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Pollen monitoring in Perm Krai (Russia) – experience of 6 years

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Abstract

Medical observations show that the level of pollinosis increased by 34.6% in central Russia in 2005–2012. This paper presents the results of 6-year pollen monitoring carried out with a Hirst-type pollen trap (Burkard Manufacturing Co. Ltd) between 2010 and 2015 in Perm Krai (Russia). Usually, sensitization of allergic people occurs in three periods: (***i***) spring due to the pollen of *Betula*, (***ii***) early summer due to Poaceae pollen, and (***iii***) late summer as a result of *Artemisia* pollen. *Betula* pollen, which is dominant (26.9–65.2% of total pollen counts), is recorded in large numbers in the period of flowering and occasionally during the entire period of pollination. Among herbaceous plants, the pollen of Poaceae, Urticaceae and *Artemisia* dominates in airborne pollen. The concentration of allergenic pollen grains in the air of Perm Krai is lower than in other European geographical regions.

Keywords: aerobiology; pollen monitoring; *Betula*; Poaceae; *Artemisia*

Introduction

Pollen allergy is a harmful problem for people worldwide and substantially decreases the quality of life of patients [1]. In recent decades, an increasing trend in seasonal allergies has been noted in many geographical regions, including Russia. For example, a considerable rise of all kinds of allergies was observed in Moscow between 1992 and 2012 [2]. Allergic symptoms are recognized to increase irrespective of gender or age. A particularly significant increase in incidences of pollinosis was discovered among children; it was 89.6 incidences per 100 000 in 1990 and 147.7 per 100 000 in 1999 [3]. Medical records in the Perm region (Russia) revealed a 34.6% rise in allergic rhinitis incidences (hay fever) between 2005–2012 [4]. In the Perm region, the most intense and frequent immune sensitization of allergic people is recorded in early spring. It is associated with the occurrence of allergenic airborne tree pollen. Moreover, sensitization is due to grasses and sagebrush. It is accepted that information about the concentration of allergenic pollen in the air is essential for allergic patients. In Perm Krai, the analysis of airborne allergenic pollen has been conducted since 2008 [5]. Since 2010, the aeropalynological data of the Perm region have been included in the Russian pollen monitoring program [6]. In Russia pollen monitoring with volumetric traps began developing rapidly from 1993. Currently, this monitoring program integrates more than 20 stations (i.e., in Moscow, Perm, Astrahhan, Barnaul, and St. Petersburg). In Europe pollen monitoring has a long tradition of systematic data collection supported by national programs over the decades. The European Bank of Aeropalynological Data contains information from many aeropalynological stations from different countries [7].

The objective of the study was to create a pollen calendar for the predominant types of allergenic pollen in the air in Perm Krai over a 6-year time period. A preliminary analysis of three dominant taxa was carried out.

Material and methods

Perm Krai is situated in the eastern part of the Russian Plains and the western foothills of the southern part of the North and Middle Urals. The length of its territory from north to south is 645 km, from west to east 417 km. The climate is temperate continental. The vegetation of the Perm Krai is diverse; steppe vegetation (Kungur island forest-steppe), broad-leaved/coniferous forests, southern and middle taiga, foothill and mountain taiga, and mountain tundra communities are found there. The specific feature of the flora is the penetration of Siberian and Asian species. Perm city is situated in the part of broad-leaved/coniferous forests. The city is the only place with a pollen trap in Perm Krai.

Monitoring of airborne pollen was carried out during the 2008–2015 period (1 April to 30 September). Over this period, two methods were applied: gravimetric (2008–2009) and volumetric (2010–2015). The traps were located in

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the city center (58°00′29.1″ N, 56°11′12.5″ E). In this paper the data from the years 2010–2015 are reported, i.e., those obtained using the volumetric method, and therefore it is possible to provide a comparison of our data with those reported in other studies.

The gravimetric method was applied using a Durham trap. The volumetric method of pollen monitoring was carried out with a Hirst-type pollen trap (Burkard Manufacturing Co. Ltd). The trap was installed at a height of 20 m a.g.l. on the roof of the building of the Perm State National Research University in 2010. The research methodology followed the recommendations of the International Association for Aerobiology.

