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# Dispersal of Amaranthaceae and Chenopodiaceae pollen in the atmosphere of Extremadura (SW Spain)

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A study over six consecutive years of the pollination dynamics of the Amaranthaceae and Chenopodiaceae in Badajoz, and a comparative study over three years with stations in Mérida and Cáceres showed that there were different factors affecting this process. Thus, the proximity of croplands was found to be important in determining the magnitude of the concentrations, and this was also confirmed with a study of the concentrations measured directly in the croplands. Autumn and summer rainfall was found to affect, and also to have a certain influence on the length of the flowering period.

The daily variations in pollen levels were studied in relation to meteorological parameters, finding a correlation that was positive with respect to temperature and negative with respect to atmospheric humidity and the distance travelled by the wind, i.e. airflow measured in hm with a revolving-cup anemometer. These correlations were the same in all three of the localities studied. The direction of the wind, however, was found to have different effects according to the locality studied. This is explained by their positions relative to the irrigation zones in the region.

The pattern of diurnal pollen release from these taxa shows the greatest levels to be reached between 10:00 and 12:00 hours in Mérida as well as in Badajoz. In Cáceres, however, the distribution throughout the day was very even, with few hourly variations. This may be due to the sparse representation of these species in the neighbourhood of the Cáceres trap, with the pollen having been transported from sources that were farther away.

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The airborne pollen of the families Amaranthaceae and Chenopodiaceae in the Iberian Peninsula presents the highest levels in the traps situated in the Mediterranean coastal provinces: Huelva (González et al. 1998), Almería (Cariñanos et al. 1998), Málaga (Trigo et al. 1998), Murcia (Moreno-Grau et al. 1998), Alicante (Fernández et al. 1996), and saline soil, interior zones of the Zaragoza region (Bermejo et al. 1998) where the halophytes of these species abound to such an extent that on occasions they account for up to 10% of the airborne pollen. In the interior of the Peninsula, this pollen type is found to be well represented at stations located in areas influenced by irrigation: Córdoba (Galán et al. 1998), Sevilla (Candau et al. 1998), Granada (Díaz & Alba 1998), and Badajoz (Silva et al. 1998). In other Spanish localities, the type appears less important, the levels declining with decreasing influence of the Mediterranean climate.

From these data and a study of the ecology of these taxa, one might group their habitats into two types of main sources: high salinity zones, and croplands. In croplands, these species are weeds. They are plants that prosper in land left fallow, especially in irrigated land since a great number of species of the genus *Amaranthus* appear in temperate areas as introduced from tropical areas.

In Extremadura, there exist in total 30 species apart from a number of cultivated species such as spinach (*Spinacia oleracea*) and beet (*Beta vulgaris*). Most of them are nitrophytes and neophytes which are well adapted to irrigated land, the more abundant are *Amaranthus albus*, *A. retroflexus*, *A. hypocondriacus*, *A. hybridus*, *A. graecizans* ssp. *silvestris*, *A. blitoides*, *A. muricatus*, *A. deflexus*, *A. viridis*, *Atriplex rosea*, *A. prostrata, Chenopodium ambrosioides*, *C. vulvaria*, *C. murale* and *C. album*. The sources of this type of pollen in Extremadura are therefore concentrated in the zones of intensive cropping, especially the Vegas (floodplains) of the Guadiana and of the Tietar. The relative positions of the stations studied with respect to these areas are shown in Fig. 1. Badajoz is situated at the western end of the Vegas Bajas of the Guadiana, and 66.4% of its surroundings area is dedicated to crops, in particular, 31.3% to irrigation (MAPA 1982 a). Mérida, 61 Km E of Badajoz, is located between the Vegas Bajas and Vegas Altas: 70.3% of its surrounding area is dedicated to crops, with 11.3% under irrigation (MAPA 1982 b). Cáceres lies to the North of these two localities: 89 km NE of Badajoz, and 68 km N of Mérida. It is surrounded by 66.3% of cropland, with only 1.8% being under irrigation (MAPA 1984).

These pollen types present one of the longest periods of appearance in the pollen counts. We studied the behaviour of its levels in the locality of Badajoz over a 6-year period,

 

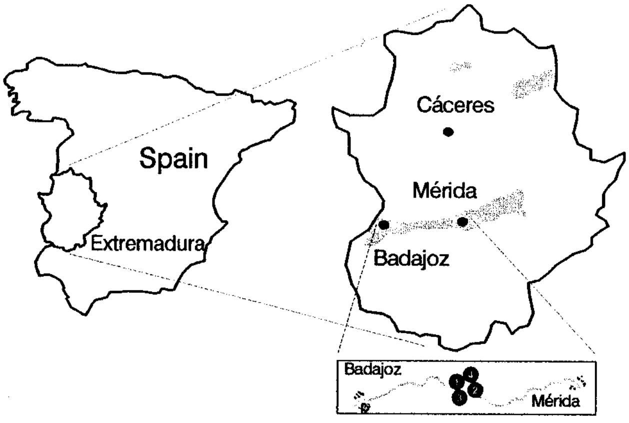


*Fig. 1.* Location of the three traps in the region of Extremadura. The main irrigation zones are indicated by shading, and the inset shows the four farms studied using portable traps.

and compared it with measurements taken over 3 years in Mérida and Cáceres. A series of differences were established between years and between stations. In the present work, we shall endeavour to explain these differences as a function of the relative locations of the sources of the pollen, as well as of the influence of other factors. We shall also make use of specific studies performed during 1998 in cropland zones of the Vegas Bajas of the Guadiana.

