from those WP, two HP, Urticaceae and Poaceae, were added. During the summer period (December–March), airborne pollen was dominated by HP, mainly *Amaranthus*-Chenopodiaceae, Poaceae, *Artemisia* and *Ambrosia tenuifolia*. In the second year (July 2008–June 2009), the same seasonality was found, with 84 % of total annual pollen grains from July to November and 14 % of the total from December to March.

Table 1 Woody and herbaceous pollen types identified in the atmosphere of Santa Rosa, from July 2007 to June 2009

Woody pollen types		Herbaceous pollen types
Aceraceae *Acer*	Pinaceae	Amaranthaceae *Gomphrena*
Anacardiaceae *Schinus**	Platanaceae *Platanus*	Amaranthaceae-Chenopodiaceae *Amaranthus*-Chenopodiaceae
Apocinaceae *Nerium oleander*	Rhamnaceae *Condalia microphylla**	APIACEAE
Araucariaceae *Araucaria*	Rosaceae	Asteraceae *Ambrosia tenuifolia*
Arecaceae	Rutaceae *Citrus*	Asteraceae *Artemisia*
Berberidaceae *Berberis*	Salicaceae *Populus* *Salix*	Asteraceae *Taraxacum*
Betulaceae *Betula pendula*	Santalaceae *Jodina rhombifolia**	Asteraceae[a]
Esterculiaceae *Brachychiton*	Simarobaceae *Ailanthus altissima*	Brassicaceae
Casuarinaceae *Casuarina cunnighamiana*	Tamaricaceae *Tamarix gallica**	Cyperaceae
Celtidaceae *Celtis**	Tiliaceae *Tilia*	Euphorbiaceae *Euphorbia*
Cupressaceae	Ulmaceae *Ulmus*	Fabaceae *Lotus* *Melilotus*
Ephedraceae *Ephedra**	Vitaceae *Parthenocissus* *Vitis*	Geraniaceae *Erodium*
FABACEAE[b]		Iridaceae
Fagaceae *Nothofagus** *Quercus*		Malvaceae
Juglandaceae *Juglans*		Plantaginaceae *Plantago*
Lithraceae *Lagerstroemia indica*		Poaceae
Malvaceae		Poligonaceae *Polygonum* *Rumex*

Table 1 continued

Woody pollen types	Herbaceous pollen types
Meliaceae	Ranunculaceae
Melia azedarach	*Clematis*
Moraceae	Solanaceae
Morus	*Solanum*
Myrtaceae	Tiphaceae
	Typha
Nictaginaceae	Urticaceae
Bougainvillea	
Oleaceae	Verbenaceae
Fraxinus	
Olea europaea	
Ligustrum	

* Components coming from native flora

[a] Includes *Perezia, Helianthus, Centaurea, Baccharis, Hyalis, Matricaria, Senecio-Conyza* type, *Parthenium*

[b] Includes *Styphnolobium japonicum, Prosopis**, *Parkinsonia aculeata**, *Prosopidastrum globosum**, *Acacia*

From April to June, only 2 % were recorded with respect to the annual total amount in both years.

The pollen richness for the first study year was increased from July to December, a month when the maximum value was obtained with 44 pollen types (Fig. 3). From January onwards, it began to descend, with June being the month of less richness, with only nine pollen types.

3.1 Woody pollen

WP dominated the airborne pollen from July to October period that recorded 83 % of the woody fraction of the first study year and 90 % in the second (Fig. 2).

Figure 4a shows the daily concentration across the study year for each woody pollen type that reached a representation higher than 0.5 % of the total annual.

The pollen curves of *Fraxinus, Ulmus, Olea europaea, Platanus, Condalia microphylla* and *Populus* were intense and brief (MPP duration less than 100 days) and, for the first three cases, with peaks above 200 grains/m^3.

The *Styphnolobium japonicum* pollen type presented an intermediate situation, the pollen curve varied between 106 days in the first year and 96 the second study year.

Cupresaceae and *Celtis-Morus* had intermediate curves (MPP duration between 100 and 180 days) with a maximum pollen peak of 1,504 grains/m^3 in Cupressaceae (in August 2007), whereas Pinaceae and Myrtaceae curves were more prolonged in time (MPP duration lasting more than 180 days).

