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Effects of sampling height and climatic conditions in aerobiological studies

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SUMMARY

This study examined the effect of sampling height on the measurement of airborne particles (pollen grains) common in the sampling area in the outskirts of the city of Córdoba, Spain. The effect of certain meteorological parameters on variations in concentration at different heights were also examined. The study was carried out throughout 1991 and 1992 using two Hirst samplers placed at two different heights (1.5 and 15 m) at the Faculty of Science at the University of Córdoba. The statistical results indicated that there were significant differences in the concentrations obtained at different heights, the values at 1.5 m being generally higher with the exception of pollen belonging to the Urticaceae *family. The pollen counts of this type were greater at the higher elevation, probably due to the small size of the pollen, especially in the* Urtica membranacea *species, and to the convective phenomena in this climatic zone in spring, the season in which this species blooms. When these height comparison studies were conducted, the importance of the effect of placing the sampler in relation to a nearby building was also observed. Higher pollen concentrations were detected when the lower sampler was located on the leeward side. The meteorological parameters studied had some influence on the vertical dispersion of the pollen, although the percentage of variation according to height was very small, probably due to the short duration of the study. However, a certain relation between the differences in concentration per height and the degree of atmospheric stability was observed.*

Key words: Aerobiology - Sampling height - Climatic conditions

INTRODUCTION

The dispersion model for airborne pollen particles and its relation to the vertical variation in pollen concentration has been studied and explained by many authors (1-6). However, only few of them have analyzed the possible influence of meteorological parameters. Hart *et al.* (3) reported that when the precipitation and wind speed increased, a greater mix of components in the lower layers of the atmosphere occurred, thus diminishing the effect of height on differences in concentration. Bryant *et al.* (1) demonstrated that on sunny days the differences in concentration at various heights were diminished, an effect which could be attributed to the turbulence caused by solar warming.

In a previous project, our group conducted a study which covered only springtime, and analyzed pollen types which are most common during this season. We observed that in general, the concentration of pollen grains was greater at a lower height (1.5 m) with the exception of *Urticaceae*, for which the concentrations increased at greater heights (2).

For methodological reasons pollen counts are usually measured at heights between 15-20 m. Given that under different climatic conditions different counts can be found from those at human height, we planned a research project which, spanning the whole year and a greater number of taxa, would study the vertical behavior of this pollen during the four seasons. Some herbaceous plants such as *Poaceae*, *Plantago* sp., *Urticaceae* and *Chenopodio-Amaranthaceae* and two arboreal species, *Olea europaea* and *Cupressus* sp., were included with the aim of relating the differences in pollen counts at different heights to plant types. Rantio-Lehtimaki *et al.* (6) demonstrated that herbaceous plants showed greater differences with height.

Given that differences in pollen count at different heights could be due to local meteorological factors which influence the dispersion and movement of the particles, the objective of our study was first, to determine whether there are significant differences in pollen counts at different heights, and second, to find the relation between this difference and the meteorological parameters.

Table 1
Meteorological parameters during the 2 years studied.

Month	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	Rain (mm)	Humidity (%)	Sun (hour)	Wind speed (km/h)
1991							
1	8.7	14.5	2.7	26.9	80	5.7	6.4
2	9.0	13.9	3.9	123.8	82	4.7	7.3
3	13.6	18.8	8.3	164.3	78	4.9	9.1
4	15.1	22.1	7.7	16.7	65	8.3	11.3
5	19.9	27.9	9.3	9.5	52	10.4	10.8
6	25.9	33.6	16.5	10.6	55	10.3	10.9
7	28.8	37.1	18.7	0.0	50	10.9	11.4
8	29.5	38.3	19.4	0.0	46	10.3	11.7
9	25.2	32.3	17.5	108.4	57	7.8	8.4
10	16.3	21.9	10.7	102.8	77	6.2	7.3
11	11.9	18.5	5.7	43.4	75	6.4	7.3
12	10.1	15.4	5.2	25.8	81	4.7	7.0
1992							
1	7.2	13.7	0.8	4.6	73	5.6	7.8
2	10.0	17.6	2.3	69.2	67	6.8	6.9
3	13.9	21.5	5.9	32.3	63	6.6	9.4
4	16.9	24.0	8.6	96.1	62	9.2	10.4
5	21.2	28.5	12.8	29.0	57	8.5	11.6
6	20.4	26.6	13.9	122.5	65	7.6	11.3
7	28.2	36.8	17.9	0.3	47	11.3	8.1
8	28.4	37.0	18.6	1.2	42	10.5	9.7
9	24.3	32.7	15.1	29.1	51	8.9	7.8
10	16.1	21.7	10.3	133.7	75	5.5	8.2
11	12.7	20.2	5.9	5.2	78	7.1	4.3
12	10.1	15.2	4.9	26.0	80	4.9	8.7

MATERIALS AND METHODS

The sampling was done continuously during two consecutive years (1991 and 1992) in the city of Córdoba, for which a climatic description is given in Table 1.

