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THE EFFECT OF METEOROLOGICAL CONDITIONS ON HAZEL *(CORYLUS* spp.) AND ALDER *(ALNUS* spp.*)* POLLEN CONCENTRATION IN THE AIR OF SZCZECIN

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S u m m a r y

The aim of the study was to determine seasonal variations in concentrations of hazel and alder pollen count due to meteorological parameters. Measurements were performed using the volumetric method. The analysed meteorological parameters were the maximum temperature, relative humidity, rainfall and wind speed. The beginning and end of a season were established by the 95 % method. During seven years of study, the highest concentration of hazel pollen in the air was noted in 2003 (the total number was two - three times higher than in the other years), with the pollen season starting in most years in the beginning of January and lasting till the end of March or beginning of April. The highest concentration of alder pollen in the air was noted in 2003, similarly as hazel pollen. The pollen season started in the beginning of January (in 2003 and 2006 in the beginning of March) and lasted till the turn of the March and April. The highest pollen count of 674 grains×m^{-3} was observed in the end of March. A positive and statistically significant correlation (Pearson's coefficient and multiple regression) was found between the hazel and alder pollen concentration and air temperature and wind speed. A negative correlation was found in case of the relative humidity. A lot of analysed correlations were significant (significance level of p=0.05), although the percentage of explained variation (R^2) was very low. Besides the individual rhythm of pollination, the meteorological conditions are the most important factors (mainly air temperature and wind speed) influencing the analysed pollen concentration in the air.

Key words: hazel, alder, pollen grains, seasonal variation, meteorological factors, Szczecin, 2000-2006

INTRODUCTION

The awareness of the potentially allergenic pollen count and its changes throughout the periods of pollen release in a given area is of great importance in prophylaxis of allergic respiratory disease becoming a social problem on all continents. In northern Europe, early springtime allergic airway diseases, such as rhinitis and asthma, are commonly caused by pollens from *Alnus* and *Corylus* (F i l o n at al. 2000).

The clinical importance for the Betulaceae pollen (*Alnus*, *Corylus*, *Betula* and *Carpinus*) depends on local variations in the vegetative flora and meteorological factors. During the hazel and alder season, large amounts of pollen are released into the air. P e h k o n e n and R a n t i o-L e h t i m a k i (1995) also found small micronic particles of *Betula* antigen in the air before the *Betula* season, but whilst *Alnus* was flowering. The correlation of atmospheric concentrations of specific aeroallergens with clinical symptoms of pollinosis help to establish threshold levels for particular pollens above which symptoms might probably occur. The well-documented cross reactivity between Betulaceae and other tree pollen allergens as well as with apple, hazelnut and peach contributes to a prolonged season of symptoms for many patients (V i k et al. 1991; S o n et al. 1999; P u c , 2003).

The aim of the study was to analyse the hazel and alder pollen counts in the air of Szczecin, compare the pollen seasons in the years 2002 – 2006 and estimate the effect of meteorological conditions on the pollen concentrations, with a view to ascertain the level of risk for this allergenic pollen.

MATERIALS AND METHODS

The analysis of pollen grain concentrations of the studied trees was conducted in Szczecin based on data from the years 2000-2006. The volumetric measurement point was located in the Szczecin city district Śródmieście (53º26'26" N, 14º32'50' E), 21 m above ground level. The measurements of pollen concentrations were carried out by the volumetric method using the Hirst-type sampler: a VST trap in 2000-2001 and a Lanzoni trap in 2002-2006. (H i r s t , 1952; R a p i e j k o , 1997; M a n d r i o l i et al. 1998). The pollen concentration was expressed as the number of pollen grains×m^{-3} per 24 h. The start and end of the pollen season was determined by the 95% method (Corden et al., 2000).

On the basis of literature data, the number of days was determined on which the pollen concentrations of the studied taxa exceeded the threshold values at which allergy symptoms develop. Rapiejko et al. (2004) reported in Poland a threshold value for hazel pollen of 35 grains×m^{-3}, for alder pollen 45 grains×m^{-3}.