Between WP types with a representation less than 0.5 % of the total annual, the presence of native flora components was highlighted such as *Prosopis, Parkinsonia aculeata, Prosopidastrum globosum*, *Schinus*, *Jodina rhombifolia*, *Tamarix gallica*, *Ephedra* and *Nothofagus*.

3.2 Herbaceous pollen

HP dominated the airborne pollen from October to March, a period that recorded 78.2 and 83 % of the herbaceous fraction of the first and second study year, respectably.

Figure 4b shows the daily concentration across the study year for each herbaceous pollen type that reached a representation higher than 0.5 % of the total annual.

Regarding pollen curves, the narrower was the one for *Artemisia* with only 42 days MPP in the first study year, while in the second it was too much longer (138 days). *Ambrosia tenuifolia* has an MPP duration between 100 and 180 days. Urticaceae, Poaceae, Brassicaceae and *Amaranthus*-Chenopodiaceae were herbaceous pollen types that remained a longer time in the air of the city, with an MPP of more than 180 days.

Among herbaceous pollen types with a representation less than 0.5 % of the total annual were various species of Asteraceae. For example, in the first year, it was found *Baccharis, Senecio-Coniza, Centaurea* and *Helianthus*, each with a contribution greater than 5 % of the total registered for the family, and *Perezia, Parthenium, Matricaria, Hyalis* and *Taraxacum,* which together amounted to 4 % of the total annual record for this family.

Figure 5 shows the meteorological data recorded in the study period.

4 Discussion

In the air of Santa Rosa in 1 year of aerobiological monitoring, 73 pollen types were found, 42 of wooden origin and 31 of herbaceous origin. This pollen

Table 2 Aerobiology variables of those pollen types representing more than 0.5 % of the total number of grains in the air of the city during both study years

Pollen type	Study period	PI	%	MPP	Peak day	Peak concentration (grains/m^3)
Cupressaceae	July 2007–June 2008	7331.1	28.5	11/07–29/11	22/08	1,504
	July 2008–June 2009	10,606.0	40.9	10/07–01/11	23/08	912
Poaceae	July 2007–June 2008	4,030.0	15.7	15/10–23/04	02/11	151
	July 2008–June 2009	1,875.4	7.2	24/09–01/05	31/10	83
Amaranthus-Chenopodiaceae	July 2007–June 2008	3,521.7	13.7	20/08–18/05	29/02	163
	July 2008–June 2009	1,750.0	6.7	27/07–09/06	14/03	36
Fraxinus	July 2007–June 2008	3,077.9	12.0	13/08–18/10	09/09	281
	July 2008–June 2009	3,184.6	12.3	13/07–12/10	25/09	285
Ulmus	July 2007–June 2008	1,208.7	4.7	27/07–04/09	02/08	290
	July 2008–June 2009	788.0	3.0	15/07–09/09	31/07	187
Urticaceae	July 2007–June 2008	1,203.6	4.7	17/08–13/02	01/10	195
	July 2008–June 2009	783.8	3.0	15/07–05/04	10/10	81
Olea europaea	July 2007–June 2008	1,100.4	4.3	26/10–02/01	02/11	222
	July 2008–June 2009	144.5	0.6	18/10–17/11	01/11	26
Styphnolobium japonicum	July 2007–June 2008	450.2	1.8	01/11–14/02	02/01	36
	July 2008–June 2009	372.2	1.4	27/10–30/01	14/11	22
Artemisia	July 2007–June 2008	312.2	1.2	06/03–17/04	08/03	119
	July 2008–June 2009	129.3	0.5	04/01–22/05	27/03	11
Myrtaceae	July 2007–June 2008	200.0	0.8	31/08–23/06	23/12	13
	July 2008–June 2009	530.4	2.0	09/09–16/06	01/01	11
Pinaceae	July 2007–June 2008	200.0	0.8	27/08–06/05	17/10	17
	July 2008–June 2009	361.2	1.4	16/07–16/01	22/10	8
Platanus	July 2007–June 2008	194.8	0.8	06/09 – 31/10	10/09 and 15/10	25
	July 2008–June 2009	753.1	2.9	09/09–19/10	19/09	65
Celtis-Morus	July 2007–June 2008	194.8	0.8	30/09–29/02	17/11	14
	July 2008–June 2009	843.7	3.3	24/08–24/01	24/01	34
Condalia microphylla	July 2007–June 2008	189.6	0.7	28/10–20/11	06/11	46
	July 2008–June 2009	182.9	0.7	23/10–16/12	04/11	25
Brassicaceae	July 2007–June 2008	187.1	0.7	17/08–18/05	24/12	14
	July 2008–June 2009	174.4	0.7	07/09–17/05	07/11	11
Ambrosia tenuifolia	July 2007–June 2008	179.3	0.7	11/12–07/05	01/03	17
	July 2008–June 2009	90.8	0.4	18/11–16/05	09/03	11
Populus	July 2007–June 2008	161.3	0.6	12/08–13/10	22/08	35
	July 2008–June 2009	290.2	1.1	16/08–12/10	16/09	35

