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Searching for a trace of *Artemisia campestris* pollen in the air

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Abstract

The aim of the study was to determinate whether *Artemisia campestris* was present in the vicinity of 8 pollen monitoring stations in Poland by examining temporal variations in daily average airborne *Artemisia* pollen data recorded by Hirst type volumetric traps. Three day moving averages of airborne *Artemisia* pollen were examined by Spearman's rank correlation test. Results show that *Artemisia* pollen seasons in Poland generally display similar unimodal patterns (correlation coefficients $r > 0.900$; $P < 0.05$). The only exception was the *Artemisia* pollen concentration noted in the outskirts of Poznań (Morasko), where the bimodal pattern was revealed. Correlations between *Artemisia* pollen data recorded at Poznań-Morasko and the other Polish sites were the lowest in the investigated dataset; this was particularly noticeable in the second part of pollen season (r ~0.730). We show that the typical bimodal pattern in *Artemisia* pollen seasons, which is characteristic of the presence of both *A. vulgaris* (first peak) and *A. campestris* (second peak), does not occur at the majority of sites in Poland and is restricted to the outskirts of Poznań. In fact, it was noted that the pollen monitoring site in Poznań-Centre, just 8 km from Morasko, only exhibited one peak (attributed to *A. vulgaris*). This shows that the influence of *A. campestris* on airborne pollen season curves is limited and can be largely disregarded. In addition, this study supports previous records showing that the spatial distribution of airborne *Artemisia* pollen within a city (urban-rural gradient) can vary markedly, depending on the species composition.

Keywords: mugwort; aerobiology; phenology; biogeography; bimodal distribution; land use; allergy

Introduction

Artemisia pollen allergens are an important cause of allergy in Europe [1,2]. Several species of *Artemisia* grow in Poland, particularly *A. vulgaris*, *A. campestris*, *A. absinthium*, *A. annua*, and *A. austriaca* [3,4]. *Artemisia vulgaris*, the most common species, is considered to be the main source of airborne pollen [3,5]. It is a ruderal plant, with a rate of occurrence exceeding 60% in ruderal habitats (Motiekaitytė 2002, in Kazlauskas et al. [6]). As a consequence, airborne *Artemisia* pollen seasons in Central Europe usually exhibit a unimodal shape, with only one main peak during the season [7–9]. However, a second peak in airborne concentrations of *Artemisia* pollen has been observed in the middle of September in southeastern parts of Europe [10]. This second peak could occur frequently at some sites and is responsible for more than 30% of airborne *Artemisia* pollen recorded during the year.

This second peak is often attributed to the pollen release in *A. scoparia* and *A. maritima* that flower in autumn. These two taxa also grow in southern Poland, but their occurrence is only sporadically reflected in the curve of airborne pollen

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seasons. Late peaks in *Artemisia* pollen season have only been observed intermittently in Polish cities, like Rzeszów and Kraków, and the intensity of such late peaks are much lower than observed in Southern Europe. On the other hand, the influence of another *Artemisia* species on the airborne pollen curve has recently been observed in Poznań (western Poland) [3]. Combinations of aerobiological, phenological and pollen production data revealed that the majority of airborne *Artemisia* pollen grains recorded in the second part of August are released by *A. campestris*. This species mainly occurs in semi-arid climates and prefers dry, sandy, open areas such as roadsides, woodland openings, old fields, wastelands, sand and gravel soils [3,11]. In such habitats, *A. campestris* frequently creates a thick and wide conglomeration in vegetation patches. A single plant can produce as much as 65.3 × 106 pollen grains [3]. As a result, a distinct increase in airborne *Artemisia* pollen concentrations was observed at the pollen monitoring station located in the outskirts of Poznań (Morasko) during second fortnight of August. In this semi-rural area, *Artemisia* pollen curves have a bimodal shape with two peaks recorded in August.