Annual pollen load (APL) and principal pollination period (PPP) were estimated for the main allergens (*Betula*, Poaceae, *Artemisia*). The APL is expressed in pollen per m^3 (Fig. 1). Statistical values [mean, standard deviation (*SD*)] and the coefficient of variation (*CV*%) were calculated (Tab. 1). Estimation of PPP: beginning with 1% and ending with 99 % of the annual pollen count.

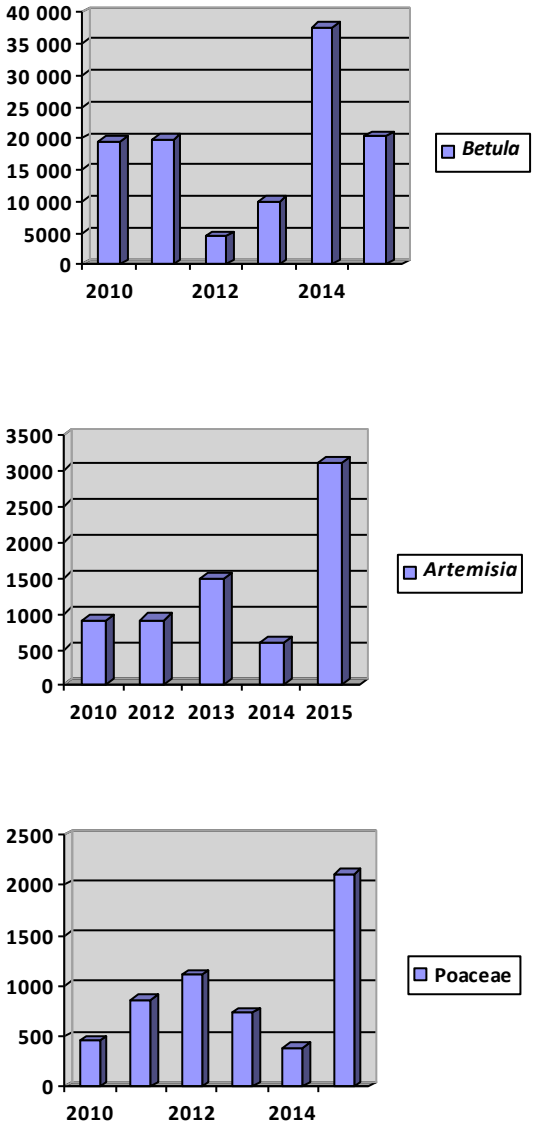

Fig. 1 Values of the annual pollen load. Dynamics of APL.

Results

The study of the qualitative and quantitative characteristics of pollen grains in the atmosphere of the city of Perm revealed that 21 pollen types occurred as part of the aeropalynological spectrum. Sixteen pollen genera and families, which had dominant pollen types in the pollen spectrum and strong allergenic properties, were selected for the pollination calendar (Tab. 2).

We distinguished 10 taxa of woody plants (*Acer*, *Alnus*, *Betula*, *Corylus*, *Picea*, *Pinus*, *Populus*, *Quercus*, *Salix*, *Tilia*) as dominants (ca. 80%) of airborne allergenic pollen in the city of Perm. Six taxa of herbaceous plants (*Artemisia*, Chenopodiaceae, *Plantago*, Poaceae, *Rumex*, Urticaceae) constituted ca. 20% of the total pollen found. *Ambrosia* pollen was found occasionally and perhaps it was adventitious, because so far no *Ambrosia* sites have been found in the Perm region. The prevalence of pollen grains of woody plants is mainly associated with the peculiarities of the city's flora.

The pollen season started in the first or second decade of April and finished in the second or third decade of September; the pollen season duration averages 17 decades.

Betula pollen (Fig. 2a) predominates in the aeropalynological spectrum among woody plants. These pollen grains constitute 26.9–65.2% and are recorded in the period of mass flowering and sporadically throughout the season. Among herbaceous plants, the pollen of Poaceae, Urticaceae and *Artemisia* (Fig. 2b) dominates.

There are significant fluctuations in the overall pollen productivity throughout the season: from 24 526 to 65 113 annual total P/m^3 (Tab. 1).

