ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 2006, 13, 201–207

# A THREE-YEAR AEROPALYNOLOGICAL STUDY IN ESTEPONA (SOUTHERN SPAIN)

Marta Recio[1], María del Mar Trigo[1], Francisco Javier Toro[1], Silvia Docampo[1], Juan Jesús García-González[2], Baltasar Cabezudo[1]

[1]Department of Plant Biology, University of Malaga, Malaga, Spain
[2]Allergy Section, Complejo Hospitalario Carlos Haya, Malaga, Spain

Recio M, Trigo MM, Toro FJ, Docampo S, García-González JJ, Cabezudo B: A three-year aeropalynological study in Estepona (southern Spain). *Ann Agric Environ Med* 2006, **13**, 201–207.

**Abstract:** An aeropalynological study was carried out in the atmosphere of Estepona, a very popular tourist resort situated in the "Costa del Sol", (southern Spain) based on the data obtained during a three year air-monitoring programme (March 1995 to March 1998) using a volumetric pollen trap. The 34 taxa that reached a 10-day mean air pollen concentration equal to or greater than 1 grain of pollen/m$^3$ of air are reflected in the calendar. The first 10 taxa, in order of abundance, were: *Cupressaceae*, *Olea europaea*, *Quercus*, *Poaceae*, *Urticaceae*, *Plantago*, *Pinus*, *Chenopodiaceae-Amaranthaceae*, *Ericaceae* and *Castanea*, the first 3 of which accounted for approximately 56% of the annual total pollen count. The greatest diversity of pollen type occurred during spring, while the highest pollen concentrations were reached from February-June, when approximately more than 80% of the annual total pollen was registered. The lowest concentrations were obtaining during January, August and September. The annual quantity of pollen collected, the intensity and the dates on which the maximum peaks were recorded differed for the 3 years studied, which can be explained by reference to various meteorological parameters, especially rainfall and temperature. The pollen calendar spectrum is typically Mediterranean and similar to those of nearby localities, in which many pollen types are represented and the long tails indicating long flowering periods.

**Address for correspondence:** Dra. María del Mar Trigo, Departamento de Biología Vegetal, Facultad de Ciencias, Universidad de Málaga, Campus de Teatinos s/n, E-29071 Málaga, Spain. E-mail: aerox@uma.es

**Key words: aerobiology, airborne pollen, pollen calendar, pollen spectrum, allergy, Spain.**

## INTRODUCTION

The biological particles present in the atmosphere vary from place to place and from day to day, not being constant throughout the year. They mainly depend on the season, the kind of vegetation growing in surrounding places, plant phenology and meteorological conditions. Many of the airborne particles, especially pollen, are important aeroallergens that may affect sensitive people, and thus pollen calendars are very useful tools for the study and prevention of pollinosis.

The station at Estepona forms part of the Spanish Aerobiology Network (REA) and covers information from a wide territory situated between the coastal aerobiological stations of Cadiz and Malaga. These all are coastal localities, Estepona being situated in a more natural environment that the others, which are capitals of their provinces. Regarding pollen allergy, clinical studies

Received: 27 July 2005
Accepted: 20 July 2006

have been carried out in the province of Malaga [15, 16], where it was observed that there existed a higher prevalence to some pollen types in the country areas, especially to *Parietaria* pollen. This paper presents a thorough study of the pollen content of the atmosphere of Estepona and its fluctuations throughout the year. The study had 3 objectives: first, to analyse the global behaviour of airborne pollen in the atmosphere of this locality, a very popular tourist resort situated in the "Costa del Sol", southern Spain, by elaboration of a pollen calendar of the area in order to better understand the incidence of pollen allergy; second, to discuss any differences detected between the different years studied and their relationship with meteorological variables and, finally, to compare the results obtained with those registered at nearby sampling stations.

## MATERIALS AND METHODS

Estepona lies in the south of the Iberian Peninsula (Fig. 1), on the shores of the Mediterranean Sea (36º25' N, 5º9' W), situated 90 km west of the city of Malaga, the provincial capital. During the period in which the samples were taken, Estepona was the most meridional aero-biological station in Europe and the nearest to north Africa, where some of the pollen types recorded originate [4]. This locality is partially hemmed in by the mountains of the Sierra Bermeja, which are very close to the sea, extending eastwards along a narrow coastal strip and opening westwards in a wide plain, the "Campo de Gibraltar".

The natural vegetation of the area is represented by forests of cork-oak and their more degraded stages, although in many places the natural vegetation has been replaced by pines. As in any urban area, ornamental flora is well represented in Estepona. Among the most abundant tree species found, there can be cited the plane tree (*Platanus x hispanica* Miller ex Münchh), white mulberry (*Morus alba* L.), tipuana (*Tipuana speciosa* Benth.), cypress, s. l. (*Cupressus sempervirens* L., *C. arizonica* E.L. Greene, *Thuja orientalis* L. and others) and jacaranda (*Jacaranda mimosaefolia* D. Don). Other very common and well-represented elements in the surrounding places are plants that constitute the ruderal vegetation: species of the genera *Urtica*, *Parietaria*, *Plantago*, *Chenopodium*, *Amaranthus*, and other weeds and grasses.

