

# Oak pollen season in selected cities in Poland in 2022

**Anna Kopacz-Bednarska<sup>1</sup>, Joanna Ślusarczyk<sup>1</sup>, Krystyna Piotrowska-Weryszko<sup>2</sup>, Monika Ziemianin<sup>3</sup>, Anna Rapijko<sup>4</sup>, Małgorzata Malkiewicz<sup>5</sup>, Kazimiera Chłopek<sup>6</sup>, Grzegorz Siergiejko<sup>7</sup>, Dariusz Jurkiewicz<sup>8</sup>, Tomasz Wolski<sup>9</sup>, Agnieszka Lipiec<sup>10</sup>**

<sup>1</sup> Institute of Biology, Jan Kochanowski University in Kielce, Poland

<sup>2</sup> Department of Botany and Plant Physiology, University of Life Sciences in Lublin, Poland

<sup>3</sup> Department of Clinical and Environmental Allergology, Medical College, Jagiellonian University, Cracow, Poland

<sup>4</sup> Allergen Research Center, Warsaw, Poland

<sup>5</sup> Laboratory of Paleobotany, Department of Stratigraphical Geology, Institute of Geological Sciences, University of Wrocław, Poland

<sup>6</sup> Faculty of Natural Sciences, Institute of Earth Sciences, University of Silesia in Katowice, Poland

<sup>7</sup> Pediatrics, Gastroenterology and Allergology Department, University Children Hospital, Medical University of Białystok, Poland

<sup>8</sup> Department of Otolaryngology with Division of Cranio-Maxillo-Facial Surgery, Military Institute of Medicine, Warsaw, Poland

<sup>9</sup> Institute of Marine and Environmental Sciences, University of Szczecin, Poland

<sup>10</sup> Department of Prevention of Environmental Hazards, Allergology and Immunology, Medical University of Warsaw, Poland

## Abstract:

Oak (*Quercus sp.*) is a common species in Poland. *Que a 1*, which triggers allergic reactions in spring, is the main oak allergen. The aim of the study was to compare the oak pollen season in 13 Polish cities in 2022. Pollen was monitored with the volumetric method. The analyses determined the annual sum of pollen grains, the length of the pollen season (using the 98% method), the highest peak pollen concentrations, the dates of maximum pollen concentrations, and the number of days with pollen concentrations above threshold values causing clinical allergy symptoms. The earliest onset of the oak pollen season was noted in Szczecin (April 11<sup>th</sup>), and the latest beginning was recorded in Lublin and Kielce (May 5<sup>th</sup>). The shortest and the longest pollen seasons were recorded in Cracow (22 days) and in Szczecin (48 days), respectively. The highest total daily concentration of pollen grains was recorded in Opole (5083) and the lowest value was noted in Białystok (112) and Szczecin (328). The highest maximum concentration of oak pollen was recorded in Sosnowiec and Kielce (625 and 543 grains/m<sup>3</sup>, respectively), whereas the lowest values were noted in Białystok and Szczecin (27 and 47 grains/m<sup>3</sup>, respectively). In most of the analyzed cities in Poland, the peak oak pollen release was recorded between May 7<sup>th</sup> and 12<sup>th</sup>. The highest risk of allergic reactions caused by oak pollen allergens was reported from Opole, Piotrków Trybunalski, and Zielona Góra.

**Key words:** oak (*Quercus*), allergens, pollen season, 2022

## Introduction

The oak (*Quercus sp.*) represents the family *Fagaceae* and the order *Fagales* [1]. In addition to birch, alder, and hazel, it is a common source of environmental allergens triggering allergic reactions.

