Urban allergy review: Allergic rhinitis and asthma with plane tree sensitization (Review)

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Abstract. Respiratory allergies represent a major public health issue in the modern world. Pollens are among the most significant causes of seasonal allergic rhinitis, with pollens of wind-pollinated trees representing an important cause. Members of the Platanaceae family (*Platanus acerifolia*, *Platanus orientalis*) are well-recognized sources of allergenic pollens worldwide, due to their high capacity of sensitization and widespread usage as ornamental urban trees. Air pollution, characteristic to all important urban conglomerates in the world and provoked by diesel exhaust gases, industrial and domestic fumes, and biogenic volatile organic compounds represents another major public health issue. Plane trees, along with other species of trees, are one of the main sources of volatile compounds. Recent studies have demonstrated a strong correlation between air pollution and respiratory allergies, with airway chemical compounds intensifying the capacity of sensitization to allergenic pollens. This study presents an overview of the known negative elements on public health of the *Platanus* family.

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1. Introduction

Platanaceae are a family of flowering plants belonging to the *Proteales* order. The family contains one single *Platanus* genus, with eight known species. The plants are tall trees, native to subtropical and temperate regions of the Northern Hemisphere. Regionally, they are called plane tree or/and sycamores in some parts of the globe (1,2). The following are recognized species of the plane tree: *Platanus acerifolia* (London plane), *Platanus chiapensis, Platanus gentry, Platanus kerii, Platanus mexicana, Platanus oaxacana, Platanus occidentalis* (American sycamore), *Platanus occidentalis subsp. rzedowskii, Platanus orientalis* (Oriental plane), *Platanus racemosa* and *Platanus wrightii*. Species of this old family of angiosperms extending back to the early Cretaceous period have been long known to hybridize, with the London plane being the best example (3). Currently, the trees grow in temperate climates, mostly in cool conditions and they are frequently found in nature, on the banks of rivers and streams (1). In the last few decades, an important use for several species has been to provide shade in pedestrian areas of many cities from Europe and North America, due to their high resistance to contamination and other stress factors (1). Some species, such as the American plane, are cultivated for timber and biomass, while the Oriental plane is cultivated for minor medicinal uses (4).

Aerobiology is the science of airborne particles of biologic origin. Aeroallergens are dispersed through the air within particles of varying size and appear from diverse sources. Pollens represent the male gamete, which is transported to the female gamete, the ovary, in order to complete sexual reproduction. Pollen dispersal mechanisms occur by wind (anemophily) or through a vector, such as an insect (entomophily) (2). Anemophilous plants also hold allergic importance. In 1930, August Thommen set out five necessary principles, in order for a plant to be considered an important cause of pollinosis. First, the pollen must contain an excitant of hay fever, it must be anemophilous or wind-borne, it must be produced in sufficiently large quantities, it must be sufficiently buoyant to be carried for considerable distances and the plant producing the

pollen must be widely and abundantly distributed (5). Pollens can be produced by grasses, weeds and trees. The exposure to tree pollens may derive from forests, home landscaping and urban ornamental vegetation (urban street-trees). In the present review, we describe and analyze the respiratory allergies provoked by members of the Platanaceae family.

2. *Platanus acerifolia*

Platanus acerifolia/hispanica (London plane tree) is a hybrid of *Platanus occidentalis L.* and *Platanus orientalis L.*, frequently used as an urban tree, due to the numerous ecosystem services provided (6). The original cross may have occurred as early as the 1640s, after which this tree became widely planted in London and other major European cities, due to the perceived tolerance for urban pollution. Its main advantages are fast growing, good tolerance to urban microclimate conditions, resistance to soil compaction and air pollution (6,7). In addition, it has the ability to accumulate pollutants in the cortex (6,8) and a high capacity to capture particulate matter (6,9). It also has a phenotypic plasticity with resistance to drought and frost and moderate wind regimes (6,7). Furthermore, the London plane tree helps regulating the urban microclimate by offering an umbrella effect and supports biodiversity (6,10). As a result, the plane tree became popular as an urban tree in many important cities of the world, both in Europe and elsewhere in the world, including London, Sydney, New York and, more recently, in Eastern European capitals like Bucharest (6,9,11). Three allergens have been identified in *P. acerifolia* pollen. Pla a 1 is an 18-kDa non-glycosylated protein that has sequence homology to invertase inhibitory proteins and pectin methylesterase inhibitor proteins. Pla a 2 is a 43-kDa glycoprotein that displays polygalacturonase activity. Pla a 3 is a non-specific lipid transfer protein (12).

