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VARIATION OF SPRING PHENOLOGICAL PHASES AND AIRBORNE POLLEN GRAINS OF THE EUROPEAN HAZEL (*CORYLUS AVELLANA* L.) IN THE ZVOLEN BASIN (SLOVAKIA) AS INFLUENCED BY METEOROLOGICAL FACTORS

Abstract: The impact of air temperature on the formation of generative organs of the European hazel (*Corylus avellana* L.) and the onsets of related phenophases during the years 1987–2009 in Central Slovakia (the Zvolen basin) are analyzed in this paper. The analyses are based on the records of 10% and full onset of catkins lenghtening, inflorescence emergence and flowering. Catkins lengthening was observed on February 7th and lasted 10 days on average, inflorescence emergence on February 20th and 8 days and flowering on March 2nd and 6 days. The earliest dates of phenophases onsets were observed in 2007, while the latest in 1987 and 2005. A large variability of daily mean air temperatures in different years resulted also in a high variability of phenophases onsets (s_x% 27.3–35.3). The onsets of spring phenophases earlier by 2.5–5.5 days were recorded at the end of the evaluated period of years as compared with the beginning. The concentration of pollen grains captured with a Burkard volumetric rotate pollen trap culminated approximately 10 days after flowering. The peak pollen grain concentration varied in a range of 50–500 pollen grains per m^3. The peaks of pollen grains concentrations in the Zvolen Basin were influenced, apart from the flowering of the European hazel also by the transport of pollen grains from higher mountainous habitats especially in the late pollen season.

Key words: phenology, European hazel (*Corylus avellana* L.), air temperature, snow cover, pollen analyses, Central Slovakia
Słowa kluczowe: fenologia, leszczyna pospolita (*Corylus avellana* L.), temperatura powietrza, pokrywa śnieżna, analizy pyłkowe, środkowa Słowacja

Introduction

Apart from climatologists, the present phenology is also in the center of interest of scientists focused on pollen allergies all over the world. A knowledge of the relations between climatic processes and the phenological response of plants as well as a knowledge of the driving atmospheric forces that influence those relations on a regional scale is the main reason for this interest. Phenological observations are a valuable source of information on the duration of pollen seasons in regions (Larcher 1988). The onset of generative phenophases depends on the course of meteorological factors and a knowledge of this dependence can be consequently used for spatial forecasts of flowering and pollen loads.

Today pollinosis belongs among the most frequent allergic diseases and almost one third of the population suffer from them. People aged 15–30 years belong to the most risky category of population (Lafférsová *et al.* 2008).

The knowledge on pollen allergens release is essential for correct diagnoses of pollinosis, timing of preventive treatment and modification of daily regime of patients. Regional Offices of Public Health are responsible for monitoring of pollen grains and spreading the information on pollen loads in Slovakia. The course of pollen season is significantly influenced by the weather conditions (especially air temperature, precipitation, and atmospheric circulation) during the growing seasons of plants (Križo *et. al.* 2004).

Plants and especially woody plants are very variable both on individual and population levels. Apart from genetic and evolutional reasons this variability is influenced also by the environmental aspect. Changes in phenological patterns, reproductive cycles, as well as in the structure of ecosystems are frequently observed phenomena as the consequences of climate change in Central Europe. Therefore phenological observations have also become an important bioindicator for the prognoses of the future spread and vitality of these plants (Bagar, Nekovář 2006; Piotrowicz, Myszkowska 2006; Škvareninová 2009).

The aim of this paper is to evaluate the generative phenophases of the European hazel (*Corylus avellana* L.) in relation to temperature variability and the consequent pollen spread in the Zvolen Basin – Central Slovakia.

Data and methods

The phenological data were observed in the Borova hora Arboretum – the Botanical Garden of the Technical University in Zvolen. The onsets of phenological phases of the European hazel (*Corylus avellana* L.) were recorded on the natural range habitats in Central Slovakia (south-western part of the Zvolen Basin) during the years 1987–2009. The northwestern exposure of habitats dominates in the area (81%), southwest and western exposures are less frequent. The altitudinal profile of the area ranged from 290 to 377 m a.s.l. (φ=48°35’N, λ=19°09’E). The meteorological data used for the analyses were gathered at the Sliac meteorological station (314 m a.s.l., φ=48°39’N, λ=19°09’E). The mean annual air temperature is 8.2°C, and the mean annual precipitation totals 757 mm (Střelcová, Škvarenina 2007).

