ORIGINAL ARTICLE

Behavior of *Platanus hispanica* Pollen, an Important Spring Aeroallergen in Northwestern Spain

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Abstract

Background and Objective: Platanus hispanica trees are considered an important source of airborne pollen allergens in many cities of Western Europe. As the prevalence of sensitization to this species is 8% to 9% in northwestern Spain, our objective was to propose models predicting both the onset of the pollen season and the mean daily pollen concentrations.
Methods: Airborne *P hispanica* pollen was monitored from 1993 through 2002 with 2 Hirst volumetric spore traps in Ourense and Santiago de Compostela in northwestern Spain. The pollination start dates were determined and the data were fitted to predictive regression models, which were tested for the year 2002.
Results: P hispanica pollen is present in the atmosphere from March to April. The main pollination period is short with a mean duration of around 40 days. The mean maximum daily concentrations exceeded 100 pollen grains/m^3. As temperature is the parameter that most influences atmospheric pollen levels, this variable was chosen as the basis for models predicting both the onset of the pollen season and daily pollen concentrations. The predicted onset date was a few days later than the real start date in 2002. However, the model gave an accurate prediction of the mean daily pollen concentration.
Conclusions: The mean daily concentrations of *P hispanica* pollen are high, and given the allergenic potential of this species, it should be taken into account as one of the most important local spring allergens. The weather-related models proposed help us to predict *P hispanica* pollen concentrations in the atmosphere.

Key words: *Platanus* species. Pollen. Aerobiology. Aeroallergen. Spain. Air temperature. Flowering onset.

Resumen

Antecedentes y Objetivo: Los árboles de *Platanus hispanica* son considerados una fuente importante de alérgenos polínicos en muchas ciudades de la Europa Occidental. Debido a que en el noroeste de España provocan un 8%–9% de sensibilizaciones, hemos propuesto modelos para predecir el inicio de la polinización y sus concentraciones atmosféricas.
Métodos: El polen atmosférico de *P hispanica* se ha monitorizado durante los años 1993-2002 mediante 2 captadores volumétricos tipo Hirst, situados en Ourense y Santiago de Compostela. Se han desarrollado modelos de regresión y de predicción del inicio de la polinización, los cuales fueron evaluados durante el año 2002.
Resultados: Este tipo polínico está presente en la atmósfera durante los meses de marzo y abril. El periodo de polinización es corto, con una duración media de 40 días. Las concentraciones máximas superan generalmente los 100 granos de polen/m^3. La temperatura es el parámetro que presenta una mayor influencia en sus concentraciones atmosféricas por lo que fue escogido para establecer modelos que nos permitan predecir tanto el inicio de la polinización como las concentraciones medias diarias. En el primer caso, la fecha estimada de inicio es similar a la encontrada durante el año 2002. Los modelos para predecir las concentraciones medias diarias presentan unos elevados niveles de predicción.
Conclusiones: El polen de *P hispanica* presenta elevadas concentraciones atmosféricas y dado su potencial alergénico, debería ser considerado como uno de los más importantes alérgenos primaverales locales. Los modelos propuestos nos ayudan a predecir las concentraciones de polen de *P hispanica* en la atmósfera.

Palabras clave: *Platanus.* Polen. Aerobiología. Aeroalergeno. España. Temperatura. Inicio floración.

Introduction

Platanus hispanica Miller ex Munich is frequently used as an ornamental tree in parks, gardens and avenues in numerous cities. The tree flowers between April and May depending on the location and weather patterns in a particular year. The flowering period is generally described as short and intense. The air-dispersion capacity of the flowers is moderate [1,2], but they produce an abundant quantity of pollen grains that have often been cited as allergenic. These plane trees, or sycamores as they are called in the United States of America, are considered an important source of airborne allergens in many cities of the US and Western Europe. Some authors have described *Platanus* species pollen grains as a trigger of seasonal asthma [3,4], while others mention them as an important cause of pollinosis, as in Madrid [5]. In the city of Ourense, the rate of sensitization to *P hispanica* pollen has been found to be 8% [6]. A higher rate of 9% has been reported for Santiago de Compostela [7].

In recent years the allergens present in these pollen grains have been characterized for various species. Thus, an allergen from *Platanus acerifolia* pollen was characterized and isolated [8] and its major allergen Pla a 1 was identified and further described [9,10]. Cross-reactivity has been observed between *P acerifolia* pollen and plant-derived foods and some authors have suggested that oral allergy syndrome may have been caused by primary respiratory sensitization [11]. Cross-reactivity between *Platanus* species pollen and some edible vegetables has been found [12], with description of a clear partial cross-reactivity between lettuce lipid transfer protein and *Platanus* species pollen extract [13].

The flowering season of plane trees and the amounts of pollen they release is influenced by the weather conditions prevailing in any given year and the previous one [14,15]. In this way the phenological behavior of different species varies not only from one site to another, but also from one year to another. Variations are greater in the case of *Platanus* species because it is commonly found in urban areas and is therefore affected by various aspects of human activity.

The aim of this paper was to assess potential weather-related differences in *P hispanica* pollen behavior between 2 areas in northwestern Spain (Ourense and Santiago de Compostela), evaluating the effect of several meteorological parameters on pollen concentrations. Despite the geographical proximity of the 2 study sites, marked climate differences were detected. The data obtained were used to create models predicting both the onset of the pollen season and the pollen concentrations that may be attained. The data of 2002 were used to determine the real validity of the models as this year was not taken into account to establish the aforementioned models.

