

Prediction of the beginning of the olive full pollen season in south-west Spain

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Abstract

Given the clinical and agricultural importance of the olive in SW Spain, we have carried out a study to predict the starting date of its full pollen season. The study covers 6 years of meteorological and palynological observations — the latter using a Cour sampler installed in Huelva (SW Spain). The results obtained show that olive full pollination begins when the plant has accumulated 731°C of daily temperature above 5°C from the end of its dormant period. The mean duration of this accumulation was 83 days. A positive relationship has been found between mean temperature of the months before the pollen season (February and March) and the date when the season starts (April). From the data available, rainfall registered between 1 September and 31 March (both before pollination), does not affect the starting date of the full pollen season, but can affect total pollen production, particularly in years with prolonged drought.

Keywords: Aeropalynology; Olive; Pollen season

1. Introduction

Aeropalynology is intended as a useful tool to predict the beginning of the pollen season (and thus of flowering) of plants producing allergenic pollen and of those with agricultural importance (Spieksma, 1988; Frenguelli et al., 1992). This aim leads to two different lines of work: (a) the effect of meteorological factors on the beginning of pollination in anemophilous plants [*Phyllirea*, Michel et al. (1979), *Ulmus campestris*, Richard (1985), *Alnus* and *Populus*, Frenguelli et al. (1991) and *Corylus avellana*, Frenguelli et al. (1992)]; (b) possible time relationships between pollen season in different taxa — known as bioindicative pollination.

That is, the pollinations of one plant predicts the beginning of pollination in others (Driessen et al., 1989; Bricchi et al., 1995).

This work reports the results of 6 years' (1989–1994) use of a Cour pollen sampler in Huelva (SW Spain). It attempts to show the effect of temperature in February and March and of the accumulated temperature on the beginning of olive full pollen season, once the tree has emerged from its dormant period. A similar study was carried out in Perugia by Frenguelli et al. (1989), using the Burkard method.

Prediction of the date of the olive pollen season permits allergy patients to take effective precautions, and farmers to apply appropriate methods, such as treating the plant with flowering retardants (to prevent early flowering and spring frost damage) or using an assisted irrigation in the weeks before flowering, to improve the future crop (Lavee, 1994).

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2. Study area

Huelva is a town on the Atlantic coast of SW Spain (37°16'N, 6°7'W). It has a Mediterranean climate ameliorated by its nearness to the sea. The annual mean temperature is 18°C; during summer this may exceed 40°C and in winter rarely falls below 0°C. Mean annual rainfall is 525 mm, which is irregularly distributed and frequently does not exceed 400 mm. Such conditions are typical of regions with southern Mediterranean climate, where the temperature for olive growing is good, but rainfall may be insufficient. In contrast, in northern Mediterranean regions the rainfall is abundant but the winter temperature may fall below –7°C, causing serious damage to the olive (Morettini, 1950).

The native Mediterranean vegetation of the region (*Quercus rotundifolia*, *Q. suber*) has been largely substituted by timber afforestation (*Pinus* and *Eucalyptus*) and herbaceous crops (cereals, sunflower and legumes) and woody plants (vines and olives).

The settlement of the area by the Phoenicians probably means that the first olives appeared in Huelva around the XVIth century B.C., as part of their being spread from Asia Minor throughout the Mediterranean region (Patac de las Traviesas et al., 1954). At present there are some 30 000 hectares under olive in the Huelva area — approximately three million trees, yielding an average annual production of 28 000 TM of olive fruit and oil (data from the Board of Agriculture and Fisheries of the Junta de Andalucía).

In Huelva, olive pollen is the second most important allergy-producing agent after that of *Gramineae*: olive pollen extract is responsible for 50.24% of positive skin reactions and appears in the formulation of 45.11% of I.T. vaccines (González Minero and Candau Fernández-Mensaqué, 1994).

