



Pollen content study of the lower atmosphere in León (Spain) by use of a tethered balloon

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Abstract

This study was undertaken in order to understand the behaviour of airborne pollen grains, namely the relationship between their concentrations and concomitant meteorological parameters, at different altitudes (ground level, 200, 400 and 600 m) of the lower atmosphere and its daily variations over one site (the experimental farm of the University of León). The experimental design involved a tethered balloon (2.25 m³), an ADAS remote meteorological station and an original radio controlled three headed pollen and spore sampler (called GABIS) using the Rotorod design. Each head sampled a different altitude, while two control samples were taken at ground level. Twenty-one takeoffs could be realized in the 5 weeks period between end of May and end of June 1997. Sampling was done early in the morning and sampling time at each altitude was of 15 minutes. Results show that 45 different types of pollen grains could be collected at this time of the year and that significant variations could be observed in the behaviour of the pollen cloud on a day to day basis, probably because of different meteorological situations. Contrary to what is generally believed, pollen was in most cases more abundant at higher altitude – on average by 30% as compared to ground level – making evident an aerobiological layer of transport at about 500 m above ground. This was especially the case for trees (*Quercus* and *Castanea*). The atmosphere Mixing Ratio was the most explicative factor at 200 m, while temperature dominated significance analysis at both 400 and 600 m.

Introduction

Transport and dispersal of pollen grains by the moving atmosphere as well as their time of residence as airborne particles are strongly linked to atmosphere physical characteristics at their time of flight, or what is usually called meteorological parameters. Since Fred C. Meier pointed out in the 30s the presence of biological particles in the stratosphere at some 10.000 m (Gregory, 1973; Boehm, 1987), several researchers have made evident long distance dispersal (Franzén et al., 1994; Hjelmroos and Franzén, 1994; Cabezudo et al. 1997, Comtois, 1997). Others have taken a different

approach and have tried to follow the time sequence of the moving pollen cloud at one site, using multiple heights sampling to map its vertical deformations (see for example J.M. Hirst data reproduced in Gregory, op. cit.; Mandrioli et al., 1980, 1984). However these studies were merely anecdotal, in the sense that they presented only a fixed view of the biological content of the atmosphere for a short period of time. No statistical analyses were ever tried, because of a lack of representativeness and small sample size. The present study has been planned to correct this deficiency.

Materials and methods

In this work an atmospheric sounding system was used, including an ADAS land station, a balloon, a tether sonde, a capstan and a new pollen and spore trapping system (G.A.B.I.S), based on the Rotorod design. (see Comtois et al., 1998 for a complete description of the system). Our aerobiological survey was carried in the León summer atmosphere. León is located at 820 m.a.s.l. in the NW quarter of the Iberian Peninsula (more precisely at 42°34' N, 1°58' W). Samples could be taken from 21 days, in the 35 days period between 21-5-1997 to 26-6-1997. Our sounding system is therefore quite efficient, since 60% of the potential days were sampled. Sampling was done between 8 a.m. to 10 a.m., a period when the atmosphere is quite still. i.e. wind speed lower than 12 m/sec. Rainy days were avoided. The balloon went up at about 2 m/sec with stops of 15 minutes each at 200, 400 and 600 m for aerobiological sampling. At the beginning and the end of each flight, ground level samples were taken (Om-1 and Om-2). Moreover, since the GABIS system was not equipped with retractable heads, they were passively exposed to the atmosphere for the whole flight period (+/- one hour). In order to have an idea of this possible contamination, a sticky tape, of the same size and type of the one used on the rotorod heads, was affixed on the sampler body (control).

After recovery of the GABIS, tapes were removed from the heads and analysed in the laboratory (at 400×) for pollen content. Pollen concentration values are expressed in pollen grains per m³ of air (P/m³) by means of conversion factors (i.e. knowing the RPM, exposed surface, sampling time and head diameter). Meteorological data were registered every 10 seconds. They were later averaged for each level stretch (i.e. 200, 400 and 600 m). Correlation analysis between pollen concentrations and meteorological parameters were stratified by each of the different sampled altitudes and by the different pollen types identified.

