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Artemisia POLLEN IN THE AIR OF LUBLIN, POLAND (2001–2012)

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Abstract. The most frequent *Artemisia* species found in Poland are ruderal plants and garden or field weeds. Some species can be grown as ornamental, medicinal, or spice plants. Pollen grains of *Artemisia* contain strong allergens and cause allergic reactions during the late summer period. The aim of the study was to analyse the *Artemisia* pollen seasons in Lublin, to determine the effects of meteorological conditions on the occurrence of pollen grains of this taxon in the air and to develop statistical predictive models. The present study investigated *Artemisia* pollen concentrations in the air of Lublin in the period 2001–2012. Aerobiological monitoring was conducted by the standard volumetric method using a Hirst-type sampler (Lanzoni VPPS 2000). The method is currently recommended by the International Association for Aerobiology. The atmospheric *Artemisia* pollen season lasted on average from the second 10-day period of July to the middle of September. The highest pollen concentrations usually occurred in the first ten-day period of August. The season start date was characterized by the lowest variation, while the daily maximum pollen concentration values showed the highest variation. Forecasting models for the pollen season start date and duration as well as for the seasonal pollen index were developed using regression analysis. The obtained forecast models largely explain the variation of the season parameters. Regression analysis can be successfully used to predict the *Artemisia* pollen season features on the basis of meteorological data.

Key words: pollen monitoring, mugwort, meteorological factors, regression analysis, forecast models

INTRODUCTION

Nine *Artemisia* species have been found to occur within the Lublin region area: *A. vulgaris* L., *A. absinthium* L., *A. abrotanum* L., *A. austriaca* Jacq., *A. annua* L., *A. verlotiorum* Lamotte, *A. dracunculus* L., *A. campestris* L. and *A. scoparia* W. et K. [Fijałkowski 1994]. *Artemisia vulgaris*, which is a pioneer plant that inhabits new areas, construction sites, and railway embankments, is most frequently encountered. It also

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grows quite often in wastelands, fields and field margins as well as on roadsides. This species occurs in abundance across Poland. A larger number of locations of *A. annua, A. austriaca* and *A. scoparia* have been found in the Lublin region compared to other regions of the country [Zając and Zając 2001].

Mugwort is grown as a spice plant (*A. dracunculus, A. abrotanum*) or an ornamental plant (e.g. *A. lactiflora* Wall. ex DC.*, A. ludoviciana* Nutt.*, A. schmiditiana* Maxim.*, A. stellerana* Bess.*, A. pontica* L.). Low species are planted in rock gardens, while higher ones in perennial borders. The silver and white leaves are the main ornament of mugworts [Marcinkowski 1991]. Due to their properties, many species are used in herbal medicine. Raw materials obtained from wild growing *A. absinthium* and *A. vulgaris* as well as from *A. dracunculus* and *A. abrotanum* cultivated in plantations are used in Poland [Strzelecka and Kowalski 2000]. *Artemisia* flowers are often visited by bees which form light coloured pollen loads when collecting pollen [Warakomska and Muszyńska 1997]. It was calculated that one flower of *A. vulgaris* could produce 49.250 pollen grains [Piotrowska 2008]. In a study of food sources for bees in suburban conditions of the city of Puławy, *Artemisia* was found to be one of the major polleniferous plants. The frequency of mugwort pollen in bee pollen loads reached 85% [Warakomska 1999].

Pollen grains of this plant contain allergens that are important reason of allergy in central and eastern Europe [D'Amato 1991, Verini et al. 2001]. The incidence of allergic sensitization to *Artemisia* pollen in allergic people in different countries ranges between 3 and 20% [Jäger and Horak 1991, Spieksma and Von Wahl 1991, Verini et al. 2001]. The research conducted in several centres in Poland has shown that 12–44.5 % of allergic people have positive results of skin tests with mugwort pollen allergens [Majkowska-Wojciechowska et al. 2007, Stach et al. 2007, Rapiejko 2008]. *Artemisia* is one of the three most frequent causes (after grasses and birch) of pollinosis in Poland [Stach et al. 2007, Rapiejko 2008]. During the late summer period, mugwort pollen allergens cause the most of seasonal symptoms of rhinoconjunctivitis (93.8%). Cross-reactions between many plant allergens have been found. Intolerance to celery, carrot, apples, and herbs (mainly chamomile) occurs in people allergic to *Artemisia* pollen [Rapiejko and Weryszko-Chmielewska 1999].

