

Ragweed and mugwort pollen in Szczecin, Poland

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Abstract

Ragweed (genus *Ambrosia*) and mugwort (*Artemisia vulgaris*) pollen grains are known to be very potent aeroallergens, often noted to enter into cross reactions. The aim of the study was to analyse ragweed and mugwort pollen release in Szczecin (western Poland) during the period 2000–2003. Measurements were performed by the volumetric and gravimetric method. Pollen seasons were defined as the periods of 90% of the total catch. Of the 4 years studied, the lowest concentration of ragweed pollen was observed in 2000. In 2000, the annual ragweed pollen count was very high, threefold higher than in 2001. There was a high *Ambrosia* pollen count in 2003, with the highest daily value of 84 grains/m³. The mugwort pollen season started in the third 10-day period of July and lasted to the end of August in all of the years studied. Analysis of pollen deposition from different Szczecin city's districts showed that the highest exposure to ragweed pollen allergens occurred in the Majowe district, which is related to the presence of numerous plants of *Ambrosia* in that district. The mugwort pollen deposition was more abundant in the Żelechowa district, which is an area with villas and gardens. Statistically significant correlations were found between the ragweed pollen count in the air and the maximum wind speed, air temperature and relative humidity and between the mugwort pollen count in the air and air temperature and relative humidity.

1. Introduction

A knowledge of potential allergenic pollen counts and changes therein throughout the periods of pollen release in any given area is of great importance in the prophylaxis of inhalant allergies, including pollen allergies, which are becoming a social problem worldwide. The most common cause of pollinosis in North America is ragweed (genus *Ambrosia*) pollen. Up until the late 1960s ragweed had been believed to occur sparsely in Europe and, consequently, it had not been considered to be a source of serious allergenic threat. In recent years, however, ragweed has appeared throughout Europe in hitherto unknown localities, and the number of people allergic to the allergens of this plant is gradually increasing (Jäger, 1991; Rich, 1994; Mandrioli

et al., 1998a). Ragweed pollen is not uniformly dispersed throughout Europe: it is abundant in Hungary, Ukraine and North Italy and less frequent in France, the Balkan Peninsula, Switzerland, Austria, Slovakia and the Czech Republic (Jäger, 1991; Yankowa et al., 1996; Jäger and Litschauer, 1998; Mandrioli et al., 1998a; Járαι-Kamlódi, 2000). The genus *Ambrosia* contains about 42 species of which only five have been noted in Europe. Three of these species have been recorded in Szczecin, Poland, since 1900: *Ambrosia psilostachya*, *A. trifida* and *A. artemisiifolia* (Holzfuss, 1933; Tacik, 1971; Tutin et al., 1976).

Ambrosia pollen cross react with almost all other composites, especially with mugwort (genus *Artemisia vulgaris*) pollen (Dahl et al., 1999) which is to be found in relative abundance

throughout Europe (D'Amato and Spieksma, 1990; Spieksma, 1991). The allergens of *Artemisia* pollen are responsible for the majority of pollinosis symptoms observed in late summer (Katial et al., 1997). According to Wallenstein and Kersten (1985) and Spieksma (1986), 3–10% of all pollinosis sufferers are allergic to the *Artemisia* antigens, with the majority also allergic to the pollen of ragweed, grass and the allergens of apple and celery (Grote et al., 1998; Hirschwehr et al., 1998). The threat related to the allergens of *Ambrosia* and *Artemisia* pollen is enhanced by the fact that the pollen of these taxa (as well as the pollen of other herbs) just above the ground level can be found concentrated at altitudes a few fold higher than 15–25 m (Alcazar and Comtois, 1999; Spieksma et al., 2000).

The objective of the investigation reported here was to analyse ragweed and mugwort pollen counts in the air of Szczecin, compare the pollination seasons in 2000 up to and including 2003, estimate the effect of meteorological conditions on the pollen count and assess the level of exposure of Szczecin inhabitants to the allergenic ragweed and mugwort pollen.

2. Materials and methods

Analyses of pollen concentrations and the distributions of pollen deposition were carried out on data collected in Szczecin in the pollen seasons of 2000–2003.

The volumetric measurement point was located in the Śródmieście district of Szczecin, at a height of 21 m above ground level. Pollen counts were made by the volumetric method utilising a Hirst-type sampler (VST trap in 2000–2002 and Lanzoni trap in 2003). Average daily concentrations are expressed as the number of pollen grains per cubic metre of air (Hirst, 1952; Rapiejko, 1997; Mandrioli et al., 1998b).

Gravimetric monitoring, performed using a modified Durham trap (Durham, 1964; Mandrioli et al., 1998b), was conducted concurrently with the above pollen counts in four Szczecin city districts – Śródmieście, Pomorzany, Żelechowa and Majowein – in order to establish the spatial distribution of pollen in the air. Average daily deposition is expressed as the number of pollen grains per square centimetre.

The dynamics of pollen seasons were analysed for *Ambrosia* and *Artemisia*. Pollen of these taxa occurs in the air in high or relatively high concentrations, thereby enhancing the possibility of the appearance of pollen allergy symptoms. The beginning and the end of the pollen seasons were established by the 90% method, i.e. a pollen season was defined as that period of time within which 90% of the annual total catch occurred (Emberlin et al., 1993).

Based on data obtained from the literature, the number of days for which pollen concentrations of the taxa studied exceeded the threshold values at which allergy symptoms develop was determined. Laaidi and Laaidi (1999) reported a threshold value for *Ambrosia* pollen of 13 grains/m³ per day in Burgundy, France, while Voltolini et al. (2000) reported 12 grains/m³ per day for *Artemisia* in Genoa, Italy.

The meteorological data for the years 2000–2003 were provided by the meteorological station located in the Dąbie district of Szczecin and by an Automatic Weather Station (Vaisala, Helsinki, Finland) mounted at the measuring site in Śródmieście. The meteorological parameters taken into consideration within the framework of assessing the effect of meteorological conditions on the airborne pollen count were daily level of precipitation, wind speed, relative humidity and air temperature, as these factors have been shown to influence pollen release (Levizzani et al., 1998; Barnes et al., 2001). The daily values of these parameters were taken as arithmetic means. The degree of correlation between specific meteorological parameters and the ragweed and mugwort pollen concentrations was described by the Pearson's correlation coefficient (*r*) (Comtois, 1998). Statistical error risk was estimated at the significance level of 95% ($\alpha=0.05$).