PI annual pollen index, *%* percentage of total number of grains, *MPP* main pollen period

richness is similar to that found in other urban areas of Argentina: 61 pollen types were found in Bahía Blanca (Murray et al. 2010), 83 in Mar del Plata (Latorre and Caccavari 2009), 79 in La Plata (Nitiu 2006), 54 in Buenos Aires (Nitiu et al. 2003), 68 in Diamante (Latorre and Caccavari 2010) and 66 in San Carlos de Bariloche (Bianchi and Olabuenaga 2006). In San Miguel de Tucuman, there have been records of the tree fraction, with 30 pollen types (García and Nitiu 2012).

When compared with other aerobiological stations in urban areas of South America, Montevideo in

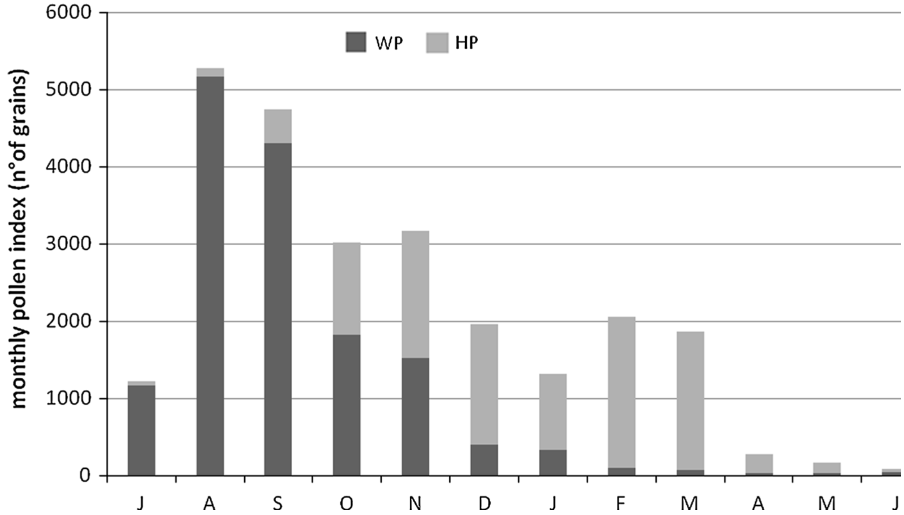
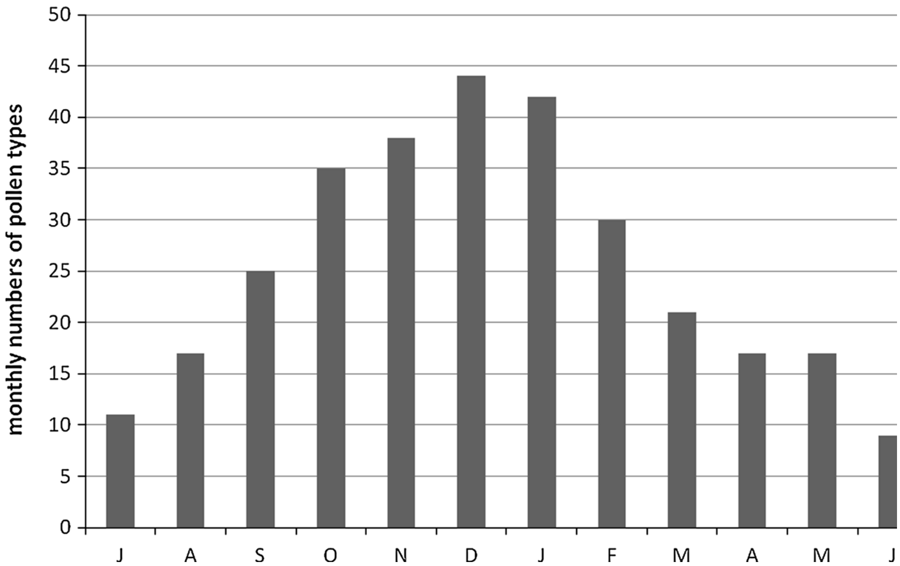