The phenological phases of the European hazel were evaluated according to the methodology of the Slovak Hydrometeorological Institute in Bratislava (SHMI). This methodology is the standard one for the observation of woody plants in Slovakia (SHMI 1984).

The dates of the 10% onset (phenophases were observed on 10% of plants) and the full onset of phenophases (record of phenophases on each of the observed plants) were recorded in order to determine the duration of phenophases. Consequently, the dates were transformed into the days of the year (Julian days) that were used for statistical analyses.

Generative phenological phases were observed as follow:

– Catkins lengthening – LA (solid catkins become elastic),
– Inflorescence emergence – IF (male flower swelling but without a release of pollen grain),
– Flowering – FW (male flower pollen grains are recorded in air).

Apart from the phenological observations the relations between the daily mean air temperature, the duration of snow cover and the records of airborne pollen grains from the station in Banska Bystrica (363 m a.s.l., φ=48°44'N, λ=19°07'E) during the years 2003–2009 were also analyzed. Air sampling was performed with a Burkard 7 day recording volumetric pollen and spore trap (Hirst 1952) located on the roof of the building of the Regional Office of Public Health in Banska Bystrica at a height of 12 m above the ground.

Results and discussion

The onset of the lengthening of catkins during the years 1987–2009 was recorded on February 7th on average (Table 1). The earliest record on January 1st 2007 was evoked by an unusually warm winter season with air mean temperatures exceeding 0°C. The latest records – March 8th 1987 and March 17th 2005 were recorded after cold winters with monthly mean air temperatures of the coldest months -7.4 or -7.5°C respectively (Fig. 1). A dependence of the lengthening of catkins on the duration

Table 1. Statistics of the onset and duration of the generative phenophases of the European hazel (1987–2009)

Tab. 1. Charakterystyki statystyczne początku i trwania generatywnych fenofaz leszczyny pospolitej (1987–2009)

Lengthening of aglets				Inflorescence emergence				Flowering			
Ø	Min.	Max.	s_x %	Ø	Min.	Max.	s_x%	Ø	Min.	Max.	s_x%
7.02	1.01. 2007	17.03. 2005	30.9	20.02	8.01. 2007	25.03. 2005	35.3	2.03.	25.01. 2007	1.04. 1987	27.3

Explanations: Ø – arithmetical mean, Min. – earliest onset, Max. – latest onset, s_x% – variation coefficient.

Objaśnienia: Ø – średnia arytmetyczna, Min. – najwcześniejszy początek, Max. – najpóźniejszy koniec, s_x% – odchylenie standardowe.

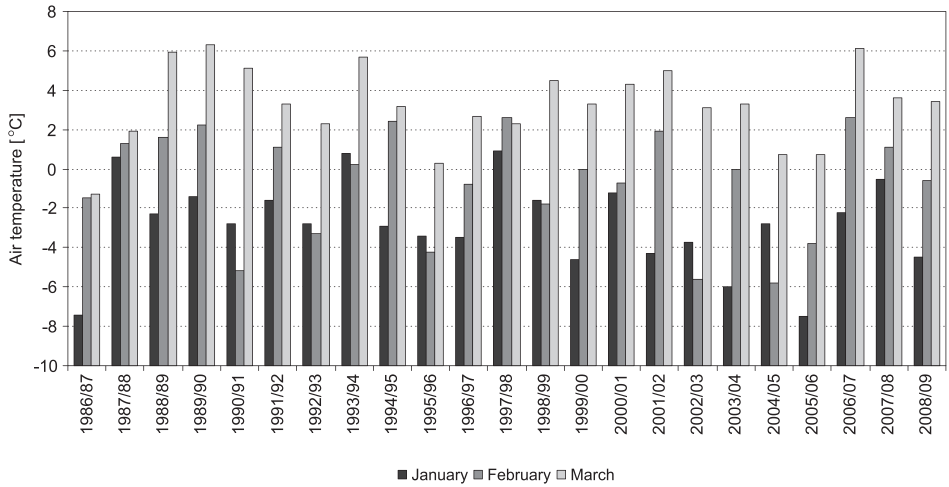

Fig. 1. Mean air temperatures in January, February and March at the Sliac meteorological station (the Zvolen Basin) in the years 1987–2009