3. Results

3.1. *Ambrosia*

During the 4 years of this study an increase in the ragweed pollen count in Szczecin was determined as evidenced by increasing annual cumulative totals and the maximum number of pollen grains in particular seasons (Table 1). The lowest concentration of ragweed pollen was observed in

Table 1. Results of aerobiological study of *Ambrosia* and *Artemisia* pollen counts (NR, not recorded)

Taxon	Parameters ^a	2000	2001	2002	2003
<i>Ambrosia</i> spp.	ps	19 August– 18 September (31)	19 August– 22 September (35)	20 August– 12 September (24)	28 August– 26 September (30)
	dn	NR	3	7	5
	tn	82	155	348	257
	Max	5	30	98	84
<i>Artemisia</i> spp.	ps	26 July– 7 September (43)	17 July– 25 August (40)	19 July– 7 September (50)	18 July– 24 August (38)
	dn	17	20	22	30
	tn	691	955	1420	1849
	Max	56	145	187	129

^aps, Pollen season (and the number of days); dn, number of days with daily pollen average above 13, which is the threshold of pollen concentration at which allergy symptoms develop; Max, daily peak pollen concentration for *Ambrosia* (Laaide and Laaidi, 1999); 12-Max, daily peak pollen concentration for *Artemisia* (Voltolini et al., 2000); tn, total number of pollen grains collected in the season; max, maximum number of pollen grains/m³.

2000. In 2001, the highest daily airborne pollen concentration – 30 grains/m³ – was noted at the end of August. The ragweed pollen count in 2002 was very high; the highest daily concentration of airborne pollen – 98 grains/m³ – was observed at the beginning of September on a day with strong wind. In 2003 a high *Ambrosia* pollen count was recorded, with the highest value of 84 grains/m³ on 8 September, 2003 (Figures 1, 2).

The pollen season in all four of the years studied began in the third 10-day period of August. In 2002, it was 1 week shorter than in the other years. The annual total of pollen grains was the highest in 2002 and equalled 348 grains (Table 1).

In sensitive persons the symptoms of pollinosis occur when the counts are above a threshold, which for ragweed is 13 grains/m³. Therefore, the greatest threat from *Ambrosia* pollen allergens in Szczecin was noted at the end of August and the beginning of September. In the years 2001–2003 the period did not exceed 7 days (Table 1).

The levels of ragweed pollen allergens to which the Szczecin inhabitants of the four districts of Szczecin were exposed were determined using modified Durham traps. The highest level of exposure to this pollen was noted in the Majowe district, which can be explained by the presence of numerous plants of *Ambrosia psilostachya* in this district (Figure 3). New localities of this taxon were noted in the Majowe district.

While the intrinsic rhythm of pollination from these taxa is the greatest influence of pollen con-

centration, meteorological conditions are the most important extrinsic factors influencing the pollen concentration in the air. *Ambrosia* pollen was usually recorded in the Szczecin aeroplankton on those days with a maximum temperature over 20°C (Figures 1, 2).

A positive, statistically significant correlation was noted between the ragweed pollen count and the maximum wind speed. This correlation indicates that the *Ambrosia* pollen present in the air above Szczecin can also be the result of long-distance transport. Statistical analysis has showed a significant correlation between the pollen count and the maximum temperature in 2000 and 2003. For three seasons there was a negative significant correlation between the ragweed pollen count and relative air humidity. No significant correlation was observed in any of the seasons between the count of ragweed pollen in the air and the level of precipitation (Table 2).

3.2. *Artemisia*

As observed for ragweed, an increase in the mugwort pollen count in Szczecin was observed over the 4-year study period (Table 1). The pollen season of mugwort started in the third 10-day period of July and lasted until the end of August. The highest pollen count of this taxon – 187 grains/m³ per day – was recorded on 31 July, 2002; in the other 3 years the *Artemisia* pollen count was lower and did not exceed 140 grains/m³ per day (Figures 4, 5). The highest annual

