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A regression model for the start of the pollen season in *Olea europaea*

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The relationship between the timing of olive pollination and some parameters which can influence this phenomenon was investigated. A model is presented which shows a strong relationship between timing of pollination, selected meteorological variables (temperature and precipitation) and annual pollen quantity. The most important correlations are with mean temperature in February, and precipitation in May. The positive correlation with annual pollen quantity confirms the relationship of this variable to the time of pollination.

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The olive tree is a cultivated species of fundamental importance, particularly in Mediterranean countries, as shown by the yield data (COI 1996). The nutritional properties of its products, the recent realization of their importance in cooking (Parras Rosa 1996), and the economic relevance of the crop both inside the E.U. and in the World Market, have recently motivated detailed research to improve knowledge in the fields of agronomy, biology, hygiene, and biotechnology (Aguilar Torres et al. 1996, Tombesi et al. 1996, Lavee et al. 1996, Ferrini e Fiorino 1996, Vergari et al., 1996, Cirio et al. 1996, Ranalli & Ferrante 1996, di Giovacchino 1996).

The olive is also one of the most important species from an allergological point of view, particularly in those areas where it is cultivated, and there have been many studies aimed at improving the treatment of allergy patients (Arobba & Negrini 1986, D'Amato et al. 1988, Barber et al. 1990, D'Amato & Spiekma 1990, Kernerman et al. 1992, Lombardero et al. 1992, Wheeler 1992, Liccardi et al. 1994).

It is therefore important to continue studying this species, particularly its time of flowering and the quantity of pollen grains produced. Some investigations have been carried out on other species, with respect to the meteorological parameters which can influence flowering (Frenguelli et al. 1988, Frenguelli et al. 1989, Driessen et al. 1990, Andersen 1991, Frenguelli et al. 1991, Larsson 1993, Emberlin et al. 1994) or, for example, on the use of some taxa as pollen bioindicators (Bricchi et al. 1995).

Some results concerning the relationship between pollination time and selected meteorological and aerobiological parameters are presented here, based on a long series of observation years in the Perugia area (1982–1995).

This methodological approach is part of a research theme (Fornaciari et al. 1997) which aims to produce forecasting models for the future yield of economic species, by using the quantity of pollen released into the atmosphere.

MATERIALS AND METHODS

The aerobiological monitoring was carried out using a 7-day recording volumetric trap, developed from the Hirst spore trap (1952), VPPS 2000 Lanzoni model. Pollen quantity is measured as the number of grains per cubic metre of air (p/m^3). A description of the trap and the methods used to prepare and to scan the samples can be found in an earlier publication (Frenguelli et al. 1981).

The trap is positioned on the roof of the Faculty of Agriculture of Perugia University, at 445 m above sea level and approximately 20 m above ground level.

The Perugia monitoring station (43°63'N; 12°23'E; 493 m above sea level) is situated on a hill dominating the central valley of the River Tiber, between Lake Trasimeno and the tyrrhenian versant of the Marches-Umbrian Apennines.

Perugia was built on a hill, the slopes of which are now covered in all directions by productive olive trees. The total area investigated is 75 ha wide, and the pollen release for the whole area is recorded by a trap the range of which is regarded as being 7 Km.

In terms of the meteorology relative humidity reaches an average value of 70%, the average annual rainfall is 900 mm and the average summer and winter temperatures are 23°C and 4°C respectively, with an annual average of 12.9°C. During the autumn and winter the prevailing winds come from the north-east but in spring and summer from the south-west.

The climate of Perugia is sub-continental. The surrounding area is characterised by sub-Mediterranean-mountain vegetation, with widespread cultivation of olive trees.

The dependent variable (R_p) is measured as the number of the days between the beginning of the year and the first day of pollen release; in reality the variable expresses the pollination delay rather than the beginning of flowering.

Pollen index (I_p) is conventionally used to indicate the annual sum of the daily pollen concentrations monitored in the atmosphere.

The other independent variables were first subjected to a selection with some significance tests for 10, 15 and 30 days. The month was the figure, which produced the least ambiguity because it greatly reduced the number of variables, which needed to be tested statistically.

Average monthly temperatures from January to June (T_{m_x}), are of fundamental importance because they influence pollination.

