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Study of the pollen emissions of Urticaceae, Plantaginaceae and Poaceae at five sites in western Spain

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Abstract

A comparative study is presented of the pollen emissions of Urticaceae, Plantaginaceae and Poaceae, collected during 1995 with Hirst samplers (Burkard or Lanzoni) at five sites in western Spain: two Mediterranean sites located in the south (Huelva and Seville) and three Atlantic sites in the north (Orense, Vigo and Santiago). The annual pollen of Poaceae and Plantaginaceae collected in the Atlantic cities was found to be twice that in the Mediterranean sites, and the total amount of Urticaceae was higher at sites with an urban environment and subject to sea influence (Vigo, Huelva and Seville). At all the sites, the start of the main pollination periods (MPP) took place in the following order: Urticaceae, Plantaginaceae and Poaceae. It was also observed that the MPP of these three pollen types began earlier in Huelva and Seville, where the mean temperatures necessary for the beginning of pollen emissions are recorded very early. Regarding the variation in pollen concentrations throughout the year, Urticaceae presented peaks of maximum concentration in March (Huelva, Seville, Vigo and Orense) and June (Santiago); Plantaginaceae in March (south) and June (north); and Poaceae in May (south) and June–July (north). At northern sites, pollen emissions of Urticaceae and Plantaginaceae continued throughout the summer, while in the south they decreased considerably from May onwards. From the allergenic point of view, the indices of reactivity described for Urticaceae and Poaceae were exceeded more often at northern sites, in particular at Vigo. The meteorological conditions associated with periods of highest pollen emission of these three herbaceous types are a rise in mean temperature, light or absent rainfall, and abundant sunshine. The statistical correlations between pollen emissions and meteorological factors were not well-defined, either for the stations or for all the taxa, although they were clearer for the Atlantic cities and for Urticaceae.

Keywords: Allergenic pollen; Plantaginaceae; Poaceae; Pollen emission; Urticaceae

1. Introduction

This work was undertaken following the authors' observation of differences in pollen counts of Urticaceae, Plantaginaceae and Poaceae at five aerobiological control stations situated in the western half of Spain at different latitudes: Huelva, Seville, Orense, Vigo and Santiago. The aim was to discover the reason for such differences.

Urticaceae, Plantaginaceae and Poaceae are three plant families with species producing allergenic pollen quantitatively abundant in the air of all the cities studied. The allergenic interest of Poaceae is well established (Subiza et al., 1992), while those of *Plantago* (Belmonte and Roure, 1991) and Urticaceae (Bousquet et al., 1986; Chaparro, 1987; Hernández de Rojas et al., 1991) are of lesser importance.

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Table 1
Sampling stations and details of their biogeography, climate and vegetation

Locality	Huelva	Seville	Orense	Vigo	Santiago
Position	37°16'N, 3°16'W	37°22'N, 2°19'W	42°27'N, 4°22'W	42°14'N, 5°2'W	42°54'N, 4°45'W
Environment	Urban	Urban	Rural/urban	Urban	Rural/urban
Altitude (m)	26	10	139	27	316
Annual rainfall (mm)*	470	571	802	1338	1545
Annual mean temp. (°C)*	18	18.3	13.8	15	12.8
Drought period (Months T > 2 × R) (see ombrothermal diagrams	May–Sept.	May–Sept.	July	July	—
Climate type**	Mediterranean	Mediterranean	NW Europe	NW Europe	NW Europe
Phytogeographical area**	Mediterranean	Mediterranean	Atlantic	Atlantic	Atlantic
Most important taxa					
Urticaceae	*Urtica urens* L., *U. dioica* L., *U. membranacea* Poiret, *Parietaria judaica* L., *P. mauritanica* Durieu			*Urtica urens* L., *U. dioica* L., *U. membranacea* Poiret, *Parietaria judaica* L., *P. lusitanica* L.	
Plantaginaceae	*Plantago coronopus* L., *P. lagopus* L., *P. lanceolata* L.			*Plantago major* L., *P. lanceolata* L., *P. coronopus* L	
Poaceae (wild)	*Poa*, *Vulpia*, *Bromus*, *Hordeum*, *Trisetaria*, *Avena*, *Dactylis*, *Agrostis*, *Holcus*			*Poa*, *Dactylis*, *Holcus*, *Agrostis*, *Aira*, *Arrhenaterum*, *Lolium*, *Bromus*, *Hordeum*, *Avena*	

The possibility of having pollen counts available for equidistant stations, using the same methodology, is presented for the first time, since pollen counts have previously been published for Huelva and Vigo using the Cour method (González Minero and Candau, 1995; Belmonte et al., 1995), for Seville using Burkard and Cour (Chaparro, 1987; González Romano et al., 1992), for Orense using Mcleod and Burkard (Iglesias et al., 1988, 1993) and for Santiago using gravimetric methods (Vieitez Cortizo, 1946). Thus, it was considered that the global aerobiological knowledge of these herbaceous plants within Spanish geography could be widened.

The different location of the five sites makes the results extrapolable to other studies comparing wider geographic areas such as Mediterranean Europe and Atlantic Europe.

Previously published comparative studies of different Spanish sites relate to pollen emissions at 18 stations referring to Urticaceae (Subiza Martín, 1987) and Poaceae (Subiza et al., 1992), at three stations in Andalusia (Candau and González Minero, 1992), and ten allergenic pollen types in two cities in the north and south of the peninsula (González Minero et al., 1994).

The geographic co-ordinates of the sampling stations are in the rectangular frame 37–42°N and 2–5°W (Table 1, Fig. 1). Seville, Huelva and Vigo have an urban environment in accord with their populations of more than 150000 inhabitants and greater industrial or commercial activity, while Orense and Santiago are smaller urban areas closer to the rural environment.

The ombrothermal diagrams (Almarza Mata, 1984) show a drought period (Rivas Martínez, 1987) averaging 5 months at the two southern stations and even absent at the northern sites. The annual mean temperatures are higher in the south and the annual precipitations are more abundant in the north.

These data enable the five sites to be fitted into two distinct climatic and phytogeographic areas: Seville and Huelva (south) in the Mediterranean area and climate, and Orense, Vigo and Santiago in the Atlantic area and climate of NW Europe (Mandrioli and Negrini, 1991) (Table 1).