## MATERIAL AND METHODS

The study was performed using traps of the Hirst (1957) type (Burkard trap) in three localities of the Region: Badajoz, Mérida, and Cáceres. In all three cases, the traps were situated within the metropolitan area. We have data from the Badajoz trap from 13 May 1993 until the end of 1998, and for the Mérida and Cáceres traps for the years 1996–1998, although in the case of Mérida the data corresponding to weeks 30 to 38 of 1996 are missing. Samples were analyzed by counting pollen grains from these families in four transversal sweeps using a magnification of 400 (40 × 10). These data were then transformed into hourly and daily concentrations in grains/m$^3$, and then into weekly averages, which were used to analyze the interannual variations in Badajoz city and the differences between the three localities.

The daily levels were used to analyse the possible correlations with the daily meteorological parameters: rainfall (mm), relative humidity (%), maximum, average, and minimum temperatures (°C), distance travelled by the wind (hm), period of calm air (hours), and wind direction (hours) in the different quadrants (NE, SE, SW, and NW). These data were obtained from the Centro Meteorológico Territorial of Extremadura from its observatories in Badajoz, Talavera la Real (20 km outside of Badajoz), Mérida, and Cáceres. The analyses were performed for each year and for each station only for the days of the main pollen season as calculated by Nilsson & Persson (1981), neglecting days which involved accumulated concentrations less than 5% of the total at both the beginning and the end of pollination.

To see whether any of the meteorological factors might explain the interannual variations in pollination, correlations were made between the values of rainfall and mean temperature in the different seasons of the year, in this case using the autumn of the previous year as the factor to be related, and different parameters relative to the annual concentration: mean concentration during the main pollen season, starting from the day on which 5% of the total pollen concentration was reached, day on which 50% was reached, and day on which 95% was reached, including the value of the number of days since 1 January. The purpose of analyzing these last three percentages was to see the influence of the mentioned meteorological parameters on the phenology of these species.

With reference to the man-made alteration of the conditions due to irrigation of land, correlations with two of the most widely grown crops of the Vegas Bajas: tomato and maize were made. The annual production values in tons were used. These were obtained from the Consejería de Agricultura y Comercio of the Junta de Extremadura, except for those of 1998, which were obtained from advance estimates of production facilitated by the Ministerio de Agricultura, Pesca y Alimentación.

The hourly concentrations were used to establish the patterns of day-by-day variations for each year and each station. For that purpose, we calculated the mean of the concentrations at each hour for those days on which this type of pollen appeared. We also calculated and plotted the 95% confidence limits.

In the study of the monitoring of the daily concentrations in irrigation crop farms of the Vegas Bajas of the Guadiana between Badajoz and Mérida, samples of 10-minute exposure time were taken with portable volumetric traps (Burkard model) on 21 days between May 5 and August 27. The samples were taken between 10:00 and 12:00 hours, when the levels of this type of pollen were highest. The locations of these sampling sites, all in irrigated farmland, are shown in Fig. 1. The crops being grown were: 1 pear, 2 peach, 3 plum and peach, and 4 plum. In the analysis, the whole sample was examined under optical microscopy at 400 × magnification, and then the concentration in grains/m$^3$ was calculated.

## RESULTS

Figure 2 shows the variations of the mean weekly concentrations in the city of Badajoz between 1993 and 1998, indicating on each plot the main pollen period. The beginning of this period occurred between weeks 16 and 19, and the end was between weeks 39 and 41. The length of the main pollen period was from 22 to 24 weeks. With respect to the magnitudes of the concentrations found, the means during the main pollen period were minimal in 1995 (4.2 grains/m$^3$), average in 1993, 1994, and 1996 (5.6, 5.1, and 5.5 grains/m$^3$, respectively) and maximal in 1997 and 1998 (7.4 and 7.7 grains/m$^3$, respectively).

With respect to the variations that took place within these periods, the behaviour of pollen varied from year to year. Thus the plots of the weekly averages show neither clear periods of increasing or decreasing concentrations, nor peaks that are repeated in the different years studied. The dates and the daily maximum concentrations reached during the year appear between the end of August and the beginning of September in 1993 (31 August, 24 grains/m$^3$), 1995 (27 August, 18 grains/m$^3$), 1996 (30 August, 35 grains/m$^3$), and 1997 (8 September, 52 grains/m$^3$), whereas in the other years they appear in June (22 June 1994, 18 grains/m$^3$; and 14 June 1998, 55 grains/m$^3$).

