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ECOLOGICAL FEATURES OF FLOWERS AND THE AMOUNT OF POLLEN RELEASED IN *CORYLUS AVELLANA* (L.) AND *ALNUS GLUTINOSA* (L.) GAERTN.

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Summary

Hazel and alder bloom as one of the first plants in climatic conditions of Poland. In the present study, detailed observations were made of the structure of flowers of *Corylus avellana* L. and *Alnus glutinosa* (L.) Gaertn. Pollen yield of the abovementioned species was determined. The number of pollen grains in the theca, anther, flower and inflorescence was calculated. A comparison was made of the number of pollen grains of these taxa recorded during the atmospheric pollen seasons analysed over a period of 8 years in the conditions of Lublin. The study demonstrates that pollen yield of the common hazel inflorescence was 66 mg, whereas for black alder it was 120 mg. It was found that the number of pollen grains produced by the alder inflorescence was 2.2 times higher than by the hazel inflorescence. The atmospheric pollen season of the studied plant taxa was recorded at similar dates, but alder pollen was in much larger concentrations.

Key words: *Corylus avellana, Alnus glutinosa,* flower features, pollen yield, number of pollen grains, pollen season

INTRODUCTION

Hazel and alder are an important source of fresh pollen for bees in early spring, since pollen flows from other plants are still unavailable. The pollen shedding in these plants usually starts in the second half of January during sunny, not very cool days. The several-year-long studies show that the maximum pollen release by hazel and alder in Lublin falls on different days of March or at the beginning of April (Weryszko-Chmielewska and Piotrowska, 2006). The most efficient pollen shedding takes place at a temperature of 15-18^{o}C (Suszka, 1980). Hazel pollen is collected by bees in the form of medium-sized pollen pellets. These pellets can have different shades, as shown by data reported by different authors: bright yellow (Maurizio and Grafl, 1969), olive-yellow (Lipiński, 1982) or grey-yellow (Jabłoński, 1998). But pellets formed from black alder pollen are often greenish-yellow (Maurizio and Grafl, 1969) or grey-green coloured (Lipiński, 1982; Jabłoński, 1998).

Corylus and *Alnus* pollen grains contain one of the strongest allergens in terms of their effects on humans. In the early-spring period, they cause allergy in sensitive persons. Hazel pollen allergens exhibit cross reactions with allergens contained in alder and birch pollen (Mattiesen et al. 1991; Spieksma and Frenguelli, 1991; Knox and Suphioglu, 1996).

An analysis of black alder *(Alnus glutinosa)* and common hazel *(Corylus avellana)* distribution in Poland demonstrates that they are evenly distributed across the country (Zając and Zając, 2001).

The aim of the study was to determine pollen yield and the amount of pollen released in the abovementioned plant species in the conditions of Lublin and to compare these results with annual sums of pollen grains obtained from detailed analyses of atmospheric pollen seasons over a period of 8 years.

MATERIALS AND METHODS

The research material consisted of common hazel *(Corylus avellana* L.) shrubs growing in a line at a sunny site and black alder *(Alnus glutinosa* (L.) Gaertn.) trees occurring individually on the bank of the Czechówka River. Observations were made in Lublin, in the western part of the city (51^{o}14' N and 22^{o}32' E).

In the present study, pollen yield of the studied species was calculated based on the weight difference of 25 inflorescences before pollen shedding and after pollen release. The method of Warakomska (1972) was used to determine the pollen weight. The average number of flowers per inflorescence was determined based on investigations of 30 inflorescences sampled from different plants. The number of inflorescences per plant was estimated in accordance with the recommendations of Demianowicz and Hłyń (1960).

The number of pollen grains produced per anther was also determined. Mature stamens were sampled for the investigations before anther dehiscence. Pollen grains were washed out of the thecae with 70% alcohol onto a microscope slide using a stereoscopic microscope, and then they were counted exactly. The obtained results were recalculated per flower and per inflorescence. Six replications were made for each species.

The occurrence of airborne pollen was recorded using a Lanzoni VPPS 2000 pollen trap, located on a building roof at a height of 18 m above ground. Pollen monitoring was conducted in the years 2001-2008.

