

ANALYSIS OF *ALNUS* spp. POLLEN SEASONS IN LUBLIN AND WARSZAWA (POLAND), 2001-2007

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S u m m a r y

The course of *Alnus* spp. pollen seasons was compared in two cities, Lublin and Warsaw, located at a small distance from each other but included in different climatic regions of Poland. The studies were conducted using the volumetric method. It was shown that *Alnus* pollen seasons started in Warsaw earlier and were much shorter than in Lublin. The span between the start dates of pollen seasons was similar and it was 53-54 days.

Peak days occurred in both cities most often in the second decade of March, but in Warsaw they were recorded several days earlier. Maximum concentrations reached higher values in Lublin, whereas annual totals were higher in Warsaw. The number of days with the concentration > 50 pollen grains × m⁻³ per 24 hours was 5-27 days for Warsaw and 10-19 days for Lublin over 7 years of study.

Key words: *Alnus*, pollen seasons, seasonal variations, regional differentiation, threshold concentrations, Lublin, Warszawa, Poland

INTRODUCTION

In Poland three species from the genus *Alnus* and their hybrids occur (Seneta and Dolatowski, 2007). *Alnus glutinosa* L. and *A. incana* L. trees grow in the lowland and in lower mountainous areas, whereas *A. viridis* shrubs are noted only in the Western Bieszczady Mountains (Szwajkowska and Szwajkowski, 1993; Zając and Zając, 2001). The two former species grow on water edges and lowland bogs, forming a swampy type of deciduous forests called alder woods of great ecological significance. *Alnus incana* is a pioneer species used in the recultivation of post-industrial areas (Seneta and Dolatowski, 2007). Alder populations are currently endangered due to the lowering of ground water levels (Mejnartowicz, 2007).

Alder pollen grains are transported by the wind for long and very long distances. It is favoured by their small size and the low falling velocity. Studies conduc-

ted in Warsaw demonstrate that in the close vicinity of flowering alder trees (up to 5 m) the average daily concentration of pollen of this taxon may reach 440,000 pollen grains in 1 m³ of air, a value which exceeds many times concentrations recorded in the city centre (Rapiejko, 2003; Rapiejko et al. 2003). During the early spring period, alder pollen is a frequent cause of allergic rhinoconjunctivitis and even bronchial asthma. For alder pollen, the threshold value is taken to be 50 pollen grains in m³ per 24 h at which pollen allergy symptoms occur (Rantio-Lehtimäki et al. 1991) or 45 pollen grains in m³ for Polish population (Rapiejko et al. 2004).

The aim of the work was to compare *Alnus* pollen seasons in Lublin and Warsaw, cities belonging to different climatic regions of Poland.

MATERIALS AND METHODS

The course of *Alnus* pollen seasons in Lublin and Warsaw was studied in the years 2001-2007. Airborne pollen counts were conducted using the volumetric method by means of a VPPS Lanzoni 2000 pollen trap (Hirst 1952). In Lublin, the trap site was located in the city centre on a building roof (51°14'N, 22°32' E) at a height of 18 m, whereas in Warsaw in the Bielany district (52°15'N, 21°00'E), 27 m above ground level. The distance between the cities is 176 km.

The pollen concentration was expressed as the number of pollen grains × m⁻³ per 24 h. The beginning and the end of the pollen season was determined using the 98% method, that is, the period was determined retrospectively when 98 percent of *Alnus* pollen grains occurred in the air (Emberlin et al. 1993).

Dynamics of the pollen seasons (Figs 5, 6) was presented on the diagrams proposed by Latałowa et al. (2002). In both cities, at a distance of 2-4 km from the trap site, alders grow along river banks, also forming larger tree clusters.

RESULTS

In the years 2001-2007, the start of the *Alnus* pollen season, determined using the 98 % method, fell in the period between 2 February and 28 March in Lublin, whereas in Warsaw in the period between 4 February and 29 March. The date of the beginning of the pollen season for this taxon in the years 2006 and 2007 in Lublin and in Warsaw was very similar, whereas in the remaining years the difference was 6-16 days (Tab. 1, Fig. 1).

After the calculation of averages for the study period, it was found that the *Alnus* pollen season started earlier in Warsaw than in Lublin by 2 days using the 98% method (Tab. 2) and by 5 days using the 100% method.

Alnus pollen seasons were much shorter in Warsaw than in Lublin, except for the year 2001 (Fig. 2). The length of the pollen season in Lublin ranged between 27 and 80 days, whereas in Warsaw between 14 and 51 days (the 98% method) (Tab. 1). The average length of the *Alnus* pollen season for the seven-year period was 35 days for Warsaw, and for Lublin 48 days (the 98 % method) (Tab. 2).

