

Airborne pollen of *Betula*, *Corylus* and *Alnus* in Zagreb, Croatia. A three-year record

RENATA PETERNEL, LIDIJA SRNEC, IVANA HRGA, PREDRAG HERCOG and JOSIP ČULIG

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The aim of this study was to construct a picture of the influence of meteorological conditions on the start and duration of the airborne Betulaceae pollen season and the pollen concentrations in the atmosphere of Zagreb, Croatia. The study during three seasons (2002–2004) used a 7-day Hirst-type volumetric pollen and spore trap. Total annual airborne pollen of *Alnus*, *Corylus* and *Betula* greatly varied from year to year. The differences in the dates of onset of airborne pollen presence of *Alnus*, *Corylus* and *Betula* noted in Zagreb in 2002–2004 were controlled by weather conditions, particularly temperature and precipitation. In all years studied, airborne pollen peaks were recorded on days with temperature above 0°C and without or minimal precipitation. The mean number of days with airborne pollen concentrations exceeding levels which provoke symptoms of an allergic reaction was 15, 16 and 29 days for alder, hazel and birch, respectively. The results of the present study may provide useful data for allergologists to reach accurate diagnoses, and timely information on concentrations of airborne pollen types and concentrations for individuals with pollen hypersensitivity.

Renata Peternel*, Lidija Srnc, Predrag Hercog & Josip Čulig, Zagreb Institute of Public Health, Mirogojska c. 16, HR-10 000 Zagreb; Ivana Hrga, Meteorological and Hydrological Service, Gric 3, HR-10000 Zagreb; Croatia.

*Corresp. Author

E-mail: renata.peternel@publichealth-zagreb.hr

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In northern and central Europe, pollen grains from the representatives of the family Betulaceae (e.g., *Alnus*, *Betula* and *Corylus*) are a significant contributor to the incidence of pollinosis (Spieksma 1990, Norris-Hill & Emberlin 1991, D'Amato & Spieksma 1992). The allergenic significance of the family Betulaceae is based on the fact that the trees are widespread and shed large quantities of windborne pollen, which rapidly release their allergenic substances in the respiratory tract (Hyde 1972). Although the pollen season for Betulaceae genera seldom lasts for more than a few weeks, the clinical importance of the Betulaceae pollen may depend also on factors such as local variation in the flora. Furthermore, the sequential shedding of pollen, together with cross-reactivity between Betulaceae and other tree pollen grains contributes to a prolonged season of symptoms for many patients (Koivikko et al. 1986). Alder (*Alnus*) trees are very common in central and northwestern Europe. In some areas, particularly in the low-lying countries, their annual total pollen counts reach high numbers (Lejoly-Gabriel et al. 1983, Spieksma 1983). *Alnus* and *Corylus* are the first airborne pollen types of the season (Spieksma et al. 1989). The high frequency of sensitization might be caused by the apparent high degree of cross-reactivity with the *Betula* pollen allergen (Eriksson et al. 1987, Dalen et al. 1981, Ipsen et al. 1985, Wahl et al. 1986). *Betula* pollen poses a considerable clinical problem for up to 10–20% of the population in northern and central Europe (Vik et al. 1991). Dose response relationships between pollen concentrations and clinical symptoms are scarce. There is no unique criterion for establishing the minimum level capable of

triggering allergic symptomatology since the response is highly individual. However, it has been pointed out that birch pollen concentrations greater than 30 grains m⁻³ over 24 h trigger severe symptoms and values greater than 80 grains m⁻³ over 24 h produce allergic symptomatology in 90% of patients (Corsico 1993). Hazel pollen induces allergic reaction at concentrations of 20–30 grains m⁻³ over 24 h and alder pollen at concentrations of 50 grains m⁻³ over 24 h (Hofman et al. 1998, Spieksma et al. 1991, Szczeklik et al. 1991, Vik et al. 1991). The aim of this study was to construct a picture of the start and duration of Betulaceae pollen season, and of the pollen concentrations during three years (2002–2004) in the atmosphere of Zagreb, Croatia, as influenced by temperature and precipitation.

