Birch pollen grains without cytoplasmic content in the air of Szczecin and Bialystok

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Abstract: Birches, due to their wide ecological amplitude are components of almost all woodland communities from very dry dune pine forests to mires, from poor to fertile ash-elm carrs and also birch pollen has the potential to be transported long distances from one region to another. This paper presents course of the pollen season and comparison of the concentrations of birch pollen grains with and without cytoplasmic content in Szczecin and Bialystok. Measurements were performed by the volumetric method (Burkard and Lanzoni pollen samplers). Pollen season was defined as the period in which 98% of the annual total catch occurred. Seasonal Pollen Index (SPI) was estimated as the annual sum of daily average pollen concentrations. The pollen season of birch started in Szczecin and Bialystok at the beginning of the April and lasted to the half of May. However total pollen was two times higher in Bialystok than in Szczecin. The maximum values of seasonal pollen count occurred in the middle of April in both cities. The risk of pollen allergy was high in Szczecin and Bialystok, and threshold values of allergy symptoms' occurrence were exceeded during the whole birch pollen season. Statistically relevant correlations between wind speed, particulate matter and birch total pollen, and also between the pollen concentration without cytoplasmic content were observed. Also, southern air circulation from Africa was noted. These coexisting factors indicate the appearance of long range transport of birch pollen from southern Europe in 2016.

Key words: allergens, pollen grains, cytoplasmic content, birch (*Betula*), Szczecin, Bialystok

Birch pollen is highly allergenic. The genus *Betula* is restricted in its appearance to the Northern Hemisphere, especially to the cool and temperate zone [1]. *Betula* belongs to the Fagales Engl. order and the Betulaceae S.F. Gray family, which also includes *Alnus* and *Carpinus* (APG II 2003) [2]. Birch is essentially a pioneer taxon, light-demanding in all places of its development, with a high tolerance of climatic and soil conditions. *Betula pendula* is well adapted to continental conditions, tolerates summer high temperatures and very cold winters.

In Poland *Betula* flowers from the second half of April almost to the end of May. Production of pollen by birches is assumed to follow a two-year-cycle [3].

The major allergens of pollen from trees belonging to the Fagales order have a degree of cross-reactivity because they are structurally and immunochemically similar, although the cross-reactivity appears to be strongest within botanically established families rather than between them [4].

It has been reported, that at the beginning birch pollen season, 90% of patients with birch pollinosis re-

ported mild symptoms above 80 g/m^3 (in Poland at concentration of 75 g/m^3 – symptoms present in all examined patients). However, during the late season, 80% patients remains symptomatic at a level below 30 g/m^3 (in Poland at concentration of 20 g/m^3 – first symptoms) [4, 5].

Knowledge of daily variations, atmospheric transport and sources areas of birch pollen is important for exposure studies and for warnings to the public, especially for large cities. The differentiation in birch pollen counts could be the result of transport from distant sources or long transport times caused by slow mowing air masses [6]. From southern direction air comes to Poland most often from mid-September to mid-November and is observed with a frequency higher than 10%. Short and repetitive periods of air movement from the south in winter and spring are characteristic. These air masses could contain among others birch pollen grains noted in April in 2016 in most cities in Poland [7].

Aim

The aim of the study was to analyse selected meteorological conditions and birch pollen concentration in the atmosphere of Szczecin and Bialystok regarding the structure of the pollen grains (grains with or without cytoplasmic content).

Material and method

Measurements of airborne alder pollen were carried out in Szczecin and Bialystok in the year 2016. Daily average *Betula* pollen counts were collected by volumetric spore traps of the Hirst design. Birch pollen grains were identified to genus level.

The pollen season was defined using the 98% method [4], whereby the start is defined as the day when 1% of the season's catch gad been recorded, and the end occurs when 99% of the total catch had been reached. The total pollen count over this period was expressed by the symbol SPI (Seasonal Pollen Index).

The meteorological data were provided by the Automatic Weather Station (Vaisala MAWS101). The meteorological parameters taken into regard in assessment of the effect of meteorological conditions on the airborne pollen were: average and maximum wind speed and wind directions. The air pollution data (µg/m^3) analysed were the concentrations of particulate matter PM_{10} (values of PM were multiplied by the value 10 to make it visible on the graph).

On the basis of literature data, the number of days with concentrations of the pollen of the *Betula* genus exceeding the threshold values at which the consecutive allergy symptoms develop were determined (tab. 1) [5].