Maximum concentrations of *Alnus* pollen grains were noted in Lublin between 5 March and 2 April, whereas in Warsaw between 17 February and 2 April (Tab. 1). The average date of the maximum *Alnus* pollen concentration from the seven-year period was 4 days earlier in Warsaw than in Lublin (Tab. 2).

In Lublin, maximum *Alnus* pollen concentrations in the seasons were generally higher than in Warsaw, in particular in the last four years (Tab. 1). The seven-year average of this parameter was 46 percent higher for Lublin (Tab. 2).

The analysis of curve patterns illustrating *Alnus* pollen seasons in both cities in particular years shows that these seasons were compact, and the two species, *Alnus glutinosa* and *Alnus incana*, occurring in the study area flowered simultaneously or their flowering dates overlapped partially, e.g. in Lublin in 2006 (Fig. 3). The pattern of *Alnus* pollen seasons for Lublin and Warsaw, made based on seven-year averages, demonstrates that threshold *Alnus* pollen concentrations (above 50 grains in m³) can be expected in Lublin between 9 March and 10 April, whereas in Warsaw between 7 March and 4 April.

Table 1
Characteristics of *Alnus* pollen seasons in Lublin and Warsaw in the years 2001-2007 (98% method).

No.	Year	City	Pollen season			Maximum concentration pg/m ³	Date
			Start	End	Length (days)		
1.	2001	Lublin	25.02	3.04	38	1740	12.03
		Warszawa	9.02	1.04	51	1145	12.03
2.	2002	Lublin	2.02	8.04	66	207	5.03
		Warszawa	8.02	25.03	45	307	17.02
3.	2003	Lublin	23.03	20.04	29	2433	28.03
		Warszawa	15.03	1.04	17	2356	23.03
4.	2004	Lublin	7.02	27.04	80	2082	19.03
		Warszawa	19.02	2.04	43	873	18.03
5.	2005	Lublin	25.03	20.04	27	1249	2.04
		Warszawa	16.03	7.04	22	987	28.03
6.	2006	Lublin	28.03	10.05	44	1443	2.04
		Warszawa	29.03	11.04	14	954	2.04
7.	2007	Lublin	3.02	28.03	54	829	12.03
		Warszawa	4.02	27.03	51	198	8.03

Table 2
Comparison of of *Alnus* pollen seasons in Lublin and Warsaw, an average from the years 2001-2007.

City	Start of season	Season length (days)	Peak day	Maximum pollen concentration $\text{pg}\times\text{m}^{-3}$
Lublin	28.02	48	20.03	1426
Warszawa	26.02	35	16.03	974

Table 3
Frequency of *Alnus* pollen counts above certain thresholds recorded in Lublin and Warsaw.

Year	City	Number of days with daily <i>Alnus</i> pollen counts			
		$>50 \text{ grains}\times\text{m}^{-3}$	$>100 \text{ grains}\times\text{m}^{-3}$	$>500 \text{ grains}\times\text{m}^{-3}$	$>1000 \text{ grains}\times\text{m}^{-3}$
2001	Lublin	15	10	4	2
	Warszawa	27	14	7	1
2002	Lublin	19	8	0	0
	Warszawa	24	13	0	0
2003	Lublin	17	9	4	2
	Warszawa	17	13	12	9
2004	Lublin	10	9	2	2
	Warszawa	5	4	3	0
2005	Lublin	12	11	2	1
	Warszawa	16	12	4	0
2006	Lublin	17	15	4	2
	Warszawa	10	8	3	0
2007	Lublin	11	7	2	0
	Warszawa	11	6	0	0
Sum	Lublin	101	69	18	9
	Warszawa	110	70	29	10

