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Comparison of diurnal variation of airborne pollen in Mar del Plata (Argentina)

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Comparison of diurnal variation of airborne pollen in Mar del Plata (Argentina)

2. Arboreal pollen

CLAUDIO F. PÉREZ, JESÚS M. GARDIOL and MARTA M. PAEZ

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Intradiurnal variation of arboreal pollen (AP) in Mar del Plata city is compared during three non - consecutive years of survey and described in relation to the associated weather. The daily pattern of pollen abundance has a maximum between 10:00 and 12:00 h, while a minimum occurs at 18:00 h. The first two years of survey showed homogeneous daily trends, but in 1995 the maximum and minimum concentrations were delayed because of the change in position of the collecting station. Arboreal pollen spectrum presented qualitative and quantitative changes in the three years analysed. Results indicate optimal conditions for diurnal dispersion of arboreal pollen are high temperatures and low relative humidity. Also interaction between source position and wind direction has important effects on the timing of the peaks of some pollen types.

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The atmospheric boundary layer evolves continuously in response to the daily cycle of warming and to changing synoptic conditions. As a result, its structure and depth change considerably in time and space. During daylight hours, solar radiation supplies energy to warm the soil and develop convective turbulent movements that promote vertical mixing of the air. The boundary layer reaches its maximum depth during these hours. At night the loss of heat has important effects on dynamic processes, leading to a decrease of turbulence, temperature and the depth of the layer. These processes promote changes in the transport of suspended particles. Airborne pollen concentrations follow this variation in response to the dynamic conditions of the medium in which the pollen is dispersed. Typical high concentrations are observed during daylight hours, with maximum values occurring between 12:00 and 14:00 h, while the lowest values are registered during the night, between 4:00 and 6:00 h. This pattern is rather common as described by authors in other countries (Spieksma 1983, Käpylä 1984, Spieksma & den Tonkelaar 1986, Galán et al. 1989, 1991; Rantio-Lehtimäki et al. 1991), but it is strongly modified by weather conditions as well as the characteristics of the emitting vegetation, such as distribution, density and height of pollen liberation. Knowledge of these patterns and their response to source position and weather proved to be of great value for exposure reduction to allergenic pollen in public health programmes in other countries, but in Argentina, there are few studies focused on the seasonal variation (Cuadrado 1978, 1979; Borromei & Quattrocchio 1990, García de Albano 1991, Majas et al. 1992, Bianchi 1992, Latorre & Pérez 1997).

The physical processes previously described affect non – arboreal pollen (NAP) as well as arboreal pollen (AP), therefore the rhythms of daily pollen concentration should be similar. Variations are expected to rely on a combination of source position and wind direction. The study of circadian pattern of non-arboreal pollen concentration in Mar del Plata was analysed in a previous paper (Pérez et al. 2001*a*).

In this study we characterise the daily pattern of the urban arboreal pollen concentration during the period 10/95 – 3/96 with regard to its relationships with location of potential pollen sources and some meteorological parameters such as wind, temperature and humidity. Comparison with previous records and the non-arboreal daily pattern (Pérez et al. 2001*a*) were also analysed.

MATERIAL AND METHODS

Location of the study

Mar del Plata is located in the Atlantic littoral zone of the Southeast of Buenos Aires Province. The temperate climate of Buenos Aires is characterised by an increasing East – West gradient of humidity and increasing continentality towards the Northwest (Burgos 1968). The topography of the city is characterised by low flat hills up to 50 m over sea level that end in coastal cliffs five to ten meters high. The pollen trap and meteorological station were installed on the roof of the Departamento de Biología, Universidad Nacional de Mar del Plata at ten meters over ground level.

The area is characterised by residential buildings and few green spaces. During 1994 the equipment had to be moved approximately 100 m from its original position. In the new position the apparatus was at 17 m above ground level.

Sampling method and pollen counts

Airborne pollen monitoring was performed with a seven-day Burkard spore trap. The sampling period lasted from 12/10/95 to 11/3/96, when most of the trees were flowering (Pérez & Paez 1998). Slides were analysed by light microscopy with a magnification of X200, counting twelve transverse traverses every two hours (Käpylä & Penttinen 1981). Results were expressed either as number of pollen grains per cubic meter of air or as percentages of total pollen counted during an hour. This data were compared with unpublished records from the periods: 12/10/88 – 11/3/89 and 12/10/92 – 11/3/93.