Two Hirst samplers (Burkard Manufacturing Co.) were used for the study, one which was located at an elevation of 15 m on the rooftop of the Science Faculty building and another at human height (1.5 m) placed at a short horizontal distance from the first. Both samplers were located in an open area with no adjacent buildings other than the science building. They were placed on the east side of the building where they were sheltered from the westerly winds.

For the analysis of the tape from the sampler, the continual horizontal transverse reading method was followed, counting four cross readings of the total width of the tape (7). The period in which 98% of the total annual pollen is detected was considered as the pollen season (8). As the daily concentrations in pollen grains per cubic meter were not normally distributed, a logarithm transformation, ln(grains/m^3 + 1), was employed. A Kolmogorov-Sminov test was then conducted to check that the data were distributed normally so that parametric statistics could be used.

The transformed data were subjected to a Pearson correlation analysis in order to make it possible to determine whether there was a covariation in concentrations at different heights and their degree of association. At the same time, a Student's *t*-test was carried out to verify whether significant differences exist between the mean of both samplers; a Wilcoxon's test was also conducted to determine whether differences in pollen distribution with respect to height exist throughout the season.

In addition, the daily standardized mean of sampler A (15 m), subtracting that of sampler B (1.5 m), was compared with the meteorological parameters (maximum, mean and minimum temperature, relative humidity, precipitation, hours of sunlight, and wind direction and velocity). A correlation analysis was then applied to determine the degree of association between the meteorological variables and the difference in pollen concentration according to height. A regression analysis allowed for the establishment of a possible prediction equation; a Wilcoxon's test was carried out to verify whether there were differences between the data from the two samplers, with the analysis being done by group according to the direction of the wind.

RESULTS

The results of the study of the pollen seasons for each of the taxa and for the two samplers located at different heights are shown in Table 2. Data from the 2

Table 2
Total annual pollen count, study start and end dates, number of days of the pollen season, and maximum pollen count at rooftop height (A) and human height (B).

	Sampler	Annual total	Start	End	Season (days)	Max. value (date)	Maximum (grains/m^3)
1991							
Poaceae	A	4,019.50	26/01/91	23/09/91	241	15/05/91	429.94
	B	5,085.17	20/03/91	11/09/91	176	18/05/91	565.51
Olea	A	37,740.55	12/05/91	28/06/91	48	25/05/91	6,784.47
	B	41,325.37	11/05/91	30/06/91	51	25/05/91	5,810.10
Cupressaceae	A	4,594.15	05/01/91	24/12/91	354	23/02/91	1,001.93
	B	3,897.42	13/01/91	25/12/91	347	23/02/91	856.64
Plantago	A	625.40	25/03/91	23/08/91	152	02/05/91	43.75
	B	751.29	29/03/91	16/07/91	110	02/05/91	42.13
Urticaceae	A	1,627.76	09/01/91	19/12/91	345	17/03/91	81.56
	B	1,135.22	09/01/91	23/12/91	349	17/03/91	77.24
Chenopodiaceae	A	892.08	09/04/91	31/10/91	206	16/06/91	19.98
	B	1,000.08	30/04/91	02/11/91	187	08/10/91	19.44
Total	A	88,631.82	21/01/91	05/11/91	289	25/05/91	7,451.53
	B	88,299.25	19/02/91	09/11/91	264	25/05/91	6,485.79
1992							
Poaceae	A	2,584.90	14/02/92	14/09/92	214	10/05/92	200.39
	B	2,383.43	16/02/92	25/09/92	223	12/05/92	161.50
Olea	A	16,143.21	25/04/92	25/05/92	31	13/05/92	3,007.41
	B	19,009.10	25/04/92	25/05/92	31	28/04/92	3,006.32
Cupressaceae	A	4,285.25	09/01/92	20/12/92	347	23/02/92	413.19
	B	4,400.26	08/01/92	25/12/92	353	16/02/92	495.83
Plantago	A	839.26	22/03/92	26/07/92	127	29/04/92	68.06
	B	1,021.26	19/03/92	28/07/92	132	01/05/92	88.04
Urticaceae	A	831.08	09/01/92	26/12/92	353	14/04/92	25.92
	B	713.91	05/01/92	27/12/92	358	16/12/92	38.89
Chenopodiaceae	A	1,425.68	24/04/92	03/11/92	194	14/08/92	33.49
	B	1,964.10	24/04/92	29/10/92	189	26/07/92	34.03
Total	A	45,156.29	29/01/92	14/11/92	291	13/05/92	3,251.54
	B	56,138.04	30/01/92	21/11/92	297	28/04/92	3,601.54

