Acta Agrobotanica

DOI: 10.5586/aa.1735

Publication history
Received: 2018-01-17
Accepted: 2018-04-17
Published: 2018-06-28

Handling editor
Bożena Denisow, Faculty of Horticulture and Landscape Architecture, University of Life Sciences in Lublin, Poland

Authors' contributions
MA: mathematical processing of data; IM: leading the project, manuscript writing and editing; OA: analysis of the received results, data processing; LK: selection of air samples; OB: analysis of the current state of the problem; OD: pollen sampling, suggestions on manuscript writing and editing; LV: study of meteorological and synoptic factors; TG, TI: manuscript writing, translation and formatting of the article

Funding
The study was supported by statutory funds of the Scientific Research Center of National Pirogov Memorial Medical University, Vinnytsya, Ukraine.

Competing interests
No competing interests have been declared.

Citation
Antomonov M, Motruk I, Alexandrova O, Kremenska L, Bobrowska O, Dudarenko O, et al. Development of an integrated indicator for prognosis of pollinosis in the human population of Central Ukraine. Acta Agrobot. 2018;71(2):1735. https://doi.org/10.5586/aa.1735

ORIGINAL RESEARCH PAPER

Development of an integrated indicator for prognosis of pollinosis in the human population of Central Ukraine

Michael Antomonov[1], Iryna Motruk[2], Olena Alexandrova[2], Lilia Kremenska[2], Olena Bobrowska[2], Oxana Dudarenko[2], Larysa Vakolyuk[2], Tamara Germanyuk[2], Tanya Ivko[2]*

[1] State Institution "O. M. Marzeiev Institute for Public Health", Academy of Medical Sciences of Ukraine, Popudrenko 50, Kyiv 02660, Ukraine
[2] National Pirogov Memorial Medical University, Pirogov 56, Vinnytsya 21018, Ukraine

* Corresponding author. Email: ivkot1981@gmail.com

Abstract

Critical values of meteorological factors were identified for improvement of ecological and public health prognosis of the concentration of pollen grains in the air that increase the risk of allergy in the human population. Risk of allergy symptoms from *Ambrosia*, *Artemisia*, or Poaceae pollen arise when the pollen grain concentration in the air increases over threshold values. In this study, an integrated indicator – the "weather factor" WF, was developed. It was based on measurements of air temperature, relative humidity, and atmospheric pressure. The results of the study can be used to assess the prognosis of the appearance of potentially dangerous concentrations of pollen grains in the atmosphere to predict the occurrence of pollinosis in the population of the central region of Ukraine, based upon weather factors.

Keywords

pollen grains; *Ambrosia*; *Artemisia*; Poaceae; "weather factor"; allergy prognosis

Introduction

Allergy is the most common cause of the development of chronic diseases in the population of Ukraine and many other countries in the world. It is an important medical, social, and economic problem. The tendency for a steady growth of allergic pathology in the population has been observed in Ukraine [1]. Pollen of the herbaceous plants is an important cause of seasonal allergies (pollinosis, allergic rhinitis, hay fever) in many countries. The most well-known pollen allergens are from *Ambrosia* and Poaceae pollen grains. These plants are common in both subtropical and temperate climates [2]. The frequency of pollinosis differs in different regions of the world [3]. However, pollinosis derived from *Ambrosia* and Poaceae pollen grains is one of the most important reasons for the emergence of seasonal allergies in Europe [2]. *Artemisia* pollen is also a sensitization factor. The prevalence of allergic rhinitis depends on many climatic and geographical factors that impact on pollen dissemination and the degree of its allergenicity. Pollen allergenicity depends on its volatility, structure, and the grain size as well as accumulation and concentration in the air.

Plants that produce allergenic pollen are characteristic of particular geographic regions. However, due to environmental and climatic factors, significant seasonal changes are observed in airborne pollen concentrations. Fluctuations in meteorological factors (e.g., wind speed, temperature, humidity) affect vegetation composition, reproductive cycles, flowering seasons, and biomass production and so the quantitative distribution of pollen grains in the air. A decrease in the abundance of flowering plants is observed in high levels of ultraviolet radiation and areas with frequent rains. For example, the high average annual air temperature and mild climate of the Mediterranean region promote pollen production throughout the year. In contrast, significant air temperature fluctuations observed in continental regions provide pollen release only in the spring–summer period [4].

