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Flowering phenology of selected wind pollinated allergenic deciduous tree species

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S u m m a r y

Systematic phenological observations have been carried out in the Dendrological Garden of Agricultural University of Poznań, Park Sołacki, Lasek Golęciński, Przybyszewskiego Street, for two years (2003, 2004). The selected species of deciduous trees, as *Betula pendula*, *Corylus avellana*, *Platanus x hispanica*. There was interdependence between the course of flowering process and weather conditions. Long and frosty winter at the turn of 2002/2003 and subzero mean temperatures in the first quarter of 2003 delayed vegetation. Rapid coming of early spring in the year 2004 accelerate the development of generative organs. Each year spring ground frost during flowering did not inhibit this process. All the investigated tree species are anemophilous and produce large amounts of allergenic pollen grain. They cause allergic reactions throughout the whole period of pollen discharge. Male inflorescences in *Corylus avellana*, blooming very early, are one of the first plants causing allergic reactions. *Betula pendula* is the next to bloom, followed by *Platanus x hispanica*. Observations of phenological phases may provide useful information forecasting the beginning of the period of increased pollen concentration in air.

Key words: phenology, flowering, trees, weather conditions

INTRODUCTION

The term phenology was introduced to science around mid-1850's by a Belgian botanist from Liège Carl Morren. However, already 100 years earlier Carl Linnaeus began systematic studies in that field, gave principles of phenology and developed its research methods (D z i u b a ł t o w s k i et al., 1931). A fervent promoter of long-term phenological studies in Poland was Ł a s t o w s k i (1948, 1951), who

devoted several separate studies to methodological issues in that field. Considerable services for the development of phenological studies in Poland are credited to S z a f e r (1922, 1959), who emphasized their importance for plant geography and ecology. The aim of this study was to follow flowering in selected wind pollinated tree species, producing large amounts of allergenic pollen grain.

MATERIAL AND METHODS

Observations were conducted in the North-Western part of the city of Poznań, covering the area of the Dendrological Garden, the Sołacki Park, the Golęciński Wood and individuals growing in Przybyszewski Street. The aim of observations in the latter site was to study the effect of exhaust gas pollution on the course of phenophases. Three tree species were selected for phenological observations: common birch *(Betula pendula* Roth), hazel (*Corylus avellana* L.) and London plane (*Platanus x hispanica* Mill. ex Münchh.). These observations were conducted on 4-6 individuals of each species, located in various sites in the investigated area.

Phenological observations were conducted in 3-4 day intervals. Flowering phases were established according to Ł u k a s i e w i c z (1984):

1. the emergence of first flower buds or buttons of flowers;
2. the emergence of first flowers (several fully opened flowers);
3. the beginning of full flowering (approx. 25% opened blooming flowers);
4. the emergence of first overblown flowers (first flowers withered or fell);
5. the end of full flowering (approx. 75% overblown flowers) ;
6. last buttons of flowers;
7. the end of flowering (the date when last flowers were overblown).

If a given species has dioecious flowers; flowering phases of female and male flowers are presented separately.

Meteorological data were taken from the monthly survey „Miesięczny Przegląd Agrometeorologiczny" (Table 1). While characterizing climatic conditions in the years of observations during flowering and in the period preceding it, it needs to be emphasized that the year 2003 was much cooler than 2004. Winter beginning the year 2003 was long and frosty. In the first quarter subzero mean monthly temperatures and low precipitation were observed. Minimal ground surface temperature dropped to -25°C. This resulted in a delayed vegetation of plants. The decrease in temperature in March together with March and April ground frosts had only a slight effect on plant development. In successive months no larger deviations were observed from the mean multiannual temperature of the month and precipitation totals. Summing up, precipitation total (345 mm) was much lower than the multiannual total (571.5 mm), and mean annual temperature was 9°C and was equal to the multiannual mean. Winter in 2004 was mild. Minimal ground temperature was not lower than -19°C. February was warmer than in the previous year, with large amounts of precipitation, which resulted

in the acceleration of plant vegetation. March, April and May ground frosts inhibited blossoming and extended the duration of successive phenophases. Summer was warm and rather wet. No climatic anomalies were observed. The precipitation total was 464.6 mm, and mean annual temperature was 9.1˚C.

Table 1

]Meteorological data for Poznań city [monthly average temperature (˚C) and precipitation sum (mm)] in the years.

