Urban Forestry & Urban Greening 34 (2018) 281–293

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

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

Do the threats of alder and birch allergenic pollen differ within an urban area?

Katarzyna Borycka, Idalia Kasprzyk*

University of Rzeszow, Department of Ecology and Environmental Biology, 4 Zelwerowicza St., 35-601 Rzeszów, Poland

ARTICLE INFO

Keywords:
Aerobiology
Allergenicity
Alnus
Betula
Spatial variation
Urban tree

ABSTRACT

Currently, the increasing frequency of inhalant allergy is often linked to the urbanization effect. The pollen forecasts for a given city are most often prepared using data from one aerobiological station. However, there is evidence that the pollen concentrations in the air might differ depending on the city area and the height of the pollen trap. This study evaluated the spatial differences in the daily concentrations of alder and birch pollen grains in an urban area in relation to the proximity of the pollen sources and meteorological parameters. Pollen grains were sampled in Rzeszów in 2014–2016 by three volumetric traps located at the roof and nose levels in two city areas that differed in the numbers of alder and birch trees. The daily pollen concentrations were categorized into three allergy symptom thresholds. The relationship between the daily pollen concentrations and meteorological variables was examined using a redundancy analysis and circular statistics. There were spatial differences in the pollen season intensity and, to a lesser extent, the variability in its course. Generally, higher concentrations were registered at the roof level and in the city suburbs than at the nose level and in the downtown area where alder and birch trees were less numerous. Despite the spatial variability of the pollen concentrations and the differences in the proximity and abundance of pollen sources, the risks for allergy sufferers were similar throughout the city. It was concluded that the main cause of this phenomenon is the high dispersal abilities of *Alnus* and *Betula* pollen grains. Although temperature seems to be a crucial factor that influences the airborne pollen of both taxa, several weather variables were found to have complex impacts on the daily concentrations.

1. Introduction

The increasing frequencies of allergic respiratory diseases are often linked to urbanization effects (Šauliene et al., 2016). The reason might be not only exposure to air pollution components themselves (especially $PM_{2.5}$) but also the interactions between the particulate matter and a surface of pollen grains (Sénéchal et al., 2015). People living in urban areas are more affected by pollen-induced allergies than those living in rural environments (Timm et al., 2016), and some studies have suggested that long-term exposure to traffic-related air pollutants results in increased risks of plant pollen sensitivity (Wyler et al., 2000). Currently, widening urban green spaces is of particular interest when a majority of the population lives in cities, as green spaces improve the quality of life by directly influencing the health and well-being of the population as well as by improving air quality and microclimate conditions (Cariñanos and Casares-Porcel, 2011). Urban greenery is the most important source of pollen, and allergenic plant species can constitute up to two-thirds of urban greenery and therefore negatively affect human health (Cariñanos et al., 2017).

The standard aerobiological monitoring for pollen-induced allergy prediction usually involves one volumetric spore trap per city, which is situated in the centre of the city in most cases (Nowosad et al., 2015; Rojo et al., 2015). However, there is evidence that the pollen concentrations in the air might differ depending on the city area (Rodríguez-Rajo et al., 2010; Fernández-Rodríguez et al., 2014a) as well as the height of the pollen trap (Spieksma et al., 2000; Fernández-Rodríguez et al., 2014b). These differences might be caused by variations in the topoclimate, local topography, land use arrangements and street canyon configurations (Gonzalo-Garijo et al., 2006; Peel et al., 2014), which determine the air movement (Berkowicz et al., 1996) and influence the pollen transport and deposition within a city (Peel et al., 2014). The concentration altitudes are also strongly influenced by the proximity and abundance of local pollen sources (Cariñanos et al., 2002; Nowak et al., 2012; Fernández-Rodríguez et al., 2014a, b). The heights of plants that release pollen and the pollen dispersal abilities (Spieksma et al., 2000; Rodríguez-Rajo et al., 2010) must also be

* Corresponding author.
E-mail addresses: katarzyna.a.borycka@gmail.com (K. Borycka), idalia@univ.rzeszow.pl (I. Kasprzyk).

https://doi.org/10.1016/j.ufug.2018.07.013
Received 3 December 2017; Received in revised form 16 July 2018; Accepted 16 July 2018
Available online 18 July 2018

considered. The pollen of some taxa disperse in the air easily and despite the dilution of the grains, their concentrations could remain high in areas far from the source of release (Gonzalo-Garijo et al., 2006). The pollen of other taxa with low dispersal abilities fall rapidly and act only locally near the source of release (Cariñanos et al., 2002; Nowak et al., 2012; Alcázar et al., 2016).

The issue that is important to allergy sufferers is that pollen traps are most often located on roofs to reflect the regional aerobiological situation. However, some studies have indicated different pollen concentrations at the nose level than at the roof level (Tormo Molina et al., 2013; Peel et al., 2014; Alcázar et al., 2016). Consequently, the thresholds for provoking allergy symptoms that were distinguished based on roof level concentrations (de Weger et al., 2013) do not reflect the true danger for allergy patients. This aspect is very rarely studied and should be considered when preparing pollen forecasts.

Among the many allergenic pollen types, the tree taxa *Alnus* and *Betula* are characterized by the high clinical relevance of their allergens (Šauliene et al., 2016). The *Alnus* and *Betula* species are among the most frequent in urban spaces (Cariñanos and Casares-Porcel, 2011; Kuchcik et al., 2016) and have some of the highest allergenicity indexes (Cariñanos et al., 2017). Moreover, their abundance in Polish broadleaved forests is among the highest in Europe (Skjøth et al., 2008). Alder and birch pollen grains are small (in average 20–25 μm) (Rantio-Lehtimäki, 1995); therefore, they easily move throughout an urban space because of their high dispersal abilities.

