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Mismatch in aeroallergens and airborne grass pollen concentrations

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HIGHLIGHTS

- High pollen concentrations do not always imply high aeroallergen levels.
- Pollen concentrations are better correlated with weather factors than allergen.
- Light winds prompt the accumulation of grass pollen near the surface.

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ABSTRACT

An accurate estimation of the allergen concentration in the atmosphere is essential for allergy sufferers. The major cause of pollinosis all over Europe is due to grass pollen and Phl p 5 has the highest rates of sensitization (>50%) in patients with grass pollen-induced allergy. However, recent research has shown that airborne pollen does not always offer a clear indicator of exposure to aeroallergens. This study aims to evaluate relations between airborne grass pollen and Phl p 5 concentrations in Córdoba (southern Spain) and to study how meteorological parameters influence these atmospheric records. Monitoring was carried out from 2012 to 2014. Hirst-type volumetric spore trap was used for pollen collection, following the protocol recommended by the Spanish Aerobiology Network (REA). Aeroallergen sampling was performed using a low-volume cyclone sampler, and allergenic particles were quantified by ELISA assay. Besides, the influence of main meteorological factors on local airborne pollen and allergen concentrations was surveyed. A significant correlation was observed between grass pollen and Phl p 5 allergen concentrations during the pollen season, but with some sporadic discrepancy episodes. The cumulative annual Pollen Index also varied considerably. A significant correlation has been obtained between airborne pollen and minimum temperature, relative humidity and precipitation, during the three studied years. However, there is no clear relationship between allergens and weather variables. Our findings suggest that the correlation between grass pollen and aeroallergen Phl p 5 concentrations varies from year-to-year probably related to a complex interplay of meteorological variables.

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1. Introduction

Grass pollen is the major cause of pollinosis in Europe (Burbach et al., 2009) and one of the most important airborne allergen sources worldwide. It contains various allergens, the major group 5 allergen (http://www.allergome.org/) has been considered on this study a major source of grass pollen in temperate areas, Phl p 5 is associated with the highest rates of sensitization (>50%) in patients with grass pollen-induced allergy (Tripodi et al., 2012). The prevalence of this allergen is also an optimal marker for grass pollen concentrations, since it occurs solely in Poaceae pollen grains (Andersson and Lidholm, 2003).

The Poaceae family comprises ca. 10,000 species (Watson and Dallwitz, 1992) flowering mostly during spring, from April to June in the Mediterranean area of Europe, although the pollen season of grass can last until September in northern, central and eastern Europe (D'Amato et al., 2007; Puc, 2011). A total of 420 species grow in Andalusia (García Rollán, 1985). In the Andalusian city of Córdoba, the grass pollen curve is mainly associated with only some species, including *Arrhenatherum album*, *Dactylis glomerata*, *Lolium rigidum*, *Trisetaria panicea* and *Vulpia geniculata* (León-Ruiz et al., 2011; Cebrino et al., 2016). Although pollen release in other

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species (e.g. *Aegilops geniculata*) coincides with the local grass pollen peak, these can produce only small amounts of pollen per inflorescence (Prieto-Baena et al., 2003; Aboulaich et al., 2009). For this reason, these species probably do not contribute much to the pollen curve.

Airborne pollen concentrations have traditionally been used as a means of establishing potential exposure to airborne allergens, but research has shown that allergy symptoms may arise even at low pollen concentrations (D'Amato et al., 2007; Fernández-González et al., 2010; Buters et al., 2012, 2015). Moreover, allergens are not only linked to pollen grains and non–pollen-bound allergens, free allergens, can be also found in the atmosphere (Wang et al., 2011). It is therefore important to additionally investigate allergen concentrations.

Early and effective estimation of airborne allergen exposure is essential for allergy sufferers. Nevertheless, pollen potency (i.e. allergens *per* pollen) varies considerably, since airborne allergen concentrations depend not only on the emission of pollen, but also on external environmental and some meteorological parameters (Cecchi, 2013). Indeed, allergen production has been shown to be affected by climate change (Cecchi et al., 2010). In fact, some papers report an increase in the allergen released from pollen which has been produced by plants exposed to elevated temperature and CO_2 concentrations, i.e. Amb a 1 in *Ambrosia artemisiifolia* L. (Singer et al., 2005). Moreover, a number of studies reports that the amount of allergen released *per* pollen grain may also vary substantially (Fernández-González et al., 2011). In Europe, a marked spatial and temporal variation in the release of Phl p 5—a major Poaceae pollen allergen—has been observed (Buters et al., 2015). Those researchers used a Chemvol High Impact sampler for calculating pollen potency in different regions in Europe and recorded for the major group 5 allergens from grass pollen an average about 2.5 pg/pollen. Other papers based on this sampler have been focused on different regions and species. Galán et al. (2013), for example, found Ole e 1 allergen released in Córdoba (Spain) up to 4.3 pg/pollen. Buters et al. (2012) reported 3.2 pg Bet v 1/pollen in five European sites and Jochner et al. (2015) up to 5.7 pg/pollen in Poaceae and up to 3.5 pg/pollen in *Betula* in southern Germany.

