Urban Forestry & Urban Greening 27 (2017) 352–362

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

# Allergenic pollen of ornamental plane trees in a Mediterranean environment and urban planning as a prevention tool

José María Maya-Manzano[a,*,1], Santiago Fernández-Rodríguez[b], Alejandro Monroy-Colín[a], Inmaculada Silva-Palacios[c], Rafael Tormo-Molina[a], Ángela Gonzalo-Garijo[d]

[a] Department of Plant Biology, Ecology and Earth Sciences, Faculty of Sciences, University of Extremadura, Avda. Elvas s/n, Badajoz, Spain
[b] Department of Construction, School of Technology, University of Extremadura, Avda. de la Universidad s/n, Cáceres, Spain
[c] Department of Applied Physics, Engineering Agricultural School, University of Extremadura, Avda. Adolfo Suárez s/n, Badajoz, Spain
[d] Department of Allergology, Infanta Cristina University Hospital, Avda. Elvas s/n, Badajoz, Spain

## ARTICLE INFO

*Keywords:*
Allergy
Bio-indicator
Green infrastructure
Green spaces
Healthy itineraries
*Platanus* pollen
Urban planning

## ABSTRACT

Green spaces and urban green infrastructure are new concepts in urban planning, and lately, the influence of green spaces in cities and how this presence affects local climate change have been taken into account. Moreover, some of the ornamental trees most used in cities provoke allergic symptoms in sensitized people. Due to the importance the plane trees in our parks and cities have as ornamental trees, this article assesses the urban *Platanus* airborne pollen concentration in the air of five cities of the SW Iberian Peninsula and tries to determine the differential factors that its distribution has by means of combining continuous monitoring of the air using volumetric spore traps and the geolocation of plane trees. They were counted separately according to the direction (Q1 NE, Q2 SE, Q3 SW, Q4 NW) around the spore trap location in circles of 100, 200, 300, 400, 500, 1000, 1500, 2000 and 2500 m in diameter. Pollen sums were distributed according to the predominant wind direction for each day. The highest concentrations for *Platanus* pollen were recorded in Don Benito. Differences amongst pollen stations were found and were mainly related to their degree of maturity and their proximity to spore traps, and finally, with the number of plane trees. Furthermore, other factors, as the pruning, which is different in each city and even in a more local way, affects pollination and is frequently unknown to aerobiological studies. The geolocation of ornamental trees can be a useful tool for providing summarized information about their behavioral differences amongst cities, which can be used to create healthy itineraries, minimizing the natural hazards in human health (allergic diseases) and could be implemented into a model to help policy-makers to create measures to improve green urban development.

## 1. Introduction

Green spaces and urban green infrastructure have recently been developed as a new concept in "Urban Planning and Development". They include ornamental trees in urban environments and natural or semi-natural vegetation, both of which improve the quality life of citizens (Breuste et al., 2015; Taylor and Hochuli, 2017). Urban green spaces have been analysed from several perspectives. Green infrastructure sources, concerning the spatial identification and its diversity in distribution as well as their functional diversity in relation to urban zones, have been studied in cities (Dlugonski and Szumanski, 2015). Land use significantly affects the distribution of urban green spaces (Li et al., 2015), avian abundance (Rega et al., 2015) and urban heat islands (Schwarz and Manceur, 2015).

An increase in the global average temperature occurred between 1880 and 2012, and it has been anticipated that this trend continues according to IPPC reports (2013). Urban areas will be most affected due to the heat island effect (Chen et al., 2017). Because of their importance to the climatic ecosystem, urban green areas have an important role in this process (Henseke and Breuste, 2015). On the other hand, resilience has become an important objective for cities in order to avoid the effects of climate change. The majority of the world's population live in urban areas and the trend is increasing. Furthermore, they have become laboratories for resilience (Meerow et al., 2016). Cariñanos et al. (2016b) have confirmed that pollen emissions are a valuable biological indicator for estimating the adaptive response of various species and the resilience of the forest mass to climate-change events.

Consequently, ornamental trees play an outstanding role in any

* Corresponding author.
*E-mail address:* jmmaya@unex.es (J.M. Maya-Manzano).
[1] Aerobiología en Extremadura (AEROUEX) http://www.aerouex.es.

http://dx.doi.org/10.1016/j.ufug.2017.09.009
Received 7 February 2017; Received in revised form 21 August 2017; Accepted 15 September 2017
Available online 18 September 2017
1618-8667/ 


**Fig. 1.** Maps of locations of spore traps.

urban, *peri*-urban and rural environment and in their landscape designs (Read and Bavougian, 2014). Several factors should be considered for the designs: aesthetics (Sadeghi et al., 2014), the mortality of trees (Lu et al., 2010), childhood asthma (Gern, 2010) and allergenic index in each species (Cariñanos et al., 2017). Architectonic barriers can also play an important role in impeding the air renovation and accumulating the pollen grains content if the air cannot flow freely through long and narrow avenues, creating isolated points with high concentrations if tall buildings are frequent (Cariñanos et al., 2002). This has been studied in air pollution, being known as building downwash effect (Thompson, 1993), but it remains as a blurred factor referring to biological pollution in aerobiological studies.