MATERIAL AND METHODS

Analysis of the pollen count distribution was performed on the basis of data collected in Zagreb in the 2002–2004 seasons. Zagreb is situated in the central part of Croatia with continental climate (Penzar 1976). A 7-day Hirst-type volumetric pollen trap (VPPS 2000; Lanzoni, Bologna, Italy) was used for pollen sampling (Hirst 1952, Raynor 1979). The sampler was placed at 19.7 m on the roof of the Grič Observatory in the center of the City of Zagreb (45°49'N and 15°59'E, 157 m above the sea level). The sampler absorbs 10 L air per minute, allowing for the pollen concentration to be determined at 2-hour intervals (for practical sampling details see Ogden et al. 1974). Five longitudinal sweeps on each slide were analysed under a light microscope, magnification ×400. Pollen concentration was expressed as pollen grain count/m³ air. The

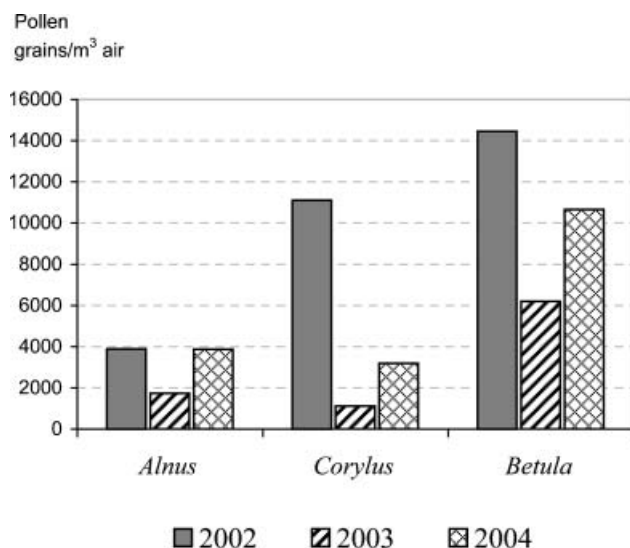


Fig. 1. Annual sums of airborne pollen concentrations (*Alnus*, *Corylus*, *Betula*) in Zagreb 2002–2004.

meteorological and phenological data were provided by the Croatian Meteorological and Hydrological Service. Pollen data set in relation to the meteorological parameters was tested with Spearman's rank test.

RESULTS

Total annual airborne pollen concentrations of the Betulaceae family members varied from year to year, yet show a certain pattern. Thus, the highest annual pollen concentrations of all three genera (*Alnus*, *Corylus* and *Betula*) were recorded in 2002 (3 883 pg m⁻³, 11 106 pg m⁻³ and 14 448 pg m⁻³), followed by a decline in 2003 (1 728 pg m⁻³, 1 110 pg m⁻³ and 6 191 pg m⁻³), to rise again in 2004 (3 872 pg m⁻³, 3 184 pg m⁻³ and 10 659 pg m⁻³, respectively) (Fig. 1). A certain pattern and correlation with weather parameters was also observed for the beginning and course of the atmospheric pollen presence. The highly favorable weather conditions in 2002 during the period preceding the flowering of alder, hazel and birch (January) resulted in an earlier occurrence of their pollen in the air. In 2002, the lowest temperature of -5.6°C was recorded on

