

Airborne pollen concentration in the region of Braga, Portugal, and its relationship with meteorological parameters

Helena Ribeiro¹, Mário Cunha² & Ilda Abreu^{1,*}

¹Department of Botany, Faculty of Science, University of Porto. Rua Campo Alegre, 1191 4150 Porto. Portugal;

²Section of Agrarian Sciences, Faculty of Sciences of the University of Porto (E-mail: mcunha@mail.icav.up.pt)

(*Author for correspondence: E-mail: ianoronh@fc.up.pt)

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Abstract

The variation in airborne pollen concentration of the Braga region (Portugal) was studied in springtime, during the flowering of *Vitis vinifera*. The data set was obtained for two consecutive years (1999 and 2000), using a Cour-type sampler. During this period, thirty-six taxa were observed in a total of 3,200 pollen grains m⁻³ of air (CPA). The main pollen types observed were *Olea*, *Poaceae* and *Castanea*, representing 74% of the pollen spectrum. The airborne pollen concentration (CPA) was significantly correlated with certain meteorological parameters. Pollen concentration was positively correlated with temperature and wind direction (East and Northeast) and negatively correlated with rainfall and number of rainy days.

1. Introduction

The air contains an enormous number of particles of various origins, shapes and sizes found in suspension, constituting atmosphere aerosol. The atmosphere concentration of different pollen types varies enormously from one country to another, in regions of the same country, and even among different cities, because pollen emissions depend on vegetation and environmental conditions. Generally, meteorological factors have an important influence on this airborne concentration. Aerial transport may have an important impact on earth life, which increases with economic expansion around the world (Wilkening et al., 2000).

Compared with other European countries, very few aerobiological studies have been conducted in Portugal. The important ones, in Évora, are by Pinto-da-Silva in 1950–1960, Paiva and Leitão (interruptedly since 1978) in Coimbra, Porto and Lisboa and Brandão and Lopes (1990, 1992, 1995). No aerobiological studies have been performed in the Braga region.

The study area corresponds to the Braga district, in the Minho province situated at the Northwest corner

of Portugal, 50Km North of Porto. The river Minho, which has given its name to the region, is the natural border between the provinces of Minho in Portugal and Galicia in Spain.

This district has an area of 187 km², being surrounded by the mountains Bom Jesus, Sameiro, Falperra and Parque Natural do Gerês. Bounded to the North by the district of Viana do Castelo, to the East by that of Vila Real, to the South by that of Oporto and to the West by the Atlantic Ocean, the Braga region has a privileged geographical situation.

Portugal is part of the Atlantic European area, affected by the Gulf Stream with a cold season (Paiva and Leitão, 1989). The climate of Braga is affected by maritime influence, being described as rainy with low temperatures in winter and low humidity and high temperatures in summer. The most frequent winds are from the Northwest with an average annual mean temperature of 14 °C and a mean rainfall of 126.2 mm/year with a total maximum of 1,514.9 mm/year.

Human and animal influences mostly determine Portugal's vegetation, apart from some mountains in the North and some maritime fringe areas. The

main permanent agriculture is the vineyard, occupying 10% of agricultural land; *Pinus pinaster* is the main forestall species occupying 91.5% of forest area.

The sampler being situated in the westernmost zone of Europe could be a reference point for the European Aerobiological net information.

Since vines are one of the most important plants in this area and flower during the springtime, when the highest quantity and quality pollen are recorded, the aim of this work was to analyse the pollinic spectrum in the Braga region, during the flowering months of *Vitis vinifera*, for two consecutive years (1999 and 2000).

2. Materials and methods

A sampling method developed by Cour (1974) was used. Airborne pollen grains were trapped on two vertical gauze filters with a surface area of 400 cm². To determine the volume of air flowing through the filters, an anemometer (Cimel Enerco 402) was used. Filter efficiency varies with wind speed between 17 and 24% (Cour, 1974); therefore an average coefficient of 20% was used to estimate data for the analysis variables. The sampler and wind sensor was set up on the top of the S. Paio de Merelim's church tower in Braga (41°33' N, 8°24' W), approximately 20 m above ground level.

