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COMPARATIVE STUDY OF THE PRESENCE OF AEROPOLLEN FROM *PLANTAGO* SP. AT SEVERAL LOCATIONS IN SPAIN

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SUMMARY: This paper presents results corresponding to *Plantago* pollen counts in the air at 16 sites in Spain during different sampling periods over the last 3 to 7 years. Information on quantitative aspects, such as total pollen counts and average daily concentrations, as well as on the characteristics of the main pollen season (MPS), enabled the authors to gain a better understanding of the geographic and seasonal variability of *Plantago* pollen in Spain. *Plantago* pollen is present in the air in Spain from March to October; the period from April to July presents the highest concentrations, which rarely exceed 50 g/m^3. Málaga presented the highest average annual values, and Granada the lowest. Interannual variations for the same site were sometimes significant, and minimum annual values appeared to coincide with periods of severe drought. In general, *Plantago* pollen is more present in the air of the southern half of the Peninsula, where the MPS starts earlier and is shorter. At the sites in Galicia and Cataluña, the MPS starts later (in April or May) and lasts longer (until September or October).
KEY WORDS: airborne pollen, *Plantago*, Spain, interannual variability, geographical variability.

RESUMEN: Recogemos en este artículo los resultados obtenidos sobre el polen atmosférico de *Plantago* en 16 localidades españolas, para un periodo de muestreo que varía entre los tres y siete últimos años. La información obtenida sobre aspectos cuantitativos, como son polen total, concentraciones medias diarias, etc. y las características del periodo de polinización principal (PPP), nos ha permitido conocer mejor la variabilidad geográfica y estacional del contenido atmosférico de polen de *Plantago* en nuestro país. El polen de *Plantago* está presente en la atmósfera de España de marzo a octubre, siendo el periodo de abril a julio cuando se registran las mayores concentraciones, que raramente superan los 50

g/m³. Málaga es la ciudad con valores medios anuales mayores, y Granada la que registra los valores más bajos. Las variaciones interanuales para una misma localidad, son en ocasiones muy notables y los valores anuales mínimos parecen coincidir con periodos de acusada sequía. En general el polen de *Plantago* tiene mayor incidencia atmosférica en las localidades de la mitad sur peninsular, y el PPP se inicia antes y es más corto, en estas últimas. En las localidades de Galicia y Cataluña el PPP se inicia más tarde, abril o mayo, y se prolonga durante más tiempo, hasta septiembre u octubre.
PALABRAS CLAVE: polen atmosférico, *Plantago*, España, variabilidad interanual, variabilidad geográfica.

INTRODUCTION

Plantago (SPIEKSMA *et al.*, 1993) pollen is one of the most important pollen types in Europe and is always described as allergenic. The aforementioned authors state that it is present in the air simultaneously with Gramineae in almost all of Europe in May, June, July and August.

Allergic sensitization to *Plantago* pollen is fairly common. It was first reported by BERNTON (1925) and there is a relatively large bibliography available on the subject; just in Europe, numerous researchers have carried out studies on this pollen type, including BOUSQUET *et al.* (1984), CHARPIN *et al.* (1962), D'AMATO & LOBEFALO (1989), DUCHAINE & SPAPEN (1961), MERRETT *et al.* (1980), SERAFINI (1957) and WATSON & CONSTABLE (1991). These authors report that between 3%-36% of patients are allergic to *Plantago*, most being polysensitized and, therefore, also allergic to the pollen of other plants, mainly Gramineae.

In Spain, the first authors to describe *Plantago* pollen as allergenic were IZCO *et al.* (1972), SÁENZ DE RIVAS (1978) and SUBIZA MARTÍN *et al.* (1986). SUBIZA *et al.* (1995) reported an average airborne *Plantago* pollen count in Madrid of 3.6%, with positive skin tests of 53% to *P. lagopus* pollen, 32% to *P. lanceolata* and 55% to *P. lagopus* and/or *P. lanceolata*. Furthermore, GARCÍA GONZÁLEZ (1995) in Málaga reported that 8% of patients were allergic to *P. lancelata*. Recently, several articles have yielded clinical results from tests carried out in several Spanish cities, with sensitization percentages varying between 15% for Málaga (TORRECILLAS *et al.*, 1998) and 78.24% for Toledo (MORAL DE GREGORIO *et al.*, 1998).