Mugwort pollen is of very great clinical importance due to its high allergenic activity and abundant occurrence and that is why it is very important to be able to predict pollen seasons of this plant. Forecasting by means of regression analysis was used for different taxa [Latałowa et al. 2002, Smith and Emberlin 2006, Emberlin et al. 2007, Stach et al. 2008, Piotrowska 2012, Piotrowska and Kubik-Komar 2012]. Such data were not found for *Artemisia*. The aim of the present study was to carry out long-term monitoring of *Artemisia* pollen contents in the air of Lublin and to develop statistical predictive models for the particular features of the pollen season taking into account meteorological factors.

MATERIAL AND METHODS

The aerobiological studies were carried out in Lublin (central-eastern Poland). The climate of the Lublin region is temperate, considered to be transitional between oceanic and continental climates. The average annual air temperature in Lublin (1951–2000) amounts to 8.1°C [Kaszewski 2008]. *Artemisia* pollen content in the air was measured in the period of 2001–2012 by the standard volumetric method that is currently used in aerobiology. In this way, the results from the countries all over the world can be comparable. Pollen monitoring followed the recommendations of the International Association for Aerobiology (IAA) [Mandrioli et al. 1998]. The Hirst-type spore trap (Lanzoni VPPS 2000) was applied. The sampler was placed on the flat roof of the building of the University of Life Sciences 18 m above ground level (51°14'37'' N, 22°32'25'' E; 197 m above sea level). Silicone fluid was used as the adhesive substance and glycerine jelly stained as the mounting medium. Pollen grains were identified in four horizontal sweeps of the slide at a microscope magnification of × 400.

The dates of *Artemisia* airborne pollen season were calculated by the 98% and 95% methods for the start and end of the season, respectively [Jäger 2003]. In accordance with these methods, the start of the pollen season was defined as the date when 1% of the seasonal cumulative pollen count was trapped, while the end of the season when the seasonal cumulative pollen count reached 97.5%. These methods allow one to exclude very low pollen concentrations occurring irregularly and coming from distant transport or from secondary re-deposition [Emberlin et al. 1994, Galan et al. 1995]. Mean daily pollen concentrations were expressed as number of pollen grains per cubic meter of air ($P \cdot m^{-3}$). The following pollen season parameters were analysed: start, end, duration (length of pollen season), peak value (daily maximum pollen concentration), peak date (date of daily maximum pollen concentration) and SPI (seasonal pollen index – the sum of pollen grains during the given season). The pollen season features were characterized by the measurements of data dispersion. The relationships between individual parameters were determined based on Spearman's correlation analysis.

Monthly and 10-day meteorological factors for the period from March to August were used to investigate the weather impact on pollen seasons. The following meteorological data were applied for the analysis: air temperature (mean, minimum and maximum), relative air humidity, rainfall, cloud cover, and wind speed. The meteorological data for the period 2001–2010 were obtained from the Meteorological Observatory, located at a distance of about 1.5 km from the pollen sampling site, of the Meteorology and Climatology Department of the Maria Curie-Sklodowska University in Lublin, while in the period 2011–2012 such data were obtained from an automatic weather station Vantage Pro 2 located next to the pollen trap. The relationships between dependent variables (season parameters) and the independent ones (weather factors) were determined using the Spearman correlation analysis. A multiple stepwise forward regression analysis was applied to the production of the statistical forecast models. Before its application, the scatterplots of independent and dependent variables as well as their correlation were analyzed. The data for the period of 2001–2010 were used to calculate the regression equation. The best-fitting regression models were chosen based on the value of the adjusted coefficient of determination ($AdjR^2$). The data for 2011–2012 served as a test of the model. The observed and model-derived data are compared in the figures. Statistical analysis were performed using STATISTICA ver. 8 software.