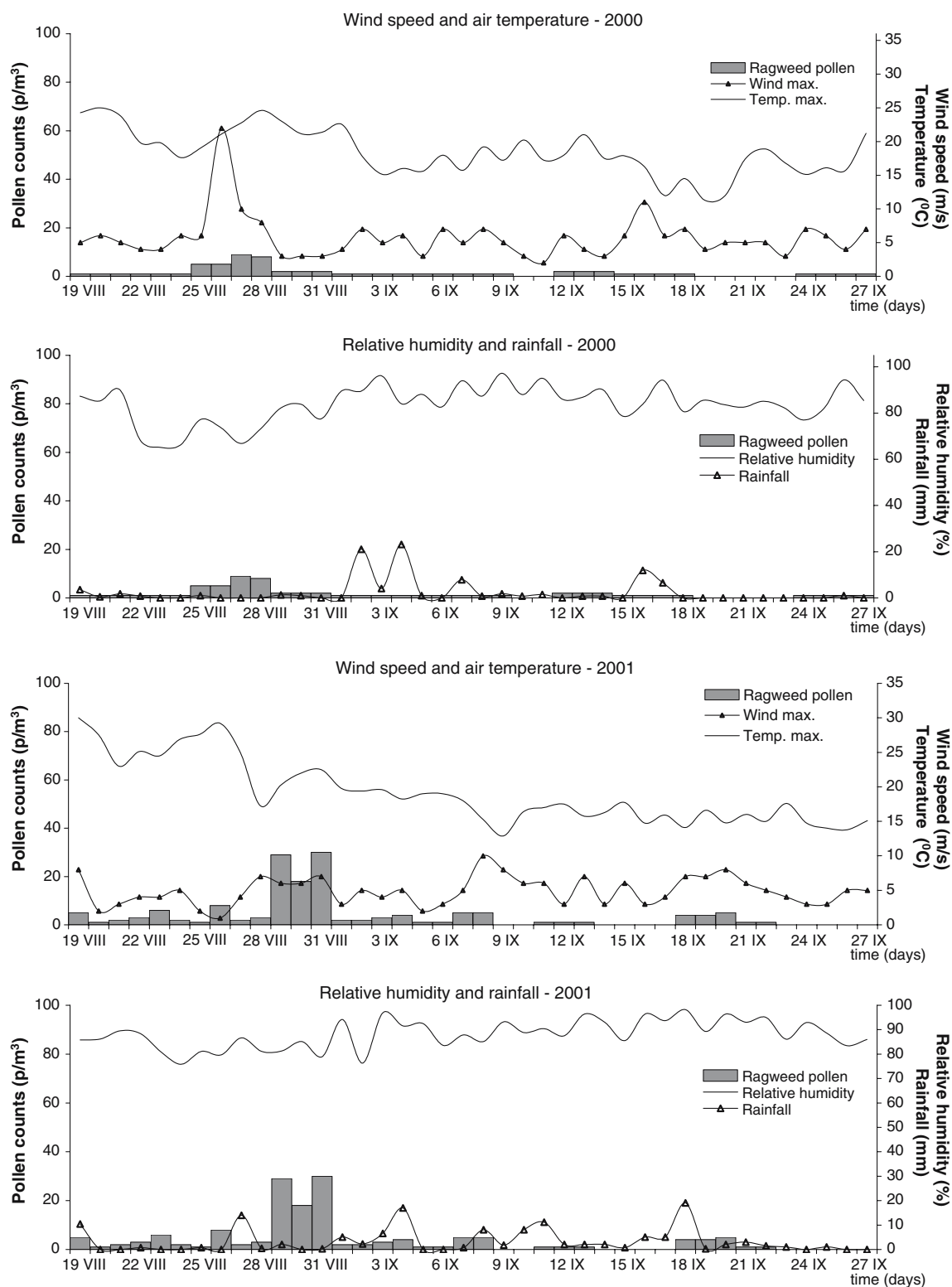


Figure 1. The effect of selected meteorological factors on ragweed (*Ambrosia*) pollen counts in 2000–2001.

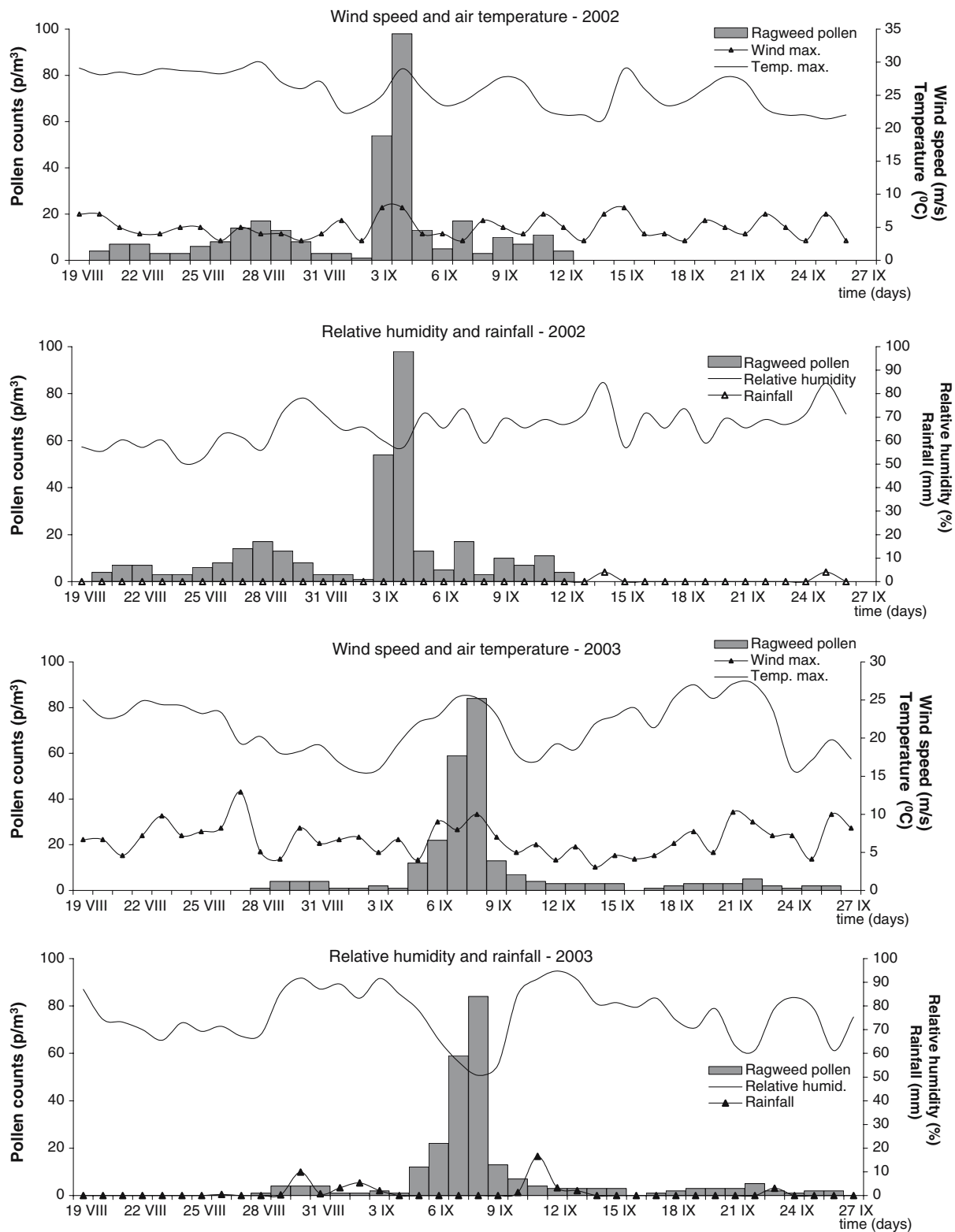


Figure 2. The effect of selected meteorological factors on ragweed (*Ambrosia*) pollen counts in 2002–2003.