Artemisia campestris is a common species in Poland, occurring almost in the whole country [4], however its abundance has not been precisely established. Based on previous observations carried out in Poznań [3], which revealed that *A. campestris* was almost as common as *A. vulgaris*, and its pollen contributed markedly (30%) to total *Artemisia* pollen sum, it is expected that high densities of *A. campestris* will also impact on the curve of *Artemisia* pollen seasons in other cities. Airborne pollen counts may serve as a good bio-indicator of the flora composition and diversity providing important information about its distribution and abundance [12–14]. Based on the pollen trace in aerobiological data it should be possible to determinate whether certain plant species occur in a particular area. The aim of this study was, therefore, to investigate whether *A. campestris* was present in the vicinity of 8 pollen monitoring stations in Poland by examining temporal variations in daily average airborne *Artemisia* pollen data.

Material and methods

Aerobiological analysis

Daily average airborne *Artemisia* pollen data were collected at nine pollen monitoring sites located in Poland (two in Poznań), by volumetric pollen traps of the Hirst design [15] situated at roof level (Tab. 1). Detailed characteristics of pollen monitoring stations are presented in Tab. 1. Slides were counted following the methods described in literature, i.e., by four horizontal lines (in Poznań, Kraków, Sosnowiec, Wrocław, Lublin, Łódź and Szczecin) or 12 longitudinal transects (in Rzeszów) [16,17]. These two counting methods have been shown to produce comparable results [18]. Daily average (00:00–24:00 h) airborne *Artemisia* pollen counts were converted into concentrations (grains/m^3).

Statistical analysis

The averaged *Artemisia* pollen curves were prepared according the method described in Bogawski et al. [3]. In short,

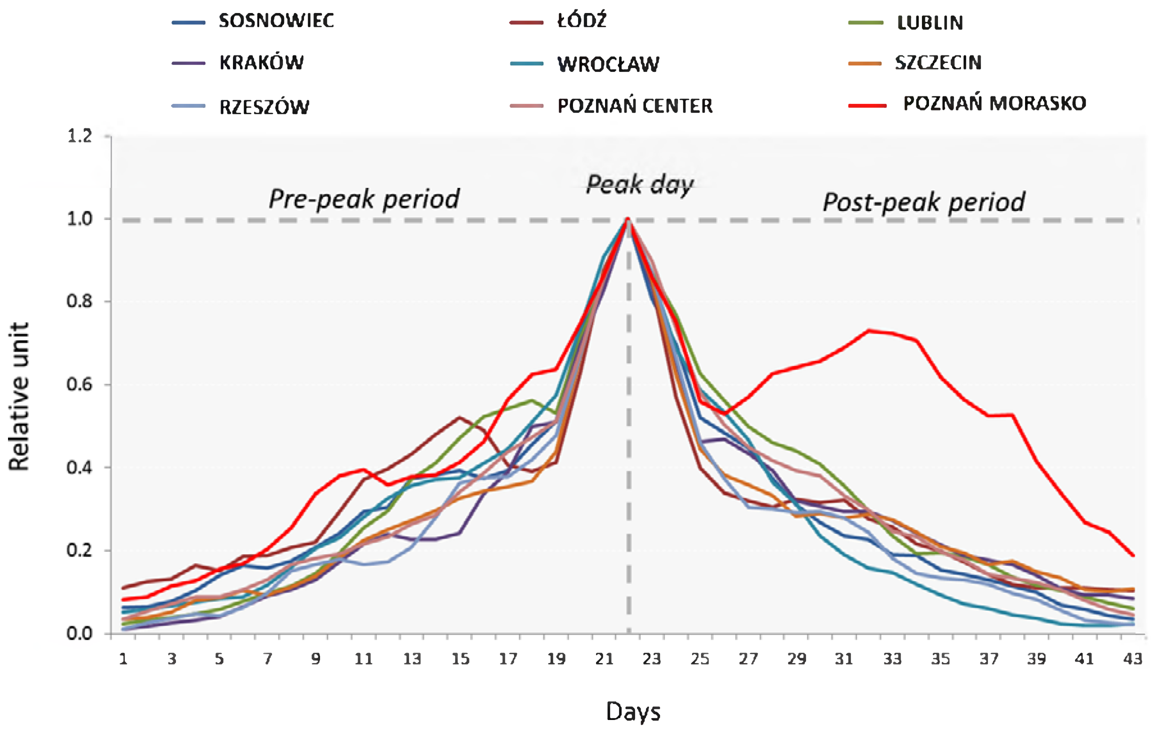
Tab. 1 Information about the nine pollen-monitoring stations used in this study.