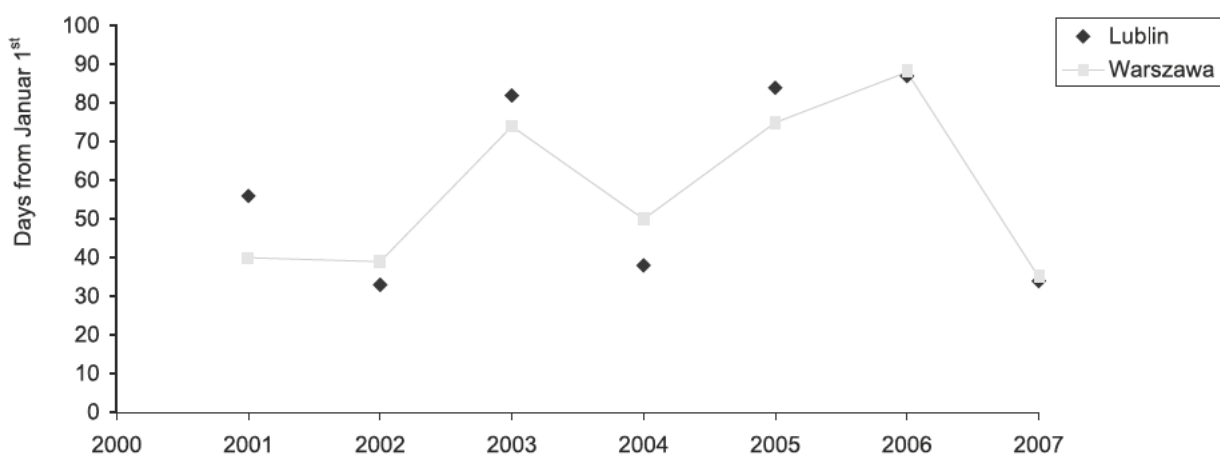


Fig. 1. Comparison of start dates of *Alnus* pollen seasons in Lublin and Warsaw, 2001-2007.

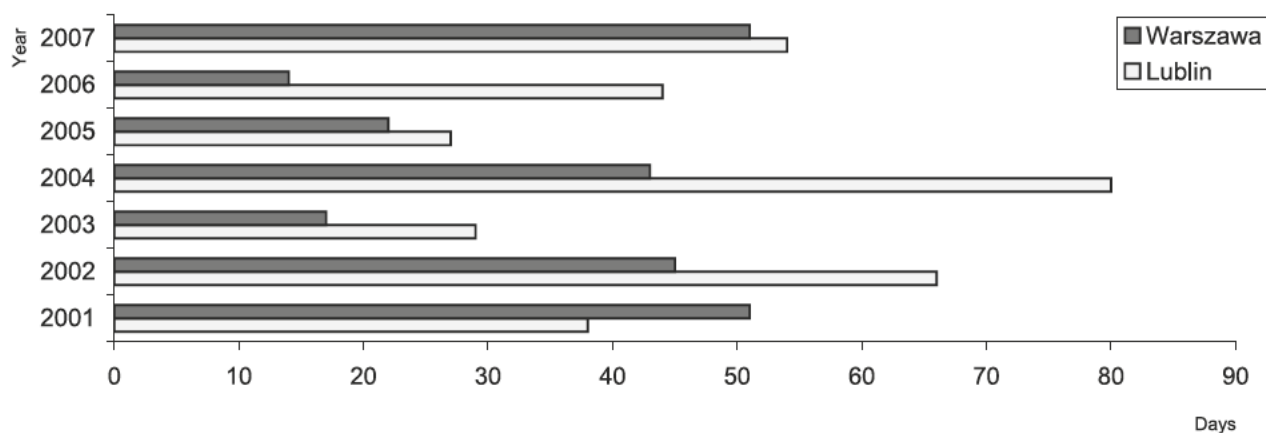


Fig. 2. Duration of *Alnus* pollen seasons in Lublin and Warsaw, 2001-2007.

Diagrams illustrating the dynamics of occurrence of *Alnus* pollen grains in the air of Lublin and Warsaw in the years 2001-2007 significantly differ in time and space (Figs 5, 6). Most diagrams exhibits asymmetry. In Lublin, only in the years 2003 and 2006 there was a rapid increase in the number of airborne pollen grains in the first phases of the season, when 50 percent of grains were noted after, respectively, 5 and 7 days of the season. At the same time, the final phases of these seasons were extended. In the remaining years, the number of pollen grains increased slowly, and pollen remained in the air longer. In Warsaw, the phase of fast increase in the number of airborne pol-

len grains was recorded only in 2006, when 50 percent of grains were in the atmosphere as early as the fifth day of the season. In 2002 a significant extension of the final phases of the season occurred in both cities.

Annual sums of *Alnus* pollen grains calculated for Lublin and Warsaw differed significantly in the study years (Fig. 7). The largest difference related to the year 2003 in which the exceptionally high annual sum of *Alnus* pollen grains (18768) in Warsaw exceeded over 2.5 times the annual sum recorded in Lublin (7095). The average annual sum of pollen grains was 6620 grains for Warsaw, and 5369 grains for Lublin.