The herbaceous representatives of the three families are different for each zone, and slight quantitative differences are observed between the various taxa (Table 1). Urticaceae: *Parietaria maurtanica* Durieu (present in the south) is replaced in the north by *P. lusitanica* L.; and Plantaginaceae with *Plantago lanceolata* L. and *P. lagopus* L.—frequent in the two regions, while *P. coronopus* L. is more abundant in the south and *P. major* L. more so in the north. The wild genera of Poaceae: *Poa*, *Bromus*, *Hordeum*, *Avena*, *Agrostis*, *Dactylis* and *Holcus* are frequent in both regions, while *Vulpia* and *Trisetaria* are more abundant in the south, and *Aira*, *Arrhenaterum* and *Lolium* more so in the north.

2. Materials and methods

The pollen counts from 1 year's sampling (1995) were obtained using Hirst-type samplers (Burkard or Lanzoni). Samples were collected at the five stations on the same day (Monday at 12:00 h). The results are expressed as daily pollen concentrations (grains/m^3).

In order to establish relationships with the meteorological factors, the daily pollen concentrations were transformed into 10-day batches (expressed as grains/m^3 of air); the means of these batches were related graphically with the 10-day means of the mean temperatures, and the total hours of sunlight and precipitation

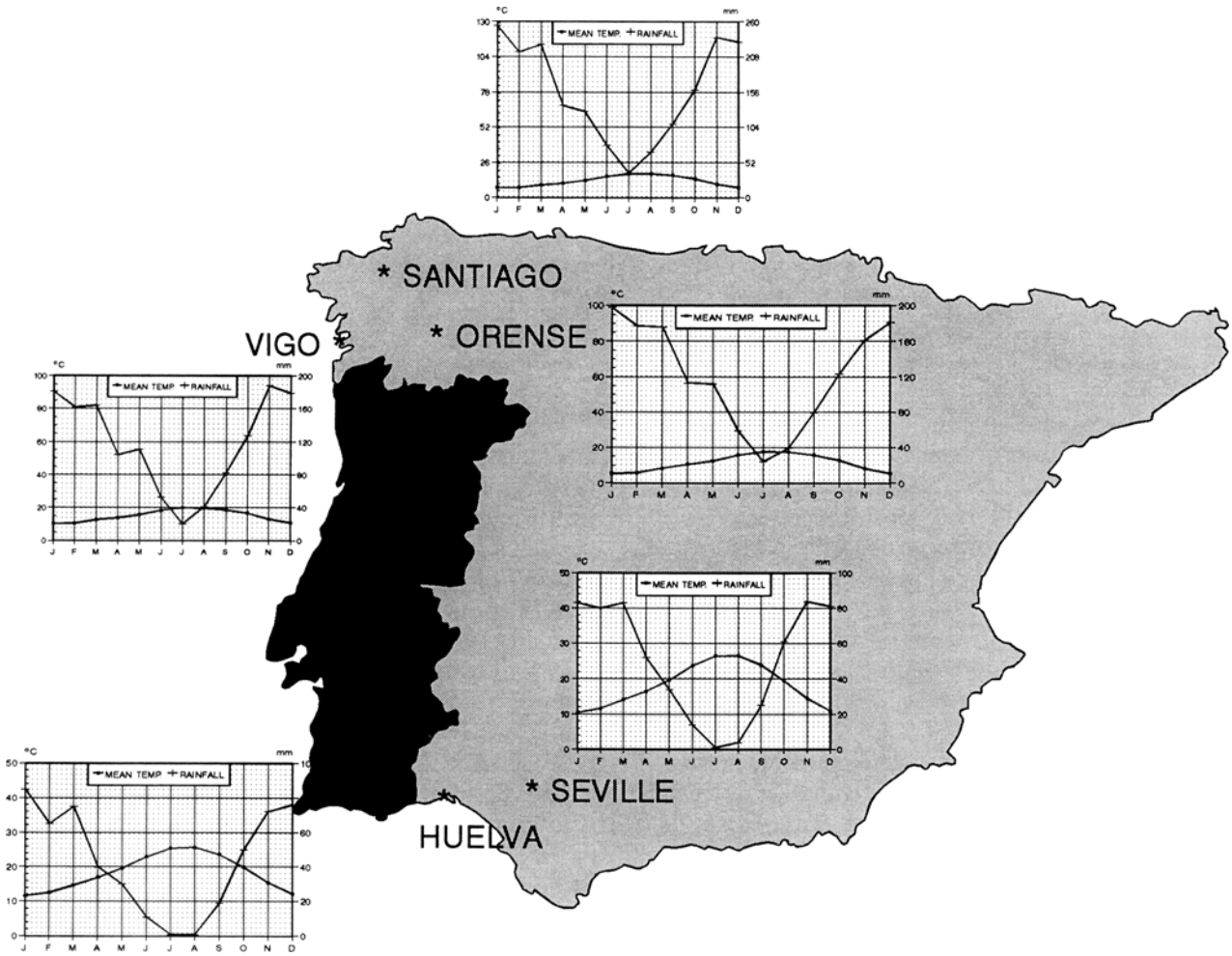

Fig. 1. Geographic location of the study sites and ombrothermal diagrams.

recorded in each 10-day period. The meteorological data were obtained from the regional centres of the National Meteorological Institute.

The periods of maximum pollen production (MPP) were calculated for each taxon. The MPP is defined as that period of the year in which between 5 and 95% of the pollen of a determinate type is collected (Emberlin and Norris-Hill, 1991).

Finally, statistical correlations between the pollen concentrations and the meteorological variables were determined using the statistics program SPSS.

3. Results and discussion

3.1. Total pollen of Urticaceae, Plantaginaceae and Poaceae collected by the end of the year

At the northern sites, the annual pollen of Plantaginaceae and Poaceae collected was approximately twice that in the south (Fig. 2). This result coincides with that of Belmonte (1987), who associated the increase in the collected pollen of Plantago and Poaceae to latitude. Weeke and Spieksma (1991), referring to Poaceae pollen, observed differences between the amounts of pollen

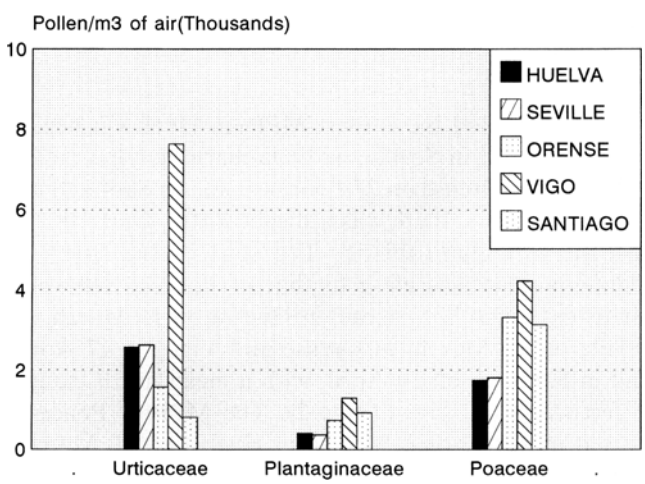

Fig. 2. Annual pollen of Urticaceae, Plantaginaceae and Poaceae expressed in grains/m^3.