Site name	Coordinates	Length of pollen data base	Elevation above ground level (m)	Surroundings of pollen monitoring station
Szczecin	53°26′ N, 14°33′ E	2000–2014	21	Small buildings, tenements, and blocks of flats surrounded by green areas with deciduous trees, and parks
Poznań-Centre	52°24′ N, 16°53′ E	1996–2014	33	The 4–8 storey buildings (tenements, university buildings, hospital), main streets with small proportion of parks
Poznań-Morasko	52°46′ N, 16°93′ E	2005–2014	18	Open semi-rural area with small building, new housing estates, mixture of green grassland, small crop producing fields and coniferous woodland
Łódź	51°47′ N, 19°28′ E	2003–2014	15	City centre with relatively high density housings, the closest park located 200 m away with native an ornamental tree species
Sosnowiec	50°17′ N, 19°08′ E	1997–2014	20	University buildings, in close vicinity there are small green areas and large allotments (community gardens) with ornamental and fruit trees
Lublin	51°14′ N, 22°32′ E	2001–2014	18	Centre of the city, university buildings and small blocks of flats, in close vicinity there is large cemetery and one large park
Wrocław	51°06′ N, 17°01′ E	2003–2014	20	Dense urban area with small proportion of green areas and tree alleys, in the vicinity of Odra River
Kraków	50°04′ N, 19°59′ E	1992–2014	20	The area of Botanic Garden surrounded by high density housing, blocks of tenements, the Old Market Square with greenbelts and small parks
Rzeszów	50°01′ N, 22°02′ E	1997–2013	12	University buildings in the city centre, surrounded by small buildings, busy roads and small patches of grass and synanthropic vegetation

3-day moving averages of daily average airborne *Artemisia* pollen data were calculated for every pollen season. These pollen curves were normalized by attributing a value of 1 to the peak day that occurred before 15th of August (flowering of *A. vulgaris*). If the peak day occurred after 15th of August, i.e., the period when *A. campestris* starts flowering [3], the second day with the highest pollen concentration (before 15th of August) has been chosen as a peak day. This happened 4 times: in Poznań (Morasko campus on the outskirts of the city) in 2006 and 2014, and in Rzeszów in 2005 and 2006. This manipulation has been applied so that the peak day attributed to *A. vulgaris* (which mainly flowers until the middle of August) can be calculated separately from the peak day of *A. campestris*. Next, the pollen season curves were set together and centred to selected peak day. The general mean pollen season curve has been calculated for every station. Spearman's correlation coefficient was used to analyze the relationships between *Artemisia* pollen seasons curved recorded at different cities. To avoid days with very low pollen concentrations, the length of pollen data sets were limited to 43 days with the highest pollen levels, i.e., three weeks before peak day (pre-peak period, 21 days) and three weeks after peak days (post-peak period, 21 days). Following pollen data sets have been compared: (***i***) whole data sets (43 days); (***ii***) pre-peak and post-peak periods (both $n = 21$ days). The statistical significance of differences between correlation coefficients has been tested using website software Statistics Calculators version 3.0 (http://www.danielsoper.com/statcalc3). In addition the peak records during 2005–2014 have been compared between pollen monitoring sites. This time period has been chosen as this is a common period for all investigated station (except Rzeszów, 2005–2013).