Table I. Simple correlation matrix.

	Ip	Rp	TmJanuary	TmFebruary	TmMarch	TmApril	TmMay	TmJune	RaA	RaM	$\Sigma T1$	$\Sigma T2$	Nof1	Nof2
Ip	1													
Rp	0.79685	1												
TmJanuary	-0.24381	-0.30282	1											
TmFebruary	-0.27199	-0.66749	0.40811	1										
TmMarch	-0.52244	-0.44511	0.45216	0.31739	1									
TmApril	-0.26744	-0.30969	-0.18712	-0.09880	0.46640	1								
TmMay	-0.29027	-0.40440	-0.13015	-0.18595	-0.14346	0.46640	1							
TmJune	-0.13015	-0.18595	-0.14346	-0.18595	-0.14346	0.46640	0.46640	1						
RaA	-0.34610	-0.22456	0.33860	0.01425	0.32407	-0.08479	0.24186	-0.32751	0.24824	-0.48556	0.53524	-0.48404	0.28441	0.35397
RaM	0.53524	0.66781	0.12508	0.08937	-0.08139	-0.08139	-0.08139	-0.08139	0.00400	0.00400	0.53524	-0.48404	0.28441	0.35397
$\Sigma T1$	-0.50227	-0.52599	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146	0.20146
$\Sigma T2$	-0.48404	-0.34110	0.64361	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039	0.37039
Nof1	0.28441	0.14202	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022	-0.34022
Nof2	0.35397	0.21923	0.20676	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553	-0.08553

To emphasise the importance of temperature, two variables were introduced: the thermal sum, that is the sum of daily temperatures over 5°C for two different periods ($\Sigma T1$ and $\Sigma T2$). The aim was to verify, in the simple and multiple correlation matrices, which of the variables was more closely linked to the dependent variable. Among the dependent variables, rainfall figures for April and May (RaA and RaM), and the number of chilling hours (Nof1 and Nof2) were included, because they influence plant physiology. All abbreviations are described in the List of selected variables.

The model is constructed on the basis of multiple regression, characterised as the qualification and quantification of the variables through an estimation of the parameters associated to the same proxies. Specific statistical tests were used, to examine the robustness of the relationship.

The first step was the construction of a "simple correlation matrix", with the double aim of (a) eliminating the less relevant variables (low correlation values or multicollinearity) and verifying the existence of a high level of correlation between the independent variables and the dependent one, and (b) obtaining "predictor variables". International reference texts (Rao 1971, Belsey et al. 1980), indicate that a level of significance of 0.6 is the value distinguishing between a good and a medium level of correlation. A lower value than 0.4 is insufficient to guarantee a link between the variables.

A partial correlation coefficient was used to evaluate the correlation between two variables, without the influence of the other variables. This parameter is of particular importance in those cases in which the variables being considered operate in different periods, in explaining the causal independence of the relationship with the dependent variable.

After specification of the model and its parameters together with the standard tests, other examinations were made with the aim of identifying anomalous observations, for which the Cook test was used, and of verifying the existence of first class autocorrelation, for which the Durbin & Watson test was used.

It is important to emphasize that the observation period (14 years) cannot statistically estimate the relationship in a definitive way. However what we would like to explore is a research theme, that has not been developed in any detail until now, but which could be improved in the future through a wider series of observations.

SELECTED VARIABLES

Rp = Delay of pollination

Ip = Pollen Index

TmJanuary = Mean January temperature

TmFebruary = Mean February temperature

TmMarch = Mean March temperature

TmApril = Mean April temperature

TmMay = Mean May temperature

TmJune = Mean June temperature

RaA = Total amount of rain in April

RaM = Total amount of rain in May

$\Sigma T1$ = Sum of daily temperatures over 5.0°C (15 February/15 March)

$\Sigma T2$ = Sum of daily temperatures over 5.0°C (15 March/15 April)

Nof1 = Number of chilling hours calculated on the basis of 0°C (15 February/15 March)

Nof2 = Number of chilling hours calculated on the basis of 0°C (15 March/15 April)

RESULTS

The coefficients of correlation between all the selected variables are shown in Table I. From this data it is possible to construct Table II, in which the coefficients of correlation between the dependent and independent variables are extracted. Some variables (TmJanuary, TmApril, TmJune, RaA, $\Sigma T2$, Nof1 and Nof2) show insufficient levels of

Table II. Correlation coefficients with the dependent variable.

