

Allergenic airborne pollen monitoring of Vigo (NW Spain) in 1995–2001

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Pollen data from the atmosphere of Vigo, NW Spain was collected using a Hirst type pollen trap over a seven-year period (1995–2001). A total of 56 different pollen types were identified, among which Urticaceae, Poaceae, *Betula* and *Quercus* represent the greatest risk for people suffering from allergic rhinitis (hay fever) or other allergic diseases. Although in the atmosphere of Vigo the presence of allergenic pollen is constant throughout the year, the months of March and April account for 40% of the annual total pollen count. Two main risk periods have been identified for asthma and allergies: (1) March – April, and (2) June – July, the latter is of greater importance due to high concentrations of Poaceae pollen. Correlation analysis with meteorological parameters demonstrates that rainfall, relative humidity, maximum temperature, sun hours and north-easterly winds are the main factors influencing the average daily pollen concentrations in the atmosphere.

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The influence of airborne pollen on human health is widely documented in people of all ages and is generally referred to by the blanket term “pollinosis”. In recent years, pollution is believed to have increased the severity of such symptoms. Nilsson and Berggren (1991) suggested that various pollutants, both organic and inorganic, could be transported adhering to the walls of pollen grains. It is estimated that around 23% of the urban population in Spain are skin prick-test positive to some pollen (Dominguez 1992). For such people, it is of great interest to ascertain which specific plant or plants produce the pollen triggering their allergies and when such pollination takes place. An understanding of the factors influencing the release and dispersion of pollen grains is also important for the correct diagnosis and subsequent treatment of the symptoms triggered.

A study of the influence of pollen on allergy sufferers in the city of Vigo, by Belmonte et al. (1998), showed that of all patients testing positive to pollen extracts, 78% were sensitive to pollen from Poaceae, 12% to *Parietaria*, 9% to *Plantago*, 4% to *Quercus*, 3% to *Pinus*, 2% to *Olea*, *Platanus* and *Castanea* and 1% to *Betula* or Cupressaceae pollen. Despite the low allergenic capacity usually attributed to *Pinus* pollen, it is worth noting that inhabitants of Vigo have displayed mono-specific skin-test reactions to pine (Marcos et al. 2001).

Advances in aerobiological research has identified which pollen grains trigger allergic processes and how pollen concentrations vary throughout the year resulting in the development of pollen calendars from a number of cities (Dopazo et al. 2000, Emberlin et al. 1990, Latorre 1999, Méndez 2000, Recio et al. 1998, Rodríguez-Rajo et al. 1998, Rogers 1997). This study presents data on airborne pollen content for the city of Vigo over a seven-year period (1995–2001). The aim was to determine the time course for

the most allergenic pollen in the atmosphere, with a view to ascertain the level of risk for this population.

MATERIAL AND METHODS

The Spanish city of Vigo with 375,000 inhabitants is located in the northwestern corner of the Iberian Peninsula (Fig. 1). A Hirst-type LANZONI VPPS 2000 volumetric 7-day recording sampler was used to collect the airborne pollen. The sampler was situated on the left bank of the Vigo estuary (42°14'15"N; 8°43'30"W), in the city centre on the roof of the Town Hall, at a height of 15 m above ground level. In this area the annual mean temperature is 14.9°C, mean maximum temperature is 18.8°C and mean minimum temperature is 11°C. Annual rainfall is 1412 mm, distributed irregularly through the year, with only 22 and 38 mm of rain collected in July and August, respectively.

Biogeographically, Vigo is situated in the Atlantic Province of the Euro-Siberian Region. Climax vegetation consists of *Quercus robur* deciduous forest, sometimes together with species such as *Arbutus unedo* or *Laurus nobilis*. Along the river channels, the dominant formations are alder groves with *Alnus glutinosa* accompanied in some areas by *Betula celtiberica* and *Salix atrocinerea*. As a result of human activity, the autochthonous forest has been drastically reduced and substitutive shrubs have spread, giving rise to widespread communities of Leguminosae (*Cytisus scoparius*, *C. striatus*, *Ulex* spp., etc) and Ericaceae. For the last forty years, fast-growing species like *Pinus pinaster*, *P. radiata* and *Eucalyptus globulus* have been used for reforestation purposes (Rivas-Martínez 1987). The main crops are vines and forage species.

The Lanzoni sampler is calibrated to handle a flow of 10 litres of air per minute, thus matching the human breathing rate. Pollen grains impact on a cylindrical drum covered by a melinex film coated with a 2% silicon solution. The drum was changed weekly and the exposed tape was cut into seven pieces, which were mounted on separate glass slides. Daily values are expressed as number of