3. Materials and methods

The work was carried out using a Cour pollen sampler situated in the centre of the town of Huelva, at approximately 1 km from the meteorological observatory. An electronic anemometer (ENERCO 407) placed next to the sampler measured wind speed and direction, so that weekly pollen concentrations, expressed as grains/m³ of air, could be calculated.

During the 6 years of study (1989–1994) the work was carried out from January to June. Samples were collected, treated and analysed following the Cour method (Cour, 1974). Pollen concentrations are expressed as grains per week/m³ of air. Changing of filters was done on Mondays, therefore in this and other studies carried out with the Cour collector we shall consider the first week of the year that which includes January the 1st, in practical terms, the first week of the year and which has a different date every year.

The meteorological factors considered were as follows:

1. Accumulated mean daily temperature > 5°C measured from the first day of the week following the week of emergence from dormancy until the last day of the week before the week when the full pollen season began. The latter was taken as that week in which the weekly concentration of olive pollen exceeded the annual mean (Cour et al., 1987). The week of emergence from dormancy was dated (retrospectively) as that giving the lowest mean temperatures of the year (January or the beginning of February) and after which the mean weekly temperature began to rise. The thermal conditions for emergence from dormancy and the temperature threshold for accumulation are concepts that have to be set for each taxon and each geographical region (Richard, 1985).

2. Means of the mean temperatures in the months (February and March) previous to that of flowering (April), which were correlated with the first day of the week in which the pollen season began. To make clear this relationship a linear regression analysis has been used. A similar method was used by Frenguelli et al. (1989).

3. Lastly, to know whether or not rainfall affected the starting date of the full pollen season, the soil water content was determined in April of each year (the month including, in all cases, the week when the full pollen season began). The soil water content was calculated subtracting accumulated normal rainfall (ANR) from accumulated rainfall (AR). AR for April is that recorded between 01–09 of the previous year and 31–03 of the current year. ANR was calculated from AR values of the past 30 years. This is a model proposed by 'la Consejería de Agricultura and Pesca' and a similar model has been used by Candau et al. (1994).

All meteorological data used in this work were supplied by the Regional Centre of the National Meteorological Institute of Huelva.

4. Results

4.1. Effect of accumulated daily temperatures on the beginning of the olive pollen season

Fig. 1 shows the variation in mean weekly temperature throughout the first 6 months of each year of the study, and the weekly concentration of olive pollen expressed as grains/m³ of air. The weeks of emergence from dormancy and of beginning of full pollen season are indicated by arrows.

The date of emergence from dormancy ranged between week 2 (04–11/01/1993) and week 5 (28/01–04/02/1991); the mean temperature in those weeks varied between 8.14°C (1991) and 11.01°C (1992), with 9.38°C as the mean of the 6 years (Table 1).