Table I lists the results of the correlation study between the seasonal rainfall and temperatures, and the parameters relative to the annual pollen amount. Firstly the mean pollen concentration during the main pollen period shows significant positive correlations ($p < 0.05$) with the summer's rainfall. The day of the beginning of the main pollen period

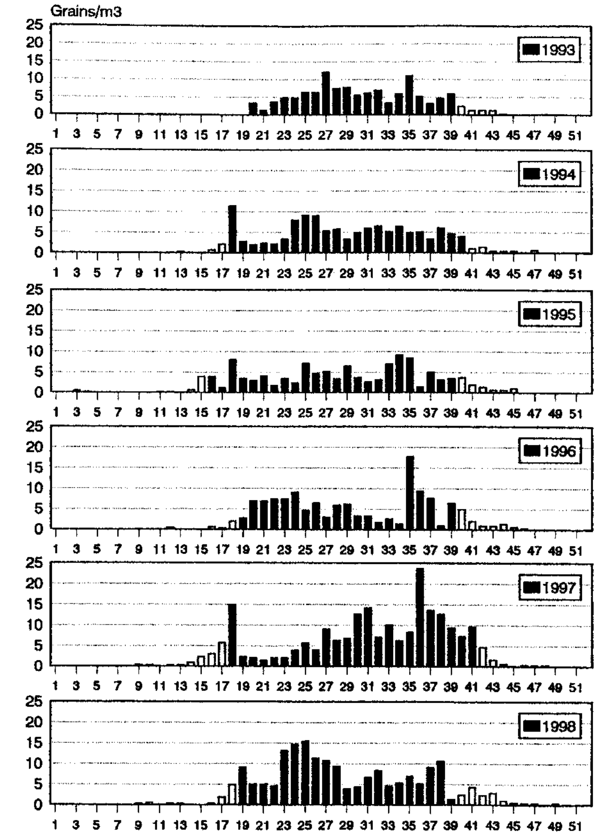


*Fig. 2.* The weekly means of the pollen concentrations in the city of Badajoz (grains/m$^3$). The weeks included in the main pollen period are shown in black.

is directly and significantly related to the autumn and winter rainfall, and the day of the end of the said period to the winter temperature and the summer rainfall. The day, on which the accumulated amount reaches 50%, was not significantly correlated with any of the factors studied.

With respect to the comparison between the mean concentration in the main pollen period of this pollen type in Badajoz and the tomato and maize production figures, the analysis showed there was a positive correlation: the value was r = 0.705, p = 0.1179 in the case of tomato, and r = 0.882, p = 0.0199 for maize. The latter crop therefore showed a significant correlation.

The data relative to the stations of Mérida and Cáceres for the years 1996 – 1998 are plotted together with the Badajoz data in Fig. 3. It is clear firstly that the greatest concentrations are reached in Badajoz, followed by Mérida and then Cáceres. With respect to the variations, one sees that in 1996 and especially in 1997 the three plots followed a similar pattern, coinciding in their peaks and in their decreases. The pattern was also similar in 1998, although in Badajoz in week 25 there was a maximum, with the mean weekly concentrations reaching 20 grains/m$^3$, which was not reflected in the other two stations.

The influence of the values reached by the different meteorological parameters studied on the daily variations in

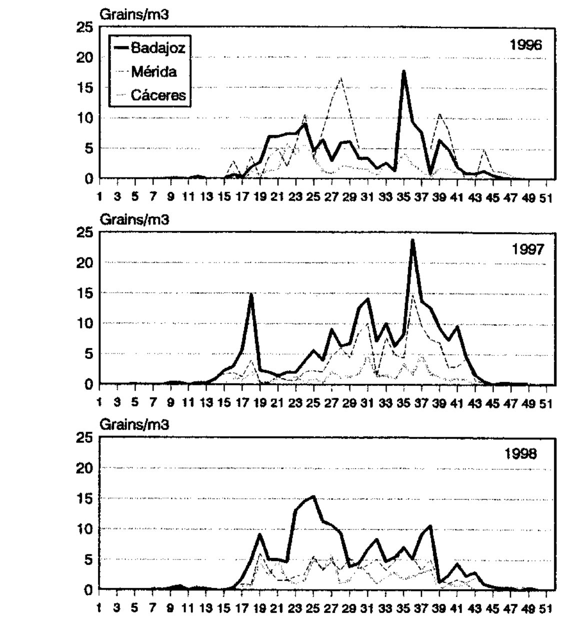


*Fig. 3.* The mean weekly concentrations (grains/m$^3$) in the stations of Badajoz, Mérida, and Cáceres during 1996, 1997, and 1998.

Table I. *Values of the correlations between annual pollen amounts.*

Mean – and the dates reaching 5%, 50% and 95% of pollen concentration of Amaranthaceae and Chenopodiaceae in Badajoz and meteorological parameters (Rain, Temperature). Mean is the annual pollen frequency. The correlation values (r) and the probability of r = 0 (p) are given.

