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FLOWERING PHENOLOGY AND POLLEN SEASONS OF *Corylus* spp. IN LUBLIN (POLAND), 2008-2011

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Abstract

In the years 2008-2011, phenological observations of flowering of male inflorescences were carried out in seven taxa from the genus *Corylus*: *C. americana*, *C. avellana*, *C. avellana* 'Contorta', *C. avellana* 'Pendula', *C.* × *colurnoides*, *C. cornuta*, *C. maxima*, grown in the Maria Curie-Skłodowska University Botanical Garden in Lublin. Simultaneously, the hazel pollen seasons in the atmosphere of Lublin were analysed using a Durham sampler. The aim of the work was to assess the flowering in seven *Corylus* taxa in relation to selected meteorological elements and to describe the pollen seasons in the years 2008-2011.

During the study years, the annual phenological cycles in the studied *Corylus* taxa differed markedly in terms of timing of the onset of the successive flowering phases. During the four years of observations, the earliest beginning of hazel flowering was found at the end of January, whereas the latest – at the end of March. The earliest full bloom took place in the first decade of February, and the latest – in the first decade of April. The end of flowering was reported in February or in the first or second decade of April. Each year, *C. avellana* was the first to produce flowers and it was subsequently followed by *C. americana*, *C.* × *colurnoides*, *C. maxima*, *C. avellana* 'Pendula', *C. avellana* 'Contorta', and *C. cornuta*. The pollen seasons in the study period began at the end of January, in the second decade of February, or in the first decade of March. The end of the pollen seasons most frequently took place in the first or second decade of April. The length of the pollen seasons ranged from 38 to 49 days, while the length of the flowering periods in the individual taxa was 22 days on average. During the four study years, the onset of flowering in *C. avellana* and the beginning of the pollen season coincided on the same day, whereas the onset of flowering in the other taxa was usually reported after the beginning of the pollen seasons. The flowering period of *C. avellana* 'Contorta' and *C. cornuta* lasted from 5 to 16 days after the pollen season. The development of inflorescences was most closely related to maximum temperature and relative air humidity.

Key words: aerobiology, *Corylus* spp., flowering, phenology, meteorological elements, pollen season

INTRODUCTION

Phenological studies are employed in many branches of natural sciences and widely applied in practice. Records of the dynamics of seasonal changes occurring in the plant or animal world are used in environmental sciences for studying the interactions between living organisms and their environment. Phenology is also an important branch of science for meteorological research, especially in climatology and biometeorology. Phenological events may serve as good indicators in assessment of potential trends in climate change, which is important in various branches of economy (Lieth, 1974; Sokołowska, 1980; Kramer, 1994; Tomaszewska and Rutkowski, 1999; Menzel et al. 2006; Studer et al. 2007; Schleip et al. 2008). Investigations of flowering phenology facilitate interpretation of aerobiological research results and ensure more precise allergy forecasts. This is especially important in forecasting the concentration of airborne pollen allergens (Hänninen, 1983; Lattore, 1999; Jato et al. 2002; Kasprzyk, 2003; Estrella et al. 2006; Stach et al. 2006; Kasprzyk and Walanus, 2007; Weryszko-Chmielewska et al. 2010).

The time of appearance of the characteristic vegetation phases (phenophases), e.g. flowering and unfolding, is closely related to the climate of the study areas. Spring phenophases in the temperate climate zone are dependent on thermal conditions prevailing in the current year and the year preceding flowering (Wielgolaski, 1999; Puc, 2007; Dąbrowska, 2008; Piotrowska and Kaszewski, 2009; Rizzi Longo and Pizzulin Sauli, 2010; Veraiankait et al. 2010; Weryszko-Chmielewska et al. 2010; Črepinšek et al.

2011; Škvareninová et al. 2011). Phenological phenomena are often modified by individual meteorological elements, e.g. air humidity, solar radiation, draught, and soil properties (Kramer, 1994; Wielgolaski, 1999).

Corylus avellana is a characteristic plant for the early spring growing period. Hazel plants in Poland bloom at the turn of February and March. Male inflorescences are clustered in pendulous cylindrical inflorescences – catkins (Szafer et al. 1986). During flowering, the inflorescence axis becomes elongated, thereby making the flowers less compact, which facilitates pollen release from the anther. One inflorescence comprising on average 240 flowers releases approximately 8 736 000 pollen grains sized 24.6 × 22.0 µm (Piotrowska, 2008).

The aim of the work was to assess flowering in seven *Corylus* taxa grown in the Maria Curie-Skłodowska University Botanical Garden in Lublin in the years 2008-2011 in relation to selected meteorological elements and to describe the pollen seasons. The results obtained may be helpful in cultivation of hazel nuts (*C. avellana*) and their ornamental varieties as well as in acclimation of foreign taxa. Additionally, they may facilitate answering the question whether the prevailing climatic conditions are suitable for cultivation of these plants in our country.