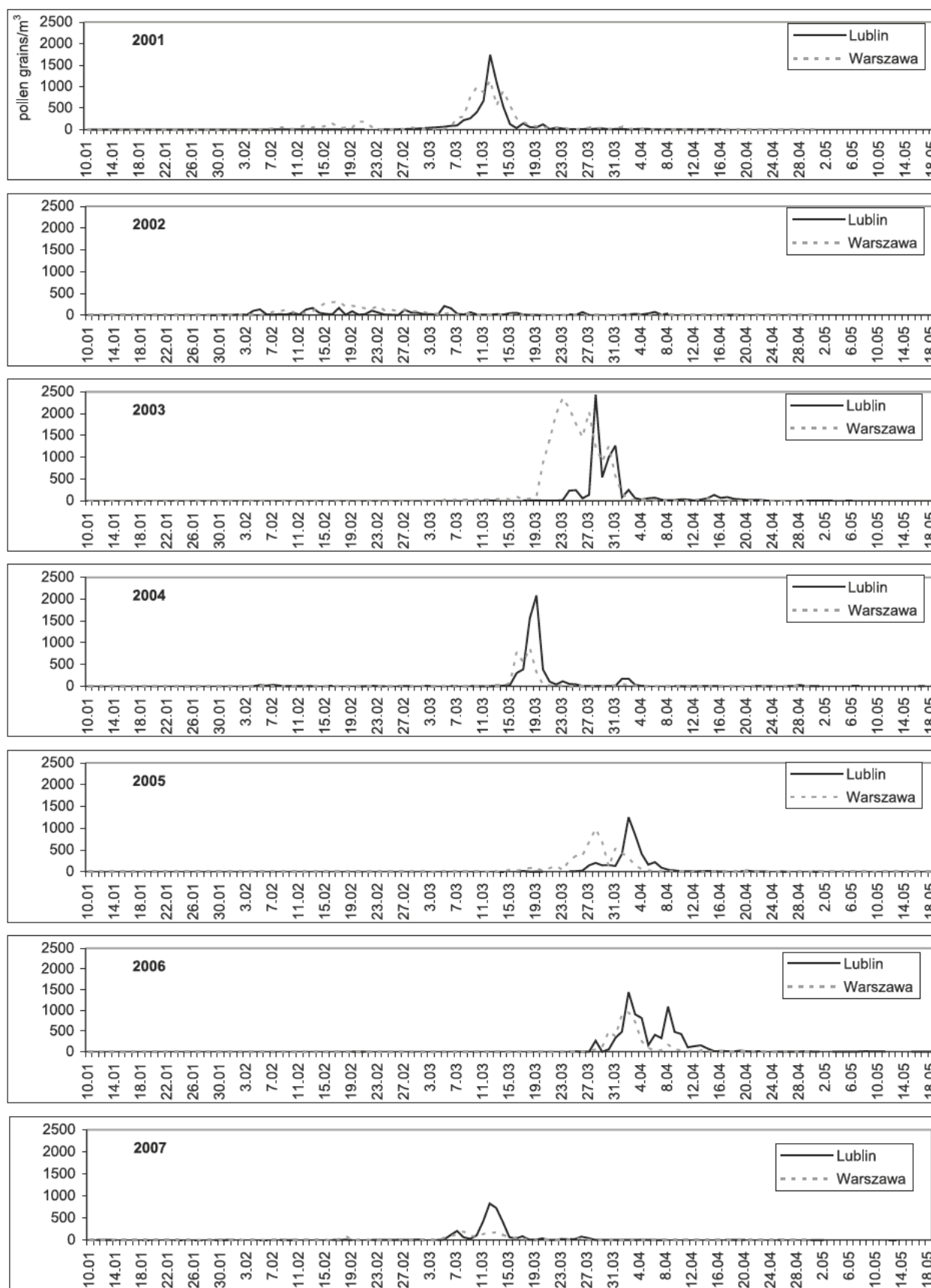


Fig. 3. Annual variations of *Alnus* pollen concentration in the air of Lublin and Warsaw, 2001-2007.