Fig. 2 Monthly pollen index of woody pollen (WP) and herbaceous pollen (HP)

Fig. 3 Monthly number of pollen types across the first study year



Uruguay (Tejera and Beri 2005), and Santiago de Chile (Rojas Villegas and Roure Nolla 2001) had a similar composition to that found in Santa Rosa and other temperate Argentine locations.

In the composition of airborne pollen, except for San Carlos de Bariloche, in Santa Rosa and in the other urban stations mentioned, there were predominant tree pollen types belonging to introduced species and a very poor representation of pollen coming from the native flora.

Instead, Caxias do Sul, in Brazil, is the town that was the best differentiated in its composition of airborne pollen, which could be explained by the higher rainfall record that influences the type of vegetation of the region (Vergamini et al. 2006).

Considering the emission sources of woody pollen types with airborne pollen higher than 0.5 %, the Cupressaceae pollen type was the most abundant. Exotic representatives of this family are widely used in the green spaces of the town, especially *Cupressus sempervirens, C. arizonica* and various species of *Thuja* and *Juniperus.*

The *Fraxinus* pollen type corresponds to the exotic species *Fraxinus pennsylvanica, F. excelsior* and *F.*

Fig. 4 Daily concentrations of pollen grains (grains/m^3) during the study period for each pollen type that reached a representation of more than 0.5 % of the total annual. **a** WP, **b** HP

