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Airborne pollen of ornamental tree species in the NW of Spain

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Abstract This study analyzed airborne pollen counts for the tree taxa most widely used for ornamental purposes in the northwestern Iberian Peninsula (*Platanus*, Cupressaceae, *Olea*, Myrtaceae, *Cedrus*, and *Casuarina*) at four sites (Vigo, Ourense, Santiago, and Lugo), using aerobiological data recorded over a long period (1993–2007). The abundance and the temporal and spatial distribution of these pollen types were analyzed, and the influence of weather-related factors on airborne pollen counts was assessed. *Platanus* (in Ourense) and *Olea* (in Vigo) were the taxa contributing most to pollen counts. In general terms, the results may be taken as indicators of potential risk for pollen-allergy sufferers and therefore used in planning future green areas.

Keywords Aerobiology · Ornamental plants · Pollen · Allergy · NW of Spain

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Introduction

The creation, replacement, and refurbishment of gardens, and the planting of trees along streets and avenues are a common occurrence in all cities. The criteria generally applied tend to be environmental and/or aesthetic. Environmental criteria include the adaptability of potential species to the local climate; soil, water and light requirements; and resistance to pests, diseases, and pollution. Aesthetic or landscaping criteria include growth habit, rate of growth and development, texture, color, and seasonality. The potential effect of new tree masses on the health of the local population is rarely taken into account (Elvira et al. 2005; Sabariego et al. 2005).

Many plants—however beautiful or appealing in parks and gardens—may pose a certain risk, especially for children, due either to their morphology (thorns, spiky or pointed leaves, etc) or to their ability to cause contact allergies, respiratory allergies (Dopazo et al. 2002), or poisoning of varying severity (Fernández-Rivas et al. 2008).

Several studies have highlighted the correlation between high airborne pollen counts and the worsening of allergy symptoms, expressed as an increased demand for healthcare services (Carracedo et al. 2008) or an increase either in the number of patients requiring emergency treatment or in the number of hospital admissions (Linares et al. 2005). However, similar situations

may arise even when airborne pollen counts are less elevated, either because highly allergenic pollens exceed risk thresholds or because of cross-reactivity (Sin et al. 2008).

This study focused on the ornamental tree species most widely planted in the northwestern Iberian Peninsula that are considered allergenic pollen producers (*Platanus*, Cupressaceae, *Olea*, Myrtaceae, *Cedrus*, and *Casuarina*). Recent studies have highlighted the clinical impact of these pollen types (Carracedo et al. 2008; Dopazo et al. 2002; Ferreiro et al. 1998, 2002; Rodríguez-Rajo et al. 2004).

Materials and methods

Sampling sites and sample characteristics

Sampling was carried out at four sites in the northwestern Iberian Peninsula (Vigo, Ourense, Santiago, and Lugo), selected in view of their population density and the availability of long-standing aerobiological databases (Fig. 1).

Pollen sampling was performed using Lanzoni VPPS 2000 volumetric traps located on top of several buildings at a similar height (between 10 and 20 m above ground level). Melinex tape coated with a 2% silicone solution was used as the pollen-trapping surface. The exposed tape was cut into seven pieces, which were mounted on separate glass slides. Pollen grains were counted following the model proposed by the Spanish Aerobiological Network (R.E.A.), based on four longitudinal transects along the slides (Galán et al. 2007).

Fig. 1 Location of sampling stations

Daily mean pollen counts for each pollen type studied, expressed as pollen grains per cubic meter of air, were used to calculate weekly, monthly, and annual means. The method used also enabled intradiurnal variations to be charted hour by hour. A total of 52 annual aerobiological data records were analyzed for the four cities (almost half a million hourly data); data spans, number of inhabitants, and estimated green area for each site are shown in Table 1.

In view of the distribution of pollen counts for each pollen type at each site, the pollen season for each species was taken as the period during which pollen was continuously recorded (Jato et al. 2006), rather than the traditionally used main pollination period (Spieksma et al. 1995).

Spearman's correlation test was used to determine the effect of weather-related variables (rainfall; relative humidity; maximum, minimum, and mean temperatures; and hours of sunlight) on airborne pollen counts, setting confidence intervals at 99% ($p \leq 0.01$) and 95% ($p \leq 0.05$). Weather variables were correlated with daily data for the pollen season, data for the periods prior to the peak daily pollen count (peak day), and data for the study period as a whole.

Weather data was obtained from stations close to the pollen traps (not further than 2 km) and supplied by the Spanish Agency of Meteorology. All statistical analyses were performed using the SPSS for Windows software package version 15.0.