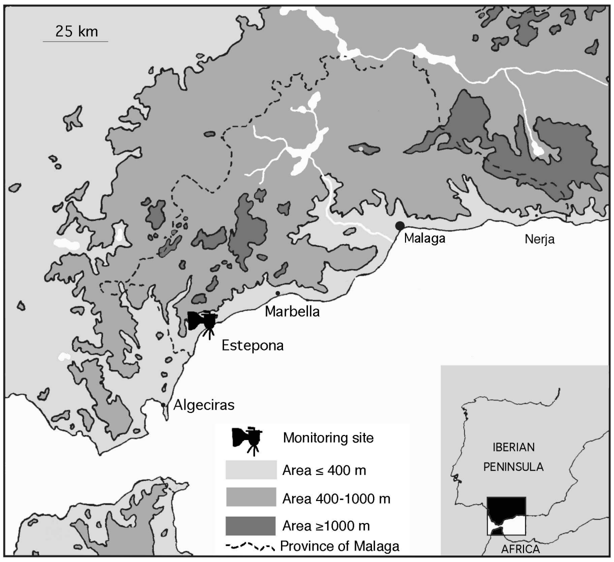


**Figure 1.** Monitoring site and geographical features of area studied.

Estepona has a coastal Mediterranean climate, characterised by hot dry summers and mild winters (Tab. 1). The mean annual temperature is 18ºC, January being the coldest month (13ºC) and August the hottest (24.2ºC). The thermal amplitude is 11.2 ºC, a low value compared with those registered in other continental areas situated further inland. This is due to the influence of the sea, which acts as a regulator, evening out temperature fluctuations. The annual average rainfall is 547 mm, July

**Table 1.** Monthly and annual rainfalls (mm) and temperature values (ºC) obtained at stations of Estepona Sporting club (1995) and Marbella Puerto Banús (1996-1997), and mean values obtained during previous period (1972-1995) at the former meteorological station.

| | | J | F | M | A | M | J | J | A | S | O | N | D | Annual values |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | Tm | 11.8 | 13.1 | 13.2 | 14.4 | 17.7 | 19.5 | 22 | 23 | 19.4 | 18.6 | 16.2 | 13.7 | 16.8 |
| | R | 45 | 18.5 | 14 | 15 | 4 | 22 | 4.5 | 0 | 1.5 | 0 | 59 | 298 | 481.5 |
| | NR | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 0 | 3 | 0 | 5 | 22 | 43 |
| 1996 | Tm | 14.5 | 13.1 | 14.5 | 16.7 | 17.8 | 21.6 | 22.9 | 22 | 20.4 | 18.1 | 15.5 | 13.7 | 17.6 |
| | R | 337.7 | 38.6 | 141.3 | 63.9 | 114.9 | 0 | 0.1 | 19.6 | 45.1 | 84 | 117.5 | 410 | 1372.7 |
| | NR | 22 | 6 | 9 | 5 | 10 | 0 | 1 | 1 | 2 | 1 | 5 | 19 | 81 |
| 1997 | Tm | 13.2 | 14.8 | 16 | 17.7 | 19.2 | 20.7 | 22 | 23.4 | 22.8 | 20.8 | 17.2 | 14.5 | 18.5 |
| | R | 228.9 | 0.2 | 0 | 32.2 | 48.9 | 11.1 | 0 | 1.5 | 181 | 14.1 | 154 | 154.2 | 826.1 |
| | NR | 13 | 1 | 0 | 7 | 7 | 3 | 0 | 1 | 6 | 5 | 13 | 12 | 68 |
| 1972-1995 | M | 28 | 24 | 27 | 29 | 32 | 40 | 41 | 42 | 36 | 33 | 30 | 24 | 42 |
| | Tm | 13 | 13.4 | 14.8 | 15.9 | 18.6 | 20.9 | 23.6 | 24.2 | 22.3 | 19.3 | 16.2 | 14 | 18 |
| | m | - | 1.5 | 2 | 8 | 8 | 6 | 11.5 | 15 | 10 | 8 | 5 | 4 | 1.5 |
| | R | 78.4 | 71.3 | 49.3 | 43.1 | 22 | 4.3 | 1.8 | 7.1 | 16.7 | 61.5 | 105.2 | 86.6 | 547.3 |

Tm - mean temperature, R - rainfall, NR - number of days with rainfall, M - maximum temperature, m - minimum temperature.

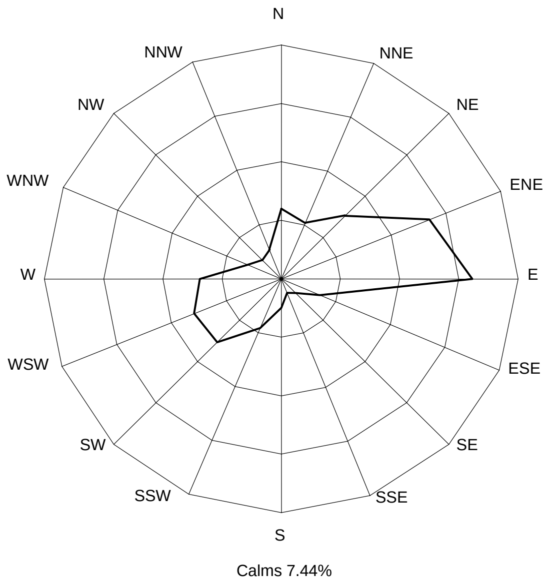


**Figure 2.** Annual mean frequency of wind directions observed at Estepona Sporting Club meteorological station 1989-1995 (mean values).

being the driest month (1.8 mm) and November the wettest (105.2 mm). The rain falls mainly during winter and autumn and is frequently torrential, so that quantities of water similar to the daily total can be registered in a matter of minutes. Another very important characteristic of the rainfall in this area is its irregularity, substantial interannual differences being the norm.