Results

Averaged curves of airborne *Artemisia* pollen seasons had very similar unimodal and symmetrical pattern in most cities. The only exception was the aerobiological station in Poznań-Morasko (Fig. 1). In most cases, the Spearman correlation coefficients between pollen season curves at all investigated cities exceeded $r = 0.900$ ($P < 0.05$; Tab. 2). Whereas the pollen season curve in Poznań-Morasko had a bimodal shape and calculated correlation coefficients



PEAK [P/m³]	Lublin	Wrocław	Poznań Morasko	Poznań Center	Szczecin	Łódź	Sosnowiec	Kraków	Rzeszów
MEAN	105.9	90.2	89.7	69.5	58.8	51.4	49.0	48.2	44.4
MAX	145.8 (2009)	185.7 (2008)	135.3 (2009)	158.7 (2009)	148.3 (2011)	91.7 (2011)	87.0 (2006)	106.3 (2009)	100.4 (2013)
MIN	61.0 (2006)	33.7 (2014)	29.0 (2006)	26.7 (2008)	19.7 (2006)	17.7 (2010)	16.0 (2010)	24.8 (2014)	13.4 (2005)

Fig. 1 Comparison of *Artemisia* pollen season curves recorded at nine pollen monitoring stations in Poland. The table below the figure shows the real values of *Artemisia* pollen level at peak days recorded during the decade 2005–2014, i.e., the common period for all stations (except Rzeszów, 2005–2013).

Tab. 2 Spearman correlation coefficient between *Artemisia* pollen seasons recorded at nine pollen monitoring stations in Poland (all correlations are statistically significant, $P < 0.05$).

Location	Poznań-Morasko	Poznań-Centre	Szczecin	Łódź	Sosnowiec	Lublin	Wrocław	Kraków
Whole pollen season								
Poznań-Centre	→ 0.841		0.979*	0.907	0.963*	0.985*	0.943*	0.980*
Szczecin	→ 0.848	0.979*		0.879	0.931	0.990*	0.902	0.986*
Łódź	→ 0.644	0.907*	0.879*		0.962*	0.912*	0.959*	0.846*
Sosnowiec	→ 0.695	0.963*	0.931*	0.962*		0.954*	0.990*	0.907*
Lublin	→ 0.812	0.985*	0.990*	0.912	0.954*		0.929*	0.977*
Wrocław	→ 0.645	0.943*	0.902*	0.959*	0.990*	0.929*		0.879*
Kraków	→ 0.892	0.980*	0.986*	0.846	0.907	0.977*	0.879	
Rzeszów	→ 0.798	0.989*	0.970*	0.932*	0.970*	0.980*	0.956*	0.959*
Pre-peak period								
Poznań-Centre	→ 0.986		0.999*	0.934*	0.988	0.996	1.000*	0.996
Szczecin	→ 0.984	0.999*		0.932*	0.990	0.995	0.999*	0.995
Łódź	→ 0.905	0.934	0.932		0.936	0.929	0.934	0.925
Sosnowiec	→ 0.970	0.988	0.990	0.936		0.983	0.988	0.982
Lublin	→ 0.982	0.996*	0.995	0.929*	0.983		0.996*	0.992
Wrocław	→ 0.986	1.000*	0.999*	0.934*	0.988	0.996		0.996
Kraków	→ 0.981	0.996*	0.995*	0.925*	0.982	0.992	0.996*	
Rzeszów	→ 0.984	0.995	0.994	0.930*	0.983	0.991	0.995	0.988
Post-peak period								
Poznań-Centre	→ 0.729		0.988*	0.978*	1.000*	0.999*	0.996*	0.999*
Szczecin	→ 0.738	0.988*		0.955*	0.988*	0.987*	0.992*	0.987*
Łódź	→ 0.743	0.978*	0.955*		0.978*	0.977*	0.971*	0.977*
Sosnowiec	→ 0.729	1.000*	0.988*	0.978*		0.999*	0.996*	0.999*
Lublin	→ 0.722	0.999*	0.987*	0.977*	0.999*		0.995*	0.997*
Wrocław	→ 0.725	0.996*	0.992*	0.971*	0.996*	0.995*		0.995*
Kraków	→ 0.727	0.999*	0.987*	0.977*	0.999*	0.997*	0.995*	
Rzeszów	→ 0.730	0.999*	0.991*	0.974*	0.999*	0.997*	0.995*	0.997*

