

The phenology of flowering and fluctuations of airborne pollen concentrations of selected trees in Poznań, 2003-2004

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S u m m a r y

The aim of the study was to describe the relationships between the flowering phase of selected tree species, whose pollen is known to be allergenic, and fluctuations in the pollen in the air, and to use results obtained for making allergological forecasts.

Studies were conducted of five tree taxa: *Populus*, *Ulmus*, *Salix*, *Aesculus*, and *Tilia*, in the years 2003-2004. Aeropalynological analyses concerned the above mentioned genera, while in phenological studies specific species were investigated, i.e. the most common representatives of a given genus found in Poland, that is *Populus wilsonii*, *Ulmus laevis* Pall. C. K.Schneid., *Salix caprea* L., *Aesculus hippocastanum* L. and *Tilia cordata* Mill.

Aerobiological monitoring was performed using a the volumetric method and phenological observations of flowering phases were made according to the Łukasiewicz method.

While observing the emergence of individual phenological symptoms and measurements of the concentration of pollen of the investigated taxa in the air of Poznań, a distinct acceleration was observed in 2004, a year that was characterized by a milder winter. This applied not only to the species blooming in early spring, but also to the later ones. Pollen grains of the investigated taxa, except for *Aesculus*, appeared earlier in aeropalynological observations than the macroscopically observed beginning of flowering in selected trees. Apart from a poplar, the end of flowering in the other trees occurred each year earlier than would follow from the aerobiological observations. This may be explained by the abundance of species within a taxon, and the effect of medium and long-distance transport.

Key words: phenology, airborne pollen concentrations, *Populus*, *Ulmus*, *Salix*, *Aesculus*, *Tilia*

INTRODUCTION

Increasing incidences of allergies caused by allergens of plant pollen and fungal spores have recently been observed, and have given rise to enhanced interest in this problem (D'Amato et al., 1998; Bonini, 1999). For several years now, studies have been conducted for the purpose of allergological research in numerous countries, including Poland, on the contents of bioaerosols in the outside air (Szczepaniek et al., 1995). It has been known that the occurrence and changes in microspore concentrations of allergenic plant and fungal species depend to a large extent on weather conditions. Apart from detailed studies on aeroplankton, phenological observations of flowering phases seems to be very helpful in the assessment of the beginning, peak-and end of the pollen discharge season.

The aim of the study was to describe the relationships between the flowering phase of selected trees and shrub species, whose pollen is known to be allergenic, and fluctuations in the pollen in the air. The applied aim of the study was to include these relationships for making allergological forecasts. Attempts are made to show that systematic phenological studies, connected with weather observations, will make it possible to predict more precisely when increased allergological risk may occur. For several years now, two independent teams in the city of Poznań have been conducting aeropalinalogical studies (Stach, 2002; Stach et al., 2002) and phenological observations (Kluza and Zientarska, 1999a, b). In 2003 studies of *Corylus*, *Betula* and *Quercus* (Stach et al., 2004) were undertaken. The outcomes of the present studies will constitute the baseline for a more comprehensive methodology and the direction of further cooperation between aerobiologists and phenologists.

MATERIAL AND METHODS

The studies were conducted in the years 2003-2004. The five tree taxa, used as comparative material, are listed in the order of the appearance of their allergenic pollen: *Populus*, *Ulmus*, *Salix*, *Aesculus*, and *Tilia*. Moreover, the first two are anemophilous, the third is entomo- and anemophilous, and the last two are entomophilous. Aeropalinalogical analyses concerned the above mentioned genera, while in phenological studies specific species were investigated, i.e. the most common representatives of a given genus found in Poland, that is *Populus wilsonii*, *Ulmus laevis* Pall.C.K.Schneid., *Salix caprea* L., *Aesculus hippocastanum* L. and *Tilia cordata* Mill.