Establishing the concentration threshold values of pollen grains in the air is essential for the prediction of pollinosis. When setting such threshold values, the identification of the most relevant weather factors responsible for any rise in the amount of pollen and the creation of an integrated indicator are of great importance. Any integrated indicator must meet the following requirements:

- selection of the most informative factors,
- prediction of the spread of pollen in the air,
- ease of use [5].

An integrated indicator provides an opportunity to improve the diagnosis, prevention, and treatment of pollinosis caused by the pollen of wind-pollinated plants [5]. The purpose of the present study was to develop such an integrated prognostic indicator, we term the "weather factor" (WF), which is both simple and effective to use for the prediction of the risk of development of seasonal pollinosis in the human population of Central Ukraine.

Material and methods

The research was performed in 2012–2014 in Vinnytsya, Ukraine (49°23′30″ N, 28°46′82″ E, 235 m a.s.l.). The observation period each year was from 1st May to 31st October; samples were collected daily. In total, 552 air samples were taken. Aerobiological monitoring of pollen concentrations employed a Burkard pollen trap. The device was located on the roof of the chemistry building of the National Pirogov Memorial Medical University, Vinnytsya at a height of 25 m, according to the standard rules of the European Aeroallergen Network [6,7] (Fig. 1).

Fig. 1 The Burkard sampler located on the roof of the Chemistry Building of the National Pirogov Memorial Medical University, Vinnytsya, Ukraine.

For the investigation, an air flow rate of 10 L min^{-1} was selected. Particles suspended in the atmosphere settled on a sticky ribbon Melinex surface, affixed to the drum of the sampler. One sample was made from each piece of the Melinex. Each was fixed in gelatine and stained using magenta with glycerin. The pollen of the herbaceous plant species stained in pink, facilitating identification.

The samples were analyzed by light microscopy with a microscope (400×) equipped with a high-sensitivity microphotographic camera (Axioscop, Zeiss, Germany). Counts were made on 12 transects for each slide. The concentrations of pollen grains on the vertical transects were measured every 2 hours. All data obtained were converted to concentrations of pollen grains in m^{-3} of air.

To determine critical values of meteorological parameters characteristic for increased concentration of *Ambrosia*, *Artemisia*, and Poaceae pollen grains, two datasets were prepared from the total data available. The first dataset contained the value of pollen grain concentrations lower than the average for the pollen season. The second dataset had the values of pollen grain concentrations higher than average for the pollen season. The significances of difference between mean values were established using *t* tests [5].

Ambrosia (Asteraceae) pollen is distinguished from the pollen grains of other members of the Asteraceae by the size of the spikes, the structure of the colpe, and the thickness of the exine (Fig. 2). The pollen grains of *Ambrosia* are 15–24 μm in diameter, somewhat flattened to nearly spherical (isopolar), the exine is thin and the spines are short.

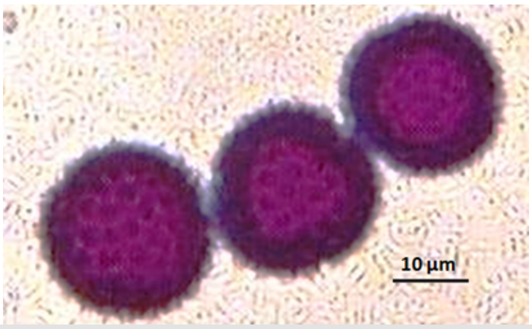

Fig. 2 *Ambrosia* pollen.

The pollen grain of *Artemisia* (Asteraceae) is spheroidal and three-colporate. It is small (15–28 μm) in size, the exine is thick (2–3 μm) with short thorns (Fig. 3) [8].

Fig. 3 *Artemisia* pollen grain.

Poaceae pollen grains are spheroidal to oval, sometimes elliptical (Fig. 4), 22–122 μm in diameter with one pore of round or oval shape, which surrounds a roller from the raised outer shell [8].

Fig. 4 Poaceae pollen.

The identification of pollen grains was carried out using the determinants of aerogenic allergens, which have been issued by the National Allergy Bureau of the American Academy of Allergy, Asthma and Immunology [9], and according to the Pollen Identification Key software from the French National Aerobiological Monitoring Network [10]. Data were entered into the European Aeroallergen Network (EAN) database [7] using the software package SPSS. Meteorological and synoptic data were obtained from the Vinnytsia Regional Center for Hydrometeorology. Excel was used for the initial tabulation and analysis of all data, and statistical analysis (Spearman's rank correlation, *t* test for independent samples) was performed using STATISTICA 10.0 software [11].