The statistical significance of differences between correlation coefficients calculated for Poznań-Morasko and other sites has been marked (* $P < 0.05$). Note: only correlation coefficients in rows have been compared with each other (indicated by "→").

were much lower and, in most cases, differences between coefficients were statistically significant ($r = 0.644–0.892$; $P > 0.05$). Interestingly, the Spearman correlation coefficient between *Artemisia* pollen levels recorded at two monitoring stations in Poznań was significantly lower ($r = 0.841$) than between pollen concentrations at Poznań-Centre and other cities (r ~0.950, $P > 0.05$; except Łódź $P = 0.907$). In the pre-peak period, the correlation coefficients between *Artemisia* pollen levels at all sites (including Poznań-Morasko) were exceeded $r > 0.930$. In contrast, when the post-peak period was considered, the correlation coefficient between pollen season curves at Poznań-Morasko and other investigated sites dropped to $r = 0.720–0.730$ (the difference between correlation coefficients were statistically significant, $P < 0.05$).

The highest daily maximum *Artemisia* pollen concentrations were recorded in Lublin, Wrocław and Poznań-Morasko (3-day moving averages of daily average airborne *Artemisia* pollen exceeded 105.9 Pm^{-3}, 90.2 Pm^{-3}, and 89.7 Pm^{-3}, respectively; Fig. 1). In Poznań-Centre monitoring station the peak value was slightly lower than in Poznań-Morasko. The lowest daily *Artemisia* pollen concentrations were observed in Sosnowiec, Kraków and Rzeszów (>50 Pm^{-3}).

Discussion

Bogawski et al. [3] found that the bimodal curve of the *Artemisia* pollen season recorded in Poznań-Morasko was related to the flowering of two *Artemisia* species, i.e., *A. vulgaris* (first peak) and *A. campestris* (second peak). Our study shows that such patterns in *Artemisia* pollen seasons are not widely observed in other sites in Poland. Indeed, the airborne *Artemisia* pollen season recorded in the centre of Poznań, which was located just 8 km from Poznań-Morasko, only exhibited one peak and was similar to *Artemisia* pollen seasons recorded at the other sites included in the study.

Pollen monitoring stations are often located in city centres, and it is assumed that one station is usually enough to express the aerobiological situation in whole city area [19]. Several studies that compared the aerobiological situations in two sites within the same city revealed that, in general, inter-site variation in the most common pollen types was not high. The highest differences were observed in relation to herbaceous [20] and/or ornamental plants [19,21,22]. The latter are usually planted in parks, squares, gardens, and along streets, and are not observed in large number outside of urban areas. The urbanophilous and thermophilous plants, with a distribution restricted mainly to city centres [23], often show similar aerobiological patterns.

Conversely, pollen grains of urbanophobic species (plants unable to live in urban areas) might be underrepresented in the city centre. *A. campestris* prefers open areas (roadsides, old fields, wastelands) and as such could be considered as an urbanophobes. In Poznań, *A. campestris* grows mainly in the semi-rural areas and its very rare in the city centre (Paweł Bogawski, personal observation, 2014). This may explain why the second peak in daily average airborne *Artemisia* pollen concentrations was not observed in Poznań city centre. Similarly, the unimodal pollen season pattern recorded in the other monitoring stations also suggests that airborne *Artemisia* pollen grains are primarily released by *A. vulgaris* (the most common species in Poland) and the contributions of *A. campestris* is limited.

In this context, it is worth noting that although *Artemisia* species belong to anemophilous plants, their pollen grains are not as well adopted to wind transport as other pollen grains that are smaller and lighter (e.g., *Betula* or *Ambrosia*) [24–28]. Spieksma et al. [29] showed that the presence of nearby stands of *Artemisia* (within 100 m) had a very strong influence on the amount of pollen recorded by the trap. In such localities, the level of *Artemisia* pollen at ground level might be more than 5 times higher than at roof level. Local sources of *Artemisia*, therefore, strongly modify pollen season curves and the effect of remote sources can be largely disregarded. This indicates that the spatial and temporal distribution of airborne *Artemisia* pollen grains within the city may vary markedly, depending on the floral vegetation composition. It should be stressed that different *Artemisia* species have different ecological and phenological features [3,12,30] as well as produce different amounts of pollen [3]. That, in turn, may have an important impact on people suffering from *Artemisia* pollen allergy, as there is a risk that they could be exposed to different levels of allergenic pollen in different city districts.