Despite these sensitization figures, which are very high in some cases, most authors agree that it is difficult to evaluate the true importance of *Plantago* in polynosis symptoms due to the low rate of monosensitized patients and the fact that those allergic to *Plantago* are usually also allergic to Gramineae and other airborne pollen types at the same time of the year.

The abundant literature available on the composition of the pollen spectrum in the air of Spanish cities shows that *Plantago* pollen is present in all of them, albeit in varying amounts and generally never more than 10%. However, the only aerobiological studies of *Plantago* pollen have been those by SILVA *et al.* (1996) in Badajoz and RECIO *et al.* (1997) in Málaga. Two comparative studies have been published by BELMONTE & ROURE (1991) and GONZÁLEZ MINERO *et al.* (1998) at several sites and on several pollen types, including *Plantago*. The authors therefore hope that this study, which focuses on fairly large and representative number of Spanish sites, provides useful additional information on the geographical and seasonal variability of airborne *Plantago* pollen in Spain.

The genus *Plantago*, the most important in the family Plantaginaceae, is represented in Iberian flora by around 30 species of herbaceous, annual or perennial plants, hemicryptophytes and, albeit more rarely, chamaeophytes or bushes. The numerous small flowers, generally regular and hermaphrodite, tetrameric and with characteristic stamens comprising large filaments and exserted anthers, are grouped in terminal bracteate spikes or heads. They are protogynous with secondarily anemophilous and, in some cases, entomophilous pollination. Except for species of aquatic, saline or high mountain habitats, the remainder are ruderal and are found on arable land, and common to grasslands, roadsides, abandoned cultivated fields, transited areas and urban environments. The most common caulescent species ("plantains") on the Iberian Peninsula are:

Plantago major L., throughout the Peninsula, but more common in the North; it is mainly found in relatively damp areas, particularly on limestone, clay and slightly nitrophilous soils. It flowers from May to September.

Plantago coronopus L., annual, and occasionally biannual or perennial, very common throughout Spain on dry land, uncultivated land, roadsides, coastal sandy areas; edaphically indifferent, it prefers sandy soils and forms part of very diverse plant communities. It flowers from February to June.

Plantago media L., found throughout virtually the whole of Spain, it is edaphically indifferent and montane, mainly found in dry grasslands and along roadsides. It flowers from May to August.

Plantago lanceolata L. throughout the Peninsula, from sea level to high altitudes; it can be found in meadows with variable humidity, grasslands, extensive sandy areas, roadsides, etc., and forms part of very diverse communities. It flowers from April to June.

Plantago lagopus L., throughout Spain and *Plantago albicans* L. in the Mediterranean region; these are species of dry and sandy soils, the latter preferring basic substrates. They flower from March to July.

Among the caulescent species, the most widely distributed are the annual species *Plantago arenaria* Waldst. & Kit. and *Plantago afra* L. ("zaragatona") and the perennial specie *Plantago sempervirens* Crantz, ruderal plants and plants growing on dry-soil arable or cultivated land, flowering from March to July.

The morphology of genus *Plantago* pollen suggests that it is stenopalynous (UBERA *et al.*, 1988); its pollen is spherical, secondarily apolar, small- or medium-sized (D = 19-35 µm), pantoporate, with 5-16 simple operculate pores (D pore = 3-5 µm), which are sometimes surrounded by a 2-2.5 µm ring or annulus (CLARKE & JONES, 1980). The surface is generally scabrate or verrucate. The main differences at species level are size, greater or lesser number of pores, presence or absence of ring, and the external relief of the exine.

