

Olea europaea airborne pollen in southern Spain

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Background: *Olea europaea* pollen is one of the most abundant constituent pollens in Seville (southern Spain). It is responsible for many documented cases of pollinosis in the area.

Objective: To contribute to the useful knowledge of *Olea europaea* for allergists.

Methods: The number of *Olea europaea* pollen grains in the atmosphere was recorded during 8 consecutive years (1987–1994), using a Cour collector.

Results: The concentration of *Olea europaea* pollen was as high as 250 to 1015 grains/m³ only during 1 or 2 weeks in April and May. Overall annual production of *O. europaea* pollen alternated between years. The beginning of the main pollination period was related to the mean temperature of the preceding months (February and March). Pollination occurred when the mean temperature in both months was higher than 14 °C; conversely it was delayed when the mean temperature was lower. Main pollination period length depended upon both temperature and rainfall during this period: temperatures higher than 19.5 °C and absence of rainfall shortened the main pollination period, while lower temperatures (15 to 18 °C) together with rainfall rates above 100 mm lengthened it.

Conclusions: Climatic variables such as preceding mean temperature and rainfall impact on pollen anthesis of *Olea europaea* affect onset and duration of pollination. A consideration of yearly cycles of pollen production as well as these variables should allow pollen forecasting.

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INTRODUCTION

Olea europaea is a tree of simple, opposite, and coriaceous leaves. Its roots can reach 12 m in depth and it can grow up to 10 m tall. It has a thick trunk and rounded top.¹ The adult plant is estimated to have a million flowers,² which are white, either unisexual or hermaphrodite, and arranged in compact bunches. The fruit is an edible drupe (olive) from which olive oil is obtained, rich in oleic acid and a basic element of the so-called “Mediterranean diet.” The plant is amphiphilous—primarily insect pollinated, but with secondary wind pollination. The pollen is small to medium in size, with three furrows, and a reticulated sur-

face.³ It is very light compared with that of other *Oleaceae*, weighing 4.9 ng—half that of *Fraxinus americana* and one-quarter that of *Syringa vulgaris*.⁴

Olea europaea is a species adapting well to extreme climatic conditions—it can resist both high temperatures and periods of rainfall deficit.⁵ These characteristics, in addition to the economic exploitation of the plant, have no doubt contributed to its expansion throughout the Mediterranean area⁶ (during the 16th century at the hands of the Phoenicians), and also to its more recent introduction in other regions of the world with Mediterranean climate: California, Chile, southwest South Africa, and Australia.⁷ Such is the historic, climatologic, and economic background to the present-day widespread implantation of olive groves. In countries of the Mediterranean basin, especially in areas of southern Italy and southern Spain,⁸ the olive, harvested for the extraction and commer-

cialization of olive oil, is an important source of income.

The floral, palynologic, cultural characteristics described above contribute to the existence of large amounts of *Olea europaea* pollen in the air of many regions of European Mediterranean countries, where it is one of the most clinically relevant allergens.⁹ In Spain, *Olea europaea* pollen is the second most important pollinosis-producing agent after that of Gramineae.¹⁰ In regions such as Seville (southern Spain), *Olea europaea* pollen, together with that of Gramineae, is the foremost etiologic element of pollinosis described in the area.^{11,18}

This work is based on the aforementioned considerations. Different aspects of *Olea europaea* aeropalynology have been studied. The pollen count data have been collected during 8 years with a Cour collector from the air of Seville. By disseminating our results, we intend to help allergists in different regions in the world who are facing problems originated by *Olea europaea* pollen. At the same time we wish to complement what has already been reported in monographs on *Olea europaea* aeropalynology carried out previously in this same city^{11–13} and other nearby ones in southern Spain: Córdoba,^{14,15} Granada,¹⁶ and Jaen.¹⁷

MATERIALS AND METHODS

The province of Seville is located in the southwest of the Iberian Peninsula. It has an area of 1,400,003 hectares (3,459,407 acres) and a population of 1,300,000 inhabitants. The geographic coordinates of Seville city are 37°23'N, 5°58'W. Its climate is mild Mediterranean. The average temperature is 18.8 °C and the rainfall 600 mm. The latter is concentrated in fall and at the beginning of spring, with a minimum during the summer. In the province, 174,000 hectares (429,954

