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The effect of recent climatic trends on Urticaceae pollination in two bioclimatically different areas in the Iberian Peninsula: Malaga and Vigo

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Abstract Malaga (Mediterranean coast) and Vigo (Atlantic coast) are representative of two bioclimatically different areas belonging to the Mediterranean and the Eurosiberian region, respectively. This contribution represents a study on recent trends in the principal meteorological parameters in these areas and their influence on the phenology of Urticaceae (nettle family) atmospheric pollen, one of the main causes of pollinosis in Spain. The study covers the period 1991–2006 for Malaga and 1995–2005 for Vigo, and compares the differences in climate and phenological behaviour observed at both localities. The sampling of atmospheric pollen was performed with Hirst volumetric pollen traps. The two localities present different tendencies as far as temperature is concerned: while the mean annual temperature in the Mediterranean region has increased by 0.06°C/year, the same parameter has decreased in the Atlantic area by 0.1°C/year. This tendency is even more pronounced as far as the minimum temperatures are concerned, especially during spring in Malaga and autumn in Vigo. On the other hand, wind speed has tended to increase, periods of calm have diminished and winds blowing off the sea have increased in both places. These changes in meteorological parameters have advanced the end of the pollen season in Malaga and delayed its start in Vigo. Total annual pollen counts have decreased in Vigo, while the number of pollen-free days has increased in both areas.

1 Introduction

The production and release of pollen by plants is a biological phenomenon controlled by genetic factors associated with each species as well as by climatic factors. This

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is especially important in the case of anemophilous plants, whose pollen grains are often responsible for pollinosis. Many studies have emphasised the influence of meteorological parameters in the variations observed in atmospheric pollen concentrations, a close relationship that has permitted the modelling of short and long term pollen forecasts as a function of one or more of these parameters. The pollen of the family Urticaceae is considered particularly allergenic by many authors and is, along with the pollen of olive and grasses, one of the main causes of pollinosis in the Mediterranean region (D'Amato and Spieksma 1991; Panayotopulu et al. 1991; D'Amato et al. 1992). In Malaga, Torrecillas et al. (1998) found a 30% prevalence of allergy in atopic patients. However, despite being considered a typically Mediterranean taxon, this pollen type is also abundant in the atmosphere of the Atlantic coast of North-west Spain (Rodríguez-Rajo et al. 2004a) where, along with grasses, it is an important cause of pollinosis, inducing allergenic symptoms in 12% of the atopic population (Vidal et al. 2001). The family Urticaceae includes many species, mainly herbaceous, the most frequent in the studied areas being *Parietaria judaica* L., *P. mauritanica* Durieu (only in Malaga), *Urtica urens* L., *U. membranacea* Poir. and *U. dioica* L. (Paiva 1993a, b). They are cosmopolitan plants widely represented in both study areas since they tend to prefer maritime and urban zones, normally growing on nitrified soils such as rubble and abandoned plots of land.

The prospect of climatic change has led to numerous studies being published into the effect that such change will have on the life cycles and distribution of different plant species. For example, it has been demonstrated that the atmospheric levels of the pollen of many species, among them Urticaceae, tended to increase in the last decades of the tenth century and beginning of the eleventh century, while changes that affect the pollination period of the same have occurred in different European regions (Emberlin et al. 1997; Spieksma et al. 2003; Clot 2003; Rodríguez-Rajo et al. 2004b; García-Mozo et al. 2006; Tedeschini et al. 2006). A concomitant general increase in pollinosis has also been detected during the same period (Wüthrich 1989; Jackson 2001; Beggs 2004).

The principal aim of this study was to analyse the changes and trends that have occurred in recent years in the atmospheric pollen count of Urticaceae in two bioclimatically different areas of the Iberian Peninsula, where Urticaceae is one of the major causes of allergy: Malaga, a town on the Mediterranean coast of southern Spain belongs to the Mediterranean region, and Vigo, on the Atlantic coast of north-west Spain lies within the Eurosiberian region. Furthermore, we study whether different meteorological parameters have behaved in a homogeneous way during the years studied or whether they present some sort of tendency that may be related with the changes observed in the pollination period and pollen production of Urticaceae in these two biogeographical areas.

2 Materials and methods

2.1 Study area

The city of Malaga is situated in the south of the Iberian Peninsula (36°47′ N, 4°19′ W), on the Mediterranean coast, and lies in an alluvial plain that is partially surrounded by mountains. Due to the city's orography and geographical situation, the dominant winds have a SE (blowing off the sea) and NW (from the interior) component. The climate is Mediterranean (Martonne 1964), the mean annual temperature being 18°C, the mean maximum 22.8°C and the mean minimum 13.8°C. Annual rainfall is 575 mm on average, falling mainly in autumn (October to December) and winter (January to March), while the summer (June to September) is the driest period (Fig. 1). According to Rivas-Martínez (1987), Malaga is biogeographically situated in the Mediterranean Region.