As in other nearby coastal localities of similar geographic characteristics, the predominant winds in Estepona are easterly and westerly (Fig. 2), due to the fact that the locality is partially surrounded by mountains. Wind direction plays an important role in the atmospheric pollen content because when winds blow from the sea (E), they partially clean the atmosphere, sweeping the pollen towards the interior. However, winds blowing from inland (W) are capable of bringing with them large amounts of pollen grains from remote places. On the other hand, the proximity of Estepona to the Straits of Gibraltar means it has short periods of calm, representing about 7% of the total.

Samplings were carried out using a Hirst type volumetric pollen trap [19], a 7 day recorder, model VPPS 2000, by Lanzoni s.r.l. The pollen trap was installed on the roof of the "Ramón García" school, approximately 15 m above ground level. This school is situated in the western-central part of the city, in an open area with no nearby buildings to obstruct air circulation. The sampler operated continuously from 3 March 1995-5 April 1998, aspirating a flow of 10 l per minute. Counts of the different pollen types were made with the aid of a light microscope, 4 longitudinal sweeps per slide being made using a ×40 objective (0.45 mm microscopic field) according to the methodology proposed by REA [6, 7, 9]. The pollen concentrations are expressed as the number of pollen grains/m$^3$ of air, the mean daily values being used for the elaboration of tables and graphs.

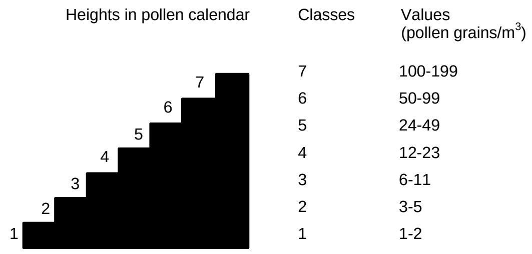


**Figure 3**. Ten-day mean pollen count classes depicted by growth heights column in pictorial calendar.

The pollen calendar was constructed following Spieksma's model [32], which transforms 10-day mean pollen concentrations into a series of classes according to Stix and Ferretti [33], and represented in pictogram form by columns of increasing height (Fig. 3). The pollen concentration values used in the calendar are the means of 10 consecutive days, each 10-day period corresponding approximately to a third of a month. Since samplings began on 3 March 1995 and finished on 5 April 1998, the calendar values correspond to the means of 3 years, except in the case of March, for which the values correspond to the mean of 4 years. The order of the different taxa in the pollen calendar follows the order in which the maximum peaks appear, and only those taxa which showed a minimum 10-day mean of 1 pollen grain/m$^3$ are included.

The meteorological data used are those of the stations at Estepona Sporting Club (1995) and Marbella-Puerto Banús (1996-1997), situated 15 km east of the sampling site. All the data were provided by the Meteorological Centre of Eastern Andalusia.

Finally, for a global appreciation of the incidence of the different taxa in the atmosphere of Estepona, we constructed a Table containing the values reached by the pollen types in the different years, as well as the annual mean and mean annual percentage. Graphs obtained for the total pollen during the monitoring period were also drawn.

## RESULTS

The mean annual pollen count obtained during the period studied (1995-1997) was 25,257 pollen grains, the lowest value being recorded in 1995 and the highest in 1997 (Tab. 2). During these years, the greatest concentrations were always detected from February-June, a period in which more than 80% of the total annual pollen was collected, March, April and May being the months in which the highest peaks occurred.

Based on the mean annual total pollen count, the 10 principal taxa were: *Cupressaceae*, *Olea europaea*, *Quercus*, *Poaceae*, *Urticaceae*, *Plantago*, *Pinus*, *Chenopodiaceae-Amaranthaceae*, *Ericaceae* and *Castanea*, in order of abundance. The first 3 taxa (*Cupressaceae*, *Olea europaea* and *Quercus*) were responsible for 55.7% of the annual total, so any change recorded in their quantities would have a substantial effect on the annual total count.

**Table 2.** Annual values and percentage obtained for different taxa at the sampling station in Estepona during the period studied.