| | | Previous autumn | | Winter | | Spring | | Summer | |
|---|---|---|---|---|---|---|---|---|---|
| | | Rain | Temp. | Rain | Temp. | Rain | Temp. | Rain | Temp. |
| | r | 0,7400 | 0,2600 | 0,1100 | 0,5600 | 0,1900 | −0,6000 | 0,8700 | 0,3300 |
| Mean | p | 0,0903 | 0,6226 | 0,8332 | 0,2500 | 0,7127 | 0,2084 | 0,0251 | 0,5189 |
| | r | 0,8400 | 0,5100 | 0,8400 | −0,2000 | 0,6500 | −0,6800 | 0,2000 | −0,4000 |
| Day 5% | p | 0,0787 | 0,3764 | 0,0751 | 0,7526 | 0,2344 | 0,2060 | 0,7482 | 0,4999 |
| | r | −0,2100 | −0,1500 | −0,0200 | 0,3000 | 0,3900 | 0,0600 | 0,5800 | −0,2800 |
| Day 50% | p | 0,6871 | 0,7733 | 0,9649 | 0,5593 | 0,4473 | 0,9048 | 0,2305 | 0,5892 |
| | r | 0,4400 | 0,4000 | 0,1300 | 0,8800 | −0,1300 | 0,2600 | 0,7400 | 0,21 |
| Day 95% | p | 0,3882 | 0,4308 | 0,8091 | 0,0223 | 0,8073 | 0,6239 | 0,0911 | 0,6968 |

Table II. *Values of the correlations between the daily pollen concentrations and the values of the different meteorological parameters in the years 1993–1998 for Badajoz, and 1997–1998 for Mérida and Cáceres.*

The values of the correlation (r) and probability of r = 0 (p) are given.

| BADAJOZ | 1993 | | 1994 | | 1995 | | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (n = 134) | | (n = 168) | | (n = 171) | | (n = 145) | | (n = 166) | | (n = 152) | |
| Mean Temp. (°C) | 0,44 | 0,0001 | 0,41 | 0,0001 | 0,43 | 0,0001 | 0,12 | 0,1374 | 0,61 | 0,0001 | 0,12 | 0,1383 |
| Max. Temp. (°C) | 0,46 | 0,0001 | 0,43 | 0,0001 | 0,44 | 0,0001 | 0,17 | 0,0339 | 0,63 | 0,0001 | 0,14 | 0,0860 |
| Min. Temp. (°C) | 0,34 | 0,0001 | 0,30 | 0,0001 | 0,37 | 0,0001 | 0,01 | 0,8752 | 0,46 | 0,0001 | 0,05 | 0,5194 |
| Wet (%) | −0,46 | 0,0001 | −0,40 | 0,0001 | −0,41 | 0,0001 | −0,28 | 0,0007 | −0,40 | 0,0001 | −0,24 | 0,0033 |
| Rain (mm) | −0,23 | 0,0063 | −0,20 | 0,0101 | −0,02 | 0,7744 | −0,11 | 0,1927 | −0,19 | 0,0153 | −0,14 | 0,0841 |
| Wind dist. (hm) | −0,16 | 0,0575 | −0,26 | 0,0007 | −0,34 | 0,0001 | −0,28 | 0,0006 | −0,33 | 0,0001 | 0,04 | 0,6660 |
| Calm (hours) | 0,20 | 0,0171 | 0,12 | 0,1267 | 0,28 | 0,0002 | 0,28 | 0,0005 | 0,14 | 0,0734 | 0,02 | 0,8198 |
| Quad. 1 (hours) | 0,52 | 0,0001 | 0,29 | 0,0001 | 0,31 | 0,0001 | 0,41 | 0,0001 | 0,44 | 0,0001 | 0,09 | 0,2892 |
| Quad. 2 (hours) | 0,45 | 0,0001 | 0,29 | 0,0001 | 0,36 | 0,0001 | 0,51 | 0,0001 | 0,29 | 0,0002 | 0,12 | 0,1387 |
| Quad. 3 (hours) | −0,44 | 0,0002 | −0,23 | 0,0023 | 0,00 | 0,9532 | −0,31 | 0,0002 | −0,29 | 0,0002 | −0,28 | 0,0005 |
| Quad. 4 (hours) | −0,17 | 0,0502 | −0,12 | 0,1291 | −0,20 | 0,0123 | −0,39 | 0,0001 | −0,18 | 0,0228 | 0,13 | 0,1036 |

| MÉRIDA | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|
| | (n = 76) | | (n = 168) | | (n = 156) | |
| Mean Temp. (°C) | 0,43 | 0,0001 | 0,67 | 0,0001 | 0,41 | 0,0001 |
| Max. Temp. (°C) | 0,43 | 0,0001 | 0,66 | 0,0001 | 0,42 | 0,0001 |
| Min. Temp. (°C) | 0,39 | 0,0005 | 0,57 | 0,0001 | 0,33 | 0,0001 |
| Wet (%) | −0,35 | 0,0021 | −0,51 | 0,0001 | −0,39 | 0,0001 |
| Rain (mm) | −0,09 | 0,4546 | −0,18 | 0,0191 | 0,02 | 0,7863 |
| Wind dist. (hm) | −0,14 | 0,2207 | −0,17 | 0,0949 | −0,17 | 0,0335 |
| Calm (hours) | 0,19 | 0,1073 | −0,08 | 0,4603 | 0,12 | 0,1252 |
| Quad. 1 (hours) | −0,29 | 0,0104 | 0,04 | 0,7260 | 0,17 | 0,0391 |
| Quad. 2 (hours) | 0,03 | 0,7886 | 0,07 | 0,5144 | 0,31 | 0,0001 |
| Quad. 3 (hours) | 0,24 | 0,0348 | −0,07 | 0,4904 | −0,27 | 0,0008 |
| Quad. 4 (hours) | 0,03 | 0,8175 | 0,07 | 0,5138 | −0,12 | 0,1253 |