The genus *Quercus* is the largest genus in the family *Fagaceae* comprising up to 600 species. Due to the large number of species and morphological diversity, the taxonomy of *Quercus* is extremely complex [2]. The genus *Quercus* is characterized by a wide ge-

ographic distribution. It occurs most commonly in the temperate zone, occupying large areas of the northern hemisphere mainly in North America and Asia [3]. The oak is widespread in Europe as well. It also occurs across Poland, mostly in mixed forests growing in river valleys [1, 4]. Two species of oak are common in Poland: the English oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* Liebl.). Additionally, the downy oak (*Quercus pubescens* Willd.) growing in Bielinek on the Oder and the red oak (*Quercus rubra* L.), which is a non-native species found increasingly often in forests and parks, are common species in Poland [4–7]. Oaks are monoecious and anemophilous deciduous trees flowering in spring, mainly in April and May, in Poland [8]. However, the pollen seasons of the English oak and the sessile oak do not coincide fully [1]. The difference in the terms of their pollen season may be approximately 2 weeks [7, 9].

Oak pollen has moderate allergenic properties [4, 5]. Nevertheless, literature data indicate that, between the birch and grass pollen seasons in the spring period, oak pollen allergens are responsible for the development of allergic reactions. The main allergen of oak is the 17-kDa protein *Que a 1* [5]. Due to the common components, it may cross-react with e.g. privet and olive pollen and with allergens of other species of the order *Fagales* [10–12].

## Aim

The aim of this study was to analyze and compare the oak pollen season in 13 cities in Poland: Białystok, Bydgoszcz, Cracow, Kielce, Lublin, Olsztyn, Opole, Piotrków Trybunalski, Sosnowiec, Szczecin, Warsaw, Wrocław, and Zielona Góra in 2022.

## Material and method

The concentration of pollen grains in the selected Polish cities was determined with the volumetric method using Lanzoni and Burkard devices. The amount of pollen grains in the air was monitored on a weekly basis and analyzed for 24-h periods. The concentration of pollen grains was expressed in 1 m<sup>3</sup> of air. The following parameters were determined and analyzed in the study:

1. the annual sum of pollen grains
2. the length of the pollen season determined with the 98% method, which assumes that days with 1% and 99% of the annual sum of pollen grains indicated the beginning and end of the pollen season, respectively [13]
3. the highest peak pollen concentrations and the dates of maximum pollen concentrations
4. the number of days with threshold values triggering clinical allergy symptoms.

As shown by literature data, the first symptoms of allergy in subjects sensitive to oak pollen allergens may appear when the pollen concentration in 1 m<sup>3</sup> of air is  $\geq 16$ . In turn, the concentration of  $\geq 91$  oak pollen grains/m<sup>3</sup> of air causes allergy symptoms in a majority of sensitive subjects [14].

## Results

The oak pollen season in 2022 in most of the analyzed Polish cities began between April 11<sup>th</sup> and 30<sup>th</sup> and lasted until the third decade of May. The earliest onset of the pollen season was noted in Szczecin (April 11<sup>th</sup>) and Sosnowiec (April 13<sup>th</sup>). In turn, the latest beginning of the pollen season was recorded in Warsaw (May 3<sup>rd</sup>) and in Lublin and Kielce (May 5<sup>th</sup>). The earliest end of the pollen season was recorded on May 20<sup>th</sup> in Cracow and Zielona Góra, whereas the latest end was noted in Olsztyn (June 1<sup>st</sup>). The shortest period of oak pollen release was found in Cracow (22 days), Kielce (23 days), and Lublin (24 days), while Szczecin (48 days) and Sosnowiec (44 days) were characterized by the longest pollen release period. Since no data on pollen were available from two days in Wrocław, the exact date of the pollen season end was not determined. The great similarity in the course of the pollen season between Wrocław and Zielona Góra may suggest that the pollen season in Wrocław ended around May 20<sup>th</sup> as well (tab. 1; fig. 1–7).

The lowest annual pollen grains sum was recorded in Białystok (112) and Szczecin (328). In turn, the highest number of pollen grains was recorded in the atmospheric air of Opole and Zielona Góra, respectively 5083 and 3240. The annual sum of pollen grains in the other Polish cities, i.e. in Olsztyn, Lublin, Cracow, Bydgoszcz, Sosnowiec, Warsaw, Kielce, Piotrków Trybunalski, and Wrocław, ranged from 1222 to 2944 (tab. 1; fig. 1–7).