MATERIALS AND METHODS

Flowering phenophases

The phenological observations of flowering were carried out on seven *Corylus* taxa grown in the Maria Curie-Skłodowska University Botanical Garden in Lublin in the years 2008-2011. The observations involved two specimens of common hazel (*C. avellana* L.) growing naturally in the botanical garden at the edge of loess ravines and single specimens of *C. americana* Marshall, *C. avellana* L. 'Contorta', *C. avellana* L. 'Pendula', *C.* × *colurnoides* C.K. Schneid., *C. cornuta* Marshall and *C. maxima* Mill. (Figs. 1 and 2). Except for *C. avellana*, the seeds of the study plants were introduced into the garden several years ago from other botanical gardens (Table 1). The study specimens grow amongst trees and shrubs in insolated localities in the north-eastern part of the garden. The distances between them range from 20 to 400 m (Fig. 1). All the specimens were adult (Table 1), in good condition, and fully acclimatized. The plants were identified in accordance with the papers of Krüssmann (1976), Rehder (1977), Walters (1980), Seneta and Dolatowski (2008).

The phenological observations of the flowering stages of the seven *Corylus* taxa were carried out twice a week between 12.00 and 1.00 p.m. 10 inflorescences in each specimen were observed. The following stages of plant development were assessed: loose inflorescences, flowers with closed anthers (phase 0); inflorescences with a few open pollen-releasing anthers (phase 1); inflorescences with several empty anthers (phase 2); inflorescences with open pollen-releasing anthers and with empty anthers (phase 3); inflorescences with empty anthers only (phase 4).

The flowering onset was defined as a moment when several open anthers in the inflorescence started releasing pollen (phase 1); the period when the majority of anthers in the inflorescence released pollen was regarded as full bloom (phase 2 and 3); the end of flowering was defined as a moment when all anthers were empty (phase 4).

Spearman's analysis was employed to determine the relationships between the dynamics of development of male inflorescences in the seven *Corylus* taxa and the meteorological conditions: maximum temperature, relative air humidity, maximum wind speed, and precipitation from January to April in the years 2008-2011. Spearman's r correlation coefficients were calculated with the use of the version 7.1 of the STATISTICA programme (StatSoft Inc. 2007). The data were obtained from the weather station of the UMCS Institute of Meteorology and Climatology situated 3 km from the sampling site.

Corylus pollen seasons

During the study years, the pollen seasons were identified based on the analysis of pollen fall performed by the gravimetric method using a Durham sampler (Durham, 1964) that was located on a building roof at a height of ca. 5 m in the western part of Lublin (220 m a.s.l.; 51° 16`N, 22° 30`E). The building was located in the north-western part of the botanical garden. The surroundings of the garden consist of a compact detached housing area and blocks of flats. The north-western part borders a green belt composed mainly of maple, birch, ash, hazel as well as other ornamental and fruit trees and shrubs. The garden comprises 68 naturally growing several-year-old flowering *C. avellana* specimens (Fig. 1). The *C. avellana* species is common in the area of Lublin and Lubelszczyzna (Zając and Zając, 2001). The area of Lublin is dominated by west and south-west winds (Lorenc, 2005).

The pollen fall was expressed as the number of pollen grains $\cdot 1 cm^{-2}$ slide collected per two days. The length of the hazel pollen season was determined by the 98% method, which regards the day when 1% of the cumulative annual sum of pollen was recorded as the beginning of the season; in turn, 99% of the recorded pollen denoted the end of the season (Emberlin et al. 1993).

RESULTS

Flowering periods

The average length of male inflorescences in the *Corylus* taxa observed before flowering was 8-35 mm; *C. cornuta* exhibited the shortest inflorescences (Table 1 and Fig. 2). During full bloom, the inflorescence axis became elongated by 50% on average (Table 1). During the flowering period, *C. americana* inflorescences were lemon colour and the others were yellow (Fig. 2). The phenological observation indicates that the timing of the consecutive flowering phases in the selected *Corylus* taxa is not a constant phenomenon (Table 2 and Fig. 3.).

C. avellana. Among the taxa studied, *C. avellana* was the first to bloom each year. The earliest onset of flowering was recorded on January 26, 2008, and the latest on March 4, 2011. The earliest full bloom period was reported on February 5-11, 2008. In the other study years, full bloom was found between March 20 and 28. The earliest end of flowering was observed on February 22, 2008; during the next three years it took place between April 2 and 6. In 2009 *C. avellana* flowering was halted by unfavourable weather conditions on February 11 and it was continued on March 3. During the four years of study, *C. avellana* was characterized by the longest flowering periods lasting from 28 to 58 days (Table 2).