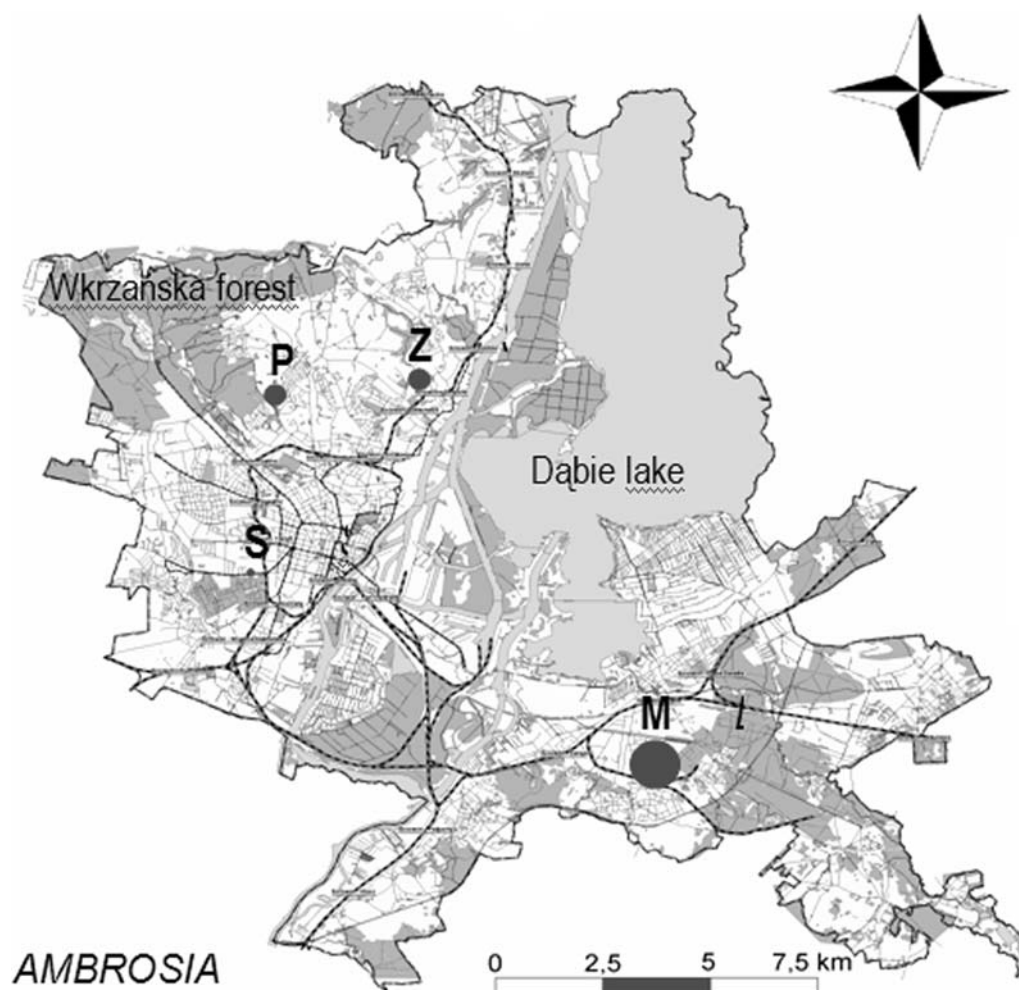


Figure 3. Differences in ragweed (*Ambrosia*) pollen deposition in the four districts of Szczecin studied, based on the mean results collected in the years 2000–2002. Z Żelechowa, P Pomorzany, S Śródmieście, M Majowe. The size of the filled circles are proportional to the mean total concentration of seasonal pollen sum in the respective district.

Table 2. Correlation coefficients between *Ambrosia* and *Artemisia* pollen counts and meteorological parameters (NR not recorded)

Taxon	Years	Meteorological factors			
		Temperature maximum (°C)	Rainfall (mm)	Wind speed maximum (m/s)	Relative humidity (%)
<i>Ambrosia</i> spp.	2000	0.4993*	−0.1233	0.4501*	−0.5091*
	2001	0.1254	−0.0811	0.2676*	−0.3529*
	2002	0.1838	NR	0.5811*	−0.1741
	2003	0.3794*	−0.1451	0.3989*	−0.5993*
<i>Artemisia</i> spp.	2000	0.4416*	−0.0848	−0.1299	−.02383*
	2001	−0.0175	0.0487	0.1261	−0.1621
	2002	0.5364*	−0.0676	0.0375	−0.2685*
	2003	0.3202*	−0.0748	−0.2735	−0.1461