Other studies used a wind-oriented multi-vial Cyclone sampler for the allergen quantification. Alcázar et al. (2015) recorded an average of 0.4 pg/pollen in *Platanus* in Córdoba (Spain). Plaza et al. (2016) found an average of 4.6 pg/pollen for three years in *Olea* in Córdoba (Spain). Rodríguez-Rajo et al. (2011) reported in Poaceae an average of 4.6 pg/pollen in Orense and 8.9 pg/pollen in León (Spain). The different methodology between both samplers could influence the results, i.e., Chemvol sampler uses polyurethane foam as impacting substrate to collect the particles and Cyclone uses vials.

In view of the above, this study sought to evaluate the correlation between airborne grass pollen and Phl p 5 allergen concentrations in Córdoba, and to analyze the impact of weather-related variables on both.

2. Materials and methods

2.1. Study area

The study was carried out in Córdoba (37°53′N, 4°45′W; 123 m a.s.l.), a medium-sized city in the south-western Iberian Peninsula (Fig. 1), with 328.704 inhabitants; industrial development is light. Olive and rain-fed cereals are the main crops grown in the vicinity of the city, while natural Mediterranean vegetation can be found in most areas of the province. Córdoba city has a Mediterranean climate with some continental features; the annual average temperature is 18.1 °C and total annual rainfall is 591 mm (30-year averages, 1982–2011, data from the Spanish Meteorology Agency, AEMET). Surface winds in Cordoba mainly blow from the southwest and northeast, reflecting the city's location in the River Guadalquivir valley, which channels surface winds along its axis (Hernández-Ceballos, 2011).

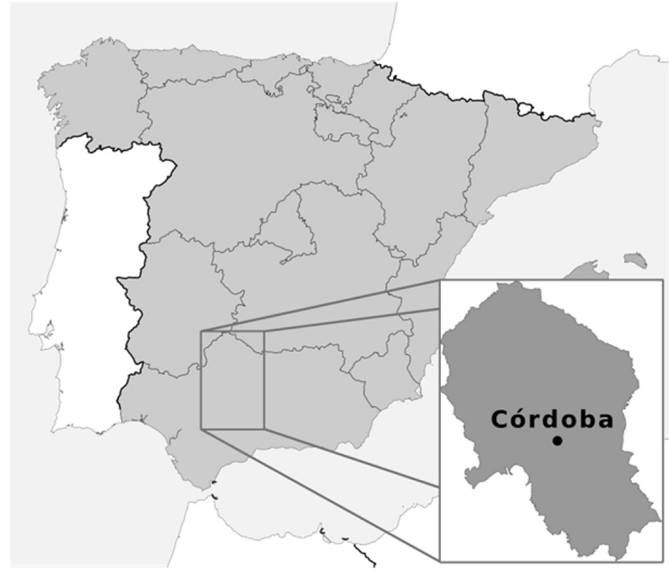

Fig. 1. Geographical situation of the aerobiological sampling station.

2.2. Sampling and measuring of airborne pollen and aeroallergens

Airborne Poaceae pollen and Phl p 5 particles were sampled over a 3-year period (2012–2014) at 22 m above ground level, on the rooftop of a university building at the University Campus, in the northeast of the city. The area is situated between the foothills of the Sierra Morena and the Guadalquivir River, and surrounded to the south by fields planted with various crops.

Airborne Poaceae pollen was collected using a 7-day Hirst-type volumetric spore trap (Hirst, 1952), following the methodology recommended by the Spanish Aerobiology Network (REA) Management and Quality Manual (Galán et al., 2007) and in accordance with the minimum requirements of the European Aerobiology Society (EAS) (Galán et al., 2014). Concentrations were expressed as the daily average number of pollen grains per cubic meter of air.

The Poaceae pollen season was defined using the criteria recommended by Peel et al. (2014): the pollen season start date was taken as the first day with a daily average equal to or greater than 10 pollen grains/m^3, while the end date was taken as the first day with Poaceae pollen concentrations of less than 10 grains/m^3.

Air was simultaneously sampled with a low-volume Cyclone Burkard sampler, whose sampling efficiency has previously been described (Emberlin, 1995). This consisted of a continuous volumetric and wind orientation sampler that uses a suction flow rate of 16.5 L/min (Burkard Manufacturing Co. Ltd.). Phl p 5 particles were collected dry in a 1.5 ml Eppendorf vial every 24 h. Daily samples were stored at −40 °C until extraction. Airborne allergens were sampled during the Poaceae pollen season, but also two weeks before and after the pollen season considering previous year's data (García-Mozo et al., 2010) in order to detect the potential presence of allergens outside the flowering period.

2.3. Extraction and quantification of airborne allergens

Extraction of samples from the Cyclone sampler was carried out

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