years of the study, including the summary of concentrations, start and end date of the season, length of duration, maximum value and the day on which this value was reached are also shown.

In order to determine whether there was an association between the pollen values obtained with the two samplers and the degree of significance, a correlation analysis was undertaken. The correlation indices (Pearson coefficient) and the degree of significance are shown in Table 3. This test was applied to different taxa separately for each year and for the 2 years combined. The curves at different heights followed a similar tendency with a degree of significance of 99.9%.

Table 3
Correlations between pollen counts at rooftop and human height.

	1991-1992	1991	1992
Chenopodiaceae	0.740**	0.698**	0.740**
Cupressaceae	0.932**	0.943**	0.926**
Olea europaea	0.960**	0.978**	0.906**
Plantago sp.	0.867**	0.847**	0.883**
Poaceae	0.898**	0.878**	0.922**
Urticaceae	0.770**	0.806**	0.710**
Total pollen	0.904**	0.910**	0.896**

**0.001 (99.9%).

The Student's t-test showed significant differences between the means of the two samplers (p <0.05) (Table 4). These results differed from those obtained in the spring months, when differences according to height were only shown for the taxon *Urticaceae*, with a concentration greater at 15 m (2). When the whole year was considered, in the cases in which there were differences between the means, these were greater in the sampler located at 1.5 m, with the exception of the *Urticaceae* family which had a higher mean at greater heights.

In order to establish differences in the distribution of the pollen content according to height throughout the entire season, a Wilcoxon's test was conducted (Table 5). The results showed significant differences in the distributions obtained with the two samplers for the majority of the taxa. Days on which the pollen concentration at human level (1.5 m) was higher than that for 15 m were the most frequent, with exception of the *Urtica-*

Table 4
Paired sample Student's *t*-test for differences between pollen counts at rooftop and human height.

	Mean, 15 m	Mean, 1.5 m	Difference of Mean	Degrees, freedom	2-tail, probability	*t* value
Chenopodiaceae						
1991	1.5210	1.6658	−0.1447	184	0.000	−3.67
1992	1.9045	2.1688	−0.2644	185	0.000	−6.29
1991 + 1992	1.7133	1.9180	−0.2047	370	0.000	−7.07
Cupressaceae						
1991	0.8180	0.8040	0.0140	338	0.551	0.60
1992	0.7743	0.9283	−0.1539	341	0.000	−5.34
1991 + 1992	0.7961	0.8664	−0.0703	680	0.000	−3.73
Olea europaea						
1991	5.2035	5.4524	−0.2490	47	0.000	−4.61
1992	5.6545	5.8667	−0.2122	30	0.043	−2.12
1991 + 1992	5.3804	5.6150	−0.2346	78	0.000	−4.61
Plantago sp.						
1991	1.2304	1.4467	−0.2163	108	0.000	−3.75
1992	1.4343	1.6189	−0.1847	123	0.000	−4.01
1991 + 1992	1.3389	1.5383	−0.1995	232	0.000	−5.48
Poaceae						
1991	1.7518	2.0252	−0.2733	174	0.000	−5.05
1992	1.4856	1.6530	−0.1673	208	0.000	−4.90
1991 + 1992	1.6070	1.8226	−0.2156	383	0.000	−6.97
Urticaceae						
1991	0.9415	0.8082	0.1333	337	0.000	3.65
1992	0.8029	0.7474	0.0556	347	0.088	1.71
1991 + 1992	0.8712	0.7774	0.0939	685	0.000	3.85
Total						
1991	4.1793	4.4272	−0.2478	254	0.000	−5.36
1992	3.8374	4.0994	−0.2620	285	0.000	−6.24
1991 + 1992	3.9986	4.2539	−0.2553	540	0.000	−8.21

ceae family, for which the opposite occurred in both years studied.