January 4, and did not fall below 0°C after January 20 (in January, the mean monthly temperature was 2.2°C, and the total precipitation 24.9 mm). This led to a shift in the initial occurrence of alder, hazel and birch pollen in the air (February 5, February 1 and March 1, respectively) by about one month relative to the next year. The period from January to February 2003 was by far most unfavorable in all three studied years. Temperatures below 0°C accompanied by precipitation persisted up to February 25. This caused approximately one month delay in the date of the first flowering. In 2004, however, the initial occurrence of alder and hazel pollen in the air generally resembled the pattern observed in 2002, whereas birch flowering time started towards the end of March, as in 2003. In all three years (2002, 2003 and 2004), peaks in atmospheric pollen concentrations were recorded on the days characterized by temperature above 0°C and no or minimal precipitation: *Alnus* 3.4°C, 12.8°C and 10.0°C; *Corylus* 7.0°C, 12.8°C and 10.6°C; and *Betula* 14.1°C, 12.6°C and 16.4°C, respectively. Those dates correspond to the dates of the peak flowering (Table I, Fig. 2). The percentages of pollen of the Betulaceae family members also differed considerably between years, being lowest in 2003. Finally, using the Sperman's rank test for the whole period we found correlations between higher air temperature and high pollen concentrations as well as high precipitation and low pollen concentrations (Table III). The number of days with airborne pollen concentrations exceeding the level provoking the symptoms of allergic reaction ranged from 9 to 20, i.e. 26–31% for alder, depending on the duration of pollen season. For hazel, the percentage ranged from 18% in 2003 to 43% in 2002, whereas birch showed a very high percentage in 2002 (83%) and 2003 (93%), with a lower percentage in 2004 (52%) (Table II). The occurrence of alder, hazel and birch pollen in the Zagreb City atmosphere during the 3-year period is presented in Fig. 3.

DISCUSSION

The pollen of *Alnus* and *Corylus* appear first in the annual pollen spectrum in Zagreb. It was recorded in the atmosphere during February and March, which is consistent with the results reported for Lublin, Szczecin and Warsaw, although these cities are located far more northward than

Table I. Presence of *Alnus*, *Corylus* and *Betula* pollen in Zagreb atmosphere 2002–2004.

Taxa	Year	Date of the first flowering	Date of the peak flowering	Period of pollen occurrence	Pollen peak day	Pollen conc. in a peak day (p. m ⁻³ air)
<i>Alnus</i>	2002	Feb-19	Feb-24	05/02–06/04	Feb-19	91
	2003	Mar-18	Mar-19	02/03–07/04	Mar-12	196
	2004	Mar-10	Mar-13	02/02–04/04	Mar-16	519
<i>Corylus</i>	2002	Feb-05	Feb-10	01/02–20/03	Feb-15	96
	2003	Mar-08	Mar-10	28/02–19/04	Mar-12	256
	2004	Feb-06	Feb-09	01/02–02/04	Feb-07	773
<i>Betula</i>	2002	Mar-12		01/03–16/04	Mar-18	1652
	2003	Apr-08		29/03–30/04	Apr-13	872
	2004	Mar-30		31/03–30/04	Apr-04	2527

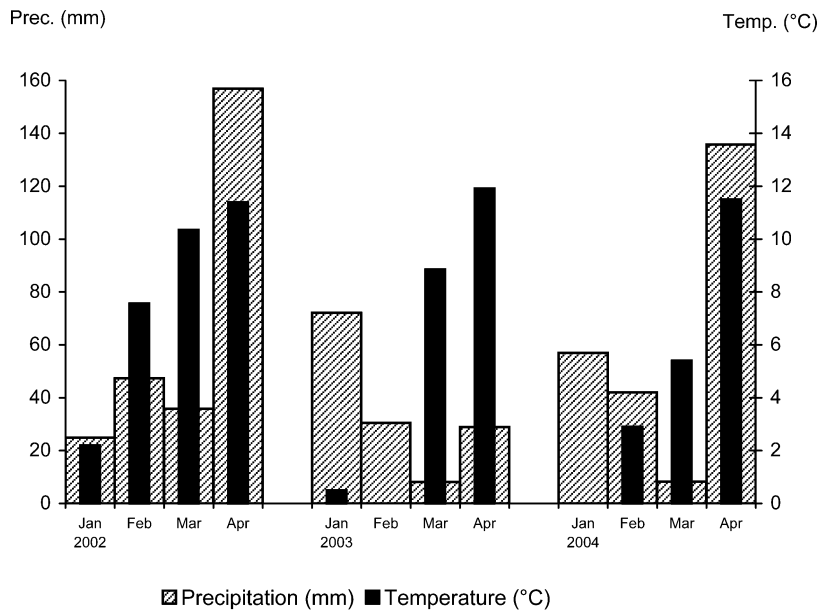


Fig. 2. Mean monthly air temperature and total monthly precipitation in Zagreb 2002–2004 (January–April).

