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THE INFLUENCE OF WEATHER CONDITIONS ON THE COURSE OF POLLEN SEASONS OF ALDER (*ALNUS* SPP.), HAZEL (*CORYLUS* SPP.) AND BIRCH (*BETULA* SPP.) IN LUBLIN (2001-2006)

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S u m m a r y

The start and rate of florescence of *Alnus*, *Corylus* and *Betula* are dependent on meteorological conditions. In the present paper we have analysed the effect of mean, maximum and minimum temperature, relative air humidity and precipitation on the onset of the pollen season as well as on its length and annual count of pollen grains in alder, hazel and birch. The measurement of pollen fall was done by the gravimetric methods with the use of Durham sampler. Correlation coefficients were calculated between the determined characteristics of the pollen season and weather conditions. In the six-year research period 2001-2006 it was observed that low temperatures in January produced a delayed start of the pollen season in alder, hazel and birch. The beginning of flowering in these taxa was also influenced by thermal conditions prevailing directly before the season (ca. 10 days). The pollen season of the trees in question tended to be prolonged alongside with the increase in relative air humidity, but it was shortened due to higher temperatures. The volume of alder and hazel pollen release increased together with the rise in relative air humidity and precipitation. The annual counts of birch pollen increased along with rising temperature and decreasing relative air humidity and precipitation in the season.

Key words: aerobiology, pollen seasons, *Alnus, Corylus, Betula,* meteorological conditions

INTRODUCTION

Anemophylous plants of the temperate zone are characterised by a pollen production cycle related to the seasons of the year (Ł u k a s i e w i c z , 1968; W e r y s z k o - C h m i e l e w s k a (ed.), 2006). Alder, hazel and birch are among those plants which flower earliest and in which the start of pollen release is dependent on atmospheric conditions, especially on the air cumulative (above zero) temperature (S c a m o n i , 1955). Thus, weather factors may evoke temporal shifts in the timing of pollen seasons as well as distortions in the production and dispersal of pollen grains (E m b e r l i n et al. 2002). The intensity of pollen release and total count of pollen grains are also affected by the meteorological conditions in the previous year (August), when the sporogennous tissue begins to develop (R o d k i e w i c z et al. 1996).

The aim of the study was to analyze the impact of mean, maximum and minimum temperatures, relative air humidity and precipitation on the onset of the pollen season as well as on its length and annual count of pollen grains in alder, hazel and birch.

MATERIALS AND METHODS

The study on pollen-fall of alder (*Alnus* spp.), hazel (*Corylus* spp.) and birch (*Betula* spp.) was carried out in the years 2001-2006 in the area of the Maria Curie-Skłodowska University Botanical Garden in Lublin (51º 16`N, 22º 30`E GPSmap 60).

The measurement of pollen fall was conducted by the gravimetric method with the use of Durham sampler (D u r h a m , 1964) placed on a building's roof 5 metres above ground level (220 m AMSL, GPS map 60). Qualitative and quantitative estimation of pollen grains deposited on slides of the sampler was conducted on a weekly basis. 12 vertical stripes were analyzed from each microscopic preparation. The results were converted into pollen grain concentration on the area of 1 cm^{-2} (p×cm^{-2} a week).

The date of the start and end of the pollen season, total annual concentration and the length of the season were determined for each taxon. The beginning of florescence was determined (for statistical study) by the number of days passed from the 1st of January to the initial pollen production moment. In order to analyze the influence of meteorological factors on the selected features of the pollen season, daily values of five weather elements were taken into account: maximum and minimum mean temperature, relative air humidity, precipitation in the period from January to May of 2001-2006, and the mean temperature of August from the period 2001-2005. The data come from the weather station of the UMCS Institute of Meteorology and Climatology situated 3 km from the trap site. Correlation coefficients were determined to examine the dependencies between the chosen season features and weather conditions.

RESULTS

The influence of weather conditions on the start of the pollen season in *Alnus*, *Corylus* and *Betula*. In the study years, there was a noticeable variation in the date of the start of the alder pollen season (Tab. 1). This is confirmed by a high coefficient of variation (33%). The earliest start of the pollen season was noted in the last week of January 2002. It was usually triggered by maximum temperature above 4°C, prevailing for about 4-5 days. In 2002, the maximum temperature measured one week before the start of the pollen season was 5.8°C, and it did not fall below 10°C during the first 10 days of pollen release. The mean temperature in January and February of that year reached 1.4°C, which was higher than that in the other research years by approximately 3°C. The significant effect of low temperatures on the start of the pollen season in alder is corroborated by the correlation coefficients (Tab. 2). Significant, negative values of the correlation coefficient were obtained for the mean temperature of January and February measured during 5 days before the season. This is in agreement with the assumption that the frostier January and February are, the more delayed the alder pollen season is. The dependence between the beginning of the season and the weather parameters studied is not statistically significant.