For the analysis of the pollen concentration in relation to meteorological parameters, maximum temperature, maximum wind speed, mean daily precipitation and mean daily relative humidity were used. Weather data were provided by the meteorological station of the Physical Oceanography Laboratory, University of Szczecin, located nearby the spore monitoring site. The degree of correlation between particular meteorological parameters and the concentrations of tree pollen was described by the Pearson's correlation coefficient r and multiple regression using the Statisitica program version 6.1 StatSoft Inc. (Stanisz, 1998).

RESULTS

Hazel. In subsequent seasons in the years 2000–2006, a weak increase in the pollen count of *Corylus* in Szczecin was observed (Fig. 1). However, this tendency is not reflected by the annual total pollen (Tab. 1). From among the seven hazel pollen periods analysed, the lowest maximum day pollen count of 7 grains×m^{-3} was noted in 2001, in the end of January. The highest maximum pollen count was noted in 2006, in the end of March and equal of 186 grains×m^{-3}. In most years, the pollen seasons started in the beginning of January and lasted till the end of March or beginning of April (Tab. 1). The symptoms of pollen allergy occur after some threshold pollen count value, which for hazel is 35 grains×m^{-3}. The threat from *Corylus* pollen allergens in Szczecin was low, the period with high pollen concentrations lasted 2-5 days and was noted at the end of February. Only in 2003 the threat of those pollen allergens was high and lasted 11 days (Tab. 1).

In most of the seasons studied, the pollen count of *Corylus* was statistically significantly correlated with the weather factors analysed (Tab. 2-4). In 4 of the 7 seasons, a positive and statistically significant Pearson's correlation was observed between the hazel pollen count and the maximum air temperature and wind speed. In all the seasons, the pollen count was negatively and statistically significantly correlated with the relative air humidity (Tab. 2). Multiple regression analysis was performed in order to determine which meteorological variables were associated with pollen counts. The multiple regression analysis for hazel pollen concentration showed very weak correlation with minimum air temperature and wind speed. In most cases, correlation was non-significant (Tab. 3, 4).

Alder. In the following study years, a clear increase in annual total pollen was noted (Fig. 1). The pollen season in all the 7 years studied began earliest on the 4th of February 2002 and latest on the 27th of March 2006. The shortest pollen season was observed in 2006

Table 1
Results of aerobiological study of hazel (*Corylus*) and alder (*Alnus*) pollen count.

Taxon	Parameters	2000	2001	2002	2003	2004	2005	2006
Corylus	ps	4 II-31 III (57)	2II-30 III (56)	29 I – 2 III (53)	24 II – 2 IV (37)	4 II – 19 III (44)	1 III – 6 IV (37)	18 III – 11 IV (26)
	dn	3	2	2	11	2	2	5
	tn	383	103	486	972	445	276	473
	max	31 (25 II)	7 (20 II)	46 (21 II)	111 (24 III)	60 (15 III)	57 (17 III)	186 (28 III)
Alnus	ps	8 II-28 III (50)	18 II-30 III (42)	4 II – 18 III (43)	8 III – 8 IV (32)	6 II – 2 IV (56)	15 II – 6 IV (51)	27 III – 14 IV (19)
	dn	16	9	24	21	20	18	10
	tn	2 527	925	2 307	4 751	4 181	3 105	2 935
	max	331 (27 II)	145 (28 III)	136 (12 II)	626 (27 III)	641 (15 III)	518 (27 III)	674 (28 III)

ps – pollen season, dn – the number of days with pollen count above 35 grains×m^{-3} for hazel, 45 grains×m^{-3} for alder (Rapiejko et al. 2004) – threshold of pollen counts at which allergy symptoms develop, tn – total number of pollen grains collected in the season, max – maximum number of pollen grains×m^{-3}.

Table 2
Pearson's correlation coefficients between hazel (*Corylus*) and alder (*Alnus*) count and weather parameters (2000-2006).