Materials and Methods

The study was carried out from 1993 though 2002. Two Hirst type samplers (VPPS 2000, Lanzoni, Bologna, Italy) were placed in the cities of Ourense and Santiago de Compostela in northwestern Spain. Ourense (42°50′ N, 7°51′ W) lies 130 m above sea level in a depression created by the rivers Miño, Loña, and Barbaña and surrounded by steep slopes rising to 400 m above sea level. Santiago de Compostela (42°49′ N, 8°27′ W) lies 270 m above sea level in an open area surrounded by small hills. According to the Worldwide Bioclimatic Classification System, Ourense has a very warm, dry summer; annual rainfall is around 754 mm and the mean annual temperature is around 14°C. Vegetation is typically Mediterranean, with considerable Atlantic influence and *Quercus pyrenaica* is the predominant forest species. Santiago has a temperate subhumid ombrothermic index, with annual rainfall of around 1078 mm, and an annual mean temperature of 13.7°C [16]. Natural vegetation in Santiago de Compostela is Eurosiberian and *Quercus robur* the predominant tree species.

Samples were counted and prepared by using the methodology proposed by the Spanish Aerobiology Network [17] and identified by means of 2 reference guides [18,19]. Pollen grains were counted by means an Optiphot II microscope (Nikon, Tokyo, Japan) with a ×400 magnification. The onset of the main pollination period (MPP) was considered to start on the first day on which primary pollen grains were continuously recorded and to continue while no more than 2 consecutive days without pollen were detected [20]. The end of the MPP was the date with the last recording greater than 10 pollen grains/m^3 in the context of at least 2 consecutive days with pollen.

The meteorological data used (maximum, mean, and minimum temperatures; relative humidity; hours of sunshine; and wind speed and direction) were supplied by the Spanish National Meteorology Institute. Correlations between these parameters and pollen concentrations were analyzed by using the Spearman nonparametric correlation test. The same test was also applied to pollen concentrations and the values of certain meteorological variables (temperatures, temperature range, accumulated temperatures, and hours of sunshine) on the preceding 2 to 7 days. To establish the intradiurnal variation pattern, the method used selected the days without rain and with pollen concentrations over the mean values of the MPP [21]. In order to create a model to predict pollen concentrations, a linear regression analysis was carried out, using as predictors the meteorological parameters showing the best correlation coefficient. Finally, the influence of temperature on the onset of flowering was evaluated by calculating the thermal sum of maximum temperatures during the period prior to the beginning of the pollination period. We studied periods in 10-day increments, from 10 days before the start of the pollen season and then adding 10-day periods to a maximum of 100 days.

Results

Airborne *P hispanica* pollen was detected in the month of March at both locations (Figures 1 and 2). The average total annual pollen collected during the studied period was 1137 grains in Ourense and 800 grains in Santiago de Compostela (Table 1). Slight differences were observed between the 2 cities with regard to the onset of the MPP, which took place an average of 7 days earlier in Ourense. This difference varied over the study period, reaching a maximum delay of 15 days in 2001.

Table 1. Characteristics of the *Platanus hispanica* Pollen Seasons in 2 Cities in Northwestern Spain

Year	Annual Pollen Counts, grains	Maximum Pollen Counts, grains/d	Days with >50 grains	Main Pollination Period		
				Duration, d	Start	End
Santiago de Compostela						
1993	191	21	0	8	March 22	March 30
1994	350	93	1	29	March 15	April 13
1995	911	164	6	33	March 13	April 15
1996	196	47	0	13	April 02	April 15
1997	2445	478	11	24	March 07	March 31
1998	1779	272	10	21	March 07	March 28
1999	480	93	3	28	March 17	April 14
2000	510	114	1	28	March 13	April 10
2001	220	30	0	21	March 27	April 17
2002	916	121	6	26	March 20	April 15
Mean (SD)	800 (756.6)	143 (138.4)	4 (4.2)	23 (7.7)	March 17	April 9
Ourense						
1993	475	70	1	28	March 10	April 7
1994	930	103	7	24	March 08	April 1
1995	1181	246	8	23	March 13	April 5
1996	515	128	1	24	March 23	April 16
1997	815	190	6	17	March 07	April 24
1998	995	183	8	34	Feb 23	April 29
1999	203	33	0	15	March 21	April 5
2000	2225	363	12	33	March 09	April 1
2001	1669	357	9	25	March 12	April 6
2002	2364	325	11	22	March 18	April 09
Mean (SD)	1137 (629.1)	200 (118.0)	6 (4.2)	24 (6.4)	March 11	April 5

Onset was earlier in Santiago de Compostela (by 4 days) only in 1999, while the date of the start of the MPP coincided in the 2 cities in 1995 and 1997 (Table 1). The date of the end of the MPP occurs on average 4 days later in Santiago de Compostela. However, differences were greater for this variable, since the MPP ended earlier in Ourense in 4 years. The length of the MPP also differed between the 2 cities. It was longer in Ourense, with a mean duration of 24 days, than in Santiago de Compostela, where the mean duration was 23 days. Even so, in years when Ourense recorded a very short MPP, its duration was longer in Santiago de Compostela. The highest daily concentrations over the whole period were 478 pollen grains/d in 1997 in Santiago de Compostela and 363 pollen grains/d in 2000 in Ourense. Lower maximum pollen concentrations in Santiago de Compostela were recorded, as 21 and 30 pollen grains/d in 1993 and 2001, respectively. In Ourense the lowest maximum counts recorded were 70 and 33 pollen grains/d in 1993 and 1999, respectively. The average maximum daily pollen concentrations were higher in Ourense than in Santiago de Compostela.

