A THREE-YEAR AEROPALYNOLGICAL 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


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/m3 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

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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

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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 aerobiological 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.

Estepona has a coastal Mediterranean climate, characterised by hot dry summers and mild winters (Tab. 1). The mean annual temperature is 18°C, January being the coldest month (13°C) and August the hottest (24.2°C). 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

![Figure 1. Monitoring site and geographical features of area studied.](image)

Table 1. Monthly and annual rainfalls (mm) and temperature values (°C) 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.

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Tm - mean temperature, R - rainfall, NR - number of days with rainfall, M - maximum temperature, m - minimum temperature.
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/m³ of air, the mean daily values being used for the elaboration of tables and graphs.

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

Figure 3. Ten-day mean pollen count classes depicted by growth heights column in pictoral 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/m³ 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.
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/m³. 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/m³) occurring in March.

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/m³. 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...
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, Urtica* and *Betula* is noticeable. *Betula*, *Rumex*, *Quercus*, *Plantago* and *Olea* appear mainly in spring, and others such as *Apiaceae, Typha, 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.
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 observed 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

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