Pollen types were identified based on available literature (Heusser 1971, Bassett et al. 1978, Moore et al. 1991, Faegri & Iversen 1992).

Data for temperature, relative humidity, wind speed and direction were collected near the pollen trap. Each datum corresponds to mean values calculated from 30 readings of the sensors taken every two minutes.

Data analysis

The diurnal pattern was determined by calculating the average concentration for each hour, thus establishing a representative day (Fig. 1).

Analysis of the daily spectrum for each year is based on selected pollen types. Pollen frequencies (expressed as percentages) were ranked in descending order. Pollen types were selected until their cumulative sum reached 80% of the total pollen sum (Fig. 2). Daily patterns for selected pollen types (Myrtaceae, *Platanus* and *Celtis*) were represented as percentages of the total pollen sum for each taxon (Fig. 3).

In order to analyse the influence of meteorological parameters on the daily patterns of the selected pollen types, mean hourly pollen concentrations were calculated for low, medium and high values of: relative humidity, temperature and wind speed (Figs. 4 – 6).

RESULTS

Comparison of mean arboreal concentration with previous records

Figure 1 shows the daily patterns of mean pollen concentration for 1988, 1992 and 1995. Pollen concentration showed a sharp increase between 6:00 and 10:00 h until the maximum daily concentration was reached. The timing of the maximum varies from year to year. For 1988 it reached 1.5 pollen grains $\cdot m^{-3}$ at midday (Fig. 1A), while in 1992 reached 2 pollen grains $\cdot m^{-3}$ at 10:00 h (Fig. 1B). In 1995, maximum concentration was registered later at 16:00 h, with 2 pollen grains $\cdot m^{-3}$ (Fig. 1C). Once the maximum was reached, pollen concentration start to decrease from 16:00 h (1988 and 1995) and 14:00 h. (1992), towards the lower values held at night. In the records of the years 1988 and 1992, minimum concentration was reached at 18:00 h with values of 0.7 pollen grains $\cdot m^{-3}$; while for 1995, the daily minimum was registered at 4:00 h, with 0.7 pollen $\cdot m^{-3}$ (Fig. 1A – C). In 1988 and 1992, few pronounced increases in pollen concentration were registered at 22:00 h, although the trend continued its decrease until 4:00 (1988) and

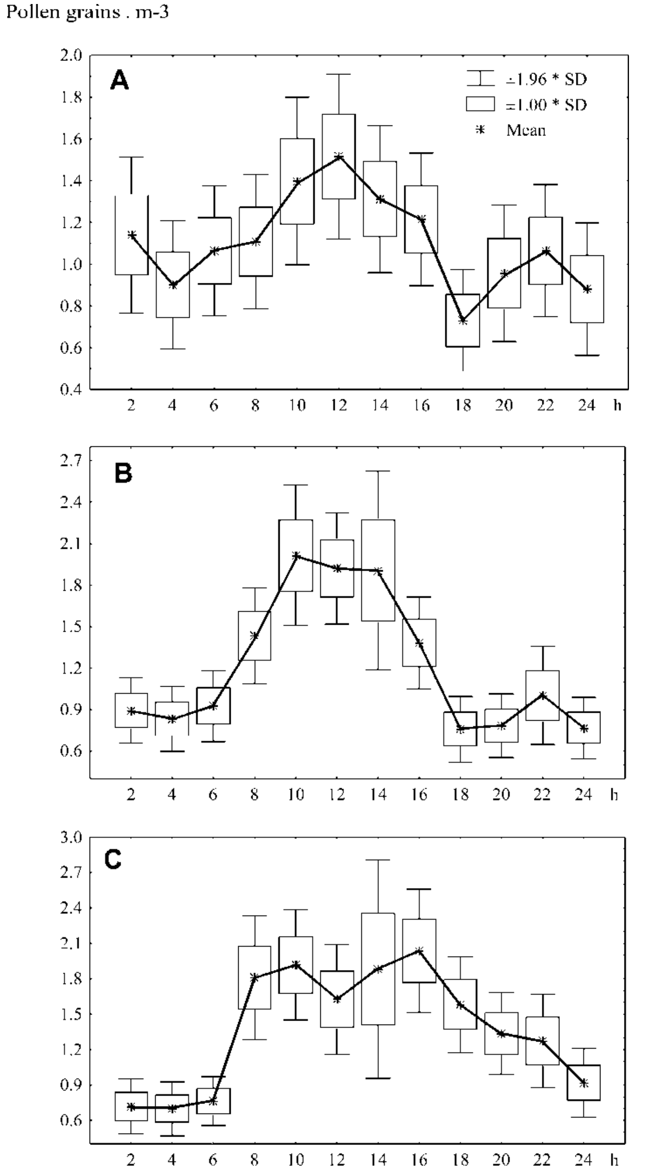

Fig. 1. Mean hourly concentrations and standard deviations (SD) of arboreal pollen for: 1988 (A), 1992 (B) and 1995 (C).