Pollen types

Of the 50 pollen types regularly monitored in local aerobiological analyses (Jato et al. 2008), a selection was made of those species widely introduced into the area as ornamentals and those growing in large green areas. Six pollen types were defined in terms of species and/or genera following Trigo et al. (2008).

Table 1 Characterization of the sampling sites and studied periods

	GPS coordinates	Aerobiological data (years)	Height (m.a.s.l.)	N° of people	Estimated green area (m^2)
Vigo	42°14′ N, 8° 43′ O	1995–2007	50	294,772	753,360
Orense	42°21′ N, 7° 51′ O	1993–2007	130	107,186	1,000,000
Santiago	42°53′ N, 8° 32′ O	1993–2007	270	93,712	1,708,017
Lugo	43°0′ N, 7° 53′ O	1999–2007	50	93,853	720,000

The *Platanus* pollen type includes *Platanus hispanica* Miller ex Munich, a hybrid deriving from *Platanus orientalis* L. and *Platanus occidentalis* L., while the Cupressaceae type includes several genera of this family (*Cupressus* and *Thuja*) and related families (e.g., Taxaceae and Taxodiaceae) due to the difficulty in distinguishing their pollen grains. *Olea* is monospecific (*Olea europaea* L.). The Myrtaceae pollen type comprises two major species, *Myrtus communis* L. and *Eucalyptus globulus* Labill, both used as ornamentals; *Eucalyptus* is additionally used for reforestation. *Cedrus* comprises a number of species, including *Cedrus deodara* (Roxb. ex D.Don) G. Don fil. and *Cedrus atlantica* (Endl.) Carrière, while the *Casuarina* pollen type includes several species of that genus, the most common being *Casuarina cunninghamiana* Miq., *Casuarina stricta* Aiton and *Casuarina equisetifolia* Foster & Foster.

Results

The annual average counts for the six pollen types as a whole were higher in Vigo and Ourense than at the other two sites (Fig. 2a). Over the years covered at all sites, pollen counts also displayed a progressive increase in these two cities and a progressive decline in Santiago and Lugo (Fig. 2b). The study group of introduced species accounted for an average of 10.2% of the total pollen count in Vigo over the study period as a whole

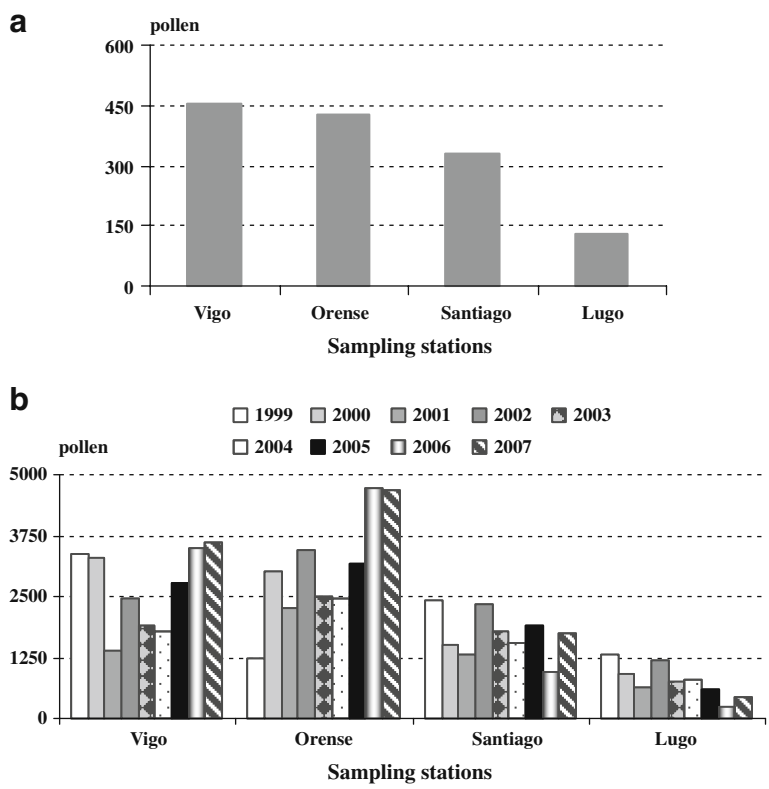

Fig. 2 **a** Average annual total pollen counts for the six selected pollen types over the study period; **b** annual total pollen counts from 1999 to 2007