Ryc. 1. Średnia temperatura powietrza w styczniu, lutym i w marcu na stacji meteorologicznej Sliac (Kotlina Zwoleńska) w latach 1987–2009

of snow cover was also found (Fig. 2, 3). These trends were not significant. When the snow cover was recorded for a limited number of days or absent at all (1990, 1998, 2007 and 2008) the onset of the phenophase was observed in the last decade of January. On the other hand, a lot of days with snow (1987, 1996, 2005, 2006) delayed the onset of the phenophase into the first half of March. The high variability (s_x=30.9%) of the phenophase onset is caused by the variability of air temperatures from year to year. The lengthening of catkins lasted 7–20 days with the average of 11 days. Solar radiation also influenced the onset of the phenophases. A sunny, warm weather accelerated the onset of the phenophases by 2.5 days according to the results of long trend analyses (Škvareninova 2009) (Fig. 2).

The onset and duration of inflorescence emergence over years resulted from the course of air temperature in the winter season (Fig. 2). The phenophase onset was recorded on February 20th on average with a high variability of 35.3%. The latest date (March 25th) was recorded in 2005, being the coldest year of the period with the mean air temperature in February -5.8°C. The warm winter in 2006/2007 accelerated inflorescence emergence and the earliest onset of the phenophases – January 8th was recorded in that year. Inflorescence emergence was shorter by 8 days as compared with the lengthening of catkins. According to trend analyses in the period of 1987–2009 the onset by earlier 5.5 days was recorded at the end of the period as compared with the beginning.

Flowering onsets in the Zvolen Basin were observed on March 2nd on average. The earliest date was recorded on January 21st 2007, the latest on April 1st 1987. Different dates have been published in literature. During the years 1987–2006

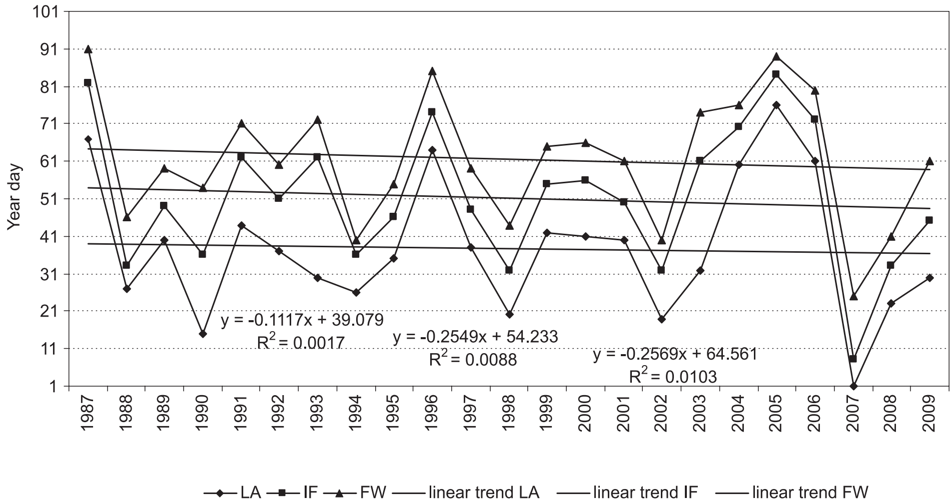

Fig. 2. Course of the generative phenophases and their linear trends in the years 1987–2009
Ryc. 2. Przebieg generatywnych faz fenologicznych i ich trendy liniowe w latach 1987–2009