MATERIAL AND METHODS

Data were obtained from 16 Spanish cities and towns in Galicia (Santiago, Vigo, Orense), Cataluña (Barcelona, Gerona, Lérida, Tarragona), León, Madrid and Andalusia (Jaén, Córdoba, Priego, Granada, Málaga, Estepona, Antequera). The main characteristics of each station and the varying number of sampling years are shown in Table 1.

For pollen collection, all stations used Hirst-type spore traps placed between 15 and 30m above the ground. The methodology used for sample collection and analysis was in all cases that recommended by the Spanish Aerobiology Network (REA) (DOMÍNGUEZ *et al.*, 1991).

In accordance with RECIO *et al.* (1997), the MPS was first determined graphically, representing the accumulated percentage curve for *Plantago* pollen from January 1 (PATHIRANE, 1975). The MPS corresponds to the period between the points of inflexion of the resulting sigmoid curve. The authors were therefore able to verify that the points of inflexion were very close to the initial 2,5% and 97,5%; as a result, the MPS was considered to be the period in which 95% was taken, eliminating the initial and final 2,5%.

RESULTS

The main quantitative data, annual totals, maximum concentrations, number of days with concentrations above 20 grains/m^3 and main characteristics of the main pollen season (MPS) for all study years and sites are shown in Table 2, which also includes the average values of the parameters for each site, except Antequera, which was only sampled for one year. Total annual *Plantago* pollen counts varied between the maximum of 3.211 pollen grains recorded in Málaga in 1996 and the minimum of 85 pollen grains obtained in Granada in 1995; interannual variations for each site are shown in Table 2. It is surprising to note that in León, Madrid and all the southern sites (Córdoba, Priego, Granada, Málaga and Estepona), the lowest *Plantago* pollen count was recorded in 1995,

Site	Geographic coordinates	Altitude	Bioclimatic belt	Environment	Years sampled	N° of years
Santiago	42° 53'N, 8° 32'W	270	EU euc	Urban	1993-98	6
Vigo	42° 14'N, 8° 43'W	50	EU th	Urban	1995-98	4
Orense	42° 21'N, 7° 51'W	120	MD ms	Urban	1993-98	6
Barcelona	41° 24'N, 2° 09'W	90	MD tm	Urban	1994-98	5
Gerona	41° 54'N, 2° 46'W	125	MD ms	Urban	1996-98	3
Lérida	41° 37'N, 0° 38'W	202	MD ms	Rural/urban	1996-98	3
Tarragona	41° 07'N, 1° 15'W	48	MD ms	Urban	1996-98	3
León	42° 34'N, 5° 35'W	830	MD sm	Rural/urban	1994-98	5
Madrid	40° 27'N, 3° 45'W	600	MD ms	Urban	1993-98	6
Jaén	37° 46'N, 3° 47'W	560	MD ms	Rural/urban	1996-98	3
Córdoba	37° 50'N, 4° 45'W	123	MD tm	Urban/rural	1992-98	7
Priego	37° 26'N, 4° 11'W	650	MD ms	Rural	1994-98	5
Granada	37° 11'N, 3° 35'W	685	MD ms	Urban/rural	1992-98	6
Málaga	36° 47'N, 4° 19'W	5	MD tm	Urban/rural	1992-98	7
Estepona	36° 25'N, 5° 9'W	0	MD tm	Rural/urban	1995-97	3
Antequera	37° 02'N, 4° 33'W	577	MD tm	Rural	1998	1

TABLE 1. Main characteristics of each station and sampling period. Phytogeography and bioclimatic belt (RIVAS-MARTÍNEZ, 1987): Eurosiberian region (EU); - eucoline (euc); thermocoline (th); Mediterranean region (MD); Supra-Mediterranean (sp); - Meso-Mediterranean (ms);- Thermo-Mediterranean (tm).

in marked contrast to the rest of the period and clearly reflecting the effects of the severe drought.

Plantago pollen is usually present in the air of all the study sites from March to October. Figure 1 shows average daily pollen concentrations for each REA site in the study period.