Results

The concentrations of *Artemisia* pollen were higher than average when the air velocity and relative air humidity were low and the air temperature, the dew point, the moisture deficit, and atmospheric pressure were high. The increase in the concentration of *Artemisia* pollen in the air was observed when the critical value of air temperature was >17.74°C, the dew point >10.62°C, moisture deficit – 13.49 mbar, atmospheric pressure – 980.75 hPa and when the critical value of relative humidity was <66.95%, the wind direction – 168.03°, and the wind speed was <3.315 m s^{-1}. The low air humidity and the increase in atmospheric pressure during the summer–fall period therefore contributed to active release of airborne *Artemisia* pollen (Tab. 1).

The concentrations of *Ambrosia* pollen were higher than average when the dew point, relative air humidity, and moisture deficit were all low.

The increase in the concentration of *Ambrosia* pollen in the air could be expected when the wind direction is 174.785°, the wind speed >3.385 m s^{-1}, and the atmospheric pressure >980.915 hPa as well as the dew point being <9.95°C, the relative humidity <67.14%, and the moisture deficit <12.90 mbar. Therefore, a high air velocity, air temperature, and atmospheric pressure resulted in the active release of *Ambrosia* pollen and its high concentration in the air in our study (Tab. 2).

A high concentrations of Poaceae pollen was observed when the air temperature, the wind speed, the dew point, and humidity deficiency were all high as well as when the relative humidity and atmospheric pressure being low. An increase in the concentration of Poaceae pollen was recorded when the air temperature was >17.425°C, the dew point >10.56°C, the moisture deficit >13.64 mbar as well as the relative humidity was <67.525% and atmospheric pressure >980.235 hPa (Tab. 3).

An increase in pollen concentration of the herbaceous plants studied was recorded when the air temperature was >18°C, the atmospheric pressure was >980 hPa, and the relative humidity <67%.

An integrated characteristic for meteorological factors (integrated indicator), the WF, was designed on the basis of our results as: $WF = (P \times T) / V$, where P is actual value of pressure (hPa), T is temperature (°C), and V is the relative air humidity (%).

The critical value of WF was calculated as the average value between the arithmetic mean in comparable samples when a statistically significant difference between the values was found.

The values of WF were calculated for every registration. Comparison between mean values of WF for herbaceous plants was then made by t tests. Two groups of meteorological factors were compared: (***i***) when the pollen count was high, and (***ii***) when pollen was absent (for the *Artemisia* – ARTE present ARTE_B = 1 and ARTE absent ARTE_B = 0; for *Ambrosia* – AMBR present AMBR_B = 1 and AMBR absent AMBR_B = 0; for Poaceae – POAC present POAC B = 1 and POAC absent POAC_B = 0).

Critical values were obtained for the three most significant meteorological factors attributable to the increase of pollen concentrations, i.e., average daily air temperature, relative humidity, and atmospheric pressure (Tab. 4–Tab. 6). The increase of *Artemisia* pollen concentration in the air could be associated with an air temperature >18.275°C and relative humidity <66.42%. An increase in *Ambrosia* pollen could be expected when the air temperature is >17.342°C, the relative humidity <67.122%, and the atmospheric pressure >980.753 hPa. The Poaceae pollen concentration was attributable to an air temperature >17.859°C, relative humidity <66.738%, and atmospheric pressure <980.192 hPa. The critical value of WF for *Artemisia* (WF_{ARTE}) was 330. If the value was more than this critical value, there was an increase in the concentration of *Ambrosia* pollen grains in the air and the risk of allergic reactions to *Artemisia* also increased (Tab. 4).

The critical value of WF for *Ambrosia* (WF_{AMBR}) was 310. If the value of the WF was higher than this critical value, the increase in the concentration of *Ambrosia* pollen grains in the air was observed and the risk of allergic reactions to *Ambrosia* increased (Tab. 5).

The critical value of WF for Poaceae (WF_{POAC}) was 320. If the value was higher than this critical value, the concentration of Poaceae pollen in the air increased and the risk of allergic reactions to Poaceae increased (Tab. 6).