24:00 h (1992), when it started a new daily cycle (Fig. 1B – C). Because of an episode of high concentration of Lauraceae and *Celtis*, in 1988 pollen concentration at 2:00 h was rather high compared with the results from subsequent years.

AP daily pollen spectra

According to the selecting criterion adopted, 80% of the daily pollen sum in 1988 is represented by Lauraceae, *Celtis*, Myrtaceae, *Juglans*, *Quercus* and *Platanus* (Fig. 2A), in 1992 by Myrtaceae, Fabaceae, *Celtis*, *Quercus ilex*, *Quercus*, *Juglans*, *Platanus* and *Castanea* (Fig. 2B), and finally in 1995 by Myrtaceae, *Quercus*, *Celtis*, *Juglans*, *Platanus* and *Fraxinus* (Fig. 2C). The remaining 20% correspond to the cumulative percentage of the rest of the spectrum, named

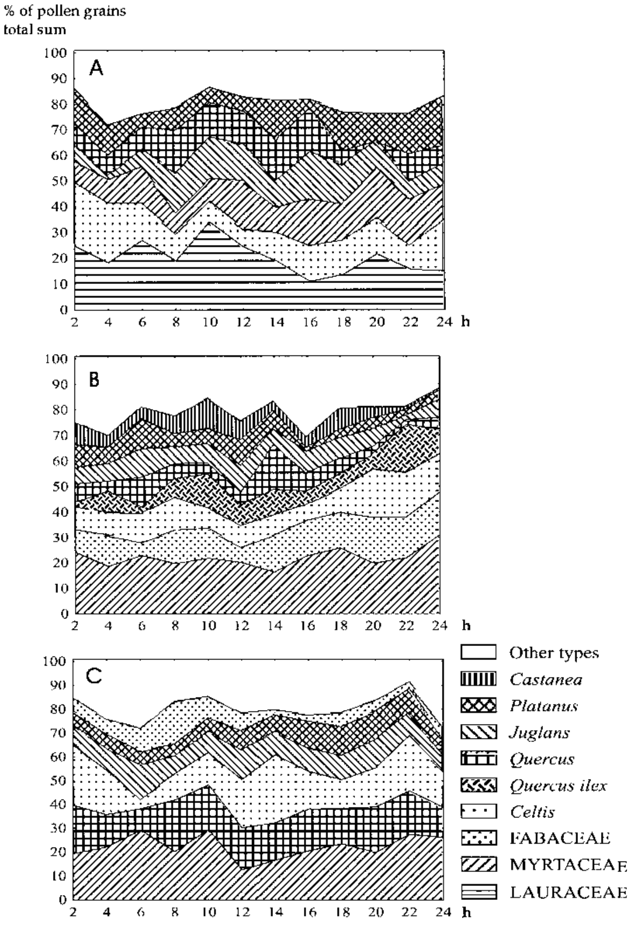

Fig. 2. Hourly arboreal pollen spectra for 1988 (A), 1992 (B) and 1995 (C). Pollen frequencies are expressed as percentages of the total hourly sum.