Table 2
Data on the main pollination periods (MPP)

Locality	Urticaceae			Plantaginaceae			Poaceae		
	Start	End	Duration	Start	End	Duration	Start	End	Duration
Huelva	16 Jan.	20 Aug.	216 days	15 Mar.	15 Jun.	90 days	20 Mar.	9 Jun.	160 days
Seville	20 Jan.	15 Sep.	238 days	23 Mar.	15 Jul.	114 days	8 Mar	2 Nov.	239 days
Orense	27 Feb.	7 Oct.	222 days	17 Apr.	25 Aug.	134 days	7 Apr.	31 Jul.	115 days
Vigo	20 Feb.	27 Sep.	220 days	17 Apr.	25 Aug.	130 days	13 Apr.	20 Aug	129 days
Santiago	22 Mar.	6 Nov.	229 days	30 Apr.	28 Aug.	120 days	5 Apr.	23 Jul.	109 days
Difference[a]			3 days			−25 days			82 days

[a] Difference between South and North: mean duration southern sites minus mean duration northern sites.

collected in European Atlantic and Mediterranean cities, and attributed them to climate.

In the case of Urticaceae, the greatest amounts were recorded in Vigo, Seville and Huelva (Fig. 2). These differences can be explained by ecological criteria, relating the amounts of Urticaceae pollen with the level of industrial activity at the site, since a more industrialised area produces higher levels of nitrogen oxides that nitrify the soil, providing an appropriate environment for Urticaceae development (Jäger et al., 1991). This argument is valid for Vigo, Seville and Huelva, three sites with a very marked urban environment, in contrast to Orense and Santiago (cities with a rural environment). The difference in Urticaceae pollen could be due to the closeness of Vigo and Huelva to the Atlantic Ocean, or, in the case of Seville, to the lack of orographic barriers separating it from the sea. Such factors would contribute to a continuous and intense pollination of the Urticaceae, and are not present in inland cities such as Orense and Santiago. This reasoning, supported by Pinto da Silva (1964) and Candau et al. (1993), explains why Urticaceae pollen is the majority family in the spectra of two Atlantic cities such as Oporto and Cádiz.

3.2. Starting date and duration of main pollination period (MPP)

Urticaceae had the earliest MPP; in Huelva it began on 16 January, in Seville on 20 January, in Vigo on 20 February, in Orense on 27 February and in Santiago on 22 March. Thus, there was a mean north–south difference of 45 days (Table 2). The start of the MPP of Plantaginaceae was close to that of Poaceae but very far from that of Urticaceae: in Huelva on 15 March, in Seville on 23 March, in Orense and Vigo on 17 April and in Santiago on 30 April, with a mean north–south difference of 22 days (Table 2). The MPP of Poaceae started in Seville on 8 March, in Huelva on 20 March, in Santiago on 5 April, in Orense on 7 April and in Vigo on 13 April, with a mean north–south difference of 25 days (Table 2).

This time difference in the start of the MPP is attributed to the five degrees of latitude separating the two regions, delaying the northern cities reaching the temperatures necessary for MPP initiation. These temperatures are constant for each pollen type, and independent of the geographical area within the temperate regions (Cour et al., 1980, 1987; González Minero and Candau, 1996). The MPP of Urticaceae begins when the mean temperature of the 10-day period in which is included the starting day is 10.98°C; that of Plantaginaceae when this temperature is 16.4°C, and that of Poaceae when the temperature is 16.6°C (Fig. 3).

The duration of the MPP differs depending on the type (Table 2). Urticaceae had the longest MPP (between 215 and 238 days), with small differences between the five stations. Urticaceae have a long MPP as a direct result of their long flowering period—a phenomenon described for sites of Mediterranean climate (26), but not habitual in Atlantic sites.

Plantaginaceae had the shortest MPP (between 90 and 135 days), being on average 25 days shorter at the southern sites.

Poaceae had an intermediate MPP (between 109 and 239 days), being on average 82 days longer in the south. This difference is understandable if we take into account the number of taxa included in Poaceae, with distinct phenology in the various zones of Spain, characterised in the Mediterranean area by an irregular and spread-out flowering, and in the Atlantic area by a more uniform flowering. This situation has been described at European level by Weeke and Spieksma (1991).

3.3. Variation in the 10-day concentrations throughout the year

Figs. 4–6 show the variation throughout the year in the 10-day mean pollen concentrations grouped by type and, within types, arranged by starting date of the MPP. On each curve is indicated the day and the amount of the maximum concentration collected.

In Huelva, Seville and Vigo, the periods of highest pollen concentration of Urticaceae were recorded in March (45, 42, 105 grains/m^3 respectively), in Orense in March (14 grains/m^3) and June (15 grains/m^3), and in Santiago in June (10 grains/m^3) (Fig. 4). At the five sites, curves were obtained with irregular rises and falls due to the spread-out flowering of the species of *Urtica* and *Parietaria*.

The aerobiological curves of Urticaceae for Huelva and Seville showed a sharp decrease in the concentrations from May onwards (Fig. 4). This decrease coincided with the end of flowering in *Urtica* (although the flowering of *Parietaria* continues during the summer, it is not significant in south-western Spain). This aerobiological behaviour is characteristic of the south-west of the peninsula (Candau et al., 1993), but not of the Spanish Mediterranean area as a whole, given that on the coast, significant pollen emissions of Urticaceae (mostly from *Parietaria*) are observed during the summer months (Subiza Martín, 1987). The pattern of Urticaceae in south-west Spain contrasts with that at the Atlantic sites of the north, where *Urticaceae* pollen