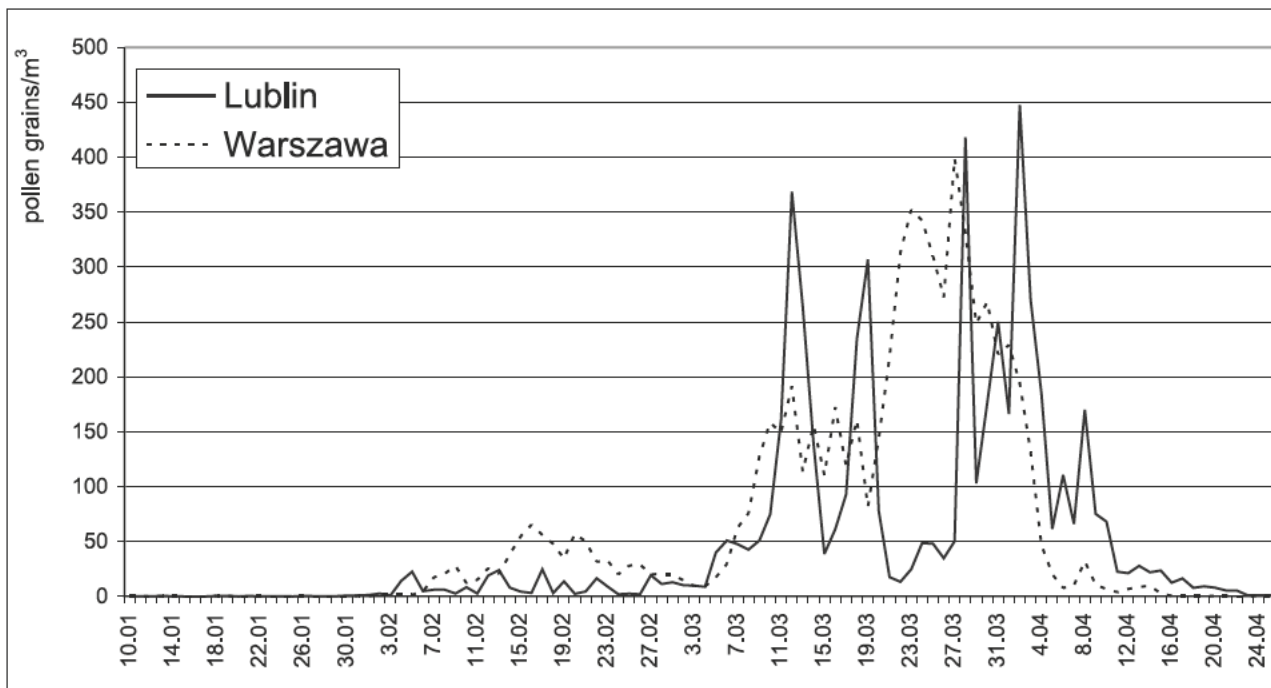


Fig. 4. Comparison of *Alnus* pollen season in Lublin and Warszawa (averages from 2001-2007).

The number of days with a high and very high *Alnus* pollen concentration, important for allergy sufferers, was large in all the study years in the case of both cities. A pollen concentration exceeding 50, 100, 500 and 1000 $\text{pg} \times \text{m}^{-3}$ occurred on many days, with a higher frequency in Warsaw (Tab. 3). However, a concentration of over 1000 pollen grains $\times \text{m}^{-3}$ was noted in five years in Lublin and only in two years in Warsaw.

DISCUSSION

Over the period of 7 years, the span between the start dates of *Alnus* pollen seasons was similar in both cities and it was 54 days (2 February – 28 March) for Lublin and 53 days (4 February – 29 March) for Warsaw. Similar differentiation with respect to the beginning of *Alnus* pollen seasons was noted in 5 years of study (2001-2005) in other Poland's cities: in Rzeszów 53 days (Kaspzyk, 2006), in Kraków 51 days (Myszkowska, 2006). But in some other cities, these differences were smaller and they were 45 days in Poznań (Stach, 2006), in Sosnowiec 42 days (Chłopek and

Dąbrowska, 2006), and in Szczecin 28 days (Puc, 2006). Also in Worcester (UK) over a period of 10 years (1996-2005), the start of the *Alnus* pollen season was within the range of 39 days (5 January – 13 February) (Emberlin et al. 2007).

The authors of the latter paper report that in Worcester a slight trend for earlier *Alnus spp.* pollen seasons was noticeable. The studies also show that both in Worcester and in Poznań there is a trend towards longer *Alnus* pollen seasons (Smith et al. 2007).

Our studies conducted in Lublin and Warsaw did not demonstrate such trends in *Alnus* pollen seasons, probably due to a short period of observation.

Warsaw and Lublin are located in different climatic regions, not uniform in terms of the frequency of occurrence of days with particular weather types. Warsaw is included in the Central Masovian Region (*Region Środkowomazowiecki*) which is characterised by 252 days of warm weather per year, whereas Lublin is situated in the Eastern Lesser Poland Region (*Region Wschodniomazowski*) where the number of such days is 245 (Woś, 1999). The abovementioned climatic