Table II. Number of days with airborne pollen concentration exceeding the threshold value V_t for allergic reactions for *Alnus*, *Corylus* and *Betula* (2002–2004) and length of pollen season (in days).

Year	<i>Alnus</i> ($V_t = > 50 \text{ p.m}^{-3} \text{ air}$)	<i>Corylus</i> ($V_t = > 20 \text{ p.m}^{-3} \text{ air}$)	<i>Betula</i> ($V_t = > 30 \text{ p.m}^{-3} \text{ air}$)
2002	16/61	21/48	39/47
2003	9/34	9/51	31/33
2004	20/63	19/62	16/31

Zagreb (Weryszko-Chmielewska et al. 2001). Interestingly, the onset of pollen season of these three taxa occurred at about the same time as in Greece, which is more southerly than Croatia (Gioulekas et al. 2004), and in most countries of western and central Europe (Spijksma 1991). The differences in the beginning of flowering of *Alnus* and *Corylus* observed in Zagreb during the 2002–2004 period were most probably due to the weather conditions, which are known to affect their pollen release (Szczepanek 1994, Rodriguez-Rajo 2004). A similar pattern was also recorded for the occurrence of birch pollen. Like the majority of northern and central European countries, in Zagreb, birch

pollen first occurred during March, however, in the above mentioned Polish cities it is reported to initially occur in mid-April. The flowering of birches is generally characterized by high maximal airborne pollen concentration that may frequently reach several thousand pollen grains m^{-3} over 24 h and short-term pollen presence in the atmosphere; in Zagreb, it ranged from 31 to 47 days, exceeding the data from Poland (20–27 days) (Weryszko-Chmielewska et al. 2001). In Zagreb, the length of pollen season of *Alnus* with a mean of 52 days was found to be comparable with that in Ourense and Santiago (Galicia, north-western Spain) (Rodríguez-Rajo 2004), whereas the pollen season of

Table III. Summarized results of the statistical analysis pollen data in relation to the meteorological parameters for the period of three years (2002–2004).

STAT. NONPAR STATS	Spearman Rank Order Correlations MD pair-wise deleted			
Par of Variables	Valid N	Spearman R	T(N-2)	p-level
TEMP_F & ALNUS_F	84	0.553858	6.02370	0.000000
TEMP_F & COR_F	84	0.669870	8.16985	0.000000
TEMP_M & COR_M	93	0.389313	4.03190	0.000115
TEMP_M & BET_M	93	0.413481	4.33202	0.000038
PREC_A & ALNUS_A	90	−0.379262	−3.84506	0.000227
PREC_A & COR_A	90	−0.262300	−2.54987	0.012507
PREC_A & BET_A	90	−0.321470	−3.18470	0.002005