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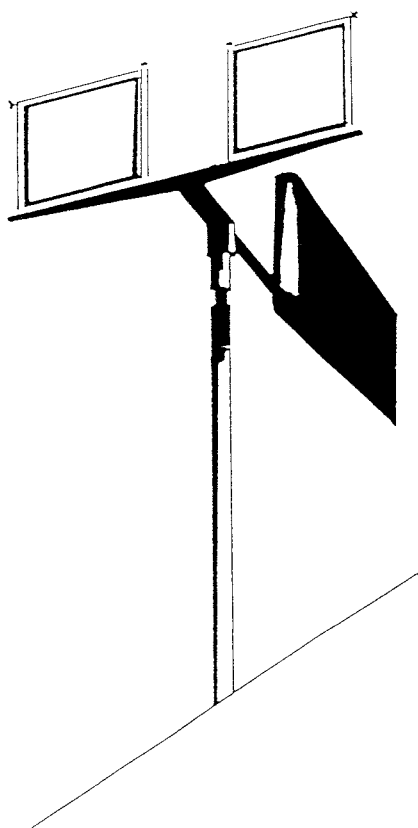


Figure 1. Cour collector.

acres) of crops are dedicated to olive groves, that is, 12.43% of the land and approximately 17.4 million olive trees (at the rate of 100 trees per hectare or 40 per acre). This number of trees represents 8.14% of Spanish olive groves and 2.14% of the world total.

Olea europaea airborne pollen was counted with a Cour collector (Fig 1) installed at a height of 15 m on a flat roof of the School of Pharmacy, Seville University, checking the air of the city uninterruptedly for 8 consecutive years (1987 to 1994). The collector used 400 cm² sterile gauze filters impregnated with silicone oil and fitted to a vane. The apparatus included a totalizing anemometer, indicating the wind flow through the filter during the exposure period. Samples were processed according to the methodology proposed by Cour and designed at the Palynology Laboratory at Montpellier (France)¹⁹: the filters are subjected to a series of chemical treatments in the

laboratory to destroy the gauze and release the pollen, which is then acetylated and colored to help in its identification (this treatment is economically very costly and involves eight hours of work per filter treated). Then a proportional part of the filter was analyzed. The microscopic identification of *Olea europaea* pollen was done according to the type described by Candau in 1987.³ The period of sample exposure was weekly; therefore, pollen concentrations are expressed in grains weekly/m³ of air, so that hourly or daily concentrations cannot be calculated. The only way to obtain daily concentrations is to change the filter every day, which none of the various authors using the Cour method²⁰⁻²⁴ has done because of the cost.

The meteorologic data in this work were obtained from information provided by the National Institute of Meteorology.

The concepts of main pollination period (those weeks of the year when a specific pollen type collected represents between 5% and 95% of that collected by the end of the year),²⁵ and week of maximum pollen emission (that week of the year when the highest concentrations for a determined pollen type are recorded) have been used.

RESULTS

The years of the study comprised a set of climatologically dry years, with rainfall generally lower than 600 mm (Fig 2), and the annual seasonal variations in the pollen concentration of *Olea europaea* must be seen within this framework. The years 1992 to 1993 and 1994 were especially dry, with annual rainfalls consecutively lower than the average of 600 mm. This situation can be considered normal in a Mediterranean climate, which is characterized by recurrent drought periods (Fig 2).

Table 1 shows the annual amounts of *Olea europaea* pollen collected and the percentage of total and tree pollen these amounts represent. The 2138.79 grains/m³ of *Olea europaea* pollen collected represent in mean terms 33.31% of the total pollen and 40.88% of the tree pollen.

The annual amounts of *Olea europaea* pollen varied each year, with a difference of 153% in relation to the mean (2138.79 grains/m³) between 1991 (year of highest collection) and 1993 (year of lowest collection). The different years can be grouped in three categories, according to the amount of *Olea europaea* pollen collected. Years of low pollen production (less than 1500 grains/m³): 1988, 1990, 1993,