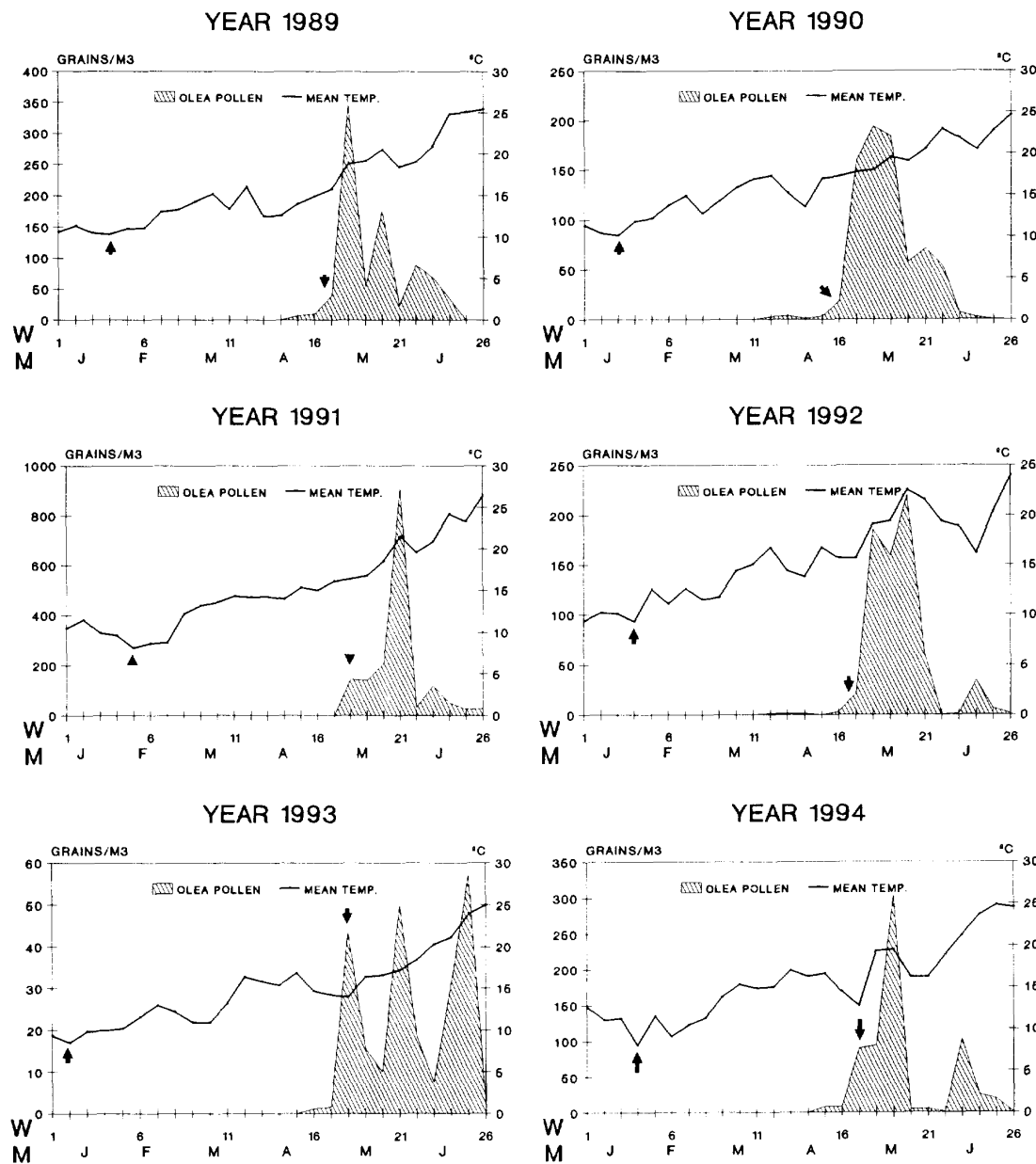


Fig. 1. Mean weekly temperature in °C and weekly concentration of olive pollen expressed as grains/m³. The arrow located between January and February marks the week of emergence from dormancy and that located in April indicates the week in which the full pollen season begins.

Over the years, there was a difference of 14 days in the starting date of the full pollen season: day 106 (16 April 1990) and day 120 (30 April 1993), with the mean being day 111 (21 April) (Table 1).

Accumulated temperature also varied in duration and amount over the years: the shortest periods (75 days) were registered in 1989 and 1994, and the longest in 1993 (102 days); the mean was 83 days (Table 1). The

accumulated temperature was between 725°C and 729°C, except in 1993, with 758.46°C; the mean value was 731.38°C (Table 1).

4.2. Effect of the mean temperature in February and March on the beginning of the olive pollen season

The lowest mean temperature for February and

Table 1
Palynological and meteorological data for the olive during the 6 years of study