C. americana. January 26, 2008, was the onset of flowering for both *C. americana* and *C. avellana*. In the other years, *C. americana* bloomed in March. Its earliest full bloom was recorded on February 4-8, 2008, and the latest on March 26-30 in 2009-2010. The earliest end of flowering for this species was recorded on February 18, 2008. In the other years, the end of flowering was recorded in similar periods on April 10 and 13. The length of the flowering periods ranged between 22 and 34 days (Table 2).

C. × *colurnoides*. During the four years, the earliest flowering was recorded in 2008 (February 3), and the latest in 2010 (March 23). The earliest full bloom period for this taxon was reported on February 14 and 18, 2008. During the last three years of the study, full bloom was recorded on March 26-31. The length of the longest flowering periods (30 days) was reported during the first two years (Table 2).

C. maxima. The earliest flowering of *C. maxima* began on February 14, 2008. That year, the earliest end of flowering was observed as well (March 7, 2008). In the years 2009-2011, the flowering onset was reported between March 14 and 30, and it ended between April 9 and 11 (Table 2).

C. avellana 'Pendula'. The earliest onset of flowering of this taxon was reported on February 26, 2008. In the other years of the study, the flowering onset was recorded in the second and third decades of March. In 2008 full bloom was recorded at the turn of February and March, and in late March in the other years. The earliest end of flowering was reported on March 17, 2008, whereas in the other years of the study it was recorded in the first decade of April (Table 2).

C. avellana 'Contorta'. The earliest onset of flowering was recorded on March 13, 2008, and the latest on April 1, 2011. The earliest full bloom was reported on March 27-29, 2008. In the other years, the full bloom period ranged between April 7 and 11. The flowering of this taxon ended in the first or second decade of April (Table 2).

Table 1
Geographic distribution and short characteristics of seven *Corylus* taxa
in the collection of the Maria Curie-Skłodowska University Botanical Garden in Lublin.

Taxa	Geographic distribution	Origin	Introduction of the plants into the Botanical Garden in Lublin	Length of inflorescence before and after flowering (mm)
Corylus americana	North America	Botanical Garden in Washington	1986	35/66
Corylus avellana	Europe, Caucasus, Turkey	Botanical Garden in Lublin	1995*	33/60
Corylus avellana 'Contorta'	*cultivar*	Arboretum in Kórnik	1983	22/64
Corylus avellana 'Pendula'	*cultivar*	Arboretum in Kórnik	1999	28/69
Corylus × *colurnoides*	*cultivar*	Arboretum in Kórnik	1987	26/52
Corylus cornuta	North America	Botanical Garden in Warsaw	1975	8/17
Corylus maxima	Southern Europe, Caucasus, Turkey	Botanical Garden in Madrid	1983	29/55

* The plant has been growing naturally since 1995.

Table 2
Flowering dates of male inflorescences of seven *Corylus* taxa, with the identification of three phenological phases. Spearman's r correlation coefficients for the growth of male inflorescences of seven *Corylus* taxa and the weather parameters (2008-2011).

Phenological phases of flowering					Pearson's r correlation coefficients	
	beginning	full	end	days		
			Corylus americana			
2008	26.01	4-8.02	18.02	24	Max. temp. (°C)	0.11
2009	10.03	26-30.03	10.04	32	Relative humidity (%)	-0.04
2010	23.03	26-30.03	13.04	22	Max. wind (m/s)	0.07
2011	9.03	23-29.03	11.04	34	Precipitation (mm)	0.11
			Corylus avellana			
2008	26.01	5-11.02	22.02	28	Max. temp. (°C)	0.62*
2009	6.02	26-28.03	3.04	58	Relative humidity (%)	-0.49*
2010	23.02	24-27.03	2.04	40	Max. wind (m/s)	0.06
2011	4.03	20-23.03	6.04	34	Precipitation (mm)	0.13
			Corylus avellana 'Contorta'			
2008	13.03	27-29.03	2.04	21	Max. temp. (°C)	0.57*
2009	20.03	7-10.04	17.04	29	Relative humidity (%)	-0.26**
2010	30.03	9-11.04	16.04	18	Max. wind (m/s)	-0.15
2011	1.04	7-11.04	20.04	20	Precipitation (mm)	0.08
			Corylus avellana 'Pendula'			
2008	26.02	28.02-3.03	17.03	21	Max. temp. (°C)	0.70*
2009	12.03	27-31.03	10.04	30	Relative humidity (%)	-0.36*
2010	23.03	25-27.03	9.04	18	Max. wind (m/s)	0.09
2011	21.03	24-26.03	6.04	17	Precipitation (mm)	0.16
			Corylus × *colurnoides*			
2008	3.02	14-18.02	3.03	30	Max. temp. (°C)	0.69*
2009	9.03	26-28.03	7.04	30	Relative humidity (%)	-0.41*
2010	23.03	28-31.03	13.04	22	Max. wind (m/s)	0.15
2011	21.03	26-29.03	1.04	12	Precipitation (mm)	0.22
			Corylus cornuta			
2008	3.03	7-10.03	15.03	13	Max. temp. (°C)	0.71*
2009	26.03	5-10.04	17.04	23	Relative humidity (%)	-0.43*
2010	30.03	6-12.04	20.04	22	Max. wind (m/s)	0.08
2011	24.03	29.03-1.04	11.04	19	Precipitation (mm)	0.26**
			Corylus maxima			
2008	14.02	24-26.02	7.03	23	Max. temp. (°C)	0,48*
2009	14.03	31.03-2.04	10.04	28	Relative humidity (%)	-0.26**
2010	23.03	28-30.03	9.04	18	Max. wind (m/s)	0.09
2011	30.03	4-6.04	11.04	13	Precipitation (mm)	0.04