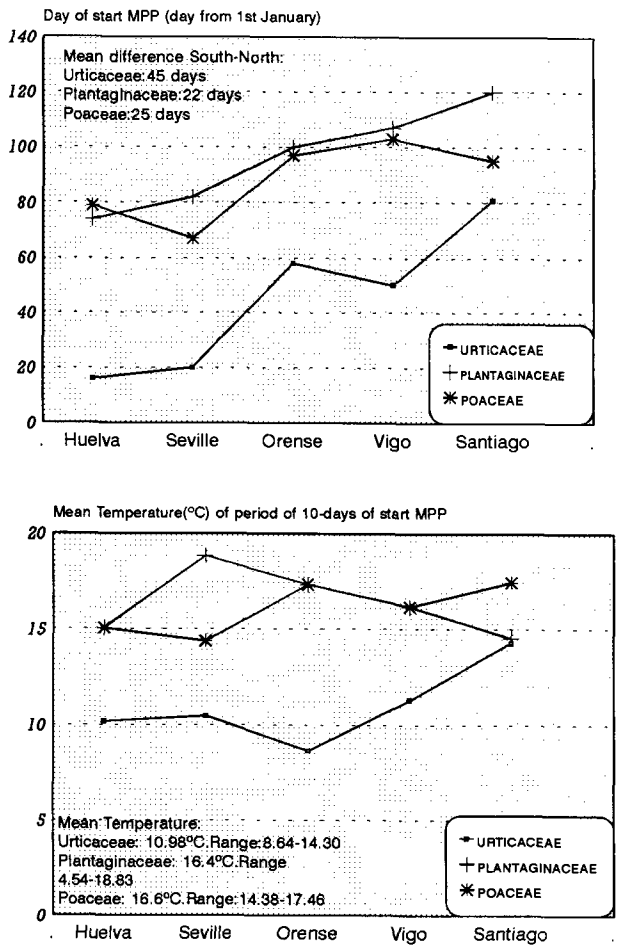

Fig. 3. Relationship between the starting days of the main pollination periods (MPP) of the different pollen types and mean temperatures of the 10-day period in which the respective starting days are included.

Table 3
Number of days in the year on which the indices of reactivity of Urticaceae and Poaceae were exceeded. See text for details

Locality	Urticaceae N° days with concentration >		Poaceae N° days with concentration >	
	80 g/m^3	5 g/m^3	20 g/m^3	50 g/m^3
Huelva	0	94	20	10
Seville	1	98	20	5
Orense	0	101	42	18
Vigo	20	130	49	25
Santiago	1	105	40	25

continued to be collected throughout the summer (Fig. 4), a situation also described for sites on the European Atlantic coast (Emberlin and Norris-Hill, 1991; Negrini et al., 1992). From the allergy viewpoint, only in Seville and (above all) Vigo did the daily concentration of *Urticaceae* exceed the 80 grains/m^3 established by Negrini et al. as the critical value for symptomatology in 90% of patients allergic to the pollen of *Parietaria* (Spieksma et al., 1980) (Table 3).

The annual variation in the concentrations of Plantaginaceae was the lowest of the three types studied, since, except in Vigo, the 10-day mean did not exceed 15 grains/m^3 (Fig. 5). At the southern sites, emissions began in March, fell at the end of April, and recovered in May. At the northern sites, the emissions of Plantaginaceae began in April, with a maximum in June, and continued irregularly until September, as reported for other European Atlantic cities (Charpin et al., 1977).

The aerobiological curves of Poaceae are characterised by low concentrations of pollen during much of the year and a very short period of maximum pollen production (Fig. 6). In Huelva and Seville the highest concentrations (40–50 grains/m^3 10-day mean) were collected during 20 days in May, similar to that described for other southern cities of Spain such as Córdoba (Galán et al., 1989) and Granada (Díaz de la Guardia et al., 1995), and of Italy such as Naples (Weeke and Spieksma, 1991) and Palermo (Zambito et al., 1992). In Orense, Santiago and Vigo, the highest concentrations (60–100 grains/m^3 10-day mean) were collected during 30 days between June and the first fortnight of July, similar to that described for Atlantic cities on the Irish coast (McDonald, 1980), Paris (Ickovic et al., 1990), London (Varney et al., 1991), Leiden, Brussels and Cardiff (Weeke and Spieksma, 1991). Table 3 shows the number of days in the year on which the concentration of Poaceae pollen exceeded that for symptomatology: 5 grains/m^3 (Subiza et al., 1992), 20 grains/m^3 (Solomon, 1984) and 50 grains/m^3 (Lewis et al., 1983). According to the data in this table, such indices are least frequent in Huelva and Seville, and most frequent in Vigo and Santiago (Table 3).