RESULTS

Hazel and alder belong to plants with unisexual flowers, arranged monoeciously. They form male *Amentiflorae*-type inflorescences with a long, slender axis, the so-called base.

Catkin male inflorescences of ***Corylus avellana*** grow on shoots in clusters, most frequently grouping 3-4 of them. Flowers are arranged spirally on the axis and initially they form a rigid, relatively compact arrangement (Figs 1, 2). They are formed in the summer of the previous year. The first–formed flower primordia were observed in the second half of June. At the beginning of September, when their average length was 1.4 cm, pollen grains were found to be already fully developed. In the period which immediately preceded pollen shedding, the inflorescences reached the length of 3.6 cm, on the average. During flowering, the inflorescence extended by over 100%, it became slender, susceptible to wind blasts. The bracts were characteristically bent back, forming in its upper part a bowl-shaped hollow (Fig. 4) in which a part of pollen settled from the higher located anthers; it is favourable for the pollen dispersal by wind and, at the same time, facilitates pollen collection by bees.

Hazel male flowers are composed of four stamens subtended by bracts (Fig. 5). The stamen filament is divided as far as the base, and two thecae are not joined by the connective (Fig. 3), which is a special adaptation to anemophily. The bracts which enclose the stamens exhibit a roof-tile-like arrangement and they are covered with numerous hairs (Fig. 2). One outer bract and two inner bracts – with total dimensions of 3.22 mm x 2.45 mm – are fused together. In the examined material, the thecae reached the average length and width dimensions of 1.16 mm x 0.61 mm. Initially, the filament was short – 0.2 mm, but during pollen shedding it extended

Table 1
Characteristics of male inflorescences and flowers of *Corylus avellana* and Alnus *glutinosa*.

Traits investigated		***Corylus avellana***	***Alnus glutinosa***
Number of inflorescences per plant		2430	7370
Number of flowers per inflorescence		240	580
Number of stamens per flower		4	4
Theca	Length [mm]	1.16	0.92
	Width [mm]	0.61	0.52
Number of pollen grains produced by:	Theca	4550	4210
	Anther	9100	8420
	Flower	36 400	33 680
	Inflorescence	8 736 000	19 534 000
Pollen weight per inflorescence [mg]		66	120

