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Plant pollen content in the air of Lublin (central-eastern Poland) and risk of pollen allergy

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Abstract

Pollen monitoring was carried out in Lublin in 2001–2012 by the volumetric method using a Hirst-type spore trap (Lanzoni VPPS 2000). Daily pollen concentrations considerably differed in the particular years. The pollen counts with the biggest variability were observed in the first half of a year when woody plants flowering. The highest annual pollen index were noted for the following taxa: *Betula, Urtica*, Pinaceae, Poaceae and *Alnus*. *Betula* annual total showed the greatest diversity in the study years. The number of days on which the pollen concentration exceeded the threshold values, thereby inducing allergies, was determined for the taxa producing the most allergenic pollen. The above-mentioned taxa primarily included the following: Poaceae, in the case of which the highest number of days with the risk of occurrence of pollen allergy was found (35), *Betula* (18), and *Artemisia* (10). The following taxa: *Alnus* (14 days), *Populus* (11 days), *Fraxinus* (10 days), and *Quercus* (8 days), were also characterized by a large number of days on which their pollen concentrations exceeded the threshold values. The occurrence of periods of high concentration of particular pollen types were also noted. Risk of pollen allergy appeared the earliest at the beginning of February during *Alnus* and *Corylus* blooming. High concentrations of other woody plants were recorded from the last ten days of March to about 20 May, and of herbaceous plants from the first/last half of May – beginning of October.

Key words

pollinosis, risk, threshold pollen concentrations, Poland

INTRODUCTION

Knowledge about the taxonomic spectrum, seasonality, and concentrations of airborne pollen grains is particularly important from the aerobiological point of view. In recent years, a rapid increase in allergy incidence has been observed. Epidemiological research shows that pollen allergy is becoming a serious health and social problem in Poland. On the basis of a study carried out in the city of Łódź, allergy was diagnosed in 40% of children at school age [1], whereas after several years, already in more than 60% [2]. Many studies have demonstrated that children living in cities show a much higher prevalence of allergic diseases than children growing up in rural conditions [2, 3, 4]. Among various reasons, the higher exposure of urban children to traffic pollution and their more frequent use of drugs are mentioned [5, 6]. Over the last decades, a significant increase in pollinosis incidence has also been found in other European countries [7]. Pollen allergy is a seasonal disease and the course of the disease depends on airborne pollen concentrations. Aerobiological and allergological studies confirm a significant relationship between pollen concentration and disease symptoms in patients with pollen allergy [8, 9].

Airborne pollen of particular plant taxa exhibits different levels of allergic risk. That is why different threshold concentration values at which allergy symptoms occur in most sensitive people have been determined for many pollen types. The pollen of *Ambrosia* which induces allergy already at low concentrations (20 P/m^3) shows the strongest allergenic properties [10]. On the other hand, the pollen of Cupressaceae/Taxaceae exhibits a weaker sensitizing effect, which is reflected in the higher threshold values determined for these types of pollen (200 P/m^3) [11]. Large pollen grains, for example, of *Fagus* are carried away from the parent plant for short distances and fall to the ground quite quickly, and they are therefore recorded in small amounts in pollen monitoring. Hence, the appearance of *Fagus* allergy seems to be rather seldom.

The strongest pollen allergens of deciduous trees from Fagales order (*Alnus*, *Betula*, *Carpinus*, *Quercus*) are identified as ribonucleases, while in coniferous trees and herbaceous plants of the family Asteraceae, the major allergens are pectin lyases, which are involved in the degradation of pectins [12].

The aim of the presented study was to determine the number of days and periods of occurrence of pollen concentrations exceeding the threshold value at which most allergic people show allergy symptoms with respect to some allergenic taxa. The range of fluctuations of pollen concentrations for all plant taxa recorded in the air of Lublin is also presented. Moreover, an analysis was performed of the variations in annual pollen counts for some types of pollen, dividing them into 3 groups, depending on their percentage in the pollen spectrum which is associated with the level of risk to allergy sufferers.