Table 2 Maximum, minimum and average of annual total pollen and maximum daily mean pollen concentration (value and date) of pollen types analyzed

		Vigo	Orense	Santiago	Lugo
Platanus	Annual maximum (pollen/year)	1,470 (2007)	2,971 (2007)	2,445 (1997)	73 (2003)
	Annual minimum (pollen/year)	191 (2001)	203 (1999)	191 (1993)	13 (2000)
	Annual average (pollen)	649	1,554	711	37
	Peak value (pollen/m^3/date)	220 (09-Mar-00)	678 (02-Apr-06)	478 (18-Mar-97)	12 (16-Mar-03)
Cupressaceae	Annual maximum (pollen/year)	1,096 (1999)	1,371 (2006)	1,397 (1997)	940 (2002)
	Annual minimum (pollen/year)	312 (2001)	265 (2001)	169 (1996)	158 (2006)
	Annual average (pollen)	737	667	829	523
	Peak value (pollen/m^3/date)	162 (06-Jan-99)	211 (20-Dec-93)	193 (28-Jan-03)	213 (05-Jan-99)
Olea	Annual maximum (pollen/year)	1,380 (2006)	469 (1994)	323 (1999)	261 (1999)
	Annual minimum (pollen/year)	392 (2007)	58 (2003)	0 (2006)	0 (2006)
	Annual average (pollen)	700	220	68	79
	Peak value (pollen/m^3/date)	382 (26-May-99)	113 (02-May-99)	145 (26-May-99)	60 (28-May-99)
Myrtaceae	Annual maximum (pollen/year)	1,180 (1997)	105 (1994)	734 (1997)	120 (1999)
	Annual minimum (pollen/year)	123 (1998)	12 (1998)	82 (1996)	40 (2006)
	Annual average (pollen)	386	63	249	65
	Peak value (pollen/m^3/date)	86 (14-Apr-95)	12 (18-Feb-04)	35 (21-Oct-97)	14 (31-Aug-07)
Cedrus	Annual maximum (pollen/year)	1,001 (2005)	179 (2007)	564 (1993)	223 (2004)
	Annual minimum (pollen/year)	76 (2004)	5 (1994)	6 (2002)	5 (2002)
	Annual average (pollen)	220	59	121	61
	Peak value (pollen/m^3/date)	322 (26-Oct-05)	29 (23-Oct-01)	63 (24-Oct-05)	46 (12-Feb-04)
Casuarina	Annual maximum (pollen/year)	119 (2007)	28 (2007)	5 (1999)	6 (1999)
	Annual minimum (pollen/year)	12 (2003)	0 (1994)	0 (1993)	0 (2002)
	Annual average (pollen)	36	7	0	1
	Peak value (pollen/m^3/date)	23 (24-Oct-07)	3 (05-Aug-07)	3 (20-Set-04)	1 (11-Jul-99)

(maximum 14.9% in 2005), compared with averages of 11.7% for Ourense (maximum 17.6% in 2000), 10.7% in Santiago (maximum 19.3% in 1997), and 4.6% in Lugo (maximum 6.3% in 2004). However, counts for each pollen type varied among cities. In terms of seasonal means, *Platanus* was the major contributor in Ourense and recorded the highest counts in all the cities studied. Cupressaceae predominated in Santiago, Vigo, and Lugo, the highest annual mean pollen count being recorded in Santiago. *Olea*, Myrtaceae, *Cedrus*, and *Casuarina* were more abundant in Vigo. In Lugo, only Cupressaceae recorded fairly high counts (Table 2). The graphs of mean annual counts for the study period as a whole for each pollen type and city (Fig. 3a), and of the highest annual and maximum daily mean pollen counts (Fig. 3b), highlight the relative abundance of each pollen type compared to the rest. *Platanus* displayed the highest values in every case; similar counts were recorded for Cupressaceae and *Olea* and for Myrtaceae and *Cedrus*, while *Casuarina* was of very minor importance (Fig. 3a, b).

This study of the quantitative abundance underlined the city in which each taxa could have a higher allergenic risk and clinical impact. Therefore, its is very important to analyze the pollen season length, to ascertain the number of days on which counts exceeded potential risk thresholds, to develop intradiurnal models, and to conduct a statistical study to find the main meteorological factors affecting airborne pollen concentrations taking into account the taxa of *Platanus* in Ourense, Cupressaceae in Santiago, and *Olea*, Myrtaceae, *Cedrus*, and *Casuarina* in Vigo.