* – a statistically significant correlation coefficient <0.01; ** <0.05

Fig. 1. Schematic plan of the Maria Curie-Skłodowska University Botanical Garden in Lublin indicating the locations of the *Corylus* taxa studied:
1 – *C. americana*, 2 – *C. avellana* (specimens studied), 3 – *C. avellana* 'Contorta', 4 – *C. avellana* 'Pendula', 5 – *C.* × *colurnoides*, 6 – *C. cornuta*, 7 – *C. maxima*; DA – Durham sampler; Black dots – wild-growing several-year-old *C. avellana* specimens (n= 67)

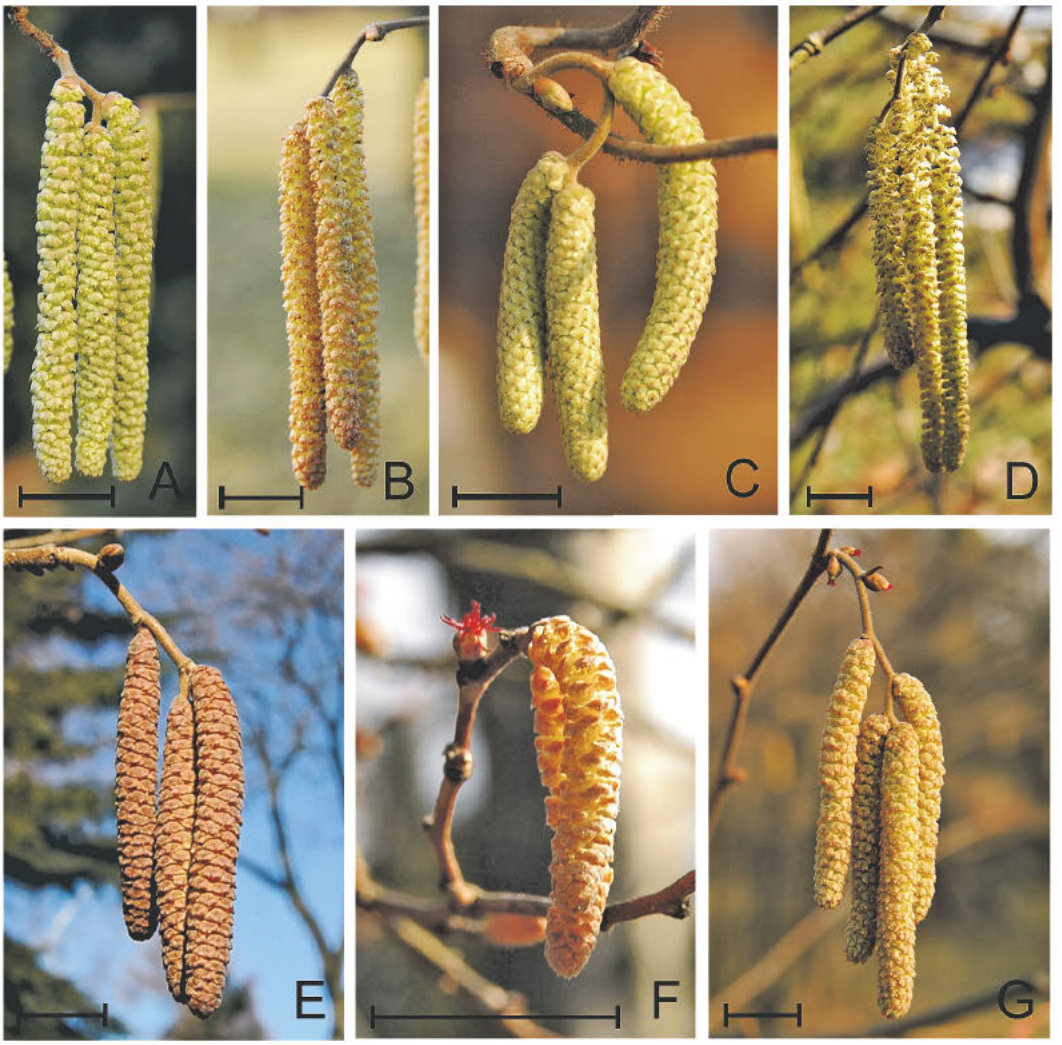

Fig. 2. Male inflorescences of seven *Corylus* taxa:
A – *Corylus americana*; B – *Corylus avellana*; C– *Corylus avellana* 'Contorta'; D – *Corylus avellana* 'Pendula'; E – *Corylus* × *colurnoides*; F – *Corylus cornuta*; G – *Corylus maxima*, scale bar = 10 mm

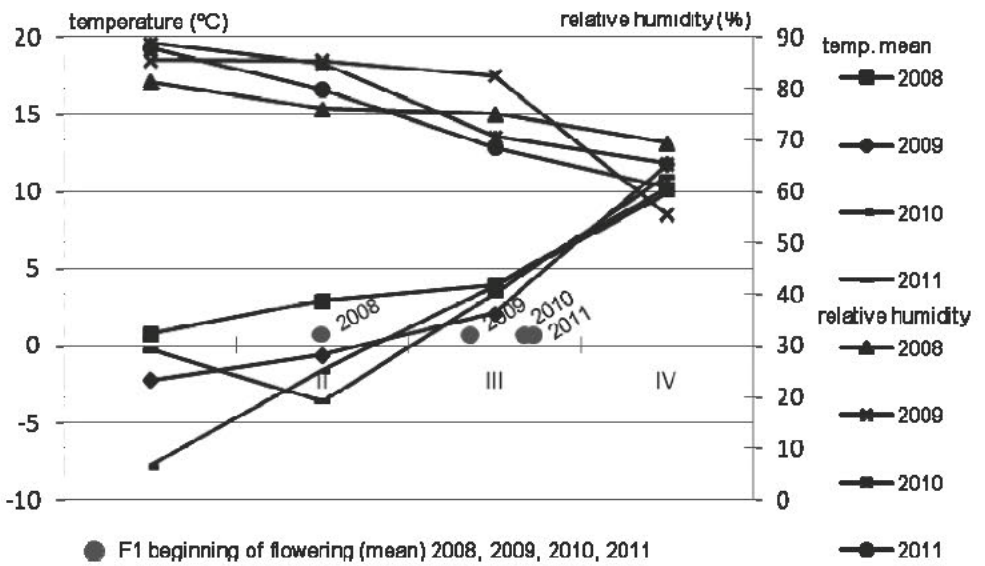

Fig. 3. Mean monthly temperature and relative air humidity from January to April

C. cornuta. Among the taxa observed, *C. cornuta* was the last to flower each year. The earliest onset of flowering was recorded on March 3, 2008. In the other years of the study, the flowering onset was reported in the third decade of March, and the end of flowering – after 20 days, on average. The flowering periods were relatively short (13-23 days) (Table 2).

The statistical analysis revealed a statistically significant Spearman's r correlation between the rate of male inflorescence flowering in six *Corylus* taxa and maximum temperature and relative air humidity during the four years of the study. The correlation between the flowering dynamics and wind speed and precipitation was insignificant (Table 2).

Pollen seasons

Pollen seasons are the result of *Corylus* flowering and pollen release. During the four years, the earliest pollen season for *Corylus* was recorded on January 30, 2008, and the latest one in early April 2009 and 2011 (Table 3). The earliest end of pollen seasons was reported on March 18, 2008. In the other years of the study, pollen seasons ended in the first or second decade of April. In 2009 and 2011, the onset and end of pollen seasons were recorded on similar days (March 3 and 4 and April 12 and 10, respectively). In those years, the pollen seasons were characterized by the highest maximum concentrations and the highest annual sums of pollen grains. The annual sums of pollen exceeded the value of 500 grains in both years. The length of the pollen seasons ranged from 38 to 49 days. The maximum pollen grain concentration was recorded on February 26 and 27, 2008, while in the other years it persisted between March 23 and 29 (Table 3).