MATERIAL AND METHODS

The aerobiological study was conducted in Lublin from 2001–2012. A Lanzoni VPPS 2000 pollen sampler was placed on the roof of a building at a height of 18 m above ground level, near the centre of city. Qualitative and quantitative microscopic

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analysis of the pollen collected on the tape was performed on 4 longitudinal transects of the slide. On the basis of the percentage of annual totals of particular pollen types in the pollen spectrum of Lublin, 3 groups were created: with a high (7–24%), medium (0.7–3.7%), and low (0.1–0.6%) pollen content in the air. They are presented separately in charts, including some descriptive statistics.

The number of days and dates on which the pollen concentration exceeded the threshold value were determined for some plant taxa. The threshold value for individual taxa followed Rapiejko [13] (*Corylus, Alnus, Betula, Quercus, Fagus*, Poaceae, *Secale, Artemisia*), Galan [11] (Cupressaceae/ Taxaceae, *Populus, Ulmus, Fraxinus, Carpinus, Rumex, Plantago,* Chenopodiaceae, Asteraceae), and Jäger [10] (*Ambrosia*).

RESULTS

Over the 12-year study period (2001–2012), the atmospheric pollen season in Lublin lasted, on average, from the end of January – beginning of October. During the remaining period, single pollen grains were recorded (<5 P/m^3). Between years, there were very large differences in pollen concentration on particular days of the year. Figure 1 shows a comparison of maximum and minimum pollen concentrations of all plant taxa relative to the mean values for the 12-year study period. The pollen concentration in the first half of the year was characterized by the highest variation, whereas the lowest variation was found during the period from 2 June – 30 August. The difference between daily maximum and minimum concentration was particularly high during the tree pollen season.

On 25 April 2003, a record number of pollen grains was recorded (13,604 P/m^3), while on the same day in 2009, there were more than 70 times fewer grains (185 P/m^3). During the pollen shed of herbaceous plants, on the other hand, only 9 times higher concentrations were found on 29 June of the year with the maximum pollen concentration (1,474 P/m^3), compared to the year with the minimum concentration (158 P/m^3) (Fig. 1). On average, 70.4% of the total annual pollen count for all taxa was recorded in the first half of the year, from the beginning of January – end of June. A comparison of the seasonal dynamics of pollen content in the air of Lublin in the years of extreme annual totals, with the highest pollen count in 2010 and the lowest in 2009, also demonstrates that the largest differences in pollen content relate primarily to the first part of the pollen season, associated with pollen release by trees and shrubs (Fig. 2).

The variations in annual pollen sums of particular taxa are shown in a chart illustrating basic descriptive statistics (median, quartiles, min, max). It demonstrates that the highest annual sums were recorded for *Betula*. At the same time, in the case of this taxon, the highest difference was observed between the maximum and minimum value (Fig. 3A). The annual sums of *Betula* pollen ranged from 3,266 – 34,134 pollen grains, with a median of 15,541. The median of the annual count of *Urtica* pollen was 15,985, while the lowest and highest values were, respectively, 10,730 and 26,846 pollen grains. The median of the annual Pinaceae pollen sum was 6,977 pollen grains, with the extreme pollen counts of 4,509 and 10,515. The annual pollen counts of Poaceae, compared to other types of pollen reaching high percentages, were

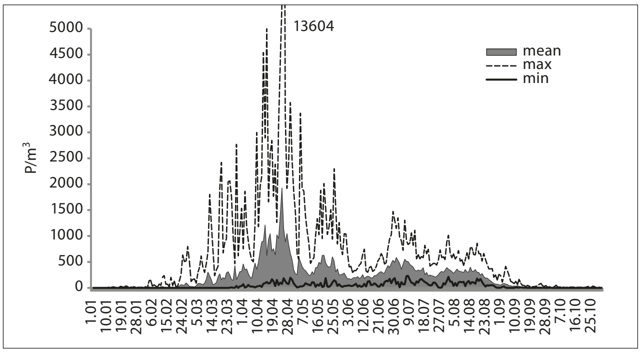

Figure 1. Mean, maximum, and minimum pollen concentrations of all plant taxa during the pollen season in Lublin, 2001–2012