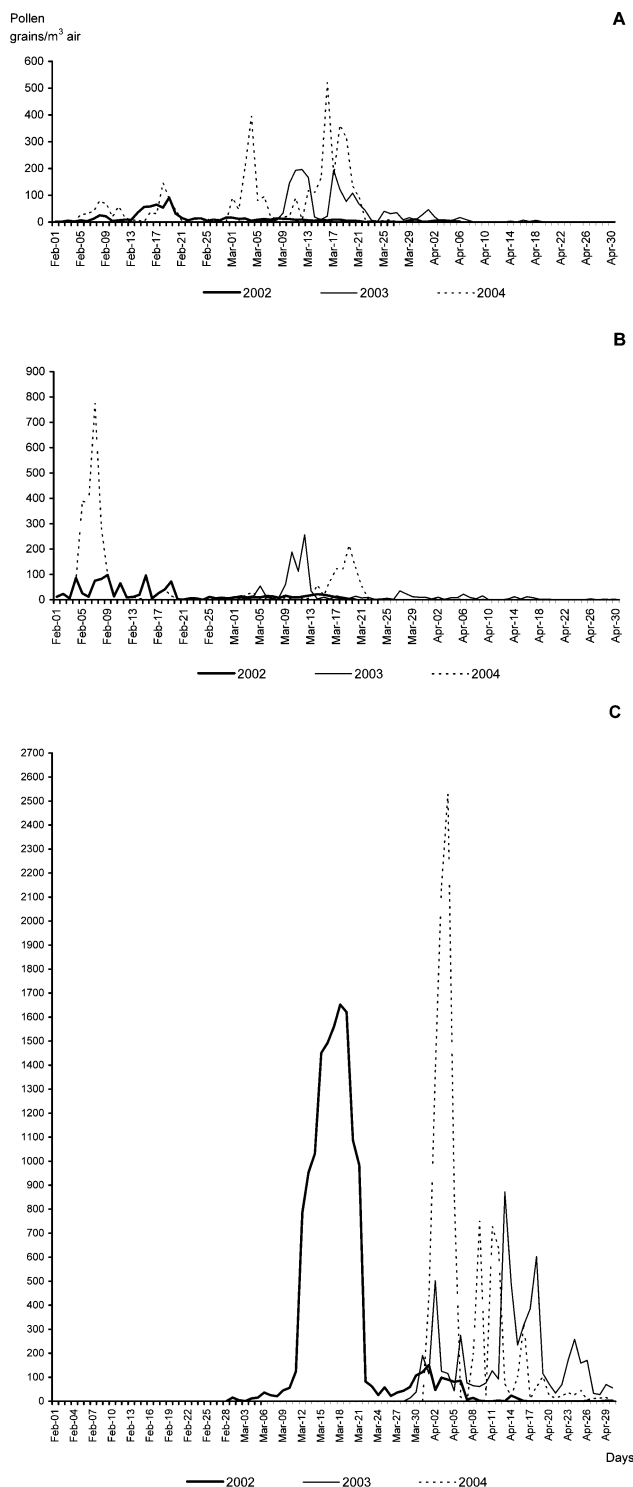


Fig. 3. Variation in mean daily pollen concentrations (A – *Alnus*; B – *Corylus*; C – *Betula*) in Zagreb 2002–2004.

Corylus was some 10 days longer than in the above mentioned Polish cities (Weryszko-Chmielewska et al. 2001). Information on the number of days with airborne pollen concentration exceeding the level associated with the occurrence of allergic reaction symptoms is of great importance for individuals with allergy to pollen produced

by members of the family Betulaceae. This figure varied greatly according to taxon and year of observation. As there is strong cross-reactivity among members of the family Betulaceae (Wahl et al. 1996), knowledge of the overlapping of their flowering periods, and thus of the periods with relatively high airborne pollen counts, may facilitate individuals at risk to avoid particular pollen exposure as the most effective method of prevention.

CONCLUSIONS

- B** Information on airborne pollen concentrations in relation to allergy symptoms helps allergic patients and allergologists develop preventive measures and therapy. Therefore, total annual airborne pollen concentration of Betulaceae for the period of three years was related to the temperature, precipitation and phenological data in Zagreb. Although the total annual airborne pollen concentrations of the family Betulaceae varied greatly from year to year, the highest concentrations were recorded in 2002. Meteorological parameters (temperature and precipitation) influenced the dates of onset of airborne pollen production and release of *Alnus*, *Corylus* and *Betula*. In 2002, airborne pollen grains of these plants occurred by about one month earlier than in 2003. The mean number of days with airborne pollen concentrations exceeding the levels provoking symptoms of allergic reactions was 15, 16 and even 29 days for alder, hazel and birch, respectively. This information may be useful to individuals with pollen hypersensitivity. Whenever possible they could plan their activities and by choosing the time and place of holidays they can avoid exposure to large doses of the allergen. These conclusions have been made on the basis of three years investigation; future studies over a longer study period will be necessary to gain a clearer insight into the relationship between weather parameters and airborne pollen concentration in the air.

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