production levels previous to flowering and the development of the vineyard areas in production. However, the APC are not, by themselves, enough to establish a prediction of real production, thus, they must be integrated in a more inclusive system that takes into account the climatic and agro-technical conditions that occur between flowering and harvest.

The evaluation of the wine forecast results obtained in Portugal clearly shows the importance of the pre- and post-floral conditions for early estimation of crop volumes. Although summers are rainless in these regions, plant-water stress is not the greatest determinant of the large annual fluctuations in wine production.

Contrary to the tendency in other European countries, Portugal, after 1997, increased its number of pollen traps (now 11) to cover the southern wine regions. Agricul tural authorities, vine-growers, winemakers and wine-traders in Portugal currently use the regional Aeropalynoclimatological Forecast Models, herein presented, as a predictive tool. The ready suitability of the method for defining the variables of the Aeropalynoclimatological Forecast Models could make a significant contribution towards improving the accuracy of the European Forecasts network, whose great investment in pollen samples is, at present, restricted in practical application.

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REFERENCES

BESSELAT, B.; COUR, P. & MONTANARELLA, L. (1997). **Méthode integrée de prevision de récolte bâsée sur le dosage pollinique de l'atmosphére: d'une prévision locale à une prevision nationale. Presented at 22th.** Congrés Mondial de la Vigne et du Vin, Buenos Aires, Argentina.

CEMAGREF &CNRS (1993). **Projet prévision de récolte. Rapport final, année 1993.** Convention CEE/CCR ISPRA press 71 p. + annexes.

COUR, P. (1974). Nouvelles techniques de détection des flux et des retombées polliniques: étude de la sédimentation des pollens et des spores à la surface du sol. **Pollens et Spores** 16(1):103-141.

CUNHA, M.; ABREU, I.; PIRES, G; MONTEIRO, L; ALMEIDA, J; SALEMA, R. & CASTRO, R. (2001). Evaluating the Sensitivity of the Statistical Limit for Pollen Sampling by "Cour Method". In: S. Grau, B. Rendueles & J. Angosto (eds). **Proceedings of the XIII Palynology Symposium A.P.L.E.,** pp. 81-86, Universidad de Cartagena press.

CUNHA, M.; ABREU, I.; PEDROSO, V.; ALMEIDA, C.; PINTO, P. & CASTRO, R. (2000). Estimativa precoce da produção de vinho pelo método aeropolínico. II – Regiões Demarcadas do Dão e Bairrada. **Ciênc. Téc. Vití.** 15(2):47-63.

CUNHA, M. (2001). **Previsão de colheitas em viticultura.** Integração de modelos aeropolinicos e bioclimáticos. Ph. D. Thesis Faculdade de Ciências da Universidade do Porto.

FORNACIARI, M.; PIERONI, L.; ORLANDI, F. & ROMANO, B. (2002). A new approach to consider the pollen variable in forecasting yield models. **Econ. Bot.** 56(1):66-72.

REIS, R & LAMELAS, H. (1988). **Tratamento Estatístico do Balanço Hídrico Decendial e dos seus Componentes com a ETP Calculada pelo Método de Penman.** Fascículo XXXVI, Instituto Nacional de Meteorologia e Geofísica Press, Lisbon.

VOSSEN, P. & RIJKS, D. (1995). **Early crop yield assessment of the EU countries: the system implemented by the Joint Research Centre.** Official Publications of the European Communities, ECSC-EAEC, Brussels, 3nd. Ed, 180 pp.

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STATISTICAL EVALUATION OF THREE YEARS OF AIBORNE POLLEN SAMPLING IN BRAGA

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SUMMARY: Over the last three years the annual variation in airborne pollen concentration (CPA) of Braga region was studied during *Vitis vinifera* flowering season. During this period, the CPA average was about 3600 pollen grains.m^{-3} of air. Thirty-six taxa were observed and the main pollen types were *Olea*, Poaceae and Castaneae that represented 75% of the pollen spectrum. The CPA was positively correlated with temperature and wind direction (East, West and Northeast) and negatively with rainfall and number of rainy days. Appropriate statistical tests showed that 65% of the variation in CPA could be explained and predicted by these climatic variables.
KEY WORDS: Braga, aerobiology, meteorological parameters, pollen grains.

