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ORIGINAL PAPER

Pollen calendars: a guide to common airborne pollen in Andalusia

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Abstract This paper presents pollen calendars for the capital cities of the eight provinces of Andalusia (south of Spain) based on the airborne pollen counts recorded in a 10-year historical database. Pollen calendars are useful in the prevention and diagnosis of hay fever, in that they enable the timing and severity of the pollen season to be clearly defined. The differences encountered—in terms of both pollen spectra and the length and timing of the pollen season (start date, peak date, peak concentration and end date)—highlight not only the considerable diversity of urban landscapes in the eight Andalusian cities, but also the effect of urban green areas and periurban landscapes on airborne pollen levels. Green areas should be designed with a view to promoting benefits for the local population and avoiding the problems associated with the massive use of allergenic plants.

Keywords Pollen calendar · Andalusia · Airborne pollen

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1 Introduction

Pollinosis transcending all boundaries has a marked clinical impact worldwide (D'Amato et al. 2007). Aerobiological research is essential in order to chart the behaviour of airborne allergens over the year; the data obtained are valuable both to allergists for planning treatments and to allergy sufferers for planning their work and recreational activities.

Pollen calendars, defined as graphs summarising the annual dynamics of major airborne pollen types in a given location (Belmonte and Roure 2002), are of particular interest since they provide readily accessible visual information on the various airborne pollen types occurring in the course of the year.

Gardens and public parks ensure a range of benefits for local residents in urban areas. The aesthetic appeal of these spaces is very important, and they usually contain a variety of exotic ornamental species, some of which are regarded as having high allergenic potential, e.g. *Casuarina*, Cupressaceae, *Morus*, *Myrtaceae*, *Palmae* (Fernández 1992) and *Platanus* (Alcázar et al. 2011). The design of green spaces and the choice of plant species used as well as the sexual selection of female

Table 1 Biogeographical data for study cities

City	Geographical coordinates	Surface area (km^2)[a]	Density (inhab/km^2)[a]	Average temperature (°C)	Maximum[b]	Minimum[c]	Rainfall (mm)	Altitude (m.s.l.)[d]	Mediterranean bioclimatic belts[e]
Almería	30°50′0″N 2°28′3″W	296.21	646.30	19.4	23.9	16.2	145	23	Thermomediterranean
Cádiz	36°32′0″N 6°17′0″W	12.3	10,077.07	18.5	21.3	15.7	603	7	Thermomediterranean
Córdoba	37°53′5″N 4°46′44″W	1255.24	261.97	17.7	24.6	10.7	536	123	Thermomediterranean
Granada	37°10′27″N 3°35′55″W	88.02	2715.49	15.1	22.7	7.5	357	685	Mesomediterranean
Huelva	37°15′50″N 6°57′47″W	151.33	981.75	18.1	23.5	12.7	490	20	Thermomediterranean
Jaén	37°46′0″N 3°46′0″W	424.3	275.11	17.3	22.1	11.8	593	550	Mesomediterranean
Málaga	36°43′10″N 4°25′12″W	395.13	1436.07	18	22.9	13.1	426	5	Thermomediterranean
Seville	37°22′59″N 5°59′47″W	141.31	4970.31	18.6	24.9	12.2	533	10	Thermomediterranean

[a] Data obtained of I.N.E. Censo 2012

[b] Average temperature of the daily maximum °C (1971–2000)

[c] Average temperature of the daily minimum °C (1971–2000)

[d] Alcazar et al. (2011)

[e] Rivas-Martínez (1987)

were analysed (Velasco-Jiménez et al. 2014), giving a total of 18 pollen types.

The 10-day average daily pollen count (Julian calendar) was taken as a single value corresponding to the arithmetic mean for a period of ten consecutive days; for 31-day months, the last group contained 11 days, as recommended by Gutierrez et al. (2006), while February was taken as a 29-day month, the last group comprising 9 days.

The pollen count classification recommended by Stix and Ferratti (1974) was used: 1–2 pollen grains/m^3 of air; then 3–5, 6–11, 12–24, 25–49, 50–99, 100–199, 200–399, 400–799, 800–1600 and finally over 1600 pollen grains/m^3 of air.

3 Results

Percentages of each pollen type exceeding 1 % of the total airborne pollen count in each city are shown in Table 2. These data provide a clear indication of inter-city differences. In all eight cities, the pollen types analysed accounted for over 90 % of the total local pollen index.

The cities displaying the greatest diversity of pollen types are Huelva and Seville, while the smallest number of pollen types is recorded for Jaén, where a larger proportion of the surface area is given over to olive groves and thus *Olea* pollen tends to predominate.

Pollen calendars for the study cities (in alphabetical order) are shown in Figs. 2 and 3; pollen types are ordered by the timing of their appearance.