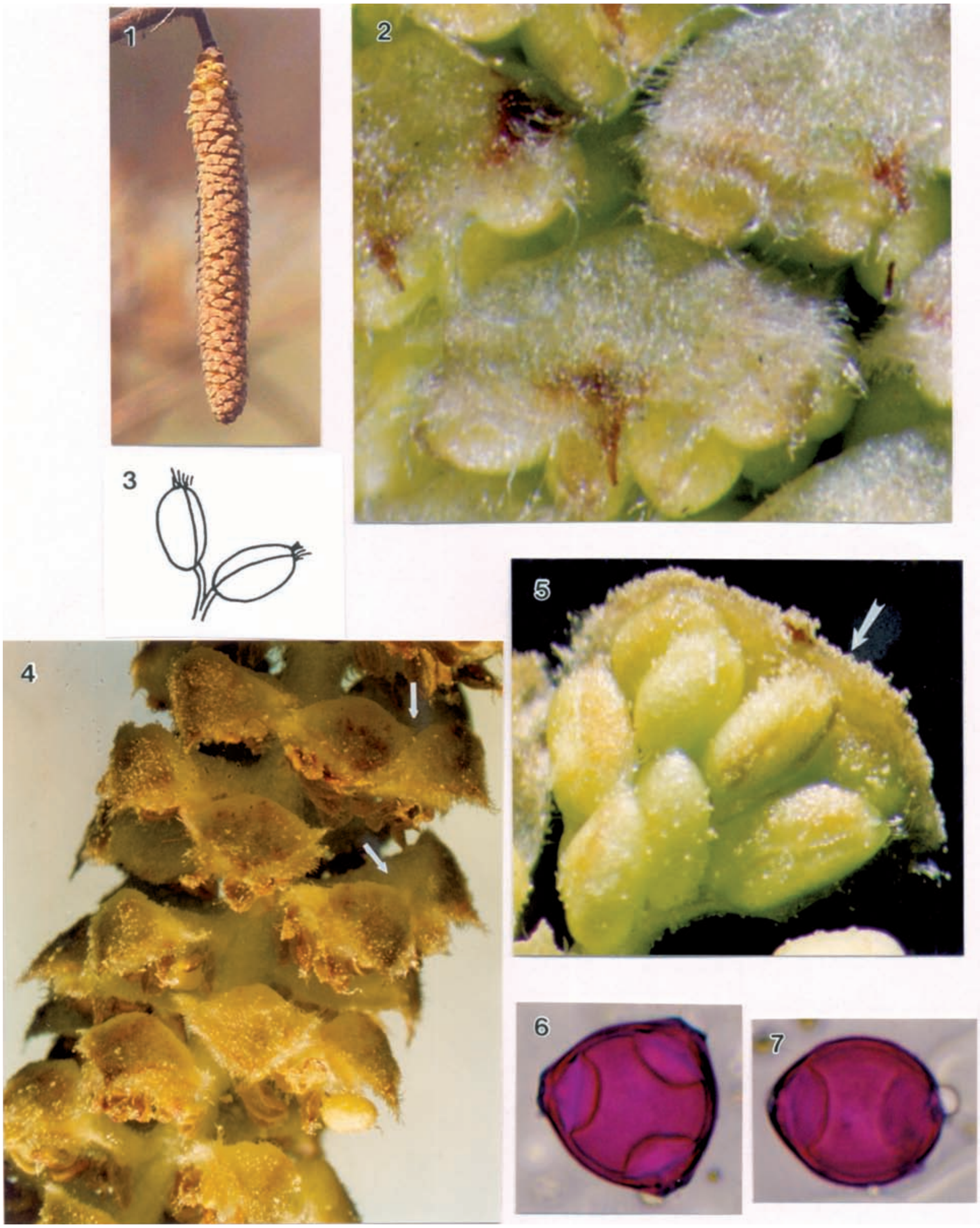

Fig. 1. Male inflorescence of *Corylus avellana*.
Fig. 2. Male inflorescence fragment before pollen shedding with visible haired bracts, x 28.
Fig. 3. Schematic diagram of the structure of the stamen with separated thecae, x 14.
Fig. 4. Male inflorescence fragment during pollen shedding with bowl-shaped bent bracts (arrows), x 9.
Fig. 5. Single male flower with 4 stamens and bracts (arrows), x 27.
Fig. 6. Pollen grain in polar view (P), x 1200.
Fig. 7. Pollen grain in equatorial view (E), x 1200.