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

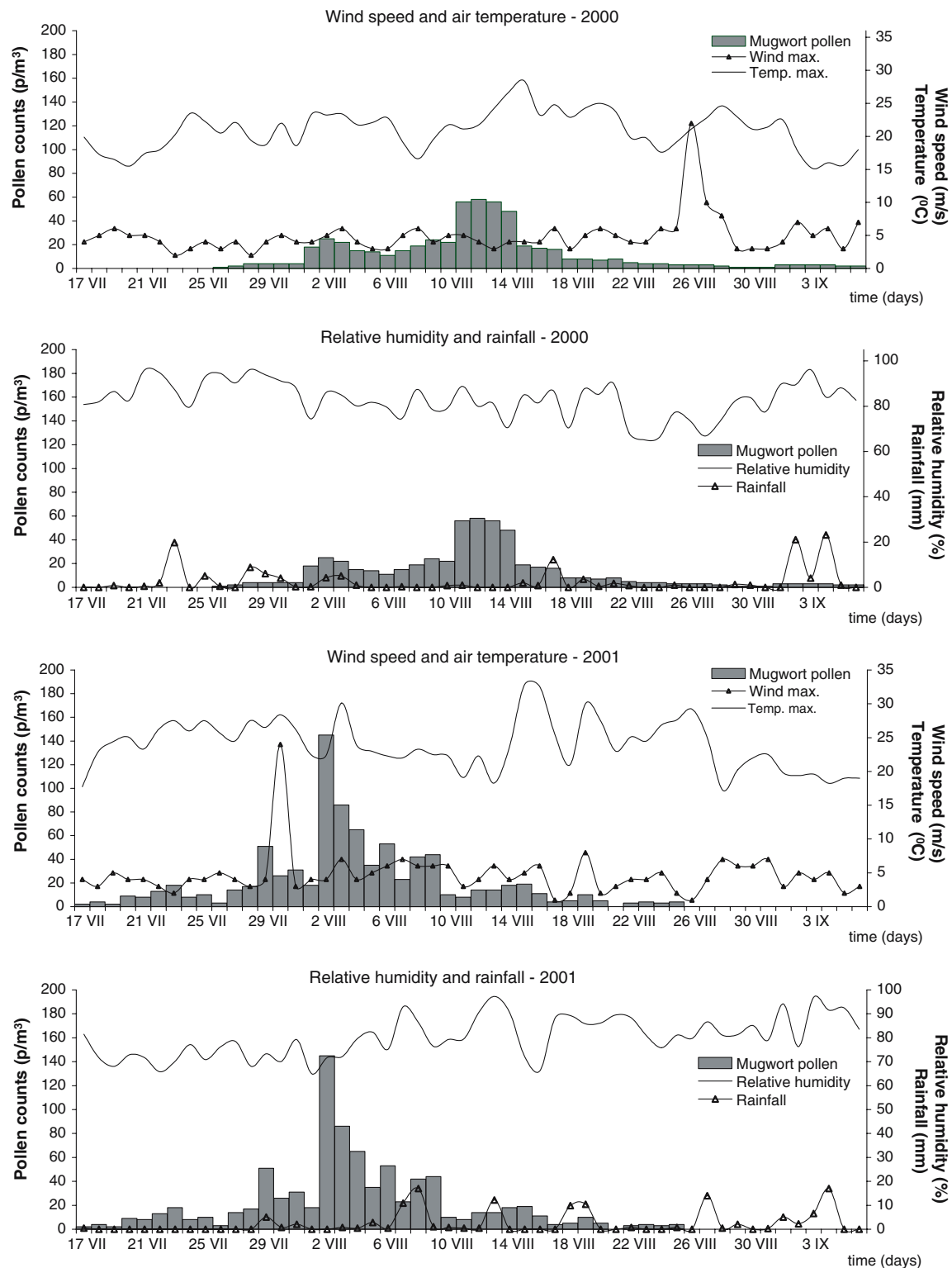


Figure 4. The effect of selected meteorological factors on mugwort (*Artemisia*) pollen counts in 2000–2001.

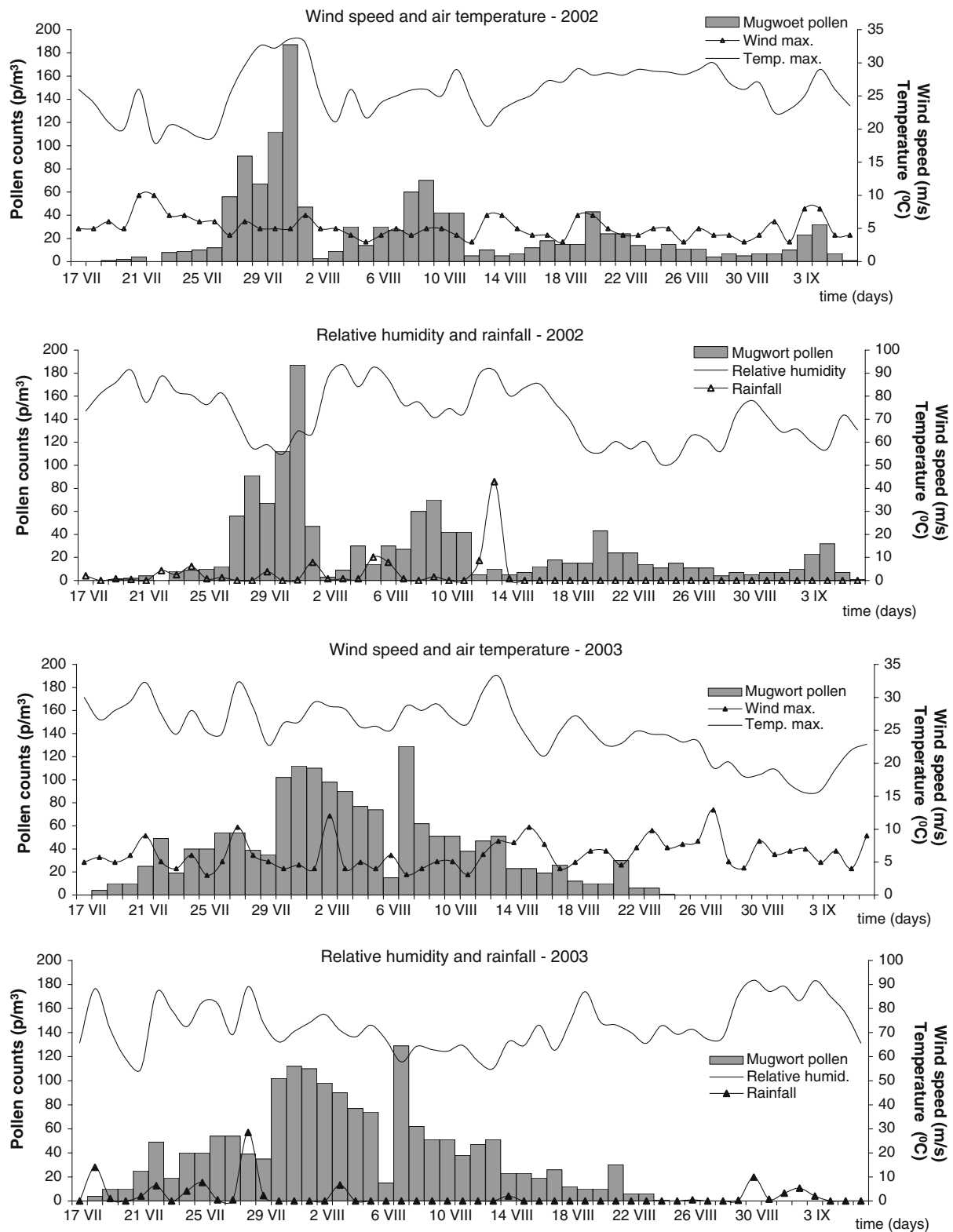


Figure 5. The effect of selected meteorological factors on mugwort (*Artemisia*) pollen counts in 2002–2003.

total of pollen grains was recorded in 2003 and equalled 1849 grains (Table 1).