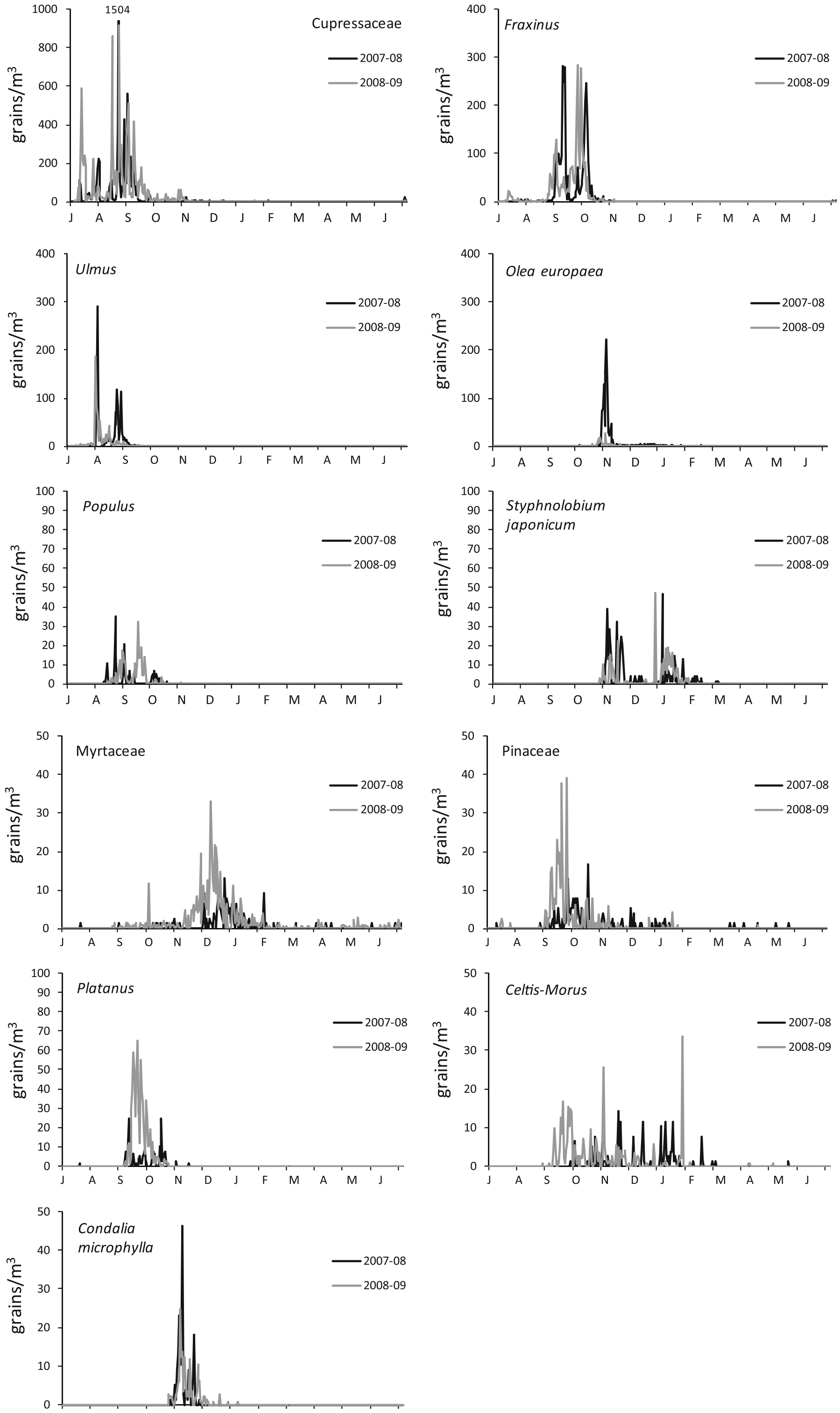
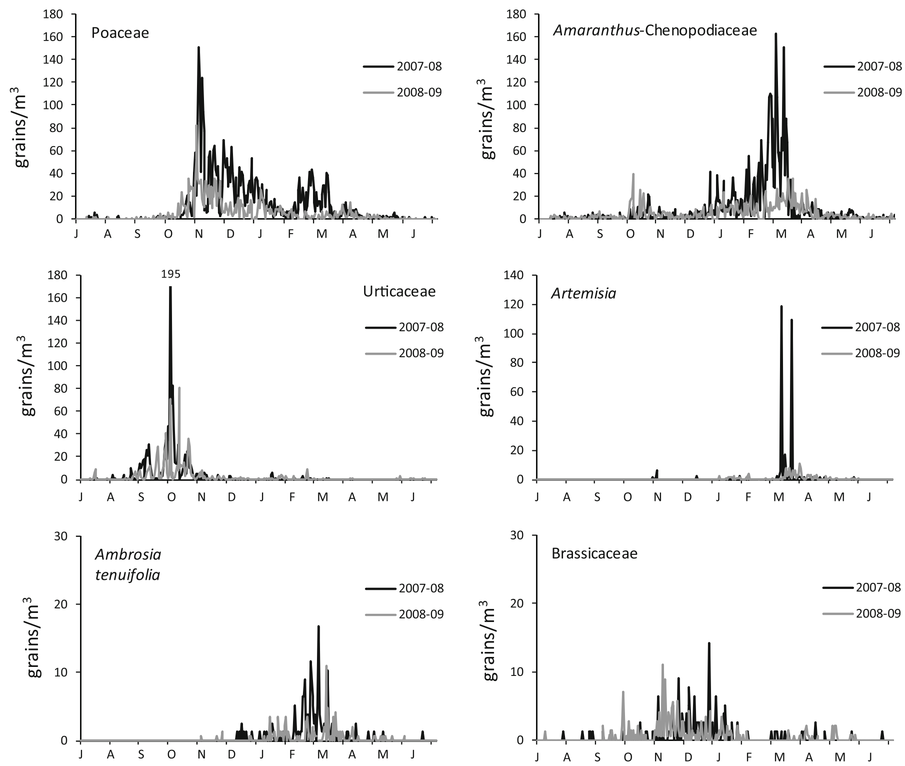


Fig. 4 continued



excelsior var. *aurea*. The first one is the most frequently used in tree city alignment. Of the three, *F. excelsior* is the earliest flowering species that occurs in August. F. *pennsylvanica* begins to bloom at the end of this month, being in full bloom in the month of September, while *F. excelsior* var. *aurea* is the taxon with the latest flowering period in October.

The *Ulmus* pollen type corresponds to the exotic species *Ulmus procera* and *U. pumila*. In general, they correspond to ancient specimens used for tree alignment along streets, avenues, routs and green spaces. They are also used for the formation of clumps to protect livestock in the fields near the town (Lahitte et al. 1999).