| Taxa | 1995 | 1996 | 1997 | Annual mean | Mean annual percentage |
|---|---|---|---|---|---|
| *Alnus* | *4* | 68 | 24 | 32 | 0.13 |
| *Apiaceae* | 26 | 186 | 93 | 102 | 0.40 |
| *Artemisia* | 101 | 185 | 86 | 124 | 0.49 |
| *Asteraceae** | 93 | 272 | 133 | 166 | 0.65 |
| *Betula* | 46 | 24 | 26 | 32 | 0.13 |
| *Cannabis* | 43 | 28 | 30 | 34 | 0.13 |
| *Castanea* | 212 | 213 | 536 | 320 | 1.27 |
| *Casuarina* | 48 | 42 | 19 | 36 | 0.14 |
| *Cruciferae* | 64 | 85 | 25 | 58 | 0.23 |
| *Cupressaceae* | *1,264* | 5,105 | 9,178 | 5,182 | 20.52 |
| *Cyperaceae* | 54 | 83 | 114 | 84 | 0.33 |
| *Chen.-Amar.* | 396 | 498 | 517 | 470 | 1.86 |
| *Echium* | 50 | 219 | 87 | 119 | 0.47 |
| *Ericaceae* | 297 | 105 | 629 | 344 | 1.36 |
| *Fraxinus* | *78* | 98 | 127 | 101 | 0.40 |
| *Ligustrum* | 6 | 21 | 59 | 29 | 0.11 |
| *Mercurialis* | *64* | 109 | 43 | 72 | 0.29 |
| *Morus* | 234 | 161 | 146 | 180 | 0.71 |
| *Myrtaceae* | 227 | 259 | 431 | 306 | 1.21 |
| *Olea europaea* | 2,599 | 2,286 | 8,637 | 4,507 | 17.84 |
| *Palmae* | 240 | 238 | 157 | 212 | 0.84 |
| *Pinus* | *666* | 539 | 1,043 | 749 | 2.96 |
| *Pistacia* | 92 | 87 | 142 | 107 | 0.42 |
| *Plantago* | 335 | 1,220 | 965 | 840 | 3.33 |
| *Platanus* | 1,177 | 111 | 136 | 475 | 1.88 |
| *Poaceae* | 717 | 3,172 | 4,033 | 2,641 | 10.46 |
| *Populus* | *45* | 59 | 52 | 52 | 0.20 |
| *Quercus* | 3,642 | 1,357 | 8,133 | 4,377 | 17.33 |
| *Ricinus* | *16* | 14 | 7 | 12 | 0.05 |
| *Rumex* | 117 | 395 | 197 | 236 | 0.93 |
| *Salix* | 16 | 21 | 40 | 26 | 0.10 |
| *Typha* | 27 | 5 | 15 | 16 | 0.06 |
| *Ulmus* | *17* | 28 | 11 | 19 | 0.07 |
| *Urticaceae* | *1,331* | 4,126 | 993 | 2,150 | 8.51 |
| Other pollen types | 1,204 | 1,085 | 853 | 1,047 | 4.15 |
| Total | *15,551* | 22,504 | 37,717 | 25,257 | 100.00 |

*Excluding *Artemisia*.
Due to the sampling started in early March, the values corresponding to some taxa such as *Alnus*, *Cupressaceae*, *Fraxinus*, *Mercurialis*, *Pinus*, *Populus*, *Salix*, *Ulmus* and *Urticaceae* could be infravalued during 1995 (in italics).

Interannual differences can be seen in the seasonal behaviour of the pollen (Fig. 4), 1997 being the year in which the highest levels of airborne pollen were reached, with weekly means of up to 700 pollen grains/m$^3$. In this year, too, the peaks occurred earlier (February). On the other hand, 1995 and 1996 were more similar with the first peak (up to 325 pollen grains/m$^3$) occurring in March.

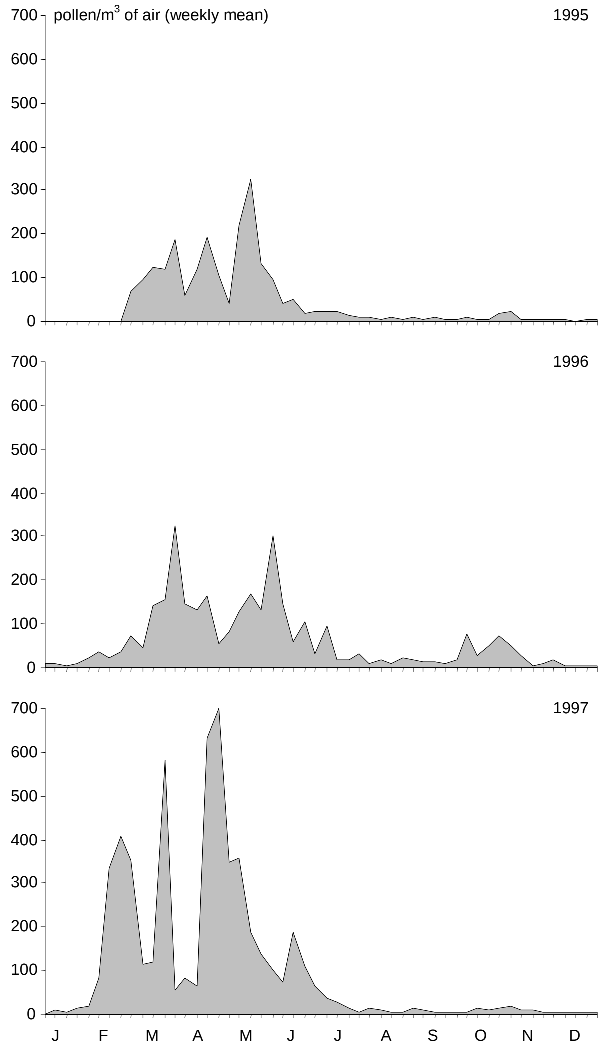


**Figure 4.** Mean weekly concentrations of total pollen during sampling years.

As the year progressed, several pollen peaks were detected, principally due, with little differences from year to year, to *Cupressaceae* and *Urticacaceae* in February-March, *Quercus* in March-April and *Quercus*, *Olea europaea* and *Poaceae* in May-early June. In addition, a small peak was sometimes detected in autumn due to the pollination of some autumn-flowering species such as *Cupressaceae*, *Casuarina* (Australian pine) and *Artemisia* (mugworth).

