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EVALUATION OF THE ABUNDANCE OF HAZEL (*Corylus* spp.) POLLEN BASED ON THE PATTERNS OF THE POLLEN SEASONS IN LUBLIN IN THE PERIOD 2001–2010

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Abstract. *Corylus avellana* belongs to early spring pollen sources for *Apis mellifera*. The aim of the present study was to evaluate the dynamics of the *Corylus* pollen seasons over a 10-year study period (2001–2010). The study was carried out in Lublin by the volumetric method that is currently used in aerobiology. Years of abundant pollen production by this taxon were determined, as well as the period of maximum pollen release in each year, which is associated with the availability of large amounts of pollen to bees. Thermal conditions accompanying the beginning of pollen shed and the conditions prevailing during abundant pollen shed were presented. In particular years, the start of the *Corylus* pollen seasons was recorded between 9 January and 25 March, with an average temperature of 4.1°C. The duration of the pollen season varied between 19 and 78 days. Years of the highest hazel pollen production were as follows: 2006, 2010, 2007, and 2005. The period of pollen abundance, associated with the presence of high *Corylus* pollen content in the air, was recorded most frequently in the second half of March and at the beginning of April, with the average temperature between 2.4 and 14.4°C, with the 10-year mean value of 8.1°C. At the temperature of 8°C, the honey bee undertakes its first foraging trips, among others, to search for water and collect pollen. The present study showed that the nitrogen content in *Corylus* pollen grains was 4.82%, while the protein content 30.13%, which demonstrates the significant nutritional value of this pollen.

Key words: aerobiology, pollen monitoring, availability to bees, nitrogen and protein content

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INTRODUCTION

Anemophilous plants produce a very large amount of pollen grains, but only a small number of them participate in flower pollination. Insects take advantage of this overproduction of pollen grains, since pollen is a source of protein. Protein has been found to constitute from 11% to 35% of the chemical composition of pollen grains [Maurizio and Grafl 1969].

It has been calculated that one male inflorescence of *Corylus avellana* produces 8,736,000 pollen grains [Piotrowska 2008] and that there are 2,548,799 pollen grains per ovule in this species [Kugler 1970]. Particular plant species release pollen in a specific diurnal cycle that depends not only on the biological properties of their flowers, but also on meteorological factors, *inter alia*, temperature, air humidity, and wind [Maurizio and Grafl 1969].

A bee colony collects 25 up to 30 kg of pollen grains within a season. Sources of early spring pollen, which includes also, among others hazel pollen, are of great importance for the bees' proper development [Maurizio and Grafl 1969, Lipiński 2010]. Hazel pollen loads, carried by bees to the hive, are average-sized and matte yellow in colour. The data presented by Maurizio and Grafl [1969] show that the pollen of this taxon contains 2.53% of nitrogen, which is closed to the lower limit for the content of this element in plant pollen. In spite of the medium nutritional value of hazel pollen for a bee colony, the above-mentioned authors stress that the pollen of this taxon is of huge value to bees, since it is the first sourced protein during the growing season. Piotrowska [2008] showed that pollen weight per hazel inflorescence was 66 mg.

In some years, hazel pollen shed begins in Poland already in January. The period of abundant pollen production in the flowers of this taxon differs across the years. The number of pollen grains produced by the flowers of *Corylus* also differs significantly across the years [Kasprzyk 2006, Puc 2007, Stach 2006, Weryszko-Chmielewska and Piotrowska 2006, Piotrowska et al. 2007, Dąbrowska-Zapart 2008, Malkiewicz et al. 2008].

Aerobiological monitoring allows the determination of airborne hazel pollen concentrations on particular days of the pollen shed. The aim of the study was to evaluate the patterns of hazel pollen seasons over a 10-year period and to identify periods of maximum pollen shed that may indicate the time of availability of large amounts of this taxon pollen to bees. The study also took account of thermal conditions accompanying the beginning of pollen shed and the period of abundant pollen release in each year. Annual pollen counts recorded in the air over Lublin in the period 2001–2010 were compared. Moreover, the content of nitrogen and protein in *Corylus avellana* pollen was investigated.