Different intradiurnal behavior patterns were obtained for the 2 sites during the studied period (Figure 3). In Ourense, high values were recorded from midday onwards, with considerable increases during the evening. Slight year-to-year differences were observed. In Santiago de Compostela, the highest values were recorded during the evening, between 7:00 PM and 8:00 PM and the year-to-year variation was less.

Table 2 shows the results of analysis of correlations between the daily mean concentrations of *P hispanica* pollen during the MPP and the various meteorological parameters studied (precipitation; relative humidity; maximum, minimum, and mean temperatures; and hours of sunshine). The results obtained in Ourense showed no correlation between pollen concentrations and any meteorological parameter (Table 2). A significant ($P < .1$) negative correlation was obtained for rainfall in only 3 of the studied years. Relative humidity presented a similar effect on pollen concentration, although it was only significant in the years 1993 and 2002. Sun hours and temperature (maximum, mean, or minimum) presented varying influences on pollen concentration. Positive correlation coefficients were obtained for sun hours with significant values for 4 years. A significant negative correlation was obtained for maximum temperature in 5 years, and for minimum temperature in 4 years. A significant positive correlation was observed for mean temperature in 1994 ($P < .1$), 1999 ($P < .001$) and 2000 ($P < .01$), while a significant negative correlation was recorded in 1998 ($P < .001$).

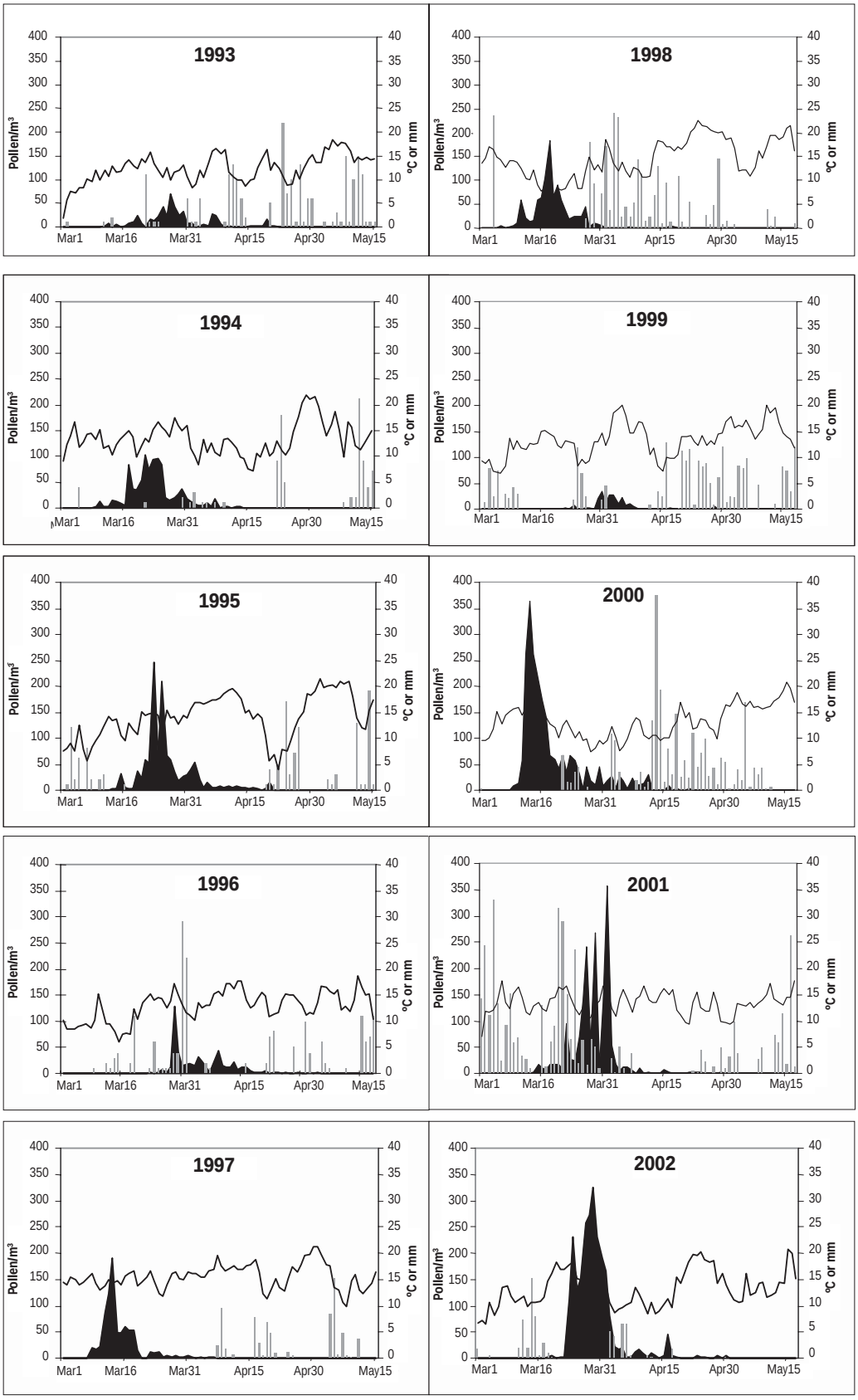

Figure 1. Rainfall (bars), daily pollen concentrations (area), and temperature (line) during the period of study in Ourense. Mar indicates March; Apr, April.