| CÁCERES | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|
| | (n = 125) | | (n = 165) | | (n = 103) | |
| Mean Temp. (°C) | 0,15 | 0,1010 | 0,41 | 0,0001 | 0,00 | 0,9777 |
| Max. Temp. (°C) | 0,17 | 0,0610 | 0,39 | 0,0001 | 0,03 | 0,7368 |
| Min. Temp. (°C) | 0,10 | 0,2609 | 0,39 | 0,0001 | −0,04 | 0,6570 |
| Wet (%) | −0,19 | 0,0318 | −0,28 | 0,0003 | −0,09 | 0,3742 |
| Rain (mm) | −0,14 | 0,1222 | −0,13 | 0,1017 | −0,15 | 0,1241 |
| Wind dist. (hm) | −0,18 | 0,0444 | −0,21 | 0,0075 | 0,02 | 0,8816 |
| Calm (hours) | 0,07 | 0,4200 | −0,02 | 0,8293 | 0,05 | 0,5982 |
| Quad. 1 (hours) | 0,22 | 0,0124 | 0,29 | 0,0001 | 0,09 | 0,3883 |
| Quad. 2 (hours) | 0,11 | 0,2336 | 0,19 | 0,0132 | 0,17 | 0,0869 |
| Quad. 3 (hours) | −0,17 | 0,0553 | 0,03 | 0,6830 | −0,00 | 0,9654 |
| Quad. 4 (hours) | −0,09 | 0,3037 | −0,25 | 0,0012 | −0,19 | 0,0612 |

the concentration is reflected in Table II, where the values (*r*) and the significance level (*p*) of the different correlations are given for each year and each station. In the case of Badajoz, the positive influence of the mean, maximum, and minimum temperatures on the concentrations is reflected in the highly significant correlations for all the years except 1996 and 1998. The daily humidity was always significantly negatively correlated with the pollen levels, and this trend was confirmed by the negative influence of the rainfall, which was significant in only three of the years.

The daily wind distance was negatively correlated with pollen levels in all of the years studied, the correlation being highly significant in all the years except 1993 and 1998. Conversely, the duration of the periods of calm air was positively correlated with the concentrations, although less significantly. With respect to the periods when the wind was from the different quadrants, the first two showed a constant and very significant positive influence on the concentrations, while the third had significant negative correlations in all the years except 1995, and the fourth was negative in all cases, although it was not significant in 1993, 1994, and 1998.

For Mérida, the correlations were also positive with respect to the temperatures and negative with respect to humidity, with significance in the three years studied. With respect to the wind related parameters, however, only the distance showed its negative influence significantly in one of the years. The rest of the parameters presented few significant correlations. Also there were even changes in the sign of these correlations. For instance, in the case of winds from quadrant 3, the correlations were significant in 1996 and 1998 but of opposite sign.

In Cáceres, while the negative correlation with humidity found in the other two stations was maintained, with significance at least in 1996 and 1997, there were significant positive correlations with temperatures only in 1997. With respect to the wind too, the negative character of the correlation with the distance travelled reached significance in 1997 and 1998, and, as was the case for Badajoz, winds from quadrant 1 were significantly positively correlated with the concentrations.

Figure 4 shows the results obtained in the four irrigation farms sampled between May and August. At farm 1, pollen presence of these families is observed from the end of June, reaching a maximum at the end of the study period with levels of 90 grains/m$^3$. At farm 2, the pattern was variable: there was pollen present throughout the study period, with several maxima of 50 grains/m$^3$. Farm 3 presented pollen occurrence from the end of May until the end of the study period, with maxima in the first fortnight of July, reaching 140 grains/m$^3$. The greatest concentrations were reached at farm 4. While there appeared pollen present throughout almost all the study period, the greatest concentrations were reached between the beginning of July and the beginning of August, with a maximum of around 400 grains/m$^3$ on July 9.

With respect to the hourly distribution of the measured levels at the three main stations, shows distribution patterns that are similar for all the years studied in the Badajoz station (Fig. 5). Very low levels were measured until 7:00 or 8:00 in the morning, at which time there was a rapid rise in

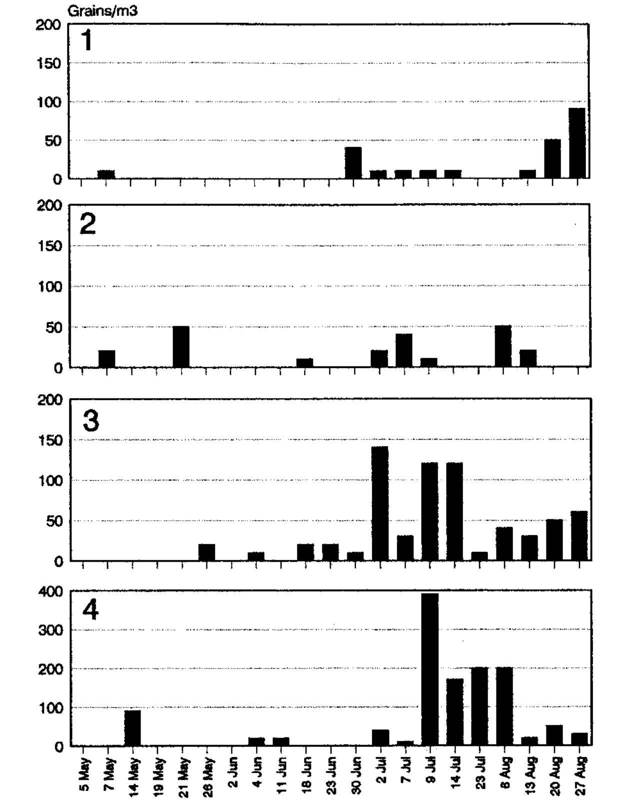


*Fig. 4.* Pollen concentrations (grains/m$^3$) in the four farms sampled on the days on which they were studied.