After exposure, the pollen grains were removed, glycerol added and the counting was carried out, independently of the pollen concentration, with ten regular transverse rows of the microscope (X630). The "Cour Method" includes the acetolysis technique, which has a positive repercussion on pollen analysis (Erdtman, 1960).

The pollen data used correspond to the mean daily values. Each observation calculates the frequency of the more significant pollen types per cubic meter of air and its percentage. The meteorological station of Braga provided daily data for mean (Tmean), minimum (Tmin) and maximum (Tmax) temperature, wind speed and direction (eight sectors) and rainfall (R). The relationship between the main meteorological parameters and daily pollen concentration was calculated using Pearson (rp) and Spearman (rs) correlation coefficients.

A stepwise regression analysis was used to evaluate the significance level of the independent variable in the dependent one (Montgomery and Peck, 1992).

An analysis of variances (ANOVA) was developed to test the significance level of the model parameters (H0: $\beta_i, \dots, n = 0$). The SPSS® version 10.0 has been used for all statistical analysis.

3. Results and discussion

An analysis of the meteorological data revealed that the two consecutive years registered the highest temperatures and lowest rainfall compared to the reference meteorological series 51/80. During this period, 36 pollen taxa belonging to 32 families were trapped in the sampler. The total concentration observed was very similar for the two study periods, 3,176 pollen grains m⁻³ in 1999 and 3,079 pollen grains m⁻³ in 2000.

Compared to *Vitis* pollen count, which represents only 1.3% of the Braga region spectrum, *Gramineae* is the dominant taxon in the atmosphere, with an average of 32%. In fact, this taxon prevails over *Olea* and *Castanea*; these three taxa represent 74% of total pollen concentration. *Olea*, *Gramineae*, *Vitis*, *Castanea* and *Urticaceae* form 82% of Braga pollen occurrence during the *Vitis* flowering period (Table 1).

As can be seen in Figure 1, apart from *Graminea* and *Urticaceae*, that always have a significant presence during the study period, *Olea*, *Vitis* and *Castanea* registered their flowering peaks consecutively.

Concerning total pollen (Figure 2), in 1999 two peaks were observed, a higher one at the beginning of the monitoring period and a second one, less evident and longer, between 14 and 24 of June. In 2000, three peaks were observed, the last two being more evident. The synchronism registered in the variations of pollen concentration with mean temperature and rainfall is important. In 1999, the influence of rainfall on the pollen spectrum was not significant as its occurrence was quantitatively low and centred in only four days. During the 2000 sampling period more dispersal rainfall was observed which affected the continuity of the pollen spectrum. As can be seen, when it rains there is a substantial decrease in the total quantity of pollen concentration. Afterwards an increase in mean temperature was followed by an increase in pollen concentration.

Spearman and Pearson correlation coefficients and significance levels between total pollen concentration and meteorological data, for a size sample of 20, can be seen in Table 2.