The presence of *Olea europaea* in the airborne pollen, with a short and intense pollination period, could be explained by the presence of ancient specimens of olive trees near the sampler.

The *Styphnolobium japonicum* pollen type corresponds to the same species, which is the most frequently used of the family Fabaceae in the urban forestation within the central radius of the town.

For the Myrtaceae pollen type, the most abundant emission sources are *Callistemon lancelolatus;* besides in the access roads to the town, there are specimens of *Eucalyptus sp*., especially *E. camaldulensis*, together with species of *E. cinerea* in green spaces.

Regarding Pinaceae, diverse exotic species of *Pinus* and *Cedrus* are used in parks and in the forestation of nearby town roads.

The *Platanus* pollen type corresponds to the flowering of juvenile *Platanus x acerifolia*. This exotic species has been used to replace trees along avenues.

Populus relates mainly to another exotic component of urban trees, *P. x canariensis.*

As expressed in Erdtman (1952), the *Celtis* and *Morus* pollen types can be difficult to distinguish, so in this paper they have been counted together. *Morus* includes exotic species of the genus present in some villages of the town. While *Celtis* corresponds to the native species, *Celtis ehrenbergiana* comes from the north of the province and surrounding areas of neighbouring provinces.

Condalia microphylla (Rhamnaceae) is also a native species characteristic of the 'caldén' forest or 'Espinal' (Cabrera 1994).

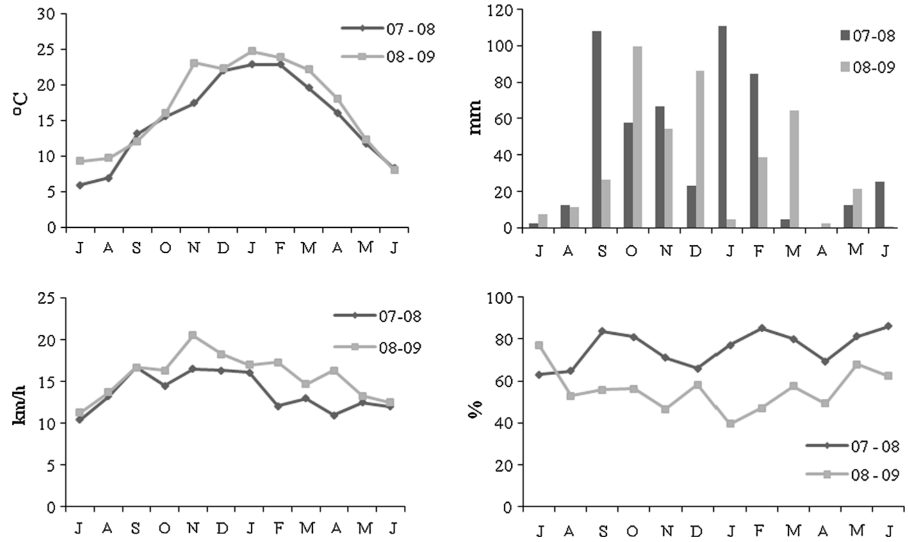


Fig. 5 Mean monthly average temperature and monthly average wind velocity (*left*). Monthly rainfall and monthly average relative humidity (*right*)

Although in a lesser amount (less than 0.5 % of the annual total), other components of the native flora of the province were present in the airborne pollen, such as *Prosopis, Prosopidastrum globosum, Parkinsonia aculeata* (all family Fabaceae), *Schinus, Jodina rhombifolia, Tamarix gallica* and *Ephedra*. Emission sources of these pollen types correspond to species in the 'caldén' forest and/or in the shrub steppe or 'Monte' (Cabrera 1994).

Of these, albeit in small number, there are in the town species of *Prosopis (P. caldenia* mainly), *Parkinsonia aculeata, Schinus areira* and *S. fascicu-lata,* and *Tamarix gallica.*

These representatives of the native flora of the 'Espinal' have also been found sporadically in the airborne pollen of Bahia Blanca city (Murray et al. 2010) and in a protected area of southern Buenos Aires province, belonging to the same phytogeographical region (Murray et al. 2007).