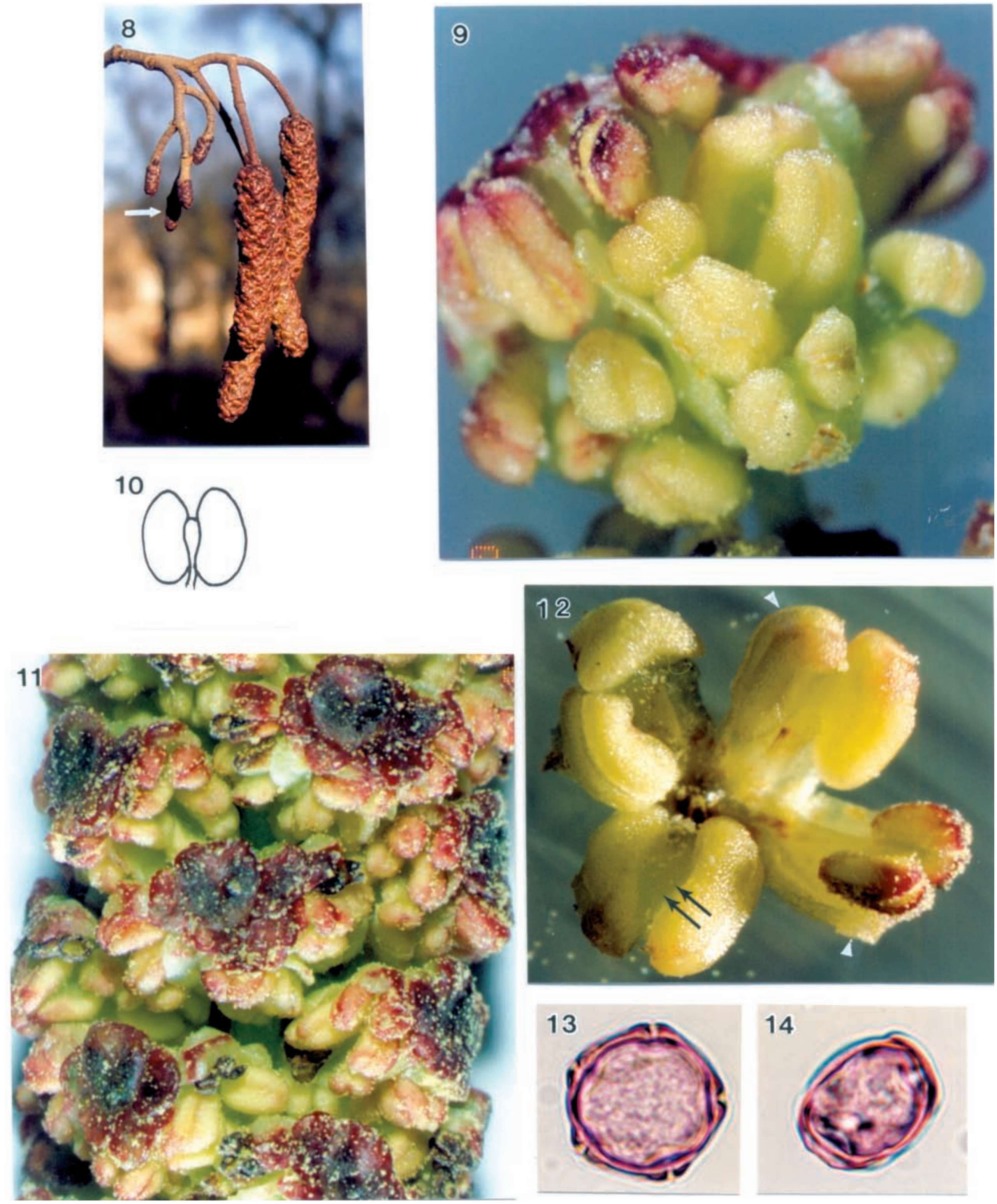

Fig. 8. Male inflorescences of *Alnus glutinosa* before pollen shedding, next to them female inflorescences (arrow).
Fig. 9. Cyme with three male flowers, x 30.
Fig. 10. Schematic diagram of the stamen structure, x 16.
Fig. 11. Cymes enclosed by claret-coloured bracts, x 10.
Fig. 12. Single male flower with 4-segmented perianth (arrow heads) and four stamens with the expanded connective (double arrow), x 32.
Fig. 13. Pollen grain in polar view (P), x 1100.
Fig. 14. Pollen grain in equatorial view (E), x 1100.