In the case of *Cupressaceae* (Table 6), if only the months which have the greatest presence of pollen in the atmosphere (January, February, March) are considered, the analysis shows that there are no differences in its distribution at different heights.

As has been previously observed for the spring months, *Urticaceae* pollen grains act differently from the rest of the taxa (2). In order to explain this phenomenon, a separate analysis was carried out of the two periods during the year in which this taxon is present in the air: the first 6 months of the year and November and December, with the latter being months during which the concentration of pollen is primarily due to the *Parietaria* genus. The results (Table 7) showed that during the first months of the year there were differences between the two samplers in both the mean and the distribution, such that the mean was greater for the sampler situated at the upper height. In the last months of the year, there were no significant differences between the pollen concentrations of the two samplers.

The influence of meteorological factors on sampling at different heights

The results of the correlation analysis between the difference of the daily means of both samplers and the meteorological variables appear in Table 8, in which only the significant cases are included. A slight influence of these parameters on a greater or lesser difference in concentration according to height can be observed, given that these coefficients are not zero. Nevertheless, the value of these coefficients is fairly low, which would explain a minimum percentage of variation in pollen count according to height.

On the other hand, the stepwise regression analysis showed that in all cases, the percent of difference in concentration per height as explained according to the meteorological parameters was very small, being no

Table 5
Wilcoxon's test for differences between pollen counts at rooftop (A) and human height (B).

	B<A	B>A	B=A	Total	Z	2-tail, probability
1991						
Chenopodiaceae	62	107	16	185	–3.4959	0.0005
Cupressaceae	92	91	156	339	–0.1672	0.8672
Olea europaea	12	36	0	48	–3.8667	0.0001
Plantago sp.	36	54	19	109	–3.6153	0.0003
Poaceae	43	116	16	175	–5.3182	0.0000
Urticaceae	131	91	116	338	–3.7251	0.0002
Total	81	166	8	255	–5.6614	0.0000
1992						
Chenopodiaceae	44	130	12	186	–6.3035	0.0000
Cupressaceae	58	121	163	342	–5.3232	0.0000
Olea europaea	15	16	0	31	–1.5677	0.1169
Plantago sp.	35	70	19	124	–3.5612	0.0004
Poaceae	58	123	28	209	–4.7721	0.0000
Urticaceae	129	115	104	348	–1.8326	0.0669
Total	90	186	10	286	–6.5877	0.0000
1991 + 1992						
Chenopodiaceae	106	237	28	371	–6.9433	0.0000
Cupressaceae	150	212	319	681	–3.7347	0.0002
Olea europaea	27	52	0	79	–4.0758	0.0000
Plantago sp.	71	124	38	233	–5.0444	0.0000
Poaceae	101	239	44	384	–7.3151	0.0000
Urticaceae	260	206	220	686	–3.8991	0.0001
Total	171	352	18	541	–8.6872	0.0000

higher than 10% (Table 9). Precipitation appeared to have no effect on variations in concentrations at different heights. The most influential factors were temperature, wind velocity, humidity and the hours of sunlight.

In the study of the influence of wind direction, the Wilcoxon's test indicated the directions in which variations in pollen concentration according to height were found (Table 10).

DISCUSSION

The results obtained in our study of taxa which are well-represented in the sampling area indicated that most appeared in higher concentrations at the lower height. This coincides with previous results obtained by Rantio-Lehtimaki *et al.* (6) and Lyon *et al.* (4), but does not agree with those of Bryant *et al.* (1) and Malik *et al.* (5). However, the latter studies were conducted in very populated areas zones, including the center of London and Delhi, respectively, where the buildings could have a negative effect on the air flow.

With regard to a possible delay in the pollen readings according to height, as have been observed by some authors (6), in our case we can affirm that in general there was no delay in the readings obtained at the upper height.

We have attempted to determine whether differences in pollen concentration according to height are smaller in the case of arboreal plants, such as those observed by Rantio-Lehtimaki *et al.* (6). While we found no variations at different heights in *Cupressus*, differences were found for *O. europaea* . These differences were caused by the position of the sampler with respect to the emission source of the pollen, as previously mentioned by Galán *et al.* (2). A greater concentration of pollen was

Table 6
Wilcoxon's test for differences between rooftop and human height pollen counts for *Cupressaceae* for the months of January, February and March.