Correlation between flowering and pollen release

In 2008 flowering of the *Corylus* taxa studied began a month earlier than in the other years (Figs. 4 and 5). It was a year in which the plants' response to weather conditions prevailing in early spring was clearly visible. The early *C. avellana* and *C. americana* species flowered first and afterwards the taxa that require higher temperatures for the flowering process (*C.* × *colurnoides*, *C. maxima*, *C. avellana* 'Pendula', *C. avellana* 'Contorta', *C. cornuta*). In 2008 during the pollen season, i.e. from January 30 to March 18, all the taxa studied flowered (from January 21 to April 2). *C. avellana* and *C. americana* began blooming a few days before the season, whereas the flowering period of *C. avellana* 'Contorta' persisted for 15 days after the end of the pollen season. Full bloom of the taxa observed in 2008 was recorded before or after the period of the maximum concentration of airborne *Corylus* pollen grains.

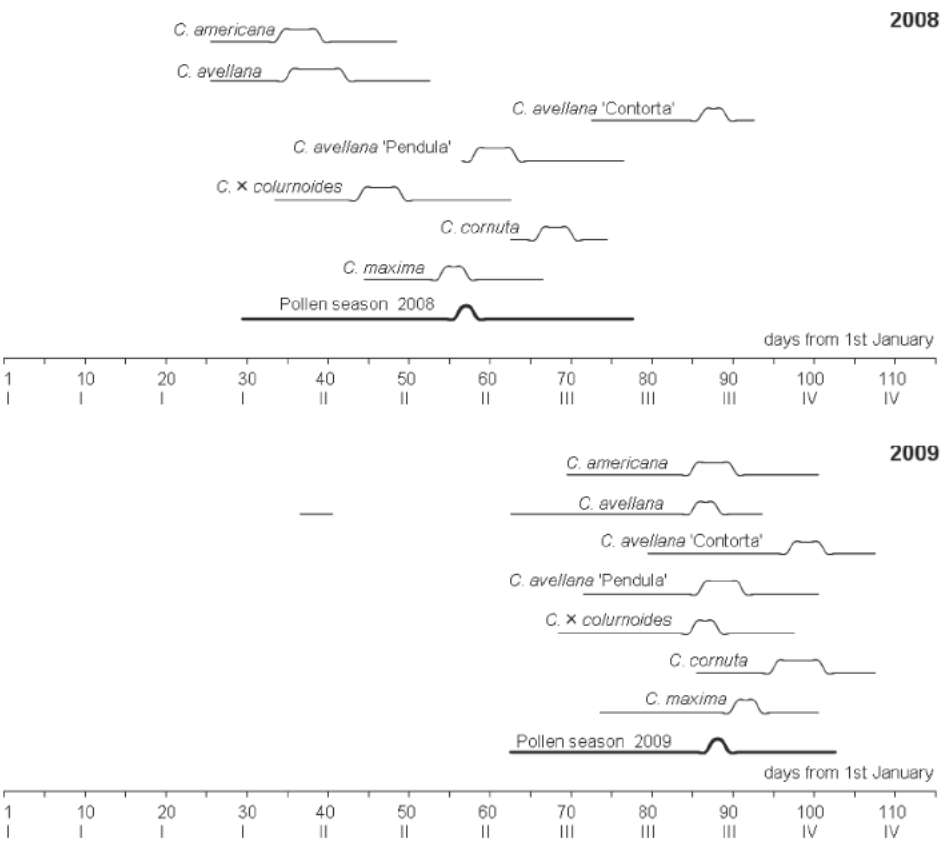

Fig. 4. Flowering periods of seven *Corylus* taxa in relation to pollen season in the years 2008-2009. Peak – full bloom/maximum concentration