Data	Years	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Temperature [°C]	2003	-1,7	-3,5	3,0	8,2	15,7	19,0	19,5	19,4	14,7	5,8	5,6	1,9
	2004	-4,0	1,6	4,7	9,4	12,5	16,0	18,0	19,9	14,3	10,5	4,2	1,7
	1993-2002	0,5	1,7	3,9	9,1	14,4	16,4	18,9	18,3	13,5	9,2	3,1	-0,3
Precipitation [mm]	2003	49,1	4,9	13,0	20,4	6,1	23,4	125	7,2	19,1	33,5	20,1	23,2
	2004	52,6	23,7	18,9	18,3	51,1	55,4	48,0	56,1	24,6	36,6	46,1	33,2
	1993-2002	28,1	37,8	50,8	36,1	47,4	56,5	86,9	50,6	66,1	47,6	31,7	31,9

Table 2

Beginning of phenological seasons for Poznań city in the years 2003 2004.

Year	Phenological seasons								
	A ante spring	B early spring	C spring	D early summer	E summer	F early autumn	G gold autumn	H late autumn	I winter
2003	17.03	22.04	07.05	26.05	19.06	08.09	13.10	17.11	10.12
2004	23.02	15.04	01.05	27.05	05.07	02.09	07.10	29.11	23.10

Using methodology proposed by Krotoska (1958), Łukasiewicz and Górska-Zajączkowska (1983), dates defining the beginnings of 9 phenological seasons were determined (Table 2). The beginning of ante spring (A) is defined by the initiation of pollen discharge from male inflorescences of hazel (*Corylus avellana* L.). The emergence of first leaves in beech (*Fagus silvatica* L.) is the beginning of the early spring (B). Full flowering of common lilac (*Syringa vulgaris* L.) defines spring (C), while early summer (D) is defined by the bloom of European elder (*Sambucus nigra* L.). The beginning of summer (E) is identified on the basis of full flowering of linden (*Tilia cordata* Mill.), while fruit drop in horse chestnut (*Aesculus hippocastanum* L.) marks early autumn (F). Gold autumn (G) begins with the full yellowing of leaves in linden (*Tilia cordata* Mill.), and the end of leaf fall in birch (*Betula pendula* Roth) denotes late autumn (H). The beginning of winter (I) falls on the day following three days with maximum air temperature below 0˚C.

RESULTS

Phenological observations of selected tree species were conducted from the beginning of early spring to spring (Table 2, 3). In plane trees in 2003 flowering exceptionally ended only at the beginning of early summer.

Each year male buttons of flowers in *Betula pendula* emerged towards the end of July in the previous vegetation season. Female buttons of flowers in 2004 opened earlier than in 2003. The successive flowering phase was more uniform in both years of observations, since phenological seasons, i.e. the first part of spring and spring, during which it occurred, were similar. Male flowers bloomed several or about a dozen days earlier than female flowers. Generally, at the time when male flowers ended flowering female flowers just started flowering.

Phases of generative development in all specimens of *Corylus avellana* and in both years of the study were very similar. Female flower buttons started to develop at the beginning of the first part of spring, while male flower buttons were produced in the first decade of August in the previous year. Female flowers started to develop several days later than male flowers. Flowering occurred in early spring and lasted longer than in male flowers.

Table 3
Course of appearances of stage of flowering.

Species	Individual	Year	The flowering phases						
			1	2	3	4	5	6	7
1. *Betula pendula*	a	2003	22.04	26.04	28.04	02.05	07.05	02.05	07.05
		2002	*17.04*	*22.04*	*26.04*	*28.04*	*26.04*	*02.05*	
		2004	15.04	19.04	22.04	26.04	01.05	29.04	03.05
		2003	*12.04*	*15.04*	*19.04*	*26.04*	*22.04*	*29.04*	
	b	2003	17.04	22.04	26.04	02.05	07.05	02.05	07.05
		2002	*17.04*	*22.04*	*26.04*	*28.04*	*26.04*	*02.05*	
		2004	05.04	12.04	15.04	19.04	29.04	22.04	01.05
		2003	*29.03*	*08.04*	*12.04*	*22.04*	*19.04*	*26.04*	
	c	2003	17.04	22.04	26.04	02.05	07.05	02.05	07.05
		2002	*17.04*	*22.04*	*26.04*	*28.04*	*26.04*	*02.05*	
		2004	05.04	12.04	15.04	19.04	29.04	22.04	01.05
		2003	*01.04*	*08.04*	*12.04*	*22.04*	*19.04*	*26.04*	
	d	2003	17.04	22.04	26.04	02.05	07.05	02.05	07.05
		2004	*2002*	*12.04*	*17.04*	*22.04*	*28.04*	*22.04*	*02.05*
			12.04	15.04	19.04	22.04	29.04	26.04	01.05
		2003	*08.04*	*12.04*	*15.04*	*19.04*	*15.04*	*26.04*	
	e	2003	22.04	26.04	28.04	02.05	07.05	02.05	07.05
		2002	*17.04*	*22.04*	*26.04*	*28.04*	*26.04*	*02.05*	
		2004	19.04	22.04	26.04	29.04	01.05	29.04	03.05
		2003	*12.04*	*15.04*	*19.04*	*26.04*	*22.04*	*29.04*	
	f	2003	22.04	26.04	28.04	02.05	07.05	02.05	07.05
		2002	*17.04*	*22.04*	*26.04*	*28.04*	*26.04*	*02.05*	
		2004	12.04	19.04	22.04	26.04	29.04	26.04	03.05
		2003	*08.04*	*12.04*	*19.04*	*26.04*	*22.04*	*29.04*	