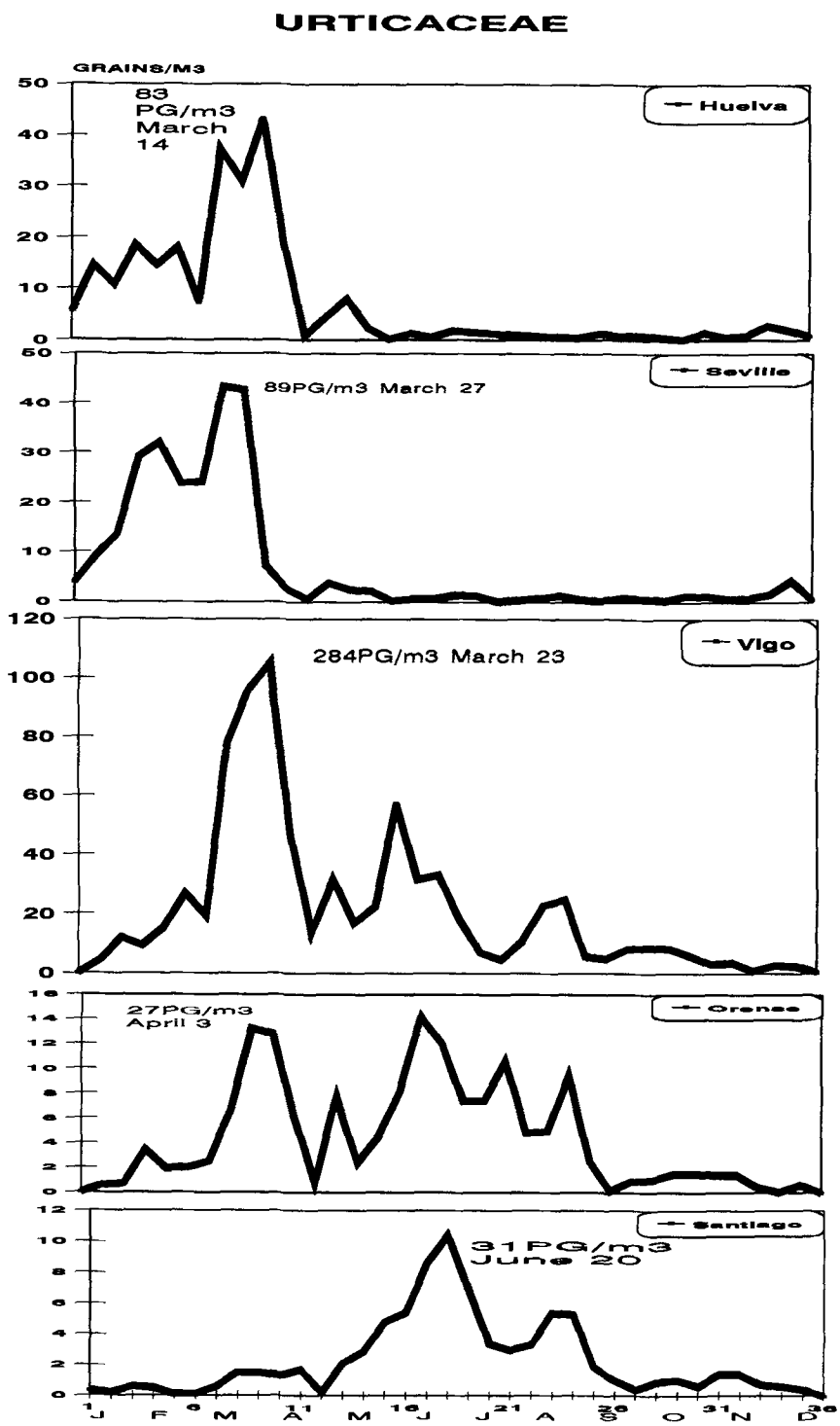

Fig. 4. Variation throughout the year of the 10-day means of the pollen concentrations of Urticaceae, expressed in grains/m^3.

3.4. *Effect of meteorological factors on pollen emissions*

The increases in pollen emissions of Urticaceae are linked to increases in mean temperature (Figs. 7 and 8), as reported for other European sites (Corden and Millington, 1991; Emberlin and Norris-Hill, 1991; Corden and Millington, 1991; Fornaciari et al., 1992). These increases in temperature were from 10 to 15°C in Huelva, Seville, Orense and Vigo, and from 15 to 20°C in Santiago. The increase in the concentrations is also linked to the absence of rainfall and to the increase in hours of sunlight above 10 h daily—particularly so in Orense and Vigo (Fig. 8). At the southern sites, the concentrations fell markedly from May onwards, coinciding with a sharp increase in temperature from 20 to 25°C, which produces wilting of these plants. At the

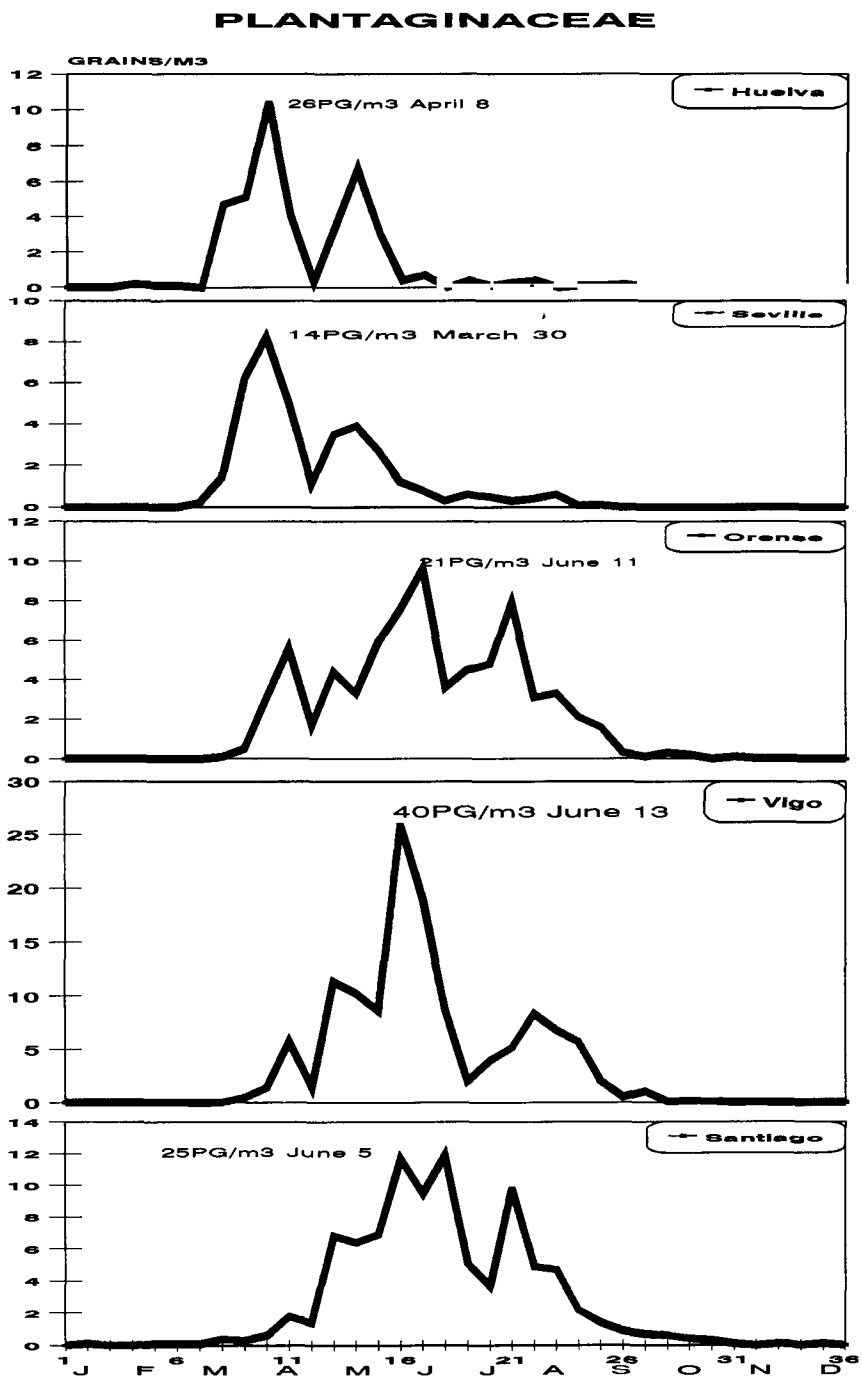

Fig. 5. Variation throughout the year of the 10-day means of the pollen concentrations of Plantaginaceae, expressed in grains/m^3.

northern sites, such wilting was impeded by the continuous light summer rains that prolong flowering of the Urticaceae until September.