Differences in values of WF for *Artemisia*, *Ambrosia*, and Poaceae pollen were all significant. This demonstrates that the values of WF can be used for the prognosis for the *Artemisia*, *Ambrosia*, and Poaceae pollen spread in the air. The critical values of WF for the increase of pollen concentration were: for *Artemisia* $WF_{ARTE} = 330$, for *Ambrosia* $WF_{AMBR} = 310$, and for Poaceae $WF_{POAC} = 320$.

This approach allowed a transition from the initial quantitative variable pollen concentrations to binary variables, pollen present (1), pollen absent (0). Using the critical values of the WF from Tab. 4–Tab. 6, it was possible to switch from the original quantitative data to their binary analogs; WF is significant (1) or is not significant (0). These transformations allow a determination of the links between concentrations of pollen and WF using the cross-tabulated data from conjugation tables (see Tab. 7–Tab. 9).

The dependence of pollen concentration of *Artemisia* on WF was significant (r_s = 0.095, $p < 0.001$). Exceeding the critical value of WF gives 45.12% probability for the increase of *Artemisia* pollen and 30.74 % probability for the lack of increase of *Artemisia* pollen (Tab. 7).

Relative risks for pollen of *Artemisia*, *Ambrosia*, and Poaceae were calculated (Tab. 7–Tab. 9). It was found that the risk of increasing the pollen concentration exceeding the critical value of the WF of 330 is equal to relative risk (RR) = 1.85 (1.10–2.74), $p < 0.05$. The dependence of pollen concentration of *Ambrosia* on WF is significant (r_s = 0.026, p

Tab. 1 The values of meteorological factors attributable to *Artemisia* pollen release in Vinnytsya, Ukraine in 2012–2014.

Meteorological factors	Statistical indicators								
	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	Critical value
Wind direction (°)	177.7400	1.219	9,696	158.330	2.050	3,600	8.235	**<0.001**	**168.030**
Wind speed (m s^{-1})	3.370	0.021	9,696	3.260	0.030	3,600	2.646	**0.008**	**3.315**
Air temperature (°C)	15.910	0.070	9,696	19.570	0.090	3,600	−28.260	**<0.001**	**17.740**
Dew point (°C)	9.580	0.055	9,696	11.660	0.070	3,600	−20.920	**<0.001**	**21.240**
Relative humidity (%)	69.190	0.195	9,696	64.720	0.340	3,600	11.660	**<0.001**	**66.955**
Moisture deficit (mbar)	12.920	0.210	9,696	14.060	0.060	3,600	−3.290	**<0.001**	**13.490**
Atmospheric pressure (hPa)	980.2800	0.077	9,696	981.220	0.090	3,600	−6.680	**<0.001**	**980.750**

Two groups with an index 0 and 1 were compared. *M* – mean; *SE* – standard error; *n* – number of samples; *t* – Student's criterion; *p* – the level of significance. Critical values are in bold.

Tab. 2 Meteorological factors attributable to *Ambrosia* pollen release in Vinnytsya, Ukraine in 2012–2014.

Meteorological factors	Statistical indicators								
	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	Critical value
Wind direction (°)	171.480	1.125	11,280	178.090	2.888	2,016	−2.258	**0.024**	**174.785**
Wind speed (m s^{-1})	3.320	0.019	11,280	3.450	0.046	2,016	−2.628	**0.009**	**3.385**
Air temperature (°C)	16.890	0.066	11,280	17.020	0.118	2,016	−0.790	0.429	**16.955**
Dew point (°C)	10.220	0.050	11,280	9.690	0.092	2,016	4.169	**<0.001**	**9.955**
Relative humidity (%)	68.330	0.186	11,280	65.950	0.436	2,016	4.990	**<0.001**	**67.140**
Moisture deficit (mbar)	13.370	0.181	11,280	12.430	0.077	2,016	2.186	**0.029**	**12.900**
Atmospheric pressure (hPa)	980.360	0.070	11,280	981.470	0.112	2,016	−6.485	**<0.001**	**980.915**

See Tab. 1 for explanation.

Tab. 3 Meteorological factors values attributable to Poaceae pollen release in Vinnytsya, Ukraine in 2012–2014.