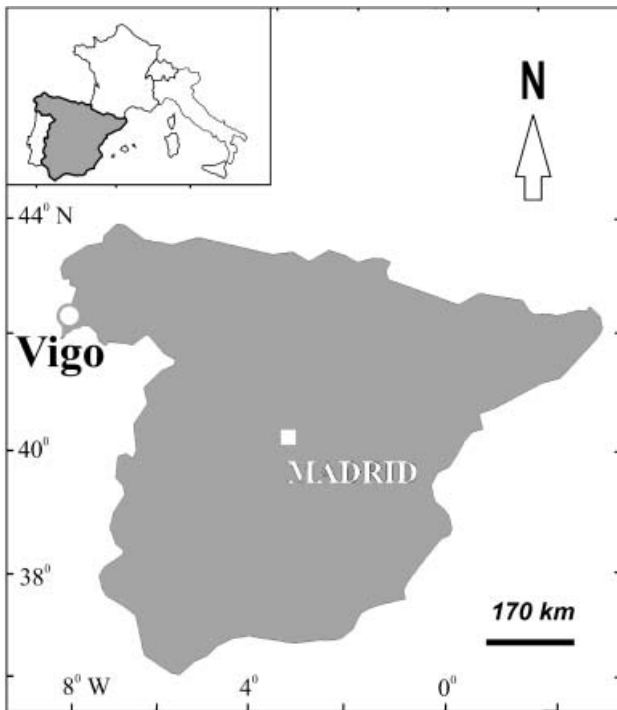


Fig. 1. Location of the study site – city of Vigo.

pollen grains per cubic metre of air. Pollen grain identification was performed using a NIKON OPTIPHOT II microscope equipped with a 40X/0.95 lens. Pollen counts were made using the model proposed by the R.E.A., consisting of four continuous longitudinal traverses along the 24-hr slide (Dominguez et al. 1992). The following main pollen period characteristics were analysed for the twelve most abundant major allergenic pollen types: (1) start and end dates of the pollen season; (2) maximum pollen count and date recorded; and (3) number of days during the pollination period on which pollen concentrations reached values representing allergenic risk. The pollination period was calculated as 95% of the annual total pollen-production season, the first days, producing up to 2.5% of total production, were removed from the calculations as well as the final days (from 97.5% to 100.0% of total production; Andersen 1991). The meteorological data used for the study were recorded by the National Institute of Meteorology (Fig. 2).

Spearman's correlation coefficient was used to identify possible relationships between meteorological parameters such as rainfall, humidity, hours of sunshine, temperature (maximum, mean and minimum) and wind speed and direction, and the daily mean pollen concentrations of the 12 best-represented pollen types. Finally, Scheffé test was applied to check for differences in rainfall patterns recorded over the study period. This test enabled us to identify the presence of anomalous years that were out of line with the general pattern and which could produce alterations in yearly atmospheric pollen content.

Alnus and *Cupressaceae* 1995 data have not been taken into account, since the sampling started January 1st, 1995, the period when the two taxa were in full flowering. This fact might induce errors in the study because their complete pollen season has not been registered.

RESULTS

Aerobiological monitoring of the city of Vigo's atmosphere was initiated in 1995 and continued non-stop until 2001. Except for

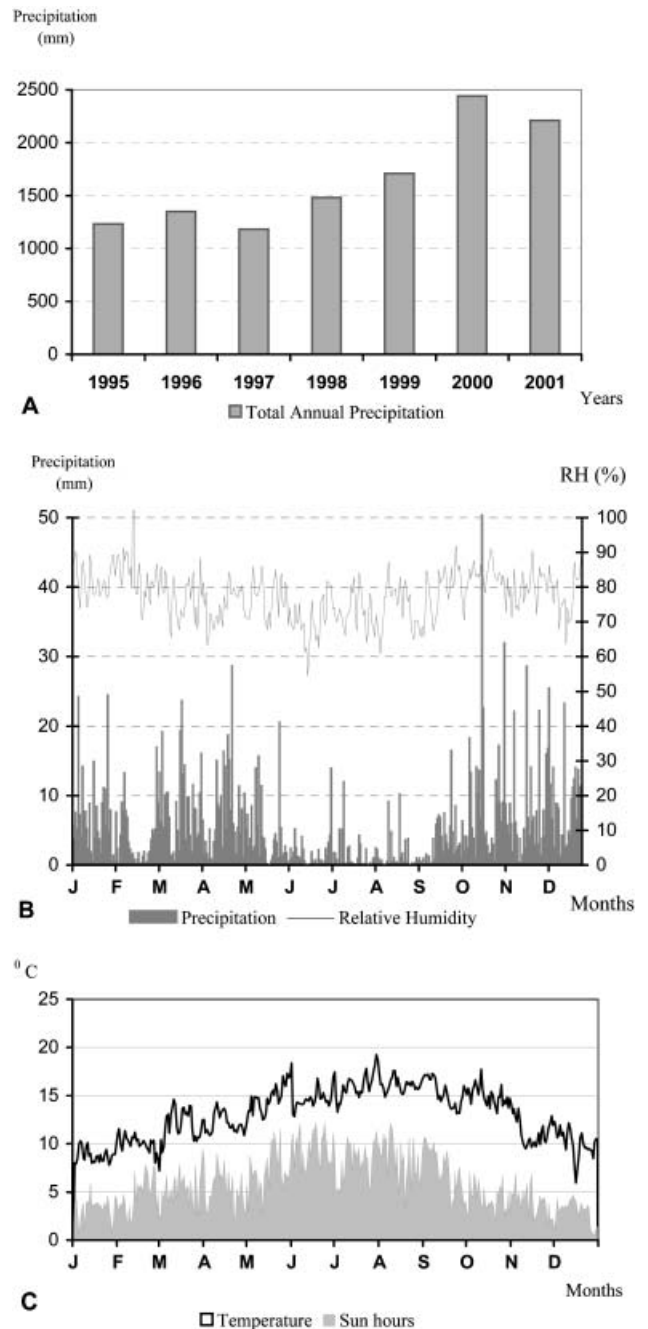


Fig. 2. Total annual precipitation (A), average values of precipitation and relative humidity (B), and average values of temperature and daylight-hours (C) during the period of the study.