The start of the pollen season in hazel varied in particular years of the study (Tab. 1). The coefficient of variation was 33.5%. Low temperatures in January delayed the start of the hazel pollen season. This is confirmed by the significant, negative correlation coefficient (Tab. 2). The acceleration of the season was caused by maximum and mean temperatures of 10 days before the season, which is indicated by the significant, positive correlation coefficients. Little relevance for the start of the hazel pollen season was ascribed to thermal conditions of 5 days, minimum temperature of 10 days as well as to precipitation during 5 and 10 days before the pollen season.

Table 1
Dates of pollen seasons and annual counts of pollen grains in *Alnus, Corylus, Betula*.

Taxon	2001	2002	2003	2004	2005	2006
Alnus spp.	26.02-22.04	28.01-07.04	10.03-20.04	05.03-18.04	28.03-17.04	27.03-16.04
	1718	356	1222	524	603	1339
Corylus spp.	26.02-01.04	28.01-17.03	24.03-06.04	21.03-04.04	28.03-17.04	27.03-16.04
	790	197	302	180	170	485
Betula spp.	26.03-20.05	01.04-26.05	21.04-11.05	05.04-09.05	11.04-22.05	17.04-14.05
	3671	1621	2796	2043	1027	5321

Table 2
Correlation coefficients between the start of the pollen season in *Alnus, Corylus* and *Betula* and selected meteorological factors.

Taxon	Temp. mean °C January	Temp. max. °C (5 days)	Temp. min. °C (5 days)	Temp. mean °C (5 days)	Precipit. mm (5 days)	Temp. max. °C (10 days)	Temp. min. °C (10 days)	Temp. mean °C (10 days)	Precipit. mm (10 days)
Alnus spp.	-0.313*	0.213	-0.324*	0.006	-0.074	0.270	-0.159	0.111	0.187
Corylus spp.	-0.397*	0.291	-0.048	0.144	-0.191	0.413*	0.125	0.303*	0.084
Betula spp.	-0.477*	0.711*	0.763*	0.747*	0.404*	0.813*	0.870*	0.836*	0.464*

* Correlation statistically significant ($p<0.05$).

Table 3
Correlation coefficients between the length of the pollen season in *Alnus*, *Corylus* and *Betula* and selected meteorological factors.

Taxon	Temp. mean °C January	Temp. max. °C Season	Temp. min. °C Season	Temp. mean °C Season	Relative humidity % Season	Precipit. mm Season
Alnus spp.	0.384*	-0.736*	-0.717*	-0.750*	0.314*	-0.062
Corylus spp.	0.170	-0.662*	-0.471*	-0.603*	0.610*	0.408*
Betula spp.	0.638*	-0.589*	-0.526*	-0.565*	0.541*	0.138

* Correlation statistically significant ($p<0.05$).

Table 4
Correlation coefficients between the annual pollen grain count in *Alnus*, *Corylus* and *Betula* and selected meteorological factors.

Taxon	Temp. mean °C January	Temp. mean °C September	Temp. max. °C Season	Temp. min. °C Season	Temp. mean °C Season	Relative humidity % Season	Precipit. mm Season
Alnus spp.	-0.163	-0.064	-0.278	-0.209	-0.257	0.490*	0.482*
Corylus spp.	-0.030	0.141	-0.646*	-0.673*	-0.664*	0.633*	0.614*
Betula spp.	-0.670*	-0.133	0.410*	0.277	0.368*	-0.666*	-0.494*

* Correlation statistically significant ($p<0.05$).

The pollen season of birch occurred, on average, in the first week of April (Tab. 1). The coefficient of variation was 10%. All the weather parametres in question had a big impact on the start date of the season, which is proved by the correlation coefficients (Tab. 2). The most significant effect was exerted by maximum, minimum and mean temperatures during 10 days prior to the season. Ground frost in January delayed the date of birch pollen production.

The influence of weather factors on the length of the pollen season in *Alnus*, *Corylus* and *Betula*. On average, the pollen season in alder lasted 44 days, in hazel 26 days and in birch 40 days (Tab. 1). The coefficient of variance was 37% for alder, 56% for hazel and 36% for birch. As a result of statistical analysis it was found that the pollen season of the examined taxa was prolonged when the relative air humidity increased, which was confirmed by positive correlation coefficients (Tab. 3). Also, low temperatures during the pollen season contributed to prolonged pollen release in these taxa, as suggested by negative values of the coefficients. The interdependence between the length of the pollen season in alder and birch and the mean temperature of January demonstrates a significant correlation; in the case of hazel, the correlation is insignificant. More abundant precipitation during the season seemed to prolong pollen release in hazel, while it did not affect significantly the pollen season of alder and birch.

The influence of weather conditions on annual counts of pollen grains in *Alnus*, *Corylus* and *Betula*. The annual counts of pollen grains in the given taxa differed markedly in the six research years (Tab. 1). This is confirmed by the obtained coefficients of variance: 56% for alder, 70% for hazel and 57% for birch. The annual pollen grain count of alder and birch was noticeably affected by relative air humidity and precipitation, whereas in birch a negative influence of these factors was observed (Tab. 4). Among the factors that were examined to check their impact on the annual pollen grain count in hazel, it was maximum, minimum and mean temperature during the season that exhibited a negative dependence. A significant, negative effect on the number of pollen grains produced in birch was exerted by temperature in January; maximum and mean temperature during the season positively affected pollen production.