Taxon	Years	Meteorological factors			
		Temp. max. (°C)	Rainfall (mm)	Wind max. (m/s)	Relative humid. (%)
Corylus	2000	0.2191	- 0.1058	0.3001*	- 0.1526
	2001	0.2520*	0.0527	0.5155*	- 0.2586
	2002	0.2032	0.0913	0.2892	- 0.2747*
	2003	0.2971*	0.0528	- 0.1033	- 0.2073
	2004	- 0.0299	- 0.1217	0.3667*	- 0.2861*
	2005	0.2170*	- 0.1007	0.0811	- 0.4335*
	2006	0.2645*	- 0.0823	0.3192*	- 0.1981
Alnus	2000	0.1984*	- 0.1995	0.02424	- 0.2090
	2001	0.1532	- 0.0901	0.5080*	- 0.5760*
	2002	0.2101	- 0.1023	0.2667*	- 0.5127*
	2003	0.4998*	- 0.0826	0.5676*	- 0.4201*
	2004	0.1769	- 0.0458	0.5811*	- 0.1561
	2005	0.3799*	- 0.1459	0.3888*	- 0.5812*
	2006	0.4198*	- 0.0998	0.4211*	- 0.3612*

* – correlation statistically significant (p<0.05).

Table 3
Hazel pollen concentration vs meteorological factors in multiple regression (2004-2006).

Year	Period	N	Variance analysis at α=0.05	Adjusted R-square	Explanatory variables	Exsplained variation (R-squere)	Correlation
2004	01.02 – - 21.03	49	F= 2.692696 P= 0.040042	0.4016	$Wind_{mid}$ Rain Humidity T_{min}	0.245 - 0.27 0.007 0.321	+ - - +
2005	27.01 – - 08.04	62	F= 2.363233 P= 0.063742	0.3771	$Wind_{mid}$ Rain Humidity T_{min}	0.182 - 0.17 0.124 0.349	- - - +
2006	15.02 – - 14.04	38	F= 3.945505 P= 0.020095	0.3206	$Wind_{mid}$ Rain Humidity T_{min}	0.304 0.155 0.104 0.153	+ - - -

Table 4
Alder pollen concentration vs meteorological factors in multiple regression (2004-2006).

Year	Period	N	Variance analysis at α=0.05	Adjusted R-square	Explanatory variables	Exsplained variation (R-squere)	Correlation
2004	01.02 – - 21.04	56	F= 1.791438 p= 0.136120	0.2538	$Wind_{mid}$	0.231	+
					Rain	- 0.17	-
					Humidity	0.022	-
					T_{min}	0.281	+
2005	19.01 – - 08.04	56	F= 0.925933 p= 0.451914	0.2854	$Wind_{mid}$	- 0.03	-
					Rain	0.007	-
					Humidity	- 0.21	-
					T_{min}	0.302	+
2006	21.02 – - 20.04	51	F= 2.933337 p= 0.082354	0.2830	$Wind_{mid}$	0.200	+
					Rain	0.026	-
					Humidity	0.073	-
					T_{min}	0.243	+

and lasted two-five weeks shorter than in the other years. The annual total pollen was the highest in 2003 and equalled 4751 grains (Fig. 1), but the maximum daily pollen count was noted in 2006 – 674 grains$\times$m^{-3}, and it was very similar to the values in 2003 and 2004 (Tab. 1). In sensitive persons, the symptoms of pollinosis occur after some threshold pollen count value, which for alder is 45 grains$\times$m^{-3}. Therefore, the greatest threat from *Alnus* pollen allergens in Szczecin was noted at the beginning of February and lasted to the end of March. In the years 2000-2006, this period lasted from 9 to 24 days (Tab. 1).

A statistically significant Pearson's correlation was noted between the alder pollen count and the maximum wind speed and relative humidity in most of the seasons. Statistical analysis also showed a significant correlation between the pollen count and maximum temperature in 2000, 2003 and 2005-2006 (Tab. 2). The multiple regression analysis for alder pollen concentration showed stronger correlation with minimum air temperature and wind speed than for hazel. In some cases, correlation was non-significant (Tab. 3, 4).