1997 and 2001, total pollen concentrations ranged from 25,000 to 30,000 pollen grains m^{-3} , with a seven-year average close to 30,000 pollen grains m^{-3} (Fig. 3). Over the first three years (1995–1997), concentrations exceeded the average, coinciding with years of hot, dry springs. In contrast, the following years were marked by heavy rainfall, especially in March and April, and the annual airborne pollen content was lower. Year 2001 had the lowest pollen count (13,645 pollen grains m^{-3}) and a total of 840 mm rain was recorded for March and April. In contrast 1997, the

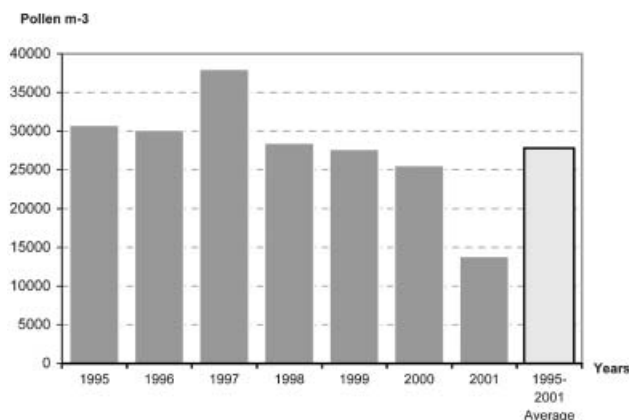


Fig. 3. Annual total pollen sum recorded in Vigo during the period 1995–2001.

year with the lowest rainfall (Fig. 2B), recorded the highest annual pollen concentrations (38,041 pollen grains m⁻³). Scheffé's test performed to identify anomalous rainy years (Table I) clearly differentiate 2000 and 2001 as years with the lowest annual pollen concentrations and highest total annual precipitation.

In general, the best-represented airborne pollen type in Vigo was Urticaceae, which attained an average of 24.7% of the annual total. Vigo is the only city in the Spanish Aerobiology Network with Urticaceae representing the largest share of the annual total (Table II). Poaceae and *Pinus* pollen reached the same average of 19.1%, followed by smaller percentages for *Quercus*, *Plantago*, *Betula*, *Olea*, *Alnus*, Cupressaceae, *Platanus* and *Castanea*.

Cupressaceae and *Alnus* pollen grains were detected in the atmosphere of the city of Vigo in the month of January, representing an average of 3% of the annual total airborne pollen (Table III). Peak values during this period were recorded for *Alnus* on January 28th, 1997, with 245 grains m⁻³ and for Cupressaceae on January 6th, 1999, with 162 grains m⁻³ (Table II). The full flowering of these taxa coincides with the start of the Urticaceae pollen period in February, which explains why February's share of the annual total is almost double that of January.

A sharp temperature increase in March favoured the flowering of the arboreal taxa *Betula*, *Pinus*, *Platanus* and *Quercus*, and herbaceous plants within the Urticaceae

family. Due to the widespread distribution of these taxa on the outskirts of the city, the months of March and April accounted for more than 40% of total annual pollen (Table III). *Pinus* is the most common tree in southeastern Galicia, as a result of major reforestation since the 1950's. Therefore, this taxon presents the highest daily peak for the study period, 1131 grains m⁻³ on March 11th, 2000 (Table II), *Quercus* is the most common tree of the climax plant formations of Galician woodlands, and is widely distributed throughout the region; this accounts for the high concentrations recorded, with a maximum of 433 grains m⁻³ on April 14th, 1995. The maximum average daily concentration of *Betula* was recorded on April 7th, 1999, with 247 grains m⁻³. The widespread presence of *Platanus*, a species with a short but intense flowering period, in the city's parks and avenues led to high concentrations during flowering, registering the maximum daily mean concentration on March 9th, 2000, with 220 grains m⁻³. However, the most abundant pollen type in spring was Urticaceae, which benefits from the mild maritime climate in Vigo. It is a common weed in the city, in ruderal areas or along the walls. The peak daily value of 404 grains m⁻³ was recorded on March 29th, 1996.

Daily average concentrations over the seven-year period shows decreasing concentrations during May, thereafter increasing again with the onset of the flowering of herbaceous species (Fig. 4). The quantities of pollen released into the atmosphere increased again during June and July, with a secondary summer peak accounting for 27% of total annual pollen (Table III). The highest concentrations at this time corresponded to Poaceae, which reached peak average daily concentration on July 4th, 1998, with 453 grains m⁻³, followed by *Castanea*, which recorded its maximum average daily concentration on July 11th, 1999, with 112 grains m⁻³, and finally *Plantago*, whose maximum concentration did not exceed 63 grains m⁻³ over the study period. A gradual decrease in pollen concentrations was observed in August, coinciding with the end of the flowering period for the species mentioned above. From September onwards, after a slight increase in pollen concentrations, emission of pollen into the atmosphere remained very low until the onset of the flowering period of winter taxa, during the second fortnight in December or first fortnight in January.