RESULTS

The atmospheric *Artemisia* pollen season lasted on average from the second 10-day period of July until the middle of September. Over the 12-year study period, the difference between the extreme start dates of the pollen season was two weeks. The earliest onset of the *Artemisia* pollen season was observed in 2010 (10 July), whereas the latest one in 2004 (23 July) and in 2009 (24 July). In the years 2004 and 2009 in which the latest start of the *Artemisia* pollen season was observed, much lower air temperature was recorded in May and June compared to the other years of the study period. The onset of the *Artemisia* pollen season is a parameter with the lowest variation (tab. 1). The end of the season was recorded earliest in 2001 (27 August) and latest in 2005 (4 October). Season duration was characterized by a rather high dispersion of the values. The difference between the shortest and longest season was 38 days. The maximum pollen concentration was usually recorded in the period between 30 July and 8 August (in 11 out of the 12 years of the study); the seasonal maximum was preceded by a two-week period of low pollen concentrations only in 2008 and it was observed exceptionally late (on 25 September). On this day, the average daily pollen concentration was 78 $P \cdot m^{-3}$. In the above-mentioned year, a similar concentration of *Artemisia* pollen (75 $P \cdot m^{-3}$) was recorded on 29 July. The mean peak value during the 12-year study period was 146 $P \cdot m^{-3}$ and it was the parameter of the pollen season showing the highest variation (tab. 1). The highest seasonal pollen index (SPI) was found in the year 2003 in which exceptionally low temperature was observed in April. The lowest seasonal pollen index was found in 2010. Slightly higher pollen counts were recorded in 2006, 2008, and 2011. The difference between the lowest and highest value of the SPI was 1288. The analysis of the SPI for the period 2001–2012 reveals that there were higher pollen counts at the beginning of this period than in the later years, but no significant trend was found (fig. 1).

Table 1. Statistics of the parameters of the *Artemisia* pollen season in Lublin in 2001–2012

Statistics	Pollen season			Peak		SPI (pollen sum)
	start	end	duration (days)	value (P/m^3)	date	
Mean	18.07	14.09	59	146	8.08	1688
Minimum	10.07	27.08	39	70	30.07	1162
Maximum	24.07	4.10	77	268	25.09	2450
SD	4.7	12.5	13.1	65.2	18.8	436.9
V (%)	2.3	4.8	22.3	44.5	8.5	25.9

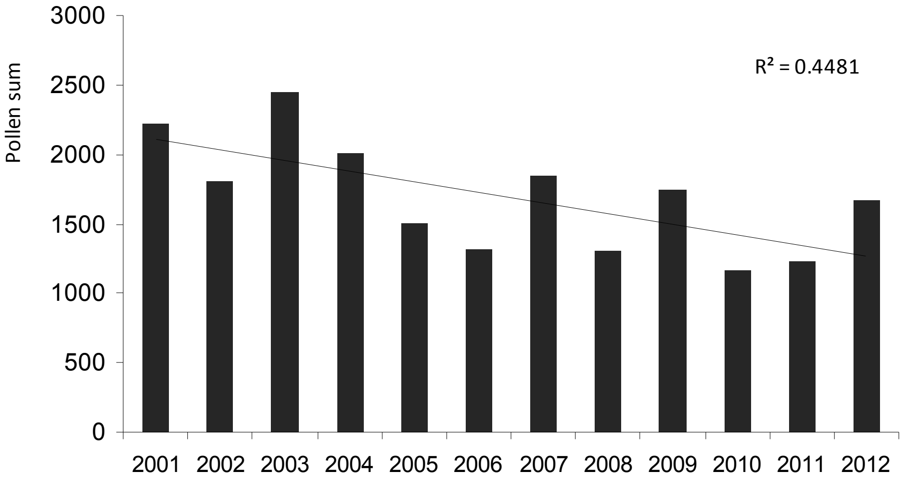

Fig. 1. *Artemisia* pollen grains sums during the pollen seasons in Lublin, 2001-2012 and trend line

The analysis of Spearman's rank correlations showed a statistically significant positive relationship between the onset of the mugwort pollen season and peak date which means that in the case of a later start date the peak value was observed to occur later. The highest correlation was between the season end date and season duration (a positive correlation). Besides, it was found that in the season that ended earlier and lasted shorter the peak value and SPI were higher. A positive correlation at a relatively low level was found between the peak and SPI values (tab. 2).