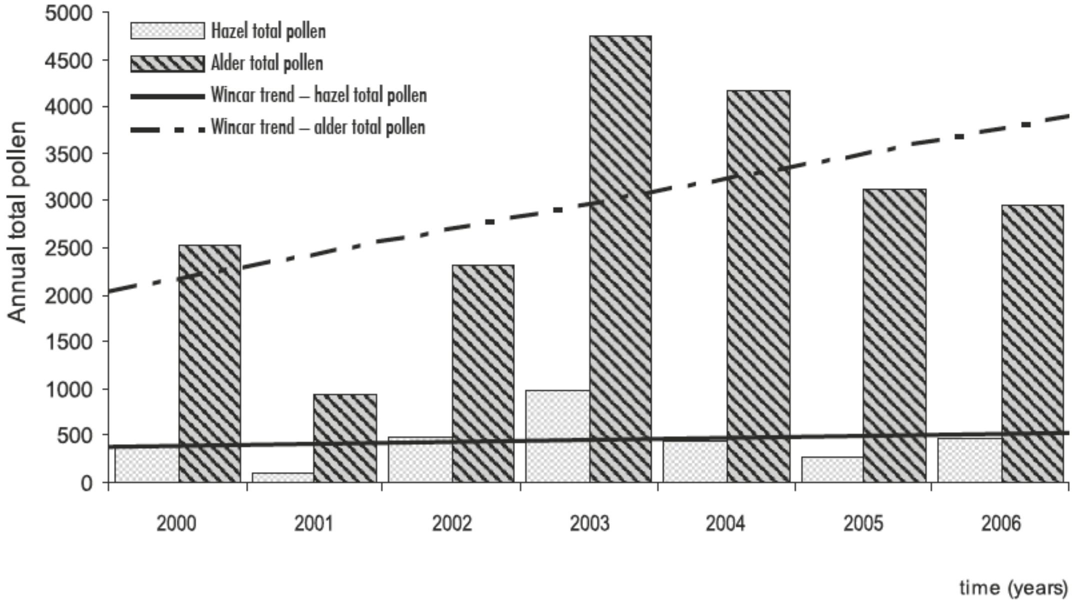

Fig. 1. Annual total hazel and alder pollen in the years 2000-2007.

DISCUSSION

Annual totals of daily airborne hazel and alder pollen concentrations are not very different between urban environments in western and northern Europe. They do not show great year-to-year fluctuations, but overall undulating courses, without any consistent increasing or decreasing trend (Stach, 2000; Peternel at al. 2003; Estrella at al. 2006). However, a weak linear increase tendency of *Corylus* and *Alnus* pollen count was observed in Szczecin.

Results obtained in the study demonstrated differences in the course of the pollen seasons of the studied taxa in the 7 years period. These differences related to the season start dates, values of maximum concentrations and annual pollen totals. Similarities included the duration of certain seasons and the dates of occurrence of high pollen concentrations, chiefly recorded for hazel and alder. Analysing the seasonal growth rate presented in pollen calendars, Szczepanek (1994) and Kasprzyk (1996) included *Corylus, Alnus* in taxa groups with compact pollen seasons, the pollen of which is found abundantly in the air. A similar picture of the pollen seasons of the studied trees was observed in Szczecin.

The start dates of the hazel and alder pollen seasons are primarily dependent on air temperature recorded in early spring. The potential number of pollen grains of this plant group also depends on thermal conditions occurring in summer and autumn in the year preceding pollination when the development of anthers starts (Garcia-Mozo et al. 2000).

The highest *Corylus* and *Alnus* pollen risk in Szczecin occurs mainly in January, February and March. High concentration values, exceeding the threshold values at which allergy symptoms are observed (Rapiejko et al. 2004), were also recorded in Warsaw in the same months. Similar observations were made in Poznań (Stach, 2002), Kraków (Szczepanek, 1994) and in Lublin (Piotrowska and Weryszko-Chmielewska, 2003). Johansen (1992) in Norway recorded additional *Corylus* pollen, outside the pollen season, most probably attributable to long-distance transportation. Combining vegetation data and pollen circulation patterns, Damialis at al. (2005) concluded that medium/long-distance transport concerns *inter alia* the pollen of *Corylus*, and airborne pollen from hazel increases with northwestern winds in Thessaloniki, Greece.