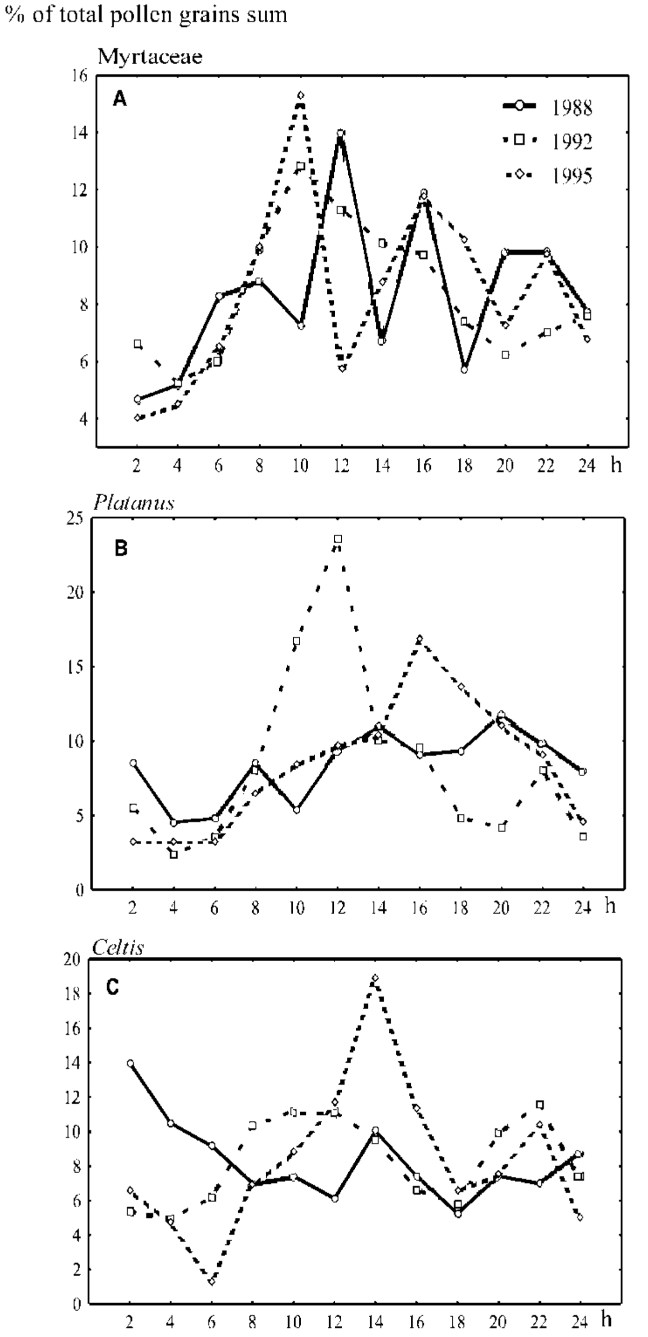

Fig. 3. Daily arboreal pollen patterns of Myrtaceae (A), *Platanus* (B) and *Celtis* (C) represented as percentages of the total pollen sum for each taxon.

as "Other types". It can be seen that the arboreal pollen spectra of the three years show variations in their composition as well as in the proportion reached by the pollen types in every year. Some pollen types such as *Platanus*, *Celtis* and *Quercus ilex* are main constituents of the airborne pollen during night hours, shown by the rise of percentages between 20:00 and 6:00 h.

Daily patterns of some selected pollen types

Myrtaceae, *Platanus* and *Celtis* were selected for this analysis because they are present in the three years of survey (Fig. 3). Myrtaceae showed a multimodal pattern with peaks at different times of the day (Fig. 3A). In 1988 there were four peaks, which appeared at 8:00, 12:00, 16:00 and 20:00 h. The situation during 1995 was also multimodal, although the peak at 8:00 h was not registered. Peaks were observed at 10:00 instead of 8:00, 16:00 and 22:00 instead of 20:00 h. Finally in 1992, the pollen pattern showed only one peak at 10:00 h. Minimum values seem to be more stable, appearing at 2:00 or 4:00 h (Fig. 3A).

During 1988, *Platanus* daily trend increase towards the evening, until the highest value is reached at 20:00 h, with 11.5% of the daily pollen sum. There were also two periods of high emission during daylight hours which took place at 8:00 and 14:00 h. In 1992, approximately 24% of the pollen captured was registered at noon, with a second peak at 22:00 h. Finally in 1995 high values were detected in the afternoon and during the night until 24:00 h when values decrease. The maximum concentration was reached at 16:00 h (Fig. 3B).