Table 2. The list of significant Spearman's correlations between the parameters of the *Artemisia* pollen season in Lublin (2001–2012)

Parameters of pollen season	Spearman coefficient
Start & peak date	0.732**
End & duration	0.960**
End & peak value	-0.781**
End & SPI	-0.725**
Duration & peak value	-0.790**
Duration & SPI	-0.741**
Peak value & SPI	0.657*

Level of significance * – 0.05, ** – 0.01

The *Artemisia* pollen seasons in Lublin were condensed. Although the pollen season lasted on average 59 days, most mugwort pollen grains were recorded within one month. In the period from 20 July to 21 August, on average 88.5% of mugwort pollen was recorded (fig. 2). Throughout the study period, the highest pollen counts were observed during the first ten days of August compared to the other 10-day periods of the pollen season, on average 47.2%, with the extreme values of 35.8% in 2002 and 62.3% in 2009. In September *Artemisia* pollen concentrations were relatively low; pollen concentrations exceeding 50 $P \cdot m^{-3}$ were noted at the beginning or at the end of this month only in the years 2002, 2006, and 2008.

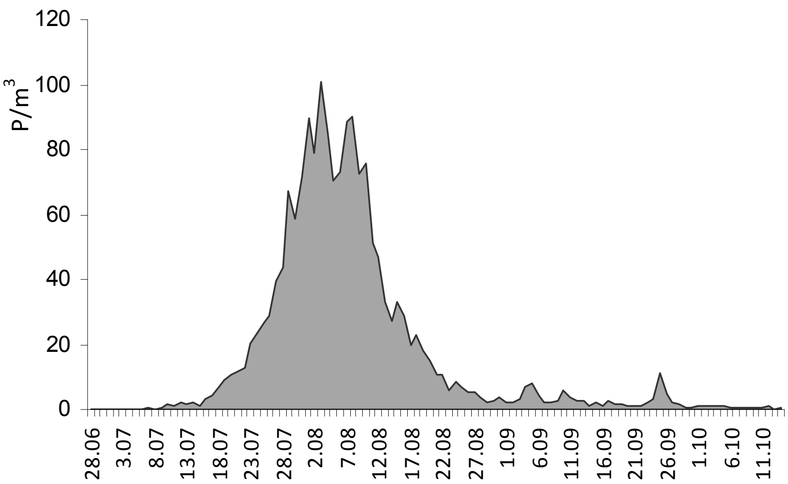

Fig. 2. *Artemisia* pollen concentrations in the atmosphere of Lublin (average for 2001–2012)

The pattern of *Artemisia* pollen seasons in Lublin was right-skewed. The coefficients of skewness ranged between 0.94 and 2.90, with the lowest value found in 2001 and the highest one in 2012.

The analysis of Spearman's correlation coefficients showed that the *Artemisia* pollen season started earlier when air temperature in May and June was high and humidity in March was low (tab. 3). The duration of the mugwort pollen season was correlated the most with relative air humidity and rainfall in July (negative correlation). Humidity in July also affected the pollen season end date. The seasonal maximum value was negatively correlated with mean and maximum temperature in the last ten days of June and it means that higher peak values were recorded in that period when temperature was lower. Rainfall and high humidity in July were also conducive the peak value. The maximum pollen concentration date depended on minimum temperature and air humidity in April (negative correlation). Low temperature in April and in the last ten days of June and high rainfall at the beginning of May were conducive to high SPI values. On the other hand, high precipitation in July had an effect on decreasing the SPI value (tab. 3).