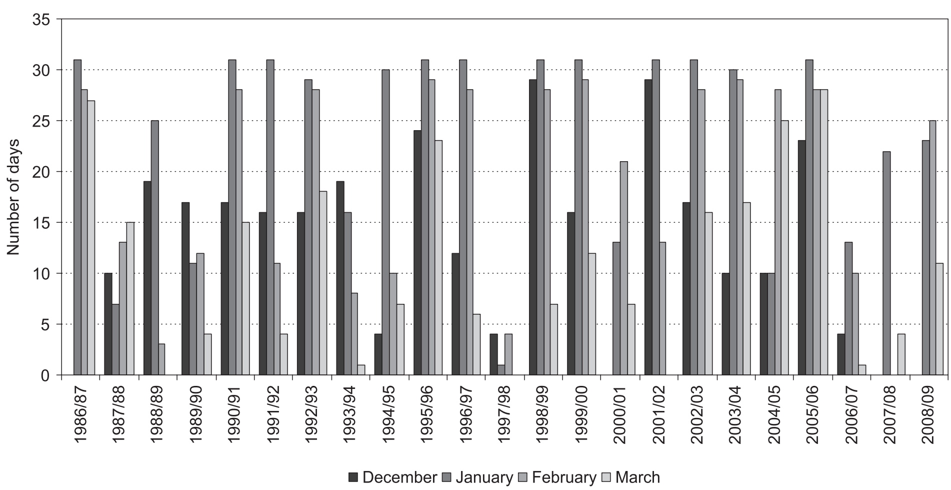

Fig. 3. Number of days with snow cover during winter (December-March) in 1987–2009
Ryc. 3. Liczba dni z pokrywą śnieżną w zimie (grudzień-marzec) w latach 1987–2009

the mean onset of this phenophase on the territory of Slovakia was observed on March 15th on average (Remišová, Vinceová 2007). March 13th was found as the mean onset of the phenophase in the Zvolen Basin in the period of 1930–1960 (Kurpelová 1972). When comparing different literature sources the earlier onsets of the phenophase are recorded today. The late dates of flowering published for some habitats are affected by altitude. During the years 1991–2005 a very late mean date of flowering – April 4th was recorded at an altitude of 625 m a.s.l. (Bednářová, Merklová 2006).

Flowering lasted 6 days on average. The shortest duration of the phenophase (4 days) was observed after the winter season 1993/1994 with a long period of mean air temperatures exceeding 0°C. The difference between the onsets of inflorescence emergence and flowering was only 4 days that year (Fig. 2). The coefficient of variation decreased to 27.3%. According to trend analyses in the period of 1987–2009 the onset of flowering earlier by 5.5 days was found at the end of period as compared with the beginning.

A later average date of the flowering onset has been published for the territory of Slovakia according to analyses for the years 1987–2006 (Remišová,Vinceová 2007). Taking into account the very different conditions of habitats in Slovakia those results are reasonable. The flowering onset in Rzeszow (SE Poland) during the years 1999–2001 was observed in the second half of February (Kasprzyk 2003). These dates are earlier by about 2–3 weeks as compared with dates from the Zvolen Basin in Slovakia. This difference is probably influenced by altitude and also by a very frequent occurrence of inversion weather situations with low temperatures during winter in the Zvolen Basin (Fig. 4).

The interannual variability between flowering and airborne grain concentrations of the European hazel is demonstrated for the years 2003, 2006, 2007, 2009 (Fig. 5).