As already stated, the pollen calendar only reflects the taxa that showed a 10-day mean pollen count equal to or greater than 1 pollen grain/m$^3$. Thirty four taxa are therefore included in the calendar (Fig. 5), although it should not be forgotten that other pollen grains from entomophilous species and other transported from long distances by the wind were also recorded in very low concentrations.

In Estepona, the period with the greatest diversity of pollen types is spring, while winter and autumn show

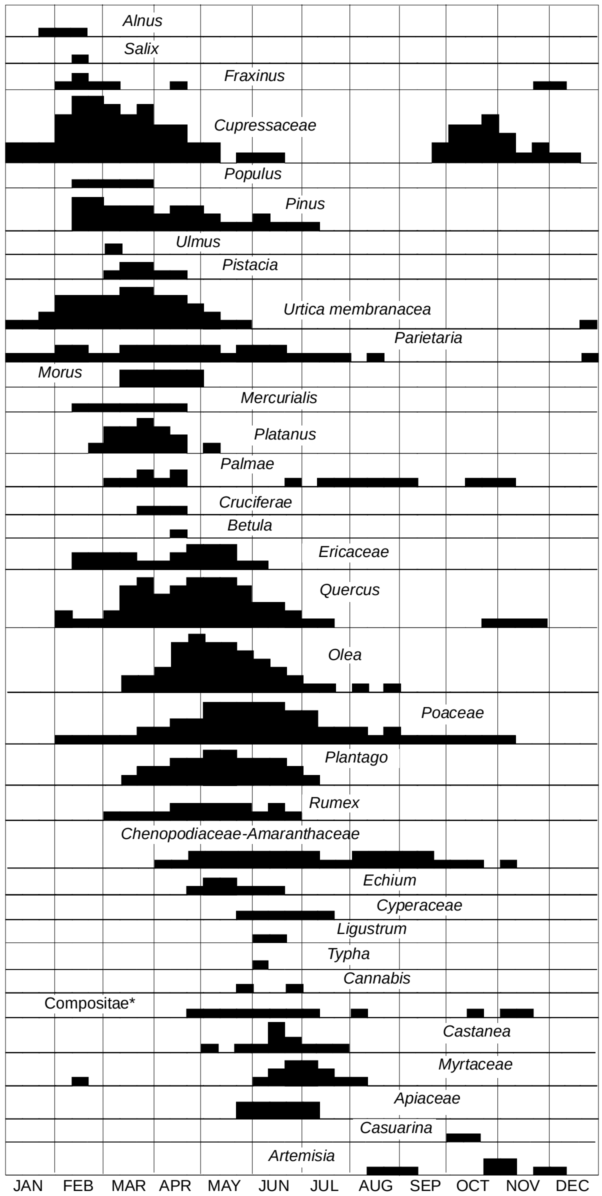


**Figure 5.** Pollen calendar for Estepona, using data obtained from March 1995-March 1998. *Excluding *Artemisia*.

lower numbers. Most taxa show seasonal behaviour: *Cupressaceae* and *Pinus* are typical winter pollen types, as are *Alnus*, *Salix*, *Fraxinus*, *Populus* and *Ulmus*. In late winter-early spring, the presence of *Pistacia*, *Urticaceae* (especially *Urtica membranacea*), *Morus*, *Mercurialis*, *Platanus* and *Cruciferae* is noticeable. *Betula*, *Rumex*, *Quercus*, *Plantago* and *Olea* appear mainly in spring, and others such as *Apiaceae*, *Thypha*, *Castanea*, *Ligustrum*, *Cannabis* and *Myrtaceae* must be considered summer taxa. Finally, some pollen types such as *Casuarina* and some species of *Artemisia* are only detected in autumn. On the other hand, there are some taxa with long pollination periods, such as *Urtica membranacea*, *Chenopodiaceae-Amaranthaceae* and *Poaceae*, that are present in the atmosphere of the locality for more than 6 months and sometimes throughout the year.