Table 3. Significant Spearman's correlations between *Artemisia* pollen season parameters and meteorological factors in Lublin in years 2001–2012

	Season parameter vs meteorological factor	Spearman coefficient
Dependent variable: season start	mean temperature in the second 10-day period of May	-0.734*
	minimum temperature in the second 10-day period of May	-0.905**
	maximum temperature in the second 10-day period of May	-0.673*
	minimum temperature in the third 10-day period of May	-0.685*
	humidity in March	0.783**
	mean temperature in May	-0.813**
	minimum temperature in May	-0.911**
	mean temperature in the second 10-day period of June	-0.771**
	minimum temperature in the second 10-day period of June	-0.875**
	maximum temperature in the second 10-day period of June	-0.734*
	minimum temperature in June	-0.740*
Dependent variable: end	humidity in the first 10-day period of July	-0.912**
	humidity in July	-0.815**
Dependent variable: duration	humidity in the first 10-day period of July	-0.891**
	rainfall in July	-0.697*
	humidity in July	-0.794**
Dependent variable: peak value	mean temperature in the third 10-day period of June	-0.782**
	maximum temperature in the third 10-day period of June	-0.673*
	humidity in the first 10-day period of July	0.733*
	rainfall in the third 10-day period of July	0.685*
	rainfall in July	0.673*
	humidity in July	0.782**
Dependent variable: peak date	minimum temperature in April	-0.746*
	humidity in April	-0.697*
Dependent variable: SPI	mean temperature in April	-0.758*
	minimum temperature in April	-0.697*
	maximum temperature in April	-0.648*
	rainfall in the first 10-day period of May	-0.693*
	humidity in the first 10-day period of May	-0.673*
	humidity in the third 10-day period of May	-0.636*
	mean temperature in the third 10-day period of June	-0.685*
	humidity in the first 10-day period of July	0.745*
	rainfall in the second 10-day period of July	0.758*
	rainfall in July	0.733*

Level of significance * – 0.05, ** – 0.01

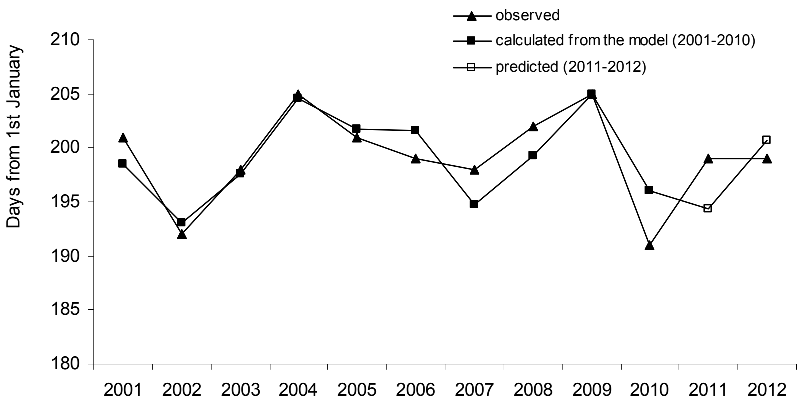

Fig. 3. The start dates of the *Artemisia* pollen season; observed versus regression model calculated values and predicted values in 2011 and 2012

The multiple regression analysis was used to develop predictive models. An attempt was made to derive models in which determination coefficients would have the highest values. The best fit was obtained for start date, duration, and SPI. The results for the other features of the season were not satisfactory and they were therefore excluded from further analysis. In the regression model that can be used to estimate the start date of the *Artemisia* pollen season, two independent variables were employed: relative air humidity in March and mean temperature in the second 10-day period of May. The derived model explains the variation of this parameter in 62% ($AdjR^2 = 0.62$). The mean difference between the value observed in the years 2001–2010 and the one calculated according to the model was 2 days, whereas the prediction in 2011 differed by 4 days and in 2012 by 2 days (fig. 3). The statistical model describing the relationship between the season onset and meteorological conditions is as follows:

$start = 174.95 + 0.593 \cdot H_{III} - 1.379 \cdot T_{mean2V}$
H_{III} – humidity in March
T_{mean2V} – mean temperature in the second ten-day period of May