Plane trees, such as *Platanus hispanica* (*P. acerifolia*) and *Platanus orientalis* (López, 1998; Rocha-Afonso, 1990), are chosen due to their tolerance to water shortages and high levels of pollution, rapid growth and the development of a wide shadow. Plane trees are deciduous, monoecious, with unisexual flowers in globose inflorescences, wind-pollinated, and *Platanus orientalis* has high pollen production ($3.3 \times 10^6 \pm 0.2 \times 10^6$), which was the highest amount per inflorescence in a study of pollen production in trees (Damialis et al., 2011). Tormo et al. (1996) recorded a pollen production per tree of more than $1 \times 10^{11}$ in *Platanus hispanica*. Pollen released by urban flora contributes to the airborne allergen content during the pollen season, and it has a considerable adverse impact on human health (Cariñanos et al., 2016a). In spite of their growing advantages, the pollen of ornamental plane trees is a major causes of respiratory allergies in Mediterranean countries such as Greece (Gioulekas et al., 2004), Italy (Bedeschi et al., 2007), France (Caillaud et al., 2015), Portugal (Ribeiro and Abreu, 2014) and Spain (Alcázar et al., 2004, 2015; Fernández-González et al.,2013). The ability of *Platanus* pollen to trigger immediate hypersensitivity reactions has been known since the 1970s (Anfosso et al., 1997). *Platanus* pollen was cited as an important cause of pollinosis in Spain in the early 1990s (Subiza et al., 1994). However, there is a great disparity in the prevalence of sensitisation to this pollen among the various published studies, ranging between 5% and 59% depending on geographical areas. Effects of cross-reactivity within *Platanus* genus have been reported (Pazouki et al., 2008), but also with other species such as *Artemisia vulgaris* or *Corylus avellana* (Miralles et al., 2002). The prevalence of this sensitisation has been increasing awareness in relation to the number of trees planted in cities (D'Amato and Lobefalo, 1989; Subiza et al., 1994; Varela et al., 1997). In a study conducted in Spain in 2003, the highest prevalence of *Platanus* pollen sensitisation was found in cities with higher concentrations of this pollen, such as Barcelona, Madrid and Zaragoza, which was above 30% (Pola et al., 2015). Clinical symptoms most often associated with *Platanus* pollen allergies are seasonal rhinoconjunctivitis and asthma (Subiza et al., 1994). Some patients also report symptoms during the months of September and October, which could be explained by the refloating of pollen attached to the leaves at the time of the leaf fall (Valero et al., 1999). Sensitisation to *Platanus* pollen is a significant additional risk factor for asthma among patients allergic to grasses, probably because it is associated with a greater degree of atopy (Varela et al., 1997).

There is a high disparity between *Platanus* pollen records, sensitization to this pollen, and clinical involvement. This could be explained by the low percentage of patients who are monosensitized to *Platanus* and the association of sensitization to other more relevant pollens, complicating the direct link between pollen and symptoms present in patients (Enrique et al., 2002; Varela et al., 1997). Other factors which can influence in a major production and pollen release and the creation of these geographical gradients are: differences between species, growing spontaneously in the eastern Mediterranean (*Platanus* orientalis) and as ornamental tree in the western Mediterranean (*Platanus hispanica*), human management (Cariñanos et al., 2017; Gabarra et al., 2002), which is different depending on the site, the predominant wind direction pattern and its persistence, which disperses differently aerobiological particles from anemophilous trees (Damialis et al., 2005) and influences in the pollen loads for each city, causing a random effect in aerobiological results (Maya-Manzano et al., 2017a).

Other factors that can be cited are the differences in altitude (Damialis et al., 2017; Fernández-Rodríguez et al., 2014b); and air temperature (Moore et al., 1991), which tends to be higher in cities than rural locations, moving the flowering season forward and decreasing the differences between day and night temperatures. As a result, the characteristics of MPS can be modified and longer exposures to pollen along the year and at night can be possible in a climate change scenery (Grewling et al., 2016; Mimet et al., 2009).

The major allergen of *Platanus* is Pla a 1, 18 kDa (Asturias et al., 2002). The presence in the atmosphere of Pla a 1 is independent of the amount of total *Platanus* pollen existing in the same period. Pla a 1 is detected in the atmosphere after the presence of *Platanus* pollen, so it would lengthen the periods of risk for *Platanus* pollen allergy, due to the positive influence that rainfall periods have over the allergens release (Fernández-González et al., 2013).

Due to this problem, recent papers on urban areas have studied the relationship between urban green zones and pollen allergies in order to