The presence of the *Nothofagus* pollen type corresponds to an extra-regional native component (Prentice 1985), coming from the Andean-Patagonian forests of SW Argentina. This pollen type, with Cupressaceae native pollen grains, is the main component of the airborne pollen in the city of San Carlos de Bariloche (Bianchi and Olabuenaga 2006) and appears practically in every aerobiological monitoring stations of Argentina, even in Montevideo, Uruguay (Tejera and Beri 2005).

In relation to the seasonal behaviour of the woody pollen types with a representation of more than 0.5 % of the total annual, it was observed that the succession of taxa in the pollen season started with Cupressaceae, which headed the annual peak in August. In this month, *Ulmus* was also important and *Populus* to a lesser extent. In September and October, the pollen of *Fraxinus* and to a lesser extent that of *Platanus* and Pinaceae was abundant. In October, *Celtis-Morus* pollen was also detected. In November, *Olea europaea* pollen was the most abundant type, and also important was the pollen of *Condalia microphylla* and *Styphnolobium japonicum*. The latter was the main contribution in December and January months that also showed Myrtaceae and Pinaceae pollen.

Of the 21 families of herbaceous pollen types present in the air of Santa Rosa, the most abundant in descending order were as follows: Poaceae, Chenopodiaceae, Urticaceae, Brassicaceae and Asteraceae. Emission sources of these pollen types were weeds that emerge spontaneously in parks, waste grounds and flower beds of the town.

These results are consistent with the composition of the flora of La Pampa province, which according to Rúgolo de Agrasar et al. (2005) has the Poaceae family as the most represented (with 79 genera and 244 species), followed by Asteraceae (92 genera and 192 species), Brassicaceae, which ranks fifth (24 genera and 43 species) and Chenopodiaceae in the sixth place (13 genera and 39 species).

The Poaceae pollen type was the most abundant of the herbaceous fraction. Within the group of winter grasses that bloom in the spring, pollen that was abundant in the town originated from *Piptochaetium napostaense*, *Poa ligularis, Lolium multiflorum* and species of the genera *Bromus* and *Stipa*, and in the nearby cultivated areas, there is pollen from wheat (*Triticum aestivum*), rye (*Secale cereale*), oats (*Avena sativa*), barley (*Hordeum vulgare*) and 'fescue' (*Festuca arundinacea*). Within the group of summer grasses, which bloom in the summer, pollen from weeds of the genera *Cynodon* are abundant (*C. dactylon, C. affinis* and *C. hirsutus*) and from *Sorghum halepense*, as well as cultivated species such as maize (*Zea mays*), sorghum (*Sorghum bicolor* and *S. sudanense*) and the naturalised fodder species *Eragrostis curvula* are very abundant on the side of roads and sandy soil sites and common in the town (Rúgolo de Agrasar et al. 2005).

The *Amaranthus*-Chenopodiaceae pollen type includes ten species known for the study area of the genus *Amaranthus,* Amaranthaceae, the most abundant being *A. quitensis*, besides abundant weeds of the family Chenopodiaceae, such as *Salsola kali* and various species of *Chenopodium* (Steibel 1986).

The representatives of the Urticaeae family present in the town belong to the genus *Parietaria (P. debilis* and *P. officinalis), Soleirolia (S. soleirolii)* and *Urtica (U. spatulata, U. urens* and *U. dioca*), *P. debilis* being the most common in cracks in buildings and shady places.

Regarding the Asteraceae family, the most abundant pollen types were anemophilous taxa from *Ambrosia tenuifolia* and *Artemisia*. From the latter, two species are known in the study area*: A. annua* (the most abundant) and *A. verlotiorum* (Troiani and Steibel 1999). Both pollen types occurred in the summer time, and the short period of pollination of *Artemisia* should be highlighted, a situation similar to that one found in Montevideo (Tejera and Beri 2005).

The presence of the *Senecio-Coniza* pollen type would be produced by *Senecio ceratophylliodes* with spring flowering and by *Coniza bonariensis* with summer flowering, both of them very abundant in the town.

The *Centaurea* pollen type corresponds to the flowering of *Centaurea solstitialis*, while *Helianthus* could correspond mainly to *H. petiolaris*, a weed very abundant in the town. The pollen record of *Baccharis* is due to the complex of species of this genus, with *B. ulicina* as the most abundant in the town, which flowers in February (Troiani and Steibel 1999).