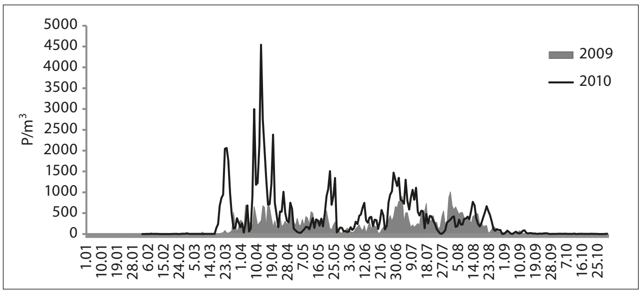

Figure 2. Daily pollen concentrations of all plant taxa in years with the highest (2010) and lowest (2009) annual pollen index

characterized by low dispersion and a median of 6,309 pollen grains, with fluctuations from 3,966 – 8,301. The median of the annual sum of *Alnus* pollen reached 4,716, whereas the lowest and highest counts were 1,133 and 8,712 pollen grains, respectively (Fig. 3A). Analysis of the annual totals for taxa of medium pollen content in the air demonstrates that *Populus* and *Fraxinus* were characterized by the highest variation, while *Plantago* showed the lowest variability (Fig. 3B). Statistical analysis of the annual pollen sums for taxa of low pollen content in the air shows that the largest dispersion of this trait related to *Tilia* and Chenopodiaceae, while the lowest one to *Sambucus* (Fig. 3C).

The risk of occurrence of pollen allergy symptoms in Lublin occurred earliest at the beginning of February (in 2002) and was associated with the presence of *Alnus* and *Corylus* pollen grains in the air. *Alnus* pollen concentrations exceeding the threshold value occurred in the period from the beginning of February – middle of April, on average for 14 days, whereas in the case of *Corylus* from the first decade of April, on average for 7 days (Tab. 1). In particular years, these dates varied and were dependent on weather conditions. High concentrations of *Populus* and *Fraxinus* pollen were recorded, on average, for 11 and 10 days, respectively: for *Populus* in the period from the second decade of March – end of April, while for *Fraxinus* from the second decade of April – beginning of May. The pollen of *Ulmus* and *Fagus* was observed in low concentrations and very rarely reached the threshold value.

In the case of trees, the highest number of days with pollen concentration exceeding the threshold value was observed for *Betula*, on average 18. High concentrations of *Betula* pollen occurred in the period between 5 April – 20 May. The pollen of *Carpinus* reached the threshold value from the second decade of April – beginning of May, on average for 3 days. As regards *Quercus*, pollen concentrations exceeding the