Year	Week of emergence from dormancy and mean temperature	Week of beginning of full pollen season	AR-ANR April (mm)	Accumulated daily temperature > 5°C	Mean temperature Feb.–Mar. (°C)	Day of start of full pollen season
1989	W4. 23-01 30-01 Mean temp.: 10.65°C	W15. 17-04 24-04 37.80 grains m ⁻³ of air	12.4	31-01 16-04. 75 days 728.56°C	14.98	107
1990	W3. 15-01 22-01 Mean temp.: 10.17°C	W16. 16-04 23-04 18.16 grains m ⁻³ of air	337.7	23-01 15-04. 82 days 725.41°C	14.95	106
1991	W5. 28-01 04-02 Mean temp.: 8.14°C	W18. 30-04 06-05 145.91 grains m ⁻³ of air	–148	05-02 29-04. 82 days 725.76°C	12.20	120
1992	W4. 20-01 27-01 Mean temp.: 11.01°C	W17. 19-04 26-04 22 grains m ⁻³ of air	–233	8–01 18-04. 81 days 725.96°C	12.65	110
1993	W2. 04-01 11-01 Mean temp.: 8.49°C	W18. 26-04 03-05 43.65 grains m ⁻³ of air	–252.5	12-01 25-04. 102 days 758.46°C	12.82	116
1994	W4. 17-01 24-01 Mean temp.: 8.17°C	W17. 18-04 25-04 89.64 grains m ⁻³ of air	–110.1	25-01 17-04. 75 days 727.92°C	13.62	109
Mean	9.38°C	59.53 grains m ⁻³		731.98°C. 83 days	13.54	111

March was recorded in 1991 (12.2°C) and the highest in 1989 (14.98°C). The six data pairs (mean temperature in February/March, and the first day of the week in which the full pollen season began) (Table 1) were used to perform a linear regression analysis. The coefficient of correlation obtained was $r = -0.842$ ($P = 0.036$). The equation of the straight line slope was also calculated (Fig. 2), $DB = -3.86 \times T_{im} + 163.66$ where DB is the day of beginning of the pollen season and T_{im} is the mean temperature for February and March.

4.3. Effect of soil water content on the beginning of the olive pollen season

Except in 1989 and 1990, with 12.4 mm and 337 mm of surplus respectively, there was a water deficit. This was especially pronounced in 1992 (–233 mm) and 1993 (–252.5 mm) (Fig. 3). ~This figure shows soil

water content in April (AR-ANR) expressed in mm (left ordinate) and the total olive pollen grains collected, for each year (right ordinate). The latter ranged between 238.07 grains/m³ in 1993 and 1664.62 grains/m³ in 1991.

5. Discussion

Our results relate the date of the olive pollen season with the plant's accumulation of a determined 'amount' of daily mean temperature above 5°C after emergence from dormancy. The heat needs of the olive were relatively constant over the years (725–729°C accumulated between 75 and 82 days), except in 1993 when there was a marked anomaly (758.46°C accumulated over 102 days). Frenguelli (1993) and Candau et al.

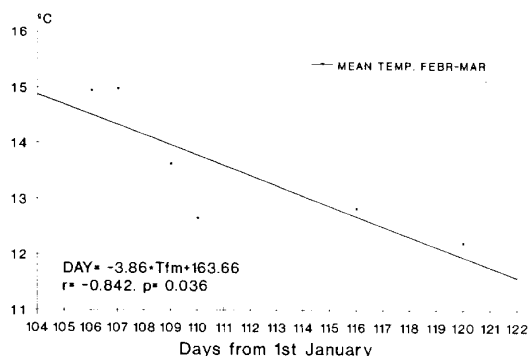


Fig. 2. Relationship between mean temperature for February and March in °C and the starting date of the olive full pollen season. The arrow located between January and February marks the week of emergence from dormancy and that located in April indicates the week in which the full pollen season begins.

(1994) associate this latter phenomenon with an early emergence from dormancy followed by an unsatisfactory accumulation of temperature, which moreover results in an irregular pollination (Fig. 1, 1993). The mean value for accumulated temperature in Huelva was 731.98°C, very similar to the 726°C found in Perugia (Frenguelli et al., 1989).