Results and discussion

All birches are wind-pollinated and produce large amounts of light pollen, which enables its wide dispersal. The production of a single catkin may amount from 5.5 to 6 millions grains and its average weight is 6.1^{-10} g [8].

During certain meteorological conditions, birch pollen has the potential to be transported long distances from one region to another. The model calcu-

Table 1. *Characteristics of birch pollen season in 2016.*

Station	Start (date)	Peak day/ value (g/m^3)	End (date)	Total (SPI)	Duration (no of days)	Days ≥ 20 g/m^3 [5]*	Days ≥ 75 g/m^3 [5]**
Szczecin	5.04	934/13.04	14.05	8760	40	38	29
Bialystok	8.04	3350/16.04	11.05	15546	34	34	27

** First symptoms of allergy; ** symptoms present in all examined patients.*

Table 2. *Correlation between the particulate matter PM_{10} and meteorological factors vs. birch pollen concentration in 2016.*

Meteorological and air pollution factors	Szczecin		Bialystok	
	Total pollen count (g/m^3)	Grains without cytoplasmic content (g/m^3)	Total pollen count (g/m^3)	Grains without cytoplasmic content (g/m^3)
Average wind speed (m/s)	*0.3137	*0.2968	0.1237	0.1037
Maximum wind speed (m/s)	*0.4462	*0.3089	*0.3461	*0.2890
PM_{10} (µg/m^3)	*0.3565	*0.3252	*0.2561	0.0672

** Statistical significance p < 0.05.*

Figure 1. *Birch pollen count and PM_{10} in Szczecin in 2016.*

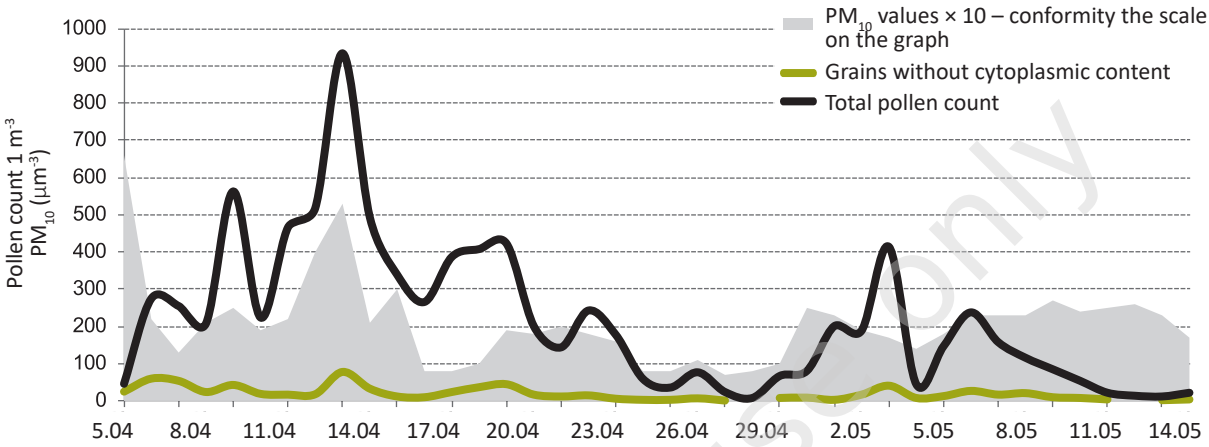
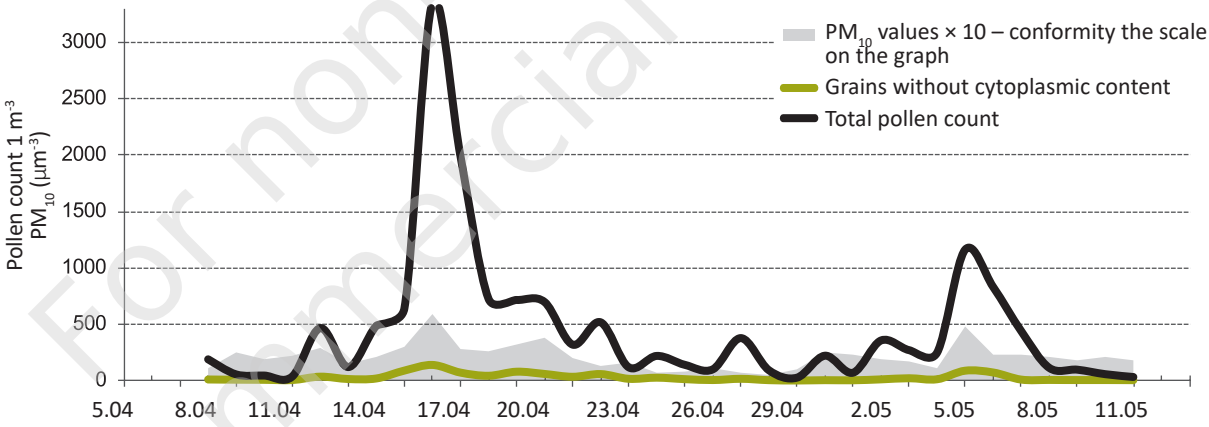