The duration, period and intensity of pollen shed of allergenic plants varied considerably between seasons (Tab. 3). Pollen productivity varied between species and between seasons. For example, the minimum and maximum number of *Betula* pollen grains differed 8.3 times between pollen seasons, Poaceae – 5.5 times, *Artemisia* – 5.3 times. The date of maximum daily concentration of pollen grains for these plants also varied – by 20 days for *Betula*, 13 days for Poaceae, and 29 days for *Artemisia*. Three pollen shed periods were distinguished. The pollen release peaks correlated with an increase in the number of patients with acute hay fever: spring (pollen shed of trees with *Betula* as the dominant pollen type), early summer (pollen shed of Poaceae), and late summer (pollen shed of *Artemisia* and weeds).

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Tab. 1 Aeropalynological characteristics of major allergenic pollen in Perm Krai (Russia) in 2010–2015.

Indicators	Year						Mean	Variance
	2010	2011	2012	2013	2014	2015		
Total number of pollen grains per season (P/m³)	29852	35878	24526	31907	57637	65113	40819	16508.3
Betula – total number of pollen grains per season (P/m³)	19473	19764	4483	10111	37267	20314	18569	11179.1
Betula – max daily concentrations during the season (P/m³)	3388	3227	449	1036	7296	2540	2989	2418.0
Betula – date of maximum concentration (day, month)	5.05	8.05	13.05	25.05	11.05	15.05	-	-
Poaceae – total number of pollen grains per season (P/m³)	460	861	1109	734	391	2147	950	642.7
Poaceae – max daily concentrations during the season (P/m³)	51	51	144	67	48	271	105	89.0
Poaceae – date of maximum concentration (day, month)	29.06	2.07	3.07	21.06	4.07	28.06	-	-
Pollen production of *Artemisia*	931	917	1483	592	580	3086	1265	950.6
Artemisia – max daily concentrations during the season (P/m³)	47	79	132	60	152	401	145	131.9
Artemisia – date of maximum concentration (day, month)	11.08	26.07	18.07	13.07	9.08	30.07	-	-

Tab. 2 Pollination calendar of allergic plants in Perm city, Russia. Mean values for 2010–2015 are given.

Taxon	Month (pollen grains/m³)																
	April			May			June			July			August			September		
Woody plants																	
Acer		2.7	20.5	732.6	482.0	20.3	1.3										
Alnus	9.4	498.4	535.2	47.2													
Betula	3.3	31.5	1236.2	8346.5	2159.0	1340.1	268.8	27.3	10.5	5.3	6.0						
Corylus		2.3	42.3	347.6	6.2	15.0	6.0	4.5	4.6	2.7	3.9	2.0					
Picea				13.9	50.8	77.8	28.9	7.0	0.5								
Pinus			1.3	196.0	694.8	1489.6	1089.1	89.0	6.5	2.1							
Populus	0.8	3.0	121.5	530.4	190.5	7.5	3.2	0.8									
Quercus		2.5	2.5	23.5	21.5	34.6	11.8	5.3	4.5	0.3	1.0						
Salix	1.0	11.0	35.3	141.8	165.1												
Tilia								0.9	13.0	70.5	31.7	40.5	0.4	0.8			
Herbaceous plants																	
Artemisia								1.0	0.2	2.0	27.7	216.5	267.1	111.6	32.8	20.6	16.9	3.6
Chenopodiaceae							0.5	3.3	13.2	15.1	20.2	65.9	31.8	35.4	21.9	17.8	3.1	
Plantago							7.5	13.7	245.3	219.2	30.8	34.2	46.4	15.5	0.6	1.1	0.8	
Poaceae						5.8	7.3	64.5	182.0	119.8	40.1	32.8	32.4	49.0	5.7	2.0	0.8	
Rumex						4.1	18.7	55.6	154.6	697.0	260.3	110.0	40.4	18.3	0.8	1.3	0.8	
Urticaceae						7.1	32.5	25.3	277.4	177.7	212.4	120.4	206.8	129.9	46.3	10.2	16.1	4.9