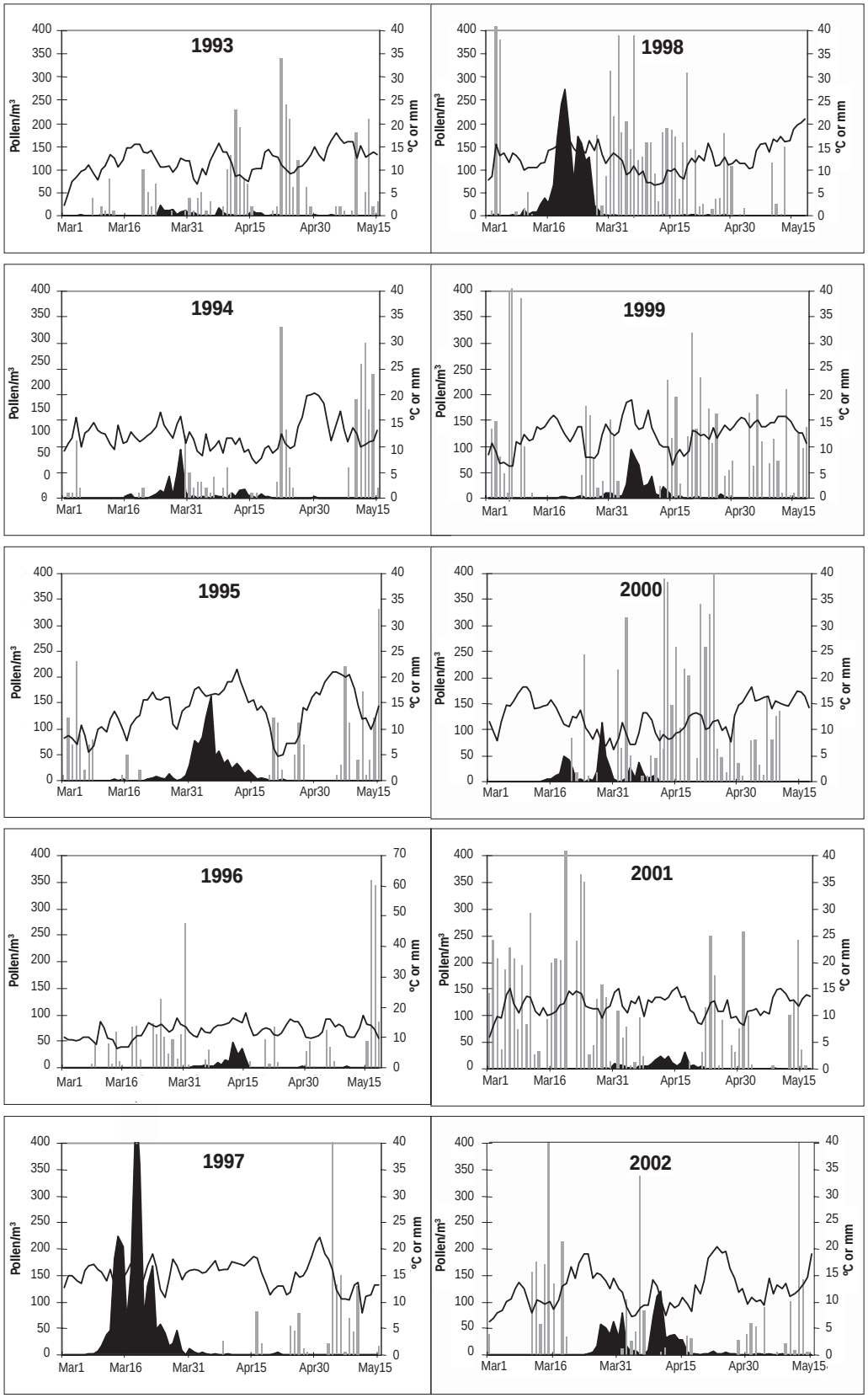

Figure 2. Rainfall (bars), daily pollen concentrations (area), and temperature (line) during the period of study in Santiago de Compostela. Mar indicates March; Apr, April.