Frenguelli et al. (1989) quantified the dependence of the date of the olive pollen season with the temperature in March and April (Perugia), which was also found in Córdoba (Galán et al., 1988). This work confirms the finding, the only variant being the geographical posi-

tion of Huelva, which results in an earlier pollination of the olive than in more northerly locations. Thus in our case, we used the mean temperatures for February and March (Fig. 2). In the regression analysis the *R* coefficient is negative; this implies an inverse relationship between previous temperatures and the day on which full pollen season begins. The pollen season will start earlier if mean temperatures in February and March are high and it will be delayed if these temperatures are low.

Another question worthy of consideration is the effect of rainfall on the starting date of the olive full pollen season, above all in areas such as Huelva, subject to cyclic periods of drought. With the data currently available, we can state that rainfall does not affect the beginning of full pollen season, since in 1989, 90, 92 and 94, this took place between 15 and 18 April (Table 1), and in each year the soil water content in April was very different. However, rainfall can affect the total amount of pollen produced (Fig. 3). Roure and Belmonte (1988) showed the positive dependence of pollination intensity in trees on the amount of preceding rainfall. This relationship may hold good in the case of the olive, since in Israel it has been shown that moderate irrigation of the olive grove in the months before flowering improves the harvest (Lavee, 1994), possibly because this supplementary water helps a more complete floral development (Rallo, 1994). The olive has a powerful root system that enables it to develop normally even in years with scarce rainfall (Morettini,

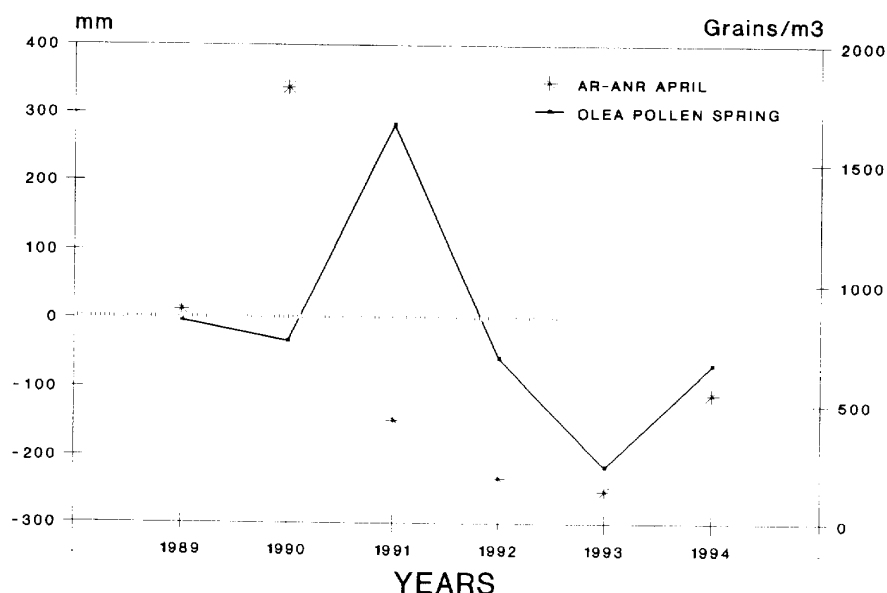


Fig. 3. Soil water content in April (AR-ANR) expressed in mm and total annual collection of olive pollen expressed as grains/m³. The arrow located between January and February marks the week of emergence from dormancy and that located in April indicates the week in which the full pollen season begins.

1950). However this capacity could be reduced when there are several consecutive years with marked water stress, as in our area from 1992 (–233 mm) to 1994 (–252 mm). In those years the decrease in soil water reserves was accompanied by a decrease in pollen production (Fig. 3).