3.1 Pollen types

Cupressaceae exceed 1 % of the total pollen count in all eight cities; recorded from early autumn to spring. The longest pollen season is recorded in Granada (292 days) and the shortest in Jaén (190 days). Two characteristic peaks are recorded over the pollen season: one in autumn and other in late winter/early spring. In both cases, peaks are highest in Granada (400 and 799 pollen grains/m^3 of air in February and March, respectively). The highest daily peak was recorded in Granada on 8 March, 2000, with a daily average of 3717 pollen grains/m^3 of air.

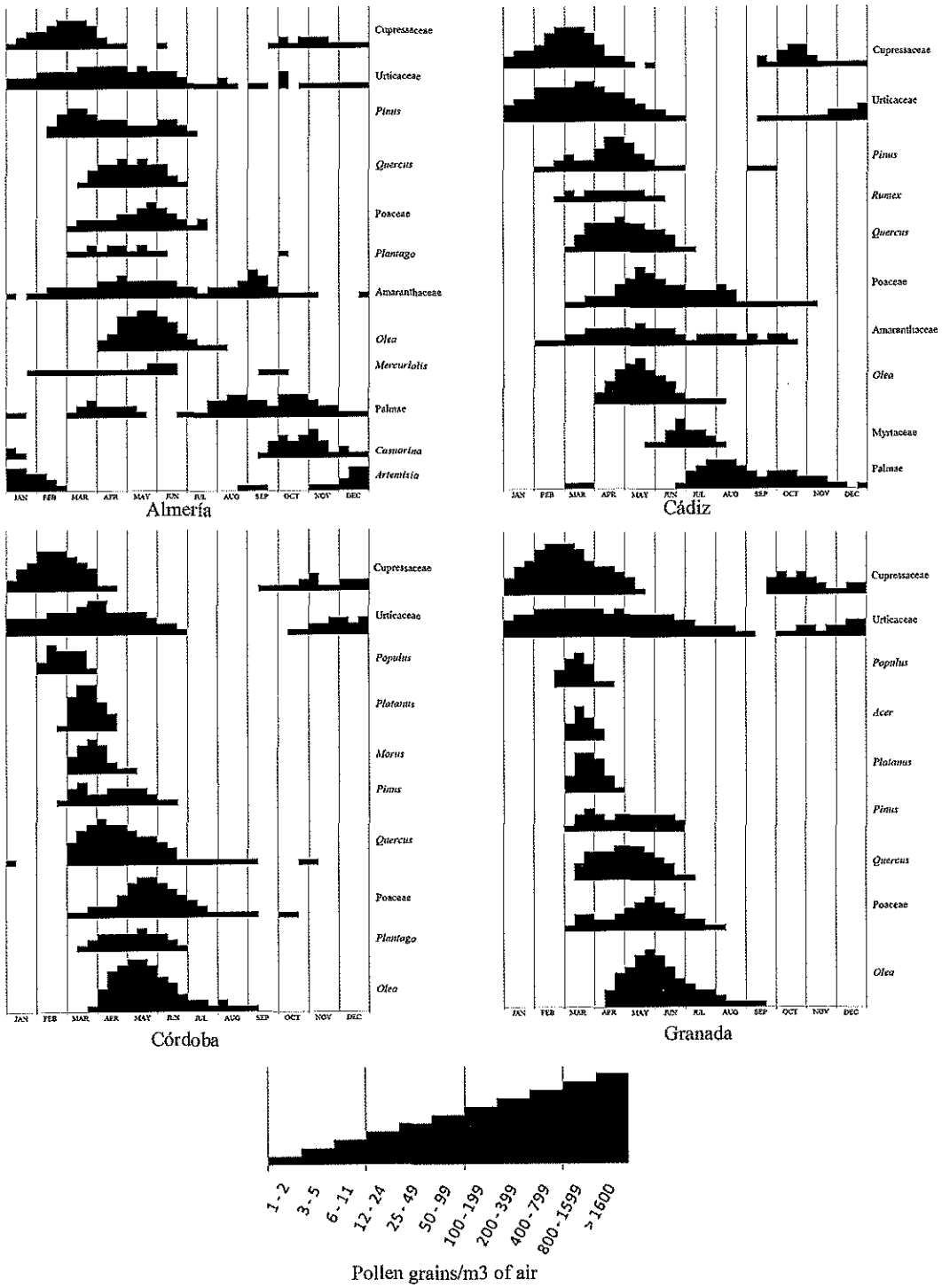

Fig. 2 Pollen calendar of Almería, Cádiz, Córdoba and Granada

Rumex exceed 1 % of the total pollen count in Cádiz, Huelva, Málaga and Seville. The pollen season starts in late winter and finishes in late spring. The highest counts range between 6 and 11 pollen grains/ m^3 of air, recorded in Huelva in mid-February and from mid-March to early May; in Seville from mid- to late

season (232 days). The highest counts are recorded in Córdoba in early April (200–399 pollen grains/m^3 of air). The highest daily peak was observed in Córdoba on 2 April, 2006 (daily average 400 pollen grains/m^3 of air).