Results and discussion

Forty-five pollen types were identified. Their concentrations at different altitude as well as in the controls are summarized in Table 1. Total pollen concentrations and the number of different pollen types appearing at 200, 400 and 600 m are represented in Figures 1 and 2. Controls revealed that less than 2% of the pollen

content can be accounted for by passive contamination. Interestingly, both pollen concentrations (per m³) and the number of significant correlations with meteorological parameters increase with altitude. It therefore seems that the upper layer of the lower atmosphere, as compared to the ground level (15–20 m) – that is usually sampled in aerobiology – is the most significant layer for aerobiological modeling. Another point of interest is that more than 40% of the significant correlations were found with the altitude effectively reached by the balloon. That is to say that small change of altitude, while sampling one atmospheric layer – due to the atmospheric dynamism – will bring important changes in the reported pollen concentrations. For example, when we were sampling at a specific layer, such as 400 m, the balloon was not restricted to that specific altitude, but was wandering in an interval of ±25 m. These small differences from the mean altitude represented as one level category (200 m vs 400 m vs 600 m) were one of the most important factor in explaining pollen concentration differences. However more data are needed in order to explain adequately these influences.

Another point is that significant correlations between meteorological variables and airborne pollen concentrations were quite different than from those usually found for roof level (15–20 m), where mean temperature is usually the most important factor. We can therefore conclude that these two aerobiological systems are quite different. Most significant correlations (Table 2) were found with *Quercus* (all altitudes), then with Oleaceae (200 and 600 m), Poaceae, Cupressaceae and *Taraxacum* (400 and 600 m) and then *Pinus*, *Betula* and *Castanea* (600 m). For example, *Quercus* concentrations were correlated with relative humidity at ground level (ρ of -0.93^{**}) mixing ratio at 200 m (ρ of 0.46^* for *Quercus pyrenaica* and of 0.91^{**} for *Quercus rotundifolia*) with air temperature at 400 and 600 m (ρ of 0.61^* and 0.67^* respectively). *Quercus* species were also correlated at 600 m with relative humidity (ρ of -0.70^{**}).

In general, the mixing ratio was the most important factor at 200 m. In fact, it explains 80% of all significant correlations. At 400 m, the same parameter explained only 16% of the correlations. At this altitude, it was temperature that was significant in 66% of the cases. At 600 m, temperature was still the predominant factor (63% of correlations) but relative humidity (18%), mixing ratio (10%) and wind speed (10%) were also sharing part of an important group of independent variables. Only at that last altitude

Table 1. Pollen types identified along with their concentrations (P/m³) at the different sampled altitudes and in the controls.

	Om-1	Om-2	Control	200 m	400 m	600 m	Total
Apiaceae	1.7	1.3	0.0	2.4	5.4	3.0	13.8
<i>Anthemis</i>	1.0	0.3	0.7	4.7	0.0	0.7	7.4
<i>Artemisia</i>	0.0	0.3	0.0	0.3	0.3	1.3	2.4
<i>Aesculus</i>	1.0	0.0	0.0	0.7	0.0	1.0	2.7
<i>Bellis</i>	2.0	3.0	0.7	2.7	2.4	3.0	13.8
<i>Betula</i>	1.0	0.7	0.3	0.7	0.7	1.0	4.4
Brassicaceae	0.7	0.0	0.0	0.3	0.0	2.0	3.0
<i>Calluna</i>	0.0	0.0	0.0	0.3	0.0	0.0	0.3
Caryophyllaceae	0.0	0.3	0.0	0.3	0.3	0.3	1.3
<i>Castanea sativa</i>	15.2	21.9	0.3	25.9	33.3	43.4	140.1
Cistaceae	0.0	0.3	0.0	0.0	0.0	0.0	0.3
Chenopodiaceae	0.0	0.3	0.0	0.0	2.4	1.7	4.4
Cupressaceae	2.7	3.7	0.0	6.4	5.4	4.7	22.9
Cyperaceae	1.0	1.3	0.0	1.3	2.4	4.4	10.4
<i>Cytinus</i>	0.0	0.0	0.0	0.7	0.0	0.0	0.7
<i>Cytisus</i>	0.0	0.0	0.0	1.7	1.0	3.0	5.7
<i>Echium</i>	0.3	0.3	0.0	0.3	1.0	1.0	3.0
<i>E. arborea</i>	4.0	5.4	1.0	3.7	7.7	3.7	25.6
<i>E. australis</i>	0.3	1.7	0.0	0.3	0.7	4.4	7.4
<i>E. umbellata</i>	0.0	0.0	0.0	1.3	0.3	0.0	1.7
<i>Fagus</i>	0.0	0.0	0.0	0.0	0.7	1.3	2.0
Iridaceae	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Juncaceae	0.0	0.7	0.0	0.0	0.0	0.0	0.7
<i>Mentha</i>	0.0	0.3	0.3	0.3	0.0	0.7	1.7
Myrtaceae	0.0	0.0	0.0	0.7	0.0	0.0	0.7
Oleaceae	23.6	13.1	0.3	31.3	19.2	21.9	109.5
<i>Platanus</i>	0.0	0.0	0.0	0.0	1.3	1.0	2.4
Papaveraceae	2.4	2.4	1.0	1.0	5.1	6.4	18.2
<i>Pinus</i>	12.5	14.8	0.3	22.2	24.6	16.5	90.9
<i>Plantago</i>	54.2	87.9	10.1	65.3	72.8	64.0	354.3
Poaceae	130.3	176.8	22.9	197.0	190.6	184.6	902.3
<i>Q. pyrenaica</i>	20.9	25.3	4.0	43.4	45.8	39.1	178.5
<i>Q. rotundifolia</i>	2.7	2.0	0.3	2.4	9.8	8.1	25.3
<i>Rumex</i>	35.0	79.2	4.4	58.6	58.3	62.0	297.4
<i>Rubus</i>	0.3	0.0	0.0	0.0	1.0	0.0	1.3
Rosaceae	0.7	0.3	0.0	0.0	0.3	0.3	1.7
<i>Sanguisorba</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.3
Scrofulariaceae	1.3	2.4	0.0	6.4	0.7	8.4	19.2
<i>Salix</i>	0.0	0.0	0.0	0.7	0.7	1.0	2.4
<i>Sedum</i>	0.0	0.0	0.0	0.3	0.0	0.3	0.7
<i>Taraxacum</i>	0.3	1.3	0.0	0.3	1.3	1.0	4.4
<i>Tragopogon</i>	0.0	0.0	0.0	0.0	0.0	1.3	1.3
<i>T. repens</i>	0.0	0.0	0.3	0.0	0.0	1.3	1.7
<i>Typha</i>	0.0	0.0	0.0	0.3	0.7	0.0	1.0
Urticaceae	3.0	3.7	0.7	8.8	9.1	9.4	34.7
N.I.	2.0	2.4	0.3	5.1	2.7	4.4	16.8
Total	318.6	451.3	47.8	493.4	505.6	507.6	2324.4