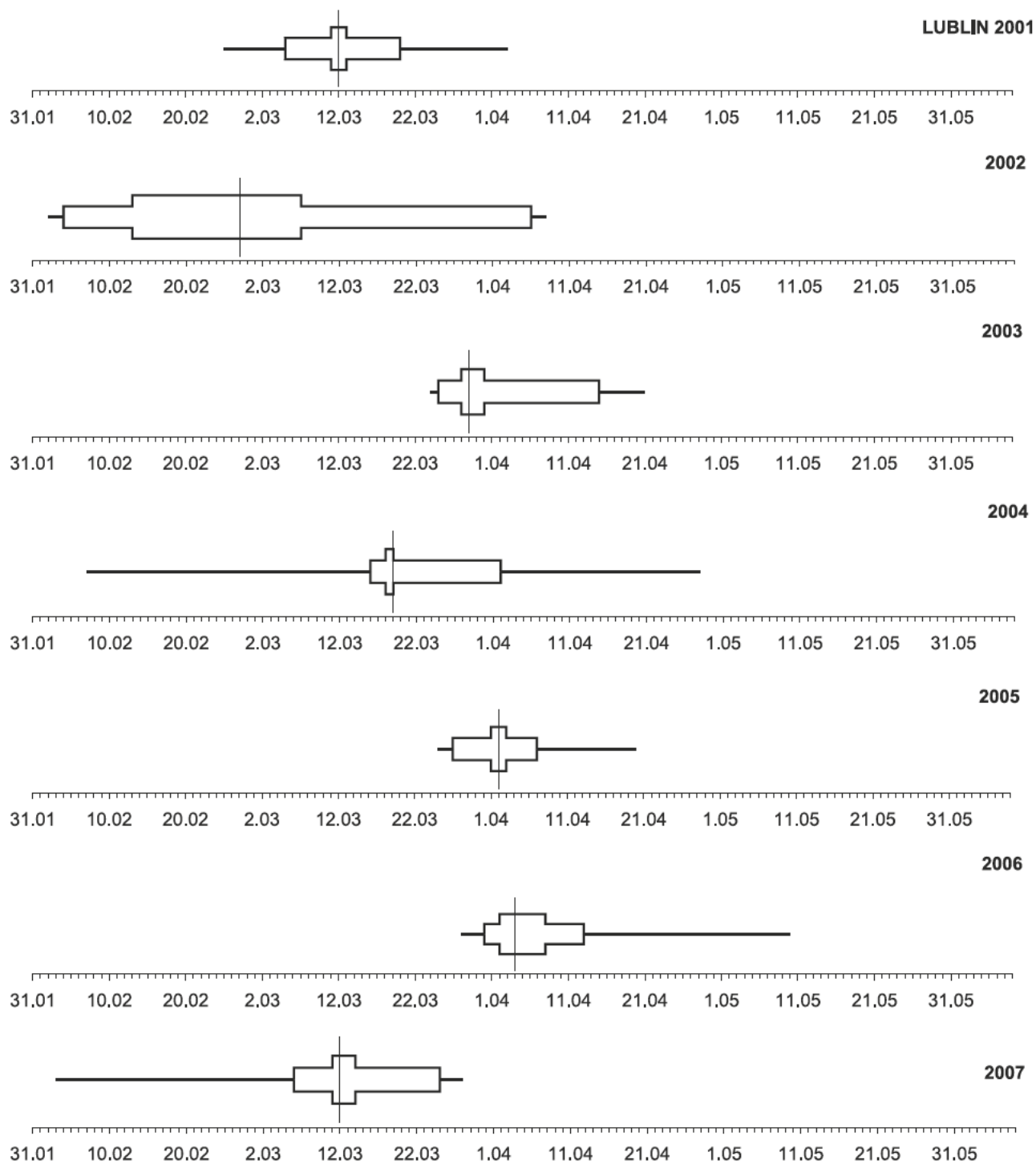


Fig. 5. Dynamics of *Alnus* pollen seasons in Lublin, 2001-2007.
Diagrams of consecutive stages of the pollen season: 1%, 5%,
25%, 50% – vertical line, 75%, 95%, 99%.