In most of the periods analysed from the second 10-day period of July to the end of August the mugwort pollen count was higher than the threshold value of 12 grains/m³ per day (Figures 4 and 5).

Analysis of the pollen distribution in the four different districts of Szczecin revealed that the highest exposure to mugwort pollen allergens occurred in the Żelechowa district, which is consists of more villas and gardens or garden allotments than the Pomorzany district, the latter being more characterised by closely built blocks of buildings (Figure 6).

Statistical analysis revealed a significant correlation between the mugwort pollen count and the maximum temperature during three seasons. In 2000 and 2002, there was a negative significant correlation between the *Artemisia* pollen count and relative air humidity (Figures 4 and 5; Table 2).

4. Discussion

Over the course of the 4 years of the study period, 2000–2003, the ragweed and mugwort pollen count in the air above Szczecin increased sequentially. This tendency towards increasing pollen

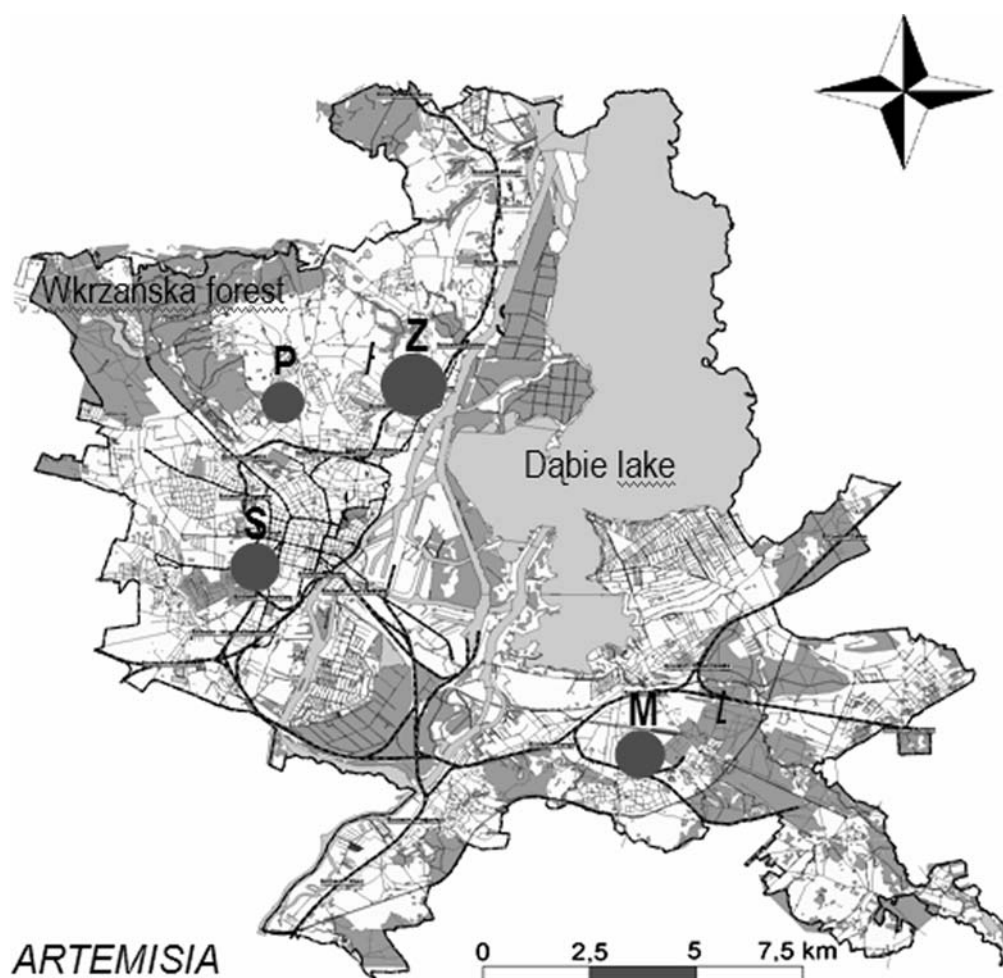


Figure 6. Differences in mugwort (*Artemisia*) pollen deposition in the four districts of Szczecin studied, based on the mean results collected in the years 2000–2002. Z Żelechowa, P Pomorzany, S Śródmieście, M Majowe. The size of the filled circles are proportional to the mean total concentration of seasonal pollen sum in the respective district.

concentrations of these taxa have been reported in Neuchâtel, Switzerland (Clot, 2003), for *Ambrosia* in North Italy (Mandrioli et al., 1998a), Vienna, Austria (Jäger, 2000) and Prague, Czech Republic (Rybniček et al., 2000). However, in contrast, in Delhi, India, a decrease in the concentration of ragweed pollen has been noted (Singh et al., 2003). In view of these differences, the results obtained in Szczecin should be confirmed in a long-term study.

Owing to the huge production of *Ambrosia* pollen (one specimen produces 0.5 million grains in a pollen season), it can be present at concentrations much higher than the threshold value (13 grains/m³ per day) for 25–30 days during the critical period (Laaidi and Laaidi, 1999). According to some authors the threshold value is the pollen count at which 60–80% of people allergic to *Ambrosia* pollen reveal acute symptoms of pollinosis (Laaidi and Laaidi, 1999; Bass, 2000; Járαι-Kamlódi, 2000). In the air above Szczecin during the years studied here, there were only very short periods (0–7 days) when the concentration of pollen grains was higher than the threshold value. For *Artemisia*, in Szczecin, the threshold concentration of 12 grains/m³ per day (Voltolini et al., 2000) was exceeded for a period of a few weeks in July and August. Similar results have been recorded in Cracow (Myszkowska et al., 2002).

Emberlin and Norris-Hill (1991) studied the spatial distribution of grass pollen count at 14 sites in London. Their results illustrate that the spatial differences in pollen counts are due to variable wind directions and depend on the distances between the site of measurement and the source of emission. In Szczecin, high pollen counts of ragweed and mugwort were recorded at the site in the vicinity of which there were many plants of these taxa. A similar proportional dependence between the pollen count in the air and the occurrence of pollinating plants near the measurement sites has been reported by Arobba et al. (2000) in Genoa. In the Szczecin district of Majowe a few new localities of a highly expansive western *Ambrosia* species were found. This species also found favourable conditions for growth along the railway tracks and near the railway station in the Dąbie district (Holzfuss, 1933).