Spearman's correlation test was carried out to find a possible degree of association between daily mean airborne pollen concentrations and the main meteorological factors

Table I. Values of the coefficients of Scheffé's Test (*95%, **99.9% significance) of total daily rainfall (in mm) during the years of the study period.

Scheffé test	1995	1996	1997	1998	1999	2000	2001
Rainfall (mm)	3377	3700	3241	3885	4684	6673	6606
1995		1.000	1.000	0.999	0.829	0.006**	0.008**
1996	1.000		0.999	1.000	0.952	0.023**	0.030**
1997	1.000	0.999		0.995	0.749	0.003**	0.005**
1998	0.999	1.000	0.995		0.983	0.045**	0.056
1999	0.829	0.952	0.749	0.983		0.362	0.409
2000	0.006**	0.023**	0.003**	0.045**	0.362		1.000
2001	0.008**	0.030**	0.005**	0.056	0.409	1.000	

Table II. Characteristics of the pollen season: starting and ending date (P.P.), value of the peak day in pollen/m³ and its date (Peak-Day), percentage of the total annual (% A.P.) and number of days with the values above a pollen/m³ threshold (e.g. Days>80).

Alnus and Cupressaceae data of the year 1995 are not included.

Taxa	Indi- cated by	year						
		1995	1996	1997	1998	1999	2000	2001
Urticaceae	P.P.	30 Jan/19 Oct	7 Feb/14 Sep	28 Jan/19 Sep	3 Feb/15 Oct	2 Feb/10 Sep	4 Feb/18 Sep	9 Feb/31 Aug
	Peak value (Date)	291 (22 Mar)	404 (29 Mar)	262 (5 Mar)	116 (18 Jun)	250 (18 Mar)	110 (14 Mar)	125 (28 May)
	% A.P.	26.2	34	27.9	26.2	27.7	17.2	13.7
	Days >80	21	42	42	17	28	3	6
Pinus	P.P.	15 Feb/9 May	28 Feb/12 Jun	10 Feb/18 Apr	12 Feb/25 May	10 Feb/27 Apr	21 Feb/7 Apr	8 Jan/31 May
	Peak value (Date)	542 (25 Mar)	294 (22 Mar)	606 (10 Mar)	1105 (3 Mar)	489 (7 Apr)	1131 (11 Mar)	408 (5 Mar)
	% Annual	20.5	13.1	18.4	20.5	16	33.9	11.5
	Days>100	23	12	21	8	13	16	1
Poaceae	P.P.	31 Mar/2 Sep	14 Apr/26 Aug	10 Mar/6 Sep	30 Mar/23 Aug	6 Apr/20 Aug	8 Apr/26 Aug	9 Apr/1 Sep
	Peak value (Date)	298 (6 Jul)	437 (25 Jun)	282 (17 Jul)	453 (4 Jul)	437 (7 Jul)	288 (24 Jun)	195 (2 Jul)
	% Annual	14.2	24.9	11.7	24	17.6	17.1	24.3
	Days>25	43	54	25	52	40	29	30
Quercus	Days>50	26	31	16	33	28	21	16
	P.P.	21 Mar/20 May	13 Mar/13 Jun	6 Mar/1 May	28 Feb/6 Jun	14 Mar/29 May	8 Mar/28 May	17 Mar/11 Jun
	Peak value (Date)	433 (14 Apr)	106 (15 Apr)	205 (17 Mar)	59 (22 May)	138 (21 Mar)	209 (15 Mar)	58 (1 Apr)
	% Annual	12.6	2.6	11.9	2.5	6.5	7.6	4.6
Plantago	Days>50	22	2	37	1	14	10	4
	P.P.	12 Apr/1 Sep	27 Apr/5 Sep	28 Mar/9 Sep	5 May/24 Aug	1 May/6 Sep	7 May/10 Sep	24 Apr/16 Sep
	Peak value (Date)	43 (1 Aug)	61 (31 May)	31 (1 May)	63 (14 Jun)	54 (26 May)	24 (13 Jun)	29 (1 Jun)
	% Annual	4.5	3.6	2.7	5.1	2.7	2	3.3
Betula	Days>50	0	1	0	1	1	0	0
	P.P.	28 Mar/30 Apr	5 Apr/9 May	14 Mar/21 Apr	18 Mar/15 May	15 Mar/23 May	10 Mar/21 May	10 Apr/7 May
	Peak value (Date)	204 (14 Apr)	73 (15 Apr)	172 (28 Mar)	29 (27 Mar)	247 (7 Apr)	27 (17 Mar)	173 (17 Apr)
	% Annual	5	1.5	3.5	0.6	4.6	0.7	7.6
Olea	Days>30	16	7	16	8	7	0	10
	Days>80	6	1	5	0	5	0	6
	P.P.	20 Apr/29 Jun	20 May/1 Jul	2 Apr/3 May	20 Apr/22 Jun	1 May/14 Jun	4 May/18 Jun	2 Apr/21 Jun
	Peak value (Date)	121 (5 May)	94 (6 Jun)	195 (2 May)	66 (19 Jun)	382 (26 May)	155 (16 May)	51 (12 May)
Alnus	% Annual	1.9	3	3	1.9	3.8	2.5	2.9
	Days>50	3	7	8	3	4	3	1
	P.P.		14 Jan/12 Mar	12 Jan/22 Feb	10Jan/4Mar	5 Jan/25 Feb	17 Jan/3 Mar	19 Dec/10 Mar
	Peak value (Date)		93 (4 Feb)	245 (28 Jan)	56 (6 Feb)	165 (28 Jan)	53 (31 Jan)	66 (8 Jan)
	% Annual		2.5	3.7	2.5	5.7	2.1	2
	Pollen>30		7	15	8	15	4	3