References

- Bricchi, E., Frenguelli, G., Mincigrucci, G., Fornaciari, M., Ferranti, F. and Romano, B. (1995) Time linkages between pollination onset of different taxa over an 11-year period in Perugia, Central Italy. *Aerobiologia* 11, 57–61.
- Candau, P., González Minero, F.J. and Romero, F. (1994) Aeropalynology of *Fraxinus* (Ash) in an urban area of southwestern Spain. *Aerobiologia* 10, 47–51.
- Cour, P. (1974) Nouvelles techniques de détection des flux et des retombées polliniques: étude de la sédimentation des pollens déposés à la surface du sol. *Pollen Spores* 16, 103–141.
- Cour, P., Cambon, G. and Rajeriarison, Ch. (1987) Facteurs heliothermiques et cycles de floraison en région tropicale soumise à la mousson. *Mén. Trav. E.P.H.E., Inst. Montpellier* 17, 15–26.
- Driessen, M.N.B., Van Herpen, R.M.A., Moelands, R.P.M. and Spieksma, F.Th.M. (1989) Prediction of the start of the grass pollen season for western part of the Netherlands. *Grana* 28, 37–44.
- Frenguelli, G. (1993) The influence of air temperature on the beginning of pollination. Conferencia Curso Especialización Aerobiología y Alergias Polinicas. May 1993, Seville.
- Frenguelli, G., Bricchi, E., Romano, B., Mincigrucci, G. and Spieksma, F.Th.M. (1989) A predictive study on the beginning of the pollen season for Gramineae and *Olea europaea* L. *Aerobiologia* 5, 64–70.
- Frenguelli, G., Spieksma, F.Th.M., Bricchi, E., Romano, B., Mincigrucci, G., Nikkels, A.H., Dankart, W. and Ferranti, F. (1991) The influence of air temperature of the starting dates of the pollen season of *Alnus* and *Populus*. *Grana* 30, 196–200.
- Frenguelli, G., Spieksma, F.Th.M., Bricchi, E., Romano, B., Mincigrucci, G., Ferranti, F. and Antognozzi, E. (1992) The role of air temperature in determining dormancy release and flowering in *Corylus avellana* L. *Aerobiologia* 8, 415–418.
- Galán, C., Infante, F., Ruiz de Clavijo, E. and Dominguez, E. (1988) Variación estacional y diaria del polen de *Olea europaea* L. en la atmósfera de Córdoba en relación con los parámetros meteorológicos. *An. Asoc. Palinol. Leng. Esp.* 4, 46–53.
- González Minero, F.J. and Candau Fernández-Mensaque, P. (1994) Variations of airborne summer pollen in southwestern Spain. *J. Invest. Allergol. Clin. Immunol.* 4(6), 277–282.
- Lavee, S. (1994) Porqué la necesidad de nuevas variedades de olivos? *Fruticultura* 62, 29–38.
- Moretini, A. (1950) *Olivicoltura*. R.E.D.A. Rome, pp. 595.
- Michel, F.-B., Seignalet, Ch. and Cour, P. (1979) Contribution palynologique, allergologique, météorologique et climatologique de l'étude des flux polliniques entre La Scandinavie et L'Afrique du Nord, premiers resultats. Les pollinoses. Laboratoires Fisons, Paris, pp. 159–181.
- Patac de las Traviesas, L., Cadahía Cicuéndez, P. and Del Campo Sánchez, E. (1954) El cultivo del olivo. Sindicato Nacional del Olivo. Madrid, pp. 646.
- Rallo, J.M. (1994) Evaluación agronómica y obtención de nuevas variedades de olivo. *Olivicultura* 62: 17–28.
- Richard, P. (1985) Contribution aeropalynologique à l'étude de l'action des facteurs climatiques sur la floraison de l'orme (*Ulmus campestris*) et de l'if (*Taxus baccata*). *Pollen Spores* 27(1), 53–94.
- Roure, J.M. and Belmonte, J. (1988) Primeros resultados para el estudio de las relaciones entre las relaciones entre la producción polínica y la producción de biomasa de las comunidades forestales. *Actas de Palinología (VI Simposio de Palinología A.P.L.E., Salamanca)*, Salamanca, pp. 205–209.
- Spieksma, F.Th.M. (1988) Retrospective and predictive systems of information on airborne pollen concentrations in relation to hay fever. *Aerobiologia* 4, 8–11.