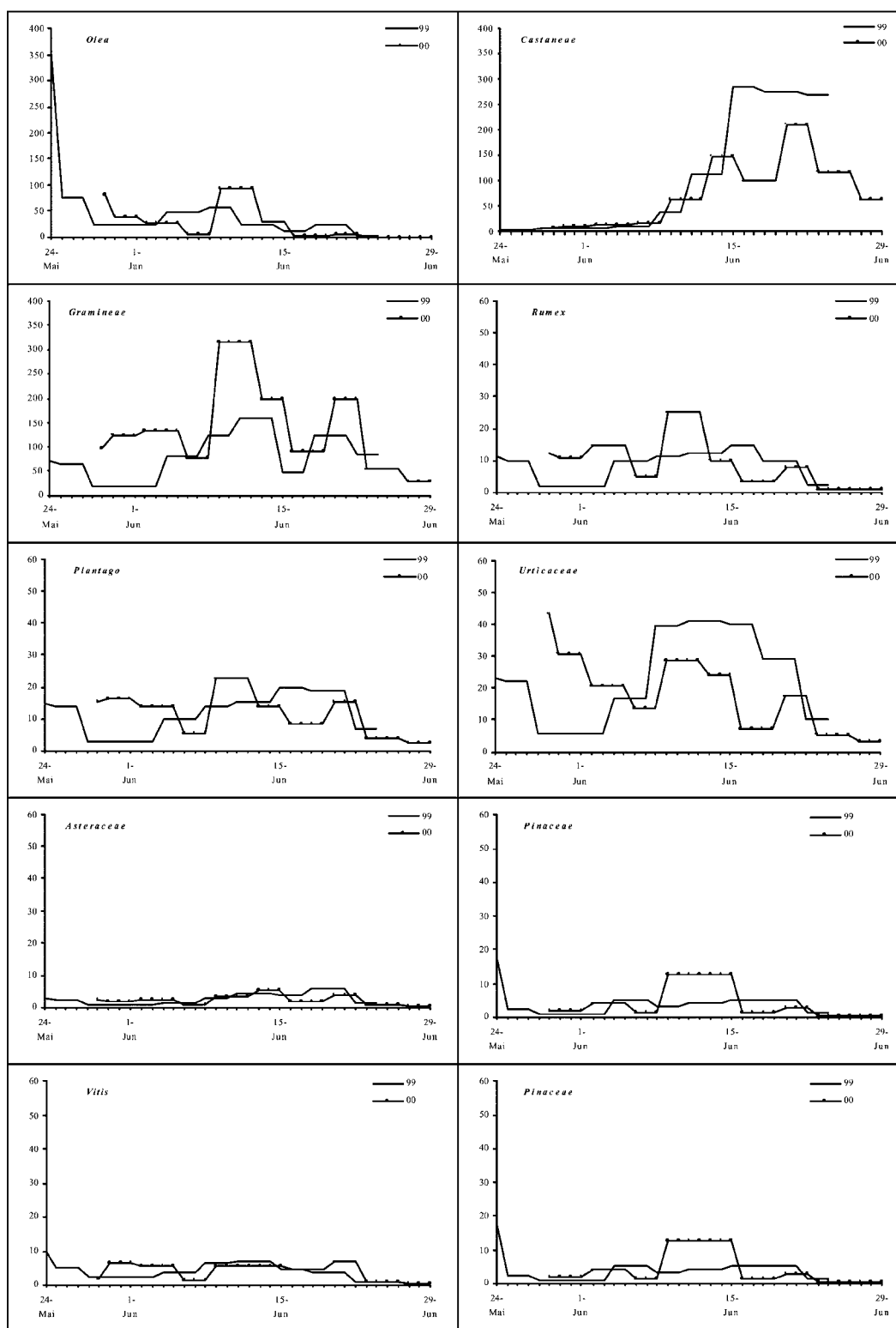


Figure 1. Most significant pollen types per cubic meter of air observed during study period in Braga region.

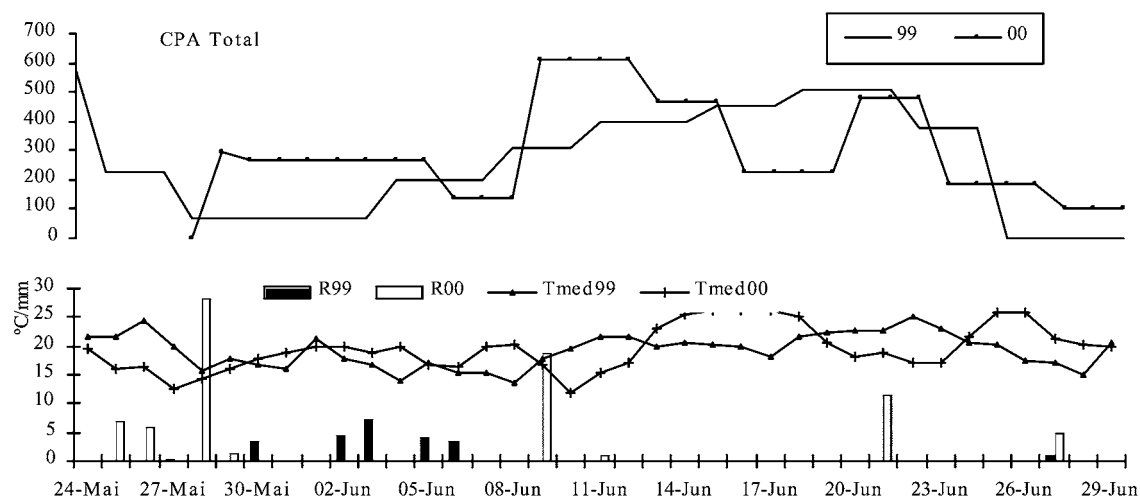


Figure 2. Total pollen emission per cubic meter of air and daily meteorological parameters during study.