Table II. (Continued)

Taxa	year							
	Indi- cated by	1995	1996	1997	1998	1999	2000	2001
Cupressaceae	P.P.		19 Dec/14 Jun	1 Nov/2 May	8 Jan/22 May	15 Dec/9 May	5 Jan/4 May	13 Nov/12 Apr
	Peak value (Date)		44 (22 Mar)	87 (6 Apr)	107 (10 Jan)	162 (6 Jan)	80 (5 Jan)	34 (21 Jan)
	% Annual		1.9	2.8	2.7	4	3.3	2.2
	Days> 40		0	3	2	4	4	0
Platanus	P.P.	9 Mar/14 Apr	18 Mar/16 Apr	3 Mar/31 Mar	22 Feb/28 Mar	13 Mar/10 Apr	3 Mar/21 Mar	6 Mar/10 Apr
	Peak value (Date)	36 (26 Mar)	43 (24 Mar)	70 (7 Mar)	161 (3 Mar)	189 (18 Mar)	220 (9 Mar)	108 (11 Mar)
	% Annual	1.2	1.4	2.3	2	2.1	5.3	1.4
	Days> 50	0	0	7	2	3	12	1
Castanea	P.P.	2 Jun/22 Aug	14 Jun/1 Sep	23 May/19 Jul	19 Jun/12 Aug	19 Jun/25 Jul	15 Jun/31 Jul	15 Jun/11 Aug
	Peak value (Date)	50 (22 Jun)	71 (11 Jul)	102 (6 Jul)	77 (14 Jul)	112 (11 Jul)	37 (17 Jun)	42 (1 Jul)
	% Annual	1.9	2.9	1.8	2.9	2.1	1	1.6
	Days> 50	0	5	1	2	3	0	0

(Table IV). The correlation was significant in a large number of cases and the values for Spearman's coefficient were generally constant. Results showed that the parameters exerting the greatest positive influence, with 99.9% significance, were maximum and mean temperatures, hours of sunshine and wind from the N-NE. Correlation values were negative ($p < 0.001$) with rainfall, relative humidity, wind speed and S-SW wind.

The data recorded over the seven years were used to prepare a pollen calendar for the city of Vigo (Fig. 5). This time period is considered the minimum required to obtain a representative estimate of the behaviour of the airborne pollen of any area. The calendar charts the average weekly value for the best-represented pollen types in the city's atmosphere over the seven-year study period: *Urtica*, *Pinus*, *Quercus*, Poaceae, Cupressaceae, *Alnus*, *Platanus*, Ericaceae, Myrtaceae, *Betula*, *Olea*, *Plantago* and *Castanea*. A different scale was used for the first four taxa in view of their high concentrations (Fig. 5). The seasonal behaviour patterns of the pollen grains making up the calendar for Vigo are similar to those found in the pollen calendars of nearby cities, such as Ourense and Santiago de Compostela (Mendez 2000, Dopazo et al. 2000).

DISCUSSION

The total annual pollen concentration in Vigo remained fairly stable throughout the study, with low values for 2001 compared to other years. The average of almost 30,000 pollen grains per year is one of the highest recorded in northwestern Spain (Méndez 2000, Dopazo et al. 2000, Fernández-González et al. 1998). It is also high in relation to the rest of Spain, exceeded only by cities with very high concentrations of a certain pollen type, which usually accounts for over half the pollen recorded throughout the year. In the Andalusian cities such as Jaén (Ruiz et al. 1998) or Cordoba (Cariñanos et al. 1999) the numbers of olive pollen reach very high concentrations, in the city of Extremadura (Tormo et al. 1999) Poaceae and *Quercus* pollen have very high values. The ornamental use of shade plane trees is widespread in Madrid resulting in high pollen concentrations during the flowering season (Gutierrez et al. 1999).

Oscillations in pollen concentrations throughout the study period were largely determined by meteorological differences during the flowering periods in the years sampled. Generally speaking, before the flowering season the most influential meteorological factors are temperature and sun hours (Frenguelli et al. 1992, Bricchi et al. 1995), while rainfall, wind direction and speed, and turbulence exert the greatest influence once the pollen grains are in the air. In this regard, attention is drawn to the peak concentrations of the various pollen types in the city of Vigo, coinciding with the optimum conditions for pollen release and dispersion. Heavy autumn rainfall following a severe dry season is reported to result in a greater number of flower buds, which develop and favour intense flowering when temperatures rise in February and March (Recio et al. 1999). If this flowering coincides with an absence of precipitation, the pollen concentrations will reach high values. This happened in 1997, when the flowering of

Table III. Relative monthly pollen concentrations during the study period.