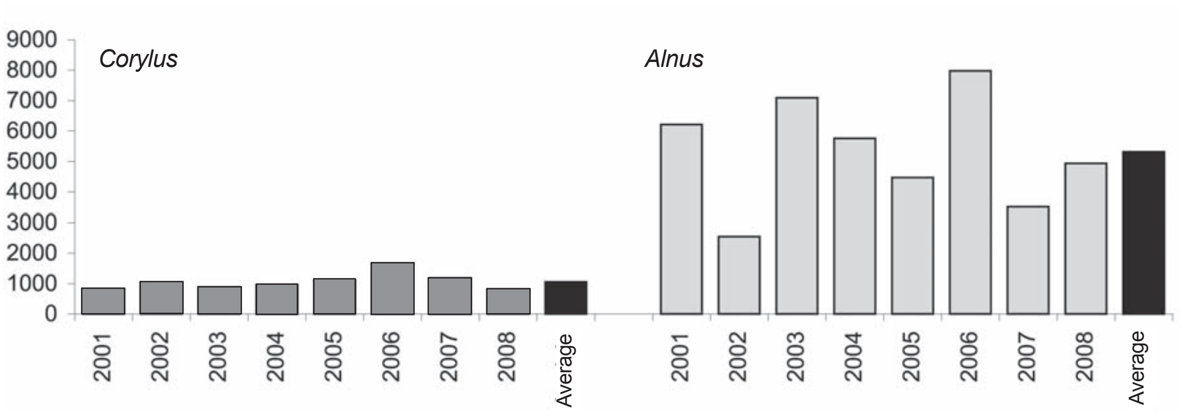

Fig. 15. Annual sums of *Corylus* and *Alnus* pollen grains in the air of Lublin in the years 2001-2008.

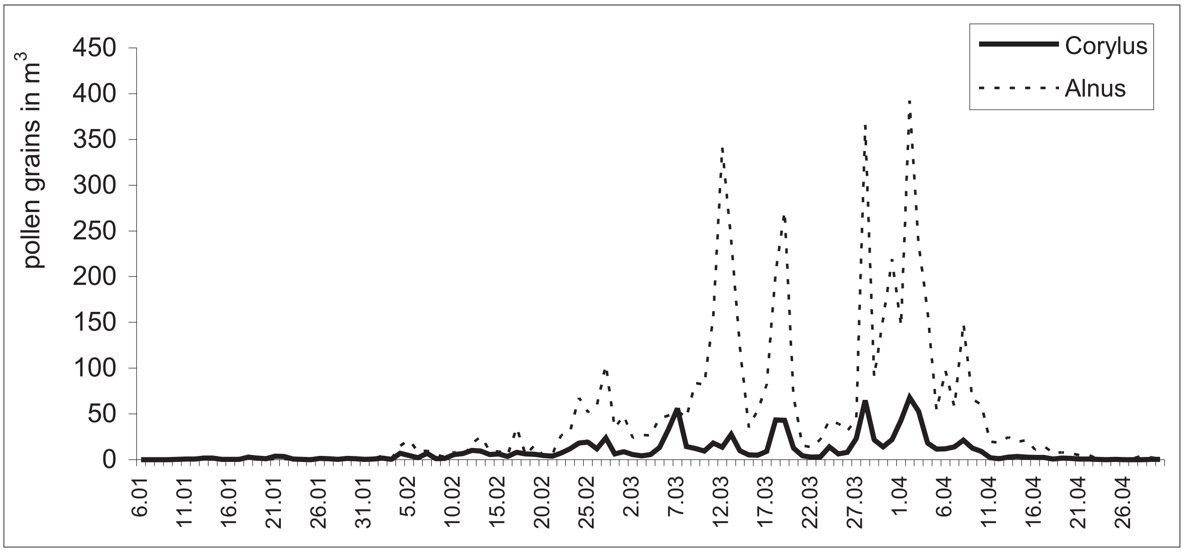

Fig. 16. The pattern of *Corylus* and *Alnus* pollen seasons in Lublin (means from the years 2001-2008).

its length up to about 1 mm. In the apical portion of the thecae, tufts of hairs were observed with the length of 0.2-0.3 mm, forming a characteristic little beard (Fig. 3).

Average pollen yield of the common hazel inflorescence obtained based on the weight difference of pollen-bearing aments and aments which have shed pollen was 66 mg. The hazel shrubs developed, on the average, 7 basal stems on which 2430 inflorescences were found. Pollen yield of the common hazel shrub was estimated at 168 g. It was also found that 100 running meters of the shrub line may produce 8400 g of pollen.

The calculations show that the male hazel inflorescence is composed of an average of 240 flowers, producing a total of 1920 thecae. In a single theca, there was an average of 4 550 pollen grains, hence the number of grains produced by one inflorescence was 8 736 000 (Tab. 1).

Triporate pollen grains of hazel, reinforced at each pore by the large thickened intine (*oncus*), reached the dimensions of 24.6 x 22.0 μm (Figs 6, 7).