Conclusion

Artemisia pollen seasons recorded in urban areas in Poland exhibited only one single peak, which was attributed to the flowering of *A. vulgaris*. The importance of *A. campestris* pollen was only reflected in one semi-rural location in Poznań, where the airborne *Artemisia* pollen season had a bimodal pattern. Spatial variations in land use strongly influence species composition, which in turn affects the distribution of pollen in the air. In the case of *Artemisia*, which produces high numbers of pollen but is poorly adapted to wind transport, local differences in pollen exposure might be very high. This specific nature of *Artemisia* pollen should be considered in allergy prophylaxis.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: study idea: ŁG, EWC, MP, IK, DM; pollen data analysis and preparation: ŁG, KB, ŁK, MP, IK, DM, KC, BMW, MM, MN, KPW, MSt, ZB, ASz, ASu, EWC; writing the manuscript: ŁG, MSm; all authors contributed in the final preparation of the manuscript.

Competing interests

The following declarations about authors' competing interests have been made: EWC is a honorary editor of the *Acta Agrobotanica*; AS is a secretary of the *Acta Agrobotanica*; other authors: no competing interests.

References

1. Burbach GJ, Heinzerling LM, Edenharter G, Bachert C, Bindslev-Jensen C, Bonini S, et al. GA2LEN skin test study II: clinical relevance of inhalant allergen sensitizations in Europe. Allergy. 2009;64:1507–1515. http://dx.doi.org/10.1111/j.1398-9995.2009.02089.x
2. Asero R, Bellotto E, Ghiani A, Aina R, Villalta D, Citterio S. Concomitant sensitization to ragweed and mugwort pollen: who is who in clinical allergy? Ann Allergy Asthma Immunol. 2014;113:307–313. http://dx.doi.org/10.1016/j.anai.2014.06.009
3. Bogawski P, Grewling Ł, Frątczak A. Flowering phenology and potential pollen emission of three *Artemisia* species in relation to airborne pollen data in Poznań (western Poland). Aerobiologia. 2015. http://dx.doi.org/10.1007/s10453-015-9397-z
4. Zając A, Zając M, editors. Distribution atlas of vascular plants in Poland. Kraków: Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University; 2001.
5. Wolf F, Puls KE, Bergmann KC. A mathematical model for mugwort (*Artemisia vulgaris* L.) pollen forecasts. Aerobiologia. 1998;14:359–373. http://dx.doi.org/10.1007/BF02694305
6. Kazlauskas M, Šauliene I, Lankauskas A. Airborne *Artemisia* pollen in Diauliai (Lithuania) atmosphere with reference to meteorological factors during 2003–2005. Acta Biol Univ Daugavp. 2006;6:13–24.
7. Stach A, García-Mozo H, Prieto-Baena JC, Czarnecka-Operacz M, Jenerowicz D, Silny W, et al. Prevalence of *Artemisia* species pollinosis in western Poland: impact of climate change on aerobiological trends, 1995–2004. J Investig Allergol Clin Immunol. 2007;17(1):39–47.
8. Malkiewicz M, Klaczak K, Drzeniecka-Osiadacz A, Krynicka J, Migała K. Types of *Artemisia* pollen season depending on the weather conditions in Wrocław (Poland), 2002–2011. Aerobiologia. 2014;30:13–23. http://dx.doi.org/10.1007/s10453-013-9304-4