In the first year of survey, *Celtis* showed two daily peaks registered at 2:00 and 14:00 h. The lowest value (approximately

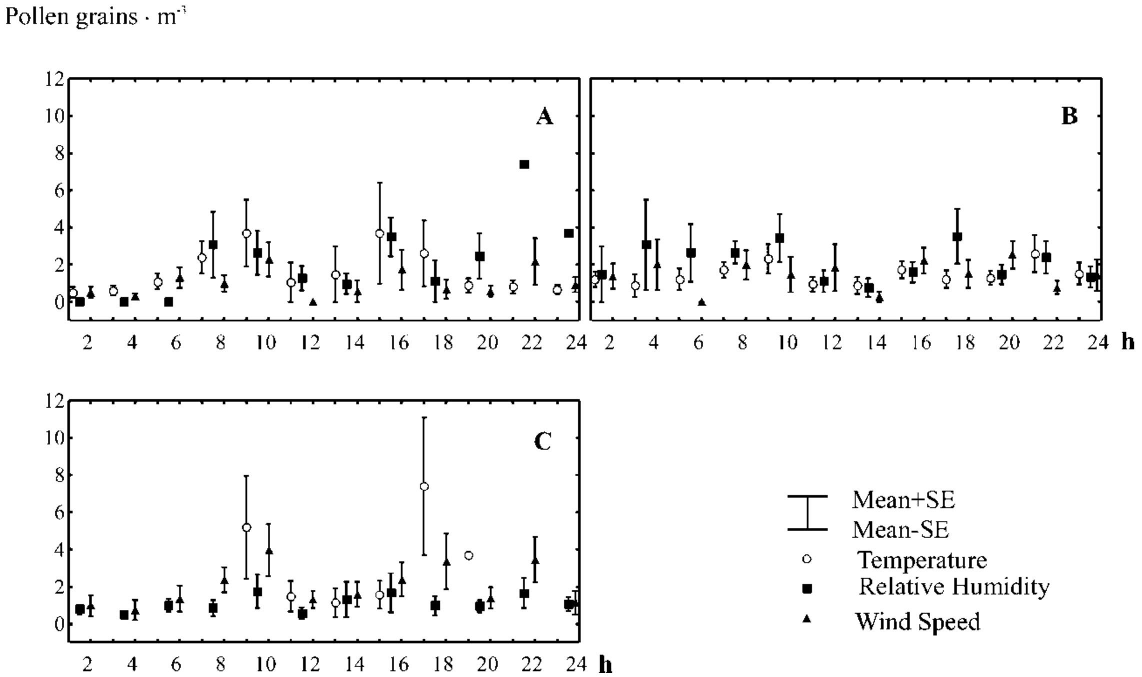

Fig. 4. Myrtaceae mean hourly pollen concentration values of temperature (T), relative humidity (RH) and wind speed (WS) during 1995: (A) low ($T \leq 14°C$, $RH \leq 48\%$, $WS \leq 2 m \cdot s^{-1}$); (B) medium ($14 < T \leq 25°C$, $48 < RH \leq 74\%$, $2 < WS \leq 3\ m \cdot s^{-1}$); (C) high ($T > 25°C$, $RH > 74\%$ $WS > 3\ m \cdot s^{-1}$). SE: Standard error of mean.

