Abstract:
The study aims to monitor the alder pollen season in selected Polish cities: Bialystok, Cracow, Lublin, Olsztyn, Opole, Piotrkow Trybunalski, Sosnowiec, Szczecin, Warsaw, Wroclaw and Zielona Gora in 2021. Pollen concentrations were recorded by volumetric method using a Burkard-type sampler operating in a continuous volumetric mode. Alder pollen season, defined as the period with 98% of the annual total catch, started in 3rd decade of February in all monitoring sites. There was a marked variation in duration of the season between the sites. It lasted from 31 in Cracow to 54 days in Bialystok (38 days on average). The highest peak daily alder pollen concentrations were observed in Wroclaw (1879 grains/m³) on February 26th. The longest exposure to high concentrations of alder pollen, lasting 22–24 days, was detected in Zielona Gora, Piotrkow Trybunalski and Olsztyn. The alder pollen season in 2021, compared to the previous year, was longer, with higher average sum of daily concentrations over the season, higher maximum daily concentrations and longer exposure to high pollen concentrations at most monitoring sites.

Key words: alder (Alnus), pollen concentration, allergens

Introduction
The genus Alder (Alnus Mill.) belongs to the order Fagales Engl. and family Betulaceae Gray [1]. Black alder A. glutinosa is common throughout Poland, except in areas at higher elevations. Gray alder A. incana is not as common, occurring mainly in the mountains and along the Vistula River and from Suwalskie Lakeland to Tuchola Forests [2].

It is an early flowering tree. The occurrence of alder pollen in the air is significantly influenced by meteorological factors [3]. Together with birch and hazel pollen, it is an important source of tree pollen allergens.
in the temperate climate zone of the Northern Hemisphere. In a European GA2LEN study, conducted in 14 European countries, the percentage of patients sensitized to alder (with positive skin prick test) ranged from 3.1% to 47.0% and the percentage with clinically relevant symptoms ranged from 2.3% to 36.2% [4].

The marker of sensitization to alder, its main allergen, is the Aln g 1 molecule, belonging to the PR-10 family of proteins (Bet v 1 homologues), to which 100% of alder sensitized patients react [5]. The Aln g 2 molecule, another alder allergen, belongs to the profilin family, proteins that are panallergens in the plant kingdom. The high degree of structural similarity within the above families of proteins lies at the basis of cross-reactivity, whereby a person allergic to alder pollen may also react to pollen of other members of the Fagales as well as to some fruits, vegetables and nuts (pollen-related food allergy/oral allergy syndrome) [6]. The Aln g 4 molecule, which belongs to the family of polkalclins, is recognized by the antibodies of 18% of alder allergy sufferers [5].

### Aim

The study aims to compare the alder pollen season in selected Polish cities: Białystok, Cracow, Lublin, Olsztyn, Opole, Piotrków Trybunalski, Sosnowiec, Szczecin, Warsaw, Wrocław and Zielona Gora in 2021.

### Material and method

The pollen count measurements were conducted during the 2021 pollen season. Pollen concentrations were recorded, in line with international standards, by volumetric method using a Burkard-type sampler operating in a continuous volumetric mode [7]. Counts were recorded over 7-day cycles and microscopic analysis was performed for each 24-hour period.

The following variables were taken into consideration:

- length of the alder pollen season, determined by the 98% method, calculated based on the beginning and end of the season defined by 1% and 99% of the annual total pollen catch, respectively [8]
- sum of the daily average pollen concentrations over the season expressed by the seasonal pollen integral (SPI) [9]
- maximum daily pollen concentration for the season and date of the highest
- the number of days with above-threshold pollen level, adopted according to the available literature.

Alder pollen concentrations were expressed as the number of pollen grains in 1 m³ of air per day (grains/m³). On the basis of the literature, the number of days when the concentrations of Alnus pollen exceeded the threshold values for the development of allergy symptoms were determined [10] (tab. 1).