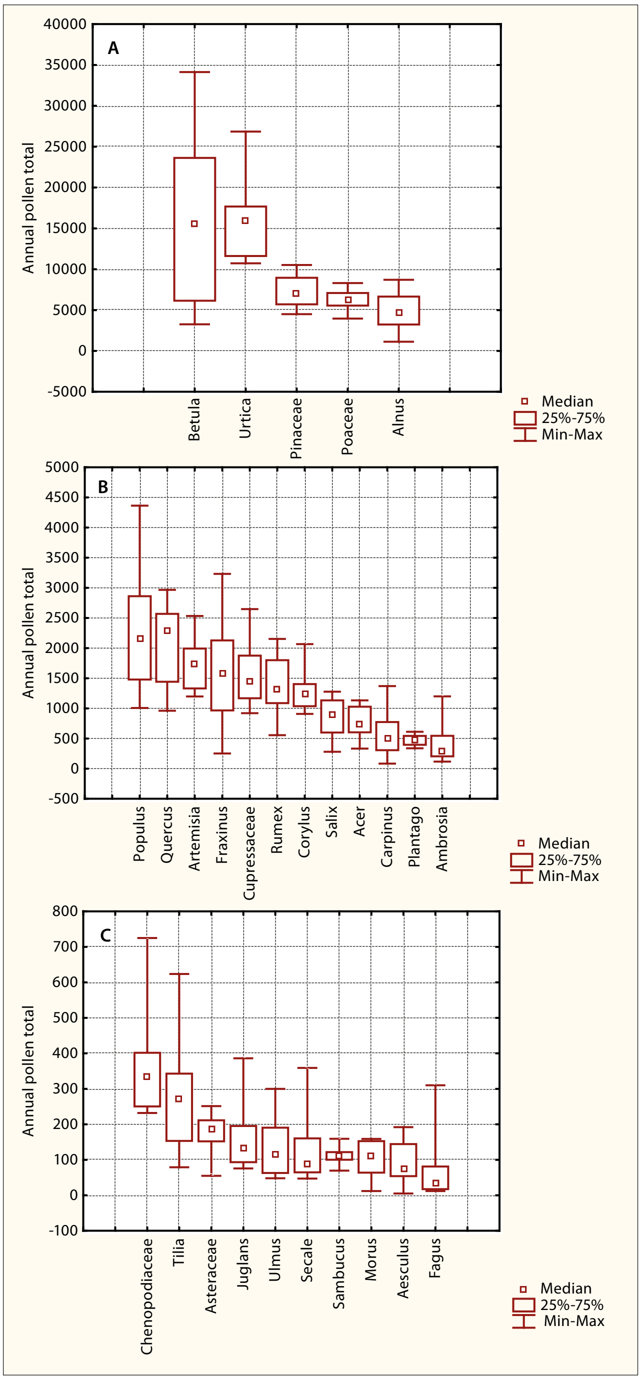

Figure 3. Variation in annual pollen sums for all plant taxa reaching high (A), medium (B), and low (C) percentages in the pollen spectrum

threshold value were recorded on average on 8 days, from the end of April – middle of May. High concentrations of Poaceae pollen occurred for many days (on average 35) during the growing season, from the middle of May – end of July. The pollen of *Secale* rarely posed a threat during a period of 7 days in the second half of May. The concentration of *Rumex* pollen reached a level exceeding the threshold value on average on 4 days, in the period from the first decade of June – the last decade of July.

Throughout the study period, low concentrations of Chenopodiaceae pollen posed a risk to allergy sufferers only in the last decade of August. High risk of *Artemisia* pollen occurred on average on 10 days within a period of 2 months, from the end of July – end of September. The concentration higher than the threshold value for *Ambrosia* pollen was observed, on average, over a period of 5 days from the middle of August – beginning of October (Tab. 1). Asteraceae and *Plantago* taxa showed low airborne pollen counts not exceeding the threshold value (50 P/m^3).

In particular years of the study, the largest differences in the dates of occurrence of pollen concentrations with the threshold value were observed for *Alnus* and *Corylus,* as well as for *Artemisia* and *Ambrosia*, while the lowest occurred for *Ulmus, Fagus*, and *Quercus*. The highest number of days with pollen concentration exceeding the threshold value was found for Poaceae, *Betula,* and *Alnus* (Tab. 1).

Table 1. Threshold values characterization of selected allergenic taxa in Lublin 2001–2012.

Taxon	Threshold (P/m^3)	Pollen concentration over threshold				
		No. of days			Occurrence dates	
		Mean	Min	Max	Earliest	Latest
Corylus	35	6.8	3	12	4.02	10.04
Alnus	45	14.2	6	20	4.02	17.04
Cupress./Taxaceae	200	1.3	0	3	21.03	25.04
Populus	50	10.7	5	20	11.03	26.04
Ulmus	50	0.2	0	1	19.04	19.04
Fraxinus	50	10.2	1	17	11.04	4.05
Betula	80	18.4	11	25	5.04	20.05
Carpinus	50	3.3	0	7	12.04	3.05
Quercus	80	7.6	1	11	28.04	16.05
Fagus	80	0.1	0	1	6.05	6.05
Poaceae	50	34.8	16	42	15.05	30.07
Secale	50	0.3	0	2	19.05	26.05
Rumex	50	3.9	0	15	9.06	24.07
Chenopodiaceae	50	0.1	0	1	28.08	28.08
Artemisia	55	10.3	3	20	25.07	25.09
Ambrosia	20	4.8	1	8	13.08	4.10