Poaceae exceed 1 % of the total pollen count in all cities. In Seville, this pollen type is presented throughout the year. The pollen season starts in late winter in all cities, the latest start date being observed for Málaga; it finishes first in eastern Andalusia in mid-summer, and later in western Andalusia in early autumn. The highest counts are recorded in Cádiz and Huelva in mid-May and in Córdoba and Seville from mid- to late May (100–199 pollen grains/m^3 of air). The highest daily peak was recorded in Seville on 25 May, 2001 (daily average 881 pollen grains/m^3 of air).

Plantago exceed 1 % of the total pollen count in Almería, Cádiz, Córdoba, Huelva, Málaga and Seville. The pollen season starts first in Cádiz in mid-winter and then in other cities in early spring and finishes in early summer in all cities. The highest counts are recorded in Cádiz between mid- and early April (50–99 pollen grains/m^3 of air). However, the highest daily peak was observed in Málaga on 29 April, 2002 (daily average 153 pollen grains/m^3 of air).

Amaranthaceae exceed 1 % of the total pollen count in Almería, Cádiz, Huelva, Málaga and Seville; recorded from mid-winter in Cádiz and Almería and from spring elsewhere, to autumn in all cities. The highest concentrations are detected in Málaga in spring and in Almería in late summer (25–49 pollen grains/m^3 of air). The highest daily peak was observed in Málaga on 25 April, 2005 (daily average 120 pollen grains/m^3 of air).

Olea exceed 1 % of the total pollen count in all cities. The pollen season starts first in Córdoba and Málaga in early spring and later in the other cities in mid-spring; it finishes first in Huelva and Seville, second in Málaga in mid-summer, later in Almeria and Cádiz—though also in mid-summer—and finally in Córdoba, Granada and Jaén in late summer. The highest pollen counts are recorded in mid-May in Jaén (over 1600 pollen grains/m^3 of air). The highest daily peak was detected in Jaén on 15 May, 2003 (daily average 12,079 pollen grains/m^3 of air).

Mercurialis exceed 1 % of the total pollen count in Almería. The pollen season starts in early winter and ends in late spring. The highest counts are recorded from late May to mid-June (3–5 pollen grains/m^3 of air). The highest daily peak was observed on 17 July, 2005 (daily average 88 pollen grains/m^3 of air).

Myrtaceae exceed 1 % of the total pollen count in Cádiz, Huelva, Málaga and Seville. The pollen season starts in late spring and finishes in mid-summer. The highest counts are recorded in Cádiz in late June (25–49 pollen grains/m^3 of air). The highest daily peak was observed in Cádiz on 28 June, 2008 (daily average 382 pollen grains/m^3 of air).

Palmae exceed 1 % of the total pollen count in Almería, Cádiz, Huelva and Seville. The pollen season displays two peaks: one in early spring and the other from summer to early winter, when most of the family's species are in bloom. The first peak covers from late winter to early spring in Cádiz, and to mid-spring elsewhere, while the second covers from early summer to late autumn in all cities except Almería where it finishes in early winter; in this second peak, counts are higher in all cities, particularly in Cádiz from late July to mid-August (25–49 pollen grains/m^3 of air). The maximum daily peak was observed in Cádiz on 20 July, 2003 (daily average 260 pollen grains/m^3 of air).

Artemisia exceed 1 % of the total pollen count in Almería. The pollen season starts in mid-autumn and ends in late winter. The highest counts are recorded from mid-December to mid-January (12–24 pollen grains/m^3 of air). The daily peak value was observed on 5 January, 2007 (daily average 147 pollen grains/m^3 of air).

4 Discussion

The value of the pollen calendar lies in the fact that it provides a highly illustrative representation of airborne pollen dynamics throughout the year (Belmonte and Roure 2002). Here, pollen calendars obtained for the provincial capitals of Andalusia yielded new information, enabling the seasonal behaviour of various pollen types to be charted over a wider area. While earlier calendars used a smaller number of years, the 10-year historical database used here provided more reliable results, reducing annual fluctuations due to environmental variations mainly prompted by changing weather patterns. Moreover, by focusing only on pollen types accounting for over 1 % of total airborne pollen counts in each city, a clearer view of pollen was obtained to which local residents are exposed. The 18 pollen types studied here accounted for over 90 % of the total pollen count in all cities and were thus representative for the pollen spectrum in Andalusia.

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