Figure 2. *Birch pollen count and PM_{10} in Bialystok in 2016.*



lations of atmospheric transport and measurements of birch pollen have shown that long-distance transport from Poland and Germany affect places such as Denmark before the local trees start to flower [6]. It has therefore been suggested that *Betula* pollen levels in Poland could be likely affected by long distance transport with air masses e.g. from Northern Africa through the Southern Europe. This phenomena was observed in Szczecin and Bialystok in spring of this year.

Tropical air masses arrive least frequently in Poland. They stay there on average for 2 per 100 days of the year. Tropical air coming from the Mediterranean Sea region contains high amounts of water vapour and has the characteristics of sea air [7]. At high humidity pollen grain sporoderm is prone to breaking (fig. 4). The release of allergen-containing respirable pollen materials may be a cause of asthma attacks after heavy rainfalls [9]. In Szczecin birch pollen grains without cytoplasmic content comprise 8.6% of total pollen, in Bialystok – 6.3% (fig. 3–7).

Air masses coming from southern Africa are very hot and dry. They are characterised by high mineral particle pollution (particulate matter PM) and have the properties of continental air [7]. In Szczecin and Bialystok statistically significant correlation was observed between wind speed and total birch pollen and also between concentration of grains without cytoplasmic content (tab. 2). Moreover, statistically signifi-

Figure 3. *Birch pollen with and without cytoplasmic content, Szczecin, × 400 (fig. M. Puc).*

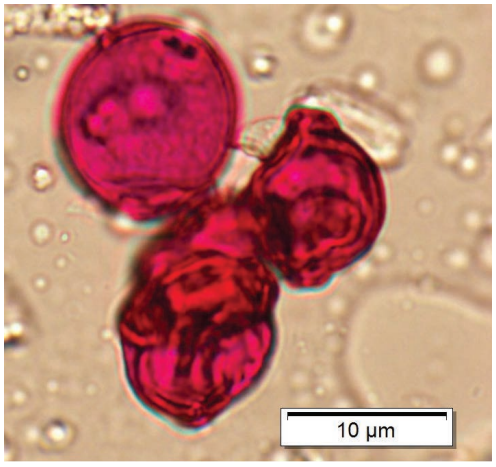


Figure 4. *Cytoplasmic content leaving the birch grain, Szczecin, × 400 (fig. M. Puc).*

Figure 5. *Birch pollen without cytoplasmic content and particulate matter PM_{10}, Szczecin, × 400 (fig. M. Puc).*

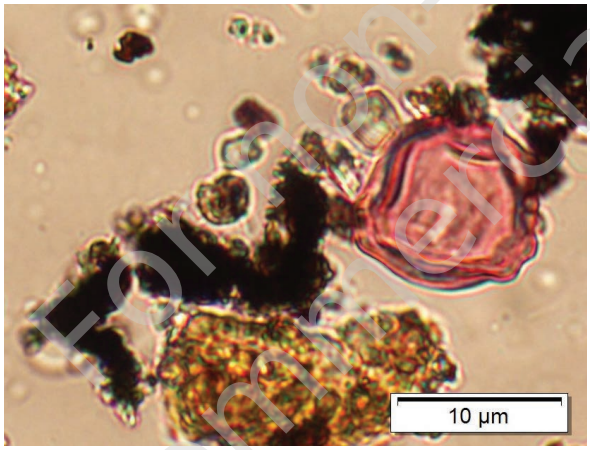
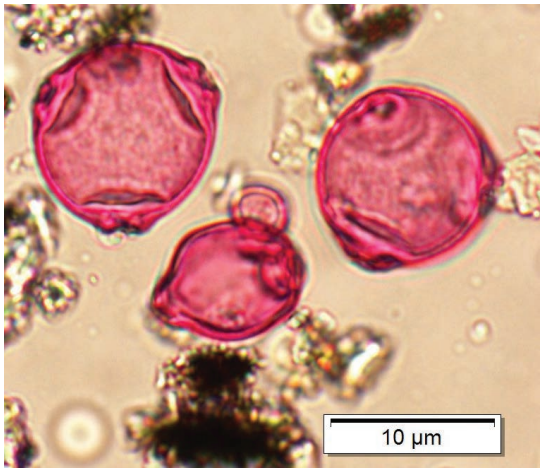
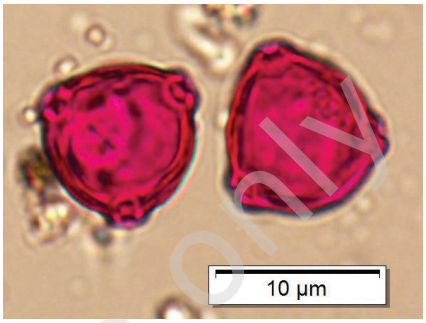


