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BRIEF COMMUNICATION

Intradiurnal variation of allergenic pollen in the city of Porto (Portugal)

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Abstract This study reports the hourly distribution of the allergenic airborne pollen types more abundant in the atmosphere of Porto (Portugal) during the studied period. This knowledge will allow an adequacy daily routine for allergic patients during the hours of higher airborne concentrations. The airborne pollen concentration was continuously performed from January 2003 to December 2007 in the city of Porto using a Hirst-type volumetric sampler. Urticaceae, Cupressaceae, *Acer* spp., and *Plantago* spp. airborne pollen presented higher concentrations in the morning, while *Alnus* spp. and *Betula* spp. pollen were mainly present during the afternoon. *Olea europaea* and *Platanus* spp. pollen were regularly distributed along the day, while Poaceae and *Pinus* spp. pollen presented two diurnal maxima.

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1 Introduction

In several industrialised countries, the prevalence of respiratory allergic diseases related with atmospheric pollen content is increasing in both number and severity (D'Amato et al. 2007). Pollen grains, released into the atmosphere in high amounts, are the principal inducers of pollinosis and other allergic reactions.

In recent years, various aerobiological studies have been performed around the world for the elaboration of pollen calendars that are indicative of the allergenic potential present in the atmosphere (D'Amato et al. 1998, 2007; Abreu and Ribeiro 2005; Docampo et al. 2007; Garcia-Mozo et al. 2007).

An important aspect of aerobiological monitoring focuses on the study of the average hourly dynamics of airborne pollen concentration during the day, which is important for clinicians and for patients who suffer from respiratory allergies since symptoms appear only when exposure reaches a certain threshold. Therefore, this knowledge is essential to reduce the exposure of allergy patients to episodes of high pollen concentration, usually associated with a period of symptom exacerbation, by adopting preventive measures, such as planning of outdoor activities (D'Amato et al. 1998; Giorato et al. 2000).

The aim of this study was to determine the intradiurnal airborne behaviour of the main allergenic pollen types present in the atmosphere of Porto in order to obtain an average hourly airborne pollen spectrum.

2 Materials and methods

The aerobiological study was conducted in the region of Porto, the second largest Portuguese city, located in northwest Portugal, which is limited by the Atlantic Ocean and the Douro River. This region has mild temperatures, January being the coldest month and July the hottest. The thermal range is low with an average minimum temperature of 10°C and average maximum of 19°C. The rainfall is irregularly distributed throughout the year, mainly concentrated in winter and spring. Prevailing winds are from the W and NW in summer and from the E and SE in winter.

Airborne pollen was continuously monitored from January 2003 to December 2007 using a 7-day Hirst-type volumetric spore trap (model Lanzoni VPPS-2000), calibrated to sample air at 10 l/min. This sampler was set on the roof of the Faculdade de Ciências in Porto (41°11′ N, 8°39′ W), approximately 20 m above ground level, and has a 2 × 14-mm intake orifice through which the sampled air is impacted onto a drum, covered with a Melinex tape, rotating once every 7 days. Pollen grains were trapped on this tape, coated with silicone oil, which was cut into seven daily segments and mounted on the slides with a mounting media of glycerol jelly. The daily and hourly mean concentration of the number of pollen grains was determined using an optical microscope at a magnification of 400× along four full lengthwise traverses. Pollen counts were transformed into daily and hourly number per cubic meter of air.

The allergenic pollen types selected were the ones more abundant in the atmosphere that represent nearly 80% of the total pollen sampled during the studied period (Abreu and Ribeiro 2005).

The intradiurnal airborne pollen concentration was determined for each year, and pollen types were studied from the hourly values of atmospheric concentration registered during the main pollen season according to the method described by Galán et al. (1991). For this, the days (1) where atmospheric pollen concentrations were superior to the third quartile (for Urticaceae and Poaceae) or to the average of the main pollen season concentration and (2) without precipitation occurrence were selected. Since the hourly counts vary widely inter-daily and interannually, its values were expressed in percentage rather than in absolute numbers.

The main pollen season was defined using a non-linear logistic regression model fitted to the values of the accumulated sum of the daily airborne pollen concentration. After adjusting the model to each pollen type and year, an one-sided *t*-test was used at the 5% level in order to estimate the beginning and ending dates of the main pollen season. These dates correspond to the thresholds where the daily difference between the pollen emission model and its superior and inferior asymptotes were significant. A more detailed description of this methodology can be found in Ribeiro et al. (2007).