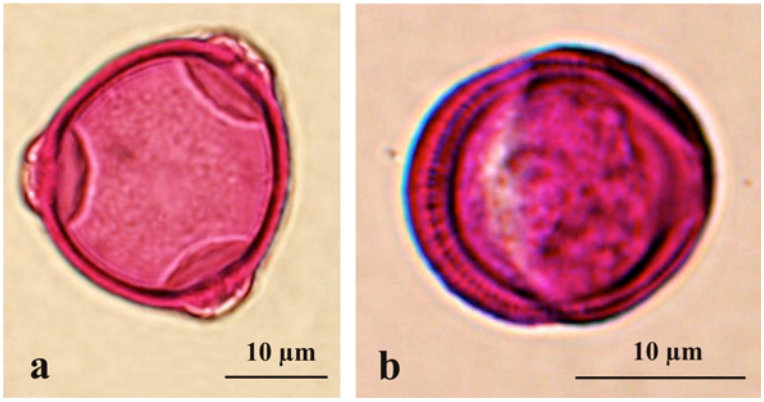

Fig. 2 Selected pollen grains in the air of Perm Krai (Russia). **a** *Betula* sp. – polar view. **b** *Artemisia* sp. – equatorial view.

Tab. 3 Characteristics of *Betula*, Poaceae and *Artemisia* pollen seasons in Perm Krai in the years 2010–2015 (based on the 98% method).

Pollen type	Year	Pollen seasons		
		Start (day, month)	End (day, month)	Length (days)
Betula	2010	24.04	21.05	27
	2011	30.04	21.05	16
	2012	16.04	6.07	81
	2013	22.04	12.06	51
	2014	29.04	29.05	30
	2015	30.04	29.05	22
Poaceae	2010	4.06	13.08	70
	2011	11.06	22.08	72
	2012	31.05	26.08	86
	2013	27.05	5.09	101
	2014	1.06	24.08	84
	2015	1.06	3.08	63
Artemisia	2010	13.07	5.09	54
	2011	17.07	19.09	64
	2012	25.06	23.08	59
	2013	13.07	21.09	70
	2014	16.07	28.08	43
	2015	18.07	14.08	27

Discussion

The number of people suffering from allergy reaches 15–30% of the population and pollinosis – the most often observed allergy – occurs in about 10–15% of the world's population. Harm reduction and minimization of pollen allergy symptoms are strictly related to the avoidance of exposure to large allergen loads. The knowledge of potentially allergenic pollen counts (pollen calendars) in a given area is of great importance for allergic patients as well as for the determination of the origins of the disease and recommendation of the most effective therapy. Aerobiological studies providing data on exposure to allergens in the air are of substantial importance for pollen allergy diagnosis.

In the Perm region, the aeropalynological profile is typical for central Russia. Therefore, we assume that the types of allergenic pollen commonly present in the air in the studied region should be included in the Russian pollen monitoring program [8].

Tab. 4 The average duration of the pollen seasons of the taxa dominant in the air of Perm Krai, Russia. The mean, standard deviation, and coefficient of variation for 2010–2015 are given.

Pollen type	Mean days	±*SD*	*CV*%
Betula	37.8	24.3	64.1
Poaceae	79.3	13.7	17.3
Artemisia	52.8	15.6	29.6

We found year-to-year variability in the start of pollen seasons and a disparity in pollen productivity of many taxa. This is in agreement with the previous finding [9–11] and proves the feasibility of long-term observations within the monitoring framework.

The number of pollen grains recorded during the pollen shed season in the European Aeroallergen Network is as follows: *Alnus* – up to 8055 p.g., *Ambrosia* – up to 14 590 p.g., *Artemisia* – up to 2287 p.g., *Betula* – up to 32 708 p.g., Chenopodiaceae – up to 3013 p.g., *Corylus* – up to 3239 p.g., Cupressaceae/Taxaceae – up to 36 442 p.g., Poaceae – up to 12 353 p.g., *Quercus* – up to 19 187 p.g., *Urtica*/*Parietaria* – up to 68 652 p.g. [7]. The 6-year averages calculated for the Perm region show lower values of pollen grains for all taxa (for example, *Artemisia* – 1269, Poaceae – 950, *Betula* – 18 568). The possible explanations for the disparities might relate to the divergence of vegetation between geographical regions or air pollution.

The genus *Artemisia* is found from the Mediterranean zone in the south to the sub-Arctic zone in the north and it is an important source of allergenic pollen in the East European vegetation region [12]. *Artemisia* pollen is capable of sensitizing people [13]. The frequency of *Artemisia* sensitization among patients suffering from pollinosis in Europe has been estimated as being between 3% and 15% [14], while the concentration of mugwort pollen just above ground level is several times higher than at a height of 15–25 m [15].