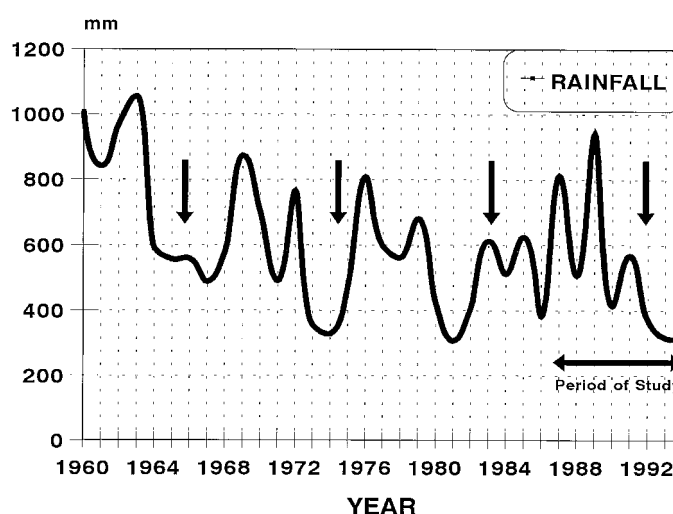


Figure 2. Annual rainfall variation recorded in Seville during the period 1960 to 1994, according to data provided by the National Institute of Meteorology.

Table 1. Annual Pollen of *Olea europaea* and its Percentage of Representation in Total Pollen and Tree Pollen

Year	<i>Olea europaea</i> Pollen, grains/m ³	(<i>Olea europaea</i> Pollen/ Total Pollen) × 100	(<i>Olea europaea</i> Pollen/ Tree Pollen) × 100
1987	2277.23	34.13	44.44
1988	1353.74	34.71	46.74
1989	3244.73	30.94	33.67
1990	1470.66	51.59	64.83
1991	4361.86	32.89	37.97
1992	2251.23	22.10	25.97
1993	1061.49	31.48	36.62
1994	1089.48	28.27	37.63
Mean	2213.11	33.31	40.98

and 1994; years of intermediate pollen production (1500 to 3000 grains/m³): 1987 and 1992; and years of high pollen production (more than 3000 grains/m³): 1989 and 1991. These differences result in an alternancy of pollen production, characterized by 1 year of high production followed by one of low production. This rate was interrupted in 1993 when a high pollen collection was expected but did not occur (Fig 3).

The variations in *Olea europaea* weekly pollen concentration throughout the year are characterized by the appearance of large amounts of pollen in the air during a few weeks between April and June. This abrupt increase in concentration, and its later fall, is an aeropalynologic pattern repeated during 6 years (1987, 89, 90, 91, 92, and 94), but not in 1988 or 1993, when peaks of maximum concentration were followed by intermittent ones of lower concentration (Fig 4).

The average date of the beginning of the main pollination period was 18th April (day 108 from 1st January), although this date could be 12 days earlier [6th April (day 96) (1990)] or 18 days later [6th May (day 126) (1991)] (Table 2). This range of 30 days for the onset of the main pollination period was related to the interannual variation of values for average mean temperature of months preceding pollination (February and March), since the lowest preceding temperatures were recorded the year that pollination was delayed most and vice versa. Figure 5 shows a linear regression relating the two parameters. The linear equation is $Y =$

$223.269 - 8.376X$, where Y is the onset of the main pollination period (expressed in number of days since 1st January) and X is the mean of mean temperatures for the preceding months (expressed in °C). The statistical constants are $r = -.93$, $r^2 = .8736$, $P < .05$, $n = 8$.

The main pollination period length varied from year to year. The shortest was 28 days (1991 and 1994), and the longest 63 days (1988) (Table 2, Fig 4).

The meteorologic conditions recorded during the respective main pollination periods also varied during these years. The lowest mean temperatures were recorded in 1988 (15.56 °C) and 1993 (18.22 °C), and the highest in

1994 (23.47 °C). Rainfalls were highest in 1988 (169.20 mm) and 1993 (103.5 mm), while the lowest were nil or nearly nil—in 1992 (0 mm), 1987 (0.80 mm), and 1991 (1.80 mm) (Table 2, Fig 4).

The week of maximum pollen emission was week 19 (between 2nd and 9th May) (Table 2). That week was normally preceded or followed by weeks of high pollen collection (Fig 4): The 514.27 grains/m³ collected during the week of highest pollen emission is 30.74% of the total *Olea europaea* pollen collected by the end of the year. These figures are mean values for the 8 years of study, and are different from year to year, varying between 249.90 and 1013.97 grains/m³ (Table 2).