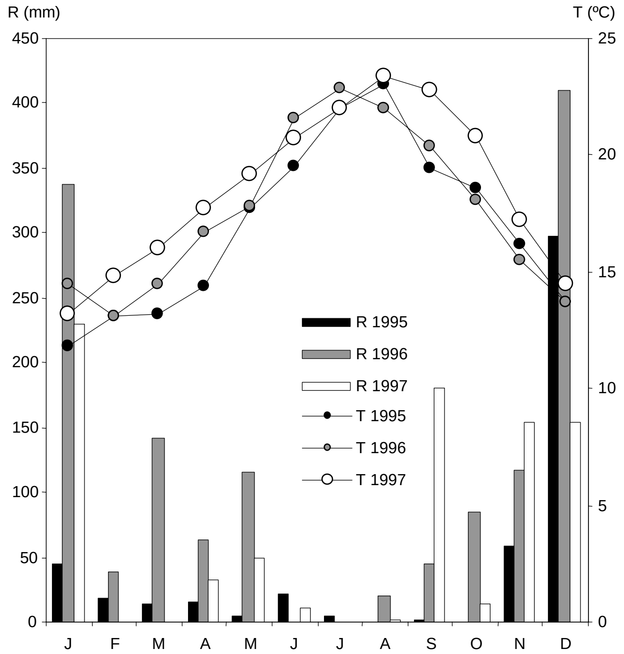


**Figure 6.** Mean monthly temperature and rainfall behaviour during sampling years.

## DISCUSSION

As many authors have observed [3, 5, 11, 12, 21, 24, 36, among others], the flowering, pollination and dispersion of pollen grains are closely related to variations in the meteorological parameters, especially rainfall and temperature. In our case, too, some of the interannual differences observed can be explained by the meteorological conditions registered during the years studied (Tab. 1, Fig. 6). In general, the rainfall pattern was very irregular, 1995 being a dry year with only 481.5 mm of rain, 62% of which fell in December. Futhermore, the year prior to the start of the study (1994) had been the driest for 50 years. In contrast, 1996 was wetter, with 1,372.7 mm being collected, which is 2.5 times higher than the yearly average. The year 1997 showed intermediate values but with an extremely dry spring and summer (only 93.9 mm collected from February-August inclusive) followed by a rainy autumn. The annual mean temperature during the monitoring period ranged from 16.8ºC in 1995 to 18.5ºC in 1997, the warmest year.

Some authors have demonstrated that the total quantity of pollen collected during a year, in the Mediterranean area, is related with the rainfall recorded from the autumn of the previous year to the spring of the year in question [24, 28, 30]. The scarcity or not of rain affects plant growth, and therefore pollen production. In our case, the autumn of 1994 and winter of 1995 were exceptionally dry, which gave rise to a year in which the quantities of pollen were the lowest for the period studied, especially in the case of herbaceous species, *Poaceae* (grasses), *Plantago* and *Urticaceae* (Figs 4 and 6). In 1996 and 1997, both of which had a wetter pre-season period, the pollen concentrations registered were higher, especially in

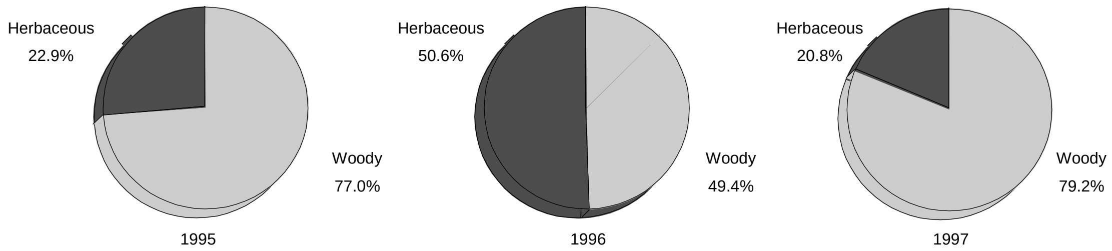


**Figure 7.** Annual percentage of pollen from woody and herbaceous plants recorded during sampling years.

1997, when the highest peaks were detected. These peaks were mainly favoured by the increase in pollen from tree species such as *Cupressaceae*, *Olea europaea* and *Quercus* (Tab. 2), as reflected in the annual total. Similar behaviour was detected during this year in many aerobiological stations in southern Spain [35].

The percentage of pollen grains from woody species was higher in 1995 and 1997 than in 1996 (Fig. 7), a difference which could be explained by the different responses of herbaceous and woody plants to the drought of 1995 and the years prior to the start of the study. In 1996, the plentiful rainfall increased the flowering and the pollen production of herbaceous species, while woody plants invested a considerable part of their energy in recovering their vegetative shoots. During 1997, the pollen from woody species, already recovered from drought stress, reached its highest percentage (79.2%), while the percentage of pollen from herbaceous plants was the lowest of the period studied (20.8%) due to the long dry period (February-September) that did not favour their development.

In absolute terms, the pollen of herbaceous taxa (*Apiaceae*, *Asteraceae*, *Cyperaceae*, *Chenopodiaceae-Amaranthaceae*, *Echium*, *Plantago*, *Poaceae* and *Rumex*) reached the lowest values in 1995 (Tab. 2). The woody taxa (*Castanea*, *Cupressaceae*, *Ericaceae*, *Fraxinus*, *Morus*, *Myrtaceae*, *Olea europaea*, *Pinus*, *Pistacia*, *Quercus* and *Salix*) presented their highest pollen concentrations of the studied period in 1997. Similar behaviour for the pollen from herbaceous and woody plants was obseved by Tavira *et al.* [34] in the city of Caceres during the same period. The pollen of *Platanus* constitutes an exception. These cultivated trees, which flower in March, suffered a drastic pruning in February 1996, the total annual pollen count decreasing from 1,177 in 1995 to 111 in 1996 and 136 in 1997.

As regards temperature, many authors have suggested that the cumulative temperature is responsible for the beginning of the main pollen season of different taxa [2, 10, 13, 14, 17, 20, 22, 25, 29]. As mentioned above, 1997 was the warmest year and the mild winter temperatures brought forward the first peak, which was detected in February, while in the previous years it was detected in March.