Table 1. Frequency of pollen types per cubic meter of air and % observed during study period in Braga region

Taxa	1999	2000	Total	% 1999	% 2000	%Total
<i>Vitis</i>	42.97	37.93	80.91	1.35	1.23	1.29
<i>Oleaceae</i>	615.76	280.46	896.23	19.39	9.11	14.33
<i>Poaceae</i>	767.33	1216.52	1983.85	24.16	39.51	31.71
<i>Rumex</i>	83.46	90.01	173.48	2.63	2.92	2.77
<i>Plantago</i>	115.61	116.91	232.52	3.64	3.80	3.72
<i>Urticaceae</i>	227.67	195.16	422.83	7.17	6.34	6.76
<i>Asteraceae</i>	24.86	22.68	47.54	0.78	0.74	0.76
<i>Quercus</i>	133.15	141.05	274.21	4.19	4.58	4.38
<i>Castanea</i>	998.74	742.56	1741.32	31.44	24.11	27.84
<i>Pinaceae</i>	44.58	38.93	83.52	1.40	1.26	1.34
<i>Aceraceae</i>	3.96	1.75	5.72	0.12	0.06	0.09
<i>Brassicaceae</i>	3.26	4.87	8.14	0.10	0.16	0.13
<i>Chenopodiaceae-Amarantaceae</i>	5.28	14.18	19.47	0.17	0.46	0.31
<i>Cistus</i>	2.06	69.05	71.12	0.06	2.24	1.14
<i>Cupressaceae</i>	5.37	1.01	6.37	0.17	0.03	0.10
<i>Cyperaceae</i>	7.91	4.93	12.84	0.25	0.16	0.21
<i>Echium</i>	8.90	10.56	19.45	0.28	0.34	0.31
<i>Ericaceae</i>	17.63	11.58	29.22	0.56	0.38	0.47
<i>Myrtaceae</i>	21.26	16.83	38.10	0.67	0.55	0.61
<i>Euphorbia</i>	26.92	15.43	42.36	0.85	0.50	0.68
<i>Fabaceae</i>	7.31	16.12	23.43	0.23	0.52	0.37
<i>Juglans</i>	0.17	7.78	7.96	0.01	0.25	0.13
<i>Phaseolaceae</i>	0.24	5.86	6.11	0.01	0.19	0.10
<i>Rosaceae</i>	3.84	7.15	10.98	0.12	0.23	0.18
<i>Salix</i>	0.44	6.81	7.25	0.01	0.22	0.12
<i>Typha</i>	4.03	0.98	5.01	0.13	0.03	0.08
<i>Umbelifera</i>	3.71	2.18	5.89	0.12	0.07	0.09
Total	3176.42	3079.28	6255.83	100	100	100

Table 2. Spearman and Pearson correlation coefficients and significance levels for the total pollen concentration and meteorological parameters

Meteorological Parameters		Correlation Coefficients	
		Spearman	Pearson
Temperature maxi		0.76**	0.83**
Tmean		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

* significance level 5%.

** significance level 1%.

ns no significant.

Although coefficient values differ, all of them are highly significant and point in the same direction: all negative for rainfall and number of rainy days and positive for temperature (minimum, mean and maximum) and wind directions East and Northeast.

Spearman and Pearson coefficients show that temperature (minimum, mean and maximum) and wind direction are the meteorological parameters that best explain atmospheric pollen concentration variations, showing their fundamental importance on the dispersion and transport of pollen grains, coinciding with similar observations made by other authors (Meiffren, 1988; Reccio et al., 1996; Grau et al., 1998). As can be seen in Table 2 the best correlation was found between total pollen concentration and mean daily temperature ($r = 0.87$; $p < 0.01$). A negative correlation between rainfall and number of days with rain was also found ($r = 0.64$; $p < 0.01$).

When the multiple regression analysis was performed, two models were found to fit. The best one was that which considered mean temperature and East wind direction (Table 3). Though rainfall is highly correlated with atmosphere pollen concentration, it was not selected because it is auto correlated with temperature, not improving the model.