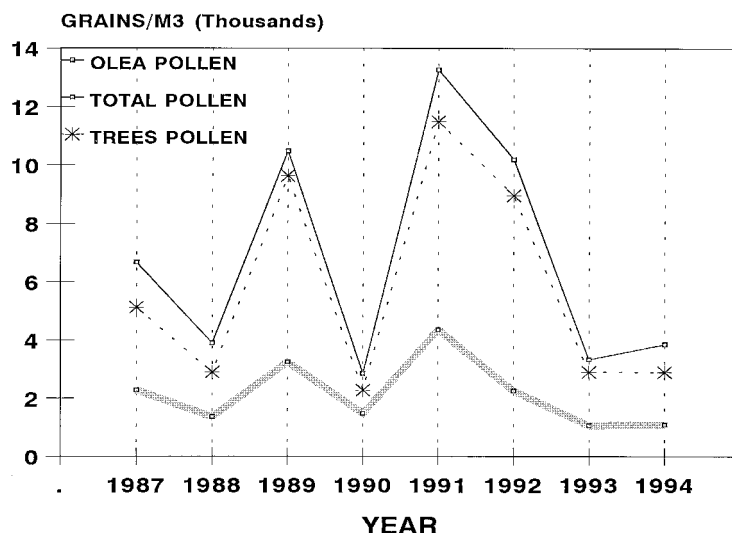


Figure 3. Interannual variations of *Olea europaea* pollen concentration, total pollen and tree pollen (expressed in grains/m³).

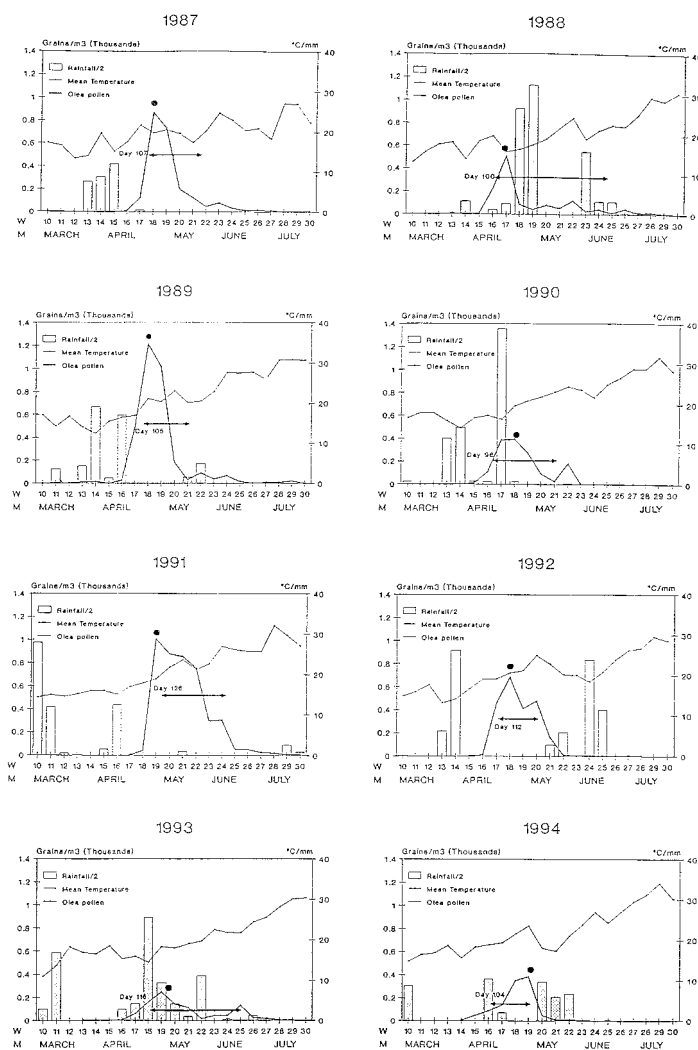


Figure 4. Seasonal variation of the weekly pollen concentrations of *Olea europaea* (grains/m³) in the different years of study. The day of onset and the length of the main pollination period (double arrow) and the week of maximum pollen emission (circle) are indicated. Variation of mean weekly temperature (°C) and weekly rainfall (mm). (The value for rainfall has been divided into two, in order to make the graph easier to understand).