DISCUSSION

Research results of Frenguelli et al. (1991), Norris-Hill (1998), Gonzales et al. (1999), Jato et al. (2000), Adams-Groom et al. (2002), Emberlin et al. (2002) and Peternel et al. (2005) indicate that the main meteorological factor deciding about the starting date of pollen seasons in alder, hazel and birch is the temperature. The available literature does not specify unequivocally either the temperature which initiates florescence or its duration time. According to Scamoni (1955), temperature of 10 days before the pollen season is the most significant in alder pollen release. However, the results obtained here for alder demonstrate the lack of significance in this respect, while this observation holds true for hazel and birch, where the temperature of 10 prior days exerted a significant, positive influence on the start of the season. Ground frost in January delayed the start of pollen seasons in alder, hazel and birch, which is corroborated by the study of Latałowa et al. (2002).

In his phenological observations of early flowering of anemophylous trees, Łukasiewicz (1968) noticed a big impact of relative air humidity on the prolongation of their pollen season. Similar results were obtained in our study. The results of the present research prove that higher temperature accelerates and shortens the pollen season. Comparable results were achieved by Gaweł et al. (2003).

On the example of alder, Uruska (2003) observed a positive impact of mean temperature of August on the annual count of pollen grains. According to the research conducted on alder, hazel and birch in Lublin, there is a statistically insignificant correlation with this weather element in September. The annual count of birch pollen grains in the air in Lublin was positively correlated, in a statistically significant manner, with maximum and mean air temperature during the season. A similar dependence was also observed by Kasprzyk (1996) in Ostrowiec Świętokrzyski, Rasmussen (2002) in Denmark, Porsbjerg et al. (2003) in Nuuk, Rodriguez-Rajo et al. (2003) in Lugo, Peternel et al. (2004) in Zagreb, Méndez et al. (2005) in Ourense, and Puc (2006) in Szczecin. An increasing annual birch pollen count correlated with a decrease in relative air humidity was detected by Norris-Hill and Emberlin (1993) in London, and Weryszko-Chmielewska et al. (2006) in Szczecin. Similar results were also noted in Lublin. It is, however, striking that there is no negative correlation between the annual pollen grain count in alder and hazel and relative air humidity. Studies typically demonstrate the fact that relative air humidity and precipitation confine pollen grain emission to the atmosphere. Such an observation for alder is presented by Puc (2003) in the study conducted in Szczecin.

CONCLUSIONS

1. Low temperatures of January delayed the start of the pollen season in alder, hazel and birch. A significant effect on the start of the alder pollen season was exerted by minimum temperature of 5 days prior to pollen release, while in the case of hazel maximum and mean temperatures of 10 days preceding the pollen season were pivotal. All the weather parameters studied influenced significantly the date of the start of the birch pollen season.
2. The pollen season of alder, hazel and birch was prolonged along with increased relative air humidity, and was shortened in higher temperatures. Increased precipitation also produced prolongation of the hazel pollen season. Higher temperatures of January prolonged the alder and birch pollen seasons.
3. Annual pollen grain counts of alder and hazel increased together with increased relative air humidity and precipitation during the season. Lower temperatures decreased the pollen grain count of hazel. Weather conditions during the season such as: higher temperatures, low relative air humidity, less abundant precipitation and low temperatures of January, increased the total number of birch pollen grains.

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Wpływ warunków pogodowych na przebieg sezonów pyłkowych olszy (*Alnus* spp.), leszczyny (*Corylus* spp.) i brzozy (*Betula* spp.) w Lublinie w latach 2001-2006

Streszczenie

Początek i przebieg kwitnienia *Alnus*, *Corylus, Betula,* uzależniony jest od warunków meteorologicznych. W pracy analizowano wpływ temperatury średniej, maksymalnej i minimalnej, wilgotności względnej powietrza oraz opadów na datę początku sezonu pyłkowego, jego długość oraz sumę roczną ziaren pyłku olszy, leszczyny i brzozy. Pomiary opadu pyłku wykonano metodą grawimetryczną przy zastosowaniu aparatu Durhama. Pomiędzy wyznaczonymi cechami sezonu pyłkowego a warunkami pogodowymi wyliczono współczynniki korelacji. W sześcioletnim okresie badawczym 2001-2006 stwierdzono wpływ niskich temperatur stycznia na opóźnienie rozpoczęcia sezonu pyłkowego olszy, leszczyny i brzozy. Na rozpoczęcie kwitnienia tych taksonów miały również istotny wpływ warunki termiczne panujące bezpośrednio przed sezonem (około 10 dni). Sezon pyłkowy olszy, leszczyny i brzozy wydłużał się wraz ze wzrostem wilgotności względnej powietrza w sezonie, natomiast skracał pod wpływem wyższych temperatur. Wysokość produkcji ziaren pyłku olszy i leszczyny zwiększała się wraz ze wzrostem wilgotności względnej i opadów w sezonie pyłkowym. Roczne sumy ziaren pyłku brzozy zwiększały się wraz ze wzrostem temperatury, spadkiem wilgotności względnej powietrza i opadów w sezonie.