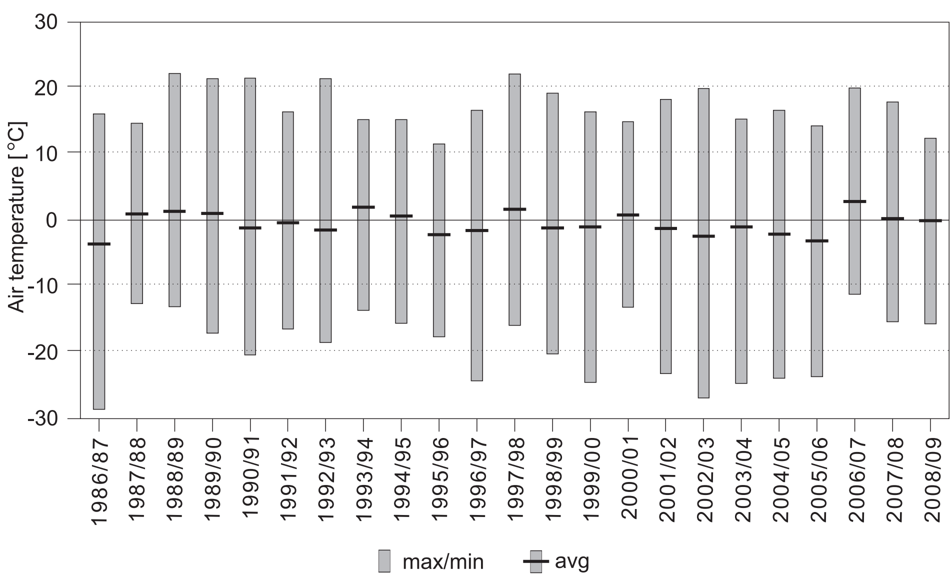

Fig. 4. Maximum, minimum and mean air temperatures in the winter season (December-March) at the Sliac meteorological station (the Zvolen Basin) in the years 1987–2009

Ryc. 4. Maksymalna, minimalna i średnia temperatura powietrza w zimie (grudzień-marzec) na stacji meteorologicznej Sliac (Kotlina Zwoleńska) w latach 1987–2009

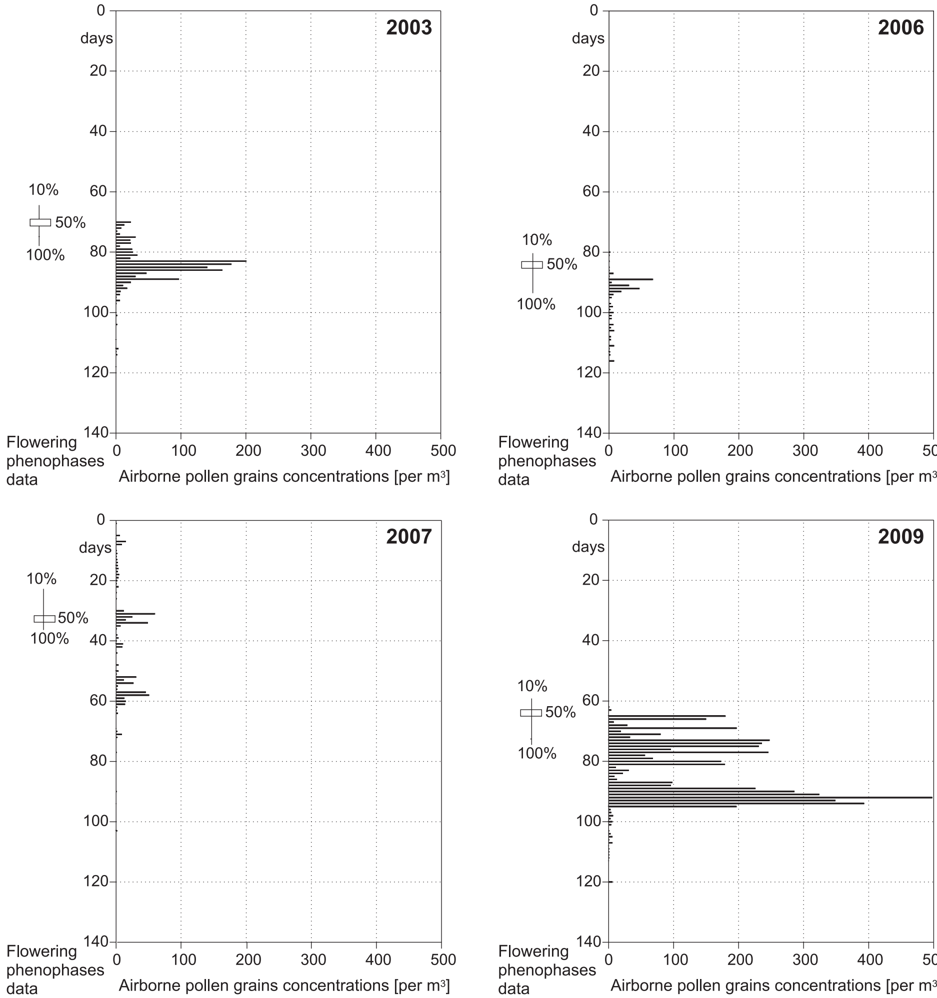

Fig. 5. Flowering of the European hazel (left) and airborne grain concentrations (right) in 2003, 2006, 2007 and 2009

Ryc. 5. Kwitnienie leszczyny pospolitej (na lewo) i stężenie ziaren pyłku w powietrzu (na prawo) w latach 2003, 2006, 2007 i 2009

The flowering onset in 2003 (Fig. 5) was recorded on March 1st and the full flowering was observed on March 23rd. The first record of pollen grains was noted on March 11th and the peak concentration – 201 pollen grains per m^3 was recorded on March 25th. The pollen season lasted until April 1st.