RESUMEN: Durante los tres años pasados la variación anual en la concentración aeropolinica (CPA) de la región de Braga fue estudiada durante la estación floreciente de *Vitis vinifera*. Durante el período de estudio, la CPA média era cerca de 3600 granos.m-3 in upercipt del aire. Treinta y seis taxa fueron observados y las mayores CPA fueron *Olea*, Poaceae and Castaneae, los cuales representan el 75% del polen total contado. Se ha obtenido una correlacíon positiva con las temperaturas y la dirección del viento (Este, Oeste y Noroeste) y correlacíon negativa con la precipitación y el número de días lluviosos. A aplication de testes estadísticos apropiadas demuestran que el 65% de la variación en la CPA se podrían explicar y predecir por esas variables climáticas.
PALABRAS CLAVE: Braga, aerobiologia, parámetros meteorológicos, granos del pólen.

INTRODUCTION

During the last decade, in Europe, was observed an increasing number of pollen monitoring stations, for several applications namely in the alergological therapy. In Portugal, aerobiological studies are scarce and, until the present time, none was performed in Braga region. Since 1990, our researcher group develops aeropalynological studies in connection with a wine forecast programme. In the Botanical Department, during 1998, a palynological laboratory was set to perform analysis of airborne pollen, mostly for wine production forecast.

The study covers Braga's district (187 Km^2), in the Minho province, known as "Costa Verde", located at the Northwestern corner of Portugal (41°33'N; long. 8° 24' W), 50Km

North of Porto. It is surounded by Natural Parks, like Alvão at East and Peneda-Gerês at Northeast. For this reason Braga has a particular and privileged geographical situation. These parks are dominated by four vegetation levels: oak forests, sruby areas (ex: *Ulex minor, Erica australis* ssp. *Genista* sp.) and traditionally managed grazing fields (Lameiros).

The most significant feature in Braga climate is its annual rainfall level (1.514 mm) and its irregular distribution throughout the year, mainly concentrated in winter and spring. Air temperature increases inversely to precipitation: winters are cool and wet, summers hot and dry with an annual average annual of 14ºC. The main wind directions are come from the third (South and Southwest) and the first quadrant (North and Northeast), with 32% of the wind frequency directions.

Over the last three years the annual variation in airborne pollen concentration (CPA) was studied during *Vitis vinifera* flowering season.

The aim of this study was to establish a first pollen calendar in this region and investigate a possible correlation between pollen concentrations and meteorological and climatic variables in the years 1999-2001.

MATERIAL AND METHODS

The atmospheric pollen concentration in Braga region was measured, during *Vitis vinifera* flowering season (from May to July), in three consecutive years (1999 to 2001), using a sampling method developed by Cour (1974), where two filters were exposed constantly, per week, (the first one for 3 days and the second one for 4 days long). The sampler and the anemometer were set up on the roof of S. Paio de Merelim's church tower at approximately 20 m above ground level. After exposure, the pollen grains were removed, glycerol added and counting was carried out, with ten regular traverse rows of the microscopic (X630). "Cour Method" includes the acetolysis technique, which has a positive repercussion on the pollen analysis (Erdtman, 1960).

This method gives an image of the vegetation covering an area of about 50 Km around the trap (Cambon, 1981).

The more significant pollen types frequency were calculated per cubic meter of air and percentage. Data observation used were transformed to correspond to the mean daily values, in order to calculate the correlation coeficients.

The meteorological data retained in this analysis consist of daily observations of: maximum (Tmax), minimum (Tmin) and mean (Tmed) temperatures (Cº), precipitation (R; mm), number of rainy days (nR) and wind direction during the exposure of each filter from the meteorological station of Braga.

Pearson (rp) and Spearman (rs) correlation coefficients were used to calculate the relation between the main meteorological parameters and daily values of pollen concentration. The Spearman correlation test was used to evaluate the influence of non parametric variables.

The first step was the construction of a simple correlation matrix, with the double aim of: i) eliminating the less relevant variables; ii) verifying the existence of a high level of correlations between the independent variables and the dependent one, and iii) obtaining predictor variables. The model was constructed on the basis of multiple regression, characterised as the qualification and quantification of the variables through an estimation of the parameters associated. Data used corresponds to total pollen concentration observed during the study period.