The highest maximum concentration of pollen grains was recorded in Sosnowiec (625 grains/m<sup>3</sup>), Kielce (543 grains/m<sup>3</sup>), and Opole (453 grains/m<sup>3</sup>). The lowest peak values were recorded in Białystok (27 grains/m<sup>3</sup>) and Szczecin (47 grains/m<sup>3</sup>). The maximum pollen concentration values recorded in the other measurement stations ranged from 156 grains/m<sup>3</sup> (in Olsztyn) to 418 grains/m<sup>3</sup> (in Wrocław). The earliest

and latest pollen release peaks were observed on April 27<sup>th</sup> in Opole and on May 15<sup>th</sup> in Olsztyn, respectively. The maximum concentration of pollen grains in the other Polish cities was recorded between May 7<sup>th</sup> and 12<sup>th</sup> (tab. 1; fig. 1–7).

In most of the analyzed measurement stations, the number of days with threshold values  $\geq 16$  grains/m<sup>3</sup> was within the range of 16–25. Only in Bialystok and Szczecin, there were 1 and 5 days, respectively, on which the first symptoms of allergy may have appeared in allergic subjects. Additionally, there were no days with a pollen concentration  $\geq 91$  grains/m<sup>3</sup> in Szczecin and Bialystok. Olsztyn, Lublin, Sosnowiec, and Bydgoszcz were characterized by 3, 5, 6, and 7 such days, respectively. The highest number of days (19) with pollen grain concentrations above the latter threshold value was recorded in Opole. In turn, from 9 to 12 days with the concentration triggering symptoms in the majority of allergic subjects were recorded in the other 6 cities (tab. 1).

**Discussion**

In the cities of Poland analyzed in 2022, oaks released pollen with varying intensity. With the exception of Lublin, Kielce, and Warsaw, the onset of the

pollen season was recorded in the second and third decade of April, likewise in previous years [4, 15].

In comparison with 2020, the oak pollen season in 2022 began 3 and 8 days earlier in Piotrkow Trybunalski, Sosnowiec, and Bialystok, respectively, and 7–10 days later in Wroclaw, Olsztyn, Opole, Cracow, Lublin, and Warsaw. The shortest (only 1-day) and the longest (13-day) shifts in the onset of the oak pollen season were noted in Bydgoszcz and Szczecin, respectively [4]. In Kielce, the onset of the oak pollen season in 2022 was comparable to that in 2021 [9].

In 2022, the average length of the oak pollen season in the analyzed Polish cities was 32 days, as in 2018–2019 [7, 15]. The longest oak pollen season was recorded in Szczecin (48 days) and Sosnowiec (44 days), similar to 2019 (46 and 41 days, respectively) [7]. In 2022, the shortest oak pollen season was noted in Cracow, Kielce, and Lublin (22–24 days), and it was the shortest pollen period compared to 2018–2020 [4, 7, 15]. In most of the analyzed cities, the oak pollen season in 2022 ended in the third decade of May, i.e. later than in 2018–2019 [7, 15]. In 2022, the latest end of the pollen season was recorded in Olsztyn, similar to that in 2020 [4].

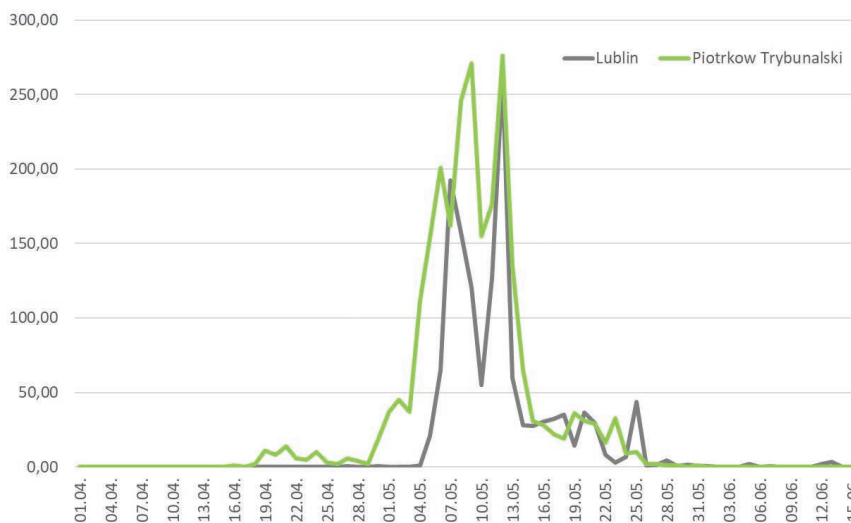
In 2022, the average annual sum of oak pollen grains in the 13 Polish cities was 2145. It was the