Variables	Coefficients
Ip	0.79685**
Rp	1
TmJanuary	-0.30282
TmFebruary	-0.66749**
TmMarch	-0.44511*
TmApril	-0.30969
TmMay	-0.40440*
TmJune	-0.18595
RaA	-0.22456
RaM	0.66781**
ΣT1	-0.52599*
ΣT2	-0.34110
Nof1	0.14202
Nof2	0.21923

correlation. Ip, TmFebruary and RaM, show a particularly strong correlation, while TmMarch, TmMay and ΣT1 are weaker. The “predictor variables” to be chosen for the regression are included within those six variables. In reality, within these six variables, it is possible to identify the role of each one independently of the others.

Firstly, the link between TmFebruary and ΣT1 (0.52) is reported in Table II; the strength of this link, together with the consistent value of the relation of both of these with Rp, raises problems concerning the numbers of variables introduced, variables which provide similar information. The problem was eliminated by excluding ΣT1, which is less important and has less partial explanational capacity. Therefore, only the variable TmFebruary has been taken into consideration.

An examination of the variables shows multicollinearity between some of the explanational variables and in particular, between Ip and TmMarch (Table I). In this way the explanational power of TmMarch is greater with Ip (0.52) than with the dependent variable Rp (0.44). In this case, too, it was decided to exclude TmMarch. This decision did not create problems because of the low incidence in terms of R² (increase of 0.5%).

The TmMay variable was excluded from the final model, because in the parametric estimate the value of the coefficient was not statistically significant.

The estimate model has the following form:

$$Rp = a + b_1Ip + b_2TmFebruary + b_3RaM$$

in which the dependent variable (Rp) is positively correlated with Ip, and with the total amount of rain during May, (RaM) and negatively correlated with the mean February temperature (TmFebruary).

Some variables, which a priori could influence the commencement of flowering have been initially eliminated; previous research reveals the importance of the mean monthly temperature during the budding-start phase of flowering (Frenguelli et al. 1989). This correlation hypothesis was not examined in our study, because the multiple regression analysis rejects those variables, which are less explanatory.

The estimated parameters are able to express something about Rp behaviour: both the coefficient significances and

their signs, comply with the original qualifications. To strengthen the estimated equation, we can underline the high level of variance and the scarce importance of multicollinearity.

In particular, the variance analysis (Table III) reveals a high level of R², with an accompanying Fisher significance of F (probability more than 99%).

The relationship of the variables is clearly shown by the estimation of the parameters (Table IV); a relatively strong tie exists between Rp and the other significant variables (Ip, TmFebruary e RaM), justified by the respective student t values. These values rise more significantly than the measure of partial correlation of each variable (Table V). We can note a high level of estimation coefficient in each measure – consistent with its own sign – and such as to hypothesize a causal independence with the other explanatory variables, which can be explained by the different periods in which they act.

Moreover, the estimation has shown a secondary presence of autocorrelation and an absence of anomalous observations (outliers), confirming the regression strength.

CONCLUSION

The conclusions that we can draw from the results reveal a complex situation. On the basis of earlier investigations, the first hypothesis was that there is a significant relationship between the start of flowering and mean temperature during the period January/June. From a physiological point of view it is reasonable to suppose that the flowering period is related to high temperature levels. This was confirmed by the results obtained.

However the number of variables introduced into our

Table III. Variance analysis.

Multiple R=0.96	F=36.374
R Squared=0.92	Probability>(0.0005)
Adjusted R Squared=0.89	DW=2.03

Table IV. Estimation of the parameters.

Independent variables	Parameters	“t” value	p level
Intercept	164.1535		0.0001
Pollen index	0.4379	3.53	0.0061
Mean temperature in February	-0.5177	-5.38	0.0004
Rain in May	0.3435	2.86	0.0186

Table V. Partial correlation matrix.