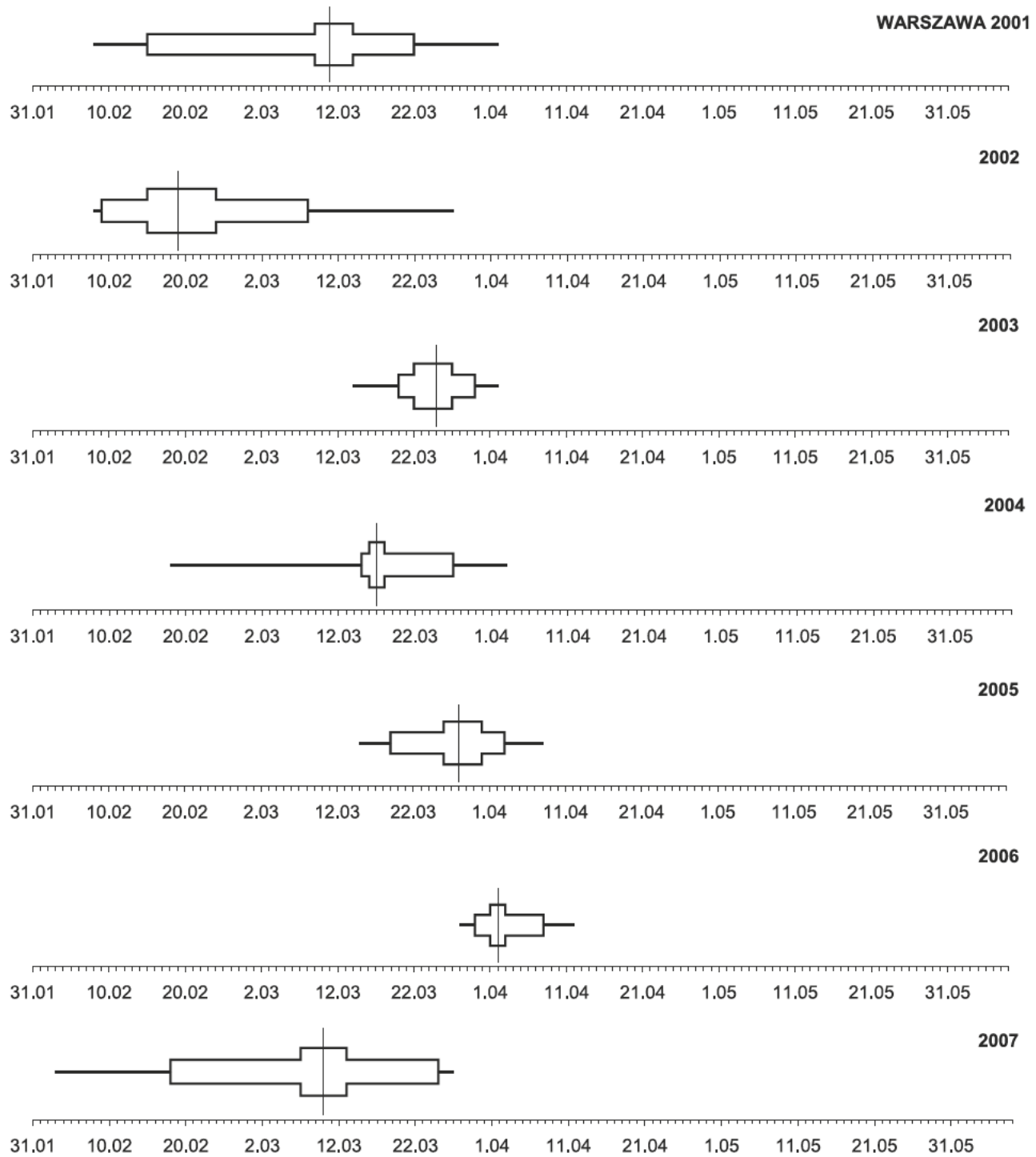


Fig. 6. Dynamics of *Alnus* pollen seasons in Warsaw, 2001-2007.