Meteorological factors	Statistical indicators								
	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	Critical value
Wind direction (°)	171.200	1.280	8,712	175	1.833	4,584	−1.722	**0.085**	**173.100**
Wind speed (m s^{-1})	3.320	0.020	8,712	3.360	0.031	4,584	−1.094	0.274	**3.340**
Air temperature (°C)	15.760	0.070	8,712	19.090	0.078	4,584	−27.516	**<0.001**	**17.425**
Dew point (°C)	9.210	0.060	8,712	11.910	0.063	4,584	−29.609	**<0.001**	**10.560**
Relative humidity (%)	68.970	0.220	8,712	66.080	0.278	4,584	8.053	**<0.001**	**67.525**
Moisture deficit (mbar)	12.310	0.050	8,710	14.970	0.435	4,584	−8.219	**<0.001**	**13.640**
Atmospheric pressure (hPa)	981.200	0.080	8,712	979.270	0.090	4,584	14.889	**<0.001**	**980.235**

See Tab. 1 for explanation.

Tab. 4 Meteorological traits and WF attributable to the increase of *Artemisia* pollen in the air of Vinnytya, Ukraine in 2012–2014.

	Statistical indicators								
Meteorological factors, WF	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	**Critical value**
Air temperature (°C)	16.577	0.061	12,139	19.972	0.158	1,445	18.330	**<0.000**	**18.275**
Relative humidity (%)	68.569	0.177	12,139	64.272	0.544	1,445	7.862	**<0.001**	**66.420**
Atmospheric pressure (hPa)	980.404	0.067	12,139	980.579	0.129	1,445	0.879	0.379	**980.492**
WF	286.272	1.873	12,139	374.643	6.499	1,445	15.044	**<0.001**	**330.000**

See Tab. 1 for explanation.

Tab. 5 Meteorological traits and WF attributable to the increase of *Ambrosia* pollen in the air of Vinnytsya, Ukraine in 2012–2014.

	Statistical indicators								
Meteorological factors, WF	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	**Critical value**
Air temperature (°C)	16.862	0.061	12,505	17.822	0.174	1,079	4.492	<0.001	**17.342**
Relative humidity (%)	68.299	0.176	12,505	65.946	0.602	1,079	3.769	<0.001	**67.122**
Atmospheric pressure (hPa)	980.360	0.065	12,505	981.145	0.177	1,079	3.463	<0.001	**980.753**
WF	293.712	1.909	12,505	318.396	6.219	1,079	3.657	<0.001	**310.000**

See Tab. 1 for explanation.

Tab. 6 Meteorological traits and WF attributable to the increase of Poaceae pollen in the air of Vinnytsya, Ukraine in 2012–2014.

	Statistical indicators								
Meteorological factors, WF	M_0	SE_0	n_0	M_1	SE_1	n_1	t	p	**Critical value**
Air temperature (°C)	16.598	0.063	11,753	19.121	0.125	1,831	15.023	0.001	**17.859**
Relative humidity (%)	68.619	0.182	11,753	64.857	0.452	1,831	7.623	<0.001	**66.738**
Atmospheric pressure (hPa)	980.508	0.068	11,753	979.876	0.117	1,831	3.524	<0.001	**980.192**
WF	288.279	1.962	11,753	343.136	4.856	1,831	10.299	<0.001	**320.000**

See Tab. 1 for explanation.

= 0.002). Taking into account the WF the probability of occurrence of *Ambrosia* pollen is 39.48% and the absence, 34.83%. It was found that the risk of increasing the pollen concentration of *Ambrosia* and exceeding the critical value of the WF of 310 is equal to RR 1.22 (1.09–1.34), $p < 0.05$ (Tab. 8).

Taking into account the WF, the probability of occurrence of Poaceae pollen is 43.20% and the absence 32.22%. The risk of increasing the pollen concentration of Poaceae and exceeding the critical value of the WF 320 is RR = 1.60 (1.50–1.70), $p < 0.05$ (Tab. 9).

Discussion

Our study confirmed the impacts of air temperature, relative humidity, velocity and direction of wind on the dispersion of pollen grains in the atmosphere. The results are similar to those of Macharadze [12] and Rodinkova [13]. According to other authors, the highest concentration of pollen grains is related to warm and dry weather as well as to a low wind speed [14]. The influence of the complex interaction of meteorological

Tab. 7 Conjugation of the presence/absence of *Artemisia* pollen with WF in Vinnytsya, Ukraine in 2012–2014.

	ARTE_B		
WF	**Pollen absent (0)**	**Pollen present (1)**	**Sum**
0 (factor is not significant)	8,407	3,732	12,139
Column (%)	91.38	85.13	
Line (%)	69.26	30.74	
1 (factor is significant)	793	652	1,445
Column (%)	8.62	14.87	
Line (%)	54.88	45.12	
Total	9,200	4,384	13,584
Total (%)	67.73	32.27	100.00

Tab. 8 Conjugation of the presence/absence of *Ambrosia* pollen with WF in Vinnytsya, Ukraine in 2012–2014.