Vigo lies in the north-west of the Iberian Peninsula (42°14′ N, 8°43′ W), on the Atlantic coast and right bank of the Vigo estuary. The predominant winds are SW (off the sea) and NE (from inland). The city has a moist oceanic climate, although with a certain Mediterranean feature (Carballeira et al. 1983). The mean annual temperature is 14.9°C, the mean maximum being 18.8°C and the mean minimum 11°C. Annual rainfall is 1,412 mm as average, irregularly spread throughout the year,

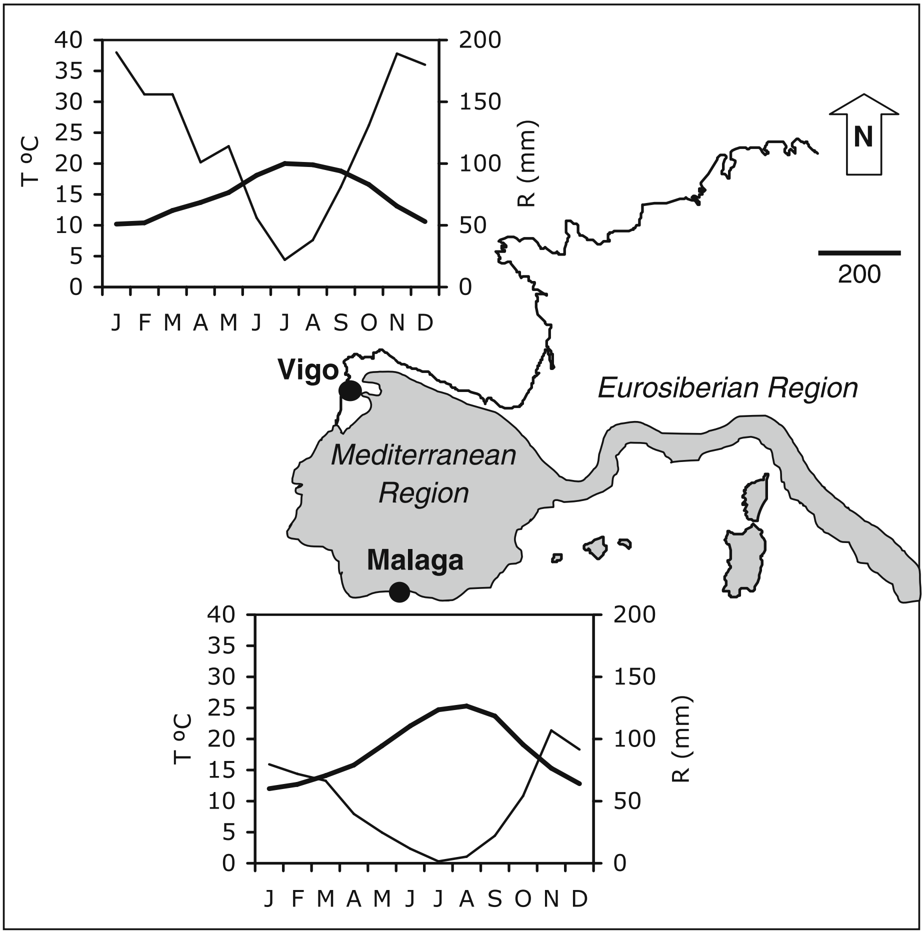

Fig. 1 Location of the studied areas in the south of Europe and their ombrothermic diagrams (*T* mean temperature—*thick line*; *R* rainfall—*thin line*)

while July and August are the driest months (Fig. 1). Biogeographically, Vigo is located in the Eurosiberian Region (Rivas-Martínez 1987).

2.2 Sampling methodology and pollen data

Air sampling was performed with 7-day recording volumetric pollen and spore traps (Hirst 1952) operating uninterruptedly in Malaga from 1991 to 2006 and from 1995 to 2005 in Vigo. The former was placed on the roof of a building in the Teatinos campus of the University of Malaga to the west of the city, while the latter was placed on the roof of the Town Hall in Vigo city centre. Both samplers were situated about 15 m above the ground level, in open spaces without nearby buildings that could obstruct the free circulation of air. The samplers were calibrated to handle a flow of 10 l of air per minute, thus matching the human breathing rate. In the traps, pollen grains (and others solid particles, biotic or not) impact on a cylindrical drum covered by a Melinex™ film coated with an adhesive substance. The drum was changed weekly and the exposed tape cut into seven pieces of 48 mm, which were mounted on separate glass slides, each one corresponding to 24 h of sampling, since the drum runs at 2 mm per hour by a clockwork mechanism. Glycerine jelly stained with fuchsine was used as mounting medium (Galán et al. 2007).