9. Piotrowska-Weryszko K. *Artemisia* pollen in the air of Lublin, Poland (2001–2012). Acta Sci Pol Hortorum Cultus. 2013;12:155–168.
10. Grewling Ł, Šikoparija B, Skjøth CA, Radisic P, Apatini D, Magyar D, et al. Variation in *Artemisia* pollen seasons in Central and Eastern Europe. Agric For Meteorol. 2012;160:48–59. http://dx.doi.org/10.1016/j.agrformet.2012.02.013
11. Gucker CL. Fire Effects Information System (FEIS) [Internet]. *Artemisia campestris*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer); 2007 [cited 2015 Dec 31]; Available from: http://www.fs.fed.us/database/feis/plants/forb/artabs/all.html
12. Carinanos P, Diaz de la Guardia C, Algarra JA, de Linares C, Irurita JM. The pollen counts as bioindicator of meteorological trends and tool for assessing the status of endangered species: the case of *Artemisia* in Sierra Nevada (Spain). Clim Change. 2013;119:799–813. http://dx.doi.org/10.1007/s10584-013-0751-2
13. Fernandez-Llamazares A, Belmonte J, Boada M, Fraixedas S. Airborne pollen records and their potential applications to the conservation of biodiversity. Aerobiologia. 2014;30(2):111–122. http://dx.doi.org/10.1007/s10453-013-9320-4
14. Karrer G, Skjøth CA, Sikoparija B, Smith B, Berger U, Essl F. Ragweed (*Ambrosia*) pollen source inventory for Austria. Sci Total Environ. 2015;523:120–128. http://dx.doi.org/10.1016/j.scitotenv.2015.03.108
15. Hirst JM. An automatic volumetric spore trap. Ann Appl Biol. 1952;39:257–265. http://dx.doi.org/10.1111/j.1744-7348.1952.tb00904.x
16. Mandrioli P, Comtois P, Levizzani V. Methods in aerobiology. Bologna: Pitagora Editrice; 1998.
17. Galán C, Cariñanos P, Alcázar P, Dominguez-Vilches E. Spanish aerobiology network (REA) management and quality manual. Córdoba: Servicio de Publicaciones Universidad de Córdoba; 2007.
18. Cariñanos P, Emberlin E, Galán C, Dominguez-Vilches E. Comparison of two counting methods of slides from a hirst type volumetric trap. Aerobiologia. 2000;16:339–346. http://dx.doi.org/10.1023/A:1026577406912
19. Velasco-Jimenez MJ, Alcazar P, Dominguez Vilches E, Galan C. Comparative study of airborne pollen counts located in different areas of the city of Cordoba (south-western Spain). Aerobiologia. 2013;29:113–120. http://dx.doi.org/10.1007/s10453-012-9267-x
20. Rodríguez-Rajo FJ, Fdez-Sevilla D, Stach A, Jato V. Assessment between pollen seasons in areas with different urbanization level related to local vegetation sources and differences in allergen exposure. Aerobiologia. 2010;26:1–14. http://dx.doi.org/10.1007/s10453-009-9138-2
21. Nowak M, Szymańska A, Grewling Ł. Allergic risk zones of plane tree pollen (*Platanus* sp.) in Poznań. Post Dermatol Alergol. 2012;29:156–160.
22. Gonzalo-Garijo A, Tormo-Molina R, Munoz-Rodriguez A, Silva-Palacios I. Differences in the spatial distribution of airborne pollen concentrations at different urban locations within a city. J Investig Allergol Clin Immunol. 2006;16:37–43.
23. Bomanowska A, Witosławski P. Selected aspects of diversity of synanthropic flora in the chosen cities of central Poland. Biodiv Res Conserv. 2008;9–10:35–42.
24. Skjøth CA, Smith M, Brandt J, Emberlin J. Are the birch trees in southern England a source of *Betula* pollen for north London? Int J Biometeorol. 2009;53:75–86. http://dx.doi.org/10.1007/s00484-008-0192-1
25. Siljamo P, Sofiev M, Filatova E, Grewling Ł, Jager S, Khoreva J, et al. A numerical model of birch pollen emission and dispersion in the atmosphere. Model evaluation and sensitivity analysis. Int J Biometeorol. 2013;57:125–136. http://dx.doi.org/10.1007/s00484-012-0539-5
26. Šikoparija B, Skjøth CA, Alm Kübler K, Dahl A, Sommer J, Grewling Ł, Radisic P, Smith M. A mechanism for long distance transport of ambrosia pollen from the Pannonian Plain. Agric For Meteorol. 2013;180:112–117.
27. Kasprzyk I, Myszkowska D, Grewling Ł, Stach A, Šikoparija B, Skjøth CA, et al. The occurrence of ambrosia pollen in Rzeszów, Kraków and Poznań, Poland: investigation of trends and possible transport of *Ambrosia* pollen from Ukraine. Int J Biometeorol. 2011;55:633–644. http://dx.doi.org/10.1007/s00484-010-0376-3
28. Smith M, Skjøth CA, Myszkowska D, Uruska A, Puc M, Stach A, et al. Long-range transport of *Ambrosia* pollen to Poland. Agric For Meteorol. 2008;148:1402–1411. http://dx.doi.org/10.1016/j.agrformet.2008.04.005
29. Spieksma FT, van Noort P, Nikkels AH. Influence of nearby stands of *Artemisia* on street-level versus roof-top-level ratio's of airborne pollen quantities. Aerobiologia. 2000;16:21–24. http://dx.doi.org/10.1023/A:1007618017071
30. Munuera Giner M, Carrión García JS, García Sellés J. Aerobiology of *Artemisia* airborne pollen in Murcia (SE Spain) and its relationship with weather variables: annual and intradiurnal variations for three different species. Wind vectors as a tool in determining pollen origin. Int J Biometeorol. 1999;43:51–63. http://dx.doi.org/10.1007/s004840050116