levels to a maximum between 10:00 and 12:00 hours. After that, the concentrations fell steadily over the course of the afternoon and evening, returning to their minimum levels by between 21:00 and 24:00 hours. In Mérida (Fig. 5), the pattern was similar to Badajoz at least for the years 1997 and 1998, with peaks between 10:00 and 14:00 hours. Cáceres (Fig. 5), however, showed a completely different pattern of behaviour, with little hourly variation, and with broad confidence limits, which imply a lack of homogeneity in the data.

## DISCUSSION

The Amaranthaceae and Chenopodiaceae present a long period of pollen emission, covering more than five months in the three stations of the region. There is certain constancy in the beginning and end of the pollen period, which were maintained from one year to the next and between stations. Differences were observed, however, in the pollen levels at the three localities, with Badajoz presenting the highest concentrations, followed by Mérida and then Cáceres. With reference to the same trap, different years showed different magnitudes of the concentrations reached, as well as differences in the dates on which the maxima were recorded.

The differences found between the pollen levels of the three stations may be explained by the fact that areas of cropland, and especially irrigated land, form the main habitat of these species in the region. Thus the amounts of similar types of pollen at the different localities might depend directly on the abundance of nearby sources. Badajoz, which is most influenced by irrigation land (31.3% of the surrounding area), presents the highest concentrations; then Mérida (11.9% irrigated area); and finally Cáceres (1.8% area under irrigation). This influence of the proximity of sources is supported by the observation that the maximum daily concentrations estimated in the four irrigation farms are all greater than the daily maximum concentrations measured in the stations of Badajoz and Mérida throughout all the 1998 pollination period. This is explained by their character of being source zones, from which the levels fall off with distance. Such an effect is occasionally manifested at distances of just a few kilometers (Fornaciari et al. 1996, Frenz et al. 1997).

The interannual variations recorded at the Badajoz station may be explained from different perspectives. At



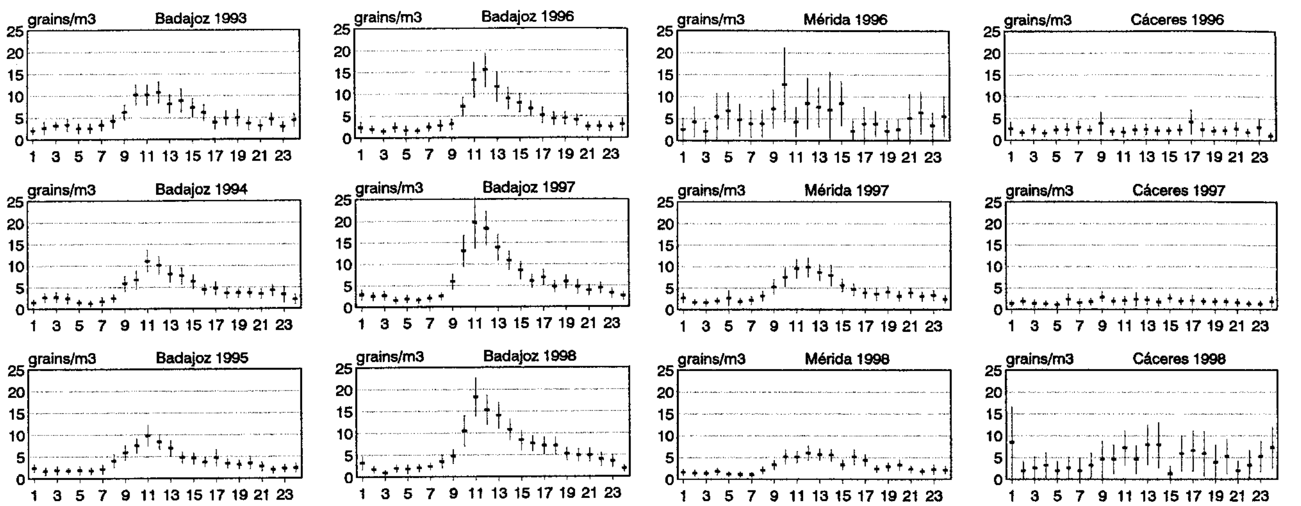


*Fig. 5.* The mean daily concentrations (grains/m$^3$) at the different hours of the day (solar time), and their 95% confidence intervals (column width), for the station of Badajoz from 1993 to 1998 and for the station of Mérida and Cáceres from 1996 to 1998. The plots only take into account those days on which the pollen type appeared.

this station, the mean pollen levels during the pollen period varied between the 4.2 grains/m$^3$ of 1995 to the 7.7 grains/m$^3$ of 1998. We tried to explain firstly these variations on the basis of the values of the rainfall and mean temperature parameters of the different seasons of the year. The result of the analysis was that the autumn and summer rainfall could indeed explain the interannual variations of concentration.