Counts of the pollen grains were made with the aid of a light microscope, according to the methodology proposed by the Spanish Aerobiology Network, the REA (Domínguez 1992). This consisted of reading four longitudinal sweeps per slide at magnification of ×400 (Domínguez et al. 1991). Finally, daily values were expressed as number of pollen grains per cubic metre of air (daily mean values).

To establish the Main Pollen Season (MPS) the method proposed by Nilsson and Persson (1981) was used. This selects the days that, taken together, represent 90% of the annual total, beginning the day that the accumulated value reaches 5% of the annual total and ending on the day that 95% of the annual total is reached. However, we did not base our readings on the calendar year (January–December) but on the “hydrological year” (October–September) since herbaceous plants initiate their biological cycle after the summer dry period as the autumn rains begin to fall.

To characterise the phenological behaviour of atmospheric pollen for Urticaceae, the dates of the beginning and end of the MPS and its duration in days were used. As indicators of pollen production, we used the annual total pollen count, the spring total pollen count and the number of days with pollen per year.

2.3 Meteorological data

The meteorological data used were daily, monthly, annual and seasonal (spring and autumn) values of the mean, maximum and minimum temperatures (degree Celsius), sunshine hours, rainfall (millimeter), number of days with rain >0.1 mm, relative humidity (percent), wind speed (kilometers per hour), frequency of wind from the quadrants centred in NE, SE, SW and NW, and the frequency of calm weather. The meteorological data for Malaga were supplied by the Territorial Meteorological Centre of Eastern Andalusia and were recorded at Malaga Airport station, which is located five kilometres south of the sampling site. The data for Vigo were supplied by the Territorial Meteorological Centre of La Coruña, corresponding to the stations of

Vigo and Vigo Airport, the first one situated a few metres from the sampling station and the second about 7 km.

2.4 Statistical analysis

To evaluate the relationship between the meteorological parameters and atmospheric pollen concentrations, Spearman correlation coefficients were calculated between the phenological pollen parameters (start and end of the MPS) and the production pollen parameters (annual total pollen and number of days with pollen), and the different meteorological parameters. The annual pollen and meteorological data were fitted to a simple linear regression line to observe tendencies. The slopes of the regression equations, the determination coefficients (R^2) and significance levels (p) were studied. Although in many cases the p value did not fall below 0.05, the values between 0.05 and 0.1 can still provide interesting information and are, in any case, useful for comparing both study sites.

3 Results and discussion

3.1 Climatic trends

The tendencies followed by the mean annual temperature values were the opposite in both places (Table 1), taking into account hydrological years (October to

Table 1 Trends shown by the most important meteorological parameters during the studied period in Malaga and Vigo

	Malaga		Vigo	
	Slope	*p*	Slope	*p*
Annual				
Mean temperature	**0.066**	0.013	−0.114	0.260
Maximum temperature	**0.051**	0.087	−0.091	0.422
Minimum temperature	**0.081**	0.005	−0.143	0.171
Autumn				
Mean temperature	0.047	0.321	**−0.282**	0.047
Maximum temperature	0.031	0.531	**−0.254**	0.045
Minimum temperature	0.062	0.313	**−0.311**	0.066
Spring				
Mean temperature	**0.107**	0.011	−0.035	0.802
Maximum temperature	0.074	0.120	−0.020	0.905
Minimum temperature	**0.141**	0.001	**−0.050**	0.072
Annual				
Sunshine	11.425	0.189	−2.676	0.578
Rainfall	4.838	0.777	−0.340	0.996
Relative humidity	0.193	0.435	−0.609	0.155
Days with rainfall	0.414	0.647	0.400	0.915
Wind velocity	**0.426**	0.000	0.144	0.266
Frequency wind calm	**−0.226**	0.012	−0.631	0.667
Frequency NE winds	0.029	0.129	−0.422	0.614
Frequency SE winds	**0.433**	0.025	**0.115**	0.002
Frequency SW winds	−0.082	0.195	**1.307**	0.073
Frequency NW winds	−0.153	0.429	−0.390	0.243

The annual values correspond to hydrological years (from October to September). The slope of the linear regression equation, as well as the p values, are also depicted. In bold: significant values ($p \leq 0.05$) or almost significant values ($0.05 \leq p \leq 0.1$)

September). The mean annual temperature in the Mediterranean area (Malaga) showed a significant ($p \leq 0.01$) tendency to increase by 0.06°C per year, while in the Atlantic area (Vigo) it decreased by 0.1°C per year, although in this case the R^2 is low and the p value is above 0.05. The same trend can be observed for the minimum temperature, although the slope and significance are greater. As can be seen from Table 1, the autumn and spring temperature trends were also contrary in each locality (rising or positive in Malaga, falling or negative in Vigo), the spring minimum and mean being significant for Malaga, and the autumn values for Vigo.