The pollen spectrum and seasonal behaviour of the different taxa included in the pollen calendar were similar to those of the nearby aerobiological sampling station of Malaga [26, 27, 37]. The main difference was the higher incidence of some pollen types such as *Urticaceae* (especially *Urtica membranacea*), *Ericaceae*, *Quercus* and *Castanea* in Estepona and *Casuarina*, *Olea europaea* and *Chenopodiaceae-Amaranthaceae* in Malaga. Nevertheless, the annual total pollen counts were always higher in Malaga than in Estepona during the period studied.

Comparing the pollen calendar of Estepona with others elaborated by different authors for localities situated in southern Spain [1, 8, 18, 31], we can observe that, in general, the behaviour followed by the different taxa is broadly similar, but with local differences. These differences are due to the species composition of the local flora that mainly affected the quantities collected by the different sampling stations, although little differences existed as regards the pollen spectrum.

Finally, the pollen calendar spectrum is typically Mediterranean, in which many species are represented and where the massive presence of pollen of *Olea europaea* (olive) and *Quercus* (cork oak, holm oak and kermes oak) as distinctive species can be observed. In addition, there is a low incidence of *Betula*, which appears more frequently in pollen calendars of central and northern Europe. The incidence of *Artemisia*, an important allergenic taxon in Eastern Europe, is also low. On the other hand, it can be seen that the graphs have long tails, which points to long pollination periods, a characteristic of Mediterranean pollen calendars [23, 32]. This is due to the mild climate and the gradual flowering of species that grow at different heights since Andalusia and, in general, the Mediterranean basin, is a mountainous area with mountains close to the sea.

## CONCLUSIONS

Estepona presents a typically Mediterranean pollen calendar spectrum, similar to those of nearby localities, in which many pollen types are represented, the long tails indicating long flowering periods.

The highest concentrations of pollen in the atmosphere of Estepona are detected from February to June, when approximately more than 80% of the pollen is registered, being *Cupressaceae*, *Olea europaea*, *Quercus*, *Poaceae*, *Urticaceae*, *Plantago*, *Pinus*, *Chenopodiaceae-Amaranthaceae*, *Ericaceae* and *Castanea* the most important pollen types, in abundance order.

The annual quantities of pollen collected during the different years studied are related with meteorological parameters, especially the rainfall registered during the preseason period.

**Acknowledgements**

The authors acknowledge the funding of this project by the Ministerio de Educación y Ciencia of Spain (DGICYT Proyect PB92-0814-02) and the Comisión Interministerial de Ciencia y Tecnología (CICYT Project AMB97-0457-CO7-05) and the help given by the Consejerías de Salud and Educación of the Junta de Andalucía.

## REFERENCES

1. Alba F: *Caracterización polínica de la atmósfera de Granada: Relación con las variables meteorológicas y modelos predictivos de los táxones más alergógenos*. PhD Thesis, Department of Botany, University of Granada, Granada 1997.

2. Alba F, Díaz de la Guardia C: The effect of air temperature on the starting dates of the *Ulmus*, *Platanus* and *Olea* pollen seasons in the SE Iberian Peninsula. *Aerobiologia* 1998, **14**, 191-194.

3. Bianchi M, Pacini E: Explosive anther dehiscence in *Ricinus communis* L. involves cell wall modification and relative humidity. *Int J Plant Sci* 1996, **157**, 739-745.

4. Cabezudo B, Recio M, Sánchez-Laulhé JM, Trigo MM, Toro FJ, Polvorinos F: Atmospheric transportation of marihuana pollen from North Africa to the Southwest of Europe. *Atmos Environ* 1997, **31**, 3323-3328.

5. Díaz de la Guardia C, Alba F, Girón F, Sabariego S: An aerobiological study of *Urticaceae* pollen in the city of Granada: correlation with meteorological parametres. *Grana* 1998, **37**, 298-304.

6. Domínguez E: The Spanish aerobiology Network. *Aerobiologia* 1992, **8**, 45-46.

7. Domínguez E: La Red Española de Aerobiología (REA). *Rea* 1995, **1**, 3-7.

8. Domínguez E, Ubera JL, Galán C: *Polen alergógeno de Córdoba*. Publicaciones del Monte de Piedad y Caja de Ahorros de Córdoba, Cordoba 1984.

9. Domínguez E, Galán C, Villamandos F, Infante F: Handling and evaluation of the data from the aerobiological sampling. *Monograf REA/EAN* 1991, **1**, 1-18.

10. Frenguelli G, Spieksma FThM, Bricchi E, Romano B, Mincigrucci G, Nikkels AH, Dankaart W, Ferranti F: The influence of air temperature on the starting dates of the pollen season of *Alnus* and *Populus*. *Grana* 1991, **30**, 196-200.

11. Galán C, Fuillerat MJ, Comtois P, Domínguez-Vilchez E: Bioclimatic factors affecting daily *Cupressaceae* flowering in southwest Spain. *Int J Biometeorol* 1998, **41**, 95-100.

12. Galán C, Alcázar P, Cariñanos P, García H, Domínguez-Vilchez E: Meteorological factors affecting daily *Urticaceae* pollen counts in southwest Spain. *Int J Biometeorol* 2000, **43**, 191-195.

13. Galán C, García-Mozo H, Cariñanos P, Alcázar P, Domínguez-Vilchez E: The role of temperature in the onset of the *Olea europaea* L. pollen season in southwestern Spain. *Int J Biometeorol* 2001, **45**, 8-12.