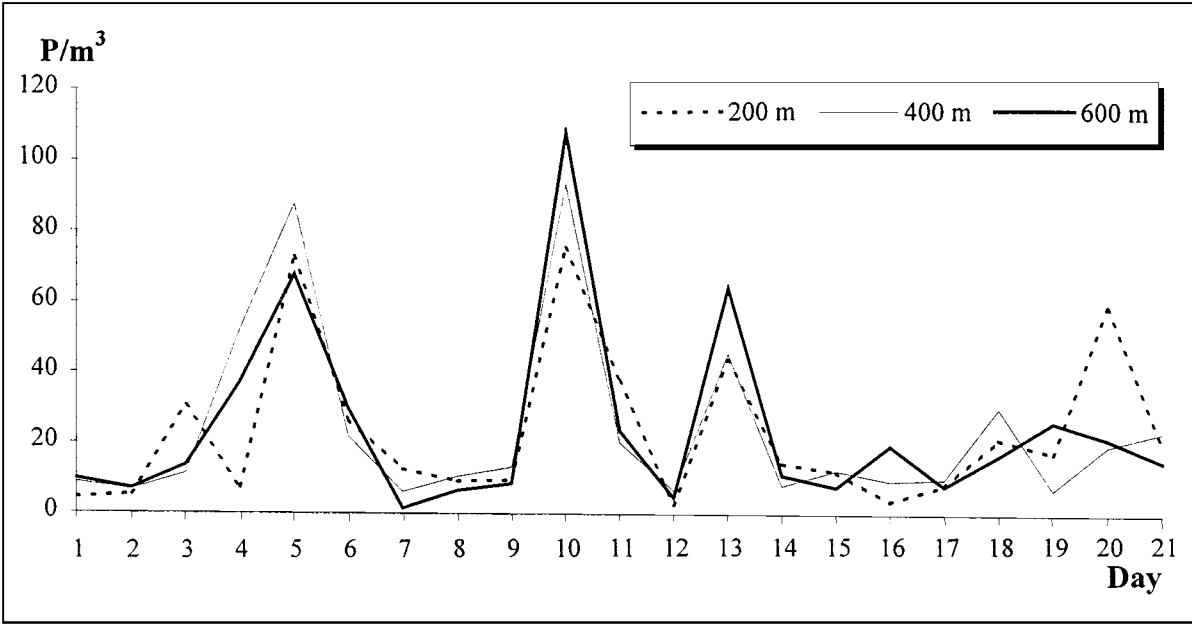


Figure 1. Total pollen concentrations (P/m^3) at each altitude level.