	AMBR_B		
WF	**Pollen absent (0)**	**Pollen present (1)**	**Sum**
0 (factor is not significant)	8,150	4,355	12,505
Column (%)	92.58	91.09	
Line (%)	65.17	34.83	
1 (factor is significant)	653	426	1,079
Column (%)	7.42	8.91	
Line (%)	60.52	39.48	
Total	8,803	4,781	13,584
Total (%)	64.80	35.20	100.00

Tab. 9 Conjugation of the presence/absence of Poaceae pollen with WF in Vinnytsya, Ukraine in 2012–2014.

	POAC_B		
WF	**Pollen absent (0)**	**Pollen present (1)**	**Sum**
0 (factor is not significant)	7,966	3,787	11,753
Column (%)	88.45	82.72	
Line (%)	67.78	32.22	
1 (factor is significant)	1,040	791	1,831
Column (%)	11.55	17.28	
Line (%)	56.80	43.20	
Total	9,006	4,578	13,584
Total (%)	66.30	33.70	100.00

factors was studied by Gubankova [15]. In addition to temperature, the release of pollen grains from anthers and their concentration in the air depends on the relative humidity [16]. An increase in relative humidity results in a decrease in the amount of airborne pollen grains. However, at a high relative humidity (i.e., during and immediately after the rain), the concentration of pollen in the air decreases [12].

According to the results of our research, the pollen production of the herbaceous plants recorded is related not only to the air temperature an relative humidity but also to atmospheric pressure. For an improvement to the ecological and hygienic prognosis, we established critical values of meteorological factors, which can then be linked with the increase of pollen concentration in the air to produce a single combined criterion, the WF, based on air temperature, relative humidity, and atmospheric pressure measurements. These weather parameters have been considered as the most important for the abundance of grass pollen in the air. When the critical values of WF are exceeded, increases in the concentration of pollen grains of *Ambrosia*, *Artemisia*, and Poaceae can be expected.

Our data can be used within the territory for the radius of operation of the Burkard device (40 km) and to regions of Ukraine which are characterized by a temperate climate with similar meteorological conditions to the city of Vinnytsya. These regions include Kirovograd, Cherkasy, the southern part of Kyiv, Khmelnytsky, and the part of Vinnytsia located within the Podolsk hill.

The results of the study will thus allow early warning of certain risks to medical institutions and individuals who are sensitive to allergens and therefore enable preventative measures in a timely manner to minimize clinical manifestations of seasonal pollinosis.

Based on our data, we have issued two newsletters and introduced the work to the National Pirogov Memorial Medical University (Vinnytsya), the Ivan Horbachevsky Ternopil State Medical University, the Zaporozhye State Medical University, the Vinnytsya regional immunological service, and the website of the Association of Allergists of Ukraine (http://www.aalu.org.ua).

Conclusions and perspectives for further investigations

- For all types of pollen recorded in our study, the average critical values of meteorological factors were calculated. A significant increase in *Ambrosia*, *Artemisia*, and Poaceae pollen concentrations was associated with the air temperature >17°C, the baromtric pressure >980 hPa, and the relative humidity <67%.
- The "weather factor" WF is proposed as an integrated indicator based on air pressure, temperature, and relative humidity, normalized with respect to their mean values. If the value of the WF is higher than the critical value, the risk of seasonal pollinosis increases.
- The risk of an increased *Artemisia* pollen concentration is likely above a critical value of the WF of 330, which is equal to RR = 1.85 (1.10–2.74), $p < 0.05$; for *Ambrosia* the WF of 310, RR = 1.22 (1.09–1.34), $p < 0.05$, and for Poaceae the WF of 320, RR = 1.60; (1.50–1.70), $p < 0.05$.
- The WF creates an opportunity to use an integrated characteristic of meteorological traits (integrated indicator) to predict the occurrence of potentially dangerous concentrations of certain pollen types in the Ukraine and likely has a wider application in other countries.