In Malaga, the annual mean temperature during the years studied was 18.6°C, about 0.6°C higher than the values reached during recent decades. Other studies covering a longer period of time confirm this trend of temperature increase in the Mediterranean area (Sahsamanoglou and Makrogiannis 1992). As regards the Atlantic area, the above mentioned trend towards a decrease in the mean annual temperature can be detected during the four decades previous to our study in Vigo.

Hours of sunshine were also studied, as were rainfall-related parameters (annual total and number of days with >0.1 mm rain) and mean annual relative humidity. In general, the slopes were positive for the Mediterranean city and negative for the city on the Atlantic coast, although non-significant values were obtained.

Wind has an important bearing on the release and transportation of pollen in the atmosphere of coastal environments. As both cities studied had two predominant winds (off the sea and from inland), we looked for wind trends that may have been responsible for changes in our annual pollen counts. Wind direction influences environmental humidity and therefore the release of pollen from plants (Gregory 1973, p 54), in this case Urticaceae. When the wind blows off the sea, particles in the atmosphere (among them pollen) are carried inland, cleaning the atmosphere. Curiously, there were positive tendencies for the wind to blow from the sea (SE in Malaga and SW in Vigo), especially in the latter. These tendencies were significant in Malaga, while the p value was 0.07 in Vigo.

However, the importance of wind speed for pollen records should not be forgotten since when the wind blows strongly the atmospheric concentration of pollen is reduced and the particles are carried further from their source and pollen may be recorded from more distant sources. In both biogeographical areas studied the same tendencies were observed for the wind speed: a positive tendency to increase in recent years (only significantly so in Malaga) and a negative tendency for the frequency of calms (also only significant in Malaga).

3.2 Phenological trends and correlation with meteorological data

As a general rule and taking into account the data for all the years studied, the MPS, on average, began on 10 December in Malaga and on 12 February in Vigo, ending on 23 June and 13 August, in Malaga and Vigo respectively, the earlier start and end observed in Malaga being attributable to the warmer southern climate (Fig. 2). Temperature, together with water availability, is known to be the determining factor for both the beginning and end of pollination, which explains the more intense pollination that occurs in Malaga during spring and the prolongation of the phenomenon during the summer months in Vigo.

As regards the phenological differences detected in this family of plants, there was a significant ($p = 0.039$) tendency to delay the start of the pollination season in

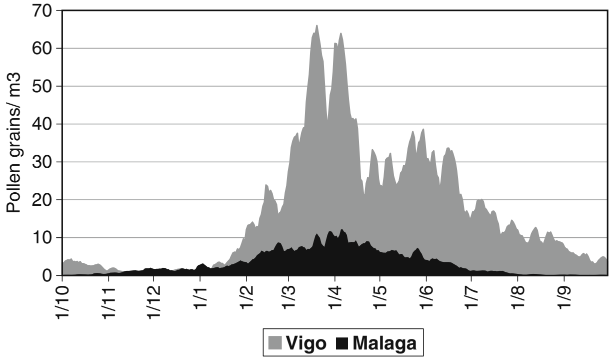

Fig. 2 Evolution of the daily mean concentrations of airborne Urticaceae pollen during hydrological year, considering the period 1991–2006 for Malaga and 1995–2005 for Vigo. The values correspond to the multiyear average of 5 day running mean

Vigo (3 days per year), while in Malaga there was a significant ($p = 0.001$) tendency to bring forward the end (2 days per year) (Fig. 3). Correlation tests carried out between phenological parameters and the most important meteorological variables of the preceding months showed that significant associations were obtained between autumn meteorological parameters in the case of the start of the pollen season, while spring temperatures were the parameters that best correlated with the end of the MPS (Table 2). Once the maximum pollination level has been reached, an increase in temperature during the post-peak period scorches herbaceous plants and pollen concentrations tend to fall sharply as a consequence of high spring temperatures and the diminution of available water (Fig. 1). The greater the increase in post-peak temperatures, the earlier the pollination period will end. In Vigo, the end of the MPS was significantly related with the mean minimum temperature in spring (Table 2), which may explain the tendency for the end of the MPS to be delayed (Fig. 3) since in this Atlantic area the minimum temperature in spring showed a tendency to fall (Table 1). In the Mediterranean area, on the other hand, the significant tendency for the end of the MPS to be brought forward (Fig. 3) was probably due to the increase in the minimum spring temperatures during the study period (Table 1).

As regards the relationship between the beginning of the MPS and autumn temperatures, no statistically significant r coefficient was obtained. However, when the same correlation test was applied considering the values of both localities jointly (Table 2), the correlation coefficient values were highly significant in all cases. The correlation between both the beginning and end of the MPS, and the pre-seasonal temperature and insolation values showed negative coefficients, while the coefficient was positive when pre-seasonal rainfall was considered. All this reflects the already known need for rain water and warm temperatures for these plants to initiate development. Furthermore, an increase in temperature favours flower development and earlier pollination. Similarly, an increase in post-peak temperatures leads to scorching, which brings forward the end of the MPS. Rainfall during the post-peak period prolongs growth and delays the end of the MPS.