	B<A	B>A	B=A	Total	Z	2-tail, prob.
1991	35	32	7	74	–0.8714	0.3835
1992	32	42	7	81	–1.7158	0.0862
1991 + 1992	67	74	14	155	–0.7008	0.4834

Table 7
Statistical analysis of the two parts of the curve for *Urticaceae* at rooftop (A) and human (B) height.

Paired samples *t*-test

Month	Mean, 15 m	Mean, 1.5 m	Difference of mean	Degrees, freedom	2-tail, probability	*t* value
1-6						
1991	1.5670	1.2590	0.3080	167	0.000	5.29
1992	1.1865	1.0643	0.1222	169	0.024	2.28
1991 + 1992	1.3756	1.1611	0.2145	337	0.000	5.39
11-12						
1991	0.9891	0.9572	0.0319	46	0.812	0.24
1992	0.9183	0.9817	–0.0635	55	0.423	–0.81
1991 + 1992	0.9506	0.9706	–0.0200	102	0.788	–0.27

Wilcoxon's test

Month	B<A	B>A	B=A	Total	Z	2-tail, probability
1-6						
1991	99	48	21	168	–4.9611	0.0000
1992	87	58	25	170	–2.5669	0.0103
1991 + 1992	186	106	46	338	–5.3504	0.0000
11-12						
1991	23	20	4	47	–0.6943	0.4875
1992	17	32	7	56	–0.9500	0.3421
1991 + 1992	40	52	11	103	–0.1188	0.9055

apparent in the sampler situated at 15 m when pollen grains were detected from the olive groves of the Subbética mountain range, 40-50 km from the city.

In the *Urticaceae* family, the behavior of the pollen grains differs according to height. The total pollen concentrations were larger in the sampler located at a greater height for both years studied. These results coincide with those obtained by Bryant *et al.* (1) and Hart *et al.* (3). However, they are quite opposite to those from the study by Rantio-Lehtimaki *et al.* (6) in which researchers in Finland observed that the pollen counts for *Urtica* sp. were eight times greater at ground level. Obviously, it must be taken into account that the climatic conditions in these countries are very different. Galán

Table 8
Correlation analysis between meteorological data and inter-trap differences.

A-B	Hours of sun	Humidity	T_{max}	T_{mean}	T_{min}	Wind speed
1991						
Chenopodiaceae						–0.1796*
Cupressaceae	–0.1870***	0.1466**	–0.1498**	–0.1464**	–0.1255*	–0.1241*
Plantago sp.				0.1937*	0.2041*	
Poaceae				–0.1568*	–0.1595*	
Urticaceae			–0.1572**	–0.1780**	–0.2214***	
1992						
Plantago sp.			–0.1991*	–0.2029*	–0.1929*	
Poaceae		0.1679*	–0.1836**	–0.1725*	–0.1599*	
Urticaceae	0.1297*					–0.1145*
1991 + 1992						
Cupressaceae	–0.1393***	0.1093**	–0.1018**			
Poaceae		0.1050*	–0.1627**	–0.1733***	–0.1681***	
Urticaceae				–0.0837*	–0.1258***	

*0.05 (95%); **0.01 (99%); *** 0.001 (99.9%).

Table 9
Regression analysis between meteorological data and inter-trap differences.

		Multiple, *r*	r^2	B	Sig., *t*
1991-1992					
Cupressaceae	Hours of sun	0.1393	0.0194	−0.0186	0.0003
Poaceae	T_{mean}	0.1733	0.0300	−0.0159	0.0006
Urticaceae	T_{min}			−0.0197	0.0000
	*	0.1625	0.0264		
	Humidity			−4.8E03	0.0066
1991					
Chenopodiaceae	Wind speed	0.1796	0.0323	−0.0181	0.0144
Cupressaceae	Hours of sun			−0.0222	0.0004
	*	0.2282	0.0521		
	Wind speed			−0.0106	0.0144
Plantago	T_{min}	0.2041	0.0417	0.0242	0.0332
Poaceae	T_{min}	0.1595	0.0254	−0.0205	0.0350
Urticaceae	T_{min}			−0.0348	0.0000
	*	0.2651	0.0703		
	Humidity			−7.3E03	0.0060
1992					
Plantago	T_{mean}			−0.0303	0.0017
	*	0.3043	0.0926		
	Wind speed			−0.0203	0.0100
Poaceae	T_{max}	0.1837	0.0337	−0.0116	0.0078
Urticaceae	Hours of sun	0.1297	0.0168	0.0217	0.0155