The highest level of explanation of the variation in *Artemisia* pollen season duration ($AdjR^2 = 0.77$) was obtained in the model in which two variables were included: rainfall in the first 10-day period of May (selected on the basis of the scatterplot) and air humidity in the first 10-day period of July. The duration of the mugwort pollen season was explained by these two independent variables in 77%. The scatterplot of observed versus predicted values using the regression formula shows a high degree of consistency (fig. 4). Nevertheless, the predicted duration of the pollen season in 2011 determined based on the regression model did not give a satisfactory result. But in 2012 the difference between the observed and predicted value was very small – 4 days. The regression analysis results are described by the following equation:

$$\text{duration} = 134.580 - 1.227 \cdot H_{1VII} + 3.162 \cdot R_{1V}$$

H_{1VII} – humidity in the first ten-day period of July

R_{1V} – rainfall in the first ten-day period of May

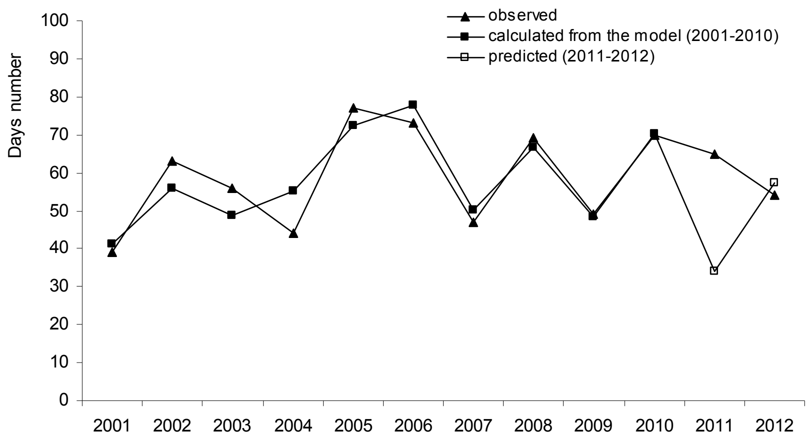

Fig. 4. The duration of the *Artemisia* pollen season; observed versus regression model calculated values and predicted values in 2011 and 2012

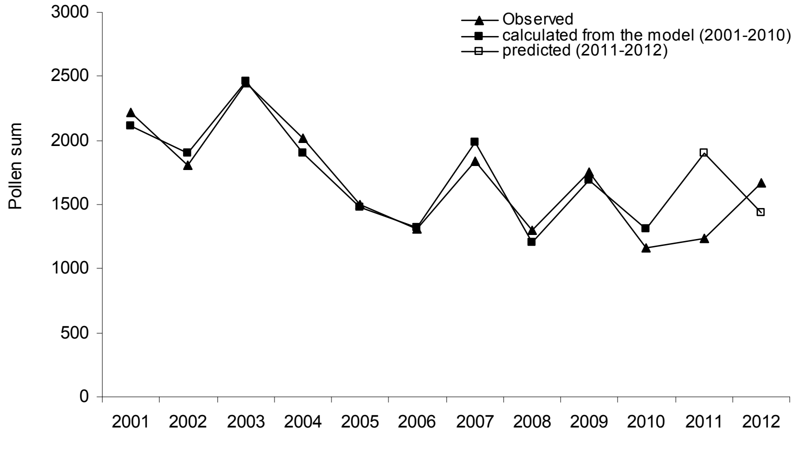

Fig. 5. Seasonal pollen index; observed versus regression model calculated values and predicted values in 2011 and 2012

The regression analysis reveals that the following three variables: minimum temperature in April, humidity in the first 10-day period of May, and mean temperature in the third 10-day period of June, had a significant effect on the values of the seasonal pollen index. The high adjusted coefficient of determination ($Adj R^2 = 0.92$) for the regression model that incorporated the above-mentioned meteorological factors is evidence of the high correlation between the variables analysed. The agreement between the actual value observed in the period 2001–2010 and the model predicted value was very high (fig. 5). The predicted SPI in 2012 produced a much better result than in 2011. The model for the correlation between SPI and meteorological factors determined by linear regression is the following:

$$SPI = 7122.490 - 199.277 \cdot T_{minIV} - 21.583 \cdot H_{1V} - 159.648 \cdot T_{mean3VI}$$

T_{minIV} – minimum temperature in April
H_{1V} – humidity in the first ten-day period of May
$T_{mean3VI}$ – mean temperature in the third ten-day period of June

