



Effects of meteorological parameters and plant distribution on Chenopodiaceae-Amaranthaceae, *Quercus* and *Olea* airborne pollen concentrations in the atmosphere of Cartagena (Spain)

Stella Moreno-Grau^{1*}, José M. Angosto¹, Belén Elvira-Rendueles¹, Javier Bayo¹, José Moreno² & Joaquín Moreno-Clavel¹

¹Department of Chemical Engineering Cartagena; and ²Department of Graphic Engineering, Cartography and Projects, University of Murcia, Spain

(*author for correspondence, e-mail: stella@plc.um.es)

(Received 3 February 1999; accepted in final form 20 December 1999)

Key words: airborne concentration, correlation models, Chenopodiaceae-Amaranthaceae, meteorological parameters, *Olea* and *Quercus*

Abstract

We have studied the effects of various meteorological parameters and plant distribution on the airborne concentrations of three different pollen types: Chenopodiaceae-Amaranthaceae, *Quercus* and *Olea*, in the city of Cartagena, situated in Southwest Europe. The aerobiological study has been carried out from March 1993 to March 1997, using a Hirst-type Lanzoni 2000 trap, situated on the roof of the city train station. Meteorological data were supplied by the Environmental Service of Cartagena's Town Hall. Daily pollen concentrations were standardised. Correlation analysis showed the importance of meteorological data on airborne pollen concentrations. On the other hand, ANOVA analyses depicted the influence of vegetation distribution in relation to sampler location and wind directions. Finally, multiple regression analyses allowed us to develop correlation models for the three different pollen types considered, accounting for 32% (Chenopodiaceae-Amaranthaceae), 19% (*Quercus*), and 26% (*Olea*) of the variation in the airborne pollen concentration.

1. Introduction

Cartagena is a Mediterranean city, located at the Southeast of the Iberian peninsula. It is one of the most arid zones in Spain, with moderate temperatures due to sea influence. The average temperature for the years considered in this study was 19.48°C, and the average annual rainfall 217.66 mm, with the lowest value of rainfall for 1995, 93.4 mm (Moreno, 1998). Aerobiological studies have proved to be important for medicine, agriculture, and other fields, but the main socio-economic implication has been on allergic afflictions caused by different pollen types. Local vegetation type, agriculture, and climate have been pointed out as important factors in relation to pollen sensitivity (Galán et al., 1995). The use of mod-

els has been shown to be an important tool in the study of the sensitization of the population to different pollen types (Norris-Hill, 1995). In this paper, we present an analysis of the influence of location of sources producing pollen and different meteorological parameters on measured pollen concentrations, and also the potential development of statistical forecasting models using multiple linear regression. Due to the great amount of different pollen types found in the aerosol of Cartagena, this study was carried out for Chenopodiaceae-Amaranthaceae, *Quercus* and *Olea*. The first of these three taxa, Chenopodiaceae-Amaranthaceae, was selected because of its high levels in the atmosphere of our town. In order to study the pollen origin and its behaviour as a function of wind speed, it was necessary to choose some pollen type

Table 1. Pearson's correlation coefficients for standardised pollen concentration of Chenopodiaceae-Amaranthaceae, *Quercus*, and *Olea* according to meteorological parameters

	Cheno-Amar.	<i>Quercus</i>	<i>Olea</i>
Rainfall	0.081** (1278)	-0.113* (459)	-0.089 (261)
Humidity	-0.068* (1277)	-0.187** (458)	0.077 (260)
Air pressure	-0.230** (1252)	-0.183** (458)	-0.118 (260)
Sunshine	0.239** (1266)	0.230** (458)	0.135* (260)
Accumulated average temperature	0.327** (1278)	0.190** (459)	0.133* (261)
Average temperature	0.279** (1277)	0.215** (458)	0.161** (260)
Average wind speed	0.055* (1277)	-0.095* (458)	-0.137* (260)

Number of data appears into brackets. *Significance level 95%. **Significance level 99%.

Table 2. Forecasting models for standardised pollen concentration of Chenopodiaceae-Amaranthaceae (StChAm), *Quercus* (StQu), and *Olea* (StOl)

Equations	R	R ²
StChAm = 25.94 - 4.46·10 ⁻³ H + 2.54·10 ⁻³ R - 2.36·10 ⁻² P + 5.12·10 ⁻⁵ S + 5.79·10 ⁻⁴ AT - 0.13 T + 4.43·10 ⁻³ W	0.563	0.317
StChAm = 26.62 - 4.68·10 ⁻³ H + 2.72·10 ⁻³ R - 2.42·10 ⁻² P + 5.07·10 ⁻⁵ S + 5.75·10 ⁻⁴ AT - 0.13 T	0.562	0.316
StQu = 22.67 - 2.34·10 ⁻² H - 3.79·10 ⁻³ R - 2.17·10 ⁻² P - 2.83·10 ⁻⁵ S - 2.51·10 ⁻⁵ AT + 0.20 T - 5.84·10 ⁻³ W	0.440	0.194
StQu = 22.71 - 2.34·10 ⁻² H - 3.87·10 ⁻³ R - 2.18·10 ⁻² P - 2.87·10 ⁻⁵ S + 0.20 T - 5.91·10 ⁻³ W	0.440	0.194
StOl = 55.39 + 1.33·10 ⁻² H - 6.41·10 ⁻³ R - 5.85·10 ⁻² P + 2.77·10 ⁻⁵ S + 1.03·10 ⁻³ AT + 0.16 T - 1.87 W	0.512	0.262
StOl = 52.22 + 1.31·10 ⁻² H - 5.55·10 ⁻² P + 3.62·10 ⁻⁵ S + 1.05·10 ⁻³ AT + 0.15 T - 1.66 W	0.510	0.260