year month	1995	1996	1997	1998	1999	2000	2001	1995–2001
January	2	2	5	2	5	3	4	3
February	4	4	9	13	8	5	7	7
March	24	16	44	25	26	50	8	28
April	31	26	17	3	19	3	22	17
May	9	9	5	14	12	10	21	11
June	15	26	5	16	14	17	20	16
July	6	10	10	19	11	7	11	11
August	5	2	3	4	2	2	3	3
September	1	2	1	1	1	1	2	1
October	1	2	1	1	1	1	1	1
November	1	0	0	1	0	0	0	0
December	1	1	0	1	1	1	1	1
Sum	100	100	100	100	100	100	100	100

spring species took place one month earlier as a result of the high temperatures. In contrast, pollen grain concentrations recorded in 1996, 1998 and 2001 for the spring flowering arboreal taxa, *Betula*, *Quercus*, *Pinus* and *Platanus*, were smaller due to considerably rainfall in March and April (up to 812 mm in 2001). Full flowering usually occurs at this time, and rainfall produced atmospheric cleansing and overcast skies resulting in a decrease in hours of sunshine. The sharp decrease in pollen concentrations observed for most pollen types in 2001 was probably the result of the high quantity of rainfall registered in the city throughout the year. During the first four months of 2001, there was 1416 mm of rain, which is more than the annual total recorded during the first three years under study. Ong et al. (1997) and Recio et al. (1997) highlighted the influence of rainfall in the months prior to the flowering of summer-flowering herbaceous taxa. Spring rainfall results in an increase in soil water content, favouring the development of herbaceous species and thus the formation of a larger quantity of pollen grains. This occurred in 1996 and 1998, when total values for pollen from herbaceous species were higher than those obtained in the other years;

thus, for example, 7523 Poaceae pollen grains were recorded in 1996, almost double the amount for other years.

In addition to the meteorological factors discussed above, another cause of the oscillations observed was the behaviour pattern for some winter/spring-flowering taxa, with alternating rhythms of pollen concentrations. This bi-annual pattern has been reported for a number of arboreal species, and is due to alternation in the mobilisation of nutrient reserves towards the tree's vegetative growth or towards reproductive structures, according to the year. A similar pattern has been described for Cupressaceae (Spieksma et al. 1995), *Alnus* (Andersen 1980), *Betula* (Nilsson & Persson 1981, Emberlin et al. 1993, El-Ghazaly et al. 1993, Latorre 1999) and *Quercus* (Andersen 1980, Spieksma et al. 1995). In Vigo, these pollen types generally displayed bi-annual behaviour over the seven study years, with the exception of *Alnus* and Cupressaceae in 2001 (Fig. 6). That year, the heavy rainfall recorded during the first three months (a total of 1283 mm) produced intense atmospheric cleansing during the flowering of these taxa. This, rather than a decrease in pollen production, produced a break in the cycle. Furthermore, continuous rainfall over a prolonged period of time hinders anther dehiscence, which was verified directly by phenological observation.

Analysis of average daily concentrations over the seven years reveals two periods of major importance for pollen-allergy sufferers (Figs 4, 5). The first occurs during the spring months, when a predominance of *Betula* and Urticaceae pollen (both of high allergenic importance) in the atmosphere was found. *Betula* is capable to produce allergy reactions not only during its main pollen season, also during the previous period and after it, due to long-distance transport (Wallin et al. 1991, Hjelmroos 1991). Furthermore, its allergens can settle on dust particles in interiors and induce allergies up to two months after attaining its maximum pollen values in the atmosphere (Yli-Panula & Rantio-Lehtimäki 1995). Although pollen reactions vary widely among allergy-sufferers, various values have been identified as thresholds for triggering allergy reactions. Thus, Corsico (1993) considers a concentration of 30 pollen grains m^{-3} of *Betula* sufficient to prompt severe symptoms. This value was recorded in Vigo on 16 days during 1995 and 1997

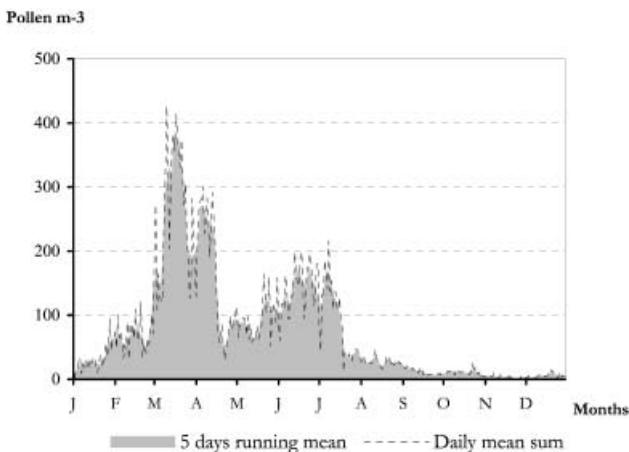


Fig. 4. Average total daily pollen concentrations and five days running mean pollen concentrations in Vigo (1995–2001).

Table IV. Coefficients of Spearman's test (*95%, **99.9% significance) between daily values of the main meteorological parameters and daily mean pollen concentrations of the 11 best-represented pollen types.