### Results and discussion

In 2021, the alder pollen season began between February 21st in Zielona Gora and 27th in Olsztyn and lasted until even the 3rd decade of April (in Białystok) (tab. 1, fig. 1, 2). In 2021 the onset of the season occurred almost a month later than in the previous year and at a similar time as in years 2019 and 2017 [11–14]. As the beginning of alder pollen season depends on weather conditions, mainly the accumulated air temperature, the length of the season may vary in individual years by 30 up to 50 days. The average length of the alder pollen season in 2021 was 38 days. It falls between the length of the season in 2019 (22 days)

### Table 1. Characteristics of Alnus pollen season in 2021.

| Feature of pollen season | Olsztyn | Opole | Piotrków Trybunalski | Szczecin | Sosnowiec | Lublin | Warsaw | Białystok | Wrocław | Cracow | Zielona Gora |
|--------------------------|---------|-------|----------------------|----------|-----------|--------|--------|-----------|----------|--------|-------------|
| Duration of pollen season (number of days) | 27.02–6.04 (39) | 23.02–28.03 (34) | 24.02–29.03 (34) | 22.02–27.03 (34) | 24.02–9.04 (45) | 25.02–8.04 (45) | 24.02–29.03 (34) | 25.02–19.04 (35) | 23.02–29.03 (35) | 25.02–27.03 (31) | 21.02–26.03 (34) |
| Seasonal pollen integral (SPI) | 10 978 (17.03) | 9818 (26.02) | 9773 (26.02) | 8047 (3.03) | 3014 (3.03) | 6631 (16.03) | 9170 (16.03) | 3205 (16.03) | 7913 (16.03) | 2185 (16.03) | 11 402 (16.03) |
| Peak value and peak date | 1786 (26.02) | 1709 (26.02) | 1564 (26.02) | 1784 (3.03) | 451 (27.02) | 951 (27.02) | 1346 (27.02) | 616 (27.02) | 1879 (27.02) | 407 (27.02) | 1638 (4.03) |
| Days ≥ 45 pollen/m³ | 32 | 24 | 23 | 28 | 16 | 25 | 27 | 14 | 17 | 17 | 24 |
| Days ≥ 85 pollen/m³ | 24 | 18 | 23 | 19 | 11 | 18 | 21 | 10 | 14 | 7 | 22 |
and in 2016 (50 days). The shortest season was recorded in Cracow (31 days), while the longest in Bialystok (54 days) (tab. 1, fig. 3, 4) [12, 15].

The highest daily alder pollen concentration was detected in Wroclaw (1879 grains/m³ on February 26th), followed by records in Olsztyn (1786 grains/m³ on March 17th) and Szczecin (1784 grains/m³ on March 3rd) (tab. 1, fig. 1, 3, 5). The maximum daily concentrations in 2021 were much higher in comparison to those detected in 2020 (tab. 1) [11]. The lowest peak daily alder pollen concentrations were recorded in Cracow (407 grains/m³ on February 27th) and in Sosnowiec (451 grains/m³ on February 27th) (tab. 1, fig. 3, 6).

The highest annual sum of alder pollen grains (SPI) in 2021 was recorded in Zielona Góra (11,402 grains), while the lowest in Cracow (2185 grains) (tab. 1). The average SPI for alder pollen season in 2021 was 7467. It was three times higher than in 2020 (2,447) but two times lower than in 2019 (12,485) [11, 12].

The highest risk of pollen allergy expressed in days with pollen levels exceeding the threshold value at which first symptoms of allergy occur (45 grains/m³) was recorded in Olsztyn (32 days) and in Warsaw as well as in Zielona Góra (27–28 days respectively). For other monitoring sites the number of days with alder pollen concentrations exceeding the threshold of first allergy symptoms was between 14 and 25 days (tab. 1) [10].

The longest exposure to high concentrations of alder pollen (85 grains/m³ and above) causing severe clinical symptoms, lasting 22–24 days, was recorded

Figure 1. Alder pollen concentration in Olsztyn and Opole in 2021.

Figure 2. Alder pollen concentration in Zielona Góra in 2021.
in Zielona Gora, Piotrkow Trybunalski and Olsztyn (tab. 1). Those records were higher than in the previous year, when number of days with concentrations of alder pollen equal or above the threshold (85 grains/m³) did not exceed 16 [11].
Conclusions
The alder pollen season in 2021 began in the 3rd decade of February. There was a marked variation in duration of the season between monitoring sites. It lasted from 31 days in Cracow to 54 days in Bialystok (38 days on average).

The highest peak concentrations of alder pollen were detected in Wroclaw, Opole, Szczecin and Olsztyn, whereas the lowest in Cracow, Sosnowiec and Bialystok. The longest exposure to high concentrations of alder pollen, lasting 22–24 days, was detected in Zielona Gora, Piotrkow Trybunalski and Olsztyn.

The alder pollen season in 2021, compared to the season in 2020, was characterized by longer average pollen season, higher average sum of daily concentrations over the season (SPI), higher maximum daily concentrations and longer exposure to high concentrations of alder pollen in the majority of monitoring sites.

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