DISCUSSION

Poland is one of European leaders in the incidence of allergic rhinitis [14, 15]. The knowledge of airborne pollen content is necessary for proper diagnosis and treatment of pollen allergy. Due to the huge scale of this phenomenon, pollen monitoring is important not only for medicine, but also for economics and the economy. Poaceae, *Betula,* and *Artemisia* belong to taxa the pollen of which most frequently causes pollen allergies in Poland [13]. On the basis of epidemiological research conducted in Łódz in the period 2003–2006, the frequency of sensitization to allergens of particular plant taxa was determined. It was found that in the case of trees, sensitization to *Betula* pollen was the most frequent (81.0%), followed by *Alnus* (72.2%), *Corylus* (70.4%), *Fagus* (70.8%), and *Quercus* (68.1%). The allergic reaction to Poaceae pollen was observed in 94.2% – 96.5% of patients. Among other herbaceous plants, sensitization to mugwort (80.1%) and Chenopodiaceae (75.1%) was found to be the most frequent [16].

During the period 2001 – 2012 in Lublin, pollen grains of Poaceae, *Betula,* and *Artemisia* at a concentration exceeding the threshold value were recorded for a relatively long period of time, on average 35, 18, and 10 days, respectively. The pollen of other allergenic taxa was observed in the air at high concentrations for 1 – 14 days, but pollen grains of *Fagus, Ulmus,* and Chenopodiaceae sporadically reached the allergologically relevant level.

Clinical manifestations of allergies to plant pollen are rhinoconjunctivitis, asthma, and more rarely contact dermatitis or urticaria [17]. The above-mentioned authors found that there was a significant correlation between daily allergy symptoms and pollen concentration, but the risk of developing symptoms during the levels of low, moderate and high concentrations was affected by the progression of the pollen season. Bronchial hyper-responsiveness is higher still for several weeks after the end of exposure to pollen [17]. Many authors stress that the sensitivity threshold at the start of the season and during it differs. Vik et al. [18] showed that at the beginning of the season most allergic people had allergy symptoms at a concentration of birch pollen above 80 P/m^3, whereas during the late pollen season symptoms in patients persisted at a pollen concentration of 30 P/m^3. Due to many factors on which sensitization depends, the threshold value of pollen concentration for particular persons can be different. People who show higher individual sensitivity and have longer and more frequent exposure to pollen grains floating in the air will react at relatively low threshold levels. Sensitization to *Ambrosia* pollen can begin with as little as 5 – 10 P/m^3 [19] or 10 – 20 P/m^3 [20]. Weisel et al. [21] found that the threshold values for grasses at which clinical symptoms occurred in the conditions in Israel were 3 – 5 P/m^3, for mugwort – 4 – 5 P/m^3, for *Cupressus* – 50 – 60 P/m^3; these are lower values than those given by other authors and the ones included in Table in the presented study. The study conducted in Israel found that clinical symptoms appeared when the pollen concentration exceeded the threshold level, and disappeared when the pollen concentration fell below this level [21].

In real life conditions, the exposure to pollen varies between the subjects, which is associated with individual sensitivity of an allergic person and his/her lifestyle. Time of exposure to plant pollen, the place of residence and work in connection with the distance to pollen sources, different behaviours, e.g. riding a bike, sleeping with the window open, driving with the vehicle windows open, etc., are of great importance. Allergic people may avoid or at least reduce the risk of symptoms by staying mainly indoors during the time of high pollen concentrations [17].

CONCLUSIONS

1. Pollen grains of Poaceae, *Betula*, and *Artemisia,* which pose the highest allergy risk in Poland, occurred in Lublin for many days at a concentration exceeding the threshold value, that is, for 35, 18, and 10 days, respectively.
2. The following taxa: *Alnus* (14 days), *Populus* (11 days), *Fraxinus* (10 days), and *Quercus* (8 days), were also characterized by a large number of days on which their pollen concentrations exceeded the threshold values.
3. Pollen occurring in amounts exceeding the threshold values on one day poses short-term allergenic risk; this applies to the following taxa: *Ulmus, Fagus, Secale*, and Chenopodiaceae.

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