DISCUSSION

The total *Plantago* pollen counts obtained here are similar to those reported in recent years for other Spanish cities, such as Huelva and Sevilla (GONZÁLEZ MINERO *et al.* 1998), Zaragoza (BERMEJO *et al.*, 1998 a, b), Badajoz (SILVA *et al.*, 1998a, b) and Mérida (MORENO *et al.*, 1998a, b). The highest average was recorded in Jaén, followed by Málaga and Madrid, while the lowest averages corresponded to Granada and Barcelona. The relative abundance of *Plantago* pollen in the air in Málaga was previously reported by RECIO *et al.* (1997). Nevertheless, the counts for Málaga are well below the 8.207 and 8.841 pollen grains recorded in Cáceres by TAVIRA *et al.* (1998a, b) in 1996 and 1997, respectively.

Average total pollen counts at each site are higher in the southern half of the Peninsula, including Madrid, than in the North. This would therefore suggest that the atmospheric incidence of *Plantago* pollen is greater in the South. However, GONZÁLEZ MINERO *et al.* (1998) reported that *Plantago* pollen concentrations were higher in Atlantic areas than in Mediterranean ones. In terms of this pollen type, in addition to the influence of climatic factors that have yet to be measured using a broad enough range of sites and sampling years, it may be important to bear in mind the influence of other factors, such as the rural or urban environments of each station.

Provided that more than five years' data are available, it is clear that there are fairly significant variations in terms of annual counts at the same station. Málaga, for example, presented extreme values of 399 in 1995 and 3.211 in 1997. Santiago, Barcelona, Madrid and Córdoba also presented significant interannual variations, albeit less than those in Málaga. There was no coincidence in the years in which maximum and mimimum values were recorded at the different sites, except in León and Madrid and in Andalusia (Córdoba, Priego, Granada, Málaga and Estepona), where minimum values were recorded in 1995. It is important to remember that 1995 was a very dry year and that *Plantago* pollen comes from herbaceous plants, the growth of which appears to be strongly influenced by accumulated rainfall in the three months prior to pollination (RECIO *et al.*, 1997).

Plantago pollen is present in the air from March to September in the southern half of the Peninsula and from April to October in the North. The duration of the MPS was 198 days for Santiago in 1996 and 58 for Jaén in 1995. Average durations varied between 174 days for Tarragona and 87 for Priego. Table 2 shows that the MPS was generally shorter at the Andalusian sites and that its duration increased further North. The Catalan stations (Barcelona, Gerona, Lérida and Tarragona) presented a longer MPS.

There are also important geographical differences in terms of the MPS start dates, which, just as in the case of peak days and total duration, may clearly be related to the phytogeographical characteristics of each station. The MPS begins in March at the Mediterranean sites belonging to the