et al. (2) concluded that the increase in pollen concentrations with greater height can be attributed to several factors. First of all, they considered the explosive mechanism of the pollen dispersion in which the pollen passes through a layer of still air to the turbulent air where it is dispersed; furthermore, the morphology of the pollen grains of this family, which are small and light with a very thin exine, causes them to be more easily dispersed into the higher strata of air when the weather is hot and calm. Bryant *et al.* (1) referred to *Urtica* sp. pollen grains with a specific gravity of 0.77, which is fairly low when compared to, *e.g.*, 1.04 for *Quercus robur* or 1.05 for *Acer pseudoplatanus*. Finally, Galán *et al.* (2) commented that due to the high temperatures during spring in Córdoba, the thermal convection phenomena which provoke upward currents of hot air are very important on calm days and allow the small pollen to easily reach a good height.

According to the statistical results obtained from the two samplers for *Urticaceae* (Table 7), during the first 6 months there were differences in height while in November and December there were no differences according to height. Therefore, the active dispersion method does not seem to play a very important role. It seems rather that the effect is related to convection phenomena which occur most commonly in the spring, as well as to grain size, given that *Urtica membranacea* blooms in the first 6 months of the year and is a species with smaller pollen grains than *Urtica urens* and *Parietaria* sp., making it therefore more easily dispersed and maintained in suspension. Giostra *et al.* (9) found that during spring and summer days convective conditions are frequent in the lower part of the atmosphere. These conditions only occur in those days which are both sunny and have low wind speeds so that the pollen can be carried to greater heights.

Despite the fact that Mandrioli *et al.* (10) maintain that convection phenomena cannot be sufficiently used to explain prolonged suspension of pollen given its large size, such phenomena could play a role in the case of the *Urticaceae* family, which has small pollen.

With regards to the meteorological factors, the parameters that appear to have some influence in the difference in pollen concentration at different heights are temperature, humidity, hours of sunlight, and wind velocity and direction. Rain did not show any effect, probably due to the fact that its scarcity and torrential character in the region cause the atmosphere to be cleansed equally at all heights.

Only in the cases of the total pollen count and of the olive tree in particular do the differences found with height not appear to depend on the meteorological parameters. For all the taxa this appears logical, given the multitude of factors that affect each species and the differential effect of these factors. For the olive tree it appears that other factors may cause a greater or lesser concentration in one sampler or another, such as distance from the source of pollen, as Galán *et al.* (2) have suggested.

As can be seen in the results of the correlation and regression analyses applied to the meteorological para-

Table 10
Wilcoxon's test for differences between readings at rooftop (A) and human height (B) for each hour and wind direction.

Taxa	Hour	Wind direction	B<A	B>A	B=A	Total	Z	2-tail prob.
Chenopodiaceae								
	13	Calm	6	13	14	33	–2.1530	0.0313
	18	SW	25	48	63	136	–2.5454	0.0109
Cupressaceae								
	1	Calm	10	29	71	110	–2.1281	0.0333
	1	NE	5	0	5	10	–2.0226	0.0431
	7	CA	15	31	53	99	–1.9666	0.0492
	18	NE	10	5	9	24	–2.1299	0.0332
Olea europaea								
	1	SW	5	14	8	27	–2.7566	0.0058
	7	Calm	22	35	20	77	–2.1690	0.0301
	13	NW	0	5	3	8	–2.0226	0.0431
	18	W	9	22	10	41	–2.0380	0.0415
	18	SW	5	26	13	44	–3.4588	0.0005
Plantago sp.								
	1	W	4	12	56	72	–2.0684	0.0386
	1	SW	2	9	46	57	–2.1339	0.0329
	7	Calm	15	28	160	203	–2.2641	0.0236
	13	NE	2	10	12	24	–2.5103	0.0121
	13	NW	1	11	13	25	–2.5887	0.0096
	13	SW	2	12	50	64	–1.9775	0.0480
Urticaceae								
	18	E	6	0	33	39	–2.2014	0.0277
Total								
	1	W	28	46	50	124	–2.8445	0.0044
	7	Calm	73	113	184	370	–2.3748	0.0176
	7	E	10	20	19	49	–2.3037	0.0212
	13	E	23	42	14	79	–3.0780	0.0021
	18	NE	6	11	4	21	–1.9882	0.0468
	18	W	37	62	39	138	–2.7277	0.0064
	18	SW	46	77	40	163	–2.7032	0.0069