**Table 1.** Characteristics of the oak pollen season in 2022.

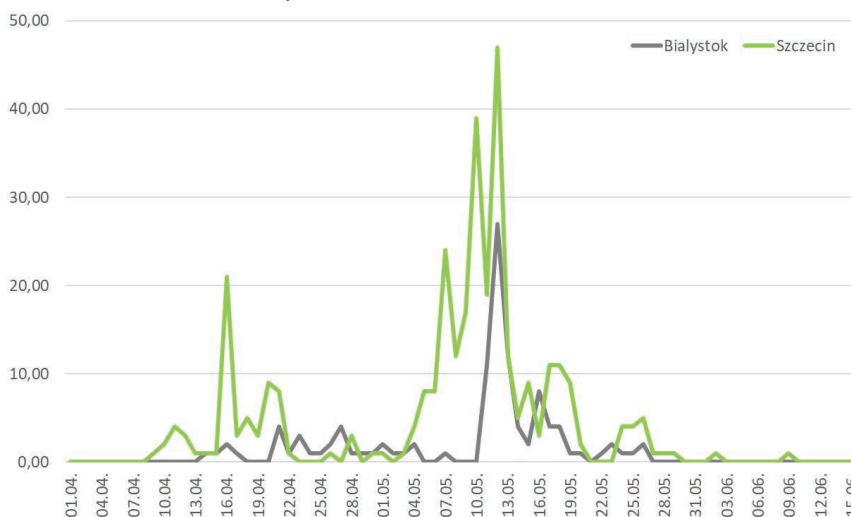
Site	Duration of pollen season (number of days)	Peak value (pollen/m <sup>3</sup> )	Peak date	Number of days with concentration above threshold		Annual pollen sum
				Days $\geq 16$ (pollen/m <sup>3</sup> )	Days $\geq 91$ (pollen/m <sup>3</sup> )	
Bialystok	15.04–26.05 (42)	27	12.05	1	0	112
Bydgoszcz	25.04–28.05 (34)	269	11.05	24	7	2098
Cracow	29.04–20.05 (22)	276	11.05	16	9	1971
Kielce	5.05–27.05 (23)	543	11.05	18	9	2426
Lublin	5.05–28.05 (24)	262	12.05	17	5	1376
Olsztyn	30.04–1.06 (33)	156	15.05	18	3	1222
Opole	23.04–23.05 (31)	453	27.04	25	19	5083
Piotrkow Trybunalski	21.04–24.05 (34)	276	12.05	23	10	2436
Sosnowiec	13.04–26.05 (44)	625	12.05	23	6	2256
Szczecin	11.04–28.05 (48)	47	12.05	5	0	328
Warsaw	3.05–29.05 (27)	399	11.05	17	9	2393
Wroclaw	23.04–*	418	7.05	21	10	2944
Zielona Gora	23.04–20.05 (28)	368	7.05	21	12	3240

\* No data from May 14<sup>th</sup> and 15<sup>th</sup> (no electricity).