The most important meteorological parameters determining pollen count in the air include

temperature, precipitation, relative air humidity, direction and speed of the wind and the amount of total solar radiation. In 2000 and 2003, a statistically significant, positive correlation was recorded between the air temperature and the ragweed and mugwort pollen count. A similar correlation has also been found in Poznań (Stach, 2002), Muracia (Munuera Giner et al., 2002) and Zagreb (Peternel et al., 2004). Stark et al. (1997) and Laaidi et al. (2003) used meteorological parameters (e.g. temperature) to predict the beginning of the pollination season of *Ambrosia*. A statistically significant effect of temperature on the ragweed pollen count was reported by Barnes et al. (2001) in the USA. Stach (2002) found a statistically significant correlation between the pollen count of *Ambrosia* and *Poa-ceae* and the amount of precipitation. With respect to *Artemisia*, similar results were noted by Munuera Giner et al. (2002). In Szczecin, no statistically significant correlation was observed between the amount of precipitation and the ragweed and mugwort pollen count. An increase in the pollen count in the air with decreasing relative humidity has been reported by, among others, Stark et al. (1997) and Barnes et al. (2001).

Belmonte et al. (2000) demonstrated that the high *Ambrosia* pollen count in Catalan is a result of long-distance transport. Similar phenomena have been noted in many European cities (Jäger, 1991; Yankowa et al., 1996; Dahl et al., 1999; Laaidi and Laaidi, 1999; Peeters, 2000; Saar et al., 2000). In Szczecin, a positive, statistically significant correlation was found between the ragweed pollen count and the maximum wind speed in all of the seasons analysed. This fact suggests that the pollen observed in the air above Szczecin is the result of long-distance transport. The phenomenon of ragweed pollen grains and sporomorphs of other taxa being transported over very long distances has been described by, among others, Yankowa et al. (1996), Laaidi and Laaidi (1999), Peeters (2000), Saar et al. (2000) and Laaidi et al. (2003).

4.1. Conclusions

Between the pollen seasons of 2000 and those of 2003 the ragweed and mugwort pollen count in the air above Szczecin showed a slight tendency

to increase; however, this observation needs to be confirmed in long-term studies.

The increase in the ragweed pollen count in the air above Szczecin is probably a result of the expansiveness of the taxon, a settling of new areas and long-distance transport.

Statistically significant correlations were found between the ragweed pollen count in the air and the maximum wind speed, air temperature and relative air humidity and between the mugwort pollen count in the air and air temperature and relative air humidity.

No statistically significant correlation was found between the ragweed and mugwort pollen count and the level of precipitation.

A statistically significant correlation between the *Ambrosia* pollen counts and maximum wind speed may prove that long-distance transport may be an important source of pollen of that taxon in the air above Szczecin.

References

- Alcazar P. and Comtois P.: 1999, The influence of sampler height and orientation on airborne *Ambrosia* pollen counts in Montreal, *Grana* **39**, 303–307.
- Arobba D., Guido M.A., Minale P., Montanari C., Placereani S., Pracilio S., Troise C., Voltolini S. and Negrini A.C.: 2000, Airborne pollen in Genoa (NW-Italy): a comparison between two pollen-sampling stations, *Aerobiologia* **16**, 233–243.
- Barnes Ch., Pacheco F., Landuyt J., Hu F. and Portnoy J.: 2001, The effect of the temperature, relative humidity and rainfall on airborne ragweed pollen concentrations, *Aerobiologia* **17**, 61–68.
- Bass D.J.: 2000, Ragweed in Australia, *Aerobiologia* **16**, 107–111.
- Belmonte J., Vendrell M., Roure J.M., Vidal J. and Cadahia A.: 2000, Levels of *Ambrosia* pollen in the atmospheric spectra of Catalan aerobiological stations, *Aerobiologia* **16**, 93–99.
- Clot B.: 2003, Trends in airborne pollen: An overview of 21 years of data in Neuchâtel (Switzerland), *Aerobiologia* **19**, 227–234.
- Comtois P.: 1998, Statistical analysis of aerobiological data, in P. Mandrioli, P. Comtois and V. Levizzani (eds), *Methods in Aerobiology*. Pitagora Editrice Bologna: Bologna, pp. 217–258.
- Dahl A., Strandhede S.-O. and Wihl J.-A.: 1999, Ragweed – An allergy risk in Sweden?, *Allergologia* **15**, 293–297.
- D'Amato G. and Spieksma F.T.M.: 1990, Allergenic pollen in Europe, *Grana* **30**, 67–70.
- Durham O.C.: 1964, Proposed standard method of gravity sampling, *J. Allergy* **35**, 17–79.
- Emberlin J. and Norris-Hill J.: 1991, Spatial variation of pollen deposition in North London, *Grana* **30**, 190–195.
- Emberlin J., Savage M. and Woodman R.: 1993, Annual variations in the concentrations of *Betula* pollen in the London area, *Grana* **32**, 359–363.
- Grote M., Fischer S., Müller W.-D. and Valenta R.: 1998, In situ localization of a high molecular weight cross-reactive allergen in pollen and plant-derived food by immunogold-electron microscopy, *J. Allergy Clin. Immunol.* **101**, 250–257.
- Hirschwehr R., Heppner C., Spitzauer S., Speer W.R., Valent P., Berger U., Horak F., Jäger S., Kraft D. and Valenta R.: 1998, Identification of common allergenic structures in mugwort and ragweed, *J. Allergy Clin. Immunol.* **101**, 196–206.
- Hirst J.M.: 1952, An automatic volumetric spore trap, *Ann. Appl. Biol.* **39**, 257–265.
- Holzfuß E.: 1933, Die Farnpflanzen Pommerns, *Dohrniana* **12**, 19–33.
- Jäger S.: 1991, Allergenic significance of *Ambrosia* (Ragweed), in G. D'Amato, F.T.M. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell Scientific: London, pp. 125–127.
- Jäger S.: 2000, Ragweed (*Ambrosia*) sensitization rates correlate with the amount of inhaled airborne pollen. A 14-year study in Vienna, Austria, *Aerobiologia* **16**, 149–153.
- Jäger S., Litschauer R.: 1998, Ragweed (*Ambrosia*) in Austria, in *Ragweed in Europe: 6th Int Congr Aerobiol*, Perugia, Italy.
- Járai-Kamlódi M.: 2000, Some details about ragweed airborne pollen in Hungary, *Aerobiologia* **16**, 291–294.
- Katial R.K., Lin F.L., Stafford W.W., Ledoux R.A., Westley C.R. and Weber R.W.: 1997, Mugwort and sage (*Artemisia*) pollen cross-reactivity: ELISA inhibition and immunoblot evaluation, *Ann. Allergy Asthma Immunol.* **79**, 340–346.
- Laaidi K. and Laaidi M.: 1999, Airborne pollen of *Ambrosia* in Burgundy (France) 1996–1997, *Aerobiologia* **15**, 65–69.
- Laaidi M., Thibaudon M. and Besancenot J.-P.: 2003, Two statistical approaches to forecasting the start and duration of the pollen season of *Ambrosia* in the area of Lyon (France), *Int. J. Biometeorol.* **48**, 65–73.
- Levizzani V., Georgiadis T. and Isard S.: 1998, Meteorological aspect of the aerobiological pathway, in P. Mandrioli, P. Comtois and V. Levizzani (eds), *Methods in Aerobiology*. Pitagora Editrice Bologna: Bologna, pp. 113–185.
- Mandrioli P., Cecco M. and Andina G.: 1998a, Ragweed pollen: The aeroallergen is spreading in Italy, *Aerobiologia* **14**, 13–20.
- Mandrioli P., Comtois P., Dominguez Vilches E., Galan Soldevilla C., Isard S. and Syzdek L.: 1998b, Sampling: principles and techniques, in P. Mandrioli, P. Comtois and V. Levizzani (eds), *Methods in Aerobiology*. Pitagora Editrice Bologna: Bologna, pp. 47–112.
- Munuera Giner M., Garcia J.S.C. and Camacho C.N.: 2002, Seasonal fluctuations of the airborne pollen spectrum in Murcia (SE Spain), *Aerobiologia* **18**, 141–151.
- Myszkowska D., Stępalska D., Obtułowicz K. and Porębski G.: 2002, The relationship between airborne pollen and fungal spore concentrations and seasonal pollen Allergy symptoms in Cracow in 1997–1999, *Aerobiologia* **18**, 153–161.
- Peeters A.G.: 2000, *Ambrosia* sp. Pollen in Switzerland, *Aerobiologia* **16**, 295–297.
- Peternel R., Srncic L., Čulig F., Zaninović K., Mitić B. and Vukušić I.: 2004, Atmospheric pollen season in Zagreb