Analysis of distribution patterns over the year, based on monthly means at each site over the study period as a whole, reflected sequential flowering. The first taxa to flower is Cupressaceae early in the year—having begun toward the end

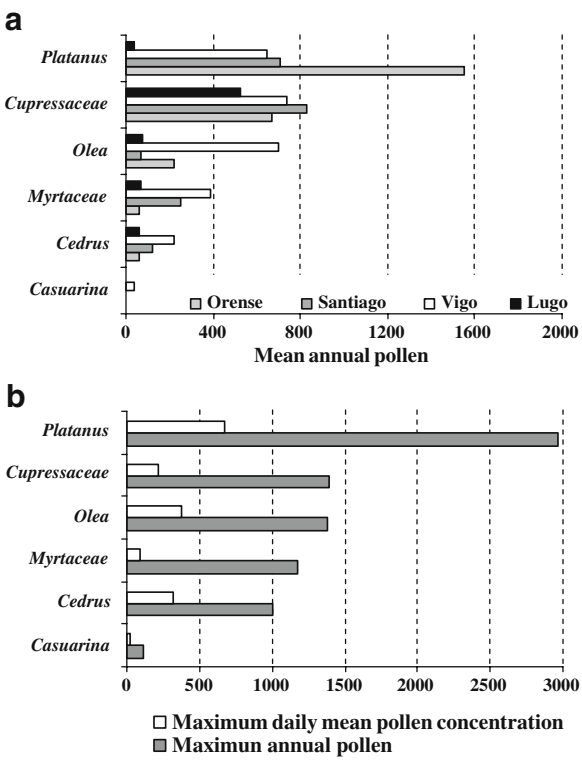

Fig. 3 Relative abundance of pollen types: **a** mean annual pollen concentration for every pollen type; **b** maximum annual pollen and maximum daily mean pollen concentration for the studied period

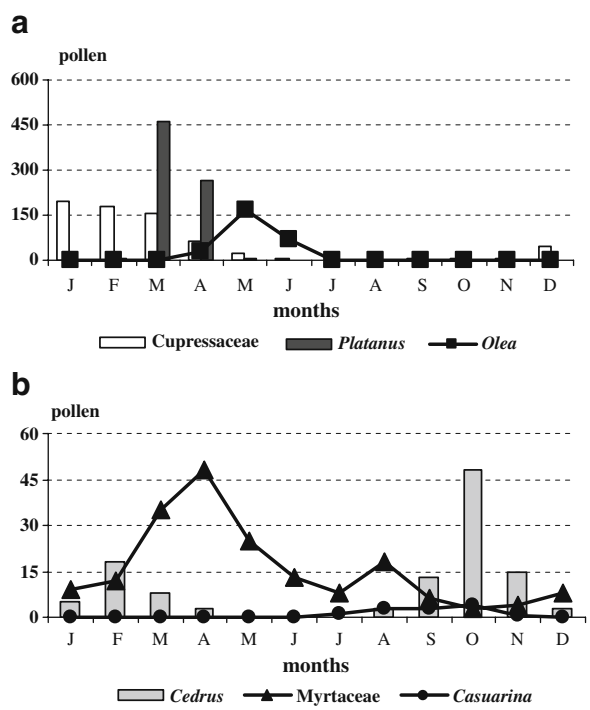

Fig. 4 Evolution of the monthly mean pollen concentration through the year (*J* January to *D* December) in all four aerobiological stations: **a** Cupressaceae, *Platanus*, and *Olea*; **b** *Cedrus*, Myrtaceae, and *Casuarina*

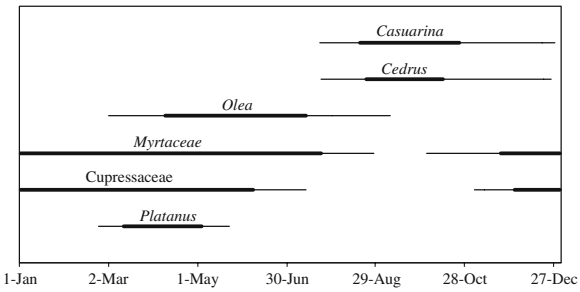

Fig. 5 Representation of the maximum and mean duration of the *Casuarina*, *Cedrus*, *Olea* and Myrtaceae pollen season in Vigo; Cupressaceae pollen season in Santiago and *Platanus* pollen season in Ourense

of the previous year—it is followed by spring-flowering taxa, such as *Platanus,* Myrtaceae, and *Olea,* and ending with *Cedrus* late in the year. *Casuarina*, which also flowers late in the year, only recorded high counts in October in Vigo (Fig. 4a, b). Pollen-season duration was variable (Fig. 5). The longest seasons were recorded for Myrtaceae (maximum duration, 300 days; mean, 265 days in Vigo) and Cupressaceae (253 vs. 190 in Santiago), followed by *Olea* (190 vs. 96 in Vigo), *Casuarina* (159 vs. 68 in Vigo), and *Cedrus* (156 vs. 53 in Vigo); the shortest season was recorded for *Platanus* (89 vs. 53 in Ourense).