Also, the hourly average values of some meteorological parameters (temperature, relative humidity, and wind velocity), calculated during each main pollen season were analysed.

3 Results

During the studied period the interannual variability of the hourly distribution patterns of the pollen types studied did not show great differences.

The lowest airborne pollen concentrations were recorded during the night, while the morning period presented higher concentrations. Apart from each species daily maximum, an increase in the airborne pollen concentration for all studied species at the first hours of the day was also observed (Fig. 1).

The highest airborne pollen concentrations of Urticaceae, Cupressaceae, *Acer* spp., and *Plantago* spp. were observed during the morning period. Urticaceae airborne pollen started to increase at the first hours of the day (7 a.m.), reaching a maximum value between 10 and 11 a.m. that corresponded on average to 18% of its daily total (maximum of 28% in 2006 and minimum of 12% in 2003). The highest airborne pollen concentration of Cupressaceae occurred between 9 and 10 a.m., representing 14% of its daily total (maximum of 25% in 2006 and minimum of 9% in 2003). *Acer* spp. and *Plantago*

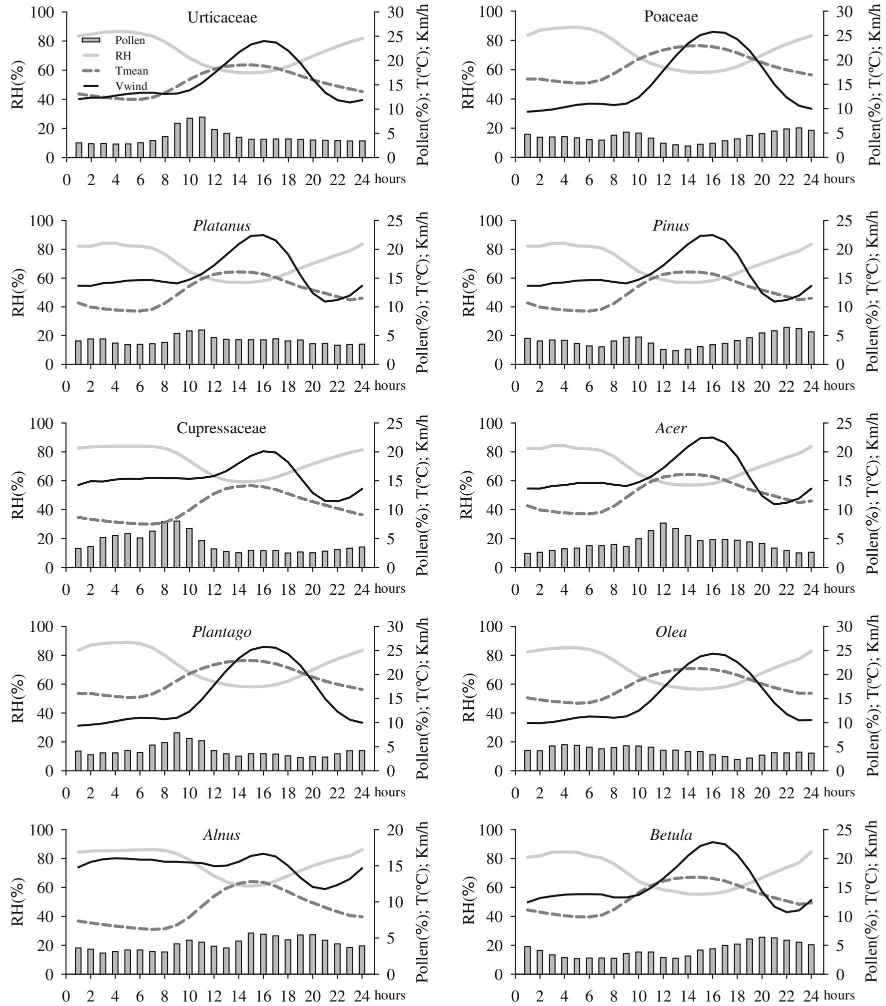

Fig. 1 Average hourly distribution, expressed in percentage, of some allergenic pollen in the Porto atmosphere. Average hour monthly mean temperature (T_{mean}), relative humidity (H_{R}), and wind velocity (V_{wind}) observed during the main pollen season of each pollen type analysed are represented

spp. airborne pollen concentration peaked at 9 and 12 a.m., respectively, both peaks representing 8% of their daily total.

Olea europaea and *Platanus* spp. airborne pollen were present in the atmosphere in similar concentrations along the day, although this last pollen type has a slight increase in airborne concentration from 9 to 11 a.m.