14. Galán C, García Mozo H, Vázquez L, Ruíz L, Díaz de la Guardia C, Trigo MM: Heat requirement for the onset of the *Olea europaea* L. pollen season in several sites in Andalusia and the effect of the expected future climate change. *Int J Biometeorol* 2005, **49**, 184-188.

15. García-González JJ: *Calendario polínico de la ciudad de Málaga: Prevalencia de tests cutáneos*. PhD Thesis, Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Malaga, Malaga 1994.

16. García-González JJ, Vega-Chicote JM, Rico P, Moscoso del Prado J, Carmona MJ, Miranda A, Pérez-Estrada M, Martín S, Cervera JA, Acevez JM: Prevalence of atopy in students from Malaga, Spain. *Ann Allergy Asthma Immunol* 1998, **80**, 237-244.

17. García-Mozo H, Galán C, Gómez-Casero MT, Domínguez-Vilchez E: A comparative study of different temperature accumulation methods for predicting the start of the *Quercus* pollen season in Cordoba (Southwest Spain). *Grana* 2000, **39**, 194-199.

18. González-Romano ML, Candau P, González-Minero FJ: Pollen calendar of Seville and its relation to allergies. *J Invest Allergol Clin Inmunol* 1992, **2**, 323-328.

19. Hirst JM: An automatic volumetric spore trap. *Ann Appl Biol* 1952, **39**, 257-265.

20. Jato MV, Frenguelli G, Rodríguez-Rajo FJ, Aira MJ: Temperature requirements of *Alnus* pollen in Spain and Italy (1994-1998). *Grana* 2000, **39**, 240-245.

21. Jato MV, Rodríguez-Rajo FJ, Seijo MC: *Pinus* pollen in the atmosphere of Vigo and its relationship to meteorological factors. *Int J Biometeorol* 2000, **43**, 147-153.

22. Jato MV, Dopazo A, Aira MJ: Airborne pollen data of *Platanaceae* in Santiago de Compostela (Iberian Peninsula). *Aerobiologia* 2001, **17**, 143-149.

23. Nilsson S, Spieksma FThM: *Traveller's Allergy Service Guide.* Swedish Museum of Natural History and Fisons Sweden AB, Skärholmen 1992.

24. Recio M, Cabezudo B, Trigo MM, Toro FJ: *Olea europaea* pollen in the atmosphere of Malaga (S. Spain) and its relationship with meteorological parameters. *Grana* 1996, **35**, 308-313.

25. Recio M, Cabezudo B, Trigo MM, Toro FJ: Accumulative air temperature as a predicting parameter for daily airborne olive pollen (*Olea europaea* L.) during the pre-peak period in Malaga (Western Mediterranean area). *Grana* 1997, **36**, 44-48.

26. Recio M, Cabezudo B, Trigo MM, Toro FJ: Pollen calendar of Malaga (Southern Spain), 1991-1995. *Aerobiologia* 1998, **14**, 101-107.

27. Recio M, Trigo MM, Toro FJ, Cabezudo B: Aerobiología en Andalucía: Estación de Málaga (1997). *Rea* 1998, **4**, 41-44.

28. Recio M, Trigo MM, Toro FJ, Cabezudo B: Airborne pollen of *Quercus* in Malaga (S. Spain) and its relationship with meteorological parameters. *Acta Bot Malacitana* 1999, **24**, 77-88.

29. Rodríguez-Rajo FJ, Frenguelli G, Jato MV: The influence of air temperature on the starting date of *Quercus* pollination in the South of Europe. *Grana* 2003, **42**, 145-152.

30. Rodríguez-Rajo FJ, Iglesias I, Jato MV: Allergenic airborne pollen monitoring of Vigo (NW Spain) in 1995-2001. *Grana* 2004, **43**, 164-173.

31. Sabariego S: *Estudio aerobiológico del pollen y las esporas de la atmósfera de Almería: Modelos de pronóstico e incidencia de sensibilización en la población atópica*. PhD Thesis, University of Almeria, Almeria 2003.

32. Spieksma FThM: Regional European pollen calendars. **In:** D'Amato G, Spieksma FThM Bonini S (Eds): *Allergenic Pollen and Pollinosis in Europe*, 49-65. Blackwell Scientific Publications, Oxford 1991.

33. Stix E, Ferretti ML: Pollen calendars of three locations in Western Germany. **In:** Charpin J, Surinyach R, Frankland AW (Eds): *Atlas European des Pollens Allergisants*, 85-94. Sandoz, Paris 1974.

34. Tavira J, Tormo R, Muñoz-Rodriguez AF, Silva I, Gonzalo-Garijo MA: Calendar of polen content in the city of Cáceres. *Rev Esp Alergol Inmunol Clin* 1998, **13**, 288-293.

35. Trigo MM: Incidencia del polen en España. Resumen del año 1997. *Rea* 1998, **4**, 11-13.

36. Trigo MM, Cabezudo B, Recio M, Toro FJ: Annual, daily and diurnal variations of *Urticaceae* airborne pollen in Malaga (Spain). *Aerobiologia* 1996, **12**, 85-90.

37. Trigo MM, Recio M, Toro FJ, Cabezudo B: Aerobiología en Andalucía: Estación de Málaga (1995-1996). *Rea* 1998, **3**, 33-36.