**Figure 1.** Oak pollen concentration in Lublin and Piotrkow Trybunalski in 2022.



**Figure 2.** Oak pollen concentration in Bialystok and Szczecin in 2022.



**Figure 3.** Oak pollen concentration in Wroclaw and Zielona Gora in 2022.

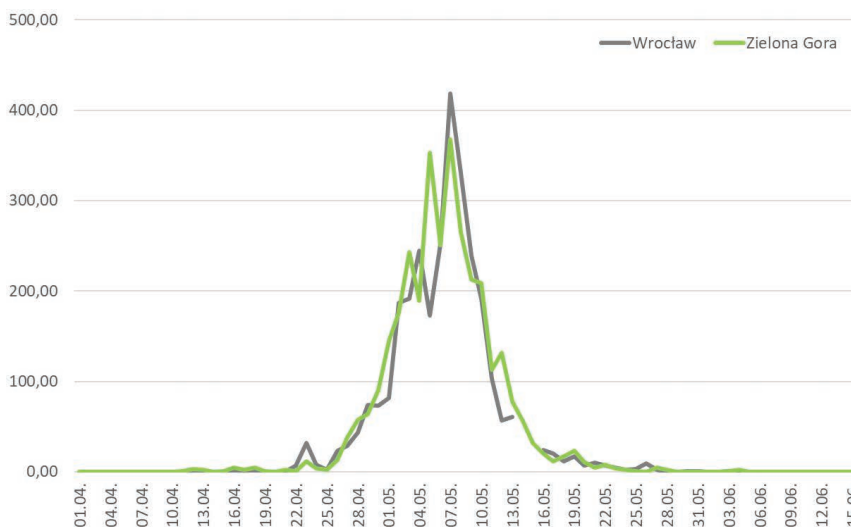


Figure 4. Oak pollen concentration in Bydgoszcz and Cracow in 2022.

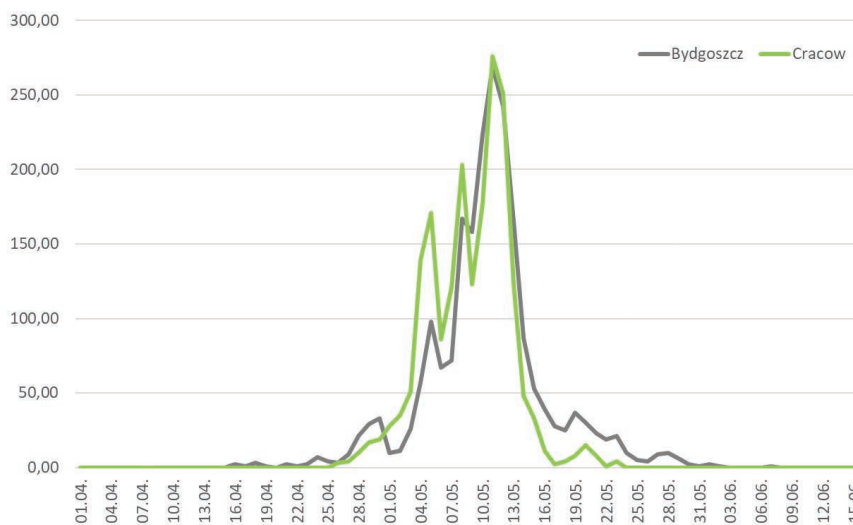


Figure 5. Oak pollen concentration in Warsaw and Kielce in 2022.