DISCUSSION

Despite the entomophilous and secondarily anemophilous character of *Olea europaea*, pollen of this species is the most represented in the total pollen content of the air of Seville, more so than other pollen types such as *Quercus* and *Gramineae*.²⁶ The representative average percentage of 33.31% is higher than that reported for other Mediterranean regions^{32–38} with available data (Table 3). This is no doubt due to the floral, palynologic,

and cultural characteristics of the plant already described: the great number of flowers per tree, a very light pollen that can easily be suspended in air currents, and the widespread implantation of the crop in the studied region. The allergic population is fortunate that the pollen of *Olea europaea* is present in high quantities only during the 1 or 2 weeks of high pollination—as shown in the air of Jerusalem more than 30 years ago.²⁷ This behavior is similar to that of other arborous types with reg-

ular flowering concentrated in very few weeks of the year: *Alnus glutinosa*, *Platanus hybrida*, and *Casuarina*.²⁶

Another important fact of *Olea europaea* aeropalynology, previously reported by different authors, is the alternation in its pollen production. This is due to the plant's biologic cycle. Once flowering and pollination has occurred (April and June), the fruit is formed and will remain on the plant during a number of months before it is collected (between September and January of the following year). During this period on the plant, gibberellins are accumulated in the seed endosperm. These are plant hormones that inhibit (in November) flowering, which will thus not occur until the following spring.³³ It is known that high pollination implies a great production of fruits,³⁴ and consequently a high production of seeds and gibberellins. A high pollination will therefore result in both a low flowering and low pollination the following year. In our study, production alternated every year except for 1993 (Table 1, Fig 3). That year the plant showed the effect of prolonged drought, and the tree's known resistance to adverse pluviometric conditions broke down. Another important factor was the presence of 103.5 mm of rainfall and a mean temperature of 18.22 °C (the second lowest of the years of study) (Table 2, Fig 4) during the main pollination period. Such meteorologic conditions were not appropriate for a proper pollination, as will be commented on later.

The average date for the onset of the main pollination period—around April 18th (day 118)—is later than that reported for areas in Israel and earlier than that for the rest of Spain and for other Mediterranean countries (Table 3). The onset date appears to be closely related to temperatures of the months preceding pollination, in which *Olea europaea* dormancy finishes³⁵ and the floral buds begin to sprout.^{8,33} The accumulating daily temperatures directly and positively affect bud maturation and consequently the date of flowering

Table 2. Data of the Main Pollination Period and the Week of Maximum Pollen Emission

Year	Main Pollination Period				Week of Maximum Pollen Emission	
	Beginning (Day from 1st January)	Length	Mean Temperature, °C	Rainfall, mm	Date	G/m ³
1987	107. April, 17	W17-W21 (35 days)	19.76	0.80	W18. A24-M1	861.71
1988	100. April, 11	W16-W24 (63 days)	15.56	169.20	W17. A18-A25	509.57
1989	105. April, 15	W17-W21 (35 days)	20.35	3.10	W18. A22-A29	1013.97
1990	96. April, 6	W16-W21 (42 days)	19.48	80.10	W18. A20-A27	391.05
1991	126. May, 6	W19-W24 (42 days)	18.90	1.80	W19. M6-M13	100.41
1992	112. April, 22	W17-W20 (28 days)	20.57	0	W18. A29-M6	846.14
1993	116. April, 26	W18-W25 (56 days)	18.22	103.50	W19. M3-M10	249.90
1994	104. April, 14	W16-W19 (28 days)	23.47	24.80	W19. M5-M12	384.92
Mean	108. April, 18	W17-W22 (42 days)	19.54	47.91	W19. M2-M9	514.27

and pollination.³⁵ Thus, high temperatures in February and March will bring forward flowering and pollination, and the opposite will occur if these temperatures are low (Fig 5). The coefficient of correlation between preceding temperatures and onset date of the main pollination period obtained in this work ($r = -.93$) is similar to those published in other works on the aeropalynology of *Olea europaea*: in a similar study carried out in two Italian cities³⁵ using the Burkard method and

taking as onset of the main pollination period the day on which the accumulated pollen collected exceeded 5% of the annual total, coefficients of $r = -.845$ y $r = -.95$ were obtained (maximum temperature of the month preceding pollination versus date of the onset of main pollination period). On the other hand, using the criterion proposed by Rantio-Lehtimäki et al.³⁶ for establishing onset date (the day when 1% of the annual pollen is exceeded, provided this is not an isolated

day separated by more than 1 week from an acceptable concentration), the linear correlation coefficient in the present work would fall from $r = -.93$ to $r = -.83$. All these coefficients are high (taking into account the few years of sampling) and show a clear relationship between preceding temperatures and onset of the main pollination period of *Olea europaea*; a relationship that will have to be confirmed with a longer period of observation. This behavior, described for other woody plants (*Ulmus campestris*,²² *Corylus avellana*,³⁷ *Alnus*, and *Populus*,³⁸ and *Fraxinus*³⁹), can be used to predict pollinations so that warnings can be published in the mass media. Such has been carried out by the Spanish Aerobiology Network since its creation in 1992.