RESULTS

Forty-four different pollen types from 36 families were identified, using our reference pollen collection, including pollen of trees, shrubs, grasses and cultivated plants. In this study, eight main pollen types were considered significant. The observed CPA values were similar in 1999 and 2000 and higher concentration was found in 2001 (Tab. 1; Fig. 2). The CPA average was about 3.600 pollen grains.m^{-3} of air.

The CPA of Braga during study period is dominated by *Poaceae*, *Olea* and *Castaneae*, representing, these three taxa 75% of total pollen concentration (74% in 1999, 76% in 2000 and 73% in 2001). The most significant pollen types and its percentage of ocurence can be observed in Figure 1. Poaceae, Castaneae, *Olea*, Urticaceae and *Vitis*, form 82% of Braga pollen occurrence during *Vitis* flowering period. These taxa were followed by *Rumex*, *Quercciferae*, and *Plantago*.

Apart from Poaceae and Urticaceae, that have always a significant presence during study period, *Olea*, *Vitis* and Castaneae registered their flowering peaks consecutively (Fig. 2).

Although Castaneae and *Olea* are the second and third most abundant pollen type, its presence, during the study period, corresponds to the beggining and to the end of the flowering season, respectively (Tab. 1).

Spearman and Pearson correlation coefficients and significance levels between total pollen concentration and meteorological data can be seen in Table 2.

Although coefficient values were different, all of them were highly significant and point in the same direction, all negative for rainfall (r=-0,64; p<0,001) and number of rainy days (r=-0,62; p<0,001) and positive for temperature (maximum, minimum and mean) and wind directions East (r=0,69; p<0.001), Southeast (r=0.48;p<0,05) and Northeast (r=0,62; p<0.001).

Still with respect to pollen distribution according to wind direction, only Northwest wind, with lower pollen concentration, displayed statistically significant differences from other wind directions. High significant positive correlations were also found with East and Northeast wind directions that carried great quantities and diversity of pollen from the Natural Parks.

When the multiple stepwise regression analysis was performed, appropriate statistical tests showed that 65% of the variation in CPA could be explained and predicted by mean temperature, number of rainy days and wind direction.

Taxa	1999		2000		2001		Average	
	Sum	%	Sum	%	Sum	%	Sum	%
Vitis	42,9	1,4	37,9	1,2	74,5	1,6	51,8	1,4
Olea	611,1	19,4	279,5	9,1	642,2	13,9	510,9	14,1
Poaceae	767,3	24,3	1.312,1	42,7	1.432,8	31,1	1.170,7	32,7
Rumex	83,5	2,6	90	2,9	157,9	3,4	110,4	3
Plantago	115,6	3,7	116,9	3,8	165,5	3,6	132,7	3,7
Urticacea	227,7	7,2	195,2	6,3	332,1	7,2	251,6	6,9
Quercciferae	133,2	4,2	141,1	4,6	145,2	3,2	139,8	4
Castaneae	998,7	31,7	742,6	24,2	1.298,6	28,2	1013,3	28
Total Pollen	3.151		3.072		4.601		3.608	

TABLE 1. CPA and percentage of the eight most frequent pollen types observed from 1999 to 2001 in Braga region.

The standard error of the CPA estimation, decreased from 3,4% when daily mean temperature is the only predictor to 2,8% when the model includes wind direction (NW%) and number of rainy days (nR). However, it is important to emphasise that the observation period (3 years) cannot statiscally estimate the relationship in a definitive way.

DISCUSSION

This preliminary study of airborne pollen concentration of Braga region, carried out during three consecutive years, is open to confirmation and refinement with more data in order to provide the first pollen calendar in this region.

In all years the same types of pollen were observed. The only difference was the little fluctuation in flowering season and pollen concentration related to biotic factors.

In fact, this study showed the influence of the atmosphere biotic fraction, such as temperature, rainfall and wind, in pollen quantity and quality present in a determined geographical area. These fraction controls, more or less intensely, the pollen dispersion and transport, with a positive influence for temperature and negative for rainfall (CARIÑANOS *et al.*, 1998; MORENO-GRAU *et al.*, 1998). Concerning wind directions, their influence depends also on the vegetation composition of study area.