MATERIALS AND METHODS

Corylus pollen concentrations over the Lublin air were measured by the volumetric method that is currently used in aerobiology. Daily pollen monitoring was conducted in Lublin, which is situated in the central-eastern region of Poland, in the period 2001–2010. A VPPS 2000 Lanzoni volumetric pollen and spore trap was used. The sampler was placed on the roof of a building in the centre of Lublin, in Akademicka Street, at the height of 18 m. Microscopic analysis of the slides was performed and the *Corylus* pollen seasons were determined following the recommendations of the International Association for Aerobiology [Jäger 2003]. *Corylus* pollen content in 1 m^3 of air per day was estimated.

Single *Corylus* shrubs, planted in the parks and squares, were observed near the sampling sites used for aerobiological monitoring. Large clusters of these shrubs are found in the area of the forest on Zalew Zemborzycki (a man-made lake), located at a distance of about 5 km from the aeroplankton sampling sites.

Classical statistical parameters: arithmetic mean, minimum and maximum values, standard deviation (SD), and coefficient of variation (V%), were used to characterize the hazel pollen seasons. In order to determine the direction and strength of asymmetry of the season, the coefficient of skewness was calculated; it has a zero value in symmetrical distribution. A positive value of this coefficient shows a right skew, while its negative value shows a left skew [Wołek 2006].

Nitrogen and protein content in dry samples of pollen grains were investigated using the Kjeldahl nitrogen determination method.

RESULTS

The dates of occurrence of the first *Corylus* pollen grains in the air over Lublin varied over the 10-year study period (tab. 1, figs 1–2). The years in which the pollen season started earliest are as follows: 2007, 2001, 2002, 2004, 2008, and the following first start dates were recorded in these years: 9 January, 28 January, and 4 February. The duration of the pollen seasons also differed significantly between years and it lasted from 19 up to 78 days. The shortest seasons occurred in the following years: 2010, 2009 and 2005, while the longest ones in 2007 and 2001.

Figure 2 illustrates the patterns of the *Corylus* pollen seasons in Lublin. The charts demonstrate that some of the seasons can be classified as a compact season (2001, 2002), while some other ones represent a scattered pattern (2004, 2008).

The *Corylus* pollen season curve, drawn on the basis of the 2001–2010 results, shows that the pattern of this pollen season is asymmetrical with a high rate of pollen release in the second part of the season (fig. 3). The coefficient of skewness had a positive value in all studies years. It was the highest in 2007 (6.84), and the lowest in the years 2005 (1.12) and 2010 (1.23). In the other years, the values of the skewness coefficient were in the range between 2.03 and 4.18. The positive values of this coefficient prove that the *Corylus* pollen season was right-skewed during the years of the study.

The period of intense pollen shed, associated with high airborne pollen concentrations (> 30 grains m^{-3}), occurred during the same time in some years (tab. 1). It lasted from 5 up to 16 (on average 9) days in each year and fell between 5 March and 10 April in the period 2001–2010. Annual *Corylus* pollen counts ranged from 804 to 1650 grains per 1 m^{-3}. Years of the highest hazel pollen production were as follows: 2006, 2010, 2007, and 2005 (fig. 4). High annual pollen totals were most frequently accompanied by short pollen seasons.