The peaks in Plantaginaceae are linked to increases in mean temperature (10–20°C), absence of rainfall, and abundant sunshine. The interruption in pollen emissions at the end of April in Huelva and Seville is noteworthy, and was related to the decrease in temperature to values below 15°C (unusual for that time of year) (Fig. 7). At Orense and Santiago, such decreases were observed in July, coinciding with the presence of rainfall (Fig. 8).

Poaceae followed the same pattern as Urticaceae and Plantaginaceae, given that the increase in pollen emissions was linked (at all the sites) to the increase in mean temperature in May (south) and June (north): at Huelva, Seville, Orense and Vigo this increase was from 15 to 20°C, and at Santiago from 10 to 15°C (Figs. 7 and 8). Similar relationships have been shown by different authors (Charpin et al., 1977; Marcucci et al., 1984;

Table 4
Pearson correlation coefficients between pollen concentrations and meteorological parameters T (temperature), R (rainfall) and S (sunshine)

		Huelva			Seville			Orense			Vigo			Santiago		
		T	R	S	T	R	S	T	R	S	T	R	S	T	R	S
Urticaceae	Entire MPP	−0.46***	−0.52	0.08	−0.55***	0.00	−0.19**	0.33***	−0.25***	0.45***	0.05	−0.16*	0.32***	0.37***	−0.16*	0.21*
	Ascending MPP	0.06	−0.08	0.11	0.36*	0.02	0.48**	0.43***	−0.34**	0.46***	0.68***	−0.05	0.47**	0.28**	−0.21	0.14
	Maximal MPP	−0.38	0.00	−0.30	0.27	0.08	0.10	0.54***	−0.33*	0.38**	0.33*	−0.34**	0.55***	0.01	−0.11	−0.01
	Descending MPP	−0.32***	−0.06	−0.09	−0.36***	−0.05	−0.07	0.68***	−0.21*	0.45***	0.17	−0.06	0.51***	0.57***	−0.19	0.45***
Plantaginaceae	Entire MPP	0.27**	0.01	−0.04	−0.14	0.12	0.05	0.29**	−0.23**	0.46***	0.14	−0.13	0.51***	0.09	0.07	0.15
	Ascending MPP	0.36**	−0.20	0.23	0.53*	0.00	−0.31	0.49***	−0.26	−0.48***	0.33*	−0.18	0.47**	0.29	−0.18	0.20
	Maximal MPP	−0.20	−0.13	0.17	0.54**	−0.25	0.23	−0.18	−0.32	0.53**	0.55*	−0.19	0.50*	0.17	0.12	0.08
	Descending MPP	0.06	0.08	0.02	−0.13	−0.07	−0.06	0.55***	0.00	0.30*	−0.14	−0.20	0.39**	0.34*	−0.02	0.14
Poaceae	Entire MPP	−0.10	0.22**	0.18*	−0.01	−0.01	0.25***	0.45***	−0.12	0.26**	0.23**	−0.12	0.43***	0.43***	−0.14	−0.02
	Ascending MPP	0.22	0.25	0.11	0.27*	−0.05	0.23	0.40**	0.25*	0.44***	0.62***	−0.28*	0.61***	0.26*	−0.26*	0.34**
	Maximal MPP	0.02	0.00	0.61*	0.30	0.00	0.30	0.33	−0.38	0.24	0.26	−0.10	0.44	0.55*	0.20	0.00
	Descending MPP	−0.21*	0.47***	0.16	−0.06	0.06	0.12	0.26	−0.08	0.37*	0.11	−0.10	0.25	0.14	−0.15	−0.18