Table 2. Spearman Correlation Coefficients Between the Main Meteorological Parameters and Daily Mean *Platanus hispanica* Pollen Counts of the Preceding 7 Days During the Main Pollination Period

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Santiago de Compostela										
Rainfall	–0.486	–0.410†	–0.365†	–0.290	–	–0.525†	–0.285	–0.293	–0.719‡	–0.155
% humidity	–0.555	–0.421†	–0.616‡	–0.031	0.467†	–0.895‡	–0.194	–0.034	–0.500†	–0.121
Maximum temperature	–0.131	0.357*	0.789‡	0.722‡	–0.105	0.862‡	0.388†	–0.120	0.628‡	–0.076
Mean temperature	–0.580	0.398†	0.746‡	0.902	–0.091	0.718‡	0.440†	–0.283	0.595‡	–0.112
Minimum temperature	–0.565	0.020	–0.161	0.695‡	–0.037	–0.211	0.485‡	–0.430*	–0.167	–0.048
Sun hours	0.236	0.316*	0.647‡	0.240	–0.050	0.743‡	0.161	0.340*	0.782‡	0.072
Pollen, day 1	0.300	0.444†	0.889†	0.847‡	0.841‡	0.856‡	0.804‡	0.595†	0.721†	0.734‡
Pollen, day 2	0.369	0.369†	0.830†	0.893‡	0.669‡	0.765‡	0.661‡	0.263	0.578‡	0.507†
Pollen, day 3	0.296	0.137	0.733‡	0.833‡	0.613‡	0.738‡	0.601‡	–0.109	0.524**	0.328
Pollen, day 4	0.004	0.023	0.697‡	0.858‡	0.562‡	0.677‡	0.654‡	–0.228	0.538‡	0.168
Pollen, day 5	0.000	0.033	0.636‡	0.850‡	0.416†	0.637‡	0.645‡	–0.229	0.471*	0.119
Pollen, day 6	–0.432	0.109	0.614‡	0.859‡	0.268	0.563‡	0.677‡	–0.047	0.525*	0.077
Pollen, day 7	–0.368	0.090	0.639‡	0.877‡	0.105	0.547‡	0.652‡	0.141	0.510*	0.087
Ourense										
Rainfall	–0.395*	0.215	–0.196	–0.200	–	–0.347*	–0.226	–0.142	0.106	–0.397*
Percent humidity	–0.322*	–0.121	–0.279	–0.058	0.343	0.120	–0.244	–0.153	–0.121	–0.534‡
Maximum temperature	0.344*	0.290	0.394*	0.174	–0.039	–0.879‡	0.535†	0.420†	0.103	0.181
Mean temperature	0.107	0.372*	0.190	0.024	0.004	–0.843‡	0.682‡	0.426†	0.125	–0.100
Minimum temperature	–0.021	0.024	–0.373*	–0.311	0.146	–0.583‡	0.535*	0.054	–0.073	–0.441†
Sun hours	0.248	0.231	0.211	0.341*	0.420*	0.533‡	0.152	0.356†	0.202	0.241
Pollen, day 1	0.573‡	0.091	0.600†	0.582‡	0.472	0.613‡	–0.327	0.616‡	–0.231	0.711‡
Pollen, day 2	0.426‡	–0.042	0.493	0.268	0.210	0.336	–0.306	0.589‡	0.014	0.383
Pollen, day 3	0.349†	0.261	0.064	0.388*	0.168	0.174	0.487	0.538*	0.385	0.158
Pollen, day 4	0.164	0.479	–0.171	0.509*	0.212	0.109	–0.270	0.253	0.126	–0.203
Pollen, day 5	0.265	–0.248	–0.454	0.332	0.152	0.014	–0.345	0.183	0.273	–0.320
Pollen, day 6	0.196	0.115	–0.438	0.276	–0.196	–0.021	0.045	0.105	0.130	–0.526
Pollen, day 7	0.214	0.297	–0.315	0.243	–0.284	–0.001	0.450	–0.098	0.368	–0.681‡

*$P < .1$. †$P < .05$. ‡$P < .001$.

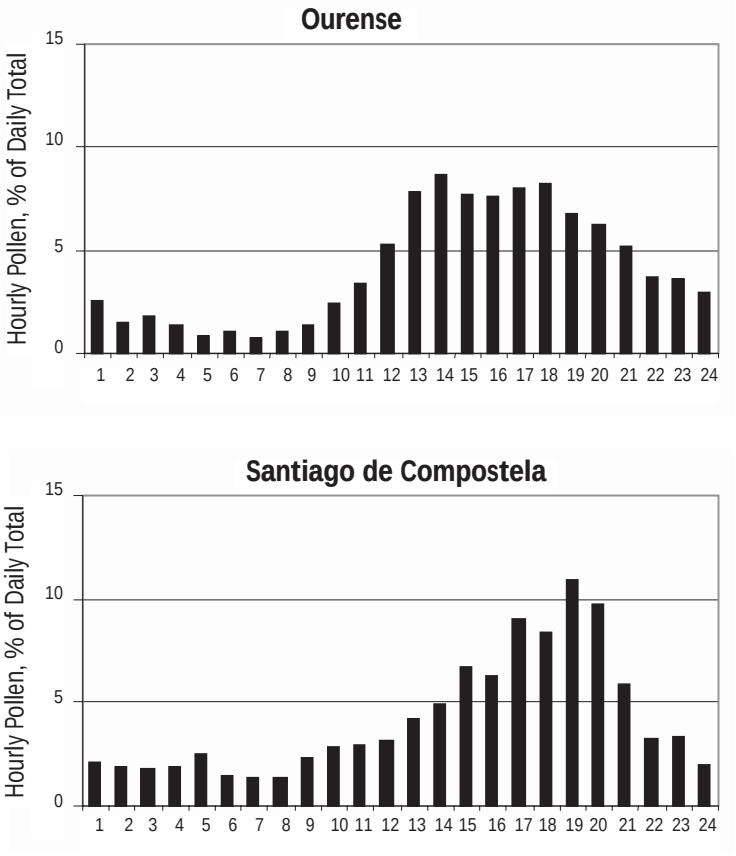

Figure 3. Hourly pollen concentrations (percentage of the daily total that was collected in each hour).