Meteor. Factors		Taxa									
	<i>Alnus</i>	<i>Betula</i>	<i>Castanea</i>	<i>Cupress.</i>	<i>Olea</i>	<i>Pinus</i>	<i>Plantago</i>	<i>Platanus</i>	<i>Poaceae</i>	<i>Quercus</i>	<i>Urticaceae</i>
Rainfall	-0.433**	-0.628**	-0.338**	-0.205**	-0.107*	-0.369**	-0.343**	-0.330**	-0.537**	-0.533**	-0.374**
Humidity	-0.444**	-0.614**	-0.398**	-0.202**	-0.149*	-0.412**	-0.356**	-0.418**	-0.414**	-0.537**	-0.420**
Tmax	0.274**	0.576**	0.424**	0.171**	0.132*	0.387**	0.380**	0.523**	0.543**	0.563**	0.184**
Tmin	0.053	0.195**	0.073	0.007	0.186**	0.080*	0.134**	0.093	0.333**	0.130*	-0.107**
Mean Temp.	0.175**	0.486**	0.343**	0.115**	0.155*	0.304**	0.307**	0.441**	0.493**	0.436**	0.050*
Sun hours	0.348**	0.490**	0.391**	0.083*	-0.037	0.235**	0.389**	0.195*	0.484**	0.378**	0.320**
Wind Calm	0.187**	-0.138*	0.032	0.096*	0.095	-0.086*	-0.061	-0.108	0.021	-0.077	-0.047
Wind N-NE	0.387**	0.565**	0.438**	0.140**	-0.083	0.380**	0.458**	0.417**	0.391**	0.542**	0.410**
Wind NE-S	0.046	-0.073	-0.156*	0.086*	0.044	0.003	-0.179**	0.003	-0.197**	-0.092*	-0.009
Wind S-SW	-0.394**	-0.308**	-0.414**	-0.098*	0.119*	-0.200**	-0.371**	-0.184*	-0.272**	-0.307**	-0.246**
Wind SW-N	-0.150*	-0.094	0.131*	-0.243**	-0.048	-0.191**	0.189**	-0.265**	0.074*	-0.102*	0.020
Wind speed	-0.287**	-0.073	0.082	-0.106**	-0.326**	-0.088*	0.105**	-0.135*	-0.057	-0.154**	-0.053*

(Table I). A value of 80 grains m^{-3} , which produces symptoms in 90% of patients (Viander & Koivikko 1978, Detandt & Noland 1996), was recorded on six days during 1995 and 2001. The allergenic nature of the Urticaceae family has been pointed out by numerous authors (D'Amato & Spieksma 1990, Bass & Bass 1990), and the family is considered the second largest cause of pollinosis within the Mediterranean area (Díaz de la Guardia et al. 1998). Studies by Belmonte et al. (1998) in Vigo have shown that *Parietaria* produced positive skin tests in 12% of patients sensitive to some pollen. Similar values have been obtained in other coastal areas of Northwest Spain (Ferreiro & Fontan 1984), thus underlining the importance of *Parietaria* pollinosis, not only throughout the Mediterranean but also in other Atlantic coastal areas. It is essential to determine when people sensitive to this pollen type are at the greatest risk. Negrini et al. (1992) pointed out that 90% of patients sensitive to *Parietaria* pollen experience symptoms when atmospheric concentrations exceed 80 pollen grains m^{-3} . During the period under study in Vigo, this value was reached on 42 days in 1996 and 1997, thus testifying to the importance of this taxon for the city's allergy-sufferers.

Other pollen types recorded at this time of year are of moderate allergenic importance, either because their average daily concentrations display low or medium values, such as *Alnus*, Cupressaceae, *Quercus* and *Platanus*, or because the allergic reactions are only triggered by high concentrations, such as *Olea* (a major allergen in southern Spain) and *Pinus*. Even so, there have been cases of patients testing positive to *Pinus* pollen extracts, some of which were asymptomatic for pine pollen (Marcos et al. 2001). These patients live in areas with extensive masses of pine trees where *Pinus* pollen concentrations become very high so it is suggested that the pine pollen should be considered to be of low allergenicity, as pointed out by Fountain & Cornford (1991). Allergy reactions occur in cases of prolonged exposure to high concentrations, above 100 grains m^{-3} (Fountain & Cornford 1991). Studies by Jato et al. (2000) show that high average daily concentrations are frequently recorded in Vigo.

June and July are also key months for many of Vigo's allergy-sufferers; 78% of patients sensitive to some pollen are sensitive to Poaceae pollen (Belmonte et al. 1998). Davies & Smith (1973) and Ong et al. (1997) point out that moderate allergy responses appear when average daily concentrations exceed 25 grains m^{-3} . These values were reached in Vigo on over 50 days in some study years. Similarly, concentrations of over 50 grains m^{-3} are shown to be capable of producing clinical symptoms in all allergic patients (Negrini et al. 1992); this value was exceeded in Vigo on 16 days in 1997 and 33 days in 1998. *Plantago* pollen present low concentrations in Vigo and only reached 50 grains m^{-3} one day during some study years. Despite these low values, allergens of *Plantago* are the fourth in importance of inducing pollinosis in Vigo.