Level of significance * $p<0.05$, ** $p<0.01$, *** $p<0.001$

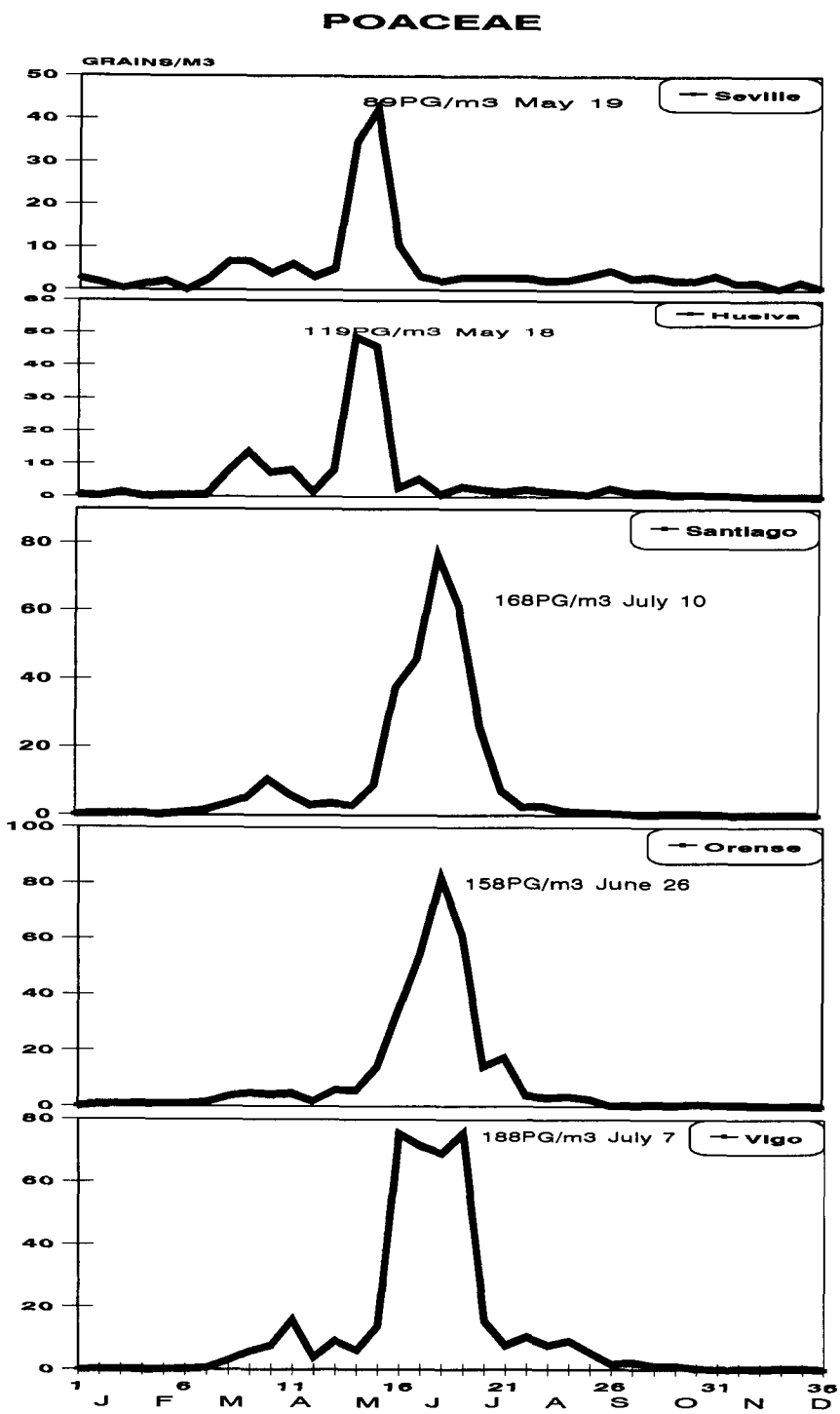

Fig. 6. Variation throughout the year of the 10-day means of the pollen concentrations of Poaceae, expressed in grains/m^3.

Spieksma et al., 1985; Galán et al., 1989; Díaz de la Guardia et al., 1995). It is noteworthy that at the northern sites, the peaks for Poaceae coincided with a period of rainfall and decrease in sunshine (Fig. 8), so that the concentrations recorded would possibly have been higher under different meteorological conditions.

Table 4 shows the Pearson correlation coefficients between the daily pollen concentrations (expressed as grains/m^3) and three daily meteorological variables: mean temperature (expressed in °C), precipitation (expressed in mm), and hours of sunlight. These calculations were made for the complete MPP of each taxon and for the ascending phase of the MPP (days between which were collected 5 and 35% of the pollen), the maximum phase of the MPP (days between which were collected 35 and 70% of the pollen), and the descending

phase of the MPP (days between which were collected 70 and 95% of the pollen). A similar model of data treatment was proposed by Bricchi et al. (1992).

In general, the degree of correlation of pollen/meteorological variables is diverse and depends on both the pollen type and the site (Table 4).

The highest number of correlations for the three pollen types was established for Orense, and the lowest for the two Mediterranean cities.

The type with the highest number of correlations was Urticaceae, especially with temperature, with which it presented a greater or lesser degree of correlation at all the sites. Poaceae showed correlations between temperature and pollen concentrations at the three Atlantic sites throughout the MPP and in the ascending phase, but no relationship during the maximum period of the MPP—a similar situation has been described for Italian cities (Bricchi et al., 1992).

4. Conclusions

The joint study of the pollen emissions of Urticaceae, Plantaginaceae and Poaceae over 1 year at five sites in western Spain (two Mediterranean site and three Atlantic sites) using the Hirst methodology shows the aerobiological differences of the three pollen types in the various areas of Spain. Such differences must be confirmed with further years of sampling.

Because of the distinct climate, latitude and geographic area, concentrations of Poaceae and Plantago pollen are higher at the Atlantic sites than at the Mediterranean ones. The collection of Urticaceae pollen depends also on other factors, such as level of industrial activity and the population's closeness to the sea.

The main pollination periods took place at the five sites in the following order: Urticaceae, Plantaginaceae