A late flowering and pollen release after a long winter was observed in 2006 (Fig. 5). The total number of pollen grains was low with the peak concentration of only 67 grains per m^3. A very early first record of pollen grains recorded with a Burkard trap was found in 2007 (Fig. 5). The record of pollen grains before flowering (after January 1st) was very probably caused by the flowering of the European hazel in a city with warmer microclimatic conditions as compared with the observation of habitats in the Zvolen Basin. The first peak (59 grains per m^3) recorded on January 1st corresponds with the observation of 50–100% flowering. The second peak (51 grains per m^3) recorded at the end of February was probably evoked by the transport from higher altitudes due to a specific circulation situation.

The highest pollen concentration was found in 2009. The peak concentration (498 grains per m^3) was recorded after the end of 100% flowering (Fig. 5). Two peaks were probably again influenced by pollen transport from higher altitudes. Apart from Slovakia, a high interannual variability of the onset and duration of the pollen season was also found in Krakow (S Poland) (Myszkowska *et al.* 2004; Myszkowska, *et al.* 2007; Myszkowska, Piotrowicz 2009; Piotrowicz, Myszkowska 2006; Piotrowicz 2010). Very early beginning of pollen seasons (in January) was recorded in years 1994, 2006, 2007.

Conclusions

The European hazel (*Corylus avellana* L.) is a representative forest as well as landscape phenological bioindicator. A high variability in the onsets and duration of the spring phenophases comprising catkins lengthening, inflorescence emergence and flowering was observed during the years 1987–2009. Apart from air temperature, the snow cover plays an important role for the onsets of phenological phases during the winter season. A small tendency to earlier onsets of phenophases was found during the evaluated period of years.

Relations between the flowering of the European hazel and airborne pollen concentrations were evaluated in the years 2003–2009. The variability of peak concentrations ranged between 50–500 pollen grains per m^3. These peaks were recorded 10 days after the flowering onset on average. Apart from the flowering of the European hazel, these peaks in the Zvolen Basin were also influenced by the transport of pollen grains from higher mountainous habitats especially in the late season. Monitoring of the European hazel flowering can play an important role in pollen loads forecasting.

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References

Bagar R., Nekovář J., 2006, *Tendence vývoje vegetace v přírodních lesních oblastech Moravy*, [In:] J. Rožnovský, T. Litschmann, I. Vyskot (eds.), *Fenologická odezva proměnlivosti podnebí*, Brno, ČHMÚ, 1–23, http://www.cbks.cz/sborník06/prispevky/BagarNekovar.pdf.

Bednářová E., Merklová L., 2006, *Zhodnocení fenologických fází keřového patra na okraji smrkového porostu v oblasti Drahanská vrchovina*, [In:] J. Rožnovský, T. Litschmann, I. Vyskot (eds.), *Fenologická odezva proměnlivosti podnebí*, Brno, ČHMÚ, 1–8, http://www.cbks.cz/sborník06/prispevky/Bednarova.pdf.

Hirst J. M., 1952, *An Automatic Volumetric Spore Trap*, Annals of Applied Biology, 39, 257–265.

Kasprzyk I., 2003, *Flowering phenology and airborne pollen grains of chosen tree taxa in Rzeszów (SE Poland)*, Aerobiologia, 19, 113–120.

Križo M., Benčaťová B., Lafférsová J., Hochmuth L., Braslavská O., 2004, *Peľová sezóna vo Zvolenskej kotline*, [In:] *Ekologická diverzita Zvolenskej kotliny*, Zvolen, 180-182.

Kurpelová M., 1972, *Fenologické pomery*, [In:] M. Lukniš *et al.* (ed.), *Slovensko, príroda*, Obzor, Bratislava, 275–282.

Lafférsová J., Benčaťová B., Hochmuth L., Klement T., Snopková Z., 2008, *Peľová informačná služba na Slovensku pod gestorstvom verejného zdravotníctva*, [In:] *Medical practice – mesačník pre lekárov ambulantnej starostlivosti*, 2, 40–44.