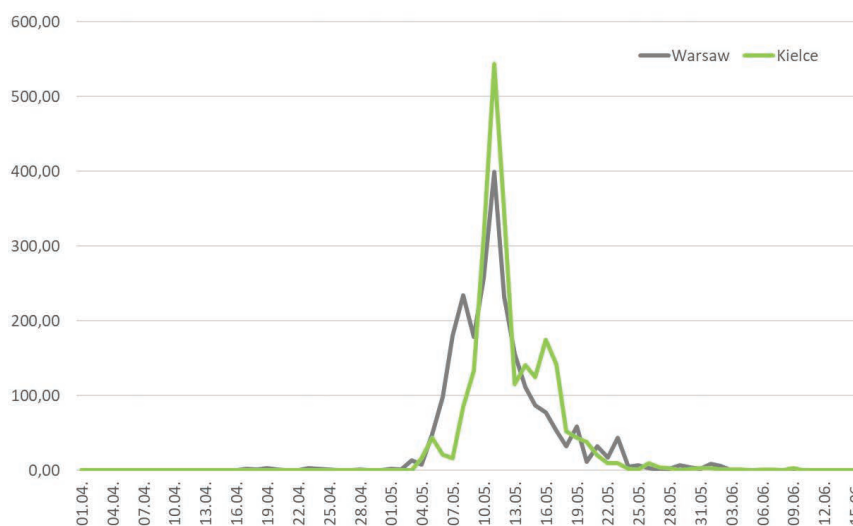
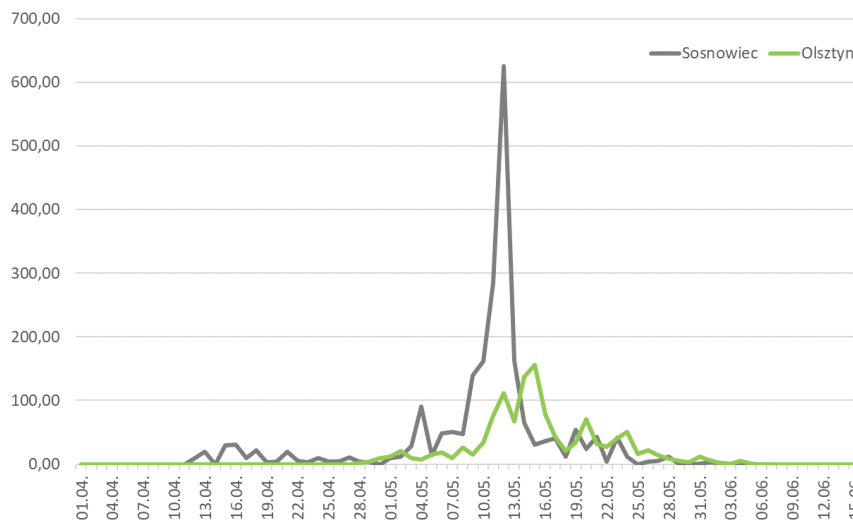
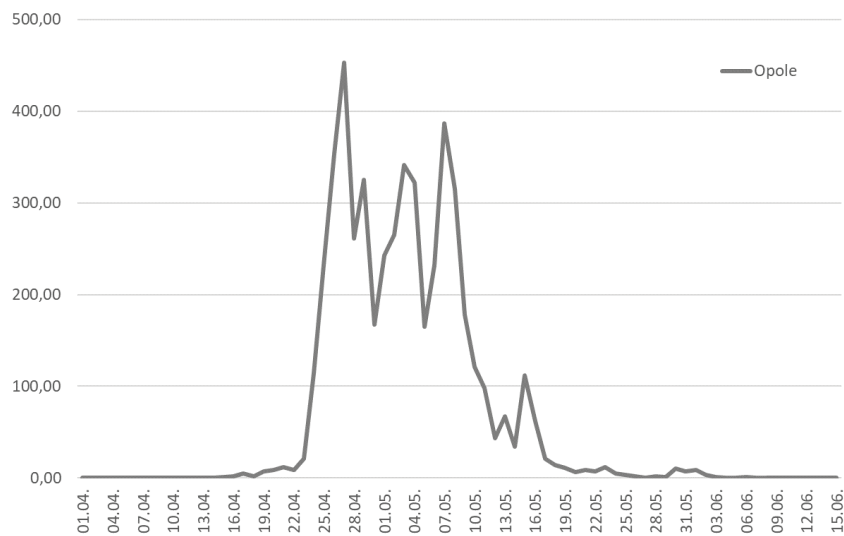


Figure 6. Oak pollen concentration in Sosnowiec and Olsztyn in 2022.



**Figure 7.** Oak pollen concentration in Opole in 2022.

closest value to the average pollen grain sum recorded in 2018 [15], and higher than the values of this parameter recorded in 2019–2020 [4, 7]. The lowest pollen grain sum in 2022 recorded in Białystok, likewise in previous years [4, 7, 15], and the highest sum was noted in Opole, similar to the value recorded in 2020, where the annual sum of oak pollen grains had one of the higher values [4].

The course of the oak pollen season presented in the graphs indicates a large variability of pollen release recorded in the analyzed measurement stations. The curves reveal the presence of several pollen peaks, which was possibly related to the different terms of different oak species flowering. The greatest similarity in the course of the oak pollen season was observed between Cracow and Bydgoszcz and between Wrocław and Zielona Góra.