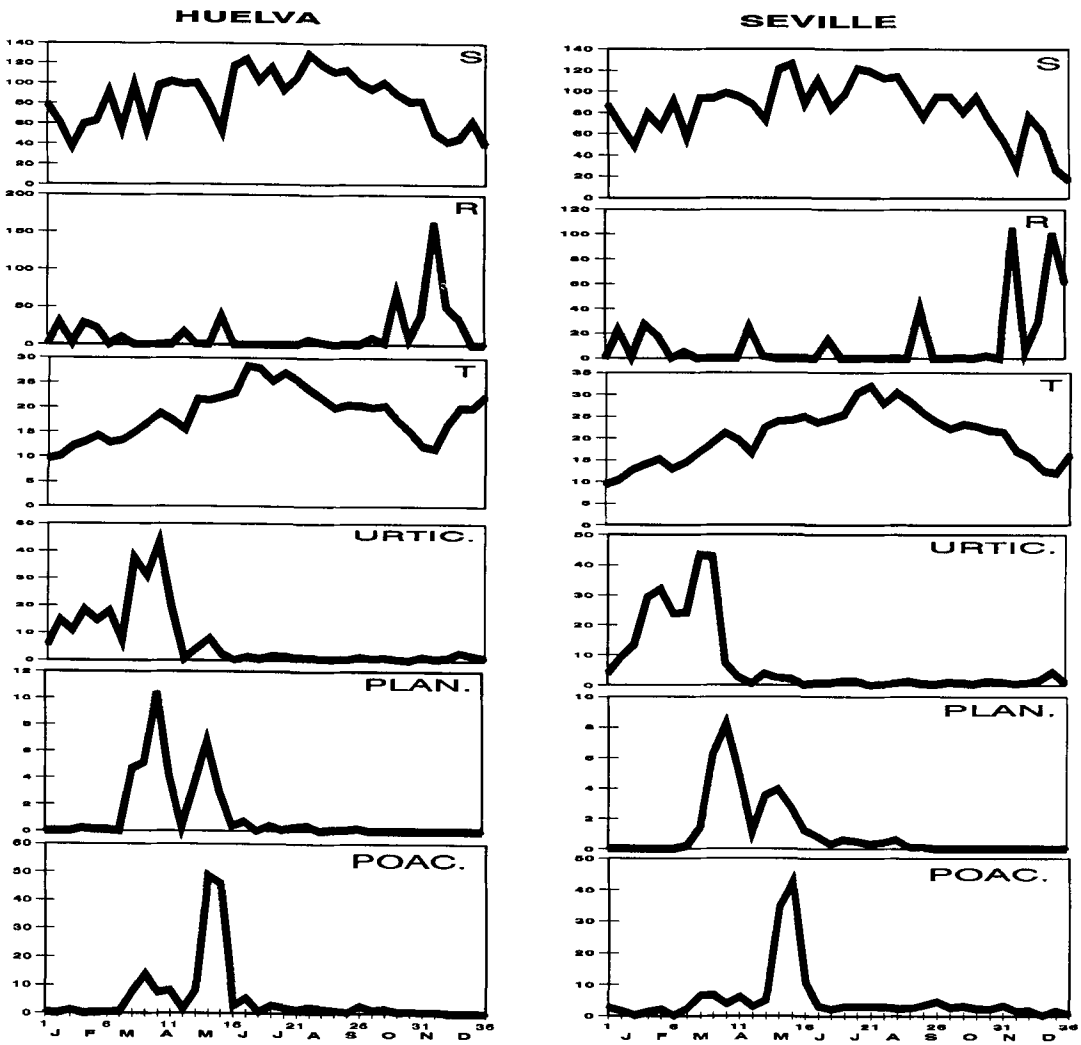

Fig. 7. Relationship between the pollen emissions of Urticaceae, Plantaginaceae and Poaceae (means of 10 days) and the meteorological parameters (means of 10 days). Mediterranean sites. URTIC = Urticaceae, PLAN = Plantaginaceae, POAC = Poaceae, T = temperature (°C), R = rainfall (mm), S = sunshine (h).

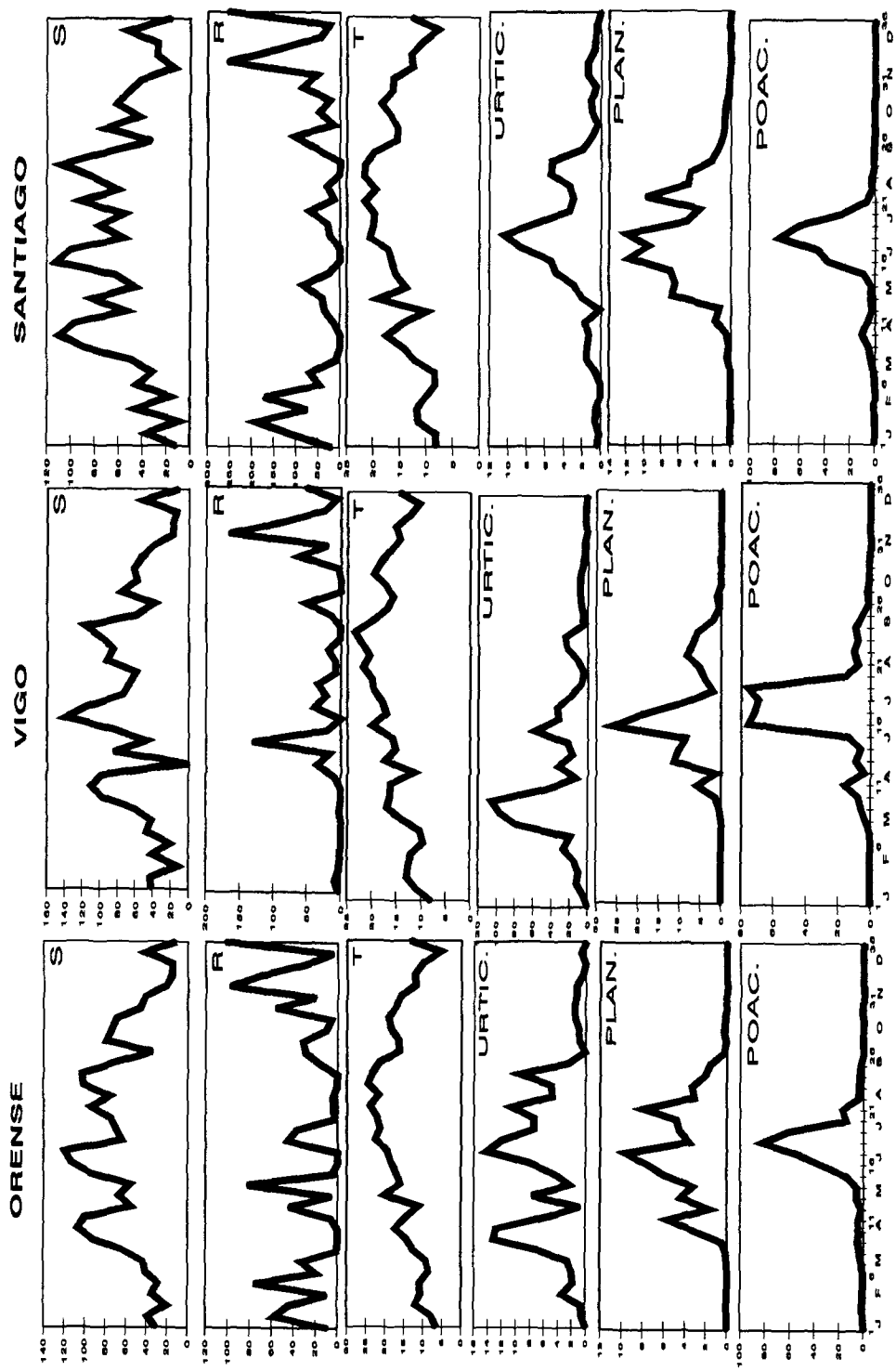

Fig. 8. Relationship between the pollen emissions of Urticaceae, Plantaginaceae and Poaceae (means of 10 days) and the meteorological parameters (means of 10 days). Atlantic sites. URTIC = Urticaceae, PLAN = Plantaginaceae, POAC = Poaceae, T = temperature (°C), R = rainfall (mm), S = sunshine (h).

and Poaceae. They were earlier in the southern cities—the temperature necessary to initiate the MPP in each pollen type being reached at different times in the two regions. The temperatures come from a single year of observations and are subject to greater or lesser ranges depending on the site, so that in the absence of further years of research, they should be considered a first approach to the study of the relationships between temperature and start of pollen emissions.

The aerobiological curves of Urticaceae and Plantaginaceae were very different in the two regions of Spain: in the south the greater part of the pollen was collected in the first half of the year, while in the north, the pollen emissions continued during the summer. These differences were not as marked for Poaceae, in which the behaviour was similar at all the sites, apart from the temporal difference between north and south and differences in the concentrations collected.

From the allergy point of view, the reactive pollen concentrations of Urticaceae were considerable in Vigo, while the concentrations of Poaceae could be significant at the five sites, and particularly so at Vigo and Santiago, the two most Atlantic sites.

The pollen emissions of these three herbaceous types depend partly on meteorological conditions that are similar in the various regions of Spain: increase in mean temperature (10 to 15°C for Urticaceae and Plantaginaceae, and 15 to 20°C for Poaceae), abundant sunshine (above 10 hours daily), and absence of precipitation.

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