Alnus glutinosa male inflorescences grow at the top of twigs in clusters of 3–5. Their dark brown-claret colour is given by the fused bracts: the outer bract, two inner bracts and two bracteoles, from underneath of which bright yellow stamens come out (Fig. 8). On the surface of the inflorescence, yellowish resin substances occur which are also collected by bees. In the angles of the partially lignifying bracts, cymes grow which are arranged alternately in relation to the main inflorescence axis. The cymes are composed of three male flowers (Fig. 9), differently than in hazel where single flowers occur enclosed with bracts. The black alder flower with a small 4-segmented perianth, with 4 stamens, reaches a diameter of 2.5 mm (Fig. 12). The anthers with the length and width dimensions of 0.92 mm x 1.06 mm are partially divided and they have strongly developed connective (Figs 10, 12).

It was calculated that a single black alder tree produced an average of 7370 inflorescences. The average pollen weight per inflorescence was determined at the level of 120 mg, whereas pollen yield of one black alder tree was 884 g.

According to my calculations, one male inflorescence contains an average of 580 flowers. One stamen produced an average of 8 420 pollen grains, whereas one inflorescence 19 534 000 (Tab. 1). Alder pollen grains are classified as small; they mostly have 5, sometimes 4 or 6 pores with the characteristic thickened exine (*arci)* between the pores. The dimensions of the examined grains reached 24.2 x 18.8 µm (Figs 13, 14).

Annual sums of hazel and alder pollen grains recorded during pollen monitoring in the years 2001-2008 were markedly different. In the case of hazel, the mean annual sum of pollen grains from the 8-year study was 1052; the lowest value (796) was recorded in 2008 and the highest (1650) in 2006. The mean sum of alder pollen grains (5313) in the years 2001-2008 was five times higher than in the case of hazel. In the particular years, these values ranged between 2545 (2002) and 7979 (2006) (Fig. 15).

A comparison of the hazel and alder atmospheric pollen seasons demonstrates that pollen of the above-mentioned plant taxa occurs in the air at similar dates. The significantly higher content of pollen of alder than hazel is also noticeable. Maximum pollen concentrations of both taxa are also recorded at similar dates. High concentrations are noted between 7 March and 8 April (Fig. 16).

DISCUSSION

Pollen yield of the common hazel inflorescence determined by the present paper's author was 66 mg. The average pollen weight per hazel inflorescence, determined earlier by Warakomska (1970), was approximate, as it amounted to 69 mg. No data on alder pollen yield has been found in literature.

It is more difficult for bees to form pellets from pollen of anemophilous than entomophilous plants, since it is loose, devoid of pollenkitt, and it is also characterised by a smooth surface of the exine. However, in early spring, due to small diversity of flowering plants, they also use this pollen flow. Pollen grains are the only source of protein and they are necessary for the proper development and normal functioning of the bee family (Bieńkowska, 1997; Jabłoński, 1998). It is estimated that bees are able to collect an average of 30% of pollen from flowers of anemophilous plants, and about 50% from flowers of entomophilous plants (Jabłoński, 1998). Under adverse weather conditions, it is recommended that bees should be additionally fed with pollen from hazel or alder inflorescences (Lipiński, 1982).

Bees are encountered more often in hazel inflorescences than in flowers of other anemophilous plants due to the adaptation of bracts to pollen retention (Lipiński, 1982; Bieńkowska, 1997). The frequent occurrence of this species at sheltered sites (for example, as the forest understorey) also has an advantageous effect, since thereby hazel pollen is more easily accessible (Lipiński, 1982).