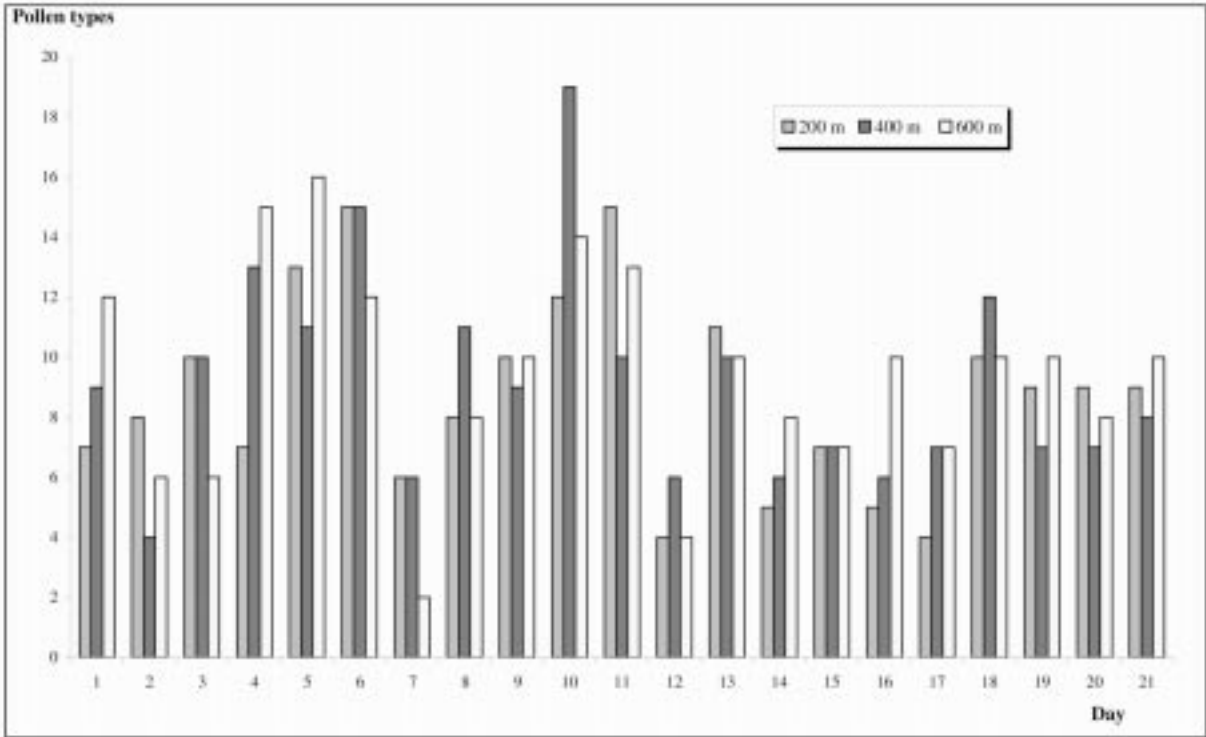


Figure 2. Number of different pollen types captured at each altitude level.

Table 2. Listing of the different species significantly correlated with meteorological parameters, stratified for each altitude.

Parameter	Sampled altitude		
	200 m	400 m	600 m
Mixing ratio	Apiaceae <i>Plantago</i> <i>Quercus</i>	Poaceae	Cyperaceae <i>Cytisus</i>
Temperature	Oleaceae	<i>Bellis</i> <i>Quercus</i> <i>Taraxacum</i> Cupressaceae	<i>Bellis</i> <i>Quercus</i> <i>Taraxacum</i> Poaceae <i>Pinus</i>
Relative humidity	<i>Bellis</i>	Cupressaceae	<i>Castanea sativa</i>
Wind speed			Papaveraceae

was wind speed, the factor hypothesized as the most significant, governing some pollen concentrations. No difference were found in the mean significant correlation at each altitude (average ρ of 0.672 at 200 m; of 0.615 at 400 m; and of 0.669 at 600 m). Only the factors list was different. Highest mean correlation on the species level was found for Oleacea (0.715), *Quercus* and Cupressaceae (respectively of 0.665 and 0.655) and finally Poaceae (0.490).

Conclusions

Airborne pollen behaviour is a complex phenomenon. There is no distinctive pattern that can be applied to all species. However it can be said that mixing ratio is the most important factor at 200 m, while air temperature governs pollen concentrations above this altitude. Only at the highest altitude reached was wind speed of any influence. Still it must be remembered that our sampling is not representative of all pollen seasons, and that sampling was restricted to the first hours of the morning, i.e. at the limit between night and day meteorological systems. More contrasted situa-

tions should be sampled to truly set up a catalogue of all pertinent interrelations between the physical parameters of the atmosphere and the behaviour of the pollen cloud. However, we believe that our first experimental results did open a new and stimulating window on the aerobiology of the lower atmosphere.

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