Year		Annual Total	MPS (95%)				Peak value	n>20
			Start day	Peak day	End day	Duration of season		
Santiago	1994	1144	06-May.	14-Jul.	19-Sep.	137	37	10
	1995	936	13-Apr.	04-Jun.	17-Sep.	157	25	4
	1996	236	14-Apr.	07-Jun.	29-Oct.	198	9	0
	1997	1230	12-Apr.	27-Jul.	27-Sep.	168	40	12
	1998	1298	11-May.	30-Jun.	31-Ago.	112	50	12
		996	**26-Apr.**	**30-Jun.**	**23-Sep.**	**150**	**34**	**9**
Orense	1993	597	20-Apr.	20-Jun.	07-Sep.	141	19	0
	1994	564	27-Mar.	08-Jun.	06-Sep.	164	15	0
	1995	744	07-Apr.	10-Jun.	15-Sep.	162	21	1
	1996	534	19-Apr.	24-Jul.	11-Sep.	146	20	1
	1997	656	28-Mar.	02-May.	16-Sep.	173	17	0
	1998	514	27-Mar.	19-May.	07-Sep.	165	19	0
		602	**06-Apr.**	**09-Jun.**	**11-Sep.**	**159**	**19**	**0**
Vigo	1995	1402	13-Apr.	01-Ago.	01-Sep.	142	43	19
	1996	1073	27-Apr.	31-May.	07-Sep.	134	61	12
	1997	830	28-Mar.	01-May.	30-Sep.	187	31	4
	1998	1457	05-May.	24-May.	24-Ago.	112	45	18
		1191	**18-Apr.**	**06-Jun.**	**08-Sep.**	**144**	**45**	**13**
Barcelona	1994	267	04-Apr.	01-Jun.	31-Ago.	150	19	0
	1995	275	09-Apr.	25-Jul.	07-Sep.	152	13	0
	1996	524	12-Apr.	19-May.	11-Sep.	153	26	2
	1997	622	06-Apr.	17-Jul.	19-Sep.	167	17	0
	1998	374	05-Apr.	11-Jun.	15-Oct.	194	11	0
		412	**07-Apr.**	**15-Jun.**	**17-Sep.**	**163**	**17**	**0**
Gerona	1996	857	12-Apr.	26-May.	11-Oct.	103	30	7
	1997	1235	15-Mar.	16-Jul.	22-Sep.	192	48	9
	1998	559	03-Apr.	16-May.	05-Sep.	156	27	2
		884	**31-Mar.**	**09-Jun.**	**23-Sep.**	**150**	**35**	**6**
Lérida	1996	983	17-Apr.	26-May.	27-Sep.	164	55	6
	1997	622	02-Apr.	27-May.	15-Oct.	197	14	9
	1998	1431	22-Apr.	23-May.	03-Sep.	135	60	17
		1012	**14-Apr.**	**26-May.**	**25-Sep.**	**165**	**43**	**11**
Tarragona	1996	835	08-Apr.	13-May.	04-Oct.	180	48	12
	1997	726	01-Apr.	06-May.	04-Oct.	187	36	3
	1998	559	03-Apr.	16-May.	05-Sep.	156	27	2
		706	**04-Apr.**	**12-May.**	**25-Sep.**	**174**	**37**	**6**
León	1994	849	30-Apr.	08-Jun.	22-Ago.	115	44	12
	1995	557	13-Apr.	22-May.	06-Sep.	147	15	0
	1996	922	16-Apr.	20-Abr.	11-Sep.	149	36	12
	1997	586	06-Apr.	09-Jun.	28-Jun.	84	41	6
	1998	980	19-Apr.	20-Jun.	31-Aug.	135	46	9
		779	**17-Apr.**	**29-May.**	**20-Aug.**	**126**	**36**	**8**
Madrid	1993	1335	11-Apr.	04-May.	11-Jul.	92	69	21
	1994	1263	31-Mar.	31-May.	30-Jul.	122	72	18
	1995	469	09-Apr.	21-May.	07-Sep.	152	19	0
	1996	1205	16-Apr.	29-May.	31-Jul.	107	79	17
	1997	1740	13-Apr.	04-May.	11-Aug.	121	116	27
	1998	2413	14-Apr.	26-Apr.	28-Jul.	106	70	48
		1404	**11-Apr.**	**20-May.**	**04-Aug.**	**117**	**71**	**22**
Jaén	1996	2345	11-Apr.	01-May	07-Jun.	58	100	44
	1997	2303	20-Mar.	17-Apr.	10-Jul.	113	75	49
	1998	2628	23-Mar.	26-Apr.	04-Jul.	104	184	46
		2425	**29-Mar.**	**25-Apr.**	**27-Jun.**	**92**	**120**	**46**

TABLE 2. Annual total of airborne *Plantago* pollen, number of days with concentrations over 20 g/m³ (>20), and main characteristics of the "Main Pollen Season" (MPS).

thermo-Mediterranean and lower Meso-Mediterranean bioclimatic belts, and gradually occurs later in April at the middle and upper Meso-Mediterranean and Supra-Mediterranean stations. At the Euro-Siberian sites of Santiago and Vigo, MPS start dates corresponded to the second fortnight of April and the first two weeks of May and presented greater interannual differences (39 days in Vigo and 30 in Santiago).