The number of pollen grains produced in the thecae of common hazel and black alder was similar and it was 4550 and 4210, respectively. However, it was found that a single alder inflorescence, characterised by a larger number of flowers, produced over two times more pollen than a hazel catkin. The number of pollen grains in the *Corylus avellana* inflorescence, calculated by the present paper's author, is 8 736 000, and for *Alnus glutinosa* 19 534 000, whereas according to literature data it is estimated at 3 933 000 for hazel and 4 445 000 for alder (Pohl, 1937 after Erdtman, 1954; Maurizio and Grafl, 1969). The above differences may be attributable to many reasons, among others, habitat conditions, meteorological factors before and during flowering which may disturb the microsporogenesis and also affect the inflorescence length. Molina et al. (1996) report that the number of pollen grains determined in stamens from different trees of the same species may be various, for example, for *Quercus rotundifolia* it was within the range of 1530 – 9800. The present paper's author did not observe large deviations in the number of pollen grains in the stamens of the studied plant species. Recently, publications have appeared which show that plants have produced more pollen in the last decades as a result of warming (Emberlin, 1994; Frei, 1998; Emberlin et al. 2007).

Based on results of pollen monitoring conducted in Lublin in the years 2001-2005, it can be stated that hazel and alder pollen is accessible for bees in the greatest amounts, depending on the weather, in March or at the beginning of April (Weryszko-Chmielewska and Piotrowska, 2006). Multi-year observations (41 years) relating to flowering dates of the most important melliferous plants in Poland indicate a high deviation in the start date of hazel flowering, which is ±32.4 days (Gromisz, 1993). Significant differences were found between the extreme dates of the pollen season start in the years 2001-2005 in Lublin, and for hazel this difference was 47 days, whereas in the case of alder it reached 51 days (Weryszko-Chmielewska and Piotrowska, 2006). Fluctuations in the start dates of pollen seasons occur not only between particular years, but also between regions. Weryszko-Chmielewska and Rapiejko (2007) observed a difference amounting to 6-16 days between the start dates of the alder pollen seasons in Lublin and Warsaw in the same years of study.

CONCLUSIONS

1. Black alder is characterised by higher pollen yield than common hazel. The pollen weight per one hazel inflorescence is 66 mg, whereas for alder it is 120 mg. Pollen yield of a common hazel shrub was estimated at 168 g, whereas for a black alder tree it was 884 g.

2. The study shows that the number of pollen grains in the theca of common hazel and black alder is approximate, but the alder inflorescence produces 2.2 times more pollen than the hazel inflorescence.
3. The pollen weight produced by inflorescences of the studied species is correlated with the number of grains: about a twice larger number of alder pollen grains is accompanied by about twice larger weight of pollen.
4. More abundant pollen shedding of alder than in hazel is also reflected in the patterns of atmospheric pollen seasons of these taxa and annual sums of airborne pollen grains recorded.

REFERENCES

Bieńkowska M., 1997. Pyłek kwiatowy i jego pozyskiwanie. Wyd. Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach, 239.

Demianowicz Z., Hłyń M., 1960. Porównawcze badania nad nektarowaniem 17 gatunków lip. / A comparative study on nectar production of 17 linden species. Pszczeln. Zesz. Nauk. 4 (3-4): 133-151.

Emberlin J., 1994. The effects of patterns in climate and pollen abundance on allergy. Allergy, 49 (s18): 15-20.

Emberlin J., Smith M., Close R., 2007. Changes in the pollen seasons of the early flowering trees *Alnus* spp. and *Corylus* spp. In Worcester, United Kingdom, 1996-2005. Int. J. Biometeorol. 51: 181-191.

Erdtman G., 1954. An introduction to pollen analysis. Waltham, Mass., USA.

Frei T., 1998. The effects of climate change in Switzerland 1969-1996 on airborne pollen quantities from hazel, birch and grass. Grana, 37: 172-179.

Gromisz M., 1993. Daty zakwitania ważniejszych roślin miododajnych w Polsce w latach 1946-1986. / Dates of flovering of more important melliferous plants in Poland in the years 1946-1986. Pszczeln. Zesz. Nauk.: 89-101.

Jabłoński B., 1998. Wiadomości z botaniki pszczelarskiej. / News from apicultural botany. In: J. Prabucki (Red.) Pszczelnictwo, Wydawnictwo Promocyjne „Albatros", Szczecin: 775-858.

Knox R. B., Suphioglu C. 1996. Environmental and molecular biology of pollen allergens. Trends in Plant. Science, 1 (5): 156-164.