In 2022, the highest concentration of oak pollen grains was recorded in Sosnowiec, characterized by a relatively long pollen season of the plant. This concentration was almost twice as high as the average value calculated for the 13 measurement stations. The lowest peak concentration of oak pollen grains was recorded in Białystok, similar to that shown in previous years [4, 7, 15]. In 2022, the highest oak pollen concentration was recorded on May 11<sup>th</sup> and 12<sup>th</sup> in 9 of the analyzed Polish cities. The dates of the maximum pollen concentrations in 2022 and 2020 coincided in Bydgoszcz and Warsaw, and only a one-day shift was observed in Piotrków Trybunalski and Sosnowiec [4]. The average maximum concentration values recorded in 2022 were higher than those determined in 2019 and 2020 [4, 7]. For example, in comparison with the values recorded in 2020, the maximum pollen con-

centration was almost 3-fold higher in Cracow, over 4-fold higher in Sosnowiec, and over 2-fold lower in Lublin [4]. In Kielce, the maximum concentration of pollen grains in 2022 was over 2-fold higher than in 2021 [9]. In 2022, the maximum concentration of pollen grains in Kielce and Lublin was observed already on days 6 and 7 days after the onset of the oak pollen season.

In the 2022 pollen season, the highest risk of symptoms of allergic reactions induced by oak allergens was determined in Opole, Piotrków Trybunalski, Zielona Góra, Wrocław, and Bydgoszcz. In most of the analyzed cities, the number of days with an exceeded threshold value of 91 grains/m<sup>3</sup> generating allergy symptoms in the majority of allergic subjects was higher than in 2020. The highest number of days with a pollen concentration above the threshold values was observed in Opole, as in 2020. In turn, the risk of oak pollen-induced allergy in Lublin was lower than in 2020 [4].

## Conclusion

In 2022, the oak pollen season began at the earliest in Szczecin, and at the latest in Lublin and Kielce. The shortest oak pollen season was recorded in Cracow, and the longest in Szczecin.

The highest annual sum of daily concentrations of oak pollen grains was recorded in Opole, and the lowest values of the parameter were noted in Białystok and Szczecin.

In most of the analyzed cities in Poland, the maximum oak pollen concentration was recorded between May 7<sup>th</sup> and 12<sup>th</sup>. The highest peak concentra-

tions were recorded in Sosnowiec and Kielce, and the lowest values were noted in Białystok and Szczecin.

The highest risk of allergy symptoms triggered by oak pollen allergens was observed in Opole, Piotrków Trybunalski, and Zielona Góra.

## References

1. Szafer W, Kulczyński S, Pawłowski B. *Rośliny Polskie*. PWN, Warszawa 1988.
2. Wrońska-Pilarek D, Danielewicz W, Bocianowski J et al. Comparative pollen morphological analysis and its systematic implications on three European oak (*Quercus* L., Fagaceae) species and their spontaneous hybrids. *PLoS ONE*. 2016; 11(8): e0161762. <https://doi.org/10.1371/journal.pone.0161762>.
3. Panahi P, Pourmajidian MR, Fallah A et al. Pollen morphology of *Quercus* (subgenus *Quercus*, section *Quercus*) in Iran and its systematic implication. *Acta Societatis Botanico-rum Poloniae*. 2012; 81(1): 33-41. <https://doi.org/10.5586/asbp.2012.005>.
4. Rapijko A, Malkiewicz M, Ziemianin M et al. Oak pollen concentration in the air of selected Polish cities in 2020. *Alergoprofil*. 2020; 16(4): 15-20. <https://doi.org/10.24292/01.AP.1643311220.3>.
5. Rapijko P. Alergeny pyłku dębu. *Alergoprofil*. 2007; 3(3): 34-8.
6. Lipiec A, Puc M, Malkiewicz M et al. Analiza stężenia pyłku dębu w wybranych miastach Polski w 2015 r. *Alergoprofil*. 2015; 11(3): 45-9.
7. Dąbrowska-Zapart K, Chłopek K, Malkiewicz M et al. Oak pollen season in selected cities of Poland in 2019. *Alergoprofil*. 2019; 15(2): 12-6. <https://doi.org/10.24292/01.AP.152150919>.
8. Puc M, Myszkowska D, Chłopek K et al. Pylek dębu w powietrzu Polski w 2017 r. *Alergoprofil*. 2017; 13(3): 124-8. <https://doi.org/10.24292/01.ap.300917>.
9. Kopacz-Bednarska A, Ślusarczyk J, Połowska J. Oak and hornbeam pollen season in Kielce in 2021. *Alergoprofil*. 2022; 18(1): 21-8. <https://doi.org/10.24292/01.AP.181050322>.
10. Weryszko-Chmielewska E, Piotrowska K. Cechy morfologiczne kwiatów i pyłku wybranych roślin alergicznych. In: Weryszko-Chmielewska E. *Aerobiologia*. Wyd. Akademii Rolniczej, Lublin 2007: 95-137.