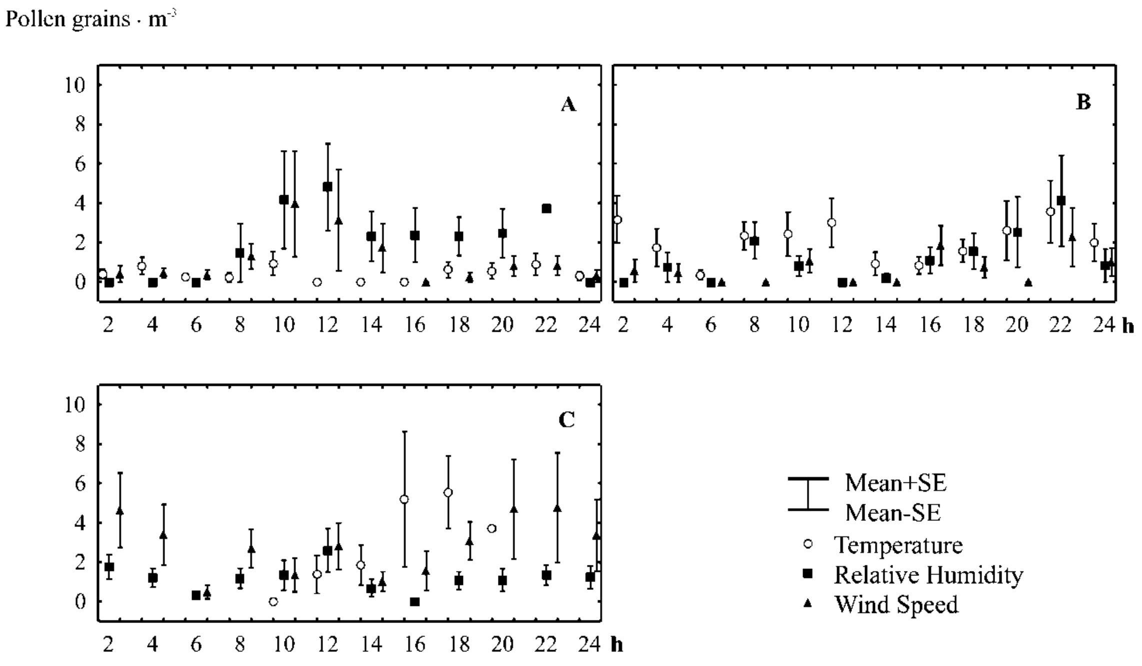

Fig. 5. Celtis mean hourly pollen concentration values of temperature (T), relative humidity (RH) and wind speed (WS) during 1995: (A) low ($T \leq 14°C$, $RH \leq 48\%$, $WS \leq 2 m \cdot s^{-1}$); (B) medium ($14 < T \leq 25°C$, $48 < RH \leq 74\%$, $2 < WS \leq 3\ m \cdot s^{-1}$); (C) high ($T > 25°C$, $RH > 74\%$ $WS > 3\ m \cdot s^{-1}$). SE: Standard error of mean.

5%) appeared at 18:00 h (Fig. 3C). As occurred with *Platanus*, in 1988 the greatest proportion of *Celtis* settled down at night, when 58% of the total sum of *Celtis* and 55% of *Platanus* were captured between 20:00 and 6:00 h (Fig. 3B, C). In 1992, *Celtis* showed two daily peaks: the first one at 12:00 h with 11% and the second one at 22:00 h with 11.5%, while in 1995 maximum concentration was reached at 14:00 h, with another less