Extreme daily values were 6 pollen grains in Granada in 1995 and 184 in Jaén in 1998. Only on two other occasions did this exceed 100 grains/m^3: 116 in Madrid in 1997 and 142 in Málaga in 1996. Average maximum concentrations above 50 grains/m^3 were only recorded in Madrid, Jaén, Córdoba, Priego and Málaga. In Orense, Barcelona and Granada, daily concentrations were very low, only exceeding 20 grains/m^3 on a few occa-

Year		Annual Total	MPS (95%)				Peak value	n>20
			Start day	Peak day	End day	Duration of season		
Córdoba	1992	1148	22-Mar.	01-May.	19-Jul.	121	88	13
	1993	911	29-Mar.	31-May.	23-Jul.	117	51	13
	1994	752	21-Mar.	09-Apr.	26-Jun.	98	52	8
	1995	172	17-Mar.	19-May.	27-Aug.	164	9	0
	1996	1576	04-Apr.	26-May.	30-Jun.	88	93	29
	1997	1603	15-Mar.	18-Jun.	30-Jun.	108	51	29
	1998	1377	17-Mar.	29-Apr.	04-Aug.	141	73	22
		1077	**22-Mar.**	**15-May.**	**19-Jul.**	**120**	**60**	**16**
Priego de Córdoba	1994	942	22-Mar.	10-May.	17-Jun.	88	81	15
	1995	284	18-Mar.	18-May.	04-Jul.	109	15	0
	1996	908	08-Apr.	28-May.	13-Jun.	67	72	14
	1997	956	22-Mar.	02-May.	22-Jun.	93	53	16
	1998	592	20-Mar.	26-Apr.	03-Jun.	76	37	7
		736	**24-Mar.**	**11-May.**	**18-Jun.**	**87**	**52**	**10**
Granada	1992	634	07-Apr.	30-Apr.	01-Aug.	118	26	5
	1993	347	30-Mar.	16-May.	07-Aug.	131	14	0
	1994	505	20-Mar.	10-Apr.	07-Jul.	110	27	2
	1995	85	28-Mar.	20-Apr.	24-Jul.	119	6	0
	1996	308	08-Apr.	26-May.	13-Jun.	67	30	2
	1997	384	21-Mar.	24-Mar.	08-Jul.	110	22	1
	1998	382	23-Mar.	22-May.	17-Jun.	87	17	0
		378	**29-Mar.**	**30-Apr.**	**12-Jul.**	**106**	**20**	**1**
Málaga	1992	1102	23-Mar.	17-Apr.	26-Jul.	127	56	13
	1993	1518	28-Mar.	15-May.	10-Jul.	105	68	24
	1994	1686	20-Mar.	07-Apr.	23-Jun.	96	95	24
	1995	399	16-Mar.	20-Apr.	24-Jun.	101	24	1
	1996	3211	31-Mar.	14-Apr.	03-Jul.	95	142	50
	1997	2388	17-Mar.	04-May.	06-Jul.	112	83	52
	1998	1907	25-Mar.	26-Apr.	29-Jul.	97	78	37
		1744	**23-Mar.**	**23-Apr.**	**05-Jul.**	**105**	**78**	**29**
Estepona	1995	319	20-Mar.	28-Mar.	06-Jul.	109	12	0
	1996	1202	08-Apr.	02-Jul.	07-Jul.	91	70	24
	1997	965	20-Mar.	10-May.	09-Jul.	112	36	9
		829	**27-Mar.**	**03-May.**	**07-Jul.**	**104**	**39**	**10**
Antequera	1998	1409	14-Apr.	12-Jun.	13-Jul.	91	69	27

TABLE 2 (Cont.). Annual total of airborne *Plantago* pollen, number of days with concentrations over 20 g/m^3 (>20), and main characteristics of the "Main Pollen Season" (MPS).

sions. Only at sites where annual values exceeded or approached 1.000 pollen grains did average daily concentrations exceed 20 grains/m³ on a relatively high number of days.