Variables	Partial correlation coefficient	“t” value	p level
Pollen index	0.761907	3.52905	0.0064
Mean temperature in February	-0.873396	-5.38015	0.0004
Rain in May	0.690498	2.86381	0.0186

analysis decreased only in February. This month is generally characterised by the lowest annual temperatures. It is evident that if temperatures rises during that period, in the buds, which have already been induced in the preceding year, the process which leads to the formation of flowers is activated.

For the second significant variable (RaM), the positive correlation with Rp can be explained in two ways. Firstly, when the precipitation is abundant, the level of solar radiation is very low. The second reason, which seems the more reasonable, is however linked to a mechanism which is widely documented in plants, whereby they respond to low levels of rainfall by anticipating anthesis. (We should not forget the lowered efficiency of the pollen trap under these conditions, in that the pollen which has been released into the atmosphere because of the rain, falls to the ground. Only after being partially dehydrated can it be resuspended and transported by the wind, and reach the trap.) This phenomenon would be in keeping with the adaptation of the crop to arid environments; flowering is a critical moment for all plant species, and they exhibit a high water requirement during this period.

For the third variable of the model, the pollen index (Ip), the positive relationship which emerges, can be interpreted as a part of the same phenomenon. When a lack of water occurs, causing a crisis, the plant anticipates anthesis. This confirms the hypothesis that a plant produces a lower quantity of pollen during phases when resources are lacking.

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REFERENCES

Guigal Torres, F. J., González Fernández, P. & Pastor Muñoz-Cobo, M. 1996. Miglioramenti della fertilità del terreno dell'oliveto con l'applicazione periodica di compost di residui solidi urbani. Confronto con il sistema di non lavorazione con suolo nudo. – *Olivæ* 64: 40–45.

Andersen, T. B. 1991. A model to predict the beginning of the pollen season. – *Grana* 30: 269–275.

Arobba, D. & Negrini, A. C. 1986. Etude aerobiologique des Oleaceae à Genes (Italie) de 1981 a 1983. – *Grana* 25: 205–213.

Barber, D., Carpizo, J., Garcia-Rumbao, M. C., Polo, F. & Juan, F. 1990. Allergen variability in *Olea europaea*. – *Ann. Allergy* 64: 43–46.

Belsey, D. A., Kuh, E., Welsch, R. E. 1980. Regression diagnostic. – J. Wiley & Sons, New York.

Bricchi, E., Frenguelli, G., Mincigrucci, G., Fornaciari, M., Ferranti, F. & Romano, B. 1995. Time linkages between pollination onsets of different taxa over an 11-year period in Perugia, Central Italy. – *Aerobiologia* 11: 57–61.

Cirio, U., Nobili, P., Salvati, S., Tripi, A., Bruno, B. M. & Castiglione, S. 1996. OLEADIF: un sistema esperto per la diagnosi dei danni causati dai parassiti dell'olivo e la loro conoscenza. – *Olivæ* 60: 23–26.

COI. 1996. Il mercato internazionale dell'olio d'oliva. – *Olivæ* 64: 12–15.

D'Amato, G., Mullins, J., Noland, N., Spieksma, F. Th. M. & Wachter, R. 1988. City spore concentrations in the European

Economic Community (EEC). VII Oleaceae (*Fraxinus*, *Ligustrum*, *Olea*). – *Clin. Allergy* 18: 541–547.

D'Amato, G. & Spieksma, F. Th. M. 1990. Allergenic pollen in Europe. – *Grana* 30: 67–70.

di Giovacchino, L. 1996. Influenza dei sistemi di estrazione sulla qualità dell'olio d'oliva. – *Olivæ* 63: 52–63.

Driessen, M. N. B. M., Van Herpen, R. M. A. & Smithuis, L. O. M. J. 1990. Prediction of the start of the grass pollen season for the southern part of the Netherlands. – *Grana* 29: 79–86.

Emberlin, J., Jones, S., Bailey, J., Caulton, E., Corden, J., Dubbles, S., Evans, J., McDonagh, N., Millington, W., Mullins, J., Russel, R. & Spencer, T. 1994. Variation in the start of grass pollen season at selected sites in the United Kingdom 1987–1992. – *Grana* 33: 94–99.