Our results are similar to the ones presented by FERNÁNDEZ *et al.* (1993) and MARTÍNEZ *et al.* (1990) that showed a positive correlation with thermal parameters, in the Iberian Peninsula, for plants whose flowering occurs before summer.

Braga's pollen spectrum includes plants used for agricultural purposes (*Vitis*, *Olea* and Castaneae).

Comparing the results obtained in the study period of this work, with the same period of studies made in Northern Spain, higher values of Castaneae concentration were registed yearlier in Braga region, (IGLE-

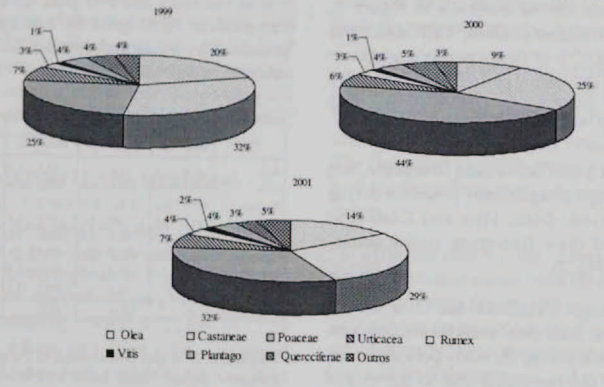

FIGURE 1. Frequency of pollen types observed from 1999 to 2001 in Braga region.

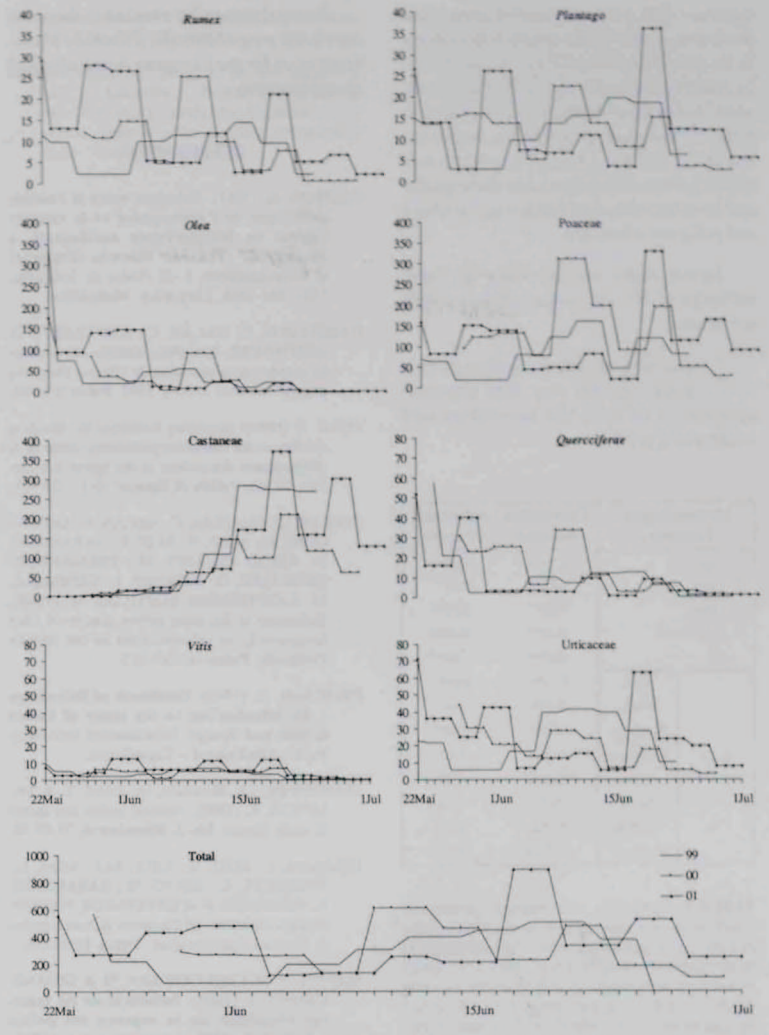

FIGURE 2. Annual spectrum of most significant pollen types observed from 1999 to 2001 in Braga region.

SIAS *et al.*1999). *Olea* and *Vitis* flowering peaks are similar, in time of occurence, with Northen Spain cities (DIAZ DE LA GUARDIA *et al.*, 1999). So could be important to establish a forecast model for estimating the annual variation in these cultures and to define the beginning and the end of the main pollen period. It is also important to correlate these three species and to carry studies of phenology, ecology and pollination biology.