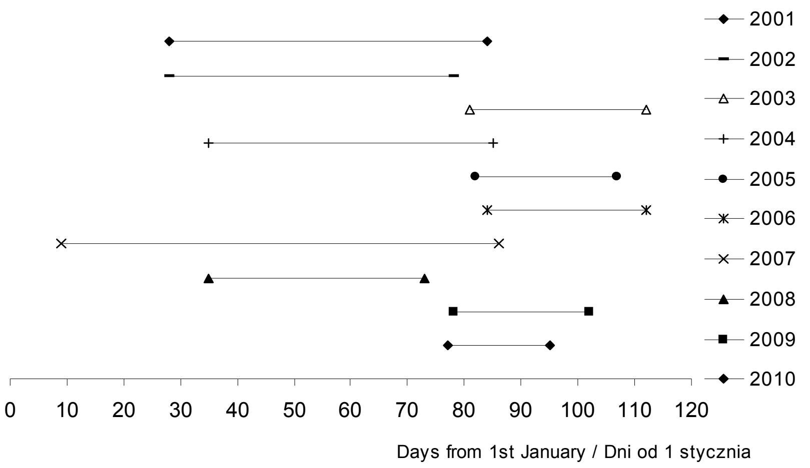

Fig. 1. *Corylus* pollen seasons (period of compact occurrence of airborne pollen grains), 2001–2010
Ryc. 1. Sezony pyłkowe leszczyny (okres zwartego występowania ziaren pyłku w powietrzu) w latach 2001–2010

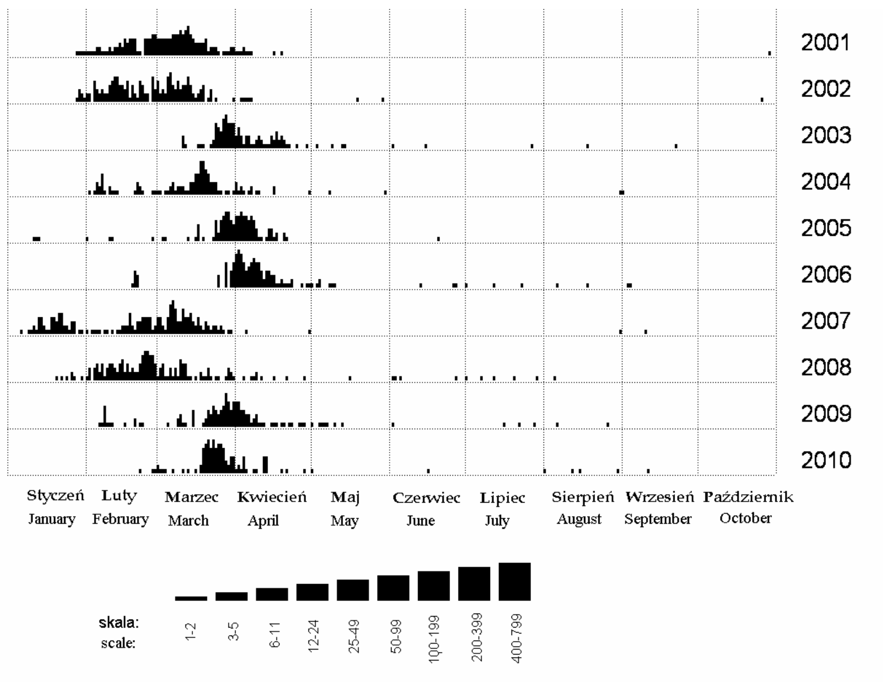

Fig. 2. The airborne *Corylus* pollen calendar for Lublin in 2001–2010
Ryc. 2. Kalendarz występowania ziaren pyłku *Corylus* w powietrzu Lublina w latach 2001–2010