The influence of autumn rainfall on the flowering of herbaceous plants has been amply documented. In regions with hydric stress such as in the present study zone, pollen frequency is influenced by rainfall before flowering (Subiza et al. 1992), while further northwards (Antépara et al. 1995), this stress diminishes the influence of rainfall and declines in favour of the influence of temperatures. It should be borne in mind, however, that in irrigation zones this stress is palliated by the conditions of cultivation, so that its importance is reduced. The explanation of the observed influence of summer rainfall is that by the summer most of the crops have been harvested and irrigation ceases, allowing hydric stress to influence: summer rainfall may therefore prolong the length of the flowering period and thereby the volume of pollen amount. This is confirmed by the significant correlation between summer rainfall and the date by which 95% of the pollination has been reached.

Apart from meteorological factors, the extension of the area devoted to irrigation also seems to be a factor that has to be taken into account. This was corroborated by the significant correlation found between the annual pollen concentrations and the production of crops such as maize. The association between the variations of concentrations of one pollen type, mainly nitrophilous, and the variations in the areas devoted to certain crops has been noted by such authors as Dechamp et al. (1997) who relates the increasing amounts of *Ambrosia* pollen in France with the areas under sunflower.

In areas under irrigation, agricultural activity can alter the meteorological conditions, creating areas of a different microclimate in which the populations of these species would respond differently. This would explain the different responses observed in the study of the concentrations in the four farms situated in irrigation areas. Thus, the joint effect of the high variability of different habitats created by the conditions of farming could be a third factor to explain the different behaviour of the pollen amount of these species in different years. In addition to this variability the great number of species that are included in this pollen type in the region, could also explain the long period of pollen occurrence.

Within the main pollen period, the variation in daily concentrations at the Badajoz station can be explained by the daily values of by variation of the different meteorological parameters. Thus, the correlations found between the concentrations of the pollen types and the three thermal parameters, which were positive and almost always significant, would imply rises in concentrations when higher daily temperatures were recorded.

With respect to rainfall, we observed a lack of significant correlations. Its importance, however, was evident indirectly through the negative correlations that appeared when the concentration data were analyzed against the relative humidity. This factor always gave highly significant negative correlations. As with other anemophilous pollen types, this shows the negative influence of humidity on pollen dispersal.

In Badajoz, the correlations between the concentrations and the wind conditions show firstly how the negative effect of the distance travelled by the wind and, contrarily, the positive effect of the periods of calm air, are consequences of the proximity of the sources to the trap. Secondly, the positive effect of the wind from quadrants 1 and 2 (NE and SE) and the negative effect of quadrants 3 and 4 (SW and NW) are due to the location of the sources in the Vegas Bajas of the Guadiana, situated to the E of the locality of Badajoz. This is further evidence that the irrigation lands are the main source of Amaranthaceae and Chenopodiaceae pollen in this area of the interior of the peninsula.

With respect to relationships with temperatures, the stations of Mérida and Cáceres present a similar behaviour to that of Badajoz, although with less significance in the correlations in the Cáceres case. This may be due to the low concentrations found at this site. The same may be said of the negative relationship found between the concentrations and the relative humidity, and with less significance, with the rainfall. All this is evidence that the action of these meteorological parameters is general in the Region, as has been found in other localities (Herrero & Fraile 1997).

With respect to the wind parameters, it seems that for the three stations, although with different degrees of significance, wind speed acts negatively, which indicates that the greatest concentrations tend to be recorded on days with little air movement. It is in the influence of the different directions of the wind, however, where the behaviour of the three stations is different. Thus, in Cáceres, as was mentioned above for Badajoz, there were positive correlations with winds from quadrants 1 and 2, and negative with those from quadrant 4, while in Mérida the few significant correlations found were of changing sign, implying the relatively small influence of these factors on the concentrations. The relationships found in Cáceres may be explained in the same way as for Badajoz, as a function of the situation of the nearest sources in quadrants 1 and 2, and the non-existence of sources in quadrant 4.

With respect to the dispersal pattern of Amaranthaceae and Chenopodiaceae pollen over the course of the day, this is very notable and repeated in all the years studied in Badajoz and Mérida. The variation in concentrations was very large from the first hours of the day to the hours when the maximum values were reached at around 11:00. This pattern is similar to that found by other authors (Käpylä 1981, Galán et al. 1989, 1991; Cabezudo et al. 1995). It could be interpreted as an indicator of the nearness of this trap to the pollen-emitting sources, so that the rate at which the pollen is released at anthesis is reflected in the rate at which it is captured by the trap. This is in agreement with the postulates of Trigo et al. (1997). In Cáceres, by contrast, there is a total lack of any rate of change during the day, with the grains appearing at any hour with little variation in concentration. Also the confidence intervals are wide, indicative of a certain degree of variability. This is likewise explained by the near absence in the neighbourhood of Cáceres of habitats suited to the growth of these species, so that the observed concentrations may to a great degree reflect the transport of pollen from far-off sources, with the pattern of anthesis no longer being reflected at the location of the trap.