Finally, the average seasonal behaviour of Urticaceae pollen during the period studied was compared (Fig. 4) with the pollen curve followed during the years with the warmest and coldest autumn–winter periods (Vigo) and springs (Malaga). In Malaga, the end of the MPS was earliest in 2001 (the warmest spring) and delayed in 1996 (the coldest spring), while in Vigo the MPS started earlier in 1997–1998 (the warmest autumn–winter) and was delayed in 1999–2000 (the coldest autumn–winter).

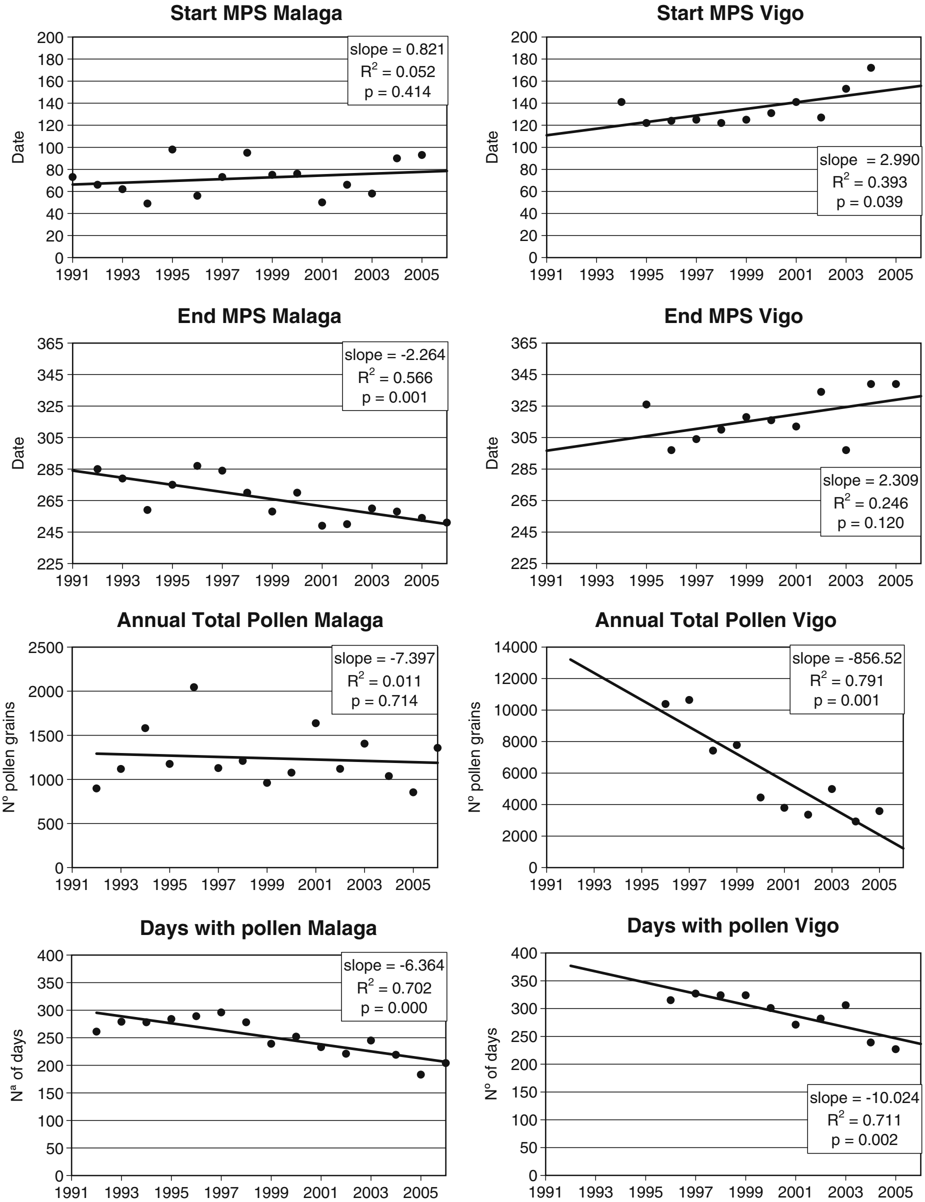

Fig. 3 Trends of the annual start and end dates of Urticaceae MPS, annual total pollen index and number of days with Urticaceae pollen

3.3 Pollen production trends and correlation with meteorological parameters

The pollen of Urticaceae is more abundant in Vigo, where the annual mean index is 6,113 compared with the annual mean index of 1,228 in Malaga (Fig. 2). The greater intensity and higher number of days with rain in Vigo (Fig. 1) are ideal for

Table 2 Spearman correlation coefficients (r) and p values obtained between date of start/end of Urticaceae MPS and several meteorological parameters during autumn (for start of MPS)/ spring (for end of MPS)