Figure 6. *Birch pollen with (above 10 µm) and without (below 10 µm) cytoplasmic content, Bialystok, × 400 (fig. M. Puc).*



cant correlation was noted between birch pollen counts and particular mater (tab. 2, fig. 1, 2), which indicates that part of the birch pollen observed in the air of Szczecin and Bialystok was transported by air masses in long range transport.

Figure 7. *Birch pollen without cytoplasmic content, Bialystok, × 400 (fig. M. Puc).*



Dynamics of birch pollen season in 2016 was similar in Szczecin and Bialystok (tab. 1). The start of birch pollen season in 2016 occurred in the beginning of April and lasted to the half of May in both cities. The highest record SPI (15546) and record airborne concentration, 3350 pollen g/m^3, was noted in Bialystok on the 16th April. The risk of pollen allergy was high in Szczecin and Bialystok and threshold values of allergy symptoms' occurrence were exceeded. In comparison to data from 2015 [10] in northern Poland, in 2016 pollen concentration of birch was very high in both analysed cities.

Conclusions

The course of birch pollen season in Szczecin and Bialystok was similar in 2016, however total pollen and maximum value was two times higher in Bialystok than in Szczecin.

The period with pollen counts exceeding the threshold value lasted during the whole pollen season in Bialystok and almost the whole season in Szczecin.

Correlation analysis with weather parameters demonstrated that the average and maximum wind speed are the important factors influencing the pollen structure (grains without cytoplasmic content) and pollen concentrations in the atmosphere.

The presence about 9% birch grains without cytoplasmic content on microscopic slides from Szczecin and Bialystok and *Betula* pollen concentration in Poland could be probably affected by long distance transport with air masses from Northern Africa through the Southern Europe.

References:

1. *Jalas J, Suominen J (ed). Atlas Florae Europeae. Distribution of vascular plants in Europe, II. Cambridge University Press, Cambridge 1988: 167-210.*

2. *APG II system. An update of the Angiosperm Phylogeny Group Classification for the Orders and Families of Flowering Plants: APG II. Bot J Linn Soc 2003, 141(4): 135-149.*
3. *Szczepanek K. Pollen calendar for Cracow (South Poland) 1982–1991. Aerobiologia 1994, 10: 65-75.*
4. *Emberlin J, Savage M, Woodman R. Annual variations in the concentrations of Betula pollen in the London area, 1961--1990. Grana 1993, 32: 359-363.*
5. *Rapiejko P, Lipiec A, Wojdas A et al. Threshold pollen concentration necessary to evoke allergic symptoms. Int Rev Allergol Clin 2004, 10(3): 91-93.*
6. *Skjoth CA, Sommer J, Stach A et al. The long range transport of birch (Betula) pollen from Poland and Germany causes significant pre-season concentrations in Denmark. Clin Exp Allergy 2007, 37: 1204-1212.*
7. *Woś A. Klimat Polski. PWN, Warszawa 1999.*
8. *Dyakowska J. Podręcznik palynologii. Metody i problemy. Wydawnictwa geologiczne, Warszawa 1979.*
9. *Grote M, Vrtala S, Niederberger V et al. Expulsion of allergen containing materials from hydrated rye grass (Lolium perenne) pollen revealed by using immunogold field emission scanning and transmission electron microscopy. J Allergy Clin Immunol 2000, 105: 1140-1145.*
10. *Rapiejko P, Puc M, Woźniak-Kosek A. Pyłek brzozy w powietrzu wybranych miast Polski w 2015 r. Alergoprofil 2015, 11(2): 53-61.*

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