In this study we can notice the great influence of Natural Parks in Braga pollen spectrum.

Concerning allergenic pollen grains, such forecast model may find practical application in both the prevention and treatment of pollinosis.

Meteorological Parameters		Correlation Coefficients Spearman	Pearson
Tmax		0,76**	0,83**
Tmed		0,82**	0,87**
Tmin		0,66**	0,70**
Rainfall (R)		-0,64**	-0,45ns
NR		-0,63**	-0,62**
Wind directions	East	0,57**	0,69**
	North	0,53*	0,44ns
	Northeast	0,63**	0,62**
	Northwest	-0,24ns	-0,25ns
	West	-0,11ns	-0,28ns
	South	-0,31ns	-0,12ns
	Southeast	0,16ns	0,48*
	Southwest	-0,32ns	-0,17ns

TABLE 2. Spearman and Pearson correlation coefficients and significance levels for the total pollen concentration and meteorological parameters. ** significance level 1%, Tmax (maximum temperature), NR (nunber of rainy days); * significance level 5%, minimum temperature; ns no significanc, Tmed (mean temperature).

Being the sampler situated at the most occidental zone of Europe, it could be a reference point for the European Aerobiological net information.

REFERENCES

CAMBON, G. (1981). **Relations entre le contenu pollinique de l'atmosphére et le couvert végétal en Méditerranée occidentale, à Montpellier (France), Valencia (Espagne) et Oran (Algérie)**. I –II –Thèse de Spécialité, Univ. Sci. Tech. Languedoc, Montpellier.

CARIÑANOS, P.; GALÁN, C.; ALCÁZAR, P. & DOMÍNGUEZ, E. (1998). Análisis del contenido polínico de la atmósfera de Chirivel (Almería) durante los años 1996 y 1997. **Polen** 9:51-62.

COUR, P. (1974). Nouvelles technique de détection des flux et des retombées polliniques: étude de la sedimentation des pollens et des spores à la surface du sol. **Pollen et Spores** 16(1):103-141.

DIAZ DE LA GUARDIA, C.; GALAN, C.; DOMÍNGUEZ, E.; ALBA, F.; RUIZ, L.; SABARIEGO, S.; RECIO CRIADO, M.; FERNÁNDEZ-GONZÁLEZ, D.; MENDEZ, J.; VENDRELL, M. & GUTIÉRREZ BUSTILLO, M. (1999). Variations in the main pollen season of *Olea europaea* L. at selected sites in the Iberian Peninsula. **Polen** 10:103-113.

ERDTMAN, G. (1969). **Handbook of Palynology – An introduction to the study of Pollen Grains and Spores.** Scandinavian University Books, Munksgaard – Copenhagen.

FERNANDEZ, D.; SUAREZ, D.; DIAZ, T. & VALENCIA, R. (1993). Airborne pollen and spores of León (Spain). **Int. J. Biometeorol.** 37:89-95.

IGLESIAS, I.; JATO, V.; AIRA, M.J.; SBAI, L.; VALENCIA, R.; RECIO, M.; SABARIEGO, S.; CERVIGÓN, P. & CARIÑANOS, P. (1999). Annual variations of *Castanea* airborne pollen at thirteen Spanish sites. **Polen** 10:51-58.

MARTIN, J.; SUAREZ-CERVERA, M & SEOANE-CAMBA, J. (1990). **Influencia de los factores climáticos en la captura del pollen aerovagante. Pollen, esporas y sus Aplicaciones**. Actas del VII Simposio de Palinologia, APLE, pp.385-390. Granada.

MORENO-GRAU, S.; BAYO, J.; ELVIRA-RENDUELES, B.; ANGOTO, J.; MORENO, J. & MORENO-CLAVEL, J. (1998). Statistical evaluation of three years of pollen sampling in Cartagena. Spain. **Grana** 37:41-47.

RIBEIRO, H. (2001). **Conteúdo polínico da atmosfera da região de Braga, durante os meses de floração de *Vitis vinifera*, nos anos de 1999 e 2000, utilizando o método de Cour**. Porto, Relatório final de curso, Faculdade de Ciências.