A statistically significant Pearson's correlation between the hazel and alder pollen concentration and air temperature, wind speed and relative humidity was recorded in most of the seasons in Szczecin. Similar correlations with regard to alder pollen by Peternel et al. (2004), in Zagreb (Croatia) were observed. In Poznań (Stach, 2000), likewise in Szczecin, a statistically significant dependence between air temperature and the alder pollen concentration was recorded. Results of multiple regression analysis suggest that minimum temperature and wind speed were the most influential variables for the *Corylus* and *Alnus* pollen occurrence in the air of Szczecin. Similar results with reference to grass pollen concentration were noted in London (Smith and Emberlin, 2006).

CONCLUSIONS

Differences in the character of the pollen seasons of the taxa studied in Szczecin relate to the start dates of the pollen seasons and maximum concentrations.

Between the seasons of 2000 and those of 2006, the hazel and alder pollen counts in Szczecin show a weak tendency to increase. This observation needs to be confirmed in long-term studies.

The highest hazel pollen count was noted from the beginning of February to the end of March; the highest alder pollen count was noted from the first decade of February to the first decade of April. In that time, the concentrations of both sporomorphs exceeded threshold values provoking allergy pollinosis symptoms in sensitive persons only on some days.

A positive and statistically significant correlation (Pearson's coefficient and multiple regression) was found between the hazel and alder pollen concentration and air temperature and wind speed. A negative correlation was found in case of the relative humidity. Some of analysed correlations were significant, although the percentage of explained variation (R^2) was very low.

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Wpływ warunków pogodowych na stężenie pyłku leszczyny (*Corylus*) i olszy (*Alnus*) w powietrzu Szczecina

Streszczenie

Alergeny pyłku leszczyny i olchy są częstą przyczyną pyłkowicy występującej w Europie północnej i środkowej. Schorzenie to jest wywoływane przede wszystkim przez antygeny pyłku roślin wiatropylnych. W klimacie umiarkowanym rośliny wiatropylne wykazują charakterystyczny cykl pylenia związany z porami roku. Ziarna pyłku badanych drzew najobficiej występują w powietrzu na przełomie zimy i wiosny, a termin początku sezonu pyłkowego i jego przebieg w znacznej mierze zależą od warunków pogodowych. W prowadzonych od roku 2000 badaniach aeroplanktonu Szczecina, analiza stężenia pyłku leszczyny i olszy posłużyła do porównania obrazów pylenia oraz oceny wpływu warunków pogodowych na stężenie pyłku. Pomiary stężenia pyłku prowadzono metodą objętościową z zastosowaniem aparatu wolumetrycznego VST oraz aparatu VPPS Lanzoni 2000. W ciągu siedmiu lat badań, sezon pyłkowy leszczyny rozpoczynał się pomiędzy 2 lutego a 18 marca i trwał z reguły do końca marca, wyjątkowo w 2006 r. – do pierwszej dekady kwietnia. Największe zagrożenie alergenami pyłku tego taksonu zarejestrowano w trzeciej dekadzie marca 2003 r. W kolejnych sezonach stężenie maksymalne pyłku *Corylus* nie przekraczało 186 ziaren$\times$m^{-3} w ciągu doby. Sezon pyłkowy olszy rozpoczynał się pomiędzy 4 lutego a 27 marca i trwał do pierwszych dni kwietnia. Podobnie jak w przypadku leszczyny, w 2006 r. sezon pyłkowy olszy trwał rekordowo długo – do połowy kwietnia. Najwyższe stężenie pyłku tego taksonu, przekraczające 600 ziaren$\times$m^{-3} w ciągu doby zanotowano pod koniec marca 2003 r. i 2006 r. oraz w połowie marca 2004 r. W pozostałych sezonach stężenie pyłku *Alnus* było niższe i zawierało się pomiędzy 136 a 518 ziaren$\times$m^{-3} w ciągu doby. Analiza statystyczna wykazała istotną statystycznie korelację r Pearsona pomiędzy stężeniem pyłku leszczyny i olszy a maksymalną temperaturą powietrza, maksymalną prędkością wiatru oraz wilgotnością względną. W przypadku regresji wielokrotnej zaobserwowano słabe korelacje pomiędzy stężeniem pyłku obu taksonów a temperaturą minimalna powietrza i prędkością wiatru.