The maximum counts of *Alnus* spp. were observed between 3 and 5 p.m., which corresponded on average to 18% of its daily total (maximum of 19% in 2007 and minimum of 13% in 2004). *Betula* spp. airborne pollen peaked between 7 and 10 p.m., corresponding on average to 24% of its daily total (maximum of 29% in 2007 and minimum of 17% in 2004).

Poaceae and *Pinus* spp. airborne pollen concentration presented two daily peaks. Their airborne pollen concentration started to increase at 8 a.m., reaching a maximum value between 9 and 10 a.m. (Poaceae: average of 5% of its daily total, maximum of 7% in 2005, and minimum of 4% in 2003; *Pinus* spp.: average of 12% of its daily total, maximum of 10% in 2003, and minimum of 4% in 2007). After this peak the airborne concentration decreases abruptly until 2 p.m. to increase progressively again between 3 p.m. until a peak at 9 p.m. for *Pinus* spp. and until 11 p.m. for Poaceae.

4 Discussion

The highest airborne pollen concentrations were found during the daylight hours. The same pattern of occurrence was also observed in several other studies (Käpylä 1981; Galán et al. 1991; Norris-Hill and Emberlin 1991; Rodríguez-Rajo et al. 2003; Latalowa et al. 2005; Nitiu 2006) confirming the occurrence of anthesis and pollen dispersion during daylight. However, some authors reported a night time anthesis (Reddi and Reddi 1985; Kasprzyk 2006).

The morning increase in the airborne pollen concentration observed for all studied species coincides with a period of thermal inversion, increase in wind velocity, and decrease in relative humidity (Fig. 1). These conditions facilitate anther dehiscence, pollen emission, and dispersion (Reddi and Reddi 1985; Emberlin and Norris-Hill 1991; Norris-Hill and Emberlin 1991; Vázquez et al. 2003).

The morning airborne pollen peak concentration of Cupressaceae, *Platanus* spp., and *Plantago* spp. and the afternoon peak of *Alnus* spp. and *Betula* spp. observed in our study was also reported by other authors (Kasprzyk et al. 2001; Pérez et al. 2003; Rodríguez-Rajo et al. 2003; Nitiu 2006; Dacosta et al. 2004).

Besides the morning diurnal maximum, Urticaceae, *Olea europaea*, and *Platanus* spp. pollen presented similar concentrations during the other hours of the day. This fact is important because it can contribute to the exacerbation of the allergic symptoms due to the cross-reactivity with other pollen types also present in high concentrations in the atmosphere.

Poceae and *Pinus* spp. airborne pollen concentration presented an increase from the first daylight hours until noon, rising again during the mid afternoon and evening. The occurrence of these second daily maxima may be related to the influence of meteorological factors associated with the atmospheric boundary layer instability. The atmospheric pollen content varies according to the wind velocity, direction, or turbulence. Also, the increase of the air relative humidity can accelerate the airborne pollen hydration, making them heavier and facilitating their gravitational settling. So, as the sunset and beginning of the night approached, a gradual decline of the air temperature and wind velocity was observed. This was accompanied by an increase in the relative humidity and a reduction of atmospheric turbulence. All these factors facilitate the deposition of pollen grains, transporting them towards the soil (Reddi and Reddi 1985) and allowing their capture by the sampler, and explain the higher counts found at the end of the afternoon.

Another explanation pointed out by several authors is the occurrence of an irregular distribution of Poaceae pollen in the atmosphere throughout the day that is related to the existence of around 400 anemophilous species (D'Amato et al. 2007) presenting different anthesis time (Galán et al. 1991; Norris-Hill 1999; Laaidi and Thibaudon 2002).

5 Conclusions

The average hourly airborne concentration dynamics of the pollen types analysed made it possible to distinguish three different groups: (1) pollen with only one diurnal maximum, tending to present the occurrence of higher counts in the morning from 7 to 12 a.m. (Urticaceae, Cupressaceae, *Acer* spp., and *Plantago* spp.) or in the afternoon from 3 to 8 p.m. (*Alnus* spp. and *Betula* spp.); (2) pollen with a regular pattern during every hour of the day (*Olea europaea* and *Platanus* spp.); (3) pollen with two diurnal maxima (Poaceae and *Pinus* spp.).

The aggravation of allergy symptoms in individuals predisposed to allergenic diseases is related, among other factors, to airborne pollen concentrations of species capable of inducing allergenic reactions. Therefore, the analysis of the airborne pollen average hourly dynamics enables the determination of higher concentration periods constituting an important tool to implement prophylactic procedures and symptom prevention.

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