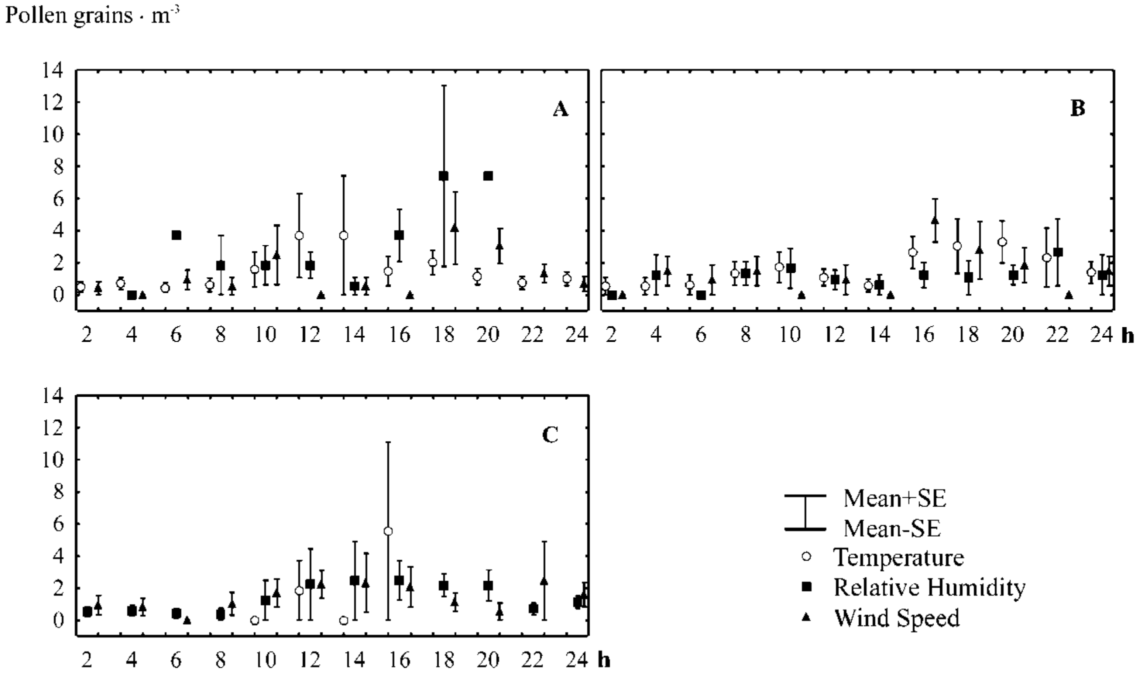

Fig. 6. Platanus mean hourly pollen concentration values of temperature (T), relative humidity (RH) and wind speed (WS) during 1995: (A) low ($T \leq 14°C$, $RH \leq 48\%$, $WS \leq 2 m \cdot s^{-1}$); (B) medium ($14 < T \leq 25°C$, $48 < RH \leq 74\%$, $2 < WS \leq 3\ m \cdot s^{-1}$); (C) high ($T > 25°C$, $RH > 74\%$ $WS > 3\ m \cdot s^{-1}$). SE: Standard error of mean.

pronounced peak at 22:00 h. The minimum concentration was reached at 6:00 h with 2% of the daily total sum.

Meteorological variables and pollen relationships

Table I, shows mean hourly values of temperature, relative humidity, wind speed and prevailing wind directions for the period analysed. Meteorological parameters have a diurnal cycle with maximum values of temperature and wind speed, and minimum values of relative humidity between 12:00 and 16:00 h.

In the morning prevailing wind directions are from inland until 10:00 h when the wind changes to the NE sector, that is from the coast. Coastal winds persist until 22:00 h when they turn to the N sector.

Table I. *Mean hourly values of temperature, relative humidity and wind speed. Period 10/95 – 3/96.*

Hours	Temperature (°C)	Relative Humidity (%)	Wind speed ($m \cdot s^{-1}$)	Prevailing Wind direction
2	14.1	89.2	2.1	NW
4	13.5	89.8	1.9	NW
6	13.9	88.7	2.1	NW
8	16.8	76.9	2.6	NW
10	19.5	64.3	3.0	NW – NE
12	20.7	60.2	3.1	NW – NE
14	21.7	60.9	3.1	NE
16	20.0	64.9	3.1	NE – S
18	17.5	71.8	2.7	NE
20	16.1	78.0	2.3	NE
22	15.9	82.6	2.2	N – NE
24	14.9	86.4	2.1	N

Myrtaceae

Only two meteorological variables have parallel relationships with the concentration of this pollen type: temperature and relative humidity. Results show high concentrations at 10:00 and 18:00 h associated with temperatures higher than 25°C (Fig. 4C) and also a slight growth of concentration at 10:00 and 16:00 h when temperature is lower than 14°C (Fig. 4A). Relative humidity below 48% favours the rise of pollen concentration of Myrtaceae at 8:00, 16:00 h and specially 22:00 h (Fig. 4B).

Celtis

Concentration of this pollen type is related to moderate temperatures (between 14 and 25°C) at two times of the day: the first one between 8:00 and 12:00 h, and the second during the night at 22:00 h (Fig. 5B). Temperatures higher than 25°C strongly affect pollen concentration of *Celtis*, particularly between 16:00 and 18:00 h (Fig. 5C).

Relative humidity lower than 48%, help the growth of atmospheric concentration of *Celtis*, between 10:00 and 22:00 h, while for intermediate values (from 48% to 74%), pollen concentration increased at 8:00 and 22:00 h (Fig. 5A, B). Wind speed is related to the atmospheric pollen content of *Celtis*, when values are below $2\ m \cdot s^{-1}$ or higher than $3\ m \cdot s^{-1}$. In the first case, it was observed that high concentrations at 10:00 and 12:00 h occur, while for the second the rise of concentration occurred at night, between 20:00 and 4:00 h (Fig. 5A – C).

Platanus

This pollen type is sensitive to low values of relative humidity (lower than 48%) which carries an increase in pollen concentration at 16:00, 18:00 and 20:00 h (Fig. 6A), and low to mid-values of wind speed that are related to pollen concentration from 16:00 to 20:00 h (Fig. 6 A, B).

DISCUSSION

The arboreal pollen daily trend followed broadly the typical shape described in other papers (Bianchi 1994), with high concentrations during daylight hours and low concentrations at night. AP maximum concentration was reached between 10:00 and 12:00 h, while the minimum occur at 18:00 h with a slight increase at 22:00 h. In comparison with its non – arboreal counterpart the maximum is reached shortly afterwards (Pérez et al. 2001 *a*).