Table 3. Spearman Correlation Coefficients Between a Day's *Platanus hispanica* Pollen Count and the Mean Temperature of Each of the Previous 7 Days in Ourense, Spain

Mean Temperature	1993	1996	1998	1999	2000
Day 1	0.329	–0.138	–0.764†	0.528	0.419*
Day 2	0.247	–0.380	–0.611†	0.327	0.572†
Day 3	0.297	–0.236	–0.521†	–0.026	0.657†
Day 4	0.289	0.100	–0.537†	–0.190	0.611†
Day 5	0.354*	0.232	–0.429*	–0.289	0.738†
Day 6	0.511†	0.330	–0.2171	–0.577	0.741†
Day 7	0.649‡	0.435	–0.0805	–0.489	0.697†

*$P < .1$. † $P < .05$. ‡ $P < .001$

These results led us to select those years in which the mean temperature was significantly correlated with mean pollen concentration in order to explore the correlation between pollen concentration and the mean temperature of the previous days (up to 7) in those years in Ourense (Table 3). The 5 years taken into account can be divided into 2 groups. The first group includes the years 1993, 1996, and 2000, in which the correlation coefficient of the previous day increased and the value of *P* decreased, reflecting a higher correlation between pollen concentration on that day and the previous day's mean temperature. In the second group (years 1998 and 1999) the correlation coefficients were not significant or the significant correlation was negative.

In Santiago de Compostela, there was a significant negative correlation between rainfall and pollen concentrations in the years 1994, 1995, 1998 ($P < .01$), and in 2001 ($P < .001$). The significant correlation between relative humidity and pollen count was also negative in those years, while it was positive in 1997. Sun hours and temperature were significantly related to pollen count in 5 years: 1994 and 2000 ($P < .1$) and 1995, 1998, and 2001 ($P < .001$). The degree of association between pollen concentrations and temperatures varied, as

minimum temperature was only significantly related in 1996 and 1999 ($P < .01$) and 2000 ($P < .l$). Mean temperatures were significantly correlated with pollen counts in 1995, 1998, and 2001 ($P < .01$) and in 1994 and 1999 ($P < .05$). Maximum temperature correlated with pollen counts in 1995, 1996, 1998, and 2001 ($P < .001$).

Predicting Pollen Concentrations

As a high positive significant correlation was found between pollen concentrations and mean temperature 7 days earlier in 3 years (1993, 1996, and 2000), data for those years were entered into the regression model to predict airborne plane tree pollen concentrations. The model obtained by using pollen concentration as the dependent variable and the mean temperature 7 days earlier as the independent variable gave an R^2 value of 0.295 for Ourense, accounting for the low percentage of variability. In order to improve these results the daily mean plane tree pollen concentrations recorded during the previous days were introduced into the equation for Ourense; the new equation presented an R^2 of 0.485, thus notably improving the prediction equation proposed for that city. In the case of Santiago de Compostela, regression analysis was carried out using maximum temperature as an independent variable, and including the years 1995, 1996, 1998 and 2001. The model presented an R^2 value of 0.481. In order to improve this result, the previous day's pollen concentrations were also included in the equation as independent variables. The R^2 value rose to 0.675 and this prediction equation was therefore proposed for Santiago de Compostela.

Predicting Onset of Flowering

Table 4 shows accumulated maximum temperatures calculated for the days before the flowering date in blocks of 10 days up to 100 days. The results showed that the coefficient of variation was lower in the 100-day period prior to flowering in Santiago de Compostela, whereas it was lower in the 50-day period before onset of flowering in Ourense. Values for accumulated maximum temperature were higher in Ourense (average temperature, 16.02°C in the 50-day period, compared to only 14.72°C in Santiago de Compostela). These differences were greater for the 100-day period (average temperature, 15.87°C in Ourense and 13.67°C in Santiago de Compostela).

Discussion

P hispanica flowering is almost simultaneous in both cities during March but takes place slightly earlier in Ourense due to higher temperatures during the period prior to flowering [22-24], suggesting that the onset of *P hispanica* flowering is governed by the temperatures recorded in February. The earliest flowering seasons take place in years when the temperatures just before flowering are higher [22, 25].

Intradiurnal variation in both cities was high during afternoon hours, although in Ourense values remained high during a longer hourly interval, in which 50% of the total daily pollen was collected. Studies conducted in other Spanish cities also show the highest values during afternoon hours [21,26], although the highest values in Vigo were obtained at night for this pollen type [27], influenced by this city's wind pattern due to its coastal location. *P hispanica* pollen was lower in both cities than in other Spanish cities, such as Madrid or Barcelona, where daily means around 1000 pollen grains/m^3 have been reported [28,29]. The biennial rhythm reported for Seville [24] was not found in the 2 northwestern Spanish cities we studied, just as such a rhythm has not been reported for other Spanish locations, such as Granada [25] or various parts of Catalonia [29].