The last aspect concerning *Olea europaea* aeropalynology relevant to this study is the influence of temperature and rainfall on pollen emission once pollination has begun. Various authors have indicated the positive effect of temperature on another maturing and dehiscence, and therefore on pollen content in the air.⁴⁰⁻⁴² The effect of temperature is increased or decreased by the presence or absence of rainfall. In the Mediterranean climate, high temperatures are associated to absence of rainfall, and low temperatures with presence of rainfall, although it is difficult to demonstrate statistically, as rainfall is scanty and irregularly distributed. For the main pollination peri-

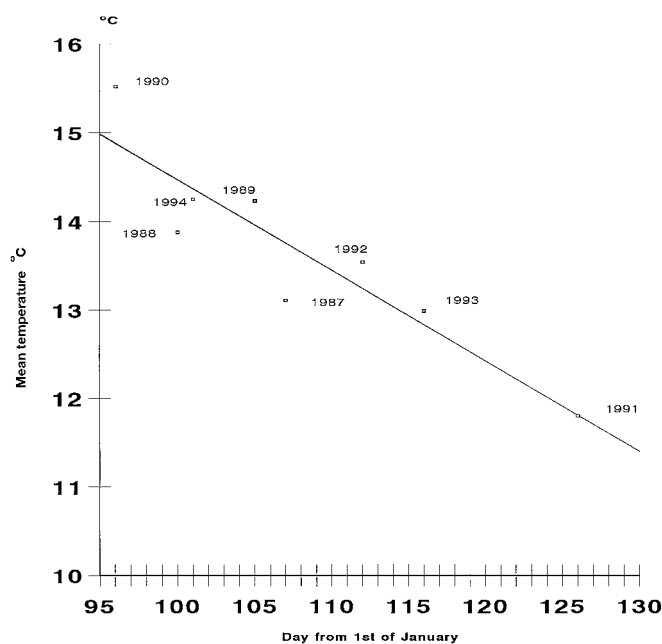


Figure 5. Relationship between day of onset of main population period (expressed as number of days from 1st January) and average mean temperatures (°C) for the 2 months previous to pollination (February and March).

Table 3. Percentage of Representation in the Total Pollen and the Beginning of the Pollination of *Olea europaea* in Different Mediterranean Locations

Location	Country	%	Start of Pollination	Reference
Negev	Israel	–	End of March	27
Thessalonika	Greece	4.8	Beginning of May	28
Granada	Spain	–	Beginning of May	16
Córdoba	Spain	–	Beginning of May	15
Jaén	Spain	–	Beginning of May	17
Montpellier	France	4.0	Middle of May	29
Genoa	Italy	8.50	End of May	30
Oporto	Portugal	9.10	End of May	31
Naples	Italy	18.02	End of May	8

ods of *Olea europaea* considered overall, there is an inverse relationship (though not significant) between mean weekly temperature and total weekly rainfall (linear correlation coefficient: $r = -.56$, $r^2 = .31$, $P = .576$; exponential correlation coefficient: $r = -.59$, $r^2 = .35$, $P = .384$). With such biologic support, we can relate low temperatures and presence of rainfall to long, irregular periods of pollination, and high temperatures and absence or deficit of rainfall to short, regular pollination periods. The longest main pollination periods were 1988 (63 days) and 1993 (56 days), with mean temperatures and rainfalls respectively of 15.56 °C and 169.20 mm, and 18.22 °C and 103.50 mm. In contrast, 1994 and 1992 both had a main pollination period of 28 days, with mean temperatures and rainfalls respectively of 23.47 °C and 24.80 mm, and 20.57 °C and 0 mm (Table 2, Fig 4).

Finally, the alternation in the pollen production of *Olea europaea* has in the particular case of Seville a high incidence in the interannual variation of total pollen and tree pollen (Fig 3). *Olea europaea* can possibly be considered as a biologically indicative species among the Mediterranean anemophilous plants.

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