The graphs illustrating average daily pollen concentrations Figure 1 reveal a long pollination season with significant fluctuations in daily concentrations.

CONCLUSIONS

Plantago pollen is present in the air in Spain from March to September, the highest concentrations being recorded in April, May and June.

Sites in the southern half of Spain presented higher average *Plantago* pollen

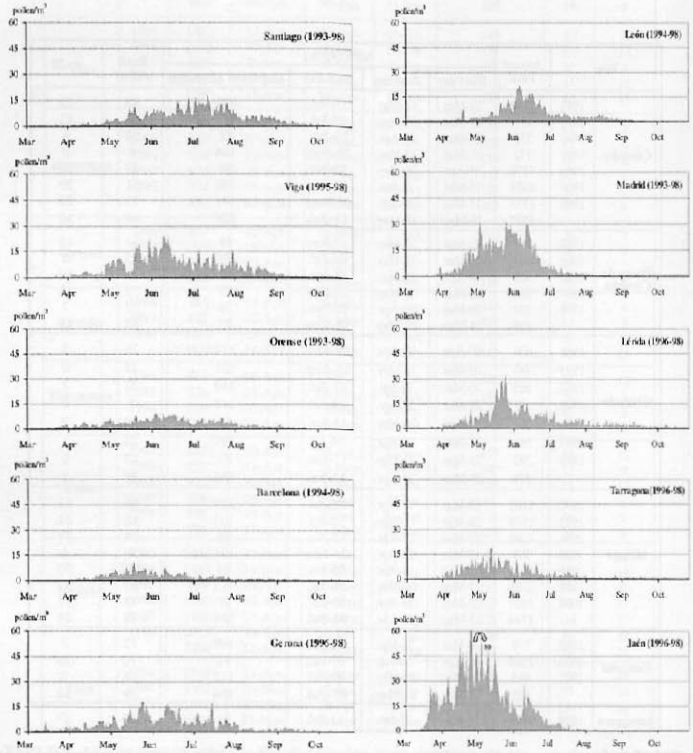

FIGURE 1. Average daily pollen concentrations for each REA site during the study period.

counts than those in the North. Only in Santiago, Vigo, Lérida, Madrid, Jaén, Córdoba, Málaga and Estepona did the annual pollen count exceed 1.000. As regards the incidence of *Plantago* pollen at each site, the authors consider that the trap surroundings are more important than factors such as latitude.

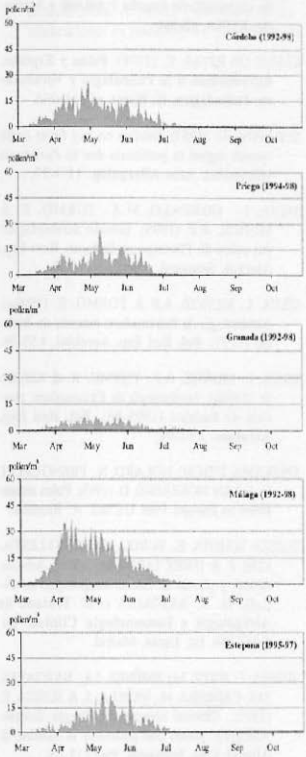

FIGURE 1(Cont.). Average daily pollen concentrations for each REA site during the study period.

Average daily concentrations of over 20 grains/m³ were recorded over a period of more than ten days in Vigo, Madrid, Jaén, Córdoba, Priego, Málaga and Estepona. In Orense, Barcelona and Granada concentrations of over 20 grains/m³ were seldom reached.

The main pollen season starts earlier, and is shorter, in the Andalusian stations. The pollen season at stations in Catalunya and Galicia began later, lasted longer and did not end until September or even October.

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