Ferrini, F. & Fiorino, P. 1996. Proposta per la messa a punto e l'uso di una banca del polline in olivicoltura. – *Olivæ* 62: 52–55.

Fornaciari, M., Pieroni, L., Ciuchi, P. & Romano, B. 1997. A statistical model for correlating airborne pollen grains (*Olea europaea* L.) with some meteorological parameters. – *Agr. Med.* 127: 134–137.

Frenguelli, G., Romano, B., Mincigrucci, G., Paola, G. & Bricchi, E. 1981. Calendario pollinico di Ascoli Piceno I – Anno 1981. – *Ann. Fac. Agr. Univ. Perugia* 35: 389–402.

Frenguelli, G., Spieksma, F. Th. M., Bricchi, E., Nikkels, A. H., Mincigrucci, G., Dankart, W. & Romano, B. 1988. Correlazione tra l'inizio della stagione di pollinazione di *Alnus*, Poaceae e *Artemisia* e la temperatura dell'aria nei mesi precedenti. – *Proc. 3^o Congr. Naz. Ass. Ital. Aerobiologia*, Pavia 1998, pp. 31–34. Ed. Univ., Pavia.

Frenguelli, G., Bricchi, E., Romano, B., Mincigrucci, G. & Spieksma, F. Th. M. 1989. A predictive study on the beginning of the pollen season for Gramineae and *Olea europaea* L. – *Aerobiologia* 5 (1): 64–70.

Frenguelli, G., Spieksma, F. Th. M., Bricchi, E., Romano, B., Mincigrucci, G., Nikkels, A. H., Dankart, W. & Ferranti, F. 1991. The influence of air temperature on the starting dates of the pollen season of *Alnus* and *Populus*. – *Grana* 30: 196–200.

Hirst, J. M. 1952. An automatic volumetric spore trap. – *Ann. Appl. Biol.* 39: 257–265.

Kernerman, S. M., Mc Cullough, J., Green, J. & Ownby, D. R. 1992. Evidence of cross-reactivity between olive, ash, privet and Russian olive tree pollen allergens. – *Ann. Allergy* 69: 493–496.

Larsson, K. 1993. Prediction of the pollen season with cumulated activity method. – *Grana* 32: 111–114.

Lavee, S., Avidan, N., Haskal, A. & Ogradovich, A. 1996. Riduzione della fase giovanile nei semenzali di olivo. Strumento di sviluppo del miglioramento genetico. – *Olivæ* 60: 33–41.

Liccardi, G., Russo, M., Saggese, M., Lobefalo, G., Noschese, P., Piccolo, A., Visone, A., D'Amato, M. & D'Amato, G. 1994. Clinical significance of allergenic sensitization to *Olea europaea* L. pollen in Naples area, Italy. – *Aerobiologia* 10 (1): 59–64.

Lombardero, M., Quirce, S., Duffort, O., Barber, D., Carpizo, J., Chamarro, J., Lezaun, A. & Carreira, J. 1992. Monoclonal antibodies against *Olea europaea* major allergen: allergenic activity of affinity-purified allergen and depleted extract and development of a radioimmunoassay for quantitation of the allergen. – *J. Allergy Clin. Immunol.* 89: 884–894.

Parras Rosa, M. 1996. La domanda di olii d'oliva. – *Olivæ* 63: 24–33.

Ranalli, A. & Ferrante, M. L. 1996. Caratteristiche merceologiche di olii extravergini d'oliva estratti con coadiuvante enzimatico pectolitico. – *Olivæ* 60: 27–32.

Rao, P. 1971. Some notes on specification in multiple regression. – *American Statistic* 25 (5): 37–39.

Tombesi, A., Michelakis, N. & Pastor, M. 1996. Raccomandazioni del gruppo di lavoro di tecniche di produzione in olivicoltura e produttività. – *Olivæ* 63: 38–51.

Vergari, G., Patumi, M. & Fontanazza, G. 1996. Utilizzo dei marcatori RAPDs nella caratterizzazione del germoplasma di olivo. – *Olivæ* 60: 19–22.

Wheeler, A. W. 1992. Hypersensitivity to the allergens of the pollen from the olive tree (*Olea europaea*). – *Clin. Exp. Allergy*, 22: 1052–1057.