DISCUSSION

Most *Artemisia* species flower during the period from July to September, whereas *A. scoparia* until October. Under favourable conditions, the flowering of *Artemisia vulgaris* can even last until November [Rutkowski 1998]. The dates of the *Artemisia* pollen season in Lublin largely coincide with the timing of flowering of this species. During the 12-year study period, the onset of the pollen season was recorded on different days of July, on average on 18 July, whereas the end of the season occurred on average in the middle of September. Similar dates for *Artemisia* pollen seasons were also recorded in Gdańsk [Latałowa et al. 2005], in Germany [Melgar et al. 2012], and in Lithuania [Kazlauskas et al. 2006]. Spieksma et al. [1989] found that the pollen season in the Netherlands started about 10 days earlier than in Italy. Maximum *Artemisia* pollen concentrations occurred about a month earlier in central Europe than in the Mediterranean [Spieksma 1990].

The start date of the *Artemisia* pollen season in Lublin was characterized by much lower variation than the other parameters of the season. In the case of mugwort, small differences in pollen season start dates are observed, because it flowers in the period when weather conditions are largely stable [Stach 2000, Latałowa et al. 2005]. A comparison of Poland's eight cities (Rzeszów, Lublin, Łódź, Wrocław, Sosnowiec, Kraków, Poznań, Szczecin) during the period 2001–2005 shows that the pollen season started earliest in the western part of the country. In all the cities in question, the dates of maximum mugwort pollen concentrations occurred in the first half of September [Weryszko-Chmielewska 2006]. Stach et al. [2007] found that in Poznań there were trends towards earlier *Artemisia* pollen season starts and longer duration, possibly caused by climate change. Over the 12-year study period in Lublin, no trends were found for the above-mentioned features of the pollen season.

The analysis of mugwort pollen seasons in Lublin in 2001–2012 years demonstrates that the largest variations between years relate to maximum concentrations and SPI. Weryszko-Chmielewska [2002] and Navarro et al. [2011] found that annual *Artemisia* pollen counts showed very high variation and that they were related to season length. The lowest annual counts were recorded in the longest season, but a reverse relationship was also observed. The present study also found that there was a very high negative correlation between SPI and season duration. Significantly SPI values were recorded in the longer seasons. Compared to Poland's other cities in the period 2001–2005, the highest annual *Artemisia* pollen totals were found in Lublin [Weryszko-Chmielewska 2006]. This can result from the presence of numerous sites of *A. vulgaris*, but also of many other species which, according to Zając and Zając [2001], occur in greater numbers in the Lublin region than in other regions of Poland. Based on the studies carried out during the period 2001–2005, the shortest mugwort pollen seasons were found in Kraków and Rzeszów and they were accompanied by the lowest annual mugwort pollen totals [Weryszko-Chmielewska 2006].

Annual sums of mugwort pollen in western Europe are generally small [Spieksma et al. 2003]. The annual pollen index in Lublin was more than six times higher than the values recorded by the above-mentioned authors in Derby (UK), Brussels (B), and Helmond (NL). Even lower annual counts of mugwort pollen were recorded in Germany [Melgar et al. 2012]. The mean value of the annual pollen index (191) was there slightly higher than the mean peak value in Lublin (146 $P \cdot m^{-3}$). On the other hand, annual *Artemisia* pollen counts recorded in Lithuania were almost twice higher than in Lublin [Kazlauskas et al. 2006]. On the basis of long-term observations in 13 countries of Europe, it was found that in the majority of sampling sites there was a significant decreasing trend in the annual *Artemisia* pollen index [Ziello et al. 2012]. These authors suggest that this can be explained by the intensification of weed control and less agricultural land set-aside. The study conducted in Lublin also revealed a decreasing trend in the seasonal pollen index, but it was not statistically significant.

