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Aerobiologia 11 (1995) 105–109

Aerobiologia
International Journal of Aerobiology

Airborne pollen grain concentrations at two different heights

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Received 24 June 1994; accepted 11 August 1994

Abstract

The present study describes the airborne pollen grain concentrations at two different heights (1.5 m and 15 m, respectively). The survey was carried out in 1991 and 1992, using two Burkard spore-traps, both set up at the University of Córdoba, Faculty of Sciences. Generally, and for all herbaceous plants, pollen detection started and ended around the same date on both samplers. However, in the case of *Olea europaea*, the pollen was detected in advance by the sampler located at 1.5 m compared with the one located at 15 m, probably due to the fact that olives growing close to the low sampler flower before the great olive plantations located some 60 km south of the city. No significant differences between the counts of both samplers have been observed, except in the case of Urticaceae, where the sampler situated on top of the building recorded higher pollen concentrations in both years. Similar annual peaks of Urticaceae are probably due to the buoyancy of their small, light grains and the explosive pollination mechanism which liberates pollen grains from the anthers of the Urticaceae family, including *Urtica* and *Parietaria*.

Keywords: Airborne; Pollen; Sampling height

1. Introduction

When carrying out a survey of airborne pollen, it is important not only to select a suitable sampler but also to choose the appropriate location and height for its installation. In general terms, the sampling site should be representative, accessible and within reach of a power supply. If the survey is designed to ascertain the most representative pollen count in a given area, the sampler should be placed in an open site, at a certain height above ground level, ensuring that buildings do not obstruct airflow and affect pollen concentration. Most sampling sites are situated 15–20 m above ground level.

It is also important to determine pollen concentrations at human height; although the concentrations at this height may be lower, a clearer indication may be gained of the levels to which people are really exposed, in order to find the threshold values of airborne pollen concentrations provoking allergic reactions in sensitized subjects. This aspect of aerobiology is of particular concern to a number of researchers studying vertical variation in pollen abundance (Bryant et al., 1989; Rantio-Lehtimäki et al., 1991a) and the effects of variations in sampling height on diurnal patterns (Rantio-Lehtimäki et al., 1991b).

The present study describes the results obtained in spring 1991 and spring 1992, as this is the season when the flowering of most of the species causes allergies in Córdoba. Of all the patients attending the Córdoba Hospital Allergy Unit with respiratory difficulties, 60.3% were affected by pollinosis provoked, in most cases, by sensitivity to Poaceae and *Olea europaea* pollen (82.5% and 60%, respectively); sensitivity to *Plantago* (29.2%) and *Parietaria* (2.5%) has also been recorded; *Urtica* extracts are not commercially available in our area (Domínguez et al., 1993a).

2. Materials and methods

The survey was carried out in 1991 and 1992, using two Burkard spore-traps; both were set up at the University of Córdoba Faculty of Sciences, one on the roof of the building at 15 m above ground level (trap A), and the other at a height of 1.5 m above the ground (trap B). Pollen counts were made by means of four continuous horizontal scans, at a magnification of ×400. Results

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0393-5965/95/$09.50
SSDI 0393-5965(95)00120-G

were multiplied by a factor of 0.54 in order to give a mean daily pollen concentration per cubic metre.

Córdoba is a semirural city with 300 000 inhabitants, situated on the fertile plain of the River Guadalquivir 120 m above sea level. Natural vegetation to the south of the city has been almost totally replaced by agriculture, while to the north the Sierra flora remains largely intact. The climate is broadly Mediterranean, with a slight continental influence. Mean annual rainfall is 670 mm and the mean temperature is 18°C (maximum average 30°C, minimum average 7°C), according to the data for the last 40 years supplied by the 'Observatorio Especial y Medio Ambiente' in Córdoba. Rain tends to be torrential, mainly occurring over an average 72 days per year (mean value over 78 years). The percentage of wind-free intervals in the city is generally very high