meters in relation to the difference in concentration according to height (Tables 8, 9), for the majority of the taxa studied temperature provoked a greater concentration of pollen at the lower height. It seems logical that as a higher temperature favors the liberation of pollen grains from the anthers, a greater concentration of pollen is detected at a lower height (closer to the pollen source). The effect of relative humidity is the opposite. A rise in this value seems to have a negative effect on the emission of pollen, meaning the higher pollen counts at a greater altitude could be attributed to pollen in suspension, also possibly being associated with turbulent states which cause a greater mixing of the atmospheric strata. Equally important is the factor of daylight hours for *Cupressus*, given that this plant blooms in winter and that this could be a limiting factor for this season of the year.

With regard to the influence of wind, in calm conditions the pollen count was normally greater at lower heights; this was not the case for the *Urticaceae* family, whose pollen ascends due to convective phenomena, which are more common under calm conditions and high temperature. With easterly winds, the concentration was greater with increasing elevation, whereas with westerly winds it was greater at a lower height. This coincides with the results of Kapyla (11), who observed greater concentrations at lower height when the samplers were located on the leeward side of the building. In our case, this was true when there was a westerly wind.

If samplers are located on the leeward side of the building the streamlines are considerably more turbulent because of the vortex and eddies immediately behind it, and the pollen counts can be overestimated. It can therefore be observed that the position of the sampler in relation to nearby buildings is a factor to be considered when studying differences in pollen concentration according to height.

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RESUMEN

En este trabajo se estudia el efecto de la altura del captador en las concentraciones polínicas registradas en la atmósfera de las plantas con polen alergógeno más frecuentes en la zona de muestreo, así como el efecto de ciertos parámetros meteorológicos en las diferencias de concentración registradas con la altura. El estudio se efectuó durante 1991 y 1992 con la ayuda de dos muestreadores tipo Hirst (Burkard Manufacturing Co.) localizados en la Facultad de Ciencias de Córdoba a dos alturas diferentes (1,5 y 15 m). Normalmente los estudios de aerobiología se realizan a 15-20 m para evitar el efecto pantalla de los edificios. No obstante, es de gran interés, sobre todo por su aplicación en el campo de las alergias, estudiar el contenido polínico a la altura a la que normalmente respiran los seres humanos y comprobar si existen diferencias significativas con los resultados obtenidos a 15 m. Para ello se han realizado varios tests estadísticos entre los datos obtenidos a 15 y 1,5 m. Dado que los datos no seguían una distribución normal, se les efectúo una transformación logarítmica, consiguiendo así normalizarlos para poder realizar análisis paramétricos con ellos. Se ha efectuado test de correlación, el t-test, el test de Wilcoxon y el análisis de regresión. Los resultados estadísticos indican que existen diferencias significativas en las concentraciones obtenidas a diferente altura, siendo normalmente más elevadas las mediciones realizadas a 1,5 m, excepto en el caso del polen de la familia Urticaceae, *en la cual ocurre lo contrario. Los registros polínicos de esta familia son más elevados a una altura mayor probablemente debido al pequeño tamaño del grano de polen, sobre todo en el caso de* Urtica membranacea. *También hay que tener en cuenta la frecuencia de fenómenos convectivos en la zona durante la primavera que originan corrientes ascendentes de aire, favoreciendo un transporte vertical de los granos de polen de pequeño tamaño, que presentan una mayor concentración a más altura. También se ha observado que a la hora de realizar estudios de comparación de la concentración polínica a diferente altura, es muy importante tener en cuenta la importancia de la orientación en la ubicación del captador situado a 1,5 m, respecto a un edificio vecino de donde se toma el suministro eléctrico para el funcionamiento del aparato. A este respecto se detectan concentraciones de polen mayores cuando el captador está situado a sotavento. Los parámetros meteorológicos estudiados ejercen cierta influencia en la dispersión vertical del polen, aunque el porcentaje de la variación con la altura que explican es muy pequeño debido probablemente a que se ha estudiado un periodo de tiempo muy corto. No obstante se ha observado cierta relación entre la diferencia de concentración con la altura y el grado de estabilidad de la atmósfera.*

Palabras clave: Aerobiología - Polen a diferente altura - Condiciones climáticas

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