Lipiński M., 1982. Pożytki pszczele, zapylanie i miododajność roślin. PWRiL, Warszawa.

Mattiesen F., Ipsen H., Lowenstein H., 1991. Pollen allergens. In: D'Amato G., Spieksma F. Th. M., Bonini S. (Eds.): Allergenic pollen and pollinosis in Europe, Blackwell Scientific Public. London.: 36-44.

Maurizio A., Grafl I., 1969. Das Trachtpflanzenbuch. Ehrenwirth Verlag, München.

Molina R. T., Rodrigez A. M., Palacios I. S., López F. G., 1996. Pollen production in anemophilous trees. Grana, 35: 38-46.

Spieksma F. Th. M., Frenguelli G., 1991. Allergenic significance of *Alnus* (alder) pollen. In: D'Amato G., Spieksma F. Th. M., Bonini S. (Eds.): Allergenic pollen and pollinosis in Europe, Blackwell Scientific Public. London.: 85-87.

Suszka B., 1980. Rozmnażanie generatywne. / Generative propagation. In: Białobok S. (Red.). Olsze / Alder (*Alnus* Mill.). Nasze drzewa leśne, 8. PWN, Warszawa-Poznań: 99-144.

Warakomska Z., 1970. Wydajność pyłkowa leszczyny, dane niepublikowane, maszynopis. / Pollen yield of hazel, unpublished data, manuscrip.

Warakomska Z., 1972. Metoda określania wydajności pyłkowej drzew wiatropylnych. / A method of determination of pollen yield of anemophilous trees. XI Nauk. Konf. Pszczelarska w Puławach, Streszczenie referatów: 22-24.

Weryszko-Chmielewska E., Piotrowska K., 2006. Pyłek wybranych taksonów roślin w powietrzu Lublina w latach 2001-2005. / Pollen of selected plant taxa in the air of Lublin in the years 2001-2005. In: E. Weryszko-Chmielewska (Red.) Pyłek roślin w aeroplanktonie różnych regionów Polski. Praca zbiorowa. Katedra i Zakład Farmakognozji z Pracownią Roślin Leczniczych Wydziału Farmaceutycznego Akademii Medycznej im. Prof. Feliksa Skubiszewskiego, Lublin, 2006:105-115.

Weryszko-Chmielewska E., Rapiejko P., 2007. Analysis of *Alnus* spp. pollen seasons in Lublin and Warszawa (Poland), 2001-20007. Acta Agrobot. 60 (2): 87-97.

Zając A., Zając M., 2001. Atlas rozmieszczenia roślin naczyniowych w Polsce, Pracownia Chorologii Komputerowej Inst. Bot. UJ i Fundacji dla UJ, Kraków.

Ekologiczne cechy kwiatów oraz obfitość pylenia *Corylus avellana* L. i *Alnus glutinosa* (L.) Gaertn.

Streszczenie

Leszczyna i olsza stanowią ważne źródło świeżego pyłku dla pszczół wczesną wiosną, gdy pożytek z innych roślin jest jeszcze niedostępny. Z kilkuletnich badań wynika, że maksymalne uwalnianie pyłku przez leszczynę i olszę w Lublinie przypada w różnych dniach marca lub na początku kwietnia. W prezentowanej pracy przeprowadzono szczegółowe obserwacje budowy kwiatów leszczyny pospolitej i olszy czarnej, określono ich wydajność pyłkową oraz liczbę ziarn pyłku w pylniku. Z przeprowadzonych badań wynika, że średnia masa pyłku jednego kwiatostanu leszczyny pospolitej wynosiła 66 mg, zaś olszy czarnej 120 mg, co jest związane z większą liczbą kwiatów w kwiatostanie olszy. Stwierdzono, że kwiatostan olszy produkuje 2,2 razy większą liczbę ziarn pyłku niż kwiatostan leszczyny. Atmosferyczny sezon pyłkowy badanych taksonów roślin rejestrowany był w zbliżonych terminach, ale pyłek olszy występował w znacznie wyższych koncentracjach.