Within the Brassicaceae pollen type, there are several species of exotic 'mostacillas', like *Capsella bursa-pastoris, Diplotaxis tenuifolia* and species from the genera *Sisymbrium* and *Hirschfeldia*, and the native species from the genera *Lepidium* and *Descurainia* (Prina 1995). All of these species grow naturally, being very common on road verges, waste grounds, roads and green spaces with little or no maintenance.

In relation to the seasonal behaviour of the herbaceous pollen types represent as more than 0.5 % of the total annual, Urticaceae was the first contribution in late winter, with its pollen peak in October. During this month, Poaceae appeared, whose pollen peak was in late October and early November corresponding to the flowering of winter grasses. This pollen type remained the most abundant during December. In January, the presence of *Amaranthus*-Chenopodiaceae pollen was highlighted, followed by Poaceae and Brassicaceae to a lesser extent. In February and March, there was a significant contribution of *Amaranthus*-Chenopodiaceae, Poaceae corresponding to the flowering of summer grasses, and to a lesser extent from *Ambrosia tenuifolia.* In turn, in March, there was a significant record of *Artemisia.*

Analysing interannual variation of airborne pollen, an important difference between amounts of HP of both years was found. The five more abundant HP were in average twice more abundant in the first study year than in the second one, with high values of airborne pollen particularly in October–November 2007 and March 2008.

Comparing monthly averages of meteorological data of both study years, the first one had lower mean temperature (except for September), lower mean wind velocity and higher mean relative humidity (except for July) than the second one. But the greater difference was in relation with total and monthly distribution of rainfall. The period of July 2007–June 2008 had 91.4 mm more rainfall than July 2008–June 2009, being September 2007 a month with 108.3 mm, 4.1 mm more rainfall than September 2008; in return, October 2008 had 1.7 mm more rainfalls than October 2007, month with 57.6 mm.

Comparing with historical averages from 1977 to 2010 of the study site, September has an average of

47.4 mm of rainfalls, while October has 72.2 mm (Vergara and Casagrande 2012). So really September 2007 was a rainy month while October 2007 was a drier month.

These differences could explain the greater airborne HP peak in spring 2007, because it could favour vegetative phase of herbaceous plants and then a better reproductive phase onset. After that, lower rainfalls in October could avoid airborne pollen wash. In summer time, a similar situation was found: January 2008 had 24 times more rainfalls than January 2009, and February 2008 twice more than February 2009. This relationship was reversed in March, when *Amaranthus*-Chenopodiaceae, *Artemisia* and *Ambrosia tenuifolia* pollen peak take place. In effect, March 2009 had 14 times more rainfalls than March 2008. These results are consistent with that of Cariñanos et al. (2004) who found in an arid environment for herbaceous species a stronger flowering if higher rainfall occurred in 2–4 weeks before the reproductive phase.

In Santa Rosa town, it would be necessary to have more years of airborne pollen data in order to be able to evaluate the impact of the interannual variation of meteorological factors for airborne pollen intake.

5 Conclusions

The airborne pollen of the town of Santa Rosa, in 2 years of aerobiological monitoring, was composed of 73 pollen types, 42 of wooden origin, which represented 66 % of the total with winter-spring seasonality, and 31 of herbaceous origin, which accounted for 30 % of the total with spring-summer seasonality.

In the composition of the woody airborne pollen, the formation of urban vegetation was shown, consisting mainly of exotic taxa from species of trees used in tree alignment, but also showed components typical of the phytogeographical region where the town is found. In particular, the *Condalia microphylla* record should be highlighted, as a component of the 'Espinal' phytogeographical region.

On the other hand, the greatest abundance of herbaceous airborne pollen corresponded to four of the ten families most representative of La Pampa province.

We should highlight the importance of the set up of a new aerobiological monitoring station in Argentina, with internationally standardised volumetric methodology, which allows researchers to obtain data that can be compared with other locations in the region and in the world. The continuity of this monitoring will enable us to have a solid database that will make it possible to develop a representative pollen calendar of the town, thus contributing to the development of aerobiology in the country.

Future research will focus on the production of pollen and pollen allergens, and their relationship to the meteorological variables in order to understand the future variation in the Central Argentina's vegetation.

Acknowledgments This research work was funded by the Science, Technology and Extension Unit, Faculty of Agriculture, University of La Pampa, Argentina.

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