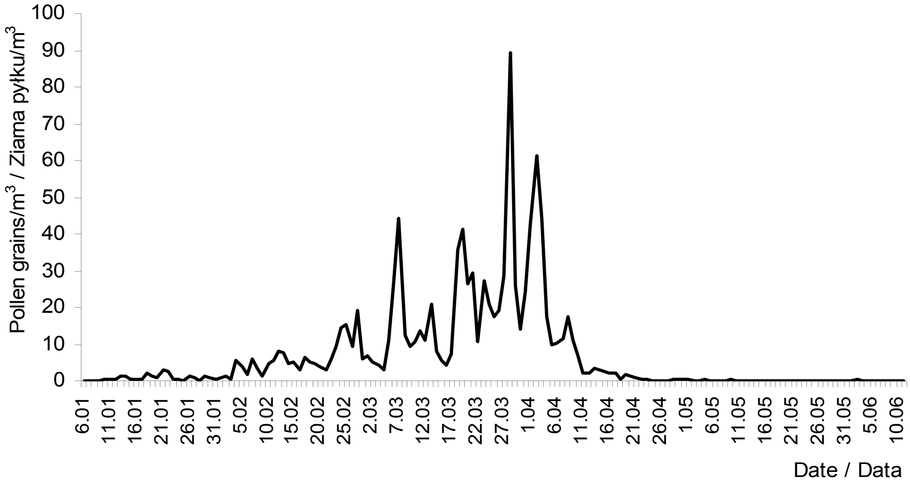

Fig. 3. The hazel pollen season pattern (means for 2001–2010)
Ryc. 3. Sezon pyłkowy leszczyny (średnie z lat 2001–2010)

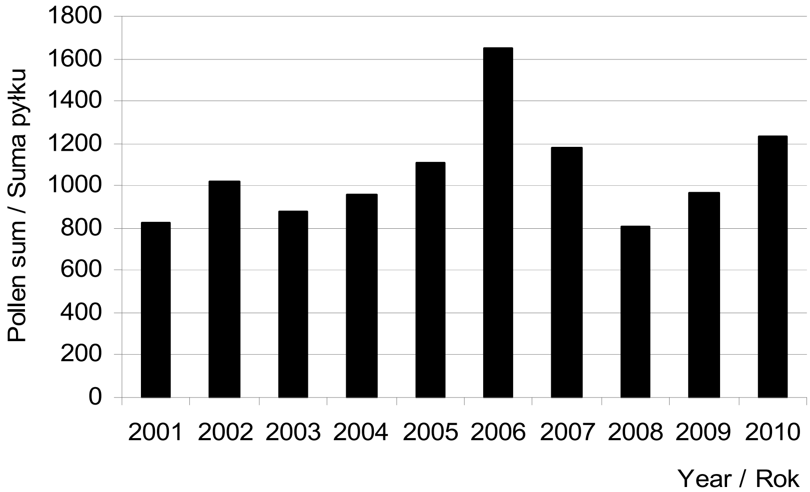

Fig. 4. Comparison annual total sums of *Corylus* pollen grains in 2001–2010
Ryc. 4. Porównanie sum rocznych ziaren pyłku *Corylus* w latach 2001–2010

Average and maximum air temperature on the start dates of pollen shed and average temperature in the period when high pollen concentrations were recorded were compared across the years. It was found that the occurrence of the first hazel pollen grains in the atmosphere was accompanied by an average temperature from -2.5 to 8.2°C and the maximum temperature amounted from 1.2 up to 10.2°C. An average temperature of more than 4°C was most frequently recorded during this time (over a period of 7 years). But in the period when high *Corylus* pollen concentrations occurred, the 10-year mean temperature was in the range between 2.4 and 14.4°C, while the means for particular periods ranged from 6.7 to 10.6°C.

Table 1. Characteristics of *Corylus* pollen seasons and temperatures accompanying pollen shed
Tabela 1. Charakterystyka sezonów pyłkowych *Corylus* oraz temperatury towarzyszące pyleniu