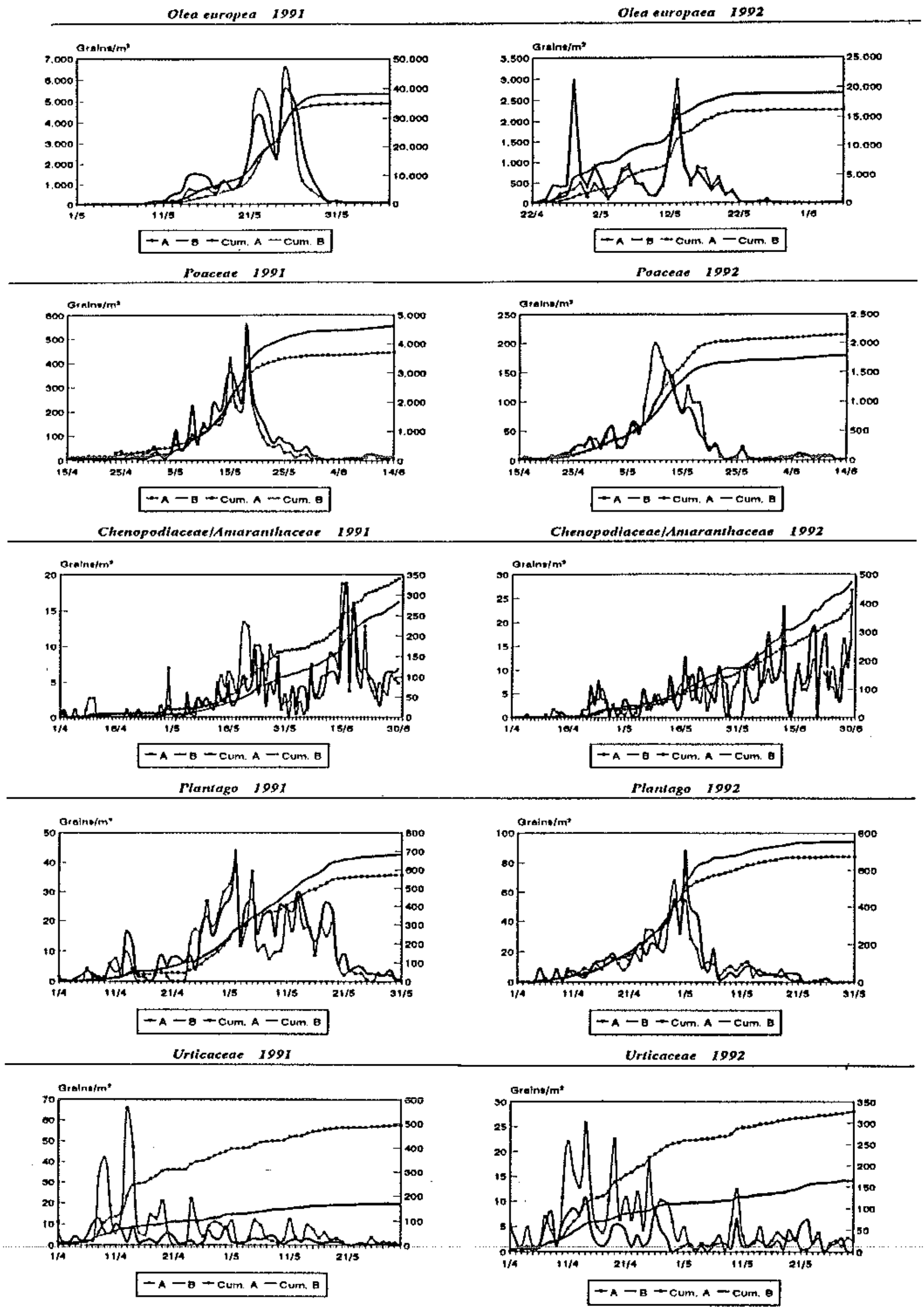

Fig. 1. Individual pollen count curves for the two sampling heights studied, together with the cumulative curves for each trap (A = 15 m; B = 1.5 m).

(30%). Winds are mostly westerly and southwesterly.

The sampling site is situated on the outskirts of the city in an open area free from the screening effects of surrounding buildings. However, because of power supply requirements, the sampler was placed close to, though not touching, the building. Since the sampler was situated on the NEE side, pollen grain monitoring was adversely affected when winds were predominantly from the south-west.