Poaceae belong to one of the most species-rich families in the world. Representatives of the grass can be found in almost every habitat. In the temperate zone of Europe, the grass pollen is the most important agent causing pollinosis. Poaceae pollen allergens are the most frequent cause of allergic inflammation of nasal mucosa and conjunctivitis. In France and the Netherlands, about 80% of pollinosis sufferers are allergic to antigens of Poaceae pollen [16]. The number and species of airborne pollen vary according to the time of day, weather conditions, geographical location, and proximity to pollen sources. The distance from a source of grass pollen is important especially for allergy sufferers. With very few exceptions, all grass pollen types show a very high degree of cross-reactivity within the genera of the Poaceae family, and also with *Betula* and *Artemisia* pollen. It makes Poaceae pollen monitoring necessary worldwide.

Betula pollen is one of the main causes of allergy during spring in Perm Krai. Currently, *Betula* pollen is observed in Northern and Central Europe in early spring and early summer. Birch pollen is abundant in the air during April and May, and is a well-known major tree allergen in Central and Northern Europe with a significant impact on human health. Estimates suggest that between 10 and 20% of the population of Northern and Central Europe are allergic to birch pollen [17].

The current opinion on climatic change is that global warming will continue but the resultant rates and patterns of temperature changes are uncertain. In this scenario, it is useful to know the likely responses in the phenology of species, especially those with direct implications for health. In the case of the birch, Poaceae and *Artemisia*, there is increasing awareness of their importance for allergy.

To sum up, airborne pollen concentrations depend on many factors, including the vegetation structure, the ability of particular taxa to spread their pollen, and the topoclimate and weather conditions in the current and preceding years. The distribution and vegetative development of plants as well as their reproductive habits are influenced by their geographical location, climate and meteorological parameters. Pollen seasons generally become shorter and less intense at higher latitudes, which is associated with the lower number of pollen grains. But annual meteorological parameters have a greater influence on the duration and intensity pollen seasons of individual plant species than their location.

Conclusions

In Perm Krai, sensitization of allergic people is related mainly to the occurrence of the allergenic pollen of *Betula*, Poaceae, and *Artemisia*. Intensification of allergy symptoms is observed in spring (which is related to *Betula* pollen), in early summer (Poaceae), and in late summer (*Artemisia*).

The pollen of *Betula* dominates in the aeropalynological spectrum (26.9–65.2%); it is recorded in large numbers in the period of flowering and occasionally in during the entire period of pollination.

On average, the concentration of allergenic pollen grains in the air of Perm is lower than in other European geographical regions.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: idea of the study: LN, NM; laboratory analyses: LN, NM; tables and graphs: LN, NM; writing the paper: LN, NM.

Competing interests

No competing interests have been declared.

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Monitoring pyłkowy w Kraju Permskim (Rosja) – doświadczenie z okresu 6 lat

Streszczenie

Obserwacje medyczne wskazują, że poziom zachorowań na pyłkowicę w centralnej Rosji wzrósł o 34.6% w latach 2005–2012. Niniejsza praca przedstawia rezultaty z 6-letniego okresu monitoringu pyłkowego prowadzonego z wykorzystaniem aparatu typu Hirsta (Burkard Manufacturing Co. Ltd) w Kraju Permskim (Rosja), w latach 2010–2015. Objawy alergii u ludzi uczulonych występują zazwyczaj w trzech okresach: (***i***) wiosną z powodu występowania pyłku *Betula*, (***ii***) wczesnym latem z powodu pyłku Poaceae oraz (***iii***) późnym latem w wyniku występowania pyłku *Artemisia*. Pyłek *Betula*, który jest dominujący (26.9–65.2% sum pyłku), jest notowany masowo w okresie kwitnienia oraz sporadycznie w trakcie całego okresu pylenia. Spośród roślin zielnych pyłek Poaceae, Urticaceae i *Artemisia* jest dominujący wśród pyłku występującego w powietrzu. Stężenie alergennego pyłku w powietrzu w Kraju Permskim jest niższe niż w innych europejskich regionach geograficznych.