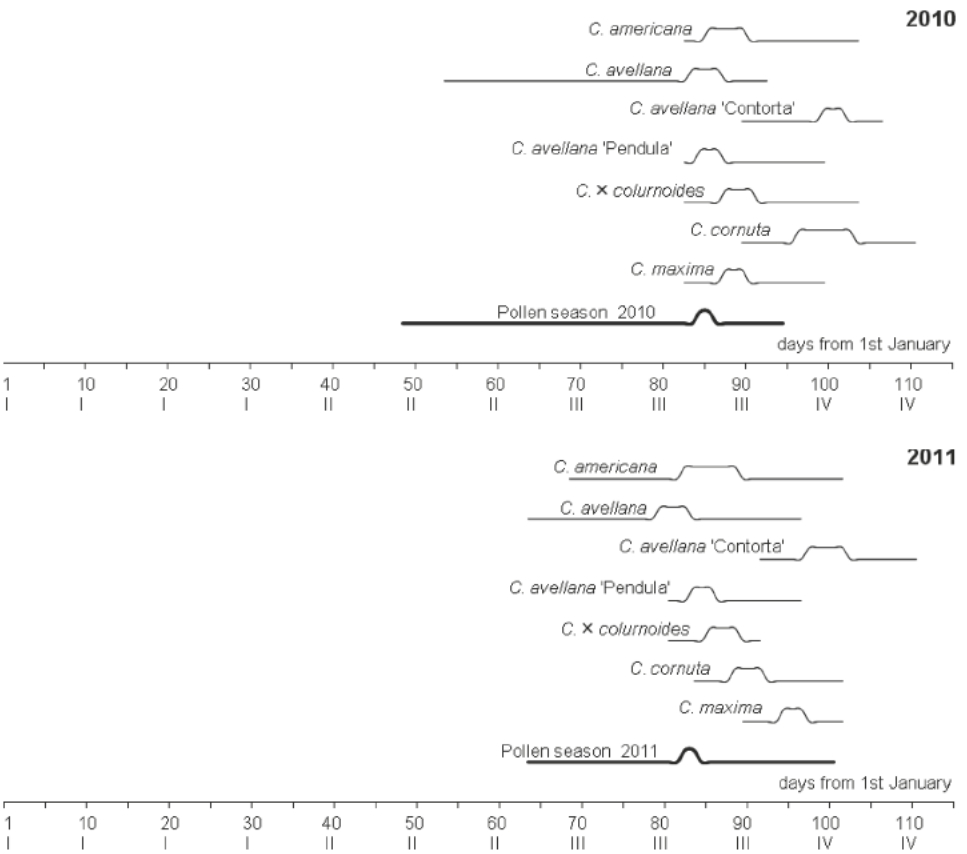

Fig. 5. Flowering periods seven of *Corylus* taxa in relation to the pollen seasons in the years 2010-2011. Peak – full bloom/maximum concentration

Table 3
Characteristics of the *Corylus* pollen seasons
on the basis of aerobiological monitoring in Lublin, in the period 2008-2011.

Investigated trait	2008	2009	2010	2011
Start of season	30.01	3.03	18.02	4.03
End of season	18.03	12.04	4.04	10.04
Duration (days)	49	41	47	38
Max. concentration (number of grains/cm^2)	71	394	66	237
Date of occurrence of max. concentration	26-27.02	28-29.03	25-26.03	23-24.03
Total pollen	370	704	236	541

Flowering of *Corylus* in the years 2009-2011 was more condensed (Figs 4 and 5). Full bloom in most of the taxa studied coincided with the period of the maximum concentration of airborne *Corylus* pollen grains. The onset of flowering in *C. avellana* was usually recorded on the day of appearance of first *Corylus* pollen grains in the air, whereas the flowering of the other taxa was typically reported after the beginning of the pollen seasons. Flowering of the late taxa, i.e. *C. avellana* 'Contorta' and *C. cornuta*, persisted for 5 to 16 days after the end of the pollen season.

DISCUSSION

In Lublin, hazel begins flowering in February or March, and only exceptionally in January, and ends in late March or early April. This is confirmed by the reports of Weryszko-Chmielewska and co-authors (2008, 2010). The pollen season in Lublin begins at the turn of January and February or in early March and ends in April. The results of the present study correspond to the investigations conducted by Weryszko-Chmielewska and Piotrowska

(2006). In southern Europe, hazel begins flowering the earliest, and in the north of Europe – the latest. In the north-east of Italy, the onset of hazel flowering is recorded in the third decade of January, while the pollen season starts at the turn of January and February (Rizzi Longo and Pizzulin Sauli, 2010). In the north-east of Slovenia (Črepinšek et al. 2011) and northern Croatia (Peternel et al. 2005), the onset of flowering and pollen release were recorded in the first decade of February. In central Slovakia, hazel begins to flower, on average, on March 2, and the pollen season starts 4 days later (Škvareninová et al. 2011). In the West Midlands, UK, the pollen season of *Corylus* begins, on average, in mid-January (Emberlin et al. 2007). In Lithuania, the onset of hazel flowering was recorded at the turn of March and April (Veraiankait et al. 2010). In western Norway, in turn, the flowering period starts in the first decade of April (Wielgolaski, 1999). The results obtained by the above-mentioned authors indicate that the time span between the dates of flowering onset of *C. avellana* in Europe is 10 weeks. In southern Europe, *C. avellana* flowering begins at the turn of January and February, in the central part – in early March, and in the north - at the turn of March and April. The results obtained in the present study partly correspond to the data provided by other authors (Lattore, 1999; Kasprzyk, 2003; Peternel et al. 2005; Emberlin et al. 2007; Škvareninová et al. 2011), who claim that the pollen season begins, on average, 4-18 days after the onset of flowering and continues for even a month after the end of the latter. In general, *Corylus* pollen grains appear in the air within a few days after the onset of flowering and they remain in the air for several weeks after its end, which is related to long-term transport of pollen from remote regions (Szczepanek, 2003). On average, the highest concentration of airborne pollen was found when the flowering of *Corylus* began to decrease (Rizzi Longo and Pizzulin Sauli, 2010).