2. *Corylus avellana*	a	2003	24.03	27.03	31.03	03.04	07.04	03.04	07.04
			2002	*17.03*	*20.03*	*24.03*	*27.03*	*24.0*	*03.04*
		2004	01.03	08.03	11.03	15.03	18.03	15.03	22.03
			2003	*23.02*	*01.03*	*11.03*	*18.03*	*15.03*	*22.03*
	b	2003	24.03	27.03	31.03	03.04	07.04	03.04	07.04
			2002	*17.03*	*20.03*	*24.03*	*27.03*	*24.03*	*03.04*
		2004	01.03	08.03	11.03	15.03	18.03	15.03	22.03
			2003	*23.02*	*01.03*	*08.03*	*18.03*	*15.03*	*22.03*
	c	2003	24.03	27.03	31.03	03.04	07.04	03.04	07.04
			2002	*17.03*	*20.03*	*27.03*	*31.03*	*24.03*	*03.04*
		2004	15.03	18.03	22.03	25.03	29.03	25.03	29.03
			2003	*26.02*	*04.03*	*11.03*	*18.03*	*15.03*	*22.03*
	d	2003	24.03	27.03	31.03	03.04	07.04	03.04	07.04
			2002	*17.03*	*20.03*	*24.03*	*27.03*	*24.03*	*03.04*
		2004	04.03	08.03	11.03	15.03	18.03	15.03	18.03
			2003	*26.02*	*04.03*	*11.03*	*15.03*	*11.03*	*18.03*
	e	2003	24.03	27.03	31.03	03.04	07.04	03.04	07.04
			2002	*17.03*	*20.03*	*24.03*	*27.03*	*24.03*	*03.04*
		2004	04.03	08.03	11.03	15.03	18.03	15.03	18.03
			2003	*26.02*	*04.03*	*11.03*	*15.03*	*11.03*	*18.03*
3. *Platanus x hispanica*	a	2003	22.04	02.05	07.05	12.05	15.05	12.05	22.05
			22.04	*02.05*	*07.05*	*12.05*	*15.05*	*12.05*	*22.05*
		2004	22.04	29.04	03.05	06.05	13.05	06.05	17.05
			22.04	*29.04*	*03.05*	*06.05*	*13.05*	*06.05*	*17.05*
	b	2003	28.04	02.05	07.05	12.05	15.05	12.05	15.05
			28.04	*02.05*	*07.05*	*12.05*	*15.05*	*12.05*	*15.05*
		2004	22.04	29.04	01.05	03.05	10.05	06.05	13.05
			22.04	*29.04*	*01.05*	*03.05*	*10.05*	*06.05*	*13.05*
	c	2003	28.04	07.05	12.05	15.05	19.05	15.05	26.05
			28.04	*07.05*	*12.05*	*15.05*	*19.05*	*15.05*	*26.05*
		2004	22.04	29.04	01.05	06.05	13.05	10.05	17.05
			22.04	*29.04*	*01.05*	*06.05*	*13.05*	*10.05*	*17.05*
	d	2003	28.04	07.05	12.05	15.05	19.05	15.05	26.05
			28.04	*07.05*	*12.05*	*15.05*	*19.05*	*15.05*	*26.05*
		2004	22.04	29.04	01.05	06.05	13.05	10.05	17.05
			22.04	*29.04*	*01.05*	*06.05*	*13.05*	*10.05*	*17.05*

Explanation for table

- (1 7) Explanation in material and methods
- 17.03 Female inflorescences
- *17.03* Male inflorescences
- (a f) Individuals

In *Platanus x hispanica*, phases of generative development in all its specimens were similar. Buttons of flowers appeared in the first part of spring. Male and female flowers developed at the same time, at the turn of the first part of spring and spring.