Larcher W., 1988, *Fyziologická ekologie rostlin*, Praha, Academia.

Myszkowska D., Dyga, W., Piotrowicz K., 2004, *Sezony pylenia Alnus i Corylus w Krakowie w latach 1997-2005*, Alergologia, Immunologia, 2, 2–3, 34–35.

Myszkowska D., Jenner B., Cywa K., Kuropatwa M., Stępalska, D., Piotrowicz K., 2007, *Pollen seasons of selected tree and shrubs taxa in Kraków and its neighbouhood*, Acta Agrobotanica, 60 (2), 71–77.

Myszkowska D., Piotrowicz K., 2009, *Dynamika sezonu pyłkowego na tle warunków meteorologicnych w Krakowie, w roku 2009*, Alergologia, Immunologia, 6, 4, 136–140.

Piotrowicz K., 2010, *Sezonowa i wieloletnia zmienność typów pogody w Krakowie*, IGiGP UJ, Kraków.

Piotrowicz K., Myszkowska D., 2006, *Początek sezonów pyłkowych leszczyny na tle zmienności klimatu Krakowa*, Alergologia, Immunologia, 3, 3–4, 86–89.

Remišová V., Vinceová A., 2007, *Kvitnutie liesky obyčajnej (Corylus avellana* L.*) na Slovensku za obdobie 1987–2006*, [In:] J. Rožnovský, T. Litschmann, I. Vyskot (eds.), *Klima lesa*, Křtiny, ČHMÚ, 1–6, http://www.cbks.cz/sborník06/prispevky/remisova_vinceova.pdf.

SHMI, 1984, *Guidbook for phenological observations of forest plants*, SHMÚ Bratislava, 1–23.

Střelcová K., Škvarenina J., 2007, *Meteorologické laboratórium s on–line prenosom meteorologických údajov z regionálnych meteorologických staníc do internetu*, www.tuzvo.sk.

Škvareninová J. 2009, *Fenológia rastlín v meniacich sa podmienkach prostredia*, Vydavateľstvo Technickej univerzity, Zvolen.

Wpływ elementów meteorologicznych na zmienność wiosennych fenofaz oraz występowanie ziaren pyłku leszczyny pospolitej (*Corylus avellana* L.) w Kotlinie Zwoleńskiej (Słowacja)

Streszczenie

W pracy przeanalizowano wyniki obserwacji fenologicznych leszczyny pospolitej (*Corylus avellana* L.) w powiązaniu z temperaturą powietrza. Obserwacje wykonywano w latach 1987–2009 w środkowej Słowacji (Kotlina Zwoleńska). Dotyczyły one 10% początku faz fenologicznych: wydłużanie kotek, butonizacja i kwitnienie. Wydłużanie

kotek przebiegało w danym okresie średnio od 7 lutego i trwało 10 dni. Butonizacja rozpoczynała się 20 lutego ze średnią długością trwania 8 dni. Fenofaza kwitnienia rozpoczynała się w omawianym okresie średnio 2 marca i trwała 6 dni. Początki faz fenologicznych rozpoczynały się najwcześniej w latach 2007 i 2005. Fenofazy charakteryzowały się dużą zmiennością (s_x% 27,3–35,3) pod wpływem znacznych wahań dobowej temperatury powietrza w poszczególnych latach. Początki wiosennych faz fenologicznych rozpoczynały się wcześniej o 2,5–5,5 dnia. Najwyższe stężenie ziaren pyłku, wychwytywanych za pomocą rotacyjnego pochłaniacza objętościowego (Burkard), występowało około 10 dni po rozpoczęciu fenologicznej fazy kwitnienia. Zróżnicowanie maksymalnej liczby ziaren pyłku zmieniało się w zakresie od 50 do 500 na m^3. Występowanie kilku maksimów stężenia ziaren pyłku jest związane z jednej strony z kwitnieniem leszczyny w Kotlinie Zwoleńskiej, a z drugiej strony bardzo późne wysokie notowania są spowodowane przenoszeniem ziaren pyłku przez przepływające powietrze z wyższych obszarów górskich.

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