The main research problem is the spatial differentiation of the daily concentrations of allergenic alder and birch pollen grains in an urban area in relation to the proximity of the pollen sources. For this reason, we conducted aerobiological monitoring in two city areas and at two heights and estimated the abundances of *Alnus glutinosa* and *Betula pendula* trees. It has been assumed that significant differentiations between stations would not exist throughout the pollen season, but the pollen concentrations would be higher in the areas where the pollen sources are more numerous. Are there local differences in the aeroallergen risks for citizens? This problem was examined by evaluating the number of days with concentrations above the threshold values at the roof and nose levels and in two city areas. Furthermore, this research aimed to examine the comprehensive influence of meteorological parameters on the daily pollen concentrations.

2. Materials and methods

2.1. Study area

The study was carried out in Rzeszów, which is a middle-size city in southeast Poland (50°01′45″N, 22°00′57″E; Fig. A1). For most of the year, the region is influenced by polar-maritime and polar continental air masses (Woś, 2002). In 1997–2016, the coldest month in Rzeszów was January with a mean temperature of -2.0 °C, and the warmest month was July with a mean temperature of 19.6 °C. The mean annual temperature was 8.9 °C. Over this period, the total mean precipitation was approximately 700 mm, with minimum values in January and February (37 and 35 mm, respectively) and maximum values in July (119 mm) (Tutiempo Network, 2017).

We located two sampling stations that were approximately 3 km apart in the downtown area and the city suburbs (Fig. 1). The downtown is a densely built-up area where blocks of flats and industrial buildings predominate. There are small groups of ornamental trees within the estates, and single trees or formed hedges are along the streets. There are more green spaces in the city suburbs than in the centre. Forests predominated by silver birch occur on the surrounding slopes. In addition, black alder and willow trees are numerous on small brooks. Single-family houses with gardens are the predominant buildings in this area.

A. glutinosa (L.) Gaertn. (black alder) and *Betula pendula* Roth. (silver birch) trees were frequently noted in the area of study (Borycka et al., 2017a). Silver birch is often planted due to aesthetic values, fast growth and small environmental requirements. It is frequent in urban parks, in urban forests, in a densely built-up area, as well as along the streets. Black alder prefers moist ground, so in contrast to the birch, it is not typical urban tree and is not planted in the city. However, a large part of the Rzeszów area is located in the Wisłok valley, which makes the groundwater level high. Moisture conditions favor the occurrence of black alder, especially besides the small flows that are numerous in the city suburbs. Thus it can be considered as often found in the city, although it is rare in a built-up area. It was estimated that the number of black alder trees in the 1 km buffer around the aerobiological stations in the city suburbs was approximately 220 individuals, and they usually form dense groups near the brooks. No black alder trees were noticed in the downtown area. According to the estimation downtown, there were 580 trees of silver birch, and they grew predominantly as solitaires or in small groups (up to 25 individuals). In the suburbs, approximately 1800 individuals were found in the forms of small forests (groups of hundreds of individuals) or as small groups or hedges (Fig. 1).

2.2. Aerobiological data

The objective of the study was to measure the airborne pollen grains of *Alnus* and *Betula*. The pollen grains were sampled by three Hirst's type volumetric spore traps in the period from 2014 to 2016. One trap was located downtown at the roof level at 12 m a.g.l. (AS 1), and two others were located in the city suburbs: one at roof level at 12 m a.g.l. (AS 2) and the second at nose level at 1.5 m a.g.l. (AS 3). The arrangement of the experiment allowed us to compare samples from two different sites in the city (horizontal gradient) and two different heights at the same site (vertical gradient). Because of technical problems, we obtained aerobiological records for alder from only two stations (AS 1 and AS 2). The aerobiological sampling as well as the preparation of microscopic slides and the counting of grains were done according to the procedures described by Stach and Kasprzyk (2005).The pollen grains were identified to the genus level (*Alnus* and *Betula*). For further analysis, the raw data were converted to daily concentrations per cubic metre (pollen grains·m^{-3}). The main pollen season (MPS) was determined according to criterion: the threshold values for allergy symptoms (de Weger et al., 2013). We assumed that the *Alnus* MPS began on the first day when the average daily pollen concentration reached the threshold value of 45 pg·m^{-3}, and the MPS ended on the last day at this value. For *Betula*, we assumed that the threshold value was 30 pg·m^{-3}. In 2016, three week after the end of the *Betula* pollination period (Borycka et al., 2017a) the concentrations substantially increased but as we earlier proved it was the result of long-distance transport (Borycka et al., 2017b). Therefore we did not take into consideration these days. We also distinguished the peak pollen dates (the day with the maximum concentration value in a year) and calculated SPIn index (the seasonal pollen integral; the sum of the average daily concentrations during the MPS - Galán et al., 2017). We also counted the number of days per year when the average daily concentrations exceeded the thresholds for allergy symptoms. Three threshold values were considered: no symptoms when the concentrations are below 45 and 30 pg·m^{-3} for alder and birch, respectively; 45-100 pg·m^{-3} for alder and 30-100 pg·m^{-3} for birch for the first symptoms; and above 100 pg·m^{-3} for both species for severe symptoms (de Weger et al., 2013).

2.3. Meteorological data

The meteorological station was situated in the city suburbs near AS 3 (Fig. 1). The following parameters were analysed: * minimum, maximum and mean temperature - Tmin, Tmax, Tmean (ºC); * mean relative humidity - H (%); * total precipitation - P (mm); * actual sunshine duration - I (s·h^{-1}), and * prevailing wind direction WD (º).