Poszukiwanie śladów ziaren pyłku *Artemisia campestris* w powietrzu

Streszczenie

Celem pracy było stwierdzenie, czy bylica polna (*Artemisia campestris*) występuje w pobliżu 8 stacji monitoringu aerobiologicznego w Polsce, poprzez prześledzenie czasowej zmienności dobowych wartości stężenia ziaren pyłku *Artemisia* zarejestrowanych za pomocą aparatów wolumetrycznych typu Hirst. Trzydniowe średnie ruchome średnich wartości stężenia ziaren pyłku bylicy w poszczególnych miastach zostały porównane ze sobą za pomocą testu korelacji rang Spearmana. Wyniki wykazały, że sezony pyłkowe bylicy w Polsce mają generalnie podobny jednomodalny przebieg (współczynnik korelacji $> r = 0.900$; $P < 0.05$). Jedynym wyjątkiem była stacja monitoringu aerobiologicznego zlokalizowana na przedmieściach Poznania (Morasko), gdzie sezon pyłkowy *Artemisia* miał dwumodalny przebieg. Współczynniki korelacji pomiędzy stężeniem ziaren pyłku bylicy odnotowanym na Morasku a innymi miastami w Polsce były najniższe w analizowanej bazie; było to szczególnie widoczne w drugiej części sezonu pyłkowego (r ~0.730). Wykazaliśmy, że typowy dwumodalny przebieg sezonu pyłkowego bylicy, który związany jest z obecnością ziaren pyłku bylicy pospolitej, *A. vulgaris* (pierwszy szczyt pylenia) i bylicy polnej, *A. campestris* (drugi szczyt pylenia), nie występuje w większości badanych stanowisk miejskich i jest ograniczony jedynie do terenów podmiejskich Poznania. Co ciekawe, sezon pyłkowy bylicy w centrum Poznania, oddalonego jedynie 8 km od stacji pomiarowej Morasko, charakteryzuje się tylko jednym szczytem pylenia (przypisanym *A. vulgaris*). Wyniki te pokazują, że wpływ ziaren pyłku bylicy polnej na przebieg sezonu pyłkowego rodzaju *Artemisia* na obszarach miejskich jest bardzo ograniczony. Badania te, wspierają wcześniejsze prace, wykazujące, że przestrzenny rozkład stężenia ziaren pyłku bylicy w mieście (na osi centrum miasta – tereny podmiejskie) waha się znacząco w zależności od występujących tam gatunków z rodzaju *Artemisia*.