In order to compare the results obtained at the two heights, curves for different pollen types and a cumulative curve were plotted for each trap. Comparative parametric and non-parametric statistical analyses were carried out between traps. Correlation analyses of sampling heights were performed for the different pollen types to identify any behavioral differences. Finally, a correlation analysis was made of inter-trap differences taking into account certain meteorological parameters such as maximum temperature, minimum temperature, rainfall and humidity.

For a detailed examination of Urticaceae pollen release, the diurnal variation pattern was determined using only data from those days on which pollen concentrations exceeded the seasonal mean. A correlation analysis was performed comparing these data with diurnal temperature, sunshine and humidity patterns.

As *Urtica* and *Parietaria* are difficult to distinguish optically, our aerobiological data include both taxa in Urticaceae, although *Urtica* spp. are more common in our area than *Parietaria*.

3. Results

Fig. 1 shows individual pollen-count plots for the two sampling heights studied, together with the cumulative curve for each trap (A = 15 m, B = 1.5 m). No significant differences were observed between pollen counts for each trap, except in the case of Urticaceae, where trap A recorded higher pollen concentrations in both years surveyed. The difference was demonstrated statistically by means of parametric and non-parametric comparative analyses; both yielded similar values, with a degree of significance of 99% (Table 1).

A correlation analysis was performed to compare the

Table 1
Variance analysis and Chi-square approximation for Savage test

	Variance analysis		Savage test	
	F-value	Probability	Chi-Q	Probability
Chenopodiaceae	0.11	0.73	0.15	0.70
Olea	0.15	0.70	0.03	0.85
Plantago	0.97	0.33	1.54	0.21
Poaceae	0.22	0.64	0.32	0.57
Urticaceae	15.96	0.001	14.77	0.001

Table 2
Correlation analysis

	A and B	A – B and A	A – B and B
Chenopodiaceae	0.74***	0.28***	0.45***
Olea	0.93***	0.31***	0.07
Plantago	0.89***	0.01	0.45***
Poaceae	0.94***	0.24**	0.56***
Urticaceae	0.47****	0.95***	0.18

Column 1, correlation rates between A and B; Column 2, correlation rates between the difference (A – B) and A; Column 3, correlation rates between the difference (A – B) and B.
**95%.
***99%.
***99.9%.

records of both samplers (A and B) for each taxa. Results are shown in Table 2; correlations showed 99.9% positivity for each of the data pairs.

An inter-sampler correlation analysis was made, followed by a correlation analysis of each sampler and the difference between the two (A – B and A, A – B and B) (Table 2). Differences between pollen counts may thus be due to variations recorded by both samplers (as is the case with Poaceae and Chenopodiaceae-Amaranthaceae), to variations only in trap A (*Olea* and Urticaceae) or to variations only in trap B (*Plantago*). It should be noted that these differences refer to the shape of the curve, irrespective of the actual pollen counts for each trap. In some cases, differences in curve shape did in fact coincide with differences in pollen levels. Over the sampling season as a whole, higher pollen counts were recorded for *Olea* in trap B, while variations between the two traps were entirely due to trap A. This was not, however, true for Urticaceae (Table 2).

Detailed analysis of the graphs allowed several specific conclusions to be drawn. Andalusia is the largest olive and olive-oil producing region in the world. It is therefore not surprising that *Olea europaea* should record the highest airborne pollen concentrations of all the taxa studied, with mean daily levels of 7700 grains/m^3 over 1991 (Domínguez et al., 1993b). Comparison of annual curves revealed that at the start of the pollen season, in both years, higher levels were recorded by trap B. This can be attributed to olives that grow in the

Table 3
Correlation rates between meteorological data and inter-trap differences (A – B)

	Humidity	Rainfall	T_{max}	T_{min}
Chenopodiaceae	−0.07	−0.03	0.11	−0.04
Olea	0.03	0.03	−0.05	0.02
Plantago	0.05	0.04	0.03	0.13
Poaceae	−0.02	0.03	−0.08	0.02
Urticaceae	−0.03	−0.06	−0.17	−0.26***

**99%

Table 4
Correlation rates between differences (A – B) Urticaceae pollen and temperature

Days	T_{min}	Increase T_{max}
184	−0.26***	−0.03
47	−0.21	−0.45***

***99%.

low zones nearest to the sampling site, and which flower earlier than the extensive olive-groves situated some distance to the south of the city. Higher pollen counts are detected by trap A (15 m) only when pollen concentrations are very high, because olive pollen is transported over long distances in the upper atmosphere (Fig. 1).