Years Rok	Start of season Początek sezonu			Period of high pollen concentrations Okres wysokich koncentracji pyłku (>30 P × m^{-3})				Season duration Długość sezonu days – dni
	date data	temperature temperatura °C		dates daty	duration długość days – dni	temperature temperatura °C		
		mean średnia	max			(from – to) (od – do)	mean średnia	
2001	28.01	2.0	5.6	9.03–14.03	6	7.7–11.8	9.0	57
2002	28.01	7.8	10.2	5.03–9.03	5 (+8)	3.7–10.1	6.7	51
2003	22.03	-2.5	1.2	24.03–31.03	8	4.4–10.5	7.8	32
2004	4.02	7.7	9.0	16.03–21.03	6	8.6–13.0	10.6	51
2005	23.03	4.1	9.5	24.03–8.04	16	2.4–14.4	7.3	26
2006	25.03	4.2	8.5	28.03–10.04	14	3.1–11.0	7.3	30
2007	9.01	8.2	9.6	6.03–11.03	6	5.1–9.7	7.4	78
2008	4.02	4.8	8.2	23.02–27.02	5	6.4–8.8	7.6	39
2009	19.03	0.2	1.4	27.03–2.04	7	4.4–8.9	7.1	25
2010	18.03	4.2	6.6	19.03–27.03	9	5.8–14.4	10.0	19
Mean – Średnia	23.02	4.1	7.0	15.03–7.04	8.2	5.2–10.2	8.1	40.8
Min	9.01	-2.5	1.2	23.02–27.02	5.0	2.4–4.4	6.7	19.0
Max	25.03	8.2	10.2	28.03–10.04	16.0	8.6–14.4	10.6	78.0
SD	29.1	3.5	3.3	11.1–14.0	3.8	2.0–2.7	1.3	18.2
V%	54.2	84.8	47.3	14.9–17.2	46.6	38.4–26.5	16.4	44.7

The obtained data demonstrate that the period when the highest amounts of hazel pollen were available to bees shifted between years, which is related to weather conditions. This period was observed earliest in the years 2002 and 2007 (5 March and 6 March). In some years, it lasted longer (14, 16 days), whereas in some other years it was very short (5, 6 days).

The mean temperature above 7°C, on average 8.1°C, was most often recorded in the period of pollen abundance, which is associated with the possibility of honey bee foraging on hazel.

The nitrogen content in the examined samples of *Corylus* pollen grains was 4.82%, while the protein content 30.13%.

DISCUSSION

The present study shows that over the 10-year period there was a considerable variation in the beginning of *Corylus* pollen shed in Lublin. The pollen seasons started between 9 January and 25 March (a difference of 76 days). Great variations in the start date of *Corylus avellana* pollen shed were also observed in other cities during a 5-year period of aerobiological monitoring (2001–2005). In Rzeszów these differences reached 56 days [Kasprzyk 2006], in Poznań 54 days [Stach 2006], in Kraków 39 days [Myszkowska 2006], in Szczecin 20 days [Puc 2006], while in Lublin they reached 48 days over the same period.

Various authors have found that the beginning of the *Corylus* pollen season is significantly affected by cumulative temperature in the period preceding pollen release [Frenguelli et al. 1992, Minero et al. 1999, Weryszko-Chmielewska et al. 2008, Piotrowska and Kaszewski 2009] as well as by temperature during the pollen shed period [Piotrowicz and Myszkowska 2006, Jabłońska and Rapiejko 2010].

The start of the *Corylus* pollen season recorded in different European countries falls also in January – February: in Italy in the first decade of January [Cristofori et al. 2010], in the United Kingdom most often in different decades of January [Emberlin et al. 2007], in Greece in February [Gioulekas et al. 2004], in Croatia also during this period [Peternel et al. 2007]. Dąbrowska-Zapart [2010] presents a graphic picture of hazel pollen seasons in which she distinguishes 5 models differing in duration, the occurrence of one or several pollen concentration maxima and in the date of occurrence of maximum concentration. The pattern of the *Corylus* pollen seasons recorded in Lublin mostly fits the models presented by the above-mentioned author.

Inter-annual fluctuations also relate to the amount of pollen produced by plants in particular years. This is manifested in the annual accumulated sums of airborne *Corylus* pollen; e.g. in 2006 the aforementioned pollen sum was almost twice higher than in 2001, 2003, and 2008.

A comparison of annual totals of *Corylus* pollen grains contained in the aeroplankton of different cities of Poland in the period 2001–2005 shows that much higher values were recorded in Lublin than in other cities: Szczecin, Poznań, Kraków, Rzeszów, Wrocław, and Sosnowiec [Weryszko-Chmielewska 2006]. These differences can result from the diversity of plant cover in different regions of Poland, but also from the fact that there is large-scale commercial farming of *Corylus* in the Lublin region.