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## REFERENCES

Antépara, I., Fernández, C., Gamboa, P., Jauregui, I. & Miguel, F. 1995. Pollen allergy in the Bilbao area (European Atlantic seaboard climate): pollination forecasting methods. – Clinical and Experimental Allergy 25: 133–140.

Bermejo, D., García, A. M., Sancho, P. & Valero, C. 1998. Aerobiología en Aragón: Estación de Zaragoza (1995–1996). – REA 3: 45–48.

Cabezudo, B., Trigo, M. M. & Recio, M. 1995. Aerobiología de la Costa del Sol. Málaga. – REA 1: 47–49.

Candau, P., Tomás, C., González, F. J., Morales, J. & Pérez, A. M. 1998. Aerobiología en Andalucía: Estación de Sevilla (1995–1996). – REA 3: 41–44.

Cariñanos, P., Galán, C., Alcázar, P. & Domínguez, E. 1998. Aerobiología en Andalucía: Estación de Chirivel (1995–1996). – REA 3: 9–12.

Dechamp, C., Rimet, M. L., Meon, H. & Deviller, P. 1997. Parameters of ragweed pollinations in the Lyon's area (France) from 14 years of pollen counts. – Aerobiologia 13(4): 275–279.

Díaz, C. & Alba, F. 1998. Aerobiología en Andalucía: Estación de Granada (1995–1996). – REA 3: 21–24.

Fernández, J., García, F., Milán, J. M., Soriano, V. & Ferrer, A. 1996. Importance of chenopod-amaranth pollens in the South-East of Spain. – Allergy 31(51): 125.

Fornaciari, M., Bricchi, E., Frenguelli, G. & Romano, B. 1996. The results of 2-year pollen monitoring of an urban network in Perugia, Central Italy. – Aerobiologia 12(4): 219–227.

Frenz, D. A., Melcher, S. E., Murray, L. W. & Sand, R. E. 1997. A comparison of total pollen counts obtained 5.6 km apart. – Aerobiologia 13(3): 205–208.

Galán, C., Cariñanos, P., Alcázar, P., Infante, F., Castro, A. & Domínguez, E. 1998. Aerobiología en Andalucía: Estación de Córdoba (1995–1996). – REA 3: 13–16.

Galán, C., Infante, F., Ruiz de Clavijo, E., Guerra, F., Miguel, R. & Domínguez, E. 1989. Allergy to pollen grains from Amaranthaceae and Chenopodiaceae in Cordoba, Spain. Annual and daily variation of pollen concentration. – Annales of Allergy 63(11): 435–438.

Galán, C., Tormo, R., Cuevas, J., Infante, F. & Domínguez, E. 1991. Theoretical daily variation patterns of airborne pollen in South-West of Spain. – Grana 30: 201–209.

González, F. J., Morales, J., Candau, P., Tomás, C. & Pérez, A. M. 1998. Aerobiología en Andalucía: Estación de Huelva (1995–1996). – REA 3: 25–28.

Herrero, B. & Fraile, C. 1997. Annual variation of airborne pollen in the city of Palencia, Spain, 1990–92. – Grana 36(6): 358–365.

Hirst, J. M. 1957. An automatic volumetric spore trap. – Annals of Applied Biology 39(2): 257–265.

Käpylä, M. 1981. Diurnal variation of non-arboreal pollen in the air in Finland. – Grana 20: 55–59.

MAPA 1982 *a*. Mapa de cultivos y aprovechamientos. Badajoz. – Ministerio de Agricultura, Pesca y Alimentación, Madrid.

MAPA 1982 *b*. Mapa de cultivos y aprovechamientos. Mérida. – Ministerio de Agricultura, Pesca y Alimentación, Madrid.

MAPA 1984. Mapa de cultivos y aprovechamientos. Cáceres. – Ministerio de Agricultura, Pesca y Alimentación, Madrid.

Moreno-Grau, S., Elvira-Rendueles, B., Angosto, J. M., Bayo, J., Moreno, J. & Moreno-Clavel, J. 1998. Aerobiología en Murcia: Estación de Cartagena (1995–1996). – REA 3: 89–92.

Nilsson, S. & Persson, S. 1981. Tree pollen spectra in the Stockholm region (Sweden), 1973–1980. – Grana 20: 179–182.

Silva, I., Muñoz, A. F., Tormo, R. & Recio, D. 1998. Aerobiología en Extremadura: Estación de Badajoz (1995–1996). – REA 3: 9–12.

Subiza, J., Masiello, J. M., Subiza, J. L., Jerez, M., Hinojosa, M. & Subiza, E. 1992. Prdiction of annual variations in atmospheric concentrations of grass pollen. A method based on meteorological factors and grain crop estimates. – Clinical and Experimental Allergy 22: 540–546.

Trigo, M. M., Recio, M., Toro, F. J. & Cabezudo, B. 1997. Intradiurnal fluctuations in airborne pollen in Málaga (S. Spain): A quantitative method. – Grana 36: 39–43.

Trigo, M. M., Recio, M., Toro, F. J. & Cabezudo, B. 1998. Aerobiología en Andalucía: Estación de Málaga (1995–1996). – REA 3: 33–36.