CONCLUSIONS

The data obtained showed that the pollen of Urticaceae, Poaceae, *Betula* and *Quercus* represent the greatest risk for

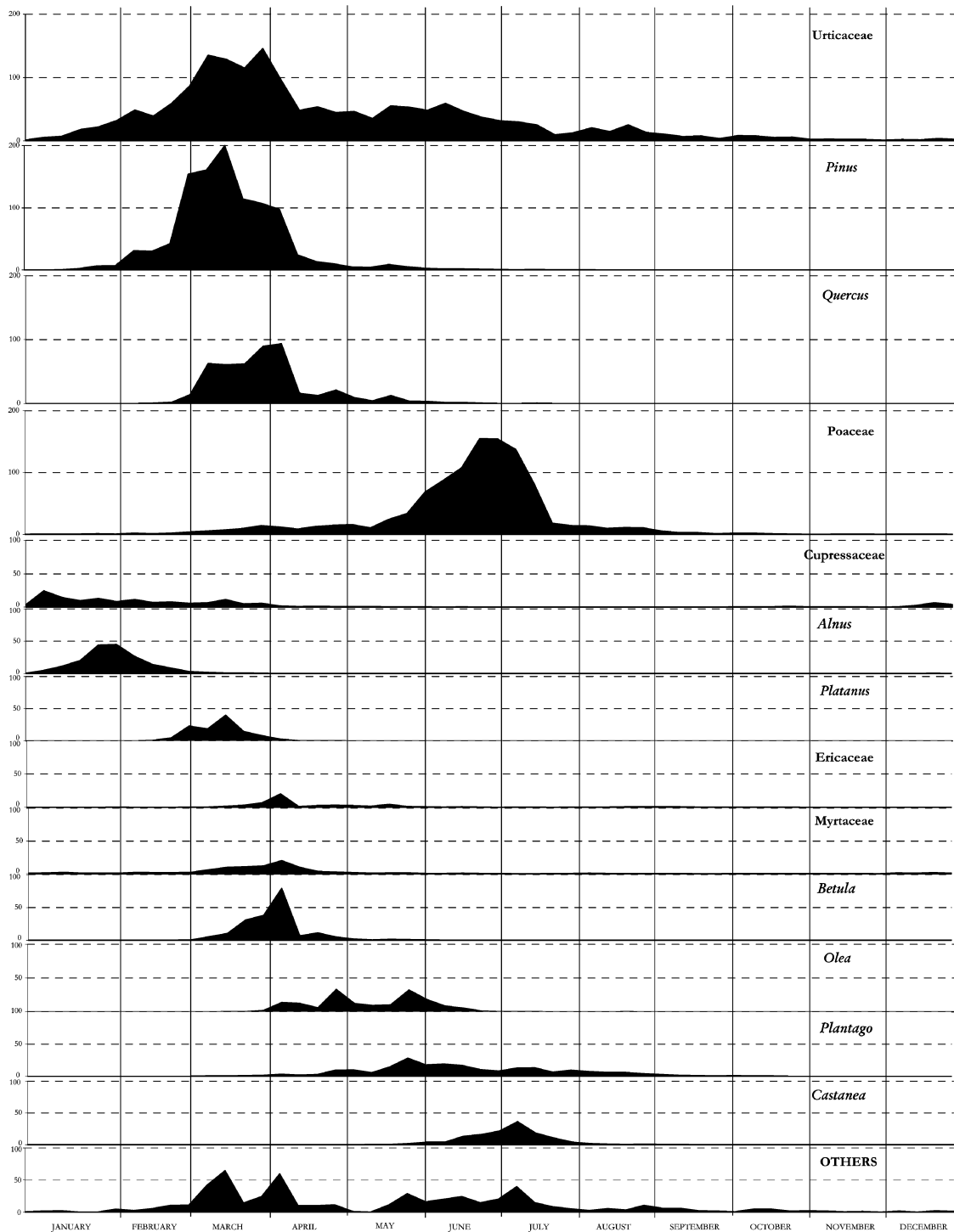


Fig. 5. Pollen calendar showing monthly distribution of recorded pollen grains in 1995–2001 at Vigo.

pollen-allergy sufferers in Vigo. The pollen of *Plantago* and *Pinus* also needs to be considered, especially in the areas with large expanses of these species. Over the year there are two periods of high risk for pollinosis sufferers: the first occurs during March – April, due to *Betula* and *Urticaceae* pollen, and the second, which is the most important, occurs

during June – July, with the flowering of the *Poaceae* family. Correlation analysis with meteorological parameters showed that rainfall, relative humidity, maximum temperature, hours of sunshine and north-easterly winds were the most important factors influencing average daily airborne pollen concentrations.

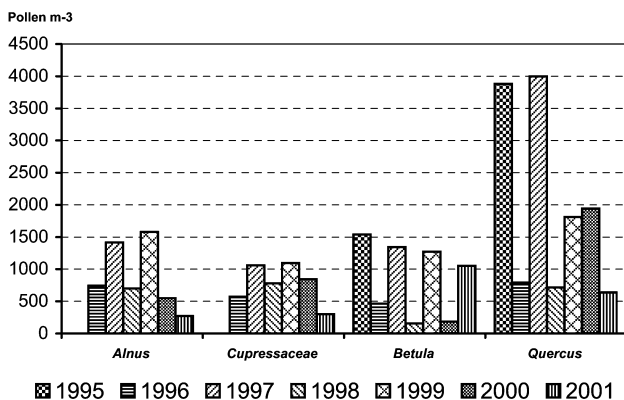


Fig. 6. Annual total pollen sum of *Alnus*, Cupressaceae, *Betula* and *Quercus* in Vigo recorded during the period 1995–2001 (*Alnus* and Cupressaceae data of the year 1995 are not included).

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