The number of days on which counts exceeded potential risk thresholds was also determined (Table 3). The reference values used, which depended on abundance and allergenic potential, were as reported by Galán et al. (2007) for each type. *Platanus*, Cupressaceae, and *Olea* counts of 51–200 grains per cubic meter were deemed to pose a moderate risk, compared to 31–50 grains per cubic meter for Myrtaceae and *Casuarina*, while the high-risk threshold was set at 200 grains per cubic meter for *Platanus*, Cupressaceae, and *Olea*, and at 50 grains per cubic meter for Myrtaceae and *Casuarina*. Lugo was the only aerobiological station where any risk level was reached during the study years.

Intradiurnal models obtained using data both for the study period as whole and for the year when maximum annual totals were registered are shown in Fig. 6. Slight variations were recorded in all pollen types. *Platanus* counts displayed, in both cases, a progressive increase from noon onwards, peaking at around 6 P.M. Cupressaceae counts peaked at around noon, with higher counts over the study period as a whole. *Olea* peaks were

Table 3 Total number of days on which daily mean pollen concentrations exceeded allergy risk thresholds during the period studied, yearly average and maximum value (Galán et al. 2007)

	Platanus (Ourense)		Cupressaceae (Santiago)		*Olea* (Vigo)		Myrtaceae (Vigo)		*Cedrus* (Vigo)		*Casuarina* (Vigo)	
	51–200	>200	51–200	>200	51–200	>200	31–50	>50	51–200	>200	31–50	>50
1993	1	0	0	0								
1994	7	0	0	0								
1995	8	2	2	0	3	0	1	1	0	0	0	0
1996	1	0	0	0	7	0	0	0	2	0	0	0
1997	6	0	6	0	8	0	7	2	0	0	0	0
1998	8	0	2	0	3	0	0	0	0	0	0	0
1999	0	0	4	0	4	1	0	0	0	0	0	0
2000	12	4	1	0	3	0	0	0	1	0	0	0
2001	9	3	0	0	1	0	0	0	0	0	0	0
2002	11	5	4	0	1	0	0	0	0	0	0	0
2003	10	2	2	0	1	0	0	0	0	0	0	0
2004	12	2	1	0	2	0	0	0	0	0	0	0
2005	11	5	3	0	2	0	0	0	4	1	0	0
2006	10	5	0	0	9	0	0	0	0	0	0	0
2007	17	3	1	0	2	0	0	0	0	0	0	0
Total	123	31	26	0	46	1	8	3	7	1	0	0
Average	8	2	2	0	4	0	1	0	1	0	0	0
Maximum	17	5	6	0	9	1	7	2	4	1	0	0

recorded earlier in the day in 2006 (3–4 P.M.) than over the whole study period (5–6 P.M.). Myrtaceae counts displayed little variation in the course of the day, while *Cedrus* and *Casuarina* recorded two daily peaks: one at around noon and another in the evening (Fig. 6).

Finally, the influence of the main weather-related parameters on airborne pollen counts was analyzed statistically using Spearman's test to correlate daily pollen data with the main weather parameters: rainfall; relative humidity; maximum, minimum, and mean temperatures; and hours of sunlight (Table 4). Data for the whole period and also for the pre-peak period for each sampling site and the most common tree taxa were used. The correlation results show that, in general, rainfall and relative humidity had a negative influence on pollen counts, while a positive correlation was observed for both temperature and hours of sunlight. However, the results were not always statistically significant. The meteorological parameter accounting for most of the variance in pollen counts differed depending on the taxon and the recording period: *Platanus* counts displayed a highly significant negative correlation with minimum temperature and rainfall ($p < 0.01$) and positive with the sun hours ($p < 0.05$) during the pre-peak period. A high positive correlation was observed between Cupressaceae counts and maximum temperature and sun hours during the pre-peak period ($p < 0.01$), while a negative correlation was recorded for rainfall and humidity ($p < 0.01$). For *Olea*, a strong positive correlation was recorded between pollen counts and temperatures over the pre-peak period and hours of sunlight ($p < 0.01$). Pre-peak temperatures also exerted a positive influence on Myrtaceae counts ($p < 0.01$). Correlation coefficients were lower for *Cedrus* and *Casuarina*, although—as for all taxa—correlations were stronger over short periods (year or season compared to whole study period) and in the pre-peak period.