H= Humidity; R= Rainfall; P= Air pressure; S= Sunshine; AT= Accumulated temperature; T= Temperature; W= Wind speed.

with lack of heavy vegetation around the sampling point; this was *Quercus*. Finally, *Olea* was chosen for its agronomic and allergenic interests.

2. Materials and methods

From March 1993 to March 1997, atmospheric pollen was sampled using a Hirst sampler (Lanzoni VPPS-2000), situated at the roof of the train station in Cartagena, at 10 m height. Pollen was counted following REA methodology (Domínguez, 1995). The number of pollen grains daily per cubic meter was calculated as stated in Moreno-Grau et al. (1995). For this study, we have assessed the pollen season for each pollen type, defined as the time period accounting for 97.5% of total pollen each year, having eliminated only 2.5% values from right tail. The meteorological parameters selected for this study were: rainfall, humidity, air pressure, sunshine, average temperature and wind (direction and speed), all of them supplied by the Environmental Service of Cartagena's Town Hall. Daily pollen contents were standardised in order to eliminate seasonal variations from one year to another, which mask the real pollen patterns. For this purpose, the logarithmic transformation proposed by Moseholm et al. (1987) was used, with the following relationship:

ithmic transformation proposed by Moseholm et al. (1987) was used, with the following relationship:

$$n_p = \ln \left[\frac{p_r \cdot 1000}{p_y} + 1 \right]$$

where:

n_p = standardised pollen count

p_r = daily pollen count

p_y = total pollen content in the season

This type of transformation reduces the relative error or coefficient of variation without modifying significantly the importance of the relative variance (Galán et al., 1995). Wind direction was classified within 12 sectors, with an amplitude of 30° each one, from (1) N (345°–15°) to (12) NNW (316°–344°). In the same way, wind speed values were divided into 4 intervals: range 1 (0–4 km/h); range 2 (5–9 km/h); range 3 (10–15 km/h), and range 4 (>15 km/h). In order to study the influence of plant distribution on pollen counts, an analysis of variance (ANOVA) was developed on standardised pollen concentrations according to wind direction. SPSS for Windows 7.5 has been used for all statistical analyses. Also, a bivariate analysis (Pearson coefficient) was carried out to study the most

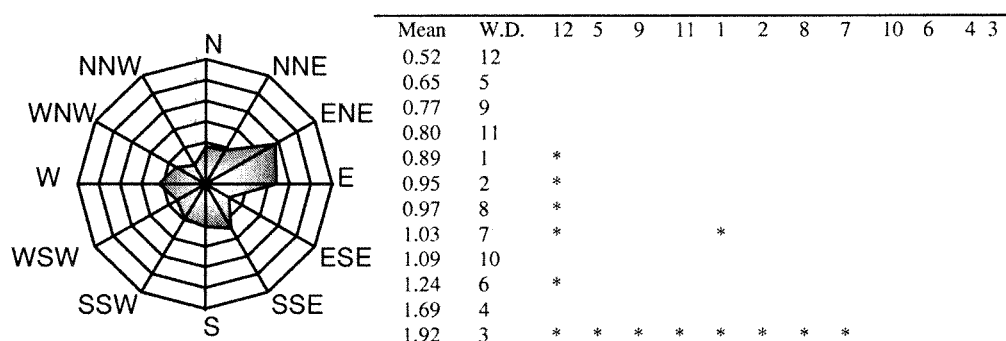


Figure 1. Wind rose of standardised Chenopodiaceae-Amaranthaceae concentrations for wind directions. (W.D. = Wind Direction. 1 = N, 2 = NNE, 3 = ENE, 4 = E, 5 = ESE, 6 = SSE, 7 = S, 8 = SSW, 9 = WSW, 10 = W, 11 = WNW, 12 = NNW)