Aerobiological monitoring was performed using a volumetric trap (Hirst, 1952) located in the city centre at the height of 36 m above the ground level. Pollen discharge seasons were determined on the basis of the International Association for Aerobiology findings (Jäger, 2003). Phenological observations of flowering phases were made according to Łukasiewicz (1984) in the Dendrological Garden of the Agricultural University of Poznań, located approx. 2.5 km north of the aerobiological measurement point. Out of the whole phenological spectrum only a part of the generative phase was used, i.e. the phase of buds of flowers and the phase of flowering. The

emergence of the following phenomena were used to determine this fragment of the spectrum: the emergence of male buttons of flowers, the beginning of flowering, full flowering, the first overblown flowers, the last flower buttons, the end of full flowering and the end of flowering. The emergence of the signs of the beginning of flowering, full flowering and the end of flowering proved useful for the purpose of comparison with aeropalinological studies.

The investigations were related to the weather conditions with special emphasis on the temperature and precipitation. Meteorological data were taken from the monthly survey of meteorological data „Miesięczny Przegląd Agrometeorologiczny” (Table 1). While characterizing weather components in the years of observations, in the period of flowering and the time preceding it, it was found that the year 2003 was much cooler than 2004. The 2003 winter was long and frosty. In the first quarter subzero mean monthly temperatures and low precipitation were observed. Minimum temperature at the ground dropped to -25°C. This resulted in delayed plant vegetation. A lowering in the temperature in March, and March and April ground frosts had only a slight inhibitory effect on the development of plants. In successive months no

Table 1

Meteorological data (monthly average temperature [°C] and total precipitation [mm])
in the years 2003, 2004 and mean of 1951-1990.

Months	Temperature (°C)			Precipitation (mm)		
	2003	2004	Mean of 1951-1990	2003	2004	Mean of 1951-1990
January	-1.7	-4.0	-2.0	49.1	52.6	29
February	-3.5	1.6	-1.3	4.9	23.7	25
March	3.0	4.7	2.5	13.0	18.9	27
April	8.2	9.4	7.5	20.4	18.3	36
May	15.7	12.5	13.1	6.1	51.1	50
June	19.0	16.0	16.7	23.4	55.4	61
July	19.5	18.0	18.0	125.0	48.0	73
August	19.4	19.9	17.2	7.2	56.1	57
September	14.7	14.3	13.4	19.1	24.6	43
October	5.8	10.5	8.8	33.5	36.6	36
November	5.6	4.2	3.6	20.1	46.1	36
December	1.9	1.7	0.1	23.2	33.2	38
Mean/total	9.0	9.1	8.1	345	464.6	511

larger deviations from the mean multiannual monthly temperature and precipitation totals were found, only July was characterized by exceptionally high rainfall (125 mm). Summing up, precipitation total (345 mm) constituted only 60% multiannual total (571.5 mm), while the mean annual temperature was 9°C and was equal to the multiannual mean. The winter in 2004 was mild. Minimum ground temperature was not lower than -19°C. February was warmer than in the previous year, with high precipitation total, which resulted in accelerated plant vegetation. March, April and May ground frosts caused an inhibition of blooming and elongation of successive phenophases. Summer was warm and rather wet. No climatic anomalies were observed. Summing up, the precipitation total was 464.6 mm, whereas mean annual temperature was 9.1°C.

RESULTS

A tendency was found for earlier flowering when comparing 2004 with the year before. The poplar started and finished the process of flowering earlier than in the preceding year 2003. Pollen grains of this taxon were reported earlier than flowers in every year. Full flowering, corresponding to the maximum of the pollen discharge season, was identical to in the first year of the study, while in the second year it was observed earlier. In contrast, the end of flowering was recorded later than the last pollen records. In the next season poplar pollen was present in the air for a longer time.

In the first year of the study, the occurrence of pollen grains of the elm was recorded later than implied by phenological observations, while in the second year pollen grains were observed earlier. Every year the maximum of the pollen production season and its end came later in relation to phenological observations.

Also the willow bloomed earlier in 2004 than in 2003. In both years of the study its pollen was detected earlier in the air and the height maximum of the pollen discharge season came later.

The flowering of the chestnut began earlier in the warmer year of 2004 and lasted longer than in the previous year. In 2003 pollen of this taxon was recorded earlier than the flowering process was observed, and the maximum and end of the

Table 2

Phenological symptom and aerobiological data for selected taxa in Poznań, 2004.