References

1. Pukhlik BM, Dyatyatkis YM, Gogunskaya IV, Kholodenko TY. The issue of prevalence and economic efficiency of treatment of allergic diseases of the respiratory organs in Ukraine. Clinical immunology, Allergology, Infectology; 2012;2;5–7.
2. D'Amato G, Cecchi L, Bonini S, Nunes C, Annesi-Maesano I, Behrendt H, et al. Allergenic pollen and pollen allergy in Europe. Allergy; 2007;62(9):976–990. https://doi.org/10.1111/j.1398-9995.2007.01393.x
3. Smith M, Jäger S, Berger U, Šikoparija B, Hallsdottir M, Sauliene I, et al. Geographic and temporal variations in pollen exposure across Europe. Allergy. 2014;69(7):913–923. https://doi.org/10.1111/all.12419
4. Globe G, Martin M, Schatz M, Wiklund I, Lin J, von Maltzahn R, et al. Symptoms and markers of symptom severity in asthma – content validity of the asthma symptom diary. Health Qual Life Outcomes. 2015;13:21. https://doi.org/10.1186/s12955-015-0217-5

5. Motrut II. Ecological-hygienic estimation of pollen of herbaceous plants on the basis of hourly observations in the summer–autumn period [PhD thesis]. Kyiv: "O. M. Marzeiev Institute for Public Health" NAMSU; 2017.
6. Rodinkova VV. Scientific substantiation of the system of monitoring and prevention of the influence of allergenic factors of biological origin on the state of health of the urban population of Ukraine [PhD thesis]. Kyiv: "O. M. Marzeiev Institute for Public Health" NAMSU; 2015.
7. European Aeroallergen Network [Internet]. 2018 [cited 2018 May 25]. Available from: http://www.polleninfo.org
8. Saarto A. Using a long-distance transport model of birch pollen in pollen forecasting – Finnish experiences. Allergo J. 2013;22(7):477.
9. American College of Allergy, Asthma, and Immunology. Allergy facts [Internet]. 2014 [cited 2018 Jun 22]. Available from: http://acaai.org/news/facts-statistics/allergies
10. Gruzieva O, Pershagen G, Wickman M, Melén E, Hallberg J, Bellander T, et al. Exposure to grass pollen – but not birch pollen – affects lung function in Swedish children. Allergy. 2015;70(9):1181–1183. https://doi.org/10.1111/all.12653
11. Antonomov MY. Mathematical processing and analysis of medical and biological data. 2nd ed. Kyiv: M. Yu. Antonomov; 2018.
12. Macharadze D. Climate and allergy. Journal of the Russian Association of Allergists and Clinical Immunologists; 2006;5;23–30.
13. Rodinkova V. Airborne pollen spectrum and hay fever type prevalence in Vinnytsya, Central Ukraine. Acta Agrobot. 2015;68(4):383–389. https://doi.org/10.5586/aa.2015.037
14. Rodinkova V, Kremenska L, Palamarchuk O, Motruk I, Alexandrova E, Dudarenko O, et al. Seasonal changes in plant pollen concentrations over recent years in Vinnytsya, Central Ukraine. Acta Agrobot. 71(1):1731. https://doi.org/10.5586/aa.1731
15. Gubankova SG. The study of pollen in the air of Moscow. Palynology in medicine. Proceedings of the III International Palynological Conference; 1971; Novosibirsk, Russia. Moscow: USSR Academy of Sciences; 1973. p. 26.
16. Fletcher AJ. Trading futures: economism and gender in a changing climate. Int Soc Work. 2015;58(3);364–374. https://doi.org/10.1177/0020872814556825

Próba stworzenia zintegrowanego współczynnika pogodowego w celu prognozowania wystąpienia polinoz w populacji Centralnej Ukrainy

Streszczenie

Określono krytyczne wartości czynników meteorologicznych w celu poprawy prognozowania ekologicznego i zdrowotnego na bazie stężeń ziaren alergennego pyłku w powietrzu. Ryzyko wystąpienia objawów alergii wywołanych przez pyłek ambrozji, artemizji lub Poaceae występuje, gdy stężenie ziaren pyłku w powietrzu wzrasta powyżej wartości progowych. W naszych badaniach w oparciu o pomiary temperatury powietrza, wilgotności względnej i ciśnienia atmosferycznego opracowano zintegrowany wskaźnik – współczynnik WF „czynnika pogodowego". Wyniki badań mogą być wykorzystane do prognozy pojawienia się potencjalnie niebezpiecznych stężeń pyłku w atmosferze w celu przewidywania występowania alergii dla populacji Centralnej Ukrainy.