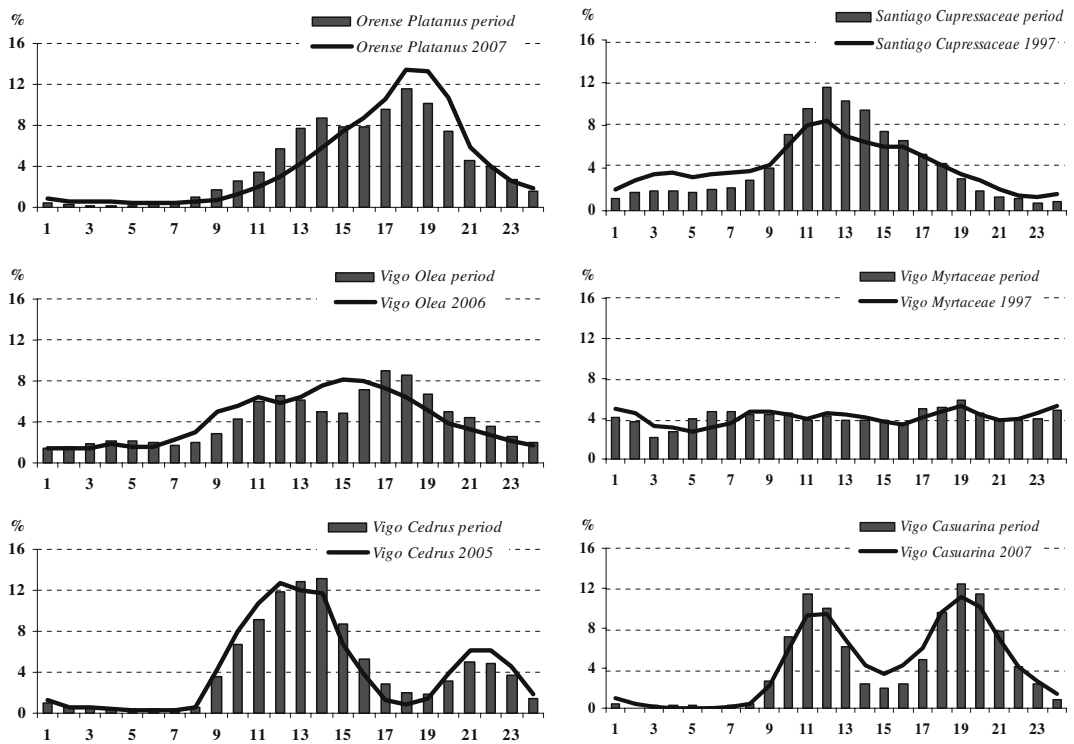

Fig. 6 Intradiurnal models. In *line*, the average of the all-year values. In *columns*, the values of the year when the annual maximum was registered: *Platanus* 2007 in Vigo; Cupressaceae 1997 in Santiago; *Olea* 2006 in Vigo; Myrtaceae 1997 in Vigo; *Cedrus* 2005 in Vigo; and *Casuarina* 2007 in Vigo

Table 4 Spearman correlation coefficients obtained between airborne pollen concentrations and the main meteorological factors (Rainfall -Rainfall-, Relative humidity -RH-, Maximum Temperature -Max. T-, Minimum Temperature -Min. T-, Mean Temperature -Mean T- and Sun hours -Sun h-)

		Rainfall	RH	Max. T	Min. T	Mean T	Sun h
Platanus (Ourense)	Seasonal	−0.177**	−0.071	0.032	−0.204**	−0.110**	0.053
	Pre-peak	−0.057	0.001	0.065	−0.084	−0.032	0.150*
Cupressaceae (Santiago)	Seasonal	−0.306**	−0.337**	−0.158*	−0.398**	−0.344**	0.189*
	Pre-peak	−0.283**	−0.340**	0.376**	0.093**	0.277**	0.321**
Olea (Vigo)	Seasonal	−0.062*	−0.054	−0.032	−0.090**	−0.057*	0.014
	Pre-peak	−0.167**	0.076	0.255**	0.279**	0.287**	0.149**
Myrtaceae (Vigo)	Seasonal	−0.038	−0.311**	−0.100	−0.195**	−0.148*	−0.012
	Pre-peak	−0.059*	−0.197**	0.200**	0.092**	0.181**	0.092**
Cedrus (Vigo)	Seasonal	0.074**	−0.104**	0.102**	0.071**	0.096**	−0.036
	Pre-peak	0.092**	−0.082*	−0.001	−0.026	−0.004	−0.093**
Casuarina (Vigo)	Seasonal	−0.192**	−0.170**	0.143**	0.062	0.085*	0.169**
	Pre-peak	−0.188**	−0.166**	0.134**	0.079	0.005	0.139**