From a physical point of view, dispersion is a process mainly governed by mechanical forces and atmospheric stability, therefore the rhythm of daily pollen concentration should be the same for AP and NAP. Differences in the timing of the maximum of NAP and AP could be explained based on source position and wind direction. Herbs are dominant in the city outskirts. They are widespread N, NW, W and SW of the sampling station (Pérez 2000). The maximum concentration of NAP occurs at 8:00 h, when the prevailing wind is from the NW sector. At 10:00 h, wind changes direction from inland to NE, passing through the city centre where trees are primary located, leading to the AP maximum two hours later than NAP. The 22:00 h peak is the only one that shows a peak to both the AP and the NAP fractions. Recent studies allow to conclude that this night peak correspond to pollen re-entrainment brought about by air recirculation from a sea – land breeze system (Pérez et al. 2001 *b*, Gassmann et al. 2002).

The first two years of survey showed quite homogeneous daily trends, but the last year of the study (1995) produced a pattern, which did not conform to those previously observed. The maximum and minimum concentrations were reached with some delay with regard to previous years therefore this could be an effect of the change of position of the collecting station. Comparison of the meteorological records in the new location with the previous ones (Pérez 2000) showed that wind speed and direction were significantly modified while temperature and relative humidity showed no significant changes. New conditions of mechanical turbulence could led to better dilution of the pollen grains in the air and in consequence, different daily patterns could be detected in situations where the dynamical flow is also different.

The comparison considers the selected pollen types present in the three years of survey. Myrtaceae exhibited three peaks of airborne concentration during the three years. The first one and more important in amount of pollen registered appeared at 10:00 h, although the timing in 1988 was 12:00 h. The second one appeared at 16:00 h, while the third and less pronounced, was observed in the night at 22:00 h. During these hours, wind frequencies prevail from NE, NW and S. The peaks are related with high density of trees at some distance of the trap (Latorre & Bianchi 1997). The main source of Myrtaceae pollen is *Eucalyptus globulus* Labill., which has a high density and an extended flowering season compared with other *Eucalyptus* species (Latorre 1997). High densities of these trees were registered in NW, W, SW and S directions from the trap (Latorre & Bianchi 1997).

Platanus acerifolia (Ait.) Willd. is the main cultivated tree of parks and avenues of the city. The timing of the maximum concentration is variable, appearing at 12:00, 16:00 or 20:00 h depending on the year considered. In general, the pattern is fairly extended and it shows high pollen concentrations particularly during the afternoon, when the predominant winds come from NE sector, passing through the centre of the city. Almost 60% of the trees within a square kilometre centred in the sampling station are located towards East quadrant (Latorre & Bianchi 1997).

Celtis showed a mid-afternoon peak approximately at 14:00 h and a second rise at early night (22:00 h). There are two sources for this pollen type: *Celtis australis* L. and *Celtis tala* Gill. ex Planch. The former is the only species grown in the city, but it flowers long before the sampled period. The second one is a native species that is blooming during this period (Latorre 1997). *Celtis tala* is not an important pollen source either in the city or in the nearest city outskirts. The greatest populations are located some dozens of kilometres to the North and North – Northeast, in the southernmost outskirts of the "Subdistrito del Tala" (Cabrera 1976). Therefore, it is considered a regional component brought by the NE winds that prevail from 14:00 h onwards (Pérez et al. 2001 *b*).

Platanus and *Celtis*, showed high pollen concentrations during night hours. Käpylä (1984), found this situations to be related with strong thermal and mechanical turbulence that favour the suspension during daylight hours. This could be considered a plausible explanation for the slight increase of the pollen curves around 22:00 h when weakest winds allow the settling of pollen previously carried up by mid-afternoon upward flows, specially for local sources such as *Platanus*. This is why nightly pollen increase of this taxon is correlated with light wind speed (Fig. 6A). Probably for *Celtis* it is more reliable to consider the conditions of regional transport mentioned above. Transport from distant sources need stronger wind speed, which improve mechanical turbulence. The rise in pollen concentration at 22:00 h, and its relation with wind speed higher than $3\ m \cdot s^{-1}$, give strength to this hypothesis (Fig. 5C). The best conditions for diurnal dispersion of arboreal pollen are high temperatures and low relative humidity. Maximum concentrations require low relative humidity ($<48\%$) independently from the time of occurrence. In the case of *Celtis* and *Platanus* whose dispersion is strongly influenced by coastal winds (NE sector), low relative humidity becomes a relevant factor.

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