	Malaga		Vigo		Malaga and Vigo	
	r	p	r	p	r	p
End of MPS						
Spring average mean temperature	−**0.622**	0.020	0.125	0.693	−**0.822**	0.000
Spring average maximum temperature	−**0.541**	0.043	0.414	0.191	−**0.792**	0.000
Spring average minimum temperature	−**0.614**	0.022	−**0.527**	0.095	−**0.837**	0.000
Spring total sunshine	−0.268	0.316	−0.214	0.499	−**0.778**	0.000
Spring total rainfall	**0.466**	0.081	0.141	0.656	**0.788**	0.000
Spring average humidity	0.089	0.748	−0.100	0.752	**0.690**	0.001
Start of MPS						
Autumn average mean temperature	−0.015	0.955	−0.207	0.513	−**0.761**	0.000
Autumn average maximum temperature	0.365	0.172	−0.114	0.719	−**0.683**	0.001
Autumn average minimum temperature	−0.132	0.621	−0.198	0.532	−**0.601**	0.003
Autumn total sunshine	0.045	0.867	0.180	0.570	−**0.658**	0.001
Autumn total rainfall	−0.073	0.784	−0.132	0.677	**0.587**	0.004
Autumn average humidity	−0.182	0.511	−0.416	0.188	0.258	0.217

In bold: significant values ($p \leq 0.05$) or almost significant values ($0.05 \leq p \leq 0.1$)

the development of these plants and a consequent increase in herbaceous vegetal biomass production, which is accompanied by greater flower and pollen production (Thompson et al. 1972; Bond et al. 2007). On the other hand, low temperatures do not favour the development of the seed embryo and the growth of the plants under study. For this reason, the significant tendency for the pre-seasonal (autumn) temperature in Vigo to fall may be one of the reasons for the significant drop in the number of pollen grains (856 grains per year) recorded during the study time (Fig. 3).

The correlations analysis showed positive associations with the relative humidity and number of days of rain in Vigo (Table 3), which lends weight to the importance of the rain-related parameters mentioned above. However, the correlation between the annual total pollen count and annual mean temperatures, was not significant probably because the fall in temperatures observed in this Atlantic-influenced city occurred mainly in autumn (Table 1). As already mentioned, it is the low autumnal temperatures that inhibit seedling development and, therefore, reduce biomass production.

Negative correlations were obtained with wind speed and the frequency of on-shore winds. It seems that the change in wind patterns (Table 1) affected the capture of atmospheric pollen of Urticaceae in Vigo since, concomitant with the decrease in the total annual count, the number of days with pollen decreased, and both are related with the increased frequency of winds blowing off the sea (SW in Vigo) and mean annual wind speed. The strong SW winds blow atmospheric pollen inland, which is borne out by the negative and significant correlation between the spring pollen count and mean wind speed ($r = -0.630$; $p = 0.046$) and on-shore winds (SW) ($r = -0.534$; $p = 0.091$) during the season in which Urticaceae pollen production is at its height.

In Malaga, on the other hand, no significant tendency was observed as regards the annual total pollen index of this taxon, but there was a significant drop in the number of days with pollen, which fell by 6 days per year (Fig. 3). The correlation analysis