11. Hauser M, Roulias A, Ferreira F et al. Panallergens and their impact on the allergic patient. *Allergy Asthma Clin Immunol*. 2010; 6: 1. <https://doi.org/10.1186/1710-1492-6-1>.
12. Majsiak E, Buczyłko K. Częstość występowania swoistych immunoglobulin E dla alergenu brzozy, olchy, leszczyny i dębu wśród 8254 osób z różnych regionów Polski. *Alergoprofil*. 2016; 12(2): 74-80.
13. Emberlin J, Savage M, Jones S. Annual variations in grass pollen seasons in London 1961-1990: trends and forecast models. *Clin Exp Allergy*. 1993; 23(11): 911-8.
14. Burge HA. Monitoring for airborne allergens. *Ann Allergy*. 1992; 9: 9-21.
15. Sulborska A, Weryszko-Chmielewska E, Piotrowska-Weryszko K et al. Stężenie pyłku dębu w powietrzu wybranych miast w Polsce w 2018 r. *Alergoprofil*. 2018; 14(3): 67-71. <https://doi.org/10.24292/01.AP.290918>.

A. Kopacz-Bednarska – ID – <http://orcid.org/0000-0003-0664-1450>  
 J. Ślusarczyk – ID – <http://orcid.org/0000-0001-8022-3244>  
 K. Piotrowska-Weryszko – ID – <http://orcid.org/0000-0003-3827-3218>  
 M. Ziemianin – ID – <http://orcid.org/0000-0003-4568-8710>  
 A. Rapijko – ID – <http://orcid.org/0000-0002-8906-2405>  
 M. Malkiewicz – ID – <http://orcid.org/0000-0001-6768-7968>  
 G. Siergiejko – ID – <http://orcid.org/0000-0003-4084-8332>  
 D. Jurkiewicz – ID – <http://orcid.org/0000-0003-3729-2679>  
 T. Wolski – ID – <http://orcid.org/0000-0002-1368-6107>  
 A. Lipiec – ID – <http://orcid.org/0000-0003-3037-2326>

Author's contributions:

A. Kopacz-Bednarska: 40%; J. Ślusarczyk: 15%; other authors: 5% each.

Conflict of interests:

The authors declare that they have no competing interests.

Financial support:

Research in Kielce funded by research funds for 2022 as a research project SUPB. RN.22.133. Research in Białystok, Bydgoszcz, Piotrków Trybunalski, Olsztyn, Opole, Warsaw and Zielona Góra funded by Allergen Research Center Ltd. (Ośrodek Badania Alergenów Środowiskowych Sp. z o.o.).

Ethics: The contents presented in this paper are compatible with the rules the Declaration of Helsinki, EU directives, and standardized requirements for medical journals.

Copyright: © Medical Education sp. z o.o. This is an Open Access article distributed under the terms of the Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). License (<https://creativecommons.org/licenses/by-nc/4.0/>), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material, provided the original work is properly cited and states its license.

## Correspondence

**Joanna Ślusarczyk, MD, PhD, Assoc. Prof.**

Department of Environmental Biology, Institute of Biology, Jan Kochanowski University in Kielce  
 25-406 Kielce, ul. Uniwersytecka 7

phone: (+48 41) 349-63-18

e-mail: joanna.slusarczyk@ujk.edu.pl