Table 3 shows that all t tests have a significance level below 0.05. These results support evidence that each of the independent variables (mean temperature

and wind direction East) explain and influence atmosphere pollen concentration, as its coefficients differ from zero. All F tests have a high significance level ($p < 0.00$) which leads us to reject the nullity of the independent variable coefficients. On the other hand, the analysis of confidence intervals shows that none of them contain the value zero, leading to a rejection of $H_0: \beta_1 \dots \beta_n = 0$; all independent variables have a significant influence on airborne pollen concentration.

The meteorological parameters mean temperature can explain and predict about 76% of total atmospheric pollen concentration. The model (Table 3, model 1) shows that pollen concentration is approximately zero for a mean temperature of 12.2 °C. This result is important because in conjunction with weather forecasts it provides a reasonably accurate pollen concentration prognosis for the coming week.

When the multiple regression analysis was performed (Table 3, model 2), appropriate statistical tests show that 81% of the variation in airborne pollen concentration can be explained and predicted by those climatic variables. The standard error of the estimate decreases from 71.81 CPA when Tmed is the only predictor, to 65.28 CPA when the model includes East wind direction.

Previous studies comparing airborne pollen concentration with meteorological parameters have also reported low regression coefficients (rp). Grau et al. (1998) reported 0.47 for the total airborne pollen of Cartagena and Galán et al. (1995) reported 0.13 and 0.27 for Cordoba and London respectively in a comparative analysis of grass pollen count.

4. Conclusion

This two year study of airborne pollen content of Braga provides data to establish a first pollen calendar in this region. Our results show that 36 taxa were observed in the atmosphere of the Braga region; where *Olea*, *Poaceae* and *Castanea* were the most representative.

The pollen spectrum includes several plants used for ornamental (*Rosaceae*, *Cupressaceae* and *Asteraceae*) and agricultural purposes (*Vitis*, *Olea* and *Castanea*) and other typical species of Entre-Douro e Minho.

During the sampling period the pollen variations were homogeneous, with a total of 3,176.5 pollen grains m^{-3} in 1999 and 3,079.4 pollen grains m^{-3} for 2000.

Table 3. Results of multiple regression analysis and statistical coefficients of main significant dependent variables

Model	Variables Entered	Model summary					Coefficients of dependent variables			
		rp	R ²	R ² adj.	S _E	F _{test}	B	S _E	t _{student}	Sig.
1	Constant	0.869	0.756	0.742	71.81	52.64	-519.68	111.79	-4.45	0.000
	Tmed.						42.55	5.87	7.26	0.000
2	Constant	0.900	0.810	0.786	65.28	34.14	-399.84	120.06	-3.33	0.004
	Tmed.						34.76	6.46	5.38	0.000
	wind East						0.95	0.45	2.14	0.048

Total and individual pollen concentration decreased during rainfall periods. After these periods, mean temperature and consequently pollen concentration increased. These results are in accordance with those obtained with a cross-correlation matrix plot. There was a positive correlation between atmospheric pollen concentration, temperature and wind directions East and Northeast and a negative one with rainfall and number of rainy days with significance levels below 0.05 and 0.01. Our results are similar to those presented by Fernández et al. (1993) and Martine et al. (1990) that showed a positive correlation with thermal parameters in the Iberian Peninsula for plants whose flowering occurs before summer. The positive influence of wind from East and Northeast can be interpreted as pollen which comes from a localised origin, in this case from “Parque Natural do Alvão” and “Parque Natural Peneda Gerês”. The negative influence of rainfall is generally mentioned in all aeropalynological studies. This is probably due to its effect on atmosphere pollen concentration, since water droplets provoke atmosphere washing and sedimentation. According to statistical tests 81% of total atmosphere pollen concentration may be explained by weather parameters such as mean temperature and wind direction.

In most of taxa studied, “refloating” was recorded, most intensely in 2000, which may be due to higher rainfall and associated with higher temperature, atmospheric turbulence and convection (Meiffren, 1988; Caramiello et al., 1990; Recio et al., 1996).

This is a preliminary study, based on data from only two consecutive years being open to confirmation and refinement with more data.

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