In the years of observations, the climatic conditions disturbing the typical course of flowering in selected tree species was the long and frosty winter at the turn of 2002 and 2003, and low precipitation and subzero mean annual monthly temperatures in the first quarter of 2003. However, they did not have a major effect on plant development. Frost damage was not observed in the investigated specimens.

DISCUSSION

As was reported by W i t k o w s k a (1990), flowering depends on the temperature and the date of last ground frosts. In early flowering plants, the dates marking the beginning of the emergence are more varied than in late flowering species.

Information found in literature indicates that hazel begins flowering at the beginning or mid-March and this process is adversely affected by thawing weather in January and February followed by much cooler weather (S o k o ł o w s k a , 1962). In this study in 2004 this species bloomed already towards the end of February.

K a c z m a r e k (1959, 1964, 1965) reported that in 1958 this process occurred around mid-February and in 1962 already in the third decade of January. This resulted from warm mild winters. In contrast, in the years 1963-65, as a result of very severe, frosty and long winters, flowering was delayed and started only in April.

Birch usually started flowering in the second decade of April (K a c z m a r e k, 1964; W i t k o w s k a, 1983). It was similar in the years 2003-2004. In 1974, due to considerably warmer weather in March and April, this phase occurred already in the beginning of April (W i t k o w s k a, 1983), while in 1958 and 1963 cold weather caused its delay until the beginning of May (K a c z m a r e k, 1959, 1964).

CONCLUSIONS

1. In selected tree species the period of flowering, i.e. the phase of buttons of flowers and the phase of flowering, lasted from the beginning of early spring until the beginning of early summer.

2. The flowering phase was similar in all individuals of one species and no effect of pollutants on the course of this process was observed.

3. The long and frosty winter at the turn of 2002/2003 and subzero mean temperatures in the first quarter of 2003 delayed vegetation.

4. As a result of mild and short winter at the turn of 2003/2004 early spring started earlier than usual, so vegetation, and thus also flowering, were accelerated.

5. Each year spring ground frost during flowering did not inhibit this process.

6. All the investigated tree species are anemophilous and produce large amounts of allergenic pollen grain. They cause allergic reactions throughout the whole period of pollen discharge.

7. Male inflorescences in *Corylus avellana*, blooming very early, are one of the first plants causing allergic reactions. *Betula pendula* is the next to bloom, followed by *Platanus x hispanica*.

8. Observations of phenological phases may provide useful information forecasting the beginning of the period of increased pollen concentration in air.

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Fenologia kwitnienia wybranych gatunków wiatropylnych, alergogennych drzew liściastych

Streszczenie

Systematyczne obserwacje fenologiczne były prowadzone w Ogrodzie Dendrologicznym Akademii Rolniczej w Poznaniu, Parku Sołackim, Lasku Golęcińskim i na ulicy Przybyszewskiego w latach 2003-2004. Obiektem obserwacji były wybrane gatunki drzew *Betula pendula*, *Corylus avellana* i *Platanus x hispanica*. Analizie poddano zależność pomiędzy warunkami pogodowymi a procesem kwitnienia. Długa i mroźna zima na przełomie 2002/2003 roku oraz ujemne średnie temperatury w pierwszym kwartale 2003 roku opóźniły wegetację. Wczesne nadejście przedwiośnia w roku 2004 przyspieszyło rozwój organów generatywnych. Coroczne wiosenne przymrozki w okresie kwitnienia nie zahamowały tego procesu. Wszystkie badane gatunki drzew są wiatropylne i produkują duże ilości alergogennych ziarn pyłku. Powodują one reakcje alergiczne przez cały okres swego pylenia. Kwiatostany męskie *Corylus avellana* zakwitające bardzo wcześnie, są jednymi z pierwszych roślin powodujących reakcje alergenne. Następnie zakwita *Betula pendula*, a potem *Platanus x hispanica*. Obserwacje faz fenologicznych mogą być przydatnymi informacjami zwiastującymi zbliżanie się okresu zwiększenia stężenia pyłku w powietrzu.