The values of the *P hispanica* pollen recorded in the studied areas during the MPP were significantly influenced by rainfall over the period, although the intensity of this influence varied from year to year. In years with high rainfall, pollen concentrations were lowest, with sharp drops in concentration on rainy days, as in Santiago de Compostela during 1994 or 2000, when 44 and 112 mm of rain, respectively, were recorded. In contrast, the highest values were found for rain-free MPPs (as in the case of Ourense in 1995) or during rainy years but when the rainfall was concentrated at the end of the MPP when mean daily pollen concentrations were already low (as in Ourense in 2000 when 17 mm of rain was recorded over the last few days). The correlation between *P hispanica* concentrations and rainfall, which is the weather-related variable with the strongest influence, was negative, as rainfall leads to a decrease in atmospheric plane tree pollen concentrations. Other factors can also play a role. As *P hispanica* grows in many public gardens, pollen concentrations can be affected by a wide range of human actions with various effects. Pruning by means of pollarding is a tradition that drastically reduces the tree's vegetation and therefore its capacity for producing and releasing pollen grains. Thus, low annual values such as those recorded in Ourense in 1999 coincided with heavy pruning before flowering. On the other hand, when such pruning is carried out at the start of flowering, the considerable movement of vegetation favors the release of a large number of pollen grains into the atmosphere, resulting in much higher concentrations, as occurred in Ourense in both 2000 and 200l. This effect interferes with the analysis of correlation with weather-related data, and thus makes it difficult to establish a predictive model.

The correlation between pollen counts and temperature varied considerably over the study period at both sampling sites. Correlations were significant and positive in some years, significant and negative in others, and occasionally nonsignificant. In years when the correlation coefficient was positive, temperature remained stable or increased slightly on the days with the highest pollen concentrations. In contrast, in years when the correlation coefficient was negative, temperature dropped substantially after the onset of flowering, as occurred in Ourense in 1998. In this case, the highest values for *P hispanica* pollen coincided with the lowest values for mean temperature, altering the general degree of association between temperature and pollen [30]. These years could be considered anomalous, to be deleted from subsequent analyses.

Table 4. Accumulated Temperatures in ºC for Periods in Increments of 10 Days, Until 100 Days, for Ourense and Santiago de Compostela, Spain.

	10 d	20 d	30 d	40 d	50 d	60 d	70 d	80 d	90 d	100 d
Ourense										
1993	152	303	475	635	773	931	1006	1111	1235	1375
1994	175	324	451	587	705	834	981	1110	1441	1592
1995	146	283	450	613	770	770	904	1016	1483	1618
1996	162	347	483	625	755	884	998	998	1366	1494
1997	229	398	563	716	847	986	1062	1205	1742	1824
1998	183	378	555	748	892	1028	1159	1306	1541	1668
1999	219	364	524	666	816	951	1068	1203	1546	1658
2000	203	390	549	718	837	950	1046	1189	1518	1620
2001	172	322	510	657	792	910	1051	1187	1455	1595
2002	165	313	472	644	817	956	1095	1210	1301	1426
Mean (SD)	181 (28.1)	342 (39.3)	503 (42.8)	661 (51.6)	801 (53.2)	920 (75.0)	1037 (69.4)	1154 (94.6)	1463 (142.3)	1587 (128.9)
Coefficient of variation, %	15.5	11.5	8.5	7.8	6.6	8.2	6.7	8.2	9.7	8.1
Santiago de Compostela										
1993	185	336	457	625	787	927	1072	1196	1253	1306
1994	170	308	441	542	688	790	911	1040	1160	1286
1995	117	236	369	522	659	779	890	1014	1144	1306
1996	163	304	468	589	717	836	964	1092	1228	1379
1997	203	350	494	636	760	907	992	1126	1262	1387
1998	176	343	540	666	798	946	1071	1209	1349	1482
1999	164	294	442	562	716	833	952	1082	1206	1364
2000	225	386	532	679	806	926	1044	1169	1287	1415
2001	150	290	414	588	745	872	986	1103	1231	1356
2002	133	277	405	546	685	828	963	1103	1203	1327
Mean (SD)	169 (31.7)	312 (42.6)	456 (54.6)	595 (54.2)	736 (51.3)	864 (59.7)	984 (62.5)	1104 (59.8)	1230 (63.2)	1367 (59.3)
Coefficient of variation, %	18.8	13.6	12.0	9.1	7.0	6.9	6.3	5.4	5.1	4.3