In both years, the pollen season for the other species studied here — all herbaceous — started at the same time (Fig. 1). With the exception of Urticaceae, the herbaceous pollen concentration curves for each trap were very similar. Conspicuous peaks in the trap A curve correspond to days when a westerly or southwesterly wind hindered the entrapment of pollen grains at the lower sampling height (trap B).

To account for some of the differences observed between traps, correlation analyses were performed between the trap differences (A – B) and a number of meteorological parameters such as humidity, rainfall and maximum and minimum temperatures. A negative correlation at 99% was noted only between Urticaceae and minimum temperature (Table 3). When this analysis was restricted to those days in which counts were higher than 5 grains/m^3 in trap A, there was no longer any significant correlation. Instead, there was a statistically significant correlation with maximum temperature (i.e. the daily increase in temperature with respect to the previous day) (Table 4). The correlation was negative, indicating that decreases in maximum temperature from one day to the next led to an increase in pollen levels recorded by trap A. This correlation was not observed for trap B.

Urticaceae recorded a strong positive correlation between diurnal airborne pollen pattern and sunshine/temperature, while the correlation with humidity was negative. This may be related to the pollen-release mechanism characteristic of this group, involving the explosive opening of the anther and subsequent release of pollen grains when there is an increase in ambient temperature and in hours of maximum sunlight. This correlation has been demonstrated statistically (Table 5) and is also evident from the graphs of diurnal variation (Fig. 2).

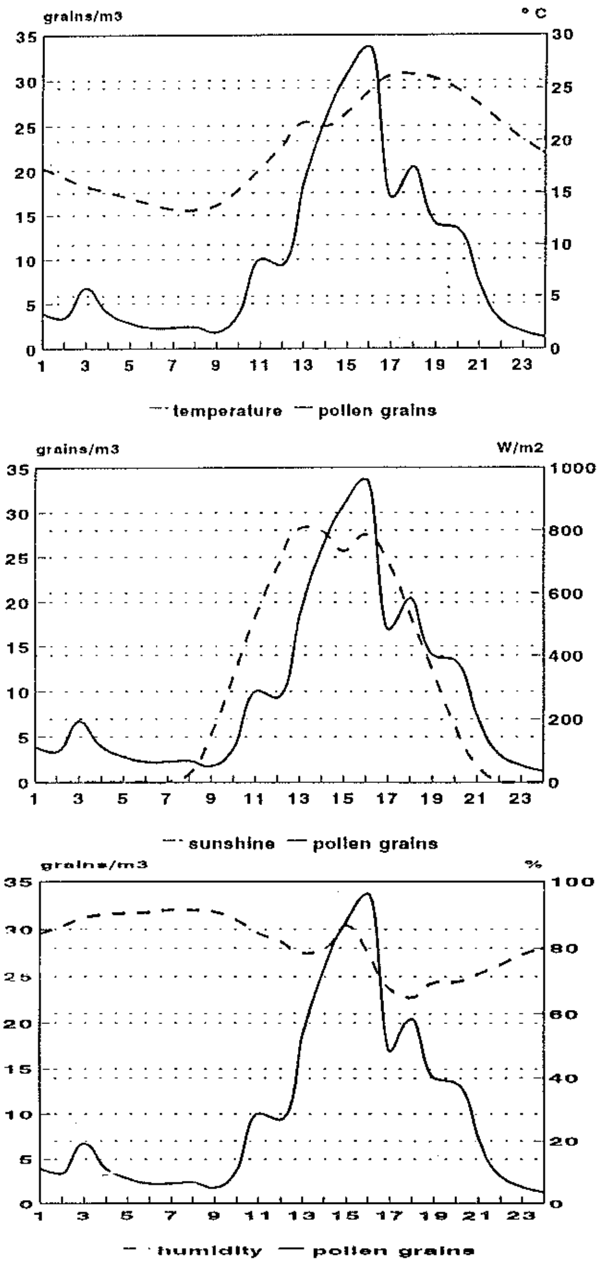

Fig. 2. Diuirnal variation of Urticaceae pollen grains and some meteorological parameters (temperature, sunshine and humidity).