The study conducted in Lublin demonstrates that the mean temperature in the second ten-day period of May and humidity in March had the greatest effect on the beginning of pollen season. Puc [2009] found that the starting date of the *Artemisia* pollen season and its duration showed the strongest correlation with temperature and air humidity. According to Spieksma et al. [1989], the onset of the mugwort pollen season depends on maximum temperature in July. Two or three variables that were most correlated with a given feature of the pollen season were included in the forecasting models. The projected start date of the *Artemisia* pollen season in the years 2011 and 2012 gave a very good result, since it differed from the actual value on average by 3 days. The predicted duration of the *Artemisia* pollen season in 2012 was also satisfactory, but in 2011 the predicted and observed duration differed markedly. This was probably due to the effect of air humidity at the beginning of July. In 2011 in the first ten-day period of July, air humidity was extremely high and reached 87.5%, whereas mean humidity in the other years was 66.1%. In analysing the effect of weather conditions on the seasonal pollen index, the meteorological factors from the period of flower set and pollen formation were mainly taken into consideration. 3 independent variables were included in the regression model for SPI. The prediction in 2011 was much weaker than in 2012. This was probably attributable to the fact that in 2011 two out of the three independent variables used in the model had extreme values. The minimum temperature in April in 2011 was higher by 1.3°C than the average for the other study years, whereas the mean temperature in the third 10-day period of June was lower by 4.1°C than the 11-year average. The developed predictive models will be verified and improved in further research.

CONCLUSIONS

The *Artemisia* pollen seasons in Lublin had a rather regular pattern and the highest pollen concentration usually occurred in the first half of August. The annual *Artemisia* pollen counts in Lublin were much higher than in western Europe and in the other cities of Poland. The regression analysis reveals that the mean temperature in the second 10-day period of May and air humidity in March had the greatest effect on the onset of the *Artemisia* pollen season. The highest level of explanation of the variation in duration was obtained in the model using humidity in the first 10-day period of July and rainfall in the first 10-day period of May. The value of SPI was primarily dependent on minimum temperature in April, mean temperature in the third ten-day period of June, and humidity in the first ten days of May. The derived models explain 62–92% of the variation in season start date and duration as well as in SPI. Predictions of the parameters of the *Artemisia* pollen season using the derived regression models are strictly correlated with weather elements and the forecasts are less accurate in the case of extreme values of the meteorological factors, that are used in the forecasting models. Based on the obtained results, it can be concluded that regression analysis can be efficiently used to predict the mugwort pollen season on the basis of meteorological data.

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PYŁEK *Artemisia* W POWIETRZU LUBLINA, POLSKA (2001–2012)

Streszczenie. Najczęściej występujące w Polsce gatunki *Artemisia* to rośliny ruderalne lub chwasty ogrodowe i polne. Niektóre uprawiane są jako rośliny ozdobne, lecznicze lub przyprawowe. Ziarna pyłku *Artemisia* zawierają silne alergeny, które wywołują reakcje uczuleniowe u wielu osób w okresie późnoletnim. Celem pracy była analiza zawartości ziaren pyłku bylicy w powietrzu Lublina w ciągu 12 lat badań (2001–2012) oraz określenie zależności między parametrami sezonu pyłkowego a czynnikami meteorologicznymi, a także opracowanie modeli prognostycznych. Monitoring aerobiologiczny prowadzono metodą wolumetryczną, zalecaną przez Międzynarodowe Stowarzyszenie Aerobiologiczne, z zastosowaniem aparatu typu Hirsta (Lanzoni VPPS 2000). Atmosferyczny sezon pyłkowy *Artemisia* trwał średnio od drugiej dekady lipca do połowy września. Największe koncentracje pyłku występowały zwykle w pierwszej dekadzie sierpnia. Najmniejsze zróżnicowanie rejestrowano dla dat rozpoczęcia sezonu, natomiast największe dla wartości maksymalnych stężeń. Przy zastosowaniu analizy regresji utworzono modele prognostyczne dla początku i długości sezonu pyłkowego oraz sezonowego indeksu pyłkowego. Otrzymane modele w dużym stopniu wyjaśniają zmienność parametrów sezonu. Analiza regresji może być z powodzeniem wykorzystywana do prognozowania cech sezonu pyłkowego bylicy na podstawie danych meteorologicznych.

Słowa kluczowe: monitoring pyłkowy, bylica, czynniki meteorologiczne, analiza regresji, modele prognostyczne

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