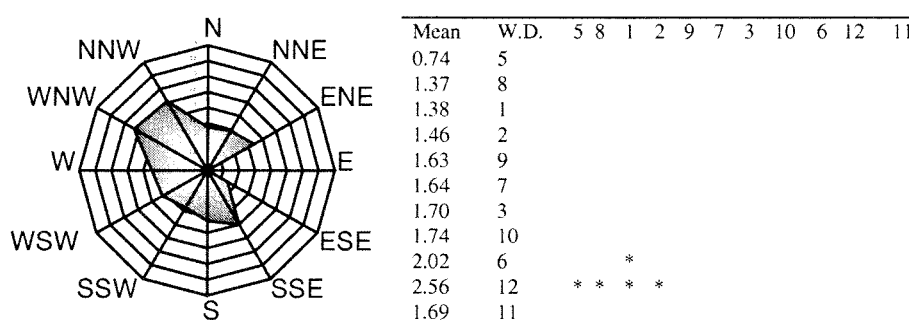


Figure 2. Wind rose of standardised *Quercus* concentrations for wind directions. (W.D. = Wind Direction. 1 = N, 2 = NNE, 3 = ENE, 4 = E, 5 = ESE, 6 = SSE, 7 = S, 8 = SSW, 9 = WSW, 10 = W, 11 = WNW, 12 = NNW)

important meteorological factors affecting pollen concentration. Finally, multiple lineal regression was used to get different forecasting models for studied pollen types, following Backward option from SPSS, which removes on each step that variable with a significance ≤ 0.05 .

3. Results

Table 1 shows Pearson's correlation coefficients for standardised pollen concentrations of three pollen types and different meteorological parameters, including number of data used for each bivariate correlation. In Table 2 the two best correlation models are given for each pollen type using multiple lineal regression, with standardised pollen concentration as dependent variable and different meteorological parameters as independent variables. Figures 1, 2, and 3 show wind roses of standardised pollen concentrations for wind directions and multiple range test tables

for Chenopodiaceae-Amaranthaceae, *Quercus*, and *Olea*.

4. Discussion

Bivariate correlation between standardised pollen concentrations and different meteorological parameters was significant for most of them, although with different levels according to pollen type considered. Only average temperature showed a particularly positive strong correlation with three pollen types, which reveals the importance of this meteorological parameter in flowering and pollen production. As Moseholm et al. (1987) have shown, the development of pollen grains, within the anther from the pollen mother cell is probably a temperature dependent process. The same can be said for sunshine, a meteorological variable which induces anther dehiscence and filament extension, together with a falling relative humidity, a meteorological

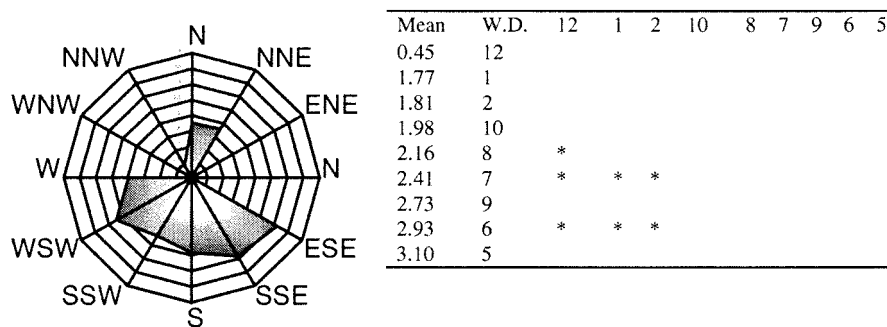


Figure 3. Wind rose of standardised *Olea* concentrations for wind directions. (W.D. = Wind Direction. 1 = N, 2 = NNE, 3 = ENE, 4 = E, 5 = ESE, 6 = SSE, 7 = S, 8 = SSW, 9 = WSW, 10 = W, 11 = WNW, 12 = NNW)

parameter inversely related with standardised pollen concentration for Chenopodiaceae-Amaranthaceae and *Quercus*. Determination coefficients (R^2) for Chenopodiaceae-Amaranthaceae, *Quercus*, and *Olea*, were 0.32, 0.19, and 0.26, respectively, which means that only 32%, 19%, and 26% of the variation in airborne concentrations can be explained by those climatic variables. Previous studies have also reported low regression and determination coefficients, although these values improved when the model was developed from the start of the pollen season to the maximum daily pollen count (Galán et al., 1995). The best determination coefficient was for Chenopodiaceae-Amaranthaceae, accounting for 32% of total variability of this pollen type with six meteorological parameters. The only independent variable removed from model was wind speed. Chenopodiaceae-Amaranthaceae is a pollen type irregularly and widely distributed in our zone, so, wind speed does not influence very much its concentration. Figure 1 shows the higher concentrations of this pollen type when wind comes from east-north east direction, where a former wetland was placed and the terrain still remains without edification. On the other hand, Figure 2 and 3 show the importance of wind direction for *Quercus* and *Olea* pollen concentrations. *Quercus* pollen concentrations are the highest when winds come from the fourth quadrant, where an important distribution of this plant is located. Figure 3 shows the importance of winds coming from the second and third quadrant on *Olea* pollen capture. This is because the situation of the main parks and gardens in our city, where the olive tree grows as an ornamental specie, with respect to the pollen trap.

5. Conclusions

- Bivariate correlation between standardised pollen concentrations and different meteorological parameters has shown the importance of average temperature and sunshine, positively influencing the pollen release and dispersion, and humidity and air pressure, with a negative influence on pollen counts.
- Multiple regression models explain 32%, 19%, and 26% of the variation in the airborne pollen concentration of Chenopodiaceae-Amaranthaceae, *Quercus*, and *Olea*, respectively.
- Wind roses of standardised pollen concentrations adequately reflect plant distribution in our zone.

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