Values of the total seasonal period (Seasonal) and the prepeak pollen period (Prepeak) were considered. (*Significance levels:* ** $p < 0.01$;* $p < 0.05$)

Discussion

Pollen counts for the tree taxa most widely used as ornamentals in the northwestern Iberian Peninsula displayed certain differences depending on the sampling site, with higher values in Vigo and Ourense. This is partly due to higher total pollen counts in the two cities (24,918 grains in Vigo and 22,160 in Ourense) compared with 18,586 in Santiago and 16,606 in Lugo. These differences are attributable to biogeographical characteristics, which determine local flora composition, as well as to differences in climate. Santiago, Lugo, and Vigo lie within the Eurosiberian region, while Ourense is part of the Mediterranean region (Peinado-Lorca and Rivas-Martínez 1987). Santiago has a temperate subhumid climate, while Lugo is cool and dry, Ourense warm and dry, and Vigo warm and humid (Martínez and Pérez 1999). Differences in counts for pollen from introduced species may be ascribed more to the atmospheric dynamics of the sampling site than to any difference in the size of green areas, although pollen from ornamentals accounted in some cases for a considerable proportion of the total (Rodríguez-Rajo et al. 2004).

In qualitative terms, the aerobiological records provided a clear indication of the most common tree taxa in each area: *Platanus* in Ourense, Cupressaceae in Santiago and to a lesser extent in Lugo, and *Olea*, Myrtaceae, *Cedrus*, and *Casuarina* in Vigo. The risk of triggering symptoms in allergy sufferers posed by each pollen type was estimated mainly on the basis of allergenic potential, abundance in the air, and length of pollen season. Various studies have highlighted the elevated allergenic potential of *Platanus,* with a notable increase in asthma cases immediately before the first peak of the pollen season (Varela et al. 1997). Cupressaceae, *Olea*, and *Casuarina* pollen are more influential in the Mediterranean (Subiza 2004), the natural area of distribution of these taxa. Cypress pollen is associated with winter allergies; its allergenic significance has prompted an exhaustive analysis of its aerobiological behavior and its repercussion on the atopic population (Díaz de la Guardia et al. 2006). In spite of the fact that olive is widely regarded as the primary cause of pollen allergy in southern Spain (Florido et al. 1999), the incidence of olive-pollen allergy is thought to have increased following new plantings under the current European Union Common Agricultural Policy (Sánchez-Mesa et al. 2005). The potential risk posed by this major allergen is enhanced by possible cross-reactivity with other Oleaceae pollen (Pajarón et al. 1997) and by the effects of associated paucimicronic allergen-carrying particles (Linares et al. 2007). The aller-

genic capacity of *Casuarina* has been confirmed by a number of studies associating it with rhinitis and bronchial asthma (García et al. 1997). Finally, the allergenic capacity of Myrtaceae and *Cedrus* pollen is traditionally considered low, although moderate responses and occasional respiratory disorders cannot be ruled out (Trigo et al. 2008).

These findings, in conjunction with pollen counts and immunological response indices, may serve as a starting point for assessing potential effects on local allergy sufferers. The maximum daily mean pollen concentration (peak value) for *Platanus* (1,544 grains per cubic meter, Ourense) was lower than that reported for the Spanish cities with the higher *Platanus* pollen concentrations such as Barcelona (16,720 grains per cubic meter) and Madrid (10,273 grains per cubic meter). Moreover, the rate of sensitization, as measured by the skin prick test is only 34% of the population in Ourense (Varela et al. 1997) compared with 52% in Madrid (Subiza et al. 1994). Peak Cupressaceae pollen counts (829 grains per cubic meter, Santiago) were also much lower than those of large cities such as Barcelona (6,448 grains per cubic meter) and Madrid (7,381 grains per cubic meter). Around 2% of the population in the northwestern Iberian Peninsula may be sensitive to this pollen type (Ferreiro et al. 1998).