Table 5
Correlation rates between the intradiurnal pattern for pollen grains and the intradiurnal patterns of humidity, sunshine and temperature

	Urticaceae
Humidity	−0.7108**
Sunshine	0.9490**
Temperature	0.7438**

**95%.

4. Discussion

Generally, and for all herbaceous plants, pollen grain detection started and ended at approximately the same time period for both samplers. This is readily explained by the fact that the traps were placed at the same site, and differed only in height above ground level. Moreover, all plants studied here were abundant in areas close to the traps. However, in a survey conducted in Finland, pollen detection periods always occurred earlier for samplers situated at ground level on a mown lawn than for samplers installed at a height of 15 m (Rantio-Lehtimäki et al., 1991a,b).

For the only tree species studied, *Olea europaea*, high pollen concentrations were detected by trap B before trap A. This can be explained by the fact that olive trees growing nearer to the sampling site flowered earlier than the large olive-groves growing further to the south of the city. This confirms earlier observations according to which a sampler closer to ground level detects higher concentrations of pollen from plants close to the sampling site. Samplers situated higher above ground level detected pollen grains from a wider ranging area. Similar conclusions were reported from both Turku, Finland (Rantio-Lehtimäki et al., 1991a) and London, UK (Bryant et al., 1989).

Given that aerobiological studies and pollen forecasts generally use data from samplers located 15–20 m above ground level, olive-pollen allergy symptoms in pollinotics may be reported even before the pollen season is considered to have started.

Results of comparative parametric and non-parametric statistical analyses revealed no significant differences between the curves obtained from the two traps, except in Urticaceae, where notably higher pollen grain concentrations were always found for trap A. *Urtica* is a nitrophilous plant, more abundant than *Parietaria* in the city, growing as a weed in peripheral urban areas, and in particular close to the sampling site; in contrast to the findings reported in Finland, larger amounts of *Parietaria* pollen were detected by the samplers placed at a height of 15 m above ground level. Bryant et al. (1989) reported that not all pollen grains released close to the sampling site were detected in greater proportions in the sample collected nearer the ground. In their comparative study of two sampling heights (10 m and 55 m), the exception was also *Urtica*, where pollen levels were very similar at both heights. However, in the present study, which compares two much lower heights (1.5 m and 15 m), greater amounts of pollen grains were detected by trap A than by trap B. Bryant et al. (1989) ascribe this to the fact that Urticaceae pollen is more easily upwardly dispersed due to its small size, low density, and buoyancy in air currents.

The low pollen levels recorded at 1.5 m above ground level may also be related to the characteristic Urticaceae pollen release, an explosive mechanism which may be activated partly by purely climatic factors and partly by mechanical factors (animals and humans brushing against plants). These factors probably favour the dispersal of the small pollen grains characteristic of this family.

Finally, statistical analysis revealed a significant negative correlation with maximum temperature (i.e. the increase of temperature each day with respect to the previous day). Drops in temperature from one day to the next lead to increased pollen grain concentrations in trap A compared to trap B. This correlation was not observed for trap B. In view of these results, and given that anthesis is known to be related to higher temperature and lower atmospheric humidity, the increases in pollen levels detected by trap A on days when maximum temperatures fell may be partly explained by the fact that the sampler set at 15 m was detecting pollen clouds descending from the upper atmosphere as the temperature dropped. Descending pollen clouds had previously been carried upwards by convection currents as the ground heated. These descending pollen clouds appeared not to be detected at ground level, probably because air currents from the turbulent atmosphere counteracted strongly the effect of gravity. Conventional air currents are particularly important in the area of Córdoba given the high percentage (30%) of wind-free days.

Acknowledgements

The authors are grateful to the Spanish DGICyT for financial support granted through Project PB-92-814-00.

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