Conversely, the London plane tree has been associated with disservices and negative effects. Two major aspects are considered: Biogenic volatile organic compounds (BVOCs) and allergens (6). Biogenic volatile organic compounds produced by plants are involved in plant growth, development, reproduction and defense. They also function as communication media within plant communities, between plants and between plants and insects (13). The London plane tree is one of the principal tree species responsible for emitting monoterpenes and sesquiterpenes (6,14), known to be implicated in the generation of atmospheric ozone (6,15). The *Platanus* pollen has been identified by the European Academy of Allergy and Clinical Immunology (EAACI) as an important allergen responsible for respiratory symptoms and was introduced as mandatory to investigate pollen allergen in all patients with suspicion of allergic rhinitis in Europe (16). The London plane tree produces large amounts of pollen during the flowering period (more than four weeks in Spring from March to April) with an estimate of $3.3x10^6$ pollen grains per inflorescence (6,17) and a threshold of clinical symptoms in individuals sensitized to 50 grains of pollen/m^3 of air (6,18). These values may be influenced by different factors, such as meteorological parameters (19) and concentrations of air pollutants altering the allergenic potential in sensitive patients (20). Several studies have demonstrated the role of *Platanus acerifolia* pollen in respiratory allergies. *Platanus acerifolia* sensitization was 37.9% in 2009-2011 and 31.7% in 2015-2017 in the 'Panallergens in Pediatrics' study, a large multicenter survey of Italian children with seasonal allergic rhinoconjunctivitis (SAR) (21). High concentrations of allergic pollens including *P. acerifolia* were measured in Talca, Chile (22). A total of 34 patients from 118 subjects with allergic rhinitis presented IgE specific to *Platanus* pollen in a Spanish study (23). *Platanus acerifolia* sensitization was present in 11.4% patients in an allergic pediatric population of Cova da Beira, Portugal (24). The percentage of sensitization for *P. acerifolia* was 36.6% in a group of 210 patients with pollinosis (25). Some studies realized in Cordoba, Spain reinforced the role of *Platanus acerifolia* in urban allergies (26,27). Changes in annual pollen concentrations (an overall trend of increase in daily airborne tree pollen) for *Platanus spp* were shown to be associated with changes in the annual cycles of various meteorological parameters such as temperature, radiation, humidity, and rainfall in an aerobiological study that took place in Brussels between 1982 and 2015 (28).

3. *Platanus occidentalis* (American sycamore)

Platanus occidentalis, commonly called sycamore, American sycamore or Eastern sycamore, is generally regarded as the most massive tree indigenous to Eastern North America. The sycamore is native to lowland areas, typically reaching its largest size along streams, rivers and flood plains. The European settlers gave this tree the common name of sycamore, because its foliage resembled the sycamore of the British Isles (*Acer pseudoplatanus*), which is a maple (29). The monthly hospital admissions were significantly positively correlated with the monthly airborne pollen concentrations of *Platanus* pollen in the region of Porto, Portugal (30).

4. *Platanus orientalis* (Oriental plane)

Platanus orientalis, the Oriental plane, is representative of the Tertiary flora in Southwest Eurasia, distributed along river courses from the central Mediterranean to the Caucasus and India. *P. orientalis* is, among long-lived tree species, the one with the largest leaves in the Mediterranean region, which made it a valuable option for providing shade from ancient times (antique Greece and Rome) to Renaissance and modern times (31). Oriental plane tree is the dominant tree species in parks and streets in many cities of the Asian continent, in countries including Iran (32) and China (33,34). In Europe, it can be found in countries such as Italy (drier and warmer climate), Bulgaria (more humid and colder climate), Albania, Greece and Turkey (31). *P. orientalis* is a tall tree, 30 m in height, with massive branches. Its flowering occurs in April to mid-June (35). Three major allergens have been identified in *P. orientalis*: Pla or 1, a non-glycosylated protein, and a member of invertase/pectin methylesterase inhibitor family, with a molecular weight of 18 kDa; Pla or 2, a 43 kDa glycoprotein, and a polygalacturonase; and Pla or 3, belonging to non-specific lipid-transfer proteins (ns-LTPs), and a 9-10 kDa protein (12). The IgE-reactive components of *P. orientalis* pollen described earlier showed a higher level of

cross-reactivity with *P. occidentalis* pollen in comparison with *P. acerifolia* pollen in an Iranian study (32,36).

P. orientalis has also been studied in connection with urban pollution. Levels of Pla or 1 and Pla or 3 were considerably greater in pollen samples from highly polluted areas than in unpolluted areas, which can lead to an increase in the prevalence of allergic diseases, in a study realized in Mashhad, the second city as size in Iran (37,38). *Platanus* pollen allergenic protein (Pla a1, molecular weight of 18 kDa) increased in abundance following exposure to pollutant gases and vehicle exhaust particles in a study conducted in the town of Shanghai, China. The authors made a supposition that air pollutants can exacerbate the allergenicity of *Platanus* pollen (34). Species of *Platanus* were involved, along with other trees, in the emission of high levels of biogenic volatile organic compounds in the region of Beijing, China (33,39).

Plane trees were used as the first study case for creating a new aerobiological index: The Aerobiological Index of Risk for Ornamental Trees (AIROT). AIROT is a new tool designed to assist in urban planning and the assessment of potential allergenicity for urban green infrastructures. The plane tree was used due to its potential to provoke respiratory allergies and high use as an ornamental tree in the region of Extremadura, Spain (40-43).

5. Other *Platanus* species

Platanus racemosa (California sycamore, native to North America, North of Mexico) and *Platanus wrightii* (Arizona sycamore, native to North America, North of Mexico) is a moderate allergen, according to Pollenlibrary.com, but no other sources were found (44).

No information regarding possible implications in respiratory allergies were found for *Platanus chiapensis, Platanus gentry, Platanus mexicana* and *Platanus oaxacana*.

6. Conclusions

Plane trees have been used for centuries for urbanistic purposes, due to their ecologic properties, with beneficial results for the public environment. However, plane trees are responsible for the rising of allergic epidemics in urban zones and for producing organic volatile compounds with implications in creating air pollution. In the future, public authorities should put in balance the benefits and the pitfalls of using these trees in urban ecology.

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Authors' contributions

DV, ONB and AN contributed substantially to the conception and design of the study, the acquisition, analysis, and interpretation of the data, and were involved in the drafting of the manuscript. RC and MD contributed substantially to the acquisition, analysis and interpretation of the data and were involved in the drafting of the manuscript. RCC and CG contributed substantially to the acquisition of the data and were involved in the critical revisions of the manuscript for important intellectual content. All the authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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