During the four years of the study, the date of flowering of hazel and appearance of its pollen in the air were clearly correlated with temperature and relative air humidity. This has been confirmed in investigations conducted by other authors (Wielgolaski, 1999; Puc, 2007; Dąbrowska, 2008; Piotrowska and Kaszewski, 2009; Rizzi Longo and Pizzulin Sauli, 2010; Veraiankait et al. 2010; Weryszko-Chmielewska et al. 2010; Črepinšek et al. 2011; Škvareninová et al. 2011).

The long periods of flowering of the *Corylus* taxa in 2009 were the consequence of slight frost, which led to a pause followed by re-flowering. In 2010-2011, the meteorological conditions delayed the flowering, which contributed to the shortening of the flowering periods. These phenomena are typical of early spring plants from the temperate climate zone. The modifying effect of meteorological factors on the appearance of successive phenophases has been reported by many authors (Wielgolaski, 1999; Rizzi Longo and Pizzulin Sauli, 2010; Veraiankait et al. 2010; Weryszko-Chmielewska et al. 2010; Črepinšek et al. 2011; Škvareninová et al. 2011).

CONCLUSIONS

1. The timing of the phenological events studied, i.e. the onset of flowering, full bloom, and the end of flowering, was not constant in the selected *Corylus* taxa. The appearance of the individual flowering phases was dependent on the prevailing thermal and humidity conditions as well as the biological features of the taxa.
2. The onset of the *Corylus* pollen season as well as its length and abundance of airborne pollen grains in Lublin differed considerably between the study years.
3. Pollen grains of *C. americana*, *C. avellana* 'Pendula', *C.* × *colurnoides* and *C. maxima* may have had a substantial effect on the quantity of airborne pollen during the *Corylus* pollen season, as intensive pollen release was usually recorded during the maximum concentration of airborne *Corylus* pollen grains.

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Fenologia kwitnienia i sezony pyłkowe *Corylus* spp. w Lublinie, 2008-2011

Streszczenie

W latach 2008-2011 przeprowadzono obserwacje fenologiczne kwitnienia męskich kwiatostanów siedmiu taksonów z rodzaju *Corylus*: *C. americana*, *C. avellana*, *C. avellana* 'Contorta', *C. avellana* 'Pendula', *C.* × *colurnoides*, *C. cornuta*, *C. maxima* uprawianych w Ogrodzie Botanicznym Uniwersytetu Marii Curie-Skłodowskiej w Lublinie. W tym czasie przeprowadzono również analizę sezonów pyłkowych leszczyny w atmosferze Lublina przy zastosowaniu aparatu Durhama. Celem pracy była ocena kwitnienia siedmiu taksonów *Corylus* na tle wybranych elementów pogodowych oraz sezonów pyłkowych w latach 2008-2011.

Roczne cykle fenologiczne w latach badań różniły się wyraźnie czasem rozpoczęcia kolejnych faz kwitnienia obserwowanych taksonów *Corylus*. W czteroleciu leszczyny najwcześniej rozpoczynały kwitnienie pod koniec stycznia, zaś najpóźniej pod koniec marca. Pełnia kwitnienia miała miejsce najwcześniej w pierwszej dekadzie lutego, zaś najpóźniej w pierwszej dekadzie kwietnia. Koniec kwitnienia przypadał w lutym, w pierwszej lub drugiej dekadzie kwietnia. Co roku najwcześniej zakwitała *C. avellana*, następnie kolejno *C. americana*, *C.* × *colurnoides*, *C. maxima*, *C. avellana* 'Pendula', *C. avellana* 'Contorta' i *C. cornuta*. Sezony pyłkowe w badanym okresie rozpoczynały się w końcu stycznia, w drugiej dekadzie lutego lub w pierwszej dekadzie marca. Koniec sezonów pyłkowych najczęściej miał miejsce w pierwszej lub drugiej dekadzie kwietnia. Czas trwania sezonów pyłkowych zawierał się w 38-49 dniach, natomiast czas trwania kwitnienia poszczególnych taksonów przeciętnie wynosił 22 dni. W czteroleciu początek kwitnienia *C. avellana* i początek sezonu pyłkowego przypadał niemal w tym samym dniu kalendarzowym, natomiast początki kwitnienia pozostałych taksonów miały miejsce zwykle po rozpoczęciu sezonów pyłkowych. Kwitnienie *C. avellana* 'Contorta' i *C. cornuta* trwało od 5 do 16 dni po sezonie pyłkowym. Rozwój kwiatostanów wykazywał najsilniejszy związek z temperaturą maksymalną i wilgotnością względną powietrza.