Species	Year	A. Phenological symptoms							B. Aerobiological results			
		1	2	3	4	5	6	7	8	9	10	11
<i>Populus wilsonii</i>	2003	24.03	14.04	17.04	22.04	28.04	24.04	30.04	29.03	17.04	25.04	890
	2004	18.03	01.04	05.04	13.04	19.04	08.04	26.04	15.03	13.04	22.04	625
<i>Ulmus laevis</i>	2003	24.03	27.03	31.03	07.04	17.04	10.04	22.04	30.03	17.04	28.04	176
	2004	18.03	25.03	29.03	08.04	13.04	01.04	15.04	19.03	04.04	18.04	122
<i>Salix caprea</i>	2003	2002	14.04	17.04	22.04	28.04	24.04	30.04	28.03	01.05	10.05	390
	2004	2003	29.03	01.04	08.04	13.04	05.04	15.04	25.03	29.04	10.05	365
<i>Aesculus hippocastanum</i>	2003	10.04	02.05	05.05	09.05	15.05	12.05	26.05	30.04	17.05	17.06	44
	2004	08.04	26.04	29.04	06.05	17.05	13.05	31.05	28.04	06.05	21.06	77
<i>Tilia cordata</i>	2003	19.05	09.06	16.06	23.06	30.06	23.06	07.07	05.06	24.06	22.07	97
	2004	06.05	17.06	01.07	05.07	15.07	08.07	19.07	20.06	30.06	05.08	71

A. Phenological symptoms: 1 buds of flower, 2 beginning of flowering 3 full flowering, 4 first of flower blossoms, 5 end of full flowering, 6 last buds of flower, 7 end of flowering.

B. Aerobiological results: 8 start of season, 9 seasonal maximum, 10 end of season, 11 Seasonal Pollen Index.

pollen discharge season came later, both in that and in the successive year. In 2004 flowering was observed earlier than the presence of pollen in the air.

However, in the case of the linden, the process of flowering began earlier in 2003. Pollen was observed each year earlier in comparison to phenological observations. Full flowering in the first year of this study was reported sooner than the maximum pollen content detected in the air, while in the second year they corresponded in time. The end of flowering came earlier than the end of the pollen discharge season.

Higher values of annual pollen totals were observed in *Populus*, *Salix* and *Ulmus* (Table 2). In the investigated period in Poznań willow pollen was more abundant than that of elm. Higher annual totals of pollen grains were recorded in 2003 in *Populus*, *Ulmus*, *Salix* and *Tilia*, in case of *Aesculus* the pollen grain total was higher in 2004.

DISCUSSION

In Europe simultaneous aerobiological and phenological studies have been conducted by teams of researchers from Italy (Zanotti and Puppi, 2000). The only Polish phenological and aerobiological studies for 3 tree species were conducted in Rzeszów by Kasprzyk (2003). The studies carried out in Poznań are primarily intended to aid the preparation of allergological forecasts.

Pollen grains of the tree taxa included in this study exhibit lower allergenicity than for example the pollen of alder, birch or oak trees, although the risk imposed should not be underestimated (Lewis et al., 1983; Dominguez et al., 1984; Jato et al., 2001).

In the period under analysis, poplar pollen, although it reached the highest annual totals in comparison to the other investigated taxa, still did not reach the value found in Poznań in 1996 (Stach, 2002). In that year the annual total was three times higher than that recorded in 2003.

Willows belong to anemophilous and entomophilous plants (Suzka, 1990) and although they do not produce large amounts of pollen (Chałupka, 1990), the annual pollen totals in both years of the study were two and three times higher than the totals for the anemophilous *Ulmus* in the same years. In case of *Populus* and *Salix*, higher annual pollen totals may be explained by the abundance of the species of the given taxon found in Poznań and the number of specimens within the city and outside the city limits.

Linden is found quite frequently in street plantings and in parks of Poznań, but its pollen was observed in rather small amounts, not only in the analyzed period, but also earlier (Stach, 2002). This results primarily from the fact that *Tilia* is an entomophilous plant and has large pollen grains. Observations conducted at various altitudes (Hart et al., 1994) showed that at the altitude above 30 m *Tilia* pollen was scarcely found. Low values of annual totals for linden in different cities were also observed by other researchers, e.g. Szcepanski (1994), Kasprzyk (1996). If in Poznań at the altitude of 36 m linden pollen is often recorded, it may be assumed that at the

“nose height” of an allergic patient it may reach much higher concentrations. A similar phenomenon may occur in case of *Aesculus*. During the full flowering of chestnut trees, the allergenic threat posed by this taxon is probably higher than observations conducted on the roof would suggest.