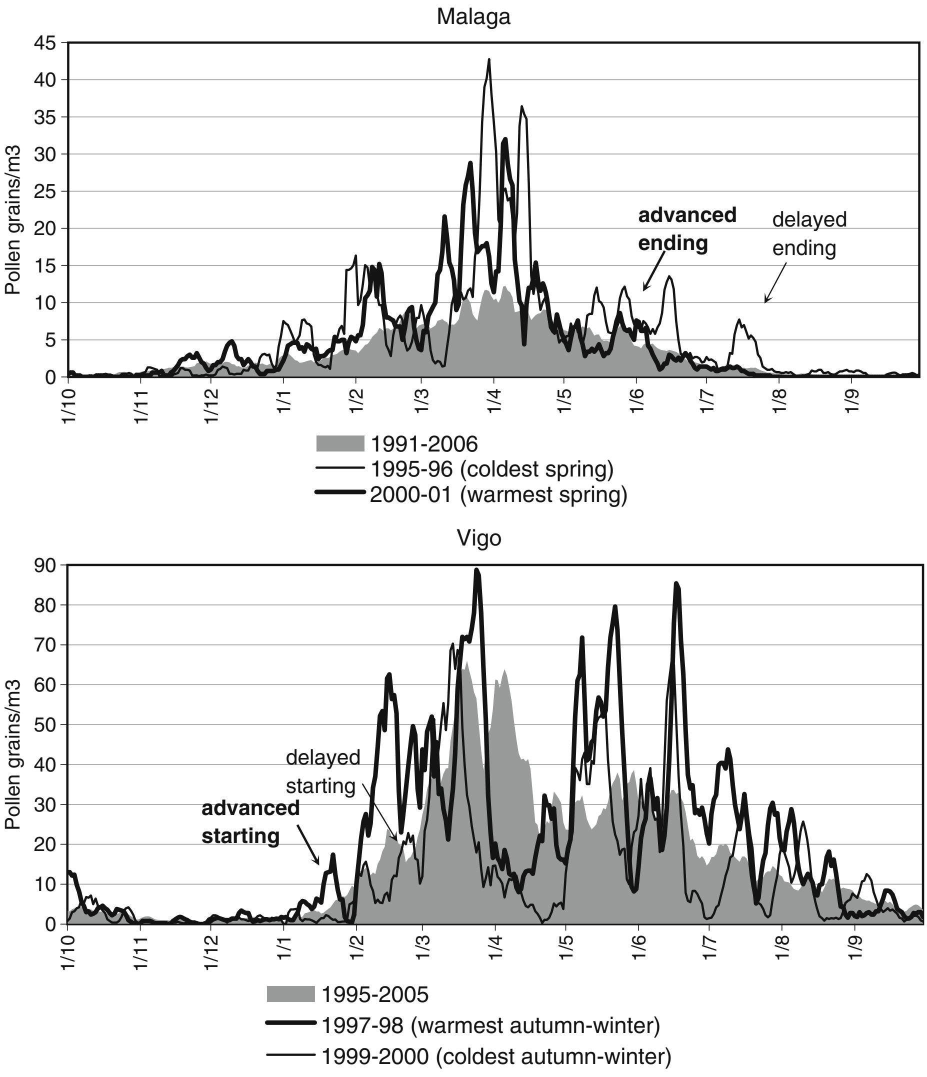

Fig. 4 Daily mean concentrations (5 day running mean) of airborne Urticaceae pollen registered in Malaga during the hydrological years with coldest and warmest springs and in Vigo during the hydrological years with coldest and warmest autumns–winters, and comparison with the average for the complete period

in Malaga (Table 3) also pointed to a negative and significant association between wind speed and on-shore winds (SE) and the number of days with Urticaceae pollen, while there was a significant positive correlation with the mean annual frequency of winds from the SW (rural inland) and frequency of calms. It was also observed that the annual production of atmospheric pollen of this taxon in Malaga is positively and significantly associated with the number of days with rain and the annual quantity of rainfall. The lack of a clear tendency in annual pollen counts (and spring pollen counts) in Malaga was probably due to the variety and complexity of the behaviour of

Table 3 Spearman correlation coefficients (r) and p values obtained between annual values of total airborne Urticaceae pollen and number of days with pollen, and several meteorological parameters

	Annual total pollen				No. of days with pollen			
	Malaga		Vigo		Malaga		Vigo	
	r	p	r	p	r	p	r	p
Annual average mean temperature	0.375	0.161	0.309	0.354	−0.285	0.287	0.233	0.484
Annual average maximum temperature	0.215	0.421	0.152	0.649	−0.271	0.311	0.021	0.949
Annual average minimum temperature	**0.415**	0.120	0.406	0.223	−0.362	0.171	0.306	0.359
Annual total sunshine	−0.376	0.175	−0.067	0.850	−0.256	0.356	−0.12	0.733
Annual total rainfall	**0.404**	0.131	0.358	0.283	0.106	0.691	0.264	0.429
Annual average humidity	0.082	0.759	**0.491**	0.141	−0.044	0.870	**0.518**	0.120
Annual days with rainfall	**0.544**	0.042	**0.542**	0.104	0.16	0.550	**0.564**	0.091
Annual average wind velocity	−0.189	0.479	−**0.621**	0.062	−**0.79**	0.003	−**0.679**	0.042
Annual average frequency of NE wind	0.246	0.358	0.524	0.166	−**0.432**	0.106	0.327	0.386
Annual average frequency of SE wind	−0.311	0.245	−0.119	0.753	−**0.522**	0.051	−0.101	0.789
Annual average frequency of SW wind	**0.544**	0.042	−**0.601**	0.117	**0.587**	0.028	−**0.56**	0.139
Annual average frequency of NW wind	0.025	0.926	0.476	0.208	0.053	0.844	0.185	0.625
Annual average frequency of calm	0.178	0.506	−0.024	0.950	**0.521**	0.051	0.125	0.741

In bold: significant values ($p \leq 0.05$) or almost significant values ($0.05 \leq p \leq 0.1$)

the main meteorological parameters that would influence them, since some (annual mean minimum temperatures) showed significant trends and others (number of days with rain and total annual rainfall) did not. Therefore, as in Vigo, it seems that the significant tendencies shown by the wind regime during recent years (increased wind speed, greater frequency of on-shore winds and decrease in frequency of calms) may be the cause of the significant decreasing trend in the number of days with Urticaceae pollen.