In Lublin, high hazel pollen abundance was most frequently noted during the period after 15 March and it lasted until the first decade of April, with an average temperature of 8.1°C. The first foraging trips of the honey bee, during which bee foragers seek water and pollen, are observed under similar thermal conditions (8°C) [Prabucki 1998].

It has been observed that at a temperature of 4–9°C *Corylus* shrubs are protogynous, whereas above 9°C they are protandrous [Strizke 1962, Kugler 1970]. This information shows that the blooming of male flowers of this taxon is promoted by slightly higher temperature than the temperature prevailing when female flowers open. But the study demonstrates that the beginning of hazel pollen shed may occur at a temperature from -2.5°C to 8.2°C.

The nitrogen content in the studied hazel pollen was found to reach 4.82% and the protein content 30.13%. The results concerning nitrogen content are much higher than the values reported by Maurizio and Grafl [1969], while those on protein content are in agreement with the results of Maurizio [1954]. These results indicate the high nutritional value of hazel pollen. However, the above-mentioned authors included hazel pollen in the lowest category in terms of nutritional value. Pollen digestibility could have been taken into account in this assessment; in the case of hazel pollen, it can be lower due to a large thickness of the cell walls, in particular in the region of the three pores. In Poland hazel pollen is found sporadically in various types of honey [Wróblewska et al. 2006]. On the other hand, Bozhilova and Anchev [1969] report that hazel pollen constituted as much as 40% of the content of all pollen grains in the examined samples.

The literature reports that abundant fruiting of hazel takes place once every 2 or 3 years [Szweykowscy 2003]. Alternation in the abundance of pollen produced by this taxon observed in Lublin over the 10-year study period does not exhibit such regularity.

CONCLUSIONS

1. The start of pollen seasons, periods of high pollen concentration, and annual airborne hazel pollen counts show high variation in the central-eastern Poland.
2. The period of high *Corylus* pollen availability to bees occurs most frequently in the second half of March and at the beginning of April.

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OCENA OBFITOŚCI POŻYTKU PYŁKOWEGO LESZCZYNY (*Corylus* spp.) NA PODSTAWIE PRZEBIEGU SEZONÓW PYŁKOWYCH W LUBLINIE W LATACH 2001–2010

Streszczenie. *Corylus avellana* należy do wczesnowiosennych pożytków pyłkowych (pollen flow) *Apis mellifera*. Celem pracy była ocena dynamiki sezonów pyłkowych *Corylus* w ciągu 10 lat badań (2001–2010) w warunkach Lublina. Badania prowadzono metodą wolumetryczną, stosowaną aktualnie w aerobiologii. Wyznaczono lata obfitego pylenia tego taksonu oraz okres maksymalnego uwalniania pyłku w każdym roku, który jest związany z dostępnością dużej ilości pyłku dla pszczół. Przedstawiono warunki termiczne towarzyszące początkowi pylenia oraz panujące w czasie obfitego pylenia. Początek sezonów pyłkowych *Corylus* notowano w poszczególnych latach między 9.01 a 25.03 przy średniej temperaturze 4,1°C. Długość sezonu pyłkowego wynosiła 19–78 dni. Lata największej produkcji pyłku leszczyny to: 2006, 2010, 2007, 2005. Okres obfitego pylenia, związany z obecnością dużej zawartości pyłku *Corylus* w powietrzu, notowano najczęściej w drugiej połowie marca i na początku kwietnia, kiedy średnia temperatura wynosiła 2,4–14,4°C, z wartością średnią z dziesięciu lat 8,1°C. Przy temperaturze 8°C odbywają się pierwsze obloty pszczoły miodnej mające na celu m.in. poszukiwanie wody i zbieranie pyłku. W badaniach wykazano, że zawartość azotu w ziarnach pyłku *Corylus* wynosiła 4,82%, a zawartość białka 30,13%, co wskazuje na znaczną wartość pokarmową tego pyłku.

Słowa kluczowe: aerobiologia, monitoring pyłkowy, dostępność dla pszczół, zawartość azotu i białka

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