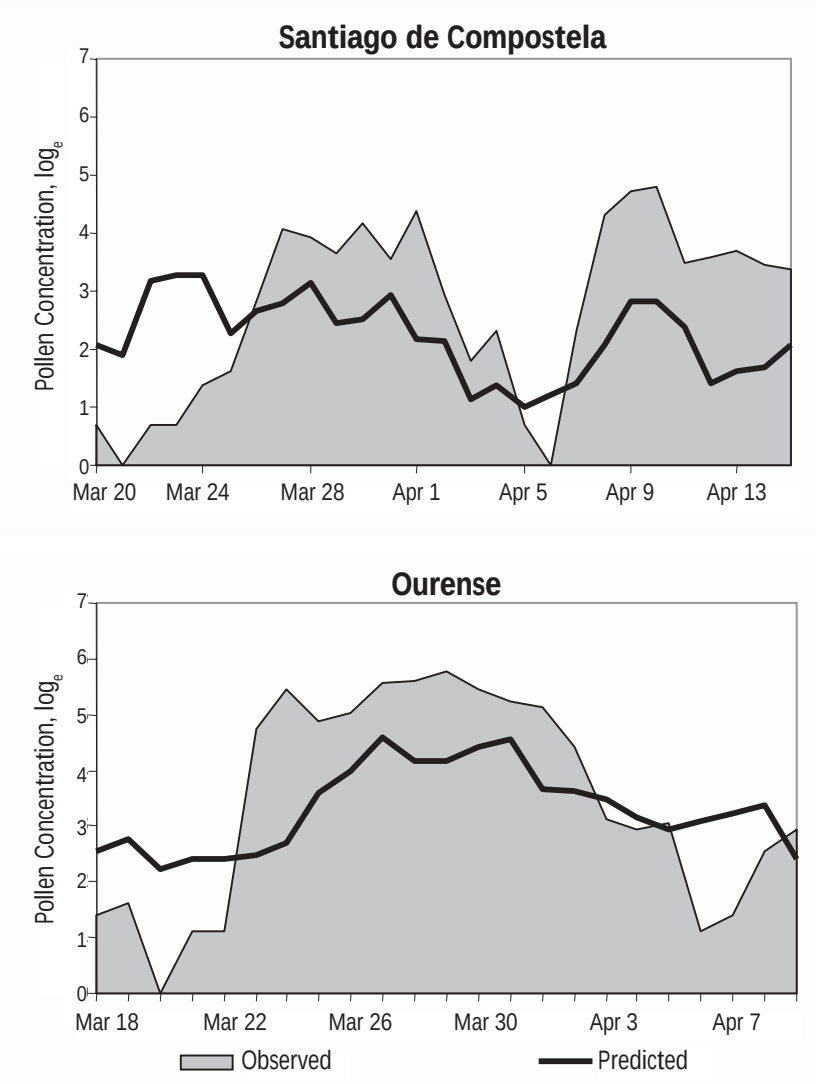

Figure 4. Predicted values (area) and observed values (line) of *Platanus hispanica* pollen concentrations during 2002 in the 2 northwestern Spanish cities.

With regard to the predictive regression analysis, in certain years in Ourense pollen behavior was constant in relation to meteorological variables. In these years (1993, 1996, and 2001) a significant positive correlation was found between pollen concentration and mean temperature recorded in the previous 7 days. The same pattern appeared in Santiago de Compostela during the years 1995, 1996, 1998, and 2001, but in relation to maximum temperatures. These series of years were chosen to develop models to predict the atmospheric pollen concentrations.

Differences between the equations for the 2 cities may be due to different geographic and bioclimatic situations. Ourense is located in a depression and has a more Mediterranean climate, while Santiago de Compostela is located in a more open area and has an eminently Atlantic climate. Therefore, meteorological parameters may exert a different influence in each city, affecting both the development of leaf buds and the dispersion of the released pollen grains. Therefore, a single model cannot predict the behavior of this pollen type in both cities.

The models obtained were checked during 2002 by comparing the curves based on the equations proposed for each city and actual data for *P hispanica* pollen concentrations (Figure 4). The shapes of the prediction curves were similar to the curves of the experimentally observed values, although predicted values were lower than those observed that year.

The models obtained to predict the onset of the pollen season were also checked during 2002. The values recorded for the sum of maximum temperatures during the days prior to flowering were similar to the mean values obtained, although there were small fluctuations at both sampling sites. In Ourense, the average temperature for the 50 days prior to the onset of flowering was 16.34°C in 2002, slightly higher than the 16.02°C predicted by the model. The date predicted for the onset of pollination based on this value was March 15, but the MPP actually started 3 days later. In Santiago de Compostela, the average of temperatures observed during the 100 days prior to the onset of the MPP was 13.26°C. The predicted average value of 13.67°C was actually reached on March 21, a day

after the MPP had started. The fact that variations from the predicted values were very slight suggests that the accumulated temperatures prior to flowering provide a good predictor of the onset of flowering.

P hispanica pollen accounts for a considerable proportion of annual total and daily mean pollen concentrations. Given its allergenic potential, it should therefore be taken into account as one of the most important local spring allergens. The MPP of this pollen type in March and April is short, but high concentrations are reached. The mean duration is around 40 days and the maximum mean daily concentrations exceed 100 pollen grains/m^3.

A single regression model cannot be established for both cities. In the case of Ourense, the influence of mean temperature was higher when the values attained during the previous days were taken into account in the prediction equations. In the case of Santiago de Compostela, maximum temperature was inc1uded in the regression equation. In both cases, the previous day's pollen concentration noticeably improved the results obtained by the regression lines. The influence of temperature during the period prior to flowering had a significant effect on the start date of the MPP. In Ourense, a mean temperature of around 16.02°C during the previous 50 days triggered flowering, while in Santiago de Compostela the lowest SD of the coefficient of variation was obtained with a 100-day period.

Acknowledgments

The authors are grateful to the Department of the Environment, Galician Regional Government, for funding this research through project XUGAPGDIDTOOMAM383OlPR.

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Manuscript received November 8, 2004; accepted for publication November 10, 2006.

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