The largest discrepancy between phenological and aerobiological observations, concerning the beginning of the pollen discharge season and the beginning of flowering, was observed in *Populus* and *Salix*. This results from the fact that aerobiological data include pollen grains of all *Populus* or *Salix* species growing in the city of Poznań and in the Wielkopolska region, whereas phenological observations are limited to one specific species. The earliest poplar pollen grains detected on the tapes of the volumetric trap are probably pollen grains of *Populus tremula*, which appear in the air earliest.

The occurrence of pollen grains in the air after the completion of flowering in the phenologically analyzed specimens indicates the medium and long-distance transport, discussed in previous studies (Stach, 2002; Stach et al., 2002).

CONCLUSIONS

While observing the emergence of individual phenological symptoms and measurements of the concentration of pollen of the investigated taxa in the air of Poznań, a distinct acceleration was observed in 2004, a year that was characterized by a milder winter. This applied not only to the species blooming in early spring, but also to the later ones.

Pollen grains of the investigated taxa, except for *Aesculus*, appeared earlier in aeropalynological observations than the macroscopically observed beginning of flowering in selected trees.

Apart from poplar, the end of flowering in the other trees occurred each year earlier than would follow from the aerobiological observations. This may be explained by the abundance of species within a taxon, and the effect of medium and long-distance transport.

In the case of anemophilous trees, much larger amounts of pollen were observed in the air than in willows and taxa pollinated only by insects.

Conducting detailed observations of the beginning of the flowering phase in relation to the weather conditions may facilitate the prediction of the beginning and full pollen discharge season in allergenic tree and shrub species. Better temporal resolution of the weather observations will help in making possible relationships more evident. Further studies are still required in this respect.

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Fenologia kwitnienia i wahania stężenia pyłku wybranych drzew w powietrzu Poznania w latach 2003-2004

Streszczenie

Celem badań było wykazanie związku pomiędzy wynikami monitoringu fazy kwitnienia wybranych gatunków drzew, których pyłek działa uczulająco, a wahaniami zawartości aeroplanktonu w powietrzu oraz ich wykorzystaniu w przygotowaniu prognoz dla potrzeb alergicznych.

W latach 2003-2004 badano pięć taksonów drzew: *Populus*, *Ulmus*, *Salix*, *Aesculus*, i *Tilia*. Analizy aeropalinologiczne dotyczyły podanych rodzajów, a w obserwacjach fenologicznych badano konkretne gatunki, często występujących w Polsce przedstawicieli danego rodzaju: *Populus wilsonii* C. K. Schneid., *Ulmus laevis* Pall., *Salix caprea* L., *Aesculus hippocastanum* L. i *Tilia cordata* Mill.

Monitoring aerobiologiczny prowadzono aparatem wolumetrycznym a obserwacje fenologiczne faz kwitnienia wykonywano metodą Łukasiewicza.

Obserwując poszczególne powroty fenologiczne oraz zawartość pyłku badanych taksonów w powietrzu Poznania, stwierdzono wyraźne ich przyspieszenie w roku 2004, cechującym się łagodniejszą zimą. Dotyczyło to nie tylko gatunków zakwitających wczesną wiosną, ale również i tych późniejszych. Ziarna pyłku badanych taksonów, oprócz *Aesculus*, pojawiały się wcześniej w obserwacjach aeropalinologicznych, niż makroskopowo obserwowano początek kwitnienia wybranych drzew. Z wyjątkiem topoli, koniec kwitnienia pozostałych drzew przypadał rokrocznie wcześniej niż wynikało to z badań aerobiologicznych. Przyczynę tego można tłumaczyć bogactwem gatunków w obrębie taksonu oraz wpływem średniego i dalekiego transportu. Kontynuacja wspólnych badań może pomóc w prognozowaniu początku i pełni sezonu pyłkowego alergogennych gatunków drzew i krzewów, pod warunkiem, że badania będą prowadzone przez wiele lat.