- (Croatia) and its relationship with temperature and precipitation, *Int. J. Biometeorol.* **48**, 186–191.
- Rapiejko P.: 1997, Wykorzystanie monitoringu zawartości pyłku roślin w atmosferze w medycynie, in *Materiały z Konferencji Naukowej: Biologia Kwitnienia, Nektarowania I Zapyłania Roślin*. Lubelskie Towarzystwo Naukowe, 13–14.11.
- Rich T.C.G.: 1994, Ragweeds (*Ambrosia* L.) in Britain, *Grana* **33**, 38–43.
- Rybniček O., Novotná B., Rybnièkova E. and Rybniček K.: 2000, Ragweed in the Czech Republic, *Aerobiologia* **16**, 287–290.
- Saar M., Gudžinskas Z., Ploompuu T., Linno E., Minkienė Z. and Motiekaitytė V.: 2000, Ragweed plants and airborne pollen in the Baltic states, *Aerobiologia* **16**, 101–106.
- Singh A.B., Pandit T. and Dahiya P.: 2003, Changes in airborne pollen concentrations in Delhi, India, *Grana* **42**, 188–177.
- Spieksma F.T.M.: 1986, Airborne pollens concentrations in Leiden, The Netherlands, 1977–1981. III. Herbs and weeds flowering in the summer, *Grana* **25**, 47–54.
- Spieksma F.T.M.: 1991, Regional European pollen calendars, in G. D'Amato, F.T.M. Spieksma and S. Bonini (eds), *Allergenic Pollen and Pollinosis in Europe*. Blackwell Scientific: London, pp. 49–65.
- Spieksma F.T.M., Noort P. and Nikkels H.: 2000, Influence of nearby stands of *Artemisia* on street-level versus roof-top-level ratio's of airborne pollen quantities, *Aerobiologia* **16**, 21–24.
- Stach A.: 2002, Pyłek roślin w aeroplanktonie Poznania w latach 1994–1997 ze szczególnym uwzględnieniem pyłku roślin taksonów alergogennych. PhD thesis, Uniwersytet Jagielloński, Cracow, Poland.
- Stark P.C., Ryan L.M., McDonald J.L. and Burge H.A.: 1997, Using meteorological data to predict daily ragweed pollen levels, *Aerobiologia* **13**, 177–184.
- Tacik T.: 1971, Rośliny naczyniowe Polski I Ziemi Ościennych, *Flora Polska, PWN* **12**, 222–225.
- Tutin T.G., Heywood V.H., Burges N.A., Moore D.M., Valentine D.H., Walters S.M. and Webb D.A.: 1976, *Flora Europea*, Cambridge University Press: Cambridge 142–143.
- Voltolini S., Minale P., Troise C., Bignardi D., Modena P., Arobba D. and Negrini A.C.: 2000, Trend of herbaceous pollen diffusion and allergic sensitisation in Genoa, Italy, *Aerobiologia* **16**, 245–249.
- Wallenstein B. and Kersten W.: 1985, Die Bedeutung einzelner Wildkräuterpollen bei der Pollinosis, *Allergologie* **8**, 251–253.
- Yankowa R., Baltadjieva D., Peneva R. and Zlatev V.: 1996, Pollen grains of *Ambrosia* in the air of Sofia, Bulgaria, *Aerobiologia* **12**, 273–277.