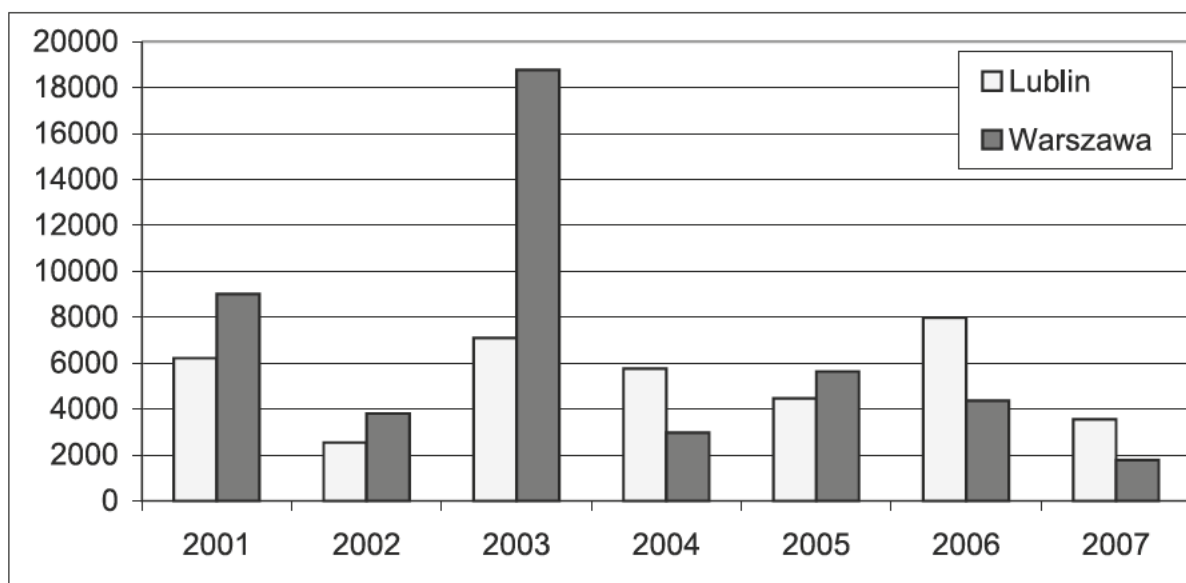


Fig. 7. Total season counts of *Alnus* spp. pollen grains in Lublin and Warsaw from 2001 to 2007.

conditions can be the reason for the earlier, by several days, beginning of the *Alnus* pollen season in Warsaw, as well as for the occurrence of the date of the maximum concentration of pollen of this taxon several days earlier than in Lublin.

Our studies demonstrate that the two alder species, *A. glutinosa* and *A. incana*, occurring in the studied area of Poland, flower simultaneously. Similar results were obtained for the Netherlands, whereas in Italy's mountainous areas *A. glutinosa* flowers from February till April and *A. incana* flowers in June (Spiekma and Frenguelli, 1991).

Diagrams illustrating the dynamics of *Alnus* pollen seasons in Lublin and Warsaw in the years 2001-2007 differ significantly in time and space. But Kasprzyk et al. (2004) obtained in 1995 similar diagrams of *Alnus* pollen seasons in seven Poland's cities, whereas in 1996 they differed significantly.

In the study, it was demonstrated that in Warsaw 5-27 days and in Lublin 10-19 days with a concentration >50 pollen grains \times m^{-3} per 24 hours occurred per year. Many days with a higher *Alnus* pollen concentration were also noted. Rapijko et al. (2004) give different threshold alder pollen concentrations necessary to induce allergic symptoms in persons allergic to allergens of this pollen. According to these authors, the first symptoms occur already at a concentration of 45 $pg \times m^{-3}$ of air, and at 85 $pg \times m^{-3}$ symptoms occur in all persons allergic to alder pollen allergens, at 95 $pg \times m^{-3}$ symptoms are intensified, and at 1200 $pg \times m^{-3}$ dyspnoe symptoms occur.

Pollen grains being a component of atmospheric aerosol indicate the plant flowering period. Results of aeropalynological studies have been recently used as phenological data which allow the start of flowering to be determined (Galán et al. 2001; Rodríguez-Rajo et al. 2006). *Alnus glutinosa* is a species occurring within a limited area in Spain. By investigating differences relating to the start and intensity of the pollen season, it can be used for demonstrating changes in its distribution and in the future for predicting possible ecological changes related to global climatic changes (Rodríguez-Rajo et al. 2004, 2006).

CONCLUSIONS

1. In Warsaw, *Alnus* pollen seasons started earlier and were much shorter than in Lublin.
2. Maximum concentrations of *Alnus* pollen grains occurred most frequently in the second decade of March in both cities, but in Warsaw they were noted several days earlier.
3. Annual sums of *Alnus* pollen grains were higher in Warsaw, and maximum concentrations of pollen of this taxon were higher in Lublin.
4. The number of days with the threshold and high *Alnus* pollen concentration, important for allergy sufferers, was large in the case of both cities.

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Analiza sezonów pyłkowych *Alnus* spp. w Lublinie i Warszawie (Polska)

Streszczenie

Porównano przebieg sezonów pyłkowych *Alnus* spp. w dwóch miastach, Lublinie i Warszawie, położonych w niewielkiej odległości ale zaliczanych do różnych regionów klimatycznych Polski. Badania prowadzono metodą wolumetryczną. Wykazano, że sezony pyłkowe *Alnus* rozpoczynały się w Warszawie wcześniej i były znacznie krótsze niż w Lublinie. Rozpiętość w zakresie startu sezonów pyłkowych była zbliżona i wynosiła 53-54 dni.

Dni z maksymalnymi stężeniami ziaren pyłku olszy występowały w obu miastach najczęściej w drugiej dekadzie marca, ale w Warszawie rejestrowano je wcześniej. Maksymalne stężenia osiągały wyższe wartości w Lublinie, natomiast sumy roczne ziaren pyłku olszy były wyższe w Warszawie. Liczba dni ze stężeniem >50 ziaren pyłku $\times m^{-3}$ w ciągu 24 godzin wynosiła 5-27 dni dla Warszawy i 10-19 dni dla Lublina w ciągu 7 lat badań.