Finally, both in Malaga and Vigo, rainfall showed no clear trend during the years studied although, graphically, it can be seen that the wettest years coincided with higher concentrations of atmospheric Urticaceae pollen (Fig. 5). In Malaga most rain falls in autumn and winter, which favours the hydric charge in the soil and the development of herbaceous plants such as Urticaceae, whose maximum pollination (in Malaga) occurs in spring. In Vigo, on the other hand, the rain is more evenly spread throughout the year and, although autumn and winter are the wettest seasons,

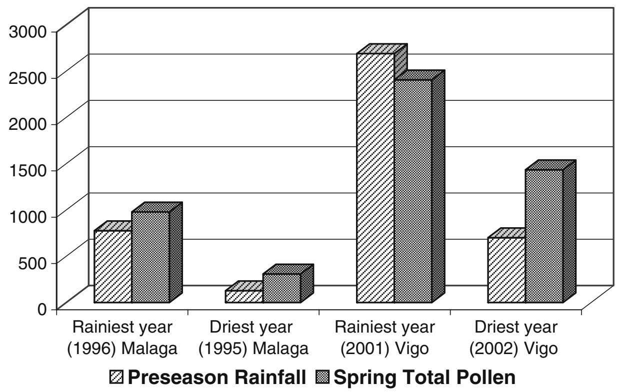

Fig. 5 Values of pre-season (October–March) total rainfall (millimeters) and spring total Urticaceae pollen (number of pollen grains) during the wettest and driest years in Malaga and Vigo

rainfall is also plentiful in spring. This prolongs the pollination period of these weeds during summer, but also has the effect of cleaning the atmosphere, diminishing the atmospheric concentrations of pollen. This double effect probably explains the lack of significant correlations with rainfall in Vigo (Table 3).

3.4 General discussion

Many articles have been published showing the influence of climate change on plant phenology and distribution. Many authors also suggest that climate changes are likely to have an impact on human health. In fact, in the case of airborne pollen, a certain number of studies have revealed that changes in the distribution and behaviour of aeroallergens could have public health iimplications (Newnham 1999; Emberlin et al. 2002; Clot 2003; Beggs 2004; Bortenschlager and Bortenschlager 2005; Pellizzaro et al. 2006). The same authors consider airborne pollen a sensitive indicator of climate change.

Similar studies to that which we present here have previously been made for the most important airborne pollen types, such as pine (Frenguelli et al. 2002; Ladeau and Clark 2006), birch (Clot 2001; Rasmussen 2002; Emberlin et al. 2002), *Ambrosia* (Wayne et al. 2002), *Platanus* (Tedeschini et al. 2006), *Quercus* (García-Mozo et al. 2006), Artemisia (Rogers et al. 2006), olive (Osborne et al. 2000), *Cryptomeria* (Teranishi et al. 2000) and also for Urticaceae (Emberlin 1994; Clot 2003; Spieksma et al. 2003). In general, authors found a tendency to an earlier beginning of the pollen season, an increase in total pollen counts as well as a longer pollen season. In the case of Urticaceae, Emberlin (1994) suggested that *Parietaria* is likely to become more prolific in disjunct locations such as the United Kingdom, and Spieksma et al. (2003) found a trend for it to increase in several cities of northwest Europe. On the contrary, Clot (2003) did not find a significant tendency for this pollen type in an overview of 21 years of data in Neuchatel, Switzerland.

For all the above, and taking into account the results obtained for Malaga and Vigo, it is clear that the influence of climate change on the abundance and phenology of atmospheric pollen must be studied locally since it may not follow the same pattern in all biogeographic areas, as occurs in the case of Urticaceae pollen.

In Malaga and Vigo we have studied a series of 15 and 10 years of pollen counts, respectively, and, although the number of years is low in the context of climate change, it may be considered representative of the influence that such change is having on the phenology of vegetation, especially in the case of herbaceous plants.

4 Conclusions

This study is an example of how recent climate changes can follow different trends in different biogeographical areas, especially as far as temperature is concerned. During the studied period, an increase in the annual mean temperature of 0.06°C/year was detected in Malaga (Mediterranean area) while a decrease of 0.1°C/year was registered in Vigo (Eurosiberian area). These trends were more pronounced in the case of minimum temperatures and most significant in spring in Malaga and in autumn in Vigo. In both cities a tendency for wind speed and the frequency of on-shore winds to increase was detected, while periods of calm decreased.

The changes observed have could influence the timing and abundance of airborne Urticaceae pollen in these two localities, bringing forward the end of pollination in Malaga and delaying the start of the same in Vigo, as well as reducing the amount of pollen recorded in Vigo and the number of days with pollen in both localities.

A study of meteorological trends and their relationship with airborne pollen concentrations will allow us to explain more effectively how climatic change may affect the phenological behaviour of plants and to foresee possible implications for human health, as in the case of pollinosis. The results obtained in this study will be probably confirmed by new data obtained in future studies.

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