The maximum average annual totals for *Olea* pollen in the cities studied (700 grains, Vigo) were considerably lower than those recorded in the olive-growing regions of southern Spain, such as Jaen (where the crop is grown extensively), which recorded the highest average annual total of Spain with 48,582 pollen grains over the period 1993–2008. Nevertheless, around 25% of the population in the study area are sensitive to *Olea* pollen (Ferreiro et al. 2002) compared to 97% in the Mediterranean area (Subiza et al. 1998).

Annual average Myrtaceae pollen counts reached a maximum of 386 grains in Vigo, one of the most important in Spain (Rodríguez-Rajo et al. 2001). Although the allergenic capacity of this pollen type is considered moderate, widespread reforestation using *E. globulus* Labill may be prompting an increase in the incidence of allergies, currently estimated to affect around 10% of the population in the study area. *Cedrus* and *Casuarina* pollen are present in the air during the winter period and may be associated with pollinosis at that time. However, its allergenic potential is considered low, and the clinical impact is unknown because these pollen types are not included in the batteries (Ferreiro et al. 2002).

A number of studies have identified pollen-count thresholds associated with moderate and high allergy risk. Thresholds vary depending on the abundance and allergenic potential of each pollen type (Galán et al. 2007). For the ornamental species most common in northwestern Spain, the greatest threat is posed by *Platanus*, with pollen counts exceeding the moderate-risk threshold on an average of 8 days by year, followed by *Olea* and Cupressaceae. The potential risk is confirmed by peak pollen counts: around 478 pollen per cubic meter for *Platanus*; 382 for *Olea*; and 193 pollen per cubic meter for Cupressaceae. Several authors report a temporal relationship between respiratory allergies and maximum airborne-pollen counts (Dopazo et al. 2002).

The pollen seasons of the study taxa can be divided into three groups: (1) short seasons (<15 weeks/year), only *Platanus*; (2) medium-length seasons (from 15 to 30 weeks/year), including *Olea*, *Cedrus*, and *Casuarina*; and (3) long pollen seasons (>30 weeks/year), including Cupressaceae and Myrtaceae. The behavior of these taxa in other areas may vary, depending on local climate and on the species included in each pollen type (Potoglu 2008). Given this seasonal distribution of pollen types, which governs allergenic potential at any given time of year, *Olea* and *Platanus* might be expected to prompt allergies in spring, while autumn-flowering taxa such as *Cedrus* and *Casuarina* may be associated with winter allergies; taxa whose pollen is present virtually throughout the year—such as Myrtaceae and Cupressaceae—are likely to contribute to both winter and spring allergies. Over the study period as a whole, peak Myrtaceae pollen counts were recorded both at the start of the year (11 grains on 4 January 1996) and at the end (eight grains on 29 December 1998), while peak Cupressaceae counts were observed in the first 4 months of the year (118 grains in January 1997 and 88 grains on 16 April 2007), and mostly during the winter months.

Models of intradiurnal variation can be used to identify the times of day when the risk of exposure is greatest. Myrtaceae counts barely varied throughout the day, whereas *Platanus* counts were higher toward evening and counts for the other types (Cupressaceae, *Olea*, *Cedrus*, and *Casuarina*) increased at around noon; *Casuarina* recorded a second peak at around 8 P.M. These may thus be considered the times of greatest risk for the atopic population.

Analysis of the influence of weather-related factors on airborne pollen concentrations confirmed, especially for Cupressaceae and *Platanus*, the well-documented washout effect caused by rain (Alba et al. 2000). The positive correlation of *Cedrus* with rainfall in some studied years probably reflected the fact that the pollen season ran from 22 August to 13 October, a low rainfall period (average, 36.1 mm), with a predominance of days with little or no rain and thus with a much less marked washout effect. Humidity also exerted a generally negative influence on pollen counts, a finding reported by other authors, especially for Cupressaceae (Díaz de la Guardia et al. 2006). Temperature and hours of sunlight generally exerted a positive influence on pollen counts due not only to atmospheric dynamics but also to the effect of anther dehiscence (Khanduri and Sharma 2002).

The results of this study confirmed the risk inherent in the indiscriminate planting of exotic flora in parks and gardens. Aerobiological criteria should be taken into account when planning green areas for leisure use. The use of entomophilous species, which produce less pollen than anemophilous species, and the introduction of exotic species with low allergenic capacity, may be valid strategies.

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